

PROTECTION OF FLOODPLAIN MARSHES

Barmah National Park and
Barmah Forest Ramsar Site



Strategic Action Plan
2019-2023 (Draft)



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Imagery

Front cover –

Main: Moira grass at southern Steamer Plain in 2016;
Front Inset 1: Waterbirds in Little Rushy Swamp;
Inset 2: Horses amongst Phragmites at Boals Deadwood, 2017;
Inset 3: Feral pigs at Tarma Lagoon in 2012;
Inset 4: Trial of manual clearing of Giant rush in 2017, with cut Giant rush in the foreground and taller Phragmites in the background (Photo credit: Danielle Beischer).

Page 30 composite:

Top left: Feral horses, Steamer Plains, 2015;
Top right: Feral horses, Steamer Plains, 2017;
Middle: Feral horses, Barmah National Park, 2017;
Bottom: Feral horses, Steamer Plains, 2017.

Back cover:

Main: Moira grass emerging from inundated wetland, Little Rushy Swamp, 2017.

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2019 – 2023 (Draft)

April 2019

Disclaimer

This plan is prepared without prejudice to any negotiated or litigated outcome of any native title determination applications covering land or waters within the plan's area. It is acknowledged that any future outcomes of native title determination applications may necessitate amendment of this plan; and the implementation of this plan may require further notifications under the procedures in Division 3 of Part 2 of the *Native Title Act 1993* (Cwlth).

The plan is also prepared without prejudice to any future negotiated outcomes between the Government/s and Traditional Owner Communities. It is acknowledged that such negotiated outcomes may necessitate amendment of this plan.

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Abbreviations and definitions

Abbreviations/acronyms	Description
Barmah Forest	The area within both the Barmah Forest Ramsar Site and Barmah National Park boundaries. The Ramsar boundary differs to the National Park by excluding Ulupna Island in the east of the park and including Barmah Island, situated immediately to the south-west of the National Park, which is part of the proposed Murray River Park. For consistent application of management actions, this plan is inclusive of the whole of Barmah National Park and Barmah Forest Ramsar Site.
CAMBA	China-Australia Migratory Bird Agreement
CMA	Catchment Management Authority
CPS	Components, Process and Services (Ramsar terminology)
DELWP	Department of Environment, Land, Water and Planning
DJPR	Department of Jobs Precincts and Regions
Distributary channels	The lower lying internal creeklines which provide a connection between wetlands within a forest.
Connecting creeks	Lower lying creeklines that form the direct connection between main river channels and low lying internal (within forest floodplain) wetland systems. May also be referred to as “effluents” in other literature.
Environmental flows	Water that is delivered to achieve ecological outcomes.
EPBC	Refers to the <i>Environment Protection and Biodiversity Conservation Act 1999</i> and or the species or processes listed within the Act.
Floodplain marshes	A collective of freshwater wetland vegetation communities that occur in low lying areas, subject to frequent inundation, with periods of drying. The extent and composition of these vegetation communities fluctuates relative to the flooding regime.
GB CMA	Goulburn Broken Catchment Management Authority
IUCN	International Union for the Conservation of Nature – maintains an international listing of threatened species.
JAMBA	Japan-Australia Migratory Bird Agreement
LAC	Limit of Acceptable Change (Ramsar terminology)
MDBA	Murray-Darling Basin Authority
ML/d	Mega-litres per day
Moira grass plains	Freshwater wetlands dominated by Moira grass (<i>Pseudoraphis spinescens</i>).
Ramsar	Refers to the Ramsar Convention Wetlands of International Importance (Ramsar Convention). This is an international treaty adopted in the Iranian city of Ramsar in 1971 that focuses on the conservation and sustainable use of wetlands.
Regulated flows	The managed flow in an irrigated system – fully managed to achieve a specified flow rate.
Regulators	Infrastructure used to deliver regulated flows such as environmental water to wetlands.
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
Unregulated flows	Flow in a river system that is not part of a controlled release to service an allocation – this includes spills from upstream storages that have filled to capacity and spilled due to high rainfall, and flows that enter river systems below storages.
YY TOLMB	Yorta Yorta Traditional Owner Land Management Board
YYNAC	Yorta Yorta Nations Aboriginal Corporation

Summary

This plan has been developed to address priority threats to the floodplain marshes within the Barmah Forest Ramsar Site and Barmah National Park. Floodplain marshes are a wetland type that includes Moira grass (*Pseudoraphis spinescens*), which has suffered a dramatic decline in extent since the Barmah Forest Ramsar Site was designated in 1982 as a wetland of international importance.

The Barmah Forest Ramsar Site is largely located within Barmah National Park (Figure 1) and is jointly managed by Parks Victoria and the Traditional Owners, the Yorta Yorta nation. It consists predominantly of river red gum floodplain forest interspersed with treeless freshwater marshes. It is a site of great importance for waterbirds and providing habitat for many wetland-dependent wildlife species. The ecological health of the area is essential to Traditional Owners' cultural and spiritual connections to the land and it supports valuable recreation and tourism activity.

The Barmah Forest Ramsar Site must be managed to maintain its ecological character. However, adverse changes have been observed to wetland attributes that are critical to this ecological character. Additional actions must be taken if these attributes are to be protected and preserved.

A key attribute of this Ramsar Site is Moira grass, a native wetland grass species that used to dominate the extensive floodplain marshlands in the area. Moira grass has a high nutrient content and is targeted by grazing herbivores, particularly by feral horses that are now present at this site.

Of immediate concern is the continued decline of Moira grass extent within floodplain marshes. Only 12% of this vegetation community remains, relative to that mapped when the site was Ramsar listed in 1982, and less than 5% of its extent in the 1930's, prior to regulation of the Murray River. This decline exceeds the limit of acceptable change for Moira grass at the site and represents a potential change in the site's ecological character.

The principal factors that are likely to have contributed to the decline in Moira grass extent are:

1. Changes to the natural flooding regime due to river regulation
2. Grazing and trampling pressure by introduced animals, particularly by feral horses (and previously, cattle)
3. Encroachment by invasive plant species

Current water management practices aim to help mitigate the risks to Moira grass plains from river regulation by delivering environmental water that increases the frequency and duration of seasonally appropriate inundation events, while reducing the likelihood of unseasonal flooding that can change the composition of wetland vegetation. This water management aims to re-invigorate floodplain marsh vegetation species including Moira grass by promoting the winter-spring flooding and summer-autumn dry period that this species requires.

Reduction in Moira grass extent has been exacerbated by the presence of introduced herbivores that preferentially graze Moira grass. Reducing the total grazing, browsing and trampling pressure is required to complement the management of environmental water to achieve protection and recovery of this critical component of the Barmah Forest Ramsar Site. Of all the introduced grazing species present, feral horses are currently considered the most destructive and their removal from the Barmah Forest is an immediate priority for action.

In addition, winter-spring floods of insufficient depth and duration, and shallow flooding over summer-autumn have, over decades, provided conditions suitable for the encroachment of native wetland plant species, predominantly giant rush and river red gum, into habitats formerly suitable for Moira grass.

This strategic action plan describes:

- the optimal watering regime required to restore the floodplain marshes;
- the program of actions required to reduce the grazing and trampling pressure applied by feral animals, particularly horses; and,
- the program to control the encroachment of invasive plants into Moira grass plains.

Feral horse control will be staged. This four-year plan describes the first stage of control and removal of feral horses, bringing the total number down to 100. The longer term aim is total removal of feral horses from the Barmah National Park.

The plan also outlines the roles and responsibilities of partners in delivering the proposed conservation actions, and includes a monitoring, evaluation and reporting framework to enable the effectiveness of actions to be assessed and inform further management.

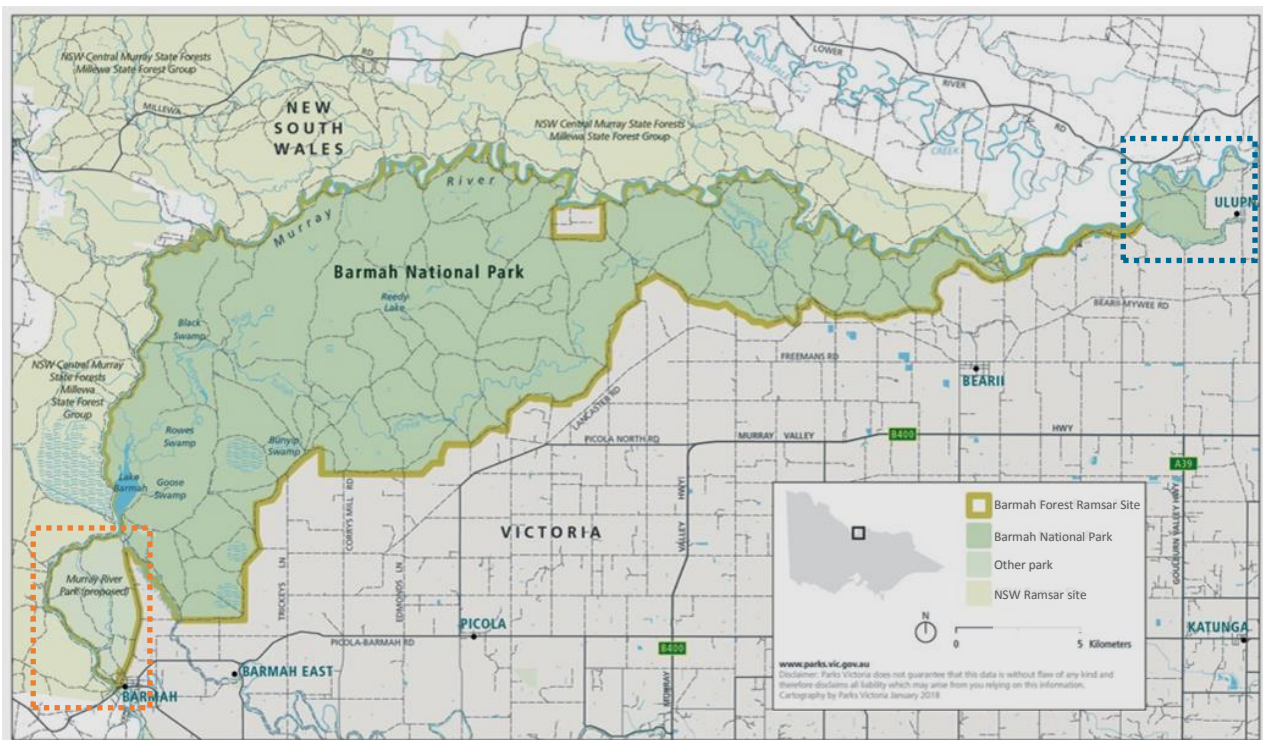


Figure 1: Location of the Barmah Forest Ramsar Site and Barmah National Park. This map shows that there is a small section of the national park near Ulupna Island in the north-east (highlighted in blue) that is not included as part of the Ramsar site; and a small section of the Ramsar site in the south-east (highlighted in orange) that is not within the national park.

1 Purpose of the Plan

The purpose of this action plan is to identify and improve management of threats to the ecological character of floodplain marshes at Barmah Forest Ramsar Site and Barmah National Park, herein referred to collectively as “Barmah Forest” (unless addressing specific attributes of each).

The need for the plan is driven by adverse changes to the floodplain marshes of the Ramsar Site that have occurred since it was listed as a wetland of international importance in 1982. The serious nature of the changes requires a review of current management to identify the additional actions required to effectively address these changes.

This plan will contribute to the objectives for environmental watering set out in the Barmah-Millewa Forest Environmental Water Management Plan (MDBA 2012), to:

- Restore the extent and distribution of healthy wetland and floodplain vegetation communities;
- Provide suitable feeding and breeding habitat for a range of waterbirds, including colonial nesting species;
- Support successful breeding and recruitment of native fish species; and,
- Provide high quality feeding, breeding and nursery habitat for native frogs, turtles and crayfish.

The overarching objective of this plan is to:

Improve the health of the floodplain marshes of Barmah Forest, increasing the extent and cover of Moira grass and associated wetland vegetation.

The plan sets out a program of actions to supplement those in existing management plans that govern land and water management in the Barmah Forest. Roles and responsibilities are outlined to deliver the proposed conservation strategies, with a monitoring, evaluation and reporting framework recommended to track progress and inform management. The plan:

- Identifies the legislative and cultural context for land management;
- Identifies the critical conservation assets and the drivers of ecological health that contribute to the ecological character of the site;
- Distinguishes the values and characteristics that are undergoing adverse changes, the nature of these changes and the benchmarks for management effectiveness (limits of acceptable change);
- Identifies additional actions required to complement the effort currently being applied to control significant risks and to improve management effectiveness; and,
- Recommends research to address knowledge gaps plus indicators to monitor, evaluate, report and inform management.

1.1 Geographic scope – floodplain marshes

This plan applies to management activities in Barmah Forest, located in northern Victoria. This site is largely a declared national park jointly managed by the Yorta Yorta people and Parks Victoria, and overseen by a Traditional Owner Land Management Board. Barmah Forest consists of the section of the Murray River floodplain south of the main river channel between the downstream end of the Ulupna Island and Barmah Township (Figure 1).

The vegetation of Barmah Forest (mapped in Figure 2) is predominantly river red gum (*Eucalyptus camaldulensis*) forest and woodland (Red Gum wetland), and, along with the adjoining Millewa group of forests in New South Wales (within the Murray Valley National Park), forms the largest stand of river red

gum in the world. The forest features a variety of permanent and temporary wetlands, including lakes, swamps, lagoons and flooded forest. These support regionally important vegetation communities, including seasonal freshwater wetlands dominated by Moira grass (forming large Moira grass plains), and provide significant habitat for many species of waterbirds (Borrell and Webster 2016).

The plan focuses on the management issues associated with the wetland vegetation classification ‘floodplain marshes’ (as per DELWP 2016), where extensive swards of Moira grass are found and where the impact of grazing animals is causing the greatest impact.

Floodplain marshes include several different vegetation communities that occur in low lying areas of the site that are subject to more frequent inundation, but with periods of drying. Using the standard Ramsar wetland classification types (Figure 2), floodplain marshes comprise the “seasonal/intermittent freshwater marshes/pools on inorganic soils” type which includes shallow freshwater marsh (‘Herb’) and deep freshwater marsh (‘Reed’) sub-categories, and “seasonal/intermittent freshwater lakes” (Open water’). In Barmah Forest, floodplain marshes include Moira grass plains, giant rush (*Juncus ingens*) beds, common reed (*Phragmites australis*) beds, moist grasslands and aquatic herblands. These wetlands can be either semi-permanent or ephemeral, fluctuating in their extent and composition relative to water availability (flooding regime).

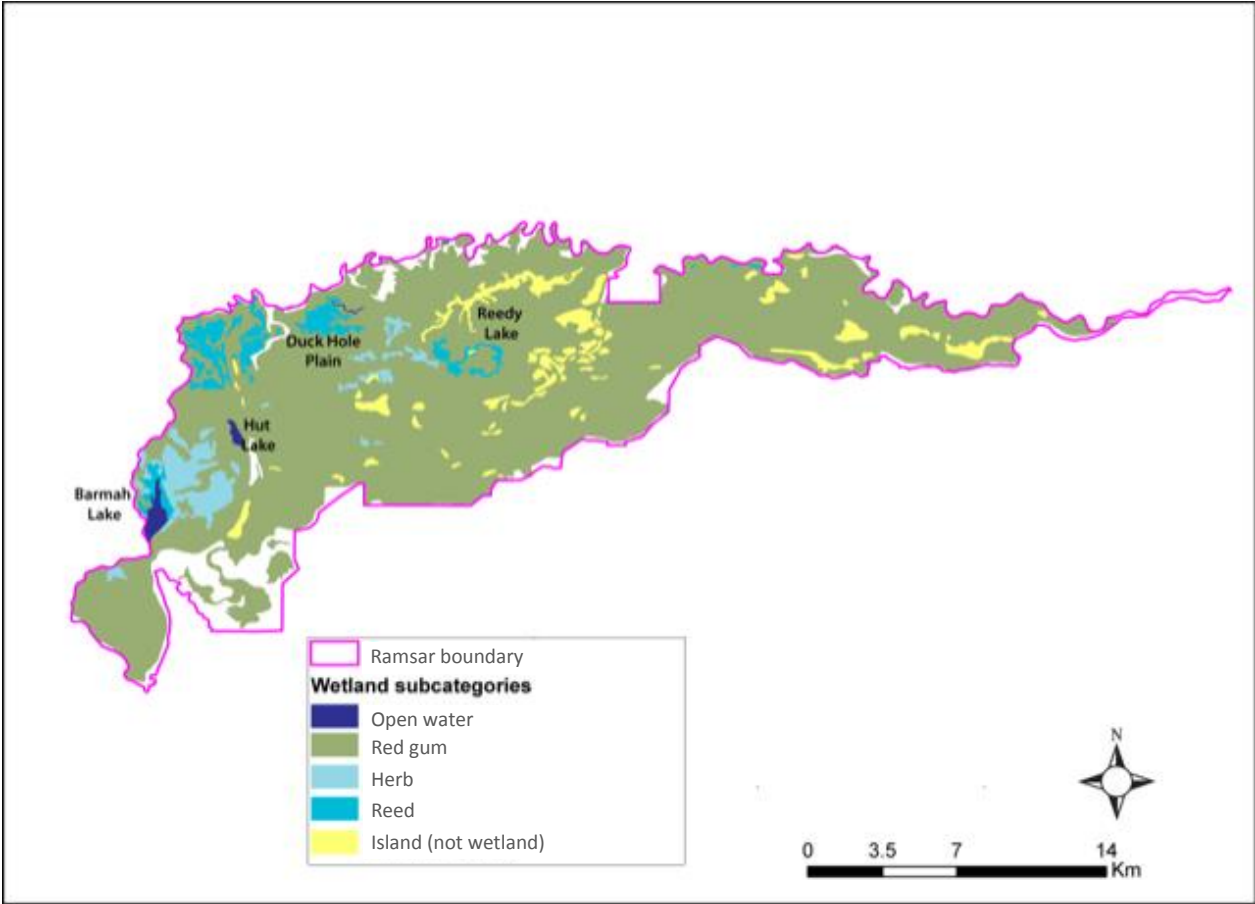


Figure 2: Vegetation types within the Barmah Forest using the Ramsar wetland classification system (Hale and Butcher 2011).

1.2 Legislative and planning context

The range of legislation, plans and other strategic documents that govern or influence the management of the Barmah Forest Ramsar Site and Barmah National Park are referenced throughout the plan. They are also identified and summarised in Appendices A and B.

1.3 Duration and review

This plan applies over a four-year period, through to June 2023. Monitoring of the plan's actions, progress against threat management objectives and conservation outcomes objectives will be a consistent activity throughout the life of the plan. In the final year of the plan a more comprehensive review will occur. If the management actions are found not to be achieving the critical conservation outcomes required to restore the Moira grass plains, alternative actions may be required. Any such actions would be developed in consultation with key stakeholders and community representatives.

1.4 Key contributions

Coordinated management is a key objective of this plan. Parks Victoria, Goulburn Broken Catchment Management Authority (GB CMA), Department of Environment, Land, Water and Planning (DELWP) and the Yorta Yorta Nations Aboriginal Corporation (YYNAC) have worked closely to draft this plan and will continue this relationship to deliver the actions in the plan.

A roundtable consultation process occurred at the start of the planning process for this action plan. Three roundtable meetings were run with participation from a cross-section of the community. Parks Victoria acknowledges the contributions of groups that participated in the three roundtable consultations. The participants were:

- Australian Brumby Alliance Inc.
- Barmah Brumby Preservation Group
- Barmah Forest Cattleman's Association
- Barmah Forest Preservation League
- Barmah Heritage Awareness Group
- Goulburn Valley Environment Group
- Hoofs 2010 Inc.
- Murray-Darling Freshwater Research Centre
- Victorian Brumby Association
- Victorian National Parks Association
- Yorta Yorta Nations Aboriginal Corporation.

Feral Horse Technical Reference Group

An independent Technical Reference Group has been established to guide Parks Victoria in the development, implementation and evaluation of feral horse management strategies in both Barmah National Park and the Alpine National Park. This independent technical advice is provided to the Parks Victoria Executive Director Environment and Science (Chief Conservation Scientist), and includes evaluations of scientific evidence, best practice animal welfare, adaptive management, and the social and community perspectives that will be applied to the planned control strategies.

The group currently consists of experts in the fields of veterinary science; animal welfare science; invasive species; mammal and ungulate biology; aboriginal affairs; and social science relating to environmental issues.

2 Aboriginal culture

The Barmah natural and cultural landscape is at the heart of Yorta Yorta Country, and is a major source of food, shelter, fibre and cultural-spiritual materials. For the Yorta Yorta people, physical health of Country is directly connected to their physical, emotional and spiritual health (YYNAC 2012). The forest, river, plants and animals are all part of Country and the cultural identity of the Traditional Owners.

The ecological values of the floodplain are fundamental to Aboriginal culture. The Bayadherra, the Broad-shelled Turtle (*Chelodina expansa*), found in Barmah Forest is a totemic species for the Yorta Yorta people.

The Barmah floodplain's connection with the Murray River and the presence of permanent water has meant that Barmah Forest provides an abundance of resources, which during pre-European settlement, sustained a large population of Yorta Yorta people. This has resulted in a high density of cultural sites in the area, which are protected under the *Aboriginal Heritage Act 2006*. Yorta Yorta cultural sites include ancestral remains, middens, artefact scatters and mounds and these remain highly important to the Traditional Owners.

