

Winton Wetlands Restoration and Monitoring Strategic Plan

- *Improving ecological function*



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For the **Winton Wetlands Committee of Management, Benalla, Victoria**

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Winton Wetlands Restoration and Monitoring Strategic Plan

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1. Executive summary

The Winton Wetlands Committee of Management (WWCoM) is responsible for the restoration of ecological function at Winton Wetlands following the decommissioning of Lake Mokoan, an initiative of the Victorian Government 2004 White Paper *Our Water Our Future*.

This restoration project is quite novel. Water storages have been decommissioned elsewhere (e.g. USA), but usually because of aging infrastructure and not with the specific aim of restoring ecological function to a system. A number of wetland restoration projects exist within the Murray-Darling system in Australia, but these usually focus on improving environmental flows.

This strategic plan provides guidance to the WWCoM on:

- the protection of existing biodiversity values across the site
- the restoration of habitat, particularly across drier areas
- areas for further research
- monitoring and reporting on management effectiveness.

This plan is a high-level strategic document. It is informed by a number of supporting plans that are either completed, under development or planned. These supporting plans provide detailed guidance on implementation as it is not possible to provide sufficient detail across all areas within the one document. These supporting plans cover:

- community engagement
- revegetation, including a detailed GIS
- fish management
- fire management
- grazing management
- pest plant management
- pest animal management.

The strategic plan will be reviewed and updated if necessary on a regular basis by the WWCoM in consultation with the Scientific and Technical Advisory Group, and others as appropriate. It is more about the 'what, where and why' of restoration, rather than a 'how to' guide. Successful implementation will come from utilising appropriate expertise.

Restoration and monitoring Objectives were developed during an expert workshop held in April 2011 and form the basis of the recommendations provided. These address strategic planning; habitat protection; pest plant and animal management; research and monitoring; and community engagement and partnerships.

The context for Winton Wetlands is set out in section 3. It describes the existing catchment and provides an overview of the ecological character of the site. Section 4 describes current conditions at the site with a focus on land-use. Detailed site information is presented for seven proposed Ecological Management Units, including Ecological Vegetation Classes present, their condition, flora and fauna species, and pest plant and animal issues.

Information on past and possible future wetland hydrology is provided based on derivations from the Goulburn Simulation Model (DSE, 2011). An assessment of current risks and threats and mitigation is also provided.

Conceptual models are provided in section 5 to frame restoration and monitoring approaches recommended for (i) hydrology; (ii) water quality; (iii) wetland vegetation; (iv) terrestrial vegetation; and (v) fauna. Restoration of terrestrial vegetation is considered the most challenging task facing management, and is discussed under a number of sub-sections. It is recommended that vegetation restoration be guided by the development of a vegetation GIS to provide information at the appropriate scale, and the employment of a Vegetation Officer to co-ordinate planning and implementation.

Enhancing the potential for natural regeneration of indigenous vegetation (and thus habitat) is the major recommended strategy, although supporting approaches are also discussed such as augmenting seed supplies through heli-seeding, or niche planting into woodland areas. Reducing biomass of exotic pasture grasses (particularly Phalaris and Paspalum), and limiting soil nutrients are key factors in enhancing natural regeneration potential. Grazing is recommended to manage Phalaris and other weedy pastures (by limiting seed set and reducing biomass); there is a need to graze additional areas than those currently under grazing license. The development of a succinct grazing management strategy is recommended.

Fire is recommended only as a tool for achieving specific ecological outcomes (e.g. suppression of seed set by annual grasses). Prescribed burning for hazard reduction is not considered appropriate for the vegetation types present.

Given the importance, complexity and interdependencies of monitoring requirements to answer the question '*Is ecological function improving*', it is recommended that a consortium of experts collaborate to develop specific monitoring protocols for the issues to be monitored.

Deliberate introduction of fauna is not recommended. Rather, the approach to restoring fauna populations should be on restoring habitat. Currently, there is little known about the existing fish communities at Winton Wetlands, particularly small-bodied fish. A fish management plan is required to address issues surrounding sustainable fish populations and exotic fish control, as identified in the Lake Mokoan Future Land Use Study.

Improvement in ecological function at Winton Wetlands will be indicated by the following:

- Water quality parameters (particularly nutrients and turbidity) are within acceptable limits for natural aquatic ecosystems
- Soil nutrients (particularly Nitrogen Phosphorus, and organic Carbon) decrease to within acceptable limits for soils typical of comparable remnant vegetation
- A sustained reduction in the cover and abundance of Phalaris and Paspalum
- A sustained increase in the cover of indigenous perennial grasses (Southern Cane-grass and Kangaroo Grass being suggested indicator species)
- Wetland vegetation adapted to ephemeral conditions, and providing structural diversity for macro-invertebrates

- Recruitment of River Red Gum in appropriate locations
- An increase in the structural diversity of woodland vegetation, indicated by an increase in the diversity and abundance of woodland birds
- An increase in the abundance of frogs, microbats, Rakali (or Water Rat) and Long-necked Turtles
- An appropriate diversity of native fish species, and reduction in exotic fish numbers
- Breeding by colonial water birds

2. Introduction

2.1. Context and scope

The Winton Wetlands Reserve is located approximately 10 km north-east of Benalla in north-east Victoria. It has a catchment of some 330 sq km (Figure 1). Drainage to the wetlands originates in the surrounding ranges known as the Chesney Hills, Warby Ranges, and Lurg Hills via a number of creeks: Winton, 5 Mile, Show, and 11 Mile Creeks being prominent. Discharge from a small but unknown number of springs also provides input. With the exception of the higher slopes and ridges, most of the catchment has been cleared for agricultural use (grazing, cropping, viticulture).

There is little doubt that the Winton Wetlands is of high cultural significance to Traditional Owners. As well as providing a wealth of food and fibre resources, its location on the boundaries of a number of language groups (Yorta Yorta, Bangerang, Taungurung, Waveroo) made it a logical place for cultural exchange. One report from an early explorer mentions a group (corroboree) of some 800 men gathered on the eastern shores of Winton Swamp (Bassett, 1988, cited in Bell 2010). Aboriginal cultural sites are dispersed across the current Reserve area.

Since European settlement, there has been an increasing diversification of landholdings from the initial Goomalibee Station. Major land-uses have included beef and dairy production, wool and lamb production, cereal cropping, viticulture, and timber utilisation. Various remnants of European occupation, with linkages to current adjacent landholders, exist across the site.

The Reserve occupies some 8750 ha, of which approximately 3500 ha is covered by a number of large and small wetlands. Much of this area is expected to be dry during prolonged dry periods, and an even greater area inundated during very wet years. The remainder comprises seasonally wet lowlands and drier rises including a major lunette separating the two of the larger wetlands, Winton Swamp and Green's Swamp. When full, these larger wetlands connect to a number of smaller ephemeral swamps located to the north-east of Green's Swamp (Figure 2). The drier areas of the Reserve have historically been used for conventional farming pursuits. Current vegetation in these parts of the Reserve varies from weedy native pasture to improved introduced pasture, with a few woodland remnants.

The area now known as the Winton Wetlands Reserve was permanently inundated in 1970 by the construction of a 7.5 km, 10 m high embankment along the western margin to establish the Lake Mokoan storage reservoir, the purpose of which was to supply irrigation and stock and domestic water to the district. At full supply level, Lake Mokoan covered an area of approximately 7880 ha, resulting in the death of an estimated 2900 ha of Red Gum woodland, and considerable disturbance to wetlands and farmland pasture present prior to inundation. During its years of operation, Lake Mokoan experienced substantial problems with water turbidity, algal blooms, and water losses averaging GL/yr through evaporation.

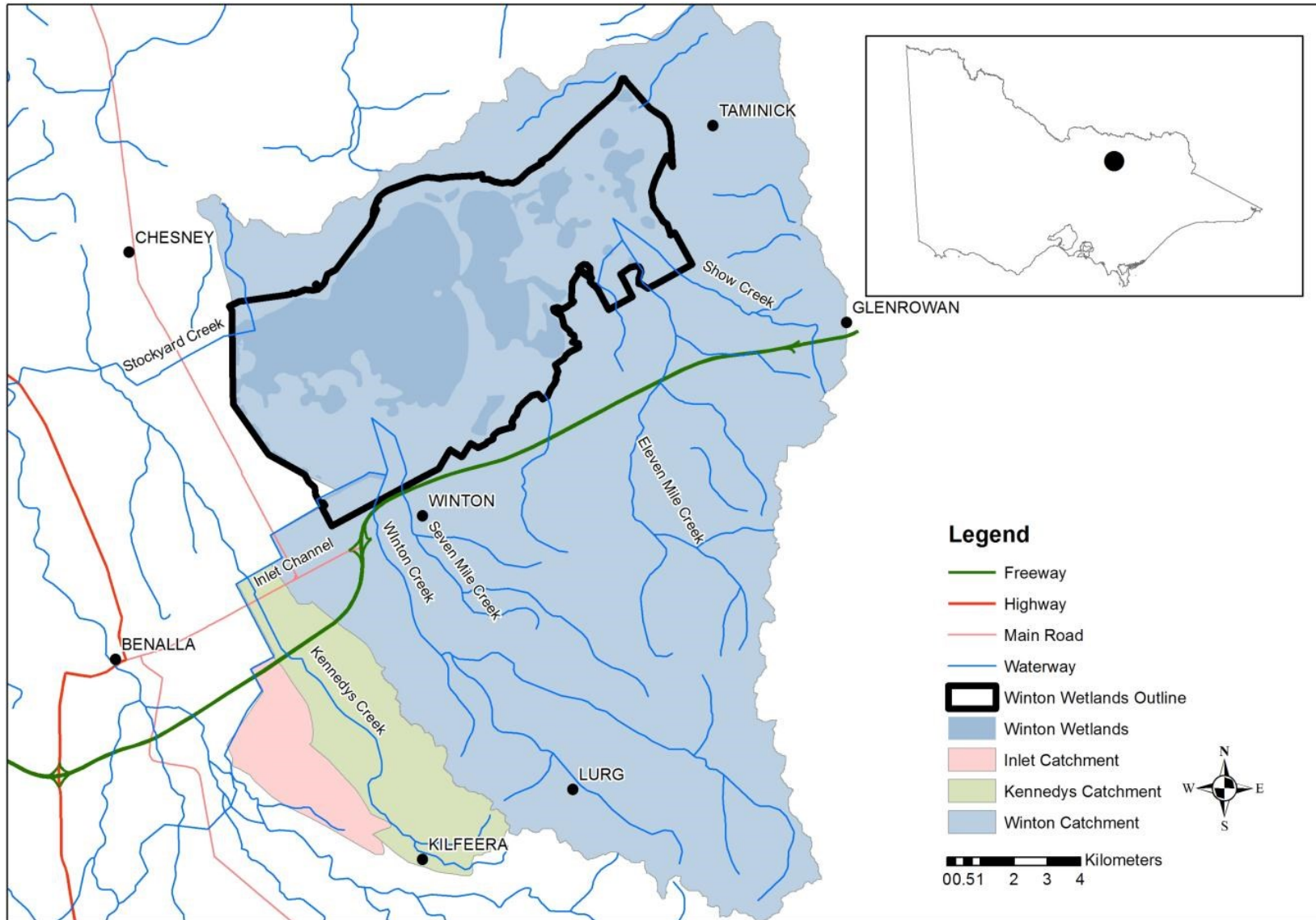


Figure 1: Winton Wetlands Catchment, showing the three sub-catchments and main tributaries

