pilbara corridors

Pilbara Bioregion Conservation Action Planning Process

Workshop Summary Document

June 2016

Acknowledgements

This Pilbara CAP Workshop Summary Document (Version 2, June 2016) is the outcome of a process involving many contributors. In particular, all of those people and organisations who took part in the Pilbara CAP workshop series in 2015 are thanked for their time and valued input. Those who commented on an earlier draft of this summary report (Version 1, December 2015) are also thanked for their important feedback.

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Pilbara Corridors acknowledges the contributions to this publication of various stakeholders and participants; however, the views contained herein do not necessarily reflect the views of the participating organisations or individuals. Greening Australia advises that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice.

The development of the Pilbara CAP is an ongoing process. A broad base of stakeholder and community input will strengthen the relevance and utility of the Pilbara CAP for all end users. To this end, Greening Australia looks forward to receiving further inputs and feedback from everyone with an interest in land management in the Pilbara.

Cover Photo: Sunrise at Panorama Point, Brad Glass

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Contents

Abbreviations

CAP	Conservation Action Planning
CCNET	Conservation Coaches Network
CMP	Conservation Measures Partnership
DAFWA	Department of Agriculture and Food WA
DMP	Department of Mines and Petroleum
EPA	Environmental Protection Authority (WA Government)
EPBC	Environment and Biodiversity Conservation Act 1999 (Commonwealth Government)
ESRM	Ecologically Sustainable Rangeland Management
GIS	Geographic Information System
NRM	Natural Resources Management

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1 Background

1.1 What is Conservation Action Planning?

Conservation Action Planning provides a framework to help land managers deliver improved biodiversity conservation outcomes within their broader business programs. It involves clearly defining conservation assets, articulating threats to these assets, formulating and implementing actions to address the threats, and measuring success (or otherwise) in a manner that will enable 'learning by doing' and thereby increased effectiveness over time.

Conservation Action Planning has a strategic, landscape-scale focus. This is necessary given that conservation assets and/or the processes that threaten these assets typically extend across multiple management jurisdictions. In many cases, it is not possible to effectively manage threats to biodiversity at local scales. Accordingly the process seeks to improve communication, collaboration and alignment of conservation plans and actions amongst groups of land managers.

Although biodiversity conservation is concerned with biological elements of the landscape (eg. flora, fauna, ecological communities) it is fundamentally a human endeavour. It is recognised that different land managers have different social, cultural, environmental and economic interests in the land that they manage. The Conservation Action Planning process seeks to complement existing land use plans and objectives wherever possible, as part of an overarching sustainable land use approach. This reflects an underlying philosophy that all sectors of the community have some responsibility for conservation.

The challenge of truly effective biodiversity conservation should not be underestimated. It is important to have realistic expectations about what can be achieved, how long it will take and what steps are involved. Inevitably trade-offs between conservation priority (determined based on biological and ecological knowledge) and conservation opportunity (the capability and willingness of people to participate in conservation actions) will need to be considered and resolved. Successful Conservation Action Planning requires the direct participation of the people who will be involved in implementing and monitoring the conservation actions.

1.2 The need for a Pilbara Conservation Action Plan (CAP)

The Pilbara biogeographic region of Western Australia (McKenzie *et al*, 2003) has a wealth of biodiversity and other environmental values, evidenced by its diverse range of terrestrial, aquatic and marine landscapes, numerous flora and fauna species and communities, nationally listed wetlands, and ecological features endemic to the region.

The Pilbara is an international hotspot for subterranean biodiversity (Eberhard *et al*. 2005; Halse *et al*. 2014), one of 15 Australian terrestrial biodiversity hotspots (Department of Environment 2016) and also one of Australia's development hotspots. Biodiversity is in decline across the Australian continent as identified in Australia Biodiversity Strategy 2010-2030 (Natural Resource Management Ministerial Council, 2010). In the Pilbara, the growing intensity of land use and resource development has placed

considerable pressure on the biodiversity of the region. There is a need to ensure that ongoing economic development is integrated with the protection of biodiversity and the land resource base more generally. Although the protected area estate in the Pilbara is substantial (i.e.. national parks, marine parks and other reserves), it does not meet nationally and internationally recognised targets for biodiversity conservation. In addition to expanding the protected area estate where possible, complementary 'off-reserve' actions are necessary and important. It is envisaged that many strategies and actions identified in the Pilbara CAP process will be focussed in off-reserve areas.

The region is of substantial economic importance to both Western Australia and Australia, and with the current and future development of mining and infrastructure development set to continue, it has been recommended that a strategic plan for biodiversity conservation be developed for the region (EPA 2014).

The Pilbara region is an important part of the Rangelands NRM region, a portion of which is currently the focus of a collaborative landscape-scale conservation program – Pilbara Corridors – funded through the Australian Government. Founding partners of Pilbara Corridors are Rangelands NRM, the Western Australian Department of Parks and Wildlife (Parks and Wildlife) and Greening Australia. Key stakeholders of the region include Indigenous communities, mining companies, and pastoralists.

While the Pilbara Corridors program has commenced the work of bringing partner organisations together and initiating landscape-scale conservation works, there is now a need to better integrate this work, coordinate a collaborative approach to the program, prioritise activities for the future, and increasingly align stakeholder activities to the priorities. This Conservation Action Plan along with other pertinent resources (e.g. Pilbara Biological Survey - McKenzie *et al*. 2009) can be used to inform the design of a strategic investment plan for biodiversity conservation in the Pilbara, which may link to the Pilbara Strategic Conservation Initiative (EPA 2014). The strategic investment plan will provide the opportunity to align funding from numerous sources including environmental offsets from resource development projects with long term goals and strategic actions established to conserve the region's biodiversity for the next 10 to 20 years.

The Project Area for this CAP process agreed upon during the workshop series comprised the Pilbara bioregion (**Figure 1**). This boundary is intended to be flexible and in certain instances, would be influenced non-ecological considerations such as management units (e.g. an entire pastoral lease or conservation reserve, **Figure 2**). The Pilbara bioregion includes four sub-regions (**Figure 1**) distinguished on the basis of geology, landform, climate, vegetation and animal communities, comprising:

- Chichester subregion: encompasses the granite/greenstone terranes of the northern Pilbara Craton but also includes the Chichester Plateau of the Hamersley Basin. While the broader Chichester subregion is characterised by deeply weathered regolith and is dominated by spinifex (*Triodia* spp.) grassland with irregularly scattered shrubs (shrub steppe), the Chichester Plateau (bordering the northern side of the Fortescue Valley) more closely reflects the soil landscape and vegetation of the Hamersley Plateau.

- Fortescue subregion: delineated by the Fortescue River valley, which cuts through the sedimentary rocks of the Hamersley Basin. This region consists of salt marshes, mulga-bunch and short grass communities, with Eucalypt (*Eucalyptus* spp.) woodlands along floodplains and associated with permanent springs.
- Hamersley subregion: the most prominent mountainous area in Western Australia, comprised of a series of topographical features (ranges, ridges, hills and plateaux) encompassing isolated and continuous chains of uplands that rise above a plateau surface. Skeletal soils have developed on the iron-rich sedimentary rocks, and generally support spinifex grassland with Mulga and Snappy Gum (tree steppe).
- Roebourne subregion: encompasses the mudflats and low dunes of the coastal plain in the western portion of the Pilbara bioregion. It is composed largely of alluvial and aeolian sediments, often with a cover of grasses and soft spinifex.

These sub-regions provide a useful biophysical context for conservation planning and management.

1.3 Aims of the Pilbara Conservation Action Planning Process

The Pilbara CAP provides a guiding framework for planning and implementing biodiversity conservation actions across the Pilbara bioregion, in a coordinated manner based on broadly agreed priorities. It is acknowledged that the Pilbara is a large region with numerous assets, threatening processes, stakeholders and varying views and opinions. Consequently, there have been a range of workshops and other processes undertaken recently that address the above, at least in part, including:

- Carwardine *et al*. (2014) Priority Threat Management for Pilbara Species Of Conservation Significance, CSIRO Ecosystems Sciences, Brisbane;
- A series of Environment Protection and Biodiversity Conservation (EPBC) Act threatened species workshops hosted by Parks and Wildlife in 2013;
- Western Australian Environmental Protection Authority (EPA) advice on Cumulative Impacts in the Pilbara (EPA, 2014) and Environmental and water assessments related to mining in the Fortescue Marsh management area (EPA, 2013); and
- the Investment Framework for Environmental Resources (INFFER^{TM}) providing a natural asset identification process and investment opportunities as a component of the Rangelands NRM Regional Plan 2014-18 (Rangelands NRM, 2013).

This CAP process builds on this work and provides a systematic and adaptive management framework for knowledge, strategic plans and Indigenous and land manager perspectives. The planning provides the framework for:

- a landscape-scale approach to conservation (i.e.. landscapes and associated species, not just threatened species) and has a strong intent to represent the region's stakeholders;
- the development of S.M.A.R.T. (i.e.. Specific, Measurable, Actionable, Realistic and Time-bound) goals and objectives;
- a shared monitoring and evaluation framework, leading to effective adaptive management and organisational alignment of activities;

- the development of a tangible strategy and action plan; and
- long-term organisational partnerships and opportunities to drive effective, on-ground actions.

There are a range of approaches and tools that can be used for the purposes of conservation planning (Game and Groves, 2016), including Open Standards for the Practice of Conservation and CAP planning. Each of these have benefits and limitations (Opdam *et al*., 2008; Groves and Game, 2012). The CAP planning process was deemed the most suitable approach for developing a conservation plan for the Pilbara Bioregion.

The Pilbara CAP will assist Pilbara land management and conservation stakeholders to align their conservation and land management work to an agreed plan.

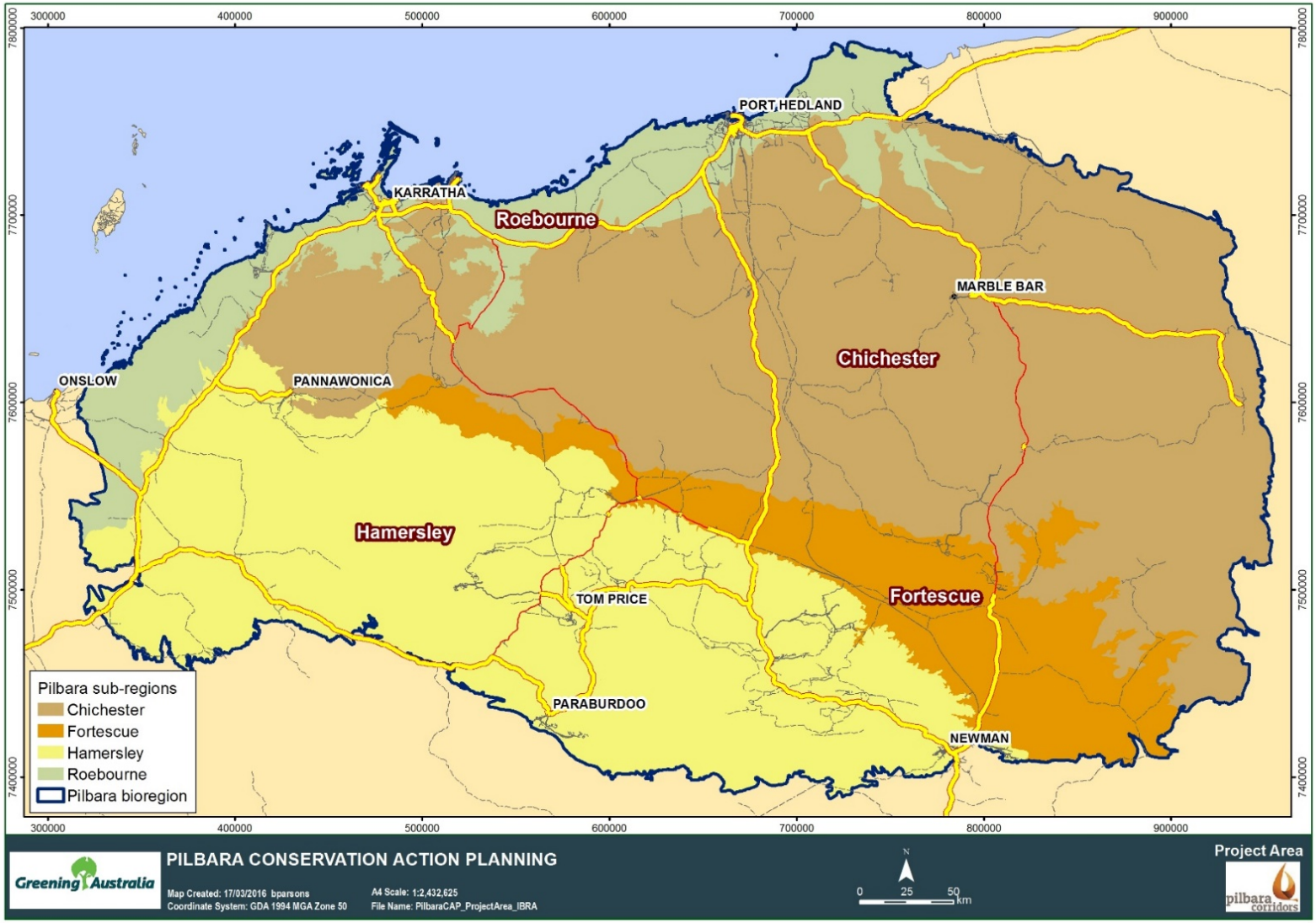


Figure 1: Project Area for the Pilbara CAP

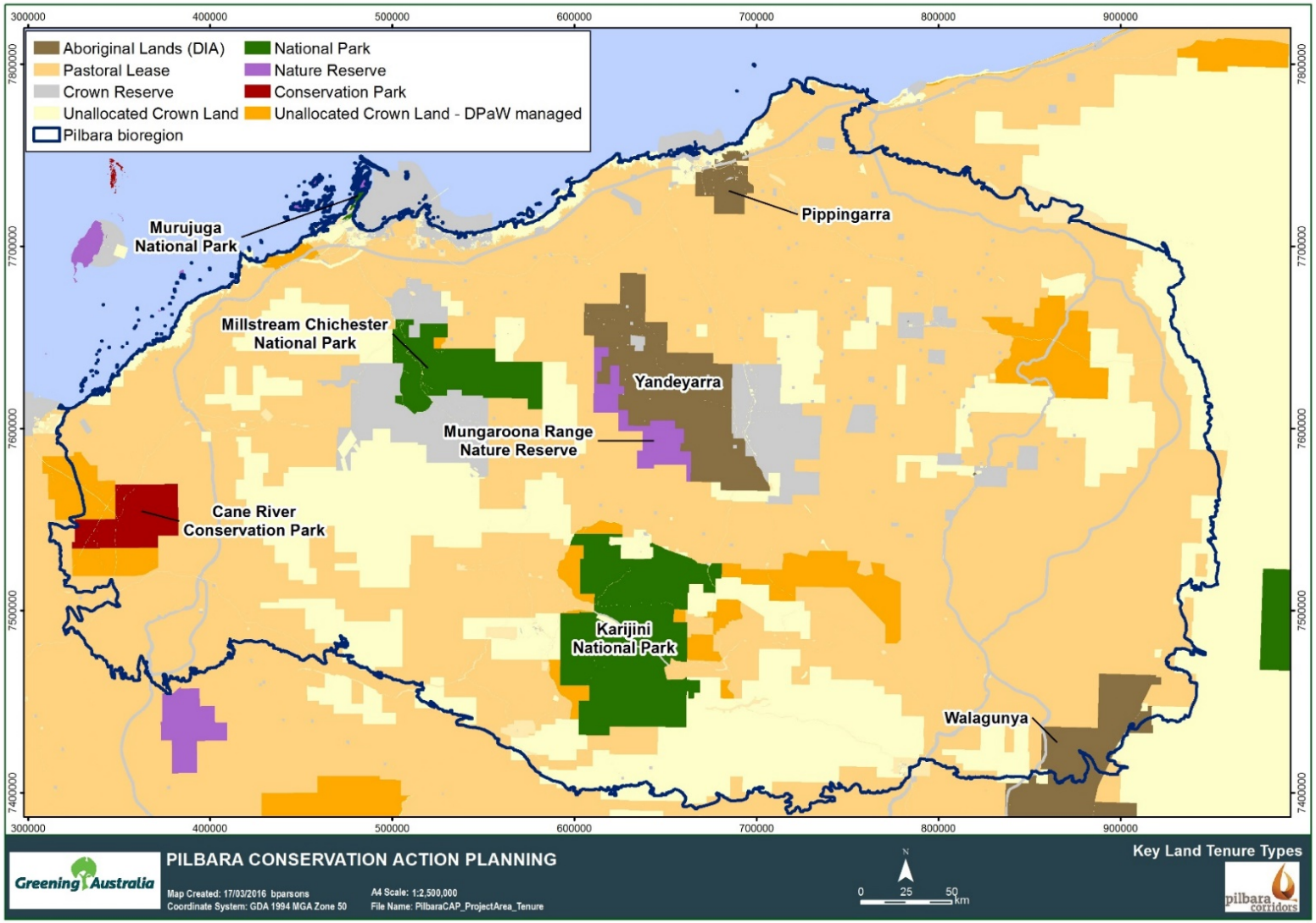


Figure 2: Key land tenure types within the Project Area

1.4 The CAP Process – an overview

A range of problems are often cited when referring to natural resource management, including:

- a lack of transparency and accountability in decision-making regarding allocation of funds;
- a lack of effective monitoring and evaluation of project outcomes; and
- the short term and isolated nature of conservation projects.

These problems are closely linked to the short term nature of funding cycles and shifting government priorities and policies at a state and federal level. Additionally, there is often a distinct gap between science and practice and a lack of collaboration between organisations working towards similar goals. There is often a lack of engagement between practitioners delivering on-ground projects and ecologists who are studying threatened ecosystems, communities and species and thinking about priorities for conservation more broadly. These problems can compromise the effectiveness and success of conservation projects.

In response to the problems detailed above, which are relevant across Australia and beyond, there exists a global movement called the Conservation Coaches Network (CCNET, http://www.ccnetglobal.com/) that exists to create coaches/facilitators to teach and train in Open Standards for the Practice of Conservation (also known as Open Standards or OS). This is an internationally recognised and widely adopted framework for natural resource management planning and implementation (**Figure 3**, CMP, 2013). The Open Standards is managed and maintained by the Conservation Measures Partnership (CMP) - a group of Non-Government Organisations and funders (CMP, 2013).

This summary document follows the 'Open Standards for the Practice of Conservation' (CMP, 2013) in conjunction with Miradi conservation planning and project management software (www.miradi.org). The Open Standards is a generic framework that has been developed into more specific versions such as Conservation Action Planning (CAP, TNC, 2007), used by The Nature Conservancy, Greening Australia and other conservation groups, and Healthy Country Planning which is used by indigenous groups in Australia (CMP, 2013). The process (**Figure 4**) combines research, analysis and desktop planning with collaborative, workshop-style planning that engages multiple stakeholders in an ongoing dialogue. This process encourages the development of measurable medium and long term goals for conservation action and is aimed at providing genuine solutions to the problems discussed above.

Whilst built on scientific principles, the approach recognises that there are often large gaps in ecological knowledge and data sets and hence a strong on-going adaptive management ethic is applied. Further input from local knowledge and additional research to address data gaps are envisaged to refine this process and plans in the future.

The key steps in the process are:

- the identification of conservation assets and nested assets within the defined project area (i.e. ecosystems, communities and species);
- an analysis of the viability (i.e.. health) of the conservation assets;

- a ranking of major threats to the conservation assets;
- the development of goals, strategies and action steps to achieve the long-term conservation of the assets; and
- the identification of practical monitoring indicators to support a robust monitoring, evaluation and adaptive management framework.

This document represents one "product" from the CAP process, i.e. a summary of existing knowledge and strategies in line with this framework, primarily based on the workshops held during 2015 and recognises that further and continued input and local knowledge are required to advance the planning and implementation phases. One of the strengths of the CAP process is that it is based on the direct involvement of stakeholders with an interest in land management. Key measures of the success of the CAP process are:

(1) the creation of lasting collaborations amongst land managers addressing priority conservation needs; and
(2) the measurable effectiveness of conservation actions at a landscape scale.

It is acknowledged that the collective ecological knowledge of the Pilbara, as reviewed in the preparation of this document, is incomplete. For some conservation assets, a lack of knowledge may prevent the accurate definition of conservation problems and possible solutions. This should not preclude the development of appropriate interim conservation strategies based on the best available information.

It is also acknowledged that the Pilbara is a large region with diverse landscapes, conservation assets, threatening processes, and stakeholders with varying interests. Within a framework of achieving lasting regional conservation outcomes, the Pilbara CAP process seeks to articulate and address stakeholder views and aspirations wherever possible.

Nearly all conservation actions are subject to the risk of failure; arising from one or a combination of technical challenges, poor management, economic factors, socio-political factors (eg. loss of community support) or stochastic events (eg. a prolonged drought). The risk of failure needs to be taken into consideration as a component of formulating conservation priorities.

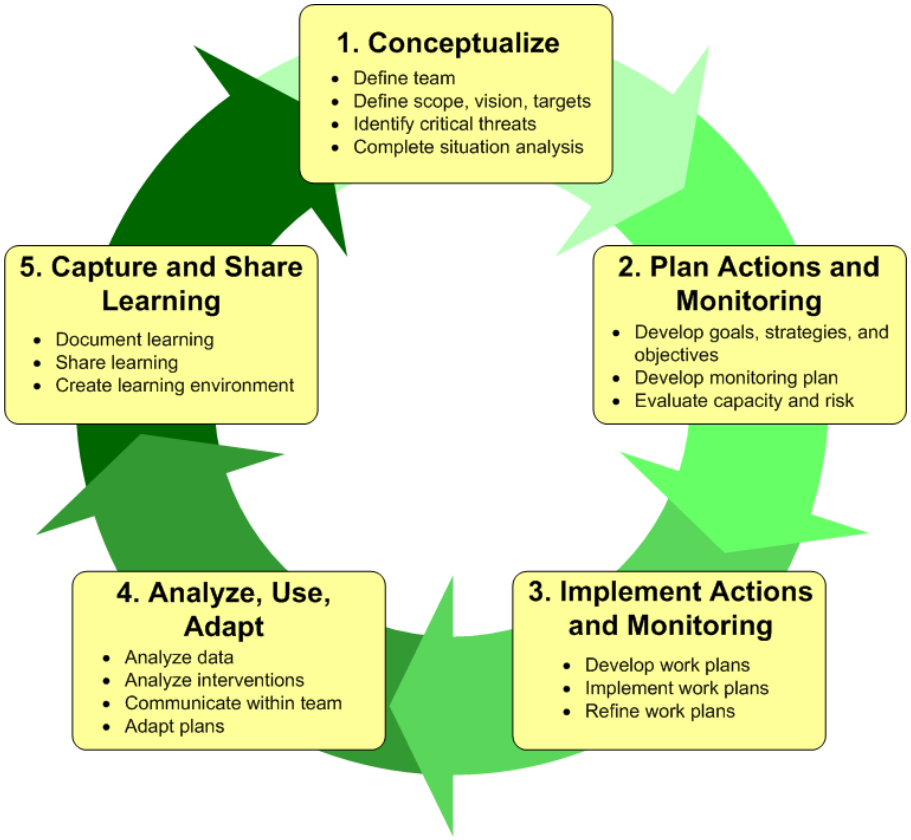


Figure 3: The 'Open Standards' adaptive management planning cycle

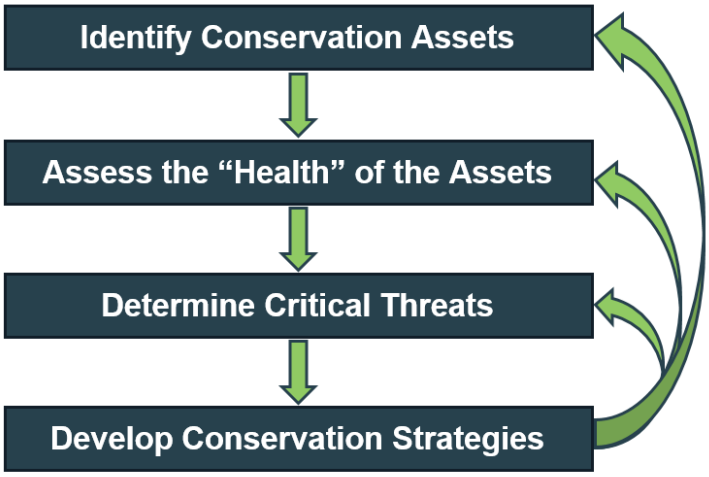


Figure 4: The major conceptual steps involved in the first stages of a Conservation Action Planning Process

1.5 Stakeholder workshops

- An introductory scoping workshop, held in Karratha in March 2015, detailed the CAP Process, key conservations assets, established an appropriate Project Area boundary and vision statement and discussed future participation.
- A second workshop, held in in Karratha in May 2015, focused on reviewing draft conservation assets, assessing their condition and determining threats to these assets. A discussion group, held in Perth in July 2015, provided further input into the outcomes of second workshop.
- A third workshop, held in Perth in late July 2015, focused on developing preliminary conservation goals, strategies and actions.

1.6 Development of a Vision for the Pilbara

A vision statement is '*a general summary statement that describes the desired state or ultimate condition that you are working to achieve*' (TNC, 2007). A statement of 'common vision' provides important source of inspiration and unification among participants in the CAP process. During the scoping workshop, several key vision statements were developed.

Table 1: Vision statements for the Pilbara CAP

Natural Landscapes and Species	Healthy, improving, ecologically functional landscapes (intact functional ecosystems, specific fauna assemblages) with viable populations of threatened species and reduced densities of invasive species to thresholds below which there is minimal impact.
Conservation Actions	Restoring native biota including successful translocations, best practice pastoralism and total grazing management, better fire management taken up by all major land managers, optimum feral animal control and weed management.
People and Values	Realistic, well-resourced management across landscapes with raised awareness of cultural values and significance of biodiversity of the Pilbara, supported by more local employment including indigenous people with Traditional Owners involved in rangeland management and leadership.
Planning and Sustainable Development	Resilient, enduring, co-ordinated, sustainable, robust strategic biodiversity management framework with resource company best practise, better integration of mining support and Traditional Owners actively engaged in successful partnerships/own enterprises in relation to land management and leadership on own country.

1.7 Situation analysis

Situation analysis is an important component of the CAP process contributing to the development of objectives, strategies and action steps. It involves the analysis of factors affecting conservation assets taking into account ecological elements (e.g. habitat, flora, fauna), ecological processes (e.g. flood, erosion, fire regime) and the interaction of stakeholders with the asset.

Specific questions addressed include:

- What factors positively and negatively affect the conservation asset?
- Who are the key stakeholders linked to each of these factors?

Answering these questions can help to identify opportunities for management interventions, possible constraints to conservation management, and the evaluation of which interventions will have the greatest impact.

Situation analyses for particular conservation assets can be summarised schematically. Eighteen situation analysis diagrams, addressing each of the conservation goals identified in the third Pilbara CAP workshop, were developed using the Miradi software program (**Appendix 3**).

In addition, as part of the workshop process, existing surveys, plans, reports, on-ground activities (including monitoring) and mapping were listed and collated to inform the planning process of the existing body of work already happening in the Pilbara. This included lists of relevant current programs and projects identified in the Pilbara CAP Workshop 3 held on 28– 29 July 2015 (**Appendix 3**).

Where possible, conservation assets and other relevant information were mapped and entered into a spatial database managed by Gaia Resources (http://pilbaracorridors.com.au/the-pilbara/knowledge-management/). There has been a substantial body of data collected (eg. by mining companies) that has not been included in this map, and there are significant areas across the Pilbara and across the layers represented by this spatial database where no data exists. Conservation assets were intersected with biodiversity records (NatureMap, 14/06/2016) to provide a relative measure of the level of knowledge existing for each asset and the relative diversity of flora and fauna taxa within each also.

1.8 Relevant Stakeholders

The Pilbara CAP is relevant to a wide range of stakeholders with an interest in land management in the Pilbara bioregion. The workshops undertaken in 2015 aimed to encompass the views of these stakeholders, including:

- pastoralists;
- Traditional Owners and Aboriginal corporations (eg. Gumula Aboriginal Corporation);
- environmental non-government organisations: International Union for Nature Conservation (IUCN), Greening Australia, Pilbara Mesquite Management Committee, Care for Hedland Environmental Association;

- mining companies: Fortescue Metals Group, Australian Premium Iron, Roy Hill Iron Ore, Citic Pacific Mining, Rio Tinto Iron Ore, BHP Billiton Iron Ore);
- Western Australian State Government: Department of Parks and Wildlife, Department of Agriculture and Food (DAFWA), Department of Mines and Petroleum (DMP), Environmental Protection Authority (EPA); Office of the Environmental Protection Authority (OEPA);
- Land Conservation District Committees (LCDC): De Grey LCDC;
- Regional NRM organisations: Rangelands NRM;
- local government: City of Karratha;
- Australian Government: Department of Environment;
- researchers (universities, IUCN) and
- environmental consultants and experts.

Note: The workshop series was a rapid information and strategy formulation exercise and while this process was well attended, it was not sufficiently represented by all relevant stakeholders. It is critical that key stakeholders responsible for management of conservation assets or addressing key threats are represented in future phases of the CAP process.

1.9 The CAP process – next steps

Conservation Action Planning is an ongoing project management cycle where products are delivered at different stages of the cycle. The key information from the Pilbara Conservation Action Planning process is stored primarily within the Miradi software (https://www.miradi.org/) and this summary document represents one "product" from the process. Although several steps have been addressed to some extent during the workshop process and subsequent work, additional key steps require further development. These include:

- further prioritisation of strategies and action steps, and developing these into projects, as appropriate;
- developing program logic for strategies;
    - creating results chains that describe the theory of change;
    - testing the links between undertaking strategies and achieving measurable outcomes;
- developing a monitoring framework with indicators of change to evaluate effectiveness of conservation actions;
- implementing the plan, including establishment of actions, timelines and budgets; and
- revising and updating the plan, where appropriate.

1.10 Regional overview of the Pilbara

Aboriginal Heritage

Excerpt edited in part from Regional Development Australia (RDA 2013).

Prior to European settlement, the Pilbara was sparsely populated with Aboriginal people, who lived in small nomadic tribes. They travelled between watering points as dictated by seasonal conditions and the availability of native food resources. They periodically burnt the landscape to flush out, and produce fodder for, native animals. Implemented over thousands of years, Aboriginal fire methods exerted an important influence over rangeland ecosystems and biodiversity.

The Pilbara region is home to a great variety of traditional landowner language groups, all of which have a strong spiritual, physical and cultural connection to the land. Aboriginal people are thought to have inhabited the region for up to 40,000 years. As such a rich cultural and historical indigenous heritage exists in the region, particularly in natural features such as rivers, hills and rock formations where people, animals and characters left traces of their journey across the landscape. These places may be valuable because of mythological lore (The Dreaming); because of past use as meeting places for special ceremonies; as burial grounds for ancestors; or as places where culture and history was recorded through rock art. The location of these important cultural sites within the natural landscape means there is considerable overlap between Aboriginal and natural heritage in the region.

Aboriginal heritage is an integral part of Aboriginal culture, customary law, and spirituality and its conservation is critical in ensuring that the unique indigenous culture in the Pilbara is not lost. Over five thousand indigenous heritage sites have been identified in the Pilbara region and are protected under the *Aboriginal Heritage Act* 1972. The geographical spread of places in the Aboriginal Heritage Sites Register largely reflects where Aboriginal heritage surveys have been conducted (EPA, 2007, cited by RDA, 2013). As heritage surveys are normally undertaken in response to development proposals, large areas of the region have not been surveyed. Therefore, site identification is biased towards areas subject to recent development. A number of particularly significant Aboriginal heritage sites have been recognised on a state, national and international level in the Pilbara. The most significant of these is Murujuga (National Park), also known as the Burrup Peninsula. There are also many additional significant surveyed sites which the custodians have chosen not to include on the register, so the number of significant sites is greater than that listed.

There are 20 native title claims in the Pilbara region, many of which are represented by the Yamatji Marlpa Aboriginal Corporation, the native title representative body for the region. To date there have been four litigated determinations in the region and nine consent determinations with an additional five land use agreements negotiated (Land, Approvals and Native Title Unit, 2016). The extensive claim areas under application and determination have recently been published by the National Native Title Tribal (2016, see http://www.nntt.gov.au/Maps/WA_Pilbara_NTDA_Schedule.pdf).

As Native Title is now enshrined in law there is a requirement to consult with and actively engage with the bundle of rights of native title groups in the course of land management planning activities. This

presents numerous opportunities for Aboriginal people to be involved with conservation and land management activities on country in the Pilbara, as outlined in the strategy section of this document.

European Heritage

Excerpt edited from Regional Development Australia (RDA 2013).

The European history of the Pilbara began at the coast in 1699 when William Dampier's ship, 'The Roebuck,' laid anchor in the Dampier Archipelago at Malus Island. A series of surveys of the Pilbara coast was undertaken by teams of explorers under the command of Captain King in The Mermaid in 1818 and Captains Wickham and Stokes in the HMS Beagle between 1838 and 1841. In 1861 Frank T. Gregory was sent to report on the country inland of the coast previously reported by King and Stokes as unfavourable. Gregory and his party used Nickol Bay, near present day Karratha, as a base and observed several large areas of land suitable for pastoralism, also naming the Ashburton, Fortescue, Sherlock, Yule, Harding, George, Strelley, De Grey and Oakover Rivers.

To encourage agricultural development, settlers were offered 40,000 ha (~100,000 acres) of land upon compliance of stocking conditions. A number of townships were then established along the coast during the late 1800's as part of the expansion of agricultural and pastoral activities, as well as the pearling industry and gold rush. The earliest towns are the now historical sites such as Cossack and Condon Creek, while many of the second wave of settlement continue to persist including towns like Roebourne, Point Samson, Port Hedland, Marble Bar and Nullagine.

The Natural Environment

Excerpt edited from Cumulative environmental impacts of development in the Pilbara region (EPA, 2014)

The Pilbara IBRA bioregion is approximately 179,000 square kilometres in size and is characterised by ancient and striking landscapes. It consists of four subregions – the Fortescue, Hamersley, Chichester and Roebourne (**Figure 1**). The Pilbara has a diversity of habitats, including mangroves, grasslands, mountain ranges, gorges, wetlands and semi-tropical woodlands. It is an area of very high biodiversity value, possessing high species richness, and many endemic flora and fauna species. It has ~150 conservation significant flora species, the greatest reptile diversity in Western Australia and is identified as one of only 15 national biodiversity hotspots. The Pilbara contains the richest known groundwater and cave-dwelling faunal diversity in Australia and possibly the world, with over 1,000 species. Recent estimates suggest this number may be as high as 3,000 species (Halse 2015).

The rich faunal diversity of the Pilbara is still being described, with new species of vertebrates as well as large numbers of terrestrial, aquatic and subterranean invertebrates being discovered. The high reptile diversity includes the greatest number of gecko species in Australia as well as high numbers of goannas, dragons and skink species. Terrestrial invertebrates show high levels of diversity and endemism with in excess of 375 taxa of ground-dwelling spiders and 429 beetle species.

Although the Pilbara is in the arid zone it has an abundance of wetlands, ranging from springs and river pools to salt marshes, claypans, and rockpools. Aquatic invertebrates show high diversity for an arid zone with about one-fifth of all species encountered currently believed to be endemic to the region (Pinder *et al*. 2010 in EPA, 2014). This high richness is considered to reflect the abundance of consistently fresh, permanent water maintained by freshwater aquifers. Of particular importance are the many groups of rare species that are restricted to a limited range of springs and spring-fed pools including those at Millstream Chichester National Park and Karijini National Park.

The ancient iron ore deposits of the Pilbara often support unique biodiversity values not present elsewhere in the region. Many of the links between the underlying geology and the biodiversity are still unknown.

Current Land Use

Excerpt edited from Cumulative environmental impacts of development in the Pilbara region (EPA, 2014)

The Pilbara region is almost exclusively Crown land, with freehold land generally concentrated along the coastline and around inland towns. Layered over the Crown land are various land uses that often overlap one another. These include mining tenements, pastoral leases, formal conservation reserves, informal conservation areas, Aboriginal Reserves and Unallocated Crown Land. With this diversity of competing land uses, major constraints apply to any further allocation of land for conservation and many conservation reserves already have mineral exploration leases or mining tenements over portions of them. Currently, only 6.4% of the Pilbara bioregion is held in the formal Parks and Wildlife managed reserve system, well below the 17% recognised internationally for biodiversity protection. The conservation reserves are not proportionally distributed among the four subregions. By far the most threatened and least protected is the Fortescue subregion, with only 0.55% currently reserved for conservation. The Chichester and Roebourne subregions are marginally better represented with 3.95% and 3.71% respectively, and the Hamersley subregion has 12.88% held within the Parks and Wildlife managed reserve system.

Pastoralism

Excerpt edited from Cumulative environmental impacts of development in the Pilbara region (EPA, 2014)

Approximately 65 per cent of the Pilbara is grazed by livestock. Van Vreeswyk *et al.* (2004) found that particular land systems have been considerably impacted as a result of preferential grazing by livestock. Preferential grazing can reduce or remove particular species and modify the composition of affected areas, particularly over the long term. Sheep were the dominant livestock in the Pilbara early part of the 20th century (1,807,800 in 1934, down to 619,000 by 1978 and nil by 2000, Van Vreeswyk *et al.* (2004)) resultant in lasting negative impacts on native vegetation, particularly in riparian systems and coastal plains. Cattle numbers in the Pilbara increased throughout 1993 – 2009 (DAFWA, 2012, in EPA, 2014), with numbers more than doubling in the East Pilbara and De Grey Land Conservation

Districts during this period. Overstocking is reported as occurring across a number of Pilbara pastoral leases (DAFWA, 2012, in EPA, 2014). Some mining companies have purchased pastoral leases that are coincident with their mining activities. Other leases are held by Aboriginal communities, Government departments and other public sector organisations. The Department of Parks and Wildlife also manages a number of former pastoral leases for conservation purposes.