Yorta Yorta Cultural Officers share traditional knowledge with the wider community through interpretive materials, artefacts, and specific education sessions.

Introduced grazing herbivores, particularly feral horses, have adverse impacts at Barmah Forest. These feral animals are highly mobile, moving throughout the landscape taking advantage of abundant food resources, and during flood events will often congregate on higher ground. This results in detrimental impacts to specific sites of cultural importance such as middens, burial sites and ceremonial grounds that often occur on higher ground/sandy rises (Figure 3). It has also resulted in significant change to the overall health of the forest, causing damage to Country.

The conservation and protection of the Barmah Forest is a high priority for the Yorta Yorta people, who seek to assist its protection according to both Yorta Yorta lore and international obligations. Restoring the ecological character of the Ramsar site will complement the protection of culture and its on-going practice throughout Yorta Yorta Country, while feral animal control will reduce disturbance to middens, artefact scatters, ancestral remains and mounds.



Figure 3: Horses traversing a site of Aboriginal cultural significance.

3 Other social values

3.1 Post European settlement history

Many members of local communities have family links to the early European settlers of the region, particularly through the activities of grazing and forestry. The first Europeans to occupy Barmah were squatters moving from the New South Wales Riverina, into lands south of the Murray. Settlement by other European immigrants began around 1856, particularly in response to the Victorian goldrushes. Local industry developed based on the primary resource opportunities available: fishing, forestry and grazing. At that time the vast red gum forests offered a plentiful source of high-quality timber for the growing mining industry. Due to the rapid population growth in the large goldfields to the south of the district, fish, mutton and beef were also in high demand. Following World War 1, Numurkah became the headquarters of the Murray Valley Soldier Settlement Area - one of the largest soldier settlement schemes in Australia. Under this scheme 700 ex-servicemen were given land to develop for agriculture (Lake 1991).

Origin of feral horses in Barmah Forest

Horses in the region were originally part of pre-mechanisation production activity, for both farm practices and utilisation of the forest resources. There are a number of sites and relics remaining within Barmah Forest that signify European settlement history, past events and the effect they had (DSE 2003).

The heritage values and connections that this area has with post-settlement primary industries (farming, grazing and forestry) are acknowledged. For some people, the horses in Barmah Forest (colloquially referred to as 'brumbies') are considered part of Australian folklore provide a living link to, or a reminder of, the pioneer and grazing history in the Barmah region. Post-settlement heritage is celebrated through events such as the annual Barmah Muster, and information provided to visitors and schools through the Barmah Forest Heritage and Education Centre at Nathalia.

A review of the history of horses and their origin in the Barmah Forest was commissioned by Parks Victoria in 2014. An independent heritage consultant undertook a literature search, an online survey, historical research and interviews with individuals and focus groups. A report was produced, which identified that *"...the majority of the current wild horse population within the National Park ... can be traced to those left in the forest by the trotting breeder and trainer Horace Adams who was not able to round up all of his horses after the last muster took place in 1952. In summary, the current population is most probably a mixture of ponies, trotters and Clydesdales, principally linked to Horace Adams' horses released during the mid-20th century interbred with any horses that were in the forest at that time"* (Context 2014).

As horses may have been present in the Barmah landscape for more than a century, some local landholders and community members place value on the feral horses and their retention in Barmah National Park. However, the Victorian *National Parks Act 1975* and other associated legislation does not allow for the ongoing presence of horses within the park – they are considered 'exotic' in an uncontrolled situation (*National Parks Act 1975*) and declared a threatening process under the *Flora and Fauna Guarantee Act 1988*. However, horse riding is permitted under regulation in the park for both individuals and licensed tour operators.

3.2 Natural heritage

The concept of natural heritage is a post-settlement cultural value. The significance for conservation of the natural heritage occurring at Barmah is reflected in its formal listing as a wetland of international importance under the Ramsar convention (Section 4.1), its reservation as a national park in 2010, and the protection of listed threatened species occurring there under national (*Environment Protection and Biodiversity Conservation Act 1999*) and state (*Flora and Fauna Guarantee Act 1988*) legislation.

Ecological significance

At the time of listing as a Ramsar Site, the Moira grass-dominated grassy wetlands at Barmah Forest represented the largest extent of the species in the Murray-Darling Basin. The extent of Moira grass was around 1500 hectares and was a notable characteristic of the Ramsar site. Moira grass at Barmah Forest is important for maintaining wetland biodiversity and provides several important ecosystem functions (Colloff *et al.* 2014), including:

- high productivity in the wet phase,
- a significant contribution to floodplain organic carbon, which is an important energy source for floodplain biota, and
- habitat provision and food resources for wildlife, particularly for waterfowl, turtles and frogs.

3.3 Socio-economic benefits

Barmah Forest is valued for tourism and recreation pursuits including camping, picnics and barbecues, boating, recreational fishing, sightseeing, bushwalking and birdwatching. Park tracks provide access to 112 kilometres of river frontage. Several commercial tourism operators conduct tours in the park, including one boat operator who conducts daily tours through the narrowest section of the Murray River from a landing in Barmah National Park. There are boat-launching areas and major tracks in Barmah Forest suitable for two-wheel drive vehicles, however seasonal and other temporary road closures occur in wet periods and periods of flood inundation.

Most of these recreational activities take advantage of the environmental assets at the site (Figures 4a and b) and therefore wetland health and wildlife are a strong attraction for both locals and visitors alike, generating direct benefits to regional communities and economies.



Figure 4: (a) A birdwatcher wading through herbland wetlands and (b): Recreational paddlers on the open water wetlands.

4 Conservation assets

Parks Victoria’s approach to conservation action planning involves identifying priority conservation assets and the key threats to them. This enables Parks Victoria to develop strategies to tackle the threats that pose the greatest risk to priority values and contribute most to meeting desired conservation outcomes. The approach has been used to develop this plan while recognising the existing framework for planning and management of Ramsar sites.

4.1 Barmah Forest Ramsar Site values

The *Convention on Wetlands of International Importance*, also known as the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are 66 Ramsar-listed wetlands in Australia, and 12 in Victoria.

In 1982, Barmah Forest was listed as a Ramsar site reflecting its significant wetland values. The Ramsar Convention obliges contracting parties to manage Ramsar sites in such a way as to maintain their ecological character to that at the time of listing. The primary purpose of management of a declared Ramsar site (*Environment Protection and Biodiversity Conservation Regulations 1999*) must be:

- to describe and maintain the ecological character of the wetland, and
- to formulate and implement planning that promotes:
 - (i) conservation of the wetland, and
 - (ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.

To be listed as a Ramsar site, a site must meet at least one of the nine Ramsar criteria. At the time of listing in 1982, the Barmah Forest Ramsar Site met six of the criteria, and it continues to do so today (Table 1).

Table 1: Ramsar criteria met.

Criteria	Justification*
1. Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	Barmah Forest is part of the largest complex of tree-dominated floodplain wetlands in southern Australia. Barmah Forest, together with Millewa Forests (on the NSW side of the Murray River) is the largest continuous stand of river red gum forest in Australia. The size and intact nature of this forested floodplain makes it clearly one of the best representatives of the wetland type ('freshwater tree-dominated wetlands') in the Murray-Darling Depression bioregion. In addition, at the time of listing, the site included some of the most extensive stands of aquatic grasslands in the bioregion, dominated by Moira grass.
2. Supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	Barmah Forest supports the following wetland-dependent species listed under the EPBC Act and/or IUCN Red List: Australasian bittern (<i>Botaurus poiciloptilus</i>) – Endangered (EPBC), endangered (IUCN) Superb parrot (<i>Polytelis swainsonii</i>) – Vulnerable (EPBC) Murray cod (<i>Maccullochella peelii</i>) – Endangered (EPBC), critically endangered (IUCN) Silver perch (<i>Bidyanus bidyanus</i>) – Vulnerable (IUCN) Trout cod (<i>Maccullochella macquariensis</i>) – Endangered (EPBC) Mueller daisy (<i>Brachyscome muelleroides</i>) - Vulnerable (EPBC) Swamp wallaby grass (<i>Amphibromus fluitans</i>) - Vulnerable (EPBC)

Criteria	Justification*
3. Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.	Barmah Forest supports at least 553 native species of flora and 273 native species of fauna (considerably more than some comparable sites in the bioregion). In addition, the site is bioregionally significant with respect to Moira grass, containing the most extensive expanses (swards) of the species in the Murray-Darling Basin.
4. Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	The Barmah Forest Ramsar Site supports breeding of waterbirds, frogs, native fishes and turtles during times of inundation. The site periodically supports thousands of colonial nesting waterbirds and is considered a drought refuge for waterbirds and native fish.
6. Regularly supports one percent of the individuals in a population of one species or subspecies of waterbird.	Assessment of this criterion must be made using the most recent official population estimates (Wetlands International 2012). Data from the DELWP flora and fauna database and local surveys (Belcher <i>et al.</i> 2016) indicate that Barmah Forest supports between 4 and 8% of the south-eastern Australian population of Australasian bittern (<i>Botaurus poiciloptilus</i>).
8. Is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	The site provides migratory routes between habitat in the Murray River, anabranches and floodplains and is considered important for recruitment of native fish (King <i>et al.</i> 2008).

* See page ii for abbreviations.

4.2 The importance of healthy floodplain marshes

At Barmah Forest, the expanse of river red gum forest is far greater than that of the floodplain marsh, but it is the latter that supports extensive swards of Moira grass, a species that is currently at high risk (Colloff *et al.* 2014; Vivian *et al.* 2015).

Floodplain marsh wetlands provide diverse and dynamic habitats that support a wide range of native species. Due to their lower position in the landscape, these wetlands tend to accumulate nutrients and carbon during their inundation, receding and drying cycle. Periodic flooding performs an important role in the movement of these nutrients and carbon between the wetland and the interconnected river systems.

Many animal and plant species have adaptations that make them dependent on periodic inundation to complete components of their life cycle. Frogs are particularly adapted to utilise wetlands, with many having adapted to survive dry periods by burrowing underground, re-emerging *en masse* when floodwaters arrive. While monitoring data is limited for the planning area with respect to frog species, numbers, breeding locations and cues, and recruitment outcomes (GB CMA and OEH 2016), the floodplain marshes are a critical component of their habitat. Similarly, yabbies have a comparable adaptation, burrowing deep underground during dry periods, emerging during the wet. In Barmah Forest the swamp yabby (*Cherax* sp. C) is considered locally abundant (Edney *et al.* 2002), while the abundance of the Murray crayfish population is unknown (GB CMA and OEH 2016).

Many insects also complete a component of their life cycle in the wetlands, such as mayflies and dragonflies during their nymph phases. Some fish species are wetland specialists, spending their whole life cycle within wetlands, while others utilise wetlands as nursery grounds during their early growth phases, moving out from wetlands to river systems when they reach maturity. Large flows that inundate floodplains trigger a pulse of productivity and promote the exchange of nutrients and carbon between rivers and their floodplains. This in turn promotes food and breeding opportunities for within-channel fish assemblages (Ellis

et. al. 2016). Barmah Forest provides temporary habitat for the threatened Murray cod, trout cod and silver perch when floods link the riverine habitat of these fish species with the floodplain (Hale and Butcher 2011).

Together with wetland plant material and seeds, these aquatic fauna species provide a crucial food source for waterfowl and waders (Hale and Butcher 2011) (Figure 5).

Between 1999 and 2016, waterbird monitoring conducted through MDBA's *The Living Murray* program (see Appendix A) identified a total of 71 species of wetland birds across the Barmah-Millewa Forest Icon Site (Borrell and Webster 2016). Given the transient nature of birds, it can be assumed that these birds occur in the forests on both sides of the Murray River. The list includes seven species that are listed under international migratory bird agreements (CAMBA, JAMBA or ROKAMBA)¹.

Specifically in Barmah Forest, this includes breeding of colonial nesting species such as Australasian darter (*Anhinga novaehollandiae*), little pied cormorant (*Microcarbo melanoleucos*), eastern great egret (*Ardea modesta*), intermediate egret (*Ardea intermedia*), Australian white ibis (*Threskiornis molucca*), straw-necked ibis (*Threskiornis spinicollis*) and royal spoonbill (*Platalea regia*). In addition, threatened species have also recently been identified in Barmah Forest including the Australasian bittern (*Botaurus poiciloptilus*) and Australian little bittern (*Ixobrychus dubius*) (Borrell and Webster 2016; Borrell and Liefting 2017; Belcher et al. 2016). Historically, 31 species of wetland birds have been recorded breeding within the Barmah Forest Ramsar Site, including at least 15 colonial nesting species (Chesterfield et al. 1984).

The greatest concentrations of nesting bird species occur following spring floods in Barmah Forest at Barmah Lake, War Plain and Boals Deadwood, and environmental water delivered between 2012-13 and 2016-17 has supported feeding and breeding habitat for an abundant array of bird species (Hunt 2017).



Figure 5: Great egrets, royal spoonbills, and wood ducks (*Chenonetta jubata*) foraging in Little Rushy Swamp.

Aquatic mammals, and reptiles and frogs are found within floodplain marsh habitat, including records for Rakali (*Hydromys chrysogaster*) and Platypus (*Ornithorhynchus anatinus*), eight species of frogs, and four water-dependent reptile species.

Turtle abundance is greater in the river and permanent wetlands, than in ephemeral habitats, however there is preliminary evidence that environmental flows improve the health of turtles occupying ephemeral floodplain habitats (Howard et al. 2016). The distribution, body condition, likelihood of mortality and nesting activity of turtles have been observed to change between years in response to the quality of aquatic habitats and effectiveness of fox control (Howard et al. 2011).

¹ Refer to 'Abbreviations and definitions' section for description of acronyms.

INFOSHEET: Moira grass

Two vegetation types are considered critical to the ecological character of the Barmah Forest Ramsar Site:

- 'Floodplain forests' dominated by river red gum forests and open woodlands,
- 'Floodplain marshes' comprising Moira grass plains (regionally significant), giant rush (*Juncus ingens*) beds, common reed (*Phragmites australis*) beds, moist grasslands, aquatic herblands and semi-permanent marshes.

Moira grass plains are a distinctive seasonal floodplain marsh occurring across the Barmah-Millewa Forests. Though Moira grass is found in many other freshwater wetlands across Australia, its dominance in these distinctive vast plains (Figure 6a and b) is unique to the Millewa (NSW) and Barmah (Victoria) forests. However, in the Barmah Forest Ramsar Site, the Moira grass floodplain marshes are now at less than 5% of their 1930s extent.



Figure 6: (a) View of Moira grass plains at Little Rushy Swamp and (b) Low view, showing emerging Moira grass spikes (taller, grass-like), amongst other native aquatic plants (wide leaves, floating on surface), in Little Rushy Swamp.

Moira grass is an aquatic species - also known as spiny mud grass - that can grow more than 2 centimetres per day under ideal conditions (Figure 7a), and reach lengths of 4 metres. It thrives when flooded in warm to hot conditions, otherwise it persists in a much smaller dry growth phase.

The timing of water delivery to the wetlands and Moira grass is important, as is water depth, length of inundation and return frequency. The drying phase of the Moira grass life cycle serves to insulate the wetland - as water recedes, the grassy mats settle as thatch (Figure 7b) on the floodplain floor, helping to slow evaporation from the wetland. After dry periods, new growth can germinate from existing rootstock, buried seeds and dried stem segments.



Figure 7: (a) Dense and tall Moira grass and (b) Moira grass thatch on ground surface at Little Rushy Swamp following flooding.

The Moira grass plains provided valuable hunting and gathering grounds for local Aboriginal people. Early settlers recognised the pastoral values of this native grass and used the Moira grass plains as a source of supplementary feed for stock. Moira grass plains provide habitat and food resources for a diversity of wildlife species, particularly for waterfowl, frogs and invertebrates.

5 Ramsar ecological character measures

5.1 Critical components, processes and services

The Barmah Forest Ramsar Site is managed to maintain its ecological character, as defined in the ecological character description (Hale and Butcher 2011). The ecological character of a Ramsar site is the sum of all the critical components, processes and services (CPS) of that wetland. Table 2 lists the four components/processes and six services that are critical to the ecological character of the Barmah Forest Ramsar Site. Species supported at the site that have national or state conservation significance are listed in Appendix C.

Table 2: Critical components, processes and services of the Barmah Forest Ramsar Site as identified in the Ramsar Site Ecological Character Description (Hale and Butcher 2011).

Critical CPS	Description
Component/process: Hydrology	The hydrology of the Barmah Forest Ramsar Site is defined by flow in the Murray River and, below certain flow levels, by regulators which control both movement of water into the forest and within it. As flows increase, the ability to control water movement diminishes with progressively more of the forest inundated as flow volumes increase. Large floods which inundate most of the forest are largely driven by large rainfall events in the catchment.
Component: Wetland vegetation	Two vegetation types are considered critical to the ecological character of the Barmah Forest Ramsar Site: 'Floodplain forests' dominated by river red gum forests and open woodlands, which cover 75% of the site, with a small components of black box woodland. The combined extent of floodplain forests and woodland is 24,000 hectares. 'Floodplain marshes' comprising Moira grass plains (regionally significant), giant rush beds, common reed beds, moist grasslands, aquatic herblands and semi-permanent marshes (see Figure 2 for vegetation type distribution map).
Component: Fish	Seventeen species of native fish have been recorded within the Barmah Forest Ramsar Site, including three native threatened fish species: silver perch, Murray cod and trout cod.
Component: Waterbirds	Sixty species ² of wetland bird have been recorded from the site, including seven species listed under international migratory agreements and two threatened species: superb parrot and Australasian bittern. During significant flood events the site supports very high abundances of waterbirds (maximum counts exceed 100,000 birds) and significant breeding of colonial nesting species. The site also supports a significant breeding population of the superb parrot.
Diversity of wetland types	The site supports part of the largest remaining river red gum forest and provides a mosaic of vegetated wetland habitats.
Biodiversity	The site supports the regionally significant Moira grass vegetation community and a significant number of plant and animal species.
Physical habitat	Barmah Forest provides habitat for feeding and breeding of wetland birds.
Threatened species	The site supports seven wetland-dependent flora and fauna species listed under the EPBC Act and/or the IUCN Red List (listed in Table 1).
Ecological connectivity	The site provides important migratory routes between riverine, wetland and floodplain habitats for fish spawning and recruitment.
Organic carbon cycling	As part of a major floodplain system, the site is important for the cycling of nutrients, particularly carbon both on the floodplain and as a source of organic carbon to receiving waterways.

² Recorded at the time the Ramsar site was listed. Current monitoring has identified a total of 71 species of wetland birds across the Barmah-Millewa Forest Icon Site (Borrell and Webster 2016).

5.2 Limits of acceptable change

The ecological character description sets out Limits of Acceptable Change (LAC) for components, processes and services that are critical to the ecological character of the Ramsar Site (Hale and Butcher 2011). These effectively form the benchmarks by which potential change in ecological character can be assessed. An assessment of the ecological character status of the Ramsar Site in 2018 (DELWP, *in prep.*, 2018) has found evidence of potential change in the ecological character of the site. The assessment detected an unacceptable level of change in the condition and trend relating to Moira grass extent (see section 5.4, Figure 9), and expressed high confidence that the LAC had been exceeded.

5.3 Floodplain marshes

Low-lying portions of the Barmah Forest Ramsar Site feature a variety of treeless wetland types, including Moira grass plains, giant rush beds, common reed beds, moist grasslands and aquatic herblands. These wetlands, referred to collectively as floodplain marshes, are associated with a variety of geomorphic settings including intermittent drainage lines, flood-runners, oxbow lagoons and floodplain depressions.

Within the Ramsar Site these wetlands are most prevalent in the centre and western regions of the forest, especially Little Rushy Swamp, Hut Lake, Steamer Plain, War Plain and surrounds of Barmah Lake (Figure 88). Other commonly referred to localities within Barmah Forest with a historic prevalence of Moira grass include Top Island, Boals Deadwood, Harbours Lake, Top Lake, and Bucks Lake (Figure 8).

