

The Enduring Pilbara

A conservation vision for a land rich in
nature, culture and resources

This is an independent report commissioned by The Pew Charitable Trusts

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Acknowledgement of country: The authors acknowledge the Traditional Owners of the Pilbara and their continuing connection to these lands. We pay respect to them and their cultures, and to their Elders past and present. We acknowledge the inextricable links between natural values and Aboriginal values and that the knowledge of Traditional Owners will be vital for maintaining both.

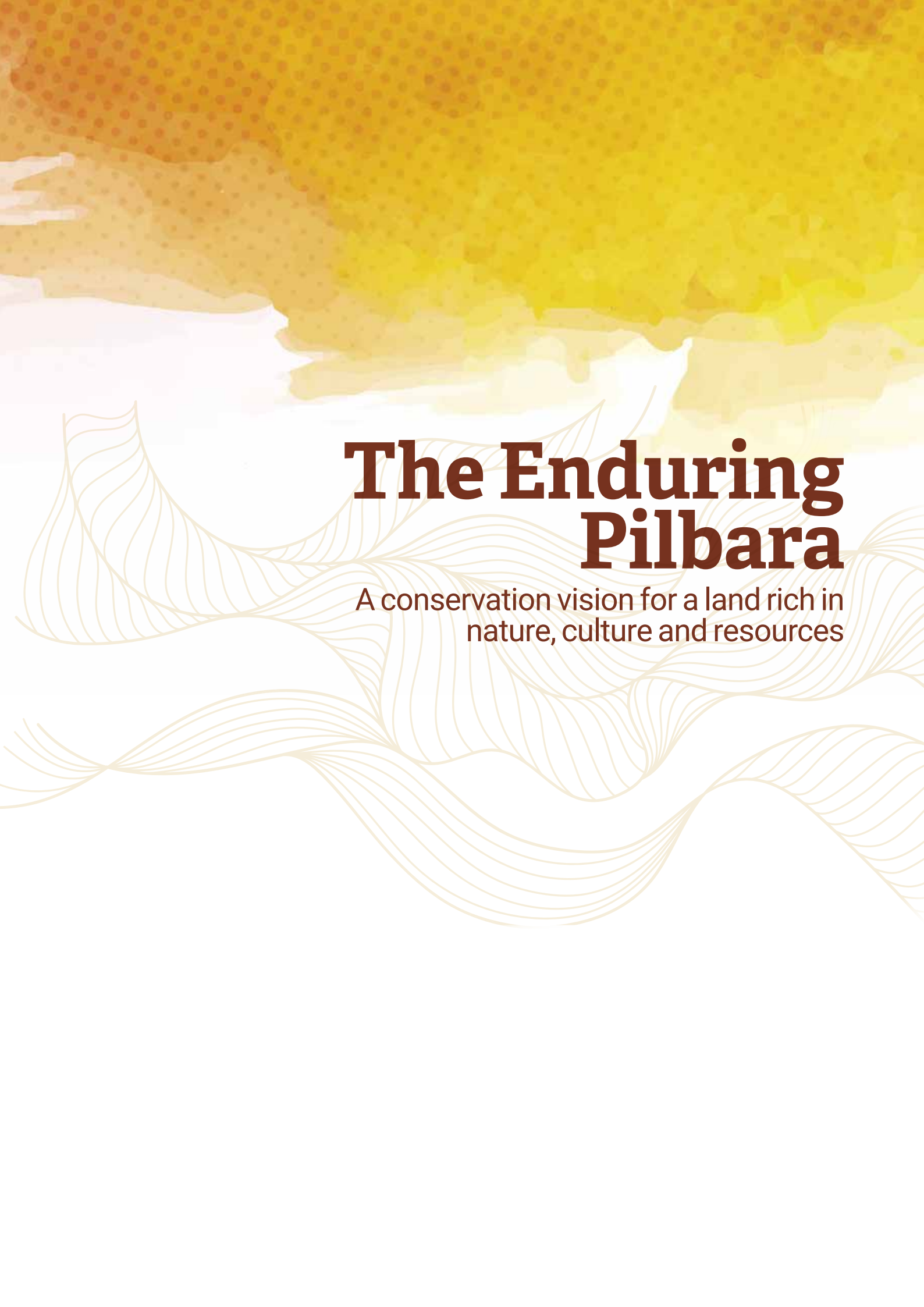
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The Centre for Conservation Geography (conservationgeography.org) is a research group established in 2011 to provide expert technical support and advice to government and nongovernment decision-makers and stakeholders. Based in Australia, we are a multidisciplinary team with expertise in marine and terrestrial protected area planning. Our skills include scientific research, evidence-based policy development, GIS analysis and mapping, and science communications and advocacy. We can support conservation decision-making across the world's ecoregions, and currently have projects in Australia, Canada and Antarctica

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Cover photo: Jajiwarra (Robe River), meaning 'no fine sand', is integral to the cultural identity of the Robe River Kuruma people. All along Jajiwarra are Aboriginal sites, including sacred Thalu (increase sites), ceremony places and archaeological sites. Image: Gavin Canning





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Foreword

The Pilbara is special to each of us.

As a botanical ecologist, Stephen worked in the Pilbara for 20 years in conservation and land management – documenting the unique flora (including many new species) of this national biodiversity hotspot, investigating the impacts of fire regimes that cause biodiversity decline and weeds such as buffel grass, and assessing the environmental impacts of mining and infrastructure proposals. Many of his efforts were informed by discussions with Traditional Owners and his desire to capture Traditional Ecological Knowledge and understand its application to the ongoing stewardship of Country by the Pilbara's Traditional Owners.

Peter has long been involved in sustainability research, advocacy and strategy work in the Pilbara. His *Pilbara Regional Sustainability Strategy* (2004) and *Pilbara 2050* (2015) report helped set up the current move to Net Zero mining, with its massive potential in green steel, lithium battery minerals and solar-electric based mining now rolling out across the landscape. His work, which also included the *Social Impact Study of the Rudall River Region* (1993), has confirmed that any future economic development not done in partnership with Indigenous people would fail the most basic sustainability test.

The *Enduring Pilbara* report, an initiative of Partnership for the Outback, brings together sound scholarship and ground-truthed awareness of local challenges and opportunities as the basis for an inspiring but realistic conservation vision for the Pilbara. It is a vision we support and an important step forward in the collective effort to achieve sustainable outcomes for the Pilbara that acknowledge nature.

The *Enduring Pilbara* is also a benchmark reference document for those seeking to understand and manage the Pilbara's magnificent environment, its threats and opportunities. The report recognises the complexities and uniqueness of the Pilbara's landscape and ecology and its enduring First Nations peoples, their rights and connections to Country, and their pivotal place in the emerging Pilbara conservation, land management and restoration economies.

Importantly, the report also grapples with economic realities – recognising that mining and pastoralism will continue to be dominant land uses and economic mainstays and calculating the investments needed to also build a thriving conservation economy, which would support and complement existing industries. We believe that the vision of the report is highly ambitious but achievable:


By 2031 the Pilbara is the world-leading exemplar of landscape-scale conservation in a region of critical economic importance. Cultural and conservation land management is comprehensively implemented across all tenures, delivered through partnerships between Traditional Owners, industry, government and community.

The report aligns with much existing work, including our own. As the world moves rapidly towards decarbonised economies, the Pilbara must illustrate how that transition can be realised, especially given its crucial role in the wider Australian economy. The move to a renewable energy net zero economy and the other big transitions needed for sustainability require effective partnerships between government, industry and community. Partnerships are the bedrock of the conservation vision in the *Enduring Pilbara* report.

Although much touted, achieving effective partnerships is challenging – they require genuine commitments and considerable investment of time, energy and funding. The partnerships needed to achieve landscape-scale cultural and conservation land management in the Pilbara will need support to sustainably lift the capacity and capability of Traditional Owners, and also, just as importantly, investment in the capacity and willingness of state agencies, pastoralists and miners to jointly manage with Traditional Owners the land and its inherent cultural and natural values.

We encourage all those who care for and have interests in the Pilbara's land and waters to read the *Enduring Pilbara* report and embrace its vision.

Stephen van Leeuwen and Peter Newman



Professor Stephen van Leeuwen is the BHP Curtin Indigenous Chair of Biodiversity and Environmental Science at Curtin University. He is a respected South West Boojarah Wardandi Noongar leader with a profound respect for Country who engages and builds collaborative relationships with Traditional Owners and other land managers to co-deliver novel and enduring outcomes for biodiversity conservation, bio-cultural land management, and the stewardship of Country. He has a diverse research pedigree extending from threatened flora survey, fire ecology and threatened flora and fauna management through to biological survey, arid zone ecology, plant taxonomy and pollination biology.

Professor Peter Newman AO is Professor of Sustainability at Curtin University. He has written 23 books and over 400 papers on sustainable cities and regions. He has worked to deliver these ideas at all levels of government, including as an advisor to three premiers and on the Board of Infrastructure Australia and the Prime Minister's Cities Reference Group. He is the Co-ordinating Lead Author for the UN's Intergovernmental Panel on Transport. In 2014 Peter was awarded an Order of Australia for his contributions to urban design and sustainable transport. In 2018/19 he was the WA Scientist of the Year.



Python Pool, a popular attraction in Millstream Chichester National Park, is part of the traditional country of the Yindjibarndi people. Image: Gavin Canning



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Opposite: In the ephemeral rivers of the Pilbara, permanent pools like this are of great cultural significance. This is Marble Bar Pool, a popular recreational site just west of the Marble Bar township – part of the traditional country of the Nyamal people. Image: Donna Colliver



1. Introduction

The Pilbara is often described as timeless. But the opposite is true – the passage of time is more evident in this landscape than almost anywhere else on Earth. Here, you can see rock that coalesced into crust when the world was starting to assume its present form and the fossilised remains of microbial colonies that are among the earliest signs of life on Earth. You can see the greatest concentration of engraved rock art in the world, created by peoples who settled the region more than 2,000 generations ago.

In such ways the Pilbara epitomises *endurance* – over geological, evolutionary and cultural timeframes.

Geologically, the region is defined by a robust piece of continental crust that has survived billions of years of tectonic upheavals. The Pilbara's plants and animals – exceptionally diverse for an arid region – are survivors of immense climatic changes, many exemplifying ingenious evolutionary innovations to cope with extremes. And through cultural and technological ingenuity and innovation, the Pilbara people have also survived and thrived, to now count among the world's oldest living cultures.

The Pilbara has been home to people for some 50,000 years or more, living in diverse societies governed by complex systems of law and custom. For almost 160 years, the Pilbara has also been an agricultural region, governed from afar for the purpose of raising sheep, then cattle. And for the past 50 or so years, the Pilbara has also been a major mining province – touted as 'the engine room' of the Australian economy for the astonishing wealth generated by extracting iron and gas from ancient rocks. Mega-mines and vast red-dirt cattle stations dominate public perceptions of the region. For residents of the Pilbara, even their votes reflect this perception – in the state's Legislative Council, the Pilbara is part of the region known simply as 'Mining and Pastoral'.

The Pilbara remains a tough landscape for life – and not just because it is naturally one of the most extreme environments in Australia. Since the late 1800s, human and non-human newcomers have intensified the pressures on life. The consequences, not unique to the Pilbara, have been a diminishment of biodiversity and degradation of landscapes. The Pilbara's Traditional Owners have suffered the catastrophes of dispossession and cultural suppression.

These are the big challenges in the Pilbara today – to arrest and remediate the harm to nature, and support Traditional Owners to thrive, connected to country and strong in culture.

Opposite: The low, deeply weathered Chichester Range contains the remnants of iron-rich lava that emerged from deep within the Earth some 2.7 billion years ago and blanketed much of the Pilbara craton. Image: Michael Pelusy

About this report

The purpose of this report is to promote a more expansive Pilbara identity, based on its natural and cultural wealth, and to set out a vision for the region and its economy based on sustaining and restoring these values.

The Pilbara bioregion is so much more than a resource zone and its rocks so much more than a source of iron ore. In **Chapter 2**, we document what else the Pilbara should be famous for – its ancient geology and fossils, rich and unique biota, relatively intact and beautiful landscapes, and diverse human cultures. Promoting these values so that the Pilbara is appreciated as much more than a ‘mining powerhouse’ and ‘economic engine room’ is important to strengthen support for conservation.

In **Chapter 3**, we consider the impacts of the new industries that have recently come to dominate the Pilbara landscape and the new species that have colonised the

region since the arrival of Europeans. With only a small conservation estate in the region, the future of impacted biodiversity depends on much more effective threat management across all tenures.

With growing appreciation of the high conservation values of the Pilbara have come efforts to arrest biodiversity decline and degradation. In **Chapter 4**, we document plans and strategies, conservation reserves, threatened species and threat abatement projects and suchlike being deployed for conservation. Much conservation activity is underway, but it is often piecemeal and short-term. The outcomes have been equivocal, often outmatched by threats. ‘Country needs people’ amply applies to the Pilbara, with major barriers to conservation having been the lack of a sustainable conservation workforce and economy.



The kaluta, as it is known by the Nyamal people, is almost unique to the Pilbara, being found also in nearby parts of the Little Sandy Desert and Carnarvon Basin. Known scientifically as *Dasykaluta rosamondae*, this small rufous marsupial is the only living member of its genus. Often abundant in spinifex grasslands, kalutas exemplify several strategies that enable a diverse range of wildlife to endure in the Pilbara. They have a low metabolic rate and enter daily torpor to save energy, store fat in their tail, tolerate large changes in body temperature, are active day or night depending on the season, shelter in burrows within spinifex hummocks and strictly limit water loss. Image: Nathan Litjens.

The combined dominance of mining and pastoralism in the Pilbara means that the primary conservation focus must realistically be on establishing conservation management on productive landscapes, in partnership with industry, whatever the tenure. In **Chapter 5**, we outline opportunities for improving conservation on each tenure and land use type. Major new opportunities lie with Traditional Owners – for they now have native title rights across most of the Pilbara, strong conservation motivation, culturally inherited land management knowledge and responsibilities, and latent capacity to establish a cultural and conservation land management workforce. There are also opportunities for pastoralists, to diversify economic activities and boost productivity through improved land management, including in partnerships with Traditional Owners. Through broadscale implementation of cultural and conservation land management, the Pilbara could become an exemplar for conservation on economically important lands.

A foundational conservation task in the Pilbara must be to enable and support Traditional Owners to assume their cultural responsibilities and to form partnerships with pastoralists, miners and government agencies for large-scale land management. In **Chapter 6**, we outline how this can be achieved and the many economic, cultural and social benefits of expanding the conservation economy in the Pilbara to supplement the mining and pastoral industries.



Figure 1-1 The Pilbara bioregion

Note for readers

Our focus in this report is the Pilbara bioregion, not the more extensive Pilbara region as defined by local government areas and for some state government purposes (see Figure 1-1). In some parts of the report, we have had to rely on data from the larger region.

The Pilbara marine environment has very high values, but the focus of this report is terrestrial only. We have also mostly neglected the Pilbara's islands, which also have high values.



2. Natural values of the Pilbara

The Pilbara mostly makes the news for the mountains of iron ore extracted each year – enough in 2020 to build more than 10,000 Sydney Harbour Bridges [1, 2]. The bioregion should also be famous for some of the world’s oldest rocks and fossils, one of the world’s most diverse reptile faunas, probably the world’s most diverse subterranean communities, and some of the world’s most enduring human cultures. These are values of global significance. The Pilbara is also outstanding, particularly for an arid region, for its richness of mammals, plants and invertebrate groups like snails and spiders. The foundations of the Pilbara’s immense biological, cultural and economic wealth – and its beauty – are its ancient and diverse landscapes.

In this chapter, we describe some of the geological, ecological and cultural features of the Pilbara.

2.1 Complex, ancient and biodiverse

The Pilbara has the potential to build upon its reputation as a region with exceptional biodiversity values in addition to exceptional mineral resources.

Josie Carwardine and others, CSIRO (2014) [3]

The Pilbara is not the most hospitable place for life – being Australia’s hottest and most cyclone-prone region and lacking much surface water (Box 2-1). But its endurance through deep time has provided long periods for life to adapt and radiate, facilitated by a complex geology that provides diverse habitats and refugia.

2.1.1 ORIGINS

The remote Pilbara region ... is one of Earth’s oldest blocks of continental crust.

David Murphy and others (2018) [4]

For the Pilbara, it’s fitting to start with origin tales. The Yindjibarndi people, whose traditional country is centred on the middle reaches of the Fortescue River, explain the origins of their country in this way, in the words of Yindjibarndi/Ngarluma Elder Roger Solomon [5]:

It is the Marrga who shaped and named the country... In other places they call this the Dreaming. But here we call it Ngurru Nyujunnggama – ‘when the world was soft’, the learning times...

Geologists, too, say the Pilbara originated when the world was soft. After the Earth formed 4.6 billion years ago, its surface remained partially molten for hundreds of millions of years, pummeled by asteroids and comets, riven by massive volcanic eruptions, heated by collisions and radioactive decay. The Pilbara craton is thought to have started forming after about a billion years, during the Archaean eon [6]. Although half or more of the Earth’s crust may have formed in this eon, most of it has since been eroded and transformed, or broken and buried as continents were made and remade [7]. This has left the Pilbara as one of the world’s best-preserved large tracts of early crust. While there are older fragments elsewhere, the Pilbara is of immense geological significance as probably the world’s ‘oldest stable crust’ [6]. It is a window into deep time [8].

The Pilbara craton is an amalgam of 5 major crustal fragments (terranes), each with different geological histories, ‘stitched together by granites’ [9]. The oldest surface – the ancient core of the Australian continent – is the East Pilbara terrane in the north, with granite and greenstone rocks that formed 3.6 to 2.8 billion years ago. The southern portion of this early crust (about two-thirds of the craton) is concealed by younger, but still very old, volcanic and sedimentary rocks that formed 2.8 to 2.4 billion years ago [10]. The local diversity of old igneous rocks (solidified lava or magma) in the Pilbara is ‘globally unique’ (Box 2-2).

Opposite: The Pilbara is a globally significant lizard hotspot. This rock dweller is a ring-tailed dragon (Ctenophorus caudicinctus), also known as the bicycle lizard, for looking like a cyclist when it runs on its back legs. As with many Pilbara reptiles, it is part of a species complex, with genetic differences between populations across the arid zone indicating as many as 4 different species, reflecting a complex climatic history of alternating drier and wetter periods. Image: Stephen Zozaya

The likely story of the early formation of the Pilbara can be read in the landscape north of Marble Bar – in the oval-shaped granite domes separated by narrow greenstone belts [6]. These belts are thought to be the remnants of a heavy basalt crust created as thick piles of dense lavas cooled and solidified on the Earth's surface. The base of this crust, melted by the hot mantle below, generated a buoyant granite plume that rose to replace most of the denser basalt, which sank back into the mantle [6]. This 'gravitational overturn', lasting about 45 million years, was followed by 2 more such overturns, at roughly 100-million-year intervals – adding to the crust's thickness and buoyancy, qualities that have helped the Pilbara endure ever since [4].

The Pilbara landscape has many such stories to tell about major events in Earth's history. In the Marble Bar region, 3.5 billion-year-old melt globules and glass spherules are the world's oldest known asteroid detritus [11]. Landscape features also reveal a history of dramatic climatic oscillations – scoured channels, U-shaped valleys and striated pavements in the north-east that are scars from the movement of glaciers, several kilometres thick, during an ice age 300 million years ago, and the infilled remnants of numerous ancient rivers that dried up tens of millions of years ago [12].

The Pilbara also offers 'the oldest convincing evidence for life on Earth' [13]. In the eastern Pilbara, fossilised colonies of cyanobacteria (stromatolites) that lived in hot springs 3.5 billion years ago indicate that life may have first evolved on land, not in deep ocean hydrothermal vents as had been proposed [13–16] (Figure 2-1, Box 2-3).

From the geological to the biological and then the cultural – the Pilbara landscape is also rich in evidence of people, who have lived here for at least the past 50,000 years (Box 2-4), surviving conditions far harsher – drier, colder, windier – than we know today [17,18] (Box 2-5). Rockshelters, rock engravings, grinding patches, middens, quarries, stone tools and many other artefacts reveal the multitude of ways in which people adapted to extreme change [19]. Today, the Pilbara is home to some 17 Traditional Owner groups (as indicated by the number of corporations representing native title holders) and many traditional languages are recognised [20].



The Pilbara provides many different rocks that are excellent raw materials for tools. The sharp tool (left), made of fine-grained ironstone, was probably used for scraping and cutting tasks. The grinding tools (right) may have been used for making flour from seeds. Images: Kane Ditchfield (left), Bill Kruse (right)



This engraving of a sea turtle is one of a million or more such petroglyphs at Murujuga (Dampier Archipelago) – one of the world's most important cultural sites. The 'Murujuga Cultural Landscape' has been nominated for World Heritage listing. Its traditional custodians are the Ngarluma, Yindjibarndi, Yaburara, Mardudhunera and Wong-Goo-Tt-Oo peoples. Image: Ken Mulvaney

Box 2-1. An extreme climate

Even by Australian standards, the Pilbara climate is extreme. It is mostly hot, sunny and dry, but also highly variable.

The Pilbara has recorded Australia's highest temperature in almost half the years since 2000 [21]. And the second-highest temperature ever recorded in Australia was 50.5 °C at Mardie Station in February 1998 [21]. Marble Bar can claim to be the hottest town in Australia for its run of 160 days in 1923–1924 when maximum temperatures equalled or exceeded 37.8 °C (100 °F) [22].

The western Pilbara has the highest number of sunshine hours in Australia, averaging over 10 hours a day, and parts of the Pilbara have the country's highest average annual potential evaporation [22].

While the average yearly rainfall in the Pilbara is about 300 mm – often exceeded more than 10-fold by evaporation [23,24] – some parts of the Hamersley Range average over 500 mm [22]. The rain mainly comes in thunderstorms and cyclones during summer and varies greatly year by year. The Pilbara coastline is the most cyclone-prone in Australia [25].

The 4 largest rain events of the year on average account for more than half the Pilbara's rainfall [26]. This variability is particularly extreme near Karratha, where the ratio of the highest-to-lowest rainfall is 1,840 – ranging from less than 0.4 to 737 mm [22]. The variability is also evident in ephemeral creeks and rivers – the annual flow in the Fortescue has varied more than 5,000-fold, ranging from 0.05 to 295 gigalitres [27].

Over the past few decades, rainfall has increased in the eastern two-thirds of the Pilbara and decreased in the west. There is no scientific consensus about the causes, but the higher rainfall in the west may be unprecedented within the past several hundred years [22].

Climate change models, on balance, indicate that the Pilbara is likely to become slightly drier by 2030 and 2050. The projected change in median rainfall is a 2% reduction by 2050 (compared to a 1961–2012 baseline) [22]. Combined with higher temperatures – 1.2 to 1.8°C projected for 2030 and 1.8 to 2.9°C for 2050 – and higher evaporation, this could substantially affect the region's hydrology, which is sensitive to small changes in rainfall [22]. Some 2050 scenarios project much larger changes, ranging from 17% less rainfall to 8% more. Although the overall wetting or drying trends are not clear, rainfall will continue to be highly variable [22].



The coastline between Broome and Exmouth is known to locals as 'cyclone alley' because more cyclones cross there than anywhere else in Australia. Image: Adwo / Alamy Stock Photo

Box 2-2. A globally unique 'geological jewel'

The Archaean to Proterozoic igneous rocks of the Pilbara region thus can be considered to be a geological jewel as an educational, research, and geotour resource for igneous rocks.

Vic Semeniuk and Margaret Brocx (2019) [28]

The rocks listed below reveal a 'crustal history' in the Pilbara lasting from the Archaean (3.6–2.7 billion years ago) to the Proterozoic (2.5–1.8 billion years ago) [28]. This 'globally unique' diversity of igneous rocks in a relatively compact area and the geological events they represent likely qualify the region as a UNESCO Global Geopark [28]. Such a designation would undoubtedly increase the geotourism appeal of the Pilbara.

Some important geological sites of the Pilbara have been designated as geoheritage reserves (sites of 'exceptional international significance' vulnerable to damage or destruction) or geoheritage sites (sites considered unique or of outstanding scientific and educational value). The 6 geoheritage reserves in the Pilbara (of 8 across the state) feature evidence of early life – Archean stromatolites and microfossils [29] (Figure 2-1, Box 2-3). The 19 geoheritage sites include examples of banded iron formation, stromatolites and unusual formations [29].

Igneous rocks in the Pilbara

| | | |
|-------------------------------|----------------------------|--------------------------------|
| Komatiite | Xenolithic dolerite/gabbro | Franodiorite |
| Mafic volcanic/volcaniclastic | Andesite | Tonalite |
| Basalt | Dacite | Granite |
| Tuff/volcanic breccia | Rhyolite | Pegmatitic granite |
| Accretionary lapilli | Rhyodacite | Granophyre |
| Dolerite | Adamellite | Felsic dykes |
| Gabbro | Monzogranite | Felsic porphyry |
| Leucogabbro | Syenogranite | Felsic volcanic/volcaniclastic |
| Pegmatitic gabbro | | |

Source: Semeniuk & Brocx (2019) [28]

Note: Listed in order from ultramafic to mafic to felsic.



The walls of Joffre Gorge are part of the world's largest known banded iron formation – the 2.5-billion-year-old, 300-metre-thick Joffre Member of the Brockman Iron Formation. Image: Pauline Kirby

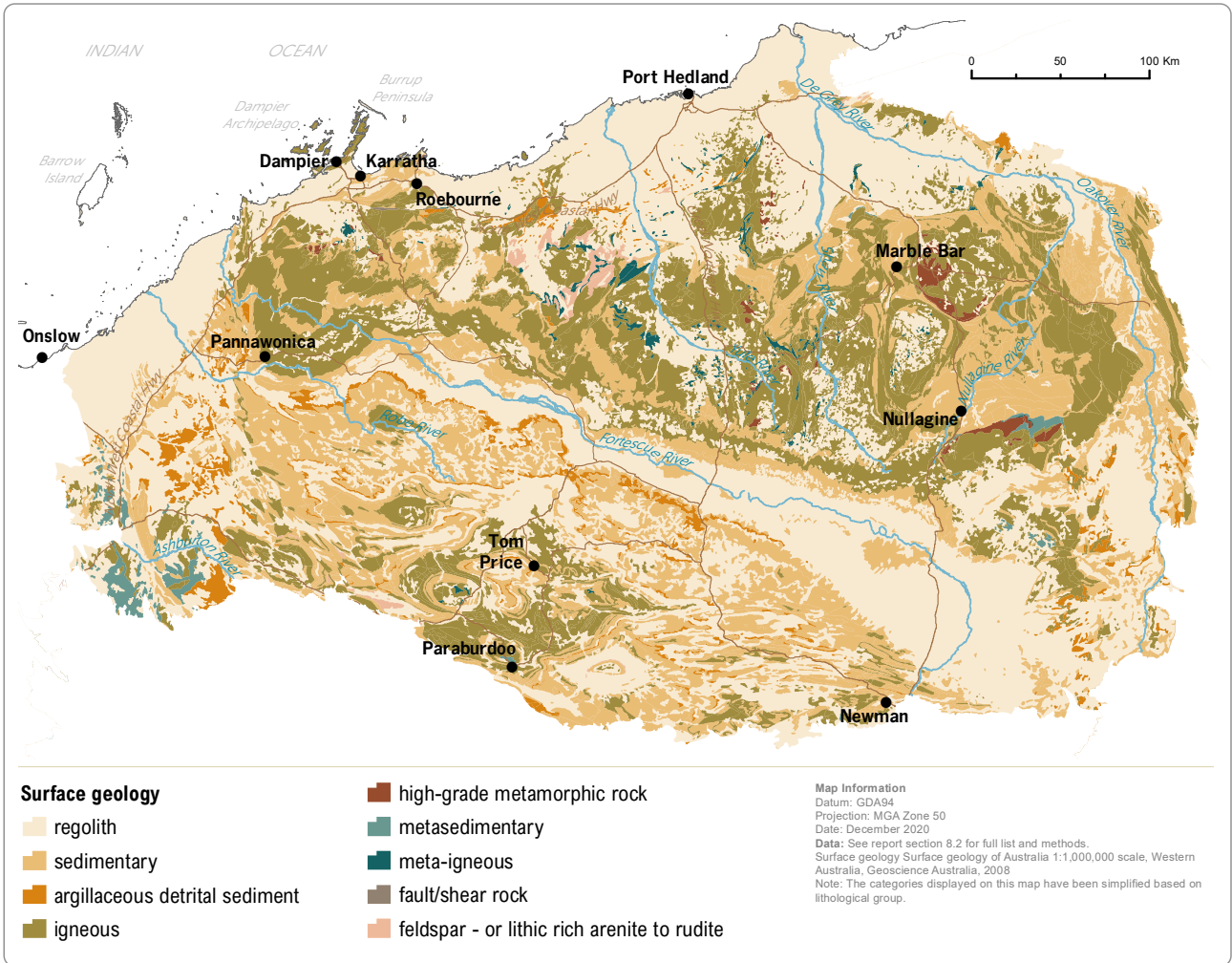


Figure 2-1. The complicated geology of the Pilbara bioregion. The Archaean granitoid domes and their surrounding greenstones are evident in the north. The central and southern regions are characterised by north-west trending belts of interlayered volcanic rock, sedimentary rock, sills and dykes.



Embedded in this rock at North Pole (in eastern Pilbara) are fossils of early life forms on Earth – the remains of colonies of cyanobacteria that may have grown up to 3.5 billion years ago. Image: Reg Morrison/AUSCAPE

Box 2-3. Evidence of early life in the Pilbara

In 2019, scientists from NASA's Mars 2020 mission visited the Pilbara to hone their methods for identifying signs of past life when a rover would land on Mars in March 2021. They came to the Pilbara because it is 'home to the oldest confirmed fossilized lifeforms on Earth' [30] and because Mars and the Pilbara have rocks of similar antiquity thought to have formed under similar conditions [31]. The Pilbara stromatolites they studied are the remains of colonies of cyanobacteria, which are single-celled photosynthesising microbes that helped oxygenate Earth's atmosphere (oxygen is a waste product of photosynthesis).

The eastern Pilbara has yielded evidence of microbes growing in hot springs, probably at the shoreline of a volcanic caldera, almost 3.5 billion years ago [16]. This is up to 580 million years earlier than the previous earliest convincing evidence of life on land, lending support to a hypothesis that life originated on land before taking to the ocean [13,14]. Stromatolites are created by the layering of microbes (mostly cyanobacteria) and trapped sediments, and come in many different sizes and shapes – convex, conical, columnar, branching.

Western Australia has a plethora of stromatolites – both fossilised and live (at Hamelin Pool in Shark Bay) – making it an important area for investigating the origins of life. Meentheena, a former leasehold property in eastern Pilbara acquired for conservation, features exceptionally well-preserved stromatolite fossils that are about 2.7 billion years old. They are thought to have formed in a giant shallow lake system and may have been able to metabolise arsenic [32]. Their significance has been recognised by a listing on the Western Australian geological heritage register. Also on the register are 8 other stromatolite sites in the Pilbara [29].



This 2-metre-high layered dome near the Nullagine River contains the fossilised waste deposits left by mats of photosynthetic cyanobacteria about 2.7 billion years ago. The oxygen discharged by photosynthesising microbes is thought to have dramatically altered the chemistry of the world's oceans and led to the oxygenation of Earth's atmosphere. Image: Reg Morrison/AUSCAPE

Box 2-4. The first people in the Pilbara

The remarkable cultural heritage of the Pilbara made headlines around the world in May 2020 when Rio Tinto blew up one of the region's 'most sacred sites' – a 46,000-year-old Aboriginal rockshelter in Juukan Gorge [33]. This severing of connections to ancestors and country brought 'incalculable cultural loss, pain and distress' to the Puutu Kunti Kurrama and Pinikura (PKKP) peoples [34]. The rockshelter was remarkable not only for its antiquity, but for artefacts that included 4,000-year-old fragments of a woven hair belt, with human hair genetically matched to the PKKP [34].

The deep human history of the Pilbara, extending back about 50,000 years (or more), is best known in the pockets of land investigated for mining exploration [35]. Sites with stone implements – some with hundreds of thousands of artefacts scattered over hundreds of hectares – dominate the archaeological record [35,36]. There are also quarries, shell middens, scarred trees, stone arrangements, grinding grounds, fish traps, walled niches, burial sites, ceremonial and mythological sites, engraved and painted artworks, as well as rockshelters and caves. Objects made of organic materials – bowls, boomerangs, spears, fishing nets, baskets, digging sticks, resin hafted tools, shields, rafts and decorative and sacred objects – exemplify the adaptive and creative human responses to resources in the Pilbara, but are rarely preserved in the acidic deposits of rockshelters [37].

One of the oldest dated sites, Boodie Cave on Barrow Island (just outside the Pilbara bioregion), provides evidence of people living on the coast from up to 51,000 years ago to some 7,000 years ago, when rising seas put the island out of reach from the mainland [17]. Food remains, as well as shell ornaments and tools, tell us much about the available resources and the diverse capabilities of the inhabitants. The diet was dominated at different times by coastal and inland species, reflecting the rise and fall of the sea. Prior to the last glacial maximum, when seas were low, the cave may have been used as an inland bivouac to hunt wallabies and wallaroos. As the sea rose, the diet became 'exceptionally rich', with fishes, turtles, marine mammals, crabs, more than 40 mollusc species and 13 terrestrial animals [17].

Inland rockshelters such as Karriyarra and Waturi Jurnti in north-eastern Pilbara also offer glimpses of how people adapted to the highly variable physical and social landscapes of the past 50 millennia [36,38]. These sites were used intermittently, including through exceptionally harsh times. They have yielded a variety of tools, including some made of bone and baler shell; ochre and tusk shell probably used for ornamentation; and 30,000-year-old paperbark, traditionally used for purposes such as wrapping and carrying food and to swaddle babies. The presence of coastal materials and different types of rocks used for tools may reflect the 'long-distance socio-economic exchange systems' that flourished in the past few thousand years [39].



This midden at Deep Gorge on the Burrup Peninsula is composed mainly of cockle shells – the remains of thousands of meals eaten by Aboriginal people. Image: Suzanne Long / Alamy Stock Photo

2.1.2 A REFUGIUM AND CRADLE OF DIVERSITY

The Pilbara is an area of exceptionally high biotic diversity and endemism.

Mitzy Pepper and others (2013) [40]

The Pilbara's wealth of species, many found only there, has earned the region recognition as a biodiversity hotspot, one of just 15 designated by the Australian Government [41]. It is known as a centre of arid zone biodiversity, with outstanding diversity or endemism, or both, for reptiles, subterranean animals, wattles and spinifexes [40,42–45]. The species richness is likely due both to lower rates of extinction than in other arid areas and higher rates of species divergence [45].

The biological riches of the Pilbara have accumulated over a vast period of time – enabled by its geological stability, the refugia it has provided for species during harsh climatic periods, and the diversity of habitats arising from its varied geology and topography [12,46–48].

Much of Australia's arid-zone diversity was born of adversity as the continent drifted north and became progressively drier from about 15 million years ago [49]. Species from wetter habitats adapted to the dry, and arid-adapted species diversified, often rapidly. And when conditions became extremely harsh during dramatic climate oscillations over the past 800,000 years, the survivors persisted in refugia [49]. During the most recent arid peak (known as the last glacial maximum), from about 33,000 to 20,000 years ago in the north-west [50], much of Australia became extremely dry and dusty, sea levels dropped more than 100 metres, inland lakes and rivers dried up, and mobile sand dunes inhospitable to life covered vast areas [51].

During the arid peaks, the Pilbara was one of Australia's most important refugial areas (areas of relative climate stability) – particularly in its ranges, on the coastal fringe, and below ground in aquifers and voids [40,49,52,53]. Rugged mountainous terrain offers a great choice of habitats, enabling species to move short distances to reach areas with a more favourable climate or microrefugia such as gorges, caves, deep crevices and springs [54,55]. On the coast, species are buffered from climate extremes by the ocean and higher humidity and rainfall [49]. And some subterranean environments offer both a stable climate and permanent water [56].

The most-testing times of past glacial cycles have left their signature in the genes of survivors. Diversity often accumulates as populations move in and out of refugia and up and down gradients. By investigating the genetic diversity and relationships of species and lineages (mainly in reptiles and plants), researchers have begun to decipher the evolutionary history of life in the Pilbara and the forces that have shaped species' diversity and distribution [46,52,55].

Geckos are more diverse in the Pilbara than elsewhere in Australia, indicating a continuous evolutionary history in the region since Australia started drying out about 15 million years ago [57,58]. For example, the widespread sand-plain gecko (*Lucasium stenodactylum*), from a Gondwanan lineage, has much higher genetic diversity (5–18 times more nucleotide diversity) in the Pilbara than in the central and southern deserts, indicating persistence and diversification in the Pilbara but decline and then recent expansion in the deserts [58,59]. There are 5 distinct genetic lineages (clades) in the Pilbara, each associated with different terrains [59].

The use of refugia in the Pilbara has been idiosyncratic, often specific to species [46]. The widespread Hamersley bloodwood (*Corymbia hamersleyana*) and western gidgee (*Acacia pruinocarpa*) probably persisted in a patchwork of many scattered local refugia [46], while the also-widespread snappy gum (*Eucalyptus leucophloia leucophloia*) appears to have contracted to the Hamersley Ranges and south-facing slopes of the Chichester Ranges [55]. Populations of the white cypress (*Callitris glaucophylla*) shrank dramatically, losing genetic diversity, probably confined to microrefugia in rocky areas [60].

The Pilbara also provided refugia for people during the last glacial period (Box 2-5).

Box 2-5. People during the last glacial maximum

If climate change is a hot topic this century, imagine the conversations 20,000 years ago, during the peak of the last glacial maximum (LGM). This was the most significant climatic event faced by the first Australians since they had set foot on the continent perhaps 60,000 years ago [61,62].

When people first settled in the Pilbara, it was probably warmer, wetter and more seasonally predictable than it is today, with more abundant water and food resources [19]. But from about 30,000 years ago, the climate became much cooler, dryer and windier. By 21,000 years ago, average temperatures had plummeted by up to 8 degrees, rainfall had declined by some 60% as the summer monsoons weakened, and sea levels had dropped by about 130 metres [63].

These must have been very challenging times as food and fresh water became much scarcer. But at least 9 rockshelters across inland Pilbara provide evidence for occupation during the LGM [19,64,65]. From Juukan, Milly's Cave, Djadjaling, Yirra and other sites in the western Pilbara ranges to Yurlu Kankala in the north-eastern gorges, hearths and stone artefacts indicate low intensity but persistent human use as the climate deteriorated [19,64]. It is likely that people chased rain, navigating the arid landscapes by identifying and tracking local rainfall patterns [66,67]. The use of these inland refugia demonstrated a remarkable capacity of the first Australians to adapt to extreme and highly variable environmental conditions.

2.2 Landscape features and ecological communities

With rugged rocky ranges and gorges, and spinifex meadows on rich-red sandy and stony plains, the Pilbara is a photographer's delight. It is the most mountainous region of Western Australia – the iron-rich Hamersley Range is the state's highest at up to 1,250 metres, while the older basaltic Chichester Range is about 600 metres high [68]. These ranges divide the two major river systems of the Pilbara – the Fortescue and De Grey.

2.2.1 SUBREGIONS AND LAND SYSTEMS

For conservation planning, the Pilbara has been divided into 4 subregions, each with distinctive geologies and landscapes [23,69] (Figure 2-2).

Roebourne: This western-most subregion (1.86 million hectares) features sandy to clayey coastal plains and islands. The shorelines are diverse – some sandy or muddy, others rocky; some with mangroves, and others with samphire or tidal algal mats. The lowlands are mainly tussock grasslands and wattle shrublands while the uplands are spinifex grasslands. The islands of the Dampier Archipelago are what remain of a coastal plain submerged from 8000 to 6000 years ago.

Chichester: This northern-most subregion (8.37 million hectares) features highly weathered granite and greenstone plains and the low basaltic Chichester Range, which stretches more than 400 kilometres. The region is traversed by the numerous flood channels of the Oakover, DeGrey, Coonan, Shaw, Yule and Turner rivers. The plains are dominated by scattered wattles and spinifex and the ranges by snappy gums and spinifex.

Hamersley: This southern-most subregion (5.63 million hectares) encompasses the rugged sedimentary and volcanic Hamersley Range, rich in banded ironstone formations, and the southern part of the Hamersley Basin. The soils are skeletal, and the vegetation is mainly spinifex grasslands with wattles and snappy gums.

Fortescue: This subregion (1.95 million hectares), lying between the Chichester and Hamersley ranges, features low-lying alluvial plains with grasslands and wattle shrublands and is dissected by the Fortescue River. At its centre is a vast ephemeral wetland, the Fortescue Marsh. Eucalypt woodlands line the permanent waterways and temporary drainage lines.

The Pilbara has been further classified into 104 land systems (areas with similar patterns of topography, soils and vegetation), of which 45 are unique to the bioregion [23,70]. These have been grouped into 20 land types by landforms, soils, drainage patterns and vegetation. Three land types make up about two-thirds of the bioregion: hills and ranges with spinifex grassland, sandplains with spinifex grasslands, and stony plains with spinifex grasslands [70].

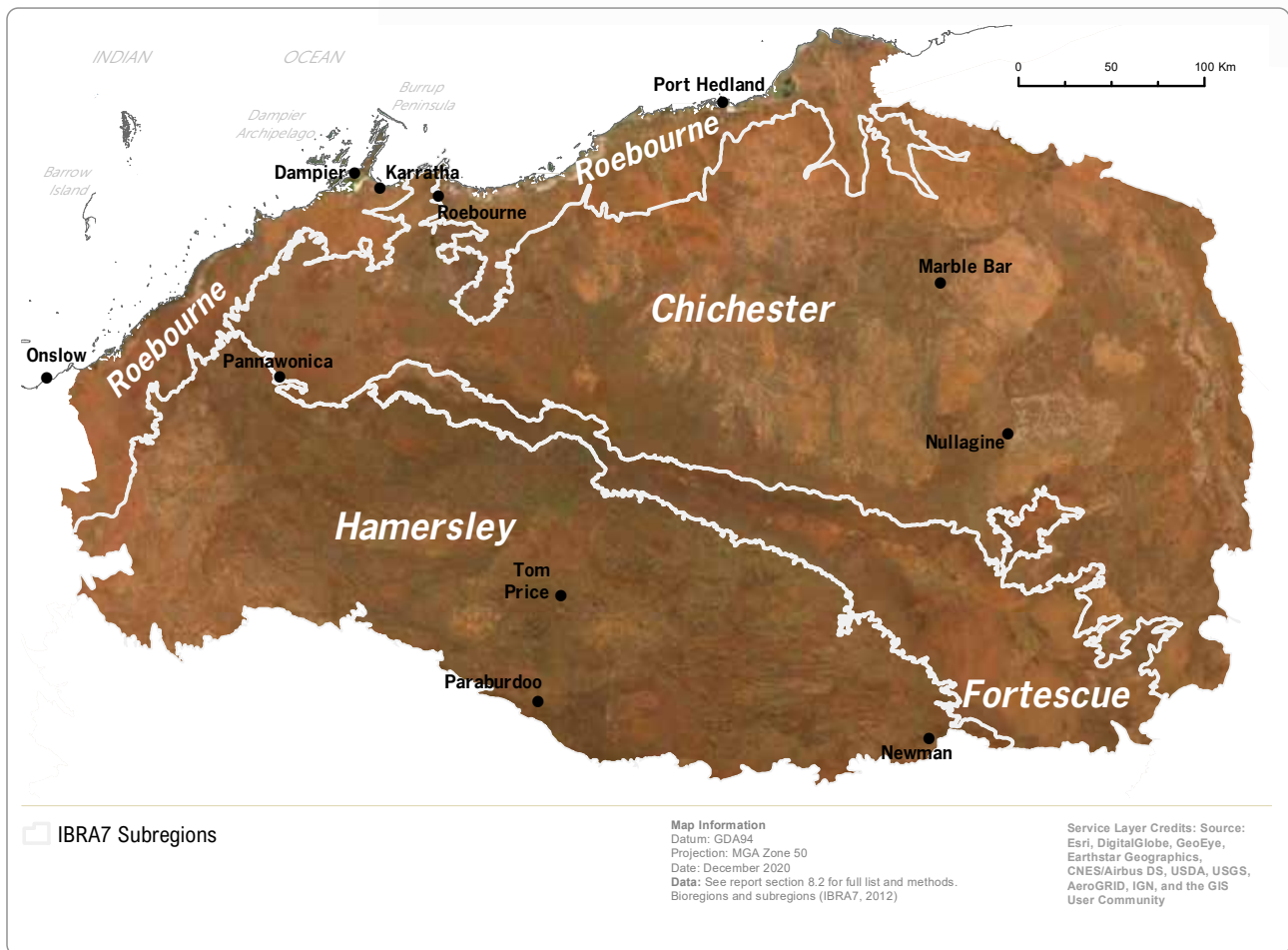


Figure 2-2. The 4 subregions of the Pilbara bioregion, as delineated by the Interim Biogeographic Regionalisation for Australia (IBRA). The Pilbara is one of 89 bioregions in Australia, which are distinguished based on climate, geology, landform, native vegetation and species information.

2.2.2 RIVERS, WETLANDS AND AQUIFERS

... an arid zone with an abundance of wetlands, ranging from springs and river pools to salt marshes, claypans, rockpools and gnammas.

Adrian Pinder and others, Department of Environment and Conservation (2010) [71]

Except after heavy rains in the summer, the 100 or so named rivers and creeks in the Pilbara [72] run dry along most of their length, although springs and permanent pools are numerous and provide refuge during the dry [23,71]. Rivers have been even drier in the past, during glacial periods, as indicated by the absence of animals in the Pilbara specialised for riparian habitats [73].

The rivers flow mostly in single well-defined channels and turn into braided tidal creeks and salt flats when they reach the coast [68]. The riparian zones of the major systems – De Grey, Oakover, Turner, Fortescue, Robe, Cane and Ashburton rivers – have been assessed as ‘generally degraded to fair’ (requiring significant management intervention for recovery), due to trampling and grazing by cattle and feral herbivores, weed invasion and fire [74]. Most floodplains are narrow and well-drained, with few wetlands – except on the coast; above, below

and fringing the Fortescue Marsh; and on several plains with internal or sluggish drainage on the Hamersley Plateau [23].

The Pilbara’s wetlands are diverse, many maintained by groundwater – claypans and clay flats, rockpools in creeks and rocky outcrops, springs, river pools (many permanent) and the large Fortescue Marsh system [71]. Six are recognised as nationally significant [75] (Figure 2-3):

- Fortescue Marshes: a floodplain (about 100,000 hectares) in the middle reaches of the Fortescue River with ephemeral lakes, marshes and pools of international significance for waterbirds (Box 2-7)
- Karijini (Hamersley Range) Gorges: spring-fed pools in the narrow, rugged gorges of Karijini National Park that are refuges for rare animals and disjunct plants

- Leslie (Port Hedland) Saltfields System: a large artificial salt lake (created in 1969), with fringing coastal flats, tidal creeks and mudflats that are a major stopover area for migratory shorebirds
- Millstream Pools: a long stretch (more than 40 kilometres) of wetlands with large pools and extensive wetland and riparian communities supporting a diverse aquatic invertebrate community including rare and unique species
- De Grey River: from the confluence of the Oakover and Nullagine rivers to the Indian Ocean, including river pools that serve as drought refuges for fish and waterbirds
- Mt Bruce coolibah-lignum flats: coolibah woodlands over thickets of lignum in Karijini National Park on red cracking clays in run-on zones that are inundated episodically.

An additional 12 wetlands have been identified as having regional significance [74]. Their condition has been assessed as 'fair' (requiring significant management intervention for recovery).

Most fresh water in the Pilbara lies underground. A watertable (the level at which all pore spaces within rocks are saturated) forms a 'subdued reflection' of the surface topography across most of the region, except in some high areas [68]. The highly varied geology of the Pilbara means there are several different types of groundwater – including near-surface aquifers in porous sedimentary rock; aquifers in fractures, weathered zones and joints; and calcrete aquifers formed in drainages by partial dissolution of calcareous rock. The largest exploitable groundwater resources are alluvial aquifers on the coastal plains and calcrete aquifers along major drainages [68].

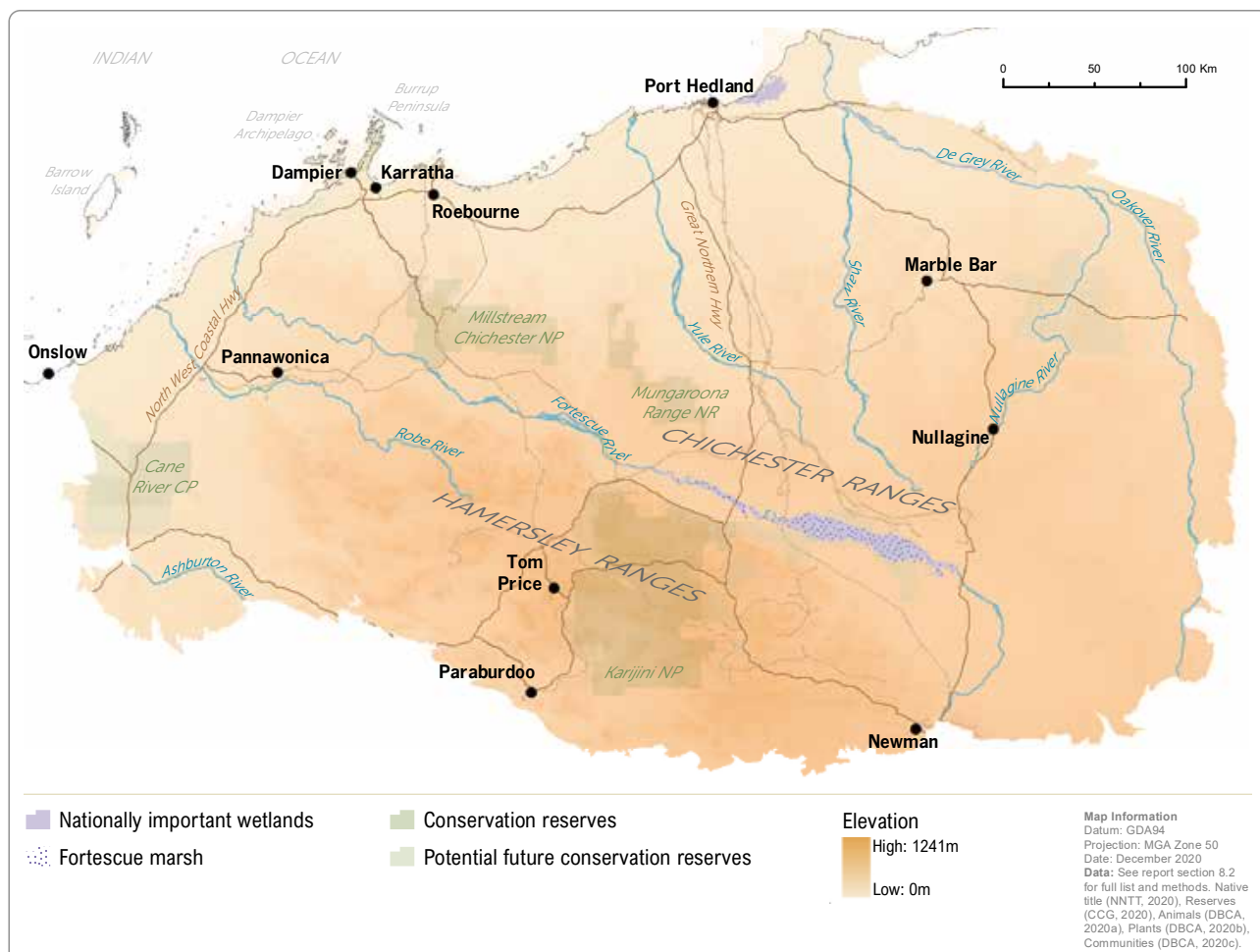


Figure 2-3 Rivers and nationally important wetlands of the Pilbara bioregion.

Box 2-6. The Pilbara's rivers and Traditional Owners

In an animated film made in 2019, Yinjibarndi Elder Middleton Cheedie narrates the Dreamtime story of how the Fortescue River came into being after two boys angered Barrimirndi, the great rainbow sea serpent [76]:

Our story begins with two young Yirdiyarra boys who were being put through Birdarra Warmulu Law – an initiation ritual. Before their initiation, they became very hungry and went out to hunt. They captured a Gurrangurran – a mulga parrot – and roasted it on a roaring fire. That smoke from the fire drifted across the land and to the sea, waking the great Barrimirndi from the depths. The burnt feathers angered Barrimirndi, as the Gurrangurran was sacred to the Creation Spirits. You see, it was against Birdarra Law to eat one.

And so began Barrimirndi's long journey to find the lawbreakers, a saga resulting in the formation of Jarnda-Nyirra (the Fortescue River), and its permanent waterholes and aquifers. Nhanggangunha (Deep Reach Pool, in Millstream National Park) was created when Barrimirndi found the two boys – 'he burst from the ground, raising the young men high in a wananggaa – a willy' and ate them. And the river started flowing when Barrimirndi released water to drown out the cries of the people mourning the boys' loss [76].