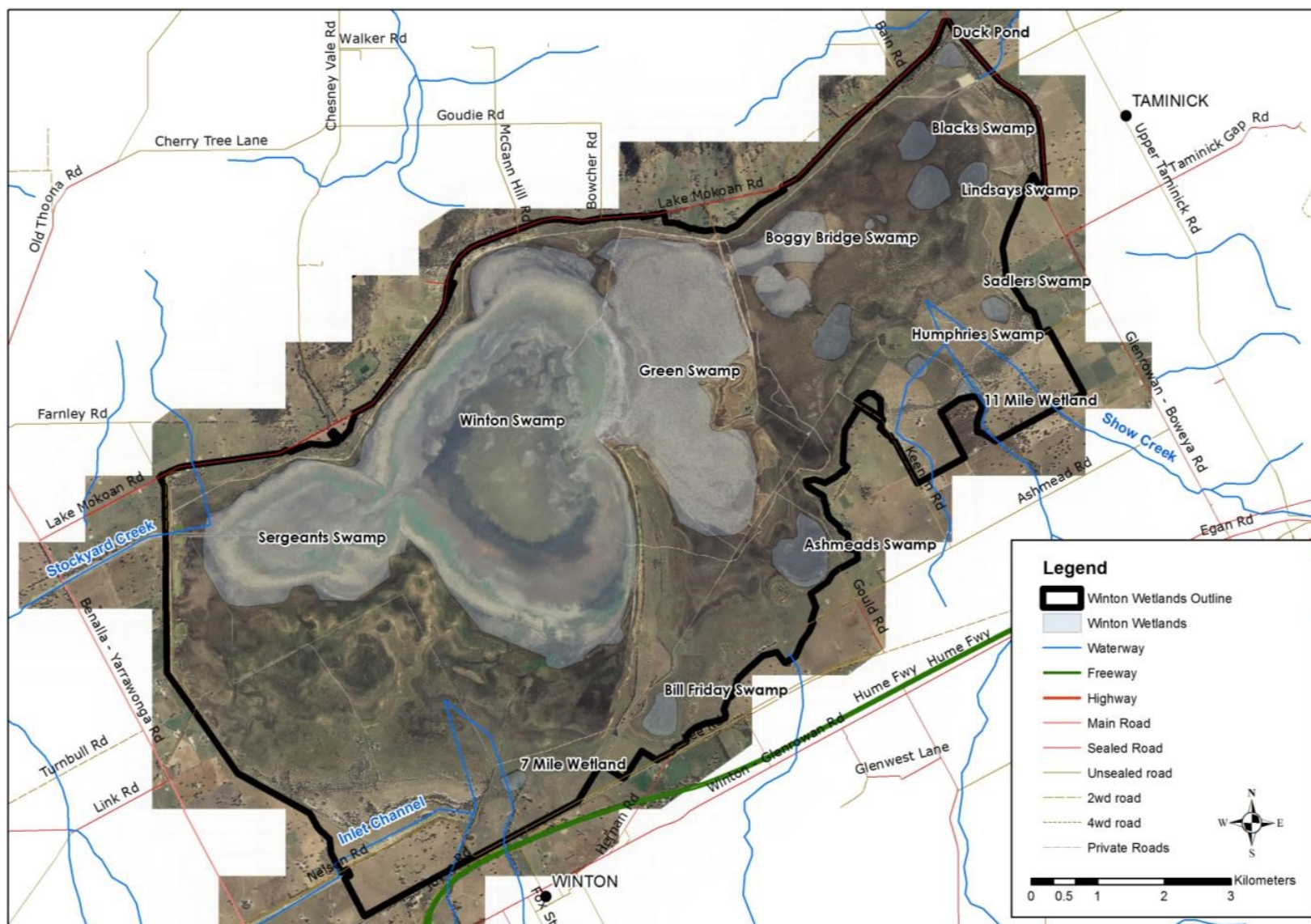


Figure 2: Winton Wetlands Reserve showing major internal features

In 2004, the Victorian Government moved to decommission Lake Mokoan and return the area to a more natural wetland state as part of the *Our Water Our Future* White Paper policy initiative. Water saved (by eliminating evaporation loss during storage) was allocated to environmental flows for the Murray and Snowy rivers. Extensive studies and consultation with stakeholders were undertaken, culminating in the Lake Mokoan Future Land-use Strategy (2006). In March 2010, the retaining wall was breached near at a level approximating the original outlet, Stockyard Creek, which runs to the Broken River.

The Winton Wetlands Committee of Management (WWCoM) was established by the Victorian Minister for Water in March 2010, and charged with implementation of the Future Land-use Strategy (FLUS). The FLUS called for the preparation of a Lake Mokoan Drawdown Plan, an Infrastructure Master Plan, and a Restoration and Monitoring Plan as key components of the 'Return to Wetland' program of rehabilitation for the site. The Infrastructure Master Plan is currently (mid 2011) being prepared by consultants, whilst the Drawdown Plan, intended to prescribe an ecologically-appropriate staged drawdown of water level to minimise biotic 'shock', was superseded by drought impacts during the period 2006–2010, with the system dry by 2009.

Whilst there is an extensive literature on wetland restoration, much of this concerns the 're-wetting' of wetlands through, for example, the application of environmental flows, or deconstruction of drainage schemes. Of the (relatively little) literature on the ecological responses of ecosystems following decommissioning of water storages (i.e. 'de-wetting'), most is focused on river health (e.g. Dwyer 2007; Riggsbee *et al.*, 2007) and physical form.

Auble *et al.* (2007) documented vegetation development on a decommissioned reservoir in Colorado, USA, and suggested the legacy of impoundment on originally dryland areas would persist for decades. Orr and Stanley (2006) examined 30 sites in Wisconsin, USA, where reservoirs of varying sizes (2–41 ha) had been decommissioned 0.5–46 years ago and found that no original vegetation communities had re-established of their own accord, and that one weed, **Phalaris arundinacea*¹, dominated many sites. They concluded that minimising the establishment of invasive species should be a focus of the ecological restoration of decommissioned dams.

Winton Wetlands appears to be quite novel in that the construction of Lake Mokoan involved inundating an extensive area of natural wetlands, not the typical practice of damming a river and drowning riparian and dryland vegetation. Thus, the potential for recovery of natural wetland vegetation following decommissioning is arguably quite strong (and has been demonstrated during 2010–11). However, **Phalaris aquatica* is present and whilst not as aquatic in habit as **P. arundinacea*, has similar potential to dominate extensive areas of both wetland and dryland if left unmanaged.

This Restoration and Monitoring Strategic Plan provides guidance for the WWCoM on

¹ Introduced (non-indigenous) species are indicated by the prefix *

- the protection of existing biodiversity values across the site
- the restoration of habitat, particularly across drier areas
- areas for further research
- monitoring and reporting on management effectiveness.

The Plan is to be reviewed and updated as necessary by the WWCoM, in consultation with the Winton Wetlands Scientific and Technical Advisory Group (WWSTAG), and others as appropriate.

The Plan has been prepared in consultation with the WWSTAG. The Group, chaired by Prof. Max Finlayson (Charles Sturt University), a leading wetland ecologist in Australia, has been established to provide expert advice to the WWCoM on the management and restoration of Winton Wetlands. Its Terms of Reference are as follows:

1. To provide scientific and technical advice to the Committee on:
 - restoration and monitoring objectives for the Winton Wetlands Reserve
 - development of the Restoration and Monitoring Strategic Plan
 - implementation of the Restoration and Monitoring Strategic Plan
 - restoration, management, monitoring, and research issues as they arise.
2. To periodically review and as necessary recommend adjustment of the Restoration and Monitoring Strategic Plan.
3. To work with the Committee to engage the community on scientific and technical aspects of restoration and monitoring.
4. To review outcomes of monitoring programs and provide advice on adaptive management options.
5. To periodically review and where appropriate recommend adjustment of these Terms of Reference.

A workshop to identify the objectives of the Plan was convened by the WWCoM on April 29, 2011 at Benalla involving STAG members and a number of invited specialists. These objectives are set out in Section 2.4.

The hierarchical approach used here follows that recommended by the Conservation Measures Partnership's² *'Open Standards for the Practice of Conservation'*. This framework collaboratively standardises concepts, planning approaches and terminology useful to, and utilised by, leading conservation agencies in adaptively managing for biodiversity conservation. The schematic diagram (Figure 3) summarises the key steps involved in the *'Open Standards'* approach.

² <http://www.conservationmeasures.org>



Figure 3: Schematic approach to Conservation Action Planning (Source: Conservation Measures Partnership)

2.2. Vision–restore ecological function

The Lake Mokoan Future Land Use Strategy has identified that *'restoration of the Winton Wetlands Reserve will be a project of national scientific, cultural and environmental significance with a focus on education, research, tourism, recreation and community development'*. It further states that a major objective of the decision to decommission Lake Mokoan is to *'restore a diverse and natural functioning wetland and terrestrial ecosystem of national significance incorporating active community involvement and strong strategic partnerships* (adapted from FLUS, 2006). The Winton Wetlands Committee of Management has been established to oversee implementation of the FLUS.

Thus, management focus will shift from the utilisation of the site as an irrigation storage to improving the ecological function of the ecosystem as its primary purpose.

There is considerable variation in the definition of 'ecological function' (Richards 2010), although often mentioned in the scientific literature (ISI Web of Knowledge search for 'ecological function' returns 622 publications, and 2,412 for 'ecosystem function'). Ecologists tend to prefer the concept of ecological function to apply to 'those biotic and abiotic processes that generate the integrity and character of ecosystems'. Hooper *et al.* (2005) suggest it broadly encompasses *'ecosystem properties, processes, goods and services'*.

For the restoration of Winton Wetlands Reserve, improvement in ‘natural ecological function’ will be demonstrated by:

- A resilient wetland ecosystem adapted, and responding positively, to wetting and drying cycles driven by a variable climate
- A wetland system with acceptable water quality parameters (not adversely impacting biodiversity values through eutrophication)
- An increase in the cover and extent of indigenous vegetation
- An increase in the diversity and abundance of native fauna (aquatic and terrestrial)
- A decrease in cover and extent of pest plants
- A decrease in the abundance of pest animals, particularly Red Fox, European Rabbit, Feral Cat, European Carp, and Mosquito Fish.

2.3. Restoration targets

The following targets have been set for the restoration of Winton Wetlands Reserve:

- By 2025, there will be approximately 3500 ha of ephemeral wetlands subject to a natural hydrological regime, supporting a diversity of aquatic ecosystems and biota
- By 2025, there will be a *minimum* of 3000 ha of terrestrial woodlands managed primarily for biodiversity conservation.

The total area of the Reserve is 8750ha. The FLUS identified a 2066 ha discontinuous Primary Industries Precinct (PIP) within the Reserve comprising 25 parcels in the southern and eastern zones (see Figure 8) and proposed that these lands could be sold off subject to determination by the Winton Wetlands Committee of Management (WWCoM). Thus, the ultimate area available for woodland restoration and management may be in the order of up to 5000 ha.

The term ‘natural hydrological regime’ is qualified because the catchment is highly modified by vegetation clearance and drainage diversions to drains and farm dams, as well as modifications to drainage and inundation patterns within the Reserve. It is also important to highlight that there is little-to-no opportunity to intervene in hydrological management to maintain water levels higher than determined by seasonal conditions.

As many of the threats and degrading processes occur at the catchment scale, the WWCoM needs to work with land managers across the catchment to improve catchment health. This should include collaborating with community groups and other agencies (e.g. GBCMA) to leverage resources for planning and on-ground works.

The area of actual wetlands varies with rainfall, this being a rain-fed system with no practical opportunity to obtain additional water other than buying it in from the Broken River system (WWCoM has an entitlement to a 22 ML allocation from this system). The site is generally of very low topographical relief, so a small rise in water-level can result in hundreds of additional hectares being inundated. When water ceases to flow through the (fixed height) outlet, an area of 3108 ha remains inundated. This figure does not include smaller wetlands that have become disconnected (but remain wet) from the main system as levels recede.

Management activities will focus on protecting and enhancing existing wetland, grassland and woodland vegetation, facilitating and/or assisting natural regeneration, and managing aquatic and terrestrial pest plant and animal species.

Ephemeral wetlands will comprise remnant, naturally regenerating, and manually revegetated woodland. Much of it will retain a cover of (drowned) River Red Gum with a sedgy-grassy understorey containing native perennial sedges, grasses, forbs, and shrubs although invasion of non-native species will require on-going management.

It is anticipated that Sergeant's and Winton Swamps will remain treeless (except for margins) and eventually become dominated by Southern Cane-grass, this being the original dominant prior to Lake Mokoan.

The development of a range of terrestrial woodland and grassland habitat will be a major focus of land management. Activities will aim to facilitate recruitment through assisted natural regeneration and revegetation of indigenous flora, and pest plant and animal control. Management tools will include fire, slashing, spraying and grazing used specifically for improving biodiversity outcomes.