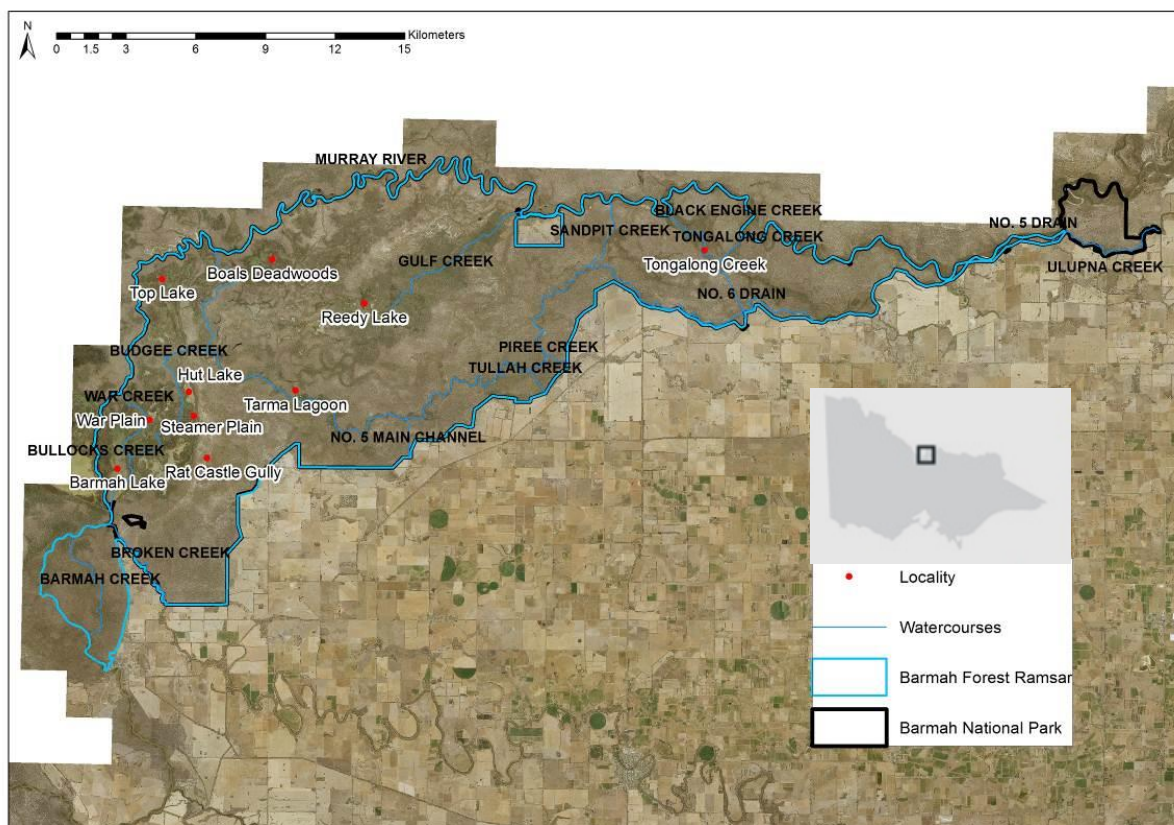


Figure 8: Key localities throughout Barmah Forest with historically extensive areas of Moira grass.

At the time of listing, the extent of two floodplain marsh vegetation communities was mapped as approximately 500 hectares of giant rush and 1500 hectares of Moira grass (Chesterfield *et al.* 1984).

5.4 Decline in extent of Moira grass

The extent of Moira grass at Barmah Forest has continued a trajectory of decline since the Ramsar Site was listed in 1982. There was an estimated 4000 hectares in the 1930s (decades before listing); 1650 hectares in 1979 (around the time of listing) and 947 hectares in 2007 (Colloff *et al.* 2014). Using these figures, Colloff *et al.* (2014) estimated the trajectory of decline of Moira grass at Barmah Forest, with an estimated halving of the 2007 extent by 2060 using an exponential fit (Figure 9).

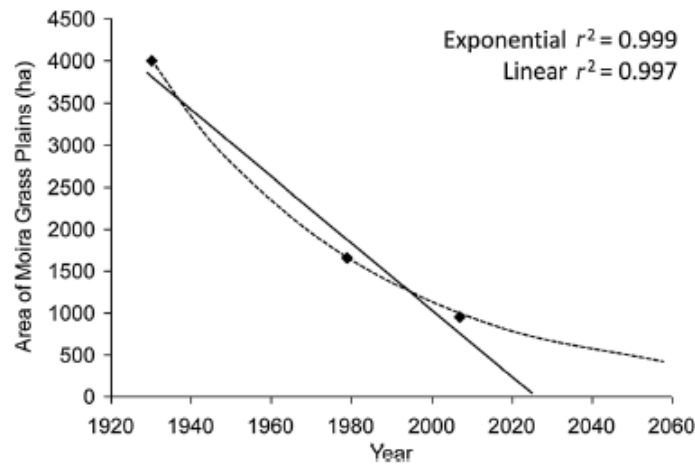


Figure 9: Rate of loss of Moira grass plains at Barmah Forest, based on historical measures of extent (Colloff *et al.* 2014), without management intervention

Without management intervention (i.e. maintaining the status quo), the possible trajectory of further decline has been described in a linear model (Figure 9, Colloff *et al.* 2014) which predicts a trend toward extinction of the vegetation community at Barmah Forest by 2026.

The LAC for floodplain marshes (Moira grass) was established based on mapped extent around the time of listing (Chesterfield *et al.* 1984). It is defined as: ‘Extent of floodplain marshes to be no less than 1,350 hectares of Moira grass’ (Hale and Butcher 2011). The LAC represents a 10% loss relative to the estimated extent at listing, 1500 hectares in 1982, based on mapping by Chesterfield (1984).

From detailed on-ground surveys, Vivian *et al.* (2015) estimated that that only 182 hectares remained in Barmah Forest in 2015, with only 50 hectares of the monospecific swards that were a historically important part of the floodplain (Vivian 2013, Vivian *et al.* 2015). This remaining area represents only 12% of the extent at the site since its Ramsar-listing, and shows a continuing trend towards the extinction predicted by Colloff *et al.* (2014). The LAC has clearly been far exceeded with a loss of 88% of the Moira grass extent since listing.

6 Ecological processes

6.1 Climate

Barmah Forest is located in the warm/grassland climatic zone of south-eastern Australia (Bureau of Meteorology 2014). The general climatic pattern is hot dry summers with cold winters. Rainfall occurs year-round, but is highest in June and lowest in February and averages around 430 millimetres per year. The three aspects of climate that most directly affect river and wetland hydrology and their dependant ecological processes are:

- 1) rainfall (both local and in the catchment),
- 2) temperature, and
- 3) relative humidity (to a lesser extent in temperate systems).

Temperatures range from cool to warm, with average summer maximum temperatures around 30°C and average minimum temperatures around 15°C. During winter, average maximum temperatures are considerably cooler (15°C) as are average minimum temperatures (4-5°C). Average relative humidity ranges from 50% during summer to 90% during winter months. This combined with the relatively low winter temperatures results in rainfall exceeding evaporation during winter, with the reverse situation for the remainder of the year (data from Bureau of Meteorology 2018).

Hope *et al.* (2017) note that while rainfall in Victoria is historically highly variable, a marked reduction in cool season rainfall has occurred over the past 30 years with a corresponding increase in warm season rainfall over the same period. Overall temperatures in Victoria have continued to increase.

6.2 Hydrology

Historically the natural hydrology of Barmah Forest was driven by natural flood events in the catchments of the Murray River, and to a lesser extent the Broken Creek. Smaller scale flood events occurred when water levels in the Murray River reached the commence-to-flow of connecting creeks³ or distributary channels⁴. When river levels are high enough, water begins to tip into these creeks and they flow through distributary channels to inundate wetlands. Large floods occur when water levels exceed the capacity of the adjoining Murray River and Broken Creek channels, resulting in overbank flows. During these events, flooding moves out of internal creeklines and low-lying wetlands and onto the broader forest floodplain.

The hydrology of the Barmah Forest Ramsar Site is now predominantly defined by the regulated flow releases in the Murray River and, below certain flow levels, by regulators that have been constructed on key connecting creeks to control movement of water into the forest. As flows increase, the ability to control water movement into the forest diminishes as the capacity of internal creeklines is exceeded and water flows across the floodplain.

It is now only during unregulated flow events, when heavy rainfall results in the fill and spill of upstream catchment dams or significant overland flow directly enters a river channel, that large overbank floods can occur, otherwise normal regulated system operations of water releases must remain within channel or through an allocation of water released for the environment.

³ The lower lying creeklines which form the direct connection between main river channels and low-lying internal wetland systems

⁴ The lower lying internal creeklines which provide the connection between wetlands within the forest.

Regulation

The flow of the Murray River is highly regulated upstream of Barmah Forest, and water is generally released from September to May, largely opposite to the natural hydrology of higher winter-spring flows and lower summer-autumn flows. Environmental water releases are now used to improve the hydrological regime in the floodplain marshes.

The hydrology of the Murray River and its tributaries was managed for water supply, flood mitigation, navigation and hydroelectricity production long before the Barmah Forest Ramsar Site was designated as a Ramsar Site in 1982. Regulation of rivers began almost a century ago with a large number of dams, locks and weirs constructed on the Murray River and its tributaries between 1915 and 1974. The flow of the Murray River is highly regulated upstream (and downstream) of Barmah Forest, and is managed by the Murray-Darling Basin Authority (MDBA), who is the River Operator (refer also to Appendix A, *Water Act 2007*).

Water that passes through the section of the Murray River that adjoins Barmah Forest includes water that has been released from Hume Dam, and water exiting from tributaries downstream of the dam. This water is then re-captured at Lake Mulwala, and released over Yarrowonga Weir before it travels 200 kilometres to pass by or through Barmah Forest (Figure 10).



Figure 10: Stylised image of the section of the Murray River between Hume Dam and the Barmah Choke (not to scale). Adapted from MDBA (2013b).

The Hume Dam generally follows an annual cycle, filling predominantly during winter and spring and releasing the bulk of regulated water from September to May, primarily to provide water to irrigated farming and to sustain urban diversion. This is largely opposite to the natural hydrology of higher winter-spring flows and lower summer-autumn flows. Some flows are diverted at Yarrowonga Weir to supply several irrigation districts upstream of Barmah-Millewa Forest. However, the bulk of the Murray River flows continue past Barmah Forest destined for irrigation districts further downstream (Ecological Associates and SKM 2011).

To control flows into the forest, regulators were constructed on several major connecting creeks in the 1930s and 1940s (Hale and Butcher 2011) and hydrology within the site has been further regulated and managed since this time. The character of the site at the time of listing was strongly influenced by river regulation, and this regulated regime forms the baseline for the hydrology of the site.

For small and moderate floods, the release and distribution of water into Barmah Forest is highly managed using water regulating structures. The operation of regulators largely determines inundation extent, frequency and duration. Variations in the opening and closing of these regulators vastly alters the distribution of water of any given magnitude, but a typical inundation model is provided in Figure 11.

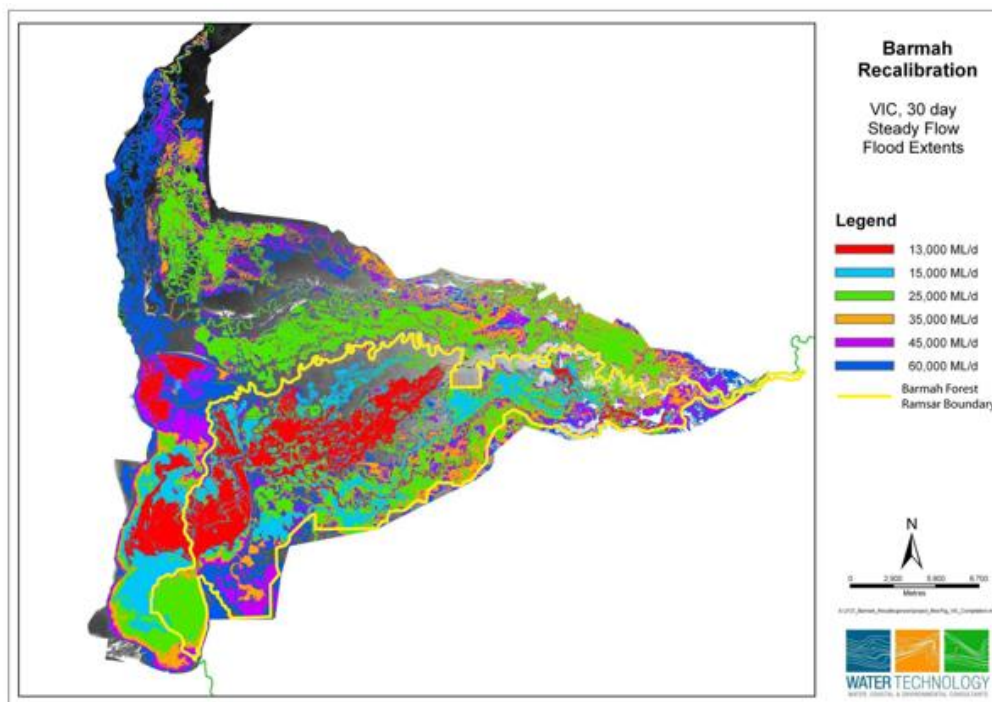


Figure 11: Inundation of Barmah-Millewa Forest with Victorian regulators open (Water Technology 2009) under different flows in the Murray River.

The Barmah Choke is a narrow section of the Murray River that occurs where it flows through Barmah-Millewa Forest (Figure 12). This forms a natural constraint on the volume of water that can be delivered along the Murray River. Under regulated flow conditions, the choke restricts the flow rate up to 10,600 ML/day⁵ downstream of Yarrowonga so flows remain in-channel through the Barmah-Millewa Forest with the forest flow regulators closed.

At flows as low as 3,000 ML/d, water can enter the forest when the forest regulators are open. At flows above around 10,600 ML/d, connecting creeks into the Barmah-Millewa Forest start to flow over the forest regulators.

The river is generally operated during the irrigation season to keep flows within the river channel through the Barmah Choke. On some occasions the requirement to deliver larger volumes of consumptive water does mean flows are diverted through Barmah Forest (and/or Millewa Forest) within the irrigation season, as part of supply agreements to deliver large volumes of water downstream (including to South Australia), without exceeding the channel capacity at Barmah Choke.

Rain rejection⁶ events also mean that Barmah Forest regulators may be opened variously throughout the year, to divert above-capacity flows into the forest and maintain river flow within channel capacity.

Regulation has significantly reduced the frequency, depth, duration and extent of flood events in Barmah Forest. Environmental water releases are now used to improve the hydrological regime in the wetlands and

⁵ The maximum regulated flow through the Barmah Choke is generally below a height of 2.6m at Picnic Point (Gauge 409006) and has equated to a flow downstream of Yarrowonga Weir of between 9,500 ML/day and 10,600 ML/day, when Barmah-Millewa Forest regulators are closed and diversions to the Edward River and Gulpa Creek Offtake regulators are at maximum desirable regulated rates (MDBA 2018a).

⁶ A rain rejection event occurs when in-channel flows are near bankfull, and a high rainfall event results in reduction in consumptive demand, even though releases from upstream storages have been made. As the water in transit is not consumed, it remains in the river channel and can result in exceedance of capacity if the water is not diverted elsewhere. Barmah Forest and Millewa Forest on the New South Wales side of the Murray River alternate each year to take these rejection flows.

the surrounding floodplain in an attempt to maintain the dependant ecological components and processes that had evolved under the more natural flood regime for river regulation.

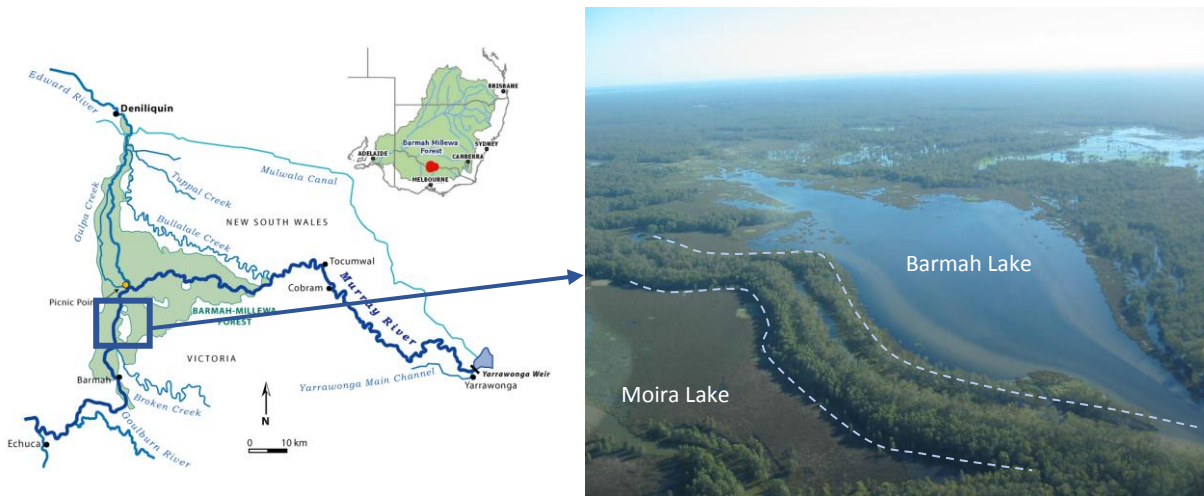


Figure 12: (a) The Barmah Choke is a narrow section of the Murray River that runs through the Barmah-Millewa Forest (through the area of green shading), with the flow rate through the choke measured on a gauge at Picnic Point (yellow dot) (MDBA 2012) and (b) Barmah-Millewa Forest in flood with Barmah Lake (right) and Moira Lake (left) highlighting part of the Barmah Choke, being a narrow section of the Murray River channel (centre - between dotted lines) (adapted from MDBC 2008).

Environmental water

Environmental water releases have been used to improve the flood regime and environmental values in Barmah Forest. Despite these changes, Moira grass has continued to decline in extent.

The Barmah-Millewa environmental water allocation is a rules-based allocation that was established in 1993 for the Barmah Forest and the neighbouring Millewa Forest on the right bank (or NSW side) of the Murray River in New South Wales. Subject to operating rules, this consists of a high security Environmental Water Allowance of 100,000 ML/year and a lower security allocation of 50,000 ML/year, which is contributed equally from Victoria and NSW. Collectively these are termed the Barmah-Millewa Environmental Water Allocation (EWA). Under the current Barmah-Millewa Forest watering operating rules, each State's share of the environmental water allowance can be borrowed by that State when allocations would be below the State's target allocations. The EWA can be carried over in storage to a maximum of 700,000 ML (Bulk Entitlement) (Ecological Associates and SKM 2011).

The EWA was first used in 1998, when 98,000 ML was released. Releases were made in 2000 (341,000 ML), 2005 (513,000 ML) and thereafter as outlined in Table 3. Significant volumes of environmental water are continuing to be recovered in the Murray system, primarily through the Murray-Darling Basin Plan, which complements the rules-based Barmah-Millewa EWA. Significant environmental water recovery has occurred since 2010 and this can be used with more flexibility than the Barmah-Millewa EWA.

Environmental watering objectives and associated water requirements are set out in the Barmah-Millewa Forest Environmental Water Management Plan (MDBA 2012). These target ecological objectives, which are set for the forests, to provide the water requirements for key vegetation communities including giant rush, Moira grass plains and river red gum forest, as well as specific flow recommendations to support waterbird breeding events. Of these vegetation communities, Moira grass has continued having the most negative decline in extent, despite the commencement of environmental water deliveries. This is attributed to the inability to achieve the most appropriate water regime (due to delivery constraints – see section 7.1), the ongoing impacts of grazing and trampling (section 7.2), and encroachment of invasive plants (section 7.3).

Table 3: Summary of flood events and use of environmental water at Barmah-Millewa Forest (GB CMA and OEH 2016; GB CMA 2018).

Year ⁷	Description
2009-10	18 GL environmental water delivered - estimated 15% of the floodplain inundated.
2010-11	Natural major flood and 428 GL environmental water delivered - estimated 90% of the floodplain inundated ⁸ .
2011-12	Late spring natural flood and 425 GL environmental water delivered - estimated 65% of the floodplain inundated ³ .
2012-13	Natural winter/spring flood and 15 GL environmental water delivered - estimated 60% of the floodplain inundated ³ .
2013-14	Natural winter/spring flood and 370 GL environmental water delivered - estimated 60% of the floodplain inundated ³ .
2015-16	Environmental water was released between July and September to maintain depth and duration of flooding on low-lying wetlands and grassy plains. Most of the environmental water was directed to Millewa Forest – estimated 17% of the floodplain was inundated.
2016-17	Large natural flood in spring and environmental water was released in December 2016 to slow the rate of flood recession from the floodplain following the final natural flood peak, for the benefit of Moira grass plains that had commenced flowering. Most of the environmental water was directed to Barmah Forest under the annual-alternating EWA arrangement with Millewa Forest - estimated 100% of the floodplain was inundated ³ .
2017-18	Varying flood levels due to different management activities. This included an inaugural trial of a Translucent Regulator strategy where forest regulators were opened in July and closed in November, irrespective of the river level – this departed from the strategy of only opening the regulator once river levels exceed channel capacity, and permitted a more natural rise and fall of water entering the forest waterways as connection with the river was more gradual. The year also experienced two natural flood peaks; the first in August that inundated approximately 40 to 45% of the floodplain, and the second in early-December that inundated approximately 17 to 20% of the floodplain. An environmental water delivery event throughout October and November 2017 at 15,000ML/d caused sustained low-level flooding during that period targeting Floodplain Marshlands (Moira grass plains) during the core natural flooding period.
2018-19	Large-scale transfer of operational water to South Australia in October-November 2018 resulted in peak inundation of 27% of Barmah Forest. Though the delivery was not environmental water, nor natural flooding, it did provide a range of ecological benefits as the timing and duration of the inundation was appropriate for Moira grass (in the areas that were flooded). A waterbird breeding event was not triggered, so environmental water was not used to supplement the operation delivery to improve ecological outcomes.

⁷ Plans for environmental water deliveries are developed from July through to June the following year. This enables each delivery plan to include a full irrigation season (which covers the period August through to May).

⁸ The extent of floodplain inundated by each of these events was a consequence of the natural flood peak - the comparably small environmental water volume (as opposed to the volumes passed during natural flooding) was used to supplement the natural flood by reducing the rate of recession caused by river regulation, or delivered to key wetlands to maintain waterbird breeding events.

