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Developing a *Yawuru bilarra* (wetland) monitoring program

Report

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Front cover photograph: Setting up monitoring transects around a depression east of Taylors Lagoon (photo R. Dobbs).

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List of Yawuru words* used in this report

barni	see <i>jarlangardi</i>
barrgara	turkey; bustard; <i>Otis australis</i>
barrgana	the cold season (June-Aug)
bilarra	wetlands; spring Country; Yawuru habitat
bilgin	<i>Eleocharis dulcis</i> (water chestnut) edible roots. Grows at Nimalarragun, east of Willie Creek
birra	bush; bush Country; inland Country
bugarri	dream: totem associated with a child
Bugarrigarra	the Dreaming; Dreamtime/'history before time began' (Yawuru definition); derived from -bugarri = dream, and -garra = more than one
bundu	plains; clearings; open Country; saline grasslands; mudflats. Yawuru habitat
bundurrbundurr	pindan Country; red plains and their vegetation; Yawuru habitat
buru	one's Country; traditional Country; land/earth/dirt/ground; can also mean time/place/season
duldul	swamp hen; <i>Porphyrio porphyrio</i>
garnburr	paperbark; <i>Melaleuca dealbata</i>
garrabul	northern nail-tailed wallaby; <i>Onychogalea unguifera</i>
girrbaju	bush honey; sugar bag
gudurrwarany	brolga; <i>Grus rubicundus</i>
jarlangardi	sand goanna; <i>Varanus gouldii</i> (also referred to as <i>barni</i> by the Country Managers)
jarmirdany	corkscrew pandanus; <i>Pandanus spiralis</i> . Found on Buckley's Plain and behind Willie Creek.
jibilyurr	plumed whistling duck; <i>Dendrocygna eytoni</i>
jibilyurr	ducks; they build nests during Man-gala (Dec–Mar) in thick grass.
jigily	Bauhinia; <i>Lysiphyllum cunninghamii</i>
jila	'living water'; permanent freshwater sources
jurru	mystical being; serpent-like figure; snake (generic)
lardig	<i>Lophostem grandiflorus</i> (important Law tree for the northern tradition). Grows around Lake Campion
Laja	the hot time (Late Sep–Nov)

liyan	feelings that express emotional strength, dignity and pride; sense of wellbeing
mabu	good; healthy; strong
Man-gala	the wet season (Dec–Mar)
manggaja	paperbark shelter
Marrul	the changing season (Apr–May)
minarla	ibis
mirdimarlu	plains kangaroo; red kangaroo
mirlimirli	paper; report; plan; book
murrga	coastal paperbark; <i>Melaleuca alsophila</i>
murrga yirr garnburr	paperbarks; paperbark Country; Yawuru habitat
narwulu	blackberry tree/ <i>Terminalia petiolaris</i> ; <i>marul</i> (Bardi) fighting sticks
rayi	spiritual essence; spirit being; childspirit
rirrwal	<i>Sesbania formosa</i> ; white dragon tree
wanggayi	<i>Acacia tumida</i> , spear wattle
Wirburu	the warming-up season (Sep–Oct)
Wirralburu	the cooling season (May–Jun)
yarrinyarri	bush onion; <i>Cyperus bulbosus</i>
yungurungu	Nyikina word for <i>jurru</i> – mystical snake, serpent

*All words and definitions are from the Yawuru Cultural Management Plan Glossary (Yawuru RNTBC, 2016) unless indicated and were also confirmed by the Yawuru language reference group.

List of Yawuru site names* used in this report

Bungarigun	Taylors Lagoon (from p18, Yawuru IPA plan)
Gumaranganyjal	Roebuck Plains (site of homestead)
Gunbanyari	Ungani Lakes (<i>Gumbanyari variation found 'Yawuru site list' item 136</i>)
Jalmagunan	Old Sheep Camp, on Roebuck Plains station (Jamanngunun & Jarmangunan variation found 'Yawuru site list' item 119)
Janding nyanjinga	rain-fed claypan e.g. <i>Janding nyanjinga</i> (Lake Champion) in dune swale evaporates in dry season freshwater eels (from p73 YCMP) (03/12/2018 Di Appleby interpretation jarndu ginyangga but proper name is Jarndunganyjal place of woman) note found in 'Yawuru site list' against item 135 'Janding nyanjinga'
Lumun-gun	well and <i>jila</i> on Roebuck Plains PL
Mimiyagaman	spring on the southern end of Roebuck Plains
Nimalarragan	Wetland east of Willie Creek
Tharndoo-Ngunjal	Lake Champion (water reserve ^9697) (p33, Yawuru IPA Plan) 03/12/2018 Di Appleby interpretation jarndu ginyangga but proper name is Jarndunganyjal place of woman) note found in 'Yawuru site list' against item 135 'Janding nyanjinga'
Walanggar	Edgar Ranges
Yidarr	Lake Eda

*All site names are from the Yawuru Cultural Management Plan Glossary (Yawuru RNTBC, 2016) with variations to site names provided by the Yawuru language reference group.

Acronyms

CM	Country Manager
CMP	Cultural Management Plan
DBCA	Department of Biodiversity, Conservation and Attractions
DPIRD	Department of Primary Industries and Regional Development
DWER	Department of Water and Environmental Regulation
ES Unit	Environmental Services Unit
GDE	Groundwater dependent ecosystem
IPA	Indigenous Protected Area
MERI	Monitoring, evaluation, reporting and improvement
NAERH	Northern Australia Environmental Resources Hub
NBY	Nyamba Buru Yawuru Aboriginal Corporation
NESP	National Environmental Science Program
TAG	Technical Advisory Committee
TO	Traditional Owner
UWA	University of Western Australia

Executive summary

Yawuru Traditional Owners are in the unique position of owning and managing a pastoral lease that extends over their traditional Country and Native Title area. Across some of the Roebuck Plains Station (pastoral lease) and Yawuru traditional Country also lies the Yawuru Indigenous Protected Area (IPA). Within these overlapping tenures and management purposes, Yawuru Traditional Owners wish to enable economic participation and benefit for their community, while also allowing people to enjoy their custodial rights, and maintain and improve the condition and vitality of their Country and its important places. Recognising these important and complex needs, the Nyamba Buru Yawuru Ltd (NBY) Environmental Services (ES) Unit and the Country Managers have facilitated and carried out research and other work on the condition of the Roebuck Plains and its *bilarra* (wetlands) to understand the best way to manage them. This includes Traditional Owner knowledge about and aspirations for *bilarra* that are recorded in the Yawuru Cultural Management Plan and IPA Plan.

These plans guide the monitoring and management activities undertaken by the NBY ES Unit and the Country Managers. Yawuru now want to check on and measure how their actions, are improving the health of the Roebuck Plains and its *bilarra* to facilitate adaptive management (when management is improved by learning from management outcomes and adapting/changing management actions if necessary). In 2018 NBY collaborated with researchers from the University of Western Australia through the National Environmental Science Program's (NESP's) Northern Australia Environmental Resources Hub to develop a *bilarra* monitoring program that was scientifically sound, would build on Yawuru's past work, address current information needs and support adaptive management.

The four-year project involved a Multiple Evidence Base approach, which sees different sources of information, like Indigenous (Yawuru) and university-based science, as all validly contributing to understanding the natural environment – in this case, *bilarra*. A key part of the project was ongoing knowledge-sharing between the Yawuru staff and the NESP researchers, and a commitment to collaboratively adapt and refine a wetland monitoring protocol (designed in northern Australia for implementation by Indigenous groups) to the Yawuru context. Importantly, the monitoring protocol was adapted to meet the information needs of the Country Managers and was also shaped by Yawuru knowledge of *bilarra* ecology and values.

Country Managers are using the adapted monitoring protocol to record information at six culturally and ecologically important *bilarra* under different management scenarios, including levels of cattle grazing. Although the monitoring protocol has only recently been finalised, the Country Managers are already using the information recorded to inform management of these *bilarra*. This report documents how the monitoring protocol was developed and some of these management outcomes.

1. Introduction

1.1 Background

The Yawuru people are the Traditional Owners (TOs) of the land and sea in and around the Broome area and were officially recognised as such in 2006 when the High Court ruled in favour of the claimants in the Rubibi Native Title claim awarding them the rights of Native Title over 5,300 km² of their ancestral lands (Yawuru Registered Native Title Body Corporate 2016). The Yawuru Corporate Group (Yawuru) is the governing body for the Yawuru people and Nyamba Buru Yawuru Ltd (NBY) was incorporated to serve as the operational arm for Yawuru.

The Yawuru Indigenous Protected Area (IPA) was established to protect the cultural and ecological significance of Roebuck Plains, while supporting the economic development of the Yawuru people through sustainable cattle production (Figure 1-1). Country Managers (CMs) are employed through the Environmental Services (ES) unit of NBY and are responsible for assisting in the implementation of management plans for the Yawuru IPA, and other projects across Yawuru land and sea Country (in accordance with the Yawuru Cultural Management Plan).

To consolidate and expand their monitoring and management of *bilarra* (wetlands) across the IPA, NBY ES staff and CMs collaborated with researchers from the University of Western Australia (UWA) through the Australian Government's National Environmental Science Program (NESP's) Northern Australia Environmental Resources Hub (NAERH). This partnership was formed to develop a monitoring program for *bilarra* across the IPA to assist the CMs to assess whether they are achieving their IPA objectives for *bilarra* and in evaluating the effectiveness of the sustainable cattle grazing operation on the IPA. There were two key stages to the project which have contributed to the way that the report is structured.

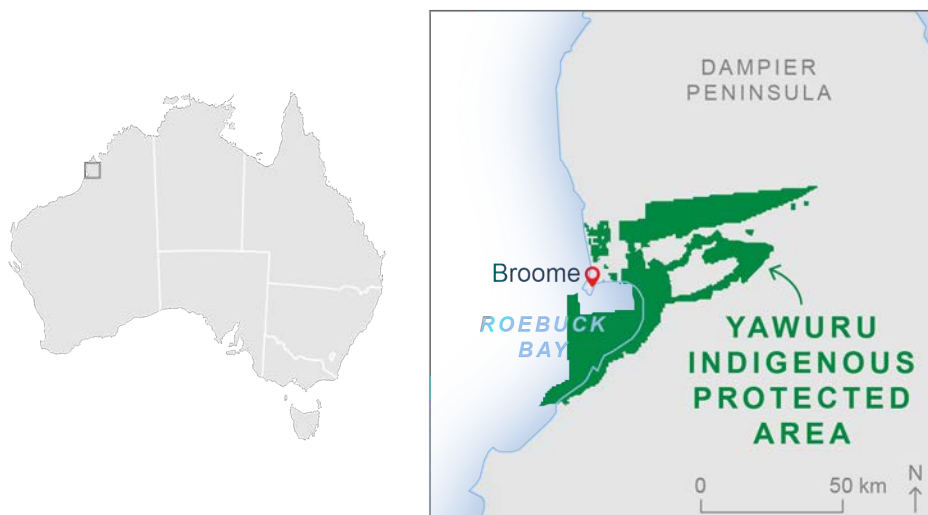


Figure 1-1. Yawuru Indigenous Protected Area covers land and sea Country near Broome in north-western Western Australia.

1.2 Stage 1: Review of literature to inform the Yawuru Indigenous Protected Area monitoring program

A literature review was undertaken drawing upon both Yawuru and non-Indigenous knowledge of *bilarra* (wetlands; spring Country; Yawuru habitat) to provide a cultural and historical context for the Yawuru IPA Wetland Monitoring Program. The monitoring program was designed to fit in with the Yawuru monitoring and reporting structure (MERI) and build on monitoring they are already undertaking. During the initial stages of the project, CMs also identified the need to compile existing knowledge on specific *bilarra* to assist with the selection of monitoring sites and indicators and summarise how the IPA *bilarra* projects they are working on interconnect and inform each other.

In the first two sections, we summarise in plain English some of the information that is publicly available about *bilarra*, focusing on cultural associations and ecological change. In our review, we rely heavily on the Yawuru Cultural Management Plan and Yawuru IPA Management Plan, and cite relevant reports, many of which have been commissioned by and written for NBY to assist in looking after/managing *bilarra*. We have also incorporated additional information documented from working with CMs and TOs during the project.

We begin by introducing Yawuru concepts that relate to all of Yawuru Country and provide a background understanding of Yawuru knowledge of and associations with *bilarra* (Section 2). We have summarised the published ecological science knowledge available (Section 3) and then address each *bilarra* individually, covering the springs, lakes and wells that are currently included in the Yawuru IPA Wetland Monitoring Program (Section 6) (Figure 1-2).

As this review has focused mainly on published information, the cultural information contained is incomplete and presented to encourage further discussion – we welcome any critique, discussion, or validation of the content by Yawuru people. By bringing this information together, it allows us to identify gaps in the research that has been done and the information that has been documented. As CMs progress with monitoring and reporting on *bilarra* through the NESP wetland monitoring project, this review provides a tool for CMs to share Yawuru knowledge and research with others (especially external stakeholders or non-Yawuru staff) to learn both the history of Yawuru work on wetlands and the cultural context of this work.

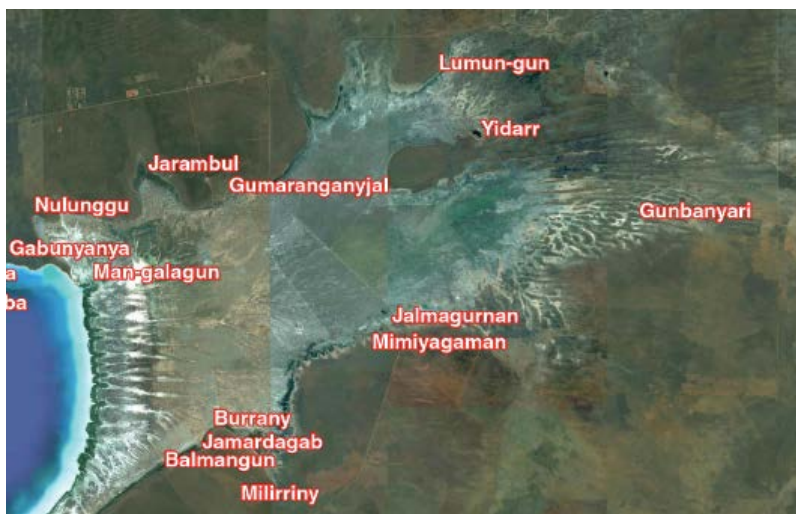


Figure 1-2. Map of some important sites and wetlands on Yawuru Country. Adapted from: Cultural Management Plan (Source: Yawuru RNTBC, 2016: 29).

1.3 Stage 2: Developing a *bilarra* monitoring program

The second stage of the project was to design a monitoring program to find out more about *bilarra* so that the CMs know whether their management actions are working. The information collected from monitoring will also help the CMs and NBY to decide how cattle can graze without damaging *bilarra* (called sustainable grazing). Section 5 details the development of this monitoring program and Section 6 summarises the results from the monitoring program, highlighting the tools developed from the project and how the information being collected is informing monitoring and management of *bilarra* now and into the future.

2. Yawuru historical and cultural associations with Roebuck Plains and *bilarra*

Understanding any part or aspect of Yawuru Country must begin with some understanding of Yawuru Law and how Yawuru people are connected to their Country. For this, we draw from the Yawuru Cultural Management Plan (Yawuru RNTBC, 2016) to explain a little about Yawuru Law, Traditions and rayi.

2.1 Introduction Yawuru Law and traditions, rayi places and *jila*

2.1.1 Yawuru Law and Traditions

The foundation of Yawuru society, Country, Law and Traditions is *Bugarrigarra*:

'In our Law, everything comes from *Bugarrigarra*, the time when creative beings traversed the Country, naming the landscape, defining the languages that people would speak and setting down our rules and customs. It is the creative epoch in which the world was given form and meaning ... During *Bugarrigarra*, ancestral beings travelled through our Country, naming places and creating the features of the land, waters and skies, and introducing rules and rituals associated with particular areas ...

Since time immemorial, the law of the *Bugarrigarra* has been and continues to be handed down through the exercise of rituals and ceremonies. The *Bugarrigarra* is also maintained through the right of the Yawuru to 'speak for and look after' Yawuru Country ...

In Yawuru Country, the *Bugarrigarra* laid down three traditions of law, which hold esoteric knowledge of our Country and guide our customary practices. They all relate secret/sacred narratives, sometimes called 'songlines' (Yawuru RNTBC, 2016: 30).

The three traditions connect Yawuru to other groups through the sharing of knowledge and practices with nearby Bardi (north), Karajarri (south), Nyikina and Mangala (inland), and Nyangumarta (south), but also with shared traditions extending down to the Pilbara and east to the central Australian desert. Shared traditions or shared cultural knowledge among Yawuru, Karajarri, Mangala and Walmajarri groups, relating to groundwater beneath the Roebuck Plain, was part of the evidence submitted for the National Heritage listing of the West Kimberley. Where possible we have noted examples of shared cultural knowledge to build upon the layers of meaning associated with the Roebuck Plains and *bilarra*.

2.1.2 *Jila, jurru and a Bugarrigarra story*

Jila are sometimes called 'living waters' and are permanent freshwater sources. Some *jila* are also called springs. These permanent waters connect right back to the *Bugarrigarra*, and most are associated with powerful creator snakes called *jurru*, as explained in the Yawuru IPA plan (NBY 2016: p59):

'Most of our *jila* or springs are thought to be inhabited by various *jurru*' (metaphysical serpents, called *yungurungu* in Nyikina), powerful beings to be respected and approached in prescribed ways).

Paddy Roe, a Nyikina elder who lived at the Sheep Camp on Roebuck Plains station, explains about the *jurru* that form the springs on Roebuck Plains:

'All springs Country ... never dry up ... *Yungurungu* is the rainbow snake. He hold that water always. Never go dry must be something underneath ... that's why these springs [are] permanent springs you know from *Bugarrigarra*. He bin like that water snakes never go 'way from this part of the Country' (quoted in Benterrak, Mueckie & Roe 1996:37/51)

The Cultural Management Plan (p190), explains more about what *jurru* are like:

'Many of our water sites are inhabited by *jurru*, powerful snake-like beings that can smell 'strangers' and cause havoc to the Country if disturbed. *Jurru* have distinctive personalities. Some are very 'cheeky' – dangerous and unpredictable. Others are docile. Active *jurru* move around under the ground, surfacing through escape holes. Evidence of *jurru* is often seen in the clouds and storms, with lightning and rain'.

In the Yawuru Cultural Management Plan (p73) Jimmy Edgar explains how all *jila* have stories:

'There is water right back to the pindan Country – all our *jila* (permanent waterholes), from reef back to *birra* (inland), have got stories. The underground streams feed the *jila*'.

Yawuru Law says it is Yawuru people's responsibility to look after living waters (IPA Plan, p61). The Cultural Management Plan (p72) explains the location of *jila*:

'Many *jila* occur on *Gumaranganyjal* (Roebuck Plains), especially around the edges at *Lumun-gun* (NE corner) and *Mimiyagaman* or Sheep Camp on the south side'.

A *Bugarrigarra* story also talks about how a woman travelled across the Broome Peninsula (the northern edge of the Roebuck Plains). As she went she spilt water from her water carrier which created water holes and soaks (see Yawuru values map in the Yawuru Cultural Management Plan, p120).

2.1.3 Rayi places

Like neighboring Bardi, Nyul and Karajarri groups (e.g. see Elkin 1933, Yu 1999), Yawuru people give significance to some wetlands because of the presence of *rayi*. Elkin (an early anthropologist) describes *rayi* as the pre-existing form of children that '...live in definite centres such as waterholes, springs, trees and rocks on the land and in the sea' (Elkin, 1933, p. 438).

Specifically, to Yawuru, the Cultural Management Plan states:

'Our people, like all living things, arise from our Country. Certain places in Yawuru Country have *rayi*, a life-giving essence that creates our spirit-children. The life force of our children, their *rayi*, will always remain connected to the place they come from.

This connection of a spirit-child to a specific place, its *bugarri*, is typically discovered through dreams or unusual events. Thus, the spirit-child enters its mother ...

Throughout life a Yawuru person remains connected to their *rayi* place, the place that gave them life. When we die our *rayi* return to that place in our Country. When we visit places, we know the *rayi* of our ancestors are there, guiding us and looking after the Country, watching the behaviour of our people.' (Yawuru RNTBC, 2016: 31).

Different Yawuru people describe how their own *rayi* or the *rayi* of their children or their children's children have arisen from Yawuru Country. For example, in the Cultural Management Plan, Elsie Edgar tells this story:

'My brother, his *bugarri* comes from No. 6 Well – *Walyjibarngaba*. My dad bin go cutting tree ... cutting special tree ... my brother jumped out ... his *rayi*, that's his *bugarri* place' (Yawuru RNTBC, 2016:31)

2.2 7,000 years of history and geoheritage

'For thousands of years [Yawuru] ancestors have lived along the foreshores of Roebuck Bay, across the pindan plains, as far inland as the *Walan-garr*, the Edgar Ranges, and along the fringes of the Great Sandy Desert' (Yawuru RNTBC, 2016: 28).

The whole wetland plain of Yawuru Country (in English, Roebuck Plain), yields an internationally significant story of people and coastal change. Some 7,000 (to 10,000) years ago the sea level in this region was 2m higher and Roebuck Plains would have been inundated with seawater (Semeniuk 2014). Between then and now the sea level gradually dropped to its present level, with the plains gradually filling with marine carbonate mud beginning at the head and slowly continuing to the present mouth (Semeniuk 2014). Hence the Roebuck Plains represents a place of outstanding history both in terms of documented coastline change from sea level drop and the response of Yawuru people (and likely other groups) to this change.

The past 7,000-year shoreline continues to be a very important feature of Yawuru Country. It separates the *bundu* (saline grasslands and mudflats) from the *bundurrbundurr* (pindan). Within this ancient shoreline is the *murruga yirr gamburr* (paperbark) habitat, along with many *jila* (permanent water sources or springs). Contained within are also many cultural sites including ancient living places and middens (Vernes and Matthews, 2013). Vernes and Matthews (2013) mapped known cultural and ecological values of Yawuru Country and found that although the entire area within the Roebuck Plains is important to Yawuru people, a 'zone of significance' occurs where the highest proportion of values exist. The zone of significance includes the entire 7,000-year-old shoreline along with wetlands lying outside of this zone including *Yidarr* (Lake Eda), *Tharndoo-Ngunjal* (Lake Champion), *Gunbanyari* (Ungani Lakes) and *Bungarigun* (Taylors Lagoon), which also overlap cultural and historical values Figure 2-1.

Cultural Conservation and Pastoral Values

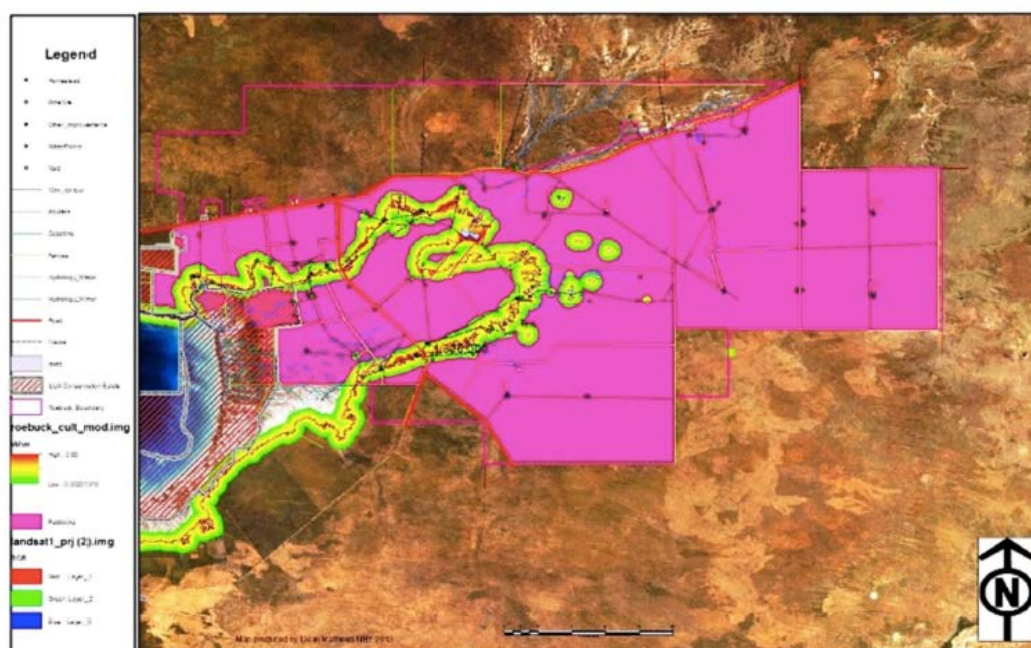


Figure 2-1. Mapping of cultural and ecological values of Yawuru Country showing a 'zone of significance' around the edge of the plains occurs where the highest proportion of values exist. Source: Vernes and Matthews, 2013: 4.

2.3 Yawuru continuing ways of life on and connected to Roebuck Plains

Yawuru people continue to value the Roebuck Plains highly in multiple interconnecting ways. Roebuck Plains has, and always will, belong to Yawuru people as began in the *Bugarrigarra*. Connection to the Roebuck Plains continues to happen through Yawuru protocols and law, as people visit the Plains and hunt, through stories and memories, through economic activities like grazing, and through Healthy Country work.