Some 1532 ha of land within the Winton Wetlands Reserve is leased to neighbouring landholders for grazing. Grazing in accordance with ecological guidelines is recommended to continue for the next 15 years while higher value areas are consolidated for nature conservation. This is compatible with the aim of maintaining a diversity of habitats, preventing the spread of major weeds such as Phalaris, and managing fire hazard.

In pursuing these targets, the WWCoM will seek to:

- identify and deploy best practice management and be recognised as a world leader in ecological restoration
- engage and involve stakeholders including the local and regional community, Traditional Owners, special interest groups, the regional economy, research bodies, and government agencies
- take a catchment-wide approach to management of Winton Wetlands
- actively monitor, evaluate and report on activities and site values to improve adaptive management of the site.

2.4. Principal Objectives

Principal objectives to achieve designated targets are grouped under the following themes:

1. Strategic planning for restoration
2. Habitat protection, enhancement and revegetation
3. Pest plant and animal management
4. Research and monitoring
5. Community engagement and strategic partnerships.

Strategies and actions have been identified for each of these objectives, and set within an immediate (2015) and longer-term (2025) time frame. A number of strategies will address multiple objectives. For example, improving understanding of catchment and wetland hydrology will contribute to all four objectives.

1. Strategic planning for restoration

By 2015, the Winton Wetlands Reserve will have:

- 1.1. Established data-based conceptual models for wetland (including hydrology) and woodland patterns and processes (drivers, feedback, end points) to guide restoration planning, identify monitoring indicators, and identify knowledge gaps
- 1.2. Developed and implemented management guidelines and recommendations for specific high-value natural and cultural sites (e.g. remnant woodlands, middens)
- 1.3. Developed a fish management strategy identifying existing fish communities, major threats, enhancement opportunities, and pest fish control strategies
- 1.4. Completed a comprehensive review and update of the Restoration and Monitoring Strategic Plan, including a report on restoration progress.

By 2025:

- 1.5. Identified longer-term (50+ years) objectives for ecological restoration and management.

2. Habitat protection, enhancement and revegetation

By 2015, the Winton Wetlands will have:

- 2.1. Facilitated tree recruitment at densities appropriate for Plains Grassy Woodland and Riverine Swampy Woodland
- 2.2. Initiated revegetation projects on riparian creeklines and other designated areas
- 2.3. Identified and initiated appropriate shrub and forb species for woodland enhancement plantings
- 2.4. Established a suitable seed bank to underpin diverse revegetation requirements
- 2.5. Implemented revegetation with native grasses and forbs in designated areas
- 2.6. Identified necessary arrangements to ensure road runoff is not directly intercepted by waterways draining directly to Winton Wetlands
- 2.7. Developed grazing management plans for designated areas to maintain grassland habitat and manage *Phalaris* biomass and seeding.

By 2025:

- 2.8. Extensive areas of ephemeral wetland dominated by emerging River Red Gum, Common Spike-sedge, Southern Cane-grass, and Plains Rush
- 2.9. Demonstrated an increase in the condition of designated species and environmental parameters considered important indicators of ecosystem function (e.g. water quality) and/or specific restoration targets

- 2.10. Demonstrated natural recruitment occurring in ephemeral wetlands and woodlands and developed a clear understanding of vegetation trajectory
- 2.11. Established an appropriate native fish assemblage.

3. **Pest plant and animal management**

By 2015, the Winton Wetlands will have:

- 3.1. Developed and commenced implementation of an exotic fish management strategy
- 3.2. Initiated control of all satellite populations of designated environmental weeds such as Phalaris, Paspalum, Pampas Grass, Willow, Poplar, and revegetated areas with indigenous species
- 3.3. Established routine program of pest plant and animal surveillance and prompt action to control new incursions
- 3.4. Established a grazing program across designated areas to manage biomass of exotic vegetation, especially Phalaris
- 3.5. Demonstrated a reduction in the cover and abundance of Phalaris and Paspalum
- 3.6. Implemented programs to reduce pest animals, particularly rabbit and fox.

By 2025:

- 3.7. Managed known sources of aquatic pests from the catchment
- 3.8. Reduced cover of exotic herbaceous vegetation by an average of 20% through competition by tree cover in woodland areas
- 3.9. Identified, controlled and revegetated existing populations of major environmental weeds
- 3.10. Developed a clear understanding of long-term weed management requirements.

4. **Research and Monitoring**

By 2015, the Winton Wetlands will have:

- 4.1. Continued refinement of conceptual models to guide wetland and woodland restoration
- 4.2. Obtained data to validate/improve the existing hydrological character model
- 4.3. Developed an understanding of soil-stored seed dynamics
- 4.4. Developed a clear understanding of the on-site relationships between soil nutrient levels, nutrient sources, and pest plant issues
- 4.5. Developed an understanding of the geomorphological history and current context of Winton Wetlands
- 4.6. Undertaken surveys of the catchment to identify potential sources of nutrients and pest plant and animals, and undertaken management activities as appropriate
- 4.7. Established key targets and monitoring indicators to document effectiveness of management on woodland, riparian and wetland restoration

- 4.8. Established woodland and wetland bird monitoring sites, with defined monitoring protocols and hypotheses being tested
- 4.9. Established benchmark woodland and wetland vegetation condition scores at 20 sites for long-term monitoring of trends in habitat condition
- 4.10. Established a water quality monitoring program to identify relationships between hydrology, water chemistry and aquatic biota
- 4.11. Data management protocols established and documented
- 4.12. Developed and initiated meaningful reporting processes to inform all stakeholders of restoration progress
- 4.13. Sponsored research into identified knowledge gaps, for example:
 - Autecology of Southern Cane-grass at Winton Wetlands
 - Carp ecology and management
 - On-site vegetation responses to management (fire, grazing, etc)
 - Weeds and soil nutrient dynamics
 - Nutrient inflows from catchment, and management options.

By 2025:

- 4.14. Published a seminal paper on 20 years of ecological restoration and management at Winton
- 4.15. Published 10 papers based on research and management at Winton Wetlands in recognised journals.

5. **Community engagement and strategic partnerships**

By 2015, the Winton Wetlands will have:

- 5.1. Undertaken a 'Winton through the Ages' project that details the geomorphological, hydrological and cultural history/values of the site
- 5.2. Completed the development of high quality environmental interpretation facilities and services to 'tell the restoration story'
- 5.3. Facilitated participation by the broader community in restoring Winton Wetlands through involvement in revegetation, flora and fauna monitoring, and water quality monitoring across the catchment
- 5.4. Established a 'Winton Wetlands Catchment Conservation Management Network' in collaboration with existing groups such as the Broken Boosey CMN, Carpet Python Project, Warby Ranges Landcare Group, and Regent Honeyeater Project to engage all land managers in the catchment in sustainable land management, pest plant and animal management, and habitat restoration (particularly for woodland fauna) outside the Reserve
- 5.5. Established a Land Management Advisory Committee to initiate innovative and ecologically appropriate use of land not immediately required for habitat restoration (and that such use ultimately facilitates and not hinders future habitat restoration)

- 5.6. Systems established to build agency and community support for recognition of Winton Wetlands as a wetland of international importance, as determined by criteria provided by the Ramsar Convention on Wetlands.

By 2025:

- 5.7. Research partnerships recognised through publication of papers and reports in international journals
- 5.8. Catchment social-ecological partnerships validated through community-owned, self-sustaining management, and effective action of a Conservation Management Network.

3. Background Information

3.1. Winton Wetlands catchment

The 370 km² Winton catchment (Figure 1) is predominately cleared (over 95%) of native vegetation. Major land-uses in the catchment are commercial stock grazing, cropping, and small rural properties. A number of commercial vineyards are also located in the Taminick area to the northeast of the Reserve.

Part of the small township of Glenrowan, at the headwaters of Show Creek, is the only urbanised area within the catchment. Total population, excluding Glenrowan, is estimated at 1000–2000. The Hume Freeway and the Melbourne – Sydney Railway dissect the catchment close to the southern boundary of the Reserve.

The most extensive area of native vegetation within the catchment lies to the north of Glenrowan on the western upper slopes of the Warby Ranges, with additional smaller areas located on the Chesney Hills to the north of Winton Swamp. The Regent Honeyeater project which focuses on establishing habitat for woodland fauna in the Lurg Hills has carried out approximately 1060 ha of indigenous revegetation and remnant protection in that part of the catchment (Thomas, 2009).

The catchment is unusual in that it exists as three sub-catchments. The original catchment of 330 km² is augmented by an additional area of 11 km² drained by the old Mokoan Inlet Channel, which although now disconnected from the Broken River still provides some input to the wetlands from local overland flow. This area is separated from the main catchment by the Kennedy's Creek catchment (26 km²), which naturally drains to the northwest into Stockyard Creek, below Winton/Sergeant's Swamp. This is noted as providing 'occasional' input to the wetland, with high flows in Kennedy's Creek now overflowing into the Mokoan Inlet Channel; these two drainage lines intersecting at the Melbourne – Sydney Railway, with Kennedy's Creek passing over the top of the Inlet Channel.

It is not yet clear how the extent of these modifications to the physical catchment, established during decommissioning, will alter wetland hydrology. The additional area represents an increase of less than 10%, however the drainage line traverses highly dispersive soils, and in the future, may carry stormwater from the eastern parts of Benalla. A revegetation program for the Inlet Channel, reworked post-decommissioning to create a more natural profile, is currently being developed by Benalla Rural City. Further investigations should be undertaken to identify opportunities for increasing retention of floodwaters, and revegetating with appropriate aquatic species, in the Channel to improve the quality of water entering the wetlands via this route.

Cultural values have been mentioned in section 2.1, and will be further detailed in separate publications (planned). It should be noted that given the cultural significance of the site, cultural heritage management plans will be required wherever substantial soil disturbance is proposed.

3.2. Ecological character overview

The Winton Wetlands are located on the eastern edge of the Victorian Riverina Bioregion, a vast landsystem (riverine plain) across northern Victoria comprised of unconsolidated alluvial sediments deposited on the floodplains of current and ancient river systems, in the southern section of the Murray-Darling Basin.

Outcrops of Victorian Uplands known as the Chesney Hills (to the north), Warby Ranges (east) and Lurg Hills (south) surround Winton Wetlands. The Chesney Hills and Warby Ranges are in the Northern Inland Slopes Bioregion, and Lurg Hills are in the Central Victorian Uplands.

Soils of the area consist of dark gradational calcareous clays on the floor of the swamps, and similar gilgai soils in slightly more elevated areas where wetting and drying is common. Wind-blown (aeolian) material has accumulated on the eastern side of Winton Swamp to form one of the most south-easterly lunettes in the Murray-Darling Basin. Slopes running off the adjacent hills are gravelly outwash material (colluvial pediments) overlying yellow and red clays (Rundle & Rowe 1974).

Average rainfall is approximately 560 mm (between the years 1882 and 2006) with most occurring between May and October. Average annual evaporation is some 1260 mm, resulting in a net deficit of 700 mm p.a.).

Water into the wetland system is provided by runoff into creeks originating in the surrounding hills; the main ones being Winton Creek, 11 Mile Creek, 7 Mile Creek, Show Creek, and Taminick Creek, although there are a number of other minor tributaries. In wet years, the wetland system would have overflowed and discharged into the Broken River via Stockyard Creek)

Flora and fauna

The vegetation of the area consists of a number of wetland Ecological Vegetation Classes (EVC's), and dryland EVCs on the surrounding slopes and lunettes. The most intermediate of these is known as Plains Swampy Woodland, which occupies seasonally moist zones between the wetlands and woodlands. Plains Swampy Woodland is dominated by River Red Gum (*Eucalyptus camaldulensis*) over a grassy/sedgy understorey variously dominated by grasses such as Brown-backed Wallaby Grass (*Austrodanthonia duttoniana*), Common Swamp Wallaby Grass (*Amphibromus nervosus*), and Rigid Panic (*Walwhalleya proluta*), together with a suite of moisture tolerant forbs (e.g. Creeping Knotweed (*Persicaria prostrata*, *P. lapathifolia*), rushes and sedges. Deeper depressions within the plain, which support surface water for longer periods, support Red Gum Swamp and include a suite of semi-aquatic plants such as Common Spike-sedge (*Eleocharis acuta*), Moira Grass (*Pseudoraphis spinescens*), Common Reed (*Phragmites australis*), Swamp Lily (*Ottelia ovalifolia*) and Common Nardoo (*Marsilea drummondii*).