7 Drivers of Moira grass decline

The principal factors that are likely to have contributed to the decline in Moira grass extent, as a critical Ramsar component, are:

1. Changes to the natural flooding regime,
2. Grazing and trampling pressure (particularly by feral horses and, prior to 2007, cattle), and
3. Encroachment by invasive wetland plant species.

7.1 Changes to the natural flood regime

The optimal water regime for Moira grass

Moira grass is dependent on flooding. To be dominant, Moira grass requires wet-dry conditions that occur annually with sufficient flood depth and duration for Moira grass to form a complete grassy cover, known as a 'sward', that excludes other plants, and a dry phase short enough to limit competitors (Colloff *et al.* 2014). Environmental water is used to supplement the flood regime with the aim of meeting these key requirements.

The optimal water regime for Moira grass would essentially emulate the 'natural' or pre-regulation flood regime of the low-lying treeless wetland plains in Barmah Forest. Under these pre-regulation conditions, in the 1930s, Moira grass extent was estimated at 4,000 hectares.

Colloff *et al.* (2014) describe the optimal water regime for Moira grass in Barmah Forest. Maximum growth occurs with floods lasting more than 5 months between mid-winter and early summer. Earlier winter floods (in June) result in poor flowering. A flood of at least 0.5 metres depth and 5-7 months duration in late winter or early spring is ideal. Water depth >1.5metres early in the growing season provides Moira grass with a competitive advantage over other plants. As the flood recedes the grass grows rapidly, and its stems ('culms') extend above the water surface, then producing flowers and setting seed. When the floodwaters recede, the floating layer of grass ('sward') is stranded on saturated mudflats. The plant then forms a thick turf, senescing but persisting through summer and autumn, limiting competition from other plants. Growth ceases when frosts occur.

The aim of the preferred operating strategy for the Moira grass plains is to achieve the minimum depth and duration required for Moira grass 6 to 10 years out of every 10, with a maximum time between flood events of 3 years. Under regulated flow conditions, a flow of at least 18,000 ML/d at Yarrawonga Weir would be required to achieve the appropriate extent and depth of flooding for the Moira grass life cycle. Duration of each of these flood events should last from 5-9 months (no more than 10 months), and include an annual dry period of 2-3 months from late summer to early autumn. The water requirements for the Moira grass plains in Barmah-Millewa Forest are set out in more detail below (Table 4).

Table 4: Water requirements for Moira grass plains (MDBA 2012).

Timing	Duration	Frequency	Depth	Maximum time between floods	River flows required at Yarrawonga
Winter to mid-summer	5-9 months (no more than 10 months). An annual dry period of 2-3 months from late summer to early autumn is needed	6-10 years out of 10 years	Minimum depth = 0.5 m	3 years	12,000-25,000 ML/d

River regulation and changed water regimes

River regulation has had a significant impact on the flooding regime required to maintain Moira grass swards, and this then is exacerbated by other agents that impose further threat to its survival such as drought conditions, grazing and invasive plants.

Following the commissioning of the Hume Dam in 1934 (and subsequent enlargements), there was a dramatic reduction in moderate winter-spring floods of Moira grass wetlands and an increase in the shallow summer flooding of the system.

The distribution of Moira grass has a strong correlation with frequent flooding in the 10,000 ML/d and 20,000 ML/d flow ranges at Tocumwal⁹ (Abel *et al.* 2006). Flows of this size have been depleted by river regulation and water extraction, with a corresponding increase in summer floods (Abel *et al.* 2006).

To maximise the delivery of water to downstream consumptive water users, the river is operated as close as possible to the channel limit (10,600 ML/d). However, this increases the likelihood of unseasonal overbank flows in summer and autumn due to rainfall rejection. Rain rejection⁶ events occur most frequently in the irrigation season in late spring, summer and autumn and typically cause Murray River flows to increase from within channel capacity to a flow rate of 12,000 to 15,000 ML/d or more, for a period of five to seven days (Ecological Associates and SKM 2011)¹⁰.

River regulation, and the associated change in frequency, timing, duration, depth, variability and extent of flooding, has a range of impacts on the natural ecological functions of the floodplain marshes in Barmah Forest. These include (but are not limited to) the inability for some species to complete their life cycle and a consequent contraction in their extent; dominance of more tolerant species resulting in displacement of others; and, where those changed conditions remain stable, a less heterogeneous landscape with reduced habitat availability.

Specifically for Moira grass, it is estimated that in the absence of environmental watering events, adequate floods to maintain this species now occur about half as often as required (MDBA 2012). In addition, flood events that extend into late summer favour other native plant species such as milfoils and giant rush, as well as algal blooms, which can outcompete, displace or smother Moira grass during the warmer conditions.

In the 10 years between 2001 and 2010, Barmah-Millewa Forest (like much of the Murray-Darling Basin) experienced unprecedented drought conditions – the Millennium Drought. In this 10-year period, the maximum time between flood events (3 years) was exceeded, and most of the forest’s wetlands and waterways dried completely – many for the first time in decades and some possibly for the first time in recorded history (Figure 13). The frequency of flooding also fell far short of the recommended 6 to 10 flood events within each 10-year period.

The contraction of the Moira grass plains observed by Ward (2016), originally highlighted by Chesterfield (1986), remains of concern given the continuing poor growth response since the Millennium Drought. This was based on 10 years of monitoring understorey vegetation response to flooding in Barmah-Millewa Forest from 2006-07 to 2015-16, across 11 wetland study sites, three of which currently supported Moira grass plains. The mean annual cover of Moira grass at those three study sites showed very low cover during the Millennium Drought. However, only one of the sites (Little Rushy Swamp) showed strong regrowth following the significant natural flows recorded for Barmah Forest since the drought, including 2010-11, 2014-15 and 2015-16, and therefore, the overall area of Moira grass has not shown the level of increase expected (MDBA 2018b).

⁹ Tocumwal is a gauging station in the Murray River downstream of Yarrawonga Weir, upstream of the Edward River offtake and Barmah-Millewa Forest (Figure 10).

¹⁰ Refer to section 6.2 for a more detailed description of river regulation and operations.

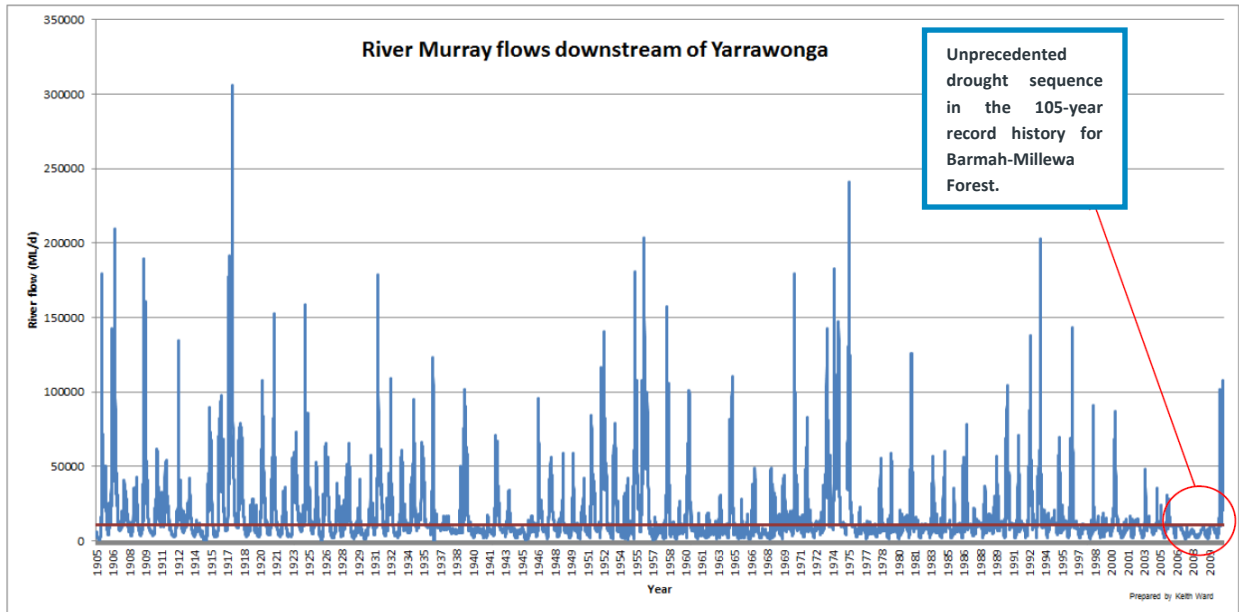


Figure 13: History of Murray River flows downstream of Yarrawonga Weir, between 1905 and 2010 at the breaking of the Millennium Drought. Red line indicates the threshold for overbank flows. (Adapted from GB CMA 2012).

Little Rushy Swamp commences to fill at a higher level on the floodplain and will therefore frequently miss unseasonal summer/autumn flooding, and when inundation does occur, it will trap water for a longer duration and more suitable depth than most other wetlands in the forest (Ward 2016). While Little Rushy Swamp has physical attributes that provide a more suitable long-term annual wet-dry water regime for Moira grass, there is evidence that improving the water regime by itself will not be sufficient to restore Moira grass across the floodplain marshes of Barmah Forest, including the reduction in cover observed at Little Rushy Swamp between 2010-11 and 2015-16 (Ward 2016).

Durant *et al.* (2016) found an absence of a persistent long-lived seed bank of Moira grass in Barmah Forest. More recent studies have shown that optimum water regime conditions for Moira grass created by the large natural flood in 2016-17 did not increase the viable seedbank (Nielsen *et al.* 2017). The authors suggested that re-establishment of populations may also be reliant on the preservation and maintenance of stolons¹¹, existing rootstock and stem fragments. Colloff *et al.* (2014) suggest that grazing by horses damages and uproots plants, decreasing plant density and thereby reducing capacity for regeneration when re-flooded, and that complementary actions such as management of grazing pressure, are also required in addition to the delivery of environmental flows.

Operational flows for consumptive use

Collaboration between MDBA river operators and environmental water managers can also provide opportunities to achieve ecological benefit from the delivery of operational water for consumptive use, particularly when these deliveries are of larger volumes, and the timing can be negotiated. An example of this occurred in spring and early summer of 2018 when a large-scale water transfer was supplied to South Australia for consumptive use (Table 3) but also inundated the Moira grass floodplain in Barmah Forest to achieve ecological benefit.

¹¹ Horizontal runners that take root to form new plants.

During the large-scale operational delivery in spring of 2018, the target flow rate was greater than 14,900 ML/d at Yarrawonga Weir. This exceeded the channel capacity through the Barmah Choke and was above the threshold for spills into the surrounding floodplain even with the forest regulators closed. The intent of the operational delivery was primarily to boost transfers to Lake Victoria in New South Wales, which acts as a storage for flows to South Australia. To achieve the most efficient transfer of operational water, while working within the constraints of the Barmah Choke, the forest regulators were opened to enable water flow to be efficiently transferred through Barmah Forest via connecting creeks and distributary channels, around the Barmah Choke. This maintained the level of the Murray River below 2.6 metres on the gauge at Picnic Point (MDBA 2018c), with water from the forest spilling back out into the Murray River below the Barmah Choke, to continue its journey to Lake Victoria.

In this way, the operational delivery also provided complementary environmental outcomes by opening up flowing habitat through Barmah Forest that supports the life cycle for large-bodied fish such as Murray cod and golden perch, plus creation of inundated pathways for movement of fish and carbon transfer between wetland, internal creeklines and riverine habitat. Some parts of the Moira grass floodplain were also inundated by this operational delivery. Where this occurred at a sufficient depth, and because the delivery occurred in the appropriate season (from spring into early summer), there were also benefits for Moira grass growth and the associated creation of suitable habitat for other species including waterbirds and small-bodied fish.

Impact of the altered hydrological regime on expansion and encroachment of Moira grass plains by invasive plant species, including two native species (giant rush and river red gum), is covered in Section 7.3.

Constraints to optimal environmental water use for Moira grass

While environmental water allocations and other water management measures have considerably improved the water regime for Moira grass from 1998 onwards, operational constraints in the delivery system prevent the delivery of all the required flow components.

The ability to achieve the preferred operating regime that includes periods of inundation, and an annual dry period, remains constrained by river rules, practices and structures that restrict or limit the volume and/or timing of regulated water delivery through the river system (MDBA 2015a).

The current flow constraints in the Murray River downstream of Yarrawonga restrict the maximum flow rates to prevent flooding of private property, and, during summer, unseasonal flood events in Barmah-Millewa Forest. This maximum flow rate, also imposed for environmental flow deliveries, is insufficient to achieve the minimum flood depth required for Moira grass. In a 15,000 ML/d flow event, some of the Moira grass plains will receive flooding on both sides of the river, but the ideal depth cannot be maintained in both Barmah and Millewa forests at the same time. Therefore, delivery of environmental water is managed to try to achieve the desirable depth on at least one side of the river by manipulating the connecting creek regulators and alternate the side of delivery to either Barmah or Millewa forest in an attempt to maximise flood depth on at least some Moira grass plains.

The delivery of flows of a much higher order (>20,000 ML/d – 77,000ML/d downstream of Yarrawonga), to replicate the mid-large less frequent flood events, would benefit the ecology of Barmah-Millewa Forest, including the Moira grass plains (MDBA 2015a, b).

Ongoing investigations (e.g. NSW DPI 2016; MDBA 2013a; MDBA 2017) are underway to identify options to overcome the constraints that impact on delivery of higher flows, however the 15,000 ML/d constraint will remain in place into the near future.

7.2 Grazing and trampling pressure

Grazing by cattle and feral horses is a major factor that has contributed to the decline of Moira grass at Barmah Forest. While cattle were removed from the Ramsar Site in 2007, feral horses remain.

Other large herbivores present in the wetland system include eastern grey kangaroos and a range of introduced mammal species, including pigs, fallow and sambar deer, goats, feral sheep and rabbits (Ecology Australia 2013, 2017).

Investigations of regeneration capacity have indicated that Moira grass in Barmah Forest has a low germination rate and an absence of a persistent long-lived seedbank (Durant *et al.* 2016). Therefore, protection and preservation of vegetative fragments from grazing during the dry season is also critical for the species to re-establish during flooding periods.

Evidence of impacts

In 1992, an area of Moira grass within the Barmah Ramsar Site was fenced as part of an experimental trial (with other sites located within other vegetation types) to exclude cattle, horses, and kangaroos from grazing the vegetation. These trials showed dramatic results in extensive growth of Moira grass within enclosures, including within plots where kangaroos were able to graze, but cattle and horses were not. The trial also showed the near-complete removal of Moira grass outside fenced plots (Figure 14 and Figure 15). This trial clearly exhibited that the strong damaging impact on Moira grass was being exerted by cattle and horses, and not by kangaroos. Removal of the fences at the completion of the 1994 trial and exposure to cattle and horse grazing resulted in the rapid depletion of remaining Moira grass from the previously fenced wetland (Figure 16).



Figure 14: Experimental grazing enclosure in Barmah Forest 1994.



Figure 15: Top Lake in 1994, showing the area grazed by cattle and horses to the left of the fence, 3 years of no grazing to the right.



Figure 16: Top Lake in 1997, after removal of the fence.

Although cattle agistment ceased in the forest in 2007, feral horses have remained and increased in number. In response to observed impacts, the GB CMA fenced seven hectares at Little Rushy Swamp in 2017 to protect Moira grass from feral horse grazing and feral pig damage. Kangaroos are able to jump over the fence and have been observed to readily graze inside the enclosure. Figure 17 illustrates Moira grass recovery in the Little Rushy Swamp enclosure before, during and after flooding in the first year.



Figure 17: Little Rushy Swamp grazing enclosure (left side of image), before, during and after flooding.

Feral horses

The impacts of feral horses on Moira grass are considered large-scale and long-lasting (SAC 2011; Ward 2013; Colloff *et al.* 2014; Vivian *et al.* 2015). Horses degrade ecosystems through grazing, browsing and trampling of vegetation, dispersing weed seeds, and disturbing the soil, creating openings for weed invasion and enriching nutrient levels (Figure 18). The hard hooves and heavy body masses of feral horses trample Moira grass plants and create pugmarks across the landscape (Figure 19), which provide a more suitable micro-habitat for establishment of invasive plants such as giant rush (Colloff *et al.* 2014). During large flooding events, horses have been observed congregating on sandy rises, compounding trampling and vegetation impacts in these areas (Figure 20), and on sites of Aboriginal cultural significance (Figure 3).

As a consequence of the damaging impacts such as these, of feral horses on the landscape, feral horses were declared a threatening process under the *Flora and Fauna Guarantee Act 1988* in 2011.



Figure 18: Weeds (including clover) germinating from horse dung at Steamer Plain, demonstrating the re-distribution of weeds.



Figure 19: Pugging, due to the hard hooves and heavy body weight of feral horses, as flood waters recede.



Figure 20: Horses congregating on high ground, at Sandridge Track, Rat Castle photopoint monitoring site (Photo credit: Goulburn Broken CMA).

The high nutrient content of Moira grass (Colloff *et al.* 2014: citing Finlayson 1991) makes this native plant a highly palatable food source, with horses frequently observed wading into deeply flooded areas to preferentially graze it when it emerges from the water surface (Figure 22 and 21). Moira grass is rapidly cropped to ground level by horses following the subsidence of floodwaters, and even when dry, stems are selectively grazed. By uprooting and eating Moira grass plants, and therefore removing reproductive

potential of the grass, feral horses can be linked to poor regeneration when the floodplain areas are re-flooded as a consequence of lower density seedbanks and reduced numbers of mature plants and stolons (Colloff *et al.* 2014).



Figure 22: Horse barrel deep amongst on Steamer Plain during flooding

Until October 2018, the population of feral horses at Barmah Forest had been increasing, and particularly since the flooding of 2010 (i.e. end of the 'Big Dry' or Millennium Drought: Selwood *et al.* 2015). The Parks Victoria helicopter surveys of summer 2012 (Wehner *et al.* 2012) observed at least 144 horses, but this is likely to be a significant underestimate as visual surveys fail to detect horses within red gum canopy cover and within tall *Phragmites* reed beds (see thermal imaging surveys below). At the time, the high numbers of young animals found in family groups indicated potentially high reproductive rates. The surveys highlighted a concentration of feral horses around Barmah Lake as well family groups distributed to the north-east (Parkes *et al.* 2017). This supported informal results of past surveys around Barmah Lake reporting that feral horses were associated with open grassy wetland areas. Wehner *et al.* (2012) also reported that a minimum of 60 feral horses were repeatedly counted on or around Steamer Plain over three days. This association has been corroborated by Vivian (2013) and Vivian *et al.* (2015), who reported that within the Barmah Forest Ramsar Site, feral horse activity was observed in CSIRO surveys as being present in most of the plains containing Moira grass.

In 2017, Parks Victoria ran a pilot aerial transect survey using military grade forward-looking infrared imaging (FLIR) and 4K visual spectrum videography flown by helicopter to estimate feral horse abundance. The 200 metre wide transects were evenly spaced at 1 kilometre intervals and detected 134 horses within the transect strips adding up to an onground area covering 10-12% of Barmah National Park (Parks Victoria, unpublished data). The intervening strips between these regularly spaced transects represents 88-92% of the survey area in which horses were not counted.



In June 2018, Parks Victoria carried out a more comprehensive FLIR aerial survey of feral horses in Barmah National Park. This survey flew 226 kilometres of 180 metre wide transects spaced 1 kilometre apart and covering around 4,027 hectares (Figure 23). This survey provides an estimate of feral horse abundance for 22,967 hectares of the park (around 80% of the total park area). A small portion (20%) of the park at the eastern end was not surveyed and was excluded from the estimation. However, the horse population density in this area is considered low.

A minimum of 147 horses were directly observed and filmed within the 90 metre wide strip transects on either side of the lines flown by the aircraft, spaced 1 kilometre apart. The area directly surveyed within those strips was 4,027 hectares, or 18% of the 22,967 hectare area to which the survey applies (i.e. horses present in the other 82% of ground between the filmed strips were not counted).

Initial analyses of these observations indicate that there are at least 620-730 feral horses within the area surveyed, and probably more. This number is a significantly larger population of horses than previously reported.