A Rangelands reform program is currently underway that aims to create new opportunities and encourage more people to live in the Rangelands, improving economic, social and land management outcomes. A key component of the proposed reforms is the establishment of a new "rangelands lease" that may permit multiple and varied land uses. Other than grazing livestock, the kinds of permitted uses under a rangelands lease will include agriculture, horticulture, tourism, conservation purposes and "Aboriginal economic development and land management".

Mining and Infrastructure

Excerpt edited from Cumulative environmental impacts of development in the Pilbara region (EPA, 2014)

The mining and energy sectors make a substantial contribution to economic activity in Western Australia and much of the activity occurs in the Pilbara. Over the past five years Western Australia's iron ore industry has experienced a time of unprecedented growth, followed by unprecedented decline. In 2011, the Pilbara region produced more than 90 per cent of Australia's iron ore and approximately 95 per cent of Western Australia's iron ore (DMP, 2012 in EPA, 2014). In addition, the Pilbara accounts for 80 per cent of the State's entire production value from minerals and petroleum (DMP, 2012, in EPA, 2014). There has been a commensurate increase in proposals referred to the EPA for assessment during this period of growth.

There are approximately one billion tonnes per annum of approved mineral export capacity in either existing or approved ports on the Pilbara coast. Supporting this is a network of rail and road infrastructure connecting mine sites with these ports. There is more than 2,800 km of rail infrastructure, comprising four major privately operated rail networks. In addition, there are also seven major rail projects approved totalling almost 1,500 kilometres of track.

Population and urban expansion

Excerpt edited from Pilbara Planning and Infrastructure Framework (Department of Planning, 2012)

Given that the Pilbara region is considered an economic powerhouse for Australia and is located close to key markets in Asia, it is predicted that by 2035, the region will have a resident population of some 140,000 persons, due to a more diverse economy that has capitalised on its competitive advantages. The region will have two cities: Karratha City (consisting of the Karratha and Dampier townsites) and Port Hedland City (consisting of Port Hedland and South Hedland). Each is expected to have a population of 50,000 by 2035. These major settlements will be supported by the Newman sub-regional centre (population 15,000). Other settlements (eg. Paraburdoo, Tom Price) will be planned to

accommodate growth largely associated with expansion of the mining and oil and gas sectors. The larger population in the region's main urban centres will support a more diversified economic base, providing a much wider range of employment opportunities. More affordable housing and a greater housing choice, together with access to higher standards of education, health, recreation and other community services and a general improvement in amenity will result in many fly-in fly-out workers choosing to live in the Pilbara on a more permanent basis. Some will choose to retire in the region.

The estimated residential population of the Pilbara was 66,300 in 2013, with fly-in-fly-out employees boosting the population by approximately a further 50,000 people (Department of Regional Development, 2015).

2 Conservation Assets

2.1 Methodology for Identifying Assets

The first step in the CAP process is to identify conservation assets (ie. ecosystems, communities or species) that collectively represent the biodiversity of a region. The process assumes that by conserving representative examples of broad-scale communities and ecosystems, the majority of species will also be conserved. Therefore, the list of conservation assets need not be long and exhaustive; rather, it should be representative.

The asset selection process begins by identifying the coarse scale ecosystems and communities for conservation. Whether to lump ecosystems and communities together or split them into individual conservation assets can be a difficult decision; in general, ecosystems and communities should be combined together if they:

- co-occur across the landscape;
- share similar ecological processes;
- share similar threats.

The next step is to screen for species and communities occurring at smaller scales that are not well "nested" within the broader set of ecosystems or communities. That is, those species and communities whose conservation requirements are not met through the conservation of the coarse scale assets. This approach is known as the coarse filter – fine filter approach (Groves, 2003). Examples of species often not captured by coarse-scale assets include:

- rare, threatened and endemic species;
- species with highly disjunct (spatially separate) populations or restricted distributions;
- keystone or highly interactive species (those that have a disproportionate influence on the structure and ecological function of the community); and
- wide-ranging species.

Species and communities that fall into the above categories may be captured by threatened species recovery programs or may need to be considered as separate conservation assets. In the context of the Pilbara, a recent process focusing on species of conservation of significance identified a range of strategies to improve the status of these species (Carwardine *et al.*, 2014). This work has been considered in the Pilbara CAP process.

2.2 Description of Assets

During the Pilbara CAP workshop series, 13 broad assets were identified:

1) Offshore Islands;
2) Coastal Mangroves and Intertidal Mudflats;
3) Sandy Beaches and Dunes;
4) Spinifex Hummock Grassland on Plains with Shrubs and Trees (eg. Acacia);
5) Tussock Grasslands on Plains;

6) Mulga Woodlands and Acacia Shrubland Communities;
7) Rivers, Creeks and Associated Floodplains on Open Plains;
8) Fortescue Marsh (EPA defined area);
9) Springs, Pools and Watercourses Associated with Gorges and Ranges
10) Clay Pans;
11) Subterranean Fauna Habitat;
12) Inland Mountain Ranges, Rocky Hills, Breakaways and Mesas; and
13) Rock Piles and Granites.

Important "nested assets" (ie. species and communities of conservation significance that are considered to be "captured" by the broader ecosystem) were identified to ensure that their requirements were considered when ranking threats and developing conservation strategies for each asset (**Appendix 1**). Knowledge regarding biodiversity within each asset varied substantially (ie. survey effort, species diversity), as evidenced by the number of Naturemap families and records present within each (**Figure 5** - **Figure 8**).

A conservation significant species is defined as a species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act), the *Wildlife Conservation Act 1950* (WA) (WC Act), the Department of Parks and Wildlife's Priority list and/or under international agreements including the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA), Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals).

NatureMap Analysis

To provide a relative measure of biodiversity knowledge and taxon diversity within each conservation asset, mapped assets were intersected with location data from NatureMap, Paul Gioia, June 2016). NatureMap data for this analysis included:

- only taxa with current names;
- only taxa naturally occurring in WA;
- only data from datasets flagged as core;
    - Fauna: ALA Vouchered Collections of WA Species (2,314 records), Atlas of Australian Birds (37,872 records), Fauna Survey Returns Database (110,649 records), Mammals on Australian Islands (49 records), Pilbara Biological Survey - Waterbirds (463 records), Pilbara Threatened Fauna (40 records), WA Threatened Fauna Database (1,334 records), WA Museum Bird Database (1,490 records), WA Museum Mammal Database (5,340 records), WA Museum Reptile Database (15,133 records), WA Seabirds (341 records).
    - Vascular Flora: ALA Vouchered Collections of WA Species (10,867 records), Cane River Flora Survey (564 records), Threatened and Priority Flora Database (451 records), Threatened Flora Seed Centre Collections (10 records), WA Herbarium Specimen Database (31,403 records).

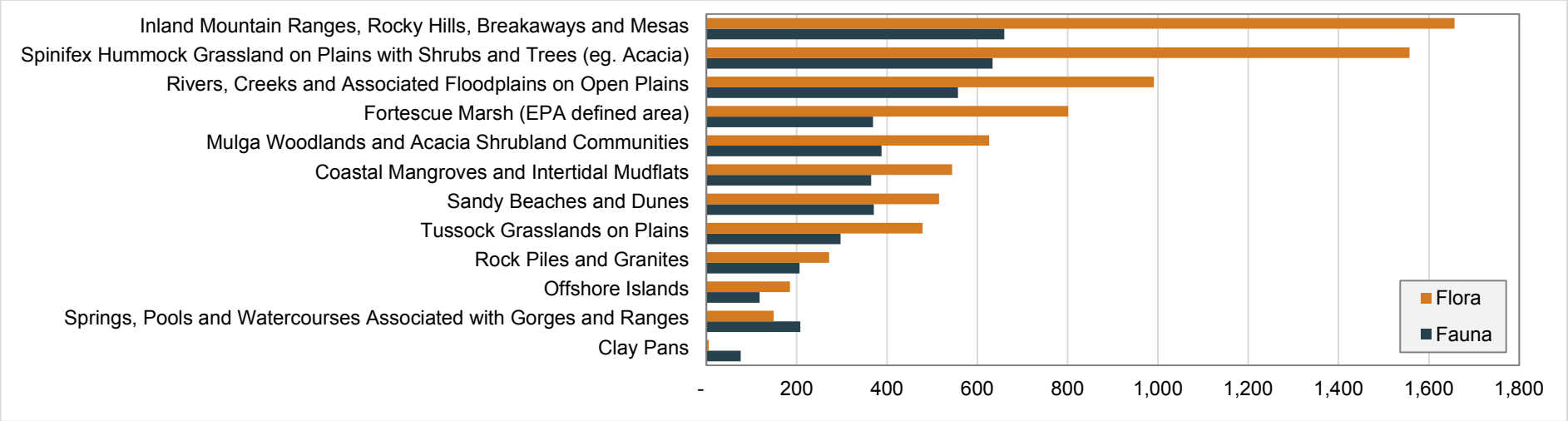


Figure 5: Number of taxa (ie species and subspecies) occurring within each conservation asset (NatureMap, 2016)

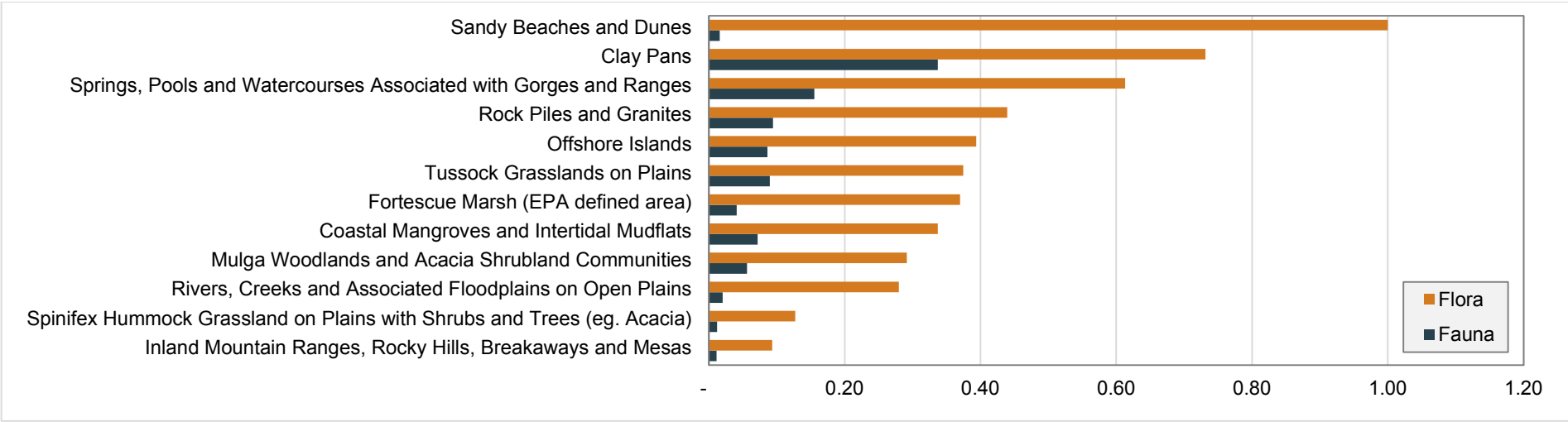


Figure 6: Number of taxa (per record) within each conservation asset (NatureMap, 2016)

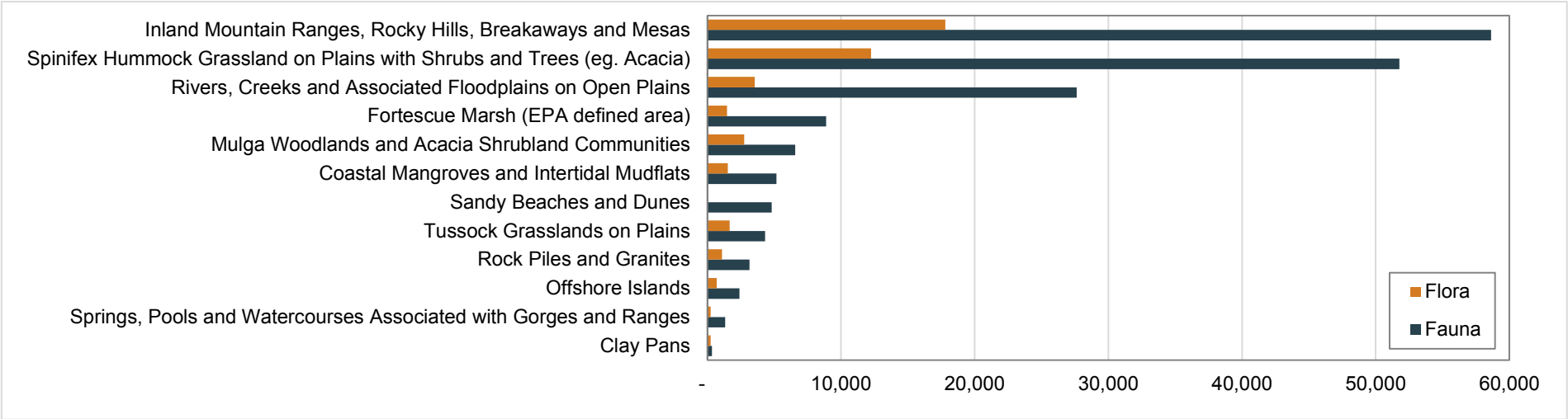


Figure 7: Number of NatureMap records occurring within each conservation asset (NatureMap, 2016)

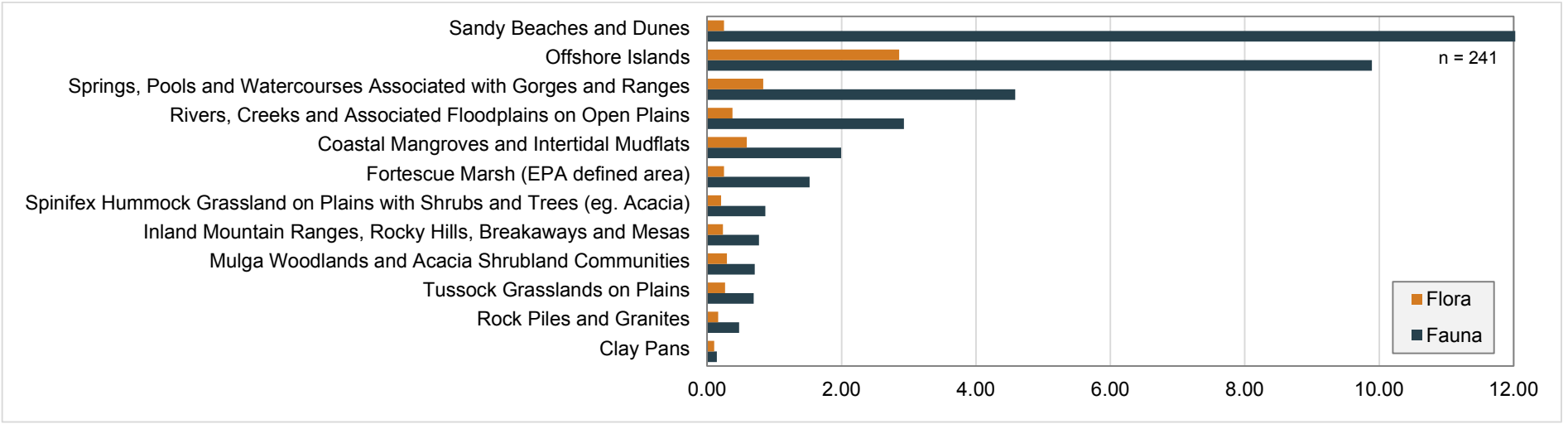


Figure 8: Number of NatureMap records occurring within each conservation asset (per km^2) (NatureMap, 2016)

Asset #1: Offshore Islands

Summary				
Description	Offshore islands of the Pilbara Bioregion; either Quaternary sand accumulations, or composed of basalt or limestone, or any combination of these three. Offshore islands range in size from 0.2 to 3,340 ha.			
Key locations	• Dampier Archipelago; • islands between Cape Preston and Onslow (as far west as Serrurier); • islands between Cape Lambert and Port Hedland; • islands off Poissonnier Point; • Bedout Island.			
Total Area (% of bioregion)	24,707 ha (0.13%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	2393	59	121	36
Flora	691	52	151	3

Plate 1: Enderby Island in the Dampier Archipelago (Photo credit: Google Earth)

Asset #2: Coastal Mangroves and Intertidal Mudflats

Summary	
Description	Mangroves occur in creek mouths and reef-sheltered embayments along the Pilbara coast. As mangrove communities are rare in arid conditions, those of the Pilbara are of great scientific importance. 80% of mangrove sites in the Pilbara region meet RNE (Register of the National Estate, Australian Heritage Commission) criteria, with 15 of these sites already listed and a further 46 sites nominated for listing, with some of these sites being recognised internationally as significant. Although there has been extensive loss of mangrove communities in the Pilbara regions due to industrial activities, those mangrove communities that still exist are in near pristine condition. Fringing mangroves of the region are typically backed by extensive intertidal flats that are characterised by a rich and diverse fauna of burrowing invertebrates, and are major habitats for migratory birds that use the mud flats as feeding grounds. These tidal flats are not only rich in burrowing invertebrates such as molluscs but also support extensive blue-green algal mats (high productivity, nitrogen fixation) and extensive areas of tidal samphire communities which harbour several undescribed and possibly Pilbara endemic samphires (Tecticornia spp.)
Key locations	Mouth of De Grey, Turner, Yule, Harding and Cane Rivers, Port Hedland, Balla Balla, Dixon Island, West Intercourse Island, Nickol Bay, Fortescue River delta, Maitland River delta, Robe River delta, Cossack to Harding Delta complex (highest diversity of mangrove plant species), Sherlock Bay, Ronsard Island
Total Area (% of bioregion)	124,693 ha (0.67%)

Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	5,173	80	200	59
Flora	1,527	66	195	10

Plate 2: Mangrove community
(Photo credit: Blair Parsons, Greening Australia)

Asset #3: Sandy Beaches and Dunes

Summary	
Description	The Pilbara coastline comprises a number of sandy beaches which intersperse the predominantly rocky shoreline. The coastline is a low energy system (in terms of wave action) with a large tidal range. The sandy beaches and dunes provide habitat for a range of fauna species, in particular nesting sites for a number of turtle species. Four of the world's seven species of marine turtles, the Loggerhead, Green, Hawksbill and Flatback Turtle occur in the waters off the Pilbara coast and nest on the region's beaches. Although most turtles nest on offshore islands, Munda Beach in Port Hedland is an important nesting area for threatened Flatback Turtles. The Munda Beach rookery is one of the largest rookeries in the state, with several hundred female turtles laying their eggs at this site each year.
Key locations	• Munda; • Port Hedland; • Point Sampson beaches; • 40 mile beach (South of Karratha); • Wickham; and • Cape Preston
Total Area (% of bioregion)	1,992 ha (0.01%)

Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	4,811	33	56	25
Flora	5	5	5	-

Plate 3: Coastal Dune community
(Photo credit: Vicki Long, Astron Environmental)

Asset #4: Spinifex Hummock Grassland on Plains with Shrubs and Trees

Summary				
Description	Much of the Pilbara bioregion comprises spinifex hummock grasslands (*Triodia* spp.) on plains with emergent shrubs (eg. *Acacia inaequilatera*) and trees (*Corymbia hamersleyana*), generally with percentage cover of 10–30%. An assessment of land systems (van Vreeswyk *et al*., 2004) found that most (88%) hummock grassland sites were in good condition, with 6% in fair and 6% in poor condition. Spinifex is a fire adapted plant, and there has been frequent burning throughout history, including "fire-stick farming" practices of the Aboriginals. Termite mounds within this asset act as refugia for a range of invertebrates, small mammals and reptiles (Thompson and Thompson, 2015). The value of Spinifex Sandplains in supporting fauna assemblages is often closely related to their history, with areas retaining a mosaic of fire ages often providing the best habitat.			
Key locations	Asset is widespread throughout the region			
Total Area (% of bioregion)	6,617,160 ha (35.7%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	51,761	90	238	66
Flora	12,255	88	338	111

Plate 4: Spinifex Hummock Grassland community
(Photo credit: Blair Parsons, Greening Australia)

Asset #5: Tussock Grasslands on Plains

Summary				
Description	Tussock grasslands occur mostly on alluvial plains, gilgai plains and drainage tracts. An assessment of land systems (van Vreeswyk *et al*., 2004) found that most (75%) of the tussock grassland sites were in good condition, with 17% in fair condition and 8% in poor condition. Tussock grasslands are generally more susceptible to grazing as their component species are palatable and preferentially grazed, particularly when they are green. Tussock grasslands support higher numbers of Priority flora species than other vegetation formations.			
Key locations	• Hamersley Station, West Angeles; • Roebourne Plains coastal grasslands, Sherlock Station and Roebourne Common, Airport Reserve (between Roebourne and Karratha), Seven Mile Creek; • Newman – old aero/glider club grounds.			
Total Area (% of bioregion)	624,704 ha (3.37%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	4,327	78	188	37
Flora	1,671	66	216	28

Plate 5: Tussock Grassland community
(Photo credit: Stephen van Leeuwen, Parks and Wildlife)

Asset #6: Mulga Woodlands and Acacia Shrubland Communities

Summary	
Description	*Acacia aneura* (Mulga) is the predominant species in rangelands to the south of the Pilbara and is often the dominant species in woodlands or tall shrublands. Where Mulga is recorded in the north and west of the Pilbara it is most commonly a component of hummock grassland communities. *Acacia xiphophylla* (snakewood) shrublands which are often mid-height shrublands, are common throughout the Pilbara, in particular in the south-west areas. Mulga is susceptible to fire and its range is restricted by the frequency and intensity of fire which increases in spinifex-dominated areas. It may occur in 'fire refuge' areas on spinifex covered ranges. Mulga typically occurs as low woodland over bunch grasses on fine textured soils in valley floors and are sensitive to hydrological changes. There is a large genetic diversity of Mulga – 12 species (Maslin and Reid 2012).
Key locations	• Red Hill Station (Mulga Communities of the Fortescue Valley); • Balfour Downs, Mulga Downs; • Mt Bruce, Mt Newman, Mt Robertson/Giles, Pamelia Hill; • Roy Hill, Munyra claypan, Wonnamunna.
Total Area (% of bioregion)	970,607 ha (5.24%)

Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	6,581	77	181	18
Flora	2,749	66	230	36

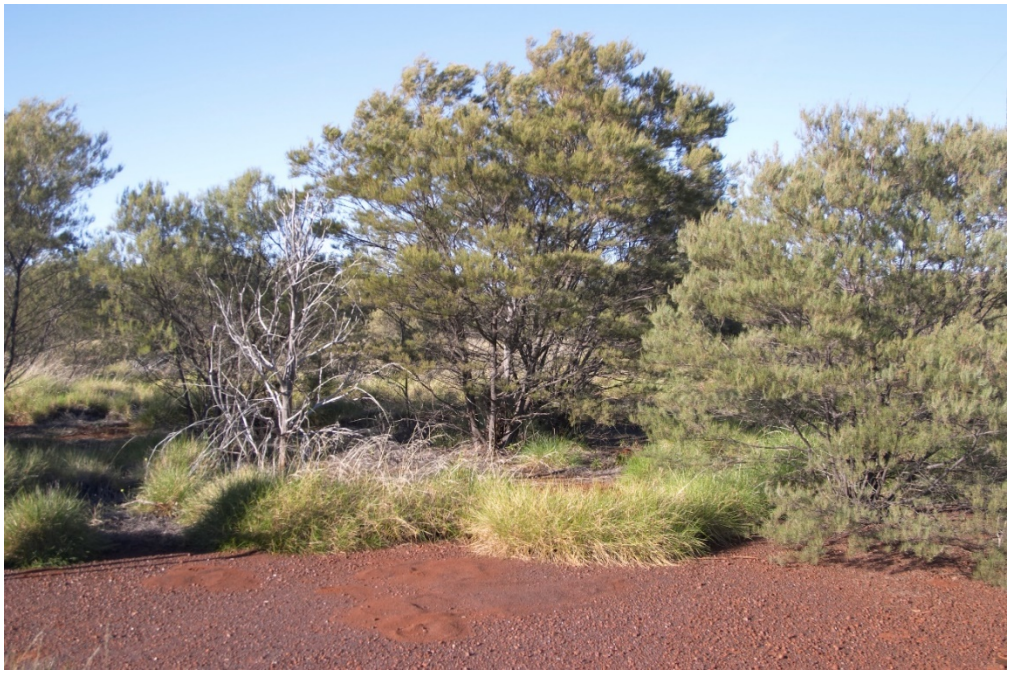


Plate 6: Mulga Woodland community
(Photo credit: Stephen van Leeuwen, Parks and Wildlife)

Asset #7: Rivers, Creeks and Associated Floodplains on Open Plains

Summary	
Description	There are five major drainage basins within the Pilbara: the Ashburton River; Onslow Coast; Fortescue River; Port Hedland Coast and De Grey River. These basins drain the rocky outcrops of the central Pilbara and discharge over the coastal plains into the Indian Ocean. Stream flows in the Pilbara region are mostly a direct response to rainfall, and as such they are highly seasonal and variable. With the exception of some small but important, spring-fed sections, all waterways in the region are ephemeral, in that surface flow ceases for at least part of each year (Lyons 2015). The riparian zone of major systems – De Grey, Oakover, Turner, Fortescue, Robe, Cane and Ashburton are degraded to fair with significant management intervention required for recovery (McKenzie *et al*., 2003).
Key locations	• De Grey River, Ashburton River, Fortescue River, Yule River, Sherlock River, Cane River, Robe River, Harding River, Maitland River, Turner River, Miaree Pool
Total Area (% of bioregion)	945,461 ha (5.1%)

Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	27,630	85	224	38
Flora	3,541	76	265	51

Plate 7: Riparian community
(Photo credit: Blair Parsons, Greening Australia)

Asset #8: Fortescue Marsh (EPA defined area)

Summary				
Description	The Fortescue Marsh is the largest ephemeral wetland in the Pilbara region and is recognised as nationally important. It is rich in plant and animal species of high conservation value and is part of an ancient and complex array of alluvial aquifers and groundwater systems. It is also at the heart of an important mining province and long-standing pastoral industry, and has high cultural and heritage importance to the Indigenous peoples of the region. A Nationally Important Wetland, it is proposed for the Fortescue Marsh to be listed as a Ramsar wetland.			
Total Area (% of bioregion)	583,630 ha (3.15%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	8,890	79	191	22
Flora	1,470	55	174	23

Plate 8: Fortescue Marsh samphire community (Photo credit: Jeff Pinder, Parks and Wildlife)

Asset #9: Springs, Pools and Watercourses Associated with Gorges and Ranges

Summary	
Description	Water pools in the Pilbara provide an important source of water in what is largely a dry landscape, and thus attract a diversity of fauna. There are numerous springs, pools and watercourses associated with gorges and ranges, some of which are relatively small and others occur in deeply incised gorges, up to 100 m deep, containing extensive permanent spring-fed streams and pools. Rare and/or restricted aquatic fauna elements are present, especially in some permanently flowing springs, including those in Millstream and Karijini National Parks.
Key locations	• Millstream Pools within Chichester Range - wetland of national significance; • Karijini Gorges - wetland of national significance; • Waterfalls of Hamersley Range with undescribed plant species, fern covered seepages on rock walls of gorges within the Hamersley Range; • Running Waters and Skull Springs on the Oakover; • Weeli Wolli Spring in the Fortescue; • Nyeetbury Spring on the Robe River; • Calcretes in Fortescue Valley near Wittenoom between BHPIO Rail and Millstream. • Ethel Gorge on the Whaleback Creek. • Minthicoondunna and Milli Milli Springs on Turee Creek within Karijini National Park • Coppins Gap Pool and Cattle Gorge on Yarrie Station • Pools of Duck Creek and Caves Creek in the western Hamersley Range • Pools and Springs of the Robe River and Bungaroo Creek
Total Area (% of bioregion)	89,729 ha (0.48%)

Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	1,339	66	145	11
Flora	243	38	86	14

Plate 9: Pool habitat at Karijini National Park (Photo credit: Melinda Salemi)

Asset #10: Clay Pans

Summary	
Description	Claypans and clay flats capture a large component of the Pilbara wetland flora, and their scattered occurrence across the lowlands of the region poses difficulties in capturing their diversity in the reserve system. Clay flats and claypans and lowland creeks with fine sediments are typically highly turbid and also display high numbers of rare plant taxa. Claypans and clay flats have rich assemblages of annual taxa and are also important for invertebrates with a number of endemics and specialists being recorded in regional surveys.
Key locations	• Freshwater claypans downstream of the Fortescue Marsh - Goodiadarrie Hills on Mulga Downs Station (PEC – Priority 1). Claypans extend onto Mt Florence and Coolawanyah Stations. • Gnalka Gnoona Claypan, Moreton Pool, Cane River Claypan, Paradise Pool, DeGrey Claypan, Munreemya Billabong, Coppin Pool, Sweet Well Claypan, Roy Hill Claypan, Mulga Downs Outcamp Claypan, Ethel Creek Claypan , Berringarra Claypan, Munjina Claypan, Claypans on Wunna Munna Flats, Lake Robinson on Coondewanna Flats, Mt Bruce Coolabah woodlands on Mt Bruce Flats
Total Area (% of bioregion)	240,821 ha (1.3%)

Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	350	47	87	4
Flora	253	35	83	8

Plate 10: Mungaratheena Clay Pan community at Mulga Downs Station (Photo credit: Adrian Pinder, Parks and Wildlife)

Asset #11: Subterranean Fauna Habitat

Summary	
Description	Stygofauna are aquatic animals that live in groundwater. Troglofauna are air-breathing terrestrial animals that live underground in caves and smaller air-filled voids (meso-caverns or vugs) beneath the ground. The Pilbara is an important region for subterranean fauna, it is arguably the world's richest bioregion for such fauna (Halse 2015). A feature of the Pilbara is that stygofauna occur across most of the landscape, often where the depth to groundwater is considerable. Another feature is high endemicity: on the basis of current taxonomy, 98% of the stygobites and 83% of the other groundwater species occur only within the region (Halse *et al*. 2014).
Key locations	• Ethel Gorge / Ophthalmia Basin Aquifer Stygobiont Community – Threatened Ecological Community; • Robe River Valley; • Millstream Aquifer. • BIF ranges of the Hamersley Range
Total Area (% of bioregion)	5,291,767ha (29.61%), NB overlaps with other conservation assets

Plate 11: *Pygolabis humphreysi* –a stygobitic isopod from Ethel Gorge priority ecological community. (Photo credit: Syngeon Rodman, MWH Global)

Asset #12: Inland Mountain Ranges, Rocky Hills, Breakaways and Mesas

Summary				
Description	The Chichester Range, Gorge Range, Ord Range, Ripon Hills, Gregory Range, Magpie Range, Hamersley Range (encompassing its constituent ranges such as the Ophthalmia Range, Packsaddle Range, Hancock Range, Eastern Ridge, Western Ranges, Channar Ranges, Rhodes Ridge etc) consist mostly of rugged, sparsely vegetated hills rising to 1,250 m. In the Chichester and Hamersley Ranges many gorges contain permanent water which is otherwise scarce in the region. The gorges vary from wide, open-sided valleys (eg. Yampire Gorge) to narrow gorges with precipitous cliffs (eg. Hancock Gorge). The vegetation of these systems is typically dominated by hummock grasses (*Triodia* spp.) under a very sparse overstorey of Snappy Gum (*Eucalyptus leucophloia*) which occurs on nearly all hills, ridges and ranges in the Pilbara. Soils are stony skeletal gritty sands, gravels, gritty loams and clays with dense surface mantles of pebbles and cobbles and frequent bedrock outcropping.			
Key locations	• Millstream Chichester National Park; • Karijini National Park; • Hamersley Range; • Chichester Range; • Mungaroona Range Nature Reserve. • Meentheena Conservation Park – Ripon Hills			
Total Area (% of bioregion)	7,649,205 ha (41.3%)			
Biota – Summary of known records (NatureMap, 2016				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	58,263	91	239	67
Flora	17,800	94	359	130

Plate 12: Wittenoom Gorges in the Hamersley Ranges (Photo credit: Karen O'Brien)

Asset #13: Rock Piles and Granites

Summary				
Description	Comprises a few key areas of which two major sites are the boulder field present at Burrup Peninsula and the abundant granite tors existing on the Abydos Plain. The Burrup Peninsula represents and evolutionary refuge for flora (vegetation is notably different to mainland) and also a minor centre for terrestrial gastropods.			
Key locations	• Burrup Peninsula (Murujuga National Park) (DEC, 2013) • Abydos Plain (containing Abydos Woodstock Reserve) • Black Range • Spear Hill • Mt Stuart tor field			
Total Area (% of bioregion)	664,229 ha (3.58%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	3,147	77	175	25
Flora	1,090	66	163	22

Plate 13: Rock Piles on the Abydos Plain
(Photo credit: Blair Parsons, Greening Australia)

2.3 Distribution of Conservation Assets

As part of the CAP process, the conservation assets were mapped using existing data sets (eg. vegetation (Beard *et al*., 2013), land systems, a digital elevation model, hydrological features) and some manual interpretation and alteration, to best represent the assets spatially (**Figure 8, Figure 9**). Several of the assets are relatively limited in extent, with three representing <1% of the area of the Pilbara, whereas two assets dominate, comprising over 75% of the aerial extent of the Pilbara (**Table 2**).

Table 2: Extent of conservation assets within the Pilbara bioregion

Asset	Area (ha)	Proportion (%)
Inland Mountain Ranges, Rocky Hills, Breakaways and Mesas	7,600,021	42.5
Spinifex Hummock Grassland on Plains with Shrubs and Trees	5,967,843	33.4
Rivers, Creeks and Associated Floodplains on Open Plains	944,301	5.3
Mulga Woodlands and Acacia Shrubland Communities	930,271	5.2
Rock Piles and Granites	663,017	3.7
Tussock Grasslands on Plains	624,295	3.5
Fortescue Marsh (EPA defined area)*	583,060	3.3
Coastal Mangroves and Intertidal Mudflats	259,722	1.4
Clay Pans	240,130	1.3
Springs, Pools and Watercourses Associated with Gorges and Ranges	29,198	0.16
Offshore Islands	24,197	0.14
Sandy Beaches and Dunes	1,992	0.01
Total Area **	**17,868,049**	**100**

* The EPA defined area contains multiple habitat types, some of which (eg. Mulga) have been excluded from their 'true/parent' asset due to an arbitrary line defining this management area. This use of this area, which has existing zones with different management implications was seen as a pragmatic when defining the Fortescue Marsh during the workshop series. However, this may be revisited in the next phase of the Pilbara CAP process, and it may be better to use the ecologically-defined Fortescue Marsh Land Management Unit as the border of this asset. The EPA defined area comprises a number of zones defined by relative environmental significance as follows: zone 1a (Northern Flank) and zone 1b (Marsh), zone 2a (Calcrete Flats), zone 2b (Poonda Plain) and zone 2c (Fortescue River Coolibah); zone 3a (Kulbee Alluvial Flank) and zone 3b (Marillana Plain) (EPA, 2013).

** Please note that subterranean fauna conservation asset overlaps a number of other assets (**Figure 8, Figure 9**) and was therefore excluded from **Table 2**. The subterranean fauna conservation asset, as defined spatially using land units, covers an area of 5,291,767 ha or 29.61% of the total area of the Pilbara Bioregion.