2.3.1 Native Title

In 2006 the Federal Court recognised that the Yawuru people are the Native Title holders of approximately 530,000 hectares of traditional Yawuru Country (Yawuru RNTBC, 2016). This includes:

'... the land and intertidal zone along the south-west Kimberley coast from Willie Creek in the north, and around Roebuck Bay to *Bangarangara* on the southern end of Thangoo station. To the east, Yawuru Country extends from the ridges of *Garuwany* near Nilabublica across to old Dampier Downs station and then south past *Dipingujarra* in the Great Sandy Desert, east of the Thangoo station' (IPA plan NBY 2016).

The Native Title claim was finally determined by the Full Federal Court in 2008. In 2010 Yawuru signed two Indigenous Land Use Agreements (ILUA) with the Western Australian Government. These ILUA outlined the creation of the Yawuru Conservation Estate (YCE) across 1,019 km² of the Native Title estate, including both terrestrial and marine landscapes, which is managed jointly by NBY, the Western Australian Department of Biodiversity Conservation and Attractions (DBCA) and the Shire of Broome (YRNTBC 2016). Native title

determination allowed Yawuru to obtain the lease for Roebuck Plains Station – a 2,760 km² active cattle station which occurs over a portion of Yawuru exclusive possession Native Title. The Yawuru IPA was subsequently established as a dedicated area that Yawuru agree to manage, with their partners, for the protection of natural and cultural values in accordance with international guidelines.

2.3.2 Roebuck Plains Station

The Roebuck Plains Pastoral Lease comprises 283,322 ha and livestock grazing commenced at Roebuck Plains in 1886 (see Willing 2012). The IPA plan notes that ‘...wetlands and springs were important water sources for the early settlers’ (Cultural Management Plan, p73). *Jila* (permanent water sources) and soaks made possible the development of the west Kimberley pastoral industry (Yu 2001) and continue to support the industry, which is evident with many watering points installed for cattle built over or next to traditional water sources (Vernes and Mathews 2013).

The Roebuck Plains station property was purchased by the Indigenous Land Corporation (ILC) in 1998, and in 2014 the Roebuck Plains pastoral lease was divested to the Nyamba Buru Yawuru with leaseback to the Indigenous Land and Sea Corporation (ILSC). Under the sublease the ILSC continue to operate the cattle operations and deliver training and employment outcomes for Indigenous people (Biota, 2015). Negotiations are currently underway in 2021 for the commercial cattle business to be transferred to Yawuru in the near future.

Since taking ownership of the pastoral lease in 2014, Yawuru are committed to balance the economic benefit of the station and keeping wetlands and the plains healthy. The concerns raised by Yawuru people in the Cultural Management plan have been incorporated into the Yawuru IPA plan and are being addressed through on ground work being undertaken by the NBY ES Unit and the Yawuru CMs (see Section 4.1).

2.3.3 Hunting on Roebuck Plains

The Yawuru use and occupancy mapping project accurately mapped how people use Country. Gardner (2014) and Mathews and Doran (cited in IPA plan: Yawuru RNTBC 2016) have also mapped information obtained from TOs which highlights the ongoing hunting activities and the link between valuable hunted species and wetlands (see Figure 2-2). The map (Figure 2-2) shows how most hunting happens across the wetland area of the Plains, including around specific *jila* and lakes.

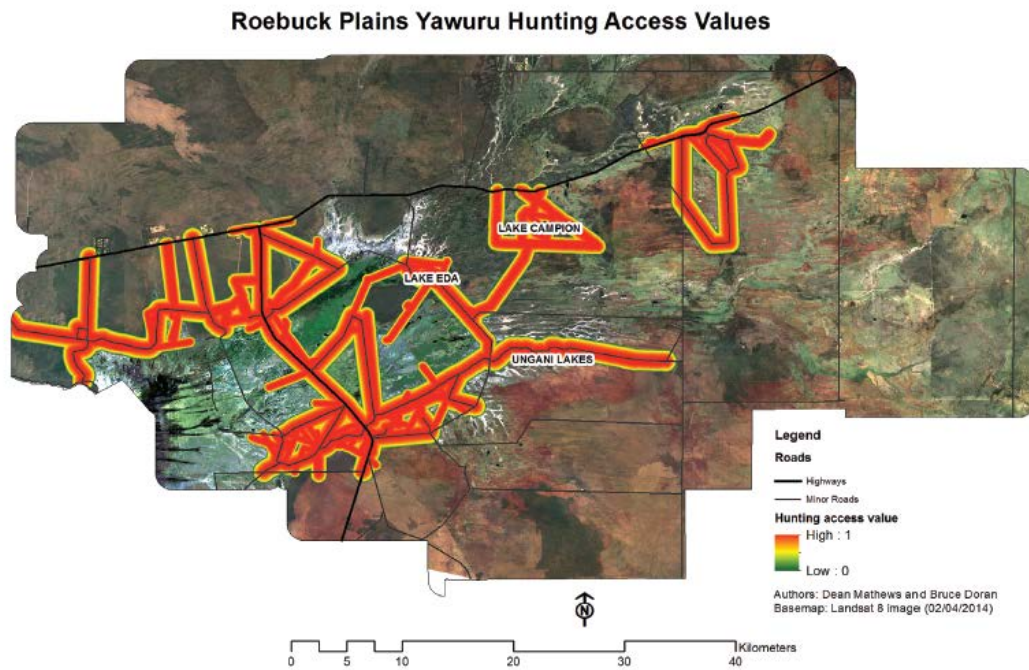


Figure 2-2. Hunting access by Yawuru People. Source: Yawuru IPA Plan.

2.3.4 Actively remembering the past

The *Mangara* Yawuru Storylines is a community-based archive initiated by Yawuru and documents stories and histories related to Roebuck Plains and Yawuru people. The archive contains photographs, documents, oral histories, films, books, media, and other cultural materials.

3. Yawuru traditional and scientific understanding of *bilarra*

3.1 Roebuck Plains

Roebuck Plains has surface inflow to the east and south-east sides from Deep Creek, originating 40km north-north-east and numerous small creeks which flow during the wet season (*Mangala*). During a good wet season, the floodplain is inundated with water and large volumes of freshwater flow from Roebuck Plains out into the Bay.

3.1.1 Concerns for Roebuck Plains

Yawuru TOs and researchers have both voiced concerns about the health of the Roebuck Plains. Semeniuk (2014) were concerned that grassland diversity and samphire health has declined over the past 10 years.

When assessing pastoral activities, for Yawuru, Willing (2012) noted a significant increase in Roebuck Station stocking rates:

'The potential carrying capacity of the property has been estimated at 21,080 cattle units (WA Stock State Database, 2010). In December 1999, it was reported that the property supported 18,000 head of cattle. Up until 2001, the station maintained relatively low stocking rates. Since then, 49% of the lease area has been stocked at rates above the Potential Carrying Capacity – primarily in paddocks in the pindan sandplain Country.' (Willing 2012).

As with individual *bilarra*, changes across the Plains are evident across seasons. During a Yawuru Technical Advisory Group (TAG) meeting TOs noted that the marine plains are currently sparse (groundcover has declined) due to the extensive flooding in the 2017–18 wet season: marine couch died back as it can't tolerate extensive inundation.

On main road either side for 90kms north of Broome has only just dried. All grass on downside where water sat is dead grass not going to grow. (Deb Pigram Oct 2018) 'Quite dry Country but underneath [its] wet - will take a couple of years to come back (recover). (Jimmy Edgar Oct 2018)

This loss of plant ground cover may have caused scouring (where soil is blown away from winds). These dust storms are commonly seen by the Country Managers.

TO's have also expressed concerns that the road has caused a dam effect that has reduced flow and affected the regime of the marine plains. (Dean Mathews Oct 2018).

3.2 Yawuru habitat types

Yawuru recognise eight habitats on the *birra* (land-side) of their Country, three of which specifically relate to wetlands (*bilarra*, *murrnga yirr garnburr* and *bundu*) that are further described below.

Table 3-1. Habitat types recognised by Yawuru on the birra (land-side) of their Country.

Yawuru habitat name*	Description
<i>niyamarri</i>	sand dunes
<i>mayingan manyja balu</i>	vine thicket areas behind coastal sand dunes
<i>bundurrbundurr</i>	pindan Country
<i>warnangarri</i>	rocky Country
<i>bilarra</i>	wetlands
<i>murruga yirr garnburr</i>	paperbarks (<i>Melaleuca alsophila</i> and <i>Melaleuca dealbata</i>)
<i>bundu</i>	saline grasslands/samphire/saltmarsh/mudflats
<i>gundurungu</i>	mangroves

*As detailed in the Cultural Management Plan (Yawuru RNTBC, 2016).

3.3 *Bilarra* habitat

There are a variety of *bilarra* (wetlands) present on Roebuck plains. While there are no permanent rivers or creeks, important *bilarra* include semi-permanent lakes and many *jila* (permanent freshwater sources or springs) that exist around the ancient (7,000–10,000-year) shoreline, edging the *bundu* zone (Plains/saline grasslands).

Important lakes on Roebuck Plains include:

‘...*Yidarr* (Lake Eda), Lake Champion & *Gunbanyari* (Ungani Lakes) which are rain-fed claypans in swales between relict dunes on the eastern side of Roebuck Plains. Springs such as *Mimiyagaman* are found on the southern side of Roebuck Plains. ...Roebuck Plains has hundreds of waterholes around its perimeter.

Many *jila* occur on *Gumaranganyjal* (Roebuck Plains), especially around the edges at *Lumun-gun* (NE corner) and *Mimiyagaman* or Sheep Camp on the south side.’ (Cultural Management Plan, p72)

Research undertaken with Yawuru CMs and TOs have highlighted the interconnected nature of the Roebuck Plains wetlands and the uniqueness and variety of wetlands across Yawuru Country. Semeniuk (Semeniuk 2014) refers to the Roebuck Plains as a ‘megascale wetland’, containing nine different wetland groups that are highly integrated but contain a diversity of features and processes.

Based on his work with Vic Semeniuk (see Semeniuk 2014 for more detail), Pius Gregory (Traditional Owner and Country Manager) developed a diagram which summarises how the different types of *bilarra* are formed and connected to Roebuck Bay (Figure 3-1). *Bilarra* such as Lake Eda and Ungani are reliant on rainfall runoff from drainage lines, while other *bilarra* are formed by more localised runoff including Lake Champion and Taylors. Soaks and springs occur around the edge of the plains (melaleuca zone or *murruga yirr garnburr* zone), where groundwater is pushed up when the sands meet the marine plain mud and other springs are formed through cracks (Pius Gregory, NESP 29th August 2018).

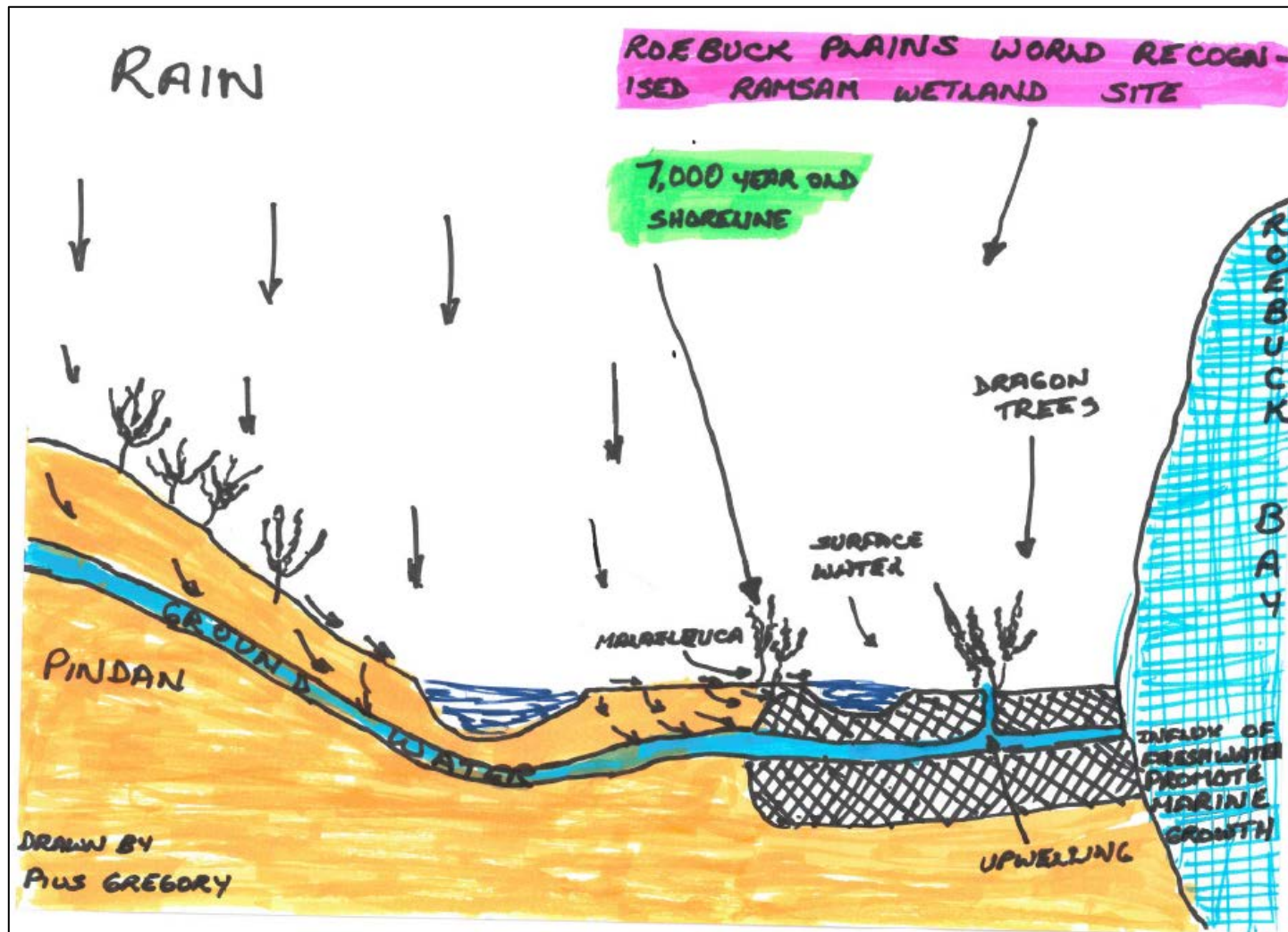


Figure 3-1. Roebuck Plains bilarra formation and connection to saltwater, drawn by Pius Gregory, Yawuru Traditional Owner for this project, based on his knowledge of the Plains and the knowledge he has gained from working with Vic Semeniuk. Yellow represents sand and black hatching represents marine plains mud.

In addition to the cultural associations with *bilarra* described in Section 2, Yawuru people know that these freshwater lakes and *jila* were very important places for their ancestors as a source of drinking water. *Bilarra* also support culturally important plants and animals. For example, a species list from the Cultural Management Plan (Yawuru RNTBC: p73-75) follows:

Box 3-1. Key *bilarra* plants and animals.

'We find *yarrinyarri* (bush onion) near the springs. You can get other water animals, like eels, there too.

Lophostem[on] gra[n]diflorus – *lardig* (important Law tree for the northern tradition). Grows around Lake Campion (eastern Yawuru Country)

wanggayi – *Acacia tumida* (spear wattle)

bilgin – *Eleocharis dulcis* (water chestnut) edible roots. Grows at *Nimalarragun*, east of Willie Creek

jarmirdany – *Pandanus spiralis* (corkscrew pandanus). Found on Buckley's Plain and behind Willie Creek.

Tachybaptus novaehollandiae – Australasian Grebe

minarla – *Theskiornia aethiopica* (white ibis). Abundant in Mangala (Dec–Mar)

Freshwater eels – *Anguilla sp.* Formerly an important food.

duldul – *Porphyrio porphyrio* (purple swamphen)

jibilyurr – ducks. They build nests during *Man-gala* (Dec–Mar) in thick grass. Traditionally hunted with *narwulu* (hitting stick) after creeping close. Nowadays guns used.

jibilyurr – *Dendrocygna eytoni* (plumed whistling-duck/duck [generic])

rirrwal – *Sesbania formosa* (white dragon tree). Grows at springs around Roebuck Plains and Buckley's Plains.

frogs and tadpoles – Important food for duck and snakes, especially plumed and wandering whistling-duck'.

Yawuru knowledge holds detailed information about how *bilarra* are interconnected with plants and animals, and with customary activities like hunting. For example, the CMs explain how *barrgara* (turkey) needs open water for drinking and some goanna hide in pools to escape hunters (both turkey and goanna are hunted). The Yawuru seasonal calendar summarises some of these connections in addition to the ways Yawuru people access resources (like goanna and honey) according to seasonal cues and knowledge. For example, in *Man-gala* (wet season) there is an abundance of frogs, and many lizards are out hunting but the lizards are thin and tend to be eaten later in the year when they fatten up. In *Barrgana* (cold season) there are many bush onion bulbs to eat and during *Laja* (hot season) the honey fly makes honey nests in the *Jigily* tree and Inland Bloodwood which is collected

and eaten (Yawuru Seasonal Calendar accessed 2021). These, and many other connections, support a range of Yawuru activities and rights.

The Roebuck Plains system is also recognised for the bird species that it supports locally, nationally, and internationally (see Rogers et al, 2001, Watkins and Jaensch, 2007, Hassell, 2015). *Bilarra* provide a significant drought refuge area for waterbirds and a major migration stop-over area. Bird surveys have recorded the presence of more than 45 EPBC Act listed migratory bird species with at least 3 species of migratory shorebirds occurring in internationally important numbers (Little Curlew, Oriental Plover and Oriental Pratincole) (Watkins & Jaensch 2007; Jaensch 1993). Two nationally threatened species on the Roebuck Plains include the Australian Painted Snipe and the Greater Bilby. Cross-cultural collaboration with the Yawuru CMs and WWF-Australia ecologists have also led to new detections of the Spectacled Hare-wallaby (SHW), (*Lagorchestes conspicillatus*) which was presumed to be locally extinct (Wysong et al 2022).

The Roebuck plains system and Roebuck Bay are both listed in the Directory of Important Wetlands which was developed to recognise the value of wetlands to conserve and protect them. The Roebuck Plains system is listed as a Nationally Important Wetland (meeting five out of the six inclusion criteria including uniqueness, the plants, and animals it supports, and historical and cultural importance). The listing includes the northwest claypans, Lake Eda and adjacent connected lakes including Lake Champion, Taylors Lagoon, and the Ungani Lakes (Jaensch 2010; Biota 2015). The adjoining Roebuck Bay was recognised as an internationally important wetland (declared a Ramsar site in 1990) and listed on the National Heritage Register in 2011. Researchers have recommended that the Ramsar listing for Roebuck Bay be extended to include the Roebuck Plains based on its cultural and natural historical values and contemporary wetland and related species diversity (Watkins & Jaensch 2007; Semeniuk 2014).

3.3.1 Concerns for *bilarra*

Concerns for *bilarra* or wetlands that are described in the Cultural Management Plan (p73) include trampling and fouling by cattle, risk from groundwater extraction from station bores lowering groundwater levels and historical changes to *bilarra* including pastoralists converting springs into dams.

In 2012, Willing (2012) recommended that wetlands needed protection from trampling and fouling by cattle, noting that: ‘Many small spring systems on the edge of Roebuck Plains are in ecological decline from both cattle impacts and groundwater changes. For example, remnant stands of *Sesbania formosa* trees show major bark damage and no active recruitment. In some places protective fencing has not been maintained by current management or is inadequate to protect critical wetland habitat’.

Semeniuk also described an overall concern that ‘...overgrazing and excess nutrient input by cattle has altered and will continue to alter the basic vegetation associations’ (Semeniuk, 2014: 70). While undertaking research with Yawuru CMs, they found that most of the wetlands and associated vegetation on Roebuck Plains is degraded, but that this degradation could be reversed through management.

3.4 *Murruga yirr garnburr* habitat

Murruga yirr garnburr (paperbarks) fringe the *bundu* (saline grasslands and flats of Roebuck Plains), inhabit seepage zones along the margins/contact of the Roebuck Plain and the pindan sandplain or dunes and provide a corridor beside sandy creek beds such as Deep Creek and Collins Creek that enter the Roebuck Plains from the north-east. *Murruga yirr garnburr* (paperbarks) occur around various wetland types, *Murruga* is the coastal paperbark or *Melaleuca alsophila* and *garnburr* is *M. dealbata*. (See the Cultural Management Plan: Yawuru RNTBC 2016: 52-55).

The Cultural Management Plan describes how:

'The larger trees, *garnburr*, are always found near a major *jila*, such as at *Yardugarra*, and are respected' (Yawuru RNTBC 2016: 53).

Both *murruga* and *garnburr* were used to build *manggaja* (paperbark shelters) in the wet season, with the bark used for roofing. In the Cultural Management Plan Jimmy Edgar describes how their wood is used for clapsticks and bark of *murruga* is used for cooking. Mr P. Edgar describes how these trees host grubs that are delicious when cooked, their leaves provide medicine for colds, and they can be cut open to provide water. Mrs C. Djiagween describes how paperbarks are a source of *girrbaju* (sugar-bag or honey). Paperbark wood, due to its resistance to termites, meant it was preferred as a timber for early station buildings and fencing (Yawuru RNTBC 2016).

The *Murruga yirr garnburr*/Acacia shrublands provide an important habitat type as vegetation on Roebuck Plains is otherwise characterised by plants which reflect the strongly seasonal conditions, have either annual life cycles or can withstand drought periods and mostly small in height (Semeniuk 2014). Dense stands of *murruga yirr garnburr* provide important habitat for insects, birds and animals, including goanna populations that are particularly hunted in *Marrul* season when they are fat (Yawuru RNTBC 2016: 55). The *garrabul* (*Onychogalea unguifera* or Northern nail tail wallaby) is also associated with this habitat, which provides cover for the wallaby that then feeds on nearby grasslands at dawn or dusk (Yawuru RNTBC 2016). During a trip to Ungani Lakes, where paperbarks fringe the lakes, CM Johani described how bees feed on the paperbark flowers and nest in the trees, providing honey. 'Goanna hide by burying themselves under the base of these trees. Yawuru people sometimes stuff goannas with the paperbark leaves when cooking the goanna' (Johani Mamid, NESP 19th June 2019).

3.4.1 Concerns for *murruga yirr garnburr*

The CMs have expressed concerns that these areas are heavily used and trampled or grazed by cattle.

Ecologist Tim Willing summarised management concerns for *murruga yirr garnburr*:

'This paperbark community, full of volatile oils, is easily damaged by wind-driven bushfires - as has happened in recent years on the east side of Buckley Plain. Such fires produce a dense black smoke and frequently kill large paperbark trees. The community regenerates relatively slowly. Furthermore, fire-damaged stands are rapidly invaded by weeds such as wild passionfruit (*Passiflora foetida*). Accordingly, management priority should be improved fire management - including strategic early season protective burning strategies.'

It is also important that groundwater extraction is carefully monitored to ensure that no significant decline occurs in the water-table, which supports this habitat' (Willing, 2012: 33).

Dean Matthews noted in 2020 that the melaleuca fringing zone is currently nice and dense has come back denser after the floods (before that it was bare) (Dean Mathews NESP 2021).

3.5 Bundu habitat

Although the current focus of this project is on the freshwater *bilarra* sites located within the IPA it is important to consider/note the landscape that the Roebuck Plains adjoins and the importance of *bilarra* associated with the Saline Grasslands, Samphire & Salt Marsh (*Bundu*).

Roebuck Bay is one of the most important sites in Australia for migratory shorebirds (Watkins 1993). Located behind the mangroves are broad tidal flats with *wirn-gil*/samphire (*Tecticornia* spp.) and other shrubs usually found growing on the landward margins (RNTBC 2014). These large intertidal flats are used as feeding grounds by many thousands of shorebirds and the roost sites along its northern beaches have been a focus for banding studies and regular counts in the past 20 years. The work that Yawuru undertake on *bilarra* on the Roebuck Plains aims to ensure that the operation does not result in any adverse impacts on the adjacent Roebuck Bay Ramsar Site (Watkins & Jaensch 2007).

Kidneybean Claypan is a large wetland within this area which provides important habitat for migratory bird species (Rogers *et al* 2001). This site supports many waterbirds including Black-winged Stilt *Himantopus*, Masked Lapwing *Vanellus miles*, Whiskered Tern *Chlidonias hybridus*, and Black Swan *Cygnus atratus* known to nest at Kidneybean Claypan, in addition to several mangrove-specialised passerines in that habitat (RAMSAR, 2003). Mathews and Semeniuk have also described how the unique geology and geomorphology of the western Dampier Peninsula gives rise to a diverse range of freshwater seepages of ecological importance and of great cultural significance to Yawuru people (Mathews *et al* 2011; Semeniuk 2011)

3.5.1 Concerns for bundu

Impacts from cattle and vehicle access have been recorded and it is important to keep vehicles on the existing tracks to Kidneybean Claypan, as wheel ruts make a lasting impression on the local grasslands (Rogers *et al.* 2001). There has been some concern also that groundwater use may impact on these wetlands and that a barrage located at *Nimalarragan* is impacting and impeding flow downstream (Dobbs *et al* 2013).