Although this brief account does not do the story justice, it may help convey the cultural and spiritual importance of rivers and permanent waterholes to the Yinjibarndi people and other Traditional Owner groups along the Fortescue (the Kuruma, Ngarluma, Banjima and Nyiyiparli), and the deep responsibility they feel for keeping the river healthy [77]. Middleton Cheedie closes the story of Barrimirndi with this warning:

Barrimirndi is still said to rest at the bottom of Nhanggangunha. That is why Ngarda – the Yinjibarndi people – protect this land. If we anger Barrimirndi again, he could leave, taking all our water with him.

For Yirdjibarndi people, Jirndawirrinha (Millstream), with its many pools and springs, is one of their most significant places. These are not static waters created in the distant past, but living waters, where Barrimirndi still resides and that require ritual and spiritual maintenance [78,79].

It is not just the Fortescue. All the Pilbara's major rivers and permanent pools are of great significance to their Traditional Owners, each named and tied to stories. While each local Traditional Owner group speaks for and has responsibility for their own country, they share creation stories across the landscape and responsibility for the health of rivers and pools and their creation beings [78–83]. Their knowledge is closely tied to the utility of rivers and pools, and the resources they have provided over thousands of years as refuges. While management plans are in place for certain water bodies [84,85], Traditional Owners have expressed grave concerns about water use by industry and the impacts on rivers and pools [80–82,86,87] (see Box 3-6).



During the long dry season, the Pilbara's rivers cease flowing, but there is always water in Crossing Pool (Fortescue River) and other waterholes sustained by groundwater. Image: Nick Rains

Box 2-7. Fortescue Marsh (Martuyitha/Manggurdu)

When the Fortescue Marsh floods, as it does about every 4 years [88], it can occupy over a thousand square kilometres, and attract over a quarter of a million waterbirds of more than 60 species [89,90]. Consisting of saline plains and lake beds about 100 kilometres long and 5–20 kilometres wide, the Fortescue Marsh is the terminus of the Upper Fortescue River, whose surface flows are blocked to the west by the Goodiadarri Hills [91,92]. It is the largest wetland of inland north-west Australia [88].

The Fortescue Marsh is recognised by the Western Australian Government as a priority 1 ecological community, by the Australian Government as an important wetland [75] and internationally as a 'key biodiversity area' [93]. It is considered a potential Ramsar wetland site [91,94]. It also has great cultural significance as the traditional lands of the Banjima, Nyiyaparli and Palyku peoples [94]. Nyiyaparli believe Martuyitha (Fortescue Marsh) is 'the heart of the region's water system' [83].

The Fortescue Marsh is a diverse ecosystem with salt-tolerant chenopod shrublands, saltwater couch grasslands, fringing mulga woodlands, and groundwater-dependent eucalypt and wattle riparian communities [95]. More than 350 native plant taxa and 730 native vertebrate animals have been recorded [92,94]. The area is underlain by 'an ancient and complex array of alluvial aquifers and groundwater systems', which provide saline habitats for stygofauna, many yet to be described [96,97]. Most of the stygofauna and many other invertebrates in the area have a very restricted distribution [95]. Fortescue Marsh is important for several species of high conservation value, including the night parrot, northern quoll, bilby and Pilbara olive python [94].

A large part of the area is proposed as a nature reserve [94,98]. Joint planning and management with the Traditional Owners is needed to ensure its highly significant cultural and ecological values are well protected.



Fortescue Marsh is the traditional country of the Banjima, Nyiyaparli and Palyku peoples. Traditional burning regimes are being reinstated to create a mosaic of vegetation of different ages and reduce the risks of large intense wildfires. Image: Western Australian Department of Biodiversity, Conservation and Attractions



The Pilbara's rivers and their many permanent pools are of great spiritual significance to the Traditional Owners – they are living waters, where creation spirits often reside, and require ritual and spiritual maintenance. Above is Eel Pool (lined with cajibut trees), on the Davis River, country of the Nyamal people, and below is Ashburton River (near Onslow), country of the Thalanyji people. Images: Tourism Western Australia



2.2.3 THE COAST AND NEARSHORE ISLANDS

Some 18,000 years ago, when sea levels were 120 metres lower, the Pilbara shoreline lay about 160 kilometres west of Murujuga (Burrup Peninsula) [99]. The islands of the Dampier Archipelago would have been rocky hills in the hinterland backing a vast coastal plain. During this cold, exceptionally arid period, small mobile groups of people probably relied heavily on the rich food resources of intertidal habitats [99]. As the climate warmed, the sea rose, reaching the outer Dampier Archipelago about 10,000 years ago. Middens show that people were then eating shellfish, crabs, lobsters and other animals of mangrove habitats that expanded as conditions became more humid. More-recent middens from about 4,000 years ago indicate another change in shoreline habitats, with people eating a broader range of shellfish species from a rocky shoreline, sandy beaches and mudflats [99].

Under current sea levels, the Dampier Archipelago is a chain of 42 islands, islets and rocks, ranging in size up to 33 square kilometres. Murujuga (meaning 'hip bone sticking out') was also an island until it was joined to the mainland in the mid-1960s by a rail and road causeway built for industry [100].

The Pilbara coast has globally significant geoheritage values – as the world's 'most geologically, geomorphologically, and sedimentologically diverse' arid tropical coast [101].

The coast and nearshore islands also have high conservation and cultural values. The Dampier Archipelago hosts important mammal populations, diverse reptiles and plants and several endemic land snails [102,103]. One of the values of many Pilbara islands is their freedom from feral cats and foxes, enabling them to serve as refuges for threatened species such as the bilby, northern quoll and Rothschild's rock-wallaby [103,104]. The plant communities of Murujuga are mostly different from those on the mainland and rich in restricted plants [100]. Two priority 1 ecological communities – rock pool and rock pile communities – occur there [95].

The striking block volcanic rocks of the Archipelago feature more than a million engraved artworks – the most dramatic evidence of people's long occupation of the Pilbara coastline and a cultural heritage of global significance [105,106] (Box 2-8). These and other occupational remains are 'one of the most significant long-term records of Aboriginal symbolic and economic adaptation to fluctuating sea levels in Australia' [105]. The engravings tell an ecological story, with different fauna depicted at different times – emus, macropods and thylacines from earlier times and the addition of marine fish, dugongs and turtles in more-recent times [107].



Murujuga (Burrup Peninsula) features one of the world's greatest rock art sites and a cultural landscape nominated as a World Heritage site (managed jointly by the Murujuga rangers and state government) as well as an industrial estate (lying just to the west of here). Image: Shutterstock

Box 2-8. The globally significant cultural values of Murujuga

It's a special place for Aboriginal people. That's where our Ancestors been walking around there, before.

Pansy Hicks, Murujuga Circle of Elders (2014) [108]

The Murujuga Cultural Landscape represents a masterpiece of human creative genius.

Australian Government (2020) [106]

Murujuga (the Dampier Archipelago and surrounds) is 'home to one of the largest, densest and most diverse collections of rock art in the world' [109]. In recognition of its global significance, the Murujuga Cultural Landscape was added to the tentative World Heritage list in January 2020 [106,109–111].

The estimated 1 million rock engravings lie across 37 hectares of the Burrup Peninsula, nearby coastal areas and surrounding islands [106]. The art is 'visually outstanding, has been produced with superlative technical skill, and has often been deliberately positioned to achieve a particularly high impact on the viewer' [106].

The engravings reveal 'expressions of ideation, religion, ancestral cosmology', and feature a great diversity of images, including simple archaic faces, extinct fauna (the thylacine and a fat-tailed kangaroo), fishes, turtles and dugongs, and records of early European contact such as the Mermaid (a British ship that visited in 1818) [112]. They show people 'engaged in hunting, dancing, ceremony and social union' [106]. Murujuga is also replete with quarries, middens and stone structures [113].

Five Traditional Owner groups, collectively known as Ngarda-Ngarli, share responsibility for Murujuga – Ngarluma, Yindjibarndi, Yaburara, Mardudhunera and Wong-Goo-Tt-Oo [108]. For the Ngarda-Ngarli, all rock art in Murujuga Ngurra (Murujuga country) was created by Marrga, the ancestral creator being who shaped the world when it was still soft. Reg Sambo, of the Murujuga Circle of Elders, says when he was young [108]:

... the old people, the Ngarluma people, they tell me some of those rock paintings may not have been made by us Aboriginal people you know, might have been spirits been in the land many millions of years ago. They called it Ngugubura, spiritual beings that lived in the land before and with the Aboriginal people somehow.

For example, Marntawarrura (Black Hills), the highest point on Murujuga, were formed when Waramurrunga, ancestral beings in the form of a flying fox, were turned to stone by a vengeful spirit [108].

The Ngarda-Ngarli Traditional Owners have set out their vision for management of Murujuga in the Murujuga Cultural Management Plans [108], one of the most comprehensive and bold plans of its type in Australia. It establishes a clear direction for the management and preservation of the rock art, culture and environment, and surrounding areas with similar cultural and environmental values. The Murujuga Aboriginal Corporation, which operates the Murujuga Rangers, is responsible for implementing the plan and jointly manages Murujuga National Park, which was created in 2005 as Western Australia's 100th national park and the first to be jointly managed with Traditional Owners [110,114].

However, the park excludes many areas with rock art and lies next to an industrial site housing the Woodside Pluto natural gas plant, Yara fertiliser and ammonium nitrate plants and the facilities for the Woodside Energy-operated North West Shelf Venture project [108,115]. There is ongoing tension over industry's impact on Murujuga's rock art [116,117], and other cultural and environmental values.

In such ways Murujuga encapsulates many of the environmental, cultural and economic strengths and challenges of modern Pilbara, and the uneasy balance between sustaining an extractive resources economy and respecting culture and environment – as described by archaeologist Ken Mulvaney [107]:

Nigh on fifty years of industrial exploitation of the Pilbara has seen the transformation of these art-strewn slopes into one of Western Australia's largest industrial hubs. ... What has lain in tranquil splendour for millennia incalculable now is troubled by the frenzy of modern commerce.



Image: Ken Mulvaney

2.3 Animals, plants and ecological communities

The origins of the Pilbara's animals and plants are diverse: most are arid-zone species but many are tropical, with more than 700 also occurring in the monsoonal tropics [118]. And some wet-climate and rainforest plants persist in refugia [119]. Many species, particularly those associated with rocks, are unique, or almost so, to the Pilbara [23,40,73].

A substantial number of species and ecological communities are threatened. Nationally or internationally, 35 animals are listed as threatened. At the state level, 31 animals, 3 plants and 2 ecological communities are listed as threatened and an additional 29 animals, 183 plants and 29 ecological communities are listed as state priorities. Those listed as priorities 1 to 3 are possibly threatened but poorly known, and those listed as priority 4 require monitoring (they may be rare, near threatened, or recently removed from the threatened list).

Box 2-9. Ethel Gorge aquifer stygobiont community

A rich array of stygofauna – mainly oligochaetes, amphipods, copepods, ostracods, isopods and syncarids – live in or near the Ethel Gorge aquifer system in south-east Pilbara near the town of Newman. So far, about 80 species have been recorded [126]. The aquifers lie in the internally draining part of the Fortescue River Basin, over an area of 200 km², each aquifer about 1–8 km wide [126].

Mining near Ethel Gorge started in 1992, and a 1998 BHP Billiton proposal to mine iron ore below the watertable was approved with a management plan to regulate impacts on the ecological community [126]. The stygofauna community was listed as endangered in 2001 and remains so despite an adaptive management plan (in place since 2006) and assurances by the company that the potential impacts on stygofauna habitat can be managed [127]. Mining occurs within 10 km of Ethel Gorge and, if not managed effectively, could harm the ecological community through mine dewatering, groundwater extraction, salinisation of the mine pit or discharge of surplus water [127].



Ethel Gorge. Image: Esri World Imagery

2.3.1 SUBTERRANEAN ANIMALS

Some of the most surprising animals of the Pilbara live in the perpetual darkness of underground aquifers, fissures, voids and caves. Discoveries since the late 1990s of hundreds of highly specialised, narrowly endemic subterranean invertebrates in the Pilbara (and elsewhere in Western Australia) are one of the great unfolding stories of ecology [44,96,120].

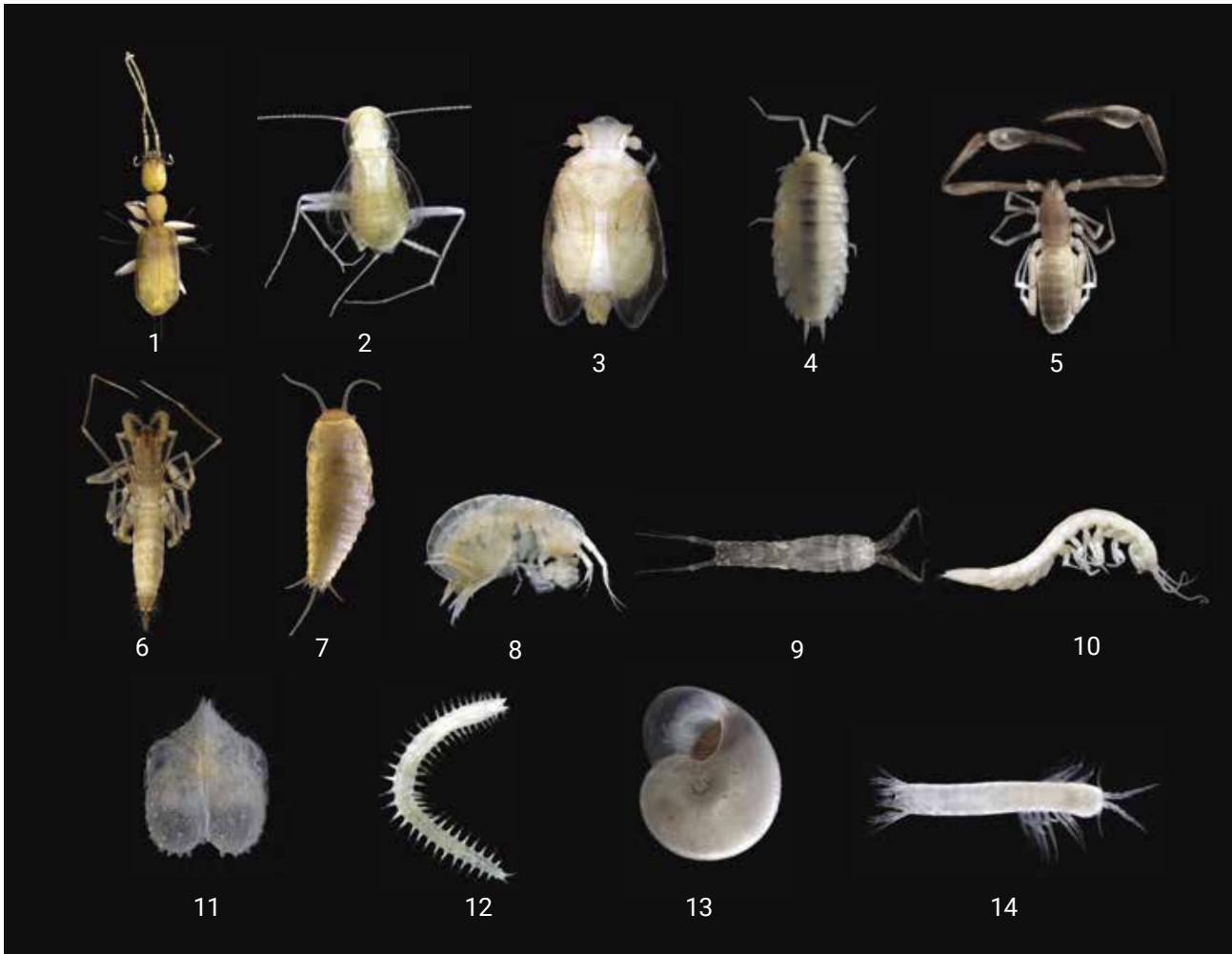
The animals living in groundwater, known as stygofauna, are dominated in the Pilbara by crustaceans – ostracods, copepods and amphipods [44]. The Pilbara's troglofauna – air-breathing animals living in voids a metre or more below ground – include bugs (mostly planthoppers), cockroaches, isopods, millipedes, arachnids and diplurans (two-pronged bristletails) [44].

The diversity of subterranean animals in the Pilbara is globally significant – one of the highest, if not the highest, in the world for both stygofauna and troglofauna [44,96,121]. More than 600 stygofauna species and close to 700 troglofauna species have so far been collected, and the total tally for the Pilbara is likely to approach 3000 species [44]. Almost all are unique to the bioregion.

Subterranean ecosystems were probably initially colonised, as refugia, as inland Australia became increasingly arid over the past 5–10 million years and surface waters became ephemeral [122]. Despite the lack of light (and thus no photosynthesis), limited sources of energy and often low oxygen, subterranean ecosystems offer the benefit of stability – unlike many surface habitats, particularly in arid areas. Subterranean animals are typically colourless and eyeless but have highly developed chemical and touch receptors. They mainly rely on organic matter seeping from the surface to sustain bacteria, archaea and fungi at the base of their food web [123,124]. Due to energy constraints, subterranean animals typically have a slower metabolism, lower reproductive rate and longer lifespan than related animals on the surface [125].

The surging discoveries of subterranean animals in the Pilbara have been due mainly to surveys conducted for assessments of large mine proposals [44]. With pits that can extend 20 kilometres and down to depths of hundreds of metres, and dewatering needed of up to 150 gigalitres a year, big mining projects can threaten entire populations and entire species of subterranean animals. Subterranean animals can also be threatened by the disposal of water, via reinjection into aquifers for example, or its use for irrigation. One subterranean community has been listed as endangered (Box 2-9) and 3 are listed as priority 1 (Table 2-6).

Conserving subterranean animals is challenging. Their small ranges make them highly vulnerable to extinction from single developments and little is known about their ecology and distribution. An underlying barrier is the low level of awareness by the public and policymakers – 'there is no impetus to protect species that people know little about and which have poorly documented ecological roles' [44].



Here are examples of some of the immense diversity of troglifauna (top row) and stygofauna (bottom row) in the Pilbara, many not yet scientifically described. Images: Jane McRae, Bennelongia

Top: 1. Beetle, 2. Cockroach (*Nocticola*), 3. Planthopper (*Phaconeura*), 4. Isopod (*Hanoniscus*), 5. Pseudoscorpion (*Indohya*), Middle: 6. Schizomid (*Draculoides*), 7. Silverfish (*Atelurinae*), 8. Amphipod (*Amphipoda*), 9. Copepod (*Haifeira pori*), 10. Isopod (*Pygolabis*) Bottom: 11. Ostracod (*Gomphodella yandi*), 12. Polychaete (*Namanereis pilbararensis*), 13. Snail (*Hydrobiidae*), 14. Syncarid (*Billibathynella*)

2.3.2 REPTILES AND FROGS

The Pilbara region has one of the most diverse reptile assemblages in the world.

Paul Doughty and others (2011) [73]

Lizards and snakes have flourished in Australia over the past 20 million years as the continent has become more arid – and they reach a pinnacle in the Pilbara. Hot, geologically diverse and rocky, the Pilbara is well made for snakes and lizards. This region has the highest reptile diversity in Western Australia [128] and is part of an Australian lizard hotspot running from central Australia to the Pilbara coast [129]. More than 150 lizard and snake species (not counting sea snakes) have been recorded so far, and many are unique to the Pilbara [57,73,129–137]. Geckos, skinks, goannas, dragons, blindsnakes and elapid snakes are particularly diverse.

A quarter to a third of the known geckos, skinks, and goannas in the Pilbara are unique to the bioregion [73,130] – much higher than in other, similar-sized parts of the Australian arid zone – and other species are endemic to the rocky areas of the Pilbara and the adjacent Gascoyne bioregion [73,128,130]. Endemism is particularly high in reptiles associated with rock [73]. One conspicuous feature of many Pilbara lizards is their rich reddish colour matching the colour of ironstones [73].

The number of known species in the Pilbara has grown rapidly in the past 20 years as DNA studies have revealed much greater diversity than is evident judging by appearances alone. In 2007, for example, sliders (burrowing lizards) in the Pilbara previously regarded as one species, the wood mulch-slider (*Lerista muelleri*), were revealed as 6 species [138]. Likewise, 7 new gecko species were revealed when *Gehyra punctata* was investigated, most endemic or near-endemic to

the Pilbara [57]. There is likely to be much more hidden diversity in the Pilbara reptiles.

Other Pilbara reptiles include the flat-shelled turtle (*Chelodina steindachneri*), the saltwater crocodile (sighted occasionally on the coast) and 3 threatened marine turtles – the flatback, green and hawksbill – that nest on Pilbara islands and also occasionally on the mainland (but only flatbacks and greens) [73,139]. All 3 species are threatened (Table 2-1). Little is known about the ecology of marine turtles in the Pilbara and most potential habitat has not been confirmed [139]. The hawksbill rookery on Rosemary Island in the Dampier Archipelago is the largest known in the Indian Ocean and one of the largest – ‘if not the largest’ – in the world [139,140]. It has been monitored by volunteers (managed by Parks and Wildlife) since 1986 [140]. Recent aerial surveys have revealed substantial turtle activity on many other islands, indicating that the Dampier Archipelago is likely to be of global importance for marine turtles [140].

The Pilbara also hosts 13 frog species: 3 are endemic or near-endemic to the Pilbara, 4 are widespread arid-zone species, and 4 are tropical, linked to Kimberley populations by a thin strip of coastal shrubland [73].

No reptiles or frogs are known to have gone extinct in the Pilbara. Fifteen reptiles are listed as threatened or priority species in Western Australia, 6 are listed nationally as threatened and 5 are listed internationally (Table 2-1, Figure 2-4). The endangered Nevin’s slider (*Lerista neviniae*) is particularly vulnerable because it occurs in only a few thousand hectares in coastal sands habitat often close to major industrial development. It is the Pilbara reptile ‘most likely to face significant habitat reduction and population size in the next 20 to 50 years’ [73].

Table 2-1. Threatened and priority reptile species in the Pilbara

| Common name | Scientific name | WA status ^B | National status ^B | IUCN status ^B |
|--|--------------------------------------|------------------------|------------------------------|--------------------------|
| Nevin’s slider ^A | <i>Lerista neviniae</i> | Endangered | Endangered | Critically endangered |
| Flatback turtle | <i>Natator depressus</i> | Vulnerable | Vulnerable | Data deficient |
| Great desert skink | <i>Liopholis kintorei</i> | Vulnerable | Vulnerable | Vulnerable |
| Green turtle | <i>Chelonia mydas</i> | Vulnerable | Vulnerable | Endangered |
| Hawksbill turtle | <i>Eretmochelys imbricata</i> | Vulnerable | Vulnerable | Critically endangered |
| Pilbara olive python ^A | <i>Liasis olivaceus barroni</i> | Vulnerable | Vulnerable | Not assessed |
| Four-lined slider (Karratha) ^A | <i>Lerista quadrivincula</i> | Priority 1 | Not listed | Data deficient |
| Gane’s blind snake (Pilbara) ^A | <i>Anilius ganei</i> | Priority 1 | Not listed | Least concern |
| Pin-striped finesnout ctenotus ^A | <i>Ctenotus nigrilineatus</i> | Priority 1 | Not listed | Least concern |
| Dampierland plain slider | <i>Lerista separanda</i> | Priority 2 | Not listed | Least concern |
| Pilbara barking gecko ^A | <i>Underwoodisaurus seorsus</i> | Priority 2 | Not listed | Least concern |
| Spotted ctenotus (northeast) | <i>Ctenotus uber johnstonei</i> | Priority 2 | Not listed | Not assessed |
| Unpatterned robust slider slider (Robertson Range) | <i>Lerista macropisthopus remota</i> | Priority 2 | Not listed | Not assessed |
| Northwestern coastal ctenotus | <i>Ctenotus angusticeps</i> | Priority 3 | Not listed | Least concern |
| Lined soil-crevice skink (Dampier) ^A | <i>Notoscincus butleri</i> | Priority 4 | Not listed | Least concern |
| Northern Pilbara tree-dragon ^A | <i>Diporiphora vescus</i> | Not listed | Not listed | Vulnerable |

A. Endemic to the Pilbara bioregion. B. Current to 1 August 2020.

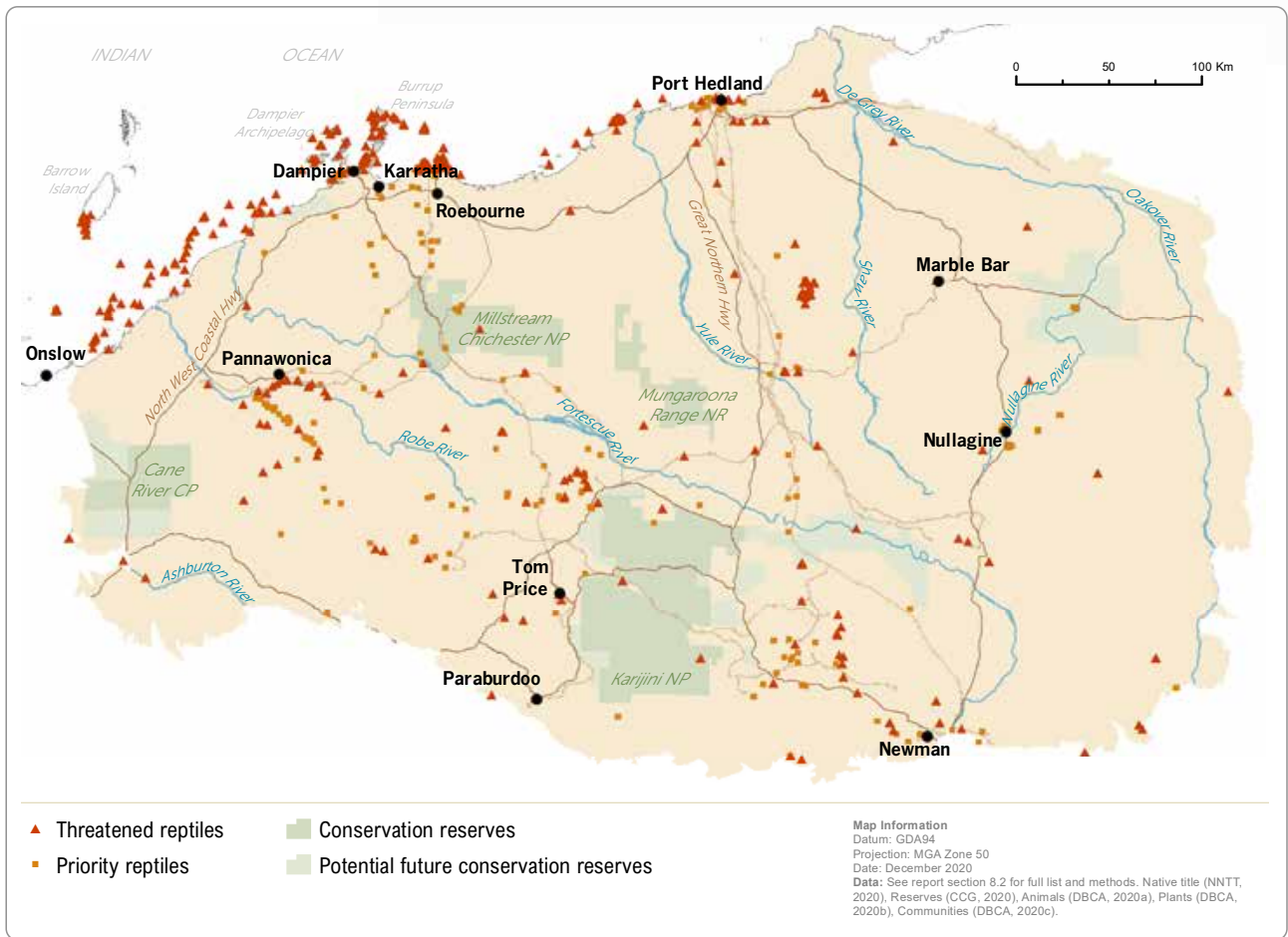


Figure 2-4 The distribution of state-listed threatened and priority reptile species in the Pilbara

Note: This map indicates a survey bias in the Pilbara. Records of the distribution of threatened and priority species are closely aligned in several places to the locations of mines and railways, due to surveys being required for the assessment of new mining infrastructure. Most of the coastal and nearshore records are for marine turtles.



Nevin's slider is one of Australia's most threatened reptiles. It is a nocturnal sand-swimming skink, known only from near Cape Lambert over an area of less than 500 hectares, some of which has been subject to clearing and destructive recreational activities. Image: Greg Harold

PROFILE: Pilbara olive python (*Liasis olivaceus barroni*)

The importance of the Pilbara

Although currently recognised as a subspecies, the Pilbara olive python has sufficient genetic difference from the Kimberley population (another subspecies) to be considered a separate species [141]. It is separated from other populations by vast expanses of the Great Sandy Desert [141]. The Pilbara population is restricted to the Pilbara and north Gascoyne bioregions.

About the Pilbara olive python

Up to 6.5 m long [130], this python is the second longest snake in Australia and one of the half dozen longest in the world [142]. It is a top-order predator of mammals, reptiles and birds, inhabiting riparian vegetation during the warmer months when hunting and rocky habitats at other times [73,141].

Little is known scientifically about the biology, population or distribution of Pilbara olive pythons. There are no effective monitoring techniques, for they are nocturnal and cryptic, occur at low densities, can't be trapped and usually don't trigger camera traps [143].

This python is well known to Traditional Owners – called 'bargumyji' by the Yindjibarndi people and 'palkunyji' or 'parkunarra' by the Kurrama people. It was once an important food and remains an important spirit figure in explaining how rivers and waterholes were formed [141].

Conservation status and threats

| Western Australian status | National status | International status |
|---------------------------|-----------------|----------------------|
| Vulnerable | Vulnerable | Not assessed |

Because of its large size, low densities and diet (large vertebrates, including some threatened species) the Pilbara olive python is likely to be susceptible to decline, but there is not enough information about historical or current populations to determine trends [143].

Potential threats include habitat destruction and degradation by mining, habitat degradation around water bodies due to cattle, predation by foxes and feral cats on young pythons and important food species (such as bats, quolls and rock-wallabies), and altered fire regimes [143]. Cane toads could be a threat if they arrive in the Pilbara.



Image: Brian Bush

2.3.3 MAMMALS

As in other arid regions, the mammals of the Pilbara are masters of endurance – often persisting in low numbers when resources are low and rapidly recolonising habitats when conditions improve. Most do not need to drink water but obtain enough from their food. Some store fat in their tails. Many small bats and marsupials can enter daily torpor, dropping their metabolic rate by 90% or more compared to when they are active. In this way, they can survive on little or no food for days to months and greatly reduce their exposure to predators [144].

For an arid region, the Pilbara once had a rich mammal fauna. Before European colonisation there were at least 60 species, a number exceeded in Australia’s arid bioregions only in the Carnarvon bioregion [145]. Six species are unique to the Pilbara or almost so (extending slightly into adjacent regions) – 2 undescribed planigales (tiny carnivorous marsupials), western pebble-mound mouse, little red kaluta, Pilbara ningau, and Rothschild’s rock wallaby [146].

Despite the toughness of arid-zone mammals, many have been unable to endure the new predators introduced in the 1800s – feral cats and foxes. The Pilbara has lost 20% of its known mammal fauna (12 species), almost all in the preferred weight range of prey for cats and foxes (35–5500 grams) (Table 2-2). Most survivors vulnerable to cat or fox predation have lost much of their former range, including 2 species confined to coastal islands and 1 to the coast [145]. Of the 48 surviving mammal species, 4 are listed as threatened (at state and national levels) and 7 are listed as priority species by the Western Australian

Government (Table 2-3, Figure 2-5). The extinctions and declines mean that the Pilbara mammal fauna is now dominated by small species (weighing less than 35 grams). It also means that important ecological functions have been compromised, such as the turnover of soil (Box 2-10).

Despite the losses, the Pilbara still has 60 mammal species, due to the addition of 12 introduced mammals, including cats, foxes, pigs and donkeys [146].



At less than 6 cm long (with a 7 cm tail), the Pilbara ningau is one of Australia’s smallest marsupials. It is found only in the Pilbara and adjacent parts of the Gascoyne bioregion and Little Sandy Desert in spinifex. Image: Ray Lloyd

Table 2-2. Extinct Pilbara mammals

| Mammal group | Regionally extinct | Globally extinct |
|--------------|--|--|
| Dasyurids | Chuditch (<i>Dasyurus geoffroi</i>) Red-tailed phascogale (<i>Phascogale calura</i>) Kultarr (<i>Antechinomys laniger</i>) | |
| Bandicoots | Golden bandicoot (<i>Isodon auratus</i>) ^A | |
| Macropods | Woylie (<i>Bettongia penicillata</i>) Rufous hare-wallaby (<i>Lagorchestes hirsutus</i>) Black-footed rock-wallaby (<i>Petrogale lateralis</i>) ^C | Boodie (inland) (<i>Bettongia lesueur graii</i>) ^B |
| Rodents | Golden-backed tree-rat (<i>Mesembriomys macrurus</i>) Central rock-rat (<i>Zyzomys pedunculatus</i>) | Lesser stick-nest rat (<i>Leporillus apicalis</i>) Long-tailed hopping mouse (<i>Notomys longicaudatus</i>) |

Sources: [145,147]

Notes: **A.** Survives on Barrow Island. **B.** Another unnamed subspecies of the boodie survives on Barrow Island and has been reintroduced to Boodie Island and translocated to Alpha Island (Montebello Islands) and Lorna Glen. **C.** Survives on Barrow Island and recently discovered at Karlamilyi National Park [148].

Table 2-3. Threatened and priority mammals in the Pilbara

| Common name | Scientific name | WA status | National status | IUCN status |
|--|---|------------|-----------------|---------------|
| Northern quoll | <i>Dasyurus hallucatus</i> | Endangered | Endangered | Endangered |
| Ghost bat | <i>Macroderma gigas</i> | Vulnerable | Vulnerable | Vulnerable |
| Bilby, dalgyte, ninu | <i>Macrotis lagotis</i> | Vulnerable | Vulnerable | Vulnerable |
| Pilbara leaf-nosed bat | <i>Rhinionictis aurantia</i> (Pilbara) | Vulnerable | Vulnerable | Not assessed |
| North-western free-tailed bat | <i>Mormopterus cobourgianus</i> | Priority 1 | Not listed | Least concern |
| Brush-tailed mulgara | <i>Dasyercus blythi</i> | Priority 4 | Not listed | Least concern |
| Rakali, water rat | <i>Hydromys chrysogaster</i> | Priority 4 | Not listed | Least concern |
| Spectacled hare-wallaby (mainland) | <i>Lagorchestes conspicillatus leichardti</i> | Priority 4 | Not listed | Not assessed |
| Kerakenga, northern short-tailed mouse, Lakeland Downs mouse | <i>Leggadina lakedownensis</i> | Priority 4 | Not listed | Least concern |
| Ngadji, western pebble-mound mouse | <i>Pseudomys chapmani</i> | Priority 4 | Not listed | Least concern |
| Long-tailed dunnart | <i>Sminthopsis longicaudata</i> | Priority 4 | Not listed | Least concern |

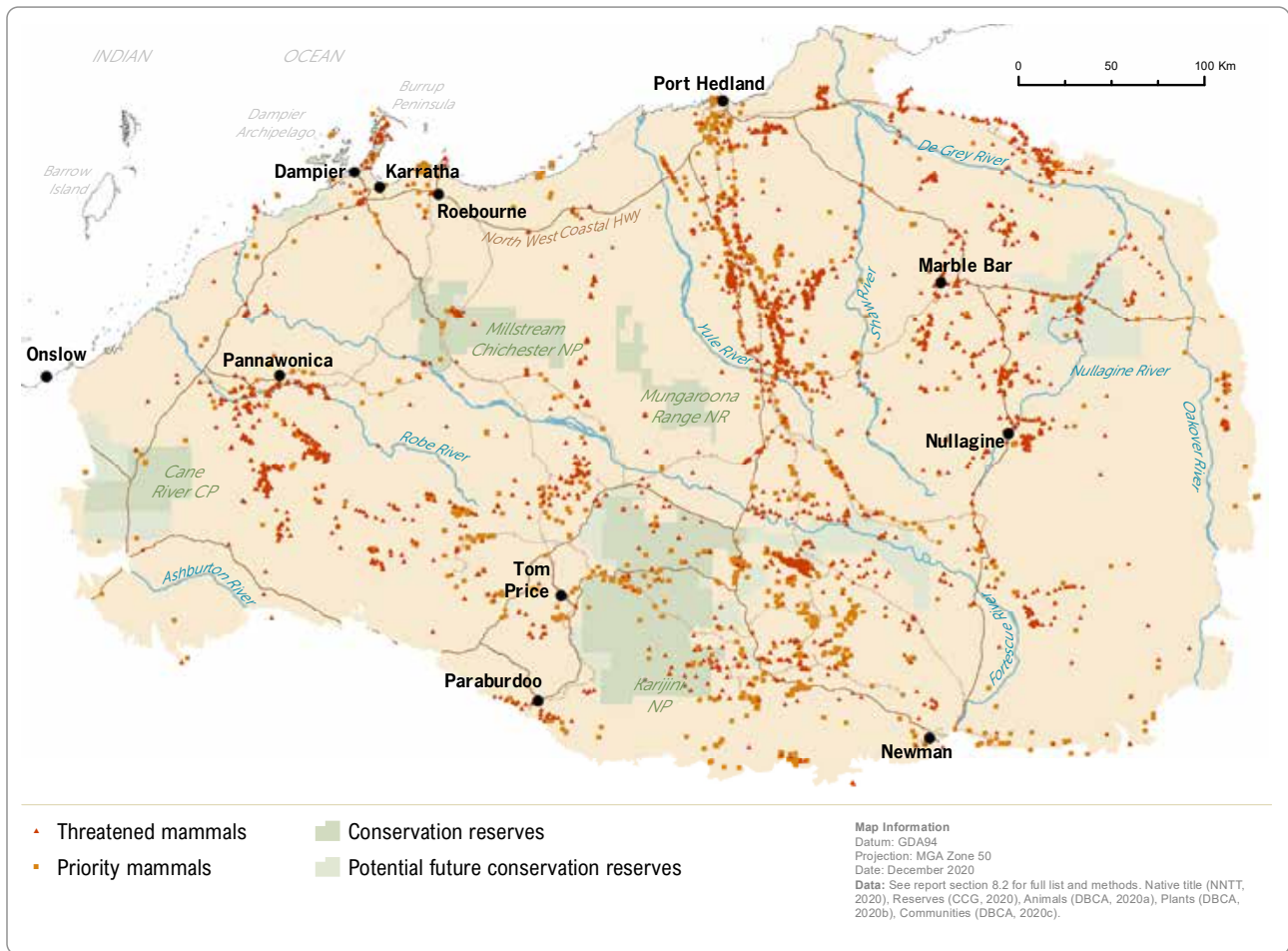


Figure 2-5. The distribution of state-listed threatened and priority mammal species in the Pilbara

Note: This map indicates a survey bias in the Pilbara. Records of the distribution of threatened and priority species are closely aligned in several places to the locations of mines and railways, due to surveys being required for the assessment of new mining infrastructure.

Box 2-10. The loss of the night diggers

Pilbara nights are much less busy these days than they were 150 years ago. When the likes of bilbies, boodies and woylies were common, the nights were filled with energetic digging. They turned over and shift immense volumes of soil while building burrows and foraging for fungi, seeds, tubers, roots and soil animals. A bilby or boodie could excavate 30 tonnes of soil a year, a woylie 6 tonnes [149]. In the process, they mixed, aerated and broke down the soil, modified the topography, created pits that captured leaf litter, faeces, seeds and water and created refuges for many other species. Now, the boodie, woylie and golden bandicoot are gone from the Pilbara and the greater bilby is scarce.



A bilby burrow is a feat of engineering – spiral-shaped, up to 3 metres long and 2 metres deep, with multiple entrances – designed to protect it from predators and maintain a comfortable temperature. A bilby may maintain up to a dozen burrows – as refuges from predators and some for sleeping in. Some burrows remain in use for hundreds of years. Images: Terrestrial Ecosystems



PROFILE: Northern quoll (*Dasyurus hallucatus*)

The importance of the Pilbara

The Pilbara is the main stronghold of the endangered northern quoll, with many populations in other regions collapsed or likely to collapse in the near future due to poisoning by cane toads [104,147]. There is a tantalising prospect of maintaining the Pilbara stronghold by closing off water points south of the Kimberley to prevent the spread of cane toads, or at least considerably delay them [150].

The 4 populations of northern quolls – in the Pilbara, Kimberley, Top End and Queensland – are each genetically distinct lineages [151]. The Great Sandy Desert has been a long-standing barrier to gene flow between quolls in the Pilbara and Kimberley [104].

About the northern quoll

Quolls are the largest native predatory mammal in the Pilbara, but smaller than feral cats and other introduced predators [152]. They live mainly in complex rocky habitats that provide dens and protection from predators and fire, and they eat a wide range of small animals and vegetation [152]. Their lifespan is short. Most males die within a year, their immune system collapsing due to escalating stress hormones as they compete frenetically for females during a short breeding season [153]. This 'suicidal reproduction' – common also in antechinuses and phascogales – makes evolutionary sense 'because females profit from sperm competition' [153]. Female quolls in the Pilbara bear litters of up to 8 young with up to 8 different fathers – a higher degree of female promiscuity and multiple paternity than described for any other marsupial [154]. Females can survive for up to 3 years.

Conservation status and threats

| Western Australian status | National status | International status |
|---------------------------|-----------------|----------------------|
| Endangered | Endangered | Endangered |

Northern quolls were once abundant across northern Australia from Brisbane to the Pilbara. Now they are restricted to a few fragmented populations, mainly in rocky areas [147]. The impact of cane toads has been 'catastrophic', including the near-extinction of quolls from western Arnhem Land [147]. In the Pilbara the main threats are thought to be predation by feral cats, foxes and dogs, altered fire regimes and over-grazing by introduced herbivores [155].

Cane toads are expected to reach the Pilbara within 2 decades or so [156]. To get there, they must traverse a narrow, 400-km-long corridor between the Great Sandy Desert and the Indian Ocean, where there are few natural water sources. It may be possible to block the toads there by preventing their access to artificial water sources – for example, by replacing dams with troughs and erecting toad-proof fences around water sources [150] (see Box 3-3). The Pilbara quolls will be in great peril if toads arrive, although there may be potential to train some in advance to avoid toads [157].



Image: Henry Cook

PROFILE: Greater bilby (*Macrotis lagotis*)

The importance of the Pilbara

The Pilbara is one of the few regions where bilbies still survive. They used to occur across about three-quarters of the Australian continent, including most of Western Australia, but have now contracted to the driest and least fertile parts of their former range [158,159]. The known Pilbara populations are small, isolated and highly vulnerable.

About the bilby

Bilbies live in scattered populations of 2–3 individuals on plains with soils suitable for burrowing [160]. In the Pilbara they tend to associate with wattle species whose root systems are inhabited by cossid moth grubs, a favoured food [161]. They also eat other invertebrates such as spiders and termites as well as grass and sedge seeds and bulbs.

As inveterate diggers for food and shelter, bilbies earn their title as ‘ecosystem engineers’ [162]. They may build a new burrow every 2 to 3 weeks, tunnelling up to 4.5 metres, down to 3 m depth, leading to burrow densities of up to 22 per square kilometre [147,162]. While one bilby may regularly use more than a dozen burrows, many other species also benefit [160,163]. A study in the western Kimberley found more than 40 species using bilby burrows [160].

Conservation status and threats

| Western Australian status | National status | International status |
|---------------------------|-----------------|----------------------|
| Vulnerable | Vulnerable | Vulnerable |

The loss of bilbies has been due mainly to feral cats, foxes and altered fire regimes [147]. In south-east and south-west Australia the last bilbies were recorded just 5–12 years after the arrival of foxes [158]. Apart from the western deserts, the distribution of bilbies is mostly outside the distribution of foxes [158,159]. The installation of artificial water sources for cattle grazing or due to mining and infrastructure development may facilitate the expansion of foxes into areas where they are currently rare [158]. Foxes are common along the Pilbara coast and in some riparian areas but sparse in inland areas [158]. Feral cats are likely to prey on bilbies when easier prey items become scarce, when cat densities are high or after fire [147,164]. Although dingoes and dogs are known to eat bilbies, their impact has been assessed as minor and they may benefit bilbies in some areas by suppressing cat and fox activity [147]. Bilbies show an innate antipredator response to dingoes/dogs but not to cats [165]. Buffel grass spread is likely to be a significant threat by changing fire regimes and displacing bilby food plants [159].

The bilby is of great spiritual importance to Traditional Owners across its present and former range [159] and bilby monitoring and recovery work is a strong focus of Indigenous ranger programs across central and northern Australia [166,167].



Image: Auscape / AlamyStock Photo



Australia used to have 2 bilby species. The yallara (lesser bilby) became extinct probably in the 1960s due to cats and foxes. Image: Oldfield Thomas' Catalogue of the Monotremes & Marsupials in the British Museum

PROFILE: Ghost bat (*Macroderma gigas*)

The importance of the Pilbara

A quarter to a third of all ghost bats probably live in the Pilbara – an estimated 1,500 in the Chichester subregion and 350 in the Hamersley subregion (in 2015) [168]. They are isolated and genetically distinct from other ghost bat populations. And only in the Pilbara are ghost bats not yet subject to threats from cane toads.

About the ghost bat

With a wingspan of 60 cm, the ghost bat is the second-largest echolocating species of bat (microchiropterans) in the world, and the largest in Australia [168]. It is a top-order predator in the Pilbara, with a broad diet of large insects, locusts, small mammals, birds, reptiles and frogs [168,169].

The species once occupied most of Australia but contracted northwards with increasing aridity in recent glacial periods [168]. Since European colonisation, ghost bats have contracted further northwards, with much of their arid zone distribution lost in recent decades [168].

The ability of ghost bats to persist in the Pilbara depends on the availability of deep underground roosts in humid, temperature-stable caves or disused mines [168]. Females display a high degree of philopatry (remaining in or returning to their birthplace to give birth). Most known roost sites in the Pilbara are abandoned mine adits (horizontal tunnels) [147].

Conservation status and threats

| Western Australian status | National status | International status |
|---------------------------|-----------------|----------------------|
| Vulnerable | Vulnerable | Vulnerable |

The Pilbara population of ghost bats is thought to have declined by more than 30% since the early 1990s [168].

The main threat is the loss and degradation of roost sites, particularly maternity roosts. Much of the Pilbara population was known from 6 abandoned mining tunnels, but 2 have disappeared and the others show signs of collapse, flooding and human intrusion, and are part of mining exploration leases [168].

Poisoning by cane toads has emerged as a recent major threat. Ghost bats in Kakadu National Park are thought to have declined by more than 90% due to their consumption of toads, and there have also been substantial declines in western Queensland [147]. Only in the Kimberley have ghost bat populations probably been stable, but this may change as cane toads spread.

Ghost bats are also threatened by barbed wire fences. As seen in the Pilbara, a single fence near a colony can eventually entangle all individuals [168].



Image: Lochman Transparencies

PROFILE: Pilbara leaf-nosed bat (*Rhinonictes aurantia* Pilbara form)

The importance of the Pilbara

This bat occurs only in the Pilbara and adjacent fringes of the Gascoyne bioregion [147]. It is recognised as a distinct form of the orange leaf-nosed bat, the only arid-zone population of the species, thought to have been isolated for at least 30,000 years due to a lack of rocky outcrops suitable for roosting in the Great Sandy Desert [170]. The use of different frequencies for echolocation is one of the distinctions of the Pilbara form [171]. Its taxonomic status (for example, whether it is a separate subspecies) has not been resolved [171].

About the Pilbara leaf-nosed bat

This is a small, fast-flying, highly agile bat that hunts beetles, moths and other insects at night. It survives close to its eco-physiological limits in the Pilbara, and needs a high rate of insect capture to sustain its energetically demanding form of hunting and nearby daytime roosts that help maintain its body temperature and conserve water (this species cannot enter torpor) [147,171]. The availability of daytime roosts is thought to be the primary constraint on where it occurs [171]. Many of its roosts are disused underground mines.

Conservation status and threats

| Western Australian status | National status | International status |
|---------------------------|-----------------|----------------------|
| Vulnerable | Vulnerable | Not assessed |

The major conservation priority is to preserve the limited number of known daytime roosts used by the Pilbara leaf-nosed bat. Most known maternity roosts are caves in banded ironstone that may be mined or underground gold or copper mine adits that are collapsing or being open-cut mined [147]. Unless there is intervention to protect maternity roosts, most will be destroyed within 2 to 4 decades.



This orange leaf-nosed bat is the northern form of *Rhinonictes aurantia*, which occurs across the Kimberley, Northern Territory and Queensland – isolated from the Pilbara by the Great Sandy Desert. Image: Nathan Litjens

2.3.4 BIRDS

More than 300 bird species have been recorded in the Pilbara, including seabirds and occasional vagrants [172]. Two subspecies are near-endemic to the Pilbara – the Pilbara grasswren and the Pilbara collared kingfisher [172,173]. The relatively high diversity of birds in the Pilbara reflects the variety of habitats and proximity to tropical, arid and subhumid regions [172]. But, reflecting the harsh and changeable conditions of the Pilbara, fewer than half the recorded species are residents [172]. Many are nomads, moving in when conditions are favourable or when conditions elsewhere are worse.

Important bird habitats include the islands, coastal habitats such as mangroves, major watercourses with fringing red gum forests, and the central uplands, which support several species rare elsewhere. Some changes in the Pilbara have benefited birds. Sewage ponds are used by shorebirds, ducks, rails and dotterels, and the intake area of the Port Hedland Saltworks has become important for migratory shorebirds, with more Asiatic dowitchers, broad-billed sandpipers and Mongolian sand plovers recorded in a single saltworks pond than from the entire Eighty Mile Beach [172].

Thirteen species recorded in the Pilbara are listed as threatened at a state or national level and another 5 as priority species in Western Australia (Table 2-4, Figure 2-6). Seven are shorebirds threatened mainly by habitat destruction on their migratory path to breed in the northern hemisphere [174]. Threats in the Pilbara include the impacts of grazing by introduced herbivores, adverse fire regimes, invasive shrubs and grasses and, in some places, mining infrastructure [175]. The Pilbara is particularly important for one of Australia's most threatened and iconic birds – the recently rediscovered night parrot [176].



The near-endemic grasswren of the Pilbara is an isolated subspecies of the rufous grasswren, *Amytornis whitei whitei*.
Image: Barry Deacon

Table 2-4. Threatened and priority birds in the Pilbara

| Species | WA status | Australian status | International status |
|---------------------------------------|-----------------------|-----------------------|---------------------------------|
| Curlw sandpiper | Critically endangered | Critically endangered | Near threatened |
| Great knot | Critically endangered | Critically endangered | Endangered |
| Bar-tailed godwit (northern Siberian) | Critically endangered | Critically endangered | Near threatened (species level) |
| Eastern curlew | Critically endangered | Critically endangered | Endangered |
| Night parrot | Critically endangered | Endangered | Endangered |
| Red knot | Endangered | Endangered | Near threatened |
| Lesser Sand Plover | Endangered | Endangered | Least concern |
| Australian painted snipe | Endangered | Endangered | Endangered |
| Greater sand plover | Vulnerable | Vulnerable | Least concern |
| Grey falcon | Vulnerable | Vulnerable | Vulnerable |
| Fairy tern | Vulnerable | Vulnerable | Vulnerable |
| Black bittern | Priority 2 | Not listed | Least concern |
| Barking owl (southwest subpopulation) | Priority 3 | Not listed | Least concern (species level) |
| Pilbara grasswren | Priority 4 | Not listed | Least concern |
| Letter-winged kite | Priority 4 | Not listed | Near threatened |
| Blue-billed duck | Priority 4 | Not listed | Near threatened |
| Princess parrot | Priority 4 | Vulnerable | Near threatened |
| Southern giant petrel | Not listed | Endangered | Least concern |

A. Endemic to the Pilbara bioregion. B. Current to 1 August 2020.



The Pilbara subspecies of the Torresian kingfisher, *Todiramphus sordidus pilbara*, is found from the De Grey River to the Exmouth Gulf. Image: Les George

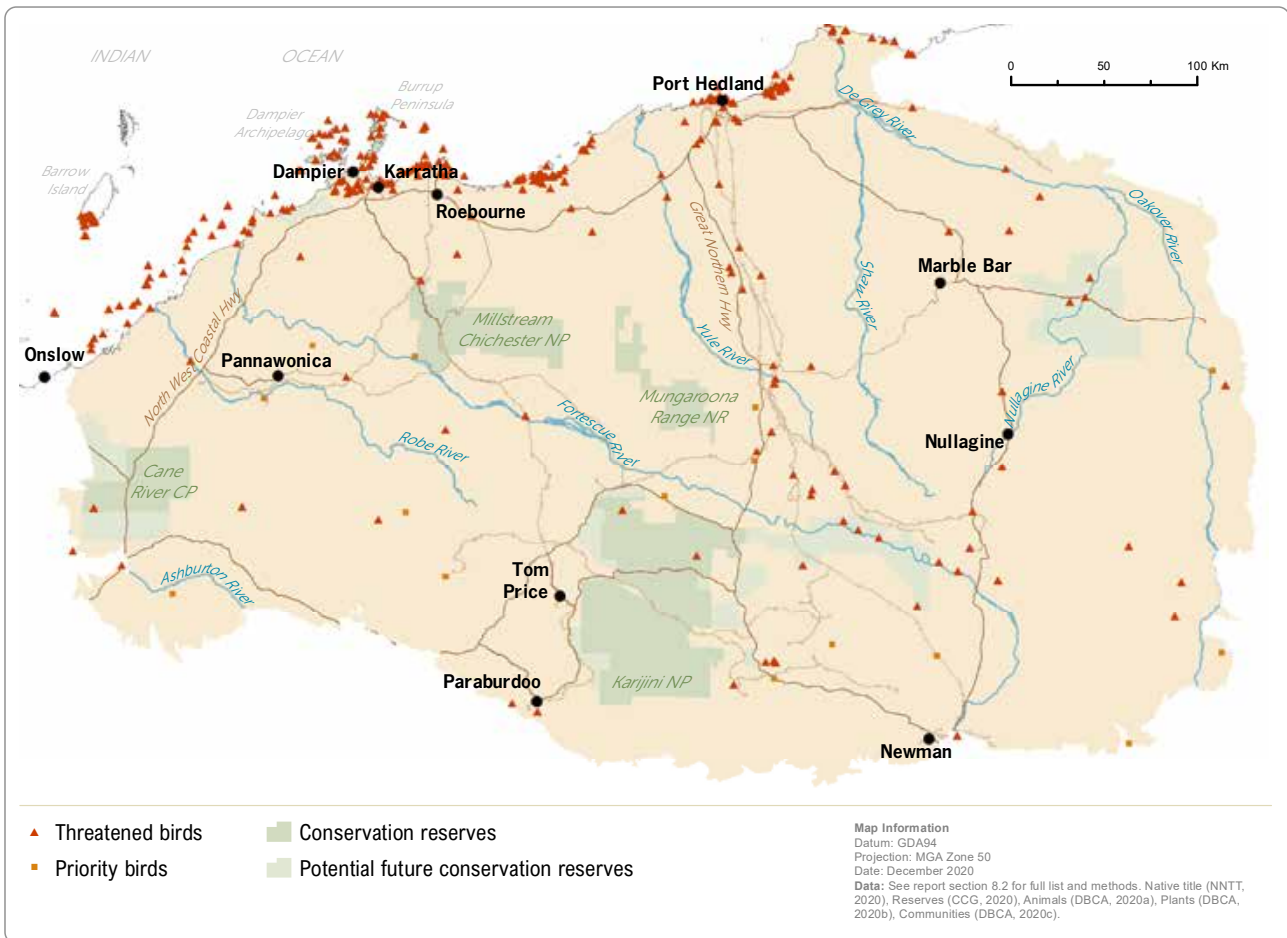


Figure 2-6. The distribution of state-listed threatened and priority bird species in the Pilbara

Note: Most records are for threatened migratory shorebirds and fairy terns. Most of the inland records are for grey falcons.