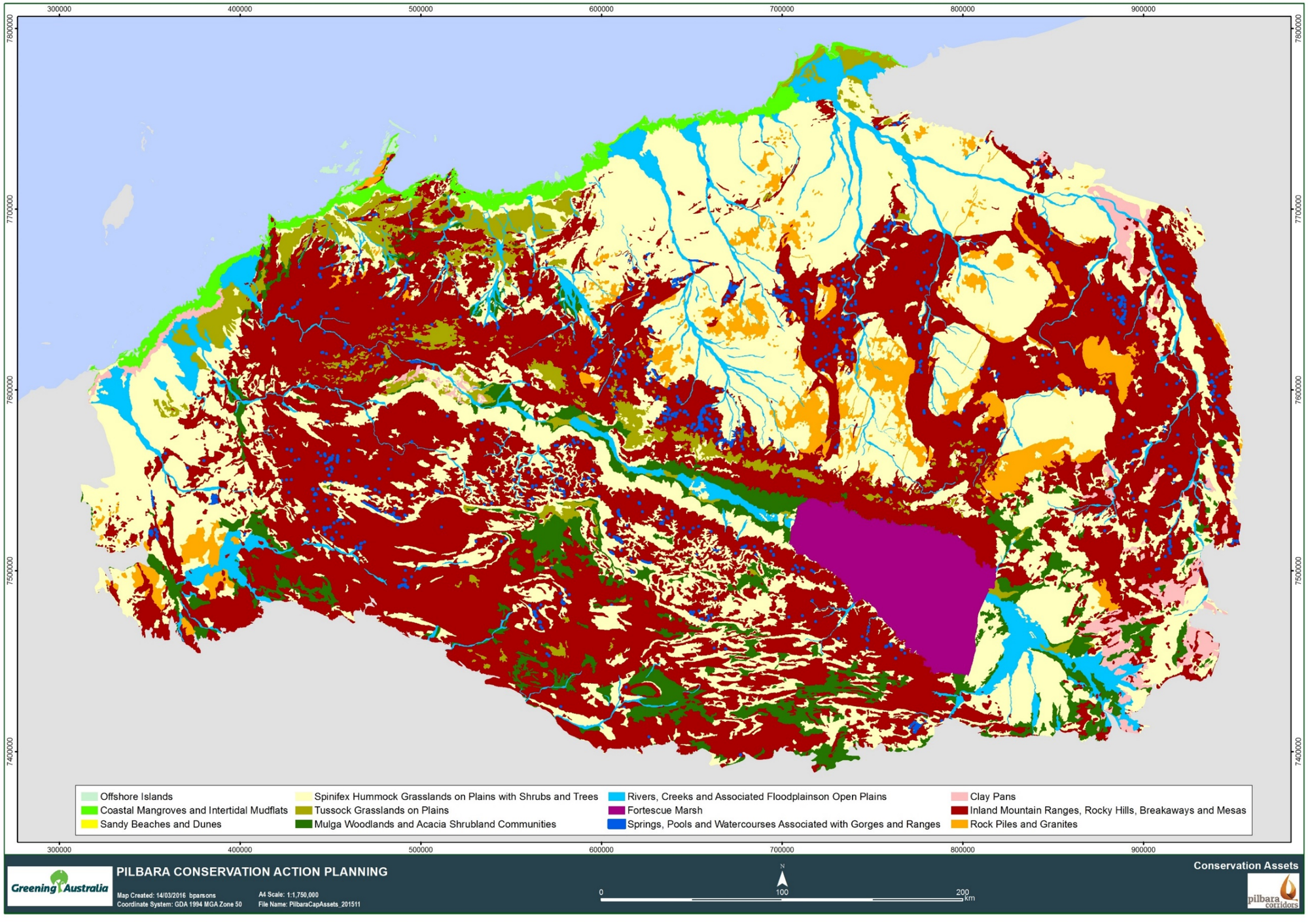


Figure 9: Distribution of broad conservation assets within the Pilbara bioregion (layers created by Gaia Resources, 2015)

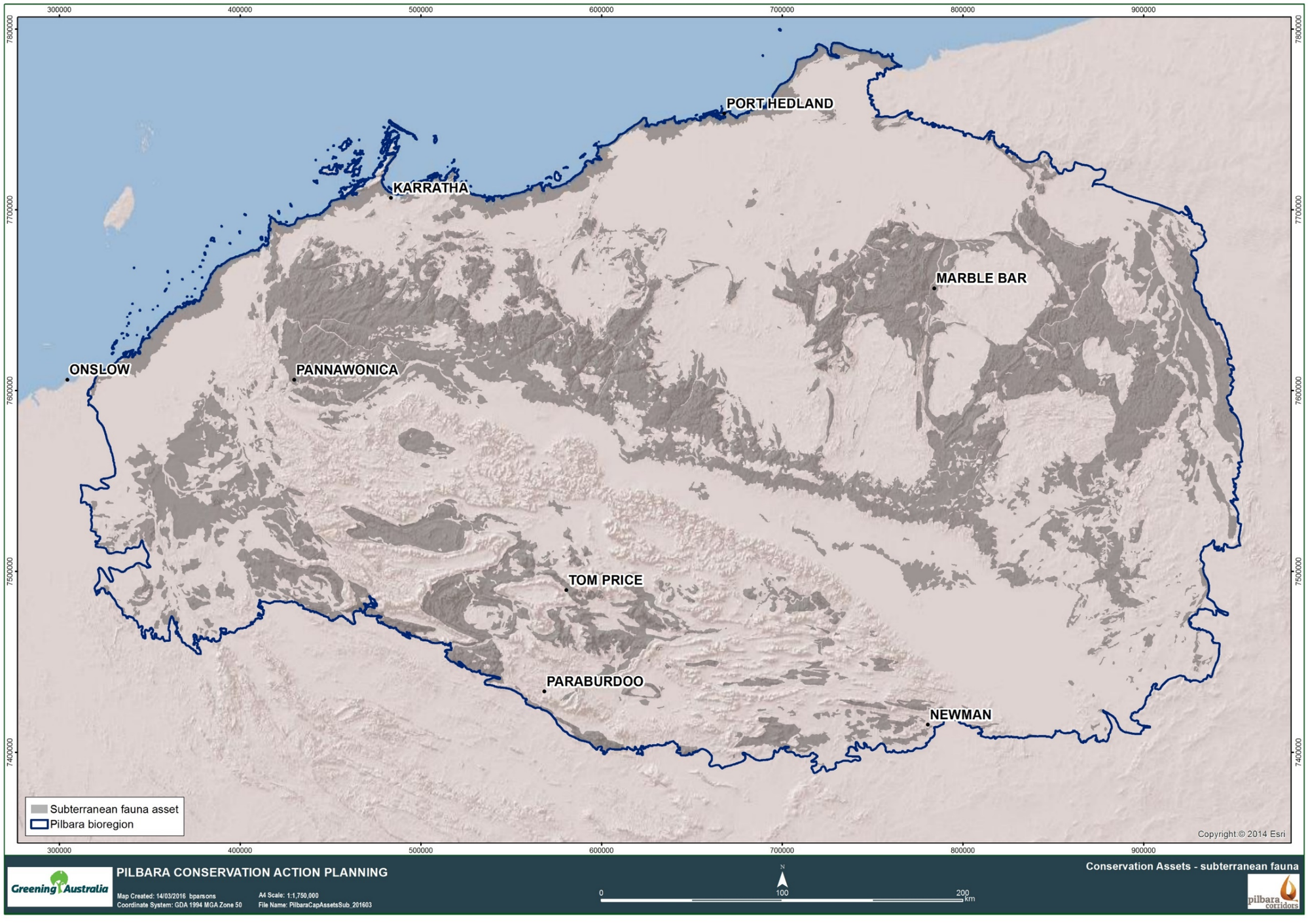


Figure 10: Distribution of the subterranean fauna conservation asset within the Pilbara bioregion (layers created by Gaia Resources, 2015)

3 Viability (Health) of Conservation Assets

3.1 Methodology for Assessing Viability (Heath) of Assets

The assessment of viability (or overall health) of the conservation assets was conducted during the Pilbara CAP workshop series using a simple ranking process that examines indicators based on four categories: very good, good, fair and poor (**Table 3**). Several key questions were posed to help understand the viability (health) of the identified assets as follows:

- Size (total area): has there been large-scale clearance of this asset (how much, where, what, % of total distribution)?
- Condition:
  - Fauna/Flora – are the assemblages intact (what's lost, declining, still present)?
  - Water quality –is water quality (turbidity, organics, chemistry) within reasonable parameters?
- Landscape Context:
  - Fire regime – do regimes maintain healthy flora and fauna assemblages (if not, what is the issue, where, how significant)?
  - Connectivity – are native species able to move between key habitat areas (if not, what are the issues and where, how significant)?
  - Hydrological regime – are natural flows / hydrological regimes able to that maintain the health and condition of this asset (or has this been disrupted and causing significant issues – where, what)?

Table 3: Criteria used to rank viability (health) of conservation assets

Very Good: Most desirable status; Requires little intervention for maintenance
Good: Indicator within acceptable range of variation; Some intervention required for maintenance
Fair: Outside acceptable range of variation; Requires human intervention
Poor: Restoration very difficult; May result in complete loss / extinction

The 'key ecological attribute method' is a more rigorous tool to determine the health of conservation assets, based on ecological attributes, a series of indicators, and agreed measures for determining the condition rankings (good, fair, poor etc.) of assets. It is suggested that the key ecological attribute method is undertaken in the next phase of the CAP process.

3.2 Viability (Health) Assessment Results

The assessment of viability (or overall health) of the conservation assets is presented overleaf (**Table 4**).

Table 4: Assessment of viability (health) of conservation assets

Size	Condition	Landscape Context
Offshore Islands		
• 80 – 100 islands.	• significant variation in terms of intactness, development (eg. infrastructure) and resultant condition of flora and fauna assemblages. • archipelago islands are in better condition than the sandy islands. • islands with bird nesting colonies are in worse condition – birds introduce buffel grass seed.	• fire regime – require more information, five to six islands have been burnt by lightning as the ignition source. • connectivity – naturally isolated.
Coastal Mangroves and Intertidal Mudflats		
• mostly intact.	• fauna – limited knowledge, although condition considered good. • flora – no weeds, no loss of mangrove species, water quality impacts from dredging and port infrastructure.	• disruption around towns and port sites due to changes in hydrological regimes, pastoral outlets, infilling of coastal creeks, discharges, new roads and solar salt concentration and evaporation ponds. • mangroves generally not on areas of pastoral leases as lease boundaries do not start until 40 m above high tide mark.
Sandy Beaches and Dunes		
• no significant clearing	• large scale erosion, potentially natural, localised erosion around towns, generally poor-fair condition. • transformed vegetation on the dunes with buffel increasing. • fauna – changes in nesting patterns of turtles due to artificial light etc. requires monitoring, shorebirds require monitoring. • flora – buffel grass affecting dune habitats. • Fire wood harvesting by recreational users degrading some sites and encouraging weed invasion.	• habitat is naturally discontinuous. • fire common in dunes near towns and recreation areas
Spinifex Hummock Grassland on Plains with Shrubs and Trees		
• no significant clearing	• fauna – more fauna assemblage data required, continued decline in certain assemblages (eg. Spectacled Hare-wallaby, Emu, Australian Bustard). • flora – assemblage has changed, buffel grass now prevalent in sandplain country.	• fire regime – frequently burnt as part of pastoral operations. • National Parks are burned regularly as well. Size of fires considered an issue – fires are too big, although frequency is not considered an issue. Those pastoralists conducting patchwork burns

		prevent larger fires. Some areas (eg. front of Hamersley Range) are fire prone.
Tussock Grasslands on Plains		
• Significantly changed, with localised exceptions (most inland)	• fauna – continued decline in iconic or regularly seen fauna (eg. Emu, Australian Bustard) (fauna assemblages not adequately known) • flora – decline in assemblage, buffel grass has largely taken over, especially along coast and on alluvial floodplains and flats associated with major drainage systems.	• fire regime – few fires on pastoral areas as this habitat does not carry fire well, patchy burns in in National Parks. • connectivity – unchanged.
Mulga Woodlands and Acacia Shrubland Communities		
• no significant clearing but extensive localised clearing has occurred. • Impacted by total grazing pressure from native and introduced herbivores. • Impacted by altered fire regimes, in particular too frequent burning.	• fauna – continued decline in threatened and iconic fauna taxa (fauna assemblage not well understood) (eg. Greater Bilby, avifauna, bats) • fauna - significant refugial habitat for short range endemics. • flora – more information required	• fire regime – changed completely, more frequent, broader scale, more intense, mulga is killed and gradually replaced by grasses leading to a more intense fires. • connectivity – significant fragmentation.
Rivers, Creeks and Associated Floodplains on Open Plains		
• localised impacts, clearing for access, but limited to infrastructure (roads, rail, pipelines, basic raw materials), less than 10% overall • low loss overall but severe losses at local scale due to mining of channel iron deposits.	• fauna – no known change to aquatic assemblage, more information required. • flora – erosion of banks, hydrological regime changes, weeds, cattle trampling of banks, buffel grass replacing vegetation, minesite dewatering and subsequent water discharge impacting riparian vegetation.	• water quality – declining due to cattle, sedimentation, eutrophication, sand lenses, increased turbidity, runoff from roads, movement of asbestos through the landscape (old stockpiles eroding) and leakage of acid sulphates for Potential Acid Forming (PAF) waste rock stockpiles • connectivity –still largely intact, native fish won't go through culverts in dams, changes in hydrological regime affecting flow rates and availability.
Fortescue Marsh (EPA defined area)		
• mining development impacting on the margins of the Marsh but not on the Marsh itself	• fauna – continued decline (uniformity of habitat, predation), no known change to aquatic assemblage, spectral signature of the power lines creating a "wall" effect, collared Judas donkeys don't move up the hills from the Marsh due to fencing. • flora – mulga in poor condition from grazing pressure and buffel on southern side of Marsh, weeds, too much fire, direct clearing, change	• water quality – naturally saline in the Marsh. • landscape context – natural flows are disrupted, surface water runoff impacted from rail, roads and mining operations.

	surface hydrology and possibly groundwater mounding from reinjection also a problem on northern side. Chenopod shrubland mostly intact, with localised weeds infestations and possibly some localised hydrological impacts from groundwater drawdown and reinjection water table mounding.	• connectivity – mining development around the Marsh will have impacts on feed-in waterways, loss of connectivity. • fire regime – impacting on mulga, more frequent post mining development.
Springs, Pools and Watercourses Associated with Gorges and Ranges		
• localised impacts, clearing for access, but limited to infrastructure (roads, rail, pipelines, basic raw materials), less than 10% overall.	• fauna – no known change to aquatic assemblage, decline in terrestrial assemblage from habitat loss and fragmentation. • flora – dust from mine sites. • feral cattle accessing pools created from increased discharge.	• water quality – reasonable although affected by runoff from cattle – increased sedimentation and eutrophication. • mine sites destroying some pools.. • Weeli Wolli Springs – example of an asset that has experienced changes to hydrological regime. • Pit voids, pit lakes, rail and road developments are causing fragmentation.
Clay Pans		
• no loss	• aquatic fauna – more information needed, especially for invertebrates. • flora – mostly in good condition, except where buffel grass is present at margins of habitat.	• changes to the physical structure of the clay pans (eg. pig rooting, cattle trampling).
Subterranean Fauna Habitat		
• low loss overall but severe losses at a local scale.	• fauna – poor understanding, most taxa are undescribed and short-range endemics.	• water quality – 99% of Pilbara water is potable based on Pilbara survey. • connectivity – not a big issue (between aquifers) as subterranean fauna have extremely low mobility, however it could be an issue within an aquifer if for example a small aquifer is fragmented. • stygofauna are highly endemic with distribution often limited to local aquifers. As such they are highly vulnerable to dewatering activities and below water table mining.
Inland Mountain Ranges, Rocky Hills, Breakaways and Mesas		
• low loss, excluding mining exploration, including mining projects.	• fauna - loss of Ghost Bat habitat in the Hamersley Ranges. Adits and natural roosts being lost for Pilbara Leaf-nosed Bats. Northern Quoll impacted from mine development. • flora – declining condition from too frequent fire.	• fire regime – weeds like ruby dock and natal redtop promoting an increased opportunity for fire. • connectivity – loss of bats roosts impacting on connectivity of bat habitat at broad scales.

Rock Piles and Granites		
• modest loss of asset – Abydos Plain, changes from rail infrastructure. • Localised significant loss and modification to landforms on then Burrup Peninsula from hard rock and ballast quarries, basic raw material operations and clearance for industrial and petrochemical developments.	• fauna – continued decline in diversity (eg. Spectacled Hare-wallaby at Shay Gap, Burrup Pilbara Olive Pythons on Burrup Peninsula). • flora – continued decline in diversity due to fire, grazing, weeds. • poor condition in places due to presence of Passiflora (eg. Burrup Peninsula).	• fire regime – Burrup and Abydos Plain experience too frequent fire. • connectivity – fragmentation due to infrastructure, potentially restricting fauna movement, habitat change from altered water flows.

During the workshop process and subsequent review of a previous asset ranking process (**Appendix 4**), a significant amount of variation in the viability (health) of conservation assets and 'nested assets' was documented. A more detailed approach to ranking the condition of assets, focusing on key ecological attributes, and linked to appropriate measureable indicators would strengthen the CAP process, provide a more rigorous table of asset condition and is suggested that this be undertaken in a future step of this process.

The 'key ecological attribute' method involves the following steps:

Step 1: Identify a small number (3 - 5) of key ecological attributes for each conservation asset.

Step 2: Identify appropriate indicators for each key ecological attribute.

Step 3: Develop criteria for rating the current status of each indicator.

Step 4: Rank the current status of each indicator to determine the overall viability of the conservation assets.

4 Assessment of Threats

4.1 Description of Threats

A detailed description of threats to the Pilbara's biodiversity can be found in Carwardine *et al*. (2014), and is summarised below:

Fire

Much of the vegetation of the Pilbara is well adapted to fire, and many species require fire as part of their life cycle. However, when fires are too frequent or intense, negative ecosystem impacts occur, such as the loss of understory growth that provides many reptiles and mammals with protection from predators, and the loss of food resources, such as seeding grass for graminivorous birds. It has been postulated that Aboriginal burning practices in the Pilbara involved burning patches of vegetation creating of a mosaic of burnt and unburnt areas, a practice that regulates fuel loads and manages against large intense fires. Changes in land cover and development of infrastructure may lead to more frequent and/or intense wildfires in the hummock grasslands and these altered fire regimes have been implicated as one of the causes of decline and extinctions of medium-sized mammals in arid Australia.

Plate 14: Fire within Spinifex Hummock Grasslands (Photo credit: Craig Wimble)

Over-grazing and Feral Herbivores

Much of the Pilbara is allocated to pastoral leases. The conservation and land management practices implemented by the bioregion's pastoralists are therefore key to conserving and managing the region's biota. Early settlers introduced a range of grazing animals such as cattle and sheep and others now considered feral in some situations, including pigs, camels, donkeys and horses. Some of these invasive herbivores

occur across all tenures, including national parks while others are now confined to localised and restricted habitats, such as pigs within riparian areas along the De Grey River and rabbits on alluvial flats associated with the Fortescue Marsh. The main impacts of introduced herbivores in the Pilbara are compaction and erosion of soil, loss of grazing-sensitive plant species, reduced native grass biomass, introduction of weed seeds and trampling of seedlings and mature plants. Widespread loss of vegetation caused by invasive herbivores can lead to a reduction in vegetation structure and thus habitat and food resources for native animals, and the loss of vegetation cover can expose small native animals to increased risk of predation. If areas are subject to high total grazing pressure resulting from high livestock and/or feral herbivore numbers, then soil erosion and ground cover loss can occur on these areas, and this may also lead to eutrophication of waterways, and sedimentation of wetlands and riparian habitats, including the nationally significant listed wetlands of the Pilbara.

Plate 15: Cattle grazing, an activity of relevance to biodiversity conservation in the Pilbara (Photo credit: Sara Rawlings)

Introduced Predators

Feral cats are widespread across the Pilbara while red foxes appear to be confined to the coastal plain of the Roebourne subregion and may move further inland along the frontages of some of the larger drainage systems such as the Robe, Fortescue and De Grey Rivers. Together they are responsible for range reductions and population declines of many native fauna species and in particular, small to medium sized mammals. The role of top predators such as dingoes, goannas and raptors in exerting control over the interactions between cats, foxes and their prey is an area of growing interest. The regular baiting of dingoes and wild dogs as a measure to protect livestock may exacerbate the problem of introduced feral cats, as cat behaviour appears to be suppressed by dingoes. Cane toads are currently an irregular, episodic arrival in the region, but the establishment of this species in the Pilbara has the potential to reduce populations of native predators as well as many reptiles, small frogs and invertebrates.

Plate 16: Feral cats, a significant threat to fauna within the Pilbara bioregion (Photo credit: Sarah Comer, Parks and Wildlife)

Invasive Weeds

Invasion by exotic plant species is often associated with inappropriate fire and grazing regimes as well as mining operations. Compared to other regions of Australia, the exotic flora of the Pilbara (103 taxa) is relatively small, representing only 6% of the Pilbara's total flora (Keighery 2010, cited by Carwardine *et al*., 2014); however, the threat of weed incursions is increasing with a 20% increase recorded from 2004 to 2010. Of the 103 weeds identified by Keighery (2010, cited by Carwardine *et al*., 2014), 14 species occur across the region at a landscape scale, altering fire patterns, modifying soil characteristics, or competing directly with native species. A further 21 species pose a threat to particular habitats, especially wetlands and islands. Major weeds currently impacting on landscapes and biodiversity values or which pose a future risk (Parks and Wildlife, 2013) include Mesquite (*Prosopis* sp), Buffel Grass (*Cenchrus ciliaris*), Birdwood Grass (*Cenchrus setiger*), Kapok Bush (*Aerva javanica*), Ruby Dock (*Acetosa vesicaria*), Bellyache Bush (*Jatropha gossypiifolia*), Leucaena (*Leucaena leucocephala* subsp. *leucocephala*), Raintree (*Albizia lebbeck*), Stinking Passion Flower (*Passiflora foetida*), Cactus (*Cylindropuntia* spp. and *Opuntia* spp.), Calotropis (*Calotropis procera*) and Caribbean Stylo (*Stylosanthes hamata*).

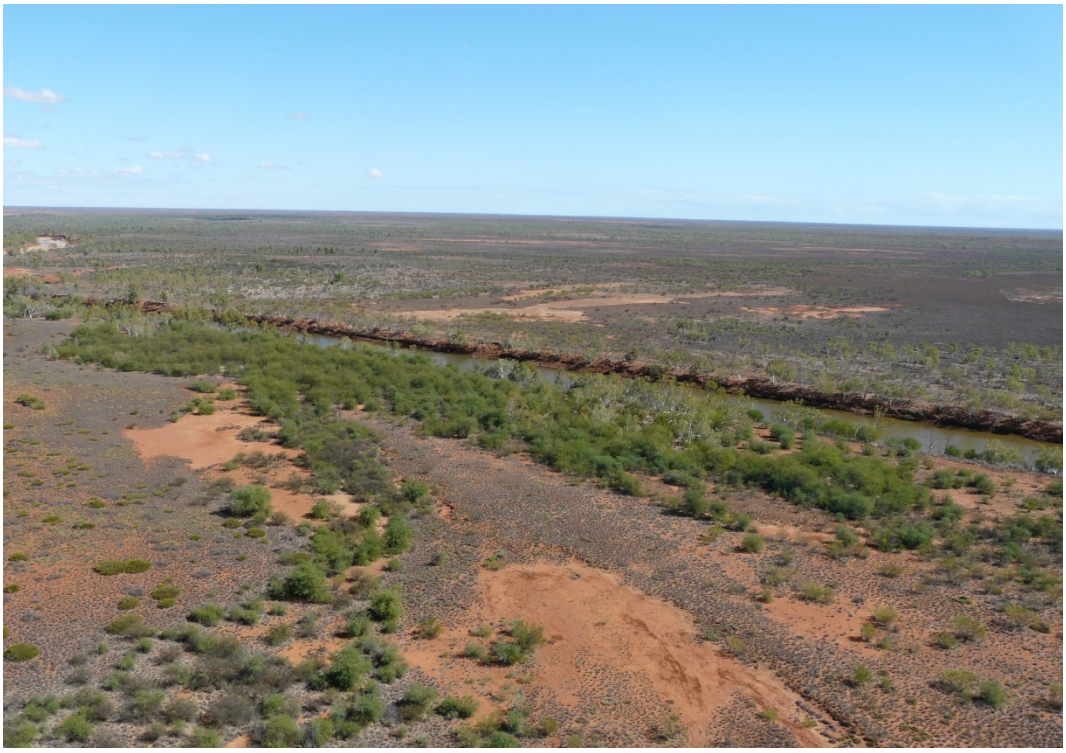


Plate 17: An infestation of Mesquite on the Ashburton River (Photo credit: Linda Anderson, PMMC)

Hydrological Change

Mine dewatering removes groundwater and can create permanent surface flows if discharged directly into ephemeral drainage systems. This has impacts both above and below the surface. Below the surface, dewatering may affect the rich groundwater dependent ecosystems of the Pilbara. The Pilbara has been identified as an international hotspot for stygofauna (groundwater dwelling). The stygofauna of the Pilbara remain poorly documented and the extent of the impacts of changed hydrology are unknown. On the surface, the presence of permanent water or changed flow regimes can alter the ecological composition of aquatic-dependent species.

Hydrological change is particularly relevant to aquatic invertebrates, as many invertebrates are adapted to intermittent presence of water. Abstracted groundwater that discharges into existing permanent water bodies may alter water quality or promote invasive species. Permanent water on the surface (from mine dewatering or other sources, such as stock watering points) may also attract terrestrial vertebrates, and may support increased populations of introduced pest species in arid areas.

Plate 18: A novel ecosystem created by water discharge at Ophthalmia Dam, in the eastern Pilbara (Photo credit: Blair Parsons, Greening Australia)

Mining

Today mining is a significant industry in the Pilbara, representing 38% of Western Australia's Gross Regional Product (GRP) and 6% of Australia's Gross Domestic Product (GDP). The mining industry has direct impacts on the region's flora and fauna including the loss and alteration/fragmentation of habitat. Indirect impacts result from the construction of roads, railways and infrastructure, growing use of water resources and altered hydrological regimes, contamination of water and soil resources, and altered fire regimes with an increase in man-made wildfires.

Plate 19: An aerial view of the Marandoo mine in Pilbara Bioregion (Photo credit: Rio Tinto Iron Ore)

Irrigated Agriculture

Owing to the Pilbara's arid environment, irrigated agriculture in the region is typically localised and small-scale. The Northern Australian Taskforce found the potential for sustainable expansion of irrigated agriculture in the Pilbara to be low, but political and economic interest in the proposition of northern Australia as a 'food bowl' of Australia remains and there is interest in investigating and investing significant resources and revenue in the development of irrigated agricultures schemes in the Pilbara utilizing excess mine water. The level of water extraction required for large-scale agricultural development in the region may lead to significant impacts on its ecology, especially of ephemeral riparian systems and extensive alluvial plains where irrigated crops may be grown. In addition the choice of species for such programs may lead to an increased threat from invasive plants within the region.

Plate 20: Irrigated crop at Hamersley Station in the Pilbara (Photo credit: DAFWA)

Tourism Expansion

The Pilbara is increasingly recognised for its natural values, and as such, the region has experienced an increase in tourism. Parks and Wildlife regulates ecotourism within the conservation estate at present, but inadequate regulation on other land tenures and at entry points could lead to negative impacts on biodiversity including increased risk of fire, the introduction of exotic species and associated fragmentation and pressure on sensitive communities from infrastructure developments.

Plate 21: Karijini National Park, a location subject to significant pressure from tourism (Photo credit: Scott Godley, Parks and Wildlife)

4.2 Methodology for Assessing Threats

The threat assessment process ranks the overall severity of various threatening processes to each asset based on the following criteria (**Table 5**). Subsequent to assessment of threats, a summary rating is generated by the CAP software, resulting in a threat summary table.

Table 5: Criteria used to assess threats to conservation assets

Category	Description	Very High	High	Medium	Low
Severity of damage (where it occurs)	The level of damage that can reasonably be expected within 10 years under current circumstances	Destroys or eliminates the conservation asset	Seriously degrades	Moderately degrades	Slightly degrades
Scope of damage	The geographic scope of impact on the conservation asset that can be reasonably expected within 10 years under current circumstances	Very widespread	Widespread	Localised	Very localised
Irreversibility of damage	How reversible the damage is	Not reversible	Reversible, but not practically affordable	Reversible with reasonable commitment of resources	Easily reversible at low cost

4.3 Threat Assessment Results

During the Pilbara CAP workshop process, 25 threats were listed and ranked (**Table 6**).

The rankings of threats in the table below are indicative, rather than definitive, and can be improved upon with better data and re-evaluation. The information presented below came from synthesis of collective knowledge from a range of sources during the workshop series. Acknowledged shortcomings of this ranking process include:

- insufficient data (or access to data), especially at the large scale of the assets;
- the fact that threats rarely affect assets independently of each other;
- knowledge gaps of certain ecosystems and biases from individuals attending workshops; and
- or lack of input from experts who did not attend workshops.

An overview of threats across the identified Pilbara conservation assets is used as a guide for identifying critical threats (usually, but not always those ranked very high and high), across all assets and for individual assets (**Table 6**). Threat rankings should be revisited by the CAP team and stakeholders to ensure that any outcomes that contrast with the collective intuition are reviewed, and if appropriate, adjusted.

Table 6: Summary of major threats, based on ratings developed during the CAP workshop process

Threats Across Assets	1) Offshore Islands	2) Coastal Mangroves and Inter-tidal Mud flats	3) Sandy Beaches and Dunes	4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg.	5) Tussock Grasslands on Plains	6) Mulga Woodlands and Acacia Shrubland Communities	7) Rivers, Creeks and Associated Floodplains on open plains	8) Fortescue Marsh (EPA defined area)	9) Springs, Pools and Watercourses associated with Gorges and Ranges	10) Clay Pans	11) Subterranean Fauna Habitat	12) Inland mountain ranges, rocky hills, breakaways & mesas	13) Rock Piles and Granites	Overall Threat Rank
Weeds (Buffel Grass, Kapok, Ruby Dock, Passiflora, etc)	H		M	H	H	H	VH	M	H			H	H	VH
Introduced Predators (cats, foxes, dogs)	M	M	H	H	H	H	H	M				M	H	VH
Clearance from Mining (Mine sites)	L							M	H	L	H	VH	M	H
Feral Herbivores (Donkeys, Horses, Camels)				M	M	M	M	M	H	M		M	M	H
Mesquite and Parkinsonia - WONS Weeds							VH							H
Feral Bees						H	M	M				H		H
Climate Change (sea level rise, increased cyclones, warming climate)	H	H	H											H
Inappropriate Fire Regimes (too hot, too frequent, too large)				H	L	M	H					H	M	H
Clearance from Infrastructure Development (roads, rail, ports, other development)		M	L	M	L	H		H	M	L		H	H	H
Unsustainable Stock Grazing Pressure			H	M	H	M	M	M	M	L		M	M	H
Altered Hydrology from Infrastructure Development (roads, rails, etc)		L		M	M	M	M	M	M		L	M		M
Water Abstraction (eg. urban use)				L	L	L	M	L	L		M	L		M
Reinjection of Mine Water underground				L	L	L	L	M	M		L	L		M
Dams				L	L	L	M	L	L		L	L		M
Mine Water Discharge into Creeks and Springs				M	M	M	M	M	M		L	L		M
New Irrigated Agriculture (eg. irrigated pasture)				L	L	L	M	L	L	L	L	L		M
Unmanaged Access / Recreational Impacts	L	L	M				M	L		L		L	L	M
Mine Dewatering (increased river flows, reduction in groundwater)				L	L	L	M	M	M		M	L		M
Pigs							L	L	L	L				L
Introduction of mice, rats, etc (lack of biosecurity)	M													L
Removal of Basic Raw Material							M							L
Sedimentation from Infrastructure Development (dredging, etc)		M												L
Invasive Aquatic Invertebrates									M					L
Rubbish Dumping		L	L											L
Pollution from Mining Activities (includes eutrophication, dust, hydrocarbon)		L								L	L			L
Threat Status for Assets and Project	H	M	H	H	H	H	VH	H	H	M	M	VH	H	VH

5 Goals, Strategies and Actions

5.1 Methodology for developing strategies

The CAP process requires setting measurable goals that, if achieved, would ensure the long term conservation of the assets. In particular, goals are developed in line with the SMART principles (ie. specific, measurable, actionable, realistic and time-bound) and are aimed at addressing high priority threats or achieving improvements in size, condition and landscape context attributes. During the workshop process, the goals were developed with as much adherence to SMART principles as was practicable during the time available; however, it is acknowledged that some goals need to be improved in the future.

Please note that at this stage of the process it is rare to have SMART goals across the board, and this will be addressed in future phases of the process where more specific objectives for sub-sections of strategies are developed.

Upon establishment of measurable goals, effective strategies are identified and action steps to achieve conservation objectives developed. This is a three step process (**Table 7**).

Table 7: Methodology for developing strategies and action steps

Step 1 Conduct a thorough situation analysis of the key factors related to the conservation goals
This includes consideration of the causal factors underlying particular threats and potential hurdles for enhancing the condition of conservation assets (eg. social, cultural, economic and individual motivations). This can help pinpoint opportunities for intervention and guide decisions about which regional delivery mechanisms are best employed to achieve the conservation goals (eg. direct targeting of landholders, competitive market based instruments, education programs, legislative or policy changes).
Step 2 Brainstorm conservation strategies
Conservation strategies are the broad courses of action required to achieve the conservation goals. There are essentially three “pathways” for strategy development that should be considered for threat abatement goals. These include: ● direct protection or management of land or water ● influencing a key decision maker ● addressing a key underlying factor
Step 2 Brainstorm action steps
Once the major conservation strategies are identified, they may be broken down into smaller, more detailed action steps.

Use of Conceptual Models

A conceptual model is a visual method of representing a set of causal relationships between factors that are believed to impact on one or more of the conservation assets. A good model should explicitly link the conservation assets to the direct threats impacting them, the factors (ie. indirect threats) influencing the direct threats, and the strategic activities proposed to mitigate those factors (**Figure 10**). The Miradi software program (www.miradi.org) can be used to develop conceptual models.

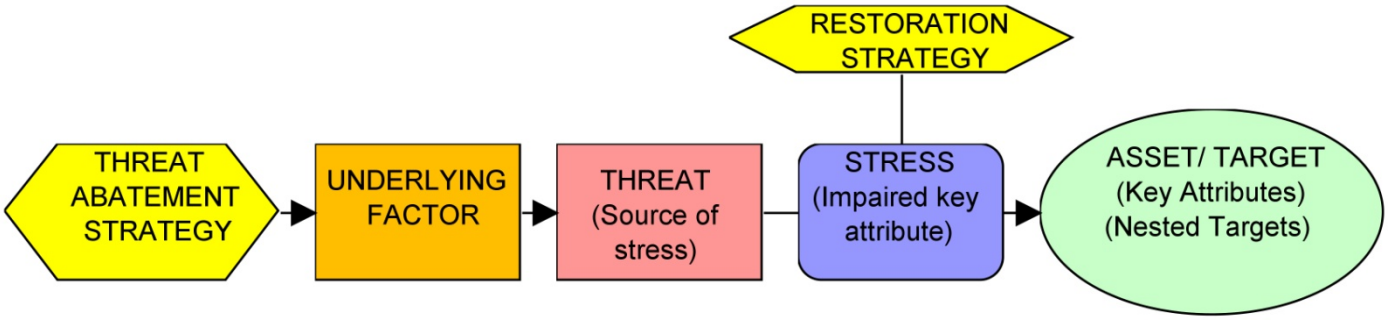


Figure 11: Conceptual model key to different types of factors in the CAP process

During the CAP workshop process, 18 goals were developed to address key threats and improve the viability (health) of assets. These goals were based on those key threats ranked as high or very high, and those threats associated with altered hydrology from infrastructure development. The goals were developed for groupings of assets, grouped based on similar landforms, threats or other affinities.

Brainstorming sessions were conducted to look at underlying factors, and 60 strategies and their associated action steps were developed. In addition, existing Pilbara projects and programs were identified and listed during this workshop. In undertaking the situation analyses in the workshop, initial conceptual models and other information was captured on butcher's and later developed in the Miradi software program as diagrams (**Appendix 3**).

The strategies were later given an initial prioritisation rating (Very High Effectiveness, High Effectiveness, Medium Effectiveness and Low Effectiveness) in Miradi, which takes a number of factors into account, under two criteria: Potential Impact and Feasibility. This initial prioritisation process will be revisited as part of the future CAP process.

During process, the role of Traditional Owners and other Indigenous people was seen as extremely important in developing and implementing the strategies and action steps further. It was also noted that the existing CSIRO study (Carwardine *et. al*, 2014), which focused on threats and strategies to protect species of conservation significance, contained substantial strategy information and where appropriate this information was incorporated into the current process. Additionally, strategies for the EPA-defined Fortescue Marsh area (EPA, 2013) were incorporated into the CAP process strategies, as appropriate.

5.2 Strategy Results

This section details the 18 goals that were developed to address the highest ranked threats, together with 60 strategies agreed upon during the workshop series (**Table 8**). The strategies along with their associated action steps are provided in **Appendix 2**.