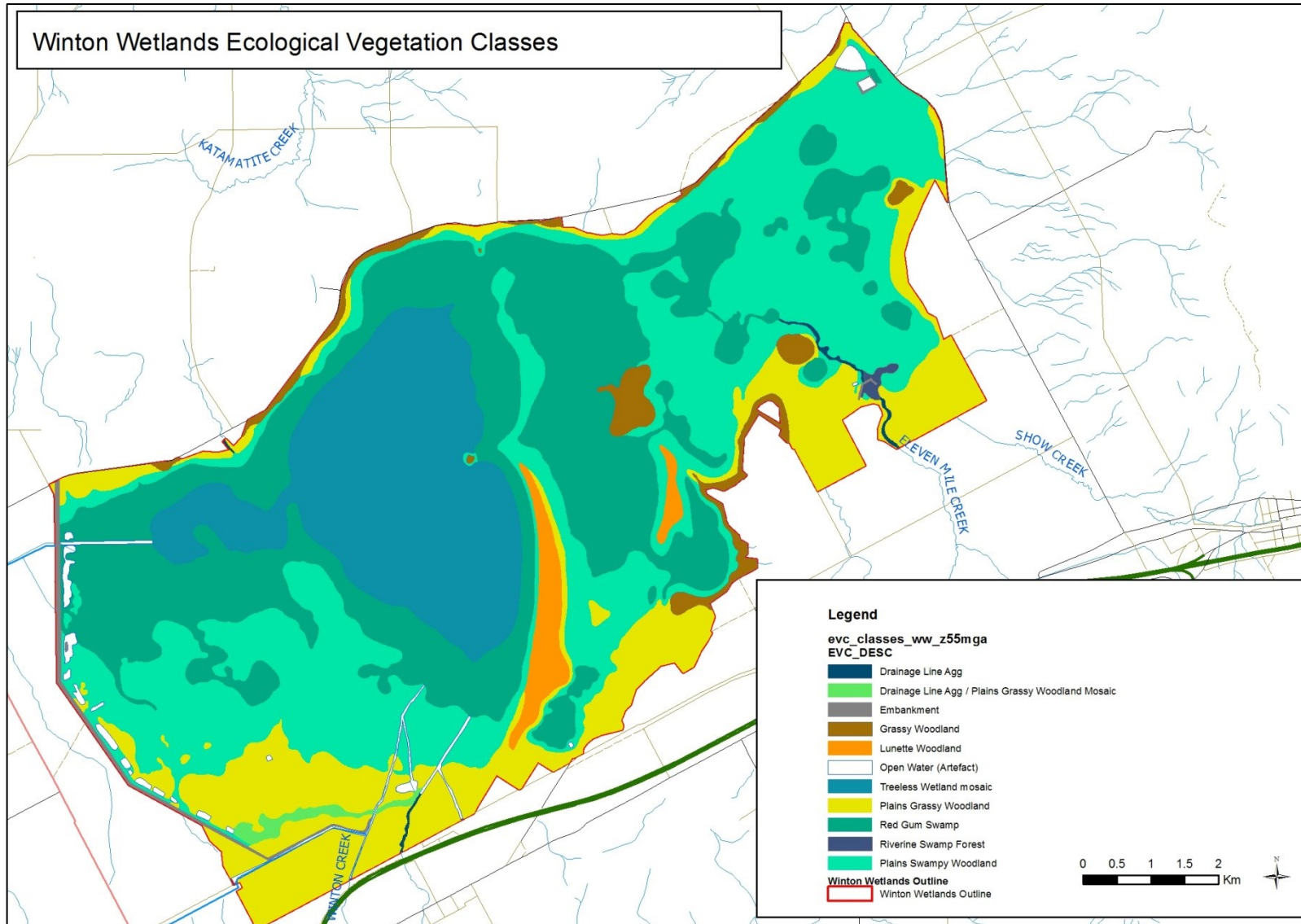


Figure 4: Ecological Vegetation Classes at Winton Wetlands

The largest and deepest of the swamps (Sergeant's and Winton) are treeless, too inundated to allow tree establishment. Although highly modified through permanent inundation by Lake Mokoan, it is thought the original vegetation of these swamps was dominated by Cane Grass (*Eragrostis infecunda*), which can tolerate extremes of temporary wet and dry conditions.

More elevated plains, which are wet only occasionally, support Plains Grassy Woodland dominated by River Red Gum (*Eucalyptus camaldulensis*). Grey Box (*E. microcarpa*) is occasionally present in the driest sections. No intact remnants exist at the site, so the understorey cannot be confirmed but was likely to have been originally dominated by a number of native grasses including Kangaroo Grass (*Themeda triandra*) and possibly also Common Tussock (*Poa labillardieri*) and Weeping Grass (*Microlaena stipoides*). Current remnants are dominated by a range of Wallaby Grasses (*Austrodanthonia* spp.) and Spear Grasses (*Austrostipa* spp). Few forb species persist owing to the prolonged grazing history.

The fragile soils of the lunette have been heavily disturbed by grazing and occasional cropping, such that little semblance of the original vegetation is readily apparent. It is believed that dominant trees were most likely Blakely's Red Gum (*E. blakelyi*) and Yellow Box (*E. melliodora*), with White Cypress-pine (*Callitris glaucophylla*) also present. Smaller trees (or tall shrubs) include Lightwood (*Acacia implexa*), Drooping She-oak (*Allocasuarina verticillata*) and possibly also Buloke (*A. luehmannii*). Low shrubs were probably common in the understorey given the relatively free-draining soils.

Outwash slopes on the surrounding hills support Grassy Woodland and Grassy Dry Forest (in increasing order of altitude and gradient). The Goulburn Broken CMA has published information sheets on these and other EVCs (see <www.gbcma.vic.gov.au>).

The Winton Wetlands has historically been an important site for waterbirds in Victoria. More recently it has been identified as a site of international significance for the conservation of Latham's Snipe (Carr & Conole 2007), a migratory bird listed under a bilateral agreement with Japan (JAMBA), where it spends the northern hemisphere summer. Many hundreds of Latham's Snipe spend their southern summer at the Winton Wetlands, in numbers that are likely to be considered significant under the Ramsar convention on internationally important wetlands (Conole, 2007). Other notable wetland bird species occurring at Winton Wetlands are the White-bellied Sea-eagle, which nests in the numerous dead trees occurring around the swamp that drowned following inundation by the Mokoan irrigation storage, the Australasian Bittern, Freckled Duck (both nationally endangered), Australasian Shoveler and Hardhead, two species of duck listed as vulnerable in Victoria.

The endangered Inland Carpet Python occurs in the hills surrounding the Winton Wetlands, and this is the eastern most occurrence of this reptile in Victoria. A large suite of woodland birds, including Grey-crowned Babbler, Swift Parrot, and Regent Honeyeater, also occur in the surrounding hills and maintenance of connectivity between the wetlands, woodlands and adjoining hills will be important for habitat diversity and the long-term future of these species.

3.3. Available information

Conole *et al.* (2005) reviewed the literature about the biological values of Lake Mokoan as part of background work for the Lake Mokoan Future Land Use Study. They found that while a number of reports were prepared for Goulburn Murray Water during the 1990s as part of the Lake Mokoan Rehabilitation Program, these were focused on addressing issues associated with poor water quality (high turbidity, blue-green algal blooms and paucity of macrophyte vegetation), rather than systematic assessments of the flora and fauna values of the aquatic and terrestrial environments present.

No assessment of existing values was undertaken in planning for the construction of Lake Mokoan. Helen Aston, a botanist at the National Herbarium of Victoria, undertook an opportunistic assessment of flora and vegetation structure during visits over the period 1959–1962. Fortunately, she retained her records and photographs and these remain the only documented evidence of ecological conditions prior to construction.

Although no mapping of vegetation communities was undertaken, Aston (1959, 1962, unpubl.) noted that the main swamps (Winton and Sergeant's) were dominated by Southern Cane-grass (*Eragrostis infecunda*) with 'timbered edges' dominated by River Red Gum (*E. camaldulensis*), whilst Green's Swamp was dominated by River Red Gum across its extent. Also noted within the Cane-grass community were occasional patches of Cumbungi (probably *Typha orientalis*) and '*Cladium glomeratum*' (now *Baumea rubiginosa*), although if in standing water this is more likely to be *B. arthropphylla*. Species noted within the understorey of the timbered edges were *Eleocharis acuta*, *Myriophyllum propinquum* (*syn. M. crispatum*), *Utricularia flexuosa* (*syn. U. australis*), and *Potamogeton tricarinatus* (*syn. P. sulcatus*), with species of the green algae *Characeae* also common (probably of the genus *Nitella* or *Chara*). Southern Cane-grass was also noted as being present in this zone.

Aston did not document values of the smaller swamps to the northeast of Green's Swamp, although it is certain that these were also Red Gum Swamps based on the current extent of dead trees and the hydrological regime. She did note that the understorey vegetation of Green's Swamp was similar to that of the timbered edges around Winton Swamp. She also noted that Giant Rush (*Juncus pallidus*) and Moira Grass (*Pseudoraphis spinescens*) were conspicuous in 'damp areas above the current water level subjected to periodic flooding' (Aston 1959, 1962).

The information provided by Helen Aston, combined with contemporary understanding of wetland hydrology and the relevant EVCs, is sufficient to provide wetland restoration models (see section 6).

Quantitative data on the flora and fauna values were collected and documented by Carr and Conole (2006), a study undertaken subsequent to the report by Conole *et al.* (2005). They noted the comparative absence of systematically collected biodiversity data relevant to Lake Mokoan, with the exception of three quadrats sampled by Doug Frood in 1990. Carr and Conole included Frood's quadrat data in an Appendix to their report.

The authors identified nine EVCs (although 3 were represented by one quadrat only) from the 38 vegetation quadrats sampled. A further two EVCs were observed but not sampled. The survey identified 234 plant species of which 52% are indigenous. A total of 113 terrestrial and amphibious fauna species were recorded, being 54% of the total faunal species (211) recorded for the area in the Victorian Wildlife Atlas (DSE 2004). These species were detected by observation and active searching; no trapping or call-back was undertaken.

Roberts *et al.* (2007, 2008, 2010) undertook a number of projects during the decommissioning phase to document vegetation dynamics over the course of the planned drawdown, establish baseline monitoring data, and develop a predictive model for vegetation development. These investigations were complicated by inadequate baseline information on bathymetry, which made it difficult to locate sampling quadrats in appropriate locations coupled with drought, which caused drawdown to proceed much more dramatically than planned. Despite these challenges, a monitoring protocol for further work was established and the authors were able to conclude that both River Red Gum and Southern Cane-grass were recruiting even during drawdown conditions.

Davidson and Mann (2010) subsequently added another 63 taxa to the inventory of vascular plant species for Winton, although no quantitative data were recorded and no exotic taxa were included in their inventory.

A list of plant taxa recorded at Lake Mokoan during these surveys is provided in Appendix 1.

Hamilton (2010) also surveyed the fauna of the area and recorded 111 indigenous species. Using a number of detection methods, including remote photography, audio-recording, call-playback, trapping, and active searching, he recorded five amphibians, 11 reptiles, eight microbats, and 17 birds not detected by Carr and Conole (2006). Seventeen of these taxa, including all of the microbats, are noted as not being recorded for the Lake Mokoan 'data review area', i.e. Lake Mokoan and a 10 km radius thereof in the Atlas of Victorian Wildlife (Carr and Conole, 2006). These findings indicate both the lack of previous ecological research and a poor understanding of the area's faunal biodiversity. Appendix 2 lists all faunal taxa recorded within a 4 km radius of Winton Wetlands Reserve (the data review area) as recorded in the Victorian Biodiversity Atlas. Hamilton's (2010) records have been added to this to compile a contemporary list.