PROFILE: Night parrot (*Pezoporus occidentalis*)

The importance of the Pilbara

Cryptic, enigmatic and elusive – the night parrot is one of Australia's rarest and most sought-after birds. A 2005 sighting near Fortescue Marsh in the Pilbara was one of just 4 confirmed sightings in Western Australia this century [176], the others being in the Goldfields, East Murchison and Great Sandy Desert in 2017 [177–179]. The only other confirmed population is in western Queensland. There are widespread historical records across Western Australia, Northern Territory, South Australia and Queensland, but the current distribution is unknown. Prior to the 1990 discovery of a dead night parrot in Queensland, the species was thought likely to be extinct due to a lack of confirmed sightings for over a century [180].

About the night parrot

This small, dumpy, seed-eating, night-active parrot inhabits remote arid and semi-arid spinifex grasslands and shrublands of samphire, bluebush and saltbush [177]. Little is known of its ecology [181]. Although seen drinking water, it may gain sufficient moisture from foraging on succulent plants [182]. Nests have been found in big old spinifex clumps.

Conservation status and threats

| Western Australian status | National status | International status |
|---------------------------|-----------------|----------------------|
| Critically endangered | Endangered | Endangered |

The population size of night parrots in the Pilbara (and elsewhere) is unknown. Threats are also uncertain but likely to include predation by feral cats, adverse fire regimes (frequent or large fires), grazing by domestic or feral herbivores, habitat loss or degradation by mining and climate change [177]. Indigenous rangers have recently been at the forefront of finding and monitoring night parrots [183].



Image: Bruce Greatwich

2.3.5 FISHES

The freshwater fish of the Pilbara are dominated by the relatively few species that can survive the extremes of massive flooding and high-velocity flows after cyclones and the long dry season when rivers contract to isolated pools. But it doesn't mean that fish are scarce, as Njama elder Peter Coppin recounted [184]:

See, we come from the De Grey River and down Yarrie way. I remember the old people was dancing there, woman and men, for the ceremony for makin' more fish. ... Used to get them with a net. Christ, you couldn't hardly lift them out of the water! Every year, every year, they used to do that, every year before the rain.

Ten freshwater fish species have been recorded in Pilbara rivers [185], and another lives in groundwater. The rivers also host 16 fishes that spend most of their lives in the ocean or estuaries, some of which may have a freshwater juvenile phase, including barramundi, mangrove jack and sea mullet [185]. There are also at least 2 introduced species: sailfin molly [186] and mosquito fish [185].

At least 2 freshwater fishes are thought to be unique to the Pilbara – the Fortescue grunter, found only from the Ashburton River to the upper reaches of the Fortescue [187], and an undescribed catfish (*Neosilurus* sp.) in the Robe River that has not been captured for many years [185]. The Fortescue grunter has recently been assessed by the IUCN as endangered. Of concern are recent invasions of exotic fish in its range and declines in habitat quality due to mining [188].

There are likely to be additional endemic fish in the Pilbara, for there are significant genetic differences between populations in the Pilbara and elsewhere of at least 3 species (bony bream, Hyrtl's tandan, western rainbowfish) and between Fortescue grunters, indicative of potential new species [185,189–191]. This 'apparent high degree of endemism and genetic divergence' between populations in the Pilbara and elsewhere warrants investigation [189].

The most unusual fish in the Pilbara is the blind cave eel (*Ophisternon candidum*) recently discovered in aquifers in the Robe River area and also known from Barrow island and Cape Range Peninsula [192]. This is one of just 3 vertebrate animals in Australia known to live their entire lives underground (the others are gudgeons in the same region). This eel grows up to 400 mm long, lacks eyes and skin pigment, and eats mainly crustaceans. It has recently been assessed by the IUCN as endangered, mainly due to mining [192]. All Pilbara populations occur in mining leases with large-scale open-cut mining and dewatering [193].

Two threatened sawfish species may migrate between salt and fresh waters in the Pilbara. The north-west region is regarded as 'a global hotspot' for sawfish [194]. A likely nursery for green sawfish was recently discovered in the Ashburton estuary and surrounding tidal mangrove creeks [195]. It was the first pupping site recorded in Western Australia and, based on numbers, 'is potentially the most important globally' [195]. The only confirmed records of freshwater sawfish are from the Ashburton River below a tidal water barrier, and they have occasionally been reported from the De Grey River [185]. Sawfish are an important food source and 'cultural and spiritual icon' for many Traditional Owner groups in northern Australia [196,197].

The main threats to freshwater fish are likely to result from mining (dewatering and impacts on water quality), water extraction and climate change [185,198]. One climate change analysis predicted that fish extinction rates in 6 Pilbara rivers will be amongst the highest in the world by 2090 due to reduced water availability under climate change [198]. Four species are currently listed as threatened or priority species at a state level (Table 2-5, Figure 2-7).

Table 2-5. Threatened and priority fishes in the Pilbara

| Species | WA status | Australian status | International status |
|---|------------|-------------------|-----------------------|
| Fortescue grunter (<i>Leiopotherapon aheneus</i>) | Priority 4 | Not listed | Endangered |
| Blind cave eel (<i>Ophisternon candidum</i>) | Vulnerable | Vulnerable | Endangered |
| Freshwater sawfish (<i>Pristis pristis</i>) | Priority 3 | Vulnerable | Critically endangered |
| Green sawfish (<i>Pristis zijsron</i>) | Vulnerable | Vulnerable | Critically endangered |



The green sawfish nursery in the Ashburton River estuary and adjacent tidal mangrove creeks is potentially the most important in the world for this critically endangered species. Image: Kathie Atkinson/AUSCAPE

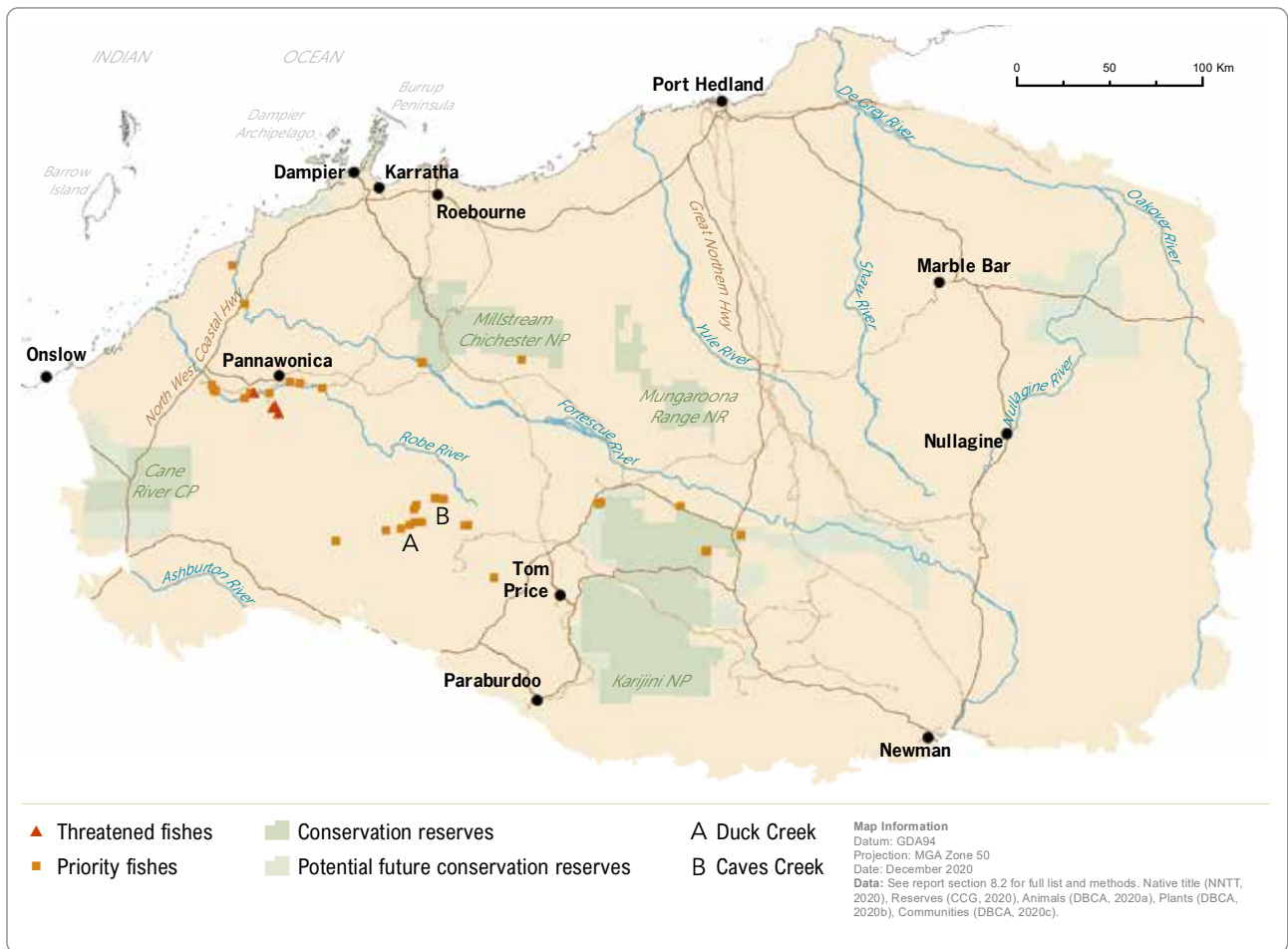


Figure 2-7. The distribution of state-listed threatened and priority fish species in the Pilbara

2.3.6 SNAILS, SPIDERS AND OTHER INVERTEBRATES

The Pilbara region is not the obvious place to look for snails.

Michael Johnson (2011)

We know that the Pilbara hosts a plethora of unique vertebrate animals – with the region's reptiles, in particular, often diverging from similar species widespread across the arid zone and with look-alike species often harbouring much cryptic diversity [40]. Is this also so for the invertebrates – 'the movers, shakers and ecosystem makers' that everywhere make up the bulk of biomass [199]? We know it is the case for subterranean invertebrates, with their 'astonishing', globally significant levels of diversity and uniqueness in the Pilbara [40] (section 2.3.1). But for most terrestrial and freshwater invertebrate groups, too little is known about their taxonomy, diversity and biogeography in the Pilbara and elsewhere in Australia to discern the significance of the region. Symptomatic of the national neglect of the spineless is that fewer than a third of Australia's estimated number of invertebrate species have even been described [200].

Take scorpions, for example – important predators (and prey for other species) in arid ecosystems. Of the 22 species collected in the Pilbara from 2003 to 2006 during the Western Australian Government's biodiversity surveys, just one had been scientifically described [201]. Ten of the undescribed species are in genus *Lychas*, the most widely distributed scorpion group in Australia. This is double the number of *Lychas* species described for all of Australia, but because there are many undescribed *Lychas* elsewhere, their relative richness in the Pilbara is unknown.

A similar situation applies to spiders – only 15% of the 375 ground-dwelling species (dominated by jumping, ant and goblin spiders) collected during the biodiversity surveys had been described [202]. The number of goblin spiders collected (70 species) far exceeded the number described in Australia at that time but a few dozen species have since been described and hundreds of other undescribed specimens exist in museum collections [202].

Trapdoor spiders and their kin (Mygalomorphae) are of high conservation interest, susceptible to decline because they tend to be long-lived, specialised for particular habitats and unable to disperse far [203]. Twenty-eight trapdoor spiders with small ranges are listed as threatened or priority species in Western Australia. Trapdoor spiders are difficult to survey because in most species only the males can be reliably identified (and not in all cases) but males make up only about 5% of specimens collected. The Pilbara survey recorded 36 species [202] but, as is the case for lizards, they are much more diverse than appearances suggest. A recent genetic study, for example, found that the spider described as *Aname mellosa* has a spectacular 10 distinct genetic lineages in the Pilbara whose members can't be distinguished by appearance alone [203]. There are only 32 described *Aname* species across Australia [204].

About a third of the 429 ground-dwelling beetle species collected in the Pilbara biodiversity surveys had been described, but many more are yet to be discovered [205]. The Pilbara 'may be an important and previously unrecognised refugial area' for beetles, with a high rate of endemism – about a third of the collected species were locally endemic [205]. Many are flightless, indicating limited habitat but a 'generally stable' environment.

Surprisingly, the Pilbara is also a refugial area for land snails – with several species unique to the region [206]. Many have small ranges, making them vulnerable to major developments [207]. Snails' secret to living in the Pilbara is their capacity to shut down when it is dry and hot – some can survive 2–3 years of dormancy, under large rocks, in deep crevices or buried in soft soils – and then quickly eat and mate during the first few days after a storm. 'Whether they eat or mate first when the rain comes probably depends on when they meet another snail' [206]. Life is slow for arid-zone snails. *Rhagada capensis*, a 2-centimetre snail from coastal Pilbara, takes 5 years to reach maturity and then lives another 5 or so years [206]. Most recent species discoveries have resulted from surveys for mining projects, indicating there are likely to be many undiscovered species [207].

For an arid zone, the Pilbara also has a diverse array of aquatic invertebrates, particularly at the level of individual wetlands [71]. This is probably due in part to the abundance of wetlands maintained by groundwater aquifers and the diversity of habitats in river pools. Over 1,000 species – mainly flies, beetles, rotifers, water mites and micro-crustaceans – were recorded in surveys of 100 wetlands, and there are probably about 1,200 species altogether [71]. About a fifth are known only from the Pilbara and close to half may be undescribed. Some rare or restricted species occur in permanently flowing springs (such as in Millstream and Karijini National Parks) and in ephemeral wetlands such as Fortescue Marsh and freshwater claypans [71].

Thirteen invertebrate species endemic to the Pilbara are listed as threatened or priority species by the state – most are subterranean (section 2.3.1) – and 7 are listed internationally (Table 2-6, Figure 2-8).

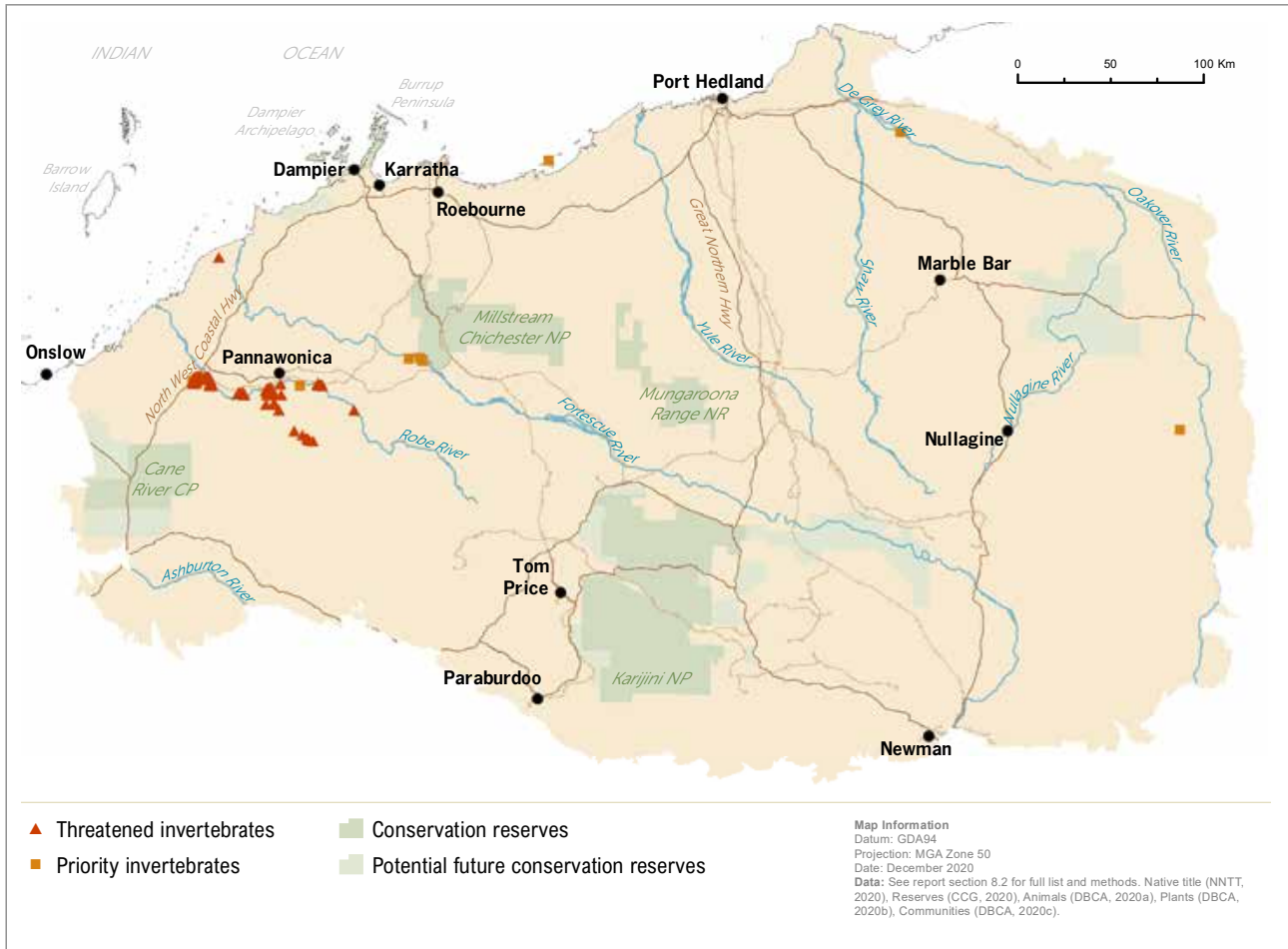


Figure 2-8. The distribution of state-listed threatened and priority invertebrate species in the Pilbara



Little is yet known about the spiders of the Pilbara – most are not even described – but they promise to be another highly diverse group of animals with much to reveal about the deep past. The pale spider on the left (found in a mining survey in 2013 and not yet named) lives underground in fissures. It is blind (eyes are no use in perpetual darkness) and hunts with the help of highly sensitive hairs on its legs. *Missulena langlandsi* (right), described only in 2013, is a mouse spider known only from the floodplain of Weeli Wolli Creek. The colour on this individual indicates it is a male, the females being all black. Mouse spiders build burrows with trapdoors. Females typically stay near their burrows their whole life while males will wander in search of mates. Images: Volker Framenau



This desert scorpion, *Urodacus hoplatus*, is able to withstand the harsh conditions by building a spiral burrow that provides a favourable microclimate (some species in this genus build burrows up to a metre deep). The Pilbara has more than 20 species of scorpion, but little is known about them – something that can be said about many invertebrate groups. Image: Robert McLean

Table 2-6. Threatened and priority Pilbara invertebrates

| Species | WA status | Australian status | International status |
|--|------------|-------------------|----------------------|
| Middle Robe draculoides (<i>Draculoides mesozeirus</i>) | Vulnerable | Not listed | Not assessed |
| a freshwater amphipod (<i>Nedsia hurlberti</i>) | Vulnerable | Not listed | Not assessed |
| a freshwater amphipod (<i>Nedsia sculptilis</i>) | Vulnerable | Not listed | Not assessed |
| Mesa A paradraculoides (<i>Paradraculoides anachoretus</i>) | Vulnerable | Not listed | Not assessed |
| Mesa B/C paradraculoides (<i>Paradraculoides bythius</i>) | Vulnerable | Not listed | Not assessed |
| Mesa G paradraculoides (<i>Paradraculoides gnophicola</i>) | Vulnerable | Not listed | Not assessed |
| Mesa K paradraculoides (<i>Paradraculoides kryptus</i>) | Vulnerable | Not listed | Not assessed |
| Lance-beaked cave shrimp (<i>Stygiocaris lancifera</i>) | Vulnerable | Not listed | Vulnerable |
| Linnaeus' pseudoscorpion (Mesa A) (<i>Ideoblothrus linnaei</i>) | Priority 1 | Not listed | Not assessed |
| Mesa A Lagynochthonius pseudoscorpion (<i>Lagynochthonius asema</i>) | Priority 1 | Not listed | Not assessed |
| Pilbara threadtail (<i>Nososticta pilbara</i>) | Priority 2 | Not listed | Endangered |
| Depuch Island charopid land snail (<i>Dupucharopa millestriata</i>) | Priority 2 | Not listed | Vulnerable |
| Pilbara dragonfly (<i>Antipodogomphus hodgkini</i>) | Priority 3 | Not listed | Endangered |
| Pilbara pin (<i>Eurysticta coolawanyah</i>) | Not listed | Not listed | Vulnerable |
| Pilbara emerald (<i>Hemicordulia koomina</i>) | Not listed | Not listed | Vulnerable |
| Pilbara wisp (<i>Agriocnemis kunjina</i>) | Not listed | Not listed | Vulnerable |

2.3.7 PLANTS

Plants of the Pilbara, like the animals, are masters of endurance – able to withstand nutrient poverty and large fluctuations in temperature and moisture. The soils of the Pilbara are typically skeletal, shallow and stony [23]. Most are of low fertility and slightly acidic, although clays associated with basalts and soils in valley floors tend to be more alkaline and fertile.

The dominant plant families of the Pilbara are characteristic of those across Australia's arid zone – grasses, legumes, mallows, daisies and chenopods. But with more than 2000 taxa recorded, the Pilbara has a richer flora than most other arid regions [208]. The number of known species has approximately doubled in the past 20 years, and there are likely to be more [208,209]. About 15% of plants are endemic [210].

The likely reasons for the high plant diversity are similar to those for animals – the complexity of the landscape with multiple soil types and landforms, the long-term geological stability, and refugia that enabled survival during periods of peak aridity [46].

Wattles are particularly rich in the Pilbara – with more than 125 species recorded [210]. The region is recognised as an Australian centre of richness and also of endemism [43]. Other diverse groups are the emu bushes (*Eremophila* species) [210] and the spinifexes (Box 2-11).

A substantial proportion of Pilbara plant species (close to 10%) are of conservation significance, with 186 listed as threatened or priority species in Western Australia (Table 2-7, Figure 2-9). About a quarter of these have not yet been scientifically described.

Box 2-11. A spinifex hotspot

A dozen new spinifex species for the Pilbara have been described since 2015 [211]. With at least 26 species (and more likely), more than a quarter of Australia's known species, the Pilbara is a centre of spinifex diversity [211]. With 10 endemic and 5 near-endemic species, the Pilbara is also a centre of spinifex endemism. Eight species are of conservation concern, listed by the Western Australian Government as priority 1 or priority 3 species.

Spinifexes are 'foundational species' – dominating about a fifth of the Australian continent, used by many reptiles, mammals and birds for food, nesting and refuge from predators, competitors and extreme temperatures, and ecologically influential for their flammability [212].

The spinifex ancestors probably arrived in Australia from 14 to 24 million years ago (from where is not yet known) and diversified as Australia became more arid [213]. But with so much of Australia offering suitable spinifex habitat, why does the Pilbara stand out for diversity and endemism?

A recent study of one spinifex group (the *Triodia basedowii* complex) suggests it is likely to have been a combination of increased speciation due to the diversity of the Pilbara landscape and reduced extinction due to refugia in the Pilbara [45]. This group of spinifexes (previously known just as 2 species) is richest in the Pilbara, with 5 of 7 likely species occurring there, and 4 restricted or almost restricted to the region. They occur on different geologies in the Pilbara, suggesting that habitat specialisation has driven diversification [45]. But with so few species elsewhere, it is also likely that refugia in the Pilbara have allowed spinifex species to persist that went extinct elsewhere during peaks of aridity [45].



Image: Reg Morrison/AUSCAPE

Table 2-7. Threatened and priority Pilbara plant taxa (Western Australian status)

| Scientific name | Status | Scientific name | Status |
|--|-------------------------|---|------------|
| <i>Aluta quadrata</i> | Endangered | <i>Acacia levata</i> | Priority 3 |
| <i>Pityrodia</i> sp. Marble Bar | Endangered ^A | <i>Acacia subtiliformis</i> | Priority 3 |
| <i>Thryptomene wittweri</i> | Vulnerable ^B | <i>Amaranthus centralis</i> | Priority 3 |
| <i>Abutilon</i> sp. Onslow | Priority 1 | <i>Ampelopteris prolifera</i> | Priority 3 |
| <i>Acacia aphanoclada</i> | Priority 1 | <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> | Priority 3 |
| <i>Acacia corusca</i> | Priority 1 | <i>Astrebla lappacea</i> | Priority 3 |
| <i>Acacia cyperophylla</i> var. <i>omearana</i> | Priority 1 | <i>Atriplex flabelliformis</i> | Priority 3 |
| <i>Acacia fecunda</i> | Priority 1 | <i>Atriplex lindleyi</i> subsp. <i>conduplicata</i> | Priority 3 |
| <i>Acacia leeuweniana</i> | Priority 1 | <i>Corchorus congener</i> | Priority 3 |
| <i>Acacia</i> sp. Marble Bar | Priority 1 | <i>Corynotheca asperata</i> | Priority 3 |
| <i>Acacia</i> sp. Nullagine | Priority 1 | <i>Crotalaria smithiana</i> | Priority 3 |
| <i>Atriplex eremitis</i> | Priority 1 | <i>Croton aridus</i> | Priority 3 |
| <i>Atriplex spinulosa</i> | Priority 1 | <i>Cyanthillium gracile</i> | Priority 3 |
| <i>Barbula ehrenbergii</i> | Priority 1 | <i>Dampiera anonyma</i> | Priority 3 |
| <i>Bothriochloa decipiens</i> var. <i>cloncurrrens</i> | Priority 1 | <i>Dampiera atriplicina</i> | Priority 3 |
| <i>Calotis squamigera</i> | Priority 1 | <i>Dampiera metallorum</i> | Priority 3 |
| <i>Cochlospermum macnamarae</i> | Priority 1 | <i>Dysphania congestiflora</i> | Priority 3 |
| <i>Corchorus</i> sp. Yarrie | Priority 1 | <i>Eleocharis papillosa</i> | Priority 3 |
| <i>Dicrasyllis mitchellii</i> | Priority 1 | <i>Eragrostis crateriformis</i> | Priority 3 |
| <i>Dipteracanthus chichesterensis</i> | Priority 1 | <i>Eragrostis lanicaulis</i> | Priority 3 |
| <i>Eragrostis</i> sp. Mt Robinson | Priority 1 | <i>Eragrostis</i> sp. Erect spikelets | Priority 3 |
| <i>Eremophila capricornica</i> | Priority 1 | <i>Eragrostis surreyana</i> | Priority 3 |
| <i>Eremophila maculata</i> subsp. <i>filifolia</i> | Priority 1 | <i>Eremophila coacta</i> | Priority 3 |
| <i>Eremophila pilosa</i> | Priority 1 | <i>Eremophila forrestii</i> subsp. <i>viridis</i> | Priority 3 |
| <i>Eremophila</i> sp. Mt Channar Range | Priority 1 | <i>Eremophila magnifica</i> subsp. <i>velutina</i> | Priority 3 |
| <i>Eremophila</i> sp. Snowy Mountain | Priority 1 | <i>Eremophila rigida</i> | Priority 3 |
| <i>Eremophila</i> sp. West Angelas | Priority 1 | <i>Eremophila</i> sp. Hamersley Range | Priority 3 |
| <i>Eucalyptus lucens</i> | Priority 1 | <i>Eremophila spongiocarpa</i> | Priority 3 |
| <i>Euphorbia inappendiculata</i> var. <i>queenslandica</i> | Priority 1 | <i>Eriochloa fatmensis</i> | Priority 3 |
| <i>Euphorbia parvicaruncula</i> | Priority 1 | <i>Eucalyptus rowleyi</i> | Priority 3 |
| <i>Fimbristylis</i> sp. Shay Gap | Priority 1 | <i>Euphorbia australis</i> var. <i>glabra</i> | Priority 3 |
| <i>Gomphrena</i> sp. Martins Well | Priority 1 | <i>Euphorbia clementii</i> | Priority 3 |
| <i>Goodenia pallida</i> | Priority 1 | <i>Euphorbia stevenii</i> | Priority 3 |
| <i>Goodenia pedicellata</i> | Priority 1 | <i>Fimbristylis sieberiana</i> | Priority 3 |
| <i>Helichrysum oligochaetum</i> | Priority 1 | <i>Fuirena incrassata</i> | Priority 3 |
| <i>Heliotropium parviantrum</i> | Priority 1 | <i>Geijera salicifolia</i> | Priority 3 |
| <i>Hibiscus campanulatus</i> | Priority 1 | <i>Glycine falcata</i> | Priority 3 |
| <i>Hibiscus</i> sp. Mt Brockman | Priority 1 | <i>Gomphrena cucullata</i> | Priority 3 |
| <i>Indigofera roseola</i> | Priority 1 | <i>Gomphrena leptophylla</i> | Priority 3 |
| <i>Isotropis forrestii</i> | Priority 1 | <i>Goodenia lyrata</i> | Priority 3 |
| <i>Josephinia</i> sp. Woodstock | Priority 1 | <i>Goodenia</i> sp. East Pilbara | Priority 3 |
| <i>Lepidium amelum</i> | Priority 1 | <i>Grevillea saxicola</i> | Priority 3 |
| <i>Lindernia</i> sp. Pilbara | Priority 1 | <i>Gymnanthera cunninghamii</i> | Priority 3 |

Table 2-7. Threatened and priority Pilbara plant taxa (Western Australian status) - Continued

| Scientific name | Status | Scientific name | Status |
|--|------------|---|------------|
| <i>Minuria tridens</i> | Priority 1 | <i>Heliotropium murinum</i> | Priority 3 |
| <i>Myriocephalus scalpellus</i> | Priority 1 | <i>Heliotropium muticum</i> | Priority 3 |
| <i>Pentalepis trichodesmoides</i> subsp. <i>incana</i> | Priority 1 | <i>Indigofera ammobia</i> | Priority 3 |
| <i>Ptilotus wilsonii</i> | Priority 1 | <i>Indigofera gilesii</i> | Priority 3 |
| <i>Rhodanthe ascendens</i> | Priority 1 | <i>Indigofera Dolichocarpa</i> | Priority 3 |
| <i>Rorippa</i> sp. Fortescue Valley | Priority 1 | <i>Iotasperma sessilifolium</i> | Priority 3 |
| <i>Samolus</i> sp. Fortescue Marsh | Priority 1 | <i>Nicotiana umbratica</i> | Priority 3 |
| <i>Scaevola</i> sp. Isabella Range | Priority 1 | <i>Dolichocarpa</i> sp. Hamersley Station | Priority 3 |
| <i>Solanum</i> sp. Mosquito Creek | Priority 1 | <i>Olearia mucronata</i> | Priority 3 |
| <i>Stemodia</i> sp. Battle Hill | Priority 1 | <i>Owenia acidula</i> | Priority 3 |
| <i>Synostemon hamersleyensis</i> | Priority 1 | <i>Phyllanthus hebecarpus</i> | Priority 3 |
| <i>Tecticornia globulifera</i> | Priority 1 | <i>Pilbara trudgenii</i> | Priority 3 |
| <i>Tecticornia</i> sp. Christmas Creek | Priority 1 | <i>Pterocaulon xenicum</i> | Priority 3 |
| <i>Tephrosia rosea</i> var. Port Hedland | Priority 1 | <i>Ptilotus subspinescens</i> | Priority 3 |
| <i>Tetradlea butcheriana</i> | Priority 1 | <i>Rhagodia</i> sp. Hamersley | Priority 3 |
| <i>Tribulus minutus</i> | Priority 1 | <i>Rostellularia adscendens</i> var. <i>latifolia</i> | Priority 3 |
| <i>Triodia mallota</i> | Priority 1 | <i>Rothia indica</i> subsp. <i>australis</i> | Priority 3 |
| <i>Triodia</i> sp. Karijini | Priority 1 | <i>Sauropus arenosus</i> | Priority 3 |
| <i>Triodia</i> sp. Silvergrass | Priority 1 | <i>Schoenus punctatus</i> | Priority 3 |
| <i>Triodia veniciae</i> | Priority 1 | <i>Sida</i> sp. Barlee Range | Priority 3 |
| <i>Vittadinia</i> sp. Coondewanna Flats | Priority 1 | <i>Sida</i> sp. Hamersley Range | Priority 3 |
| <i>Adiantum capillus-veneris</i> | Priority 2 | <i>Solanum albotellatum</i> | Priority 3 |
| <i>Aristida lazaridis</i> | Priority 2 | <i>Solanum kentrocaule</i> | Priority 3 |
| <i>Arthropodium</i> sp. Ironstone | Priority 2 | <i>Solanum</i> sp. Red Hill | Priority 3 |
| <i>Cladium procerum</i> | Priority 2 | <i>Sporobolus blakei</i> | Priority 3 |
| <i>Cucumis</i> sp. Barrow Island | Priority 2 | <i>Stackhousia clementii</i> | Priority 3 |
| <i>Dicladantha glabra</i> | Priority 2 | <i>Stylidium weeliwollii</i> | Priority 3 |
| <i>Eremophila pusilliflora</i> | Priority 2 | <i>Swainsona thompsoniana</i> | Priority 3 |
| <i>Eremophila</i> sp. Rudall River | Priority 2 | <i>Tecticornia medusa</i> | Priority 3 |
| <i>Euphorbia inappendiculata</i> var. <i>inappendiculata</i> | Priority 2 | <i>Terminalia supranitifolia</i> | Priority 3 |
| <i>Gompholobium karijini</i> | Priority 2 | <i>Themeda</i> sp. Hamersley Station | Priority 3 |
| <i>Gomphrena pusilla</i> | Priority 2 | <i>Triodia basitricha</i> | Priority 3 |
| <i>Goodenia hartiana</i> | Priority 2 | <i>Triodia chichesterensis</i> | Priority 3 |
| <i>Hibiscus</i> sp. Gurinbiddy Range | Priority 2 | <i>Triodia pisoliticola</i> | Priority 3 |
| <i>Indigofera ixocarpa</i> | Priority 2 | <i>Triodia</i> sp. Mt Ella | Priority 3 |
| <i>Ipomoea racemigera</i> | Priority 2 | <i>Triumfetta echinata</i> | Priority 3 |
| <i>Isotropis parviflora</i> | Priority 2 | <i>Vigna triodiophila</i> | Priority 3 |
| <i>Kohautia australiensis</i> | Priority 2 | <i>Xanthoparmelia nashii</i> | Priority 3 |
| <i>Oxalis</i> sp. Pilbara | Priority 2 | <i>Xerochrysum boreale</i> | Priority 3 |
| <i>Paspalidium retiglume</i> | Priority 2 | <i>Acacia bromilowiana</i> | Priority 4 |
| <i>Pentalepis trichodesmoides</i> subsp. <i>hispida</i> | Priority 2 | <i>Bulbostylis burbridgeae</i> | Priority 4 |
| <i>Scaevola</i> sp. Hamersley Range basalts | Priority 2 | <i>Eremophila magnifica</i> subsp. <i>magnifica</i> | Priority 4 |

| Scientific name | Status | Scientific name | Status |
|---|------------|--|------------|
| <i>Solanum octonum</i> | Priority 2 | <i>Eremophila youngii</i> subsp. <i>lepidota</i> | Priority 4 |
| <i>Solanum pycnotrichum</i> | Priority 2 | <i>Goodenia berringbinensis</i> | Priority 4 |
| <i>Tetradlea fordiana</i> | Priority 2 | <i>Goodenia nuda</i> | Priority 4 |
| <i>Teucrium pilbaranum</i> | Priority 2 | <i>Lepidium catapycnon</i> | Priority 4 |
| <i>Trianthema</i> sp. Python Pool | Priority 2 | <i>Livistona alfredii</i> | Priority 4 |
| <i>Abutilon</i> sp. <i>Pritzelianum</i> | Priority 3 | <i>Ptilotus mollis</i> | Priority 4 |
| <i>Acacia daweana</i> | Priority 3 | <i>Ptilotus trichocephalus</i> | Priority 4 |
| <i>Acacia effusa</i> | Priority 3 | <i>Rhynchosia bungarensis</i> | Priority 4 |

A. Listed under the EPBC Act as endangered. B. Listed under the EPBC Act as vulnerable.

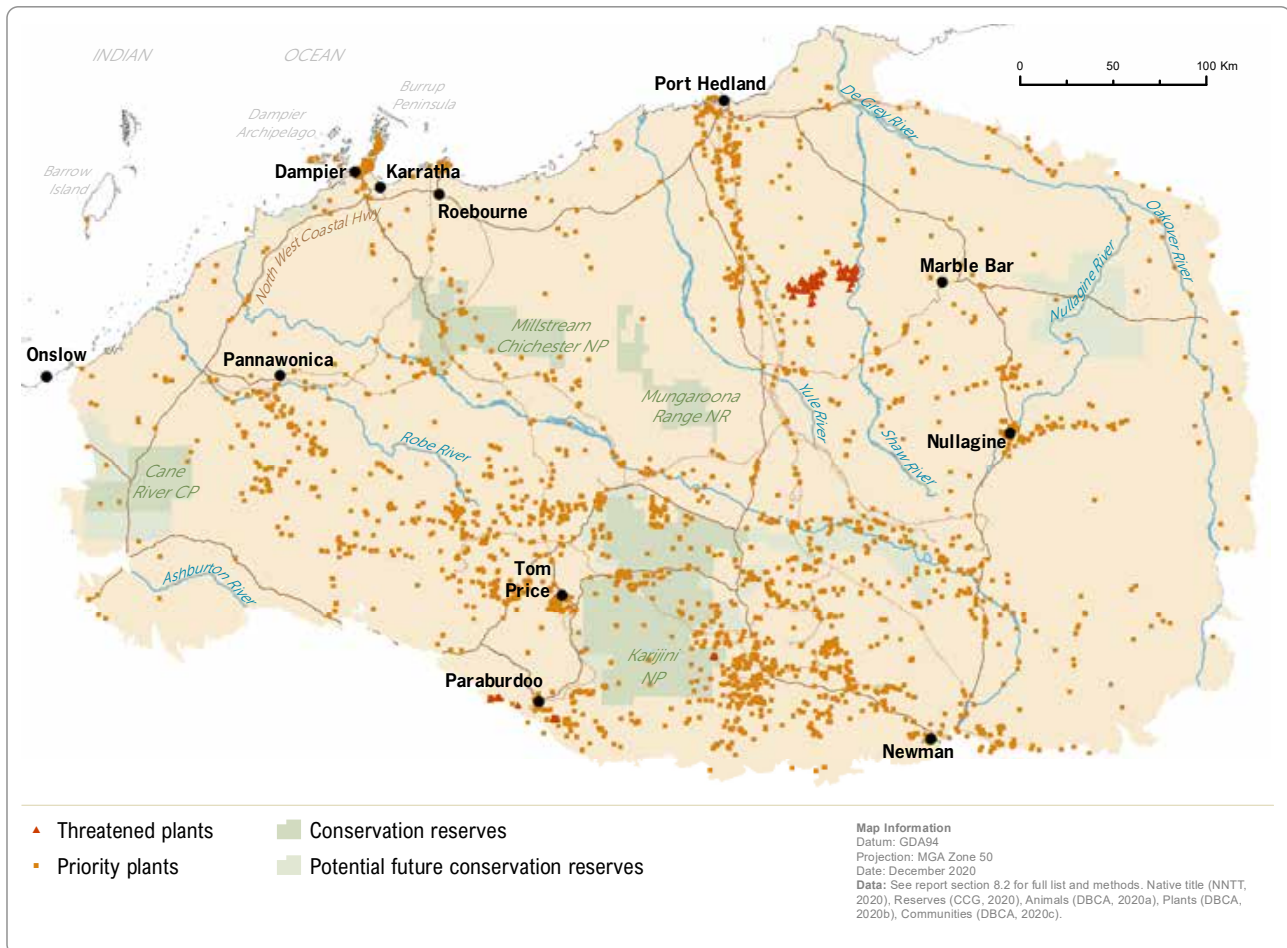


Figure 2-9 The distribution of state-listed threatened and priority plant species in the Pilbara

Note: This map indicates a survey bias in the Pilbara. Records of the distribution of threatened and priority species are closely aligned in several places to the locations of mines and railways, due to the surveys required for approving new mining infrastructure.

2.3.8 ECOLOGICAL COMMUNITIES

In recognition that it is important to protect biodiversity holistically – including the interactions between species, ecological processes, and the many thousands of species yet to be identified or whose conservation status is unknown – the Western Australian Government identifies at-risk ecological communities for conservation management [214]. An ecological community 'is a naturally

occurring group of plants, animals and other organisms interacting in a unique habitat' [214].

Two ecological communities in the Pilbara are listed as threatened – Themeda grasslands on cracking clays on Hamersley Station and the stygofauna community in the Ethel Gorge aquifer (Box 2-9). An additional 29 communities are listed as state priorities (Table 2-8, Figure 2-10).

Table 2-8. Threatened and priority ecological communities in the Pilbara

| Community name | WA status | Threats |
|---|----------------------|---|
| Ethel Gorge aquifer stygobiont community | Endangered | Mining (dewatering and salinisation) |
| Themeda grasslands on cracking clays (Hamersley Station) | Vulnerable | Cattle and feral animals (grazing, trampling, nutrient enrichment), hydrological changes, land clearing, weed invasion (particularly mimosa bush), altered fire regimes |
| Brockman Iron cracking clay communities of the Hamersley Range | Priority 1 | Grazing, clearing (mining, agricultural development), altered fire regimes. |
| Stygofaunal community of the Bungaroo Aquifer | Priority 1 | Groundwater drawdown (mining) |
| Burrup Peninsula rock pile communities | Priority 1 | Clearing, altered fire regimes, emissions, weed invasion (buffel grass, stinking passion flower, kapok) |
| Burrup Peninsula rock pool communities possibly air pollution | Priority 1 | Recreational impacts, potential development, |
| Coolibah – Lignum Flats (sub-type 2) (Lake Robinson) | Priority 1 | Dewatering (mining), grazing, clearing (for infrastructure corridors), altered fire regimes, weed invasion |
| Coolibah – Lignum Flats (sub-type 3) (Mt Bruce flats) | Priority 1 | Dewatering (mining), grazing, clearing (for infrastructure corridors), altered fire regimes, weed invasion |
| Fortescue Marsh (Marsh Land System) | Priority 1 invasion. | Clearing (mining), altered hydrology, grazing, weed |
| Freshwater claypans downstream of Fortescue Marsh (Goodiadarrie Hills on Mulga Downs Station) | Priority 1 | Grazing, weed invasion, infrastructure corridors, altered hydrological flows, altered fire regimes |
| Subterranean invertebrate communities of mesas | Priority 1 | Mining in the Robe Valley region |
| Subterranean invertebrate community of pisolitic hills | Priority 1 | Mining |
| Stony chenopod association of the Roebourne Plains | Priority 1 | Grazing, clearing, weed invasion (especially buffel grass) |
| Roebourne Plains coastal grasslands with gilgai microrelief on deep cracking clays | Priority 1 | Grazing, clearing (mining, infrastructure, urban development), weed invasion, raw material extraction |
| Sand Sheet vegetation (Robe Valley) | Priority 1 | Grazing, clearing, weed invasion (particularly buffel grass) |
| Tanpool land system | Priority 1 | Grazing |
| Weeli Wolli spring community | Priority 1 | Dewatering and re-watering (mining), weed invasion, increased visitation. |
| West Angelas cracking-clays | Priority 1 | Mining and infrastructure disturbance, weed invasion, fragmentation, altered fire regimes |
| Four plant assemblages of the Wona land system | Priority 1 | Grazing, weed invasion |
| Riparian flora and plant communities of springs and river pools with high water permanence | Priority 2 | Altered hydrology (mining), altered fire regimes, weed invasion (buffel grass, stinking passion flower), grazing (camels), visitation |

| Community name | WA status | Threats |
|---|--------------------------|---|
| Coastal dune tussock grassland dominated by <i>Whiteochloa airoides</i> | Priority 3 Priority 3 | Weed invasion (buffel grass, kapok), altered fire regimes, grazing, raw material extraction |
| Eighty Mile land system (buffel grass) | Priority 3 | Altered fire regimes, grazing, erosion, weed invasion |
| Vegetation of sand dunes of the Hamersley Range /Fortescue Valley | Priority 3 | Weed invasion (especially buffel grass), grazing, altered fire regimes, erosion, clearing (mining and infrastructure) |
| Horseflat land system of the Roebourne Plains | Priority 3 | Grazing, weed invasion, fragmentation, clearing |
| Kanjenjie land system | Priority 3 | Grazing |
| Kumina land system | Priority 3 | Mining |
| Stony saline clay plains of the Mosquito land system | Priority 3 | Grazing (livestock and feral herbivores), clearing |
| Narbung land system | Priority 3 | Grazing |
| <i>Triodia pisoliticola</i> assemblages of mesas of the West Pilbara | Priority 3 | Clearing (mining and associated infrastructure) |
| Invertebrate assemblages (Errawallana Spring type) Coolawanya Station | Priority 4 | Grazing |
| Invertebrate assemblages (Nyeetberry Pool type) | Priority 4 | Hydrological change, feral animals |

Sources: 95,215,216

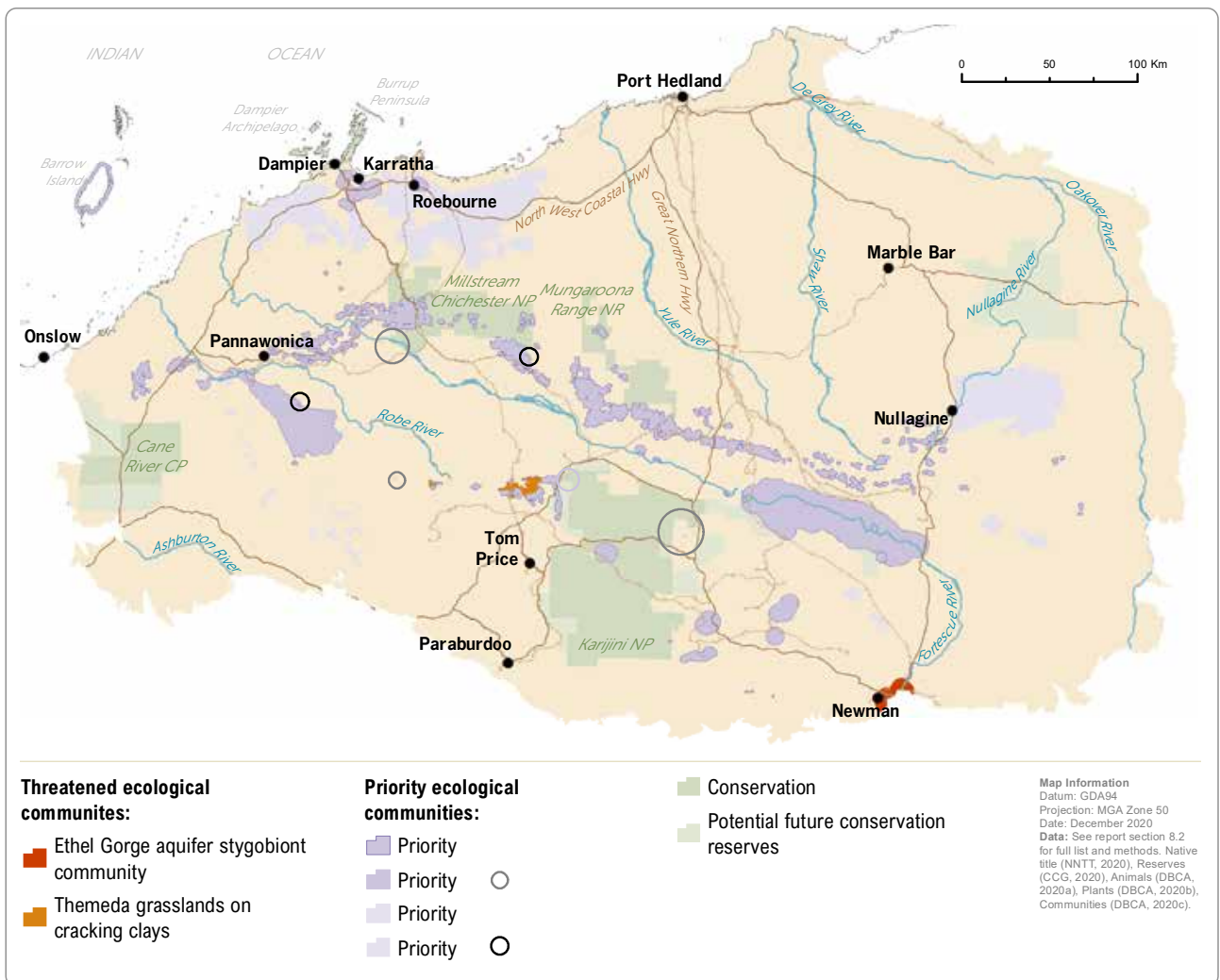


Figure 2-10. Threatened and priority ecological communities in the Pilbara



3. Land uses and threats to nature in the Pilbara

The Pilbara was designated one of 15 'biodiversity hotspots' by the Australian Government not only for its outstanding natural values, but because of the threats to those values [41]. Although the region is one of Australia's most ecologically intact, much has been modified or damaged since pearlers and pastoralists arrived almost 160 years ago, establishing a new economic regime founded on resource extraction and sheep and cattle grazing [217]. The most severe threats in the Pilbara are those that operate almost everywhere in Australia – invasive plants and animals, altered fire regimes, overgrazing, habitat destruction, changes to water flows and water quality, and other impacts of major land uses.

In this chapter we describe the major land uses and their history in the Pilbara, and then the major threats to nature.

3.1 Major land uses

The arrival of Europeans almost 150 years ago set in motion chains of events that changed our lands and our people forever. Many of us are old enough to remember the time before mining companies and archaeological excavations. Many things have changed in our land, but what has not changed is that we are still here, with our people, our lore ceremonies and our traditional cultural kinship and Language.

Maitland Parker and Slim Parker, Elders of the Martidja Banjima Aboriginal Community (2018) [19]

Altogether, 82% of the Pilbara is leased for pastoralism (60%) or mining (55%) or both – compared to 6% dedicated primarily to nature conservation. This extensive exploitation puts pressure on sensitive ecosystems such as wetlands and rivers, and native plants and animals. It also makes for a lopsided economy (Chapter 6) and challenges for Traditional Owners to exercise their land management responsibilities and rights.

3.1.1 PASTORALISM

The valuable bluebush and saltbush pastures of the coastal fringe disappeared first ... There are only traces left of the original plant cover.

Henk Suijendorp, Western Australian Department of Agriculture (1976) [218]

In 1861, government surveyor Francis Gregory, reconnoitring the Pilbara for its pastoral potential, wrote in his journal that although 'very stony', the land was fertile enough to 'afford a fair prospect of success to judicious

settlers' and far better than the 'average of the settled districts' in Western Australia [219]. He described kangaroo grass taller than horses' backs, a 'large expanse of fertile plain', 'fine pasture country', 200,000 acres of land suitable for growing sugar and cotton, and a vision of the Fortescue Valley hosting 'a rich and thriving settlement' [220].