Table 8: Strategies and action steps developed during the workshop process

Coastal Assets Group

Assets	Threats	Goal	
1) Off-shore Islands 2) Coastal Mangroves, Inter-tidal Mud flats 3) Sandy Beaches and Dunes	Introduced predators (cats, foxes, dogs)	By 2025 reduce predator pressure on populations of native fauna species (sea turtles, migratory birds, shorebirds, marsupials, reptiles etc.) to allow populations to become self-sustaining within their range. (NB Migratory species spend much of their lifecycle outside the Pilbara).	
Strategy 1a) Identify priority assets and high risk areas for introduced predators (using a modelling exercise where the highest asset values are)			High Effectiveness
Strategy 2) Develop and implement an integrated introduced predator control strategy			High Effectiveness
Strategy 3) Implement cat management activities			High Effectiveness
Strategy 4) Undertake applied cat research to guide future management			Medium Effectiveness
Strategy 5) Implement vertebrate pest control program around key coastal fauna sites			Medium Effectiveness
Strategy 6) Implement a Communications/Education strategy around introduced predators			Medium Effectiveness
3) Sandy Beaches and Dunes	Unsustainable Stock Grazing Pressure	By 2025 manage grazing pressure to the asset to protect grazing-sensitive ecosystems and species (TBD), retain habitat structure and minimise the risk to threatened flora and fauna populations and cultural assets (TBD = to be determined)	
Strategy 7) Strategic fencing to exclude stock from priority assets.			High Effectiveness
Strategy 8) Engagement with pastoralists via Ecologically Sustainable Rangeland Management (ESRM) Plans to protect coastal biodiversity			High Effectiveness
Strategy 9) Implement Nutritional Self Shepherding Trial			Medium Effectiveness
1) Off-shore Islands 3) Sandy Beaches and Dunes	Weeds (Buffel, Kapok, Ruby Dock, Passiflora, etc)	By 2025, control TBD% of key, prioritised infestations to prevent further spread or for significant, isolated conservation assets eradication of weed occurrence.	
Strategy 1b) Identify priority assets and high risk areas for weed infestations (using a modelling exercise where the highest asset values are)			High Effectiveness
Strategy 10) Develop and implement a Pilbara-wide integrated weed control strategy			High Effectiveness
Strategy 11) Develop biosecurity strategy and action plan targeted at high risk coastal and island areas			Medium Effectiveness
Strategy 12) Implement a coastal weed education strategy			Medium Effectiveness
Strategy 13) Develop a weed research strategy			Medium Effectiveness

Inland Mountain Ranges, Rocky Hills, Breakaways and Mesas

Assets	Threats	Goal
12) Inland mountain ranges, rocky hills, breakaways & mesas	Clearance from Mining (Mine sites) Clearance from Infrastructure Development (roads, rail, ports, other development)	By 2020 ensure new mining developments and associated clearance are managed to environmentally appropriate standards and limit development in regionally significant ecological areas (eg. threatened species habitat)
Strategy 14) Develop a transparent, co-ordinated approach to data collation, management and sharing		Medium Effectiveness
Strategy 15) Development of a regional land-use plan to inform design and assessment of mining related development		High Effectiveness
Strategy 16) Influence a coordinated approach to conservation actions via regulatory mechanisms (including offsets) across the Pilbara region		High Effectiveness
Strategy 17) Integrate ecological outcomes into mine planning and closure process		Medium Effectiveness
12) Inland mountain ranges, rocky hills, breakaways & mesas	Inappropriate Fire Regimes (too hot, too frequent, too large)	By 2020, patchy, cool, early season fire regimes are in place across 10% of the asset annually to protect fire-sensitive ecosystems, maximise habitat diversity and minimise the risk to threatened flora and fauna populations.
Strategy 18) Develop a Pilbara-wide fire ecology research strategy		Medium Effectiveness
Strategy 19) Develop a regional operational fire management plan		Medium Effectiveness
Strategy 20) Develop a fire education strategy		Medium Effectiveness
12) Inland mountain ranges, rocky hills, breakaways & mesas	Weeds (Buffel Grass, Kapok, Ruby Dock, Passiflora, etc)	By 2025, X% (or X,000ha) annual reduction of key, new infestations of Ruby Dock and town escapees eg. Leuceana, Washingtonia, Cotton Palm, Malay almond, to prevent further spread.
Strategy 1b) Identify priority assets and high risk areas for weed infestations (using a modelling exercise where the highest asset values are)		High Effectiveness
Strategy 10) Develop and implement a Pilbara-wide integrated weed control strategy		High Effectiveness
Strategy 13) Develop a weed research strategy		Medium Effectiveness
Strategy 21) Weed control strategy for mining related development (primarily ruby dock)		Medium Effectiveness
Strategy 22) Weed control strategy for town weeds education/information strategy for town weeds		Medium Effectiveness
Strategy 23) Improve Biosecurity Management		High Effectiveness
Strategy 24) Collation of weed data to get baseline and measure change over time - centralised data base that includes monitoring programs		Medium Effectiveness
Strategy 25) Develop an inland weed education strategy		Low Effectiveness

Plains Assets

Assets	Threats	Goal	
4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities	Introduced predators (cats, foxes, dogs)	By 2025 reduce introduced predator numbers in key areas (eg. areas of significant habitat for Matters of National Environmental Significance (MNES); key source locations) by 75%	
Strategy 1a) Identify priority assets and high risk areas for introduced predators (using a modelling exercise where the highest asset values are)			High Effectiveness
Strategy 2) Develop and implement an integrated introduced predator control strategy			High Effectiveness
Strategy 3) Implement Cat Management Activities			High Effectiveness
Strategy 4) Undertake Applied Cat Research to guide future management			Medium Effectiveness
4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities	Inappropriate Fire Regimes (too hot, too frequent, too large)	By 2020 actively manage (using agreed metrics TBD) regionally significant areas to protect (X%) of key fire-sensitive ecosystems, maximise habitat diversity and minimise the risk to threatened flora and fauna populations*.	
Strategy 1c) Identify priority assets and high risk areas for fire sensitivity (using a modelling exercise where the highest asset values are)			High Effectiveness
Strategy 18) Develop a Pilbara-wide fire ecology research strategy			Medium Effectiveness
Strategy 19) Develop a regional operational fire management plan			Medium Effectiveness
Strategy 20) Develop a fire education strategy			Medium Effectiveness
Strategy 26) Engagement with pastoralists via Ecologically Sustainable Rangeland Management (ESRM) Plans to integrate fire management for pastoralism with the protection of fire sensitive ecosystems			Medium Effectiveness
4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities	Unsustainable Stock Grazing Pressure	By 2025 actively manage total grazing pressure in regionally significant areas to protect sensitive ecosystems and maintain sustainability.	
Strategy 27) Industry driven improvements			Medium Effectiveness
Strategy 28) Engagement with pastoralists via ESRM plans to ensure that landscape scale property planning includes biodiversity objectives			High Effectiveness
Strategy 29) Implement stewardship program in priority areas (legislative barriers)			Medium Effectiveness
Strategy 30) Indigenous community linking with pastoral properties			Medium Effectiveness
Strategy 31) Develop a program for Pilbara wide remote sensing-based condition monitoring (Landsat, Veg machine CSIRO)			Medium Effectiveness

Strategy 32) Artificial water points phased out strategically on relinquished pastoral leases and pastoral lease boundaries fenced			High Effectiveness
4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities	Weeds (Buffel Grass, Kapok, Ruby Dock, Passiflora, etc)	By 2020 (TBD) reduce (extent TBD) of significant weeds (calotropis, bellyache bush, cactus, new & emerging weeds), and maintain 5% annual reduction of key infestations of mesquite, to prevent further spread and by 2018 identify outlying occurrences of landscape scale/widespread weeds (kapok, ruby dock, passiflora) that can be targeted for eradication. (TBD = to be determined)	
Strategy 1b) Identify priority assets and high risk areas for weed infestations (using a modelling exercise where the highest asset values are)			High Effectiveness
Strategy 10) Develop a Pilbara-wide integrated weed strategy			High Effectiveness
4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities 7) Rivers, Creeks and Associated Floodplains on open plains 8) Fortescue Marsh (EPA defined area) 9) Springs, Pools and Watercourses associated with Gorges and Ranges 11) Subterranean Fauna Habitat 12) Inland mountain ranges, rocky hills, breakaways & mesas	Altered Hydrology from infrastructure development (roads, rails, etc) (PRIMARY THREAT)	By 2025 re-establish and maintain appropriate hydrological regimes by reducing impacts on natural flows from infrastructure barriers in priority waterways and aquifers	
Strategy 33) Ensure that new design standards for infrastructure address the issues of altered hydrological flows			Medium Effectiveness
Strategy 34) Develop environmentally directed road grading methodology			Medium Effectiveness
Strategy 35) Avoid negative impacts of Groundwater Drawdown to important flora/fauna habitat. (EPA, 2013)			High Effectiveness
Strategy 36) Avoid negative impacts of surface discharge of excess water to important flora/fauna habitat (EPA, 2013).			High Effectiveness
Strategy 37) Undertake Strategic Research to address key knowledge gaps for the Fortescue Marsh (EPA, 2013)			High Effectiveness
Strategy 38) Communication strategy to improve understanding of underground water sources differences and interactions.			Medium Effectiveness

Rock Piles and Granites

Assets	Threats	Goal	
13) Rock Piles and Granites	Clearance from Infrastructure Development (roads, rail, ports, other) Introduced predators (cats, foxes, dogs)	By 2025 ensure regionally significant & culturally significant areas are protected from direct & fragmentation impacts	
Strategy 1a) Identify priority assets and high risk areas for introduced predators (using a modelling exercise where the highest asset values are)			High Effectiveness
Strategy 39) Assess impact of infrastructure on cultural assets of rock-piles and granites			High Effectiveness
Strategy 40) Assess impact of infrastructure on fauna and flora of rock-piles and granites			High Effectiveness

Subterranean Fauna Habitat

Assets	Threats	Goal	
11) Subterranean Fauna Habitat	Clearance from Mining (Mine sites)	CAR Reserve systems for subterranean fauna to be quantified by 2025 and 17% (IUCN recommendation) of subterranean fauna (stygofauna / troglofauna) habitat to be retained by 2050	
Strategy 41) Develop research questions - such as how good is underground habitat as a surrogate for species			Medium Effectiveness
Strategy 42) Research (esp. for stygofauna) as to how much drawdown (and reinjection) of water is possible before impacts (thresholds)			Medium Effectiveness
Strategy 43) Develop a monitoring program for stygofauna			Medium Effectiveness
Strategy 44) Design and implement a reserve system for subterranean fauna			High Effectiveness
Strategy 45) Avoid (where possible) and minimise impacts to Subterranean Fauna and their habitats (EPA, 2013)			High Effectiveness

Wetlands and Other Water Dependent Systems

Assets	Threats	Goal	
8) Fortescue Marsh (EPA defined area) 9) Springs, Pools and Watercourses associated with Gorges and Ranges 10) Clay Pans	Clearance from Infrastructure Development (roads, rail, ports, other development) Clearance from Mining (Mine sites)	By 2020 ensure regionally significant ecologically and culturally significant areas are protected from direct impacts.	
Strategy 14) Develop a transparent, co-ordinated approach to data collation, management and sharing			Medium Effectiveness
Strategy 15) Development of a regional land-use plan to inform design and assessment of mining related development			High Effectiveness
Strategy 16) Develop a co-ordinated Pilbara-wide offset strategy			High Effectiveness
Strategy 17) Integrate ecological outcomes into mine planning process			Medium Effectiveness
Strategy 46) Avoid (where possible) and minimise clearing/disturbance of areas of native vegetation that represents important flora/fauna habitat. (EPA, 2013)			High Effectiveness
Strategy 47) Develop new guidelines for restoration - methods for monitoring, measure how effective restoration is			High Effectiveness
Strategy 48) Determine the proportion of assets within formal reserves and ensure that each is represented adequately as per the system Comprehensive Adequate Representative (CAR) Reserve Management (~17%)			Medium Effectiveness
7) Rivers, Creeks and Associated Floodplains on open plains 8) Fortescue Marsh (EPA defined area) 9) Springs, Pools and Watercourses associated with Gorges and Ranges 10) Clay Pans	Feral herbivores (Donkeys, Horses, Camels) – (PRIMARY THREAT) Pigs – (SECONDARY THREAT)	By 2020 manage for feral herbivores over X ha to reduce adverse impacts to an agreed, acceptable threshold levels	
Strategy 49) Review and summary of the past years of donkey control work (includes other species) [Should take < 6 months & cost $25k]			Medium Effectiveness
Strategy 50) Control and eradication of feral herbivores around key locations			Very High Effectiveness
Strategy 51) Education to address cultural barriers to control			Medium Effectiveness
Strategy 52) Pig eradication - De Grey River			High Effectiveness
Strategy 53) Develop Pilbara wide user-friendly maps for different species of feral animals			Low Effectiveness
7) Rivers, Creeks and Associated Floodplains on open plains 8) Fortescue Marsh (EPA defined area)	Inappropriate Fire Regimes (too hot, too frequent, too large)	By 2025 mosaic, cool, appropriate season fire regimes in place across the Fortescue Marsh (EPA area)	
Strategy 54) Hot works from rail - education, adherence to Standard Operating Procedures – compliance			High Effectiveness
Strategy 55) Ensure implementation of the range of strategies to ensure appropriate fire regimes in adjacent asset areas (PLAINS and INLAND MOUNTAINS ETC. ASSETS).			Medium Effectiveness

7) Rivers, Creeks and Associated Floodplains on open plains 8) Fortescue Marsh (EPA defined area) 9) Springs, Pools and Watercourses associated with Gorges and Ranges	Weeds (Buffel Grass, Kapok, Ruby Dock, passiflora, etc)	By 2025 there are no new incursions of weeds (priority weeds) and the impact, distribution and density of weeds is reduced (by x amount) in key asset locations.	
Strategy 56) Ensure that key strategies from WONS for Wetland Assets and Weeds for the Inland Mountains etc. integrate and cover weed strategies for these Wetland Assets			Medium Effectiveness
Strategy 57) Prevent introductions of aquatic weeds			High Effectiveness
Strategy 58) Strategy to remove date palms (historically planted)			Medium Effectiveness
7) Rivers, Creeks and Associated Floodplains on open plains	Mesquite and Parkinsonia - WONS Weeds	By 2025 reduce and maintain densities of Parkinsonia to <1% in the Fortescue Catchment and undertake 30,000 ha/year of Parkinsonia and Mesquite surveillance and control in other key assets	
Strategy 1b) Identify priority assets and high risk areas for weed infestations (Need to know using a modelling exercise where the highest asset values are)			High Effectiveness
Strategy 59) Reduce and maintain densities of Parkinsonia to <1% from the Fortescue Marsh			High Effectiveness
Strategy 60) Undertake 30,000 ha/year of Parkinsonia and Mesquite surveillance and control in other key assets			High Effectiveness

6 Monitoring, Evaluation and Adaptive Management

6.1 Methodology for Developing a Monitoring Program

The CAP process requires the development and implementation of a rigorous monitoring, evaluation and adaptive management program. This serves a number of important functions including:

- determining whether the conservation and land management strategies and actions are achieving the desired goals;
- showing trends in the condition of assets and the levels of threat;
- demonstrating the effectiveness and efficiency of investment into the conservation program;
- linking local conservation outcomes with other programs to describe the local-global biodiversity outlook; and
- securing future funding for sustaining action.

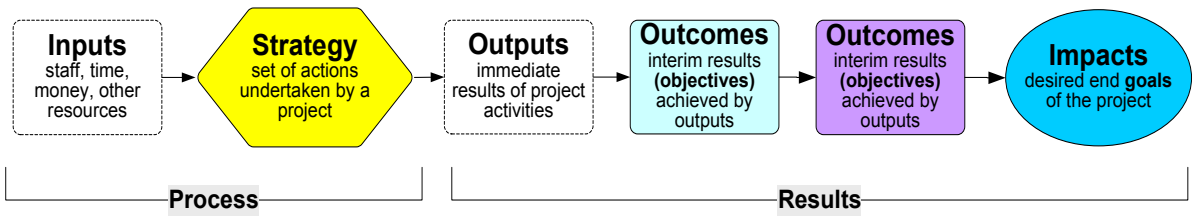
In particular, two types of monitoring and evaluation are identified in the CAP framework:

1) monitoring and evaluation for strategy effectiveness; and
2) resource condition (ie. asset condition and / or level of threat).

The latter is analogous to a medical "check-up", where the doctor measures indicators such as blood pressure to provide early warning signs of systemic problems. Ideally, a monitoring and evaluation program should include both components.

Results Chains

Results chains are used to test assumptions that an action will achieve a desired goal. By identifying interim results or milestones along a trajectory towards the delivery of an outcome, results chains make implicit assumptions about the expected results of activities explicit. This process typically results in more rigorous strategy development. Once a sequence of outputs and outcomes are represented as a results chain diagram, it is relatively easy to visualise and identify monitoring indicators and milestones along the way to a conservation goal (**Figure 11**).



Note: Results chains do not generally show inputs and outputs but rather focus on performance-oriented results

Figure 12: Conceptual diagram of a results chain (Foundations of Success, 2007)

This is an aspect that needs to be developed further in the next phase of the CAP process. During the above process, a series of SMART objectives, linked to outcomes (interim results) are developed, so that progress made in the shorter term (outcomes based on interim results) can be assessed on the path to achieving the broader, longer-term goals that have been set.

6.2 Current Monitoring in the Pilbara Bioregion

During the Pilbara CAP workshop process, knowledge of existing monitoring programmes was documented. This exercise revealed that there is a significant number of monitoring programmes occurring, although some are out of date (e.g. one off projects, programmes that have ceased) and some are unstructured, compromising their value in measuring the status of, and changes in, conservation assets over time (**Table 9**). Furthermore, much of the monitoring being undertaken in the Pilbara is site specific and its broader relevance at a landscape level may be questionable. Existing monitoring programs and projects will be useful for viability (health) and threat assessment of conservation of assets, and to measure the success of implementation of strategies identified in this Pilbara CAP process over time.

Table 9: Existing monitoring programs within the Pilbara Bioregion

Vegetation Condition Monitoring	
WA Rangelands Monitoring Sites	Sites exist on all pastoral leases, programme managed by DAFWA.
AusPlots	Assesses 1 ha sites for rangelands condition and soils, to be extended to fauna in the future. Early in establishment but programme aiming for approx. 70 in the Pilbara bioregion.
DAFWA Rangelands Survey	Completed in 2004, includes soil mapping; land systems for the Pilbara derived from it. Land systems represent the best mapped information for land management.
Parks and Wildlife	400+ permanently marked baseline inventory sites across the Pilbara capturing floristic and vegetation structural details.
Other local scale monitoring	Primarily mining and resource companies, and via a wide range of environmental consultants. Documentation may be available via Environmental Impact Assessment process.
Fauna Monitoring	
Kangaroo counts	Managed by Parks and Wildlife and contribute to Australian Commonwealth Rangelands Information System). This count includes feral species and is conducted every 3-5 years.
EPBC listed species	Northern Quolls, Pilbara Leaf-nosed Bats, Greater Bilby, turtles. Research is in early stages but EPBC listed species are often monitored on a local scale for mining projects as a matter of compliance.
Other local scale monitoring	• Wedge-tailed Shearwater – some project work on offshore islands; • Dampier Salt bird surveys – via Birdlife Australia; • Fortescue Marsh – national bird survey through UNSW; • Freshwater Fish –Dave Morgan, Murdoch University (Morgan *et al*, 2009); • Pilbara Biological Survey as a potential baseline dataset.
Feral Animals	
Judas donkey program	Not monitoring per se but provides a regular index of abundance. Additionally, some satellite collars are being put on horses around the Fortescue Marsh area with the aim of monitoring movements.

Opportunistic sightings	Submitted to DAFWA from pastoralists, also collected at mining projects at a local scale.
Feral cats	Monitored at the Fortescue Marsh by Parks and Wildlife, pre- and post-baiting only.
Weeds	
Mesquite	Not monitoring per se, weed sightings and control only via Pilbara Mesquite Management Committee.
Other local scale monitoring	Multiple weeds monitored on a local scale for mining projects as a matter of compliance, use of unmanned aerial vehicles and remote sensing is increasing.
Fire Regime	
Local scale	Fire age maps exist for some key areas around Karijini and Millstream Chichester National Parks.
North Australia Fire Information (NAFI)	NAFI is being extended WA rangelands wide, including the Pilbara (a current initiative by the Fire Forum and Rangelands Fire Leadership Group). This will provide combined fire scar histories, remote sensing and fire monitoring, and reporting capabilities.
CSIRO Sentinel, Landgate Firewatch	Remote sensing and fire monitoring.
Water Monitoring	
Local scale monitoring	Licencing and water monitoring has to be conducted and submitted to Department of Water (eg. Water Information Reporting including water quality) and Department of Environmental Regulation.
Australian River Assessment System	A Commonwealth programme with 5 or 6 monitoring sites in the Pilbara.
Bureau of Meteorology	Gauging stations exist on some rivers in the Pilbara, including flowmeters and water stations.
Pilbara hydrogeology water study	Conducted by CSIRO, Department of Water and BHP.

Note:

Much of the monitoring being undertaken in the Pilbara lacks the necessary rigour to be useful or is based on objectives that are not clear enough to be of scientific value. It is acknowledged that some monitoring programs (**Table 9**) are data collection exercises, rather than monitoring and evaluation per se and information from some local scale monitoring by mining/resource companies may not currently be accessible.

The next phase of the CAP process will assist with developing a rigorous monitoring and evaluation framework. This will start with the development of ecological attributes, indicators and measures, and ensuring that goals and objectives are written in the SMART format. This monitoring and evaluation framework should clearly indicate what will be evaluated, what is the acceptable standard for determining success or failure, when it will be evaluated and by whom. These are essential elements in that need to be addressed in the future.

Evaluation needs to be rigorous; the methodology and data collected should be transparent, such that the evaluation can be independently verified.

6.3 Monitoring Indicators for the Pilbara Bioregion

A shared and effective monitoring program for the Pilbara Bioregion should achieve two major outcomes:

- Monitoring of effectiveness of strategies:
  - provide quantitative data to assess the effectiveness of the conservation strategies and action steps and identify areas for refinement;
- Resource condition monitoring:
  - provide quantitative data to assess the current status of the key ecological attributes and overall viability (health) of the conservation assets;
  - provide quantitative data to assess the current status of the key threats;
  - establish/augment baseline data to monitor future changes in the status of the key ecological attributes and overall viability (health) of the conservation assets;
  - establish/augment baseline data to monitor future changes in the status of the key threats.

Monitoring indicators should be closely associated with the status of key ecological attributes that are relevant to the conservation assets and address size, condition and landscape context attributes. A monitoring program should also make use of any existing data and monitoring activities in the region so as to ensure resources are used efficiently. This may involve creating links with other organisations that may have complementary aims or legislative requirements to undertake environmental monitoring.

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APPENDIX 1 Detailed Description of Assets

Asset #1: Offshore Islands

Summary				
Description	Offshore islands of the Pilbara Bioregion; either Quaternary sand accumulations, or composed of basalt or limestone, or any combination of these three. Offshore islands range in size from 0.2 to 3,340 ha.			
Key locations	• Dampier Archipelago; • islands between Cape Preston and Onslow (as far west as Serrurier); • islands between Cape Lambert and Port Hedland; • islands off Poissonnier Point; • Bedout Island.			
Total Area (% of bioregion)	24,707 ha (0.13%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	2393	59	121	36
Flora	691	52	151	3
Nested Assets				
Plant communities	• Most islands, especially rocky ones, are dominated by *Triodia* spp. and hummock grasslands (*Spinifex longifolius*), with emergent trees and shrubs (eg. *Acacia coriacea*, *A. bivenosa*) are also found. • Mangrove communities on islands including internationally significant examples around the Dampier Archipelago.			
Mammal assemblage	• Rothschild's Rock-wallaby (*Petrogale rothschildi*), Pale Field-rat (*Rattus tunneyi*), Northern Quoll (*Dasyurus hallucatus*) on Dampier Archipelago			
Reptile assemblage	• Sea Turtle breeding - Loggerhead Turtle (*Caretta caretta*), Green Turtle (*Chelonia mydas*), Hawksbill Turtle (*Eretmochelys imbricata*) and Flatback Turtle (*Natator depressus*). • Pilbara Olive Python (*Liasis olivaceus barroni*)			
Bird assemblage	• Breeding seabirds, including Wedge-tailed Shearwater (*Puffinus pacificus*), Mangrove Heron (*Butorides striatus*), Reef Heron (*Egretta sacra*), Pied Oystercatcher (*Haematopus longirostris*), Sooty Oystercatcher (*Haematopus fuliginosus*), Silver Gull (*Larus novaehollandiae*), Fairy Tern (*Sterna nereis*), Caspian Tern (*Sterna caspia*), Crested Tern (*Sterna bergii*), Bridled Tern (*Sterna anaethetus*), White-bellied Sea Eagle (*Haliaeetus leucogaster*), Brahminy Kite (*Haliastur indus*), Osprey (*Pandion haliaetus*), Pelican (*Pelecanus conspicillatus*) (Keast and Cohen Islands) and Beach Stone Curlew (*Esacus neglectus*) (Johnstone *et al.* 2013).			
Cultural heritage	• A range of places including engraving, habitation sites, quarries, shell middens, stone arrangements, ethnographic sites – ceremonial sites and mythological sites.			

Asset #2: Coastal Mangroves and Intertidal Mudflats

Summary	
Description	Mangroves occur in creek mouths and reef-sheltered embayments along the Pilbara coast. As mangrove communities are rare in arid conditions, those of the Pilbara are of great scientific importance. 80% of mangrove sites in the Pilbara region meet RNE (Register of the National Estate, Australian Heritage Commission) criteria, with 15 of these sites already listed and a further 46 sites nominated for listing, with some of these sites being recognised internationally as significant. Although there has been extensive loss of mangrove communities in the Pilbara regions due to industrial activities, those mangrove communities that still exist are in near pristine condition. Fringing mangroves of the region are typically backed by extensive intertidal flats that are characterised by a rich and diverse fauna of burrowing invertebrates, and are major habitats for migratory birds that use the mud flats as feeding grounds. These tidal flats are not only rich in burrowing invertebrates such as molluscs but also support extensive blue-green algal mats (high productivity, nitrogen fixation) and extensive areas of tidal samphire communities which harbour several undescribed and possibly Pilbara endemic samphires (Tecticornia spp.)
Key locations	Mouth of De Grey, Turner, Yule, Harding and Cane Rivers, Port Hedland, Balla Balla, Dixon Island, West Intercourse Island, Nickol Bay, Fortescue River delta, Maitland River delta, Robe River delta, Cossack to Harding Delta complex (highest diversity of mangrove plant species), Sherlock Bay, Ronsard Island
Total Area (% of bioregion)	124,693 ha (0.67%)

Biota – Summary of known records (NatureMap, 2016)

	Records	Families	Genera	Con sig species*
Fauna	5,173	80	200	59
Flora	1,527	66	195	10

Nested Assets	
Plant communities	The deep-water fringe is dominated by White Mangrove (*Avicennia marina*) with Spotted-Leaved Red Mangrove (*Rhizophora stylosa*) behind, and Spurred Mangrove (*Ceriops tagal*) on the landward edge. On gently sloping rises Club Mangrove (*Aegialitis annulata*) is found and River Mangrove (*Aegiceras corniculatum*) lines the seaward ends of creeks.
Mammal assemblage	• Nine species of microbats comprise a distinct community residing in mangroves with three endemic to these communities (*M. loriae*, *Nyctophilus arnhemensis* and *N. geoffroyi pallescens* ; Water Rat (*Hydromys melanogaster*)
Bird assemblage	• MANGROVE SPECIES: Striated Heron (*Butorides striatus*), Bar-shouldered Dove (*Geopelia humeralis*), Collared Kingfisher (*Todiramphus chloris*), Dusky Gerygone (*Gerygone tenebrosa*), Red-headed Honeyeater (*Myzomela erythrocephala*), Mangrove Robin (*Eopsaltria pulverulenta*), Mangrove Golden Whistler (*Pachycephala melanura*), White-breasted Whistler (*Pachycephala lanioides*), Shining Flycatcher (*Myiagra alecto*), Mangrove Grey Fantail (*Rhipidura phasiana*), White-breasted Woodswallow (*Artamus leucorynchus*) and Yellow White-eye (*Zosterops luteus*). • INTERTIDAL SPECIES: numerous migratory species including Eastern Curlew (*Numenius madagascariensis*), Common Sandpiper (*Actitis hypoleucos*), Cattle Egret (*Ardea ibis*), Ruddy Turnstone (*Arenaria interpres*), Sharp-tailed Sandpiper (*Calidris acuminata*), Sanderling (*Calidris alba*), Red Knot (*Calidris canutus*), Curlew Sandpiper (*Calidris ferruginea*), Pectoral Sandpiper (*Calidris melanotos*), Re-necked Stint (*Calidris ruficollis*), Long-toed Stint (*Calidris subminuta*), Great Knot (*Calidris tenuirostris*), Greater Sand Plover (*Charadrius leschenaultii*), Lesser Sand Plover (*Charadrius mongolus*), Oriental Plover (*Charadrius veredus*), White-

	winged Black Tern (*Chlidonias leucopterus*), Eastern Reef Egret (*Egretta sacra*), Oriental Pratincole (*Glareola maldivarum*), White-bellied Sea-eagle (*Haliaeetus leucogaster*), Caspian Tern (*Hydroprogne caspia*), Broad-billed Sandpiper (*Limicola falcinellus*), Bar-tailed Godwit (*Limosa lapponica*), Black-tailed Godwit (*Limosa limosa*), Little Curlew (*Numenius minutus*), Whimbrel (*Numenius phaeopus*), Red-necked Phalarope (*Phalaropus lobatus*), Glossy Ibis (*Plegadis falcinellus*), Pacific Golden Plover (*Pluvialis fulva*), Grey Plover (*Pluvialis squatarola*), Common Tern (*Sterna hirundo*), Little Tern (*Sternula albifrons*), Lesser Crested Tern (*Thalasseus bengalensis*), Grey-tailed Tattler (*Tringa brevipes*), Wood Sandpiper (*Tringa glareola*), Common Greenshank (*Tringa nebularia*), Marsh Sandpiper (*Tringa stagnatilis*), Terek Sandpiper (*Xenus cinereus*) (Johnstone *et al*. 2013).
Cultural heritage	• Aboriginal middens – from antiquity back to around 7,000 years ago, ethnographic sites - ceremonial sites, mythological sites and fish traps. Shell middens on at Burrup tested with radio carbon dating suggest 18,000 years of occupation, and the trumpet shell radiocarbon has been dated to about 18,000 BP at Gum Tree Valley (Lorblanchet 1992, in Mulvaney, 2011) -

Asset #3: Sandy Beaches and Dunes

Summary				
Description	The Pilbara coastline comprises a number of sandy beaches which intersperse the predominantly rocky shoreline. The coastline is a low energy system (in terms of wave action) with a large tidal range. The sandy beaches and dunes provide habitat for a range of fauna species, in particular nesting sites for a number of turtle species. Four of marine turtles, the Loggerhead, Green, Hawksbill and Flatback Turtle occur in the waters off the Pilbara coast and nest on the region's beaches. Although most turtles nest on offshore islands, Munda Beach in Port Hedland is an important nesting area for threatened Flatback Turtles. The Munda Beach rookery is one of the largest rookeries in the state, with several hundred female turtles laying their eggs at this site each year.			
Key locations	• Munda; • Port Hedland; • Point Sampson beaches; • 40 mile beach (South of Karratha); • Wickham; and • Cape Preston			
Total Area (% of bioregion)	1,992 ha (0.01%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	4,811	33	56	25
Flora	5	5	5	-
Nested Assets				
Plant communities	• Spinifex (*Spinifex longifolius*) hummock grasslands, with emergent trees and shrubs (eg. *Acacia coriacea*, *A. bivenosa*) • Note that Buffel grass (*Cenchrus ciliaris*) and Kapok (*Aerva javanica*) have taken over most dunes. • Coastal dune native tussock grassland dominated by *Whiteochloa airoides* (PEC, Priority 3).			
Reptile assemblage	• SEA TURTLES: Loggerhead Turtle (*Caretta caretta*), Green Turtle (*Chelonia mydas*), Hawksbill Turtle (*Eretmochelys imbricata*), Flatback Turtle (*Natator depressus*). • *Lerista nevinae* (a species of skink) in the vicinity of Cape Lambert.			
Bird assemblage	• INTERTIDAL SPECIES: numerous migratory species may frequent intertidal areas although they are likely to be more reliant on the "Coastal mangroves and intertidal mudflats" asset. Species include: including Eastern Curlew (*Numenius madagascariensis*), Common Sandpiper (*Actitis hypoleucos*), Cattle Egret (*Ardea ibis*), Ruddy Turnstone (*Arenaria interpres*), Sharp-tailed Sandpiper (*Calidris acuminata*), Sanderling (*Calidris alba*), Red Knot (*Calidris canutus*), Curlew Sandpiper (*Calidris ferruginea*), Pectoral Sandpiper (*Calidris melanotos*), Red-necked Stint (*Calidris ruficollis*), Long-toed Stint (*Calidris subminuta*), Great Knot (*Calidris tenuirostris*), Greater Sand Plover (*Charadrius leschenaultii*), Lesser Sand Plover (*Charadrius mongolus*), Oriental Plover (*Charadrius veredus*), White-winged Black Tern (*Chlidonias leucopterus*), Eastern Reef Egret (*Egretta sacra*), Oriental Pratincole (*Glareola maldivarum*), White-bellied Sea-eagle (*Haliaeetus leucogaster*), Caspian Tern (*Hydroprogne caspia*), Broad-billed Sandpiper (*Limicola falcinellus*), Bar-tailed Godwit (*Limosa lapponica*), Black-tailed Godwit (*Limosa limosa*), Little Curlew (*Numenius minutus*), Whimbrel (*Numenius phaeopus*), Red-necked Phalarope (*Phalaropus lobatus*), Glossy Ibis (*Plegadis falcinellus*), Pacific Golden Plover (*Pluvialis fulva*), Grey Plover (*Pluvialis squatarola*), Common Tern (*Sterna hirundo*), Little Tern (*Sternula albifrons*), Lesser Crested Tern (*Thalasseus*			

	bengalensis), Grey-tailed Tattler (*Tringa brevipes*), Wood Sandpiper (*Tringa glareola*), Common Greenshank (*Tringa nebularia*), Marsh Sandpiper (*Tringa stagnatilis*), Terek Sandpiper (*Xenus cinereus*) (Johnstone *et al*. 2013).
Cultural heritage	• Asset contains burial sites, shell middens, ethnographic sites - ceremonial sites and mythological sites – highly sensitive to ground disturbance activity eg. vegetation removal, fencing

Asset #4: Spinifex Hummock Grassland on Plains with Shrubs and Trees

Summary				
Description	Much of the Pilbara bioregion comprises spinifex hummock grasslands (*Triodia* spp.) on plains with emergent shrubs (eg. *Acacia inaequilatera*) and trees (*Corymbia hamersleyana*), generally with percentage cover of 10–30%. An assessment of land systems (van Vreeswyk *et al*., 2004) found that most (88%) hummock grassland sites were in good condition, with 6% in fair and 6% in poor condition. Spinifex is a fire adapted plant, and there has been frequent burning throughout history, including "fire-stick farming" practices of the Aboriginals. Termite mounds within this asset act as refugia for a range of invertebrates, small mammals and reptiles (Thompson and Thompson, 2015). The value of Spinifex Sandplains in supporting fauna assemblages is often closely related to their history, with areas retaining a mosaic of fire ages often providing the best habitat.			
Key locations	Asset is widespread throughout the region			
Total Area (% of bioregion)	6,617,160 ha (35.7%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	51,761	90	238	66
Flora	12,255	88	338	111
Nested Assets				
Plant assemblage	• Twenty-one species of hummock grasses have been recorded in the Pilbara with the most common species being *Triodia lanigera*, *T. longiceps*, *T. pungens* and *T. wiseana*. • THREATENED PLANTS or COMMUNITIES: Stony saline plains of the Mosquito Land System (PEC), known to contain two endemic Acacias; • Priority flora species including: *Acacia aphanoclada*, *Atriplex spinulosa*, *Fimbristylis* sp. Shay Gap (K Newbey 10293), , *Lepidium amelum*, *Dampiera atriplicina*, *Euphorbia clementii*, *Euphorbia drummondii* subsp. Pilbara (BG Thomson 3503), , *Ischaemum albovillosum*, *Olearia fluvialis*, *Olearia mucronata*			
Reptile assemblage	• In the spinifex grasslands, reptiles dominate. Often, ants and termites feed on the spinifex seed and the reptiles in turn feed on the ants. • Species include the Woma Python (*Aspidites ramsayi*), Pin-striped Finesnout Ctenotus (*Ctenotus nigrilineatus*) and numerous other taxa.			
Mammal assemblage	• Greater Bilby (*Macrotis lagotis*), Brush-tailed Mulgara (*Dasycercus blythi*), Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*).			
Threatened birds	• Bush Stone-curlew (*Burhinus grallarius*), Princess Parrot (*Polytelis alexandrae*), Peregrine Falcon (*Falco peregrinus*)			
Cultural heritage	• Artefact scatters are often concentrated in vicinity of ephemeral water bodies. Ethnographic sites – ceremonial sites and mythological sites. Archaeological sites, specifically habitation sites adjacent to water.			

Asset #5: Tussock Grasslands on Plains

Summary				
Description	Tussock grasslands occur mostly on alluvial plains, gilgai plains and drainage tracts. An assessment of land systems (van Vreeswyk *et al*., 2004) found that most (75%) of the tussock grassland sites were in good condition, with 17% in fair condition and 8% in poor condition. Tussock grasslands are generally more susceptible to grazing as their component species are palatable and preferentially grazed, particularly when they are green. Tussock grasslands support higher numbers of Priority flora species than other vegetation formations.			
Key locations	• Hamersley Station, West Angeles; • Roebourne Plains coastal grasslands, Sherlock Station and Roebourne Common, Airport Reserve (between Roebourne and Karratha), Seven Mile Creek; • Newman – old aero/glider club grounds.			
Total Area (% of bioregion)	624,704 ha (3.37%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	4,327	78	188	37
Flora	1,671	66	216	28
Nested Assets				
Plant assemblage	• Tussock grasses vary from dense, well developed plants (eg. *Eriachne benthamii*) to open forms (eg. *Chrysopogon fallax*). Other common tussock grasses include *Aristida holathera* var. *holathera*, *A. latifolia*, *Astrebla pectinata*, *Chrysopogon fallax*, *Eragrostis eriopoda*, *E. xerophila*, *Eriachne benthamii*, *E. obtusa*, *Eulalia aurea*, *Paraneurachne muelleri* and *Themeda triandra*. • THREATENED PLANTS or COMMUNITIES: Barley Mitchell Grass (*Astrebla pectinata*) Grassland on clay or loamy soils, Kangaroo Grass (*Themeda*) Grasslands - Hamersley Station grass plain, *Eragrostis* sp. (*xerophila*) grasslands on Roebourne Plains, West Angeles Cracking Clays (PEC), Wona Land System (PEC), Roebourne Plains gilgai grasslands (PEC), • Brockman Iron cracking clay communities of the Hamersley Range (PEC) • Priority flora species including *Goodenia omearana* ms			
Reptile assemblage	• 14 *Ctenotus* species, 11 *Varanus* species, 8 *Ctenophorus* species, Woma (*Aspidites ramsayi*)			
Mammal assemblage	• Planigales (eg. Long-tailed Planigale *Planigale ingrami*, Common Planigale *Planigale maculata*) inhabit cracking clays, includes new species found at West Angelas			
Bird assemblage	•			
Cultural heritage	• Surface (some outcrops) grinding sites, artefact scatters, some Tussock grassland areas are more attractive for food and material resources. Rock art (engravings) on exposed granophyre (sometimes low lying), ethnographic sites			

Asset #6: Mulga Woodlands and Acacia Shrubland Communities

Summary	
Description	*Acacia aneura* (Mulga) is the predominant species in rangelands to the south of the Pilbara and is often the dominant species in woodlands or tall shrublands. Where Mulga is recorded in the north and west of the Pilbara it is most commonly a component of hummock grassland communities. *Acacia xiphophylla* (snakewood) shrublands which are often mid-height shrublands, are common throughout the Pilbara, in particular in the south-west areas. Mulga is susceptible to fire and its range is restricted by the frequency and intensity of fire which increases in spinifex-dominated areas. It may occur in 'fire refuge' areas on spinifex covered ranges. Mulga typically occurs as low woodland over bunch grasses on fine textured soils in valley floors and are sensitive to hydrological changes. There is a large genetic diversity of Mulga – 12 species (Maslin and Reid 2012).
Key locations	• Red Hill Station (Mulga Communities of the Fortescue Valley); • Balfour Downs, Mulga Downs; • Mt Bruce, Mt Newman, Mt Robertson/Giles, Pamelia Hill; • Roy Hill, Munyra claypan, Wonnamunna.
Total Area (% of bioregion)	970,607 ha (5.24%)

Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	6,581	77	181	18
Flora	2,749	66	230	36

Nested Assets	
Plant assemblage	• open Mulga (*Acacia aneura* s.l.) woodlands and shrublands (with *A. subcontorta*) over tussock grasses (*Themeda triandra*, *Chrysopogon fallax*, *Eragrostis* spp.) and soft hummock grasslands (*T. melvillei*, *T. pungens*); • Snakewood shrublands and hard hummock grasslands with emergent (*Corymbia hamersleyana / C. semiclara*) or snappy gums.
Reptile assemblage	• Comprises species often widespread further to the south of the Pilbara, including arboreal species *Strophurus wellingtonae, Diporiphora amphiboluroides, Varanus bushi* (Doughty *et al*. 2011).
Mammal assemblage	• Several significant species have been recorded within this asset such as Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Western Pebble-mound Mouse (*Pseudomys chapmani*), Long-tailed Dunnart (*Sminthopsis longicaudata*), although most of these species are not specifically associated with it.
Invertebrates	• Short Range Endemic (SRE) invertebrates, high diversity of ants.
Bird assemblage	• Suite of birds - including a suite of parrots and the edge of their range • The mulga woodlands are important habitat for the Desert Gerygone (*Gerygone fusca mungi*), Inland Thornbill (*Acanthiza apicalis*), Slaty-backed Thornbill (*Acanthiza robustirostris*), Chestnut-rumped Thornbill (*Acanthiza uropygialis*), Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*), Grey Honeyeater (*Conopophila whitei*), Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*), Red-capped Robin (*Petroica goodenovii*), Hooded Robin (*Melanodryas cucullata*), White-browed Babbler (*Pomatostomus superciliosus*), Crested Bellbird (*Oreoica gutturalis*), and Grey Butcherbird (*Cracticus torquatus*). Many of these species are at their northern limit in the Pilbara.
Cultural heritage	• Wide range of cultural remains, particularly artefact scatters some of which are probably habitation sites – plant community attractive for both food and material. Ethnographic sites.