4. Yawuru *bilarra* monitoring and management on Roebuck Plains

4.1 Caring for Roebuck Plains and wetland habitats

4.1.1 Caring for Roebuck Plains, and supporting heritage and livelihoods

An IPA plan has been developed to deliver the outcomes identified in the Yawuru Cultural Management Plan (CMP) developed by TOs to inform the management of Yawuru land and seas.

The Yawuru IPA Plan explains how Yawuru want to:

'manage the Yawuru IPA with their partners, for the protection of natural and cultural values in accordance with international guidelines. Yawuru Country Managers are engaged by NBY to undertake the on-ground management works on behalf of the Yawuru RNTBC in accordance with the IPA POM' (IPA plan: Yawuru RNTBC 2016)

The IPA covers the significant wetlands and springs on Roebuck Plains station. It joins with, overlaps, and includes large portions of the Yawuru/DBCA conservation estate, including the Roebuck Bay intertidal zone and the Marine Park for which Yawuru have additional comprehensive joint management plans.

The Yawuru IPA is/was the first IPA in Australia declared over a commercial cattle station (Biota 2015). The IPA plan states that:

'It is the parties' intentions that the pastoral business continues whilst these natural and cultural heritage values are protected and enhanced' (RNTBC 2016).

To reconcile the potentially conflicting interests of operating a successful pastoral enterprise and protecting the natural and cultural values of Roebuck Plains and catchment area, NBY have developed a model based on UNESCO's nomination of heritage sites and on the global standard for defining and recording protected areas developed by the IUCN (International Union for Conservation of Nature). The Yawuru IPA Plan of Management adopts the IUCN guidelines for Protected Area management under categories 4 (Habitat/Species Management Area) and 6 (Protected area with sustainable use of natural resources) designations. A key aim of the plan is to protect important cultural and ecological assets while minimising the impacts of the pastoral enterprise through various management techniques including strategic fencing and rotational or selective grazing (IPA plan Yawuru RNTBC 2016).

The plan identifies a series of high priority areas on Roebuck Plains station (Zone 1), recognised for their cultural and natural values, that require protection within the pastoral lease, and on existing water reserves. Most wetlands and springs are considered high priority and are contained within Zone 1 (see Figure 4-1). Many of these areas are to be fenced to allow for stock exclusion, this being core IPA business. The edge of the plains and wetlands and springs are surrounded by buffer zones (Zone 2) where pastoral activities are closely monitored for their impact on the identified natural and cultural values (IPA plan RNTBC 2016).

To help with the implementation of the IPA plan, Yawuru have developed a monitoring and evaluation plan (MERI) for the IPA guided by the Cultural Management Plan and IPA Plan objectives and strategies and based on open standards for conservation planning. NBY have set up a TAG which consists of NBY staff, TOs, CMs and researchers to keep this process on track.

Bilarra protection is a key target of the IPA Plan and monitoring the sustainable grazing regime on the IPA is a key program within the MERI plan. The MERI process will help NBY to measure how CMs' actions, including fencing and changes to grazing regimes, are improving the health of the Roebuck Plains and its wetlands. It will also help NBY to report back to the Yawuru community and to funders (e.g. Australian Government) on the changes (improvements) to Country that have occurred through the management actions of the ES Unit and CM team.

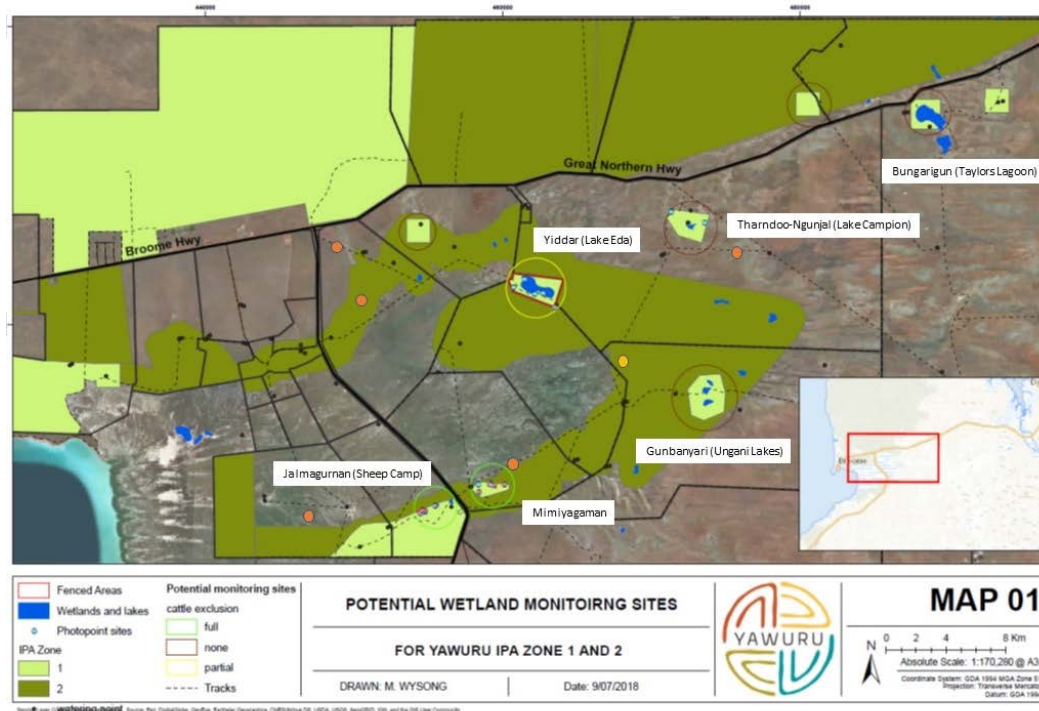


Figure 4-1. Indigenous Protected Area (IPA) wetlands, IPA zones and fencing.

4.1.2 Collaborations to assist with caring for Roebuck Plains

To inform the IPA plan, and to help NBY develop their monitoring and management activities, Yawuru CMs and TOs have actively collaborated on research projects on *bilarra* and the surrounding Roebuck Plains.

NBY have commissioned or assisted on a number of projects focused on a western science perspective of how *bilarra* and the Roebuck Plains function. Over many years, Vic Semeniuk (Semeniuk and Semeniuk 2014; Semeniuk, 2011), with the collaboration and assistance of Yawuru TOs and CMs, have studied the landforms, sediments, hydrology, wetlands, springs, and plant communities of Roebuck Plains. This work led to the CMs being trained in techniques that measure the water level and water quality at wetlands and the commencement of a groundwater monitoring program. In partnership the CMs installed over 30 piezometers across the wetlands to monitor groundwater levels and movement monthly.

The purpose of this monitoring is to ensure changes can be identified early, preventing damage to significant cultural and ecological sites and values (groundwater dependent ecosystems such as springs, wetlands) due to land use changes in the catchment.

In 2018, NBY organised for a hydrogeologist from the Western Australian Department of Water and Environmental Regulation (DWER) to spend time with NBY staff and as part of this partnership a review of this piezometer data was conducted to provide recommendations for this groundwater monitoring program (Searle 2019). The recommendations from this report were summarised (NBY 2020) and the analysis was updated by Strike (2021) who also assessed whether the current monitoring program will provide enough information to meet Yawuru's IPA objectives. These reviews were both used to update and improve the piezometer monitoring program.

More recently, the CMs have worked with DWER to undertake research on several springs thought to be dependent on groundwater (DWER 2019). This study aims to identify potential groundwater-dependent ecosystems (GDEs) on Yawuru Country within the La Grange study area and the sources of water they are likely to be accessing. This information is necessary to determine if changes due to groundwater use are likely to impact wetland health. The research builds on work undertaken by Vic Semeniuk and the CMs (Semeniuk and Semeniuk 2014) and focuses on potential GDEs of high ecological and cultural value including *Murruga yirr garnburr* (paperbark zone), *Mimiyagaman* and Ram Paddock. As part of their licence requirements for centre pivot irrigation, NBY are also investigating how to best monitor to ensure that the use of water for this licence doesn't impact on the surrounding aquifer and *bilarra*.

NBY has a mapping partnership with the Australian National University (ANU) that helps Yawuru better understand Country and improve land use decision-making (Mathews et al. 2018). Vernes and Mathews (2013) mapped the various pastoral, ecological and cultural values and uses of the area (from existing data sets and reports such as the Cultural Management Plan) to identify common values and assist with management. As mentioned previously (in Section 2.3.3) Gardner (2014) and Mathews and Doran (cited in IPA plan: Yawuru RNTBC 2016) also mapped information obtained from TOs through a land use project which highlights the ongoing hunting activities and the link between valuable hunted species and wetlands.

NBY have undertaken partnerships and built relationships to expand their knowledge on the animals present at *bilarra*. They have worked closely with the Broome Bird Observatory staff who have provided advice and recommendations on bird species, numbers and concerns at key wetlands (*i.e.* see Hassle 2015). Yawuru CMs and TOs have also collaborated through the UWA and DWER Waterways Education Program to understand threats and generate baseline data for wetlands and springs located on the Roebuck Plains (Dobbs et al. 2013) and with DBCA to undertake biodiversity sampling at key sites including *Nimalarragan* (Pinder et al. 2019).

Various projects have been commissioned by NBY to assist with the management of the Plains from a sustainable cattle grazing perspective. Leading up to the transfer of Roebuck Station to NBY, NBY commissioned Willing (2012) to undertake a review of the Station's operations. This review had a cultural and environmental focus and concentrated on the wetlands and biodiversity of the pastoral lease. In 2015, Yawuru supported the development of an Ecologically Sustainable Rangelands Management (ESRM) plan for Roebuck Plains

station with the aim to continue commercial cattle production in a manner that minimised impact on areas of high cultural and ecological significance (Biota 2015). This report provided best practice grazing and environmental management advice to guide the development of the IPA plan. In 2015, NBY also commissioned UWA to undertake a review of *bilarra* and cattle impacts to support the expansion of wetland fencing activities by the CMs and provide recommendations on how they could proceed with a wetland monitoring program (Tingle et al, 2017).

This NESP monitoring project provides the next step in this process, collaboratively developing a *bilarra* monitoring program to assess and support management of *bilarra* and sustainable grazing on the IPA. Figure 4-2 shows the timeline of the research and work detailed above which has provided an important foundation for development of the *bilarra* monitoring program.

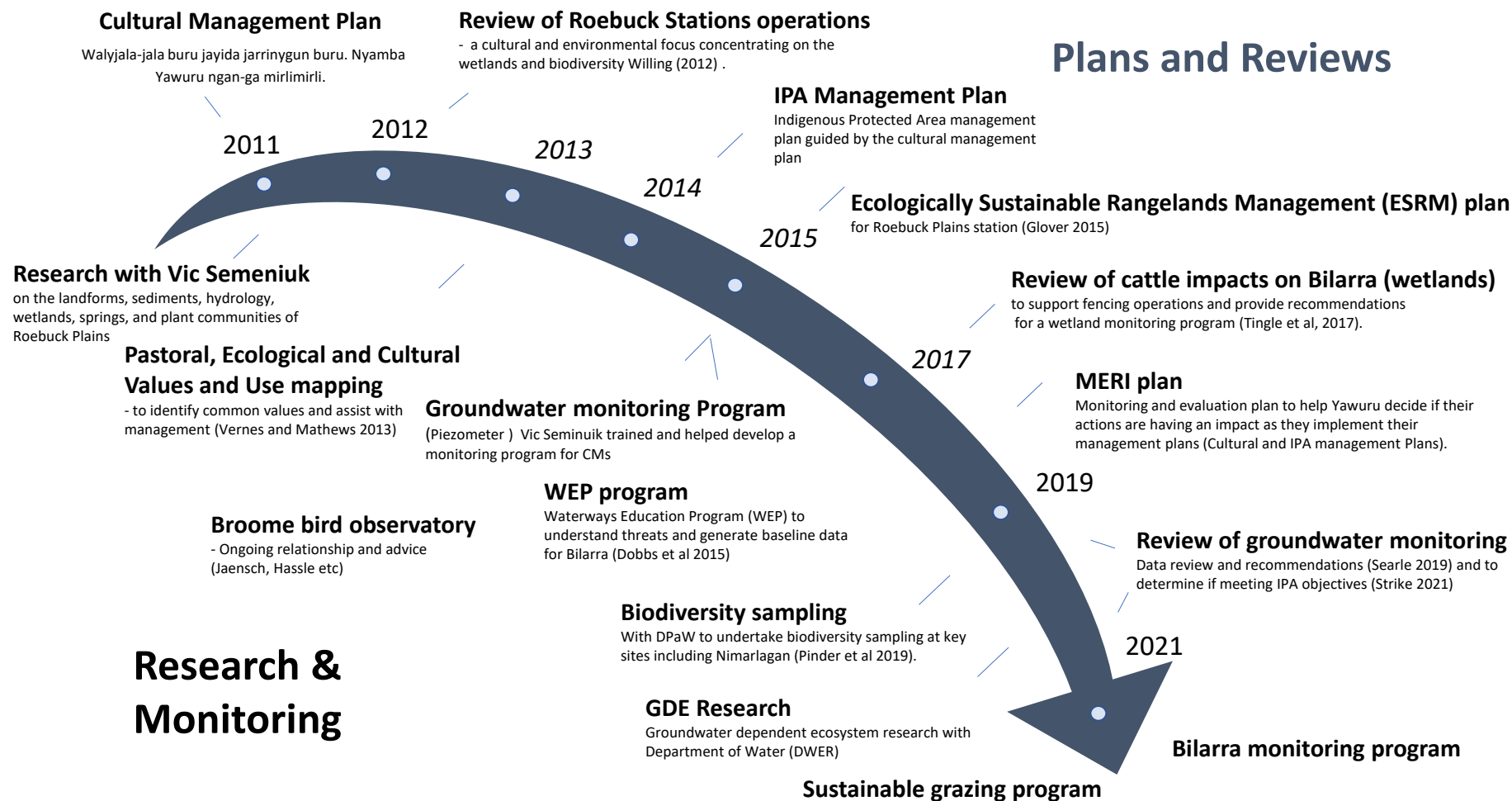


Figure 4-2. Timeline of plans, reviews, research and monitoring to assist with caring for Roebuck Plains – all guided by the Cultural Management Plan and providing an important foundation for the bilarra monitoring program.

4.1.3 Management and monitoring of *bilarra*

4.1.3.1 Two-tier approach

To manage and improve the condition of wetlands on Roebuck Plains, Semeniuk and Semeniuk (2014) advise that the Plains should be thought of as a single unit in terms of human culture, lifeforms (plants and animals), and ecology. They advise this because the Plains are highly integrated (connected) from east to west and north to south. They recommend a two-tier approach to the care or management of Roebuck Plains and its wetlands. The first tier is about managing the whole of Roebuck Plains by maintaining water flow (surface and groundwater) and preventing erosion of pindan sands onto the carbonate mud flat. Preventing erosion requires protecting the vegetation surrounding the plains by avoiding over-clearing or over-grazing. The second tier is about management of individual sites (wetlands) according to each site's geological, hydrological (water flow) or plant-related issues (Semeniuk and Semeniuk, 2014).

This two-tier approach is consistent with the way Yawuru people understand the Plains. Yawuru people recognise important sites or places (wetlands) and trails across the Plains that arise from the *Bugarrigarra*, link to the history of Yawuru ancestors, and continue to be significant places today. Yawuru people also recognise the interconnectedness of everything that exists on, underneath and around the Plains. For example, the relationship of groundwater to springs and the dependency of animal populations like goanna to the plants surrounding *bilarra* (known as the riparian zone) and habitats including surface water (*bilarra and jila*) as well as the *Murruga yirr garnburr* (paperbarks) habitat that fringes the *bundu* (saline grasslands and flats of Roebuck Plains).

Yawuru TOs have endorsed the two-tier system of management by incorporating it within the NBY Cultural Management and IPA Plan, and the Yawuru CMs implement this system of two-tier management (as described below and summarised in Figure 4-3).

4.1.3.2 On-ground monitoring and management of *bilarra* and associated habitats

Over the last six years, the ES team (which includes the CMs) have carried out activities to monitor and manage *bilarra* with both a site/place focus (on individual wetlands) and a plains/landscape focus. The CM's activities follow recommendations (strategies and actions) outlined in the IPA plan and detailed in the MERI reporting process, and include wildfire prevention, invasive species management, zoning, and landscape scale monitoring.

Preventing damaging wildfires is a key activity of the CMs. The NBY ES unit, works with the Roebuck Plains Station management, DBCA and Department of Fire and Emergency Services to undertake landscape scale management of fire to reduce large wild-fires and protect vegetation. This fire management includes an annual program of prescribed aerial and ground burning in designated areas across the Yawuru IPA, and wildfire suppression as needed when unmanaged fires do occur.

Cats, dingoes, and, in the near future, cane toads, are invasive species that present a risk to important native species across Roebuck Plains. The CMs are involved in several projects to help manage these invasive species. Related projects include cane toad and goanna monitoring in partnership with the University of Sydney, camera trap studies through Rangelands NRM to monitor predators, and investigations into trapping and removal of predators (feral cats and dingoes) across the IPA.

The CMs also conduct or help with a range of monitoring projects that extend across the whole Plain. Each landscape-scale monitoring project helps to build knowledge about the Plains as a whole and provides information on if the Plains are improving in condition or declining. The landscape scale monitoring activities include gathering data on weather, groundwater levels, plant condition, stocking levels and fire activity.

Understanding the groundwater under the Roebuck Plains is key to deciding how much water can be extracted for pastoral activities and other industry, without taking so much that dependent *bilarra* and associated habitat and species (plants and animals) start to decline. One way to better understand groundwater is by using piezometers, which are bores used to monitor regional groundwater levels. Piezometers measure depth from the ground surface to the water table and also the quality of water. The CMs have been trained in how to accurately install and monitor piezometers and maintain 40 piezometers to monitor groundwater movement and quality through different substrate (ground) types including pindan, saltmarsh and *bilarra* across the Roebuck Plains Station. The CMs have expanded this monitoring with DWER to include plants and surface water quality at a number of sites which are thought to be dependent on groundwater (groundwater dependent ecosystems (GDEs)). This monitoring has started to deliver data which will help to understand the connection between ecologically and culturally important habitats (such as *bilarra* and *monsoon vine thickets*) and the regional Broome Sandstone aquifer. The purpose of this monitoring is to ensure that any changes to these habitats can be identified early, preventing damage to significant cultural and ecological sites.

Through their research with Yawuru TOs, Semeniuk (2014) found that the condition of plants across most of the Plains had declined in the decade prior to this research. NBY wish to know how best to graze cattle so that the condition of plants across the Plains can be improved and maintained (sustainable grazing). To inform these decisions, using a 2019 grant from the State NRM program, the ES Unit installed 24 small (100 m X 50 m) fenced grazing exclusion plots across three key habitat types; *bundurrbundurr* (pindan), *murruga yirr garnburr* (paperbark), and the marine plain. The CMs monitor these plots to compare ground and plant condition inside the fences (not grazed) to outside the fences (grazed) and TOs and CMs assess the health of Country based on Yawuru values. As explained in Section 4.1, NBY have developed a system of zoning to assist with sustainable grazing across the Yawuru pastoral lease. The plan identifies high priority areas on Roebuck Plains station (Zone 1), that require protection from cattle and buffer zones (Zone 2) where pastoral activities are closely monitored for their impact on natural and cultural values. The fences have been set up across different management zones to also inform Yawuru's sustainable grazing management approach.

The CMs have assisted with Rangelands Condition Monitoring (RCM), undertaken on the Roebuck Plains Station by Department of Primary Industries and Regional Development's (DPIRD's) Agriculture and Food division. This contributes to a regional assessment of pastoral rangeland condition and involves yearly monitoring including site photographs, vegetation assessments (recording percentage of key pastoral species), recent stocking and fire history.

Through each of these monitoring projects the CMs are gathering data to learn more about the ecology of Roebuck Plains and to know how landscape-scale factors (especially groundwater use, grazing activities, pests and fire) can best be managed to improve or maintain the condition of the ground surface and plants across the whole Plains.

In addition to this landscape-scale work, the CMs carry out monitoring and management of individual *bilarra*. Most *bilarra* and *jila* are considered high priority, recognised for their cultural and natural values, and are contained within Zone 1. CMs have therefore fenced several culturally important *bilarra* (see Section 6) to protect them from cattle. Some of the wetlands are fenced to completely exclude cattle whereas some include gates or access points that can allow cattle to be rotationally grazed within a sustainable grazing regime. The CMs monitor groundwater and changes at individual wetlands through piezometers and photo point monitoring.

4.1.4 Expanding *bilarra* monitoring through this project

The monitoring and management carried out by the CMs on Roebuck Plains focuses on:

- Learning more about groundwater including how it behaves across/under the whole Plains area, and how it is connected to *bilarra* and wetland plants;
- Tackling threats especially fires and invasive animals; and
- providing an overall picture of landscape condition.

With a commitment to sustainable grazing practices and a significant investment in fencing (Zone 1 IPA sites), the NBY wanted to expand their monitoring to understand if this fencing and the grazing regimes outlined in their IPA plan are improving the condition of *bilarra* and the surrounding vegetation. Accordingly, NBY ES unit and the CMs established a partnership with NESP to create a site-based *bilarra* monitoring program. Yawuru wanted this program to be informed by existing and past work, meet current information needs, and that embraced both Yawuru and University knowledge of wetlands. Section 5 describes the development of this *bilarra* monitoring program.

The NAERH NESP project builds on this work by expanding individual *bilarra* (site) monitoring to help the CMs assess how well their management actions are protecting *bilarra*. As the CMs are undertaking several monitoring and research projects at *bilarra*, a poster was made under the NAER NESP project to summarise these monitoring activities across the Plains. This poster helps to show how the NESP project supports existing monitoring activities and summarise how the monitoring is building knowledge of *bilarra* and informing management by the CMs (Figure 4-3).

Roebuck Plains – Yawuru monitoring to inform management of *Bilarra*

Looking after *Bilarra*

Yawuru Country Managers look after *Bilarra* in different ways, following recommendations written in the Yawuru IPA Plan. The Country Managers help to look after *Bilarra* places/sites as well as Roebuck Plains as a whole landscape. Managing both wetland places and the whole landscape follows the two-tier system of management recommended by researcher Vic Semeniuk, and also follows Yawuru knowledge of how *Bilarra*, the Plains and Roebuck Bay are all interconnected.

The Country Managers do wetland monitoring to find out more about *Bilarra* and to know whether their management actions are working. The *Bilarra* chosen for monitoring cover different types of wetlands including permanent *jila* (springs) and semi-permanent lakes (as detailed by Semeniuk's work with the Country Managers and summarised by Pius Gregory below). The information collected from monitoring will help the Country Managers and NBY to decide how cattle can graze without damaging *Bilarra* (called sustainable grazing).

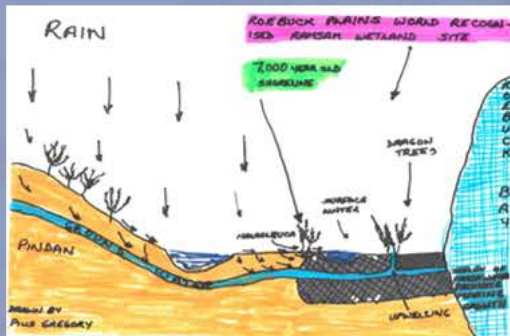


Diagram showing how different *Bilarra* form on the Roebuck Plains by Pius Gregory

Checking on *Bilarra* (monitoring)

- **Monitoring transects** -The Country Managers have set up transects to check on plants, the ground surface and water quality around *Bilarra*. The six *Bilarra* chosen include both *jila* and lakes, some that have been fenced to keep cattle out and some still have cattle. The monitoring will help to show if the plants and ground surface are different around *Bilarra* that are fenced compared to *Bilarra* that are not fenced.
- **Photopoints** The Country Managers take photos at the *Bilarra* in different seasons to help show how they change across seasons, after fire and changes in cattle numbers.
- **Monitoring groundwater (piezometers)** – The Country Managers measure groundwater levels using piezometers (shallow bores) at individual *Bilarra*. This helps to understand how *Bilarra* are linked to groundwater and avoid any impacts on these *Bilarra* from groundwater use.

Checking on Roebuck Plains (research and monitoring)

- **Monitoring fenced plots** – The Country Managers have fenced 24 small (100m X 50m) plots to see what happens when cattle are completely kept out. The 24 plots are in three habitat types; *bundurrbundurr* (pindan), *murrja yirr garnburr* (paperbark), and the marine plain. The Country Managers measure plants and groundwater surface both inside and outside the plots, to show what happens when cattle are removed. The information collected will be combined with the *Bilarra* monitoring information to help NBY know how to graze cattle and look after *Bilarra* at the same time.
- **Photopoints** – The Country Managers also take photos in different vegetation zones across Roebuck Plains to help show how they change across seasons, with fire and with different cattle numbers.
- **Monitoring Groundwater (piezometers)** - The Country Managers also monitor groundwater movement across the Plains through different substrate types including pindan, saltmarsh and wetlands to avoid any negative impacts to from groundwater use.