4. Current Conditions

4.1. Land Use

Some 1532 ha of the Winton Wetlands Reserve continues to be leased to ten neighbouring landholders for cattle and sheep grazing cattle and sheep following decommissioning and transfer to the WWCoM, (Figure 5). These licenses are currently reviewed on an annual basis subject to recommendations adopted via this Plan. Section 5.6.7 discusses proposed modifications to licenses in order to promote biodiversity outcomes.

The following are notable land-uses in areas surrounding the Reserve:

- Cropping (mostly cereal) to the west and east
- Vineyards to the northeast in the Taminick area
- Grazing to the northwest in the Chesney Hills, and in the Taminick area
- Lifestyle blocks on the northern shore along Lake Mokoan Road, particularly in the vicinity of the former Lake Mokoan Yacht Club.

Natural vegetation predominates on upper slopes of the Warby Ranges and Chesney Hills.

In addition to primary production uses, major infrastructure and utilities including the Melbourne – Sydney Railway, Hume Freeway, and a major electricity transmission line cross or are near Winton Wetlands. The expanding industrial and semi-rural parts of Benalla occur to the southwest of the Reserve. An irrigation pipeline easement to supply irrigators previously diverting from Lake Mokoan traverses the reserve from west to east along the northern shores of the wetlands to Duck Pond. An off-take from the pipeline traverses south along Boggy Bridge Road to Ashmead’s Road. These pipelines also service fire-fighting supply points.

4.2. Ecological Management Units

For the purposes of this plan, the Reserve has been sub-divided into seven management units (Figure 6) to assist restoration management and other activities (e.g. information delivery), although in reality the entire catchment is the basic ecological management unit.

Units have been mapped over a 5cm (Digital Elevation Model) DEM to give an idea of terrain (blue lowest, red highest). The boundaries for Winton and Sergeant’s Swamps have been modelled at the 161.15 m AHD contour, slightly above the outlet level of 161.14 m AHD. Note, however, that standing water could be observed (and mapped by Davidson and Mann 2010) well beyond the modelled high water mark during the very wet periods of late 2010. The units are described in the following sections.

It should be further noted that these units have been sub-sectioned by Davidson and Mann (2010) and Davidson (2011) to better understand vegetation condition and biomass management requirements and logistics. This information is available on the Winton Wetlands GIS.

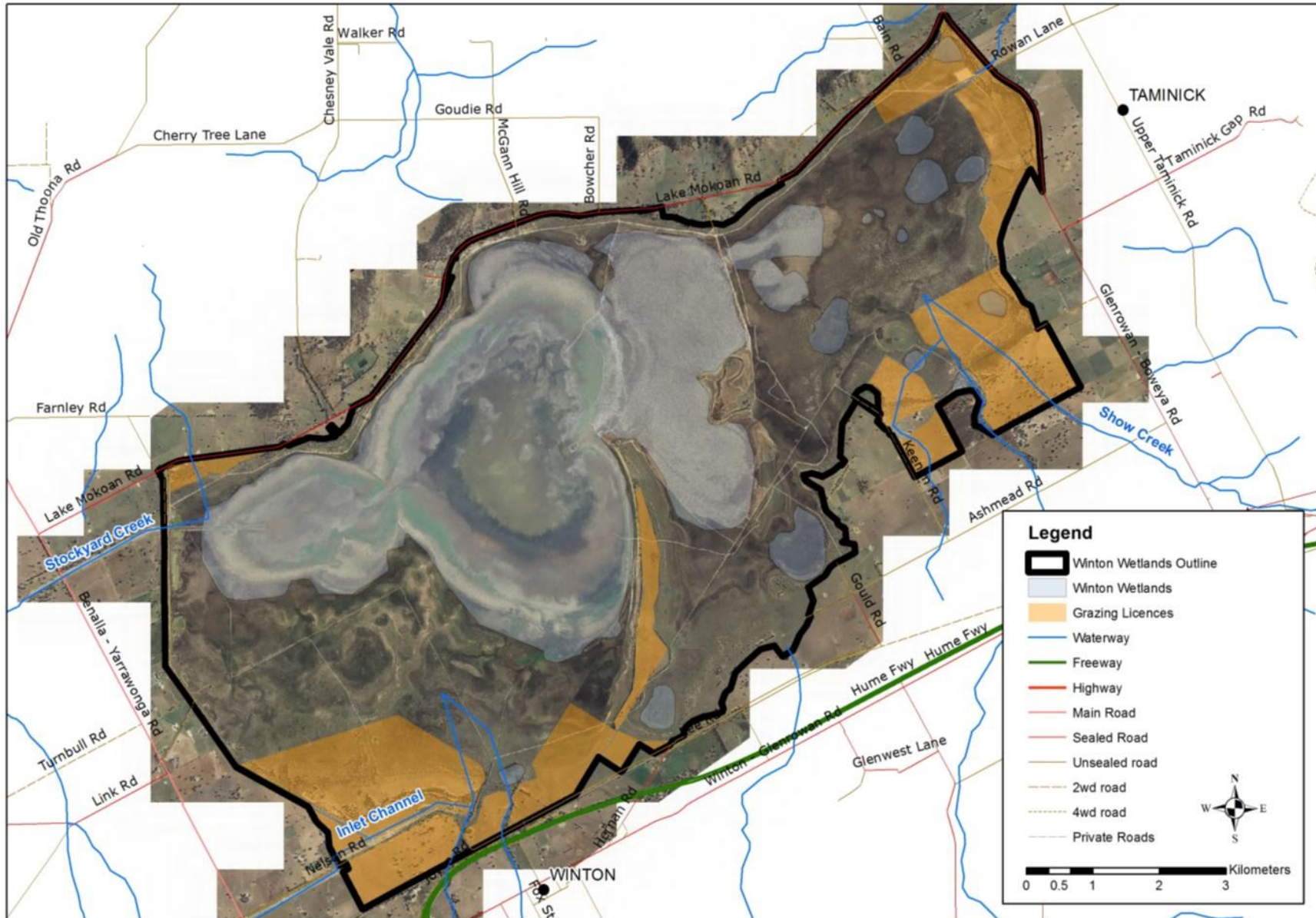


Figure 5: Areas under grazing license at Winton Wetlands Reserve

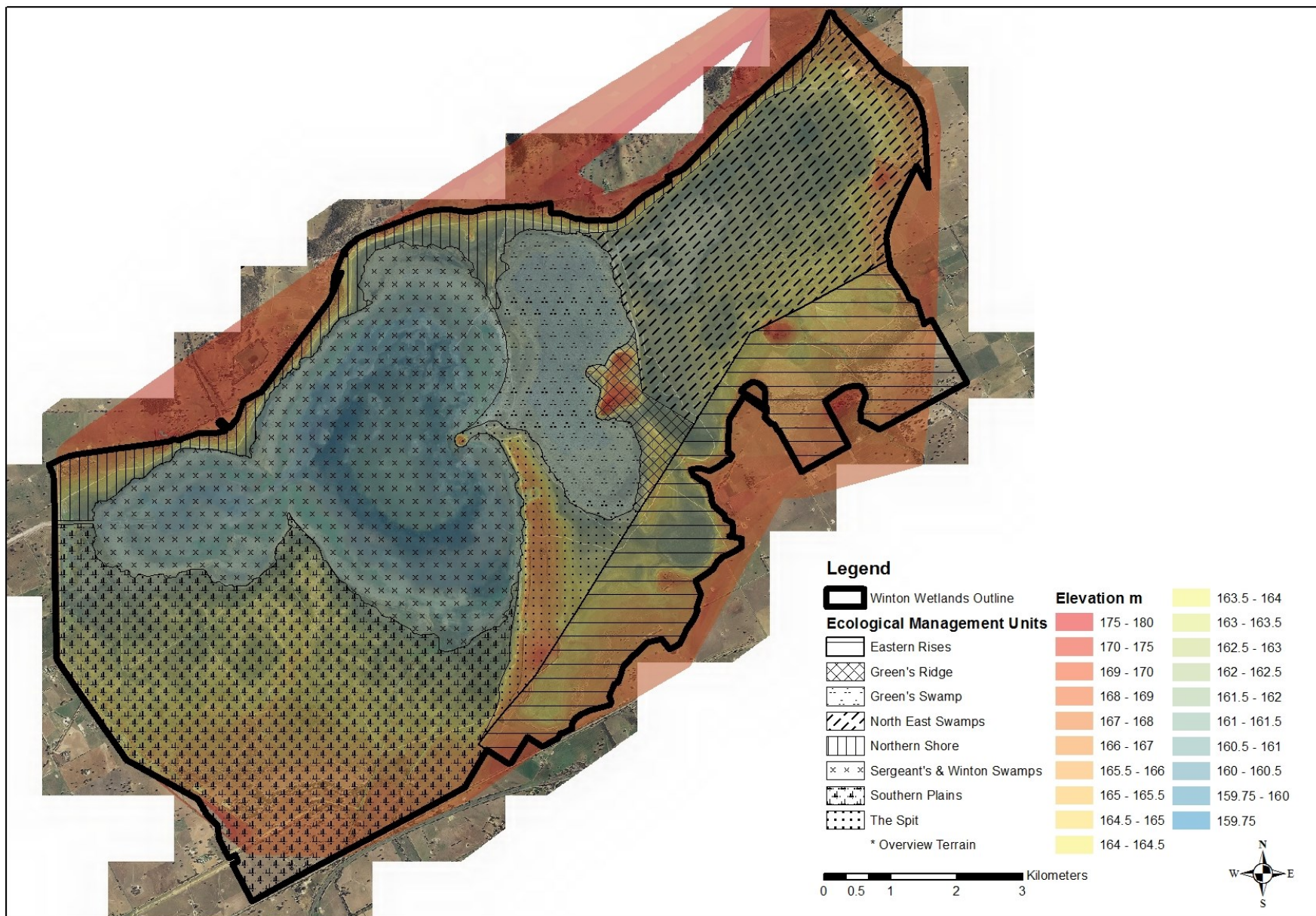


Figure 6: Proposed Ecological Management Units at Winton Wetlands, here shown over a semi-transparent Digital Elevation Model (DEM) of the site's terrain

4.2.1. Northern Shore

The Northern Shore Unit is approximately 518 ha and extends from high water (at 161.14 m AHD - the height of the outlet channel) in Sergeant's and Winton Swamps up to the Lake Mokoan Road boundary, with the exception of some freehold land opposite Chesney Vale Road and either side of Boggy Bridge Road. Public access is good for a length of approximately 3 km, centred on the former Lake Mokoan Yacht Club and main car park and the area has high amenity value, with extensive views over Winton Swamp to Warby Ranges, Lurg Hills and Mt Buffalo in the distance. Grazing licenses exist on two parcels at the south-western and north-eastern extremities of the zone. These parcels can carry a high biomass of Phalaris when ungrazed and grazing should be continued to limit the seeding of Phalaris and manage fuel hazard.

Native vegetation in this unit is in relatively good condition, with the Reserve's most intact example of Grassy Woodland occurring opposite Lakeside Drive (Davidson and Mann 2010). Soils are a sandy colluvium out-washed from the adjacent Chesney Hills and, as such, are relatively infertile and support relatively few weeds and low biomass, except where pasture improvement was undertaken in the past. The field layer is in relatively good condition and dominated by Wallaby (*Austrodanthonia* spp.), and Spear Grasses (*Austrostipa* spp.) where a tree canopy exists (mostly Grey Box *Eucalyptus microcarpa*, Blakely's Red Gum *E. blakelyi*, Yellow Box *E. melliodora*, and River Red Gum *E. camaldulensis*). Native forbs are few, although an impressive display of Bulbine Lily (*Bulbine bulbosa*) and Chocolate Lily (*Arthropodium strictum*) was observed in the Spring of 2010. The shrub layer is a notable feature of this part of the Reserve and provides an important resource for woodland birds. Closer to the water's edge exists a fringing zone of littoral vegetation variously dominated by Rigid Panic (*Walwhalleya proluta*) in drier areas, Plains Rush (*Juncus semisolidus*), Hollow Rush (*J. amabilis*), Southern Cane-grass (*Eragrostis infecunda*) and/or Water Couch (*Paspalum distichum*). Much of the length is characterised by the presence of drowned River Red Gums in the pre-Lake Mokoan littoral zone. Phalaris (**Phalaris aquatica*) and Paspalum (**Paspalum dilatatum*) are problematic weeds.