Asset #7: Rivers, Creeks and Associated Floodplains on Open Plains

Summary	
Description	There are five major drainage basins within the Pilbara: the Ashburton River; Onslow Coast; Fortescue River; Port Hedland Coast and De Grey River. These basins drain the rocky outcrops of the central Pilbara and discharge over the coastal plains into the Indian Ocean. Stream flows in the Pilbara region are mostly a direct response to rainfall, and as such they are highly seasonal and variable. With the exception of some small but important, spring-fed sections, all waterways in the region are ephemeral, in that surface flow ceases for at least part of each year (Lyons 2015). The riparian zone of major systems – De Grey, Oakover, Turner, Fortescue, Robe, Cane and Ashburton are degraded to fair with significant management intervention required for recovery (McKenzie *et al*., 2003).
Key locations	• De Grey River, Ashburton River, Fortescue River, Yule River, Sherlock River, Cane River, Robe River, Harding River, Maitland River, Turner River, Miaree Pool
Total Area (% of bioregion)	945,461 ha (5.1%)

Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	27,630	85	224	38
Flora	3,541	76	265	51

Nested Assets	
Plant communities	• The broad valleys of the larger rivers (De Grey, Oakover, Shaw, Turner, Yule, Fortescue, Robe, Cane and Ashburton) support galleries of River Red Gum (*Eucalyptus camaldulensis*), Coolabah (*E. victrix*) and Melaleuca (*M. argentea*) that extend deep into the interior.
Reptile assemblage	• This asset of not considered to support a distinct reptile assemblage, due to the lack of extensive well-developed habitats that are distinct from surrounding areas, and the effects of past arid climate cycles (Doughty *et al*. 2011). • Supports Pilbara Olive Python (*Liaisis olivaceus barroni*)
Mammal assemblage	• Northern Quoll (*Dasyurus hallucatus*), Greater Bilby (*Macrotis lagotis*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Ghost Bat (*Macroderma gigas*), Northern Brush-tailed Possum (*Trichosurus arnhemensis*)
Bird assemblage	• River valleys and permanent pools on the Yule, Turner and De Grey provide a refuge for birds, within fringing forests/woodlands of river gums and a number of species are more common along these watercourses than in other habitats. They include Black Bittern (*Ixobrychus flavicollis*), Peaceful Dove (*Geopelia striata placida*), Australian Ringneck (*Platycercus zonarius*), Blue-winged Kookaburra (*Dacelo leachii*), Black-tailed Treecreeper (*Climacteris melanura*), Red-browed Pardalote (*Pardalotus rubricatus*), and Star Finch (*Neochmia ruficauda subclarescens*).
Cultural heritage	• Petroglyphs on rock walls are sites of special Aboriginal significance, artefact scatters, sub-surface remains, high potential for quite dense sites, NB: pools along Fortescue east of Fortescue Marsh and along northern shore. Ethnographic sites – ceremonial sites and mythological sites. High cultural values for permanent water (mythological and large habitation sites).

Asset #8: Fortescue Marsh (EPA defined area)

Summary				
Description	The Fortescue Marsh is the largest ephemeral wetland in the Pilbara region and is recognised as nationally important. It is rich in plant and animal species of high conservation value and is part of an ancient and complex array of alluvial aquifers and groundwater systems. It is also at the heart of an important mining province and long-standing pastoral industry, and has high cultural and heritage importance to the Indigenous peoples of the region. A Nationally Important Wetland, it is proposed for the Fortescue Marsh to be listed as a Ramsar wetland.			
Total Area (% of bioregion)	583,630 ha (3.15%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	8,890	79	191	22
Flora	1,470	55	174	23
Nested assets				
Plant communities	• Extensive areas of high quality Mulga woodland on north side of Marsh; • Several new and undescribed flora species; • Possibility of a monotypic endemic genus; • Extensive samphire shrublands, with four endemic species associated with these; • Numerous populations of several Priority Flora species; • Several range-end or disjunct outlying populations of SW or Kimberley (tropical) species.			
Mammal assemblage	• Northern Quoll (*Dasyurus hallucatus*), Brush-tailed Mulgara (*Dasycercus blythi*), and Bilby (*Macrotis lagotis*).			
Invertebrates	• Endemic or near-endemic invertebrates in both saline marsh and fringing freshwater claypans; • Richness comparable to Pilbara average of 150 species per wetland but Marsh has a disproportionately large number of significant species compared to other Pilbara wetlands; • Potential for SRE (including troglofauna) assumed to be high;			
Bird assemblage	• Contemporary Night Parrot (*Pezoporus occidentalis*) record from Minga Well, adjacent the Marsh (Davis and Metcalf, 2008); • An arid wetland for waterbirds of national importance, 260,000 – 276,000 individuals from 47 species present when inundated between 1999, 2000 and 2003, and a total of 122 species, including nomadic and migratory EPBC listed birds have subsequently been recorded from the Fortescue Marsh (Bell *et al*., 2014).			
Cultural heritage	• Cultural asset – all one asset from the origin of the Fortescue to the river mouth – values relate to water. Many archaeological sites along northern shore, several sites of special Aboriginal importance.			

Asset #9: Springs, Pools and Watercourses Associated with Gorges and Ranges

Summary	
Description	Water pools in the Pilbara provide an important source of water in what is largely a dry landscape, and thus attract a diversity of fauna. There are numerous springs, pools and watercourses associated with gorges and ranges, some of which are relatively small and others occur in deeply incised gorges, up to 100 m deep, containing extensive permanent spring-fed streams and pools. Rare and/or restricted aquatic fauna elements are present, especially in some permanently flowing springs, including those in Millstream and Karijini National Parks.
Key locations	• Millstream Pools within Chichester Range - wetland of national significance; • Karijini Gorges - wetland of national significance; • Waterfalls of Hamersley Range with undescribed plant species, fern covered seepages on rock walls of gorges within the Hamersley Range; • Running Waters and Skull Springs on the Oakover; • Weeli Wolli Spring in the Fortescue; • Nyeetbury Spring on the Robe River; • Calcretes in Fortescue Valley near Wittenoom between BHPIO Rail and Millstream. • Ethel Gorge on the Whaleback Creek. • Minthicoondunna and Milli Milli Springs on Turee Creek within Karijini National Park • Coppins Gap Pool and Cattle Gorge on Yarrie Station • Pools of Duck Creek and Caves Creek in the western Hamersley Range • Pools and Springs of the Robe River and Bungaroo Creek
Total Area (% of bioregion)	89,729 ha (0.48%)

Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	1,339	66	145	11
Flora	243	38	86	14

Nested Assets	
Plant communities	• Emergent vegetation of river and creek pools in the Pilbara can include *Schoenoplectus subulatus* and *Typha domingensis*. These species typically form dense beds along banks and shallower backwaters. • *Cyperus vaginatus* and *Eleocharis* spp. may also occur in briefly inundated sites and the shallowly inundated edges of pools and springs. • Endemic flora includes Millstream Fan-palm and *Stylidium weeliwolli.*
Reptile assemblage	• Pilbara Olive Python (*Liaisis olivaceus barroni*)
Mammal assemblage	• Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantius*), Ghost Bat (*Macroderma gigas*)
Invertebrates	• High potential for Short Range Endemic Invertebrates
Bird assemblage	• Watercourses, springs and pools provide a refuge for birds, within fringing vegetation and a number of species are more common along these watercourses than in other habitats. They include Black Bittern (*Ixobrychus flavicollis*), Peaceful Dove (*Geopelia striata placida*), Australian Ringneck (*Platycercus zonarius*), Blue-winged Kookaburra (*Dacelo leachii*), Black-tailed Treecreeper (*Climacteris melanura*), Red-browed Pardalote (*Pardalotus rubricatus*), and Star Finch (*Neochmia ruficauda subclarescens*).
Cultural heritage	• Cultural assets, archaeological deposits (currently oldest dated to 47,000 years ago), habitation sites, several sites of special Aboriginal importance, rock art (paintings, engravings), of Hamersley Gorges, Weeli Wolli Springs. Ethnographic sites. High cultural values for permanent pools (large and unusual habitation sites)

Asset #10: Clay Pans

Summary				
Description	Claypans and clay flats capture a large component of the Pilbara wetland flora, and their scattered occurrence across the lowlands of the region poses difficulties in capturing their diversity in the reserve system. Clay flats and claypans and lowland creeks with fine sediments are typically highly turbid and also display high numbers of rare plant taxa. Claypans and clay flats have rich assemblages of annual taxa and are also important for invertebrates with a number of endemics and specialists being recorded in regional surveys.			
Key locations	• Freshwater claypans downstream of the Fortescue Marsh - Goodiadarrie Hills on Mulga Downs Station (PEC – Priority 1). Claypans extend onto Mt Florence and Coolawanyah Stations. • Gnalka Gnoona Claypan, Moreton Pool, Cane River Claypan, Paradise Pool, DeGrey Claypan, Munreemya Billabong, Coppin Pool, Sweet Well Claypan, Roy Hill Claypan, Mulga Downs Outcamp Claypan, Ethel Creek Claypan , Berringarra Claypan, Munjina Claypan, Claypans on Wunna Munna Flats, Lake Robinson on Coondewanna Flats, Mt Bruce Coolabah woodlands on Mt Bruce Flats			
Total Area (% of bioregion)	240,821 ha (1.3%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	350	47	87	4
Flora	253	35	83	8
Nested Assets				
Plant communities	• Small claypans are often devoid of emergent plants. At larger claypans and crab-hole flats, the dominant vegetation is usually emergent grass, commonly *Eragrostis benthamii* and *E. flaccida* but sometimes *Leptochloa* spp. and *Pseudoraphis spinescens*. *Eucalyptus victrix* also occurred across the bed and along the margins of some claypans. . Many claypans in the Fortescue River catchment support an understorey dominated by lignum (*Duma florulenta*) in association with Budda Pea (*Aeschynomene indica*), Sesbania Pea (*Sesbania cannabina*), and Silky Browntop (*Eulalia aurea*).			
Reptile assemblage	•			
Mammal assemblage	•			
Invertebrates	• The faunas of springs and claypans show some differentiation between drainage basins. Species are generally less mobile and less likely to be moved around by floods, possibly contributing to subregionally distinctive faunas. • A number of endemics were collected only in turbid wetlands (claypans and/or turbid pools), including several rotifers, hydrobiid snails, the new fairy shrimps (*Branchinella pinderi* and *B. mcraeae*), new clam shrimps (*Limnadia* sp. nov. and *Eocyzicus* sp. nov.) and ostracods (new *Paralimnocythere*, *Limnocythere*, *Bennelongia* and *Cypretta*). Several other taxa that occurred only once during the survey may also be claypan specialists, including two new Lynceus clam shrimps, a new genus of chydorid Cladocera and several additional ostracods.			
Bird assemblage	•			
Cultural heritage	• Ethnographic sites – ceremonial sites and mythological sites. Habitation sites.			

Asset #11: Subterranean Fauna Habitat

Summary				
Description	Stygofauna are aquatic animals that live in groundwater. Troglofauna are air-breathing terrestrial animals that live underground in caves and smaller air-filled voids (meso-caverns or vugs) beneath the ground. The Pilbara is an important region for subterranean fauna, it is arguably the world's richest bioregion for such fauna (Halse 2015). A feature of the Pilbara is that stygofauna occur across most of the landscape, often where the depth to groundwater is considerable. Another feature is high endemicity: on the basis of current taxonomy, 98% of the stygobites and 83% of the other groundwater species occur only within the region (Halse *et al*. 2014).			
Key locations	• Ethel Gorge / Ophthalmia Basin Aquifer Stygobiont Community – Threatened Ecological Community; • Robe River Valley; • Millstream Aquifer. • BIF ranges of the Hamersley Range			
Total Area (% of bioregion)	• 5,291,767ha (29.61%)			
Biota – Summary of known records				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	XXX	XXX	XXX	XXX
Flora	YYY	YYY	YYY	YYY
Nested Assets				
Invertebrates	• Various stygofauna and troglofauna species with restricted occurrence, in particular biota now poorly represented in the surface invertebrate biota of the Pilbara (eg. Schizomids, Whip Scorpions)			

Asset #12: Inland Mountain Ranges, Rocky Hills, Breakaways and Mesas

Summary	
Description	The Chichester Range, Gorge Range, Ord Range, Ripon Hills, Gregory Range, Magpie Range, Hamersley Range (encompassing its constituent ranges such as the Ophthalmia Range, Packsaddle Range, Hancock Range, Eastern Ridge, Western Ranges, Channar Ranges, Rhodes Ridge etc) consist mostly of rugged, sparsely vegetated hills rising to 1,250 m. In the Chichester and Hamersley Ranges many gorges contain permanent water which is otherwise scarce in the region. The gorges vary from wide, open-sided valleys (eg. Yampire Gorge) to narrow gorges with precipitous cliffs (eg. Hancock Gorge). The vegetation of these systems is typically dominated by hummock grasses (*Triodia* spp.) under a very sparse overstorey of Snappy Gum (*Eucalyptus leucophloia*) which occurs on nearly all hills, ridges and ranges in the Pilbara. Soils are stony skeletal gritty sands, gravels, gritty loams and clays with dense surface mantles of pebbles and cobbles and frequent bedrock outcropping.
Key locations	• Millstream Chichester National Park; • Karijini National Park; • Hamersley Range; • Chichester Range; • Mungaroona Range Nature Reserve. • Meentheena Conservation Park – Ripon Hills
Total Area (% of bioregion)	7,649,205 ha (41.3%)

Biota – Summary of known records (NatureMap, 2016

	Records	Families	Genera	Con sig species*
Fauna	69,806	419	1,069	78
Flora	17,638	125	404	131

Nested Assets	
Plant communities	• Snappy gum (*E. leucophloia*) and Hamersley bloodwood (*Corymbia hamersleyana*) over spinifex (*Triodia* spp.). • Summits of many of the higher peaks in the Hamersley Range (>1,000m) dominated by a mallee shrubland comprising Kingsmill's mallee (*E. kingsmillii*), Ewart's mallee (*E. ewartiana*) and Iron bloodwood (*C. ferriticola*). • The bottoms of many gorges have woodlands of River Red Gum, Coolibah, *Melaleuca* spp. and *Acacia* spp. and in some areas, thickets of fig (*Ficus brachypoda*) and Pilbara Kurrajong (*Brachychiton acuminatus*). Priority flora species including: *Acacia cyperophylla* var. *omearana*,) and *Indigofera ixocarpa* ms.
Reptile assemblage	• Reptiles species from these systems (steep rock formations with numerous crevices interspersed by patches of skeletal soils with spinifex grassland) include a number of Pilbara endemics such as *Diplodactylus galaxias*, *D. savagei*, *Gehyra punctata* and *G. 'fenestra'*; *Egernia cygnitos*, *E. epsisolus*, *E. pilbarensis*, *Ctenotus rutilans* and *Morethia ruficauda exquisita*; *Ramphotyphlops ganei* (Doughty *et al*. 2011). • Pilbara Olive Python (*Liaisis olivaceus barroni*)
Mammal assemblage	• Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) Ghost Bat (*Macroderma gigas*), Rothschild's Rock-wallaby (*Petrogale rothschildi*) are supported in areas featuring deep caves and crevices, overhangs, boulders and outcropping.
Key habitat areas	• Mountain top flora - refuge from fire for a large number restricted flora; • Deep Gorges in Hamersley Range - protection for fire intolerant species; • Bat roosts (especially Pilbara Leaf-nosed Bat and Ghost Bat) (McKenzie and Bullen, 2009);

	• Abandoned underground mines – Warrawoona, Bamboo Creek, Lalla Rookh, Comet Mine, Copper Hills.
Invertebrates	• Potential for Short Range Endemic invertebrates
Bird assemblage	• The central highlands or hilly interior support a number of bird species that are rare elsewhere, including the Striated Grasswren (*Amytornis striatus whitei*), the Rufous-crowned Emu-wren (*Stipiturus ruficeps*), Grey-headed Honeyeater (*Ptilotula keartlandi*), Western Bowerbird (*Ptilonorhynchus guttatus*), Spinifex-bird (*Eremiornis carteri*) and Painted Finch (Emblema pictum). • Peregrine Falcon (*Falco peregrinus*)
Cultural heritage	• Cultural assets (habitation sites) in Hamersley caves and elsewhere. Ethnographic sites – ceremonial sites and mythological sites. A wide range of open sites including artefact scatters and grindstone quarries, burial sites, stone arrangements, walled rock shelters.

Asset #13: Rock Piles and Granites

Summary				
Description	Comprises a few key areas of which two major sites are the boulder field present at Burrup Peninsula and the abundant granite tors existing on the Abydos Plain. The Burrup Peninsula represents and evolutionary refuge for flora (vegetation is notably different to mainland) and also a minor centre for terrestrial gastropods.			
Key locations	• Burrup Peninsula (Murujuga National Park) (DEC, 2013) • Abydos Plain (containing Abydos Woodstock Reserve) • Black Range • Spear Hill • Mt Stuart tor field			
Total Area (% of bioregion)	664,229 ha (3.58%)			
Biota – Summary of known records (NatureMap, 2016)				
	Records	**Families**	**Genera**	**Con sig species***
Fauna	3,527	186	326	26
Flora	1,058	77	194	21
Nested Assets				
Plant communities	• Distinct vegetation communities in comparison to other areas of the Pilbara. • Significant outcrops and boulder piles support dense *Acacia* thickets at their periphery due to water accumulation. Rock fig (*Ficus brachypoda*) is also common. • Several Pilbara endemics including O'Meara's Wattle (*A. cyperophylla* subsp. *omearana*), Leeuwen's wattle (*A. leeuweniana*), Woodstock wattle (*A. levata*), and McNamara's Kapok (*Cochlospermum macnamarae*)			
Reptile assemblage	• Pilbara Olive Python (*Liasis olivaceus barroni*); • Regional endemics such as *Varanus pilbarensis*.			
Mammal assemblage	• Rothschild's Rock-wallaby (*Petrogale rothschildi*), Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Ghost Bat (*Macroderma gigas*).			
Invertebrates	• High potential for Short Range Endemic invertebrates, in particular scorpions and sedentary ground-dwelling spiders			
Cultural heritage	• Cultural assets (rock art and campsites) at a range of sites; • Largest 'gallery' of petroglyphs with the greatest abundance and highest concentration of any known site in the world (Murujuga); • A lot of small scale (un-mappable) basalt piles eg. Rocklea land-system or granites (Boolaloo land system); • Ceremonial sites, mythological sites; • Stone arrangements, grinding patches.			

APPENDIX 2 Strategies and action steps developed during the workshop process

Coastal Assets

Asset grouping	Assets	Threats	Goal
COASTAL ASSETS	1) Off-shore Islands 2) Coastal Mangroves and Inter-tidal Mud flats 3) Sandy Beaches and Dunes	Introduced predators (cats, foxes, dogs)	By 2025 reduce predator pressure on populations of native fauna species (sea turtles, migratory birds, shorebirds, marsupials, reptiles etc.) to allow populations to become self-sustaining within their range. (NB Migratory species spend much of their lifecycle outside the Pilbara).

Strategy 1a) Identify priority assets and high risk areas for introduced predators (Need to know using a modelling exercise where the highest asset values are) — High Effectiveness

Key Actions

- Develop funding proposal for asset prioritisation and monitoring that includes a costing exercise to guide what is attainable and what is not
- Undertake six month asset prioritisation (if good data does exist) - examine asset data, including on-ground (ground truthing) and modelling
- Product is a strategy and map which indicates key assets and feral carnivore occurrence and priority areas for action.

Strategy 2) Develop and implement an integrated introduced predator control strategy — High Effectiveness

Key Actions

- First step/priority is to find funding to develop an integrated carnivore control strategy, which uses existing data (should cost <$100k, two year timeframe), includes a costing exercise to guide what is attainable and what is not, and assist in prioritising actions, as well as having " ready-to-go" projects towards which funding streams can be directed
- Map key areas for predator control based on species, then prioritise (pick battles, such as those already underway like eg. Parks and Wildlife's Western Shield sites, Fortescue Marsh cat baiting work and the Wild Dog baiting areas)
- Better engagement of pastoralists and other stakeholders
- ESRM planning to include predator management (feed into landscape plans)
- Ensure that strategies for the beaches and dunes integrate with those developed for the inland areas (plains)
- Prioritise Islands for pest control programs (see Lohr, 2015)
- Integrated Pest Management Plan - role of various control techniques - eg. baiting vs other techniques including new techniques
- Co-ordinated, integrated (with other predators) wild dog management plan for the Pilbara
- Change dingo control programs to account for fox/cat control
- Implement a predator control program for towns, & other areas of human habitation: licensing, desexing, chip implant, enforcement
- Integrate management program with other threats/management (eg. burn lines - then trap along lines)

Strategy 3) Implement cat management activities — High Effectiveness

Key Actions

- Baiting
- Ground shooting localised on conservation estates

- Ground shooting on pastoral lands
- Leg-hold trapping
- Sterilize domestic cats
- Education programs for sterilization of cats, keeping cats indoors, cat registration laws

Strategy 4) Undertake applied cat research to guide future management	Medium Effectiveness

Key Actions

- Research into grooming traps
- Determine the impact of cats on threatened species in the Pilbara
- Identify spatial distribution and densities of cats; develop tools to be able to collect this information. This should include quantifying density thresholds (for mainland environments), in areas where impacts to native species are thought to be negligible and therefore "acceptable".
- Investigate interactions between dogs, dingoes, foxes and cats

Strategy 5) Implement vertebrate pest control program around key coastal fauna sites	Medium Effectiveness

Key Actions

- Explore alternative bait methodologies (to reduce off target damage) to enable control in intertidal areas
- Prioritise Islands for pest control programs
- Eradicate rats from islands.
- Eradicate cats and foxes from islands
- Secure funding for control on key coastal fauna sites

Strategy 6) Implement a Communications/Education strategy around introduced predators	Medium Effectiveness

Key Actions

- Identify and demonstrate effective examples of control (eg. before and after - Port Hedland Turtles and Foxes)

Asset grouping	Assets	Threats	Goal
COASTAL ASSETS	3) Sandy Beaches and Dunes	Unsustainable Stock Grazing Pressure	By 2025 manage grazing pressure to the asset to protect grazing-sensitive ecosystems and species (TBD), retain habitat structure and minimise the risk to threatened flora and fauna populations and cultural assets (TBD = to be determined)

Strategy 7) Strategic fencing to exclude stock from priority assets.	High Effectiveness

Key Actions

- Assess priority areas (high value assets) for fencing, that includes a costing exercise to guide what is attainable and what is not, and assist in prioritising actions, as well as having "ready-to-go" projects towards which funding streams can be directed
- Include cultural and historical sites in asset prioritisation
- Determine what length of fencing is required - map/survey, also include the type of fencing in assessment to make sure that it will not be harmful to wildlife.
- Develop fencing plan including assessment of links to other requirements such as weed management.
- Develop fence maintenance strategy (including long term funding requirements) addressing who is responsible for repairs and maintenance and who insures
- Acquire funds for strategic fencing, maintenance and monitoring of high value coastal assets - develop a compelling case, no landholder contribution

- Boundaries Act - enforcement? to what extent can/would this happen - use this as a basis for implementing
- Erect fences using appropriate contractors and groups such as Aboriginal Ranger Groups, Green Army

Strategy 8) Engagement with pastoralists via Ecologically Sustainable Rangeland Management (ESRM) Plans to protect coastal biodiversity	High Effectiveness

Key Actions

- Develop compelling reason for engagement that benefits the pastoral landscape as a whole, not only the biodiversity component
- Standardise communications material/message
- Use legislation
- Engage appropriate extension staff
- Long term planning for the right person/people
- Ensure pastoral lands board are involved in the process

Strategy 9) Implement Nutritional Self Shepherding Trial	Medium Effectiveness

Key Actions

- Seek properties that can participate in self-shepherding trials that include coastal dune areas (If successful pilot project will sell itself from pastoralist to pastoralist)
- Acquire funding for a trial in 2016 (<$10k) to implement a self-shepherding trial
- Acknowledge that dunes not part of pastoral lease - remove windmills etc., which promote stock access & camping

Asset grouping	Assets	Threats	Goal
COASTAL ASSETS	1) Off-shore Islands 3) Sandy Beaches and Dunes	Weeds (Buffel Grass, Kapok, Ruby Dock, Passiflora, etc)	By 2025, control TBD% of key, prioritised infestations to prevent further spread or for significant, isolated conservation assets eradication of weed occurrence.

Strategy 1b) Identify priority assets and high risk areas for weed infestations (Need to know using a modelling exercise where the highest asset values are)	High Effectiveness

Key Actions

- Develop funding proposal for asset prioritisation and monitoring, that includes a costing exercise to guide what is attainable and what is not
- Undertake six month asset prioritisation (if good data does exist) - examine asset data, including on-ground (ground truthing) and modelling
- Product is a strategy and map which indicates key assets, weed occurrence and density (including incursion routes and the source populations which might be significant distances from the assets we are trying to protect) and priority areas for action, based on costs (lighter infestations removed first)

Strategy 10) Develop and implement a Pilbara-wide integrated weed control strategy	High Effectiveness

Key actions

- Undertake scoping of funding requirements, current funded projects, shortfalls and budget for Pilbara weed strategy, that includes a costing exercise to guide what is attainable and what is not, and assist in prioritising actions, as well as having "ready-to-go" projects towards which funding streams can be directed
- It is suggested that standard operating procedures for mapping, costing and prioritisation are developed as the foundation for most of the other actions listed below.
- Standardize weed mapping - per species and per density (standards for mapping are required for costing control over the long term, as well as for developing norms for the amount of effort needed for their control as the problem is that currently the weed data is in a format that can not be used to assess if any progress is being made in controlling weeds)
- Map distribution of weeds - location/density, costs to control and prioritise, use predictive methodology, explore detection methodology(s)
- Develop a Pilbara-wide spatially explicit database with quantitative species data (not just point data)
- Use threatened species to lever funds for weed control work
- Develop funding application for Pilbara Mesquite Management Committee (PMMC) to expand its scope
- PMMC to rename itself & expand into a program across tenures including various partners such as mining companies and pastoralists via the Pilbara Biosecurity Group
- Work with Indigenous people to get knowledge of weed control and link to working on country
- Identify local champions/groups/ Aboriginal rangers
- Seek resources to implement weed actions including community groups, Green Army, Aboriginal Rangers, Pilbara Regional Biosecurity Group
- Incorporate weed monitoring as part of the strategy
- PMMC to develop research and monitoring plan across the Pilbara
- Implement a Prickly Pear Management Program
- Implement a buffel and kapok management program
- Include biological control methods for weed control
- Review Parks and Wildlife prioritisation of weeds on the conservation estate - both mainland and islands

Strategy 11) Develop biosecurity strategy and action plan targeted at high risk coastal and island areas	Medium Effectiveness

Key Actions

- Develop signage at boat launches areas and on fore-dunes
- Develop pamphlets on weeds and other biosecurity matters that are linked to licenses
- Learn techniques from other places such as Dirk Hartog and Barrow Islands (Chevron/Parks and Wildlife Principles could be used as a benchmark)
- Develop key winning strategies on a couple of islands and sites
- Monitor for new incursions - new weeds, new locations
- Develop Integrated Coastal Zone Strategy- Review & collated coastal management strategies
- Restrict livestock in coastal zone
- Acknowledge that dunes not part of pastoral lease - remove windmills etc., which promote stock access & camping
- Make dunes a type of conservation reserve (change tenure)

Strategy 12) Implement a coastal weed education strategy	Medium Effectiveness

Key Actions

- Source funding for a weed education strategy
- Develop a weeds booklet or electronic identification tool
- Develop signage at boat launches areas and on fore-dunes
- Develop pamphlets on weeds and other biosecurity matters that are linked to fishing licenses

Strategy 13) Develop a weed research strategy	Medium Effectiveness
Key Actions • Develop model for pool of funds • Identify key collaborators (eg. Universities, CSIRO) • Identify research needs • Use research to demonstrated impact (informed by monitoring)	

Inland Mountain Ranges, Rocky Hills, Breakaways and Mesas

Asset grouping	Assets	Threats	Goal
INLAND MOUNTAIN RANGES, ROCKY HILLS, BREAKAWAYS AND MESAS	12) Inland mountain ranges, rocky hills, breakaways & mesas	Clearance from Mining (Mine sites) Clearance from Infrastructure Development (roads, rail, ports, other development)	By 2020 ensure new mining developments and associated clearance are managed to environmentally appropriate standards and limit development in regionally significant ecological areas (eg. threatened species habitat)

Strategy 14) Develop a transparent, co-ordinated approach to data collation, management and sharing — Medium Effectiveness

Key Actions

- Break down barriers between companies to provide central repository for data sharing
- Provide portal for stakeholders to access

Strategy 15) Develop a regional land-use plan to inform design and assessment of mining related development — High Effectiveness

Key Actions

- Collate existing information
- Map extent of significant areas and publish this
- Determine valuing/prioritisation methodology (does it exist already?)
- Investigate potential for shared use of infrastructure (eg. rail corridors, common development hubs)
- Examine other processes - Fortescue Marsh-type guidelines - attempts by CSIRO, TNC's development by design
- Develop criteria for regionally significant ecological and cultural areas -veg mapping etc.
- Use data from mining assessments for cultural data
- Vegetation mapping - see CSIRO report (underway but more funds required)
- Infrastructure master plan - collate data from "identify significant areas" strategy (very low feasibility)
- Product is a regional land-use plan

Strategy 16) Influence a coordinated approach to conservation actions via regulatory mechanisms (including offsets) across the Pilbara region — High Effectiveness

Key Actions

- This CAP, CSIRO Threat Report (2014) and the Pilbara Biodiversity Audit should be used to influence conservation actions across the region
- Influence existing mechanisms for biodiversity conservation (such as offsets) to target the actions in this CAP that provide the most effectiveness
- Identify opportunities to bring together different mechanisms for biodiversity conservation to allow for alignment of outcomes or coordination of actions across the broader community.
- Use opportunities to leverage funds through other mechanisms to implement the actions in this CAP
- Evaluate offsets (outcomes-based) now and in 10 years' time again to see how well they are working

(Note: Offsets are a tool applied by regulators as a means to counterbalance significant residual impacts from development. Offsets are primarily aimed at increasing the quality/condition of the environment and not research to gain knowledge. Offsets are the responsibility of the regulators to determine and apply).

Strategy 17) Integrate ecological outcomes into mine planning and closure process — Medium Effectiveness

Key Actions

- Develop guidelines to minimise impacts
- Develop completion criteria guidelines appropriate to the Pilbara
- Consultation with stakeholders
- Best practice guidelines - explore/encourage standard conditions
- Develop planning to account for biodiversity post closure
- Retrofitting necessary features - including opportunistic

Asset grouping	Assets	Threats	Goal
INLAND MOUNTAIN RANGES, ROCKY HILLS, BREAKAWAYS AND MESAS	12) Inland mountain ranges, rocky hills, breakaways & mesas	Inappropriate Fire Regimes (too hot, too frequent, too large)	By 2020, patchy, cool, early season fire regimes are in place across 10% of the asset annually to protect fire-sensitive ecosystems, maximise habitat diversity and minimise the risk to threatened flora and fauna populations.

Strategy 18) Develop a Pilbara-wide fire ecology research strategy — Medium Effectiveness

Key Actions

- Develop the scoping and funding proposal for strategy, and in reworking the goal, consider aspects such as % availability and overall extent of unburnt patches, an optimal spread (%) of vegetation age classes at an appropriate patch size and configuration across the planning area
- Develop us a series of key questions including: What are the key gaps in our knowledge? How does this integrate with the baseline and monitoring strategies? Do we have a good handle on what is the optimal scale(s) of patch mosaic burning required across the planning area, ie. how much pyrodiversity is required? How do we improve our understanding of habitat availability, dispersal and resource needs for target biota? What role does season of burn play?
- Build a better fire history information system (NAFI/other systems from Queensland etc.)
- Undertake collation and analysis of fire histories at a landscape scale
- Explore potential effects of Climate Change on fire regimes

Strategy 19) Develop a regional operational fire management plan — Medium Effectiveness

Key Actions

- Undertake a scoping exercise that includes costings to guide what is attainable and what is not, and assist in prioritising actions, as well as having "ready-to-go" projects towards which funding streams can be directed
- It is important to know how much funding it will take to achieve this appropriately-scaled fire mosaic across the planning area, and to be realistic in terms of narrow windows of opportunity for executing prescribed burns from a climate perspective, optimal season, and availability of resources.
- Areas will need to be prioritised within this (and other) assets as it has a widespread distribution and extent across the planning area that needs to be recognised.
- Involve multiple stakeholders
- Community fire strategy - incorporate input from broad stakeholders
- Manage for multiple objectives
- Develop funding proposal for strategy
- Look at funding of EcoFire model - Rangelands NRM
- Develop a brief for a regional fire management plan (Rangelands NRM and others- using information from models used by Rangelands NRM for mosaic burning)
- First step is to review data - analysis by 2016
- Develop strategy to monitor ecological and economic investment - all the funding sources - to demonstrate if investments are working or not
- Aboriginal Rangers trained for fire management under experienced leaders

- Determine pastoralists motivations
- Develop incentives for pastoralists and Indigenous people and others to undertake "appropriate" fire management
- Accept teething problems - overburn etc.
- Implement strategic burns - Asset protection burns to become part of breaks - Prescribed burning for priority area protection
- Product is a multi-stakeholder operational fire management plan
- Integrate traditional knowledge of fire management (including cultural site information) into current ecological research/thinking - Indigenous engagement - Incorporate Local knowledge - Create/bring in workforce - Utilise existing workforce - training permits - capacity building
- Develop and implement a fire monitoring strategy, which will require much effort to measure baselines and sustain monitoring at the species, habitat and ecosystem levels

Strategy 20) Develop a fire education strategy	Medium Effectiveness

Key Actions

- Secure funding for fire education strategy
- Develop messages of what is ecological burning and why (don't necessarily be afraid of fire)
- Promote fire resilient design of infrastructure
- Fire communication strategy - increase profile of effect of large-scale intense fires

Asset grouping	Assets	Threats	Goal
INLAND MOUNTAIN RANGES, ROCKY HILLS, BREAKAWAYS AND MESAS	12) Inland mountain ranges, rocky hills, breakaways & mesas	Weeds (Buffel Grass, Kapok, Ruby Dock, Passiflora, etc)	By 2025, X% (or X,000ha) annual reduction of key, new infestations of Ruby Dock and town escapees eg. Leuceana, Washingtonia, Cotton Palm, Malay almond, to prevent further spread.

Strategy 1b) Identify priority assets and high risk areas for weed infestations (using a modelling exercise where the highest asset values are)	High Effectiveness

Key Actions

- See strategy as mentioned above.

Strategy 10) Develop and implement a Pilbara-wide integrated weed control strategy	High Effectiveness

Key Actions

- See strategy as mentioned above.

Strategy 13) Develop a weed research strategy	Medium Effectiveness

Key Actions

- See strategy as mentioned above.

Strategy 21) Weed control strategy for mining related development (primarily ruby dock)	Medium Effectiveness

Key Actions • Regulated control - weed management strategy - "off the shelf" standardisation • Contain ruby dock and maintain weed free areas • Develop a compelling "why" • Road funding includes weed control component	
Strategy 22) Weed control strategy for town weeds education/information strategy for town weeds	Medium Effectiveness
Key Actions • Education/information strategy for town weeds: Nurseries to provide alternatives to weeds, town population dumping, local government streetscape • Legislation (traffic light system) and enforcement • Provide alternatives to weeds: nursery supply, demonstration sites	
Strategy 23) Improve Biosecurity Management	High Effectiveness
Key Actions • Detect and treat new incursions before they become established • Better access management (Road, rail etc.) • Community education and engagement • Compliance and enforcement (enduring) • Build biosecurity into roads maintenance • Quarry hygiene (road metal) • Develop coordinated biosecurity strategy - who, when etc. • Develop appropriate identification tools for weeds	
Strategy 24) Collation of weed data to get baseline and measure change over time - centralised data base that includes monitoring programs	Medium Effectiveness
Key Actions • Utilise existing systems - use existing prescribed methodology if available, otherwise develop appropriate methods • Work out how much it will cost - standard metrics • Undertake prioritisation of actions	
Strategy 25) Develop an inland weed education strategy	Low Effectiveness
Key Actions • Pest controllers use correct methodology • Miners - social pressure for participation • Target town population, tourists, business, shire, road builders	

Plains Assets

Asset grouping	Assets	Threats	Goal
PLAINS ASSETS	4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities	Introduced predators (cats, foxes, dogs)	By 2025 reduce introduced predator numbers in key areas (eg. areas of significant habitat for Matters of National Environmental Significance (MNES); key source locations) by 75%
Strategy 1a) Identify priority assets and high risk areas for introduced predators (using a modelling exercise where the highest asset values are)			High Effectiveness
Key Actions • See strategy as mentioned above.			
Strategy 2) Develop and implement an integrated introduced predator control strategy			High Effectiveness
Key Actions • See strategy as mentioned above.			
Strategy 3) Implement Cat Management Activities			High Effectiveness
Key Actions • See strategy as mentioned above.			
Strategy 4) Undertake Applied Cat Research to guide future management			Medium Effectiveness
Key Actions • See strategy as mentioned above.			
Asset grouping	**Assets**	**Threats**	**Goal**
PLAINS ASSETS	4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities	Inappropriate Fire Regimes (too hot, too frequent, too large)	By 2020 actively manage (using agreed metrics TBD) regionally significant areas to protect (X%) of key fire-sensitive ecosystems, maximise habitat diversity and minimise the risk to threatened flora and fauna populations*.
Strategy 1c) Identify priority assets and high risk areas for fire sensitivity (using a modelling exercise where the highest asset values are)			High Effectiveness
Key Actions • Develop funding proposal for asset prioritisation and monitoring , that includes a costing exercise to guide what is attainable and what is not • Undertake six month asset prioritisation (if good data does exist) - examine asset data, including on-ground (ground truthing) and modelling • Product is a strategy and map which indicates key assets and a plan of where the key fire sensitive areas are.			
Strategy 18) Develop a Pilbara-wide fire ecology research strategy			Medium Effectiveness

Key Actions
- See strategy as mentioned above.