Map Image: Google © 2021 CNES/Airbus

Learning more about *Bilarra* (research)

The Country Managers are working with the WA Department of Water (DWER) to learn more about *jila* (springs) that connect to (and are dependent on) groundwater. The research will help to show how the springs are connected to groundwater and how groundwater use can happen without damaging the springs. The research will also help NBY with its own monitoring - as part of NBY's groundwater licence requirements for centre-pivot irrigation, NBY monitor to ensure the groundwater extraction doesn't affect nearby *Bilarra*.



Northern Environmental Science Program

Figure 4-3. Poster developed summarising the management and monitoring that the Country Managers are undertaking on Roebuck Plains in relation to *bilarra*.

5. Developing a *bilarra* monitoring program for the Yawuru Indigenous Protected Area

5.1 Background

In 2018 NBY engaged NAERH NESP researchers to collaboratively develop a *bilarra* monitoring program. NBY wanted a scientifically sound program that would build on Yawuru's past work, address current information needs and facilitate adaptive management (when management is improved by learning from management outcomes and adapting/changing management actions if necessary). This section describes how the CMs worked with NESP researchers to develop this monitoring program.

5.2 Project approach and goals (summary)

The initial goals of the project were to support Yawuru to assess their cattle grazing strategies at wetlands (so that the CMs know whether their management actions are working) and to inform ongoing management of wetlands and sustainable grazing protocols for the IPA.

At the beginning of the project NESP researchers were invited onto the Yawuru TAG joining NBY staff, TOs and CMs. This group was set up by Yawuru to help implement their IPA monitoring and evaluation plan (MERI). This helped to ensure that the *bilarra* monitoring program supported Yawuru monitoring and reporting needs.

The MERI plan identified the Kimberley Wetland Assessment tool (KWAT) as a tool that could be used to monitor Zone 1 IPA sites, as it had already undergone extensive trialling for northern Australian wetlands and was designed for implementation by Indigenous groups (Dobbs et al 2016). NESP researchers therefore supported the CMs to trial and adapt this wetland monitoring protocol. Importantly, the monitoring protocol was adapted to meet the information needs of the CMs and was also shaped by Yawuru knowledge of *bilarra* ecology and values.

The four-year project involved a Multiple Evidence Base (MEB) approach (see Tengö 2014), which sees different sources of information, like Indigenous (Yawuru) and University-based science, as all validly contributing to understanding the natural environment, in this case, wetlands. The project followed or was aligned with recent collaborative research and monitoring approaches developed in the Kimberley (see Dobbs et al 2017; Lincoln et al 2017; Austin et al 2019; Pyke et al 2018). A key part of the project was ongoing knowledge-sharing between the Yawuru staff and the NESP researchers, and a commitment to collaboratively adapt and refine the monitoring protocol to address Yawuru management needs.

Throughout the project, NESP researchers learnt about Yawuru connections to, and understanding of, *bilarra* and the Roebuck Plains. CMs shared information with the researchers during on-Country trips and workshops, and researchers' reviewed literature about Yawuru people's cultural connections to *bilarra*. This helped the NESP researchers to identify how Yawuru aspirations and knowledge could shape the monitoring. The NESP researchers also shared knowledge to enable the CMs to engage with the scientific process

of adapting the monitoring protocol. This supported the CMs to identify both broad and site-level research questions, and modify what data was collected and from where.

This knowledge-sharing was important to identify (or confirm) Yawuru research needs and objectives and refine the monitoring program accordingly. The ultimate goals for the *bilarra* monitoring project were to:

- Record the condition of *bilarra*, especially changes in condition over time;
- Gather data to show if CMs' management actions are having their desired outcomes;
- Provide data that can help generate sustainable grazing regimes;
- Be underpinned by sound Yawuru and University science-based knowledge of *bilarra* and the Roebuck Plains;
- Involve monitoring techniques that are sound but practical for land managers in remote localities to carry out.
- develop tools that display visually the results of the monitoring program that communicate whether *bilarra* condition has improved or declined, and that can be shared with the Yawuru community and other stakeholders.

5.3 The monitoring method

There are a variety of ecological science sampling techniques commonly used to sample freshwater habitats in northern Australia, however many of these require expert knowledge, expensive and highly technical equipment and/or costly offsite processing of samples, all factors which make them impractical for regular use by land managers in remote localities (as evident in TRaCK CSIRO trials, (Finn et al, 2012) and WEP trials, (Dobbs et al 2013)). Monitoring freshwater indicators such as aquatic biota (fish and macroinvertebrate) is resource intensive, requiring specialist skills and detailed analysis, and research suggests that resources are better allocated to monitoring feral animal populations (pressure indicator) or possibly a single stressor (e.g. physical disturbance along river banks) (Dixon et al 2010; Townsend et al 2013).

The Kimberley Wetland Application tool (KWAT) was identified as a tool that Yawuru could adapt to monitor the wetlands on the Roebuck Plains (MERI report, Tingle et al 2015). KWAT was developed specifically for Indigenous land managers in the Kimberley and was adapted from other work in northern Australia (see Dixon *et al.* 2006). The KWAT is a rapid monitoring tool for monitoring the riparian zone which is the land that adjoins, or directly influences, a body of water (Price & Lovett 2002), including the riverbank, floodplain, and the edge of wetlands.

Riparian zones are vulnerable to many of the issues and disturbances identified as being common across the Kimberley (and northern Australia), including weed invasion, groundwater use, feral animals, fire, overgrazing and erosion (Close et al 2012). As many of the CMs management activities are focused on these site-level disturbances, on-ground assessment of riparian zones was considered a good focus for the monitoring plan. Assessing riparian zones would also capture the condition of plants recognised as important by both Yawuru people and from an ecological science perspective. The plants along the edge of a wetland, for example, can provide food and shelter to important animals, and prevent erosion of soils (Figure 5-1). An example from the IPA plan notes:

Dense stands of *murruga yirr garnburr* provide important habitat for insects, birds and animals, including goanna populations that are particularly hunted in Marrul season when they are fat (Yawuru RNTBC 2016: 55).

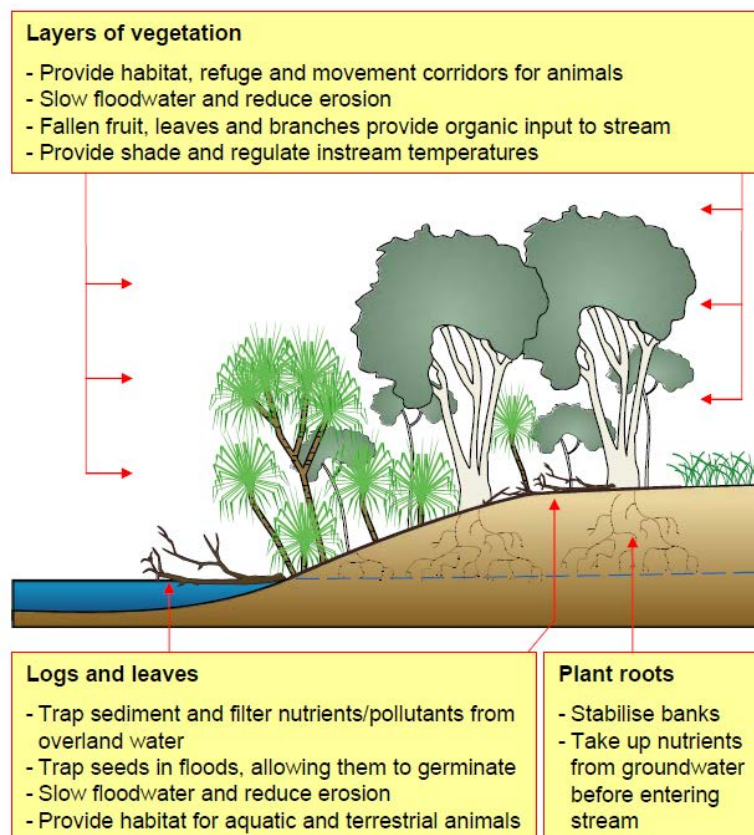


Figure 5-1. The importance of riparian vegetation (plants alongside wetlands) from (Dixon et al 2006 page 5).

5.3.1 Developing and refining the monitoring method

Together with the NESP researchers, the Yawuru CMs adapted the Kimberley Wetland Assessment Tool (Dobbs et al 2016) to meet their information needs and to incorporate Yawuru knowledge.

The riparian monitoring (also called bank assessment) uses a standard 100 m transect (line) running parallel to the wetland. The entire assessment is a visual measure of features (indicators) in and around the riparian zone (along the transect line) that indicate good or poor condition (see Table 5-1 for a list of indicators measured). Indicators are recorded within three 5 X 5m transects located 50m apart, with some indicators recorded looking back along the 100m transect (Figure 5-2a). A second transect runs from the edge of the 100m transect into the wetland to measure the transition zone between the riparian zone and surface water as this zone contains aquatic plants that are often trampled and affected by cattle (Figure 5-2b).

Multiple transects were located at each *bilarra*. The location of these transects were chosen by the CMs to include areas of concern (for example that were being eroded or had trees that appeared unhealthy) or to capture culturally important species, for example *lardig* (freshwater mangroves) at Lake Campion.

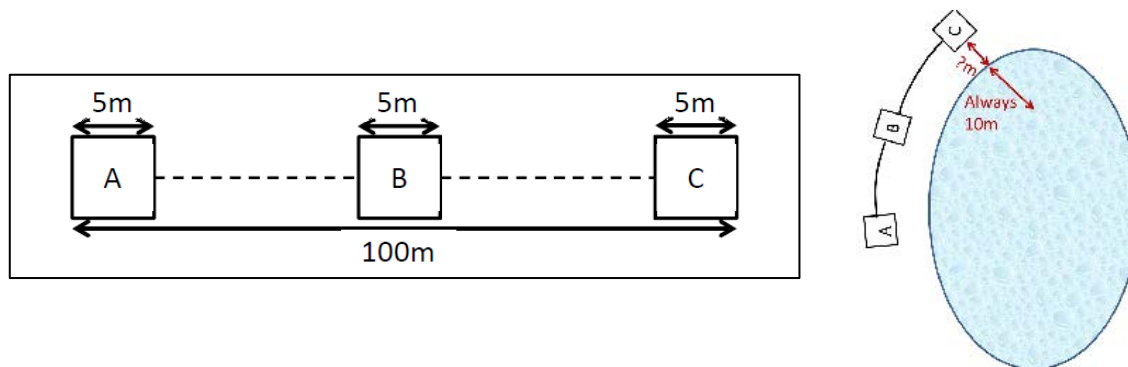


Figure 5-2. (a) Layout of the 100-m riparian transect and three 5-m quadrats and (b) layout of the transition zone transect.

Over the four years of the project (between 2018 and 2021), there were multiple project steps that saw the monitoring program gradually adapted to the Yawuru context. These steps included on-Country trips, collaborative field trials of the monitoring protocol, reviews of project progress, interviews with Yawuru knowledge holders, workshops, mapping exercises, and training sessions on specific monitoring techniques involving Yawuru CMs, staff from the Yawuru ES unit and NESP researchers.

Table 5-1 provides information on which indicators were eventually chosen for the monitoring program, how they can be impacted by cattle (from Tingle et al 2017) and how measuring these indicators helps to address Yawuru values and concerns for *bilarra*. Although indicators of riparian health were originally selected from a western science perspective, the monitoring transects capture information that relates to ways that Yawuru people define the health of wetlands for example:

- abundance and condition of native plants (including water plants, grasses, shrubs, and trees, and including those species that are culturally important)
- vegetation change over time (including the health of trees)
- amount and types of weeds present
- recruitment of trees (showing if new young trees are growing to replace older trees).

Some indicators were removed from the original program as they were not relevant, and others were added (Table 5-1). For example, the CMs chose to include a *Liyen* score for each site which allows the CMs to consider more than just the physical changes at a site but also how are these changes related to values, rights, responsibilities, and use.

The monitoring program is designed so that the indicators measured in the field can be summarised. Multiple indicators contribute to a score for the health of vegetation at each site including; Plant cover, regeneration (new plant growth) and weeds (Table 5-1). Pressures to the riparian vegetation are also scored including; cattle, fire and ferals, all of which the CMs are actively managing (see Dixon et al 2006 for details on how these are calculated). Photo points have also been included along the transect (at A, B and C) and into the water to help the CMs when reporting back on changes.

Although the riparian health indicators are slow to change and will only require monitoring once every few years in the future, the CMs wanted to start by monitoring twice a year during *Marrul* and *Laja* (early and late dry season sampling) to get a good understanding of seasonal change and practice and consolidate their use of the monitoring technique.

Table 5-1. Summary of the indicators and scores recorded in the monitoring program and justification for inclusion.

General categories	Information recorded	Why they have been included in the monitoring program
General information	Site name People present Yawuru season	<ul style="list-style-type: none"> Cattle impacts are more visible in the late dry season when cattle gather around <i>bilarra</i> CMs were interested in seasonal changes and undertaking cross seasonal field assessments (as recommended by the Yawuru MERI report). CMs monitor during <i>Marrul</i> (the early dry) and <i>Laja</i> (late dry)
Liyán (score)	How the CMs feel about a site	<ul style="list-style-type: none"> allows the CMs to consider more than just the physical changes at a site but also how are these changes related to values, rights, responsibilities and use of sites.
Plant cover (score)	Canopy continuity Canopy health Bare ground Ground cover Midstory cover Tree cover Leaf litter	<ul style="list-style-type: none"> Cattle trampling can cause loss of leaf litter and plants through grazing and trampling which are important for preventing soil erosion (soil washed off the Plains and into <i>bilarra</i> or Roebuck Bay) Plants provide habitat and food for culturally important species including goanna, <i>barrgara</i> (bush turkey) and provide nesting for important bird species The location of transects have been chosen by CMs to include culturally important plants
Regeneration (score) (If new young trees are growing to replace older trees)	Juvenile tree Nos Tree trunk sizes Adult tree Nos Dominant tree species	<ul style="list-style-type: none"> Cattle can impact on tree establishment. Younger trees (saplings) are often eaten or trodden on and some tree species including Dragon trees are selectively grazed by cattle Transects cover culturally important species/habitat zones including Dragon trees, <i>murruga yirr garnburr</i> (Paperbarks) and <i>lardig</i> (Freshwater mangrove).
Weeds (Score)	Yawuru weeds of importance Other weed species	<ul style="list-style-type: none"> Cattle grazing can promote weeds (by creating open areas), but weeds can also increase once cattle are removed (as no longer grazed or trampled). CMs are interested in managing weeds at key <i>bilarra</i>
Pressures (score)	Cattle Fire Other impacts	<ul style="list-style-type: none"> Can be used to help with understanding sustainable grazing levels The vegetation or plants around the wetland have the potential to be impacted by other concerns from the Management plan including fire, feral animals, groundwater use, this score will help assess changes.
Water quality	Salinity (how salty) Turbidity (how clear)	<ul style="list-style-type: none"> Trampling of water by cattle disturbs soils, dislodges plants and increases the level of suspended soil in the water Alongside groundwater monitoring this information can help understand any impacts from cattle as well as groundwater use (which can affect salinity)
Water extent	Length, width, and depth of water	<ul style="list-style-type: none"> Cattle can cause a decline in plant cover which can alter the extent of water maintained in wetlands CMs want to test the assumption that there will be less surface water once cattle stop trampling (creating deeper areas) and once the plants and dragon trees return (and draw down the water levels). There are also concerns that some <i>bilarra</i> are getting shallower.

Changes	Any changes that the CMs notice at the site are recorded	<ul style="list-style-type: none"> • helps interpret any changes in scores (<i>Liyan</i>, Plant Cover, Regeneration, weeds etc) and if they are a result of cattle management • Prompts CMs to consider seasonal change and if these align with seasonal calendar and any new issues that they need to follow up
Water plants	Plant cover Type of plant	<ul style="list-style-type: none"> • Water Plants in the transition zone (the area between the riparian zone and surface water) can also be affected by trampling and grazing • Reeds around some springs are linked to important creation stories (see Section 6.2.2), and Country Mangers have noted a significant change at sites which they have documented and would like to monitor
Animals of importance	Feral animals present Native animals present	<ul style="list-style-type: none"> • This contributes to the CMs work on feral animals • Culturally important species use of the wetlands
Change in plants over time	Inventory of plant species	<ul style="list-style-type: none"> • Plants have been recorded at each site to determine the change in species composition across seasons and across time

The plants (riparian vegetation) around the lake have been chosen as an indicator of wetland health and the transects set up by the CMs aim to measure the changes to the wetland under different management scenarios, including levels of cattle grazing. The CMs don't have time to measure or monitor everything. Although the CMs are focussing on monitoring plants, the monitoring program recognises that wetland management for Yawuru is bigger than just riparian (edge of water) plants. Site management posters were designed to summarise the monitoring and management at each site and to demonstrate how the vegetation is linked to other priorities including culturally important species (see Section 6).

5.3.2 Reporting back the monitoring results to support both individual/site and landscape-scale management

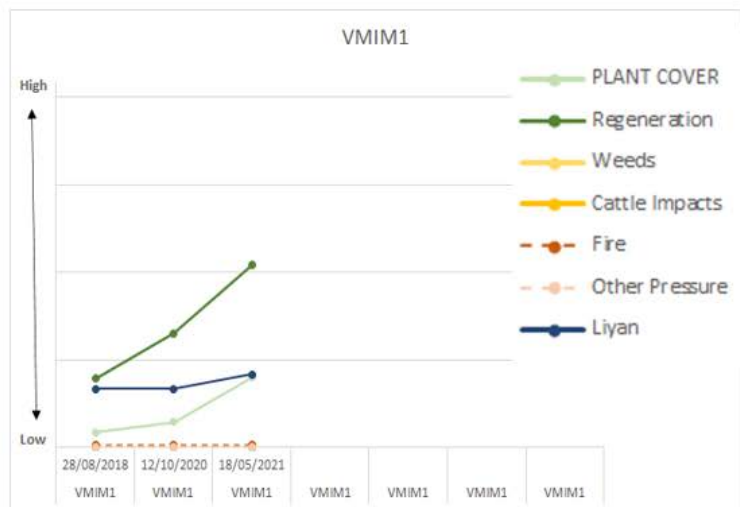
All monitoring needs to be looked at, reported on, and learnt from and therefore tools were codeveloped to assist CMs with this process. FULCRUM, a data collection tool that allows you to design custom forms and conduct field data collection on iPhone, iPad, and Android devices is the CMs preferred data collection tool. During the NESP NAERH project, CMs built their own FULCRUM form to directly link the monitoring to the Yawuru database. A simple graphing tool has also been designed so that site scores are automatically graphed. This allows CMs to detect change at a site over time and compare change in plants and groundcover against management actions, pressures that may have had an impact (including cattle, fire, groundwater use) and seasonal changes (including timing and extent of wet seasons).

A report card was developed to display some of the key information from the monitoring program. These report cards will be used to present the graphs and site information to the Cultural Advisory Committee, the MERI team, and the TAG. The Country Mangers wanted to use this report card to ensure that the ongoing monitoring and findings have input from TOs

(who can't always get out to sites) and that this information feeds back into the management of *bilarra* (see example provided Figure 5-3).

These graphs/report cards can be used to help make decisions about the health of springs and what levels of plant cover and regeneration that the CMs and TOs consider healthy. For example, although fenced sites at *Mimyagaman* are showing an increase in plant cover and regeneration (see example in Figure 5-3) the CMs have expressed concerns that the plants are starting to become overgrown which could limit access to the springs (and impact on their *Liyen* score for this site). The data from the transects will help Yawuru to set future optimal ranges of cover and help to set sustainable grazing levels at sites where cattle will have controlled access.

Although the monitoring program has only recently been finalised, Section 6 provides a summary of the last two years of monitoring data as well as how this information is already being used to inform management (i.e. adaptive management cycle).



2018 Early Dry Sampling



2020 Late Dry Sampling

Regeneration increasing with dragon trees filling Quadrat C of the transect



2021 Early Dry Sampling



Figure 5-3. An example of the report card developed for Mimiyagan to assist CMS with looking at and discussing results with the cultural advisory committee and station manager.

6. Specific *bilarra* cultural associations, history, ecological changes, monitoring results and management

6.1 Specific *bilarra*

This section provides information specific to the *bilarra* chosen by Yawuru as a focus for the IPA wetland monitoring. In addition to reviewing available literature, this section summarises knowledge provided by the CMs during field trips and workshops during the project. Unless otherwise stated all CM and TO knowledge was recorded during these trips and the name of the CM and the date of the trip have been provided (ie Pius Gregory 18th Nov 2020).

Different types of *bilarra* on the Roebuck Plains are represented including Springs, Soaks and Lakes (see Section 3.3) with a range of management actions including those that are being actively managed or plan to be managed (including fencing and rotational grazing).

The section provides site specific information for each of these *bilarra* including:

- cultural associations
- CM monitoring and management
- change following management actions
- a summary of the information collected from the NESP *bilarra* monitoring program and how this is being used to inform site management

6.2 Soaks and springs in *Jalmagurnan* (Sheep Camp Paddock – Coomacop bore)



Figure 6-1. Mimyagaman western fenced enclosure 2019.

6.2.1 Background

Jalmagurnan or Sheep Camp Paddock (including Coomacop bore) is historically and culturally important to Yawuru people. 'Sheep Camp was one of the main Yawuru living areas until the 1960s' (IPA Plan, p33). Associated with this area are significant wetlands

'...along the southern fringe of Roebuck Plains there is a series of culturally significant springs and ancient embayment's, surrounded by distinctive vegetation and containing many midden sites.' (IPA Plan, p33).

6.2.2 *Mimiyagaman, a powerful spring*

Mimiyagaman is a culturally powerful spring associated with a creator snake, or *jurru* (*yungurungu* in Nyikina). Paddy Roe, a Nyikina man who was born and grew up on the Roebuck Plains Station shares some of his knowledge about this place that is published in *Reading the Country* (Benterrak, Muecke and Roe, 1996), including about *Mimiyagaman*. For this book Paddy Roe took Krim Benterrak (an artist who created paintings of the places Paddy showed him), and Stephen Muecke around the Roebuck Plains, including to *Mimiyagaman*. Here is some of his knowledge that he shares about *Mimiyagaman* in the book.

As the three were approaching *Mimiyagaman*, Paddy was singing and Muecke notes (in a footnote) 'Sacred places are often approached with circumspection. The song is perhaps to let *Yungurugu* know that one is approaching' (p266).

Paddy Roe describes how *Mimiyagaman* is comprised of about seven springs, and the main spring never dries up. The springs don't have different names, '...it's all *Mimiyagaman*' he says (although below another name is given to one small spring). Paddy points out one 'boss' pool, and describes it:

'That's the boss, *Mimiyagaman*...that grass there that's his whatname. *Krim*: Beard. Belong to *yungurungu* snake...that's his beard you know that's him that's the last one well he's the boss of the springs... [and] if somebody break-im little bit leaves anything grass and take-im 'way, you know ooh big rain...No touching rain lightning bad you know bad lightning little cyclone always yeah' (Benterrak, Muecke & Roe 1996:95-96) (Also quoted IPA Plan, p61).

Paddy makes a comment about how *Mimiyagaman* has changed, how the grass should be high:

'But this one grass used to grow more high but too many cattle and horses eating it down you know but it should be very high so that's him' (Benterrak, Muecke & Roe 1996:96).

Paddy also describes one of the other springs and in a footnote Muecke notes that this one is called *Nilababa*. Paddy says:

'This is a little one he's covered with grass...This is his grass and he's covered with the grass this one bad little spring but good too good too save people they get water, rain good good rain no, no, no lightning or anything but good rain' (p98).

During a trip to monitor *Mimiyagaman*, Country Manager, Pius, shared a story about how this place is alive and active:

'My old uncle told me a story about this being a living place with a snake. If you make humbug here you might get chased away by a storm or rain. It's still lively here even though we are in the 2000s. If you make humbug around the springs then rain comes, when we were here with Vic the black cockatoos in the dragon trees were screeching and then it sounded like a Leer Jet went over and they stopped quiet. As we were leaving lightening nearly hit us. We got to Lake Champion and the rain followed us.' (Pius Gregory, NESP field trip 28 August 2018)

6.2.3 An important source of drinking water and habitat for food resources

The Yawuru CMs have described how *Mimiyagaman* was an important historical source of freshwater for drinking and how it continues to provide habitat and water for important hunting species. For example, Pius described evidence from middens that people lived around *Mimiyagaman* in the past:

'Old people used this place for water. We have been doing some archaeological work here to date the middens, but goannas digging has mixed up the shells making the dating hard'. (Pius Gregory, NESP field trip 28 August 2018)

'There are resident nail-tail wallaby's that hang around inside the fenced area as there is lots of good cover and grass' (Pius Gregory, NESP field trip 28 August 2018)

Mimiyagaman is associated with important food species like *barni* (goanna). Both Johani and Pius describe how the best goanna hunting is along the edges of melaleuca tree lines or around spring vegetation, including *Mimiyagaman*. *Barni/jarlangardi* (goanna) also use open water as described by Johani:

'*Barni* are always around water. When it dries up you'll find them around water and sometimes they jump into the water to hide, which makes it hard because then you can't hunt them'. (Johani Mamid, NESP field trip 28 August 2018)

In *Reading the Country* Paddy Roe pulls out a *barni* that has jumped into one of the springs at *Mimiyagaman* (with a photo, see page 97).