Gregory's optimism about the pastoral potential of the Pilbara proved alluring. Within 2 years, sheep stations were established on the Roebourne Plains, near the mouths of the Harding and De Grey rivers [23]. Over the next several decades of buoyant wool prices and optimism about the land's productivity, sheep numbers escalated [219,221]. The 1902–04 Western Australian Yearbook said that 'stock thrive and increase wonderfully' in the region [221]. By then, more than half the Pilbara was stocked, with only the rugged range areas not under lease [23,221]. In 1934, sheep numbers reached a peak of 1.8 million [219].

So rapid was this transformation that Gregory's journal is one of very few western sources offering glimpses of the pre-pastoral landscape. The Pilbara's 'fine pasture country' he described was not just ecological happenstance, but influenced by thousands of years of management by Traditional Owners using fire [222]. Gregory noted 'numerous native fires' and a plain of many miles 'covered with a short sward of bright-green grass, the native fires having swept off the dry grass a few weeks previously' [220]. As pastoralism spread, the Traditional Owners, no longer able to freely burn and hunt, and with little choice but to work for pastoralists, witnessed the rapid degradation of their lands:

Opposite: Can the Pilbara become a showcase for conservation on economically important lands – with economic activity supporting landscape-scale cultural and conservation land management rather than undermining it? This mine (Marandoo) on the lands of the Eastern Guruma people was once national park. Image: Krystle Wright

By 1900 our lands had become completely overstocked. The plains were eaten bare and waterholes over-run with sheep and cattle. Kangaroos were shot in their thousands and bush-tucker was hard to find. If you didn't work for the squatter you starved.

Roger Solomon, Yindjibarndi/Ngarluma Elder (1993) [5]

The collapse of the sheep industry in the 1930s was precipitous, with sheep numbers dropping by almost two-thirds in little over a decade [219]. The more-nutritious pastures were severely degraded – saltbush and bluebush largely lost from the Roebourne Plains, grasses depleted along the rivers, and tussock grasses displaced by spinifexes in many areas [23,219]. The expansion of soft spinifexes suited wallaroos, whose abundance added grazing pressure [218]. Droughts, dingoes, blowflies, grasshoppers, mice, financial hardship and a lack of labour were other reported tribulations [221,223]. Many leases were abandoned or amalgamated between 1946 and 1960 [218] (see Figure 3-2).

The deteriorating environmental and economic conditions contributed to the 1946 Aboriginal pastoral workers' strike [224,225]. This was the first strike of its kind in Australia, occurring 20 years before the famous Wave Hill walk-off. Although it officially lasted only 3 years, the 1946 strike started the tradition in the Pilbara of Aboriginal political engagement and actions to foster economic independence, including the purchase of pastoral stations, the creation of Aboriginal reserves, and the establishment of small-scale mining operations [225–227]. A significant proportion of today's Indigenous estate in the Pilbara is a

legacy of the 1946 strike and the movement it started.

To rescue the Pilbara's sheep industry, the Western Australian Government launched in 1962 a 5-year 'double-barrelled plan' to rehabilitate 'run-down pastoral country' [228]. It mainly involved the mass-poisoning of wallaroos and the employment of 'doggers' to kill dingoes. Meanwhile, research on the Abydos Pastoral Research Station (on the abandoned pastoral leases, Abydos and Woodstock) was demonstrating the unsuitability of the Pilbara for sheep grazing [229] (Box 5-3).

Economics ended the sheep industry. From 1969, lower wool prices and low wool cuts drove an increasing shift to cattle [219], and within a decade, cattle were the dominant grazing animal, numbering about 100,000 compared to 600,000 sheep [23] (cattle require about 8 times as much food per head as sheep [230]). A complete shift to cattle came after the 1991 collapse of the Australian Wool Corporation's reserve price scheme (a government scheme to stabilise wool prices) [231]. By the turn of the century, there were about 250,000 cattle in the Pilbara [23].

The industry today, operating across about 60% of the Pilbara bioregion, consists of 57 leasehold properties (and small parts of others), as well as 2 Aboriginal reserves, with a herd of about 260,000 cattle. Most pastoral businesses sell to the live-export market. The leaseholders are diverse, including Indigenous interests (13% of the pastoral lease area), mining companies (24% of the area) and other large corporations, and private companies (Figure 3-1). About 300 people work in agriculture in the Pilbara (Table 3-1).

Table 3-1. The Pilbara pastoral industry

| Pastoral leases | | |
|--|------|--|
| Area of pastoral leases ^A | 2020 | 10.61 million hectares |
| Number of pastoral leases ^A | 2019 | 57 (excluding leases with <10,000 hectares in the Pilbara) |
| Median lease size | 2019 | 180,000 hectares |
| Proportion of bioregion | 2020 | 59.5% |
| Proportion under native title | 2020 | 86.8% |
| Cattle | | |
| Cattle numbers ^B | 2018 | 261,000 |
| Cattle units (CU)Roboto | 2018 | 302,000 |
| Potential carrying capacity | 2018 | 260,000 CU |
| Economics | | |
| Revenue generated ^C | 2016 | \$111 million (for agriculture) |
| Agricultural jobs ^C | 2016 | 336 |

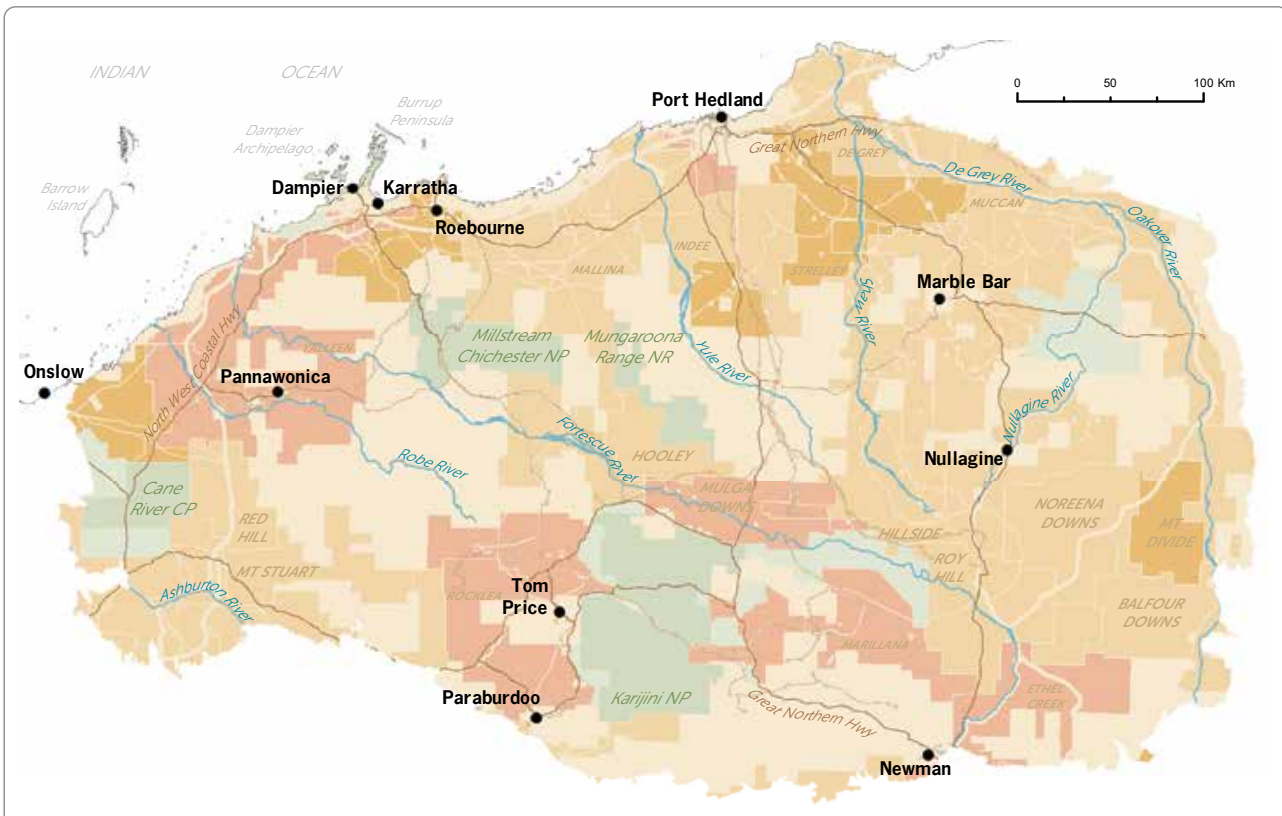
Sources: Department of Primary Industries, [232], Pilbara Development Commission [233], DPIRD 2019 (section 8.2.2)

Notes: **A.** Not all pastoral operations in the Pilbara are on pastoral leases. Yandeyarra, an Aboriginal reserve, has a management order allowing for grazing. It is not included in this data. **B.** This data is for the Pilbara region as defined by the agricultural department (not the Pilbara bioregion) and is larger than the bioregion by 3.1 million hectares. **C.** This data is for the Pilbara local government area, which is larger than the bioregion.



Prior to the introduction of livestock, Australia was the only inhabited continent lacking hoofed animals. Now, they are our dominant vertebrate animal, including in the Pilbara, where there are about 260,000 head of cattle. The ecological impacts are most evident around rivers and wetlands and on tussock grasslands, chenopod shrublands and the coastal plains. Images: Christine McPherson (top), Krystle Wright (bottom)





- Pastoral lease
- Conservation reserves
- Pastoral lease owned by Indigenous interests
- Potential future conservation reserves
- Pastoral lease owned by mining interests

Map Information
 Datum: GDA84
 Projection: MGA Zone 50
 Date: December 2020
 Data: See report section 8.2 for full list and methods. Native title (NNTT, 2020), Reserves (CCG, 2020), Animals (DBCA, 2020a), Plants (DBCA, 2020b), Communities (DBCA, 2020c).

Figure 3-1. The distribution and ownership of pastoral leases in the Pilbara

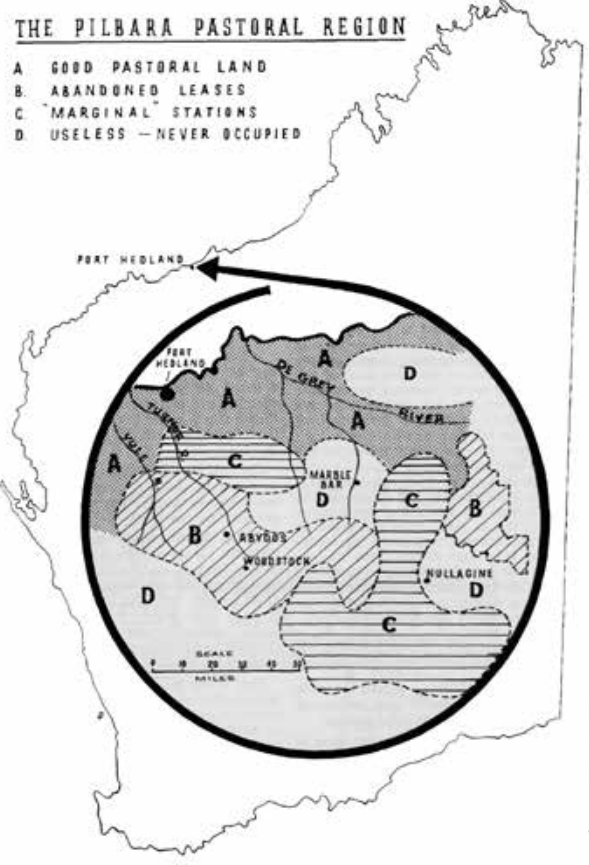


Figure 3-2. A description of the Pilbara pastoral estate in 1962 by the Western Australian Government, classifying areas as (A) good pastoral land, (B) abandoned leases, (C) marginal for pastoralism or (D) useless – ‘never occupied’.

Source: Western Australian Department of Agriculture (1962) [228]

3.1.2 MINING

The Pilbara region lacks a clear identity, it is most known for 'mining'.

Shire of Ashburton (2018) [234]

In 1938, as World War 2 loomed, the Australian Government banned the export of iron ore to prevent a proposed sale to Japan [235]. This ban was maintained until 1960 on the grounds that Australia's iron ore reserves – an estimated 320 million accessible tonnes in 1940 – were scant and should be retained for the domestic steel industry. After the embargo was partly relaxed in 1960, the news of large iron-ore discoveries in the Pilbara was 'so startling that at first it was not believed' [235]. Disbelief soon turned to political jubilation and, by 1966, when the ban was completely lifted, 3 major iron-ore projects were already underway [235–238]. A decade later, the Pilbara had 10 new towns, 4 railways and 3 deep-water ports, and the population (3,200 in 1961) had surged more than 10-fold [239].

The excitement generating Australia's political thrall to mining is evident in this excerpt from a speech by the 1968 Minister for Science, Malcolm Fraser [240]:

Iron, nickel, manganese, bauxite ... a sense of excitement seems to surround the very sound of the words today as spectacular, multi-million dollar projects, undreamed of a little while back, are on the move in that vast sweep of Australia's north and the north-west.

Today, more than half the region is under mining leases (production and exploration) (Table 3-2, Figure 3-3). Large swathes have been industrialised, with more than 25 large iron ore mines linked to 4 port terminals by almost 3,000 kilometres of railway line [241]. The astonishing volumes of iron ore extracted (more than 800 million tonnes in recent years) generate astonishing amounts of revenue (\$97 billion in 2019) [242]. It is Australia's single largest source of export revenue [243]. Although the Pilbara has been 'endowed with vast, low cost, high quality iron ore resources', at current rates of extraction the known reserves will last only another 65 or so years [244].

Long before the iron ore boom, miners were at work in the Pilbara, including Aboriginal people (Box 3-1). The first mineral shipped from the Pilbara was 60 tonnes of copper in 1872, extracted from near Roebourne [221]. Gold was discovered in 1888 at Mallina and then at Marble Bar and Nullagine, and tin was discovered in creeks east of Marble Bar [221]. Today, the Pilbara yields substantial amounts of gold, silver, manganese and copper (Table 3-2), and there are salt plants on the coast [242]. There is also a massive offshore oil and gas industry with gas-processing facilities on the Burrup Peninsula [242].



Here, the Earth's surface has been sculpted by impressive technological innovations for digging up iron ore. Below are crustaceans, beetles and other creatures living in the perpetual darkness of groundwater – exemplifying extraordinary evolutionary innovation. This is the Eastern Ridge mine in the Hamersley Ranges and somewhere below is the Ethel Gorge Aquifer Stygobiont Community. Image: Krystle Wright

Table 3-2. The Pilbara mining industry

| Mining leases | | |
|--|-----------|-----------------------|
| Production & exploration leases, area | July 2020 | 9.78 million hectares |
| Production & exploration leases, % Pilbara | July 2020 | 55% |
| Production leases, area | July 2020 | 2.06 million hectares |
| Production leases, % Pilbara | July 2020 | 11.6% |
| Economics ^A | | |
| Iron ore exports | 2019 | \$97 billion |
| Iron ore jobs | 2016 | 21,927 |
| Gold and silver sales | 2018–19 | \$940 million |
| Manganese sales | 2018–19 | \$640 million |
| Copper sales | 2018–19 | \$240 million |

Sources: Department of Mines [242], Pilbara Development Commission [233], Brent 2021 [244], DMIRS 2020a (section 8.2.4)

Notes: A. The sales and jobs figures apply to the Pilbara region, as defined by local government areas, which is larger than the Pilbara bioregion.

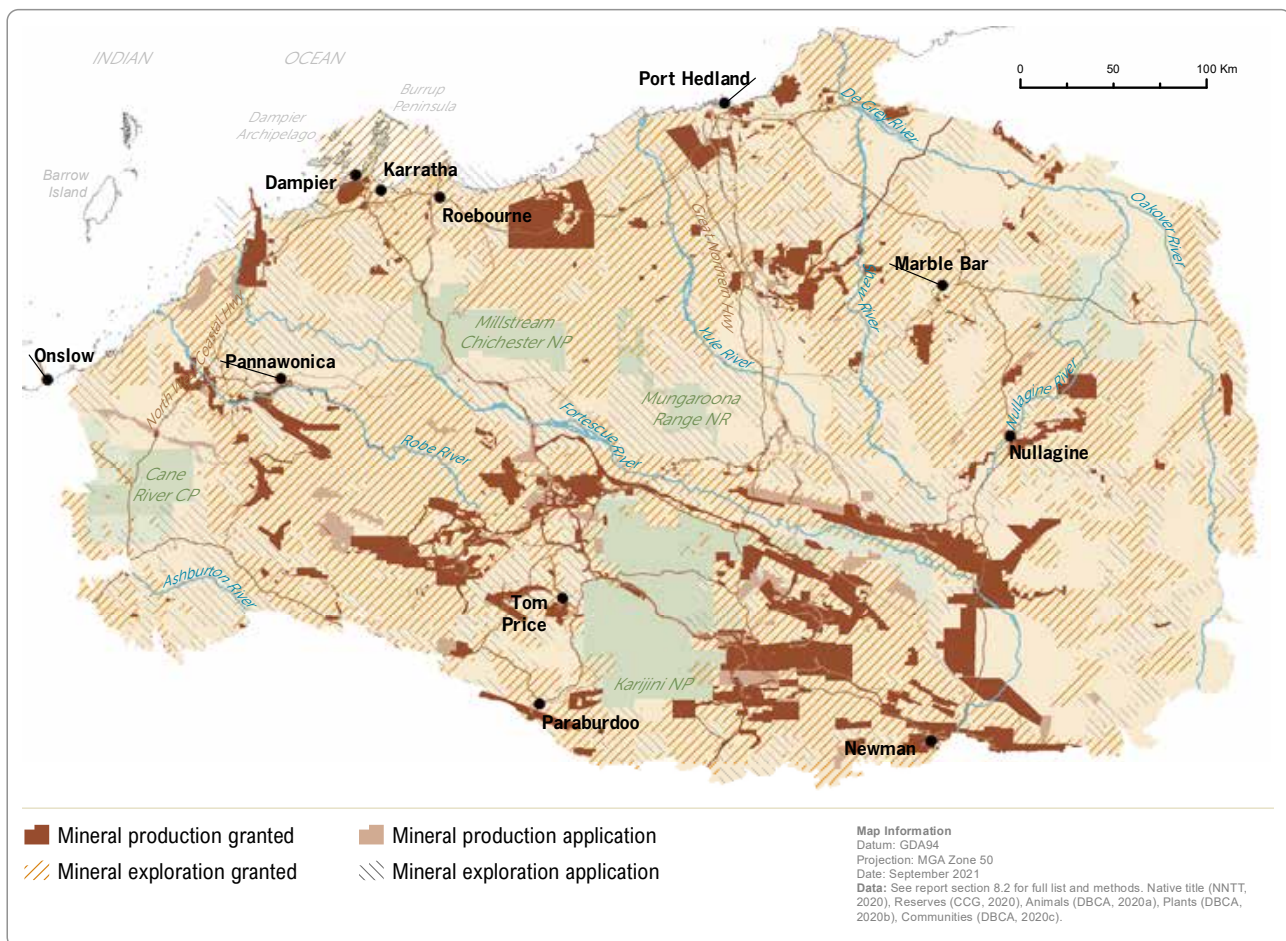


Figure 3-3. The distribution of mining tenements in the Pilbara – production leases (granted and pending) and exploration leases (granted and pending)



More than 800 million tonnes of iron ore have been shipped annually from the Pilbara in recent years. Above are stockpiles of iron ore ready for overseas shipment at a port facility on the Burrup Peninsula. Images: Krystle Wright (top), Tourism Western Australia (bottom)





Almost 3,000 kilometres of privately owned railway lines link the Pilbara's iron ore mines to ports. Iron ore trains regularly stretch more than 3 km and have exceeded 6 km. Image: Krystle Wright

Box 3-1. The Pilbara's Traditional Owners and mining

Aboriginal people are no strangers to mining. Wilgie Mia (in Western Australia) is the largest pre-contact ochre mine in Australia. An estimated 27,000 years old, it is believed to be 'the oldest continually worked mine site in human history' [245,246].

Aboriginal people took up mining in the Pilbara after gold and alluvial tin were discovered near Nullagine in the 1870s. Up to 300 were panning for gold in return for rations in the early 1900s [227]. As part of efforts to be politically and economically autonomous following the 1946 pastoral workers strike, Pilbara and desert Traditional Owners set up Western Australia's first Aboriginal-owned company, Northern Development and Mining (Nodom), in 1949. The strikers and their associates also set up the Pindan (1956) and Nomads (1960s) mining and pastoral companies. In 1967, as industrial mining started in the Pilbara, Traditional Owners held 30 mining tenements in the north-west [227].

Initially, the large corporate miners in the Pilbara mostly ignored Aboriginal people. Because Western Australia did not have a statutory land rights regime, there was no legal imperative for the state government or mining companies to talk to Traditional Owners before mining on their land (the exception being some consultation about sacred sites triggered by the Aboriginal Heritage Act 1972, which was weak then, as it is now).

Only with the passage of the *Native Title Act 1993* did this change. Miners, the state government and others were then obliged to consider the impact of their developments ('future acts') on native title rights and interests. Almost overnight, comprehensive mining agreements with Traditional Owners began to be negotiated, or legal battles were fought. The negotiated agreements cover such matters as compensation, land access, heritage and environmental protection, employment, contracting, education and training [247,248].

Today, native title is recognised across about 80% of the Pilbara (Chapter 5), and some Pilbara Aboriginal corporations are among the wealthiest in Australia, funded mainly from industry and state government agreements linked to mining and gas developments [249]. Agreements worth hundreds of millions of dollars over the life of projects are not uncommon – for example, Rio Tinto's Regional Framework Agreement in the Pilbara is worth around \$2 billion over 40 years [250,251].

While some Traditional Owners in the Pilbara have benefited economically from mining, many others continue to suffer considerable socio-economic disadvantage, and relationships with mining companies are fraught, particularly over matters of land access, heritage protection and environmental management. The recent destruction of a rockshelter at Juukan Gorge by Rio Tinto is a notorious example but, as revealed by the parliamentary enquiry into that event, such problems are widespread and significant reform is needed [34,252,253].

3.2 Threats to nature

Without management intervention, 13 of the 53 (25%) conservation significant species are likely to be functionally lost from the Pilbara in the next 20 years.

Josie Carwardine and others (CSIRO) (2014) [3]

A CSIRO assessment conducted in 2012, based on expert opinion, found that without management intervention, a quarter of 53 assessed species of conservation significance in the Pilbara were likely to be functionally lost within 20 years [3]. A similar assessment conducted today would yield different outcomes – possibly better, possibly worse – due to greater knowledge of some species and some management interventions, but also additional species of conservation concern.

Although overall trends in threatened species are uncertain, there is widespread agreement that the threats to nature in the Pilbara include invasive plants and animals, changed fire regimes, overgrazing, habitat destruction, and impacts on water flow and quality [3,69,254]. These and an emerging threat of irrigated agriculture are discussed here. Climate change is likely to be a serious threat, but the projections and likely impacts on the Pilbara are not yet clear (see Box 2-1), so it is not discussed. At this stage, the best abatement strategy for climate change impacts in the Pilbara is to abate other threats to optimise the resilience of species and ecosystems.



The introduction of red foxes to Australia in the mid-1800s brought ecological catastrophe – with feral cats, they have been the major cause of mammal extinctions and declines. The impacts of foxes are exacerbated by their propensity for ‘surplus killing’ (they kill more animals than they eat). In the Pilbara foxes occur mainly in coastal areas. Image: Nature Picture Library / Alamy Stock Photo

3.2.1 INTRODUCED PREDATORS

[We] let loose the fox and domestic cat, animals of destruction of which Australia had no parallel.

Charles Barnard (1925) [255]

One of the ecological earthquakes triggered by European colonisation was the introduction of 2 new predators. By 1890 feral cats had occupied more than 90% of Australia, a remarkably rapid spread achieved within just 70 years of their establishment in the wild around Sydney [256]. They reached the Pilbara in about 1870. Foxes arrived about half a century later, after a similarly rapid spread from Victoria [257,258].

Cats and foxes have been the likely major cause of extinction for at least 25 Australian mammals [259,260]. More than half (73 of 124) of Australia's extinct, threatened and near-threatened mammal species, excluding bats and marine mammals, are highly or extremely susceptible to predation by cats or foxes or both, including all but one of the 12 mammals lost from the Pilbara [261]. They are all in the weight range of prey preferred by cats and foxes, 35 to 5,500 grams, 90% of which have suffered either dramatic range contraction or extinction since European settlement.



Controlling feral cats to safeguard threatened species is one of Australia's great environmental challenges. Indigenous rangers are skilled cat hunters. Image: Kiwirrkurra Indigenous Protected Area

Australia used to have a lot more predators, but all predators weighing more than 40 kilograms, and most over 2 kilograms, became extinct 40,000 to 50,000 years ago. During the subsequent period of low predatory pressure, many Australian mammals are likely to have lost or relaxed their anti-predator responses [262]. They appear to be 'naïve' to the introduced predators, lacking the adaptations for detecting and evading them [261]. This may be particularly so for cats, which hunt by ambush, a strategy not used by most native predators [260]. Cats are able to quickly build up their numbers in response to favourable conditions, more quickly than many of the native animals they prey on [260].

Another introduced predator, the dingo, does not appear to have caused as much ecological havoc since arriving with people probably 3,500–5,000 years ago (the oldest known fossil, in southern Australia, is up to 3,350 years old [263] while genetic analysis suggests a dingo presence for at least 5,000 years [264]). Dingoes may have caused the mainland extinction of the thylacine and Tasmanian devil, both lost about 3,200 years ago [261,265]. That other mammals survived the new predator may be due to its preference for larger prey such as kangaroos, whose populations are less susceptible to predation [261,266,267]. However, with many smaller mammals now in very low numbers and habitats offering less refuge due to grazing and fire, even a low level of dingo predation may threaten some species [268,269]. Dingoes are known to kill northern quolls in the Pilbara [143,155]. But if dingoes also kill or suppress foxes and cats, they can also potentially benefit quolls and other threatened species [155] (Box 3-2). These interactions in the Pilbara need research [155,270].

Because dingoes kill livestock, particularly sheep, they are declared biosecurity pests in Western Australia. Under the state's conservation law, they are classified as native wildlife but declared 'unprotected'.

The state's policy is to control dingoes in and near pastoral properties, and considerable funding is provided for control via 'declared pest rates' made available to recognised biosecurity groups, including in the Pilbara [271,272].

Another new predator to Australia likely to invade the Pilbara in the 2030s is the cane toad – although it causes problems less by preying on native species than by poisoning its would-be predators (Box 3-3).

Box 3-2. Dingo: adversary or benefactor of threatened mammals?

In 2008, several cats and foxes from nearby areas were released into a 37 square kilometre enclosure in arid South Australia with a pair of dingoes and natural densities of other wildlife. They established home ranges outside the area highly used by the dingoes, suggesting they were trying to avoid encounters [273]. But within just over 2 weeks, the dingoes had killed all 7 foxes. All 6 cats also died, within 4 months, at least 3 due to dingoes [274]. This propensity of dingoes, as apex predators, to kill cats and foxes, or otherwise suppress their activity, offers hope that dingoes can help protect native wildlife threatened by cats and foxes. Dingoes have lower population densities and reproductive rates than foxes and cats, and typically hunt larger prey, so seem less likely to threaten the mammals most vulnerable to predation by cats and foxes [273]. But whether and under what circumstances dingoes are benefactors is contentious and uncertain.

There is evidence that dingoes suppress foxes, at least in some areas [275,276]. In the Strzelecki Desert, for example, comparisons across the dingo fence found that foxes were much more abundant where dingoes were rare or absent, as were kangaroos [277]. On the other side of the fence, rabbits and threatened dusky hopping-mice were more abundant, suggesting they benefited from lower fox numbers in the presence of dingoes. Although both dingoes and foxes preyed on the hopping-mice, less were eaten where dingoes were more common [278].

Whether dingoes also suppress cat populations or activity to the benefit of threatened mammals is uncertain [260,279]. Studies in northern Australia [268] and central Queensland [280] suggest not, but a study on 18 properties across northern and central Australia, on half of which dingoes were controlled, found that dingoes influenced the hunting times and movements of feral cats, potentially reducing their hunting success [281]. Dingoes may also benefit some wildlife by hunting large herbivores such as kangaroos and goats, thus reducing grazing pressure and enabling more food and shelter for small animals [260].

Dingoes have spiritual, ritual and ceremonial significance for many Traditional Owners of the Pilbara, and are a common motif in rock art and other cultural sites [270]. Given the extent of native title in the Pilbara, 'the aspiration of Traditional Owners as land managers will need to be fully considered' in how dingoes are managed in the Pilbara, including by state and state-funded agencies as well as individual and corporate landowners [270].



Image: Western Australian Department of Environment and Conservation

Box 3-3. Cane toads, a potential new invader in the Pilbara

Since their 1935 liberation in the cane fields of north Queensland, cane toads have swamped more than a million square kilometres of Australia. At first, they travelled slowly, their invasion front advancing 10–15 kilometres a year [282]. They made it to the Northern Territory by 1980, and crossed into Western Australia in 2009, by which time their pace had quadrupled to 55–60 kilometres a year [282]. In what has been dubbed the ‘Olympic village effect’, the fast toads leading the invasion front, where there are only other athletes to breed with, have evolved a much-improved capacity for long-distance travel. They grow faster, have longer forearms and narrower heads, move more often and for longer periods, and are more exploratory and willing to take risks than toads in long-colonised areas [283,284].

Cane toads have had devastating impacts on several large, frog-eating native predators, which die when they ingest the toad’s toxin [285]. In some areas, more than 90% of northern quolls, freshwater crocodiles, bluetongue skinks and some goanna species have died soon after toads arrive [285,286]. The ‘vast majority’ of northern quoll populations exposed to toads have been wiped out [287].

There is hope that affected species will eventually recover and coexist with cane toads, either by evolving resistance to toads or learning to avoid them [286]. Red-bellied black snakes in toad-exposed areas in Queensland now avoid eating toads (but still prey on frogs), have smaller heads (reducing their capacity to attack the more-lethal large toads), and are more resistant to toad toxins [285,288]. Likewise, northern quolls that have survived in a few remnant populations in Queensland avoid attacking cane toads [287]. This ‘toad-smartness’ appears to be inherited (an innate tendency now under strong selection), raising the potential for cross-breeding to spread this desirable trait [289].

By July 2020, the toad frontline was about 50 kilometres west of Fitzroy Crossing in the Kimberley [290] – just over 300 kilometres (by road) from where they will turn south towards the Pilbara. They could reach the De Grey River by the mid-to-late 2030s [156].

But invasion of the Pilbara is not inevitable. During the dry season, there are not enough natural water sources to sustain toads on their journey along the narrow coastal strip west of the Great Sandy Desert (see Figure 3-4), and artificial water sources – mainly dams and troughs installed for cattle – could be replaced or managed to prevent access by cane toads [150]. There are 2 particularly promising locations for a waterless barrier – areas spanning about 70 km that lack natural surface water sources during the dry season and where there are no more than about 110 artificial water points to be replaced by leak-free tanks and raised troughs [150]. For a modest \$4.5 million over 50 years (for infrastructure establishment and maintenance), this ‘Pilbara line’ would reduce the probability of cane toads reaching the Pilbara by more than 95% [150]. The proposal would become much more expensive if, as has been proposed by the Western Australian Government, irrigated fodder cropping is further developed in the proposed barrier area.

As the invasion front nears the Pilbara line, the prospects of success could be enhanced by introducing cane toads from long-established populations. These toads are much slower travellers (so less likely to cross the barrier), but more sexually competitive than those on the invasion front (so will outbreed the fast-moving toads) [291].

Farmers would benefit from the project – the proposed infrastructure, installed at no cost to them, would reduce water evaporation and protect dung beetles (eaten by cane toads), which remove cattle faeces and thus limit parasite transmission between cattle [292].

The Karajarri and Nyangumarta Traditional Owner groups have identified toads as a threat to their country (in the barrier area) and are already engaged in collaborative planning with other landholders and experts to implement the ‘Pilbara line’, on the assumption that government support for the initiative will be forthcoming [293,294].

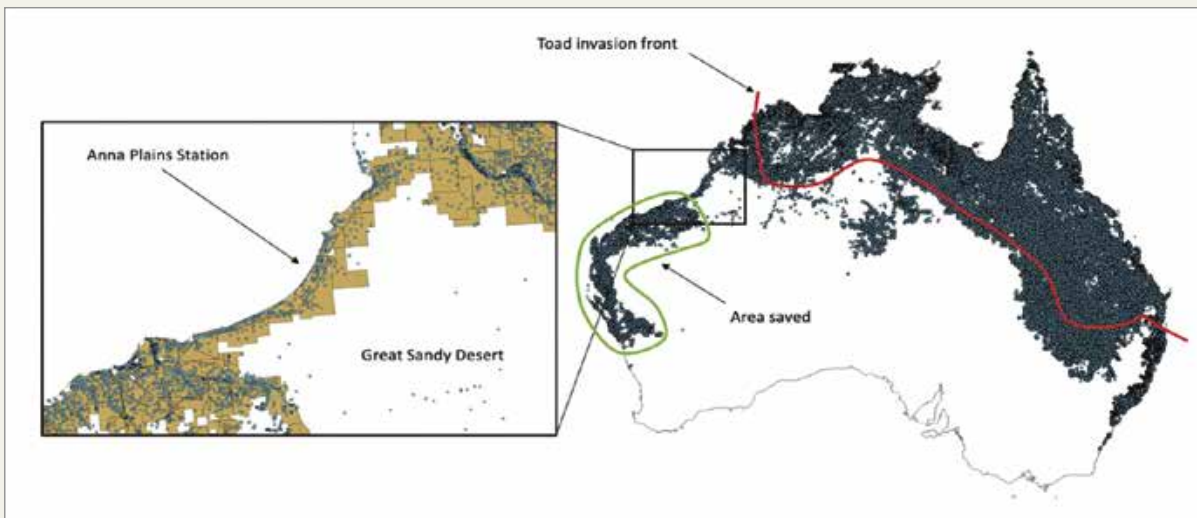


Figure 3-4. Cane toads could potentially be prevented from reaching the Pilbara by creating a waterless barrier in the narrow coastal strip west of the Great Sandy Desert.

Source: Ben Philips, University of Melbourne.



Image: Crystal Kelehear

3.2.2 INTRODUCED HERBIVORES

Degradation caused by increased fire frequencies, buffel grass and/or over-grazing is overt throughout the region.

Leslie Gibson and Norm McKenzie, Department of Environment and Conservation (2009) [146]

One of the striking differences of Australia – a sign of its distinctive evolutionary history in isolation from the rest of the world – is a complete lack of native hoofed mammals (ungulates) [295]. But one of the striking consequences of European colonisation has been that Australia now hosts a far greater weight of ungulates (of 15 different species) than all our native mammals combined [296,297]. This would be true for the Pilbara, with its 260,000 cattle as well as many thousands of horses, donkeys, camels, pigs and goats [69]. The Pilbara also has (non-hoofed) rabbits.

The Western Australian Government sums up the impacts of introduced herbivores in the Pilbara in this way [69]:

They can compact soil, cause erosion, spread weeds, and trample and graze vegetation, leading to reduced habitat and food resources for native animals and exposing them to increased risk of predation. Trampling and high livestock numbers may lead to eutrophication, erosion and sedimentation of wetlands, rivers and streams and their fringing vegetation.

Ongoing degradation at levels equivalent to other arid pastoral regions of Australia is likely in the Pilbara [23], but there have been only a few published observations, rather than systematic studies. Introduced herbivores, domestic or feral, are recorded as a threat to 19 of the 31 threatened and priority ecological communities in the Pilbara, many of which are tussock grassland or chenopod shrubland communities.

Detrimental impacts of stock grazing in the Pilbara are evident mainly in the most productive lowland areas – with the loss or degradation of tussock grasslands and chenopod shrublands in the Fortescue and De Grey valleys and on the coastal plains [175] – and in wetland and riparian habitats [23,209]. In the upper Fortescue Valley, for example, bardi bush (*Acacia synchronicia*) has formed impenetrable spiny thickets over flood-out zones where all palatable plants have been lost due to intensive grazing and livestock activity around water sources [23]. Invasive grasses, particularly buffel grass, have replaced native grasses on most alluvial flats [219], degrading and increasing the flammability of these habitats (section 3.2.3).

Riparian and wetland habitats are particularly sensitive to the impacts of large, hoofed animals. Despite clear government guidelines that recommend preventing

direct stock access to watercourses [298], the watering of stock at rivers and creeks is mostly uncontrolled – resulting in bank erosion, trampled riparian vegetation and water siltation [299]. Severe degradation has been recorded at some wetlands in the Fortescue Valley, ‘probably reflecting their use by stock for water, fodder and shade after other wetlands dry’ [91]. Particularly in the late dry season, many waterbodies become eutrophic from accumulated faeces [23,299].

Government reports on pastoral land condition have warned for many years that livestock levels in the Pilbara are too high [232]. A 2019 assessment found that cattle numbers, which had increased by 46% over the prior 20 years, exceeded the estimated ‘potential carrying capacity’ in all districts [232]. In 2019, the De Grey and East Pilbara districts were assessed as having a ‘very high risk of vegetation condition decline’ and the other 2 districts as having a ‘moderate risk’. Vegetation cover in the 3 most productive pasture types – river plains with tussock grass, alluvial plains with tussock grass, and alluvial plains with tussock grass and shrubs – had decreased despite a long period of above-average seasons, and almost two-thirds was at high (56%) or very high (7%) risk of condition decline [232].

A 2012 viability assessment had found that the stocking intensity differed for different types of leaseholders, with corporate/aggregation properties responsible for most of the overstocking. Indigenous-managed properties were stocked below their ‘present carrying capacity’ (averaging about 80%), owner-manager properties averaged about 20% above present carrying capacity and corporate/aggregation properties averaged 75% above [300].



Feral horses (shown here on Wheelarra Hill Station) can degrade wetlands and riverbanks, add grazing pressure and cause erosion. Image: Greg Harold/AUSCAPE

Box 3-4. Introduced herbivores of the Pilbara

Cattle make up the greatest mammal biomass in the Pilbara, with about 260,000 domestic animals [232] and an unknown number of stray or feral cattle, including in national parks [301]. Impacts include declines in the most palatable grasses and damage to riparian habitats, waterholes and springs.

Feral donkeys are found on most pastoral leases [23]. They were imported to transport goods from Carnarvon to the Kimberley and then liberated when motorised transport arrived in the early 1900s [302]. They mainly inhabit 'breakaway' country, especially the 'pea bush' flats, and also wattle shrublands [303]. Overgrazing by donkeys causes degradation, and they erode and foul wetlands and waterholes [303]. Shooting is regularly undertaken by pastoralists, the Pilbara Regional Biosecurity Group and state government agencies [304,305].

Feral camels are widespread, but most common in parts of the eastern Pilbara [23]. They severely damage trees and shrubs and eat out highly preferred foods such as quandong trees. They degrade wetland habitats and can drink all the water in small waterholes or soaks or foul them. Aboriginal landholders have concerns about the impacts of camels on wetlands, competition with the likes of red kangaroos, emus and bustards for grass and water, and damage to culturally significant sites, plants of cultural value and infrastructure [306,307]. Camels are controlled by aerial and ground shooting [308]. Due to cultural sensitivities, camel culling requires close collaboration with Traditional Owners [309].

Feral horses are found on most pastoral leases in low numbers [23,304].

Feral pigs occur along the De Grey River, from Warrawagine Station to the coast [304]. They damage riparian habitats and native pastures and increase soil erosion [107,304].

Rabbits are found on the alluvial flats of the Fortescue Marsh, mainly in clayey soils [3,94].

Feral goats are present on some Pilbara leases but their numbers are kept under control where there are dingoes or feral dogs [97].



With no natural predators in Australia, feral camels have become a major threat in the arid zone. Land managers across all sectors are strongly aligned about the need to manage feral camels. Image: Tourism Western Australia

3.2.3 INTRODUCED PLANTS

Weeds bide their time – in the 7 decades it took foxes and cats to conquer tens of millions of hectares, a plant with similar invasive tendencies may spread no more than a few thousand hectares. One consequence of this, both encouraging and dispiriting, is that most weeds in the Pilbara are in the early stages of invasion and have the potential to get much worse. This offers opportunities for containment or eradication, but the often-slow realisation of weed threats makes it harder to motivate serious control programs.

About 180 weed species have been recorded in the Pilbara – almost 1 in 20 of the total flora [310]. Although this is low compared to many other Australian regions, weed numbers are increasing: 19 new species were reported between 2004 and 2010 [311].

The Western Australian Government has rated the ecological impacts of 29 weeds in the Pilbara as ‘high’ (Table 3-3, see examples in Box 3-5) and the impacts of another 28 as ‘unknown’ [312]. At least 14 species have landscape-scale impacts by altering fire patterns,

modifying soil characteristics or competing directly with native species, and more than 20 weeds significantly affect particular habitats [311]. The Pilbara Conservation Action Plan rated weeds as one of two ‘very high’ threats in the Pilbara [313].

Some weeds were introduced accidentally – ruby dock, kapok bush, buffel grass and feathertop Rhodes grass came via camel harnesses or saddle packs – but most, including mesquite and parkinsonia, were introduced deliberately for ornamental or pastoral purposes [314]. Future risks may come from diversification into crops – for example, the planting of exotic pasture grasses and biofuel crops (such as giant reed) [311]. The Environmental Protection Authority has said, ‘Every effort needs to be made to prevent the spread of pasture species as a result of new pastoral diversification initiatives’ [97].

Table 3-3. Weeds in the Pilbara rated as having a high ecological impact

| Common name | Scientific name | Common name | Scientific name |
|-------------------------|--|-------------------------|--|
| Ruby dock | <i>Acetosa vesicaria</i> | | <i>Merremia dissecta</i> |
| Kapok bush | <i>Aerva javanica</i> | Balsam apple | <i>Momordica balsamina</i> |
| Century plant | <i>Agave americana</i> var. <i>americana</i> | Giant waterlily | <i>Nymphaea macrosperma (gigantea)</i> |
| Giant reed | <i>Arundo donax</i> | Common prickly pear | <i>Opuntia stricta</i> |
| Prickly turnip | <i>Brassica tournefortii</i> | Parkinsonia | <i>Parkinsonia aculeata</i> |
| Buffel grass | <i>Cenchrus ciliaris</i> | Stinking passion flower | <i>Passiflora foetida</i> |
| Birdwood grass | <i>Cenchrus setiger</i> | Date palm | <i>Phoenix dactylifera</i> |
| Water fern | <i>Ceratopteris thalictroides</i> | Lippia | <i>Phyla nodiflora</i> |
| Purpletop chloris | <i>Chloris barbata</i> | Mesquite | <i>Prosopis</i> spp |
| Feathertop rhodes grass | <i>Chloris virgata</i> | Whorled pigeon grass | <i>Setaria verticillata</i> |
| Boxing glove | <i>Cylindropuntia fulgida</i> | Stylo | <i>Stylosanthes</i> spp |
| Couch | <i>Cynodon dactylon</i> | Athel pine | <i>Tamarix aphylla</i> |
| Awnless barnyard grass | <i>Echinochloa colona</i> | Mimosa bush | <i>Vachellia farnesiana</i> |
| African love grass | <i>Eragrostis curvula</i> | Cotton palm | <i>Washingtonia filifera</i> |
| Spiked malvastrum | <i>Malvastrum americanum</i> | | |

Source: Western Australian Parks and Wildlife Service 2016 [312]



Stinking passionflower (Passiflora foetida) – a vine native to South and Central America – is a major smothering weed of the Pilbara and Kimberley that is now the focus of a concerted research and control program. A search is under way for potential biological control agents. The weed is being controlled on Murujuga, shown here, through a collaboration by Murujuga rangers, CSIRO, Woodside, local industry and the Pilbara Ports Authority. Image: Bruce Webber, CSIRO



Invasive athel pine (Tamarix aphylla), found along the Gascoyne River, can form dense stands along rivers, altering water flow patterns, causing overland flooding and bank erosion, and reducing the number and quality of waterholes. Image: © State of Western Australia (Department of Primary Industries and Regional Development, WA)

Box 3-5. Examples of harmful weeds in the Pilbara

Buffel grass (*Cenchrus ciliaris*) came to Australia in the 1870s with Afghan cameleers as stuffing for camel harnesses and saddlepacks [315]. It was later deliberately introduced to increase pasture production. Buffel is considered a desirable pasture grass – with higher protein, phosphorus and digestibility than many native grasses – and is preferentially grazed by cattle when it is green and growing [315]. But once buffel matures and sets seed, it can quickly become rank and its feed value falls below that needed for stock maintenance. Cattle may then ‘demonstrate an acute appetite’ for other grasses, which can lead to local extinction of palatable native grasses [316].

Buffel invasion of the Pilbara has been facilitated by the overgrazing and depletion of native grasses, massive flood events and drought [317]. It is now widespread, particularly on the coastal plains and floodplains of major rivers [209]. It was recorded at almost half the 98 riparian sites surveyed in 2004–2006 [299]. There are no published studies of the specific impacts of buffel grass in the Pilbara. Elsewhere, it is known to reduce the richness of plants [318] and ants [319] and adversely affect some wildlife [320]. One harmful consequence is an increased fire risk. Buffel grass produces large volumes of standing dead matter and forms a relatively continuous ground layer that burns hotter and more frequently than native grasses do [315]. It regenerates more quickly on ash beds than many native species, creating a positive feedback loop that favours buffel regeneration [321,322].

Mesquite (*Prosopis species*) was introduced to the Pilbara in the 1930s to serve as drought fodder, shade for livestock and a garden tree [323]. About 300,000 hectares of the Pilbara is infested, including 9 pastoral stations and unallocated crown lands [324]. The largest infestation in Australia, 150,000 hectares on Mardie Station, is a highly robust ‘hybrid swarm’ of 3 mesquite species [317,325]. Climate modelling indicates that mesquite could invade the entire Pilbara region [325]. The areas most at risk are floodplains. Mesquite is an aggressive weed that forms dense thorny thickets [326]. It shades out native plants, degrades wildlife habitats, alters soil properties and competes for water. It reduces the carrying capacity of pastoral properties.



Image: © State of Western Australia (Department of Primary Industries and Regional Development, WA)



Image: © State of Western Australia (Department of Primary Industries and Regional Development, WA)

Box 3-5. Examples of harmful weeds in the Pilbara

Opuntoid cactuses (*Austrocylindropuntia*, *Cylindropuntia* and *Opuntia* species) were designated Australian 'weeds of national significance' in 2012 [328]. There are scattered infestations in the Pilbara of 4 species – coral cactus (*Cylindropuntia fulgida*), devil's rope (*C. imbricata*), riverina pear (*Opuntia elata*) and prickly pear (*O. stricta*) [328] – which are likely to cause major environmental damage unless their spread is checked. The notorious prickly pear infestation of eastern Australia in the early 1900s serves as a warning of the potentially devastating consequences of cacti invasions. At its peak, before the introduction of effective biocontrol agents, it covered 24 million hectares of southern Queensland and northern New South Wales, so dense across about half that area that farming was abandoned [329]. Cacti are extremely tough and versatile plants – tolerant to drought and heat, armed with spines, and able to reproduce vegetatively from detached pieces of stem, flowers and fruits, and in some cases by seed [328]. They are spread by floods, vehicles, birds and other animals and humans (cultivation or dumping), and are very difficult to control. They are an extreme environmental and agricultural threat – likely to cause loss of biodiversity and habitat change by competing with and replacing native vegetation, and injuring and killing native animals [328].



Coral boxing glove cactus (*Cylindropuntia fulgida* var. *mamillara*). Image: © State of Western Australia (Department of Primary Industries and Regional Development, WA)

Parkinsonia (*Parkinsonia aculeata*), introduced as an ornamental and shade tree, grows along major rivers in the Pilbara, including the Fortescue, Maitland, Harding, De Grey and Robe, and in Millstream National Park [327]. It has invaded about 800 hectares bordering 785 km of rivers [324]. It creates dense, thorny, impenetrable thickets, particularly on the Fortescue and De Grey rivers, preventing the growth of herbaceous ground cover, probably reducing the duration that ephemeral water bodies hold water and altering fire regimes [327]. This weed is a major hazard for the Pilbara's wetlands and gorges.



Image: © State of Western Australia (Department of Primary Industries and Regional Development, WA)

3.2.4 ADVERSE FIRE REGIMES

When large areas of a single landscape type are subjected to large uniform disturbances, they threaten the survival of wildlife species which depend on irregular boundaries of natural fire patterns to provide a fine-grained mosaic of resources.

Earl Saxon (1984) cited in [330]

Most of the Pilbara is highly flammable. Spinifex hummocks – well-aerated clumps of dead and dry, often resinous, thin blades – are an ‘almost perfect’ fuel [331,332], and their biomass is much higher than other native grasses [333]. When under management by Traditional Owners prior to colonisation, much of the Pilbara would have been subject to small cool-season fires, resulting in a mosaic of different-age patches [222,313,332]. Now, large, intense, lightning-ignited, hot-season fires are more typical, producing large-scale ‘pyric uniformity’ [331]. In the 14 years from 1993 to 2006, almost three-quarters of the region burned, and more than a quarter burned 2 or more times [23]. Although the impacts of modern fire regimes in the Pilbara have not been well studied, they are a known threat to fire-sensitive plants and ecological communities and probably also to the bilby, northern quoll and several other threatened species.

Mulga and related wattles are mostly killed by fire, and when fires are too frequent to allow regeneration, mulga woodlands turn into spinifex grassland [334]. This has been occurring in the central Hamersley Range where spinifex is prominent in the understory of mulga woodlands [23,335]. Both mulga and spinifex regenerate from seed, but spinifex matures much more quickly and can burn again before mulga reproduces [334]. Studies in other bioregions show that mulga typically needs at least 26 years to recover after fire and replenish the soil seed bank [334]. Mistletoes are also killed by fire and are now rare in the Roebourne and Chichester subregions, where spinifex grasslands dominate [336]. This has ecological consequences, for mistletoes are important foods for insects and birds. Fortunately, fire-sheltered habitats are widespread in the Fortescue and Hamersley subregions, and have become

mistletoe strongholds [336]. Other fire-sensitive plants are cypresses, figs and snakewood [337]. Altered fire regimes is recorded as a threat for 11 of the 31 listed threatened and priority ecological communities in the Pilbara.

The replacement of traditional burning regimes across much of arid Australia with hotter, larger and more frequent fires is thought to have contributed to the decline of many small to medium-sized mammals, by reducing food availability and increasing predator risks [158,338]. The impacts of fire in the Pilbara on bilbies and quolls are the focus of current research [152,158]

Bilbies may favour recently burnt areas because fire promotes important foods such as *Solanum* species and the annual grass *Yakirra australiensis*, but they are more vulnerable to predators when cover is sparse [158]. Cats are drawn to recently burned areas for the greater ease of hunting [164].

Frequent fires are likely to have diminished northern quolls’ use of savannah and grassland habitats by exacerbating predation risks. In the Pilbara quolls mostly inhabit complex rocky areas that provide dens and greater safety from predators and fire [152]. Male quolls are likely to be most vulnerable to increased predation risks when they travel during the breeding season [155].

The threat of large-scale fires in the Pilbara has been exacerbated by the invasion of flammable grasses, particularly buffel grass, which has invaded the more-productive non-spinifex habitats (section 3.2.3). In a mutually reinforcing ‘fire-weed cycle’, fire can foster buffel invasion, thus promoting yet more fire, resulting in higher fire frequencies and loss of biodiversity [321].

The environmental, cultural, social and economic benefits of reintroducing Indigenous fire management to the landscapes of northern and central Australia are now well understood [339–341]. The Ten Deserts Project is developing tools to strengthen the capacity of Indigenous land management agencies and ranger groups to undertake effective ‘right way’ fire management, including in the Pilbara [342].



Image: Shutterstock

3.2.5 MINING IMPACTS ON HABITATS AND WATER

All our river systems should be looked after, our water should be respected and treated as the most sacred and precious resource. ... Mining companies treat all their mines as theirs for all the wealth; for traditional owners it is our homes, our heritage, our spirit and our souls. It is our essence of being.

Marnmu Smyth, Pilbara Elder [343]

Open-cut mining is necessarily highly destructive at a local scale and can also cause larger-scale damage due to changes to groundwater and surface water flows and quality, the disposal of tailings and waste, release of contaminants, weed spread, air pollution and greenhouse gas emissions. We focus here only on habitat and water impacts.

Habitat destruction

More land clearing occurs in the Pilbara than in any other Western Australian bioregion [344], the majority for mining (production, exploration and associated infrastructure). From 1997 to 2013, approved clearing averaged more than 14,000 hectares a year [97]. During the decade to 2020, approved clearing exceeded 50,000 hectares [344], and there are applications (current at 16 July 2021) for clearing an additional 29,000 hectares. The publicly accessible information about approved clearing is not comprehensive, and there is no information about the extent actually cleared.

Much of the mining, and thus the clearing, occurs on unique landforms such as banded ironstone ridges, which are often areas of high biodiversity value with specialised species [345]. Clearing also occurs for mining exploration – to provide access for drill rigs and sites for drilling. The holder of an exploration licence ‘may extract or disturb up to 1,000 tonnes of material from the ground’, or more if approved [346]. Other clearing occurs for the transportation of minerals – ports, harbours, roads, railways and dredge spoil disposal – particularly in coastal areas, which has resulted in the degradation of internationally significant geoheritage values [101]. Underground habitats for troglofauna and stygofauna have also been destroyed, although the extent is not documented.

Western Australia’s Environmental Protection Authority has warned that the cumulative environmental impacts of clearing in the Pilbara are not well understood [97].