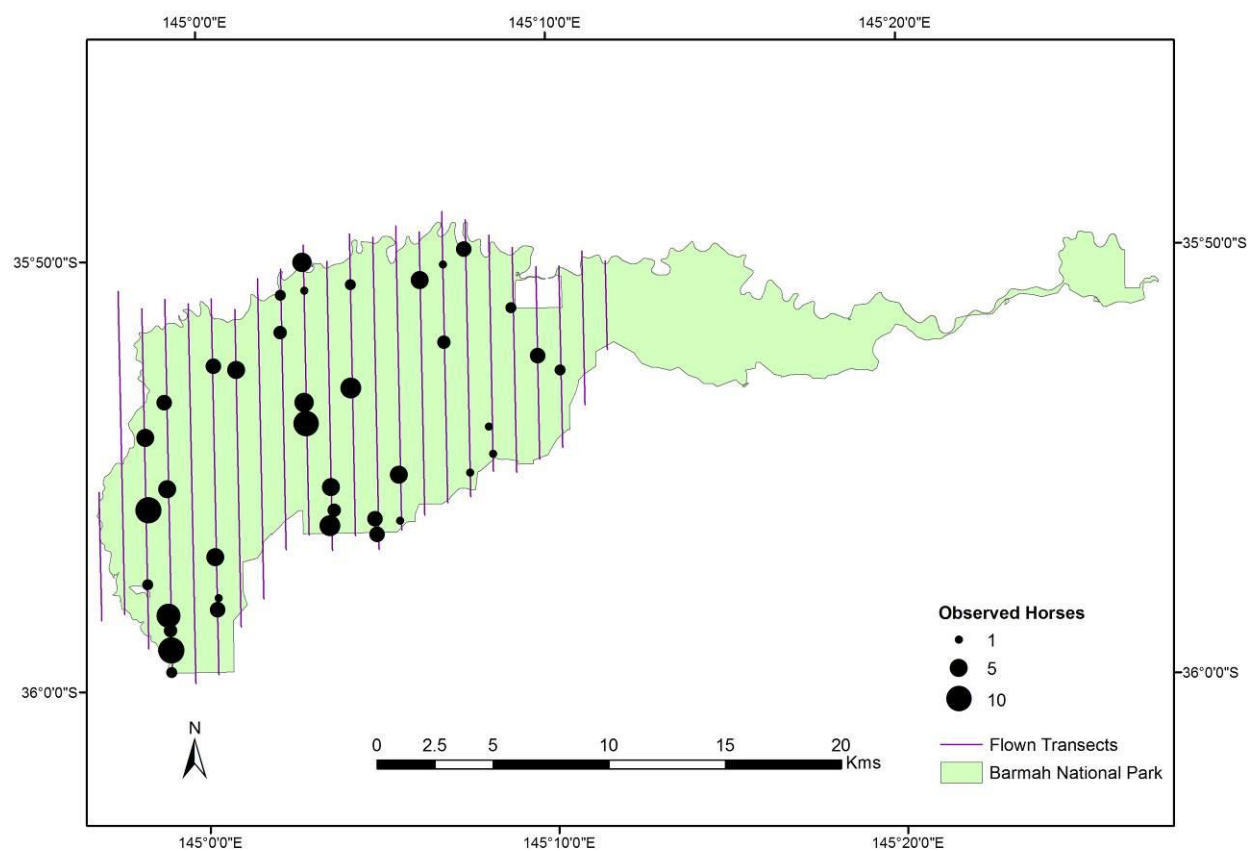
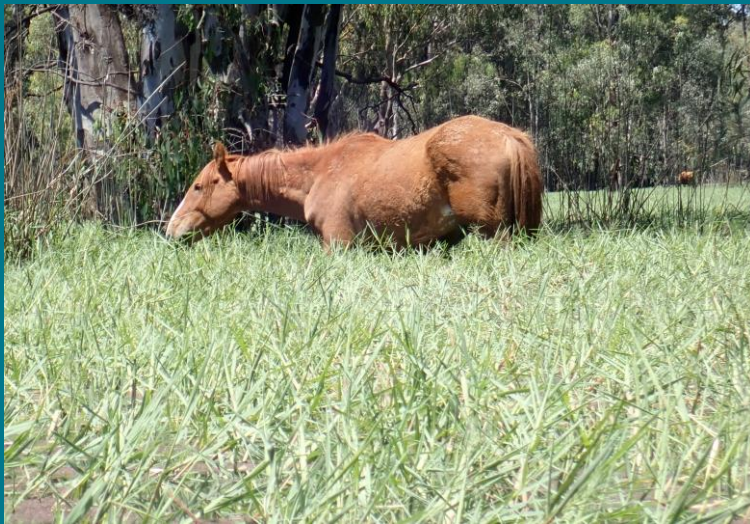


Figure 23: Aerial FLIR survey transects and observed horses in Barmah Forest, June 2018, Parks Victoria.

INFOSHEET: Conditions during spring and summer of 2018-19

In spring and summer of 2018-19, higher areas of Barmah Forest were affected by the extreme dry conditions, impacting native and introduced species that inhabit the park, including feral horses. At the same time, flooding due to a large-scale water transfer to South Australia resulted in inundation of 27% of Barmah Forest.

During this time, some members of the community reported that the flooding was preventing horses from accessing the feed that was available in the lower parts of Barmah Forest.



However, an aerial survey undertaken by Parks Victoria, observed and filmed that the horses in the park were within the flooded wetlands, feeding on submerged and emerged Moira grass. These horses appeared to be in healthy condition indicating that the presence of water did not inhibit the movement of horses through inundated areas to access abundant food resources. Ground surveys at the time also identified many adult and juvenile horses moving freely through deep water in Boals Deadwood and War Plain (Figure 24).

Figure 24: Horses feeding on Moira grass in early December during inundation caused by an out-of-Murray River bank operational delivery to South Australia.

A smaller number of horses was observed in areas with little vegetation towards the edges of the park, some were only 1–2 kilometres from areas in which they could feed. These horses were in poor body condition (<1.5 using Agriculture Victoria's Body Condition Scoring System (Ellis 2000)), and included horses being fed at illegal feeding stations within the National Park, and some being hand-fed on private land adjacent to the park. These horses also posed a risk to the community, as they were observed moving into the Barmah township and roads in search of food, as well as on to private property of adjoining landholders to access feed intended for livestock. Some horses also caused an extreme safety risk to locals and tourists from vehicular collisions when they moved onto the nearby highway, including an incident where a number of horses were hit and killed.

It is likely that the horses to the edge of the forest were low in the herd hierarchy, potentially forced out of the better feeding areas, with this theory supported by bite marks found on some poor condition horses that had to be put down.

Throughout this period, Parks Victoria monitored and reviewed the welfare of the feral horses in Barmah National Park and has had ongoing consultation with RSPCA Victoria, local and specialist equine vets, key local stakeholders and community members. Protocols to identify horses in very poor condition were implemented, and a number of malnourished horses, both adults and foals, were humanely euthanased. By January 2019, after several weeks of monitoring, the horses in the forest were showing normal behaviours and the majority were assessed as being in moderate to good condition.

As drought frequency increases and average rainfall decreases due to climate change, a reduction in palatable groundcover available for grazing species is likely to recur. Under these circumstances, and following managed inundation of the floodplain, horses will rapidly take advantage of increased growth in Moira grass. The impact of this is likely to be highly detrimental to Moira grass recovery.

Feral pigs

Riparian and wetland habitats are attractive to feral pigs where they can cause serious habitat degradation by rooting in the soil in search of food, and can also prey on the eggs and chicks of nesting water birds in wetlands (Figure 25).

Fluctuations in the population of pigs are driven largely by flood events that increase food resources, leading to significant booms in populations, while droughts reduce population extent and dramatically increase the effectiveness of control methods. Feral pigs disperse seeds of weed species, and in the process of rooting up the ground they trample vegetation and extensively disturb the soil. In addition, regular wallowing and digging of dust-beds can impact on terrestrial and aquatic systems through erosion, siltation and increased turbidity.



Figure 25: Succession of images highlighting predation of eggs by feral pigs showing ibis nesting with eggs followed by a feral pig eating the eggs, and the ibis that have returned to empty nests. (Photo credit: GB CMA)

Feral pigs are also a threat to Moira grass, uprooting and trampling Moira grass and disturbing the soil (Figure 26 a and b). The photograph taken on 15 February 2018 (Figure 26a), shows damage by pigs along the edge of the grazing enclosure at Little Rushy Swamp after flood recession.

Most feral pig activity within the area has been observed within and around treeless wetland environments in the west, where vegetation and soils are most susceptible to disturbance (Ecology Australia 2017). Monitoring of feral pig activity therefore focused on these areas and in 2016-17 feral pig disturbance was recorded at all eight monitoring plots and across 85% of transects, a considerable increase in the frequency of disturbance recorded in previous years (42.5% in 2016; 22% in 2015) (Ecology Australia 2017).



Figure 26: (a) Impact of feral pig rooting activity at Little Rushy Swamp and (b) Feral pigs moving through the landscape at Tarma Lagoon.

Feral deer

Feral deer (mostly fallow deer but also some sambar deer) have been present in Barmah Forest for at least the past decade (Figure 27 a and b). Deer degrade ecosystem quality through grazing, browsing and trampling of vegetation, ringbarking trees, as well as dispersing weed seeds and enriching nutrient levels. They also cause soil disturbance in creeks, wetlands and swamps, where they wallow in mud.



Figure 27: (a) Sambar deer and fawn recorded at a photo-point monitoring site in 2014 and (b) Young fallow deer near the Dharnya Centre

Feral goats and sheep

Feral goats have been observed in Barmah Forest and can modify habitat through grazing, browsing and trampling of vegetation, dispersing weed seeds, and disturbing the soil, creating openings for weed invasion and enriching nutrient levels. Goats can also impact native fauna, primarily through the alteration of habitat structure and composition, as well as competition with native herbivores and omnivores. Feral sheep are also present within Barmah with a breeding population having persisted since 2010. Like other feral grazers these pests are likely to impact on a range of native species and are of concern due to their potential impact on Ramsar values, especially the Moira grass plains, given its palatability.

Rabbits

European rabbits pose a grazing and browsing threat to vegetation. Monitoring demonstrates low rabbit density across the planning area, likely due to the restricted extent of suitable habitat for rabbits, that is habitat is largely limited to areas that are not prone to flooding, such as elevated ridges on sandier soils. As such, the impacts of rabbits on the Ramsar Site are generally considered to be light and localised, and of limited impact to floodplain marshes. They can disturb soil and cause erosion through scratching and the construction of warrens as well as disturbing and damaging Aboriginal cultural sites.

Kangaroos

Eastern grey kangaroos are also known to graze Moira grass (Hamilton 2014 and Ward 2016). The impact of kangaroos relative to that of feral horses has not been quantified but photo-point monitoring of grazing exclusion plots indicates it is much lower. The fences shown in Figure 14 to Figure 17 did not exclude kangaroos, which were able to easily hurdle the fences.

Kangaroos are native to Barmah Forest and no control measures are considered necessary, given the lack of evidence of their impact within grazing exclosures.

7.3 Encroachment by invasive wetland plants

Invasive plants are any plants that require some form of action to reduce their effect on the environment, economy, human health or amenity. They can be introduced species or native species that can colonise and persist in an ecosystem in which they did not previously exist. Native plants can become invasive when characteristics within their natural habitat change, enabling them to better compete with other species, displacing them by increasing their extent and/or density.

Invasive native plant species

An ecological effect of the altered hydrological regime in Barmah Forest is the expansion of giant rush and river red gums into areas that were formerly dominated by Moira grass. Under pre-regulation hydrological conditions, giant rush historically occurred as a narrow band between river red gum forest and the open wetland areas. Moira grass grew across the open plains up to the edge of the giant rush and/or river red gums.

Giant Rush (*Juncus ingens*)

The altered water regime, particularly increased frequency of summer flooding, has allowed giant rush to expand from wetland margins into areas that historically would have been both too dry in summer and too deeply flooded in winter/spring for its persistence (Vivian *et al.* 2014). Giant rush under these conditions forms dense, monospecific impenetrable swards that do not provide the ecosystems functions of the wetland grasslands of Moira grass (Colloff *et al.* 2014) (Figure 28 a and b). The spread of giant rush in the Barmah (Victoria) and Millewa (NSW) Forests over time has been mapped (Colloff *et al.* 2014) (Figure 29).



Figure 28: (a) Aerial image of giant rush amongst other species at normal density and (b) Dense sward of giant rush, with taller *Phragmites* in the background (a species which also dominates in wetter conditions) during a manual clearing trial in 2017 (Photo credit: Danielle Beischer).

Attempts to control the invasion of giant rush have been conducted through slashing and burning activities. This has had some degree of success; however, hydrology appears to be the key influence in the proliferation, or otherwise, of giant rush so the implementation of a combination of physical control and hydrology management actions is required to control this species.

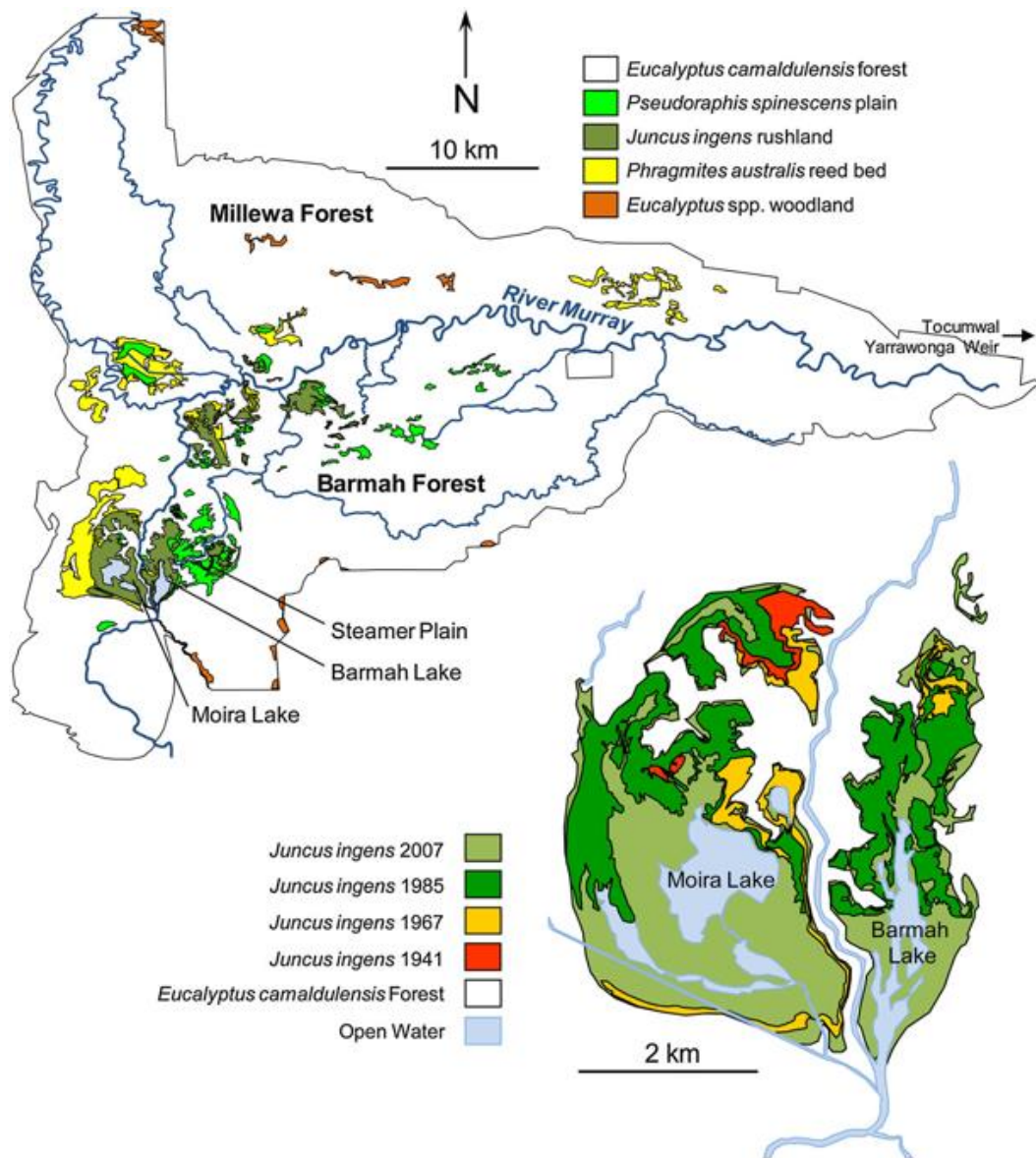


Figure 29: The distribution of dominant vegetation communities at Barmah-Millewa Forest and expansion of Giant Rush beds around Barmah and Moira Lakes from 1941 to 2007 (Colloff et al. 2014).

Following the widespread and prolonged flooding of 2010-12, trends in cover abundance of giant rush have varied across wetland sites in the Barmah Forest. At some sites, cover is declining from peak cover abundance occurring in 2012-13, at other sites cover is stable or increasing (Ward 2016). This variation may be due to differences in stem age, moisture availability and shading from the giant rush stand itself or from common reed (*Phragmites australis*) (Ward 2016).

Patches of giant rush in thick stands provide important habitat for ibis and spoonbill nesting colonies (Figure 30) however, once this species dominates in extensive large tall thickets, rather than patches amidst open water or freshwater marshland, it loses its habitat value. Additionally, this encroachment into formerly open waters compromises other habitat values, reducing the area available for waterbirds to wade and forage for food such as macro-invertebrates and fish.

To maintain giant rush in thick stands, prolonged shallow (but not permanent) flooding is desirable. To discourage giant rush, drying over the summer-autumn period is required. Managing the flood regime to maintain a balanced mosaic of habitats, is critical in the protection of Moira grass plains.



Figure 30: Royal spoonbill (*Platalea regia*) nesting in giant rush at Barmah Forest.

River Red Gum (*Eucalyptus camaldulensis*)

The decrease of floods of a magnitude between 20,000 ML/d and 35,000 ML/d has provided opportunities for river red gums to colonise lower-lying areas that were formerly dominated by Moira grass. Winter-to-spring floods that typically persist for less than five months promote river red gum recruitment (Ecological Associates and SKM 2011). Quantification of the expansion of river red gum could not be sourced and may remain a knowledge gap.

However, Ward (2016) states that the contraction in Moira grass extent is not the result of competition with river red gum or giant rush, as supported by remapping by Vivian *et al.* (2015). That study showed that the patchy occurrence of Moira grass on remaining treeless plains indicated that presence of Moira grass does not depend on treelessness alone, but that the species occurs best where treelessness exists. Ward (2016) suggests that, while river red gum encroachment is not the main factor in preventing reestablishment of Moira grass, the current management approach of removing river red gum saplings reduces one of the known threats to Moira grass, while simultaneously needing to reduce grazing pressure and to improve flood regimes.

Introduced weeds

Changed land use in the areas surrounding Barmah-Millewa Forest, such as land clearing and farming, has also brought with it a number of invasive weeds, which are also impacting on the site. Weed invasion is exacerbated by factors that enable the dispersal of seed or other propagules, and by physical soil disturbance that opens a space for the weeds to invade. This includes soil disturbance from feral animals (e.g. horses, pigs, rabbits) in conjunction with propagule (seed, stem or rhizome) dispersal on fur, feet or in

dung (Figure 18). Other disturbances that promote weed invasion include activities such as firewood collection and off-road use of vehicles. Although a wide range of introduced plants have established within the Barmah Forest, a large component of these are restricted to drier, more elevated habitats (Ecology Australia 2013).

Twenty-six “Priority 1” weed species have been identified in Barmah Forest, and of these Arrowhead (*Sagittaria platyphylla*) is the key threatening aquatic weed species impacting on the floodplain marshes and is therefore addressed in this plan (Ecology Australia 2013).

Arrowhead (*Sagittaria platyphylla*)

Arrowhead (Figure 31) can aggressively invade warm temperate shallowly flooded or marsh areas associated with rivers and streams like those found in Barmah Forest. Biennial surveys since 2006 show changes in the extent and number of infestations due to the prevailing environmental conditions, but the spread is continuing into new areas and expanding at existing sites (Maxwell 2012). Invasion has been aided by the selective grazing habits of large herbivores preferentially feeding on Moira grass, sedges, reeds and rushes that would otherwise proliferate in the 0 to 300 millimetre flooding zone and hard-hooved animals pugging and creating tracks through wetland vegetation and opening a niche for weed invasion (Maxwell 2012).



Figure 31: Arrowhead (low green vegetation below taller flowering reeds) in mouth of Boals Creek before active treatment in 2013.

8 Conservation strategies

Areas dominated by Moira grass in the Barmah Forest Ramsar Site have decreased to less than 5% of their extent in the 1930s (Colloff *et. al.* 2014; Figure 9) and urgent action is required to prevent their complete loss. The following conservation actions will be delivered over the four year duration of this strategic plan, with annual review of progress, partnerships, animal welfare outcomes and effectiveness in achieving the recovery of Moira grass and floodplain marshes.

Action is required in four areas:

- continued environmental water management to restore key components of the flood regime, and address unseasonal inundation and delivery constraints;
- control of grazing and other impacts of the feral horse population;
- continuation/expansion of current control programs for feral pigs and other introduced herbivores; and
- management of encroachment by exotic and native invasive plant species into the Moira grass plains.

The success of this plan is reliant on implementing all of these actions, as each action alone will not result in recovery of Moira grass. The impact of feral horses has been identified by both State and Commonwealth governments as impeding the effectiveness of environmental watering in recovering the extent and condition of Moira grass in the Barmah Forest. Similarly, control of exotic and native invasive plant species also requires a favourable water regime to limit the expansion of invasive species and allow Moira grass to re-establish.

Before the end of year four (the final year) of this plan, a new plan will be developed. The new plan will detail the next steps required in the four areas of action listed above. It will incorporate learnings from the monitoring, evaluation and research undertaken throughout implementation of this plan (refer to section 9), and will be ready for operation following completion of this plan, to ensure that threat mitigation strategies have continuity.

8.1 Maintain and improve current water regimes

Environmental water regimes conducive to Moira grass recovery require management of both the scale of water flows and its timing and duration.

Current management approach

Water managers currently apply the best possible water regime for Moira grass in accordance with the environmental water management plan (MDBA 2012), while noting that this does not fully achieve the preferred operating strategy for Moira grass due to current flow constraints in the Murray River downstream of Yarrowonga (Section 7.1). While investigations are underway to identify options to overcome those constraints, the ongoing use of environmental water has, and will, help to restore a more desirable flood regime for Moira grass in areas of Barmah Forest.