Strategy 19) Develop a regional operational fire management plan	Medium Effectiveness

Key Actions
- See strategy as mentioned above.

Strategy 20) Develop a fire education strategy	Medium Effectiveness

Key Actions
- See strategy as mentioned above.

Strategy 26) Engagement with pastoralists via Ecologically Sustainable Rangeland Management (ESRM) Plans to integrate fire management for pastoralism with the protection of fire sensitive ecosystems	Medium Effectiveness

Key Actions
- Make sure that fire sensitive areas are mapped before visiting properties

Asset grouping	Assets	Threats	Goal
PLAINS ASSETS	4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities	Unsustainable Stock Grazing Pressure	By 2025 actively manage total grazing pressure in regionally significant areas to protect sensitive ecosystems and maintain sustainability.

Strategy 27) Industry driven improvements	Medium Effectiveness

Key Actions
- Pastoral education - grazing, nutrition, ESRM
- Pastoralist on pastoralist education important
- Explore alternative, sustainable feed (irrigated agriculture - could be a threat too)
- Beef development officers
- Explore industry partnerships
- Improve infrastructure
- Resourcing/staff to deliver
- Keep a watching brief on programs to sell environmental services

Strategy 28) Engagement with pastoralists via ESRM plans to ensure that landscape scale property planning includes biodiversity objectives	High Effectiveness

Key Actions
- Ensure funding and support in place by 2016 for expansion of ESRM plans and aim for establishment on all Pilbara pastoral leases over the medium term
- Develop ESRM plans for all pastoral properties (currently +- 20/60)
- Research into matching stocking rates to feed on offer

- Identify "high values assets" which area being grazed unsustainably
- Implement Nutritional Self Shepherding
- Allow alternate land-use (diversification) on pastoral leases (would need legislative/policy change and advocacy)

Strategy 29) Implement stewardship program in priority areas (legislative barriers)	Medium Effectiveness

Key Actions
- Develop incentive schemes – stewardship
- Demonstrate value proposition - cost benefit

Strategy 30) Indigenous community linking with pastoral properties	Medium Effectiveness
Strategy 31) Develop a program for Pilbara wide remote sensing-based condition monitoring (Landsat, Veg machine CSIRO)	Medium Effectiveness
Strategy 32) Artificial water points phased out strategically on relinquished pastoral leases and pastoral lease boundaries fenced	High Effectiveness

Asset grouping	Assets	Threats	Goal
PLAINS ASSETS	4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities	Weeds (Buffel Grass, Kapok, Ruby Dock, Passiflora, etc)	By 2020 (TBD) reduce (extent TBD) of significant weeds (calotropis, bellyache bush, cactus, new & emerging weeds), and maintain 5% annual reduction of key infestations of mesquite, to prevent further spread and by 2018 identify outlying occurrences of landscape scale/widespread weeds (kapok, ruby dock, passiflora) that can be targeted for eradication. (TBD = to be determined)

Strategy 1b) Identify priority assets and high risk areas for weed infestations (using a modelling exercise where the highest asset values are)	High Effectiveness

Key Actions
- See strategy as mentioned above.

Strategy 10) Develop a Pilbara-wide integrated weed strategy	High Effectiveness

Key Actions
- See strategy as mentioned above.

Asset grouping	Assets	Threats	Goal
PLAINS, WETLANDS & OTHER WATER DEPENDENT SYSTEMS	4) Spinifex Hummock Grassland on Plains with shrubs and trees (eg. Acacia) 5) Tussock Grasslands on Plains 6) Mulga Woodlands and Acacia Shrubland Communities 7) Rivers, Creeks and Associated Floodplains on open plains 8) Fortescue Marsh (EPA defined area)	Altered Hydrology from infrastructure development (roads, rails, etc) (PRIMARY THREAT)	By 2025 re-establish and maintain appropriate hydrological regimes by reducing impacts on natural flows from infrastructure barriers in priority waterways and aquifers

	9) Springs, Pools and Watercourses associated with Gorges and Ranges 11) Subterranean Fauna Habitat 12) Inland mountain ranges, rocky hills, breakaways & mesas		

Strategy 33) Ensure that new design standards for infrastructure address the issues of altered hydrological flows	Medium Effectiveness

Key Actions

- Check on current design process
- Ensure environmentally directed design for railways and culverts
- Include catchment function analysis in all ESRM plans
- Seek funding for expansion of ESRM planning to include pastoral lease road effects on hydrological functioning

Strategy 34) Develop environmentally directed road grading methodology	Medium Effectiveness

Key Actions

- Source funds for grading methodology training
- Develop a training package around grading methodology
- Hold workshops for drivers, machine operators and road planners/designers
- Engage local councils, contractors, main roads, pastoralists in delivering the project

Strategy 35) Avoid negative impacts of Groundwater Drawdown to important flora/fauna habitat. (EPA, 2013)	High Effectiveness

Key Actions

- Ensure that abstraction impacts on groundwater dependent ecosystems are effectively assessed by the Department of Water through the Pilbara Groundwater Allocation Plan (DoW, 2012)
- Ensure that groundwater drawdown does not lead to the loss of keystone species within riparian communities (such as Coolibah) along major tributaries.
- Installation of bores that penetrate multiple aquifers will require a minimum standard of an ADIA Class 2 driller or have equivalent Water Drilling certification approved by the Department of Water.
- Manage groundwater drawdown so that riparian vegetation along major tributaries is not significantly impacted.
- Minimise disruption to groundwater levels or water quality gradients in aquifers that support important habitats.
- Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's Australian Groundwater Modelling Guidelines (2012).

Strategy 36) Avoid negative impacts of surface discharge of excess water to important flora/fauna habitat (EPA, 2013).	High Effectiveness

Key Actions

- Excess water should be managed in accordance with the Department of Water's Pilbara Water in Mining Guideline (2009).
- Excess water should be re-injected in accordance with the Department of Water's Pilbara Water in Mining Guideline (2009).
- Limit surface discharge of excess water, especially in vicinity of claypan habitats.
- Maintain the natural surface water flow regime.
- Prevent discharge of excess water directly to the wetland or indirectly via industry-induced surface expression of saline or fresh water. If discharge is proposed it should be in accordance with an approved management and monitoring plan and ideally be of an episodic nature (campaign discharge) to coincide with natural flooding/inundation events.
- Minimise surface discharge of excess water, especially in vicinity of claypan habitats.

• Minimise the discharge of surface water to the Poonda Plain that supports Fortescue Valley sand dune PEC communities. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's Australian Groundwater Modelling Guidelines (2012).	
Strategy 37) Undertake Strategic Research to address key knowledge gaps for the Fortescue Marsh (EPA, 2013)	High Effectiveness
Key Actions • Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh. • Undertake surveys to document and map the extent of the species composition of this important ecological communities (eg. Sand Dunes on Poonda Plain). Undertake targeted surveys to document macroinvertebrates within claypans.	
Strategy 38) Communication strategy to improve understanding of underground water sources differences and interactions.	Medium Effectiveness
Key Actions • Ensure that knowledge from a range of sources is consulted, including the in-depth understanding of Traditional Owners, the long term custodians who value water and wetland systems very highly	

Rock Piles and Granites

Asset grouping	Assets	Threats	Goal
ROCK PILES AND GRANITES	13) Rock Piles and Granites	Clearance from Infrastructure Development (roads, rail, ports, other development) Introduced predators (cats, foxes, dogs)	By 2025 ensure regionally significant & culturally significant areas are protected from direct & fragmentation impacts

Strategy 1a) Identify priority assets and high risk areas for introduced predators (Need to know using a modelling exercise where the highest asset values are)	High Effectiveness

Key Actions

- See strategy as mentioned above.
- Ensure that risks from direct fragmentation impacts are included in mapping and prioritisation exercises.

Strategy 39) Assess impact of infrastructure on cultural assets of rock-piles and granites	High Effectiveness

Key Actions

- Consult with Traditional Owners
- Secure funding
- Explore options for Indigenous self-development (if willing) of new projects to protect cultural sites (ownership eg. Murujuga)
- Cultural survey to be led by Traditional Owners to identify significant sites and define regional priorities
- Engage rangers or similar groups to patrol culturally important sites
- Monitoring, prevention and remediation of culturally important sites

Strategy 40) Assess impact of infrastructure on fauna and flora of rock-piles and granites	High Effectiveness

Key Actions

- Develop funding proposal and acquire funds
- Conduct a rapid synthesis (6 months or so) of existing studies to get answers on fauna requirements and use (feral & native - especially Northern Quoll and SREs) of these systems
- Map specific rock piles, assess rank
- Research on fragmentation to look at connectivity, metapopulation dynamics, what is a barrier
- Develop design guidelines for new and existing infrastructure to reduce barrier effects

Subterranean Fauna Habitat

Asset grouping	Assets	Threats	Goal
SUBTERRANEAN FAUNA HABITAT	11) Subterranean Fauna Habitat	Clearance from Mining (Mine sites)	13) CAR Reserve systems for subterranean fauna to be quantified by 2025 and 17% (IUCN recommendation) of subterranean fauna (stygofauna / troglofauna) habitat to be retained by 2050

Strategy 41) Develop research questions - such as how good is underground habitat as a surrogate for species	Medium Effectiveness
Key Actions • Questions include impact thresholds and tolerance • Habitat requirements - water quality. water drawdown, reinjection, humidity, resilience to disturbance, recolonising disturbed areas, physical (chemical) (trophic tools - ARC) • Ecological services and function provided by stygofauna with respect to water quality	
Strategy 42) Undertake research (especially for stygofauna) as to how much drawdown (and reinjection) of water is possible before impacts (thresholds)	Medium Effectiveness
Key Actions • Confirm which geologies (for sub-fauna) are in the conservation estate • Undertake a desk top review	
Strategy 43) Develop a monitoring program for stygofauna	Medium Effectiveness
Strategy 44) Design and implement a reserve system for subterranean fauna	High Effectiveness
Key Actions • Decide if a single large or several small reserves are optimal (driven here by heterogeneity, as opposed to the wheatbelt, driven by fragmentation) • Determine significance of habitat and system continuity	
Strategy 45) Avoid (where possible) and minimise impacts to Subterranean Fauna and their habitats (EPA, 2013)	High Effectiveness
Key Actions • Define habitat requirements of conservation significant subterranean fauna and ensure that hydrological regimes are maintained. • Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap. • Enhance survey effort to document presence and richness of subterranean fauna.	

Wetlands and Other Water Dependent Systems

Asset grouping	Assets	Threats	Goal
WETLANDS AND OTHER WATER DEPENDENT SYSTEMS	8) Fortescue Marsh (EPA defined area) 9) Springs, Pools and Watercourses associated with Gorges and Ranges 10) Clay Pans	Clearance from Infrastructure Development (roads, rail, ports, other development) Clearance from Mining (Mine sites)	By 2020 ensure regionally significant ecologically and culturally significant areas are protected from direct impacts.

Strategy 14) Develop a transparent, co-ordinated approach to data collation, management and sharing	Medium Effectiveness
Key Actions • See strategy as mentioned above.	
Strategy 15) Development of a regional land-use plan to inform design and assessment of mining related development	High Effectiveness
Key Actions • See strategy as mentioned above.	
Strategy 16) Develop a co-ordinated Pilbara-wide offset strategy	High Effectiveness
Key Actions • See strategy as mentioned above.	
Strategy 17) Integrate ecological outcomes into mine planning process	Medium Effectiveness
Key Actions • See strategy as mentioned above.	
Strategy 46) Avoid (where possible) and minimise clearing/disturbance of areas of native vegetation that represents important flora/fauna habitat. (EPA, 2013)	High Effectiveness
Key Actions • Avoid (where possible) and minimise clearing of areas of native vegetation where critical habitat (eg. EPBC species) has been identified. • Avoid (where possible) and minimise clearing of mulga vegetation. • Avoid (where possible) and minimise clearing of samphire and halophytic vegetation. • Avoid (where possible) disturbance to extant Bilby burrows and minimise clearing of native vegetation where critical habitat has been identified. • Avoid locating infrastructure on or in close proximity to major Marsh tributaries. • Minimise clearing of native vegetation and abstraction of basic raw material (sand) for construction purposes. • Limit disturbance to claypan habitats where possible. • Map the condition of riparian vegetation and undertake revegetation activities where appropriate. • Undertake an assessment of cumulative impacts to mulga vegetation communities.	

Strategy 47) Develop new guidelines for restoration - methods for monitoring, measure how effective restoration is	High Effectiveness
Strategy 48) Determine the proportion of assets within formal reserves and ensure that each is represented adequately as per the system Comprehensive Adequate Representative (CAR) Reserve Management (~17%)	Medium Effectiveness

Key Actions

- Seek acquisition and reservation of mulga-dominated woodland and shrubland vegetation types
- Seek acquisition and reservation of suitable Night Parrot habitat
- Seek acquisition and reservation of suitable Northern Quoll habitat
- Seek acquisition and reservation of areas supporting Cowra and Christmas land systems

Asset grouping	Assets	Threats	Goal
WETLANDS AND OTHER WATER DEPENDENT SYSTEMS	7) Rivers, Creeks and Associated Floodplains on open plains 8) Fortescue Marsh (EPA defined area) 9) Springs, Pools and Watercourses associated with Gorges and Ranges 10) Clay Pans	Feral herbivores (Donkeys, Horses, Camels) (PRIMARY THREAT) Pigs (SECONDARY THREAT)	By 2020 manage for feral herbivores over X ha to reduce adverse impacts to an agreed, acceptable threshold levels

Strategy 49) Review and produce summary of the past years of donkey control work (includes other species) [Should take < 6 months & cost $25k]	Medium Effectiveness

Key Actions

- Identify trigger points and thresholds for intervention per species
- Identification of known areas (Fortescue Marsh etc) where current programs are working

Strategy 50) Control and eradication of feral herbivores around key locations	Very High Effectiveness

Key Actions

- Develop funding proposal and acquire funds for key feral control strategies, which includes a robust costing exercise based on current distribution and densities of different species, infiltration routes, and what constitutes ecologically-acceptable density levels, towards which initial efforts and ongoing interventions can be directed.
- Identify priority areas - water sources/high conservation value, eg. Fortescue Marsh
- Undertake mapping of priority areas
- Decommission redundant waters sources
- Research improved control/monitoring techniques, drone technology (develop model - existing monitoring largely ineffective)
- Research biology of feral herbivores - eg. home ranges - (significant knowledge gap)
- Investigate alternative control methods
- Continue to resource and expand existing projects such as those of the Pilbara Regional Biosecurity Group
- Upskill, train, retrain professional contractors
- How to measure reduced impact contribution?
- Investigate feasibility of fencing to prevent new recruitment
- Use non-lethal methods to overcome cultural barriers to control donkeys and horses

Strategy 51) Education to address cultural barriers to control	Medium Effectiveness

Key Actions

- Source funding
- Address religious concerns
- Demonstrate impacts to important sites
- Demonstrate contribution to total grazing pressure
- Eradicate donkeys & horses - use non-lethal methods to overcome cultural barriers to control

Strategy 52) Pig eradication - De Grey River	High Effectiveness

Key Actions

- No new introductions (hunters)

Strategy 53) Develop Pilbara wide user-friendly maps for different species of feral animals	Low Effectiveness

Asset grouping	Assets	Threats	Goal
WETLANDS AND OTHER WATER DEPENDENT SYSTEMS	7) Rivers, Creeks and Associated Floodplains on open plains 8) Fortescue Marsh (EPA defined area)	Inappropriate Fire Regimes (too hot, too frequent, too large)	By 2025 mosaic, cool, appropriate season fire regimes in place across the Fortescue Marsh (EPA area)

Strategy 54) Hot works from rail - education, adherence to Standard Operating Procedures – compliance	High Effectiveness
Strategy 55) Ensure implementation of the range of strategies to ensure appropriate fire regimes in adjacent asset areas (PLAINS and INLAND MOUNTAINS ETC. ASSETS).	Medium Effectiveness

Asset grouping	Assets	Threats	Goal
WETLANDS AND OTHER WATER DEPENDENT SYSTEMS	7) Rivers, Creeks and Associated Floodplains on open plains 8) Fortescue Marsh (EPA defined area) 9) Springs, Pools and Watercourses associated with Gorges and Ranges	Weeds (Buffel Grass, Kapok, Ruby Dock, passiflora, etc)	By 2025 there are no new incursions of weeds (priority weeds) and the impact, distribution and density of weeds is reduced (by x amount) in key asset locations.

Strategy 56) Ensure that key strategies from WONS for Wetland Assets and Weeds for the Inland Mountains etc. integrate and cover weed strategies for these Wetland Assets	Medium Effectiveness
Strategy 57) Prevent introductions of aquatic weeds	High Effectiveness

Key Actions

- Source funding for aquatic weed removal
- Determine what is a weed - e.g *Typha*
- Active removal program for aquatic weeds
- Work from upstream downwards when controlling aquatic weeds
- Education program to address the issue of active recreation which can lead to introductions - accidental and deliberate

Strategy 58) Strategy to remove date palms (historically planted)	Medium Effectiveness

Key Actions

- Source funding
- Understand and address vectors for spread - cattle and bats
- Note that control can be cost neutral if re-sale - depending on location
- Education program as to why they need removal

Asset grouping	Assets	Threats	Goal
WETLANDS AND OTHER WATER DEPENDENT SYSTEMS	7) Rivers, Creeks and Associated Floodplains on open plains	Mesquite and Parkinsonia - WONS Weeds	By 2025 reduce and maintain densities of Parkinsonia to <1% in the Fortescue Catchment and undertake 30,000 ha/year of Parkinsonia and Mesquite surveillance and control in other key assets

Strategy 1b) Identify priority assets and high risk areas for weed infestations (Need to know using a modelling exercise where the highest asset values are)	High Effectiveness

Key Actions

- See strategy as mentioned above.

Strategy 59) Reduce and maintain densities of Parkinsonia to <1% from the Fortescue Marsh	High Effectiveness

Key Actions

- Source funding for the long term - 10 years
- Plan at scale for the entire region
- Integrate into existing WONS programs
- Incorporate existing mapping
- Co-ordinate control efforts
- Undertake training (preferably on site) and registration of contractors (important for all weed programs) and FIFO workers, and in the long term, locals
- Indigenous rangers used for control programs
- Use correct control methods
- Monitoring data, controlled and where it is not standardise this
- Natural regeneration possibly sufficient but active revegetation/rehabilitation may need be required - especially mechanical
- Natural regeneration - need to control with minimal impact

Strategy 60) Undertake 30,000 ha/year of Parkinsonia and Mesquite surveillance and control in other key assets	High Effectiveness

Key Actions

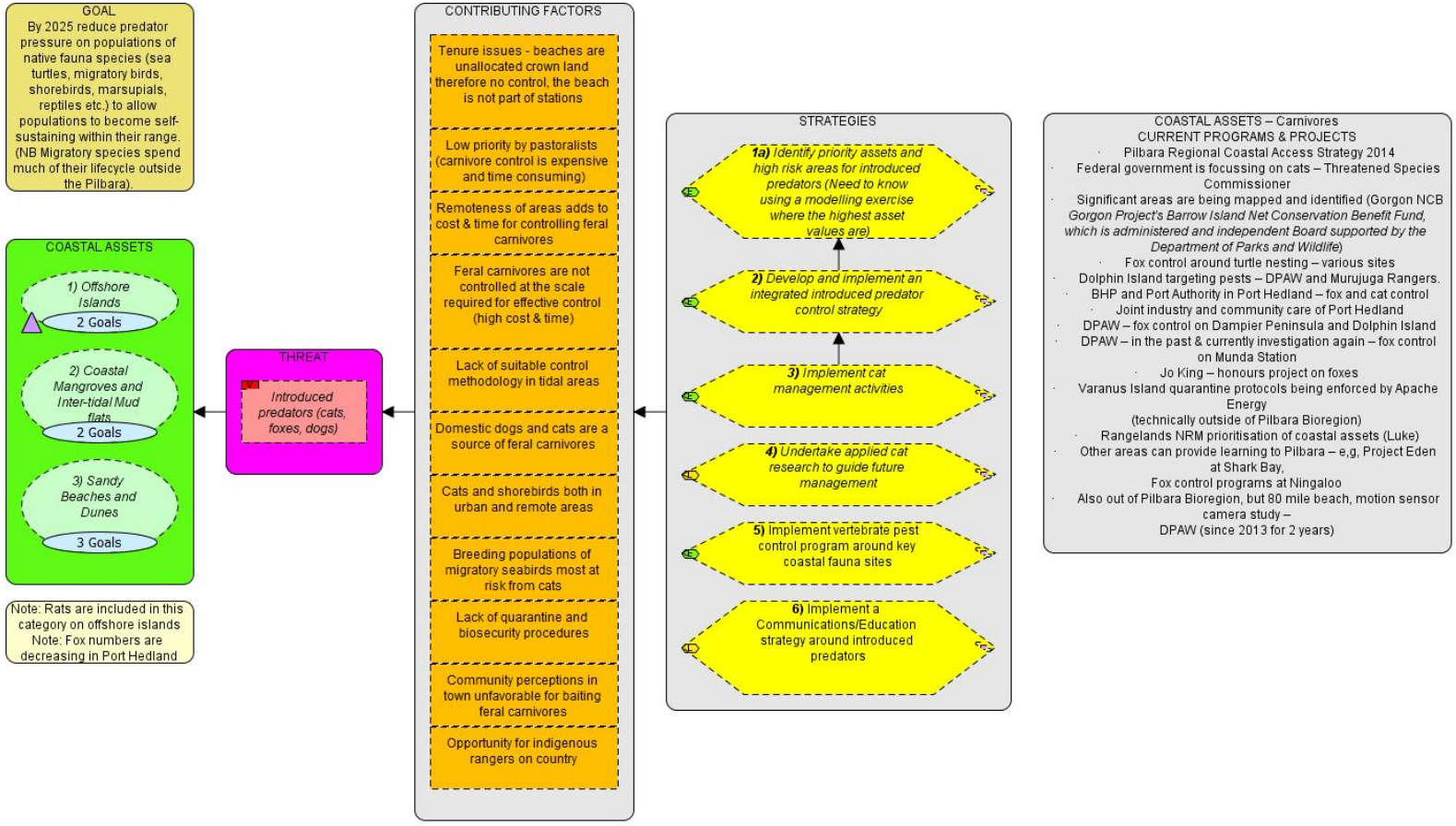
- Under take costing exercises per species (or growth form), and per density class, before any predictions can be made in terms of funding (both short and long term), as well as for influencing priorities and the need for long term control efforts.
- Source funding for the long term - 10 years
- Plan at scale for the entire region
- Undertake a pilot on Parkinsonia - costing/density audit based on works to date (FMG offsets) that can be used for inform other workIntegrate into existing WONS programs

- Incorporate existing mapping
- Co-ordinate control efforts
- Undertake training (preferably on site) and registration of contractors (important for all weed programs) and FIFO workers, and in the long term, locals
- Indigenous rangers used for control programs
- Use correct control methods
- Monitoring data, controlled and where it is not standardise this
- Natural regeneration possibly sufficient but active revegetation/rehabilitation may need be required - especially mechanical
- Natural regeneration - need to control with minimal impact
- Support biological control processes, release, approvals
- Contractors and others to mark occurrences of outliers (GPS referenced and added to Pilbara Mesquite Management Committee data base) as a matter of normal business practice
- Expand to other sub-regions - Roebourne and Hamersley to include current program (end 2016) - this will be point data, not density per areas (<$400K)

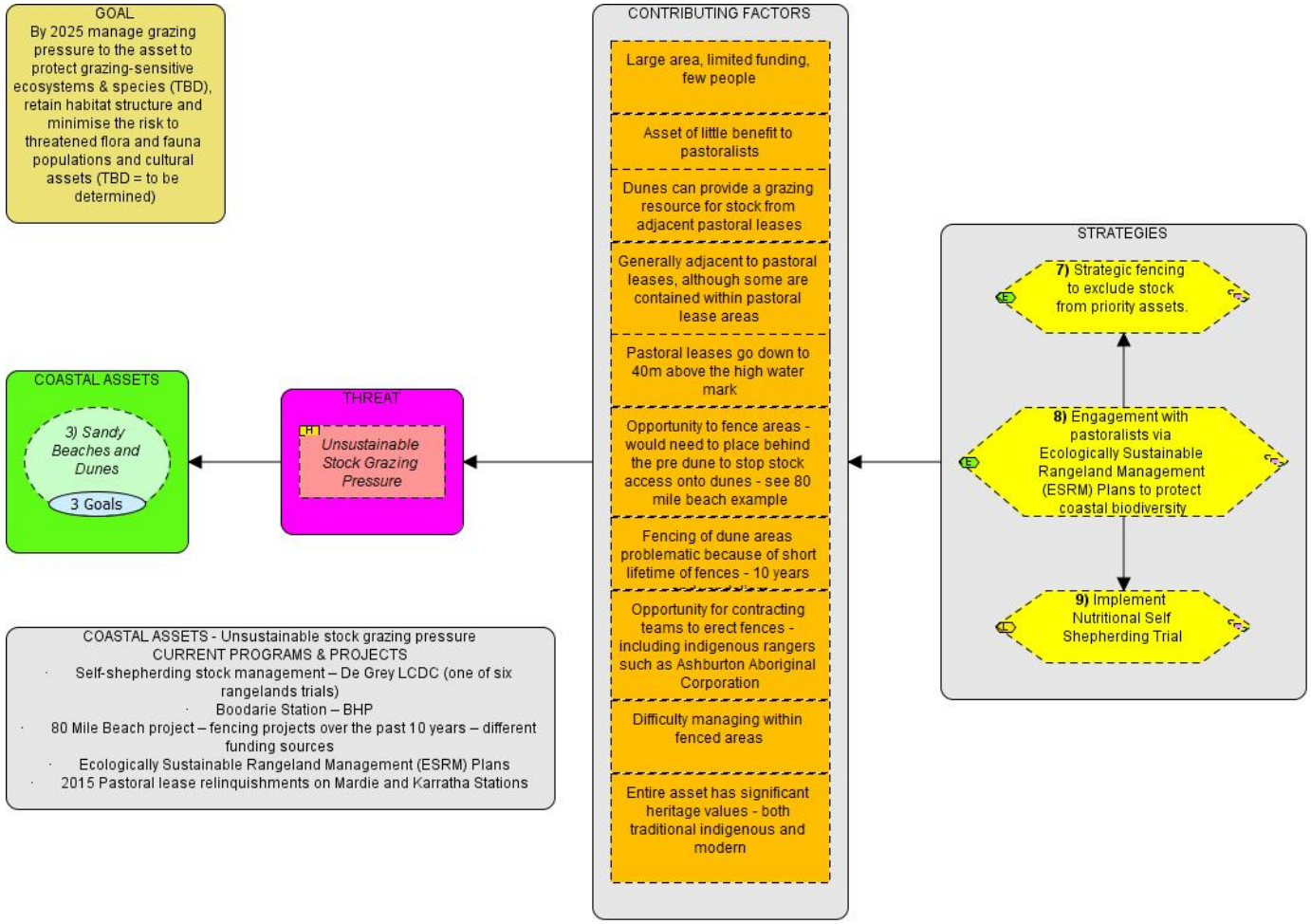
APPENDIX 3 Situation Analysis (Conceptual Model) Diagrams

The following 18 Situation Analysis Diagrams (Conceptual Models) were developed from the third CAP workshop (strategy setting) and reflect the information for the 18 Goals and 60 Strategies presented in **Section 5**. Strategies in italics are common to more than one asset or asset grouping.

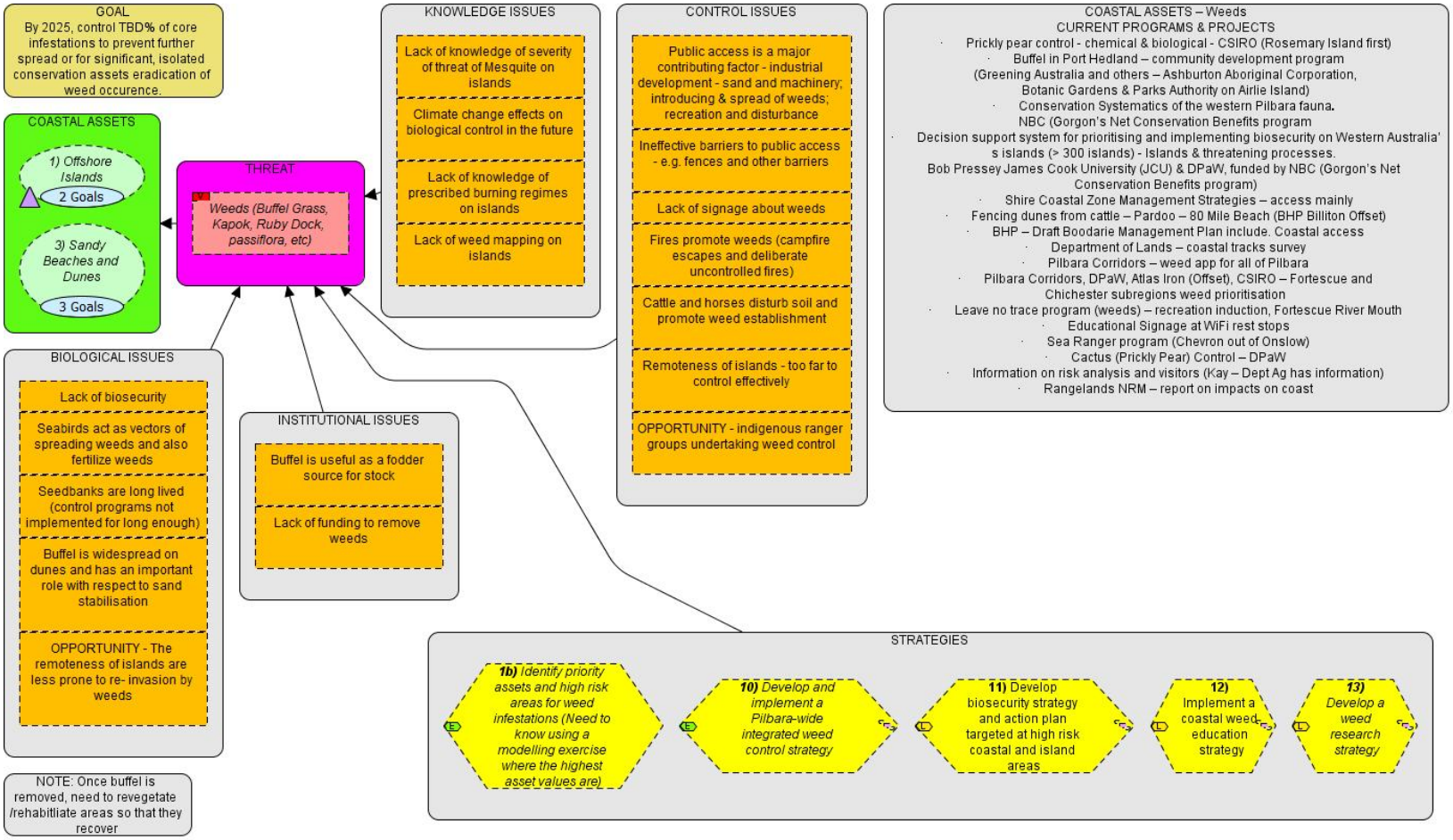
COASTAL ASSETS - Introduced predators



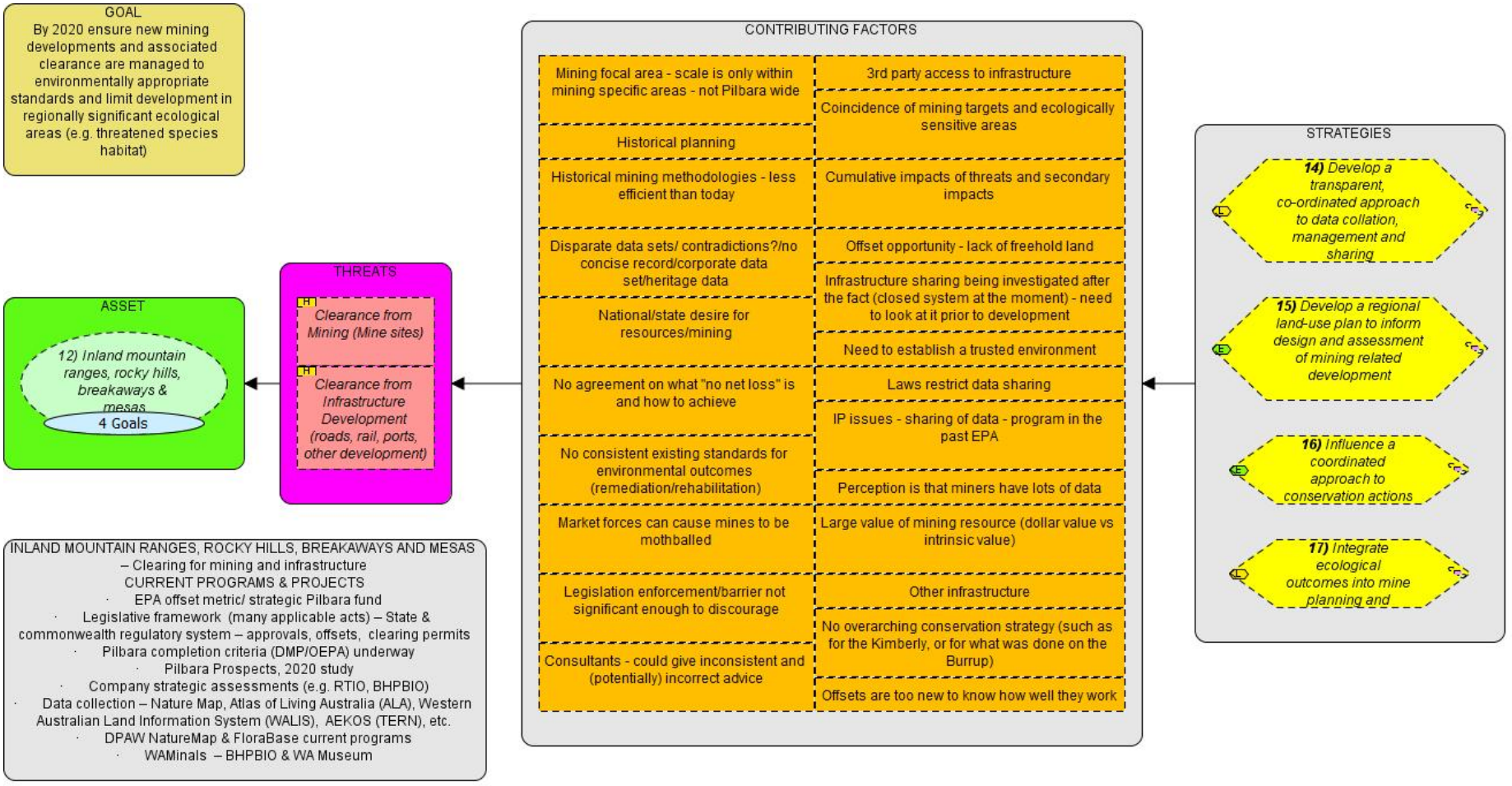
COASTAL ASSETS - Unsustainable stock grazing pressure