Outside the picnic and parking facilities, this zone is highly suitable for short-term passive recreational use. For example, an hour or so 'woodland walk' could be established to the north of the Yacht Club that could include interpretative facilities relating to both woodland and wetland ecosystems. This could terminate at Robertson's Hill, which provides an excellent lookout over both Green's and Winton Swamps.

With easy access and good visitor facilities, the Northern Shore is ideally suited as a location to implement community-based revegetation programs (including school groups). The focus should be on enhancing the shrub layer within the woodland zone, replanting River Red Gums along the littoral zone, enhancing the diversity of herbaceous aquatic plants in the littoral zone, and re-establishing native grasses between the littoral zone and the woodland zone.

4.2.2. Southern Plains

The Southern Plains Unit is a large expanse (2257 ha) of relatively low-lying land much of which was inundated for the period Lake Mokoan was at full supply level. Grazing licenses covering 400 ha exist in the southern part of the zone, either side of Winton Creek and the old Inlet Channel, which enters the Reserve at this point.

The land rises very gradually to the south, with Grey Box-dominated remnants of the original Plains Grassy Woodland still evident in the most southerly parts, particularly to the south of Nelson Road. Just to the north of this are stands of River Red Gum-dominated Plains Grassy Woodland, although most of the trees here are relatively young and probably established when Lake Mokoan first filled and formed a new high water mark. The understorey in these parts is in relatively good condition although species poor and weed cover is generally low. Stands of Phalaris occupy parts where there is little to no tree canopy.

Drowned River Red Gums define the former extent of Winton and Sergeant's Swamps, and dead trees are scattered thinly across areas that once likely supported a mosaic of Plains Grassy Wetland, Plains Swampy Woodland and Riverine Swampy Woodland/. The distribution of the original EVCs is masked by the impacts of clearing associated with agricultural use prior to Lake Mokoan being established. There is little doubt that tree clearing occurred in those times as is apparent on aerial photos from the 1940s. The field layer in this area varies in quality, with extensive stands of Plains Rush (*Juncus semisolidus*) in the wetter areas towards Sergeant's Swamp, and the shrub Drooping Cassinia (*Cassinia arcuata*) forming extensive stands in drier areas. Large expanses of native grassland occur across the site and are variously dominated by Common Blown Grass (*Lachnagrostis filiformis*), Southern Cane Grass (*Eragrostis infecunda*), Brown-back Wallaby-grass (*Austrodanthonia duttoniana*), Swamp Wallaby-Grass (*Amphibromus nervosus*) and Moira Grass (*Pseudoraphis spinescens*).

4.2.3. The Spit

The Spit is formed by a lunette along the eastern shore of Winton Swamp covering an area of 370 ha, and including some low-lying land behind (to the east) of the lunette. The south-eastern boundary of this zone is defined by Winton North Road. Soils in the elevated parts are aeolian (wind) deposited sediments blown out from Winton Swamp during extended dry periods in the past. Wave action from Lake Mokoan has eroded the shoreline leaving accreted gravels.

The lunette actually covers the entire eastern shore of Winton Swamp, although the northern half is less developed presumably due to regular over-topping by Green's Swamp and subsequent redistribution of sediments. This part of the lunette is included in the Green's Swamp EMU.

This unit is believed to be of high cultural significance (Bell 2010), as it is considered that the area was a high-use site by aboriginal people and likely to contain burial sites. A number of artefact scatter sites have been recorded in this area.

One of the most prominent geomorphological features of the Reserve is the rocky outcrop at the end of The Spit known as The Island. This feature is presumably an outcrop of the adjacent Chesney Hills, and further outcropping material may underlay the lunette itself. The Island extends out into Winton Swamp and at about 10 m above water level affords great views of the surrounding landscape. An area of River Red Gum has established at the Mokoan high water level, and the ground layer is dominated by Rough Spear Grass (*Austrostipa scabra*).

Grazing and occasional cropping have heavily disturbed the soils of the lunette and little semblance of the original vegetation remains. Introduced pastures dominate most of the site and a grazing lease exists on part of the lunette (Figure 8), terminating in the north at the site of a former house now marked by a stand of Peppercorn trees.

The dominant trees, examples of which occur along the western bank of the lunette, are Blakely's Red Gum (*Eucalyptus blakelyi*) and Yellow Box (*E. melliodora*), with White Cypress-pine (*Callitris glaucophylla*) also present, along with (possibly) White Box (*E. albens*) and Grey Box (*E. microcarpa*). Smaller trees (or tall shrubs) would have included Lightwood (*Acacia implexa*), Silver Banksia (*Banksia marginata*), Cherry Ballart (*Exocarpus cupressiformis*), Drooping She-oak (*Allocasuarina verticillata*) and possibly also Buloke (*A. luehmannii*). Low shrubs were probably common in the understorey based on the relatively free-draining soils.

It is recommended that grazing continue (for the next decade or so) on the existing lease area, but that an active revegetation program be initiated to re-establish Lunette Woodland and Plains Grassy Woodland on appropriate parts of the non-leased land. Revegetation of the leased land is not an immediate priority, but could be considered in the medium term: it will require considerable weed control and direct seeding approaches.

4.2.4. Eastern Rises

The Eastern Rises Unit is approximately 1250 ha in size, located between Winton North Road and the eastern boundary of the Reserve, and extending from Nelson Road in the south to the northern boundary. It adjoins the North East Swamps Unit at Taminick Road, near Sadler's Swamp. Grazing leases exist in the north-eastern corner of this Unit (Figure 8).

The Unit includes four distinct wetlands: Friday's Swamp, Ashmead's Swamp, Humphries' Swamp, and the 11-mile wetland that was constructed as a nutrient interception pond by Goulburn Murray Water (GMW) in the 1980s. Another outcrop known as Humphries' Hill provides commanding views across the Reserve.

The vegetation exists either as exotic pasture dominated by Phalaris (**Phalaris aquatica*), Fescues (**Vulpia* spp.), Paspalum (**Paspalum dilatatum*), Rye-grasses (**Lolium* spp.) and/or Brome grasses (**Bromus* spp.) although Wallaby Grasses (*Austrodanthonia* spp.), Spear Grasses (*Austrostipa* spp.) and Rigid Panic (*Walwhalleya proluta*) are often interspersed. Native species tend to dominate in the wetter areas and swamps: Common Swamp Wallaby-grass (*Amphibromus nervosus*), Common Blown Grass (*L. filiformis*), Moira Grass (*P. spinescens*) and Plains Rush (*J. semisolidus*) are common here. All swamps except 11-Mile Wetland carry a dead tree canopy due to previously excessive inundation history. Although

relatively young, the River Red Gums around 11-Mile Wetland and the Humphries' Lane area provide an important source of seed for tree regeneration across the Reserve.

All wetlands are relatively accessible. Friday's Swamp is in very good condition with little weed cover, significant species present, excellent water quality and ample birdlife. The Phalaris surrounding the swamp is a high threat and should be controlled forthwith and a direct seeding program undertaken to re-establish native vegetation cover. Phalaris will require ongoing management as reinvasion is probable

4.2.5. North East Swamps

The North East Swamps Unit, at 1440 ha, is the most remote and inaccessible part of the Reserve, although a small wetland/irrigation storage known as the Duck Pond provides more or less permanent open water and a suitable bird-viewing point as it can be accessed (although gates currently locked) from Glenrowan-Boweya Road. Major swamps in the unit are Boggy Bridge Swamp, Saddler's Swamp, Lindsay's Swamp and Black's Swamp, although numerous minor depressions exist throughout.

The north-eastern sector is under grazing lease. Although mature and live River Red Gums exist here, the field layer in this zone is substantially degraded and continued grazing is required to control Phalaris biomass in the short to medium term.

This unit would have been a combination of Red Gum Swamp, Riverine Swampy Woodland and Plains Swampy Woodland prior to agricultural use, comprising an extensive stand of River Red Gum over a semi-aquatic field layer dominated by Moira Grass, Common Swamp Wallaby-grass, Common Spike-sedge Plains Rush and Tall Sedge. There is evidence that tree clearing has occurred to facilitate farming, however the unit is now characterised by vast expanses of drowned River Red Gums over a field layer dominated by Plains Rush or Common Swamp Wallaby-grass.

Aerial seeding of River Red Gum should be considered the most viable option to re-establish tree cover if natural regeneration is ineffective.

4.2.6. Green's Ridge

Green's Ridge includes a rocky outcrop 'Green's Hill' and a minor lunette on the eastern shores of Green's Swamp, and covers approximately 150 ha. Much of the unit was burnt during the Green's Swamp fire of January 2010.

Remnant Grassy Woodland dominated by Blakely's Red Gum and Yellow Box exist on the outcrop known as Green's Hill over an understorey dominated by Spear Grasses and Wire Grass, with relatively few shrubs, although opportunistic weeds are common. Remnant pastures dominated by Wild Oats and Bromes occur in lower arable parts and across the lunette, and old fencelines are still evident.

The unit is considered a high priority for revegetation. Herbicide control and direct seeding and tube-stock planting with native species will be required to control exotic biomass.

Green's Hill affords commanding views over Green's Swamp towards Winton Swamp.

4.2.7. Green's Swamp

Green's Swamp is a former Red Gum Swamp of some 660 ha. Although bounded on the east by Boggy Bridge Road, it is more or less continuous with the North East Swamps landscape. As mentioned above, a low sandy lunette separates Green's and Winton Swamps.

Drowned River Red Gums are a prominent feature across such an expanse, some of which burnt during the 2010 fire (south of Boggy Bridge Road). Plains Rush now dominates the field layer along with a suite of wetland plants (*Carex tereticaulis*, *Eleocharis acuta* and *Persicaria lapathifolia*). Encouragingly, young River Red Gum recruits have been observed in the swamp during 2011.

The extent to which River Red Gums recruit across this site will be dependent on the wetting and drying regime. It is anticipated that the swamp will be frequently dry by the end of summer and unlikely to ever carry standing water for more than two to three years at a time. Such conditions would be suitable for River Red Gum recruitment, and also unfortunately, as a breeding site for European Carp (see section 5.7).

4.2.8. Winton and Sergeant's Swamp

The most notable landscape unit of the Reserve is the 2120 ha Winton and Sergeant's Swamps. Apart from the drowned River Red Gums along the shoreline, this ecosystem, historically the most inundated wetlands, probably suffered less from the impact of Lake Mokoan than other parts of the Reserve that were previously rarely inundated for any length of time. A new cohort of River Red Gums has established at the former Lake Mokoan high water mark. The new drier regime may stress these stands in the future, particularly during extended periods of low rainfall.

The past and possible future hydrological regime, is discussed in detail in Section 4.4. In summary, being a rain-fed system, the Swamps water levels will vary directly with the weather. 'Normal' rain years will see the Swamps fill over winter and recede during summer to cover an area of 1000–1500 ha. Water levels can fall and rise dramatically according to rainfall as shown in Figure 11.

Fish populations will experience considerable stress as water levels recede below critical levels due to crowding, temperature and low dissolved oxygen. There is currently no connectivity with the (downstream) Broken River system where fish would normally seek refuge – an issue discussed further in Section 5.7. Although Golden Perch and Murray Cod would have frequented the system, the lack of escape route indicates that management may need to consider 'fish rescue' operations during critical low periods.

Conversely, the vast areas of exposed swamp floor during such periods will provide excellent habitat for waders, including Latham's Snipe: Winton Swamp is considered to be nationally, if not internationally significant, for the conservation of this species (Carr and Conole 2006).

As noted earlier, Helen Aston photographed and recorded extensive stands of Southern Cane-grass *Eragrostis. infecunda* dominating the wetland (Figure 7). This species is well-adapted to tolerating extremes of wetting and drying and it is predicted that it will again dominate extensive areas as time progresses (supported by current observation).