Pius described how, when he was young, he would go from Sheep Camp, walk along the melaleuca tree line hunting and then to the smaller *Mimiyagaman spring* (Pius Gregory, NESP field trip 28 August 2018)

6.2.4 Summary of ecological science and research at *Mimiyagaman*

The springs in *Jalmagurnan*, fall under the *Mimiyagaman* Wetland Suite defined by Semeniuk & Semeniuk (2014). Under this classification, *Mimiyagaman* is described as 'mound springs and medium scale sumplands, plain underlain by mud and calcrete' and describe the vegetation: Shallow large scale sumplands, which occur near the southern boundary of Roebuck Plain, are either unvegetated or colonised by annual grasses and weeds. Springs are identified by *Sesbania formosa*, [Dragon trees] either as single trees or in copses (Semeniuk and Semeniuk 2014).

Pius explained how the springs are created from a scientific point of view, which he learnt from working with Vic Semeniuk. 'Springs bubble up as the water comes from the pindan and hits harder mud on the flats, with the water then forced under or over. The water forced under also breaks through where the springs are.' (Pius Gregory, NESP field trip 28th August 2018).

6.2.5 Historical condition and fencing

Pius described how the Roebuck Plains Station previously fenced some small springs over 20 years ago. Satellite photos reveal old fencing lines at three spring sites (Figure 6-2).



Figure 6-2. Satellite imagery from Google Earth showing old fencing: (a) (now) unfenced spring (2012), (b) western enclosure (2002) and (c) eastern enclosure (2002).

The fences appear to have not been maintained prior to the CMs' fencing activities with cattle present within the fence line in 2010 images. In 2012 Willing (2012) detailed that many small spring systems on the edge of Roebuck Plains are in ecological decline from both cattle impacts and groundwater changes. Remnant stands of [Dragon trees] *Sesbania formosa* trees show major bark damage and no active recruitment (Willing 2012).

In 2014, the localised area around Sheep Camp Bore (and other Bores including Chain Pump Bore and Jernicop), was assessed as severely degraded:

'Where the natural wetland has been excavated, groundwater is extracted, there are signs of erosion, excessive nutrient enrichment, severe algal growth, weeds > 50%, and loss of wetland plant species diversity due to altered hydrochemical conditions' (Semenuk and Semenuk 2014: Executive Summary).

Numerous weed species have been recorded invading the spring around Sheep Camp Bore (an uncapped bore located at the old homestead site). For example, Willing (2012) noted:

'Heavy infestations of the burr species *Cenchrus echinatus* and *Achyranthes aspera*, as well as Neem Tree (*Azadirachta indica*) were noted at Sheep Camp on a field trip of 4 June 2012'

6.2.6 Yawuru Country Manager management and monitoring

The main risks to these springs are extraction of water from the Broome Sandstone and Mowanjum aquifer and trampling and contamination of water by cattle, with the main objective being to conserve and protect the upwelling and freshwater discharge and the associated Dragon trees (Semenuk and Semenuk 2014). Following recommendations made by Semenuk and Semenuk (2014) and the ESRM plan (Biota 2015), the IPA Plan outlines how the area will be managed: 'By agreement between the Yawuru and the ILC, this will become a prime conservation area on the station. Fence enclosures will be renewed around three Dragon Tree (*Sesbania formosa*) springs; the most westerly enclosure will include the nearby sand-dune midden/s. Southern Sheep Camp paddock (south of the newly installed subdivision fence) will become a separate grazing unit, subject to sustainable grazing management. The overflow on Coomacop bore is located over an existing Dragon Tree spring. The ILC will maintain a stock-proof fence around this spring' (IPA Plan, p33).

In accordance with the IPA Plan the CMs have fenced two springs within Sheep Camp and removed cattle from these sites. The Yawuru CMs fenced *Mimiyagaman*, in 2013 and an additional fence was added in 2017, providing a wider buffer zone around the springs and protection of the nearby dune midden site (this fenced area is referred to as the westerly enclosure) (Figure 6-1, Figure 6-3). The CMs have also fenced a smaller spring site in *Jalmagurnan* in October 2017 (referred to as the easterly enclosure).

The CMs have set up piezometers and long-term photo-monitoring points at both enclosures and sample them quarterly. They have also set up research transects in collaboration with DWER to learn more about the link between the springs and groundwater. Following recommendations from their work with Vic Semeniuk, the CMs have set up information/education boards which detail the value of the area and take visitors to this site for cultural tours and to demonstrate their on-ground management and connection to wetlands.



6.2.7 Location of monitoring transects

At *Mimiyagaman*, three monitoring transects were set up in the western fenced enclosure and a fourth transect at a nearby unfenced spring fringed by *murruga yirr garnburr*. The transects are located to help to monitor plants of importance to Yawuru. This includes the dragon trees which are an indicator of spring sites, the native grass around the springs (the *jurru's/creator snake beard*) (see Section 2 and described in the Cultural Management Plan) and the *murruga yirr garnburr* zone (at the unfenced site). Monitoring transects have also been set up to follow springs with different fencing ages (that is springs that have had cattle excluded longer than others).

Mimiyagaman Soaks and Springs- In Jalmagurnan (Sheep Camp) Paddock

Mimiyagaman

Mimiyagaman is a culturally powerful spring associated with a creator snake, or *Jurru*. The native grass surrounding Mimiyagaman is the *Jurru's beard* (Yawuru IPA Management Plan).

The springs were an important historical source of drinking water, with nearby middens showing that Yawuru ancestors lived around *Mimiyagaman* in the past. The springs still provide habitat and water for important hunting species like *jarlangardi* (goanna) and *barrgara* (bush turkey) and support many types of birds. A resident nail-tail wallaby visits *Mimiyagaman* and lives in the nearby marsh area (5-10 km away).

Mimiyagaman is visited for cultural tours and to show how the Country Manager's actions to protect springs on Roebuck Plains are working.

Management

Mimiyagaman springs have been designated as high priority (Zone 1) in the IPA plan. Yawuru Country Managers have fenced two areas to exclude cattle - the springs were fenced in 2013 and then extended in 2017 to protect the nearby dune midden site. The Country Managers have also fenced a smaller spring site nearby (October 2017). Before fencing there were only a few mature *rirrwal* (dragon trees) left in the area, very little ground cover and the ground was dry and hard. Now *rirrwal* and grasses have grown back and lots of baby *rirrwal* are sprouting up. Cattle still have year-round access to the Zone 1 area surrounding the fences.

Some weed species have moved into the springs from the Pindan dunes, including *Calotropis*

Monitoring

The Country Managers monitor three transects twice a year to show how the springs change across seasons and years, with cattle excluded, and to assess future management actions (including fire). The transects cover the main spring, other open water springs the lie within the second fence, and the sedge area. There are also piezometers (shallow bores), long term photo point monitoring sites and the CM's also monitor water quality and plants with Department of Water.

Transect 1 (VMIM1)

Includes the sedges surrounding open springs

Plants around the springs provide habitat and a food source (e.g. insects, frogs) for different animals and birds, including *jarlangardi* (goanna), *Barrgara* (bush turkey) and finches

Transect 2 (VMIM2)

Includes the native grass (*Jurru's beard*) described by Paddy Roe (IPA Plan, p61) and *rirrwal* (dragon trees) which are an important indicator of spring sites

Transect 3 (VMIM3)

Includes an open spring with no trees

Vegetation (plant) Quadrats A B C Piezometers GW Photo points P



National Environmental Science Programme

Map Image: Google © 2021 CNES/Airbus

"All these little waterholes here, all these *Jilas* they were just dried and just hard, ... now there is water in there and that thing nice and dark green, you wouldn't see those trees in there they would have got treaded on, now they start to regrow these ones here are young ones, so that's what happened, revival of the place again"
Jimmy Edgar Yawuru Traditional Owner

A resident *garrabal* (Nail Tail Wallaby) lives in the nearby marshes



Figure 6-3. Summary poster for Mimiyagaman developed to assist with individual site monitoring and management.

6.2.8 Change following management actions (before transects put in place)

The CMs have seen significant changes at *Mimiyagaman* with the changes clearly demonstrating the benefits of cattle management and fencing. Pius described how before the fence was put in (Figure 6-4), *Mimiyagaman* was ‘...flogged by cattle. Today you can see a lot of difference. The cattle were eating the dragon trees as far as they could get their mouths, and the ground was all bare, it was a dust bowl.’ (Pius Gregory, NESP field trip 28th August 2018).



Figure 6-4. Photos showing cattle impacts within the main *Mimiyagaman* enclosure in 2012 (western enclosure) (photo D. Mathews).

Jimmy Edgar (Yawuru TO) also described the appearance of *Mimiyagaman* before the CMs put up the western enclosure fence (recounting to R. Dobbs at a Yawuru TAG meeting):

‘Oh, it was like trees were really dried up and dead and it just looked sickly. Now those trees are looking nice and lush

All these little waterholes here, all these *Jilas* they were just dried and just hard, because what we put in some of these areas, we put water monitoring things...it was hard drilling in there to get some samples ... the whole area was like rock, flat like on this side of the fence

and those trees were really dried up now there is water in there and that thing nice and dark green, you wouldn’t see those trees in there they would have got treaded on, now they start to regrow these ones here are young ones

so that’s what happened revival of the place again... there was only the four of us when we started doing this

this kind of thing gives you an idea of how if you take away the cattle and that and do it in the right manor then these type of areas can come back’.

Photo point monitoring at the western enclosure commenced after the main fence was in place. In 2014, cattle were able to access the site through a broken fence. Once fixed, the photos show how the groundcover inside the fence line recovered over the next three years (Figure 6-5). Photo points also show how the groundcover inside the fence line extension recovered over the first year (Figure 6-6).



Figure 6-5. Photo point PMIM1 showing groundcover recovery from Bargana (winter) 2015 to Bargana 2017 within the western Mimyagaman enclosure. The fence was erected in 2013, but cattle gained access to the fenced enclosure in 2014 and were then removed in 2015. First photo 2/7/2015, second photo 6/6/2017.



Figure 6-6. Photo point PMIM5 showing groundcover recovery from Bargana (winter) 2017 to Bargana 2018 in the extended fence at the western enclosure. This extension was erected in 2017. First photo 6/7/2017, second photo 15/5/2018.

Since the CMs completed the fence at the smaller (eastern) enclosure, juvenile *rirrwal* (dragon trees) have sprouted. Pius described that, ‘before fencing, the spring was just hard ground with a few older dragon trees’. Before, when Pius was young, ‘this spot had bigger dragon trees and a pool of water’ (Pius Gregory, NESP field trip August 2018). After the fence line was finalised in 2017, there was a significant decline in *rirrwal* trees, some of the older trees had died and fallen over in the floods/storms of summer 2017/2018 (Figure 6-7). Although this site is not monitored through the NESP project, fencing at this site has supported the recovery of trees at this site. When we visited the site in 2019 there is also a significant number of new *rirrwal* recruits at this site.

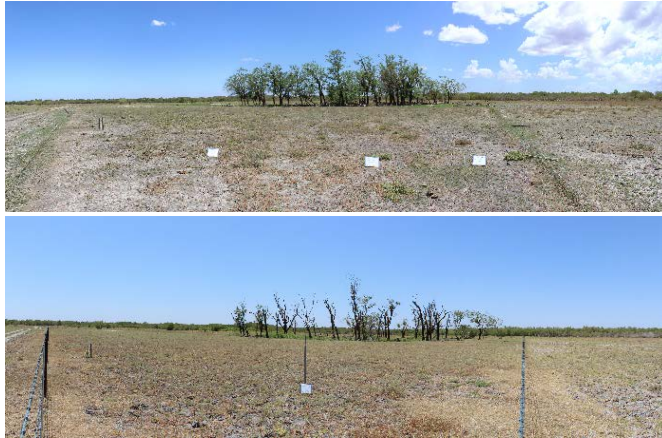


Figure 6-7. Photo point PMIM4 showing loss of Dragon trees following the 2017–18 flood. Photos taken 16/12/2015 and 20/10/2018.

During another fieldtrip day Pius recalled that ‘*Calotropis* is moving into *Mimiyagaman* (on the Pindan dunes), and the Country Managers should prioritise its eradication before it has expanded too much’ (Pius Gregory 18 June 2019).

The CMs noted that there is less surface water in the spring since the site has been fenced (only a small puddle at the base of a large tree). We discussed that as springs are vegetated with *rirrwal*, the water/springs may become smaller. Pius mentioned that *rirrwal* were an indicator of water and therefore may not have always been associated with surface water (Pius Gregory NESP field trip August 2018).

6.2.9 Information recorded from transects and how this is supporting management

Table 6-1 provides a summary of the last two years of monitoring data as well as how this information is already being used to inform management (i.e. an adaptive management cycle).

The data from the transects will help Yawuru to set future optimal ranges of cover and also improve fire management at the springs. Although fenced sites are showing an increase in plant cover and regeneration, the CMs have expressed concerns that the plants are starting to become overgrown which could limit access to the springs (Figure 6-8).

The monitoring is helping the CMs to record seasonal change with plant cover scores lower in the late dry season (when grasses die off) and the springs also become shallower and less clear (higher turbidity). The transects also show a number of weed species increasing around the springs including Birdwood grass, *Calotropis* and Wild Goosberry. Although not all of the species are actively managed by Yawuru, (that is weeds of Yawuru importance) the CMs have started removing weeds within the transects and want to add these fenced springs to their weed program.

Although cattle are currently excluded from the main enclosure, cattle still have year-round access to the Zone 1 area surrounding the springs including the unfenced spring nearby on the edge of the (paperbark) zone. Monitoring of the unfenced spring has shown very low levels of plant cover and regeneration and the water has been brackish (slightly salty) and muddy (high turbidity). The CMs have started conversations with the Yawuru ES unit about

how they can ensure the Zone 1 area (outside of the fenced springs) can be managed and the CMs are now considering fencing the unfenced spring as it is the only spring in the area not protected.



Figure 6-8. (a) Photopoint PMIM1 (May 2021) showing a significant increase in plant cover and regeneration compared to pre-transect photos (shown in Figure 6-5) and (b) unfenced spring at Mimiyagaman showing muddy (turbid) water, cattle trampling and areas of bare ground.

The area of open water at two of the springs has been declining in size (regardless of seasons), since the monitoring began. The main spring has been dry for the last two sampling events (late dry and early dry). Longer-term monitoring of the springs will reveal if this is a response to groundwater, rainfall or cattle exclusion. The CMs predict that once cattle stop trampling the spring (and creating deeper areas) and the plants and dragon trees return (and use water) the extent of surface water will continue to decline. If this decline continues then conversations will be initiated around whether Yawuru want to maintain some springs with surface water and what management actions, or rotational grazing is required for this to happen.

Table 6-1. Summary of monitoring results for Mimiyagaman.

General categories	Summary of monitoring changes	How this information is or will be used
<p>Water quality Salinity (how salty) Turbidity (how clear)</p>	<p>Fenced springs – fresh with clear water in the early dry season (low turbidity), becoming less clear in the late dry season (higher turbidity) Unfenced spring is brackish (slightly salty), and the water is muddy (high turbidity) both early and late in the dry season</p>	<p>CMs considering fencing unfenced spring. Longer-term monitoring will help to understand seasonal changes</p>
<p>Water extent Length, width, and depth of water</p>	<p>The surface water at two of the springs has been decreasing in size over the last three years.</p>	<p>Longer-term monitoring combined with the groundwater monitoring these changes will help to understand if these changes are a result of cattle exclusion. If it is cattle, then decisions will need to be made as to whether CMS and TOs want to have areas with open water.</p>
<p>Liyana (score) How the CMs feel about a site</p>	<p>The <i>Liyana</i> score for the fenced spring has remained high, while the <i>Liyana</i> score for the unfenced spring has remained low. CMs have noted that regrowth of vegetation could limit access to springs, affecting their <i>Liyana</i> score for this site if it (as it affects their connection to the site)</p>	<p>CMs considering future management actions including rotational grazing or late wet season burning if this becomes an issue</p>
<p>Plant cover (score)</p>	<p>Plant cover has been increasing at sites, with seasonal changes The springs in the more recently fenced area have shown the biggest changes with previously bare ground now covered with grasses and herbs</p>	<p>Fencing effective, plant cover recovering The plant cover score can be used to set levels for when access to springs is affecting <i>Liyana</i> and hence management actions described above are required</p>
<p>Regeneration (score) If new young trees are growing to replace older trees</p>	<p>The number of <i>rirrwal</i> (dragon trees) are increasing at this site. For example, in the first year of monitoring there was one juvenile <i>rirrwal</i> in the VMIM1 transect. Two years later baby <i>rirrwal</i> have filled a third of the transect (see an increase and photos in Figure 5-3). Acacia trees are now also sprouting around transect VMIM3 which had no new saplings when the monitoring started.</p>	<p>Fencing effective – plants regenerating With the seed bank of Dragon trees sufficient to colonise bare springs.</p>
<p>Weeds (score)</p>	<p>Weeds have been increasing at springs including Birdwood Grass and Caltrop.</p>	<p>CMs have been pulling out weeds, weed management may need to be prioritised at springs as this may be manageable at a site scale</p>
<p>Impacts Cattle</p>	<p>The springs haven't been burnt for a long time Cattle impacts</p>	<p>Fences maintained and effective</p>

Fire Other impacts	Cattle impacts are high at the unfenced spring	Although cattle are currently excluded from two spring areas, cattle still have year-round access to the Zone 1 area surrounding the springs.
Animals of importance	There was a large increase <i>barni</i> holes (and two <i>barni</i> were sighted) at the main spring in the early wet (2021)	Fencing effective, plant cover around the main spring providing good habitat, supporting culturally important species

6.3 Ram Paddock springs and middens



Figure 6-9. Ram Paddock spring in main fenced enclosure (August 2018).

6.3.1 Background

Ram Paddock contains '[s]prings of great cultural and ecological significance, which have been badly damaged by cattle' (IPA Plan, p33) (Figure 6-9).

6.3.2 A source of drinking water and habitat for food resources

Ram Paddock contains springs, ephemeral wetlands, and groundwater close to the surface. For example, at one site in Ram Paddock Pius notes 'there is no water bubbling up (no surface water), but people could have gotten water from digging' (Pius Gregory August 2018). The CMs noted that nearby, outside of the fenced area and within the tree line (pindan) there are midden sites indicating people lived here in the past and older people have talked about how they used to dig up water in the area. Yawuru people also hunt in this area.

6.3.3 Summary of ecological science and research at Ram Paddock

The springs in Ram Paddock, also fall under the Mimiyaqaman Wetland Suite defined by Semeniuk and Semeniuk (2014) and these springs along the southern shore are described as:

'...typified by scalloped margins of dune and tidal flat and clusters of springs at the periphery of the dunes. The springs comprise circular depressions within low-relief carbonate mounds.....The humic mud forming the surface of a mound is possibly the result of deposition of suspended sediment from the up-welling artesian groundwater. A small flow of artesian groundwater is evident at the surface.

Although the springs fall into the same grouping by Semeniuk, 'two of the depressions in Ram Paddock are located within a doline of calcreted calcilutite (Sandfire Calcilutite), but this is not universally the case' (Semeniuk and Semeniuk 2014).

6.3.4 Historical condition and fencing

As with Mimiyagaman, in 2012 Willing (2012) detailed that 'many small spring systems on the edge of Roebuck Plains are in ecological decline (major bark damage on Dragon Trees, no active recruitment and fencing not maintained) from both cattle impacts and groundwater changes' (Figure 6-10).



Figure 64: Trampling of groundwater spring by cattle



Figure 53: Copse of *Sesbania formosa* around spring

Figure 6-10. Wetland areas within the main enclosure and eastern enclosure (from Willing 2012).

Although some of the springs with Ram Paddock have previously been fenced by the station (Figure 6-11) these fences were not maintained when the pastoral station review (Willing 2014) and ESRM report were conducted (Biota 2015).



Figure 6-11. Satellite imagery from Google Earth showing the main Ram Paddock spring site: (a) fenced in 2002 and (b) fence not maintained with cattle tracks throughout the spring (2010).

6.3.5 Yawuru Country Manager management and monitoring

Under the ESRM plan it was proposed that the Ram Paddock Springs and Middens would be fenced off and rested from grazing (Biota 2015). The IPA plan proposed that 'Fence

enclosures to be renewed around three Dragon Tree (*Sesbania formosa*) springs in Ram Paddock, consistent with fence-lines of previous enclosures, and to be revegetated' (IPA Plan, p33).

In 2016 CMs fenced three dragon tree spring areas including one larger area (~200x600m) and two smaller spring sites (Figure 6-12). Yawuru have decided not to revegetate the area as *rirrwal* (Dragon trees) are beginning to colonise around the previously bare springs.

There are 7 piezometers located at *Ram Paddock* and the CMs sample them quarterly. The CMs have set up and monitor five photo-monitoring points and research transects in collaboration with DWER to learn more about the link between the springs and groundwater.

6.3.6 Location of monitoring transects

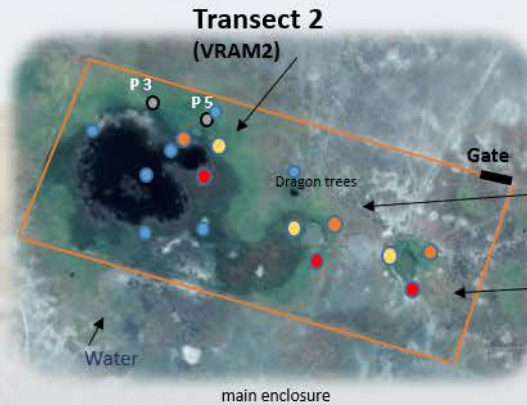
Four vegetation transects for the NESP monitoring project have been set up within the main fenced enclosure to monitor the changes around the open water springs following cattle exclusion.

Dragon Tree -Ram Paddock Springs/Soaks

Ram Paddock

Ram Paddock contains “[s]prings of great cultural and ecological significance, which have been badly damaged by cattle” (IPA Plan). Nearby, outside of the fenced area and within the tree line (pindan) there are midden sites indicating people lived here in the past.

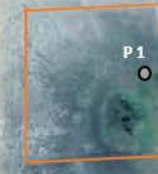
Before the fence the area was a “dust bowl, there was no grass”. Now different plant species cover the ground including grass and saltbush species. There was only one dragon tree before the fence but now dragon trees are growing around the open water. Pius Gregory Yawuru Traditional Owner



Large groups of Gudurrwarany (Brolga) have been recorded at these springs and soaks finding food in the grass

Transect 3 (VRAM3)

Transect 4 (VRAM4)



eastern enclosure

At this smaller fenced site “there is no longer water bubbling up (no surface water), but people could have gotten water from digging” Pius Gregory Yawuru Traditional Owner. This area had only several large dragon trees but now has hundreds of resprouting dragon trees

Dragon trees are an indicator of springs and groundwater close to the surface



Transect 1 (VRAM1)



Western enclosure

Management

The Country Managers fenced three spring areas including one larger area (~200x600m) and two smaller springs. In the past this area was known to have lots of dragon trees. Prior to fencing only one mature dragon tree was left in the area. The IPA Plan included a strategy to revegetate the fenced areas, but this has not been needed as the dragon trees have naturally grown back as they are protected from cattle by the fences.

Monitoring

Monitoring transects at Ram Paddock are being used to check changes to the ground surface and plant health over time as cattle are excluded from the area. Three vegetation transects have been set up within the larger fenced enclosure to monitor the changes around the open water springs. Two of these transects are on the edge of open water to monitor vegetation as it returns around these bare springs.

There are also seven piezometers and two photopoint monitoring sites located at Ram Paddock. The CMs also undertake research monitoring in the eastern enclosure with Department of Water.

Vegetation (plant) Quadrats A ● B ● C ● O ● Piezometers GW ● Photo points P ●



National Environmental Science Programme

Map Image: Google © 2021 CNES/Airbus

Figure 6-12. Summary poster for dragon tree (Ram Paddock) developed to assist with individual site monitoring and management.

6.3.7 Change following management actions (before transects put in place)

Within the main enclosure at RAM Paddock the CMs have noted that *rirrwal* are finally recruiting (new dragon trees starting to appear) 'Prior to the fencing there was only one dragon tree left. Now there are several patches where dragon trees are starting to regrow (Pius Gregory August 2018). The CMs also described how before the fence the area was a 'dust bowl, there was no grass'. Now different plant species cover the ground, with grass and saltbush species (Figure 6-13).