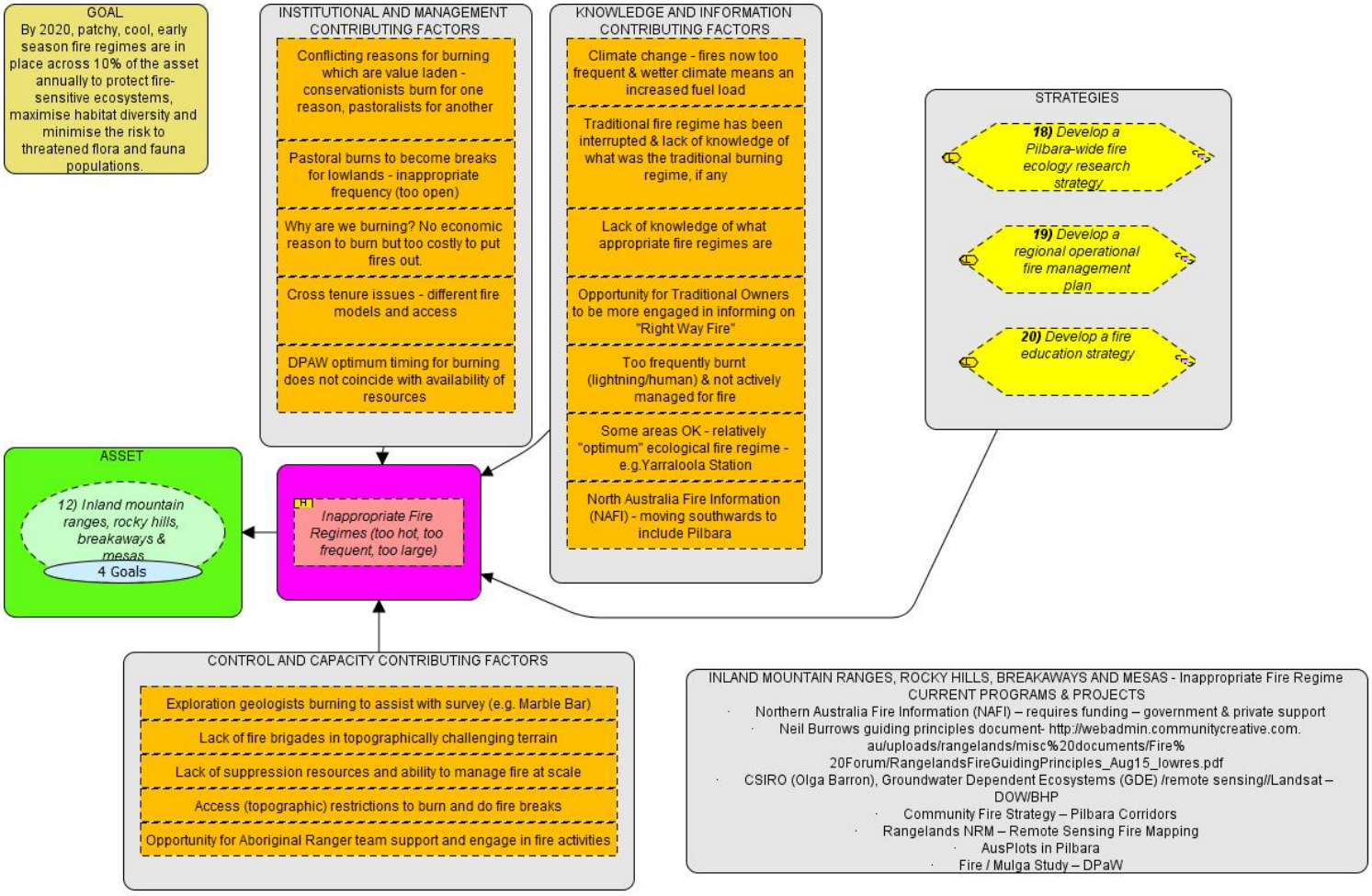
COASTAL ASSETS - Weeds



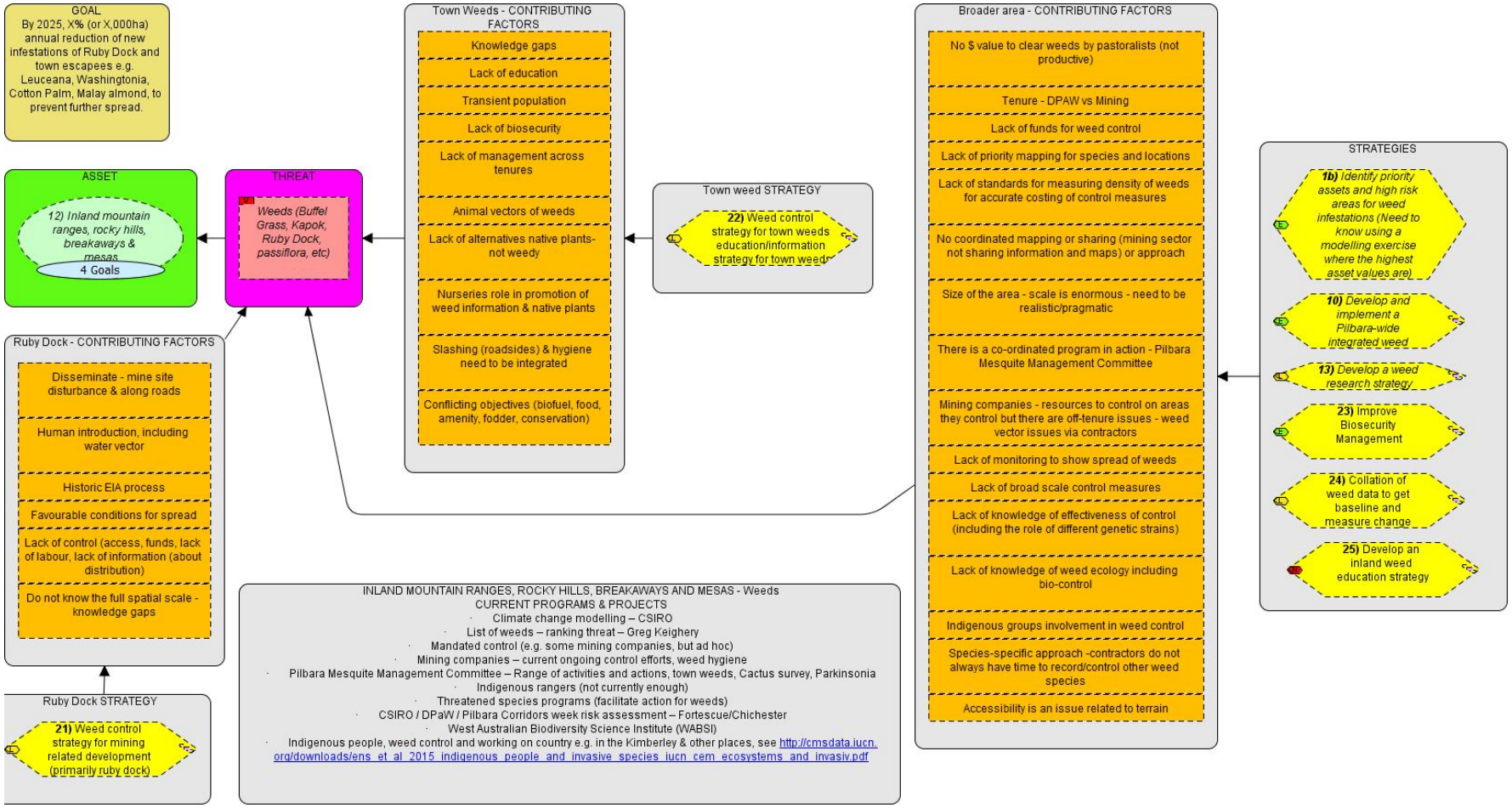
INLAND MOUNTAIN RANGES, ROCKY HILLS, BREAKAWAYS AND MESAS - Clearance from mining and infrastructure development



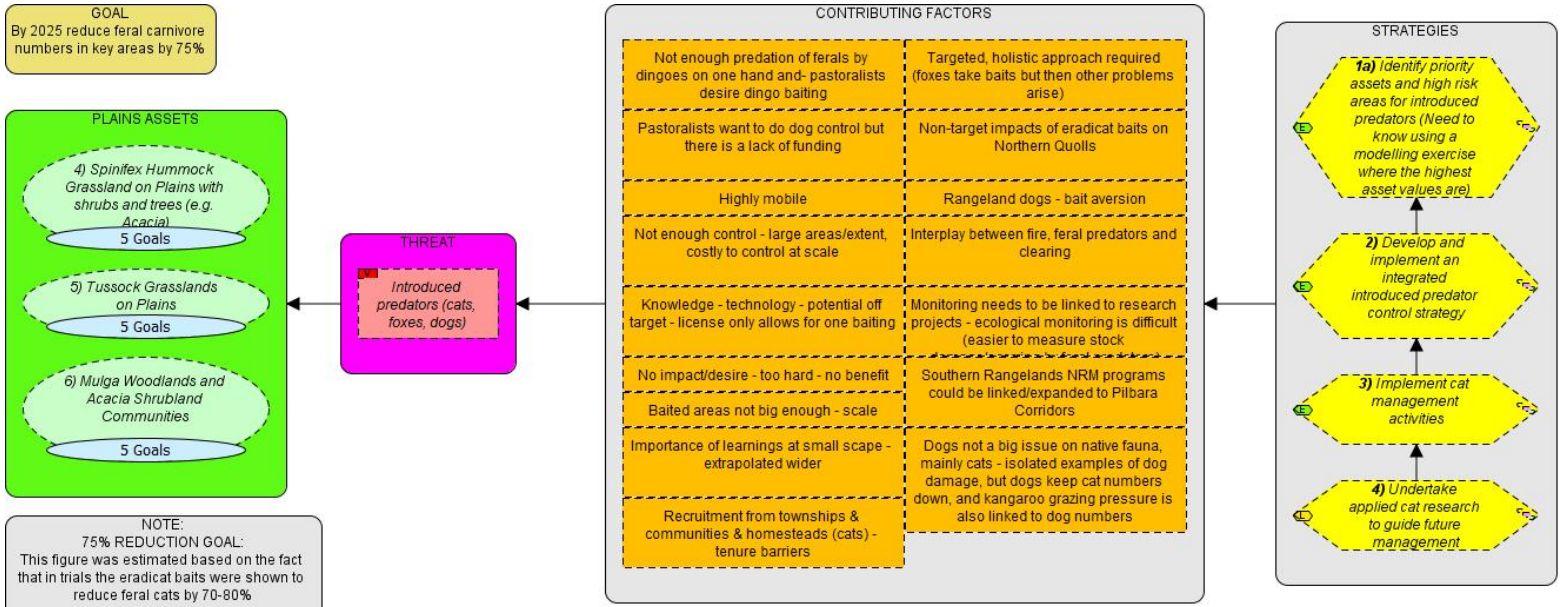
INLAND MOUNTAIN RANGES, ROCKY HILLS, BREAKAWAYS AND MESAS - Inappropriate Fire Regime



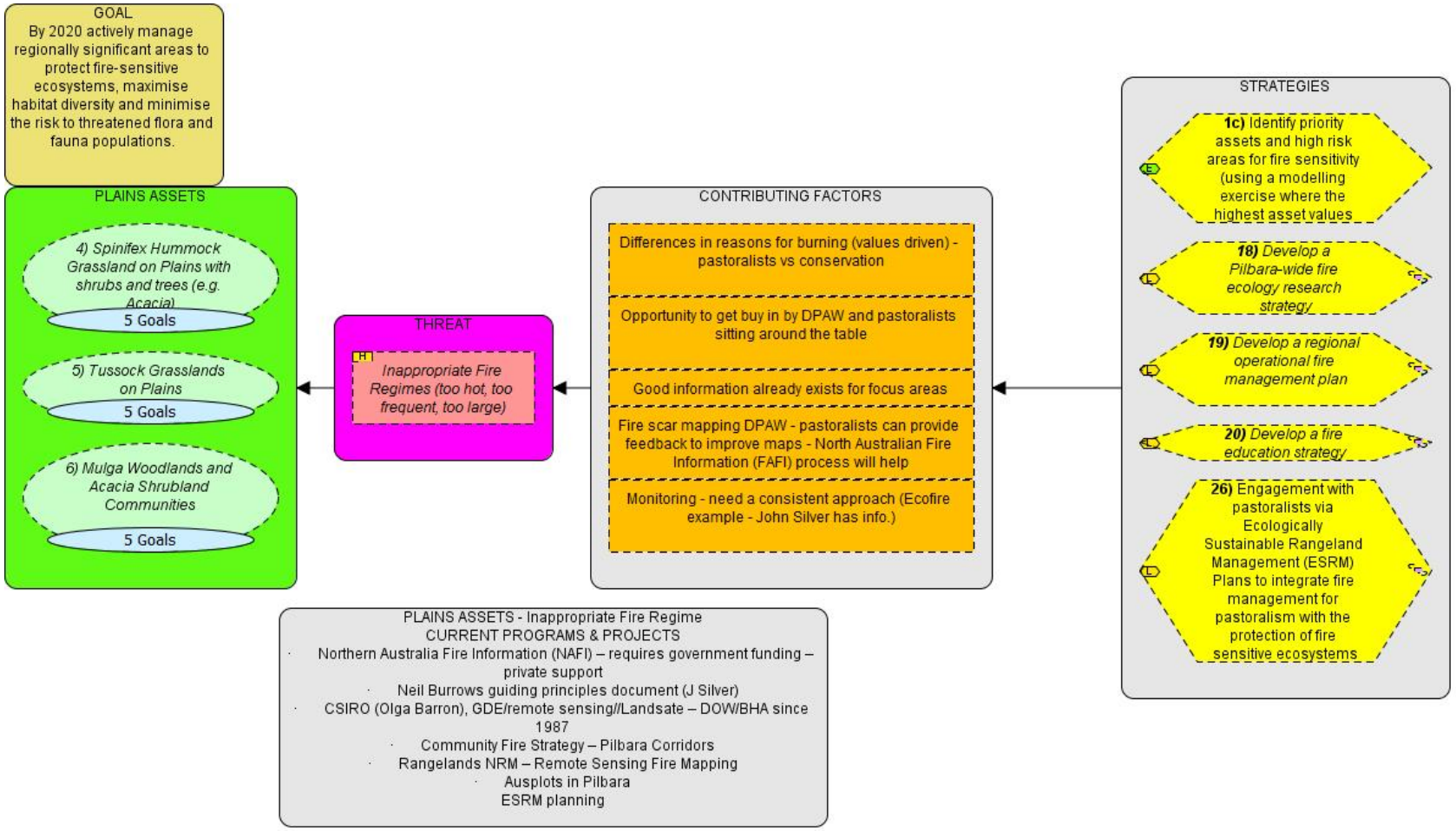
INLAND MOUNTAIN RANGES, ROCKY HILLS, BREAKAWAYS AND MESAS - Weeds



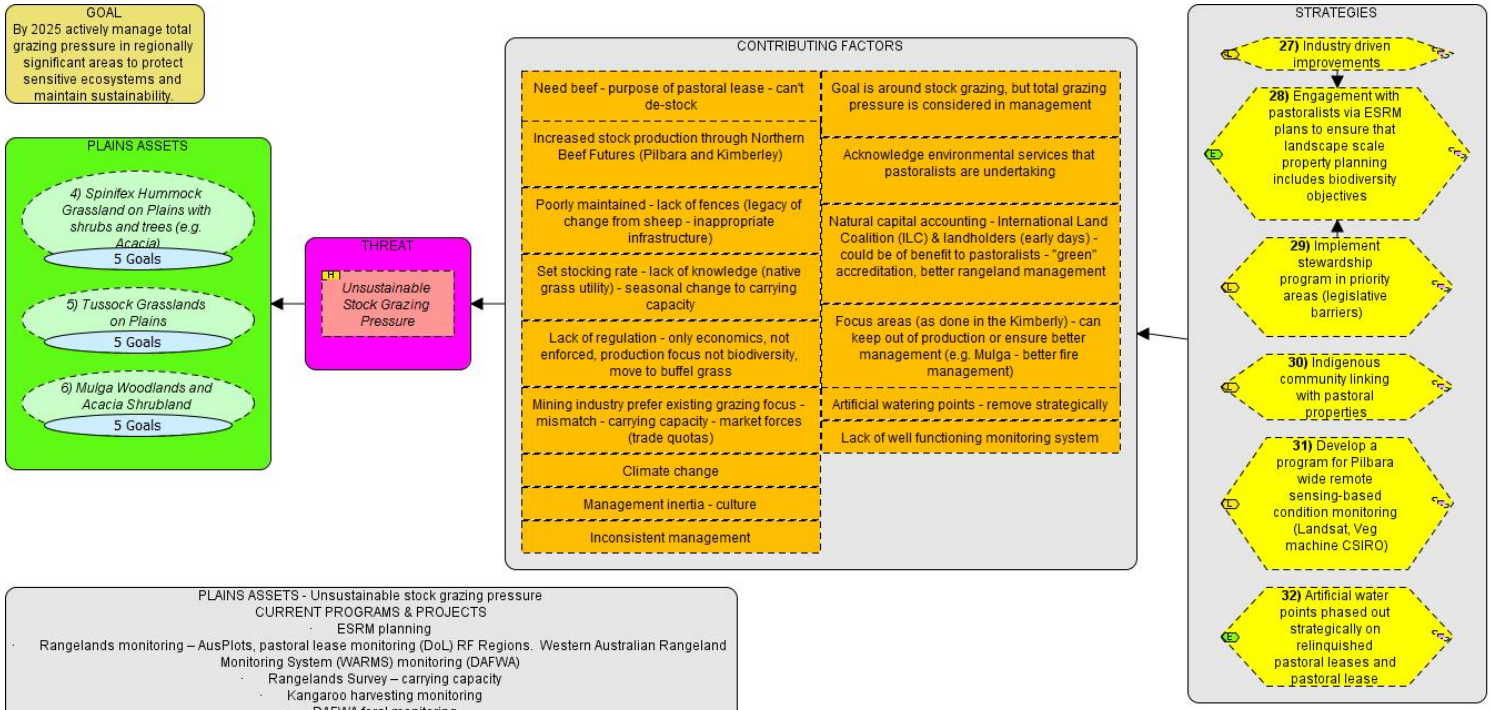
PLAINS ASSETS - Introduced predators



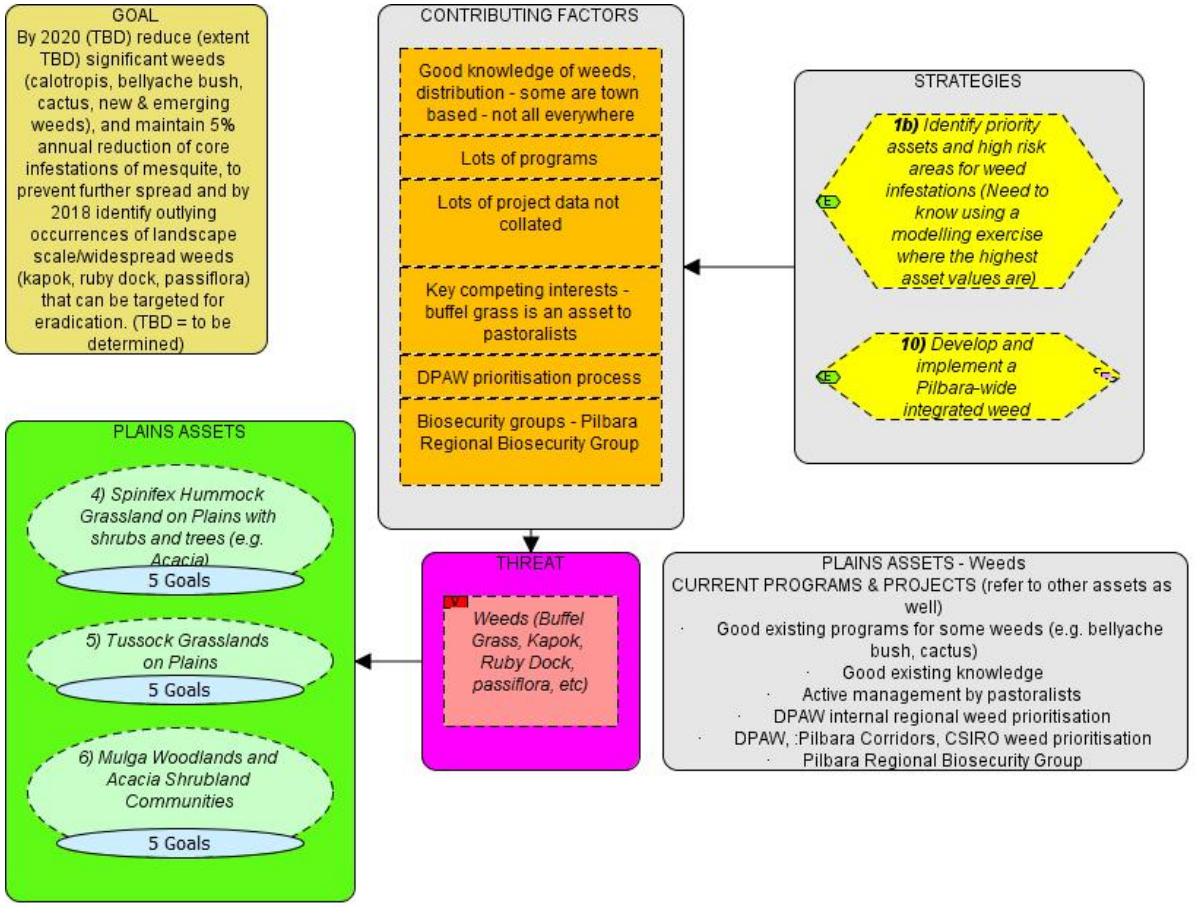
PLAINS ASSETS - Inappropriate fire regimes



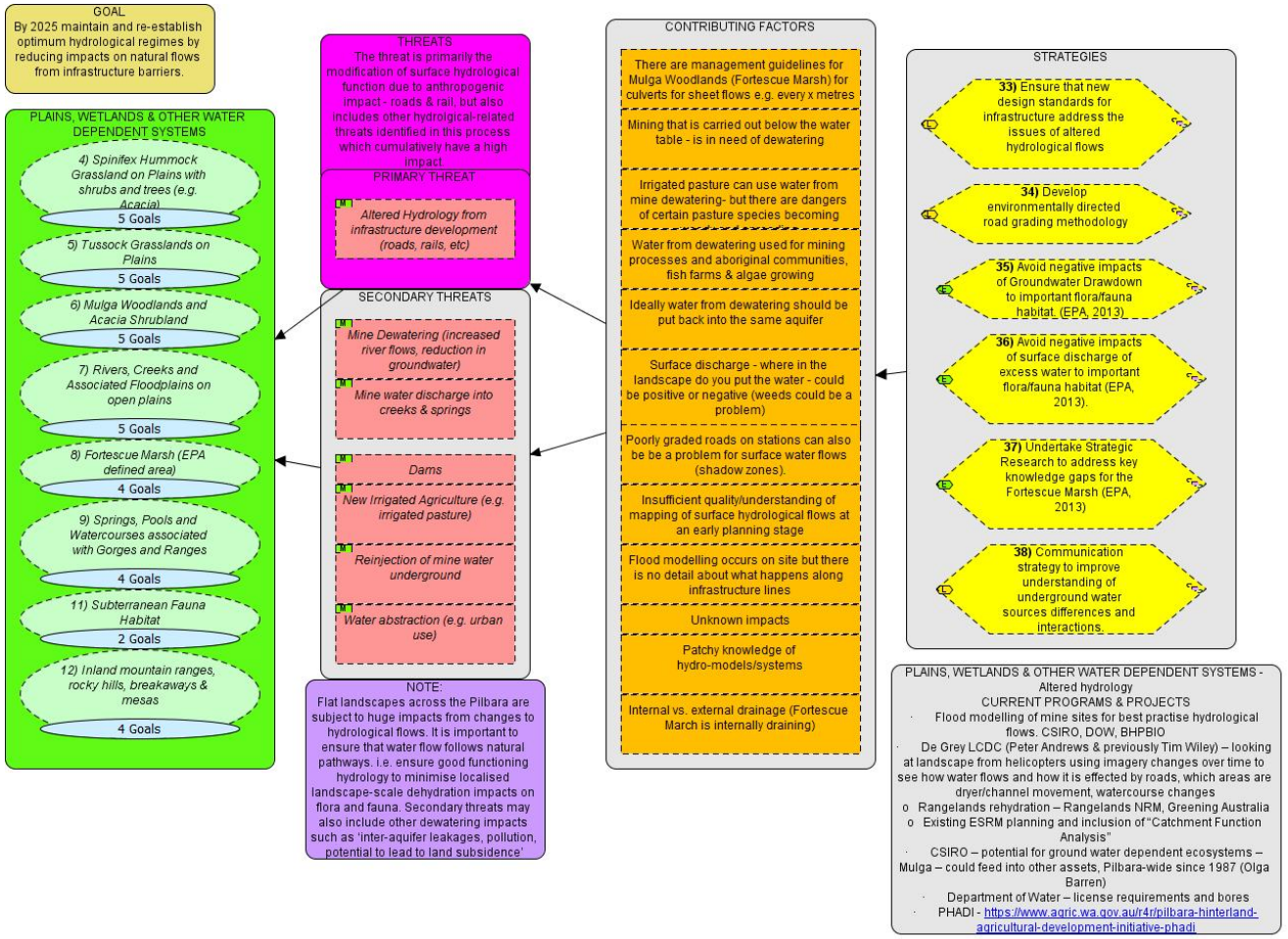
PLAINS ASSETS - Unsustainable stock grazing pressure



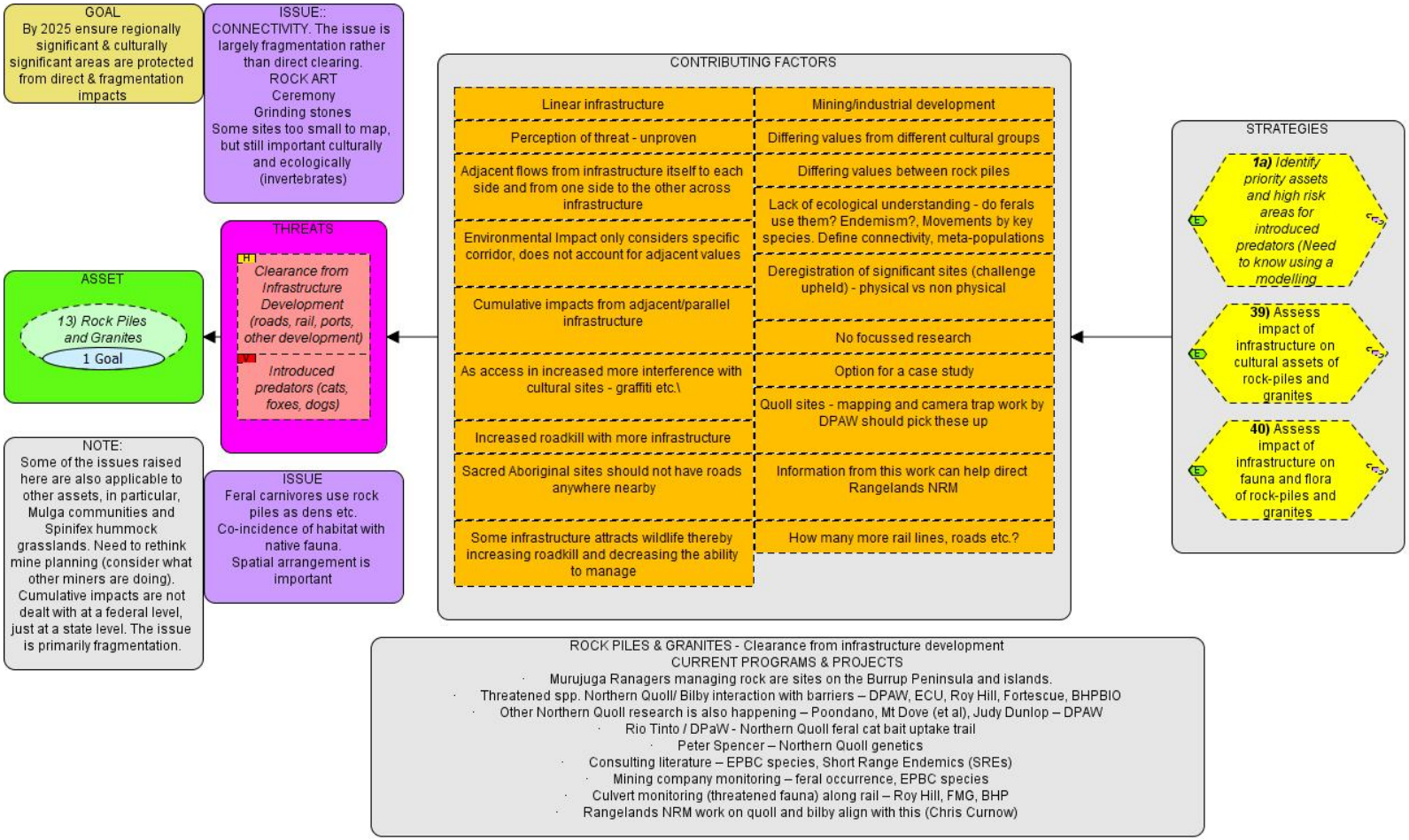
PLAINS ASSETS - Weeds



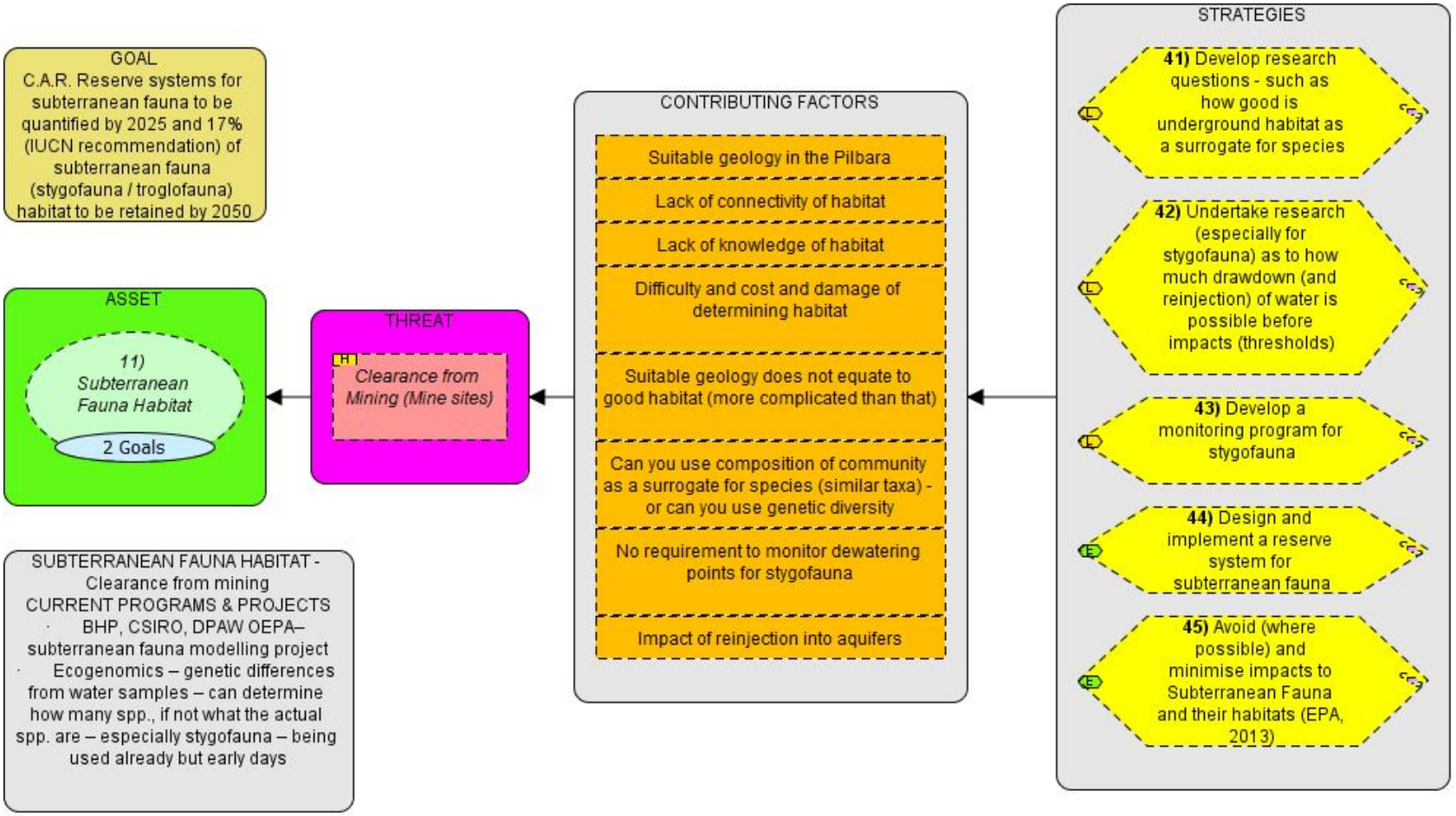
PLAINS, WETLANDS and OTHER WATER DEPENDENT SYSTEMS - Altered hydrology



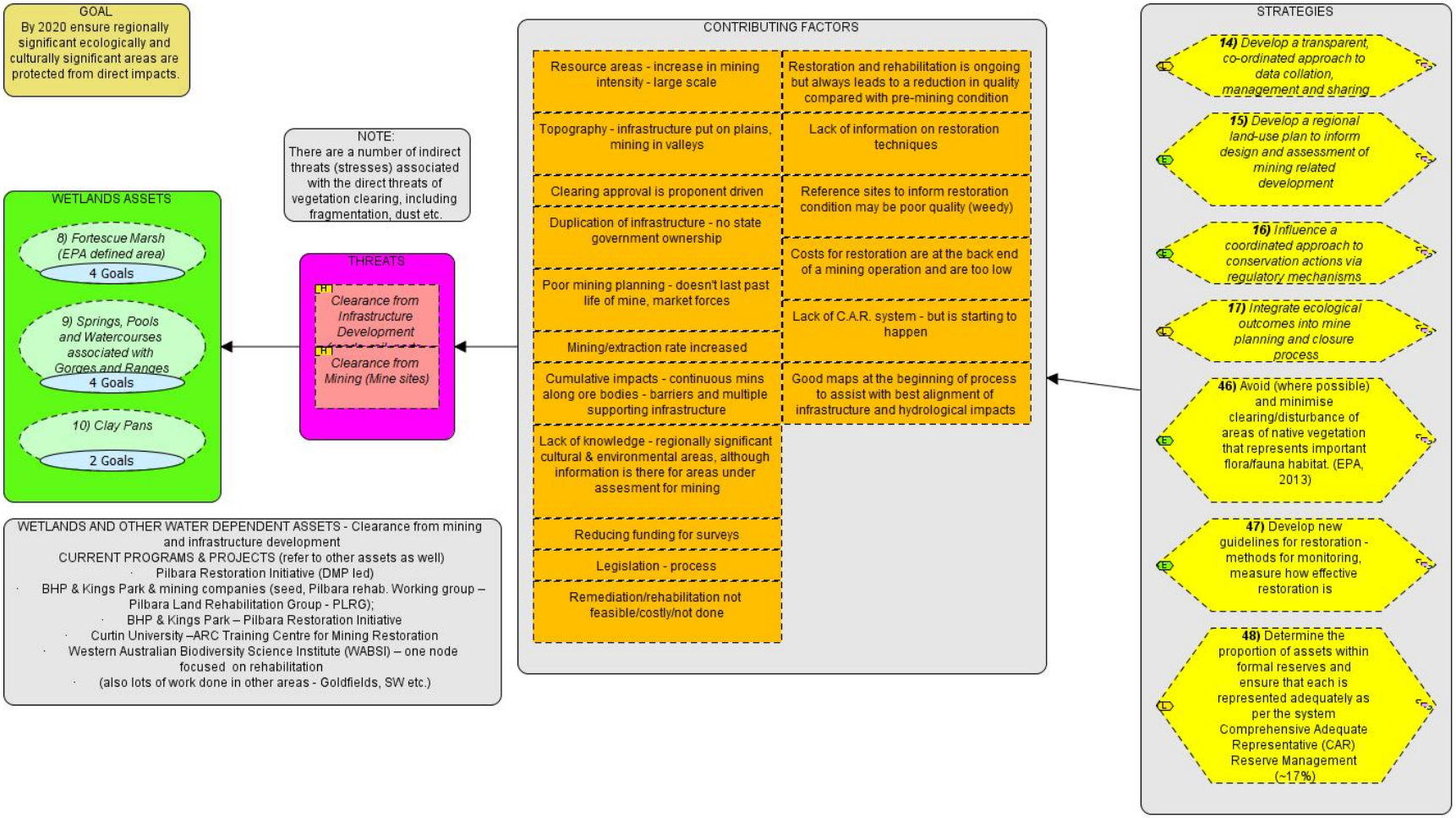
ROCK PILES and GRANITES - Clearance from infrastructure development



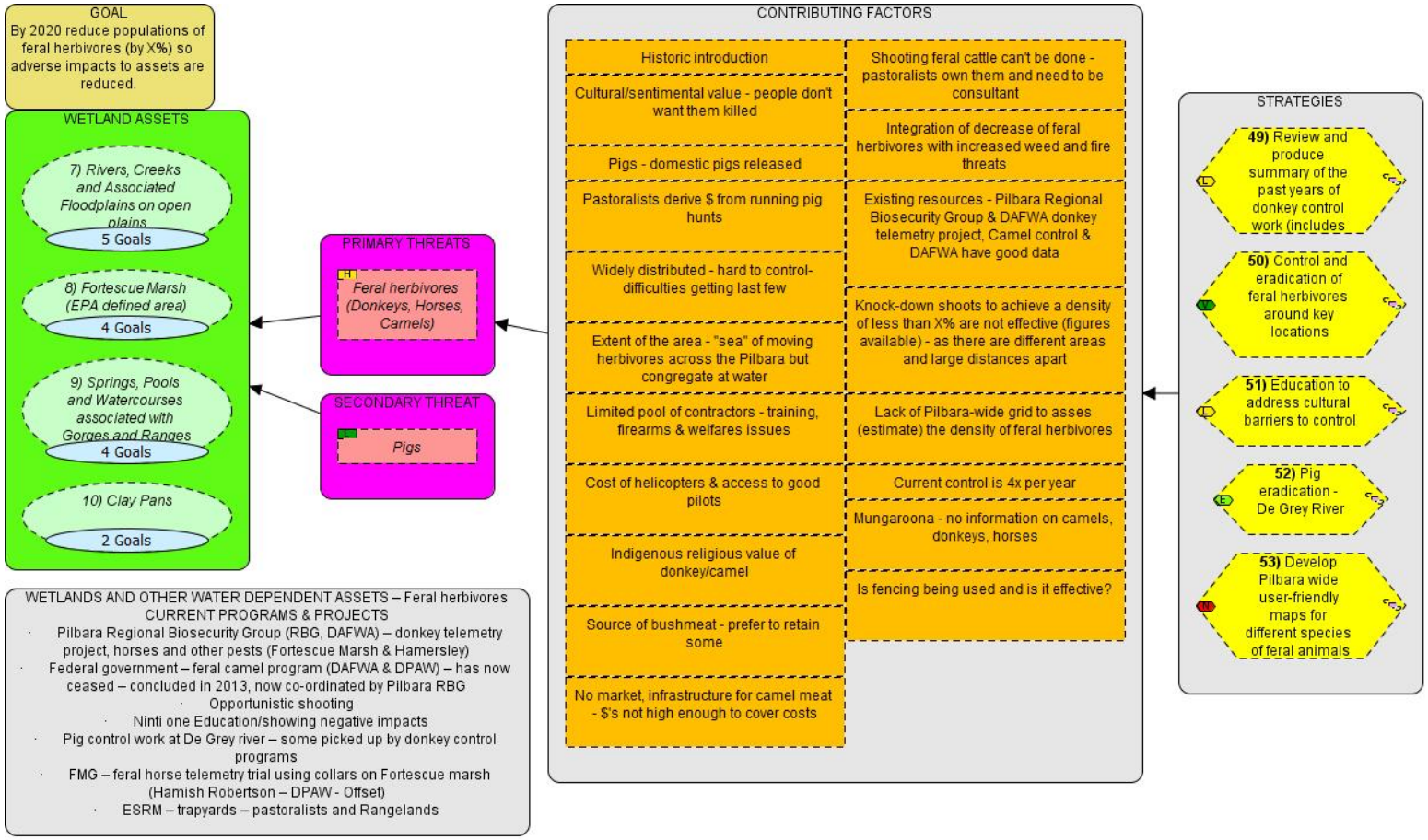
SUBTERRANEAN FAUNA HABITAT - Clearance from mining