There is a recognition of the need to minimise the impacts of unseasonal summer and autumn flooding. The New South Wales and Victorian governments have agreed arrangements for taking the increased flows from unplanned inundation events such as rain-rejection events in alternating years. When the rain rejection flows are directed to Barmah Forest, the GB CMA works to minimise their impact on Moira grass by diverting flood waters, where possible, to wetlands dominated by giant rushes. This co-operative arrangement has allowed the wetlands in each State a better chance of drying at the appropriate times in at least every second year, and thereby has assisted in returning the system to a more natural flood and drying regime (Ecological Associates and SKM 2011).

Water management objectives

Aim: To maintain and, if possible, improve the water regime for floodplain marshes, particularly Moira grass plains.

Table 5: Actions to maintain and improve current water regimes.

Strategy	Action	Responsibility (lead identified first)	Priority
Work with partner agencies to ensure that managed water regimes maintain and enhance the ecological character of the Ramsar Site, particularly floodplain marsh vegetation on open plains.	<p>Liaise on the development of watering proposals and their delivery. Priority watering actions to include:</p> <ul style="list-style-type: none"> • Provision of an appropriate water regime (frequency, timing, duration, depth, variability and extent) to increase the extent and diversity of floodplain and wetland vegetation, with particular emphasis on re-invigorating floodplain marsh species such as Moira grass. • Undertake measures to ensure preservation of vegetative fragments of Moira grass and deter further expansion of giant rush and river red gums (or invasion of introduced plant species) into Moira grass plains. • Continuing to minimise the incidence and magnitude of undesirable summer and autumn flooding of floodplain marshes (e.g. Steamer Plain, Hut Lake, Little Rushy Swamp and War Plain) due to unexpected large rainfall events leading to irrigation rejections, by instead diverting unseasonal floodwater to giant rush dominated wetlands such as Boals Deadwoods and Top Island or connecting creeks leading to higher terrain usually containing water-stressed red gums. 	Goulburn Broken CMA (GB CMA), Victorian Environmental Water Holder (VEWH) in collaboration with PV, YY TOLMB, New South Wales Office of Environment and Heritage (NSW OEH), Commonwealth Environmental Water Holder (CEWH)	High
Help to sustain the health of Country for Traditional Owners through use of environmental or cultural flows.	<p>Ensure Aboriginal water values and uses are identified and supported, for example through the Aboriginal Waterways Assessment tool enabling Traditional Owners to assess the cultural health of their Country and inform priorities for environmental water delivery.</p> <p>Use environmental or cultural flows (or both) to sustain ephemeral habitats and support culturally significant species, such as the Common Long-necked Turtle.</p>	YYNAC, PV, GB CMA, MLDRIN, DELWP	High
Monitor and evaluate the effectiveness of environmental water planning (including water deliveries and planned dry periods) in achieving the desired water regime. ¹²	Monitor the flooding regime at Barmah Forest (including frequency, timing, duration, depth, variability and extent of flooding) to assist with annual planning and determine whether the appropriate water regime is being achieved according to the environmental water management plan (MDBA 2012).	GB CMA, VEWH in collaboration with PV, YY TOLMB, NSW OEH, CEWH	High

¹² Note that the monitoring actions required to track the status of the ecological character of the floodplain marshes is described in Section 9.

8.2 Control of grazing by feral horses

To address the decline in condition of floodplain marshes, in particular the Moira grass plains, urgent management effort is required to reduce the impacts of feral horses.

The series of community and stakeholder consultation workshops held on managing feral horses in Barmah Forest identified that the two primary options to reduce impacts are removal of animals and fenced exclusion. Removing horses from the forest has been predicted as leading to significant Moira grass recovery, with Nicol et al. (2017; 2018) predicting an increase of approximately 60% of total Moira grass extent (from its current extent).

Fencing of threatened environmental and cultural assets has occurred to a limited extent in Barmah Forest in the past. This type of infrastructure requires significant capital investment as well as ongoing inspection and maintenance. It can also restrict native animal movements, potentially act as a trap or snare to species such as turtles, introduce a flight danger to waterbirds, and is visually intrusive in the natural landscape. Fencing alone does not address the impacts of horses across the wider landscape and will only be considered as part of an integrated management program.

Acquiring accurate horse population estimates

To obtain an initial estimate of feral horse numbers in Barmah Forest, Parks Victoria in 2017 and 2018 trialled the use of helicopter-mounted military grade forward-looking infrared imaging (FLIR) and 4K visual spectrum videography, as described on pages 30-31. This technique proved successful in detecting feral horses through tree canopy and other vegetation cover, finding that horse numbers were much higher than previous reports or estimates (i.e. more than 500, rather than less than 200).

The timing of thermal imaging surveys is dependent on a differential in temperature between the horses and background earth and vegetation. The initial surveys were undertaken in June 2017 and June 2018. Following extremely dry conditions and the death or euthanasia of some feral horses from malnutrition over the summer period (2018-19), an updated population measure is required. A detailed FLIR thermal imaging survey will occur in April 2019, during cool weather, and be repeated annually, to determine horse numbers and inform subsequent management actions.

Feral horse removal

This strategic action plan proposes the long-term goal of total removal of feral horses from the Barmah National Park. Horse removal from the park will be staged. The first stage, over the four year duration of this plan, aims to reduce horse numbers down to a population of approximately 100 horses from the recent (2018) estimated total population of more than 500.

The target of reduction of feral horse numbers will primarily be delivered through two principal control methods: (i) passive trapping and rehoming, and (ii) ground shooting of free-ranging horses using professional shooters. Other potential control methods are assessed in Table 6.

It is the intent of this plan to trap horses only where appropriate rehoming recipients can be secured. Parks Victoria will actively seek to work with horse interest groups to identify willing and appropriately skilled and equipped horse recipients. Captured horses will be transported offsite to rehoming partners.

Horses for rehoming will be captured primarily using passive trapping. This technique lures free-ranging horses to open yards containing baits of salt, molasses and/or lucerne (often through repeat visits of free-ranging horses to open yards). Once sufficient horses are within the yard, the gate is remotely triggered.

Trap operators will ensure that Parks Victoria’s strict operating standards and animal welfare conditions are met.

Where rehoming cannot be arranged feral horses will be culled. Shooting of free-ranging horses by contracted professional shooters has been proposed by a number of stakeholders and welfare organisations as a more humane approach than methods involving capture, transport and being put down as a final outcome (e.g. at a knackery), in terms of minimising animal suffering. This plan proposes contracting professional shooters to use specialist equipment (e.g. noise suppressors and thermal imaging equipment) to cull free-ranging horses by ground shooting under strict operational procedures. Shooting operations will be overseen by expert equine veterinarians and strictly managed in terms of humane animal welfare and public safety standards.

The focus of the first year of this strategic plan will thus be to:

- build partnerships and programs with community groups and other groups to rehome horses,
- where rehoming recipients are secured, commence trapping program,
- commence feral horse removal by ground shooting using professional shooters.

Horse removal would be phased in with targets to be increased each year to reach the four year stage-one goal of reducing the horse population down to 100.

Throughout implementation of the plan, the total horse population and the response of the floodplain marsh vegetation, particularly the Moira grass, will be monitored. Annual counts of horse numbers will be undertaken using thermal imaging aerial surveys. A review will be undertaken during the final year of the plan to determine the extent to which horse impacts on Moira grass have been reduced.

A regular evaluation of the use of all control methods will be conducted, overseen by the Feral Horse Technical Reference Group. In the final year of the plan, a broader evaluation will examine the application of the control methods, issues associated with their use, and their contribution to meeting the goals of the program, to assist in development of the next plan.

Table 6 provides a description of the available control methods and their potential application in the Barmah Forest.

Table 6: Overview of the suite of control methods for feral horse control.

Description	Application
Trapping and rehoming	
<p>Trapping involves establishing trap yards and using lures such as salt, molasses and/or lucerne to encourage feral horses to go into the trap yards. Once inside, a tripwire can be used to trigger the closure of the entry gate.</p> <p>Trapping can be more expensive than other control methods as it is labour-intensive.</p> <p>Rehoming involves the transport of the feral horse to freehold land where it can be securely and safely held and potentially domesticated.</p>	<p>Trapping has been used with success in the Victorian Alps. The installation of a trapping network is required to implement this method. There is a need to monitor traps and remove horses from trap yards in a timely manner. Trapping can be a humane and effective control method for removing feral horses.</p> <p>Trapping will be used in combination with rehoming to remove feral horses from Barmah Forest. In 2019, following the securing of rehoming partners, a trapping network will be established. Detailed locations for traps will be determined during planning prior to operational implementation. Rehoming opportunities will be identified prior to any feral horses being trapped.</p>

Description

Application

Shooting (free-ranging horses)

Shooting can provide site specific and humane ways of managing feral animals, using appropriately skilled shooters under tightly managed conditions.

Shooting by contracted professional shooters has also been proposed by a number of stakeholders and welfare organisations as a more humane approach than other methods, in terms of minimising animal stress and time to death.

Shooting of free-ranging feral horses will be used as a control method over the four year duration of this plan. It will be used to reduce feral horse numbers. It is proposed that appropriately accredited, skilled and equipped professional shooters will be contracted to cull feral horses using equipment that maximises animal welfare standards and minimises horse distress (e.g. high calibre firearms, noise suppressors and thermal imaging equipment).

Shooting may also be used in relation to trapping and rehoming, when horses such as stallions pose a threat to other horses and/or operational staff.

Removal and appropriate disposal of carcasses from shooting operations may involve contractual arrangements with a knackery.

A seasonal operational plan will be developed to define the settings for lethal control, and how shooting will be carried out. Appropriately accredited and supervised professional shooters would carry out the shooting.

A regular evaluation of the use of shooting (and other control methods) will be conducted, overseen by the Feral Horse Technical Reference Group. If required, an aerial control trial may be considered if ground-based removal techniques fail to capture horses in dense vegetation (e.g. within tall Phragmites beds within the floodplain marshes).

Euthanasia

Defined as the practice of intentionally ending a life in order to relieve pain and suffering, euthanasia is not a population control method, however its application is described here.

Euthanasia of free-ranging or captive horses may be required when horses are injured, ill, or are in very poor body condition. Population reduction will reduce the likelihood of this occurring.

Should euthanasia be required, Parks Victoria will:

- work with the RSPCA and expert equine veterinarians to accurately assess feral horse condition to identify animals requiring euthanasia, and
- use appropriately accredited and supervised Parks Victoria staff and/or professional shooters to carry out the shooting.

Mustering

Mustering involves using horse riders, ground vehicles or helicopters, or a combination of these, to gather and move groups of feral horses into a yard.

Mustering has not been used to assist in the capture of feral horses in Victorian national parks, but has a history of use for cattle removal prior to Barmah's reservation as a National Park. Mustering operations are best suited to open and relatively flat terrain and may be suitable for practical, effective and humane method removal of feral horses in the Barmah Forest.

Mustering may be trialled as a secondary method to yard feral horses and may be used as an additional capture technique during the term of this plan.

Description

Application

Fertility control

Fertility control agents can be used to manage reproduction rates of individual horses if the agent can be administered effectively and individual horses can be identified and re-treated when required. This technique has been used overseas and is generally only practical in small confined populations where individual horses can be easily captured and treated, and an immediate reduction of environmental impacts is not required.

Fertility control will not be used. This technique is typically applied to native animal populations where the management goals are addressing overabundance to reduce numbers to a sustainable ongoing population level (e.g. for koalas, kangaroos). As the long-term goal is total removal of the feral horse population from Barmah National Park, this technique is not appropriate. In addition, difficulties in delivering fertility control agents effectively in the field for large numbers of uncontained and unidentified animals, the requirement of repeated booster doses (every 1-2 years) and the inability for the technique to significantly reduce populations over a short timeframe means fertility control is not supported for horse control in Victorian parks (Parks Victoria 2017).

Post-capture management of horses

For successful rehoming to occur, Parks Victoria will need to build a cooperative partnership with groups or individuals that have an interest and appropriate skills in rehoming captured horses. The capacity of these groups and individuals to accept and rehome captured horses needs to be understood. Potential rehoming partner organisations or individuals will need to demonstrate their ability to accommodate the horses, and meet animal welfare standards. As Parks Victoria will not manage holding properties for captured horses, it is critical to understand capacity for rehoming within the community.

The capture of horses from Barmah Forest will be dependent on Parks Victoria having secured rehoming opportunities for those horses. Captured horses will require initial veterinary checks and microchipping to allow for monitoring and tracking following their surrender to the rehoming partner. If the pre-arranged rehoming partner fails to take the horse(s), they may be humanely put down and transported offsite.

There are a range of guiding and legislative documents regarding animal, and horse-specific, welfare and safety. Parks Victoria adheres to these standards, and will also develop site-specific Standard Operating Procedures that draw upon these, to ensure the management of horses in Barmah Forest is safe, effective and humane.

The following principles will be applied to the management of captured horses:

1. Animal welfare outcomes will be optimised through appropriate expectations, protocols and oversight and monitoring.
2. Transport and holding times for captured horses will be minimised.
3. Mares and dependent foals will not be separated.
4. Horses surrendered for rehoming, will be marked so as to remain traceable.

Fenced exclusion in sensitive areas

Fencing trials to date have been designed to create enclosures to measure feral horse impacts, and not as trial of a long-term or large-scale solution (Figure 32). These enclosures have provided stark evidence of the impact of feral horses and the capacity of Moira grass to recover when protected from grazing pressures.

Though fencing is not considered to be a long-term or landscape-scale solution as fences on floodplains are often damaged or destroyed by flooding and require costly ongoing repair and maintenance, the trials have been an effective interim measure. Therefore, construction of targeted small-scale fenced enclosures are proposed, where appropriate, to protect core environmental and cultural sites, as an interim solution to reducing feral horse impacts (Hamilton 2014).

These fences will be constructed to also exclude feral pigs and other introduced large grazers (section 8.3 – Objectives). These exclosures will create refuge for Moira grass and dependent biota and to provide a nucleus for re-colonisation of disturbed areas as herbivore pressure is reduced.

Revegetation within existing and new exclosures may also be trialled (refer to section 8.5).



Figure 32: Little Rushy Swamp, January 2019¹³. Fenced (lower area) showing expanse of Moira grass (bright green) and some clumps of giant rush (circular grey-green clumps at bottom centre) amongst standing water; unfenced (top area) with water reflection and reduced aquatic vegetation cover; and, dry higher ground (treed areas to the left and right) showing lack of ground vegetation.

Feral horse control objectives and actions

Aim: *The long-term aim for feral horses in Barmah Forest is to reduce their numbers to zero, thereby alleviating the total grazing and trampling pressure caused by this introduced species.*

This will be conducted in a manner that will minimise impact to cultural sites, and is humane. Removal of feral horses will enable both natural Moira grass regeneration to occur and manual habitat restoration programs to be successful, by reducing horse density and protecting core areas.

Within the four year life of this plan, the target is to reduce numbers to a maximum of 100 horses. A revised plan will be developed in the final year of this plan, and will detail the next steps toward removal of the remaining horses in Barmah Forest. This will ensure that feral horse numbers remain continuously managed, and numbers do not get an opportunity to re-build, following the completion of this plan.

¹³ Of note, the difference in river red gum canopy health and paucity of groundcover between dry and wet areas is also very apparent in this image, as Little Rushy became inundated due to the spring/summer flooding of 2018-19 (refer to Table 3), in otherwise dry climatic conditions

Table 7: Actions to reduce the total grazing and trampling pressure from horses.

Strategy	Action	Responsibility (lead identified first)	Priority
Reduce population density of horses by effective and integrated control programs	Removal targets - Year 1: remove 100-120 horses*; Year 2: remove 150-250 horses*; Year 3: remove 150-250 horses*; Year 4: remove any further horses, as needed, until the remaining population number is approximately 100. * Numbers to be informed by total population counts through annual aerial surveys.	Parks Victoria	High
	Establish a trapping network to capture (where possible) feral horses.	Parks Victoria	High
	Surrender captured horses to rehoming groups or individuals.	Parks Victoria	High
	Develop seasonal operational plans for professional shooter deployment for lethal control of free-ranging horses.	Parks Victoria	High
	For each horse removed collect the following data: <ul style="list-style-type: none"> gender, age and body condition score; removal method; and surrender outcome. 	Parks Victoria	High
	Mustering may be trialled as a feral horse control technique during the term of this plan.	Parks Victoria	Medium
Protect smaller areas where core natural and cultural values occur	Install targeted small-scale fenced enclosures in sensitive areas where an immediate reduction of impacts is needed (e.g. prioritised remnant Moira grass sites where active restoration is occurring), and fencing is feasible. These will be constructed using a design that will exclude feral horses as well as pigs and other large introduced herbivores.	Parks Victoria, GB CMA, DELWP	High
Help to sustain the health of Country for Traditional Owners.	Work closely with Yorta Yorta to protect Country and sites of cultural significance while implementing grazing control management actions.	Parks Victoria, YY TOLMB, GB CMA	High
Increase community support for rehoming captured horses and horse management	Build partnerships that contribute to the success of feral horse management at Barmah Forest. Keep the community and stakeholders informed of actions and progress. Actively develop partnerships and programs to maximise rehoming capacity. In the final year of this plan, consult the local community and other stakeholders on further steps in management of the feral horse population.	Parks Victoria	High
Reduce suffering of free-ranging horses	Euthanasia of free-ranging horses may be required when horses are injured, ill, or are in very poor body condition.	Parks Victoria	High
Monitor effectiveness of horse control in reducing population abundance	Undertake annual feral horse surveys using helicopter-based thermal imaging in late Autumn. Increased surveillance to reduce the incidence of re-introduction of feral horses.	Parks Victoria	High

8.3 Control of feral pigs and other introduced herbivores

The impact of feral pigs and several introduced herbivores (in addition to horses, addressed separately) in the planning area are listed as potentially threatening processes under the federal *Environment Protection and Biodiversity Conservation Act 1999* and/or *Victoria's Flora and Fauna Guarantee Act 1988*. They therefore require actions to be implemented to reduce their impact on native species and ecological communities.

These species include:

- Feral pigs (predation, habitat degradation, competition and disease transmission).
- Feral goats (land degradation and reduction of biodiversity through browsing and competition).
- Deer (reduction in biodiversity of native vegetation).
- Rabbits (land degradation and reduction in biodiversity of native vegetation through grazing).

Pigs, deer, goats, rabbits, and feral sheep, all occur within the planning area where they can exert grazing, browsing and trampling pressure. Cattle grazing was recognised as a threat to Moira grass but has not occurred since agistment was removed from the park in 2007. A *Pest Plant and Animal Strategy for Barmah National Park and Ramsar Site* (Ecology Australia 2013) was commissioned by Parks Victoria and GB CMA to provide direction on reducing the impact of threats to the Ramsar Site's ecological character to meet State, Federal and catchment management priorities and legislative requirements, and international obligations under the Ramsar Convention. A risk-based approach was used to rank the threat different pest species posed to vegetation, fauna and the ecological character of Barmah Forest, and prioritise actions. Among the pest animal management priorities were:

- Eradication of feral pigs
- Eradication of feral deer, goats and sheep, and
- Control of rabbits, particularly in woodlands.

In order to help protect the ecological character of the Ramsar site, funding is regularly sought to support these priority actions. Examples of recent successful funding bids include:

- National Landcare Program: In the five years between 2013 and 2018 GB CMA was funded to co-ordinate a limited control and monitoring program for foxes, feral pigs and rabbits through the National Landcare Program (2013–2018). This funding supported actions within the Goulburn Broken Waterway Strategy (GB CMA 2014), which aimed to control invasive fauna (aquatic and terrestrial) as a key threat to the Ramsar Site. Additional funding was granted, commencing in 2019-20 for a period of four years, to continue this program through the National Landcare Program phase II.
- State funding is provided from the Waterway Health Program to implement the Goulburn Broken Waterway Strategy, which includes actions in the Barmah Forest Ramsar Site. Funding has targeted activities such as invasive fauna and weed control and control of red gum sapling and giant rush encroachment.
- Biodiversity Response Planning: Funding through the Victorian Government's Biodiversity Response Planning initiative was granted to Parks Victoria in 2018 to implement projects targeting large herbivores in Barmah Forest and Lower Goulburn National Parks from 2018-19 to 2020-21.

Current management approaches

Feral Pigs

Feral pigs are considered a very high priority and control work is focused on their presence in the treeless wetlands, where their impact is highest. The methods of control are primarily trapping and shooting, with trapped pigs being shot at the trap site. Control using 1080 baits has also been used, and this is implemented using strict operating procedures. Free-ranging feral pigs are targeted through collaborative operations with

the Sporting Shooters Association of Australia, and in 2017-18 three targeted hunts occurred with 20 pigs killed. In 2018-19, an increase in the numbers of pigs controlled is expected in response to increased resourcing for feral pig control.

Monitoring of the success of feral pig control measures to date has identified that further action is required to improve the control and monitoring program to bring it to a best-practice standard. This will ensure that the most effective suite of measures is implemented on a regular basis, using consistent, standardised protocols that enable measurable target setting and reporting (Ecology Australia 2017).