There is an expectation, usually written into project conditions, that surface habitats will be rehabilitated or restored (a higher standard than rehabilitation [345]) during and after mining. In most cases in the Pilbara this does not include backfilling of void pits. Instead, the walls are stabilised and an ‘abandonment’ bund wall is placed around them [347,348]. Once a stable, non-polluting landform has been achieved, there is typically a poor

outcome from attempts to re-establish ‘a functionally appropriate, ecologically resilient and biodiverse native vegetation indicative of a native reference site’ [345].

The Environmental Protection Authority has found that most post-mining rehabilitation in the Pilbara is poor, achieving on average only about 15% of the pre-mining biodiversity [97]. This was the case even for common mulga and spinifex communities, ‘raising the prospect of significant residual impacts’. Rehabilitation can be difficult due to the complex germination requirements of most Pilbara plants, and a high failure rate in seasonally dry environments (typically more than 90%) [349]. It is much more difficult to restore specialist species, says the Centre for Mine Site Restoration, for the post-mining environment [345]:

can represent an exceptionally unfamiliar and challenging substrate, and the time scales required for natural weathering processes to mitigate problem factors such as nutrient stoichiometry and soil pH (hundreds to tens of thousands of years) are at odds with the typical 5–7 year regulatory mine closure expectations.

Changes to water flows and quality

The mining industry accounts for some 90% of water use in the Pilbara [97,350]. In 2014, water entitlements in the Pilbara totalled 565 gegalitres [351]. About half of it was for discharged mine ‘dewater’ – water that is pumped from a mining pit when it is excavated below the watertable. About half of this is used (for mining, drinking water and agriculture); the rest is mostly injected into aquifers and some is discharged to rivers and creeks [351].

The drawdown of a watertable caused by dewatering can exceed 100 metres and the dewatering cone can extend up to several kilometres around the mine [352]. Dewatering can destroy the habitat of stygofauna, dry up springs and perennial pools, and eliminate groundwater-dependent ecological communities, which are rare in the Pilbara (covering less than 0.5% of the region) [353]. Many stygofauna species have narrow distributions, and it has been estimated that about half the species known only from the vicinity of a mine could be threatened, or at least their populations could be substantially reduced, where dewatering drawdown extends over a radius of 10 kilometres or more [96]. Mine dewatering has caused springs to dry up – Minthi Springs (in Karijini National Park) [301] and Weeli Wollie Spring in the Fortescue River Basin (Box 3-6). Both have important cultural heritage and environmental values. Water is now being piped to each location to sustain the dependent vegetation communities.

The disposal of dewater can also cause problems. Adding water to rivers and creeks can change their ecology and destabilise and erode banks by changing their flow regime from seasonally intermittent to permanent [97]. The use of dewater for human purposes such as intensive agriculture brings other pressures (see section 3.2.6).

When mine dewatering ceases, water levels around the mine pit will rise, but unless the pit is backfilled, it may continue to be a groundwater sink, because the loss of water by evaporation in the Pilbara is greater than the gain through rainfall [354]. The closure plan for the Hope Downs mine proposes backfilling and the restoration of spring flow within 20 years after dewatering ceases [355]. Modelling suggests that it may not be possible to fully recover pre-mining groundwater levels even within 100 years [354].

Most pits are not backfilled, so when mining ceases they fill with groundwater and become lakes. In 2014, there were an estimated 97 pit lakes in the Pilbara, another

178 were proposed, and 670 open pits may become pit lakes in the future [97]. These lakes are typically deep, lack riparian vegetation, and often have poor water quality – often saline, alkaline or acidic, with very low levels of organic carbon, nutrients and primary production, and contaminated with metals [356,357].

Assessing the likely impacts of pit lakes is difficult – water levels may take hundreds of years to stabilise and changes in water quality may occur over thousands of years [97]. Poor water quality can threaten wildlife and limit options for post-mining use [358]. Contaminated plumes from saline or acidic pit lakes (and tailings storages) can extend for kilometres, degrading groundwater and surface environments [358,359]. The Environmental Protection Authority recommended the preparation of a comprehensive inventory of current and potential mine pit lakes and a collaborative research program to improve understanding of their impacts [97].

Box 3-6. Traditional Owners, mining and water

Traditional Owners have long raised concerns about water management and industry water use in the Pilbara [80]. These concerns stem from their profound cultural connections to waterways, established through creation stories, traditional ecological knowledge, resource use, and life histories tied to river country. A CSIRO study (funded by Rio Tinto) found that the 'drying of the country and/or the impact of water extractions for mine operations and towns' was the 'paramount' water issue raised by Traditional Owners [80].

The CSIRO report explained some of the tensions (and also complementarities) between Indigenous perspectives on water and mining companies applying a scientific framework [80]. The scientific perspective may 'not use, or consider valid' the explanations by Indigenous elders for changes in the landscape – such as those that 'rely on the existence of creative beings such as the snake Barrimirndi' [80]. This can lead to 'a rejection of the significance or the credibility' of Indigenous observations and derogate their 'depth of attachment and sense of responsibility'. Yet, Indigenous observations, typically based 'on a deep knowledge of an area', can be 'robust indicators' of environmental change and may have important management implications. Even if the interpretations of change differ, the management actions suggested by Traditional Owners can be consistent with scientific approaches. But other actions may also be required 'to reduce the risks to a place or feature within an Indigenous management framework' [80].

The CSIRO report noted several barriers impeding consultation and negotiations with Traditional Owners, including confidentiality agreements and lack of Indigenous access to communications and transport [80]. In observing a need for corporate leadership, the report foreshadowed issues that have come under close scrutiny following the Juukan Gorge disaster [80]:

However, although Indigenous people may be made superficially aware of multiple and often competing developments, they are rarely given detailed information about the potential impacts, rarely possess the necessary training and information to fully assess and evaluate cumulative impacts, and are almost never in the position of being able to effect significant changes to a development proposal based on concerns about impacts.

Weeli Wolli

This whole area here is what makes us who we are in regards to our identity... this magnificent, beautiful country... This water here, running here now, it's not natural... it's water that's been pumped from the mine site up there... When we have water running like this all year round, whereas its natural water only runs for about 3 months...

Slim Parker, Banjima Elder (2008) [86]

The Weeli Wolli catchment is rich in iron ore. Five mines are operating, and several others are being developed or assessed [355,361]. Mining has fundamentally altered the regional hydrology due to dewatering and the discharge of excess dewater into Weeli Wolli Creek.

The impacts of mining on the creek and springs have been of great concern to the Banjima and Nyiyaparli Traditional Owners, for these sites have immense cultural significance [80, 360]. They also have high ecological values, including a unique ecological community sustained by the spring and permanent pools. The spring community is listed as a Priority 1 ecological community.

Dewatering at the closest mine, Hope Downs-1, has resulted in a groundwater drawdown of up to 130 metres and a cone of depression extending to about 6 kilometres [362]. Natural spring flow has ceased and the groundwater-dependent vegetation now relies on the discharge of mining dewater. [363]. The closure plans for Hope Downs predict that spring flow can be restored within 20 years of decommissioning. But there are many uncertainties about the future of the spring and creek, due to the potential cumulative impacts of expanded mining operations [355].

Since 2007, the creek has been receiving large volumes of dewater from the Hope Downs mine. The once-ephemeral stream now has continuous flows for about 24 km and once-transient pools in this stretch are now permanent [363]. Changes have included declines in the health of river red gum, coolibah and silver cadjeput trees [361]. There may also have been changes in fish body shape. Western rainbowfish in this part of the creek tend to have more slender bodies than those in the upper catchment, perhaps due to faster-flowing water [364]. Researchers say that the 'importance of no or low (surface) flow periods in ephemeral streams to overall stream functioning ... is largely unknown' [363].

While Weeli Wolli Creek is being managed to mitigate the environmental impact of industry – and effectively so in the judgement of the Environmental Protection Authority [355] – for Traditional Owners, the changes have significantly diminished its cultural values and utility, and are an ongoing source of distress and concern [80,86].



Iron ore mining requires the creation of huge waste dumps (shown below at Mount Tom Price Mine) and the disposal of large volumes of water when mining drops below the watertable. Water from Hope Downs Mine is discharged into Weeli Wolli Creek (top left, photographed in about 2003). And after mining ends, unless the mining pit is filled in, it becomes a pit lake (top right, at Woodie Woodie). There are about 100 pit lakes in the Pilbara, with the potential for hundreds more. Images: Josef Furulyas Snr (top left), Krystle Wright (top right & bottom)



3.2.6 IRRIGATED AGRICULTURE

There is a strong push across northern Australia to develop irrigated crops of cotton, horticulture and fodder. The rising affluence of Asia has fostered concepts of the North as an 'export hub' of food and other commodities, based 'on the perception of vast and available land and water resources' [365]. CSIRO researchers have calculated that 1.34 million hectares of suitable land could be irrigated with water from about 85 large dams and other sources [366]. While small-scale irrigation projects (for horticulture and fodder, for example) can be implemented with limited environmental impacts, most large-scale storage and irrigation schemes in Australia and elsewhere have resulted in serious-to-devastating impacts on environmental and cultural values, and often economic failure as well [367,368]. Freshwater and estuarine ecosystems are among the most threatened in the world.

The prospect of irrigated agriculture is enticing to some in the Pilbara. There have been visions, for example, of growing high-density biofuel crops. In 2014, a biofuel company, ENEnergy, established by senior oil industry executives, announced it was seeking \$20 million investment in a plan to grow 10,000 hectares of giant reed (a highly invasive weed) or sorghum on 'barren land' in the West Canning Basin just north of the Pilbara bioregion [369]. By 2017 there were about 2,500 irrigated hectares in the Pilbara at 7 sites, mainly growing fodder for cattle – some using mine dewater and others using groundwater [370]. A recent proposal, to construct 10 weirs on the Ashburton River to support irrigated fodder production on Minderoo Station, was opposed by the Thalanyji native title holders and rejected under state Aboriginal heritage laws [371]. The entire Ashburton River is a registered heritage site.

Traditional Owners draw no distinction between 'the land and the waters that flow over, rest upon or flow beneath it' [372]. All require 'care and nurturing'. The degradation of springs, wetlands and rivers and the damage to cultural heritage sites in the Pilbara causes great distress to Traditional Owners (Box 3-6).

In 2014, the Western Australian Government commissioned a \$12.5 million investigation into the potential for irrigated agriculture in the Pilbara (as part of a \$44 million project across several regions) starting with the question of what soil and water resources are

available [370,373]. This Pilbara Hinterland Agricultural Development Initiative identified over 2 million hectares of 'class A1 land' in the following locations [370]:

- at the headwaters and along the slopes next to the Fortescue River valleys
- on slopes and plains next to the mid and lower reaches of the Ashburton River
- at the coastal margin of the western and northern lower slopes of ranges
- surrounding the alluvial floodplains of the major river systems, such as the De Grey and Shaw between Port Hedland and Marble Bar, and the Robe and Ashburton between Onslow and the Northern Coastal highway
- on the sandplain areas of the Great Sandy desert in the north-east
- on the south-western plains near Yannerie River.

It then identified 100–120 gigalitres of potential supply across 10 sites that could be used to irrigate 5,000 to 12,000 hectares [370]. However, these are only 'prospective locations' that could be 'further investigated for their potential to support irrigated agriculture'. The water available from aquifers could be supplemented by mine dewater and there are additional opportunities for smaller developments (those using less than 5 gigalitres a year).

Economic assessments indicated potential markets in Asia and the Middle East for high-value irrigated crops such as cassava, sesame seeds, soybeans and sorghum, but considered that biofuels are unlikely to be viable. Irrigated fodder production could improve cattle productivity and generate carbon credits. At low development costs, lucerne hay, Rhodes grass hay, cotton, peanuts, sweet potato and canning tomatoes are 'prospective' [370].

There do not appear to have been any studies of the environmental or cultural risks of expanding irrigated agriculture in the Pilbara, although the government assessment warns that there are environmental and heritage hurdles in a complex approvals process.

The generic risks with irrigated agriculture include those arising from water extraction and changed flow regimes, habitat destruction and contaminated runoff (by nutrients and pesticides) [374]. One risk already generating concern is the introduction of new weeds. The Hamersley Agricultural Project, using dewater from Marandoo Mine, has resulted in plantings of Rhodes grass (for stock feed), an exotic species with high invasive potential. Although there are conditions attached to the project intended to prevent spread, the Conservation and Parks Commission is concerned that chance events such as severe wind and floods and transport of the cropped grass will lead to invasion of Karijini National Park [301].



The occasional vivid green circles in the Pilbara are evidence of an emerging new irrigated cropping industry that could have significant environmental impacts if it becomes large-scale. Traditional Owners have expressed concerns about the cumulative impacts of industrial scale water extraction on cultural flows and on important sites such as this permanent pool in the Oakover River (bottom). Images: Shutterstock (top) Krystle Wright (middle & bottom)





4. Conservation activities and gaps in the Pilbara

Despite the outstanding biodiversity values of the Pilbara and the extreme wealth generated there, the conservation focus in the region has been limited – constrained by the dominance of mining and pastoralism on the landscape, economy and government priorities. Most conservation work has been short-term, resulting from mining offsets or grants for individual projects. Although there are conservation plans and strategies, the people and funding to implement them have been wanting. This in turn has reinforced the widespread view of the Pilbara as primarily a mining province – and its neglect, by governments and conservationists alike, as a biodiversity hotspot.

As elsewhere, conservation in the Pilbara relies on the following elements (not necessarily in this order of priority):

- an understanding of biodiversity values, threats and trends, supported by comprehensive monitoring and reporting
- an effectively managed, comprehensive, adequate and representative conservation reserve system
- costed plans and strategies identifying conservation priorities and pathways for implementation
- long-term programs for threat abatement, recovery of threatened biodiversity, and restoration of degraded areas
- a motivated conservation workforce and sustainable funding
- community and stakeholder support.

Here, we briefly examine conservation activities in the Pilbara and the extent to which these listed elements are in place. One important element not mentioned here, because it is not a focus of this report, is an effective environmental regulatory and compliance system.

4.1 Knowledge of biodiversity

Recent and ongoing development in the Pilbara has not been matched by a commensurate growth in knowledge and understanding of the Pilbara's natural environment.

Environmental Protection Authority (2014) [97]

4.1.1 SCIENTIFIC KNOWLEDGE

Knowledge of biodiversity in the Pilbara remains poor, despite a surge of species discoveries driven by the rapid expansion of mining and mandated assessments of project impacts over the past 20 years (see Figure 4-1). The first comprehensive survey of the region, the Pilbara Biological Survey from 2002 to 2007, resulted in the discovery of hundreds of new species, including about 300 subterranean animals, 8 plants, several reptiles and the majority of hundreds of collected beetles, scorpions and spiders [23,201,202,205,375].

One of the most momentous Pilbara discoveries in recent times has been the hundreds of crustaceans, arachnids and other invertebrate species living underground in fissures and groundwater – possibly the most diverse troglofaunal and stygofaunal communities in the world [44,96,120] (section 2.3.1). Although the lives and ecology of these animals remain mysterious, they have fostered a new appreciation of the surface-to-below-ground connections in the Pilbara and the refugial qualities of its old bedrock.

The pace of species discoveries in the Pilbara remains high, mainly due to surveys for new mining projects and taxonomic research revealing much cryptic diversity (different species that look alike), particularly in reptiles and spiders [73,203,376]. Many Pilbara species are yet to be described, including 40 threatened and priority plant species (22% of the total, Table 2-7) and thousands of invertebrate specimens stored in museums (section 2.3.6). When new species are discovered during mining assessment processes, there is often little time to assess their taxonomic status or conservation significance before approvals are granted [97].

Opposite: From afar, much of the Pilbara looks wild and untouched. But one of the profound conservation lessons of the past few decades is that 'country needs people' – in particular to manage fire and invasive species and to maintain its cultural values. This is the south-western side of the Hamersley Range. Image: Jean-Paul Ferrero

Recording and naming species is only the first step, and even for iconic species in the Pilbara, the scientific understanding of their ecology and threats is rudimentary. For example, 25 'key research questions' (published in 2016) about northern quolls in the Pilbara include basic questions about how they use habitat and are impacted by fire, predators and grazing [155]. One major gap, identified as a funding priority for the Pilbara Environmental Offsets Fund, is the lack of a detailed vegetation map showing the distribution of different vegetation types [377].

Most recent ecological research in the Pilbara has focused on northern quolls and bilbies, funded as mining offsets [152,161]. Other current projects include a genetic assessment of ghost bats and Pilbara leaf-nosed bats and identification of dispersal corridors and evolutionary refugia for Pilbara mammals [378]. The Environmental Protection Authority has warned that the 'individual and cumulative environmental impacts of development over the last 50 years, combined with future proposed mining, are not well understood' [97].



Managing northern quolls is one focus of Indigenous ranger groups in the Pilbara. Image: Noel Dodd

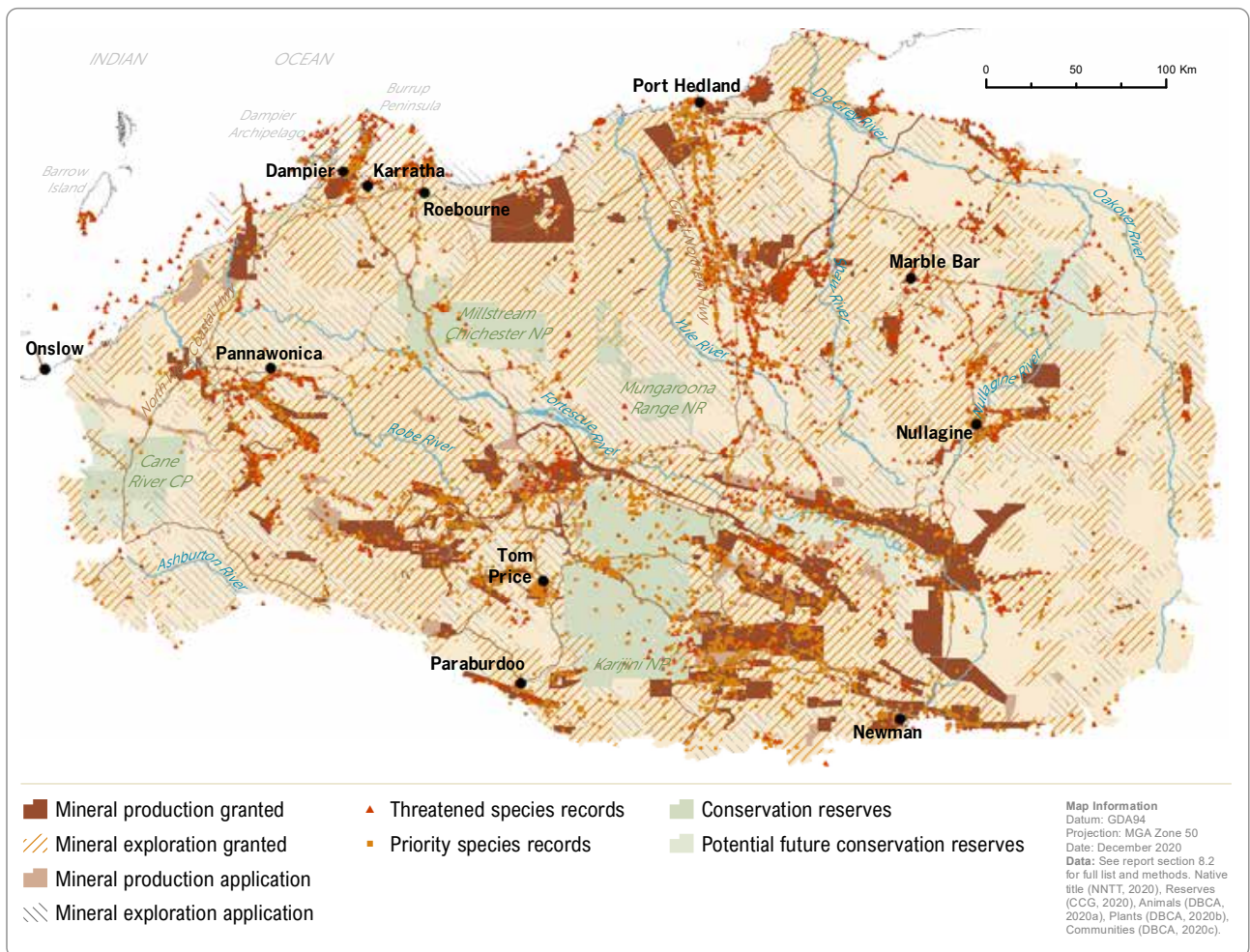


Figure 4-1. The known distribution of threatened and priority plants and animals in the Pilbara overlaid with mining tenements

Note: The alignment of most records of threatened and priority species in the Pilbara demonstrates the survey bias arising from the requirement for environmental assessments for mines and mine railways.

4.1.2 TRADITIONAL ECOLOGICAL KNOWLEDGE

Amongst Pilbara Traditional Owners, traditional ecological knowledge remains strong [379–381], as acknowledged in the Pilbara Conservation Strategy [69]:

Immense traditional ecological knowledge has been handed down from generation to generation and this can be used in conjunction with modern science to inform land management practices and decisions.

For example, the book *Traditional Ecological Knowledge of Nyangumarta Warrarn Indigenous Protected Area* (2016) compiles the knowledge of Nyangumarta elders about 67 plant species, recording their Nyangumarta name and traditional uses [382]. The documentation of traditional ecological knowledge has been a key evidentiary plank for successful native title determinations across the Pilbara [383].

Although some national park management plans acknowledge the value of traditional ecological knowledge for management (for example, the plans for Millstream Chichester and Murujuga [100,384]), such knowledge has yet to be meaningfully integrated into government and industry land management practices and programs. An emerging exception is an increasing focus on traditional fire management regimes [69].

The limited recognition and integration of Traditional Owners ecological knowledge in the Pilbara – largely due to the absence of broadscale Indigenous land management programs and limited ranger work – contrasts with the acceptance of Indigenous heritage and archaeological knowledge, which has been increasingly incorporated into industry and government processes since around the early 1970s [110,385,386].

4.1.3 MONITORING AND REPORTING

A lack of monitoring and reporting in the Pilbara is evident in the scarcity of up-to-date regional information about the status of threats, species of conservation significance, river and wetland condition and most other environmental indicators.

The 2016 Pilbara Conservation Action Plan noted the deficiency of monitoring, much of it lacking ‘the necessary rigour to be useful’ or ‘based on objectives that are not clear enough to be of scientific value’ [254]. Some monitoring programs are only for one-off projects, others are unstructured (opportunistic reports), and many are

site-specific with questionable relevance at a landscape level [254]. The documented programs included those for vegetation condition (for example, rangelands monitoring), fauna (for example, for threatened species such as northern quoll, bilby and marine turtles), feral animals and weeds (mainly opportunistic sightings), fire regimes (for example, Northern Australia Fire Information, firenorth.org.au) and water (mainly local-scale monitoring). Although mining projects have monitoring requirements, the data are mostly not publicly available.



The Yinhawangka rangers are making extensive use of drones to monitor important sites on their country. Image: Yinhawangka Aboriginal Corporation

4.2 The conservation reserve system

A well-managed conservation reserve system forms the cornerstone of biodiversity conservation, protecting viable samples of all regional ecosystems and the plants and animals they support.

Western Australian Government (2017) [387]

The Pilbara lacks what is regarded as a cornerstone of conservation: a 'comprehensive, adequate and representative' reserve system – one that protects the full range of ecological communities in each subregion, encompasses the variability of habitats within ecosystems, and with reserves large enough to be ecologically viable and ensure the long-term persistence of species and ecological communities [388].

Just 6.4% of the Pilbara is held in the formal (state-managed) conservation reserve system (Table 4-1) – well below the 17% international target for 2020 (specified in the strategic plan under the Convention on Biological Diversity, and soon to be superseded by a higher target), which is accepted as a bioregional target by the Western Australian Government [387]. Representation is particularly poor for the Fortescue (0.55% protected), Roebourne (3.71%) and Chichester subregions (3.95%) (Table 4-2). The majority of threatened and priority biodiversity – 50% of animals, 62% of plants, 81% of ecological communities – as well as 69% (71 of 103) of land systems [97] have no representation.

The Pilbara also has 6 small geoheritage reserves covering a total of 1,300 hectares (<0.01% of the Pilbara, Table 4-3). They were created to protect sites of 'exceptional international significance vulnerable to damage or destruction' – all are Archean stromatolite or microfossil sites.

The conservation reserve system in the Pilbara – and the associated recreational and tourism opportunities – could be much improved by adding former leasehold properties acquired by the state government for that purpose, subject to agreement by Traditional Owners [389]. These properties are currently held as unallocated crown land, a tenure that provides no constraints to exploration and mining activity and no requirements to seek the advice of the Department of Biodiversity, Conservation and Attractions on management conditions for exploration. Funding and legislative tools for conservation management are limited [389]. The Environmental Protection Authority had recommended these properties 'be afforded the highest possible level of conservation tenure' [97].

Under Western Australia's *Plan for Our Parks*, there is potential for 2 new conservation reserves to be created – Fortescue Marsh and Meentheena – and for Karijini National Park to be expanded [98]. These locations are of outstanding natural and cultural value [389] and have the potential to become showpiece examples of Indigenous co-management – with conservation outcomes framed from the outset by cultural land management priorities, and Indigenous governance and capacity support built into the agreements establishing each new conservation area.

The main impediment to more reserves in the Pilbara is the reluctance of the state government to protect areas potentially prospective for mining, even in areas where exploration licenses have not yet been issued and where prospects are highly speculative. Several leasehold areas designated 'lands of interest' by the then Department of Parks and Wildlife for addition to Karijini National Park were removed from consideration due to objections by the mining industry [389]. Karijini itself probably only became a national park in 1969 because a vetting process by the Mines Department was bypassed [390]. The Karijini area more broadly is still subject to mining, with Rio Tinto's Marandoo mine excised from the national park in 1991, along with a rail corridor that dissects the park.

Management of conservation reserves is hampered by insufficient funding. Of the 4 management plans covering 3 national parks and 2 nature reserves, 2 are out of date – that for Karijini National Park by more than a decade and that for the Dampier Archipelago Nature Reserves by 2 decades [391]. A 2014 assessment by the Conservation Commission of management in Karijini found there was no implementation plan and that management was reactive [301]. There was no evidence of burning to enhance habitat diversity or systematic feral animal control, and the impacts of nearby mining were evident. Staff and resources were spread too thinly and focused mainly on visitor management. A 2017 update from park managers indicated improved fire and feral animal management, although still-inadequate staff numbers. More recently, the management plan for Karijini has been reviewed and is being rewritten in collaboration with the Traditional Owners (DBCA, personal communication, August 2021).

The involvement of Traditional Owners in conservation reserve management in the Pilbara has been inconsistent. This arises from a 2-tier system of joint management, split between reserves established prior to the native title era (before 1993) and newer reserves requiring negotiations with Traditional Owners to be established. The Pilbara's largest reserves (Karijini, Millstream-Chichester and Cane River) were established prior to 1993 and the scarce financial and human resources for joint management have limited the potential for engaging with Traditional Owners. Nonetheless, for almost 10 years there has been relatively consistent Indigenous ranger work on Millstream-Chichester National Park, including fee-for-service work (DBCA personal communication, August 2021).

In the case of Murujuga, created in 2013, the native title negotiations for the park led to the creation of the state's first jointly managed park, along with funds to establish the Murujuga Rangers and the Murujuga Aboriginal Corporation [110].

A significant shift has recently occurred in the way Traditional Owners are involved in park management across Western Australia. For each new protected area created under the *Plan for Our Parks* initiative, joint management agreements are being negotiated, and funding will be provided to Aboriginal corporations and park managers to implement the agreements. Engagement and collaboration with Traditional Owner groups have also been boosted by the state's Aboriginal Ranger Program, in place since 2017, which creates ranger jobs and supports training and community development. However, effective joint management will require longer-term, more-realistic funding commitments to further develop the partnership capacities of both the state agency and Aboriginal organisations and to support Indigenous land managers operate on and off the conservation estate.

Another conservation limitation in the Pilbara (and the entire state) is the lack of a covenanting program to encourage and support landholders to protect sites of high conservation value.

Table 4-1. Formal conservation reserves in the Pilbara

| Reserve type | Protected areas | IUCN management category | Area (million hectares) | Proportion of Pilbara (%) |
|---------------------------|-----------------------|--------------------------|-------------------------|---------------------------|
| National park | Karijini | II | 0.627 | 3.52 |
| | Millstream Chichester | II | 0.238 | 1.33 |
| | Murujuga | II | 0.005 | <0.01 |
| Conservation park | Cane River | II | 0.148 | 0.83 |
| Nature reserve | Mungaroona Range | IA | 0.106 | 0.59 |
| | 8 others | IA | 0.010 | <0.01 |
| S5(1)(g), 5(1)(h) reserve | 5 unnamed | II-VI | 0.008 | <0.01 |
| Total | | | 1.142 | 6.40 |

Source: CAPAD 2018 [392]

Table 4-2. Existing and potential subregional levels of protection in the Pilbara conservation reserve system

| | Bioregion (%) | Subregions (%) | | | |
|---------------------|---------------|----------------|------------|-----------|-----------|
| | Pilbara | Hamersley | Chichester | Roebourne | Fortescue |
| Existing reserves | 6.40 | 12.88 | 3.95 | 3.71 | 0.55 |
| Potential reserves* | 3.88 | 3.74 | 2.60 | 4.13 | 9.36 |

Note: *Potential reserves are those acquired for the reserve system that are currently managed by the Department of Biodiversity, Conservation and Attractions as unallocated Crown land.

Table 4-3. Geoheritage reserves in the Pilbara

| Geoheritage reserve | Feature | Area (ha) |
|---|-----------------------|-----------|
| Buick (North Pole Stromatolites) | Archean stromatolites | 396 |
| Hickman (Spinaway Creek) | Archean stromatolites | 252 |
| Schopf (Chinaman Creek - Apex Basalt chert) | Archean microfossils | 250 |
| Trendall | Archean stromatolites | 242 |
| Lowe (Strelley West) | Archean stromatolites | 104 |
| Awramik (North Pole Microfossils) | Archean microfossils | 24 |

Source: Western Australian Government geoheritage register



The largest national parks in the Pilbara – Karijini (top) and Millstream Chichester (bottom) – were each gazetted in the late 1960s. The Traditional Owners – the Banjima, Kurrama and Innawonga peoples (Karijini) and the Yindibarndi (Millstream Chichester) – were not consulted and joint management was not considered at the time. The Western Australian Government has been seeking to redress historical injustices caused by the creation of national parks, including in the Pilbara, where the process is in its early stages. Images: Tourism Western Australia (top), Jean-Marc La Roque (bottom)



4.3 Conservation plans and strategies

Of particular importance is the role of off-reserve conservation actions, considering the limited representation of biodiversity within the formal reserve system [97].

Advice of the Environmental Protection Authority to the Minister for Environment (2014) [97]

Several regional plans and strategies have been developed for the Pilbara in the past decade, providing guidance on conservation priorities and options. There is also a plethora of local and issue-specific plans.

Priority Threat Management for Pilbara Species of Conservation Significance (2014) [3]: Developed by CSIRO, this plan provides a costed and appraised set of 17 strategies for mitigating threats to 53 species of conservation significance [3]. Based mainly on expert advice, it found that without intervention a quarter of the assessed species were likely to be functionally lost within 20 years. The 3 most cost-effective strategies over 20 years were (1) management of feral ungulates, (2) predator-free sanctuaries and (3) feral cat management, each costing less than \$1 million a year. Three complementary strategies with a combined greater-than-50% prospect of maintaining all 53 conservation-significant species were (1) domestic herbivore management, (2) fire management and research, and (3) predator-free sanctuaries, costing in total about \$5 million a year. To increase the prospect to 75% would cost \$9 million a year [393]. Beyond some control of feral ungulates, and a smattering of fire and feral cat management, these strategies have not been implemented (see the next section).

Pilbara Bioregion Conservation Action Planning Process (2016, 2018) [254,313]: Produced by Pilbara Corridors (a partnership between Parks and Wildlife, Rangelands NRM and Greening Australia), the 2016 plan resulted from stakeholder workshops that identified 13 conservation assets, ranked 25 threats, and developed 60 conservation strategies. The 2018 update refined the values and strategies, resulting in 18 priority strategies. Several are focused on threat abatement – for example, management of weeds, introduced predators and feral herbivores, fires and water. Others are focused on the protection of particular assets such as the northern quoll, bilby, threatened bats and islands. And others are about capacity building – establishing a Pilbara-based implementation group, improving on-ground management and monitoring and evaluation. Implementation has been limited by the cessation of funding for Pilbara Corridors (section 4.5), and the need to pursue grants or offset funding for individual projects.

Pilbara Conservation Strategy (2017) [69]: In response to advice from the Environmental Protection Authority [97], the Western Australian Government developed a strategy to identify 'opportunities for partnerships' to abate threats and protect conservation values at a landscape scale. The priorities are:

- Karijini – manage threats (invasive species, fire), undertake research, establish a fenced sanctuary
- Fortescue Marsh – manage threats (invasive species, fire), undertake research, add to the conservation reserve system
- fire – undertake a landscape-scale, cross-tenure prescribed burning program
- invasive species – manage (eradicate in some cases) feral herbivores, cattle, cats, redclaw crayfish, weeds.

Pilbara Environmental Offsets Fund Implementation Plan (2019), **Project Concept Plan for 2020–2025 Investment** [377,394]: The Pilbara now has a long-term funding source for conservation projects – a pool of offset funding from mining projects, with \$90 million so far to allocate over 40 years (Box 4-2). Funds will mostly be directed to priority areas (9.5% of the Pilbara) with high densities of environmental matters, opportunities for land access, and security for offset outcomes (Figure 6 3). The 2020–2025 concept plan favours long-term, landscape-scale projects that can be delivered across tenures to maximise outcomes for vegetation. It identifies 3 focus areas for spending of \$8 million up to 2025:

- coordinated fire management (\$3 million over 5 years)
- integrated riparian vegetation management (\$3 million over 5 years)
- projects to inform the design, delivery, monitoring and evaluation of projects (such as the collection of baseline information) (\$2 million over 5 years).

The concept plan flags a change from competitive grants to the co-design of projects with Traditional Owners and regional stakeholders. The first co-designed projects are likely to be funded in late 2022 and involve coordination with Pilbara Traditional Owner groups. The offsets fund has great potential to drive sustained cross-stakeholder conservation planning and implementation, and thus avoid the funding cliff that has stalled initiatives such as the conservation action planning process.

Healthy country plans: Several Traditional Owner groups in the Pilbara have developed or are in the process of developing healthy country plans, setting out a holistic vision for their country and their social, cultural, environmental and business aspirations and objectives.

The 10-year Banjima Yurlubajagu plan (2016) is inspired by the following vision [77]:

Banjima Country is a model for language, cultural lore, land and water management, demonstrating successful methods of cultural restoration and land management in Manggurdu and floodplain, Wirrawali Creek, Karijini and Birdirrla Ranges to increase population viability of native species and their habitats by Banjima people in partnership with other organisations, corporations and agencies.

Among the 10 planned projects are the establishment of a country management program and a ranger team [77].

The vision inspiring the 10-year Yinhawangka plan (2016) is that Yinhawangka country 'will have good water with all the living things that water supports', that the plants and animals the Yinhawangka people need for food and medicine will be 'healthy and abundant', that their knowledge and cultural practices will be shared and maintained by their people and that they will 'work together with pride' in their country to manage fire and other problems [395]. In realisation of one of the plan's objectives, the Yinhawangka now operate a successful ranger team, using traditional and scientific techniques, including drone monitoring, to manage their country [608].

Another notable plan is the Cultural Management Plan (2016) of the Murujuga Aboriginal Corporation, with its vision of [108] (Box 2-8):

All Murujuga Land and Sea Country will be forever cared for under the leadership of Ngarda-Ngarli, as it has been for thousands of generations.

One challenge with healthy country planning is that it occurs separately to engagement with government, industry and other stakeholders, meaning that implementation may not be realistic for all identified actions and aspirations. But it is also a strength that Traditional Owners plan independently, outside the bounds of a government or industry agenda. The plans are a useful basis for the establishment of partnerships for land management with NGOs, government and industry.

Other plans: Other relevant plans for the Pilbara include those for threatened species (such as the National Recovery Plan for the Northern Quoll [396]), for particular sites (such as the Fortescue Marsh Management Strategy [94]) and for particular threats (such as Pilbara Mesquite Management Strategy) [325].

4.4 Recovery and restoration of biodiversity and landscapes

Pilbara landscapes have been modified by pastoral use, mining activities and altered fire regimes for more than a century. ...over-grazing and too-frequent wildfires have changed vegetation cover and in many instances stripped the upper layers from soil profiles ... exotic animals and plants have been introduced, with detrimental effects on the region's biodiversity.

Norm McKenzie, Stephen van Leeuwen and Adrian Pinder, Western Australian Department of Environment and Conservation (2009) [23]

4.4.1 THREAT ABATEMENT

Priority threats in the Pilbara are weeds and invasive animals, adverse fire regimes, high grazing pressure, changes to natural water flows (hydrological regimes), and mining impacts (see Chapter 3). Threat management is patchy – mostly done for pastoral purposes or to meet regulatory requirements for mining – with little of the region managed specifically for conservation. Reporting on threats and threat management is also patchy, so it is not possible to quantify threats or track abatement progress. In the absence of information, below are a few examples of abatement work and generalisations about the level of activity.

Traditional Owner healthy country plans in the Pilbara identify weeds, invasive animals and 'wrong way fire' as threats requiring management, but information on actions implemented and their outcomes is not available. Greater collaboration between Traditional Owner groups, industry and government agencies is needed to improve the strategic focus of management, monitoring, reporting and 'two way' science to inform program development.

Weeds: A Pilbara Weed Strategy has recently been finalised [310]. It captured more than 285,000 weed records from 178 weed species across the region. For most weeds, there is 'a critically low level' of management capacity in the Pilbara, particularly on the pastoral estate [324]. However, for more than a decade, there has been a concerted focus on mesquite and parkinsonia, both weeds of national significance, led by the Pilbara Mesquite Management Committee [397] (see Box 4-1).

Other targets are bellyache bush and cactus species. In 2016, an 8-year, \$8 million research project began on controlling stinking passion flower (*Passiflora foetida*), including at Murujuga [398]. Conservation reserve managers control weeds as budgets permit. Priorities on island reserves have been identified, and control occurs opportunistically, constrained by cost and logistical complexities [399]. Western Australia lacks a biosecurity surveillance system for island reserves.

Invasive animals: Feral herbivores are occasionally or regularly controlled in parts of the Pilbara – particularly donkeys and camels, which are both environmental and pastoral threats. One major advance has been the fencing of the 327,000-hectare Cane River Conservation Park to prevent access by feral herbivores and stray cattle [378]. At Fortescue Marsh, a multi-year, collaborative aerial shooting program has reduced donkey, horse and camel numbers, and the introduction of rabbit haemorrhagic disease virus in 2017 has greatly reduced rabbit numbers [94]. There are also plans to fence high-value areas of Fortescue Marsh to exclude cattle and feral herbivores, decommission some water sources, and control cats. The limited cat control that occurs in the Pilbara is done mainly for northern quolls funded as a mining offset [152]. The state environment agency focuses much of its control effort on feral herbivores on properties adjacent to pastoral leases and also controls feral dogs and dingoes for pastoral benefit [400]. A 2014 performance assessment by the Conservation Commission of the management of Karijini National Park found a lack of systematic feral animal control, but a 2017 update indicated there had since been aerial shooting of feral herbivores and mustering by pastoralists to remove cattle [301]. The Pilbara Regional Biosecurity Group, funded by rates from pastoralists matched by state government funding, mainly focuses on dingoes/feral dogs and feral donkeys [400].

Adverse fire regimes: Since 2015, the state environment agency has undertaken prescribed burning over an average area of 350,000 hectares, burning 10–30% of the treatment area each year (DBCA, personal communication July 2021). Their goal, as specified in the Pilbara Regional Fuel Management Plan 2020–2025, is to maintain 45% of the spinifex hummock grasslands in these areas under 6 years of age (depending on annual rainfall, vegetation recovery and local knowledge). Most of their burning occurs in the conservation estate, on unallocated crown land, and along roadsides – for the purpose of protecting

settlements, creating fire buffers along transport corridors and promoting biodiversity by reducing the likelihood of large-scale bushfires. Whenever possible, prescribed burning is done in consultation and collaboration with Traditional Owners. The strategy appears to be working – the majority of bushfires ignited by lightning over the past 6 years have not required human suppression and have burned smaller areas compared to previous years (DBCA, personal communication July 2021).

There is little information about the extent of prescribed burning for hazard reduction or conservation purposes on other tenures. Rangelands NRM initiated a Kimberley and Pilbara Fire Project in 2017 to work with pastoralists (initially Yarrie Station) to reduce late season fires and benefit both productivity and biodiversity [401].

One of the goals of the Pilbara Conservation Action Plan is the widespread application of patchy, cool, early season fire regimes ‘to protect fire-sensitive ecosystems, maximise habitat diversity and minimise the risk to threatened flora and fauna populations’ [313]. There will be a more concerted focus on fire management over the next few years, as it is one of the priorities for funding under the Pilbara Environmental Offsets Fund, with a proposed initial commitment of \$3 million over 5 years [377] (Box 4-2).

Overgrazing: Grazing practices vary considerably across the Pilbara and there are exemplars of sustainable grazing management. However, a 2017 auditor general assessment concluded that knowledge of the environmental condition of leases in the Pilbara is poor, and that current systems of monitoring and administration do not achieve ecological sustainability [231]. There has been little analysis of the drivers for overgrazing and no new initiatives to address this problem. There is a lack of government incentives (such as a stewardship scheme) to protect sensitive sites, and a lack of support for ecologically sustainable diversification options.



To reduce the risks of destructive large wildfires, the Western Australian Government, in consultation with Traditional Owners, has been conducting aerial burning in conservation reserves – here at Millstream Chichester National Park. Image: Western Australian Department of Biodiversity, Conservation and Attractions

Box 4-1. The work of the Pilbara Mesquite Management Committee

Managing weeds is one of conservation's most demanding tasks – requiring excellent organisational and technical skills, collaboration with land managers, diligent monitoring and surveillance, considerable funding and long-term persistence. The longest-running conservation effort in the Pilbara has probably been the control of mesquite (*Prosopis* species), which began on Mardie Station in 1954. But mesquite continued to spread there for several decades due to a poor understanding of the weed and wavering control efforts [326,402].

For the past 20 years, a much more concerted control effort has been coordinated by the not-for-profit Pilbara Mesquite Management Committee (PMMC). The work is funded by mining companies, state and federal governments and others, and undertaken in collaboration with land managers and other stakeholders. The main goal has been to suppress mesquite populations, and this

has been achieved in a few sites. At other sites, the main effect has been to slow the spread. Four biological control agents were introduced in the 1990s, and at least one has been effective at reducing the reproduction and growth rate of mesquite [325,326,402].

Another major focus of the PMMC has been parkinsonia. Good progress has been made on eradicating it from Roy Hill Station, to protect Fortescue Marsh from invasion, with some 200,000 plants treated since 2012. Parkinsonia has been reduced at several other sites. Figure 4-2 shows the extensive scope of PMMC weed control work, with other targets being bellyache bush, cactus species and noogoora burr.

Any diminishment of control effort will result in the re-invasion and unrelenting spread of these harmful invaders.

Additional sources: PMMC documents



Figure 4-2. The location of weed control programs managed by the Pilbara Mesquite Management Committee

4.4.2 RECOVERY OF THREATENED BIODIVERSITY

Rangers are in the best position to detect new populations [of night parrots]. They know their country.

Nick Leseberg, National Environmental Science Program (2019) [403]

[M]obilising the support and knowledge of Traditional Owners [is] one of the greatest opportunities for sustained on-ground conservation action for the Greater Bilby across its range.

Greater Bilby Recovery Summit 2015 [404]

Few of the 250 or so threatened and priority species and 31 threatened and priority ecological communities in the Pilbara are the focus of recovery efforts. Most recovery work occurs as part of offset requirements for mines, including for the northern quoll, bilby and the endangered plant *Aluta quadrata* [400].

Recent research on the endangered northern quoll led by the Department of Biodiversity, Conservation and Attractions and supported by environmental offset and public good funding by several mining companies will enable more strategic conservation interventions [152]. The work has shown, for example, that northern quolls are highly 'reliant on patches of complex rocky habitat of ranges and rocky outcrops' but that males can travel large distances [152]. Trials of aerial baiting for feral cats in the Pilbara have shown it is safe for quolls and likely to be beneficial in protecting them from a major threat [405].

Indigenous rangers are gaining capacity to monitor and manage threatened species, such as bilbies, on their country. The national recovery plan for bilbies stresses that maintenance of Indigenous culture and ecological knowledge are critical for bilby conservation [159]. In the Pilbara and nearby regions, the Kanyirninpa Jukurrpa Martu, Nyangumarta, Yandeyarra, Banjima and Biriliburru rangers have all run bilby monitoring programs; and the Tarlka Matuwa Piarku Martu rangers are partners in a bilby reintroduction program in the Matuwa and Kurrara Indigenous Protected Area [406–408]. The Western Australian Government has collaborated with several ranger groups in monitoring and recovery [409] and further collaboration will eventuate with the anticipated expansion of ranger work across the Pilbara (see Box 6-5 on the Pilbara Cultural Land Management Project).

Traditional Owners will be essential to the effort to save the critically endangered night parrots, one of Australia's most elusive and threatened birds. Indigenous rangers have been the source of recent sightings and Traditional Owners who know their country are best placed to find new populations [403]. Elders at a recent workshop in the Kimberley recognised the call of the night parrot when it was played to them and could recall where they had heard it as children [403].



Budadee rangers at work on Woodstock Abydos. Image: Budadee Aboriginal Corporation



Banjima Rangers undertaking traditional fire management. Image: Banjima Native Title Aboriginal Corporation

4.4.3 RESTORATION OF DEGRADED AND MINED LANDS

The premise of many mining approvals is that after the resource has been extracted, the land can be restored to a state resembling the original. So far, this has not been achieved in the Pilbara. Despite some 70 years of mining, there is 'limited evidence that proponents have successfully rehabilitated any areas that have been subject to large-scale mining' [97]. The Environmental Protection Authority notes that current efforts achieve only about 15% of the pre-mined biodiversity [97]. There is considerable ongoing work in the Pilbara on progressive rehabilitation of current mining projects, but many mining legacy sites needing work are neglected [410].

There is also work needed to rehabilitate degraded areas on pastoral properties in the Pilbara. A 2012 assessment

found that 'many leases require a level of investment in some form of ongoing remedial action towards long term sustainability' [300]. One recent project by Greening Australia focused on restoring degraded tussock grassland on 2 pastoral properties, with seed collected by the Ngurrawaana Rangers and other Yindjibarndi people, fencing of the restoration areas to exclude grazing, direct seeding of areas and monitoring [411].

Restoring degraded riparian areas is one priority focus for the Pilbara Environmental Offsets Fund, with a proposal for a \$3 million, 5-year project to manage multiple threats to riparian vegetation [377] (Box 4-2). Restoration will be aided by another priority offsets project to map and monitor native vegetation.

4.5 Conservation capacity – people and funding

Training and employment opportunities for Aboriginal people, access to traditional lands, and maintenance of culture and ecological knowledge are critical for the conservation of wild bilby populations.

Recovery plan for the greater bilby (draft, 2019) [159].

Although there are several well-considered conservation plans and strategies for the Pilbara, the outcomes so far have been patchy, for they have lacked an essential basis for implementation – a sustainable conservation

workforce and economy. For example, Pilbara Corridors ceased to function after its 5-year grant from the federal Biodiversity Fund ran out in 2017. The organisation was established to 'provide advice, run programs and ensure work effort and funding is prioritised and coordinated to get the best biodiversity and social outcomes for the region and for all stakeholders' [412]. The Pilbara Collaboration Group, established in 2017 by 6 not-for-profit groups with an interest in NRM activities, has also ceased to function formally since its external funding ended, although it continues to meet once a year as

an informal network [413]. Rangelands NRM is also constrained by a lack of funding, for it mainly relies on grants for individual projects to function in the Pilbara.

Outcomes have also been hampered by a lack of close collaboration with Traditional Owner groups. Limited resources for land management and extensive mining industry obligations (largely heritage surveys and associated administration) have been a further constraint on participation by Traditional Owners.

Although the existing plans and strategies all recognise the importance of Traditional Owners in conservation management, and the Pilbara Conservation Action Plan proposes the development of targeted training packages for ranger groups, none have proposed an explicit focus on expanding the Indigenous ranger capacity in the Pilbara.

In this report, we recommend focusing as the highest initial priority on developing a sustainable conservation workforce and seeding a conservation economy based on collaborations across all major stakeholder groups (see Chapter 6). Only in that way can conservation become part of the Pilbara way of life and economy, rather than merely an offset of mining, a short-lived community development project, or an occasional NRM project when a funding opportunity momentarily shines on the Pilbara.

The 2018 establishment of the Pilbara Environmental Offsets Fund, which combines offset payments from mining companies to enable larger-scale, strategic conservation projects, will provide a major boost to conservation in the Pilbara, with initial funding of \$1.5–2 million a year (Box 4-2). Projects must 'lead to tangible improvements' for the offset targets and be additional to

what is already required to manage or rehabilitate land in the Pilbara [394]. After finding that a competitive grants approach did 'not support the collaboration and co-design needed to develop projects with Traditional Owners', the Western Australian Government has committed to co-designing and co-delivering projects with Traditional Owners, researchers, practitioners and land managers [377].

For enduring conservation programs in the Pilbara, a core focus must be supporting Traditional Owner-led, cross-tenure, landscape-scale cultural and conservation land management (see Box 5-2). Traditional Owners have the potential to form a substantial, committed and skilled conservation workforce, with legal access rights (native title) over most of the Pilbara. Indigenous ranger groups currently operating or being established include Banjima, Yinhawangka, Thalanyji, Kunti Kurrama and Pinikura (PKKP), Robe River Kuruma, Nyiyiparli, Kariyarra, Yinjibarndi, Nyamal, Murujuga, Nyangumarta and the Chevron Sea Rangers. Five Traditional Owner groups have healthy country or cultural management plans setting out cultural and conservation land management priorities for their lands [77,108,395,414].

Large-scale conservation management of the Pilbara will require strong partnerships between Traditional Owner groups and others with rights and interests in land – government agencies, pastoralists and mining companies. Although the majority of participants would be Traditional Owners, this will also provide economic opportunities for pastoralists, to diversify economic activities and boost productivity through improved land management.

Box 4-2. The Pilbara Environmental Offsets Fund

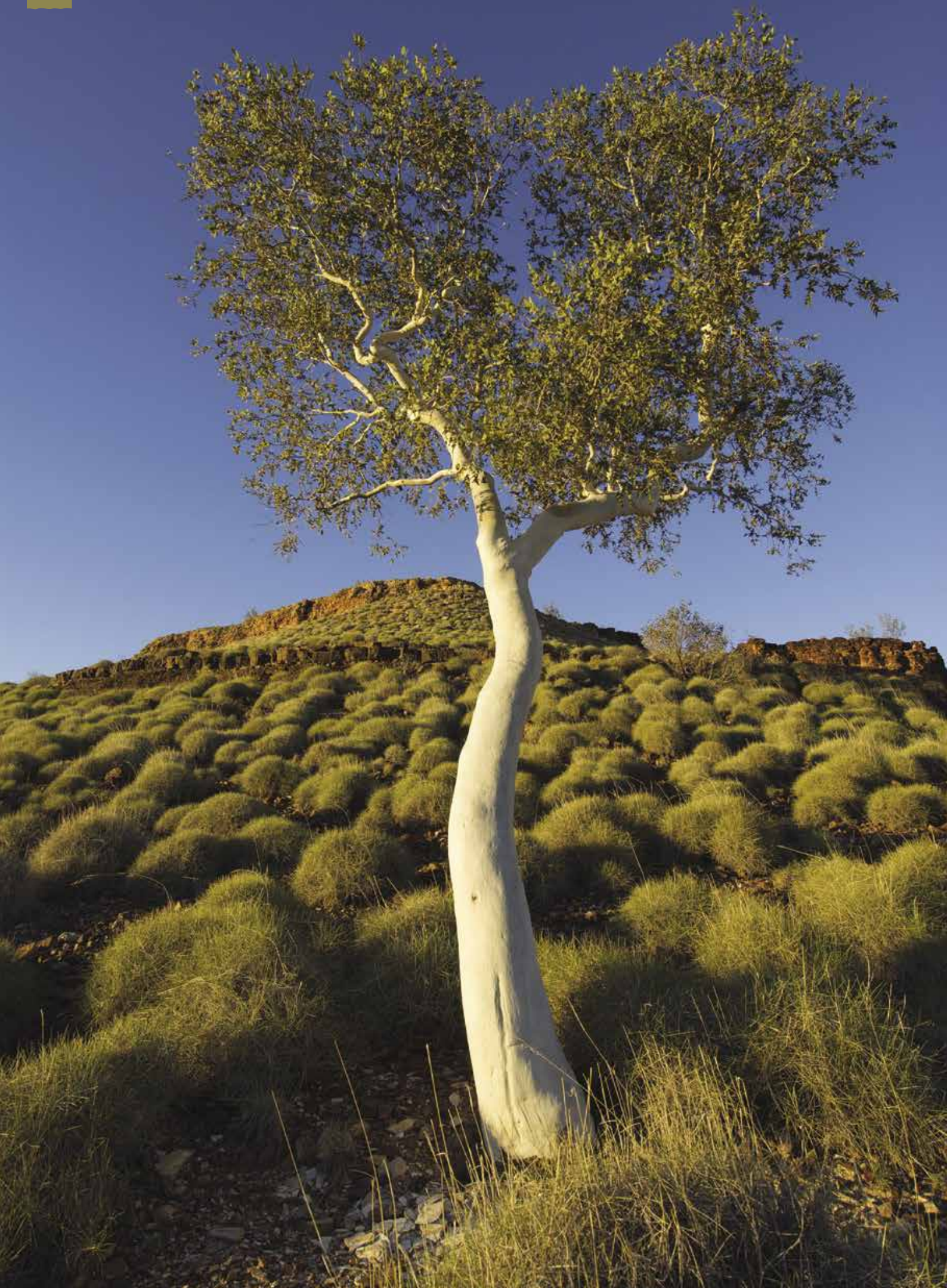
The offsets fund, established in 2018, pools offset payments by mining companies required under state and federal environmental laws. Offsets are 'actions that provide environmental benefits which counterbalance the significant residual environmental impacts or risks of a project or activity that remain after mitigation (including rehabilitation)'. Combining offsets enables larger, more strategic and beneficial projects than individual offsets.