Figure 7: Extensive cover of Southern cane-grass at Winton Swamp prior to the construction of Lake Mokoan (photo: Helen Aston, 1959)

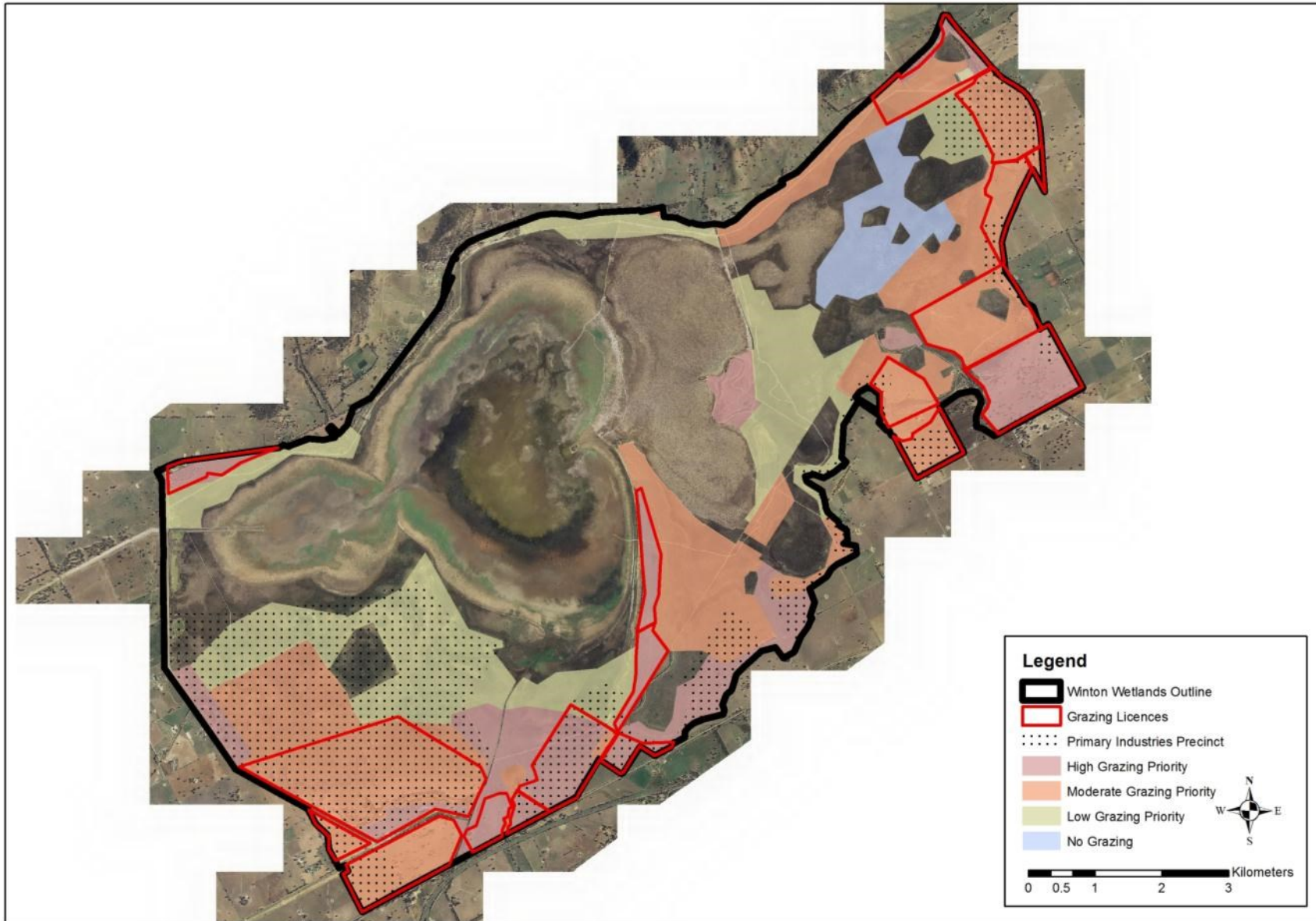


Figure 8: Areas for grazing priority, existing licenses and the FLUS Primary Industries Precinct

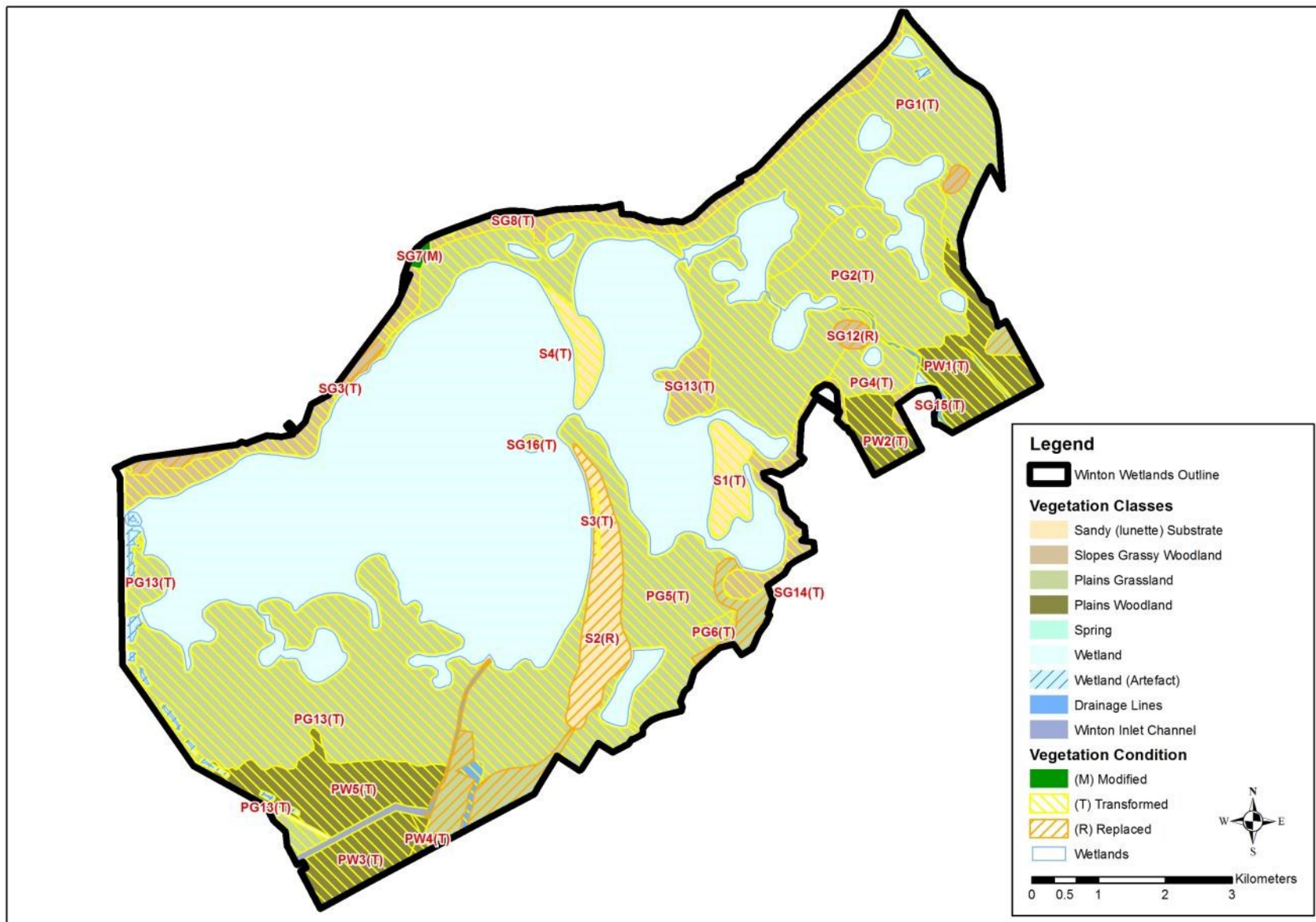


Figure 9: Vegetation Type and Condition class (after Davidson and Mann 2010) Site as numbered are discussed in Table 1

4.3. Flora and Fauna

4.3.1. Flora

4.3.1.1. Ecological Vegetation Classes

Frood (2011, unpubl) has recently updated information on Ecological Vegetation Classes at Winton Wetlands. Mapping and descriptions are provided in Appendix 3. The previous section also includes information on the distribution and composition of EVCs across the site.

4.3.1.2. Vegetation Condition

Davidson and Mann (2010) carried out a condition assessment of terrestrial vegetation at Winton, stratifying the site by vegetation type (Figure 9). The reason for the relatively large area identified as ‘wetland’ in Figure 9 is due to the system being at c.150% capacity at the time of assessment.

Davidson and Mann (2010) identified no sites considered intact or unmodified using a system developed by Thackway and Lesslie (2005) that categorises vegetation according to the degree of apparent human-induced disturbance. One small site (SG7) just east of the Yacht Club on the Northern Shore rated as ‘modified’ but in relatively good condition. The majority of the site is rated as ‘transformed’, that is, there is substantial alteration to the composition and structure of the vegetation from past land-use including the impacts of inundation. Five areas, notably much of The Spit and the area between Winton Creek and Nelson Road on the eastern edge of the Southern Plains, are rated as ‘replaced’ (i.e. by introduced pasture).

The modified site (SG7) and sites at the higher quality end of the transformed category are briefly described in Table 1 (further detail in Davidson and Mann 2010):

Table 1: Areas of better quality vegetation as described by Davidson and Mann (2010). See Figure 9 for site locations

Site No.	Description
SG7	The only site rated as Modified. The best quality area is the eastern end of the road reserve. It is Blakely’s Red Gum, White Box, Grey Box woodland (immature) with an understorey of wattles, fringe-myrtle and peas and a ground layer dominated by lilies, ferns, and annual and perennial herbs. Elsewhere in the road reserve the vegetation is weedier and less diverse. Below the road reserve the vegetation is more depleted, but still retains tree cover, a shrubby understorey and a grassy ground layer.
SG3	Remnant trees, regenerating shrubs and a simplified ground layer
SG8	Robertson’s Hill Granite out-crop vegetation with indigenous forbs and grasses. Unique vegetation within Winton Wetlands and views of Winton and Green’s Swamps. Remnant Yellow Box next to old sand quarry next to Mokokoan Road.
SG12	Although surrounding vegetation is degraded there is a patch of remnant Blakely’s Red gum, Grey Box and White Box with great views of 11 Mile Creek and a variety of wetlands.
SG13	Large island Extensive stand of remnant Blakely’s Red Gum, White Box and Grey Box with native grasses underneath including patches of Kangaroo Grass that is not found elsewhere. River Red gum regeneration present Small island has few weeds. Sand neck between islands is herb-rich. Fabulous views over Green’s Swamp.
SG14	Extensive stands of Yanganbil <i>Austrostipa bigeniculata</i> .
SG15	Diverse native grasses, advanced River Red Gum regeneration, mostly indigenous species in plantation.
SG16	A prominent island with cliffs and River Red Gum fringe, native grasses. Silver Gull nesting colony.
S1	Good patches of native ground cover and shrubs, partially burnt
S4	Sandy site that divides Green’s and Winton Swamps, while weedy has a range of native species, some not found elsewhere
PG1	Extensive areas with large areas of native grasses
PG2	Extensive areas with large areas of native grasses
PG4	Has gilgais with herb-rich ground layer

PG5	Scattered areas of better vegetation. Around the area where Ashmeads, Bowers and Lee Roads intersect there is a stand of mature River Red Gum, Grey Box and White Box, a small wetland, gilgais and species not found elsewhere on the property.
PG6	Most intact Plains Grassland area with mostly native ground flora and pea shrubs common
PG 13	Very extensive area mostly dominated by native grasses. Includes drier ridges and low lying areas with patches of significant native vegetation and species not found elsewhere
PW1	Significant woodland area including gilgais with one small herb-rich area, areas of mostly native grasses and remnant Grey Box and River red gum above FSL
PW2	Many gilgais along broad drainage line. Indigenous forbs and grasses are present.
PW3	Significant woodland area including gilgais and remnant White and Grey Box
PW4	Southern section is a small woodland remnant including Winton Creek
PW5	Significant woodland area with extensive River Red Gum regeneration, and scattered remnant Grey Box above FSL. One mature Mugga Ironbark, only one present. Section of original Winton Creek (inflow diverted by inlet channel) with shallow profile and mature trees. Areas with gilgais, forbs and mostly native grasses.
Sp1	Only natural spring identified. Badly damaged by rabbits, but diverse shrubs and ground layer species still present. Current lack of water requires investigation for restoration—possibly being extracted.
S2 & S3	The Spit. Important landform which is rare in region; however the vegetation is mostly exotic pasture except for the remnant trees on S3

4.3.1.3. Significant flora

Although previous vegetation surveys have been limited in scope and/or extent, they have confirmed the presence of a number of plant species threatened at the state or national level. Information collated from these reports (Aston 1959, 1962; Carr and Conole 2006; Roberts *et al.*, 2007, 2008, 2010; Davidson and Mann 2010) is summarised in Table 2 below. Information on distribution is sourced from the volumes of *Flora of Victoria* (Walsh and Entwistle 1994, 1996, 1999) and may need to be updated.