Feral goats, deer and sheep

Control of feral goats, deer and sheep has been undertaken opportunistically rather than through programs specifically targeting these species. Shooting of free-ranging animals has occurred when pig control is in progress or by park staff at other times. In 2017-18, 34 deer, 7 sheep, and 1 goat were destroyed.

Rabbits

Only low numbers of rabbits are found in the Barmah Forest, as evidenced by annual transect counts. Flooding of the landscape provides highly effective control of the rabbits and any existing semi-permanent populations are found at the park's higher sand ridges. These populations are controlled by fumigation, as ripping is inappropriate due to the presence of cultural values in these locations. As this plan is focussed on impacts to floodplain marshes, no actions for rabbit management are included here.

Feral pig and other introduced herbivore control objectives and actions

Aim: *To reduce total grazing pressures and other impacts exerted by feral pigs and introduced large herbivores on Moira grass and other floodplain marsh communities, by implementing strategies and actions to minimise impact to cultural sites, and that are humane.*

Table 8: Actions to reduce total grazing pressures and other impacts exerted by feral pigs and other herbivores.

Strategy	Action	Responsibility (lead identified first)	Priority Rating
Reduce population densities of feral pigs, deer, and goats by effective and collaborative control programs ¹⁴	Feral pigs – Reduce feral pig population density across the planning area to reduce ground disturbance and predation.	Parks Victoria/YY TOLMB, GB CMA	High
	Implement an on-going multi-technique control program (baiting, trapping and shooting) targeting the protection of key assets (e.g. colonial waterbird rookeries; Moira grass).		
	Install targeted small-scale fenced enclosures in sensitive areas where an immediate reduction of impacts is needed (e.g. prioritised remnant Moira grass sites where active restoration is occurring), and fencing is feasible.		
	Enclosures will be constructed using a design that will exclude feral horses as well as pigs and other large introduced herbivores (refer to section 8.2 – Fenced exclusion in sensitive areas).		
	Feral deer – Reduce population density of all deer species and maintain the density at such a low level that impacts on wetland values are minimal.	Parks Victoria/YY TOLMB, GB CMA	Medium

¹⁴ Unlike horse numbers, more accurate estimation of pig, deer, goat and sheep numbers in Barmah Forest are not available, as they are smaller and more cryptic, and therefore not as easily discriminated via FLIR aerial surveys.

Strategy	Action	Responsibility (lead identified first)	Priority Rating
	Implement an on-going multi-technique control program targeting the protection of key assets (e.g. Moira grass).		
	Feral goats – Reduce goat population densities to levels that allow regeneration of perennial shrub and ground layers. If eradication is achieved, maintain goat-free status.	Parks Victoria/YY TOLMB, GB CMA	Low
	Implement an on-going multi-technique control program targeting the protection of key assets (e.g. Moira grass).		
Eradicate herbivore populations that have not yet established	Feral sheep – Eradicate feral sheep by 2019 and maintain feral sheep-free status.	Parks Victoria/YY TOLMB, GB CMA	Medium
Monitor effectiveness of animal control programs and adapt control as needed.	Establish measurable targets and monitoring programs for pigs, deer, goats and sheep.	Parks Victoria/YY TOLMB, GB CMA	High

8.4 Manage encroachment by invasive wetland plants

Ongoing management of both introduced and native invasive species is required to maintain the ecological character of the floodplain marshes of Barmah Forest. Two native plant species, giant rush (*Juncus ingens*) and river red gum (*Eucalyptus camaldulensis*), are recognised as potential invasive species encroaching Moira grass floodplain marshes (see section 7.3).

Current management approach

The Barmah–Millewa Forest Environmental Water Management Plan (MDBA 2012) makes provision for environmental water deliveries that aim to control giant rush and encourage the reestablishment of Moira grass. The use of fire has also been trialled to manage beds of giant rush on Steamer Plain, however environmental releases for flooding to follow burning did not occur because of competing demands on limited environmental water during drought conditions in 2008 and 2009. Mayence *et al.* (2010) tested the effects of flooding and found 60% mortality of giant rush seedlings (with the remainder severely stressed) in glasshouse trials following inundation for 42 days.

Management agencies have been conducting a river red gum sapling thinning project in Barmah Forest since 2016. Sites that are targeted for works have been identified using historical imagery to locate wetland areas that were treeless plains but are now invaded by red gums as a consequence of river regulation and associated changes to hydrological patterns. The aim of the sapling thinning program is to reduce tree cover to enable the re-establishment of a grassy understorey.

Manual removal of dense stands of red gum sapling thickets is undertaken before they establish into large trees. Saplings are cut by brush-cutter or chainsaw, and glyphosate is applied immediately on the cut surface to prevent coppice regrowth. Cut saplings are managed so as not to form a barrier to the re-establishment of the grassy understorey.

Initial results of the project appear successful, with photo point monitoring showing that across the treated area, river red gums have generally not grown back and the understorey is responding positively. One site had very little understorey prior to treatment, but following treatment had complete Moira grass coverage within an area fenced from feral horse grazing (*pers. comm.* Keith Ward, Goulburn Broken CMA, 2018).

Priority weed species have been targeted using selective herbicide to spray infestations in key locations. YTTOLMB's Waka Wolla crews have also been involved in delivering other on-ground works and developed valuable skills and experience while also working on Country. Contractors have also carried out specialist work on the aquatic weed, arrowhead (*Sagittaria platyphylla*), complementing a region-wide effort driven by Goulburn-Murray Water (GMW) to stop the weed choking waterways and fouling irrigation equipment in delivery channels.

Invasive plant management objectives and actions

Aim: To reduce the encroachment of invasive native flora species (giant rush and river red gum), and control arrowhead invasion, to support Moira grass recovery.

Table 9: Actions to manage encroachment by invasive wetland plants.

Strategy	Action	Responsibility (lead identified first)	Priority rating
Reduce extent of encroaching native species (giant rush and river red gum) to restore the boundary between forest and grasslands (open plains)	Minimise the incidence and magnitude of undesirable summer-autumn flooding of floodplain marshes (e.g. Steamer Plain, Hut Lake, Little Rushy Swamp and War Plain) (refer to conservation action 8.1).	GB CMA, MDBA, VEWH, Parks Victoria/YY TOLMB	Medium
Control arrowhead to acceptable levels, particularly where floodplain marsh communities are at risk.	Continue to control arrowhead in surrounding waterways and delivery channels to reduce the source of seed and other propagules that could reach floodplain marshes. Eradicate arrowhead where localised and small populations exist.	GMW, GB CMA, site managers, DELWP, DJPR, contractors	Medium
	Respond rapidly to identify and eradicate new infestations of arrowhead within Barmah Forest. Aim for an 80% reduction in the extent and density of existing infestations of arrowhead within Barmah Forest ¹⁵ .	GB CMA, GMW, Parks Victoria/YY TOLMB, DELWP, DJPR	High
Monitor effectiveness of control programs and adapt control as needed.	Monitor the distribution and extent of arrowhead and encroaching native species in the floodplain marshes. Trial the use of ecological burning and/or mechanical control (e.g. slashing or thinning), followed by managed flooding to limit giant rush and river red gum regrowth or germination from the soil seed bank on Moira grass plains. Based on research results and Traditional Owner knowledge, implement further on-ground trials to restore the natural extent and distribution of giant rush and river red gum, in targeted locations, particularly where new thickets are emerging.	Parks Victoria/YY TOLMB, GB CMA, MDBA, VEWH, CSIRO, DELWP, research partners Parks Victoria/YY TOLMB	Medium

¹⁵ A target of 80% reduction in the extent and density of the six Priority 1 weed species (of which arrowhead is one) has been set for Barmah Forest as a whole" (Caring for our Country, Regional Delivery MERI Plan - Building the resilience of the Barmah Forest Ramsar Site) to protect its ecological character.

8.5 Active revegetation of Moira grass

To aid the re-establishment of Moira grass back into areas where it has been lost, trials for planting of Moira grass thatch are underway. This process involves establishing Moira grass thatch in the laboratory with the intent to transfer these to the field, within existing or new exclosures (Refer to section 8.2 – Fenced exclusion in sensitive areas). Funding to support this program has been provided by the MDBA’s *Living Murray* Program, and the project will commence in the 2018-19 financial year.

Moira grass revegetation objectives and actions

Aim: *To aid the re-establishment of Moira grass in areas where it no longer occurs, a re-establishment program will be implemented.*

Table 10: Facilitate the re-establishment of Moira grass through active measures.

Strategy	Action	Responsibility (lead identified first)	Priority rating
Re-instate Moira grass thatch in areas of floodplain marshland	Implement trials of laboratory thatch growth, followed by translocation into floodplain marshes, within grazing exclosures.	GB CMA, DELWP, PV/YY TOLMB	Medium
Monitor effectiveness of the re-establishment program and adapt as needed.	Evaluate survival of translocated thatch within grazing exclosures.	GB CMA, DELWP, PV/YY TOLMB	Medium

9 Monitoring, evaluation and research

9.1 Effectiveness of conservation strategies

Each of the conservation strategies (described section 8) are designed to increase the extent of Moira grass dominated areas. Each strategy includes a monitoring component to evaluate the effectiveness of threat mitigation actions. These will determine whether:

- an appropriate water regime is being delivered,
- the numbers of feral horse, pigs and other introduced herbivores are reducing,
- encroachment of invasive wetland plants is under control, and
- active revegetation of Moira grass is successful.

This monitoring is detailed in section 8, but is summarised in Table 13, along with research needs and knowledge gaps (described in section 9.2).

To successfully evaluate the effectiveness of this plan, additional monitoring is also required to determine whether implementation of these conservation strategies is having a positive impact on the restoration of floodplain marshes, particularly an increase in the extent of Moira grass-dominated plains (Table 12).

Given the site’s Ramsar status and profile as an Icon Site within the Murray-Darling Basin, strong levels of collaboration already exist between research institutions, waterway managers and land managers. Collaborative partnerships operate within existing programs, and these contribute to the monitoring and reporting of ecological character (Table 11).

Table 11: Existing collaborative partnerships that contribute to monitoring activities at Barmah Forest

Monitoring Program	Description
MDBA Living Murray Program	<p>Monitoring of the ecological outcomes of environmental watering events (GB CMA in association with the MDBA). Each year the MDBA, through its Living Murray Program, provides funding for condition monitoring and intervention monitoring for the Barmah-Millewa Icon Site.</p> <p>The primary focus of condition monitoring is to determine whether the objectives for the site, identified in the Environmental Water Management Plan, are being met. Condition monitoring is conducted annually to provide information about the health of vegetation, fish and waterbirds at sites. Annual assessments are also undertaken on the condition of stands of river red gum and black box communities at a Murray River system scale.</p> <p>Intervention monitoring is undertaken to measure response to a management activity and includes monitoring of flood extent and the ecological responses of fishes, birds and vegetation.</p>
Victorian and Commonwealth Government Ramsar monitoring	<p>In 2011 the Commonwealth Government funded a review program for assessing and reporting the status of the ecological character of Australia’s Ramsar sites. A further assessment was funded by the Victorian government in 2016.</p> <p>In response to the Victorian Auditor General’s Office <i>Meeting obligations to protect Ramsar wetlands</i> audit, Ramsar roles and responsibilities were developed for Victoria, which included assigning CMAs to undertake a site coordination role and for management and monitoring at each site to be overseen by an agency coordination committee. The response also required that each site have a monitoring, evaluation, reporting and improvement (MERI) plan to guide the collection of monitoring data to track ecological character status and inform adaptive management. The Victorian Government is funding the implementation of site MERI</p>

Monitoring Program	Description
	<p>plans until June 2020. The Barmah Forest Ramsar Site MERI Plan aims to enable tracking of the impact and effectiveness of management activities and allow adjustments to be made to management in response to knowledge gained and changing circumstances.</p> <p>The DELWP statewide Ramsar coordinator provides six monthly updates of ecological character status to the Commonwealth Department of Environment and Energy.</p> <p>The status of ecological character of each of Australia's Ramsar sites is also provided in Australia's national report to each three-yearly conference of the Ramsar Convention contracting parties.</p>
GB CMA Waterway Strategy	<p>The Goulburn Broken CMA Waterway Strategy, and associated regional works program which aims to maintain or improve the environmental condition of waterways, is also accompanied by a detailed MERI plan. This identifies the key questions for evaluation and establishes processes to monitor progress within the framework of the statewide monitoring program. For Barmah Forest Ramsar Site the monitoring program coordinated by the GB CMA must consider MDBA and Ramsar monitoring requirements. Monitoring coordinated by the GB CMA includes the Barmah National Park and Ramsar Site Pest Plant and Animal Monitoring, which complements the Pest Plant and Animal Monitoring Program (Ecology Australia 2013). This has been conducted annually from 2014 to 2018, funded through the National Landcare Program.</p>

Table 12 below prioritises the monitoring activities required to track the status of the ecological character of the floodplain marshes.

Table 12: Monitoring to track the status of the Ramsar ecological values addressed by this plan

Value	Objective	Target	Indicator	Monitoring frequency	Priority (for this plan)
Floodplain marshes	Improve the health of the floodplain marshes of Barmah Forest, increasing the extent and cover of Moira grass plains and associated wetland vegetation.	Extent and cover of Moira grass to increase (from current) by 60% by 2028.	Extent and cover	Annual	High
		Extent of giant rush and river red gum encroachment on Moira grass plains to reduce annually.	Extent	Annual	High
		Meet assessment against LAC for Mueller daisy and swamp wallaby grass	Extent and composition	Every three years	Medium

This plan (the Strategic Action Plan) will be reviewed and evaluated each year following its commencement. There will also be a formal review and evaluation of the plan in the final year of its implementation. Reports on the reviews and associated outcomes will be made available via the Parks Victoria website.

Managers will also maintain records of budget expenditure, staff, contractor and volunteer time, materials and other resources used to implement all activities associated with the actions outlined in this plan (output reporting) to inform in the development of future plans.

Feral horses

Management of feral horses in Barmah Forest is a new management activity, not previously conducted at this location. Feral horse management will be delivered in two principal components:

1. An operational component for the capture and removal of feral horses from the Barmah National Park and Barmah Forest Ramsar Site, undertaken as seasonal conditions, access and weather allows.

2. A monitoring and evaluation component to determine estimates of horse numbers, and to refine annual removal targets.

Reporting on operational component will be done through quarterly and end-of-year reports by Parks Victoria's Northern Region using data collected during horse capture and surrender activities.

Monitoring and evaluation to assess the effectiveness of the management actions toward achieving Moira grass recovery while maintaining feral horse welfare outcomes, will inform the requirement, and most appropriate method, for management action both during and after the life of this plan.

Parks Victoria's existing Feral Horse Technical Reference Group will continue to provide technical advice on the operational and the monitoring and evaluation components of the feral horse program and will remain in place for consultation across the duration of the four-year strategic plan and its implementation.

9.2 Research and knowledge gaps

Research and monitoring activities will run concurrently with implementation of the conservation strategies. Details are provided in Table 13 on how monitoring and research will assist in evaluating the performance of conservation strategies and actions identified in this plan. This proposed monitoring framework builds on an information base already collected and shared amongst partner agencies, through the *Barmah National Park & Ramsar Site - Pest Plant & Animal Strategy* (Ecology Australia 2013) which identifies knowledge gaps to be filled to assist reporting against the achievement of objectives set by this plan.

The conservation strategies presented in chapter 9 have been developed under current environmental conditions and management regimes, it is important that they be reviewed and updated regularly, on the basis of monitoring results, and incorporate any new approaches or circumstances.

Research is critical for filling gaps in knowledge and ongoing monitoring programs are an essential part of adaptive management. Insights gained from monitoring programs will help to evaluate and improve management effectiveness, as well as identify where changes in the approach or resourcing are needed. Strategies may therefore evolve over time as knowledge on the impacts of management activities improves.

For example, although climate modelling has provided predictions of the likely changes in the climate of the Murray Basin (CSIRO and BOM 2015), less is known about the consequences of this change on critical ecological factors, such as water availability for flooding regimes and the impacts on threatened species.

Research and monitoring effort can be prioritised to reduce the uncertainties that will have the largest impact on outcomes. For example, robust evidence will be required regarding the impact on Moira grass extent resulting from improved feral animal controls. This could involve a targeted experiment designed to compare impacts pre- and post-intervention, with established controls to cover the range of eventualities associated with water regimes.

In the short term, important areas of research have been recommended (Colloff et al. 2014; Hamilton 2014; Nicol et al. 2017). These include:

- Horse exclosures in sensitive areas,
- Testing impacts of different durations and depths of flooding on Moira grass growth (controlled outdoor experiment),
- Applying flows to improve Moira grass seedbank,
- Applying flows to maximise Moira grass colonisation,
- Ideal duration, timing and depth of flooding required to deter giant rush,
- Effectiveness of manual removal of red gum saplings and burning of giant rush.

Table 13: Monitoring the effectiveness of conservation strategies, and the recommended action to improve outcomes.

Objectives	Measure	Target	Existing data	Recommended additional action, data and/or research
Conservation strategy: Maintaining and improving current water regimes				
To maintain and, if possible, improve current water regimes of floodplain marshes, particularly Moira grass plains.	Finalisation and implementation of this action plan.	Action plan complete, followed by implementation of priority actions. Delivery of priority water management actions and associated monitoring.	Various monitoring projects undertaken as part of the environmental watering program in Victoria, and summarised in the annual GB CMA seasonal watering proposal and outcome reporting for MDBA, VEWH and DELWP.	Support environmental water delivery partners to conduct ongoing research into the impacts of different durations, depths and flood timings on Moira grass colonisation and seeding.
Conservation strategy: Control of grazing by feral horses				
Reduce feral horse population density down to a maximum of 100 during the life of this plan, and beyond that, to zero. Protect core areas. Optimise animal welfare outcomes.	Understand feral horse numbers across Barmah Forest and/or at priority locations e.g. aerial survey. Record number of horses removed, demographic and condition data e.g. sex, age, health. Disturbance monitoring. Area protected by fencing, construction and maintenance costs. Compliance with relevant Codes of Practice and Standard Operating Procedures for horse capture, holding and transport. Partnerships with community groups interested in rehoming horses.	Achieve capture targets. Decrease in horse density across Barmah Forest. Decrease in the rate of new disturbance, and reduction in evidence of old disturbance. Sensitive ecological and cultural sites identified and enclosure fencing installed. Retain current enclosure fencing (1,567 metres) and install further, targeted fencing, as required. 100% compliance with relevant Codes of Practice and Standard Operating Procedures for horse capture, holding and transport.	Annual aerial feral horse survey (based on methodology established in May 2017 and June 2018). Modelled population estimates across Barmah Forest. Monitoring of disturbance due to grazing at existing (and new) enclosures to collect data regarding longevity of fencing, effectiveness in protecting sensitive areas to protect and/or assist recovery. YYNAC monitoring of the status of culturally-important sites.	Annual aerial thermal imaging population surveys. Additional monitoring to address new questions regarding horse abundance if these arise, e.g. if there are large changes in horse abundance due to changing environmental conditions. Use aerial imaging to identify key areas where horses frequent to improve the effectiveness of capture techniques and locations.

Objectives	Measure	Target	Existing data	Recommended additional action, data and/or research
Conservation strategy: Control of feral pigs and introduced herbivores				
Reduce total grazing, browsing and trampling pressure, and other impacts exerted by feral pigs and other large introduced herbivores on Moira grass and other floodplain marsh communities.	<p>Measure: Bait-take, catch-per-unit-effort (CPUE).</p> <p>Measure: Fenced area protected, construction and maintenance costs.</p> <p>Measure: Feral animal densities across Barmah Forest and/or at priority locations, using aerial surveys, remote cameras, drive transects and/or faecal pellet densities.</p> <p>Measure: Disturbance monitoring.</p> <p>Activity: Colonial waterbird nest surveillance.</p>	<p>Reduced population density of feral pigs, feral goats, feral deer.</p> <p>Eradication of feral sheep.</p> <p>Sensitive ecological and cultural sites identified and enclosure fencing installed.</p> <p>Maintain current 1,567 metres of enclosure fencing.</p> <p>Decrease in the rate of new disturbance (disturbance not recorded on monitoring transects the previous year) and reduction in evidence of old disturbance.</p>	<p>Ecology Australia annual monitoring results (as per Ecology Australia 2013).</p> <p>YYNAC monitoring of the status of culturally-important sites.</p>	<p>More frequent disturbance monitoring (quarterly or seasonal) where more detailed understanding of temporal trends is needed.</p> <p>Annual feral animal aerial survey plus localised estimation of populations in selected areas.</p> <p>Monitor the impact of grazing across habitat types, as numbers reduce, to determine:</p> <ul style="list-style-type: none"> • preferential habitats • patterns of cover change • density/impact thresholds <p>Research to understand how habitat use by different pest species varies across the year.</p>
Conservation strategy: Manage encroachment by invasive wetland plants				
Reduce encroachment of invasive native flora species (giant rush and river red gums) to recover Moira grass and restore the boundary between forest and Moira grass plains.	Measure: Extent of river red gum and giant rush incursion into Moira grass plains	Extent of encroachment by giant rush and/or river red gum into Moira grass plains is reduced annually.	<p>Ecological Vegetation Class mapping (DELWP).</p> <p>Moira grass, giant rush and river red gum mapping.</p> <p>Knowledge of Traditional Owner land management practices in the use of ecological fire.</p>	<p>Determine ideal duration, timing and depth of flooding required to deter giant rush.</p> <p>Trials of targeted planned ecological burning and/or thinning to reduce encroachment of river red gums and control or eliminate giant rush, especially when conducted immediately before flooding.</p>
Control arrowhead to acceptable levels, particularly where floodplain marshes are at risk, and eradicate new and emerging weeds.	Measure: Weed extent and density	<p>80% reduction in the extent and density of arrowhead.</p> <p>No new infestations of arrowhead.</p>	Ecology Australia annual monitoring report (Ecology Australia 2013) - extent and density of Priority 1 and 2 weed species.	Further research to determine the best techniques, herbicide type(s), and timing of application for controlling invasive aquatic weeds.