So far, the conditions set for mines approved in the Pilbara since 2012 require \$90 million to be paid into the fund over the next 40 years. Offset projects must 'lead to tangible improvements' for the offset targets and be additional to what is already required to manage or rehabilitate land.

There are complicated tenure arrangements in the Pilbara, with overlapping rights and interests over land constraining where offset projects can be sited. The 5-year implementation plan for the offsets fund specifies priority areas for offset projects where ease of land access and security for offset outcomes 'intersect with high biodiversity values for offsets' in the Chichester, Hamersley and Fortescue subregions (Figure 6-3).

Recently, the Department of Water and Environmental Regulation which manages the fund has embraced a new approach to allocating funds. Rather than relying on a competitive grants process, which limited Traditional Owner participation, they will be taking a co-design approach so as to 'integrate the collective knowledge and experience of researchers, practitioners, and Traditional Owners in the design, implementation and monitoring and evaluation of projects'.

Sources: *Pilbara Environmental Offsets Fund Implementation Plan* (2019) [394], *Pilbara Environmental Offsets Fund Project Concept Plan for 2020- 2025 Investment* (2020) [377]



5. Conservation opportunities in the Pilbara

Conservation opportunities in the Pilbara abound – the values are outstanding, most of the threats are manageable and, with native title claims mostly settled and access rights established, the Pilbara’s Traditional Owners are strengthening their capacity to more fully resume their traditional custodial responsibilities to manage country.

In this chapter, we identify the major conservation opportunities in the Pilbara on different tenures. Legal rights and interests in land, which are complicated and often misunderstood in the Pilbara, strongly influence where conservation activities can and can’t occur.

5.1 Opportunities and constraints

There are 4 main categories of landowners / holders of rights to land in the Pilbara (current to July–August 2020):

- Western Australian Government: >99% is crown land, including conservation and other crown reserves, unallocated crown land and pastoral leases (Table 5-1)
- Traditional Owners: 79% is recognised as native title and 5% is under claim (Table 5-2)
- Pastoralists: 60% is under pastoral leases (Table 5-1)
- Miners: 55% is under mining and exploration tenements and an additional 14% is pending (Table 5-3)

Table 5-1. Tenure categories in the Pilbara

| | Unallocated crown land | Conservation reserves | Other reserves | Aboriginal - managed land | Pastoral leases |
|------------------|------------------------|-----------------------|----------------|---------------------------|-----------------|
| Million hectares | 4.34 | 1.14 | 0.91 | 2.04 | 10.61 |
| % Pilbara | 24.3 | 6.4 | 5.1 | 11.5 | 59.5 |

Note: Excluded are leases (general and special purpose) covering 0.3% and freehold land, roads and other tenures covering 0.6% of the Pilbara. Data downloaded in October 2020, current to July–August 2020 (see section 8.2 for sources).

Table 5-2. Native title in the Pilbara

| | Exclusive | Non Exclusive | Under Claim | Extinguished/ not recognised | Unclaimed |
|------------------|-----------|---------------|-------------|------------------------------|-----------|
| Million hectares | 1.19 | 12.96 | 0.94 | 1.32 | 1.42 |
| % Pilbara | 6.7 | 72.7 | 5.3 | 7.4 | 8.0 |

Table 5-3. Mining tenements in the Pilbara

| | Production leases | Exploration leases (additional to production) | Free of Mining | Exploration leases pending (additional to granted) |
|------------------|-------------------|---|----------------|--|
| Million hectares | 2.06 | 7.72 | 8.05 | 2.3 |
| % Pilbara | 11.6 | 43.3 | 45.1 | 13.5 |

Notes: Overlaps between leases have been removed from these figures by prioritising production over exploration and granted over pending leases. Data current to 30 July 2020.

Opposite: *Spinifex and snappy gum – a widespread vegetation type in the Pilbara. Image: Tourism Western*

Almost the entire region, including pastoral leases, is crown land, giving the Western Australian Government discretion (to varying degrees) over management priorities. However, that discretion has often been exercised in favour of economic activity rather than conservation. This has been starkly demonstrated by the granting of exploration leases over parts of Karijini National Park, in every nature reserve, on former pastoral properties acquired for conservation purposes, as well as on all pastoral leases, all substantial areas of unallocated crown land, all major water reserves and all Indigenous-owned properties.

Most of the Pilbara is used for economic activities. Mining leases cover more than half the area (more than in any other Australian bioregion) and will cover more than two-thirds if all pending exploration leases are granted. The Environmental Protection Authority has noted that mining tenure constraints in the region 'make it difficult to ... deliver long-term protection of biodiversity' [97]. The overlapping dominance of mining and pastoralism – with leases covering 82% of the bioregion – means that the conservation focus here must realistically be less on expanding conservation reserves (although that is still important) and more on establishing conservation management across the landscape, whatever the tenure. Given the high coincidence of natural, cultural and economic values across the landscape, the goal in the Pilbara should be to become an exemplar of world's best-practice conservation across economically important lands.

Major opportunities for improving conservation in the Pilbara lie with Traditional Owners – for they have native title rights across most of the Pilbara (Box 5-1), strong conservation motivation, culturally inherited land management knowledge and responsibilities, and considerable latent capacity to establish a conservation workforce. The recent establishment of the Pilbara Cultural Land Management Project – a partnership between 12 Traditional Owner groups – will help build that capacity (Box 6-5). Their aim is to implement cultural and conservation land management across native title lands in partnership with pastoralists, miners and government agencies.

A second group with conservation potential is pastoralists, for they also have rights across much of the region. However, their motivations, capacity for conservation, and external drivers are more variable and complex, reflecting in part the diversity of pastoral station ownership – individuals/families, Indigenous (Aboriginal corporations) and corporate (pastoral and mining companies, some foreign-owned and others local). Some Pilbara pastoralists have demonstrated a strong commitment to conservation

[415], while others, with the demands of managing a pastoral business, are probably limited in their capacity unless demonstration projects show that conservation can be practically integrated into their existing business model or offers economic opportunities. However, the emerging Traditional Owner capacity for cultural land management in the Pilbara offers opportunities for pastoralists to engage in conservation projects through partnerships with native title holders. This could be implemented on miner-owned pastoral leases through existing partnerships with Traditional Owners under mining agreements.

Notwithstanding the detriment of mining to biodiversity and cultural values, the mining sector contributes significantly to conservation in the Pilbara, both as part of the conditions under which they operate (for example, biodiversity surveys and offset projects) and through public good funding. Many conservation projects are funded by offsets and donations – research on northern quolls for example [152] – and hundreds of new species have been discovered in environmental assessments for mining projects [416]. The mining workforce includes staff with excellent environmental management skills and conservation commitment. However, there is limited capacity to contribute other than through funding and advice. The fly-in fly-out nature of much mining work in the Pilbara inevitably limits the capacity of employees, particularly those residing in mine site camps, to otherwise contribute to conservation [417].

The mining industry has also contributed to the skills and capacity of Traditional Owners to undertake cultural land management projects. While not as extensive as the scale of opportunity [418], many Traditional Owners are engaged in the industry, through heritage surveys, industry contracts and employment [419–427]. This is due in part to industry policy [428] and to mining land access agreements that combine compensation with support for Indigenous business development, employment and integration with industry [429–431].

On the following page, we identify conservation priorities and opportunities in each tenure category (the tenures are grouped as shown in Table 5-1; some opportunities are discussed in greater detail in chapter 6). The status of mining tenures is highly dynamic in the Pilbara, with applications for exploration covering 13.5% of the region (in July 2020) in addition to those overlapping already granted mining leases. Other than mining, tenure changes – and therefore potential conservation opportunities and threats – can arise from an expanded recognition of native title or the conversion of unallocated crown land to national park, pastoral lease, special purpose reserve or freehold (for irrigated agriculture).

Box 5-1. Rights and opportunities on native title lands

Since the passage of the Native Title Act in 1993, native title has been recognised across almost 80% of the Pilbara. What this means for land access and control by Traditional Owners is often poorly understood. Even within government and industry, knowledge is patchy, and there is often policy confusion, or no policy at all, about how to ensure that Traditional Owners can practically exercise their rights.

Native title is recognised in two forms: exclusive possession, the strongest form, includes 'the right to possess and occupy an area to the exclusion of all others', whereas non-exclusive possession means native title areas are shared with other interest holders [432,433]. In Western Australia exclusive possession mostly exists on unallocated crown lands, Aboriginal-owned pastoral leases and Aboriginal Land Trust lands, while non-exclusive native title is common on pastoral leases, unallocated crown lands and some crown reserves.

On pastoral leases, Traditional Owners have rights to access non-exclusive native title areas for the traditional activities stipulated in their native title determination [434]. These typically include rights to camp, perform ceremonies, use traditional resources, maintain sacred sites and manage lands in a way that is consistent with traditional practices [435]. These activities must not conflict with the rights of the pastoral leaseholder to run a pastoral enterprise. Despite restrictions, this means that for native title holders there is now no such thing as a permanently locked pastoral gate or native title area that cannot be managed for traditional purposes.

Pastoral land can be cooperatively managed – for both cultural and pastoral purposes, although some early attempts by pastoralists to impede access to native title holders set a poor precedent [436,437]. There is enormous untapped potential for cooperative, mutually beneficial land management, including with support by Commonwealth programs for Indigenous rangers to work on native title lands on pastoral leases and closer collaboration with state agencies operating to support pastoralists.

The Western Australia Government and peak pastoralism bodies (the Kimberley Pilbara Cattleman's Association and the Pastoralists and Graziers Association) do not currently have any public policies or guidelines about cooperative, mutually beneficial land management agreements between native title holders and non-Indigenous pastoralists. One example from elsewhere is the Queensland Government's *Guide to the Pastoral ILUA template* [438]. It makes clear that an Indigenous Land Use Agreement (ILUA) can provide mutual benefits – for example, by specifying 'practical and flexible arrangements' for when and how native title parties can access and use the area and 'how the pastoralist's lease will be protected from certain activities, such as the introduction of weeds or the lighting of fires'; and by providing for the establishment of nature refuges and the protection of traditional sites and objects. The South Australian Farmers Federation promoted pastoral ILUAs under a state-wide ILUA framework, but the focus was on standardising access arrangements for Traditional Owners and opportunities for employment, training, and tourism [439].



Nyamal Traditional Owners celebrate their native title determination in 2019. The Nyamal led the Pilbara pastoral workers strike in 1946 – the first station walk-off by Aboriginal people, 20 years before the better known Wave Hill strike in the Northern Territory. Image: Jodi Neal

Box 5-2. Cultural and conservation land management

Caring for Country keeps our cultural life, identity, autonomy and health strong. Kinship, language and culture come together in our land and sea management activities and shape our health and well-being. We rely on our power to look after Country – if we fail in our obligations to keep our Country healthy, we believe that the health of the Traditional Owners will also fail.

Our Knowledge,
Our Way in Caring for Country (2020) [440]

Cultural and conservation land management by Indigenous Australians is a holistic endeavour – combining Indigenous and western knowledge systems to pursue both cultural and nature conservation outcomes.

Indigenous and western perspectives on land management differ. In simple terms, Indigenous people see land management as a two-way interaction between people and country, whereas westerners typically view it, more linearly, as people taking actions to affect the environment [441]. But there are usually major overlaps between cultural and conventional conservation priorities – often both achieved by protecting threatened species, managing fire, controlling weeds and feral animals, rehabilitating degraded areas, managing tourism, conducting biosecurity surveillance and managing water resources. Cultural responsibilities for protecting sacred sites, sustaining culturally significant species, and transmitting traditional knowledge of country to younger generations have always been a priority for Traditional Owners; and in the past 20 years or so they have also become a focus of conventional natural resource management. In central and northern Australia the distinctions between cultural and natural resource management have become less relevant as the value of Indigenous ranger programs has become widely accepted [442].

Programs and planning that support both cultural and conservation outcomes include the Commonwealth's Indigenous protected area (IPA) and Indigenous ranger programs and many forms of Healthy country planning. Most IPAs, for example, are managed as IUCN category 5 or 6 protected areas, which have a strong focus on people, culture and nature [443].

A core element of cultural and conservation land management is respecting and applying both Indigenous and western knowledge systems. Two-way science projects are a common approach to ensuring knowledge transfer is equitable and useful [444]. The role of Indigenous knowledge and skills in conserving the bilby and night parrot are well-known examples [159,179,403].

Cultural land management programs have a broader focus than conventional conservation management. The effectiveness of a conventional threatened species program can be assessed by monitoring species recovery, but a cultural and conservation land management program focused on threatened species may also be assessed for its social return on investment and community health and wellbeing indicators. Other activities common to cultural land management include recording of stories for country, painting and art projects, ceremonial activities, bush food harvesting and traditional resource use (for a comprehensive list see [441]).

It is important to acknowledge that where Traditional Owners hold strong rights in land, they often have significant economic opportunities available to them (for example, mining or other extractive resource developments) that will support their self-determination but conflict with conventional conservation opportunities. To ensure cultural and conservation programs endure, it is important for Traditional Owners and their partner organisations to engage in planning processes that demonstrate the shared values and mutually beneficial outcomes from culture and conservation as a land use. This provides a framework for comparisons with the benefits of other potential land uses.



Image: Western Australian Department of Biodiversity, Conservation and Attractions

5.2 Opportunities on unallocated crown land

About a quarter of the Pilbara (24%, 4.3 million hectares) is classified as unallocated crown land (UCL) – land in which ‘no proprietary interest other than native title is known to exist’ [445] (Figure 5-1). This includes former pastoral leases covering 3.5% of the Pilbara (0.7 million hectares) that have been earmarked for future conservation reserves, some of which are proposed national parks under Plan for Our Parks.

Native title

Native title has been recognised or is claimed over most (95%) of the UCL area. Most is non-exclusive title. The 4.7% of the UCL estate under exclusive native title should primarily be managed on a day-to-day basis by Traditional Owners, with support from the state.

| Native title (% UCL area) | Exclusive | Non-exclusive | Under claim | Total |
|---------------------------|-----------|---------------|-------------|-------|
| | 4.7% | 84.6% | 5.4% | 94.7% |

Mining

The majority of UCL is under mining leases, with just 29% free of mining activity. About 0.7 million hectares are under production leases and 2.4 million hectares under exploration leases.

| Mining tenements (% UCL area) | Exploration | Production | Total |
|-------------------------------|-------------|------------|-------|
| | 54.1% | 16.8% | 70.9% |

Conservation significance

The UCL estate has high conservation values, as indicated by the prevalence of threatened and priority biota: 24 ecological communities and 168 species.

| Threatened & priority species & ecological communities (number recorded) | Ecological Communities | Animals | Plants |
|--|------------------------|-----------|------------|
| Threatened | 2 | 23 | 2 |
| Priority | 22 | 17 | 127 |
| Total | 24 | 40 | 129 |

Fourteen of these ecological communities have more than 20% of their total extent on UCL, including the following priority 1 communities: Brockman Iron cracking clay communities, Bungaroo, Coolibah – Lignum Flats, sub-type 2, Robe Valley Pisolitic Hills, Roebourne Plains gilgai grasslands, Weeli Wolli, West Angelas, Fortescue Marsh, Coastal dune native tussock grassland and Narbung Land System.

The 145 threatened and priority species with more than 20% of their Western Australian records on UCL in the Pilbara comprise:

- 33 animal species, including the threatened night parrot, northern quoll, ghost bat, Pilbara leaf-nosed bat, Pilbara olive python, Nevin’s slider, grey falcon, painted snipe, and 7 migratory shorebirds (curlew sandpiper, eastern curlew, great knot, lesser sand plover, red knot, greater sand plover, bar-tailed godwit).
- 112 plant species, including the endangered *Aluta quadrata* and *Pityrodia* sp. Marble Bar, 28 priority 1 species, and 17 species known only from UCL.

About 0.5 million hectares (11.5% of the UCL estate) have been identified as an investment hotspot for the Pilbara Environmental Offsets Fund. The offset potential on UCL has been constrained by the extent of mining and exploration leases (71%) and industry aspirations for future mines.

Existing management

Despite high conservation and cultural values, the UCL estate is not comprehensively managed for these values [445]. Administered under the *Land Administration Act 1997* by the Department of Planning, Lands and Heritage, there are no legislated requirements for conservation management, no publicly available relevant policies, and no management plans for properties with high values. There is an increasing focus on fire management (see section 4.4.1) and some 'good neighbour' focus on controlling wild dogs, dingoes and feral herbivores [446]. A 2018 Auditor General report found that contamination on UCL across the state was not being 'managed effectively' [410]. Contamination sources include tailings dumps from mining and chemical storage and disposal. One of the worst contaminated sites in the Pilbara – the largest in the southern hemisphere – is the former asbestos mining site at Wittenoom (adjacent to Karijini National Park) [410].

The former leasehold properties acquired for conservation reserves are managed by the Department of Biodiversity, Conservation and Attractions [446]. These properties are being rehabilitated, initially by destocking, removal of artificial water points, fencing repairs and upgrades to keep out stock, and feral animal and weed control [447].

Conservation opportunities

Indigenous-led conservation management: The recognition of native title over 90% of the UCL estate provides a strong basis for bringing these lands under cultural land management by Traditional Owners. The emerging capacity for large-scale Indigenous land management in the Pilbara requires support for Indigenous rangers and healthy country planning, and facilitation of access where it has been unnecessarily impeded by mining companies. UCL also offers potential for the establishment of Indigenous protected areas.

Establishing formal joint management arrangements on UCL areas with high conservation values would facilitate conservation and constrain harmful uses. UCL is inherently vulnerable to being converted to other tenures that could undermine (or strengthen) conservation management. For example, pastoralists have proposed joint venture arrangements with native title holders to facilitate UCL being converted to pastoral lease.

In neighbouring Kimberley and desert regions, cultural land management is now well established on UCL, with recognition that Traditional Owners are present, willing and capable land managers who have rights to use their land [448–450]. These groups have strong cultural ties to Pilbara Traditional Owners and faced similar challenges in re-establishing cultural land management. They can be of great assistance in the Pilbara by information exchange and mentoring – at forums such as the Indigenous Desert Alliance, the Pilbara Cultural Land Management project (Box 6-5) and the Kimberley Ranger Forum.

Threat management: The priority threats requiring management on UCL are undoubtedly invasive animals, weeds and fire. Much of this work could be contracted to Indigenous ranger teams.

Conservation of significant species and sites: The high prevalence of threatened and priority species and ecological communities on the UCL estate makes it a high priority for conservation projects. Some work could be funded by the Environmental Offsets Fund, although this is constrained by the extent of mining. There may be opportunities for project partnerships between Traditional Owners, the government and researchers.

Rehabilitation and water quality monitoring: Mining has been and remains extensive across the UCL estate, leaving a multitude of sites requiring rehabilitation, including tailings dams and drill rig sites. Some of this work could be contracted to Indigenous rangers. Landscape rehabilitation has been recognised as 'an obvious area for Aboriginal employment' in the Pilbara, with both economic and cultural benefits [451] (Box 6-3). Indigenous rangers could also be contracted by mining companies to monitor water quality, in watercourses and water monitoring bores, thus improving the credibility of monitoring programs.

Nature, cultural and geological tourism: The UCL estate, much of which is scenic, could provide opportunities to establish tourism businesses. A survey by the Western Australia Indigenous Tourism Operators Council identified considerable potential to expand Indigenous-operated tourism ventures in the state. While 20% of leisure visitors had participated in an 'Aboriginal cultural experience', 66% indicated they would do so if it was readily available [452]. One initiative, supported by Tourism WA, is a 'Camping with Custodians' program to provide activities and accommodation on land around national parks in the Pilbara [452]. Tourism ventures operated by Traditional Owners could help fund conservation and cultural land management.

Tourism opportunities unique to the Pilbara include those focused on its ancient and diverse geology – likely to qualify the region as a UNESCO Global Geopark [28]. Geoparks are intended to foster the protection and sustainable use of geological heritage and promote the economic wellbeing of people who live there [453]. Such a designation would undoubtedly increase the geotourism appeal of the Pilbara. In China, the geotourism revenue of 8 geoparks tripled in the 4 years after their creation [454]. Some geotourism promotion already occurs in the Pilbara, with the *Discovery Trails to Early Earth* guide featuring 6 drive trails [8].

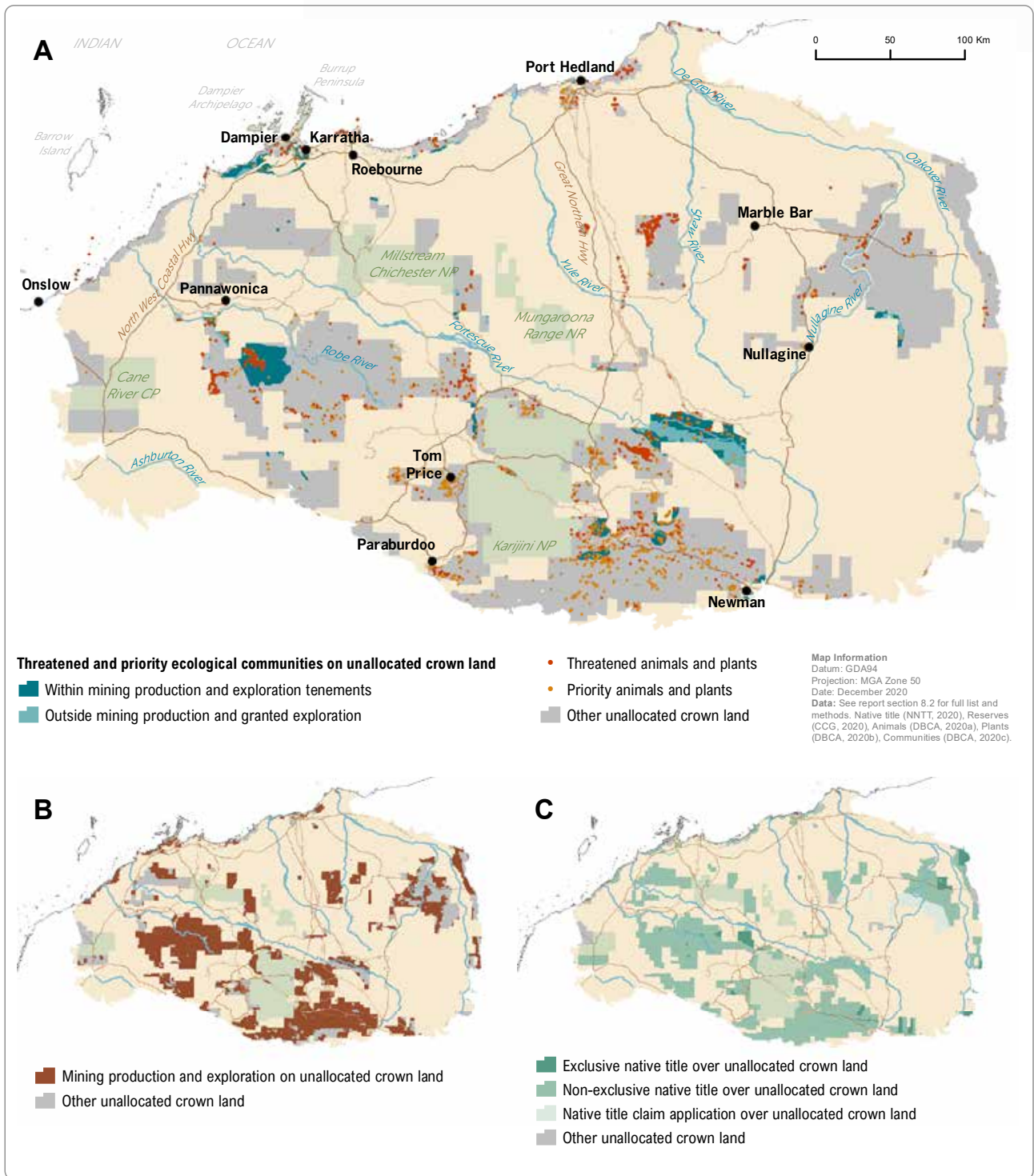


Figure 5-1. Unallocated crown lands in the Pilbara and their overlap with (A) threatened and priority species and mining tenements, (B) threatened and priority ecological communities and mining tenements and (C) native title.

5.3 Opportunities on conservation reserves

Conservation reserves cover just 6.4% of the Pilbara (Figure 5-2). The reserve system would need to expand 2.6-fold to meet the 2020 international area target of 17% (soon to be superseded by a higher target), and more than that to achieve the status of 'comprehensive, adequate and representative' [455]. The majority of threatened and priority species (50% of animals, 62% of plants) and ecological communities (81%) have no protection in reserves.

Native title

Native title, all non-exclusive, has been recognised over only a small proportion (8.0%) of the conservation reserve system. It has been extinguished or found not to exist on almost half (47.8%) the area and has not been subject to a claim on 44.1% of the area. Nonetheless, the Western Australian Government recognises the moral rights of Traditional Owners to have a meaningful role in managing these lands – although this has mostly not been achieved in practice in the Pilbara.

One possibility is that future native title compensation claims for parts of the Pilbara's conservation estate created after 30 October 1975 (when the Commonwealth's Racial Discrimination Act was passed) could trigger negotiations for improved joint management arrangements as part of a negotiated settlement with the Western Australian government (for example, over parts of Millstream Chichester National Park and Cane River Conservation Park) [456,457]. The recently passed Native Title Legislation Amendment Bill 2019 (Cth) allows historical extinguishment of native title 'over areas of national and state park to be disregarded where the parties agree'.

Whatever mechanism is used, Traditional Owners will almost certainly be seeking improved joint management arrangements over the Pilbara's national parks and other conservation properties.

| Native title (% reserve system) | Exclusive | Non-exclusive | Under claim | Total |
|------------------------------------|-----------|---------------|-------------|-------|
| | 0% | 8.0% | 0% | 8.0% |

Mining

Most of the conservation estate (93%) is free of mining activity. But this does not account for significant historical excisions. For example, a section of Karijini National Park was controversially excised in 1991 for Rio Tinto's Marandoo Mine and rail corridor, which slices the park in half. Dedicated management is necessary to manage their impacts [458,459]. While not directly impacted by mining, the precious rock art and cultural values of Murujuga National Park are at risk from industrial emissions from the adjacent Burrup and Maitland industrial estates [460,461].

| Mining tenements (% reserve system) | Exploration leases | Production leases | Total |
|--|--------------------|-------------------|-------|
| | 6.1% | 0.9% | 7.0% |

Conservation significance

The Pilbara's conservation reserves include several with values of acknowledged national and global significance. Dampier Archipelago, including Murujuga, is listed as a National Heritage place, and a World Heritage nomination for Murujuga National Park has been submitted. The high natural, geological and aesthetic values of Karijini National Park were recognised by its entry on the Register of the National Estate (now closed) [301].

The values of the Pilbara's conservation reserves are also indicated by the prevalence of threatened and priority biodiversity: 7 ecological communities and 98 species.

| Threatened & priority species & ecological communities (number recorded) | Ecological Communities | Animals | Plants |
|---|------------------------|-----------|-----------|
| | Threatened | 0 | 16 |
| Priority | 7 | 12 | 69 |
| Total | 7 | 28 | 70 |

Four of these ecological communities have more than 20% of their total extent in conservation reserves, including the following priority 1 communities: Burrup Peninsula rock pile communities, Burrup Peninsula rock pool communities and Coolibah – Lignum Flats sub type 3.

The 48 threatened and priority species with more than 20% of their Pilbara records in conservation reserves comprise:

- 12 animals, including the threatened fairy tern, greater sand plover, lesser sand plover, green turtle, hawksbill turtle and flatback turtle.
- 36 plants, including the threatened *Thryptomene wittweri* and priority 1 *Barbula ehrenbergii*, *Pentalepis trichodesmoides* subsp. *incana*, and *Rhodanthe ascendens*
- 8 plants only found in conservation reserves.

The reserves are also valuable tourism and recreational assets. Karijini National Park, renowned for spectacular gorges, waterfalls, rugged landscapes and prolific wildflowers, attracts about 300,000 visitors a year [301,452].

Existing management

The management of conservation reserves in the Pilbara suffers from inadequate staff and funding (section 4.2), out-of-date management plans [391], and mostly limited involvement of Traditional Owners. Only one protected area in the Pilbara is jointly managed with Traditional Owners – Murujuga National Park, which is Aboriginal freehold land leased to the state [462]. Other parks have Aboriginal advisory councils, but their effectiveness is variable [301]. An assessment of Karijini National Park found that staff and resources were spread too thinly and focused mainly on visitor management [301].

Conservation opportunities

Expansion of the protected area network: Despite the constraints imposed by mining, expanding the conservation reserve system in the Pilbara should be a high priority (section 4.2). The Western Australian Government's Plan for Our Parks proposed one new reserve for Fortescue Marsh, and additional reserves as contingencies (if needed to meet the government's goal to protect 5 million hectares) – a Meentheena reserve and expansion of Karijini National Park [98,463]. In June 2021, the Western Australian Government decided to proceed with both of these contingency options [464]. Adding these and other former leasehold properties acquired for conservation to the conservation estate would strengthen protection for more than 90 threatened and priority species and 6 priority ecological communities and increase bioregional protection to about 10% [389].

Improved reserve management: More funding is needed to strengthen threat management in reserves and provide services for visitors. The establishment of joint management arrangements with Traditional Owners and support for Indigenous rangers would bring cultural, social and economic as well as conservation benefits (see section 6.2).

Carbon farming: In August 2020 the Western Australian Government launched a 'carbon for conservation' project – inviting carbon farming proposals for 7 conservation reserves, including Karijini National Park [465]. Potential activities include revegetation, removal of feral herbivores, and fire management – to increase carbon stores and enhance 'conservation and cultural outcomes for Aboriginal people'. This represents an excellent opportunity for service providers to partner with Karijini Traditional Owners.



Dales Gorge, a popular tourism site in Karijini National Park, features Fortescue Falls, one of very few permanent waterfalls in the Pilbara. Image: Jessica Wyld

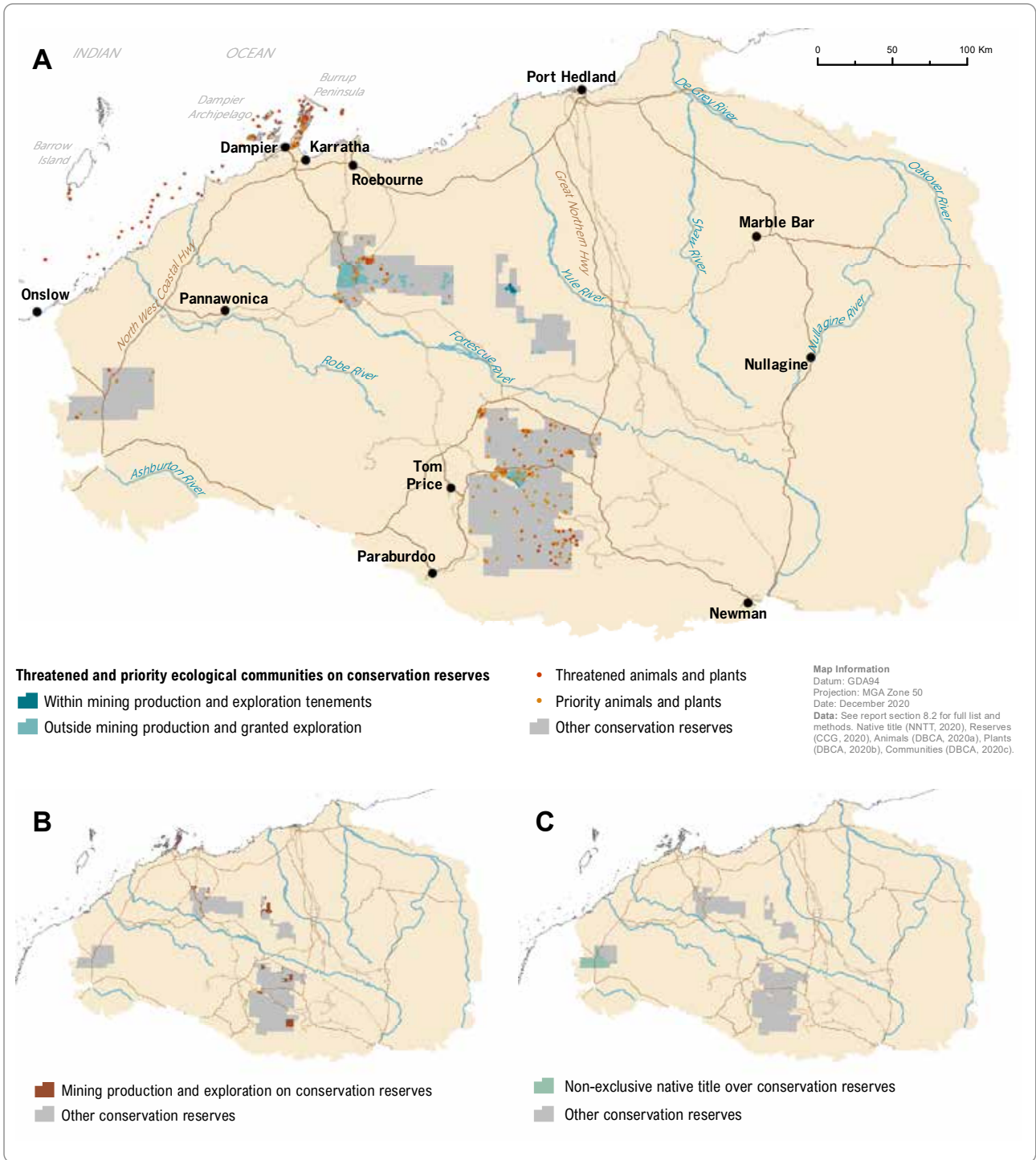


Figure 5-2 Conservation reserves in the Pilbara and their overlap with (A) threatened and priority species and mining tenements, (B) threatened and priority ecological communities and mining tenements and (C) native title.

5.4 Opportunities on other crown reserves

A variety of crown reserves cover 0.9 million hectares, about 5% of the Pilbara (Figure 5 3). They include large reserves protecting water catchments, several reserves for commons, and stock routes, which are no longer used for travelling stock.

| Other reserves (% Pilbara) | Commons | Stock routes | Water supply | Other | Total |
|----------------------------|---------|--------------|--------------|-------|-------|
| | 0.4% | 1.3% | 2.0% | 1.4% | 5.1% |

Native title

Native title has been recognised or is under claim over almost half the area of these crown reserves, particularly on stock routes (92.8%) and 'other' reserves (47.2%) but has been extinguished or found not to exist over most of the water supply reserves.

| Native title (% other reserves area) | Exclusive | Non-exclusive | Under claim | Total |
|--------------------------------------|-----------|---------------|-------------|-------|
| | 0% | 37.5% | 9.3% | 46.8% |

Mining

More than half the area is under mining tenements, leaving 42% free of mining activity.

| Mining leases (% other reserves area) | Exploration leases | Production leases | Total |
|---------------------------------------|--------------------|-------------------|-------|
| | 50.6% | 7.0% | 57.6% |

Conservation significance

Several reserves, particularly those categorised here as 'other', have high conservation values, as indicated by the prevalence of threatened and priority biota totalling 14 ecological communities and 83 species.

| Threatened & priority species & ecological communities (number recorded) | | Ecological Communities | Animals | Plants |
|--|--------------|------------------------|-----------|-----------|
| | | Threatened | 1 | 19 |
| | Priority | 13 | 13 | 51 |
| | Total | 14 | 32 | 51 |

Three priority ecological communities have more than 20% of their total extent on other crown reserves, including the following priority 1 communities: Burrup Peninsula rock pile communities and Roebourne chenopod association.

Thirty-three threatened and priority species have more than 20% of their records in this tenure category, comprising:

- 13 animal species, including the threatened curlew sandpiper, eastern curlew, great knot, lesser sand plover and greater sand plover), Nevin's slider and flatback turtle; there are also many records for bilbies.
- 18 plant species, including the following priority 1 species with more than 50% of their records in these reserves: *Ptilotus wilsonii*, *Goodenia pallida*, *Tephrosia rosea* var. Port Hedland, *Gomphrena pusilla*, *Eremophila capricornica*, *Stemodia* sp. Battle Hill.

Only a small proportion of this tenure category (4.1%, about 40,000 hectares) has been identified as an investment hotspot for the Pilbara Environmental Offset Fund.

| Offset hotspots (% other reserves area) | Commons | Stock routes | Water supply | Other | Total |
|---|---------|--------------|--------------|-------|-------|
| | 11.7% | 7.1% | 0% | 4.9% | 4.1% |

Existing management

There are no legal requirements for these lands to be managed for their conservation and cultural values. Most stock routes are unfenced and therefore likely to be used for pastoralism. A quarter of the 'common' reserves area is used for mining production and close to or more than half the common, water supply and other reserves are under exploration leases. Indicative of a lack of management is a 2018 Auditor General report finding that contamination on unmanaged reserves is 'not being managed effectively' [410].

Conservation priorities and opportunities

Indigenous-led conservation management: With native title recognised on close to half the extent of this tenure category, there are opportunities to bring some of these lands under cultural land management by Traditional Owners. This will require support for Indigenous rangers and, in some cases, facilitation of access where it has been unnecessarily impeded by mining companies. Some government and mining company responsibilities for land management could be contracted to Indigenous ranger teams. The opportunities on stock routes may be constrained due to their narrow linearity unless adjacent lands are also managed.

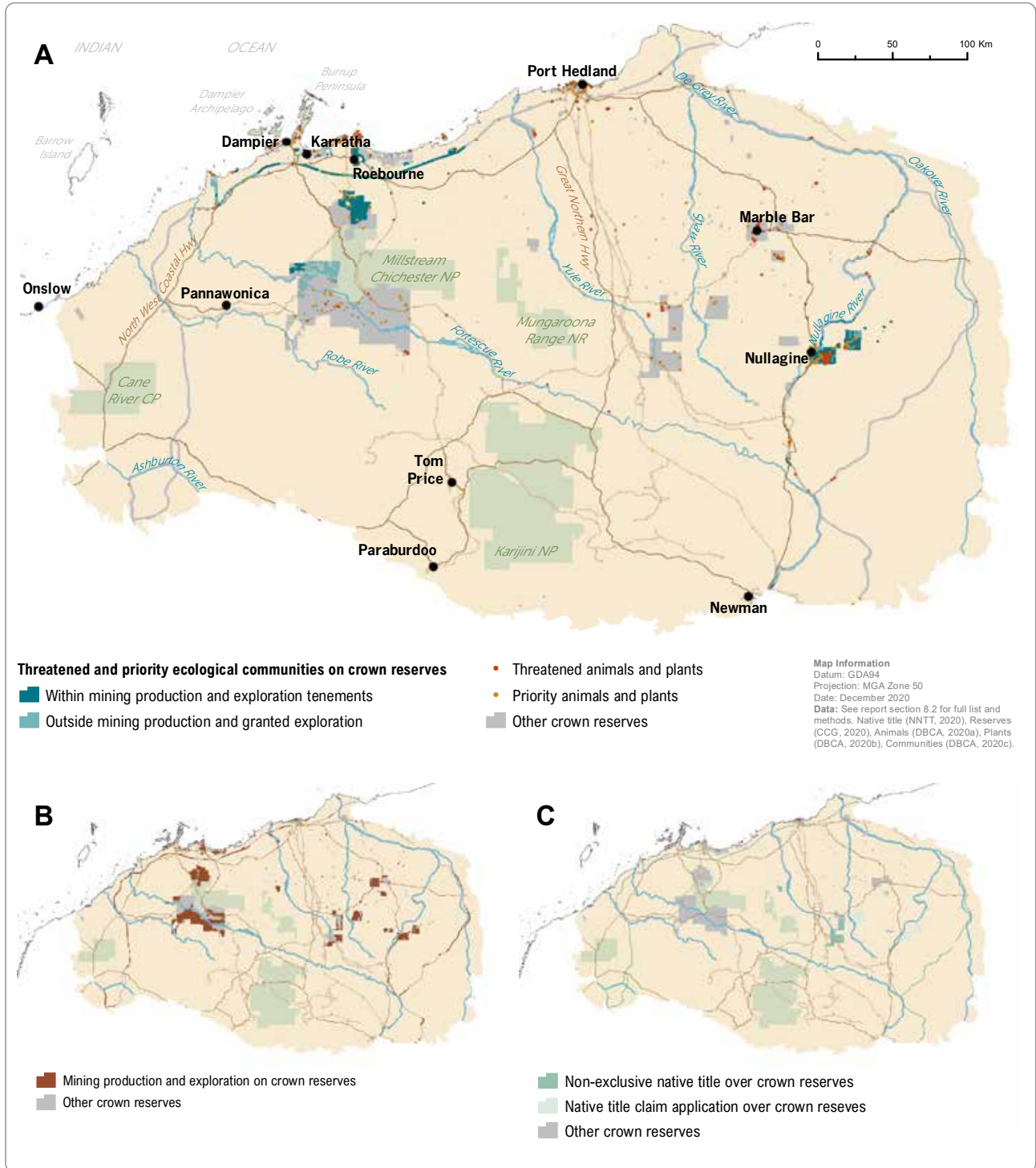


Figure 5-3. Crown reserves (other than conservation reserves) in the Pilbara and their overlap with (A) threatened and priority species and mining tenements, (B) threatened and priority ecological communities and mining tenements and (C) native title.

5.5 Opportunities on Aboriginal-managed land

Extent and tenures

Land currently managed by Aboriginal people in the Pilbara covers about 2 million hectares (11.5% of the region) (Figure 5-4). It includes pastoral leases, land held by the Aboriginal Lands Trust, and the Woodstock Abydos Protected Reserve.

| Aboriginal-managed land (% Pilbara) | Aboriginal Lands Trust – pastoral leases | Aboriginal Lands Trust – other land | Other pastoral leases | Woodstock Abydos | Total |
|-------------------------------------|--|-------------------------------------|-----------------------|------------------|-------|
| | 1.3% | 2.8% | 6.5% | 0.9% | 11.5% |

Native title

Native title has been recognised or is under claim on most (85%) Aboriginal-managed land, close to half of it as exclusive title, particularly on the Aboriginal Lands Trust estate (81% exclusive) and Aboriginal-owned pastoral leases (35% exclusive).

| Native title (% Aboriginal-managed land) | Exclusive | Non-exclusive | Under claim | Total |
|--|-----------|---------------|-------------|-------|
| | 46.9% | 37.8% | 0.4% | 85.1% |

Mining

This land category is unusual in the Pilbara for having the majority of its area (64%) free from mining and only a small proportion (4%) under mining production leases. However, this doesn't account for excisions. Since the late 1970s, when the former Woodstock Abydos pastoral leases became a special purpose reserve and Aboriginal protected area, Fortescue Metals Group and Hancock Prospecting have been granted excisions for rail infrastructure corridors. Including a BHP railway built in the 1960s, 3 separate railways with associated infrastructure now cross Woodstock Abydos [466] (Box 5-3). Australia's state of the environment report said this showed that 'even the highest form of protection available for Aboriginal heritage sites under Western Australian law may not be a guarantee of protection', and noted the 'serious cumulative adverse effect' of multiple individual approvals [466].

| Mining tenements (% Aboriginal-managed land) | Exploration leases | Production leases | Total |
|--|--------------------|-------------------|-------|
| | 32.2% | 4.1% | 36.3% |

Conservation significance

These lands are known to harbour 5 threatened and priority ecological communities and 30 threatened and priority species. Eight priority plant species have more than 20% of their records in this tenure category, including the priority 1 species *Cochlospermum macnamarae* and *Josephinia* sp. Woodstock.

| Threatened & priority species & ecological communities (number recorded) | | Ecological Communities | Animals | Plants |
|--|--------------|------------------------|-----------|-----------|
| | | Threatened | 1 | 6 |
| | Priority | 4 | 7 | 17 |
| | Total | 5 | 13 | 17 |

Woodstock Abydos has been one of the most intensively studied areas in the Pilbara. Surveys in the late 1990s found that the reptile diversity of 67 species was 'one of the richest recorded in Australia', almost two-thirds of the total recorded for the entire Chichester subregion [467]. The diversity of small mammals on Woodstock Abydos is also rich compared to most other arid zone regions [468]. Woodstock Abydos also has outstanding cultural values, including rock art of international significance, which has attracted archaeological research since the 1950s [469,470] (see Box 5-3).

About a fifth of Aboriginal-managed land, including almost three-quarters of Woodstock Abydos, is part of the identified investment hotspots for the Pilbara Environmental Offsets Fund [394].

| Investment hotspots (% Aboriginal-managed land) | Aboriginal Lands Trust – pastoral leases | Aboriginal Lands Trust – other land | Other pastoral leases | Woodstock Abydos | Total |
|---|--|-------------------------------------|-----------------------|------------------|-------|
| | 15.2% | 10.2% | 10.0% | 72.7% | 18.5% |

Existing management

With the exception of areas excised for mining infrastructure, the Woodstock Abydos reserve is a protected area (under the *Western Australian Aboriginal Heritage Act 1972*), held by the Western Australian Government since a lease held by the Mumbultjari Aboriginal Corporation was revoked in 2006 [469]. The Budadee Aboriginal Corporation, with support from the Palyku-Jartayi Aboriginal Corporation, operates a ranger team on Woodstock Abydos for the purpose of protecting its 'cultural and environmental integrity' [471] and have prepared an environmental management plan [472]. The Budadee Rangers, however, do not hold a management order for the reserve (Box 5-3). Environmental work has included surveys of significant species, feral animal monitoring and removal, weed control, seed collection and the identification of culturally significant places for rehabilitation.

On other Aboriginal-managed properties – most of which are pastoral properties (covering 7.8% of the Pilbara) – a lack of resources for Indigenous rangers has limited the capacity for large-scale conservation management.

Conservation priorities and opportunities

Indigenous-led conservation management: With more support for Indigenous ranger teams and healthy country planning, much more of this Aboriginal-managed land category could be managed to protect the conservation and cultural values. As elsewhere, the priority threats requiring management are likely to be invasive animals, weeds and fire, as well as grazing pressure on pastoral lands. There is potential for funding support from the environmental offsets fund, particularly on Woodstock Abydos.

Mining rehabilitation: With more than a third of this land category under mining leases (as well as legacy impacts from previous mining activity), there are likely to be many opportunities for Indigenous rangers to be contracted to undertake rehabilitation work. The Budadee ranger team offers environmental monitoring, water quality testing and weed control services [472].

Indigenous protected areas: IPAs are 'areas of land and sea managed by Indigenous groups as protected areas ... through voluntary agreements with the Australian Government' [473]. Australia has 78 IPAs, making up about 46% of the National Reserve System [473]. But there are none in the Pilbara – likely due to capacity constraints on Traditional Owners (in part due to a necessary focus on protecting cultural heritage from mining) as well as limited federal funding for the IPA program. Through the Pilbara Cultural Land Management Project (Box 6-5), several Traditional Owner groups have expressed a desire to establish IPAs. The successful Nyangumarta Warran IPA just north of the Pilbara is an exemplar that Pilbara Traditional Owners wish to emulate. In addition to enormous conservation benefits, IPAs provide social, economic and cultural benefits – including Indigenous employment and training, economic development, cultural maintenance, language revival, improved health and wellbeing [474].

Carbon farming: There are currently few opportunities in the Pilbara for carbon farming by the conservation methods accepted under the federal government's Climate Solutions Fund [475]. The accepted method – 'human induced regeneration of a permanent even-aged native forest' – relies on a definition of 'forest' that mostly does not apply in the Pilbara [476]. The only vegetation likely to qualify occurs mainly along the headwaters of the Ashburton and Gascoyne rivers. The regeneration method also does not recognise changed fire management as an eligible activity. However, there may be opportunities in future if the permitted method is expanded to apply to 'all vegetation types and a variety of land management activities', as has been recommended by some practitioners [477]. We understand that the carbon industry is on the cusp of expanding into the Pilbara, based on human-induced regeneration. This would add to options for Indigenous groups to diversify land use, achieve their cultural and economic goals and revitalise landscapes.



Woodstock Abydos Protected Reserve is the country of the Palyku and Kariyarra peoples. Image: Bill Kruse

Nature and cultural tourism: Tourism can support meaningful work on country that also helps sustain conservation management. One initiative, supported by Tourism WA, is a 'Camping with Custodians' program to provide activities and accommodation around national parks in the Pilbara [452]. Another opportunity is permit systems that provide tourists with access to Aboriginal-managed lands and income for Traditional Owners [478–480].

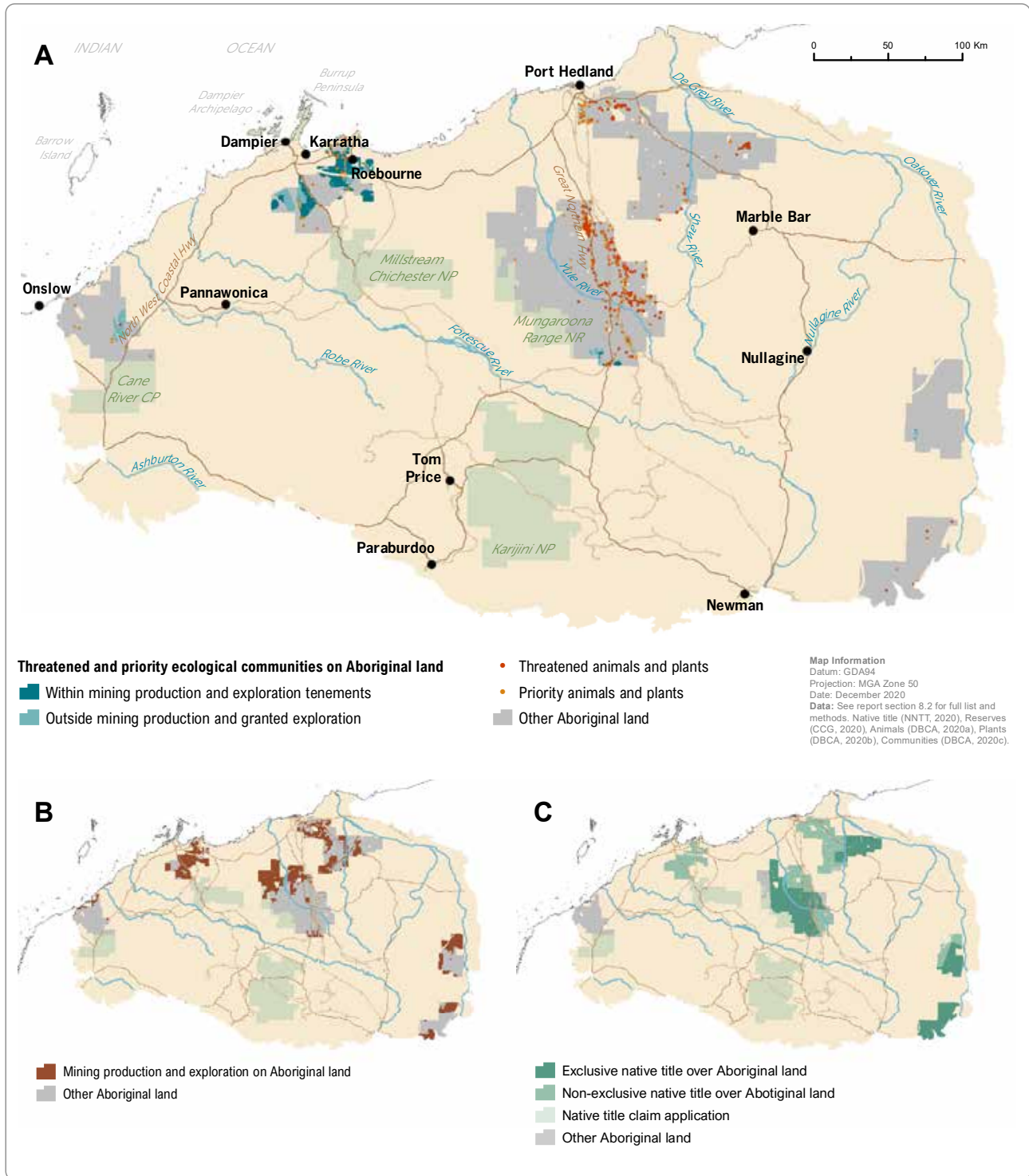


Figure 5-4. Aboriginal-managed lands in the Pilbara and their overlap with (A) threatened and priority species and mining tenements, (B) threatened and priority ecological communities and mining tenements and (C) native title

Box 5-3. Woodstock Abydos Reserve

Indigenous laws would never have allowed for the damage or destruction of ancient sites such as those found in the Woodstock-Abydos Reserves. Doing so would not only be unlawful, but madness – for anyone who harmed such a place would ultimately be harming themselves.