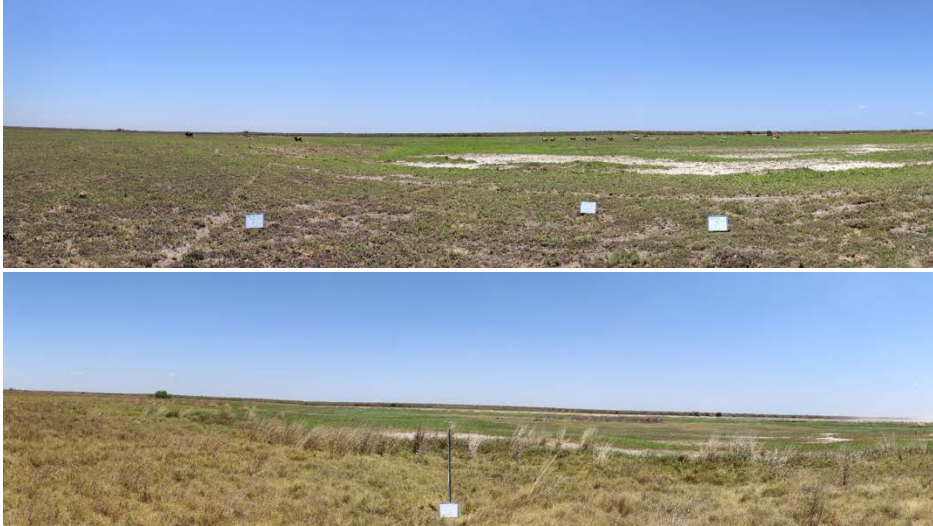


Figure 6-13. Photo point PRAM3 Dragon Tree Soak looking into middle of main fenced paddock (near VRAM 2). First photo 16/12/2015 cattle still in area, second photo 17/10/2017.

The eastern enclosure previously had only several large *rirrwal* but now has 'hundreds of resprouting *rirrwal* (Figure 6-14 and Figure 6-15).



Figure 6-14. Photos showing the difference within the eastern enclosure: a) 'senile *Sesbania formosa* trees on a degraded waterhole near Ram Paddock' (from Willing 2012) and (b) a photo taken while visiting this site on the NESP field trip August 2018 (Ram 1) showing the recruitment of *rirrwal* at this site following CM fencing.



Figure 6-15. Photo point PRAM1 showing dragon tree recovery at the eastern enclosure between 2015 and 2017. This site has been fenced we marked as a potential site but there was no water. First photo 16/12/2015, second photo 22/11/2016, third photo 17/20/2017.

6.3.8 Change recorded from transects and how this is supporting management

Table 6-2 provides a summary of the last two years of monitoring data as well as how this information is already being used to inform management (i.e. an adaptive management cycle).

Transect monitoring is starting to demonstrate the benefits from cattle management at this site, with transects showing an increase in plant cover and regeneration. The monitoring is helping the CMs to record seasonal change with springs being shallower and less clear (higher turbidity) in the late dry. Prior to setting up the monitoring transects, *rirrwal* were limited to a few patches within the fence line, *rirrwal* are now starting to colonise the bare springs where the transects are located.

There are currently no weed species recorded. This site is important for bird species and on one trip approximately a hundred *gudurrwarany* (brolgas) were feeding within the fence line. The foraging impacts around springs was recorded and will be considered when interpreting results and changes over the next monitoring events.

Table 6-2. Summary of monitoring results for Ram Paddock.

General categories	Summary of monitoring changes	How this information is or will be used
Water quality Salinity (how salty) Turbidity (how clear)	Springs fresh with clear water in the early dry season (low turbidity), becoming less clear in the late dry season (higher turbidity)	Longer-term monitoring will help to understand seasonal changes
Water extent Length, width, and depth of water	Changes in the extent of water following seasonal changes (wider and deeper in the early dry compared to the late dry)	Longer-term monitoring will help to understand seasonal changes and if the springs are following the same pattern as Mimyagaman (i.e. reducing in size as dragon trees colonise and plant cover increases)
Liyon (score) How the CMs feel about a site	The <i>Liyon</i> score at Ram Paddock has remained at a medium level	CMS are happy with the fencing of this area, but the springs are still bare and there are few dragon trees. Longer-term monitoring required before any additional management actions required.
Plant cover (score)	Plant cover has increased around the springs	Fencing effective, plant cover recovering
Regeneration (score) If new young trees are growing to replace older trees.	<i>Rirwal</i> (dragon trees) are starting to colonise the previously bare springs and regeneration has shown a small increase	Fencing effective - plants regenerating With the seed bank of <i>rirwal</i> sufficient to colonise bare springs.
Weeds (score)	No weeds recorded at Ram	Longer-term monitoring will pick up any new weed species which will be considered under Yawuru's weed management program
Impacts Cattle Fire Other impacts	The fenced area is excluded from cattle and no recent cattle impacts were recorded <i>Gudurrwarany</i> (Brolga) foraging recorded in the transects with digging impacting on the groundcover	Fences maintained and effective Changes to ground cover should consider impact from native birds.
Animals of importance	Approximately 100 <i>Gudurrwarany</i> (brolga) present during the 2020 late dry season sampling along with other bird species.	Fencing effective, plant cover around the main spring providing good feeding and habitat for bird species.

6.4 Yidarr (Lake Eda)



Figure 6-16. Lake Yidarr, Barrgana (cold season) 2017.

6.4.1 Yidarr, a culturally important lake

Yidarr has high cultural and ecological values (Vernes and Mathews 2013).

This is the biggest freshwater lake on Country. This area [*Yidarr*] was a pathway, old people passing through here ...as a stopover into Broome (Dean Mathews June 2018).

From east, Lake Gregory, this is *Bugarrigarra* Country around here...spirit travels through here. Rain further up, deep creek, the water flows here, links up other lakes north-east. Significant as link to feed nutrients to ocean, to saltwater fish, ocean, crab, fish.

[*Yidarr* is a] boundary place...main link close to Nykina side....special place...came to hunt and gather and camp...many animals live here, feed. {we would} walk across here neighbouring groups as well, corroborees....Law ceremonies here, significant sites, Grandma's Country (Kevin Puertollano June 2018).

6.4.2 Hunting and resources

Yawuru people visit *Yidarr* for hunting. During our field visit to the lake the Yawuru CMs described how the big *Marool* tree is a dinner camp spot for cooking up *barrgara* (turkey) and *barni* (goanna). Most people come to this spot because of the tree (rather than the other sides of Lake Eda). (CMs 19 June 2019).

A few decades ago, Yawuru hunted other species around *Yidarr* as well. For example, Pius described how (when he was young) they would take ducks home and grow them up. They didn't worry about the eggs, just ate the ducks for meat (Pius Gregory 19 June 2019).

There are important plants and animals

Home of honey Wallaja*.

Goanna walk and hunt through here, from place called Deep Creek, walk around and hunt goannas.....don't get same numbers now.

Also get flintstones and boomerang – lots of things old people told us about. Flintstones and boomerang trees around here... trees and plants here bigger than the desert, plenty of water....flowers in desert {also} in Yawuru Country (Kevin Puertollano Oct 2018).

[Also, there are] different birds and animals, shouldn't [just] concentrate on migrating birds [as there are] all different birds around that area. Little finches and that get out there between grazing areas. [And the] types of birds indicate what is in the lake, linked to goanna (Jimmy Edgar Oct 2018).

Watkins and Jaensch (2007) noted that Greater Bilby were recorded only once on Roebuck Plains Station in the previous 5 years (south of *Yiddarr*, in March 2003).

6.4.3 Summary of ecological science and research at Yiddarr

Yiddar is a near-permanent freshwater lake on the Roebuck Plains (Figure 6-16). It is an example of a wetland macroscale basin and is in a zone of the flat where creek discharge occurs (Semeniuk and Semeniuk 2014) Deep Creek (one of the two main drainage catchments that flow onto the marine plains) originates and enters *Yiddar* from the northeast. The lake is then connected, via an unnamed creek, to Taylors Lagoon (DEC 2009).

The Lake Eda complex as defined by Semeniuk & Semeniuk (2014) (see Section 3.3) 'comprises three mesoscale shallow basins that are seasonally inundated'. They 'owe their seasonal inundation to direct precipitation, perched by underlying sediments, and to local freshwater seepage from the dunes, which extends the period of recharge by direct rainfall'. *Yiddar* has a large open body of water after rain and extensive flooded grassland, reeds and *Sesbania*. (Hassell and Rogers 2002:14). Notable plant species around the lake included *Eleocharis spiralis*, *Phyla nodiflora* and *Sesbania erubescens* and the lake is also fringed by *murruga yirr gamburr* (*paperbarks*). Weeds have been recorded in these wetlands (including *Cenchrus echinatus* and Neem (*Azadirachta indica*)) (Willing 2012).

In 2009, a resource condition report summarised the ecological information relevant to *Yiddar* and describe the key drivers of, and threats to, the system (DEC 2009). Lake Eda is designated as a wetland of national importance under criteria 1, 2, 3, 4 and 6 of the Directory of Important Wetlands in Australia (DEC 2009). Sampling for aquatic invertebrates have revealed a high diversity of organisms. No fish were recorded in the resource condition report or when the lake was surveyed by the CMs in 2017 (Dobbs et al, 2013) but CMs and TOs noted that small fish (Stripeys) are often in the lake following the wet. The CMs have recorded garrabul (Northern nail tail wallaby) using the area around *Yiddar*.

The lake provides refuge for waterbirds in the region particularly in low rainfall years (Jaensch 1993; Willing 2012:42). DEC (2009) note that it is an internationally important migration stopover area for Little Curlew (*Numenius minutus*) and Oriental Pratincole (*Glareola maldivarum*). *Yiddar* also contains habitat for the nationally threatened Australian Painted Snipe (*Rostratula australis*) which is a vulnerable species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and has been recorded at the lake (Hassell and Rogers 2002). In September 2004, a vagrant Rosy Starling was also sighted which at the time was the first-ever record for this species in Australia (Willing 2012). The CMs describe how they have seen Black Swans following a big wet season (CMs December 2021) and 'the lake is locally renowned for its spectacular concentrations of Brolga (*Grus rubicundus*) during the late dry season'. (Willing 2012: P42).

6.4.4 Historical condition and fencing

Managers of Roebuck Plains station have previously fenced *Yiddar* to exclude cattle (Jaensch 1993) and DEC noted that the Lake was fenced to exclude stock during sampling

in 2009. Willing (2012) though noted that on 4th July 2012 ‘management do not appear to be actively protecting this wetland from grazing’.

DEC (2009) recorded cattle impacts at *Yidarr* and were also concerned that if erosion occurred higher in the catchment (this was not assessed) it may result in sediment deposition in *Yidarr*, permanently altering the geomorphology and hydrology of the lake and change its character (DEC 2009). During a Yawuru TAG meeting Jimmy Edgar lamented how *Yidarr* has changed over the years, particularly from the effects of road construction and sedimentation. He said,

Yeeda side [of the road]...water doesn't flow [to Lake Eda] anymore because roads there...Lake [*Yidarr* was] dry five years ago, now really filled out, so sediment ran into lakes...Lake Yeeda used to be deep, [but] that's silted up. Pressure from main roads, when water filled, big flush like last year those lakes look nice and green but sickening to me as gone shallow (Jimmy Edgar, October 2018).

During fieldwork for the NESP wetland project, Pius also noted that cattle have changed the channel at the western end of *Yidarr* and now the Lake is shallow. ‘The station people used to water ski here; local people would go hunting and hear the boats before they saw them’ (Pius Gregory 18 June 2019).

The extent of open water and vegetation both within and along the edge of the lake have varied over time. While eating lunch under the dinner camp tree (big narwulu/Marool), Pius noted that when he was in Year 5 (10–12 years old, 1975) and coming here to hunt *barni* there were sedges as tall as him all through where we had put the transect (Pius Gregory June 2019). The CMs identified yearly changes in rainfall and cattle trampling as a cause of this change (CMs 19th June 2019).

Vegetation transects for the Lake Eda condition report in May 2008 showed that although there were cattle impacts, the edge of the lake had very few areas of bare ground (5% or less), was covered with reeds (*Eleocharis spiralis*) and the water column was dense with *Chara* (an algae that resembles a land plant with stem and leaf like structures) (Figure 6-17). (DEC 2009). These transects though were taken soon after the wet season and located in the western basin and not in the main basin where the NESP transects are located.

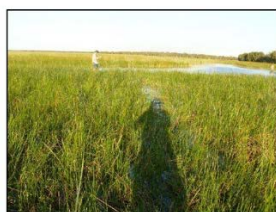


Figure 8 – Vegetation of the aquatic transect at Lake Eda.



Figure 7 – Vegetation of the riparian transect at Lake Eda.



Figure 6-17. Vegetation transect photos from the 2008 Lake Eda condition report showing very little open water and bare ground (note this site is in the western smaller basin at Lake Eda).

6.4.5 Yawuru Country Manager management and monitoring

The IPA Plan describes the following management goals for *Yidarr* (p33):

16. Lake *Yidarr* paddock and water reserve (Roebuck Plains station and water reserve ^1505)

A wetland, with permanent surface water, of great cultural and historical significance, supporting a wide variety of bird life, including migratory species that are inland specialists. To be re-fenced and grid re-installed. It is proposed that a regime of sustainable stock control be introduced. The ILC and Yawuru to agree on and install Rangeland Conditional Monitoring (RCM) sites within Lake Yidarr paddock.

Semeniuk and Semeniuk (2014) suggested five actions to support the conservation of surface and groundwater flows, freshwater purity, and maintenance of plant communities in the littoral zone; manage cattle so that the terrain is not indiscriminately trampled; set aside high-conservation exclusion areas dedicated for bird use but provide path access to Lake Eda; set up a weed eradication programme; compile quantified site species list of flora and fauna and their habitats for purposes of monitoring longer-term changes or improvements.

The existing fence at *Yidarr* was repaired by the CMs in 2017 and a cattle grid was installed at northwest entrance in 2019. This included replacing approximately three km of old fence stretching across marine plain grassland on the eastern section of the enclosure. NBY are currently in negotiations with the station manager to control grazing within the fenced area.

The CMs have set up two long-term photo-monitoring points at *Yidarr* and three NESP monitoring vegetation transects to monitor change over time and assist with decisions around cattle use and sustainable grazing. The CMs are hoping to strategically graze *Yidarr* to reduce wildfire risk and protecting bird populations by limiting cattle during key nesting times.

6.4.6 Location of monitoring transects

Transects at *Yidarr* are located to measure changes in trampling and plant health from the lower lake edge up to the *murruga yirr garnburr* zone. Transect 1 has been placed along the edge of lake near the Narwulu/*Marool* dinner tree (Blackberry tree) to monitor changes where the lake is most visited by Yawuru TO's. Transect 2 is located to help monitor changes to the ground and plants in an area that appears to be eroding. Transect 3 and 4 are located on the other side of the lake both next to each to capture the *murruga yirr garnburr* zone higher on the ridge (Figure 6-18).

6.4.7 Change following management actions (before transects put in place)

The fences surrounding *Yidarr* were repaired in 2017 just prior to the transects being put in place and therefore there has been no change evident from the photo point monitoring.

6.4.8 Change recorded from transects and how this is supporting management

The CMs are concerned about the extent of cattle trampling, high levels of bare ground, and low levels of plant cover and regeneration within transects (Table 6-3)(Figure 6-19). Longer-term monitoring will help to determine what influence seasonal changes in rainfall are having on the lake as a below average wet seasons may have also contributed to the low levels of plant cover and regeneration.

Yidarr is to be strategically grazed during the dry season to manage fire fuel loads and protect ecological and cultural values. While low intensity grazing may advantage many waterbird species by keeping the shorelines open, high cattle numbers will reduce the productivity of the margins of the wetlands and may impact on water quality. Cattle though

have been noted within the fence line across all seasons. While a cattle grid has been installed at the northwest entrance, the CMs have identified an issue with the gate at the southeast entrance being left open and that the fence next to the cattle grid at the northwest gate may need to be repaired to make the fence fully effective. Discussions have begun with the station manager about ways to reduce cattle numbers and timing (rotational grazing) to allow the plants to recover and to limit cattle trampling during key bird nesting times.

Hassell (2015) noted that ungrazed wetlands could be surrounded and choked with vegetation, and therefore recommends retaining a major portion of lakes periodically open to cattle. If management of cattle at *Yidarr* results in a significant increase in vegetation, this may limit TOs access to the lake near the *Narwulu/Marool* 'dinner' tree. The monitoring program will help set levels of cattle grazing, plant cover and regeneration in the future to ensure that this is avoided.

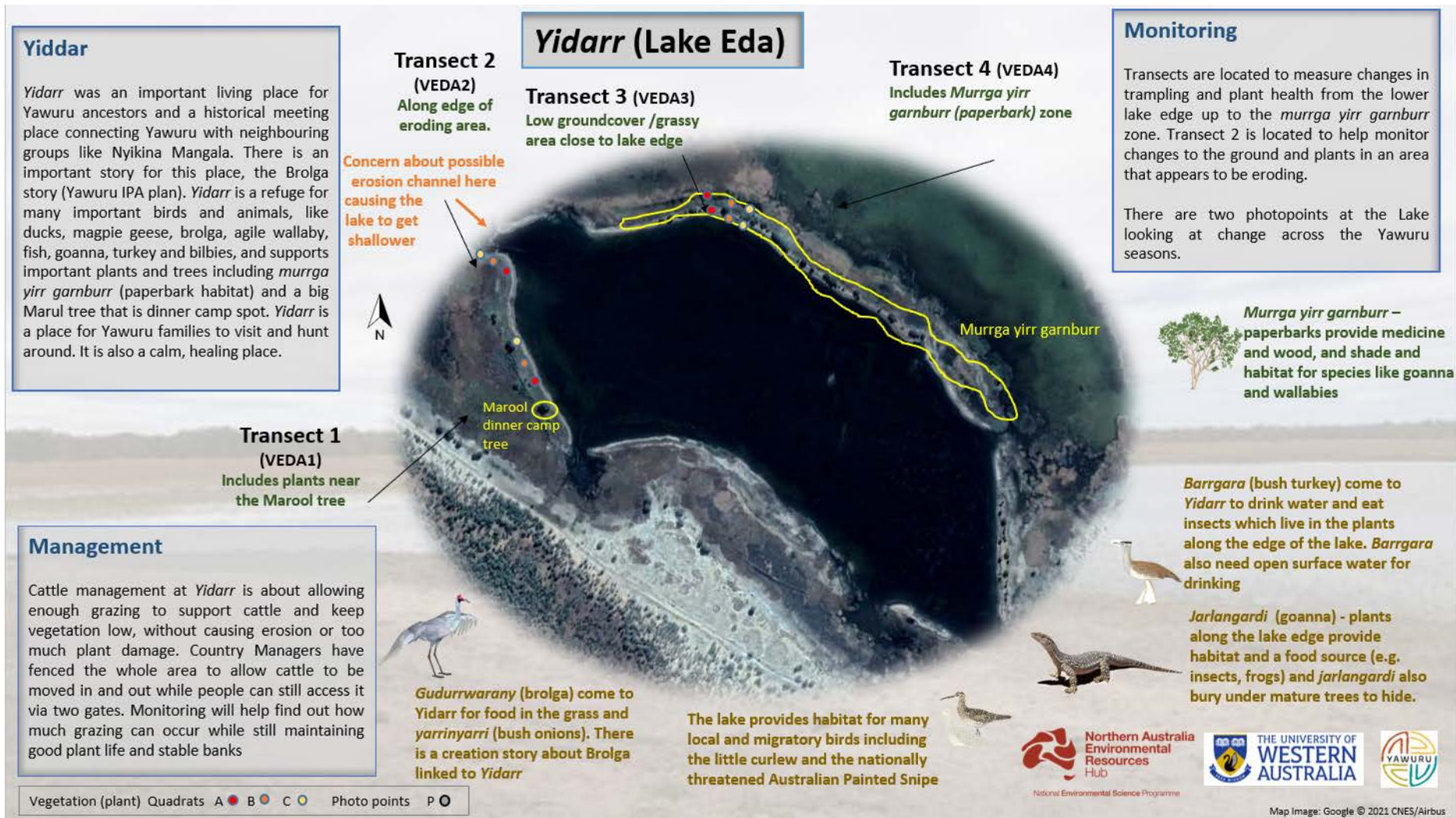


Figure 6-18. Summary poster for Yidarr developed to assist with individual site monitoring and management.

Table 6-3. Summary of monitoring results for Lake Yidarr.

General categories	Summary of monitoring changes	How this information is or will be used
Water quality Salinity (how salty) Turbidity (how clear)	Lake <i>Yidarr</i> fresh with clear water (low turbidity),	Longer-term monitoring will help to understand seasonal changes
Water extent Length, width, and depth of water	The size of the lake has made recording depth measurements difficult.	Current monitoring not sufficient to monitor change in larger water bodies. The CMs have been concerned that the depth of <i>Yidarr</i> has been declining. CMs considering putting gauges in place to assist with depth monitoring and drone or satellite imagery to track the extent of water.
<i>Liyen</i> (score) How the CMs feel about a site	The <i>Liyen</i> score for <i>Yidarr</i> has remained low	Current cattle stocking rates and timing not considered sufficient to protect ecological and cultural values. CMs planning to discuss with the station manager and determine if this is a result of management or fencing issues.
Plant cover (score)	Plant cover is currently low with large areas of bare ground.	Current cattle stocking rates impacting on plant cover. CMs planning to discuss with the station manager and determine if this is a result of management or fencing issues.
Regeneration (score) -if new young trees are growing to replace older trees.	Regeneration score at <i>Yidarr</i> consistently low.	Current cattle stocking rates impacting on regeneration. CMs planning to discuss with the station manager and determine if this is a result of management or fencing issues.
Weeds (score)	No weeds recorded within transects	Longer-term monitoring will pick up any new weed species which will be considered under Yawuru's weed management program
Impacts Cattle Fire Other impacts	Scores for cattle impacts at all transects are high (including scats, trampling, and cropping of plants)	Fencing or cattle stocking rates not effective (see comment above)



Figure 6-19. Photos demonstrating impacts from cattle trampling and low levels of plant cover within the transects along the western edge of the lake and the eastern edge up to the murruga yirr garnburr zone (VEDA2 and VEDA3 October 2020)

6.5 Tharndoo-Ngunjal (Lake Champion)



Figure 6-20. Tharndoo-Ngunjal 24 August 2017.

6.5.1 Tharndoo-Ngunjal

Tharndoo-Ngunjal is part of the Roebuck Plains Station lying on the former Stock Route (Figure 6-20). The IPA Plan describes the lake (p33) as:

A wetland of great cultural and historical significance

6.5.2 Hunting and resources

Tharndoo-Ngunjal is fringed by *lardig* (freshwater mangrove/*Lophostemon grandiflorus*) trees, which surround the lake. The Cultural Management plan explains that *lardig* is an:

‘Important law tree for the Northern tradition’ (Yawuru RNTBC 2014:74)

John Puertollano, a TO of the area shared some memories about hunting around Lake Champion, thoughts on how animal populations in the area had changed over time and explained some important ecological relationships that exist between water, riparian vegetation and some birds or animals:

Campion always had water, would sit down and relax, trying to tiptoe in the water, trying to get goanna (big goanna)... Now there’s not enough goanna [although] people are hunting a lot of goannas. Struggle with turkeys too (can’t find that many). Turkeys like grass, spinifex,

and like being close to water. *Mirdimarlu* (red kangaroo) would sleep under melaleucas. Used to have emu (too) (John Puertollano June 2019).

The CMs also shared their knowledge about plants, animals, and hunting:

'Lake Campion is a hot spot for goanna and turkey' (a documentary on hunting was filmed at this site with the CMs). 'The freshwater mangrove are good honey trees' (Pius Gregory, August 2018).

When asked if it's easier to hunt goanna if the grass is low (as it is now, being eaten down by cattle). Pius said, 'Yes it's easier to see'. The CMS were asked about a scenario in which cattle are excluded from the area and grass or plants grew back. Could hunters then burn to continue hunting and would this leave them better off, the same or worse off compared to the current situation? Pius thought they might burn and if they burn in the afternoon that's good for hunting turkey. Pius thought if the vegetation grew back, it would be a little bit harder to hunt but that the vegetation might also encourage animals to come back (and benefit hunting) (Pius Gregory, August 2018).

6.5.3 Summary of ecological science and research at Tharndoo-Ngunjal

Tharndoo-Ngunjal is located outside of the main roebuck Plains environment in the Deep Creek headwater catchment. It is an example of a *Janding nyanjinga* (a rain-fed claypan system), occupying an inter-dunal swale (Willing 2012; Yawuru RNTBC 2016; Semeniuk and Semeniuk 2014)

Hassell and Rogers (2002:14) noted that *Tharndoo-Ngunjal* rarely has any open water visible as the lake is very heavily vegetated with Spiny Mudgrass (*Pseudoraphis spinescens*) being the dominant species. The dominant floating species is used by Grebes and - more rarely - by Black Swans for nesting material (Kenneally et al. 1996, p.223). In some years the legumes *Sesbania erubescens* and *Aeschynomene indica* are an important component of lake vegetation. Insectivorous herbs such as *Byblis rorida*, *Drosera broomensis* and *D. indica* are often present around the lake (Willing, 2012: 43).

Nymphoides beaglensis has been recorded at *Tharndoo-Ngunjal* (and Taylors Lagoon) and is classified as a priority two flora. This distinct waterlily-relative or marshwort is known to extend to claypans between Broome and Derby: including Lake Campion and Yulleroo Well. The seeds are likely to be transported by waterbirds with populations appearing to expand during runs of good wet seasons and contract during drought periods (Willing 2012).

6.5.4 Historical condition and fencing

During Lord McAlpine's ownership, this wetland was fenced off in recognition of its conservation values (Willing, 2012:43). Willing also noted though that the fence was not maintained and that cattle were inside the fence line in 2012.