Objectives	Measure	Target	Existing data	Recommended additional action, data and/or research
Conservation strategy: Active revegetation of Moira grass				
Aid the re-establishment of Moira grass back into areas where it has been lost, via an active re-establishment program.	Measure: Survival rate of translocated Moira grass thatch.	100% survival of translocated Moira grass thatch	Nil – this is a new action in Moira grass recovery efforts.	Trials of Moira grass thatch planting at different depths in the wetland profile, and at different timing (seasons) to determine the best technique for translocation of this species.

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Appendix A

Legislative and planning context

Management obligations and requirements

National Parks Act 1975

Barmah National Park is reserved under the Victorian *National Parks Act 1975* and as such must be managed in a manner that will:

- Preserve and protect the natural condition of the park
- Preserve and protect indigenous flora and fauna
- Eradicate or control exotic flora and fauna
- Preserve and protect features of scenic, historical, archaeological, biological, geological, or other scientific interest.

Subject to these purposes, the park is to be used by the public for enjoyment, recreation and education, with appropriate research activities also provided for under the Act.

Commonwealth Water Act 2007

Geographically, Barmah Forest resides within the Murray Darling Basin (the Basin), and accordingly is within the jurisdiction of the Murray-Darling Basin Authority (MDBA) which is responsible for managing the water resources of the Basin as the River Operator. The MDBA conduct this through implementation of the *Commonwealth Water Act 2007* and the associated *Murray-Darling Basin Plan*, which sets the amount of water that can be taken from the Basin each year, while leaving enough for rivers, lakes and wetlands.

This includes the recovery of water for the environment, and the construction of infrastructure to enable this water to be delivered, as environmental water, efficiently. An example of this has been achieved through the MDBA managed Living Murray Program which has administered large scale infrastructure works programs to enable the delivery of environmental water. The Living Murray Program focuses on maintaining the health of six icon sites, chosen for their high ecological and economic value, and their cultural and heritage significance to Aboriginal people. The Icon Sites are areas of high conservation value — the floodplains, wetlands and forests along the Murray River, the Murray's estuary and the river itself – and with the adjoining Millewa Forest on the New South Wales side of the Murray River, Barmah Forest is part of the Barmah-Millewa Forest Icon Site. This affords the site a level of funding to conduct ecological monitoring activities covering vegetation, birds and fish to inform adaptive management at the site.

The *Murray-Darling Basin Plan*, also promotes the conservation of declared Ramsar wetlands in the Basin and takes account of the ecological character of these wetlands.

Ramsar Convention on Wetlands of International Importance

In 1982 Barmah Forest was listed as a wetland of international importance (Ramsar Site) under the Ramsar Convention, reflecting its significant environmental values.

In accordance with the Ramsar Convention, the Australian Ramsar Management Principles in the *Environment Protection and Biodiversity Conservation Regulations 2000* specify that the primary purpose of management of a declared Ramsar wetland must be:

- a) to describe and maintain the ecological character of the wetland; and
- b) to formulate and implement planning that promotes:
 - (i) conservation of the wetland; and

- (ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.

The Barmah Forest Ramsar Site Boundary Description (DEPI 2013a) defines the boundaries of the site. The management plan for the Ramsar Site is contained within the *Goulburn Broken Waterway Strategy 2014*, produced by Goulburn Broken Catchment Management Authority (GB CMA). The strategy stipulates that the Barmah Forest Ramsar Site will be managed to maintain its ecological character, which is described in an ecological character description (Hale and Butcher 2011). The description sets out limits of acceptable change for components, processes and services (values) that are critical to the ecological character of the Ramsar Site.

The Ramsar Site management plan (GB CMA 2014) identifies the following objectives:

- Improve flow regime by 2021
- Maintain or improve riparian and floodplain vegetation condition by 2025.

The *Murray-Darling Basin Plan*, prepared by the Murray-Darling Basin Authority (MDBA) under the *Commonwealth Water Act 2007*, promotes the conservation of declared Ramsar wetlands in the Basin and takes account of the ecological character of these wetlands.

Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act regulates actions that will have or are likely to have a significant impact on any matter of national environmental significance, which includes the ecological character of a Ramsar wetland (EPBC Act 1999 s16(1)). An action that will have or is likely to have a significant impact on a Ramsar wetland will require an environmental assessment and approval under the EPBC Act.

The EPBC Act establishes a framework for managing Ramsar wetlands, through the Australian Ramsar Management Principles (EPBC Act 1999 s335), which are set out in Schedule 6 of the Environment Protection and Biodiversity Conservation Regulations 2000. These principles are intended to promote national standards of management, planning, environmental impact assessment, community involvement, and monitoring, for all of Australia's Ramsar wetlands in a way that is consistent with Australia's obligations under the Ramsar Convention. Threatened species and communities listed under the EPBC Act may also occur or have habitat in a Ramsar site.

Environmental Water Management Planning

The Barmah-Millewa Forest Environmental Water Management Plan (MDBA 2012) has set objectives, which are also applicable to this plan (see Section 1), and which have been endorsed by the Murray-Darling Basin Ministerial Council.

Environmental water is available to use in Barmah and Millewa forests from a designated account (Barmah-Millewa Environmental Water Allocation) and is held by the Victorian Environmental Water Holder. On occasions, water managed by The Living Murray Program, the New South Wales Government and the Commonwealth Environmental Water Holder can also be delivered for the benefit of Barmah-Millewa Forest. Water management is guided by an Environmental Water Management Plan, developed for Barmah-Millewa Forest. This overarching plan informs annual water management proposals and planning that guides specific water management actions.

The Regional Catchment Strategy (GB CMA 2013) further recognises the objective to protect the unique character of Barmah Forest wetlands through delivery of environmental water and land management. The CMA plays an important role in water management for Barmah Forest, the majority of which actively floods during high flows in the Murray River as a result of the main river channel narrowing at this point (the Barmah Choke). Flooding is vital for the ongoing health of wetlands and the native species they support.

Flora and Fauna Guarantee Act 1988

The *Flora and Fauna Guarantee Act 1988* is the key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes. The Act's objectives aim to conserve all of Victoria's native plants and animals. The Act establishes a range of mechanisms to achieve this objective, including listing threatened species, communities and potential threats to native species. In 2011 the 'Degradation and loss of habitats caused by feral horses' was listed as a threatening process.

Park Management Planning

Barmah National Park is jointly managed between the State of Victoria and the Yorta Yorta Nations Aboriginal Corporation (YYNAC). As such, it is not within the scope of the River Red Gum Parks draft management plan released by Parks Victoria in 2017. The Yorta Yorta Traditional Owner Land Management Board (YYTOLMB) has been established to develop a joint management plan for the park. The current approved management plan was published in 1992 for what was then the Barmah State Park and Barmah State Forest. Its purpose is to direct all aspects of management in the park until such time as the management plan is reviewed.

The current park management plan for the area (DCE 1992) identifies 17 objectives including to conserve and where possible rehabilitate wetlands; maintain the existing diversity of native plant and animal species; give special protection to significant flora and fauna; control and where possible eradicate introduced plants and animals.

A new Barmah National Park joint management plan between Yorta Yorta Traditional Owner Land Management Board and Parks Victoria is currently under development. This plan identifies the significant cultural heritage values held within the plan's footprint. As the Barmah Forest Ramsar Site is approximately 95% of the national park land area, the *Protection of Floodplain Marshes* plan also recognises that environmental management objectives must align to the cultural management objectives in the Barmah NP joint management plan.

Appendix B identifies the range of plans and documents that influence the management of the site, including those mentioned above.

Appendix B

Documents influencing management of the Barmah planning area

Document	Author and date	Geographical scale
Barmah National Park		
Management Plan for Barmah State Park and Barmah State Forest	DCE 1992	Local
Joint Management Plan for Barmah National Park (in development)	Yorta Yorta TOLMB	Local
Barmah National Park Pest Plant and Animal Strategy	Ecology Australia 2013	Local
Ramsar documents		
Barmah Forest Ramsar Site Ecological Character Description	Hale & Butcher 2011	Local
Barmah Forest Ramsar Site Boundary Description	DEPI 2013b	Local
Goulburn Broken Waterway Strategy 2014-22 [which details Ramsar Site management for Barmah Forest]	GB CMA 2014	Regional
Australian National Guidelines for Ramsar Wetlands - Implementing the Ramsar Convention in Australia	Australian Government - multiple years	National
Meeting Obligations to Protect Ramsar Wetlands	Victorian Auditor-General Report 2016	Statewide
Water and waterway management plans / strategies		
Barmah-Millewa Forest Seasonal Watering Proposal (annual)	GB CMA & OEH (NSW)	Local
Barmah-Millewa Forest Environmental Water Management Plan	MDBA 2012	Local
Goulburn Broken Waterway Strategy 2014-22	GB CMA 2014	Regional
Victorian Waterway Management Strategy	DEPI 2013a	Statewide
Agreements, Acts and Conventions		
<i>Flora and Fauna Guarantee Act 1988</i>	Victoria 1988	Statewide
<i>Water Act 2007</i>		
<i>Basin Plan 2012</i>		
<i>National Parks Act 1975</i>	Victoria 1975	Statewide
<i>Reference Area Act 1978</i>	Victoria 1978	Statewide
<i>Environmental Protection and Biodiversity Conservation Act 1999</i>	Commonwealth 1999	National
Ramsar Convention on Wetlands of International Importance	UNESCO 1975	International
Japan-Australia Migratory Birds Agreement (JAMBA)	Japan-Australia 1974	Bilateral
China-Australia Migratory Birds Agreement (CAMBA)	China-Australia 1986	Bilateral
Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)	Korea-Australia 2007	Bilateral
Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	UNEP 1983	International
Other strategic documents		
Caring for Country and Culture - Whole of Country Plan 2012-2017	YYNAC 2012	Regional
Goulburn Broken Regional Catchment Strategy	GB CMA 2013	Regional
River Red Gum Forests Investigation Final Recommendations	VEAC 2008	Regional
Protecting Victoria's Biodiversity	DELWP 2017	Statewide
Statement of Management Intent – Murray Valley National Park and Murray Valley Regional Park	NSW NP&WS 2014	Local

Appendix C

Threatened species occurring in Barmah National Park

Threatened fauna

Scientific name	Common name	EPBC	FFG	Conservation status in Victoria	Taxon type
<i>Maccullochella macquariensis</i>	Bluenose Cod (Trout Cod)	Endangered	Listed	Critically endangered	Fish
<i>Botaurus poiciloptilus</i>	Australasian Bittern	Endangered	Listed	Endangered	Non-passerine birds
<i>Macquaria australasica</i>	Macquarie Perch	Endangered	Listed	Endangered	Fish
<i>Polytelis swainsonii</i>	Superb Parrot	Vulnerable	Listed	Endangered	Non-passerine birds
<i>Maccullochella peelii</i>	Murray Cod	Vulnerable	Listed	Vulnerable	Fish
<i>Ardea intermedia</i>	Intermediate Egret	-	Listed	Endangered	Non-passerine birds
<i>Egretta garzetta nigripes</i>	Little Egret	-	Listed	Endangered	Non-passerine birds
<i>Ixobrychus minutus dubius</i>	Little Bittern	-	Listed	Endangered	Non-passerine birds
<i>Morelia spilota metcalfei</i>	Carpet Python	-	Listed	Endangered	Reptiles
<i>Ninox connivens connivens</i>	Barking Owl	-	Listed	Endangered	Non-passerine birds
<i>Oxyura australis</i>	Blue-billed Duck	-	Listed	Endangered	Non-passerine birds
<i>Petaurus norfolcensis</i>	Squirrel Glider	-	Listed	Endangered	Mammals
<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler	-	Listed	Endangered	Passerine birds
<i>Stictonetta naevosa</i>	Freckled Duck	-	Listed	Endangered	Non-passerine birds
<i>Tandanus tandanus</i>	Freshwater Catfish	-	Listed	Endangered	Fish
<i>Tyto novaehollandiae novaehollandiae</i>	Masked Owl	-	Listed	Endangered	Non-passerine birds
<i>Ardea modesta</i>	Eastern Great Egret	CAMBA, JAMBA	Listed	Vulnerable	Non-passerine birds
<i>Grantiella picta</i>	Painted Honeyeater	Vulnerable	Listed	Vulnerable	Passerine birds
<i>Grus rubicunda</i>	Brolga	-	Listed	Vulnerable	Non-passerine birds
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	Marine-	Listed	Vulnerable	Non-passerine birds
<i>Lophoictinia isura</i>	Square-tailed Kite	-	Listed	Vulnerable	Non-passerine birds

Scientific name	Common name	EPBC	FFG	Conservation status in Victoria	Taxon type
<i>Melanotaenia fluviatilis</i>	Murray-Darling Rainbowfish	-	Listed	Vulnerable	Fish
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	-	Listed	Vulnerable	Mammals
<i>Geopelia cuneate</i>	Diamond Dove	-	Listed	Near threatened	Non-passerine birds
<i>Melanodryas cucullata cucullata</i>	Hooded Robin	-	Listed	Near threatened	Passerine birds
<i>Stagonopleura guttate</i>	Diamond Firetail	-	Listed	Near threatened	Passerine birds
<i>fam. Terapontidae gen. Bidyanus</i>	Silver Perch	-	Listed	-	Fish
<i>Varanus varius</i>	Lace Monitor	-	-	Endangered	Reptiles
<i>Galaxias rostratus</i>	Flat-headed Galaxias	-	Rejected	Vulnerable	Fish
<i>Anas rhynchos</i>	Australasian Shoveler	-	-	Vulnerable	Non-passerine birds
<i>Aythya australis</i>	Hardhead	-	-	Vulnerable	Non-passerine birds
<i>Biziura lobate</i>	Musk Duck	-	-	Vulnerable	Non-passerine birds
<i>Hirundapus caudacutus</i>	White-throated Needletail	Migratory - Terrestrial	-	Vulnerable	Non-passerine birds
<i>Nannoperca australis (Murray-Darling lineage)</i>	Southern Pygmy Perch	-	-	Vulnerable	Fish
<i>Pogona barbata</i>	Bearded Dragon	-	-	Vulnerable	Reptiles
<i>Tringa nebularia</i>	Common Greenshank	Migratory - Wetland	-	Vulnerable	Waders
<i>Macquaria ambigua</i>	Golden Perch	-	Rejected	Near threatened	Fish
<i>Alcedo azurea</i>	Azure Kingfisher	-	-	Near threatened	Non-passerine birds
<i>Chlidonias hybridus javanicus</i>	Whiskered Tern	-	-	Near threatened	Waders
<i>Circus assimilis</i>	Spotted Harrier	-	-	Near threatened	Non-passerine birds
<i>Climacteris picumnus victoriae</i>	Brown Treecreeper (south-eastern ssp.)	-	-	Near threatened	Passerine birds
<i>Dromaius novaehollandiae</i>	Emu	-	-	Near threatened	Non-passerine birds
<i>Gallinago hardwickii</i>	Latham's Snipe	Migratory - Wetland-	-	Near threatened	Non-passerine birds
<i>Myotis macropus</i>	Southern Myotis	-	-	Near threatened	Mammals
<i>Nycticorax caledonicus hillii</i>	Nankeen Night Heron	-	-	Near threatened	Non-passerine birds
<i>Phalacrocorax varius</i>	Pied Cormorant	-	-	Near threatened	Non-passerine birds
<i>Platalea regia</i>	Royal Spoonbill	-	-	Near threatened	Non-passerine birds
<i>Plegadis falcinellus</i>	Glossy Ibis	-	-	Near threatened	Non-passerine birds

Threatened flora

Scientific name	Common name	EPBC	FFG	Conservation status in Victoria	Taxon type
<i>Lepidium monoplacoides</i>	Winged Peppergrass	Endangered	Listed	Endangered	Forb
<i>Amphibromus fluitans</i>	River Swamp Wallaby-grass	Vulnerable	Rejected	-	Other grass
<i>Brachyscome muelleroides</i>	Mueller Daisy	Vulnerable	Listed	Endangered	Forb
<i>Cullen parvum</i>	Small Scurf-pea	-	Listed	Endangered	Forb
<i>Menkea crassa</i>	Fat Spectacles	-	Listed	Endangered	Forb
<i>Rhodanthe stricta</i>	Slender Sunray	-	Listed	Endangered	Forb
<i>Swainsona adenophylla</i>	Violet Swainson-pea	-	Listed	Endangered	Forb
<i>Brachyscome chrysoglossa</i>	Yellow-tongue Daisy	-	Listed	Vulnerable	Forb
<i>Nymphoides crenata</i>	Wavy Marshwort	-	Listed	Vulnerable	Forb
<i>Allocasuarina luehmannii</i>	Buloke	-	Listed	-	Tree
<i>Calotis cuneifolia</i>	Blue Burr-daisy	-	-	Rare	Forb
<i>Cardamine moirensis</i>	Riverina Bitter-cress	-	-	Rare	Forb
<i>Centipeda nidiformis</i>	Cotton Sneezeweed	-	-	Rare	
<i>Cymbonotus lawsonianus</i>	Bear's-ear	-	-	Rare	Forb
<i>Gratiola pumilo</i>	Dwarf Brooklime	-	-	Rare	Forb
<i>Minuria integerrima</i>	Smooth Minuria	-	-	Rare	Forb
<i>Myoporum montanum</i>	Waterbush	-	-	Rare	Tree
<i>Picris squarrosa</i>	Squat Picris	-	-	Rare	Forb
<i>Rorippa eustylis</i>	Dwarf Bitter-cress	-	-	Rare	Forb
<i>Rytidosperma setaceum</i> var. <i>brevisetum</i>	Short-bristle Wallaby-grass	-	-	Rare	Tussock grass
<i>Tripogon loliiformis</i>	Rye Beetle-grass	-	-	Rare	Tussock grass
<i>Wahlenbergia tumidifructa</i>	Mallee Annual-bluebell	-	-	Rare	Forb
<i>Atriplex spinibractea</i>	Spiny-fruit Saltbush	-	-	Endangered	Forb
<i>Eragrostis exigua</i>	Slender Love-grass	-	-	Endangered	Tussock grass
<i>Ammannia multiflora</i>	Jerry-jerry	-	-	Vulnerable	Forb
<i>Amyema linophylla</i> subsp. <i>orientale</i>	Buloke Mistletoe	-	-	Vulnerable	Epiphyte

Scientific name	Common name	EPBC	FFG	Conservation status in Victoria	Taxon type
<i>Brachyscome sp. aff. readeri</i>	Riverina Daisy	-	-	Vulnerable	Forb
<i>Coronidium scorpioides 'aff. rutidolepis (Lowland Swamps)' v</i>	Pale Swamp Everlasting	-	-	Vulnerable	Forb
<i>Cyperus bifax</i>	Downs Nutgrass	-	-	Vulnerable	Other grass
<i>Cyperus flaccidus</i>	Lax Flat-sedge	-	-	Vulnerable	Tussock grass
<i>Dianella sp. aff. longifolia (Riverina)</i>	Pale Flax-lily	-	-	Vulnerable	
<i>Digitaria ammophila</i>	Silky Umbrella-grass	-	-	Vulnerable	Tussock grass
<i>Lipocarpa microcephala</i>	Button Rush	-	-	Vulnerable	Tussock grass
<i>Sida intricata</i>	Twiggy Sida	-	-	Vulnerable	Forb
<i>Cynodon dactylon var. pulchellus</i>	Native Couch	-	-	Poorly known	Other grass
<i>Sclerolaena muricata var. semiglabra</i>	Dark Roly-poly	-	-	Poorly known	Shrub
<i>Ranunculus pumilio var. politus</i>	Ferny Small-flower Buttercup	-	-	Poorly known	Forb
<i>Cyperus victoriensis</i>	Yelka	-	-	Poorly known	Other grass
<i>Alternanthera nodiflora</i>	Common Joyweed	-	-	Poorly known	Forb
<i>Fimbristylis aestivalis</i>	Summer Fringe-sedge	-	-	Poorly known	Tussock grass
<i>Haloragis glauca f. glauca</i>	Bluish Raspwort	-	-	Poorly known	Forb
<i>Lepidium pseudohyssopifolium</i>	Native Peppercross	-	-	Poorly known	Forb
<i>Hypsela tridens</i>	Hypsela	-	-	Poorly known	Forb
<i>Alternanthera sp. 1 (Plains)</i>	Plains Joyweed	-	-	Poorly known	Forb
<i>Lotus australis var. australis</i>	Austral Trefoil	-	-	Poorly known	Forb
<i>Cardamine tenuifolia</i>	Slender Bitter-cress	-	-	Poorly known	Forb
<i>Eleocharis pallens</i>	Pale Spike-sedge	-	-	Poorly known	Tussock grass
<i>Desmodium varians</i>	Slender Tick-trefoil	-	-	Poorly known	Forb