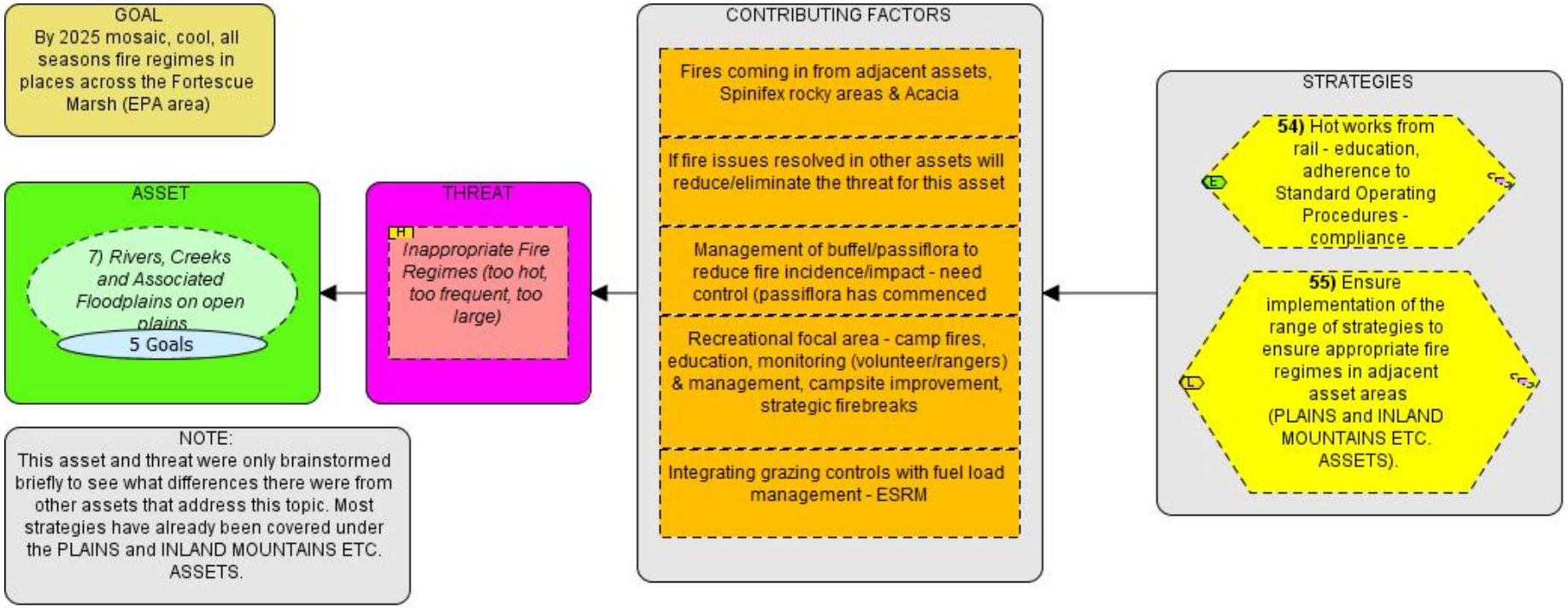
WETLANDS AND OTHER WATER DEPENDENT SYSTEMS - Clearance from mining and infrastructure development



WETLANDS AND OTHER WATER DEPENDENT SYSTEMS - Feral herbivores



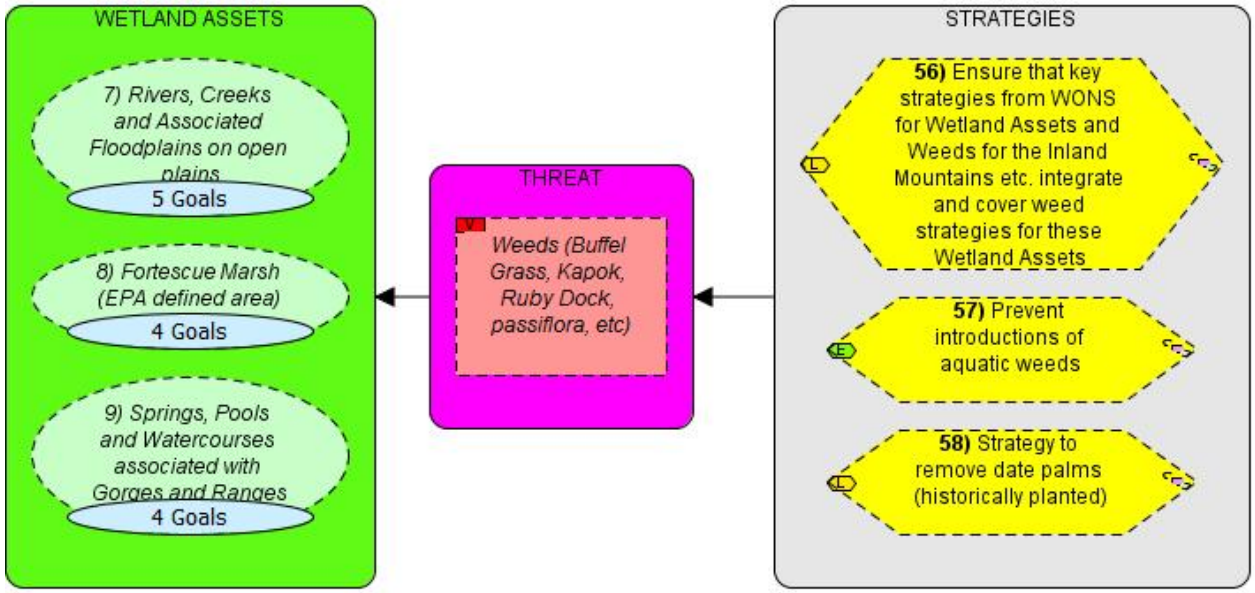
WETLANDS AND OTHER WATER DEPENDENT SYSTEMS - Inappropriate fire regime



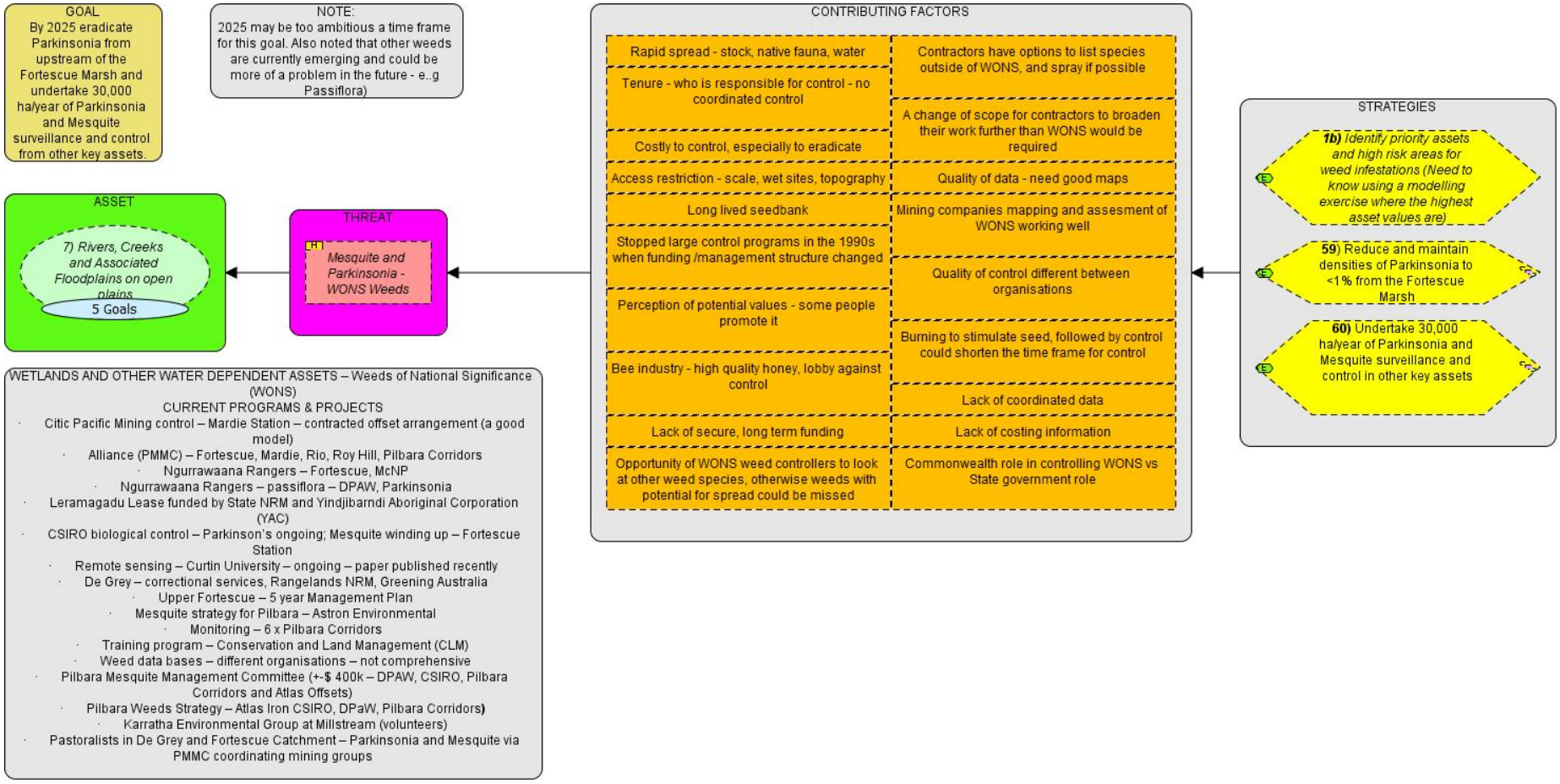
WETLANDS AND OTHER WATER DEPENDENT SYSTEMS - Weeds

GOAL
By 2025 there are no new incursions of weeds (priority weeds) and the impact, distribution and density of weeds is reduced (by x amount) in key asset locations.

NOTE:
These assets and threat were only brainstormed briefly to see what differences there were from other assets that address this topic. Most strategies have already been covered under the Weeds of National Significance (WONS) conceptual model for WETLAND ASSETS, as well as for Weeds examined for the PLAINS and INLAND MOUNTAINS ETC. ASSETS.



WETLANDS AND OTHER WATER DEPENDENT SYSTEMS - Weeds of National Significance (WONS)



APPENDIX 4: Pilbara Assets from INFFER™ process (Rangelands NRM, 2013)

Asset number	Asset name	Description	Current condition	Community and Social values	Environmental values	Economic values	Threats	Other
Desktop 10	Rocklea Dome	Geological formation			Geological	Mining	Mining	
Desktop 11	Barramundi	Iconic fish species belonging to the perch family	Good	Fishing and recreation	Iconic fish species of north Western Australia	Fishing	Fishing and predators	
Desktop 18	Lowendal Islands Nature Reserve	Islands, nature reserve			Marine animals, flora and fauna	Mining (oil and gas)	Mining (oil and gas)	
Desktop 23	Barrow Island Group Nature Reserve	Islands, nature reserve			Rare and endemic flora and fauna species. Breeding, feeding, resting, refugia, aggregating area for marine animals and birds.	Mining (oil and gas)	Mining (oil and gas), feral animals	
Desktop 4	De Grey River	River		Fishing, recreational, tourism	Water source, supports flora and fauna	Fishing and tourism	Cattle, fishing, tourism, rubbish	
Desktop 5	Hamersley Range	Mountain range with many extensively eroded gorges	Good	Culturally significant, tourism and recreation	National Park, geological, water source, flora and fauna	Mining (iron ore), tourism	Mining (iron ore), tourism, rubbish, feral animals, cattle, fire	
Desktop 6	Burrup Peninsula	Unique rock formation and the most prolific collection of Aboriginal rock art in Australia	Good	Culturally very significant	Geological, flora and fauna	Mining, port, industrial, tourism	Erosion (natural), mining, industry, port, tourism	
Desktop 7	Millstream Chichester National Park	National park, gorges and rock pools	Good	Culturally significant, tourism and recreational	Geological, water source, flora and fauna	Tourism and recreational	Tourism, rubbish, feral animals	
Desktop 8	Fortescue Marsh - Floodplain	Floodplain			Significant invertebrate diversity, high degree of species endemism, provides a habitat and refuge for native flora and fauna	Pastoral and mining	Weeds, feral animals, pastoral activities and cattle, mining, altered fire regimes	
Desktop 9	Karijini National Park	National park, gorges and rock pools	Good	Culturally significant, tourism, recreation	National Park, geological, water source, flora and fauna	Mining (iron ore), tourism	Mining (iron ore), tourism, rubbish, feral animals, cattle, fire	
KA002	White sandy dunes (on soils dataset)	White sandy dunes with sparse vegetation	Varied - degraded to good	Camping, fishing trail bikes, 4WD. Often containing significant heritage sites (eg. middens, stone tools)	Unique habitat in Pilbara contains Lerista (skink) which is only found in that habitat; coastline protection/stability (essential for cyclonic event); supports priority grassland community	Mining (sand), tourism, natural erosion protection for Karratha community and pastoral area	Coastal development, feral animals, weeds, mining	White sandy dunes are a very restricted habitat type in the Pilbara. They form significant habitat islands for restricted range species.
KA003	Rock art - Burrup Peninsula	Indigenous Rock art	Very good	Culturally significant	NA (cultural values)	Some potential tourism	Industry, vandalism	
KA004	Pilbara offshore islands (excluding Barrow Island)	Islands	Generally good	Recreational use, high density of heritage sites	"Islands" for species which are under significant pressure on mainland. Also includes unique species and habitat. Important for shorebirds/seabirds	Tourism	Uncontrolled access, unmanaged tourism, feral animals, weeds, mining (Barrow Island), sea level rise	
KA005	Montebello Islands	Marine and conservation park. Island group, low lying, shallow coral reef, white dunes	Good	Recreational, tourism, fishing, diving, camping, charter vessels	Low lying islands; diverse range of habitats, flora and fauna; birds, turtles, bilbies, dugongs, whales, coral, fish	Resource industries (gas, oil, ports, commercial fishing, recreational fishing), tourism	Mining, pearl leases, tourism, fire, introduced pests, oil spill, pollution	Currently part of the Montebello and Barrow Islands Marine Parks. Historical - site of Atomic bomb testing.
KA006	Roebourne Plains	Native grasslands. Unique vegetation	Fair to good		Under represented/not represented in the Comprehensive and Adequate Reserve (CAR) system	pastoral production (grazing), carbon storage	Grazing (domestic and feral animals), fire, weeds, development (eg. Maitland Industrial Estate)	
KA008	Rock art - various locations, excluding Burrup Peninsula	Indigenous rock art on various geology	Excellent but trend is to decline	Very high value to indigenous people, tourist value, Australian heritage value	Spiritual values	Tourism, ecotourism	Tourism (increased visitation), vandalism, emissions from industry	
KA010	Ephemeral wetlands behind Nickol Bay remnant dune and Burrup Peninsula	Ephemeral Wetlands, wet after rains for up to four months	Nickol Bay Remnant Dune wetland - good but becoming degraded. Burrup wetland - pristine	Indigenous people collect nardoo from Nickol Bay Remnant Dune wetland (food source), 4wd racing track	Rarely found sedges and other species, Burrup wetland contains priority species		Human impacts (off road bikes, 4WDs), weeds	Nickol Bay Remnant Dune: behind remnant dune on Nickol Bay, in an unusual place for a wetland. Burrup: highly unusual location for a wetland.
KA011	Maitland River	Riparian zone	Good	Recreation, fishing	Ecological community	Pastoral production	Weeds, sand mining, unmanaged access	

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KA012	Pastoral land on Mardie and Yarraloola stations	Pastoral land under threat from the invasive weed Mesquite	Degraded to fair		Biodiversity	Pastoral production	Weeds (mesquite)	
KA013	West Mid Intercourse Island	Near shore rocky island, providing sheltered habitat at shoreline (mangroves)	Good	Very high density of heritage sites, limited visitation.	Endangered species, Mangrove habitat, unique habitat.		Port Development (Maitland Industrial Estate), feral animals, weeds, sea level rise	
KA014	Bungaroo valley aquifer	Aquifer dependent on cyclonic rainfall events to recharge	Excellent	Extremely high cultural values, including idividual sites within the valley. Used as a water source.	High water quality	To be used as a water source for the west Pilbara water supply	Mining, over-abstraction	
KA015	Meentheena	Ex-pastoral property	Good	Vietnam veterans camp. Cultural value Conservation, some grazing value	Biodiversity, unique/spectacular landforms	Some pastoral production in parts	Fire, unmanaged access and use, feral animals (camels)	Could become conservation reserve with 10 Management from indigenous, locals & Vietnam veterans
KA016	Cleaverville turtle nesting sites	Beach; Turtle nesting site	Fair to degraded	4WD, motorbikes, beach access	Nesting site for flat back and hawksbill turtles	Tourism	Community use, feral predators (foxes taking eggs)	
KA017	Deep Gorge	Typical and good example of Pilbara rocky gorge with ephemeral waterway	Good. Trend is to decline.	Very high density of Rock Art, Heritage sites	Pilbara rockpile vegetation communities. Endangered species (Pilbara Olive pyhton, Quoll, Pilbara Leaf-nose Bat)	Tourism (the unofficial Rock Art site)	Human impacts (unrestricted visitor access and damage/vandalism, litter), weeds, feral animals	
KA018	Pilbara leaf-nose bat at API cave	EPBC listed, WA listed, Pilbara endemic species, world class bat cave	Excellent	Nil but holy grail for bat lovers	10,000+ Pilbara Leaf-nose Bat in the population which is the largest known by significant factor, maternity roost	Significant mineral value	Mining	Potenial constraints to mining - significant offset and management commitments required
KA019	Skull Spring (upper Oakover, De Grey River)	Spring and pools in Casuarina forest in river bed	Fair	Camping site meeting of Nomads in 1947	River forest/pool habitat		Unmanaged visitation and use	
KA020	Caves Creek		Good	Cultural	High biodiversity	Pastoral production	Mining, grazing	
KA021	Fortescue Marsh - Entire	Saline/halophyte/samphire dominated flood plain with infrequent inundation	Excellent	Contains sites but area has cultural significance as a whole	Bird habitat, ground water recharge	Mineral deposits	Mining (activity and associated infrastructure, dewatering impacts, change in groundwater hydrology and to saline/fresh water interface)	
KA022	Coondewanna Flats Priority Ecological Community	Coolibah, Mulga woodland (dominated) with tussock grassland	Very good	Scar trees - presumably culutral value, hunting	Priority Ecological Community, disjunct outcrop, undescribed species	Water resource, for mining development, pastoral production	Grazing pressure, feral animals (horses, cats), mining (and infrastructure corridors), change to flooding regime and surface water/sheetwater	
KA023	Munjina Claypan	Mulga heavy clay soils, unrepresented vegetation commons, proposed CAR addition - 2015, Mitchell grass grasslands	Varies from fair to severely degraded	Traditional owner hunting grounds	Unique vegetation types, species with disjunct distributions and undescribed taxa	High grazing value - Juna Downs (since 1983)	Grazing (of grassland and understorey in Mulga woodland), fire, clearing, dewatering for mining activities, infrastructure corridors	Heavy clay soils are highly resilient
KA024	Sand dunes of Fortescue Valley	Priority Ecological Community - red sand dunes dominated by atypical vegetation communities for Pilbara. Unique/uncommon reptile assembleges	Varied - excellent to severely degraded	Traditional owner burial sites	Atypical vegetation, unique uncommon reptiles	High pastoral production value (due to Buffel grass), sand source for concrete during mine construction	Weeds (Buffel grass), grazing, mining (sand)	
KA025	Millstream wetland	Riparian ecosystem associated with millstream springs and pools on Fortescue River		Custodian/traditional, historical, current recreational/tourism	Endemic species refuge (invertebrates, plants), riparian system, listed as a subregionally significant wetland	Tourism, water supply for West Pilbara (industry, potable)	Dewatering/unsustainable use of water, fire, weeds and pest plants, feral and pest animals including unmanaged cattle	
KA026	Ethel Gorge	Stygobot/fauna community in aquifer	Unconfirmed		Species-rich with endemic stygofauna community		Mining (dewatering), recreation	Constraint to mining development
KA027	Blind Cave Eel	EPBC listed	Unknown		Probably indicative of high quality water		Mining (dewatering potable water)	Constraint to mining and supply to West Pilbara Water Supply
KA028	*Lepidium catapycnon*	Short lived perennial; opportunistic species ie. responds well to disturbance	Unknown		Intrinsic		Clearing, increased fire frequency	Several populations in Karijini National Park probably increased abundance with increased fire and physical disturbance from mineral exploration
KA029	Mulgara	Two species of small carnivorous marsupial. Crest-tailed Mulgara (*Dasycercus cristicauda)* is EPBC and	Unknown	Traditional ecological knowledge	Naturally vulnerable and threatened. Presence is indicative of a functioning ecosystem		Altered fire regimes, predators, localised clearing (fragmentation of populations)	Students at Murdoch University are studying the taxonomy. Many locations picked up

Asset number	Asset name	Description	Current condition	Community and Social values	Environmental values	Economic values	Threats	Other
		state listed (Threatened); Brush-tailed mulgara (*Dasycercus blythi*) is not listed.						through the species tracking program
KA030	Mulgalands proposed Conservation Park	Proposed multi-use conservation park	Excellent to degraded	Spectacular landscape, Traditional Owner significance	Mulga woodlands with numerous undescribed and restricted species. Intact ecosystem with little weeds. Ghostbats, dune python etc	Significant mining deposits	Fire, changed hydrological regimes (change in surface flow from infrastructure development), grazing	
KA031	Coral (inshore coastal strip Onslow to 80 Mile Beach)	Coral communities (supports both hard and soft coral species)	Degraded	Fishing, diving, food, cultural	Marine environment	Commercial fishing	Industry, global warming, cyclones (erosion, siltation, etc)	
KA032	Flatback Turtles - at Port Hedland	Threatened species	Unknown (population has been estimated but more data needed)	Cultural links to Traditional Owners, Community interest in population and community monitoring program	Endemic species, keystone species, only turtle restricted to Australian Continental Shelf	Tourism	Sea level rise, mining, harbour developments, boating activity, coastal lighting, beach degradation, feral animals (foxes and cats), overfishing, direct habitat destruction	Appendix A1 - Marine Turtle Management Plan - BHPBIO, Care for Hedland Community Monitoring Program
KA033	Carnarvon, Canning and Pilbara Basin Aquifer	Aquifer	Good	Water Supply, town, industry, pastoralism	Biodiversity (stygofauna)	Supports life and industry	Mining (dewatering), weeds, contamination/pollution	
KA034	Intertidal and supra tidal habitat (Dampier salina)	Salt ponds at Dampier	Good	Has important heritage sites	Shorebird habitat, both for feeding and roosting. Listed as important bird site.	Salt production	Feral animals, coastal development	Importance of habitat will become more critical as sea level rises and anchor roots/feeding stems become less viable
KA035	Fortescue River	Ephemeral river with areas of permanent water and springs	Good	Tourism, Heritage, Cultural, Recreation, Opthalmia Dam water supply, Millstreatm Water Supply	High biodiversity - plants and animals	Pastoralism, tourism, Opthalmia Dam, Millstream Water Supply	Overgrazing (domestic and feral animals), tourism and recreation, fire, mining dewatering, weeds	
KA036	Marine mangroves	Mangroves, inshore, estuarine	Fair	Recreational fishing, crabbing	Fish nursery area. Habitat for birds, turtles and crabs	Commercial fishing, recreational fishing (crabs, prawns, fish)	Industry, pollution, global warming (sea level rise, more intense storm events), increased human use	
KA039	Air quality - Port Hedland and Dampier	Clean air polluted by industry, particularly iron ore crushing and transport	Degraded	High	High		Fine particles of iron ore	
KA040	Fish resource (inshore coastal)	Fish targeted by recreational fishers: coral trout, blue blone, barramundi, mackerel, targeted species	Fair	Recreational, cultural, food	Part of marine environment	Associated fishing businesses, boat stores, fishing stores, 4WD	Overfishing (within 50 kms of major towns), industry, commercial fishing, pollution / oil spills	50 km radius around large population under extreme fishing pressure. Dept of Planning report about coastal access points still in draft form.
KA041	Pastoral rangeland on Mt Florence Station (watershed of the Hamersley Ranges)	Grazing Rangeland Mulga Community	Good		Biodiversity good mulga stands soft spinifex	Quality grazing buffel grass	Mining infrastructure, interrupted water flow, erosion, water deprivation	Unique to this location due to location of railway line
KA042	Natural structures that slow water within drainage channels	Physical or plant structures that slow and spread water out on to flood plains	Varied - good to degraded	These structures create pools/billabongs within river for fishing, swimming, serpent home	Cause flood-out, creating local floodplain/ riparian habitat	High for cattle feed on flood plains for cattle production	Large flood events, over grazing, fire	Many now not functional as they have been eroded or completely washed away
KA043	Steep slopes at top/edge of catchment	Steep country below breakaway that holds up/slows downrun off in cyclonic /flooding rains	Varied - good to degraded	Indirect in that it keeps rivers clean, healthy for fishers and swimming etc	Modest biodiversity but high value ecosystem function in keeps hydrological process/rivers healthy	Pastoral productivity	Fire, overgrazing (both result in slopes devoid of vegetation, leading to erosion gullies)	These areas are dispersed across properties /landscapes, but can be mapped and managed appropriately. Flood damage can result in lost grazing opportunities and therefore lost income until land recovers
KA045	Mountain top flora (uplands of the Hamersley Ranges)	Unique vegetation types, Numerous species of biological significance and refugia	Good	Tourism value	Refugia species richness, geological diversity	Limited - mining, tourism	Mining, infrastructure developments eg beacons, tado towers, inappropriate (more frequent) fire regimes	
KA046	Pilbara Sand Cays - between Onslow and	Sandy islands of varying sizes off Pilbara coast	Varied - good to degraded	Recreation - Fishing, camping	Turtle, raptor and sea bird nesting sites, vegetation that has evolved	Tourism (primarily local), potential base for resource industry	Weeds, feral animals (mice, foxes), fire, sea level rise,	Survey (by Vicki Long) of 28 islands between Onslow and

Asset number	Asset name	Description	Current condition	Community and Social values	Environmental values	Economic values	Threats	Other
	Dampier excluding Dampier Archipelago				different forms to mainland, big tide fluctuations, mangroves	(overlapping mining tenements for iron sand mining)	unmanaged tourism and recreation, small 4wd bikes (taken over by boat)	Dampier highlighted the need to protect at least some islands.
KA047	Rare Flora (Declared Rare Flora, Priority Flora, EPBC listed flora)	Species in various locations: 114 priority flora in various locations; two species listed under both EPBC and state; one species EPBC listed but not state listed	Varied				Fire, pest and feral animals, weeds, overgrazing / grazing pressure, climate change	Use PBS delta for modelling of potential habitat - due for completion in 2013
KA048	*Acacia leeuwiniana*	Priority/geographically restricted, fire sensitive, very attractive acacia	Good	Spear trees, high for Pilbara community and botanists	Priority listing intrinsic scientific interest - unusual group in Pilbara		inappropriate fire regimes, granite mining (ballast quarries (road/rails))	
KA049	Limestone islands	Tertiary limestone island, spinifex dominated , Unusual species, *Rattus tunneyi* - only represented on islands	Unknown (assumed good)	Recreation	*Rattus tunneyi* , unique geological composition for Pilbara	Barrier island - functional value in landscape there, economic value and potential mineral value	Resource development, mining, feedstock for iron ore smelting	
KA050	Wonna Land System	Cracking clay on top of Chichester's, Volcanic geolos - basalts, Species-rich grasslands of which three types are listed as Priority Ecological Communities	Varies from severely degraded (where grazing occurs) to excellent (Millstream Chichester National Park)	Historical - harvest of sorghum, landscape value/tourism, hunting value	Numerous undescribed species, disjunct or range end species, undescribed species	Pastoral production	Fragmentation (resulting from infrastructure development), increased weed risk (particularly Buffel grass), inappropriate fire regimes, grazing	
KA051	Fortescue River - Floodplain on Mt Florence Station	Grasslands flood plain, high value land system	Fair to good		High level of biodiversity, , vegetation	High value grazing land	Erosion, inappropriate grazing, fire, mining, weeds	
KA052	Western Turner River	Riparian environment	Unconfirmed	Recreation	Riparian ecosystem	Pastoral production	Weeds (Prickly pear)	
KA060	Themeda grasslands on Hamersley Station	Tussock grasses on cracking clays	Fair (seasonal)		TEC and unique community	High value grazing land, carbon	Fire, grazing, weeds	
KA062	Arid Zone mangroves	Mangrove species including Avicennia marina and Rhizophora stylosa. Shows zonation and habitat niches	Generally good	Important traditional food gathering area, and has associated with Middens and heritage sites	Massive ecological function, coastal protection, base of food webs. Threatened and endemic Species. Unique habitat in Australia and world	Fishing, juvenile breeding ground	Coastal development	EPA has a guidance settlement for arid zone mangroves. In the Pilbara, mangroves form many of the ecological niches there woodlands play for bush birds in other areas
KA063	Titchella/Condon Beaches and Estuaries	Beach, coastal areas, estuary and fish stocks	Varied - good to degraded	Well known and used and highly valued by Port Hedland residents. Fishing/recreation	Mangroves, estuary, habitat for fish. Migratory birds, "Salt bush" coastal grass	Pastoral production	Human use impacts (unmanaged access and use, rubbish), fire, siltation due to erosion upstream	
KA064	Sea grasses - inshore coastal strip	Marine seagrass	Unknown	Recreational fishing, dugong hunting, cultural	Nursery areas for prawns/crabs, food for turtles/dugongs, healthy environment	Commercial and recreational fishing	Industry, pollution, dredging	
KA065	Grazing Rangelands	Approximately 50 pastoral leases grazing livestock	Variable good - degraded	High. Historical bases for the development in the Pilbara. Good stewardship in managing land	Representative of majority of Pilbara land systems/communities	Food production contributes to state economy, carbon	Mining, conservation estates, urban spread vs production, under recognised value of food production, feral animals, weeds, fires	
KA069	Dampier Archipelago	Inshore coastal islands, marine environment, cultural , fish resources	Fair	Recreational, camping, fishing, cultural	Coral communities, endemic species, biodiversity of coral	Industry, tourism	Industry, introduced species and invasive marine pests, fire, global warming	
KA070	Karrawine Gorge (Oakover river)	Gorge with large freshwater pool	Fair to good	Tourist camping spot, Fishing and swimming for locals, Indigenous culture	Wetlands, fish habitat, visually stunning, fossil stromatolites	Stock water, tourism	Flood damage, unmanaged human use	Currently easy access but no facilities or people management.
T001	Springs on Cheela Plains	Ecological hub as water drives biological productivity (fish, birds, etc)	Very good			Pastoral production (springs feed surface rivers for stockwater downstream)	Degradation of upstream watershed, overuse by feral animals and stock and community, mine dewatering upstream	
T002	Weeli Wolli Spring	Permanent spring fed pool	Good	Significant heritage site/story site, Recreation area	Biodiversity, Threatened Ecological Community, water source		Mining (dewatering, under threat from existing and future mining)	Heavily modified since 2006 from mine water discharge
T003	Isolated landforms eg. Mount Robinson, The Governor	Changing topography throughout region	Excellent	Aesthetics, tourism - landscape	General ecosystem component eg surface water flow/watershed. Specific ecosystem - habitat for rare endangered species (known or unknown)	Tourism, potential mining	Mining (levelling of regional breakaway of hills)	

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T004	George River - estuary/river mouth	Breeding grounds - Barramundi estuary and fish stocks	Good to fair	Regularly used by Port Hedland and Karratha locals for fishing / recreation	Breeding grounds, mangroves, estuary, migrating birds	Tourism, commercial fishing (Barramundi breeding grounds)	Fire (inland of George River (no control of burn-offs, too-frequent fires)), pollution (cargo ships, rubbish), over fishing, unmanaged use	River systems get damaged upstream from inappropriate fire regimes
T005	Catchment areas eg. Turner syncline (Rocklea Dome)	Connected ranges and hills and upslopes that feed through valleys to rivers and plains	Fair to good	4 wheel driving, camping, prospecting, cultural	Ecological framework that is fundamental to whole system functioning - headwaters	Minesites, onsite pastoral value is low but off site, downstream value to pastoral productivity is high.	Mining, human use impacts (overuse - recreational, pastoral, access), too frequent fire	
T006	Beasley River	Tributary river Hardey to Ashburton rivers	Fair (includes banks and river bed)	Recreation, prospecting, cultural	Tree species in river zone together with shrub and ground cover. River flows to lower catchment, floodplains and ocean.	Stock water	Overgrazing/use, over extraction of water, adding excessive water by mines, dams, altered flow and hydrology	Catches fertility and makes available for productive use.
T007	Native perennial grasses/grasslands	Variety of species	Degraded (generally)	Recreation - aesthetics and comfort, cultural, tourism	Habitat for many lifeforms - all components other than moisture	Grazing - highest productivity of all self-perpetuating vegetation types when in good condition. Fertile and resilient. Direct benefit is to pastoralists.	Overgrazing (stock_, fire (particularly the overuse of fire / increased fire frequency), mining, weeds , feral and native herbivores (numbers increase due to access to water)	Higher proportion of grasslands in degraded condition than other vegetation communities in the Pilbara but their condition in the Pilbara better than it is other subregions. Refer CSIRO report (via Bill Cotching)
T008	Minor inland rivers	Tributaries and inland river systems	Fair	Fishing and recreation	water, riparian vegetation, associated floodplains, drainage function, catch sediment and slow water flows when in good condition	Stock watering, some mining	Overgrazing (leading to erosion), overuse by mining (over extraction or over disposal, interruptions to flow)	
T011	Upper Yule River Catchment	Catchment with high cultural, biodiversity	Fair	High indigenous cultural value LAW ground	Bilby, mulgara, 50+ species of reptiles.	pastoral production, mine infrastructure, gold Rail lines x4	Mine infrastructure, large feral animals, uncontrolled access, prospectors, fire (late hot fires)	
T020	Mount Meharry	Highest Peak in WA	Good	Highest landform, recreation, amenity	isolated peak, supports short range endemic species	Limited tourism	Nil	
T021	Karijini Gorges	Deep incised gorges and pools within Karijini National Park	Good (protected)	Recreation, heritage	Preservation of landscapes and ecosystems	High visitation tourism site	Insufficient management of land, feral animals, fire	
T022	Fortescue Marsh - Floodplain on Marillana station	Floodplain for Fortescue Marsh, a wetland identified in 'A Directory of Important Wetlands in Australia'	Very good	Cultural significance of Fortescue Marsh itself	Wetland ecosystem risk, migratory listed bird species, buffer for wetland	Pastoral productivity, mineral exploration and extraction	Groundwater abstraction especially from multiple mining operations (affects water levels and quality, surface water flow interruption (rail, roads))	Draft, Fortescue Marsh Guidelines for mining (EPA policy document)
T023	Springs and semi-permanent waterholes between Karijini and Newman	Spring fed or deep pools, typically in upper creek systems, which provide water resources within the landscape.	Varied	Some recreational use. Some with heritage value	Refuge, water source habitat for key species	Water source for livestock	Livestock, unmanaged human use (including impacts from increased visitation)	Condition: Most are grazed and subject to stock or feral degradation but generally still maintain biodiversity values.
T024	Riparian corridors between Karijini and Newman	Riparian corridors	Varied		Linkage for fauna movement and dispersal	Important for livestock water source	Livestock, mining (in certain areas)	Key aspect in maintaining biodiversity dispersion pathways through the landscape. Fauna movement often concentrated around three corridors where vegetation is typically more dense and offers greater level of protection.
T025	Fortescue freshwater claypans downstream of the Marsh	Clay pans which are periodically inundated with flows from Fortescue River	Degraded		Extension of biodiversity values of Fortescue Marsh - distinctly different habitat	Highly productive pastoral land	Linear infrastructure (rail, road), grazing (stock and feral animals)	
T026	Weeli Wolli pools - example of pastoral lease reform	Groundwater fed spring - permanent flow	Spring itself in very good condition, creek has been heavily modified	Aboriginal heritage significance, Recreational significance of Weeli Wolli Creek, especially since more watering discharge	TEC (biodiversity), source of permanent surface water flow	Used for discharge point by mining companies	Mine waterway, human use impacts (increased visitation, rubbish, water pollution from lack of toilet facilities, etc)	Pastoral land Reform 2015
T027	Running Waters pool and spring	Spring fed or deep pool in Casuarina forest	Good to fair	Very popular camping, fishing spot for locals. Indigenous site	Small wetlands with pool	Limited grazing value	Human impacts (access, rubbish, etc)	
T028	Bush tucker and medicine plants	Native plants traditionally used for food and medicine	Fair	Very high value for indigenous people for cultural reasons. Also sometimes important for food.	Biodiversity values	Potentially very high importance for medicine	Grazing, hot fires, over exploitation	Populations have been reduced in some areas due to overuse

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T029	Cane River	River System	Riparian zone degraded in places	Contains LAW ground on river bank and other heritage values. Location of live-in training centre for indigenous people	Native fish population with no exotic species, unique swamp plant community. Recharge of Onslow water bores.	Pastoral grazing, town water supply, irrigation potential	Continued erosion in catchment, over burning, inappropriate grazing, some hydrological disruption of the river system	Being developed as key catchment demonstration research e-training property.
T030	Peedamulla Wetlands and swamp	River delta containing swamp with unusual mix of vegetation	Fair	Limited recreational and indigenous use (limited by poor access)	High due to unique plant community mix	Fairly high grazing value	Disrupted, dysfunctional drainage system	
T031	Native perennial grasses/grasslands on Cheela	Fertile soils supporting a variety of species	Fair to poor		Habitat for many lifeforms - all components other than moisture	Grazing	Overgrazing, increased fire frequency, invasive plants, feral and native herbivores	