Sally Morgan & Ambelin Kwaymullina (2007) [481]

Woodstock (traditionally known as Tharra) and Abydos are the lands of the Palyku and Kariyarra peoples. This approximately 150,000 hectare special purpose reserve on the spinifex-clad, stony granitic plains of the Chichester subregion has extremely high cultural significance – it is ‘one of the oldest and richest rock engraving sites on the planet,’ with tens of thousands of images etched into bedrock, boulders and granite hills [481]. The distinctive rock engravings are of recognised national significance – the site was listed on the Register of the National Estate in 1980 – and likely to be of international significance [482]. The site was nominated for the West Australian State Heritage Register in 2006, but the assessment has not been finalised. The area is regarded as sacred by Aboriginal people across the Pilbara, for the songlines that pass through, connecting several communities through traditional law [483].

The recent history of Woodstock Abydos exemplifies the social and environmental upheavals following European colonisation. The land was leased as 2 pastoral stations in the early 1880s. As elsewhere in the north-west, Traditional Owners were integrated into the pastoral workforce through a combination of force, necessity and interest in what settlers could offer. Family histories and stories of the pastoral period remain an important part of the Traditional Owners’ attachment to country [484–486].

Woodstock and Abydos were abandoned after just 60 years as pastoral stations, after sheep numbers dropped catastrophically – from a peak in 1933 of some 33,000 to just 7,200 in 1944 [487]. Pasture degradation, drought, depredation by dingoes, competition from burgeoning wallaroo populations, plagues of grasshoppers and mice, and the arrival of the blowfly were variously blamed for the regional industry collapse [221,223,487]. More than a dozen stations were abandoned [488].

For the next 30 years, Woodstock and Abydos were used for agricultural research, and much was learned about pasture degeneration caused by sheep, the impacts of fire on pasture, and the ecology of wallaroos [229,468]. A trial of cattle grazing found no detrimental impacts on pasture at a low stocking rate, but the production potential on spinifex pastures was rated ‘very low’ [489].

In 1978, Woodstock Abydos was vested in the Western Australian Museum for ‘preservation of Aboriginal cultural materials and historic buildings, and grazing’ and was also declared, in 1979, a protected area under the Aboriginal Heritage Act [223]. Museum researchers recorded highly diverse reptile and small mammal populations, and noted a partial recovery towards ‘the pre-pastoral state’ with extensive regeneration of perennial grasses [223]. Cattle grazing continued in the western part under an informal agreement with neighbouring Aboriginal pastoralists from the Yandeyarra reserve [223].

In 1991, the reserve was transferred to the Mumbultjari Aboriginal Corporation [223]. But their lease was revoked in 2006, during the period when Fortescue Metals Group was progressing plans to construct a railway through Woodstock Abydos. The excision for a railway was granted against the advice of the government’s Aboriginal heritage committee and objections from Palyku people [481,491].

Three separate iron ore railways now cross Woodstock Abydos: one each for Fortescue Metals, BHP and Hancock Prospecting – a ‘striking’ example of ‘development incrementally disturbing an area of outstanding heritage significance’ [466]. Another heritage loss has been the vandalism and dilapidation of the historic Woodstock homestead (after the 2006 revocation of Mumbultjari Aboriginal Corporation’s management order).

No management order for a third party to manage Woodstock Abydos has been granted since the lease was revoked. Nonetheless, since 2012, a Budabee ranger team has been operating there to protect cultural and natural heritage.

In combination with the adjacent Yandyerra reserve, Woodstock Abydos has the potential to become a significant employment hub based on tourism and cultural heritage – it is an inland Burrup Peninsula full of rock art. It also has a sizeable grazing area. The Woodstock Abydos special reserve and Aboriginal protected area were created to protect one of the most significant rock art precincts in Australia. There are many compelling reasons for it to be returned to its Traditional Owners.

5.6 Opportunities on pastoral leases

Extent and ownership

Pastoral leases in the Pilbara cover 10.6 million hectares, about 60% of the region (Figure 5-5). About a quarter of that area is leased by mining companies and an eighth by Indigenous interests. The remaining two-thirds of the estate is mainly leased by individuals or Australian companies. Aboriginal-owned leases are mainly considered in section 5.5 as Aboriginal-managed land.

| Pastoral lease ownership (% Pilbara) | Mining companies | Indigenous owners | Other ownership | Total |
|--------------------------------------|------------------|-------------------|-----------------|-------|
| | 14.4% | 7.7% | 37.4% | 59.5% |

Native title

Native title has been recognised or is under claim on most (93%) of the pastoral lease estate. The 480,000 hectares (4.5% of the estate) recognised as exclusive title are almost wholly on Indigenous-owned leases.

| Native title (% pastoral lease area) | Exclusive | Non-exclusive | Under claim | Total |
|--------------------------------------|-----------|---------------|-------------|-------|
| | 4.7% | 82.3% | 5.8% | 92.6% |

Mining

Just over half the pastoral lease area is under mining tenements, leaving 45% free of mining activity. About 1.2 million hectares is under production leases and 4.6 million hectares under exploration leases.

| Mining tenements (% pastoral lease area) | Exploration leases | Production leases | Total |
|--|--------------------|-------------------|-------|
| | 43.5% | 11.5% | 55.0% |

Conservation significance

The pastoral leasehold estate has very high conservation values, as indicated by the prevalence of threatened and priority biota totalling 23 ecological communities and 188 species. One reason for the high conservation values is that pastoral leases in the Pilbara are large (230,000 ha on average [492]) and that grazing is not uniform. Many leases include rugged and rocky areas – often with high conservation values – inaccessible to cattle or only lightly grazed.

| Threatened & priority species & ecological communities (number recorded) | Ecological Communities | Animals | Plants |
|--|------------------------|-----------|------------|
| | Threatened | 2 | 25 |
| Priority | 21 | 21 | 140 |
| Total | 23 | 46 | 142 |

Twenty-two of these ecological communities have more than 20% of their total extent on pastoral leases, including the following threatened and priority 1 communities with more than half their area on pastoral leases: Themeda grasslands, Tanpool, Brockman iron cracking clay communities, Freshwater claypans of the Fortescue Valley, Robe Valley mesas, Robe Valley pisolitic hills, sand sheet vegetation (Robe Valley), Fortescue Valley sand dunes, Nyeetberry Pool and Wona Land System.

Threatened and priority species with more than 20% of their Pilbara records on pastoral leases comprise 156 species:

- 35 animal species including the threatened night parrot, bilby, Pilbara olive python, Pilbara leaf-nosed bat, ghost bat, great desert skink and grey falcon
- 121 plant species, including the endangered *Aluta quadrata* and 39 priority 1 species
- 24 priority plant species known only from pastoral leases.

Almost 1 million hectares of pastoral leasehold land (9.2% of the estate) have been identified as investment hotspots for the Pilbara Environmental Offsets Fund.

| Offset hotspots (% pastoral lease area) | Mining company ownership | Indigenous ownership | Other | Total |
|---|--------------------------|----------------------|-------|-------|
| | 11.2% | 15.0% | 7.3% | 9.2% |

Existing management

WA does not have a stewardship program in the rangelands to attain sustainable land management and protect the environment for future generations.

Western Australian Auditor General (2017) [231]

The *Land Administration Act 1997* requires pastoral lessees to manage their lease 'to its best advantage as a pastoral property' and 'use methods of best pastoral and environmental management practice', and the Pastoral Lands Board must ensure that 'pastoral leases are managed on an ecologically sustainable basis'. However, a 2017 audit by Western Australia's auditor general found there was no agreed understanding of what ecological sustainability required and that administration of leases was inadequate to achieve it [231]. Noting there had been at least 8 reports since 1940 highlighting systemic problems with pastoral land management, the auditor general said progress to halt a decline in pastoral land condition had been limited [231]. In 2019 the Western Australian Government released draft guidelines for pastoral management that defined ecological sustainability as follows [493]:

The management, development and use of natural resources relevant to pastoral operations being undertaken on the land, with an aim to meet the needs of today while conserving ecosystems for the benefit of future generations.

What this requires is not clear from the draft guidelines. There is little focus on biodiversity, and threatened species are mentioned only in the context of fire management. The most recent assessment of the condition of pastoral lands in the Pilbara found that cattle numbers exceed the estimated 'potential carrying capacity' in all districts [232].

Pastoralists manage some threats that impact both biodiversity and productivity – particularly feral herbivores such as donkeys and camels and weeds such as mesquite. Other threats to biodiversity such as feral cats and buffel grass are mostly not managed because they are either not a threat to production or, in the case of buffel grass, they are valued for production.

Conservation opportunities

As is legally required, ecological sustainability should be at the heart of pastoralism. To achieve this and elevate biodiversity as a management priority on pastoral leases will require stewardship support to increase the economic feasibility and appeal of conservation activities (Box 6-6).

With native title recognised over most of the pastoral estate, there will be increasing interactions with Traditional Owners as they exercise their rights of access. This will provide opportunities to integrate pastoral land management with conservation and cultural land management in partnerships with Traditional Owners (see section 6.3.2). Indigenous ranger programs can provide fire, feral animal and weed management services often also valuable for pastoralism. An additional benefit can be two-way learning through the sharing of traditional ecological knowledge and pastoral management practices.

Opportunities on pastoral leases have been hindered by a generally conservative approach to working with native title holders. The pastoral industry has done little to explore the potential for positive agreements with Traditional Owners for cooperative land management. Where agreements do exist, they tend to curtail access for native title holders with a focus on limiting the impact or potential of native title rights [436,437]. Miner-owned pastoral leases provide an opportunity for cultural and conservation land management via existing partnerships with Traditional Owners established through mining agreements. For example, Rio Tinto's 6 pastoral leases in the Pilbara are all subject to agreements with Traditional Owners.

Threat management: As for other land managers, the primary banes for pastoralists are feral animals, weeds, and fire. Controlling these threats mostly makes economic sense and is legally required. The draft pastoral management guidelines suggest that Traditional Owners, 'if engaged appropriately', could provide significant insights and assistance – for example, by applying Aboriginal fire regimes [493]. Once Indigenous ranger teams have sufficient capacity, they may be available for mutually beneficial arrangements with pastoralists that enable Traditional Owners to reconnect to their country and provide pastoralists with skilled management services.

Stewardship – protection of significant sites and species:

The high conservation values of the pastoral estate are compelling reason for the Western Australian Government to develop a rangelands stewardship scheme. This was recommended in a 2009 review by the Department of Primary Industries, and the lack of such a scheme was noted in the 2017 audit of pastoral land management [231]. Stewardship schemes often provide both pastoral and environmental benefits – for example, waterpoint management to protect springs and rivers can achieve higher quality drinking water for cattle and better stock control (Box 6-6). They also contribute to creating a social licence for pastoralism, an increasing focus of the industry. There is an emerging national commitment by industry associations to strengthen support for stewardship, exemplified by the Australian Beef Sustainability Framework [494] and the National Farmers Federation's call for an environmental stewardship fund to help farmers achieve a 2030 vision of being recognised as 'trusted and proactive stewards' [495]. The Australian Government recently announced a \$30 million agriculture biodiversity stewardship pilot program [496].

Conservation covenants: A stewardship scheme could be coupled with a covenanting program to enable long-term protection for significant sites. In Queensland covenants cover 4.5 million hectares (equivalent to 26% of the Pilbara), most of it on pastoral leases (see Box 5-4).

Environmental offsets: One source of potential funding for conservation work on pastoral properties is the Pilbara Environmental Offsets Fund. About 1 million hectares of pastoral lands have been classed as investment hotspots [394].

Carbon farming: As noted above (section 5.5), there are currently few opportunities in the Pilbara for carbon farming by the conservation methods accepted under the federal government's Climate Solutions Fund [475]. But this may change soon with the likely expansion of the carbon industry into the Pilbara.

Nature and cultural tourism: Tourism offers the opportunity for income diversification and an incentive to protect significant sites.



Because most of the Pilbara has low pastoral productivity, sustainable diversification opportunities such as carbon farming, biodiversity offsets and tourism offer the potential to increase both sustainability and profitability. Image: Krystle Wright

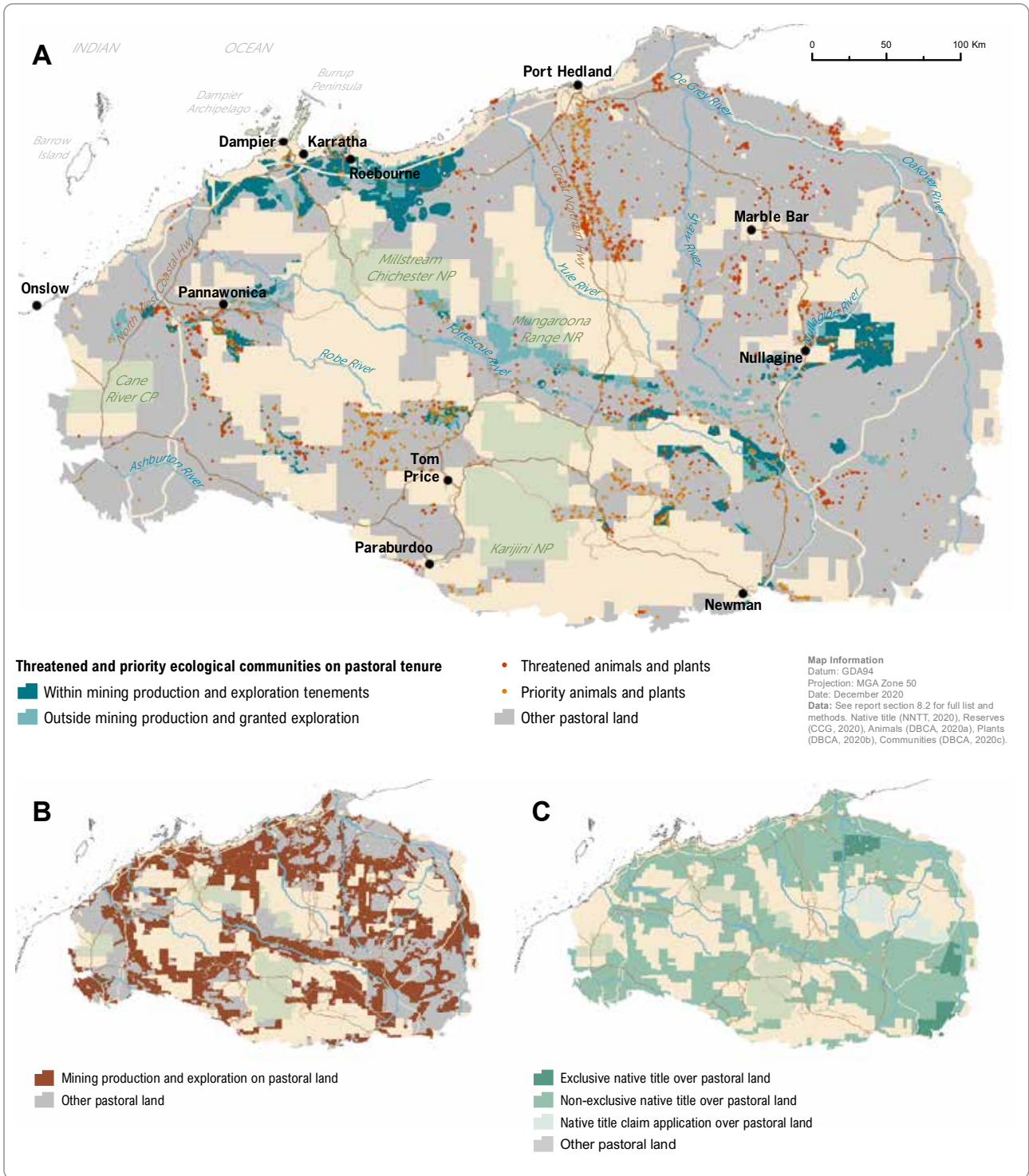


Figure 5-5. Pastoral leases in the Pilbara and their overlap with (A) threatened and priority species and mining tenements, (B) threatened and priority ecological communities and mining tenements and (C) native title.

Box 5-4. Conservation covenants on Queensland pastoral leases

Queensland has the largest private protected area network in the country, with more than 500 nature refuges covering about 4.5 million hectares, making up 30% of the Queensland protected area estate [497]. More than three-quarters of this area is on the pastoral estate.

Nature refuges are declared voluntarily, mostly as a perpetual covenant, committing current and future landholders to protect and restore conservation values on the declared area, based on a conservation agreement with the Queensland Government.

Sixty-seven nature refuges, across 3.6 million hectares, are on pastoral properties. Most are perpetual covenants and 11 are larger than 100,000 hectares [498].

AgForce Queensland has supported the nature refuge program since 2007, and says the demand by landholders to enter into nature refuge agreements has increased exponentially [499]. The organisation supports the program because it is based on voluntary agreements negotiated with the Queensland Government, recognises the role of pastoralists in protecting significant values, allows the continuation of primary production, recognises individual management requirements, does not change public access to properties, and provides incentives and assistance for landholders to meet their obligations [499].

A recent independent assessment of the program found that participants were 'overwhelmingly positive' about nature refuges [497]. In addition to the personal rewards, 70% said their nature refuge had helped them achieve business goals, such as the promotion of nature-based activities (28%), better market advantage (19%), and greater resilience to drought (9%). The majority also saw nature refuges as a means of accessing funding for land management or infrastructure projects such as fencing or moving watering points. More than two-thirds of the nature refuge landholders surveyed said the conservation values on their property had significantly (44%) or slightly improved (25%).



Rolling hills clad in spinifex with small gum trees is one of the characteristic landscapes of the Pilbara. This is Karijini National Park, the traditional lands of the Banjima, Kurrama and Innawonga peoples. Image: Pauline Kirby



6. A conservation economy for the Pilbara

The ancient rocks underpinning the biological richness of the Pilbara also drive its current economy – the 800 million tonnes of iron ore shipped from the Pilbara in 2019 generated more revenue than the entire economies of about two-thirds of the world's countries [244,500]. But while the rocky landscape has fostered ecological diversity, the mining-dominated economy has tended to suppress economic diversity.

Mining also dominates public and political perceptions of the Pilbara, with the region famed as a 'mining powerhouse' rather than 'biodiversity hotspot'. A recent tourism study found that most of the study population (in Perth, Sydney and Melbourne) did not know anything about the Pilbara, and that dominating perceptions were of mining and red dirt [501]. The common misperception of the Pilbara as just a mining precinct has tended to perpetuate an over-reliance on resource industries, blinkering decision-makers to other economic options focused on the Pilbara's outstanding environmental and cultural values.

In this chapter, we present a vision for an expanded conservation economy in the Pilbara to supplement (not replace) the existing mining and agricultural economies. What we propose has been proven elsewhere in Australia, although not yet achieved at such scale in a landscape with such complex overlapping rights and interests. Based on outcomes elsewhere, it represents an opportunity to diversify the Pilbara economy, generate new jobs and increase local prosperity, while reversing environmental decline and sustaining Traditional Owner cultures.

6.1 The promise of a conservation economy

[M]ining cannot sit comfortably with the concept of sustainability, unless there is directed focus on developing the region's other capital—the social, cultural, human and environmental.

Sarah Holcombe (2010) [451]

The United Nations Environment Programme defines a conservation ('green') economy as 'one that improves human well-being and builds social equity while reducing environmental risks and scarcities' [502]. The activities in a conservation economy are focused on maintaining and restoring natural capital and producing lasting environmental, social and financial value [503,504]. A more direct way of putting it, as expressed by Reg Sambo of the Murujuga Circle of Elders, is [108]:

If we look after our Country, the Country will look after you. Our oldest saying.

Conservation has already been identified as a 'critical' economic sector in northern Australia 'in terms of employment, tourism, and income generation from carbon farming and sequestration' [505]. In the Pilbara, core activities in a conservation economy would include:

- cultural and conservation land management on Aboriginal lands guided by healthy country planning and implemented by Indigenous ranger teams, and complementary activities such as cultural tourism, environmental offsets work and two-way science programs

- conservation management across all tenures, including a strong focus on conservation-aligned diversification on pastoral lands compatible with maintaining pastoral production
- delivery of biodiversity and carbon offsets (with environmental, social and production co-benefits)
- management of conservation reserves, other crown reserves, unallocated crown lands and waterways in expanded partnerships between the Western Australian Government and Traditional Owners, including jointly delivered fire, weed and feral animal programs
- co-management on mining leases by mining industry and Traditional Owner groups to deliver cultural and conservation land management and environmental services.

Such activities are compatible with, and would, in many cases, help sustain existing economic activities – by improving agricultural productivity, protecting natural systems for nature tourism, meeting carbon and biodiversity offset requirements for resource industries, and rehabilitating degraded and mined land. An expanded conservation economy can also help remedy acknowledged weaknesses in the current Pilbara economy.

Opposite: Most Australians know of the Pilbara only as a mining province. Protecting and promoting the region's outstanding natural and cultural values are essential for fostering more diverse economic activities, including an expanded sustainable tourism industry. This is Weano Gorge, Karijini National Park. Image: Tourism Western Australia

6.1.1 THE CURRENT PILBARA ECONOMY

It is indicative of the lack of economic diversity, that 'logo emblazoned' fluoro safety shirts are the main attire seen at the shopping centres, airports, hotels.

Soroptimist International of Karratha and Districts (2011) [506]

The Pilbara economy is overwhelmingly dominated by mining (mainly iron ore) and construction, which together account for more than 99% of industry economic output in the region (Figure 6-1). The tourism, agriculture, and arts and recreation industries generate far less revenue but are important sources of local employment. The region generates a surplus of jobs, most filled by fly-in, fly-out (FIFO) workers [507]. About two-thirds of mining workers live outside the region (according to 2016 census data). The Pilbara has been called a 'hollow economy' because

so much of the income generated in the region is spent elsewhere [508].

The lack of economic diversity is a well-recognised risk to the Pilbara [609]. As noted by Regional Development Australia Pilbara [509]:

It is a high-risk economy for small and medium size businesses in particular, as a result of an extremely high-cost structure, a small internal market and considerable fluctuations in the demand for goods and services in the resources sector.

Diversifying the economy would make it more resilient to changes in economic drivers, leaving it less vulnerable to mining downturns. It could also reduce social inequalities by generating more local jobs aligned to the broader interests and skills of residents.

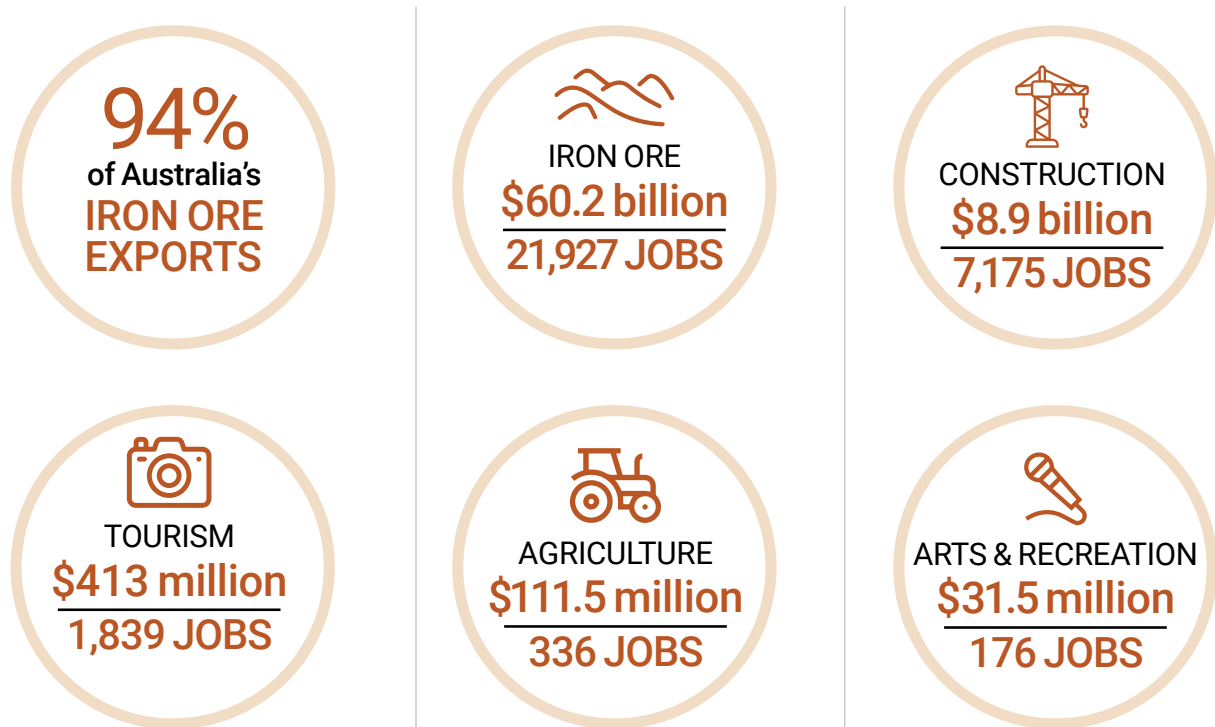


Figure 6-1. A snapshot of major sectors in the Pilbara economy

Source: Pilbara Development Commission (2019) [1], based on the 2016 census

Note: The data here applies to the broader Pilbara region rather than the Pilbara bioregion. However, all iron ore mines, most pastoral leases and most of the population are in the bioregion, so the data is mostly or approximately applicable.

The Pilbara is sparsely populated. The 2016 census recorded about 52,000 people living in the bioregion, of whom about 7,400 (14%) identified as Aboriginal or Torres Strait Islander peoples. Of people in the labour force (those in or seeking employment), 97% of non-Indigenous residents were employed in 2016 (a 3% unemployment rate), but only 82% of Aboriginal residents (18% unemployment) were employed [2]. While this is a considerable improvement since 2001 – with an approximate 15% increase in the employment rate for Aboriginal people [510] – the employment gap between Indigenous and non-Indigenous residents remains unacceptably high.

The rise in Aboriginal employment is largely due to mining. The proportion of the Aboriginal labour force employed in mining has more than doubled in the past 20 years, from about 20% in 2001 to 42% in 2016 [510]. However, although mining has increased prosperity in the region and provided jobs, the benefits have not been evenly distributed. Population geographer John Taylor estimated that only about a third of the Aboriginal population in the

Pilbara were better off in 2016 than in 2001 [510]:

What we see is a very mixed set of outcomes whereby some individuals, families and communities have clearly benefited while for others little has changed, indeed, relatively-speaking, they are now invariably worse off. ... The difference between the two is determined largely by employment, especially in mining.

These inequalities arise in part from an over-reliance on a single sector for employment and a lack of diversity in employment opportunities. Just to avoid a drop in Aboriginal employment, an additional 150 jobs have to be created each year (1,500 jobs over a decade) [510].

To address the economic inequalities in the Pilbara, job opportunities will have to be sought beyond the mining sector. Not all sectors generate jobs equally or locally. Modelling of regional economies in northern Australia found that a million dollar expansion of the accommodation sector, for example, creates almost 3 times as many new jobs as an equivalent expansion of the mining sector [511]. Some sectors are also much

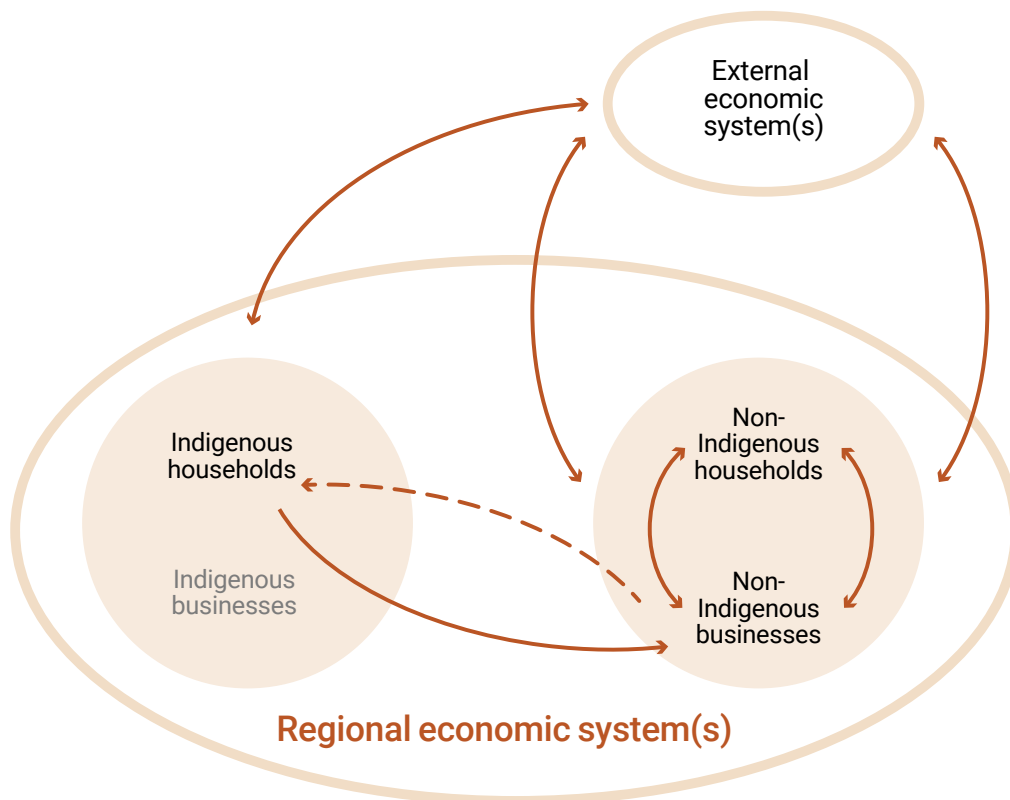


Figure 6-2. The asymmetry between Indigenous and non-Indigenous economic systems

Source: Natalie Stoeckl and others (2014) [513]

Notes: This diagram illustrates that money earned by Indigenous people typically flows directly into non-Indigenous businesses rather than circulating within Indigenous communities. The dashed line indicates the minimal flow from non-Indigenous businesses into Indigenous economy. An expanded conservation economy offers the potential to create Indigenous businesses that would draw money from the non-Indigenous economic system and enable some reinvestment within the Indigenous economy.

better aligned than others with Traditional Owner skills and interests, offering them a comparative business advantage [512].

One reason that inequalities cannot be overcome simply by increasing job opportunities in the existing economy is that the benefits of such jobs often fail to 'trickle down' to Indigenous households and communities [511–514]. This is due to a 'profound and asymmetric divide between indigenous and non-indigenous economic systems', which results in most Indigenous income flowing directly into the non-Indigenous economy, often to businesses outside the region [513]. Very little flows in the reverse direction. In a circular flow model of the economy, represented in Figure 6-2, there is little retained benefit to the Indigenous economy from economic inputs (there are almost no economic multipliers). This means that traditional development options are 'likely to generate more significant increases in employment and income for non-Indigenous people than for Indigenous people' and potentially exacerbate inequalities [511]. This is

evident in the Pilbara. Even though Aboriginal corporations in the Pilbara are some of the wealthiest in the nation [249], the benefits for Traditional Owners are limited due to expenditure flowing mainly into non-Indigenous businesses and households.

In sum, boosting the conservation economy in the Pilbara would contribute to greater local prosperity and reduced inequality – by (a) creating more diverse job and business opportunities in a sector in which Indigenous people have a comparative advantage and can apply traditional knowledge and management practices, (b) reducing the risky over-reliance on the mining sector, and (c) helping bridge the divide between Indigenous and non-Indigenous economic systems (Figure 6-2).

6.1.2 A MORE RESILIENT PILBARA ECONOMY

'In this together' – aligning economic opportunities with people's preferences

The protection country needs has to come from all of us... we're in this together.

Vince Adams, Murujuga Aboriginal Corporation (2020)

What sort of economy do Australians want? In a 2017 national survey – *Australia: Our Future, Your Voice* – a representative sample of Australians were asked to indicate their preferences across 4 future economic scenarios [515]. The majority preferred the 'community wellbeing' scenario, characterised by an 'in this together' narrative in which inequality is addressed, multi-level governments have a strong role, and there is a sense of shared responsibility [7]. Most respondents perceived, however, that Australia is heading in the opposite direction – a dissonance between the desired and perceived likely futures with 'clear policy implications' [515].

Scenario testing in northern Australia also shows a strong preference for 'in this together' visions of the future, characterised by an economy that [516]:

- is diverse and resilient
- supports local autonomy in decision-making and agency to seek fulfilling jobs
- fosters equality rather than ingraining historic inequalities.

The scenario researchers outlined economic options consistent with a northern Australia vision for a more sustainable and equitable future aligned with the 'in this together' scenario [516]. In common with many such analyses globally, it includes a transition to renewable

energy and more efficient agriculture with a reduced environmental footprint [515,516]. It also includes solutions particular to northern Australia such as greater participation in the carbon offsets market, an expanded Indigenous ranger network, diversification on pastoral lands, mining rehabilitation, and nature-based tourism [516–518].

Box 6-1 summarises some results of one scenario planning exercise in the Fitzroy River catchment to help communities navigate decision-making about future development options, focused on how different options would affect people's wellbeing.

Scenario studies highlight the frequent neglect of people's preferences in economic development strategies. Rather than expecting people to squeeze into established business and employment pathways, economic systems can be designed and modified to align with alternative local visions for the future. As noted in *Pilbara 2050*, achieving economic resilience relies not only on political will, but on the community becoming 'aware of the breadth of opportunities available, in order to ask for them' [609]. It is also 'no secret' that policies unaligned or conflicting with Indigenous people's cultural and social preferences have consistently failed [519]. A more realistic approach entails [519]:

... acknowledging and harnessing Indigenous cultural strengths and knowledge systems for looking after country and its people as part of an inclusive, responsive, innovative, diversified ecosystem services economy.

Box 6-1. Scenario thinking in action – West Kimberley development scenarios

Scenarios are a tool for helping people make sense of a world full of uncertainty – to anticipate how actions today could change the future. An example of scenario planning to help communities navigate decision-making about future development options comes from the Fitzroy River catchment in the Kimberley. In a series of workshops – some with 9 Traditional Owner groups and others with multiple stakeholders – participants were supported to collaboratively construct and assess the outcomes of alternative development pathways [520]. The desirability of different scenarios was evaluated not by asking participants to choose a ‘best’ scenario but to evaluate the likely impacts on their wellbeing.

Following is a brief sketch of the current situation and two contrasting development scenarios in the Fitzroy catchment. Scenario 1 reflected an ‘in this together’ narrative focused on investing in industries that maintain natural landscapes to increase economic opportunities in an equitable way for greater wellbeing and prosperity. Scenario 2 overlapped in many ways but also included investment in industries that modify natural landscapes. One or two other scenarios were also considered in the workshops.

Scenarios with strong policies to protect important natural and cultural values were usually (but not always) associated by participants with potential wellbeing improvement. Scenario 1 received the largest proportion of positive ratings across the wellbeing categories. Scenario 2, which included large-scale irrigation, was scored mostly positively by the multi-stakeholder group, but mostly negatively in the Traditional Owners’ workshop.

Current situation

- native title recognised over 96% of the catchment, but some problems with access to country
- fragmented regional visioning and objective setting, but opportunities for more collaborative leadership and stronger Indigenous governance
- existing policies protect environmental values, some of national or international significance
- most enterprises based on industries that maintain natural vegetation
- negotiations around development not always seen as fair or equitable.

Scenario 1 – Stronger policy and higher investment in industries that maintain natural landscapes

- land use dominated by grazing natural vegetation
- better land and water management
- better access to country, including for recreation, subsistence, and cultural activities
- extensive carbon farming using savanna burning (high carbon price)
- large increase in new conservation areas (17%), with joint management
- large increase (200%) in cultural and nature tourism (85% Indigenous businesses)
- one new small-scale barramundi farm
- similar level of resource extraction (low impact)
- 6 new medium-scale irrigated agriculture based on groundwater.

Scenario 2 – Stronger policy and higher investment in industries that modify natural landscapes

- land use dominated by grazing natural vegetation
- better land and water management
- better access to country, including for recreation, subsistence, and cultural activities
- medium-level investment in carbon farming using savanna burning (low carbon price)
- medium increase in new conservation areas (13%), including joint management
- medium increase (150%) in cultural and nature-based tourism (75% Indigenous businesses)
- 2 new small-scale barramundi farms
- medium increase in resource extraction (low impact)
- 12,000 hectares of irrigated rotation system and 18,000 hectares of Rhodes grass.

Source: Jorge Álvarez-Romero et al (2021) [520].

'Choose their own futures' – boosting economic choices

The Pilbara needs to chart a more aspirational future based on a diversified economy and enhanced liveability.

Pilbara Regional Investment Blueprint (2015) [521]

To overcome the problems of high unemployment for Aboriginal people and socio-economic inequalities will require the creation of more diverse and culturally aligned job opportunities to enable people to make choices about what constitutes fulfilling work for them. Choice is one of the principles emphasised in the Western Australian Government's proposed Aboriginal Empowerment Strategy, whose overarching goal is to empower Aboriginal people 'to live good lives and choose their own futures' [522]:

It is not for the Government, or anyone else, to define what 'success' looks like – Aboriginal people must be free to make their own decisions about what makes a 'good life' and how to achieve it.

The strong message from Aboriginal landholders and communities across northern Australia (and elsewhere) over a long period of time has been that they [511]:

want economic development but on their own terms. They are eager to participate in active management of land to address multiple objectives where these are compatible with cultural obligations.

Expanding the conservation economy in the Pilbara will provide a greater choice of livelihoods for Aboriginal people that align with their cultures, aspirations, skills and native title rights. It will enable them to contribute essential services of strategic importance to the nation [512,523].

This may suit many Aboriginal people who choose to not work in the mining industry despite the high availability of jobs in that sector [524,525]. In fact, it could lead to many more Traditional Owners working with mining companies – as co-managers of land under mining leases undertaking conservation and cultural services (section 6.3.4).

Although the majority of participants in an expanded conservation economy would be Traditional Owners, it will also provide economic opportunities for pastoralists, to diversify economic activities and boost productivity through improved land management, including in partnerships with Traditional Owners (section 6.3.2). More-diverse enterprise options (such as stewardship payments and carbon farming) 'can increase resilience by enhancing the adaptive capacity of landholders to respond to changing conditions' [526].

6.2 The role of Traditional Owners in a conservation economy

Perhaps we should be asking what incentives the nation can offer to keep – in a forever sparsely populated and climatically harsher northern Australia – a workforce large and skilled enough to sustain landscapes in which are embedded small but shifting nodes of high-risk orthodox economic activity that disperse their impacts off-site.

Rolf Gerritsen and others (2019) [511]

There has been increasing recognition of the economic and strategic importance of Indigenous land management in northern Australia, based on the knowledge and connection of Traditional Owners with their country [505]. Even in government strategies for economic development that conflict with 'in this together' visions for the future, the 'crucial role' of Traditional Owner knowledge and expertise is recognised, including for biosecurity, managing fire for carbon abatement and 'safeguarding the incredible northern environment' [523]. Cultural and conservation land management is becoming a 'critical part of the northern economy' [505].

The integral role of Traditional Owners in managing the Pilbara landscape is recognised by governments [15], industry [16], the conservation sector [17] and,

increasingly, the wider public [69,313,394,527]. With native title now resolved across most of the Pilbara (just 13% is under claim or not claimed), Traditional Owners have access and other rights to about 80% of the Pilbara, including 89% of the pastoral estate, 90% of unallocated crown land, and 84% of land under mining tenements. Native title rights are perpetual – a legal manifestation of unbroken traditional rights as well as the ongoing cultural responsibilities of Traditional Owners to manage land and sea, a point long made about the value of Indigenous land management programs [441,528,529].

The capability for broadscale Indigenous management across all tenures in the Pilbara is still emerging, but successes elsewhere demonstrate its feasibility. An expanded conservation economy would accelerate what is already normal across much of northern Australia – partnerships between Traditional Owners, industry and government for cultural and conservation land management [528]. However, its implementation in the Pilbara will be unique because of the scale of integration required with land users whose rights in crown land are shared with native title holders. More than a third (36%) of native title lands overlap with both mining tenements

and pastoral leases, and another half (51%) with one or the other. Despite the greater challenges, this also means that more resources are available for Indigenous land management. It provides an opportunity for industries and government to integrate large scale economic production with conservation and cultural maintenance.

There is compelling evidence that Indigenous land management is not only effective for conservation, but also has many economic, social and cultural benefits [530,531] (section 6.2.2). A healthy environment is essential to sustain pastoralism and nature tourism, and a growing strategic necessity for a thriving, sustainable northern Australia economy [511,523]. This is obviously so where weeds, feral animals and adverse fire regimes reduce productivity on pastoral properties or degrade

national parks. A study in northern Australia found that on-farm conservation programs focused on weed management would generate substantial co-benefits for agriculture [532]. And the management of particular weeds, such as flammable invasive pasture grasses, is essential for viable carbon offset businesses [533]. Factoring in such economic benefits means that the true costs of conservation management are less than the amounts spent.

Figure 6-3 shows the higher-opportunity areas for cultural and conservation land management in the Pilbara – the priority areas for offsets under the Pilbara Environmental Offsets Fund, Aboriginal-managed land and leases, conservation and other crown reserves, and unallocated crown land.

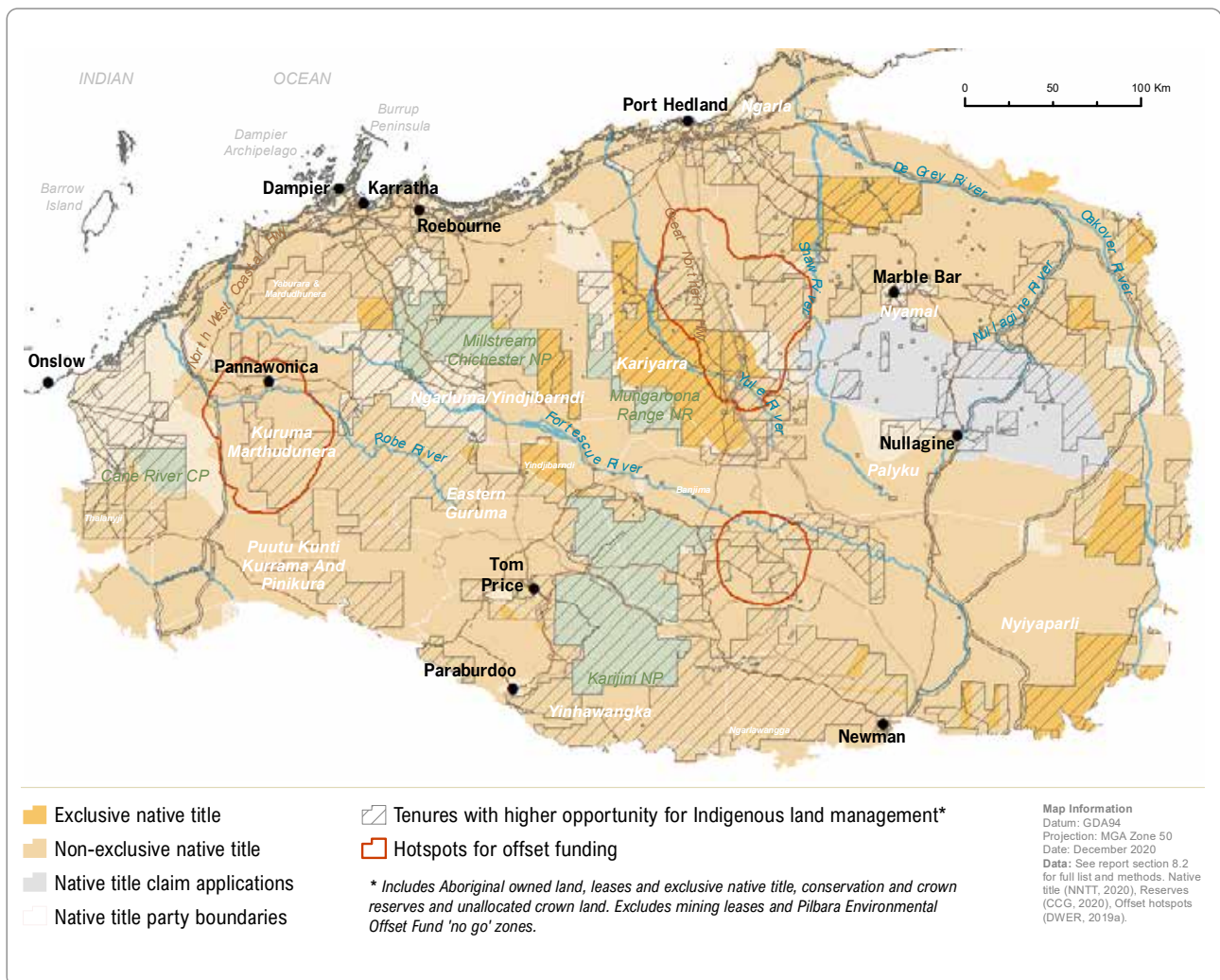


Figure 6-3. Priority areas for offsets under the Pilbara Environmental Offsets Fund and 'higher-opportunity' tenures for cultural and conservation land management

Note: Higher-opportunity tenures include Aboriginal owned land and leases, conservation and other crown reserves and unallocated crown land.

6.2.1 ECONOMIC OPPORTUNITIES FOR TRADITIONAL OWNERS

The potential activities of Traditional Owner groups in a conservation economy can be roughly grouped into 3 categories (see Figure 6-4):

- community-led opportunities – projects and activities wholly controlled by Traditional Owners (such as rangers operating on Aboriginal land)
- partnership opportunities – projects and activities in which Traditional Owner groups share control (in non-exclusive native title areas, for example), so as to expand their reach and impact or achieve a mutually desired outcome (such as joint management of conservation reserves, collaborative conservation projects on pastoral leases, and co-management on mining leases)
- commercial opportunities – projects and activities undertaken by Traditional Owner groups under fee-for-service contracts or as employees (such as rehabilitation services for mining companies and biosecurity programs and land management services for governments).

Community-led opportunities

[D]eterminations of native title are only meaningful in a practical sense if the holders of those interests and rights are able to use them to care for country, restore and maintain culture, create wealth and deliver well-being and prosperity...

Indigenous Reference Group to the Ministerial Forum on Northern Development (2019) [534]

Community opportunities – those controlled by Aboriginal groups from planning to implementation – require control over resources (in this case land), funding and baseline capacity. They are typically either ranger programs or businesses established on land owned or managed by Aboriginal corporations (11.5% of the Pilbara) and other lands under exclusive native title (an additional 1.3% of the Pilbara).

There are currently 11 ranger programs in the Pilbara – some are mature, but about half have emerged in the past 18 months – and additional programs are being planned (Box 6-5). Ranger programs largely rely on government funding, and sustained funding is necessary to maximise their benefits. The tendency of governments to vary priorities and funding availability (typical of many conservation programs in Australia [535]) is a risk factor. However, as ranger groups mature and increase capacity, they can become partially self-sustaining by taking on external contracts or by delivering products to the market such as carbon and biodiversity offsets (noting that fee-for-service contracts require careful assessment as they may not always be consistent with cultural and conservation land management priorities). In addition, some organisations have their own funds to contribute to community programs.

Culturally aligned business opportunities for Traditional Owners, which may add value to ranger programs, include cultural tourism, bush food harvesting or farming, seed collection and remediation of degraded landscapes (Box 6-2).



Traditional Owners exercising their cultural responsibilities for land management takes on many forms. Here, Murujuga rangers are managing beach access. Image: Murujuga Aboriginal Corporation.



Banjima rangers at work. Harnessing traditional ecological knowledge is a key component of successful cultural and conservation land management programs. Image: Banjima Native Title Aboriginal Corporation.

Box 6-2. Community-led business opportunities for Traditional Owners

Tourism in the Pilbara is a small but steadily growing industry [536]. Visitation to Karijini National Park, one of the major attractions, grew 4-fold over the 15 years from 1999 to 2014 [301]. With increased tourists comes a demand for more-varied experiences. The Western Australian Indigenous Tourism Operators Council has noted a growing demand for cultural tourism across the state [537]:

Ancient rock art, sacred sites, traditional bushfoods, storytelling, festivals and dance – visitor demand to experience one of the world’s longest surviving cultures is clearly on the rise.

The Pilbara Development Commission reports ‘exceptional’ opportunities for art-based, experiential tourism [536] and a WA Tourism study found that Indigenous-led tours and wildlife in the Pilbara have high appeal for potential visitors [501]. Traditional Owner-guided tours of Murujuga National Park, run by Ngurrangga Tours, exemplify the potential opportunities for Indigenous tourism businesses operating in national parks. However, most of the region’s national parks suffer a ‘notable’ lack of cultural branding [536].

One reason for optimism about the potential for increasing cultural tourism in the Pilbara is the current very low level of public awareness of the region’s attractions and misperceptions that the Pilbara is mostly about mining, as well as ‘dust, flies, heat and nothingness’ [501]. Support for cultural tourism ventures and marketing could do much to help Traditional Owners realise new business opportunities.

One opportunity for some groups could be to institute tourist permit systems with fees payable for access to Aboriginal owned or managed land. The Nyangumarta Highway, Canning Stock Route and Karajarri permit systems are nearby examples that produce income for Traditional Owners, provide tourists with access to areas that would otherwise be off limits, and promote knowledge of Traditional Owners and their lands [478–480]. Each system promotes responsible camping and 4-wheel driving and tracks visitor numbers, which is important in areas subject to unregulated tourism. This could be done in the Pilbara on reserves such as Yandeyarra and Woodstock Abydos, on Aboriginal-owned pastoral leases like Pippingarra, Peedamulla, Kangan and Mt Divide, and on areas with exclusive native title.

Looking after country can also align with new and emerging markets for boutique products such as bush foods and native seeds. Industry analysts say the market demand is high for bush foods (known as ‘functional foods’), with the global market estimated to be worth more than \$200 billion in 2018 [538–541]. Three of 13 existing commercial products grow in the Pilbara: bush tomato, quandong and wattles. There is, in particular, a growing market demand for bush tomatoes, which have high concentrations of Vitamin C and a strong pungent taste that makes them popular for use in jams, sauces, chutneys and condiments [540]. There is also a growing demand for native seeds for gardening and restoration projects [542].

Partnership opportunities

This was my country, now it's ours... [If] we look after country, the better it is for all of us.

Vince Adams, Murujuga Aboriginal Corporation (2020)

Partnership ventures can typically be established where Traditional Owners have native title rights. The recognition of native title across about 80% of the Pilbara thus provides myriad partnership opportunities. Partnerships for delivery of cultural and conservation land management are an appropriate way of sharing land (those under non-exclusive native title) while achieving beneficial environmental, cultural and relational benefits.

In the wake of the Juukan Gorge disaster, Pilbara Traditional Owners are increasingly seeking 'co-management' of mining and mining exploration lease areas on native title land. Such partnerships are an alternative to current relationships, defined largely by transactional agreements for heritage clearances and access by resource companies to native title lands. While such agreements provide cash benefits, and come with much rhetoric, they fall well short of establishing a wider values framework that can support true collaboration, co-management and enduring benefits (see section 6.3.4).

Partnerships are often based on shared interests. Government agencies can meet their land management obligations by contracting Aboriginal ranger groups to undertake cultural and conservation management on conservation reserves and unallocated crown lands (section 6.3.3). There is also considerable potential for Indigenous partnerships with government and industry for improved water resource management [80,543]. The Department of Water has expressed an intent 'to listen, learn and build strong partnerships' with Traditional Owners [543].

Interest-based partnerships can also be established with pastoralists – with potential mutually beneficial outcomes including weed and feral animal management and the restoration of traditional fire management regimes that improve pasture productivity (section 6.3.2). There are also opportunities for ranger groups to partner with pastoralists and government agencies to combine fuel reduction burns with cultural and conservation burning, sharing costs and resources. This is increasingly common in the Kimberley and desert regions, and has recently started in the Pilbara [407,544–546].

Other partnerships can be established for the purpose of providing goods and services on Aboriginal-managed lands or where native title exists – for example, delivering biodiversity offsets or running cultural tours. These rely on groups delivering products to a commercial standard but on country and commonly in ways that suit them.

We discuss partnership opportunities with pastoralists, state government and mining companies in more detail in section 6.3.

Commercial opportunities

Existing ranger programs ... could be broadened to encompass rangers providing fee-for-service activities in, for example, land and sea environmental management and research. This would provide a sustainable and viable income stream for Traditional Owners in the north, and could be coupled with career pathways that provide further opportunities for individuals in these areas..

Western Australian Government (2019) [547]

Many cultural and conservation land management activities can be undertaken either in partnership or as a commercial arrangement with Aboriginal ranger groups or individuals contracted or employed to deliver services. In a commercial arrangement, Traditional Owners are likely to have less control over how and where work is done, but the revenue generated can be spent on priorities determined by Traditional Owners. Partnerships are likely to generate less revenue but can create shared values and land management goals and build Traditional Owner capacity.

Commercial opportunities exist on a wide variety of tenures – mining leases, pastoral leases, national parks, and local and state government reserves – particularly for natural resource management and cultural heritage management.

The mining industry could be a major source of commercial opportunities. Through a co-management framework (section 6.3.4), an industry commitment to support the training and employment of Traditional Owners for such services would substantially boost the conservation economy in the Pilbara. Commercial services could include natural resource and cultural heritage management at mine sites and on pastoral leases held by mining companies, environmental monitoring and rehabilitation work (Box 6-3). Over time, it would reduce the need for FIFO workers and contractors to perform such work [233]. It would also demonstrate a commitment by mining companies to transparency and best practice, particularly if the work included water monitoring and waterway management. The impacts of mining on rivers, creeks and springs, which have extremely high cultural significance, are of particular concern to Traditional Owners [80].