Although in their article about the Painted snipe, Hassell and Rogers (2002) suggest that there is rarely open water at *Tharndoo-Ngunjal*, CM Pius shared memories about the open water at *Tharndoo-Ngunjal* and suggested that cattle changing the contours of the land could have affected this open water:

Pius described an area of tall sedges that existed on the lake in the 70s – he knew that as he'd come out hunting. There were also leeches in the lake, which he knew from his sister

washing dishes in the water. Pius noted that still there is often water in the lake all year (Pius Gregory June 2019).

As with some of the springs, the waters in the springs in the lake, have exhibited concentrations which depict nutrient enrichment (0.02–0.48 ppm) (Semeniuk and Semeniuk 2014).

6.5.5 Yawuru Country Manager management and monitoring

The IPA Plan describes the following management goals for Lake Campion (p33):

17. Tharndoo-Ngunjal/Lake Campion (water reserve ^9697)

A wetland of great cultural and historical significance, to be fenced and a regime of sustainable stock control introduced.

In accordance with the IPA Plan the CMs completely removed and replaced the old fence around *Tharndoo-Ngunjal* in 2019/2020. They are currently working with the station manager to ensure that the remaining cattle within the fenced area are removed. Prior to this the CMs noticed that many cattle are remaining within the fence late into the dry season and are having a significant negative impact on the plants surrounding the wetland.

The CMs have a photo point set up at *Tharndoo-Ngunjal* and three vegetation transects to monitor change and assist with sustainable grazing management.

6.5.6 Location of monitoring transects

The CMs have set up three transects to include 1) the lower (dry season/) lake edge, 2) zone of *lardig* (freshwater mangrove trees), and 3) *Murruga yirr garnborr* zone (Figure 6-22).

6.5.7 Change following management actions (before transects put in place)

The fence surrounding *Tharndoo-Ngunjal* was replaced in 2019/2020 and therefore there has not been enough time since fencing to see any changes in the photo point monitoring.

6.5.8 Change recorded from transects and how this is supporting management

When visiting the lake in 2019 it was dry following a poor (low than average rainfall) wet season in 2018/19 and unrestricted grazing. The main waterhole area was cattle trampled and pugged. Plants that have been present in the past (e.g. spiny mudgrass and sedges), were absent. The *lardig* (freshwater mangrove trees) surrounding some parts of *Tharndoo-Ngunjal* looked unhealthy, with quite a few dead branches and branches with no leaves with the appearance that they were dying back. Acacia (soap wattle) and cockroach bush juveniles though were recruiting around the edge of the Lake (Figure 6-21).

The fence at *Tharndoo-Ngunjal* was finalised in 2020. Monitoring at *Tharndoo-Ngunjal* has shown that cattle are still impacting the plants around the lake. There have been issues with mustering the cattle out of the fence line and to complicate the issue, there is no cattle grid at the entrance to the enclosure and this gate often gets left open leading to cattle ingress. The CMs are in discussions with the station manager to ensure that cattle are kept out of Lake Campion to allow the vegetation to recover.

A balance between plant recovery and hunting may need to be addressed in the future if the plant cover around the lake responds to cattle exclusion. CMs noted that if fencing causes plants to grow back hunting may be a little harder, but this could be balanced by the plant growth supporting higher populations of valuable species including *barni* and *barrgara* (goanna and turkey), which would be a benefit to hunters.



Figure 6-21. Photos demonstrating lardig trees in poor condition and low levels of plant cover within the transects during monitoring in June 2019.

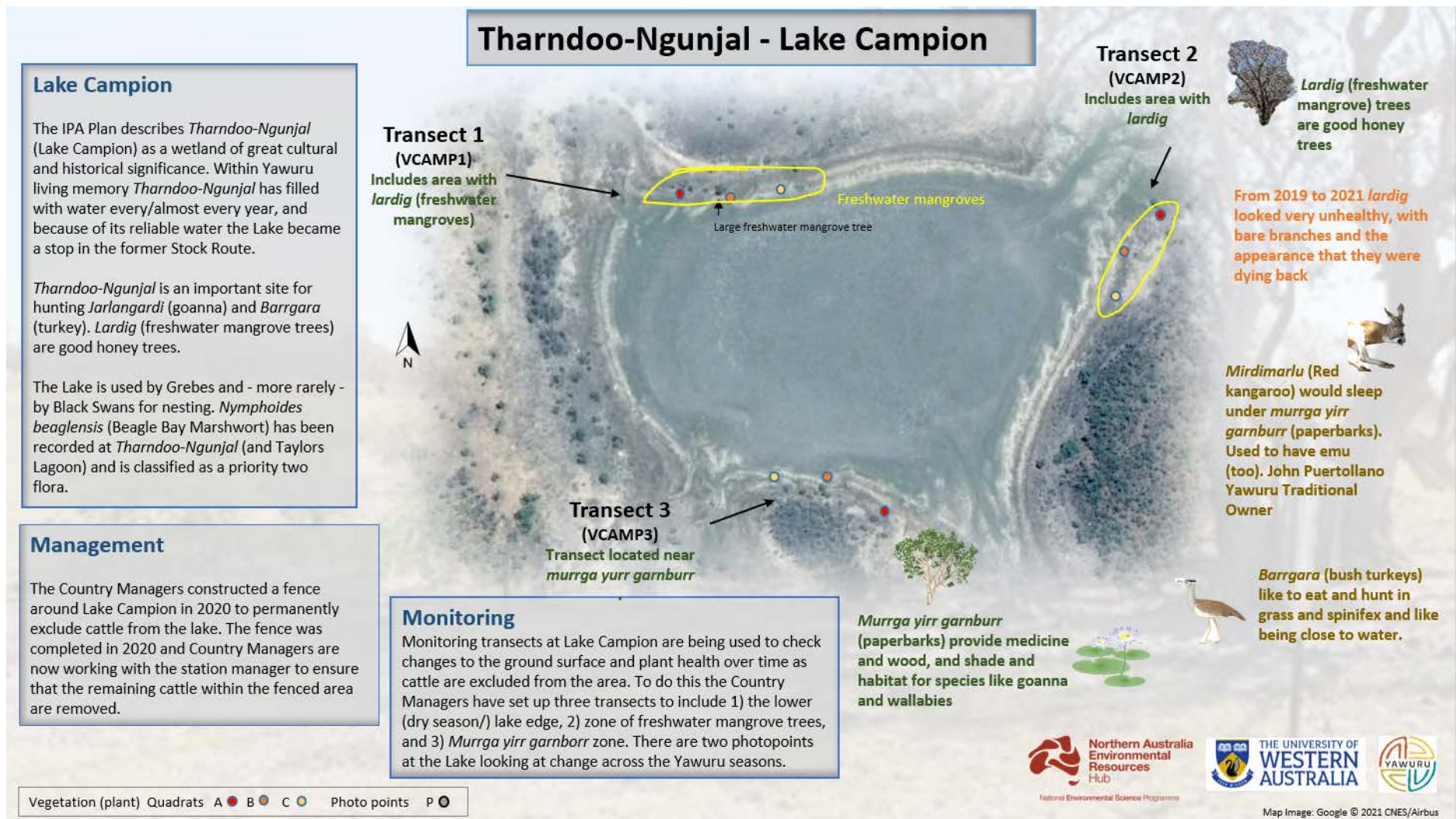


Figure 6-22. Summary poster for *Tharndoo-Ngunjal* developed to assist with individual site monitoring and management.

Table 6-4. Summary of monitoring results for *Tharndoo-Ngunjal*.

General categories	Summary of monitoring changes	How this information is or will be used
Water quality Salinity (how salty) Turbidity (how clear)	Prior to the fencing being completed, the water at <i>Tharndoo-Ngunjal</i> is fresh but high turbidity coinciding with high levels of cattle trampling.	Longer-term monitoring will help to understand seasonal changes and any benefits from the recent fencing.
Water extent Length, width, and depth of water	Seasonal changes have been noted with the Lake dry in late 2019 (following a poor wet season) and the lake returning to medium levels in early dry season 2020.	Longer-term monitoring will help to understand seasonal changes and any benefits from the recent fencing.
Liyan (score) How the CMs feel about a site	The <i>Liyan</i> score for <i>Tharndoo-Ngunjal</i> has remained low	Despite significant investment of the CMs time in erecting a fence around the lake, the cattle have only just been successfully mustered out of the fence line. CMs are frustrated that fences are being left open and cut which has the potential to set back this work.
Plant cover (score)	Plant cover is currently low with large areas of bare ground.	(See comments above)
Regeneration (score) If new young trees are growing to replace older trees	Regeneration score at <i>Tharndoo-Ngunjal</i> is consistently low and CMs are concerned about the health of <i>lardig</i> (freshwater mangroves). There is no sign of recruitment, and the health of the trees has been in decline since monitoring started.	The CMs are considering fencing off smaller areas around the freshwater mangroves
Weeds (score)	No weeds recorded within transects	Longer-term monitoring will pick up any new weed species which will be considered under Yawuru's weed management program
Impacts Cattle Fire Other impacts	Scores for cattle impacts at all transects are high (including scats, trampling, and cropping of plants)	Fencing has only just been finalised and keeping cattle out is an issue (see above comments)

6.6 Bungarigun (Taylors Lagoon)



Figure 6-23. Taylors Lagoon, April 2021.

6.6.1 Taylors Lagoon

During a monitoring trip to Taylors Lagoon, we first visited the shallow depressions to the east of the main/deepened lagoon and were accompanied by the Men's Outreach Service including John Puertollano, a TO for that area. John shared some of this knowledge about Taylors Lagoon:

'The whole area is a floodplain. The area down the front holds more water, the second area syphons down. In the past the front [artificially deepened] area would have looked more like the back depression.' John's people 'would have walked through this area from Ungani to Eda. People would have been catching the water in the first lagoon and going through (walking on). If you dig down here (at the eastern shallow depression), you'll find water.' (John Puertollano June 2019).

Taylors was a cattle watering place. Plenty of bushfood, ducks, wildlife, plenty of water, good hunting for goanna, black headed and olive pythons used to be around waterholes. (John Puertollano, 20 June 2019).

The IPA Plan (p35) describes how Taylors Lagoon (water reserve ^1510)

...continues to be a major watering point for the pastoral lease and the Kimberley–DeGrey Stock Route.

6.6.2 Hunting and resources

Mapping by Mathews and Vernes (see Section 2.3.3) highlight the use of Taylors Lagoon for hunting, this includes the main area of Taylors Lagoon as well as the depressions to the west.

6.6.3 Summary of ecological science and research

Taylor's Lagoon is a Crown Land Reserve,' (Reserve 1510): a remnant of the former Derby to De Grey Stock Route. It is a small freshwater lake (approximately 2 hectares) and along with Lake Campion it is in the Deep Creek headwater catchment (Figure 6-23). When full, the

Lagoon overflows to feed the headwaters of Collins Creek at a point 76 km East of Broome on the Great Northern Highway (Willing 2012).

Semeniuk and Semeniuk (2014) describe Taylors Lagoon as:

'It exists in a group of seasonally inundated basins and appears to have been a much larger single basin at one stage. The hydrological mechanisms recharging the lake are 1) direct precipitation, 2) seepage from surrounding dunes, 3) groundwater recharge, and 4) perching on underlying impermeable iron cemented muddy sands. Surface water in the basin is freshwater, but nutrient enriched'.

The area is important as a migratory bird habitat, with the Painted Snipe previously considered extinct in the Kimberley being recorded breeding at Taylors Lagoon (see below). A small separate billabong to the west supports significant populations of the rare, Beagle Bay Marshwort (*Nymphoides beaglensis*) (Willing, 2012: 44) which were also noted within Taylors Lagoon when we were monitoring transects following Man-gala (the wet season) in May 2021.

In his literature review of Roebuck Plains Tim Willing describes the vegetation around Taylor's Lake:

The adjacent grass flats are dominated by Couch (*Cynodon dactylon*) with patches of Spiny Mudgrass (*Pseudoraphis spinescens*). In some years, patches of tall *Sesbania erubescens* surround the lagoon (Hassell and Rogers, 2002, p.14) and these were also seen in the monitoring transects in May 2021. The heaths that occur around the edges of the sumplands die off soon after the surface water has gone. The heath is dominated by *Sesbania cannabina* with minor species such as *Hibiscus apodus* (Semeniuk and Semeniuk 2014)

6.6.4 Historical condition and fencing

Although managers of Roebuck Plains station have previously fenced Taylors Lagoon to exclude cattle (Jaensch, 1993) (Figure 6-24) it is not currently protected from cattle grazing and trampling. Weeds have been recorded in these wetlands (including *Cenchrus echinattus* and Neem (*Azadirachta indica*)) (Vernes and Mathews 2013).



Figure 6-24. Taylors Lagoon showing (a) old fence line covering both Taylors Lagoon main area and depressions to the south-east and (b) formations around the main wetland where excavated soil has been placed in rows.

Taylor's Lagoon was modified several decades ago as it was excavated for gravel which led to one pool being permanently deepened and surrounded by constructed gravel ridges and gravel islands (Figure 6-24):

'The lagoon was reportedly excavated and deepened by MRD for gravel during the sealing of the Broome/Derby Road during the 1960s, which appears to have vastly expanded its water-holding capacity. Natural rehabilitation has since taken place through re-colonisation by aquatic plants of the lagoon and by wattles on gravel ridges and miniature islands. Two outlying billabongs to the west and southwest have never been excavated for gravel and show few signs of disturbance other than grazing impacts.' (Willing, 2012: 44)

6.6.5 Summary of ecological science and research

While Taylor's Lagoon has been modified, it has provided habitat for Painted Snipe breeding during at least one point within the last 20 years (with the Painted Snipe thought extinct from the Kimberley and now considered endangered). Several ornithologists visited Taylor's Lagoon in July and August 1999, where they found a pair of Painted Snipes and eventually located a nest with three eggs (two of which were thought to have later hatched). Chris J. Hassell (who found the nest) and D. I. Rogers wrote about this finding in an article, where they described where the nest was located and included a sketch of the site. The nest was in a very small patch of spiny mudgrass on top of the main bund at Taylor's Lagoon, with the spiny mudgrass surrounded by couch. As they say:

'The nest was situated in an oval patch of grass that was on a raised 'bund' that runs for 35–40 m along a portion of the north-west edge of the lake (Fig. 1). This grass patch was 25cm tall and the surrounding Couch was only 2–5 cm tall. This area, and therefore the nest, was on dry ground. To the southeast of the nest site was a gentle 1-metre slope into dead *Sesbania erubescens* fringing the lake. This thick *Sesbania* was 4 m from the nest; it fringed the bund and therefore the nest. This 'protected' the nest site on two sides but the other two were very open. Two metres to the NE, and W of the nest was shallow water that filled a depression which takes the overflow from the main lake. This water is thickly vegetated, and a small portion of the edge was fringed with *Sesbania*.' (Hassell and Rogers, 2002:16)

Six painted snipe were netted at Taylor's Lagoon in March 2002 for DNA analysis, which confirmed the species, *Rostratula australis* as an Australian endemic (Baker 2007; Willing 2012). Twice monthly counts of waterbirds were taken by Collins and Jessop (2001) from October 1995 through to May 1996 which showed that the site also supports internationally significant numbers of Oriental Pratincole and Little Curlew (Willing 2012).

Relating to the history of Taylor's Lagoon, Country manager Pius also described how the Department of Agriculture introduced Red Claw Crayfish (*Cherax quadricarinatus*) into Taylor's Lagoon but later removed them (Pius Gregory June 2019). Freshwater crabs also occur within the lagoon (Dobbs et al 2013) with many crab holes and shells scattered around the edge of the lake following the 2018/2019 Man-gala (wet season) sampling by the CMs.

Surface water in the basin is fresh and has previously been recorded as nutrient enriched (Semenuk and Semenuk 2014).

6.6.6 Yawuru Country Manager management and monitoring

The IPA Plan describes the following management goals for Taylor's Lagoon (p35):

20. Roebuck Plains: Taylor's Lagoon (water reserve ^1510)

A wetland of great cultural and historical significance continues to be a major watering point for the pastoral lease and the Kimberley–DeGrey Stock Route, to be monitored for its ecological and cultural values.

Hassel and Rogers noted that 'If dry season breeding (such as the Taylor's Lagoon nest) is typical of Kimberley Painted Snipe, then cattle might be a problem. During the dry season, there is far less suitable wetland habitat for Painted Snipe, and as cattle tend to concentrate at water sources, it is quite likely that they could degrade the best Painted Snipe habitat or perhaps trample on nests' (Hassell and Rogers 2002).

Taylor's Lagoon is not currently fenced, and cattle have access to the area. There are recommendations for Taylor's Lagoon to be fenced and strategically grazed to reduce fire loads. Although other wetlands have been prioritised for fencing, Taylor's is in Zone 1 of the IPA and is on the list for the next round of fencing.

6.6.7 Location of monitoring transects

The CMs have set up three vegetation transects concentrating on the area where nesting was previously recorded and around the additional depressions in the broader Taylor's Lagoon fenced area (Figure 6-25).

6.6.8 Information recorded from transects and how this is supporting management

When we visited Taylor's Lagoon in 2019, the site was nearly dry with only two small wet areas present (Figure 6-26a). The area where Painted Snipe had previously been found nesting (Transect 3) was bare, and had the lowest levels of ground cover recorded across all sites monitored that year.

Although Taylor's is not currently fenced the monitoring has highlighted seasonal changes, with a significant change in the extent of water and plant species at the site following a 'good' Man-gala (wet season) between December 2021 and March 2022 (Figure 6-26b). Following this time, the main area at Taylor's Lagoon was filled with water. *Sesbania* was present in the transects, (including Transect 3), and the rare Beagle Bay Marshwort (*Nymphoides beaglensis*) was also abundant within the transects. A significant number of birds were present, small crab shells were abundant in the transects (having been eaten by birds) and numerous *barni* holes were present within Transect 1 and 2. The eastern depression was also covered in Beagle Bay Marshwort with a significant number of bird species present.

Longer-term monitoring will help the CMs to consider cattle management at Taylor's Lagoon. Based on information about Painted snipe (Section 6.6.5), it seems that even the presence of small amounts of spiny mudgrass might offer important habitat for breeding for wetland birds. The presence of the thick *Sesbania* close to the nest may also have made this good habitat as the nest had some protection. Thus, the growth of spiny mudgrass and *Sesbania* at this site (in Transect 2 and 3) will be used as one indicator of healthy Country for Taylor's Lagoon (and potentially all wetlands where these species are known to occur).

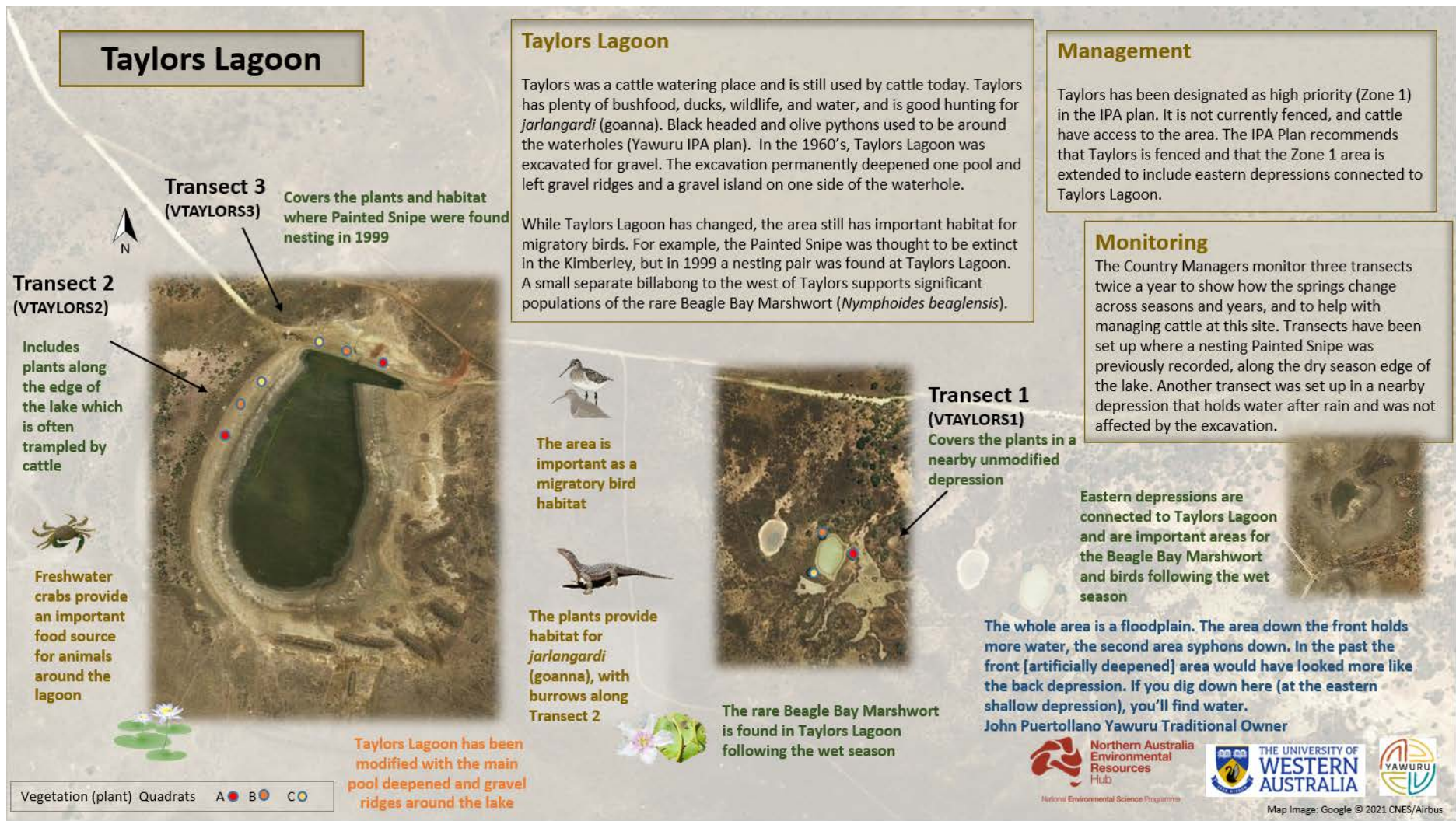


Figure 6-25. Summary poster for Taylors Lagoon developed to assist with individual site monitoring and management.

Table 6-5. Summary of monitoring results for Taylors Lagoon.

General categories	Summary of monitoring changes	How this information is or will be used
Water extent Length, width, and depth of water	Seasonal changes have been noted with the main site at Taylors nearly dry in late 2019 (following a poor wet season) and the lake returning to high levels in early dry season 2020/2021.	Longer-term monitoring will help to understand seasonal changes
Liyán (score) How the CMs feel about a site	The <i>Liyán</i> score for Taylors was low in 2019 but high in 2021 following the wet season with <i>barni</i> holes present, significant bird life and the return of plant cover to transects that were previously bare.	CMs will continue to discuss cattle management at Taylors Lagoon with the station manager to provide a better understanding of cattle impacts and how these can be distinguished from seasonal changes.
Plant cover (score)	Plant cover was very low late in the dry season with large areas of bare ground. Following a good wet season, the CMs were able to see a significant seasonal change in plant cover (but the site was too wet to access and monitor)	Longer-term monitoring will help CMs to determine if cattle management in the dry season needs to be managed to reduce late dry season impacts.
Regeneration (score) If new young trees are growing to replace older trees	Regeneration score at Taylors Lagoon is low.	Longer-term monitoring will help CMs to determine if cattle management in the dry season needs to be managed to reduce late dry season impacts.
Weeds (score)	No weeds recorded within transects	Longer-term monitoring will pick up any new weed species which will be considered under Yawuru's weed management program
Impacts Cattle Fire Other impacts	Scores for cattle impacts at all transects are high (including scats, trampling, and cropping of plants)	Fencing is being considered at this site. IF fencing was to occur then the CMs would like this to extend to cover the eastern depressions that are linked to the main Taylors Lagoon site.



Figure 6-26. Photos demonstrating seasonal change at Taylors Lagoon: (a) the lagoon was dry with very little plant growth in August 2019 and (b) *Sesbania* and groundcover growth in May 2021 following the 2020–21 Man-gala (note cattle trampling still evident).

6.7 Gunbanyari (Ungani Lakes)



Figure 6-27. Ungani Lakes showing cattle tracks at the edge and across one of the ephemeral lakes.

6.7.1 Background

Ungani is a series of ephemeral lakes (basins that remain flooded for a short period of time during a year) (Figure 6-27). It's a water place, people would have come here because of that (Johani Mamid, 19 June 2019).

6.7.2 Hunting and resources

The wetland areas at Ungani are surrounded by *Murruga yirr garnburr* (paperbarks) which provide resources including honey, shelter for goanna, leaves for cooking and wood for shelter (as detailed in Section 4.1.3)

'People don't come out here hunting as much as there's hunting closer to town'. (Vaughn Lee October 2020) 'It's harder to get here so people mainly use the Plains' (Pius Gregory October 2020)

6.7.3 Summary of ecological science and research at Ungani

A drainage line in the far east of Roebuck station flows as a single channel until it reaches parallel dunes that fringe the eastern extent of the marine plain. It is here that several ponding areas occur, the most significant of these being the Ungani Lakes (Biota 2015). The lakes are ephemeral as the water table in the dry season is too deep to sustain the wetland. These ponded areas fall under the Ungani Wetland Suite defined by Semeniuk & Semeniuk as *Sumplands and creeks deriving from impeded channel flow through linear dunes* (2014) (see Section 3.3). Wetlands here are underlain by humic mud, and mottled mud, muddy sand, and sand.