Box 6-3. Mining rehabilitation business opportunities

[I]t can be argued that Aboriginal Australians have more to lose from inadequate rehabilitation and closure practices than any other segment of the population. ... Traditional Owners, unlike many others involved in mining, do not leave when mines close. They and their homelands will bear, in some cases for many generations, the costs of any failures in mine closure policy and regulation.

Rebecca Lawrence and Ciaran O'Faircheallaigh
(2019) [548]

Australia has a poor record of mining rehabilitation. Thousands of 'legacy' (abandoned) mine sites will cost billions of dollars to repair [511]. Even in contemporary times, there are few examples of 'postmining rehabilitation that has reached a successful conclusion', in part because restoring highly modified ecosystems is inherently difficult [549]. There has also been a failure to align post-mining rehabilitation with stakeholder expectations, due to an assumption that a single path of 'return to pre-existing state' achieves the most beneficial outcome [550].

One challenge for mining companies is how best to recognise that the connection of Traditional Owners to their country endures throughout and beyond the life of a mine. It can be reflected in jointly developed mine closure criteria and agreements for the post-mining use of infrastructure or other assets for community benefit. Partnership approaches and culturally aligned standards of rehabilitation are being tested at the Argyle and Ranger mine sites [551–553].

With their land management skills and a strong stake in effective rehabilitation of their lands, Traditional Owner groups have great potential to contribute to the rehabilitation of both modern and legacy mines. This could be a major source of long-term employment for Aboriginal people [554]. Once a mine site is stable and free of contamination and has a substrate able to support flora and fauna, the skills typically needed are already held by Traditional Owners or can be developed, including landscape design, seed collection and storage, plant propagation and planting, minor earthworks, wetland construction and management, weed and feral animal control, fire management, wildlife management and monitoring [511,554]. Rehabilitation can take decades.

There are several examples of Traditional Owner involvement in mining rehabilitation. In Western Australia, the Midwest Employment and Economic Development Aboriginal Corporation has established a native seed farm to provide seeds for restoration by Karara Mining [555] and Traditional Owners in the Kimberley are supplying seed for restoration of the Argyle diamond mine site [556]. In the Northern Territory, Kakadu Native Plants Supply is an Aboriginal-run business providing plants and rehabilitation services for the Ranger uranium mine and other clients [554].



The Indigenous-owned-and-operated Karara Seed Farm (near Morawa in the Mid West) was established to produce a reliable supply of native plant seeds for use in post-mining restoration. Image: MEEDAC (Midwest Employment and Economic Development Aboriginal Corporation) via Curtin University

Pathways for the development of skills and capacity

Some valuable lessons can be learnt from Indigenous ranger enterprises The most significant is that when Indigenous peoples' aspirations, knowledge, cultures and skills are given priority in project development they often succeed.

Oxfam Australia (2019) [557]

For Pilbara Traditional Owners to more fully participate in the workforce will require pathways for developing their skills and capacity for economic activities [233]. One pathway frequently manifesting across Australia starts from community-led projects (for example, the establishment of a ranger group to work on country [557]), which then leads to partnership projects, and then to commercial fee-for-service work (Figure 6-4). Successful commercial ventures, in turn, are likely to increase capacity and provide revenue for community programs. In such a progression, Traditional Owners develop new skills that enable individuals to take on new roles and strengthen the community's capacity to develop new partnerships and pursue business opportunities. Critical to this is the establishment of sound governance processes that are culturally legitimate and founded with community support [558,559], which can be strengthened as groups gain experience in community project management.

This is not a one-way pathway – the trajectory can also be in the opposite direction. For example, some of the existing capacity of Pilbara Traditional Owners to

undertake cultural land management projects stems from their work with the mining industry. While this work has arguably partly hindered cultural land management, it has also contributed to skills development useful for community and partnership projects and for projects on exploration and mining leases.

A 2018 evaluation of fee-for-service work across Australia found that 'necessity and scarcity' are driving demand, with most fee-for-service activities initiated by partners already working with Aboriginal organisations and with only limited or more-expensive options to meet their service needs [560]. Support is needed to build groups' business capacity – business skills to liaise with potential partners, research and development and entrepreneurial skills to identify opportunities, administration skills to respond to tenders, legal skills to enter into and manage contracts, and accounting skills to know what fees to charge [560].

Murujuga rangers are one Pilbara group undertaking fee-for-service work for industry and businesses operating on their land and sea country, with work including [561]:

- feral cat trapping
- weed management
- cultural awareness programs
- rock art tours
- rock monitoring
- air quality monitoring
- boat and skipper hire for sea monitoring and water testing.



Figure 6-4. Pathways and opportunities for Traditional Owners in a conservation economy

6.2.2 THE SOCIAL RETURN ON INVESTMENT IN INDIGENOUS LAND MANAGEMENT

[The] activities provide sustenance on two levels: They bring income and they bring meaning.

Peter Yates, North Australian Indigenous Land and Sea Management Alliance (2008) [562]

Indigenous land management is a well-tested model for delivering not only environmental benefits but economic, health and wellbeing and cultural, social and political benefits [563–568]. Calculating these social returns on investment – by using financial proxies to estimate the social, economic, cultural and environmental benefits of a program relative to program costs – is an emerging field of research and methodologies are still being refined [564]. Nonetheless, there is widespread, multi-sector acknowledgement that the social returns for cultural and conservation land management programs are significant. The best estimates for Indigenous protected areas and ranger groups are about 3:1 – meaning that every \$1 invested generates about \$3 in value [565]. The return for Indigenous protected areas is largely proportional to the size of investment in ranger jobs.

An evaluation of 26 wellbeing factors (as conceived by Indigenous people themselves) in communities in northern Australia found that the greatest benefit of Indigenous land management programs was due to improvements in ‘country and culture’ (for example, knowing that country is being looked after and having a legal right to access country) and ‘community and society’ (for example, a stronger community spirit, paid jobs and

greater influence over their own life) [566]. Wellbeing can be improved in all sorts of ways – for example, by restoring access to important cultural sites along a river previously infested with mesquite, the remediation of damage from mining, and the production of customary food sources and materials for arts and crafts [563]. Studies in northern Australia have found that Indigenous residents are more adversely impacted by the erosion of natural values than non-Indigenous residents, including on measures of wellbeing [569–571].

The health benefits of Indigenous land management have been summarised as arising from [563]:

- lower health risks associated with behaviours and lifestyles (for example, exercise, diet, smoking, drinking)
- lower health risks from the social, political, ecological and physical environment (for example, governance, housing, land condition, health services, education)
- a greater sense of control, self-esteem and mastery, which have powerful indirect impacts on health by reducing stress, a significant cause of illness and chronic disease among Indigenous peoples.

Cultural, social and political benefits of Indigenous land management include opportunities for intergenerational transfer of knowledge, support for customary and social practices, and community empowerment [563]. They include education, training and skills development, reduced substance abuse, reduced anti-social behaviours, and increased access to housing and employment.



Yindjibarndi rangers working in Millstream Chichester National Park. Image: Western Australian Department of Biodiversity, Conservation and Attractions

Box 6-4. The West Arnhem Land Fire Abatement program

In 1997, a group of Indigenous rangers in Arnhem Land and non-Indigenous scientists established a cross-cultural collaboration to address the problem of massive wildfires – fierce ‘feral’ fires that were destroying fire-sensitive ecological communities [572]. Following many years of relationship building and with federal government funding, the agreed solution was to apply coordinated traditional mosaic burning using both Aboriginal and non-Aboriginal management tools and expertise [572]:

Black and white worked together in the ‘big laboratory’ of Arnhem Land to create the science of fire, fuel loads and vegetation communities that led to the accepted savanna burning methodologies.

In 2006, a 22-year carbon offsets agreement with ConocoPhillips (a global oil and gas company) enabled the West Arnhem Land Fire Abatement program to become fully operational [572]. The company agreed to pay Traditional Owner groups to generate a minimum of 100,000 carbon credits through fire management to offset a proportion of carbon emissions from Darwin’s liquefied natural gas plant [573].

Implemented initially by 5 ranger groups across 28,000 km², the program has expanded to encompass most of Arnhem Land, with fire management by 9 ranger groups across 80,000 km² now generating more than 4 million carbon credits a year [573,574]. These are sold under long-term contracts to various companies and the federal government’s emissions reduction fund, and on the voluntary market. By 2016, the program was generating an annual revenue of more than \$10 million [572].

The program has been a notable success in providing sustainable, culturally aligned economic opportunities for Traditional Owners. It has demonstrated a pathway from the establishment of ranger groups to development of a successful business in remote, economically marginal Indigenous communities with few employment prospects. Traditional Owner land management systems have been revived and modified to respond to different social and environmental conditions [572]. Over time, the governance capacity of the Traditional Owner groups has grown. The directors of the umbrella public company (ALFA NT Ltd) and the directors of the member corporations are all Aboriginal people [572].

Critical underpinnings have been Aboriginal control over land, partnerships with scientists, support from governments, and the creation of networks – ‘across communities and across cultures and knowledge systems’ [572].

Although savanna burning for carbon credits is not applicable for the Pilbara, effective fire management is critical for human-induced regeneration, a carbon farming method likely to be feasible in parts of the Pilbara (section 5.5), and for preventing damage to community and industry infrastructure.

6.3 Building partnerships in the Pilbara

We all need to do our part to look after the whole country as one.

Curtis Robinson, Kariyarra Aboriginal Corporation (2020)

Partnerships are an essential basis for a conservation economy in the Pilbara. This reflects the extensive overlapping rights and interests in land, the policies of the government and mining industry in favour of partnerships, and the benefits, power and social license that come from partnerships. The existence of native title across most of the Pilbara is foundational to most partnerships.

While largely normalised in other parts of northern Australia, conservation partnerships in the Pilbara are still emerging. Recent examples are plans to deliver Environmental Offset Fund projects in collaboration with Pilbara Traditional Owners (Box 4-2), increasing government and industry support for the Pilbara Cultural Land Management Project (Box 6-5), joint management of Murujuga National Park, and other new joint management agreements being negotiated through the government’s Plan for Our Parks initiative.

6.3.1 PARTNERSHIPS BETWEEN TRADITIONAL OWNER GROUPS

The Pilbara's Traditional Owner groups are at different stages of readiness to undertake large-scale land management. Some already have ranger programs in place, several have just begun ranger programs, and others have taken the first steps in planning. But, crucially, the potential of Indigenous land management is already well proven across Australia, including in the nearby Kimberley and Western Desert regions – on jointly managed conservation reserves, Indigenous protected areas, and other Aboriginal lands. Growing partnerships between Traditional Owner groups can facilitate knowledge sharing and collaborations that allow them to grow capacity and build up from local scale work through to meaningful delivery of country wide projects across their traditional lands, and regionally.

The recent establishment of the Pilbara Cultural Land Management Project – a partnership between 12 Traditional Owner groups – is a critical first step in strengthening the potential of Traditional Owners to participate in a conservation economy (Box 6-5). A key aim is the implementation of cultural and conservation land management across native title lands in partnership with pastoralists, miners and government agencies. This project will support the development of capable Indigenous ranger groups to operate on pastoral leases, unallocated crown lands, mining leases, conservation reserves and Aboriginal managed lands.

Box 6-5. Pilbara Cultural Land Management Project

Having members back out on country, protecting country, heritage sites, wildlife, habitats, water ways. As well as for someone like myself, being able to gain that experience as we go along, performing activities on country, learning about culture. We want to be able to put our training to work on country.

Adrian Smith, PKKP Aboriginal Corporation (2020)

I was always taught to look after country. This is why [the] Ranger program is good... to be able to go out on country, protect them and monitor them... preserving country is a part of our culture.

Royce Evans, Robe River Kuruma Aboriginal Corporation (2020)

Ranger programs are very important. Young people can find their spirit, it's where they belong. It makes them accountable for their country.

Doris Eaton, Nyamal Aboriginal Corporation (2020)

A partnership of 8 Traditional Owner groups launched the Pilbara Cultural Land Management Project in 2020 to empower Traditional Owners to take the lead in keeping their country healthy and their culture and people strong. The partnership has since grown to 12 groups, covering most of the Pilbara bioregion and some areas further south. Projects are being developed in the following agreed priorities areas:

- coming together, learning together and supporting each other
- cultural knowledge transfer, mapping and planning
- land use and access mapping
- land, water and sea management partnerships
- ranger program start-up support.

A key project aim is for all Pilbara Traditional Owner groups to implement cultural and conservation land management across their native title lands, including in partnership with pastoralists, miners and government agencies.

The current participating Traditional Owner member organisations are:

- Banjima Aboriginal Corporation
- Buurabalayji Thalanyji Aboriginal Corporation (working with the Chevron Rangers)
- Karlka Nyiyaparli Aboriginal Corporation
- Murujuga Aboriginal Corporation
- Ngarlawangga Aboriginal Corporation
- Nyamal Aboriginal Corporation
- PKKP Aboriginal Corporation (representing Puutu Kuntj Kurrama and Pinikura peoples)
- Robe River Kuruma Aboriginal Corporation
- Wanparta Aboriginal Corporation
- Wirrawandi Aboriginal Corporation
- Yindjibarndi Aboriginal Corporation
- Yinhawangka Aboriginal Corporation

The project is supported by the Pilbara Development Commission, the Indigenous Land and Sea Corporation, National Indigenous Australians Agency, state agencies (Premier and Cabinet, Environment and Water Regulation), Lotterywest, and other organisations.



Image: Nick Rains

6.3.2 PARTNERSHIPS ON PASTORAL LAND

There is no more crucial time than right now for leadership from government to reform laws to allow diversification – to take the brakes off innovation and enterprise, encourage land managers to improve the health of the soil and ultimately to sustain whole landscapes.

Evan Pensini, Pilbara pastoralist (2018) [575]

As a major custodian of land, with leases covering 60% of the Pilbara, the pastoral industry can be a major participant in and beneficiary of a vibrant conservation economy. The pastoral estate has very high conservation values (section 5.6). Particularly on leases with ranges, gorges and hilly areas, many pastoralists do not use the full extent of their lease, resulting in a patchwork of relatively intact land systems (often with high conservation values) and grazed areas. River systems on pastoral leases are also of great ecological and cultural importance. In an expanded conservation economy, land and river health would be improved while agricultural productivity and jobs would be maintained. A review of an agricultural stewardship scheme in the Northern Territory found it resulted in production and business advantages as well as environmental benefits (Box 6-6).

An increased focus on stewardship is consistent with the agricultural sector's intentions. The vision in the 2030 Roadmap, developed by the National Farmers Federation, is of Australia's farms leading the world in environmentally friendly practices and farmers being 'recognised by the community as trusted and proactive stewards' [495]. The agricultural sector has called for increased government support for environmental land management [576], and the Western Australian government has recently released 'good' pastoral management guidelines with a stronger focus on environmental management in response to the acknowledged longstanding poor management of the pastoral sector [231,493].

Another focus of the agricultural 2030 Roadmap is partnerships with native title holders [495]. With native title recognised over most of the Pilbara pastoral estate,

pastoralists will increasingly interact with Traditional Owners exercising their rights of access and seeking to manage culturally significant areas. Throughout Western Australia, almost all healthy country plans developed by Traditional Owners identify an aspiration to collaboratively manage native title lands on pastoral leases [77,395,577–579]. For example, the Yinhawangka healthy country plan says [395]:

Large tracts of Yinhawangka Country are managed by other landholders ... Once Native Title is resolved Yinhawangka Aboriginal Corporation can build relationships with these stakeholders ... through the establishment of Indigenous Land Use Agreements and Joint Management arrangements to ... establish access to areas for different purposes, develop management arrangements for collaborative cultural and natural resource management and specify rights, obligations and processes for Healthy Country Management.

There are clear opportunities to develop partnerships – to integrate pastoral and cultural land management, and potentially to undertake commercial projects. These include upcoming opportunities for the delivery of biodiversity offset projects under the Pilbara Environmental Offset Fund (Box 6-5). There are likely to also be future carbon farming and stewardship opportunities [580]. One likely trend in future will be 'value-stacking', to increase the value of carbon farming by demonstrating social and environmental co-benefits – an approach particularly suited to partnerships [581].

Aboriginal ranger programs, mostly funded by state and federal governments, operate on native title lands on pastoral leases. In the Kimberley and the Northern Goldfields, Aboriginal rangers assist pastoralists with fire, feral animal and weed management, while also managing cultural sites and monitoring and protecting biodiversity. In such ways, Aboriginal ranger groups could also provide complimentary land management services to Pilbara pastoralists.

Box 6-6. Benefits of a stewardship scheme on Northern Territory pastoral properties

From 2011 to 2018, at least 12% of pastoral businesses in the Northern Territory entered into a 10-year Territory Conservation Agreement [582]. The program supports landholders to voluntarily protect sites of conservation value – for example, by fencing wetlands, establishing alternative watering points for cattle, controlling weeds and feral animals, and applying favourable grazing or burning regimes [583]. The work is undertaken by the landholder on the basis of a 10-year contract, a mutually agreed management plan, and an up-front financial contribution from Territory NRM. Up to 2018, the public funding contributions of \$1.3 million were more than matched by contributions from landholders of \$1.8 million (cash and in-kind) [582].

A 2018 review of the program reported a strongly positive response by participants and their intention to maintain or expand their conservation commitment [582]. The review identified the following production and business benefits arising from the program:

- income diversification through stewardship payments
- improved water quality for cattle and less bogging of cattle, due to fencing off wetlands, springs and riverbanks and pumping water for stock to other sites
- improved stock control and mustering efficiency, due to fencing and water distribution that enables waterpoints to be turned off strategically
- feral animal or weed management resulting in pasture improvement or less competition for pasture.
- social licence; promotion of businesses as sustainable
- development and promotion of nature tourism enterprises.

The benefits to industry included an increased social licence to operate due to an enhanced industry reputation for sustainability. One of the goals of the beef industry's strategic plan is to show 'evidence of improving performance against a baseline for environmental and natural resource management issues of priority to cattle producers and the community' [584].

6.3.3 PARTNERSHIPS ON CROWN RESERVES AND UNALLOCATED CROWN LANDS

We recognise the practice of intergenerational care for country and its relevance to our work. We seek to listen, learn and build strong partnerships.

Department of Water and Environmental Regulation
(2020) [543]

Government-managed lands – conservation reserves, other crown reserves and unallocated crown land – covering 36% of the Pilbara and mostly under native title (67%), offer major opportunities for partnerships with Traditional Owners to implement cultural and conservation land management, including:

- formal joint management of conservation reserves (6.4% of the Pilbara), with Traditional Owners assuming on-ground management responsibilities in a staged process as they gain skills and capacity
- support for Traditional Owners to manage crown lands over which they hold exclusive native title (4.7% of the unallocated crown land area, 1.1% of the Pilbara)
- partnership arrangements to support cultural land management by Traditional Owners on other unallocated crown land (23% of the Pilbara) and other crown reserves (5% of the Pilbara), most of which are under non-exclusive native title.

The only formal jointly managed reserve in the Pilbara is Murujuga National Park. Although not without challenges, the relationship is maturing and the Murujuga Aboriginal Corporation is assuming greater day-to-day management responsibility, with improved support from government. This arrangement could be replicated in other conservation reserves in the Pilbara – as is occurring with the establishment of new national parks in the state (through the Plan for Our Parks process) [585].

Traditional Owners often aspire to autonomy in managing conservation reserves. With capacity-building support from the state and through projects such as the Pilbara Cultural Land Management Project, they can be empowered over time to achieve their own management aspirations, as well as others agreed with the government, and take on most day-to-day management responsibilities. This aspiration would see the state playing a role in developing jointly agreed management goals (statutory management plans), managing assets and infrastructure, providing scientific expertise, and contract management of services provided by Traditional Owners.

On other crown reserves and unallocated crown lands, partnerships with state agencies could enable healthy country planning and cultural land management and lead to fee-for-service contracts for land management and monitoring. This would be particularly beneficial for former pastoral lands acquired for conservation (managed by the Department of Biodiversity, Conservation and Attractions), waterways and water reserves (managed by the Department of Water and Environmental Regulation), and other unallocated crown lands under native title (managed by the Department of Planning, Lands and Heritage).

Through state settlement agreements, usually used to negotiate native title compensation claims, Traditional Owners could negotiate new arrangements with the state for their native title lands – for example, new tenures (leases) to support cultural land management, water resource management and commercial opportunities such as carbon offsetting, agriculture and tourism.

6.3.4 CO-MANAGEMENT ON MINING LEASES

One approach being adopted by leading companies to manage environmental impacts and build relationships with Indigenous communities is environmental co-management.

The Leading Practice Sustainable Development Program for the Mining Industry (2016) [586]

Mining companies encourage a ‘partnership’ approach with Traditional Owners groups in the Pilbara – it is typically part of the rhetoric in negotiated land access agreements specifying access arrangements, compensation, employment, business opportunities and other benefits. While these agreements have delivered many benefits to Traditional Owners, their implementation has often not delivered the ease of access to country that Traditional Owners need for cultural land management [241]. Traditional Owners have been relegated on their lands to function mainly as cultural advisers, employed during heritage surveys to identify cultural assets prior to drilling, blasting and other destructive work.

An alternative model, more consistent with a partnership approach and a basis for developing new ways of collaborating, would be value-driven agreements for co-management of native title lands. An Australian Government working group on leading practice in mining has defined environmental co-management as ‘an inclusive, consensus-based approach to resource use and development’ in which partners ‘share the authority and responsibility for the management of the environment in and around the mine site’ [586]. In practice, it could mean Traditional Owners co-developing conservation and cultural heritage programs and undertaking cultural land management, environmental monitoring, rehabilitation and other conservation work – in addition to meeting their obligations for heritage surveys. Under such arrangements, a Juukan Gorge disaster is far less likely to occur.

Effective co-management would also help repair and strengthen relationships that are necessary for mining companies to maintain a social licence to operate. The Juukan Gorge disaster has highlighted the potential

economic consequences of failed partnerships, with a coalition of investment companies managing \$14 trillion of assets demanding assurances from Australian mining companies about their relationships with Traditional Owners [587]. Co-management would provide business opportunities for Traditional Owners while often reducing the costs of essential environmental management, monitoring and rehabilitation services for mining companies (over the long term, supporting the training of and contracting Indigenous rangers would likely be more cost-effective than employing FIFO consultants and workers). It could help deliver outcomes sought under the *National Agreement on Closing the Gap* – including those for shared decision-making, increased employment and relationships of Aboriginal people with their land and waters [588].

As part of its reforms following the Juukan Gorge disaster, Rio Tinto has said it will [589]:

modernise agreements in the Pilbara where Traditional Owners have indicated that the current agreements have not met the aspirations of partnership we mutually sought at the outset.

A genuine partnership would acknowledge that each partner has management responsibilities on native title lands – some legal and some cultural – and collaborate to facilitate both mining and cultural and conservation management. It would acknowledge that the responsibilities by mining companies are temporary (a few decades) while those of Traditional Owners are enduring. In 100 years, most iron ore mining companies will be gone from the Pilbara – but Traditional Owners will still be there:

We think forward 100 years and ask what we hope for our children's children and their grandchildren... What we want to leave them is a future. We want a future to be one in which they are recognised, respected, equal and strong. We want this for them in order that they can carry on our tradition through our land-based ceremonies and songlines, customs and kinship.

Slim Parker, Banjima Elder (2018) [590]

6.4 Attributes of a conservation economy in the Pilbara

6.4.1 THE JOBS POTENTIAL OF A CONSERVATION ECONOMY

One of the benefits of expanding the conservation economy in the Pilbara is that it would generate a large number of jobs, particularly in relation to the size of the investment [591]. We estimate that a comprehensive cultural and conservation land management program focused on managing weeds, feral animals and fire across the bioregion would generate 430 to 670 full-time equivalent (FTE) on-ground jobs and 70 office-based jobs for a total of 500 to 740 FTE jobs. Because people often choose to work part time and because there are other land management needs, a much larger number of jobs could be created.

Table 6-1 details the potential number of jobs on different tenures in the Pilbara at different levels of management intensity. There are no published Pilbara-specific calculations of the costs of large-scale conservation management. Our estimates are therefore largely based on published calculations of the costs of natural resource management activities elsewhere in northern Australia and the jobs generated by these activities [592–595] (for detailed methods, see section 8.2). It will be essential to undertake consultation with local experts and apply local knowledge to obtain cost estimates for specific Pilbara programs.

The lands most appropriate for immediate investment in cultural and conservation land management are those owned or managed by Aboriginal people, crown reserves and unallocated crown lands. On these tenures,

management of weeds and feral animals could generate up to 109–223 FTE jobs (depending on the intensity of management needed) and fire management up to 61 FTE jobs (Table 6-1). Including ranger coordinators to support on-ground management teams, this would total 209–323 FTE jobs. On pastoral lands, a comprehensive cultural and conservation land management program could create a similar number of jobs (at a lower level of management intensity), including pastoral jobs (under an agricultural stewardship program, for example) (Box 6-6).

The potential number of jobs, including existing jobs, is at least double the number of existing jobs in the agricultural sector and four times those in arts and recreation [233]. They could make up almost half the estimated extra jobs needed over a decade to maintain the current rate of Aboriginal employment in the Pilbara (section 6.1.1) [510].

Management of fire, weeds, and feral animals is only a subset of activities with job-generating potential that warrant investment. Additional job options include those mentioned in previous sections – biodiversity surveys and monitoring, threatened species recovery, cultural heritage management and mining rehabilitation. Thriving businesses focused on threat management often generate other sorts of jobs. For example, the Wardekker rangers (in west Arnhem Land) employ up to 130 people a year (not all FTE positions) not only for conservation land management but for rock art conservation, education and cultural heritage management.

Table 6-1. Potential jobs for management of weeds and feral animals (3 levels of intensity) and fire in the Pilbara by tenure type

| Tenure | Area (million ha) | Percentage | Weed & feral animal management jobs ^D | | | Fire management jobs ^D | Coordinator jobs ^E |
|--------------------------------------|-------------------|-------------|--|------------------|----------------|-----------------------------------|-------------------------------|
| | | | Low intensity | Medium intensity | High intensity | | |
| Aboriginal-managed land ^A | 2.04 | 11.5% | 26 | 34 | 54 | 15 | 12 |
| Conservation reserves | 1.14 | 6.4% | 15 | 19 | 30 | 8 | 6 |
| Other crown reserves | 0.91 | 5.1% | 12 | 15 | 24 | 7 | 4 |
| Unallocated crown land | 4.34 | 24.3% | 56 | 72 | 115 | 31 | 17 |
| Pastoral leases ^B | 9.29 | 52.1% | 120 | 155 | 246 | 67 | 31 |
| Other ^C | 0.11 | 0.6% | 1 | 2 | 3 | 1 | 0 |
| Pilbara total | 17.83 | 100% | 229 | 297 | 474 | 128 | 70 |

Sources: Based on data from Adams & Setterfield (2016), Adams et al (2018), Heckbert et al (2008), Northern Territory Cattleman's Association (2020) [592–595]

Notes: **A.** Aboriginal-managed land includes Aboriginal-owned pastoral leases, Aboriginal Lands Trust land (reserves), Aboriginal Land Trust land with management orders allowing pastoral activities and other Aboriginal reserves. **B.** Pastoral leases in this category exclude those covered under the 'Aboriginal-managed land' category. **C.** This category includes freehold land and roads. **D.** The levels of activity needed (and the job potential) will vary considerably across properties, but there is no available data at a property level. We therefore extrapolated on a per hectare basis from published financial cost and job models from elsewhere in northern Australia. This assumes a uniform condition across the region and does not take into account any economies (or diseconomies) of scale. To counter these limiting assumptions, we drew upon 3 models for weed and feral animal management that cover low, moderate and high intensity management. There was only one published model for fire, so we could provide only a single jobs estimate. We further tested the modelled job and total costs by comparing our modelled numbers against the financial costs of a ranger program as estimated by a Western Australian conservation agency. **E.** We assumed 1 ranger coordinator position would be needed for every 6 ranger positions and used an average park ranger/coordinator award rate of \$85,000 plus 30% on-costs. For more details about the method, see section 8.2.

6.4.2 POTENTIAL INFLOWS TO THE PILBARA'S CONSERVATION ECONOMY

We estimate that a base level of about \$51 million a year is needed for managing fire, weeds and invasive animals across the Pilbara (see Table 6-2 and section 8.2 for methods) and an additional \$17 million for support roles and additional costs, for a total budget of \$68 million a year. This would support an estimated 560 FTE local jobs, including the direct costs of employment for rangers, ranger coordinators and administrative and research roles, as well as equipment, vehicle and infrastructure costs.

This estimate assumes varying intensities of invasive species management, with a lower intensity on pastoral lands than on conservation reserves and Aboriginal-managed land. The costs for fire, weed and feral animal management across the Pilbara equate to a conservative average of \$2.89 a hectare, ranging from \$2.04 on pastoral leases to \$4.28 in conservation reserves. (The latter is much less than the average \$9 a hectare spent on managing national parks and Indigenous protected areas in Australia [596,597].)

Our estimates should be regarded as a minimum baseline for the Pilbara. They do not include the additional funding needed for other types of conservation management such as some threatened species recovery work and mining rehabilitation. The estimates here are comparable with estimates from another conservation agency working in regional Western Australia. The only published cost assessment for conservation in the Pilbara, by CSIRO in 2012, found that about \$20 million a year (2021 dollars) over 20 years would be needed to mitigate threats to 53 species of conservation significance in the Pilbara [3]. But this estimate was much more narrowly focused than the current proposal on the habitats of threatened species.

The funding estimates here would encompass existing funding and effort – by Indigenous ranger groups, the Western Australian Government, pastoralists and mining companies. Because information about existing effort is so scant, it is not possible to precisely calculate the additional funding needed. However, given the limited extent of land in the Pilbara currently managed for fire and invasive species (see Chapter 4), we think it is safe to assume that new funding of at least \$50 million a year is needed.

Table 6-2. Funding needed to manage fire and invasive species across the Pilbara

| Tenure | Area (million ha) | Assumed management intensity ^A | Funding needed (\$million) | \$/hectare | Jobs assumed ^B |
|---|-------------------|---|----------------------------|------------|---------------------------|
| Aboriginal owned/ managed land | 2.04 | High | 8.70 | 4.28 | 81 |
| Conservation reserves | 1.14 | High | 4.80 | 4.21 | 44 |
| Other crown reserves & unallocated crown land | 5.25 | Medium | 15.37 | 2.93 | 146 |
| Pastoral leases ^C | 9.29 | Low | 22.33 | 2.40 | 218 |
| Other | 0.11 | Low | 0.22 | 2.04 | 2 |
| Total / average | 17.83 | Low–medium | 51.46 | 2.89 | 491 |
| Central administration roles ^D | | | 16.79 | | 68 |
| TOTAL | | | 68.25 | | 559 |

Notes: See Table 6-1 for data sources and information about methods. A. The different levels of intensity for management of invasive species are assumed on the basis of the likely management objectives for different tenures, but they would vary considerably within each category depending on the extent of the weed and feral animal problems and the individual land manager's objectives. B. Funding per ranger job is \$75,000 including superannuation, based on the average salary for park rangers in Australia and similar to current advertised government jobs in the region. Funding per ranger coordinator job is \$110,000 including superannuation, based on average salary for senior park rangers in Australia and similar to current advertised government jobs in the region. C. This category excludes Indigenous pastoral leases, which have been included in the category of Aboriginal-managed land. D. This estimate is based on an assumed 1:10 administration-staff ratio (and costs of \$110,000 per position including superannuation) and additional research and planning jobs (funding at \$225,000 per position including superannuation and additional salary loadings) as well as office and infrastructure costs. It equates to an average 30% overheads and covers similar overhead expense items.

Where would the new funding come from? Although \$68 million a year for integrated management of fire, weeds and feral animals in the Pilbara seems ambitious – much more than is currently spent and more than is typically spent in remote regions – it is a modest sum compared to the wealth generated in the Pilbara, the environmental footprint of that wealth generation, and the public funding provided to support wealth generation.

There are several compelling rationales for governments, industries and landholders to increase their investment in conservation land management in the Pilbara – to better meet existing legal, policy and social obligations and to embrace new opportunities such as carbon offsets. Following are 6 rationales and opportunities to increase inflows into the Pilbara's conservation economy.

Legal obligations for land management

All landholders, including the state and local governments, have legal and duty-of-care obligations for certain standards of land management. The Western Australian Auditor General has noted the lack of a stewardship program on pastoral lands 'to attain sustainable land management and protect the environment' [231] and deficiencies in prioritising and reviewing invasive species threats and enforcing biosecurity obligations [598]. Legal obligations for land management include the following:

- All landholders, including state government agencies, have biosecurity obligations to control declared weed and pest animal species. Pilbara pastoral leaseholders are required to pay rates to the region's 'recognised biosecurity group' for pest control, although the focus is largely on agricultural priorities such as dingoes.
- Pastoral lessees are required by law to maintain indigenous pastures and other vegetation and use best-practice pastoral and environmental management for managing stock and conserving and regenerating pasture for grazing.
- Mining licensees typically have land management obligations under their approval conditions and are required to provide offsets for unavoidable harm.

Industry social licence to operate

Social licence... must be earned rather than granted, and it can be extremely tricky to regain once lost. Although it seems trendy, it is not new. Society has always determined acceptable behaviour. What has changed recently perhaps is the range of activities that the concept of social licence is being applied to.

Australian Farm Institute (2018) [599]

The Juukan Gorge disaster has demonstrated the reputational and business risks to companies of failing to live up to their claims of social responsibility [587]. Money managers 'have been placing exponentially more importance on how companies manage environmental, social and governance risks' [587]. The social legitimacy

of industries are influenced by such factors as (a) distributional fairness (whether benefits are shared), (b) procedural fairness (whether people have a voice in decision-making), and (c) confidence in governance [600]. With most land in the Pilbara used for generating wealth – enormous wealth in the case of mining – and very little land managed for conservation, there are strong social licence arguments for greater industry contributions to cultural and conservation land management:

- Mining companies have by far the greatest capacity and a strong rationale for investing in cultural and conservation land management in the Pilbara. The costs across the 55% of the Pilbara under mining tenements would amount to just 1–4 cents a tonne of iron ore (of the quantity sold in 2019), depending on the level of management intensity, up to about 0.01% of the iron ore revenue based on prices in mid-2021 [601]. One of the most effective means for mining companies to gain the trust of and build partnerships with Traditional Owners will be to enable co-management of native title lands under mining leases (section 6.3.4).
- According to Australia's agricultural 2030 Roadmap, farmers are aiming to be 'proactive and trusted stewards' and Australia's 'most trusted' industry [495]. A pastoral industry social licence to operate can be undermined by a proportion of landholders who 'lack the necessary natural, financial and managerial resources to deliver acceptable stewardship' [599]. Although pastoralists have less financial capacity than miners to invest in cultural and conservation land management, partnerships with Traditional Owners can strengthen both stewardship capacity and the social licence (section 6.3.2).

Environmental markets

Currently [in 2018], over 450 projects and 34 million tonnes of annual abatement are rangelands-based ..., providing an income source that at times may rival or even exceed traditional grazing enterprises.

Barney Foran and others (2019) [602]

The markets for biodiversity and carbon offsets are a rapidly growing part of the global and Australian conservation economies. They offer the potential to substantially increase resources for cultural and conservation land management, including in the Pilbara:

- The Pilbara Environmental Offsets Fund will deliver several important conservation projects, with \$90 million already committed to the fund over the next 40 years [377] (Box 4-2). The proposed spending of \$1.5–2 million a year to 2025 will include projects on managing fire and threats to riparian habitats.

- Selling carbon offsets in the Australian market has become increasingly viable for pastoralists and Aboriginal ranger groups and the value of carbon credit units is predicted to more than double in a decade [603]. Recent changes in state government policy have enabled human-induced regeneration projects, the carbon farming method suitable for the Pilbara, on pastoral leases [517,604,605]. There are no registered projects in the Pilbara as yet and the proportion of the region suitable for carbon farming is yet to be determined, but opportunities are likely to greatly vary, depending on the biomass of vegetation [477].

Government programs in the public interest

Programs to support cultural and conservation land management in the Pilbara are strongly in the public interest – particularly so in the absence of a comprehensive, adequate and representative reserve system (section 4.2) – including the following 2 priorities:

- Long-term funding for Indigenous rangers by the state and federal governments is an essential element of an expanded conservation economy. The high environmental, social and cultural benefits of these programs are widely recognised (section 6.2.2).
- The high conservation values of pastoral estate warrant stewardship support for pastoralists to undertake high-priority conservation activities, including in partnerships with Traditional Owners (section 6.3.2). Funding typically becomes available in response to crises. A more sustainable approach would be to invest in restoring natural capital and strengthening resilience ‘when times are good’ [526].

Policy commitments for public land management

As one of the largest landholders in the Pilbara, including of lands with very high conservation values, the state government should strive to be an exemplar in managing lands to a high standard. This can only be achieved with more public investment in cultural and conservation land management:

- The Western Australian Government has a policy commitment to ‘effectively manage’ conservation reserves so as ‘to maintain or enhance biodiversity and ecological processes, including habitat and ecological conditions for priority and threatened species and communities, and to protect significant cultural and heritage values’ [387]. Reserve management in the Pilbara has been hindered by insufficient funding and out-of-date management plans (section 4.2). Much of it could be delivered by Indigenous rangers under joint management arrangements (section 6.3.3).

- The Parks and Wildlife Service is responsible for fire management preparedness, and control of weeds and invasive animals on unallocated crown lands and crown reserves that are not otherwise managed (mostly by local government) [606]. There is also a ‘good neighbour policy’ applying to lands managed by the Parks and Wildlife Service that commits them to cooperative management with neighbours ‘regarding areas of common interest, such as fire management, pest animal and weed control, where they are consistent with the department’s strategic directions’ [607]. Again, much of this work could be delivered by Indigenous rangers in partnerships or as fee-for-service work.

Cultural and ethical motivations

It is important to recognise that many people in the Pilbara contribute conservation effort and resources for reasons other than legal obligation and financial gain. An ‘in this together’ spirit will undoubtedly be an important motivator of the partnerships and projects needed to achieve sustainable land management in the Pilbara.



In a first for Australia, Tourism Western Australia's Camping with Custodians program has been supporting the development of high quality public campgrounds owned and operated by Aboriginal communities. Peedamulla Station is an Aboriginal-owned cattle station near Onslow offering 20 campsites. Images: Tourism Western Australia





7. A conservation vision for the Pilbara

The Pilbara is so much more than the mines, cattle and red dust of the popular imagination. Its dramatic deep history, briefly recounted in this report, provides the foundation for a more complex appreciation of the region:

Geologically – as the oldest well-preserved fragment of early Earth crust, uniquely diverse in ancient rocks, offering a window into deep time and the evolution of life.

Biologically – as an ancient refugia for life during glacial periods and a major centre for the evolution of unique plants and animals.

Culturally – as the home for more than 50,000 years of the first Australians, a landscape rich in spiritual and cultural significance, with one of the largest rock art collections in the world.

These are qualities of global significance that have endured despite the rapid transformations and travails of the past 160 years.

Economically, the Pilbara is also remarkable – as the world’s most lucrative iron ore mining province, hailed as the ‘engine room’ of Australia’s economy. Therefore, the challenge for those with influence over the future of the Pilbara is how to preserve and restore its great biological and cultural wealth while also enabling the generation of economic wealth.

Any realistic vision for the Pilbara must accept that mining and pastoralism will continue to be dominant industries. It must also recognise that extensive native title rights now engender other opportunities (conservation, cultural and economic) over most of the same landscape. In no other Australian bioregion does native title overlap so comprehensively with industrial output critical to the Australian economy, and in no other landscape are pastoralism and mining so extensively interwoven.

An essential element of a conservation vision for the Pilbara must therefore be strong partnerships between those with overlapping land rights and responsibilities – Traditional Owners, miners, pastoralists and governments. Traditional Owners exercising their cultural responsibilities for land management would be the major participants in a conservation workforce.

Another essential element of a conservation vision is ambition. Bold thinking is conspicuous in the Pilbara – manifest in the engineering, technologies and financial capital needed to dig up and ship out millions of tonnes of Pilbara rock a year. In contrast, conservation has been modest, incremental, intermittent, and generally a low government and industry priority. Encouragingly, there has been a recent growth spurt in conservation capacity, particularly with the establishment of the Pilbara Environmental Offsets Fund and the Pilbara Cultural Land Management Project. But these are still modest endeavours for a region of such outstanding values.

A more ambitious conservation endeavour – aligned with the vastness of the landscape, the significance of the conservation and cultural values, and the conservation-enabling wealth of the Pilbara – is proposed in the following vision:

By 2031 the Pilbara is the world-leading exemplar of landscape-scale conservation in a region of critical economic importance. Cultural and conservation land management is comprehensively implemented across all tenures, delivered through partnerships between Traditional Owners, industry, government and community.

Opposite: There are many ways to view the Pilbara – as one of the world’s premier iron ore provinces, as a pastoral region, as a biodiversity hotspot and climate refugia, and as a rich cultural landscape subject to native title rights and Traditional Owner custodian responsibilities. Australia’s challenge is how to align these different ways of valuing this important region. Image: Paul Mayall Australia / Alamy Stock Photo

8. References, methods and data sources

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8.2 Methods and data sources

Here, we describe the methods used for analyses, tables and maps and list the sources of data.

8.2.1 NATURAL VALUES

Throughout this report but particularly in chapters 2 and 5 we review some of the natural values of the Pilbara. The level of information available varies considerably. Some areas have not been comprehensively surveyed and not all information has been published, so the value assessments should be regarded as incomplete.

Due to a lack of comprehensive surveys, the conservation status of many species and communities in Western Australia is uncertain. These have been classified by the Western Australian Government as 'priorities' with 3

categories (1 to 3) representing different levels of risk and a fourth category for species that are rare, near threatened or need monitoring. For example, 'priority 1' species are poorly known from one or a few locations which are potentially at risk, with all occurrences very small or on lands not managed for conservation. See Table 8 1 for an explanation of the conservation classes assigned by the government to distinguish different levels of threat or risk to species and ecological communities and their priority for further surveys.

Technical Notes

Bioregions and sub-bioregions: These are designated in the Interim Biogeographic Regionalisation for Australia version 7 (DEE, nd), and are used as the planning framework nationally for assessing gaps in the reserve system and identifying priority regions for new reserves.

Threatened and priority species and ecological communities: Records were obtained from the Species and Communities Branch of the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA). Fauna species records date from 1900 to 2019. Historical records were retained if the species was suspected to still occur in the general region. The current status of some of these species in a specified area is uncertain. The ecological communities have a buffer applied by DBCA to ensure that the boundary is sufficient to pick up any developments with potential to impact groundwater or surface water and consequently the community. The buffers range from 100 to 500 metres; most are 500 metres.

Data sources: animals (DBCA, 2020a), plants (DBCA, 2020b), ecological communities (DBCA, 2020c).

Watercourses and catchments: The data source was Australian Hydrological Geospatial Fabric, Bureau of Meteorology (BOM, 2014)

Important wetlands: The data source was the Directory of Important Wetlands, Australian Government (DIWA, 2014)

Geological heritage (including stromatolites): The data source was the state register of Geoheritage sites, Department of Mines, Industry Regulation and Safety (DMIRS, 2020b)

Table 8-1: Conservation classes for flora, fauna and ecological communities listed by the Western Australian Government

| Conservation class | Description |
|--|--|
| Threatened | Threatened species are protected under the Wildlife Conservation Act 1950 and ranked according to their level of threat using IUCN categories: <ul style="list-style-type: none"> • Critically endangered – considered to be facing an extremely high risk of extinction in the wild. • Endangered – considered to be facing a very high risk of extinction in the wild. • Vulnerable – considered to be facing a high risk of extinction in the wild. • Extinct – there is no reasonable doubt that the last individual has died. |
| Priority species & ecological communities – may be threatened or near threatened but are data deficient or require monitoring | |
| Priority 1 | Poorly known from one or a few locations (for communities generally ≤ 5 occurrences or a total area of ≤ 100 ha) which are potentially at risk. Mostly outside protected areas. |
| Priority 2 | Poorly known from one or a few locations (for communities generally ≤ 10 occurrences or a total area of ≤ 200 ha) some of which are in protected areas. |
| Priority 3 | Poorly known from several locations or a few widespread occurrences and doesn't appear to be under imminent threat. Or large widespread occurrences that are under threat across much of their range. |
| Priority 4 | Adequately known but rare, near threatened or recently removed from the threatened list. Require regular monitoring. |

8.2.2 TENURE AND LAND USE TYPES

In chapters 2, 4 and 5, we describe the natural values of the Pilbara bioregion across different tenures and land use types, as described in Table 8-2.

Table 8-2. Tenure and land use types and their source data

| Category | Sub-category | Source data |
|------------------------------|--|--|
| Unallocated crown land (UCL) | Potential future conservation reserves | DBCA Lands of Interest, Western Australian Department of Biodiversity, Conservation and Attractions (DBCA, 2020d) |
| | Remaining UCL | Western Australian Cadastre (Landgate, 2019) |
| Conservation reserves | National park Nature reserve Conservation park | Australian land reserves, Centre for Conservation Geography (CCG, 2020) |
| Other crown reserves | Stock route Water supply Common Other | 1) Land Tenure, Department of Primary Industries and Regional Development (DPIRD, 2019). 2) Western Australian Cadastre (Landgate, 2019). 3) Additional checks on reserve purpose using Landgate's map viewer and reserve reports available: https://map-viewer-plus.app.landgate.wa.gov.au/ |
| Aboriginal-managed land | Aboriginal Land Trust Estate | Aboriginal Lands Trust Estate, Department of Aboriginal Affairs (DAA, 2016) |
| | Indigenous Owned Pastoral leases | Pastoral Land Tenure, Department of Primary Industries and Regional Development (DPIRD, 2019) |
| | Reserves | Reserves 22626, 23046 and 21802 with purpose of Aboriginal heritage protection (Landgate, 2019) |
| Pastoral leases | | Pastoral Land Tenure, Department of Primary Industries and Regional Development (DPIRD, 2019) |

8.2.3 NATIVE TITLE

Three datasets published by the National Native Title Tribunal were used to document native title determinations, outcomes and claims (NNTT, 2020). Native title has been determined across the Pilbara bioregion except in areas with no current registered claimants and in the southern section of Nyamal country, where there is a pending claim application.

8.2.4 MINING

We calculated the area in each tenure and land use type under granted production and production applications, and granted exploration and exploration applications – for minerals. There are no petroleum titles within the study area. The various lease, licence and permit types, and their classification for our calculations, are shown in the notes below.

Technical Notes

Spatial overlaps: To deal with spatial overlaps between mining tenements and titles, we gave preference in our area calculations to production over exploration then granted over applications.

Tenement and title classification: We classified the variety of leases, licences and permits relevant to this report as either 'exploration' or 'production' in the following ways.

| Exploration tenements | Production tenements |
|-----------------------|----------------------------|
| Exploration licence | Mining lease |
| Mineral claim | Mining lease S.A. |
| Prospecting licence | General purpose lease |
| Retention licence | Miscellaneous licence |
| Temporary reserve | Miscellaneous licence S.A. |

Main data sources: Mining tenements were obtained from the Western Australian Department of Mines, Regulation and Safety and Petroleum (DMIRS, 2020a). The Minedex database was used to indicate the location and status of mines and major resource projects (DMIRS, 2021).

8.2.5 PILBARA ENVIRONMENTAL OFFSETS FUND

Figure 6-3 in Chapter 6 shows hotspots and no-go zones for funding under the Pilbara Environmental Offsets Fund. The hotspots were delineated by circling clusters of values greater than 400 in an analysis by the Western Australian Department of Water Resources (DWER) showing priorities for investment of Pilbara Environmental Offsets Funding (Figure 8-1; DWER, 2019a). Another analysis by DWER showing 'no-go zones', which are areas to be avoided for offsets, was used to 'mask out' these areas from being displayed as higher opportunity tenures (DWER, 2019b).

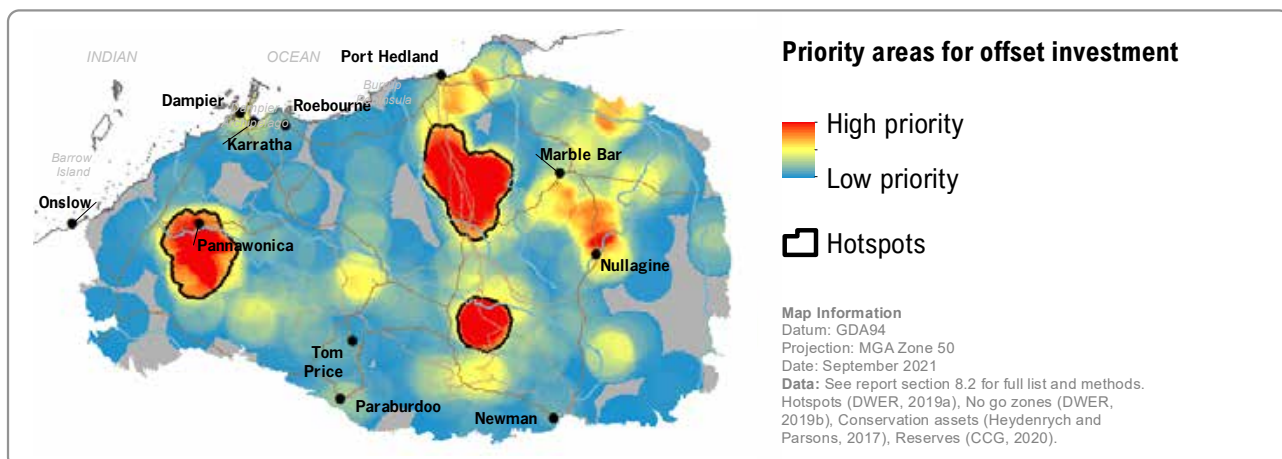


Figure 8-1: Delineating hotspots for funding under the Pilbara Environmental Offsets Fund

8.2.6 JOB AND COST ESTIMATES IN AN EXPANDED CONSERVATION ECONOMY

There is very little publicly available information about the costs of conservation land management. To estimate the potential number of jobs to manage weeds, feral animals and fire in an expanded conservation economy in the Pilbara (section 6.4.1), we extrapolated from 4 published sources in northern Australia.

Weed and feral animal management is often treated as a single integrated operational activity with management teams operating in the same areas. For example, in Kakadu National Park, an integrated weed and feral management team operates across the floodplains to control mainly mimosa, but also feral water buffalo. Fire management requires a different set of skills and often occurs in different locations, so we provide separate estimates for these jobs. All job estimates assume full-time employment and that the work is ongoing.

There were 3 available estimates of the total costs and number of jobs associated with management of weeds and feral animals in parts of northern Australia – estimates for improved weed management across the pastoral estate by the Northern Territory Cattlemen's Association (NCTA, 2020), a management model built to estimate the costs of gamba grass management in the Litchfield region (Adams & Setterfield, 2016), and a management model built and validated for Kakadu floodplains management (integrated weed and feral team) (Adams et al, 2020). Each of these estimates of management costs and jobs takes into account the direct employment costs of rangers and required equipment (for example, vehicles, spray equipment, chemicals). The models do not consider additional support such as ranger coordinators, administration, or research and planning. The associated work for each of these 3 job estimates reflects a possible spectrum of low-to-high management intensity.

Levels of activity and associated costs and jobs created vary by the size and condition of properties being managed. The NTCA (a low-intensity estimate) model is for the full pastoral estate, but the other 2 models (medium-intensity and high-intensity estimates) were built for property level modelling. Property level assessment was not possible with the available Pilbara data, so we extrapolated from all 3 models on a per hectare basis by estimating the per hectare jobs from their reported total number of jobs operating across a total area and then multiplying these by the total Pilbara area by tenure type. This unrealistically assumes the same level of activity is needed across the region (a uniform condition and extent of threats), and does not take into account any economies (or diseconomies) of scale. We believe these are acceptable assumptions given the low-, medium-, and high-level estimates that provide bounded estimates of the intensity of activity and associated jobs generated.

There was only one publicly available estimate of jobs associated with fire management (Heckbert et al, 2008). We used this to again extrapolate on a per hectare basis to estimate fire management jobs by tenure in the Pilbara.

To address the gaps in the cost models – notably coordination, administration, research and planning as well as infrastructure such as offices – we estimated these line items based on industry standards of support and average award rates for roles. We assumed a ratio of 1 ranger coordinator to every 6 rangers and a salary of \$85,000 plus 30% on-costs including superannuation for a total cost of \$110,000 per ranger coordinator. We assumed a ratio of 1 administration role to every 10 on-ground rangers and a salary of \$85,000 plus 30% on-costs including superannuation for a total cost of \$110,000. We assumed a fixed number of research and planning staff at highly skilled PhD levels (25 at \$225,000 per staff including on-costs and additional wage loadings). We included a fixed estimate of infrastructure (offices, \$5,000,000), and office-based staff equipment (\$1,500,000). To test the robustness of the modelled cost and job data we compared the estimates to an estimated cost of work program by another conservation agency working in regional Western Australia. A similar level of jobs and a total cost (\$57 million) were estimated (within a 10% margin of variance). We further tested the robustness by developing a line-item cost estimate including staff, equipment, contracts (for example, aerial surveys), infrastructure, and overheads. Costs were within a 2% variance. The costs presented are thus highly robust.

8.2.7 DATA SOURCES

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