Willing (2012) noted that the ecology of Gunbanyari (Ungani Lakes) are poorly documented and required further survey to ascertain their biodiversity value. Semeniuk & Semeniuk (2014) have since mapped and described the vegetation in the small sumplands:

'comprises grassland mosaics ringed by *Melaleuca alsophila*. [Ungani Lake] also exhibits mosaic patterns of vegetation and bare patches where there would be open water in the wet season. The centre of Lake Ungani comprises sedgeland (*Fimbristylis* sp.) and grassland (*Cynodon dactylon*), and this is ringed by *Melaleuca alsophila* shrubland.'

6.7.4 Historical condition and fencing

The ESRM report highlighted that there are areas of erosion occurring in the inflow to the Ungani Lakes and Barley Springs (Biota 2015).

6.7.5 Yawuru Country Manager management and monitoring

The IPA Plan (p33) states that Ungani Lakes is:

'A series of ephemeral lakes to be protected for their cultural and ecological significance...in future looking at ways to strategically graze to minimise risk of wildfire.'

Semeniuk recommended that to conserve and protect the system of creeks, flats, sumplands and dunes the hydrological, and geomorphic process should be protected, i.e. protect dune integrity, surface flows, and freshwater purity. He highlighted that the main risks included changes to the westward flows, through damming, or over pumping of water, and loss of recharge through modification of dunes (Semeniuk & Semeniuk 2014).

Recommended actions include: maintaining the integrity of the system and do not allow subdivision; set aside high-conservation areas where cattle are excluded; manage off-road vehicle use so that only designated tracks are used (Semeniuk & Semeniuk 2014)

The site is currently unfenced but it has been recommended that Ungani be grazed at a light stocking rate (Biota 2015). The IPA plan notes that the CMs would be looking at ways to strategically graze to minimise the risk of wildfire.

6.7.6 Location of monitoring transects

The CMs have set up monitoring transects to support sustainable grazing. Monitoring transects are located to measure changes in trampling and plant health from the sedges at the edge of the low-lying basins (transect 2) up to the *murruga yirr garnburr* zone (transect 1 and 3) (Figure 6-28).

6.7.7 Information recorded from transects and how this is supporting management

Ungani is often the first to become inaccessible with the onset of wet season rain and the last to become accessible again after the wet, therefore often exceedingly difficult to survey. Although Ungani is not accessed by CMs as often as other sites, now that the CMs have set up transects at this site they are regularly visiting Ungani, and changes will not go unnoticed for long periods of time. An example of this being that the CMs were concerned about the condition of the *Murruga yirr garnburr* zones in the areas surrounding Ungani on the drive into the main wetland areas in 2020.

The aim for Ungani is keep it unfenced and allow enough cattle grazing to reduce the risk of wildfire but without damaging the plants and soils too much. By monitoring the transects over several years the CMs will be able to determine a good level of grazing, or what is too much. This will allow a good or 'sustainable' level of grazing to be set.

When visiting Ungani Lakes on 19 June 2019 there was an area of sedges adjacent to one of the lake basins. Pius described how Lake Champion had similar sedges, but cattle had trampled them, and the CMs were concerned that cattle could affect the sedges at Ungani too if they get a chance. The CMs will compare the transect monitoring with seasonal

changes and the stocking rates provided by the station manager to help manage Ungani and compare this with results from their sustainable grazing plots to help inform management at this site.

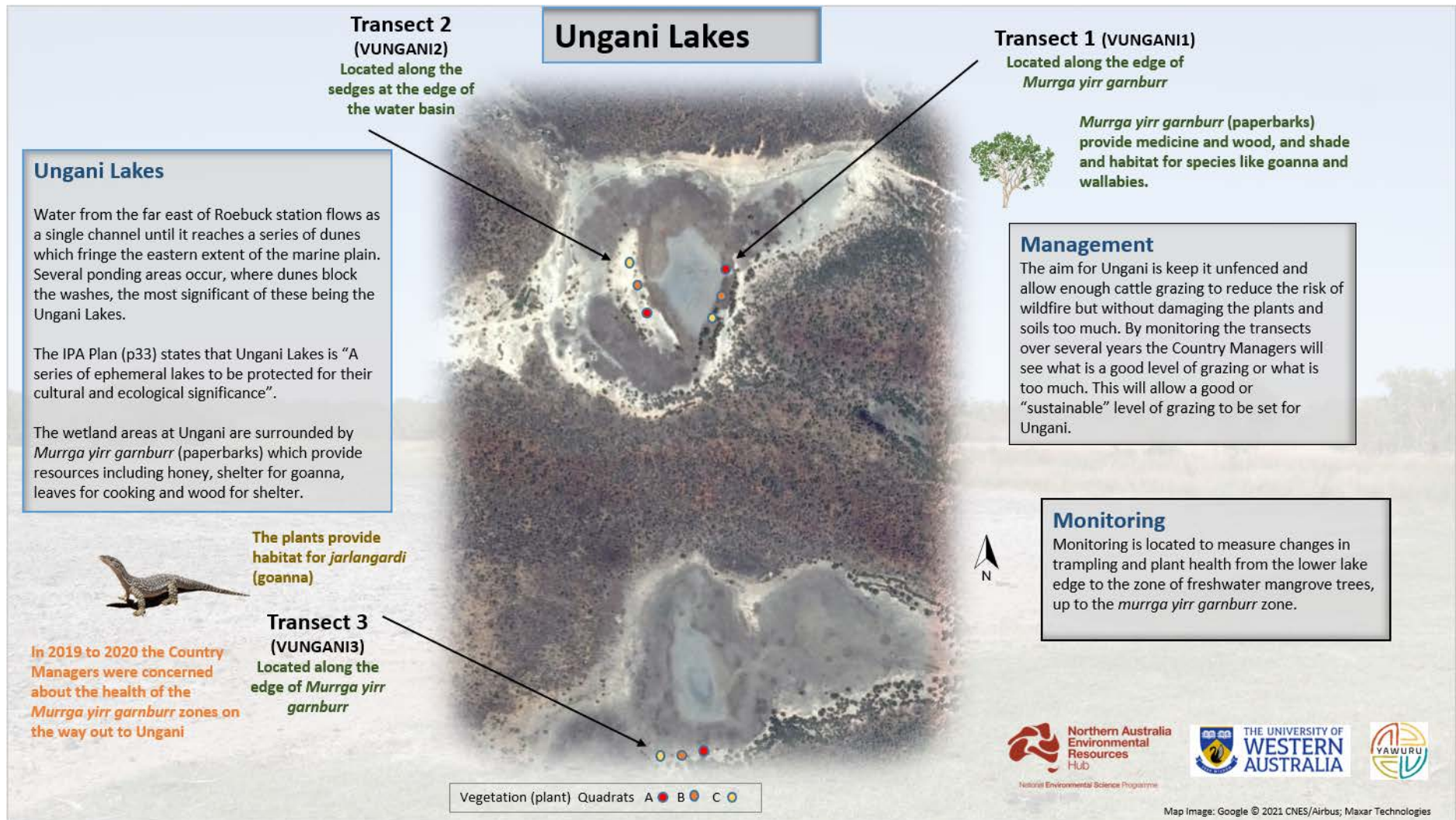


Figure 6-28. Summary poster for Ungani developed to assist with individual site monitoring and management.

7. Recommendations and research impact

7.1 What next?

The monitoring program has produced important information to assess the status of key *bilarra* across the IPA. While the monitoring program focusses on a site-based approach to managing individual wetlands, when considered alongside findings from the CMs sustainable grazing plots, it also contributes to assessing the broader landscape scale goal of sustainable grazing across Roebuck Plains (see Section 4.1.3).

The CMs will continue to monitor *bilarra* twice a year using the monitoring protocol until they have sufficient seasonal information to inform their management. The program will then be reassessed, and the monitoring may be reduced to once a year in the late dry season. This monitoring project has been supported by Environs Kimberley through the Kimberley Wetland Project. This support will extend beyond the lifetime of NESP funding to assist in interpreting monitoring findings, such that Yawuru can prioritise management activities and adapt monitoring accordingly, to best protect wetlands within their IPA.

The ongoing management requirements for each site are described in Section 6. The following recommendations were also recognised during the development of the monitoring program and when the program was aligned with Yawuru's objectives and strategies for *bilarra* and sustainable grazing:

- Consider grates as an alternative to gates (particularly at Lake Eda and Campion) to remove the issue of fences being left open and cattle accessing the Lakes at the wrong time of year.
- Regular meetings with station managers required to present monitoring results and adapt management at all sites. This will also help the CMs to compare the monitoring with stocking rates of cattle. This will enable some fenced areas (and their wetlands) to be rested, allow grazing at times that will help to reduce fuel loads and therefore reduce the chance of wildfires, and also provide optimal levels of grazing to protect both the cultural and ecological values.
- Yawuru should maintain and strengthen their ongoing relationship with the bird observatory and bird watchers to help Yawuru to document changes following management actions. Over-grazing is a major problem; however, no grazing is not necessarily good e.g. resultant growth may reduce bird diversity due to habitat alteration. Over-grazing is anticipated to reduce the abundance of insects, and this may negatively impact on bird numbers (Hassell pers. comm 2015).

Additional activities that would enhance the outcomes of the monitoring program include:

- Arranging on-Country trip *bilarra* with TOs to record their perspectives and feelings about the changes they see (this would assist CMs in discussing management and monitoring with TOs).
- The addition of Barlee Springs to the monitoring program. This site has recently been fenced, and therefore a priority for the wetland monitoring program in the future.
- Increase the knowledge from groundwater monitoring by refining the piezometers and deliver on recommended changes outlined by DWER (i.e. survey in piezometers).

- Involving TOs in monitoring trips when possible. Country Managers expressed the need to involve TOs more in the program. The CMs would like to involve TOs in field visits to show them the work they are doing and to build on the cultural information at each site.

7.2 Research impact

Yawuru have been committed to the challenge of managing the cultural and ecological values of *bilarra* while ensuring the economic viability of the pastoral business on Roebuck Plains. Yawuru's approach has been to support TOs' wishes for economic participation, community benefit and enjoyment of Native Title customary rights, while maintaining and enhancing the condition and vitality of these important places.

The Yawuru management approach and the co-designed research presented in this report has the potential to inform other TOs and CMs who are managing lands overlain with pastoral leases across northern Australia (WA, NT, Qld). It can also more broadly assist rangers and TOs across Indigenous managed lands and estates with monitoring and adaptive management of wetlands. Key aspects of the management approach and research involved:

- Incorporation of different knowledge systems, including Indigenous (Yawuru) and university-based science, as validly contributing to understanding the natural environment – in this case, *bilarra*.
- Inclusion of research staff with experience in both wetland ecology and in working with Indigenous knowledge systems and related social science approaches.
- A commitment to ensure that the monitoring program specifically focused on addressing Yawuru's current information needs (questions) and supported adaptive management of Yawuru Country. This was achieved by building on Yawuru's substantial body of related past work and co-designing the program under the IPA Monitoring, Evaluation, Reporting, Improvement (MERI) Plan with guidance from the IPA Technical Advisory Group made up of scientists and senior Yawuru knowledge holders.
- Ongoing knowledge-sharing and a commitment to collaboratively adapt and refine a scientific wetland monitoring protocol (designed in northern Australia for implementation by Indigenous groups) to the Yawuru context and management requirements. Supporting CMs to collect evaluate and communicate the monitoring.
- Developing a monitoring program that operationalised the two-tier approach recommended for managing wetlands on Roebuck Plains. That is, while the monitoring is focused on specific wetlands (site-based), evaluation of the monitoring data is considered alongside findings from other Yawuru initiatives that encompass a landscape-scale view (including fenced sustainable grazing plots).

This research is already being used to inform other ranger groups through the Kimberley Wetland Project. The Kimberley Wetland Project is an Environs Kimberley and UWA project funded through LotteryWest which is providing regional support for Kimberley Indigenous groups to manage, monitor and protect wetlands. In its final stage, the Kimberley Wetland Project will foster knowledge-sharing through a published toolkit and regional workshop, with the Yawuru monitoring program providing an important case study for other groups to learn from across the Kimberley.

References

- Austin BJ, Robinson CJ, Mathews D, Oades D, Wiggan A, Dobbs RJ, Lincoln G, and Garnett ST (2019) An Indigenous-led approach for regional knowledge partnerships in the Kimberley region of Australia. *Human Ecology*. <https://doi.org/10.1007/s10745-019-00085-9> KISSP
- Baker, A. J., Perreira, S. L., Rogers, D. I., Elbourne, R. and Hassell, C. J. (2007). Mitochondrial DNA evidence shows the Australian Painted Snipe is a full species: *Rostratula australis*. *Emu* **107** (3): 185-189.
- Benterrak, K., Muecke, S and Roe, P (1996) *Reading the Country: Introduction to Nomadology*. Edition2, Liverpool University Press, 1996ISBN0853236313, 9780853236313, 280 pages
- Biota Environmental Services (Biota) (2015) *Roebuck Plains ESRM: Documents: Roebuck Plains Report*. Prepared by Glover, R. for Biota Environmental Services, Leederville Perth, Western Australia 6007.
- Close, P.G., Wallace, J., Bayliss, P., Bartolo, R., Burrows, D., Pusey, B.J., Robinson, C.J., McJannet, D., Karim, F., Byrne, G., Marvanek, S., Turnadge, C., Harrington, G., Petheram, C., Dutra, L., Dobbs, R., Pettit, N., Jankowski, A., Wallington, T., Kroon, F., Schmidt, D., Buttler, B., Stock, M., Veld, A., Speldewinde, P., Cook, B.A., Cook, B., Douglas, M., Setterfield, S., Kennard, M., Davies, P., Hughes, J., Cossart, R., Conolly, N. and Townsend, S. (2012). *Assessment of the likely impacts of development and climate change on aquatic ecological assets in Northern Australia. A report for the National Water Commission, Australia. Tropical Rivers and Coastal Knowledge (TRaCK) Commonwealth Environmental Research Facility, Charles Darwin University, Darwin. ISBN: 978-1-921576-66-9. 561pp*
- Collins, P., and Jessop, R. (2001). Arrival and departure dates and habitat of little curlew *Numenius minutus* at Broome, north-western Australia. *Stilt* **39**, 10–12.
- DEC (2009) *Resource Condition Report for a Significant Western Australian Wetland: Lake Eda*. Report prepared for Inland Aquatic Integrity Resource Condition Monitoring Project, Strategic Reserve Fund, Department of Environment and Conservation, Perth, WA
- Dixon, I., Douglas, M., Dowe, J., Burrows, D. & Townsend, S. (2006). *Tropical Rapid Appraisal of Riparian Condition: Version 1 (for use in tropical savannas)*. Rivers Management Technical Guideline No. 7. Land & Water Australia, Canberra.
- Dixon, I., Dobbs, R., Townsend, S., Close, P., Ligtermoet, E., Dostine, P., Duncan, R., Kennard, M., and Tunbridge, D. (2010). *Field trial of the framework for the assessment of river and wetland health (FARWH) in the wet/dry tropics: Daly River and Fitzroy River catchments*. Unpublished report prepared for the National Water Commission. Tropical Rivers and Coastal Knowledge Consortium, Charles Darwin University, Darwin.
- Dobbs, R.J., Tingle, F. and Close, P.G. (2013) *Waterways Education Program, Summary report- Yawuru Rangers, CENRM report 133*
- Dobbs RJ, Davies CL, Walker ML, Pettit NE, Pusey BJ, Close PG, Akune Y, Walsham N, Smith B, Wiggan A, Cox P, Ward DP, Tingle F, Kennett R, Jackson MV, and Davies PM

- (2016) Collaborative research partnerships inform monitoring and management of aquatic ecosystems by Indigenous rangers. *Reviews in Fish Biology and Fisheries* 26(4):711-725. <http://dx.doi.org/10.1007/s11160-015-9401-2>
- Dobbs R J, Close P C, Austin B J, Tingle F, Lincoln G, Mathews D, Oades D, Wiggins A, Bayley S, Edgar J, King T, George K, Mansfield J, Melbourne J, Vigilante T with the Balanggarra, Bardi Jawi, Dambimangari, Karajarri, Nyul Nyul, Wunambal Gaambera & Yawuru Traditional Owners (2017). A Regional Framework for Saltwater Monitoring. Final Report of project 1.5.4 the Kimberley Indigenous Saltwater Science Project (KISSP). Prepared for the Kimberley Marine Research Program, Western Australian Marine Science Institution, Perth, Western Australia, 33pp.
- DWER (2019) Data collection report of Yawuru Country GDEs in the La Grange Interim results. Unpublished report for Yawuru, DWER 2019.
- Elkin, A. P. (1933). Totemism in north-western Australia. *Oceania*, 3(4), 435-481. doi:<http://dx.doi.org/10.1002/j.1834-4461.1933.tb00087.x>
- Finn, M., Featherston, P. and the Bayulu-Gooniyandi Rangers (2012). *Gooniyandi River Monitoring Report: 2009 – 2010* CSIRO Ecosystem Sciences, Darwin.
- Gardner, M. (2014) 'Hunting accessibility in a post native title setting: a participatory geographic information system analysis approach with the Yawuru community, WA', Fenner School of Environment and Society, College of Medicine Biology and Environment, The Australian National University, [Unpublished].
- Hassell, C. (2015) Inputs to 2015 ESRM Planning for Roebuck Plains Station on behalf of Broome Bird Observatory, Australasian Wader Studies Group Notes
- Hassell C.J., and Rogers D.I. (2002) Painted Snipe Nesting At Taylor's Lagoon Near Broome, Northwestern Australia. *The Stilt* 41, 14-21.
- Jaensch, R.P. (1993) Western Australia. in *A Directory of Important Wetlands in Australia* ed. Usback, S. and James, R. National Parks and Wildlife Service, Canberra [Directory of Important Wetlands in Australia - Information sheet <http://environment.gov.au/cgi-bin/wetlands/report.pl>](http://environment.gov.au/cgi-bin/wetlands/report.pl)
- Kenneally, K. F., D.C. Edinger, & T. Willing. (1996). *Broome and Beyond. Plants and people of the Dampier Peninsula, Kimberley, Western Australia.* Department of Conservation and Land Management, Como.
- Lincoln, G., B.J. Austin, R.J. Dobbs, D. Mathews, D. Oades, A. Wiggan, S. Bayley, J. Edgar, T. King, K. George, J. Mansfield, J. Melbourne, T. Vigilante with the Balanggarra, Bardi Jawi, Dambimangari, Karajarri, Nyul Nyul, Wunambal Gaambera & Yawuru Traditional Owners (2017) Collaborative Science on Kimberley Saltwater Country - A Guide for Researchers V17.03. Prepared by the Kimberley Land Council for the Kimberley Indigenous Saltwater Science Project (KISSP), Western Australian Marine Science Institute (WAMSI). Broome July 2017
- Mathews, D., Doran, B. and Parker, C., (2018). Combining Yawuru cultural mapping with conservation and agricultural values, AIATSIS National Native Title Conference, 333 Broome.

- Mathews, D. Semeniuk V, and Seminuik, C.A (2011) Freshwater seepage along the coast of the western Dampier Peninsula, Kimberley region, Western Australia *Journal of the Royal Society of Western Australia*, 94: 207–212.
- Pinder AM, Quinlan K, Shiel RJ and Lewis, L. 2019. A survey of aquatic invertebrates of Nimalarragan wetland north of Broome, Department of Biodiversity, Conservation and Attractions, Perth
- Price, P. and Lovett, S. 2002, 'Managing riparian land', Fact Sheet 1, Land & Water Australia, Canberra
- Pyke ML, Toussaint S, Close PG, Dobbs RJ, Davey I, George K, Oades D, Sibosado D, McCarthy P, Tigan C, Angus (Jnr) B, Riley E, Cox D, Cox Z, Smith B, Cox P, Wiggan A, and Clifton J (2018) Wetlands need people: a framework for understanding and promoting Australian Indigenous wetland management. *Ecology and Society* 23(3):43. <https://doi.org/10.5751/ES-10283-230343>
- Rogers, D. I., Boyle, A. and Hassell, C. J. (2001) Occasional counts No 5: wader counts on Kidneybean Claypan and adjacent Roebuck Plains, north-western Australia, *Stilt* 38: 57 - 63
- Searle (2019) NBY Groundwater Monitoring – results and recommendations. Report to NYB.
- Semeniuk, C. A., & Semeniuk, V. (1995). A geomorphic approach to global classification for inland wetlands. In *Classification and Inventory of the World's Wetlands* (pp. 103-124). Springer Netherlands.
- Semeniuk C. A., & Semeniuk V. (2011) Wetlands of the Nyamba Buru Yawuru Broome Regional area: the coastal wetlands, stratigraphy and hydrology, natural maintenance, environmental and geoheritage significance, and recommendations for management. Report to Nyamba Buru Yawuru Ltd.
- Semeniuk V. & Semeniuk C. A., (2014) Wetlands on the Roebuck Plains – Distribution, Plant Composition, Ecological Values and Status Report to Nyamba Buru Yawuru, April 2014
- Strike (2021) Yawuru Indigenous Protected Area: groundwater monitoring results and recommendations
- Tengö, M., Brondizio, E. S., Elmqvist, T., Malmer, P., and Spierenburg, M. (2014). Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. *Ambio* 43: 579–591.
- Tingle F., Dobbs., R.J. and Close P.G. (2017) Grazing and Wetland Management literature review; Roebuck Plains Station Unpublished report for Yawuru, CENRM 2017
- Townsend, S., Humphrey, C., Choy, S. Dobbs, R., Burford, M., Hunt, R., Jardine, T., Kennard, M., Shellberg, J and Woodward, E. (2013). *Monitoring river health in the wet–dry tropics: strategic considerations, community participation and indicators Tropical Rivers and Coastal Knowledge Consortium*. Charles Darwin University, Darwin.
- Vernes, T., and Matthews, D. (2013) Roebuck Plains Property Management Plan: Interpretation of GIS Mapping, report prepared by for Nyamba Buru Yawuru, October 2013.

- Watkins, D. (1993) A national plan for shorebird conservation in Australia. Australasian Wader Studies Group, Royal Australasian Ornithologists Union and World Wide Fund for Nature. RAOU Report No. 90.
- Watkins, D. & Jaensch, R. (2007) Maintaining Heritage Values on Roebuck Plains Station, Western Australia. Report to Indigenous Land Corporation.
- Willing, T. (2012) A Desktop Review Of Wetlands And Biodiversity Of Roebuck Plains Pastoral Lease And Adjacent Coastline: In The Context Of The Yawuru Cultural Management Plan, Broome, Western Australia. Report to Nyamba Buru Yawuru Ltd., Coghlan St, Broome WA 6725
- Wysong, M.L., Gregory, P., Watson, A.W.T., Woolley, L.-A., Parker, C.W., Country Managers, Y., Rangers, K. and Mangala Rangers, N. (2022), Cross-cultural collaboration leads to greater understanding of the rare Spectacled Hare-wallaby in the west Kimberley, Western Australia. *Ecol Manag Restor*, 23: 139-149. <https://doi.org/10.1111/emr.12524>
- Yawuru RNTBC (2016). Walyjala-jala buru jayida jarrinygun buru. Nyamba Yawuru ngan-ga mirlimirlu. Planning for the future: Yawuru Cultural Management Plan. The cultural management plan for Yawuru coastal country and the Yawuru Conservation Estate (3rd Edition, 2016 for digital distribution): Yawuru RNTBC
- Yawuru Registered Native Title Body Corporate (2014) Walyjalajala nagulagabu birrangun buru: Yawuru Indigenous Protected Area Plan of Management 2016 – 2026 Yawuru Registered Native Title Body Corporate, Broome, Western Australia.
- Nyamba Buru Yawuru (NBY) (2016) Yawuru Indigenous Protected Area; Plan of Management 2016
- Yawuru Seasonal Calendar [Yawuru calendar - Indigenous Weather Knowledge - Bureau of Meteorology\(bom.gov.au\)http://www.bom.gov.au/iwk/calendars/yawuru.shtml#:~:text=The%20Yawuru%20calendar%20shows%20six%20seasons.%20The%20Yawuru,Native%20Title%20Holders%20Aboriginal%20Corporation%20RNTBC%20ICN%207033%22](http://www.bom.gov.au/iwk/calendars/yawuru.shtml#:~:text=The%20Yawuru%20calendar%20shows%20six%20seasons.%20The%20Yawuru,Native%20Title%20Holders%20Aboriginal%20Corporation%20RNTBC%20ICN%207033%22). (accessed 27/09/2021)
- Yu, S. (1999) *Ngapa Kunangkul* – Living Water: A report on the Aboriginal cultural values of groundwater in the La Grange sub-basin. Unpublished report prepared by the Centre for Anthropological Research at the University of Western Australia
- Yu, Sarah (2001) 'Ngapa kunangkul (living water): An Indigenous view of groundwater' in Country: Visions of land and People in Western Australia, eds. Gaynor, A, Haebich, A, & Trinca, M, University of Western Australia Press, 2000-2001