Table 2: Significant flora recorded at Winton Wetlands Reserve

Species	Common name	Cons Status	Comment
<i>Amphibromus fluitans</i>	River Swamp- Wallaby Grass	EPBC (V)	Stronghold for this species is Murray River Valley between Wodonga and Echuca. Recorded at Friday's Swamp and Lindsay's Swamp by Carr & Conole (2006)
<i>Eleocharis macbarronii</i>	Grey Spike-sedge	DSE (k)	Rarely recorded in Victoria, mostly from Wimmera; this appears to be a considerable range extension. Recorded at Friday's Swamp by Carr & Conole (2006)
<i>Goodenia macbarronii</i>	Narrow Goodenia	FFG (L); DSE (v)	This species has recently been de-listed from EPBC Act, as populations have been shown to fluctuate considerably with seasonal conditions. Recorded at 11 Mile Wetland by Carr and Conole (2006)
<i>Dodonaea boroniifolia</i>	Hairy hop-bush	DSE (r)	Restricted to NE & NC Vict, one plant recorded by Davidson and Mann (2010) east of Ashmead's Swamp (SG11)
<i>Digitaria divaricatissima</i>	Umbrella Grass	DSE (v)	Recorded from only one other site in NE Vic. Further information is being sought on the location of this species at Winton (recorded by Roberts (2010)
<i>Gratiola pedunculata</i>	Stalked Brooklime	DSE (k)	Apparently very rare in Victoria, not north of the Divide. Recorded by Aston (1962) but specific location not provided
<i>Najas tenuifolia</i>	Water Nymph	DSE (r)	Rare in Victoria, populations restricted to Murray R. Recorded by Aston (1962) but specific location not provided
<i>Lipocarpha microcephala</i>	Button Rush	DSE (v)	Widespread but uncommon in Vic. Recorded by Aston (1962) but specific location not provided
<i>Lotus australis</i>	Austral Trefoil	DSE (k)	Widespread but uncommon in Victoria, especially on Riverine Plains. Only one other population known locally. Recorded by Davidson and Mann (2010) '10 - 50 plants' on Southern Plains (PG 13)

<i>Sclerolaena muricata</i> var <i>muricata</i>	Black Roly -poly	DSE (k)	Significant range extension for this taxon, otherwise restricted to Murray Valley downstream of Kerang. Recorded by Davidson and Mann (2010) on Northern Shore (SG4)
<i>Senecio cunninghamii</i> var <i>cunninghamii</i>	Branching Groundsel	DSE (k)	Widespread but uncommon in Victoria, occurs mostly along Murray Valley downstream of Echuca. Recorded as widespread at Winton Wetlands by Davidson and Mann (2010)

Status Code: EPBC = (Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999); FFG = Victorian *Flora and Fauna Guarantee Act* (1988); DSE = DSE Advisory List of Rare or Threatened Plants in Vic (2005); (v) = vulnerable; (r) = rare; (k) = data deficient

4.3.1.4. Pest Plants

One hundred and forty-six of the 433 plant species recorded at Winton Wetlands Reserve are not indigenous to the site. Included in this number are Australian plants growing outside their natural range (indicated by an # in Appendix 1), some of which are plants that have escaped from ornamental and utility plantings such as *Melaleuca decussata*, *Melaleuca armillaris*, *Acacia baileyana*, *Acacia saligna*, and *Acacia podalyriifolia*. Examples of this exist along the Northern Shore and Southern Plains (near Winton Creek) and on the Spit.

The site is currently understood to be mostly free of major aquatic weeds, but as noted in Section 5.5, populations of these species exist within easy dispersal distance of Winton Wetlands and vigilance and prompt action will be required to ensure populations don't become established. Aquatic weeds currently present include Willows (**Salix* spp.) and Spiny Rush (**Juncus acutus*).

The most problematic introduced species for terrestrial vegetation is Phalaris/Canary Grass (**Phalaris aquatica*). In the absence of grazing and/or other control measures, this species will come to dominate large expanses of the Reserve, reducing floristic and structural diversity, aesthetic value, and increasing fire hazard. While not as structurally destructive, St John's Wort (**Hypericum perforatum*), is also of concern: small patches exist across the Reserve and observations suggest this weed is undergoing an expansion across north east Victoria.

Twenty-seven of the most problematic weeds, including 14 taxa listed as 'Regionally Controlled' under the Victorian *Catchment and Land Protection Act* (1999) are specifically addressed in the Winton Wetlands Pest Plant Management Plan (GreenAcres 2010). This Plan is largely a GIS documentation of locations, population size, control measures and monitoring requirements. Other taxa, particularly those plants escaping from plantations, will be added to the Pest Plant Management Plan.

It is not realistic to expect Winton Wetlands Reserve to ever be 'weed free'. The site is surrounded by an agricultural landscape, has undergone fundamental changes to vegetation communities and soil structure and processes through past agricultural use and inundation. Weeds will continue to invade and expand under favourable establishment conditions. Soil structure and processes (particularly nutrient cycles) may take decades to stabilise to the extent that conditions substantially favour indigenous species. Management will need to focus on controlling the most problematic species and accept that there will be a background

of less problematic non-indigenous flora (i.e. introduced annual grasses and opportunistic forbs) present for the foreseeable future.

4.3.2. Fauna

A complete list of fauna species so far recorded at and around the Winton Wetlands Reserve is provided in Appendix 2, and summarised in the following sections. Information is drawn from reports prepared by Carr and Conole (2006), Conole (2007), Hamilton (2010) and Ramsey (2011). Further detail should be sought from those reports. Currently, we have no information on the terrestrial or aquatic invertebrate fauna.

4.3.2.1. Birds

Previous assessments of fauna at Winton Wetlands, although also limited in scope and extent, have recorded 185 species of birds present, six of which are introduced species (Appendix 2). There is little doubt that Winton Wetlands is of state significance for biodiversity conservation, given the sheer size of the wetland (amongst the largest ephemeral wetlands in Victoria), diversity of habitat, and the number and abundance of wetland bird species present.

The Flora and Fauna Guarantee listed *Victorian Temperate Woodland Bird Community* occurs in woodland zones at Winton Wetlands, principally along the Northern Shore, Eastern Rises between Ashmeads and 11 Mile Wetland, and the eastern end of the North-east Swamps along Glenrowan-Boweya Road. Significant component species are Grey-crowned Babbler (two groups), Regent Honeyeater (1 call), Diamond Firetail (common), Hooded Robin, and Brown Treecreeper.

In addition, Winton Wetland Reserve is likely to be of international importance as a wetland supporting a substantial proportion of the eastern Australian population of Latham's Snipe (*Gallinago hardwickii*) (Carr and Conole 2006). Latham's Snipe migrates from its breeding grounds in northern Japan to over-summer in Australian wetlands in south-eastern Australia. It is considered 'near-threatened' in Victoria (DSE, 2003), and is subject to an international treaty between Australia and Japan (Japan – Australia Migratory Birds Agreement, JAMBA) developed to protect habitat in respective regions. As such, it is also listed under the Commonwealth Government's migratory bird provisions of the *Environment Protection and Biodiversity Conservation Act* (1999).

By extrapolating the numbers observed during field work over the extent of suitable habitat, Carr and Conole (2006) estimated that total numbers of Latham's Snipe in the order of 300–600 birds were present at Winton Wetlands, which if verified, is greater than 1% of the migratory population estimate of 36,000 birds (Bamford *et al.*, 2008), a criterion for a site to be recognised as being of international importance under the Ramsar Convention.

Significant bird observations at Winton Wetlands (Carr and Conole 2006; Hamilton 2010; Ramsey 2011; Victorian Biodiversity Atlas) are summarised in Table 3. This table only lists species that have a designated conservation status at the state or national level. Since decommissioning, a number of bird sightings at Winton Wetlands suggest that it is of very high regional importance, with a number of new records made recently for the region (e.g. Marsh Sandpiper, Sharp-tailed Sandpiper, Red-necked Stint and Spotted Crake) (Ramsey 2011).

Table 3: Significant bird fauna recorded at Winton Wetlands Reserve

Species	Common name	Cons Status	Comment
<i>Coturnix ypsilophora australis</i>	Brown Quail	EPBC (m), DSE (nt)	Notable breeding population
<i>Turnix pyrrhorothonax</i>	Red-chested Button Quail	FFG, DSE (v)	VBA record (1977)
<i>Phalacrocorax varius</i>	Pied Cormorant	DSE (nt)	Uncommon in northern Vic
<i>Chlidonias hybridus javanicus</i>	Whiskered Tern	DSE (nt)	300+ birds breeding 2009/10 (Ramsey 2011)
<i>Chlidonias leucopterus</i>	White-winged Black Tern	EPBC (m), DSE (nt)	New record for NE Vic (Ramsey 2011) seen late 2009
<i>Sterna caspia</i>	Caspian Tern	DSE (nt)	Rarely recorded in NE Vic, 1 bird sighted near boat ramp March 2011 (Ramsey, 2011)
<i>Sterna nilotica</i>	Gull-billed Tern	FFG, DSE (e)	New record for NE Vic (Ramsey 2011), seen late 2009
<i>Gallinago hardwickii</i>	Latham's Snipe	JAMBA, DSE (nt)	Possibly nationally – internationally significant site
<i>Burhinus grallarius</i>	Bush Stone-curlew	DSE (e), FFG	VBA record, call-back yielded no response in 2010 (Hamilton 2010). Not considered present
<i>Grus rubicunda</i>	Brolga	DSE (v), FFG	Resident, poss breeding (Ramsey 2011)
<i>Platalea regia</i>	Royal Spoonbill	DSE (v)	c. ten birds late 2009 (Ramsey 2011)
<i>Egretta garzetta nigripes</i>	Little Egret	FFG; DSE (e)	VBA record (1980)
<i>Ardea intermedia</i>	Intermediate Egret	FFG, DSE (cr)	Critically endangered in Vic, thought to be breeding at Winton – highly significant (Carr & Conole, 2006; Ramsey, 2011)
<i>Ardea alba</i>	Great Egret	FFG DSE (v), JAMBA/CAMBA	Significant number of birds sighted at Winton, thought to be breeding (Carr & Conole 2006; Ramsey 2011)
<i>Ardea ibis</i>	Cattle Egret	CAMBA/JAMBA	VBA record (1980)
<i>Nycticorax caledonicus hillii</i>	Nankeen Night Heron	DSE (nt)	Possibly (colonial) breeding at 11 Mile Wetland (Ramsay 2011)
<i>Botaurus poiciloptilus</i>	Australasian Bittern	EPBC, FFG, DSE (e)	Tbc (recorded by Carr & Conole 2006) – nationally significant
<i>Ixobrychus dubius</i>	Little Bittern	FFG, DSE (e)	Probably site of State – National significance for this species (Carr & Conole, 2006), not previously recorded here
<i>Stictonetta naevosa</i>	Freckled Duck	FFG, DSE (e)	Approx. 90 birds sighted near Duck Pond, considered to be breeding here (Carr and Conole 2006)
<i>Aythya australis</i>	Hardhead	DSE (v)	Common and breeding (Ramsey 2011)
<i>Oxyura australis</i>	Blue-billed Duck	FFG, DSE (e)	Significant record (Hamilton 2010), no details
<i>Biziura lobata</i>	Musk Duck	DSE (v)	Regularly sighted when water levels high
<i>Anas rhynchotis</i>	Australasian Shoveller	DSE (v)	100s of birds late 2009, breeding at Friday's Swamp (Ramsey 2011)
<i>Circus assimilis</i>	Spotted Harrier	DSE (nt)	VBA record (1977)
<i>Haliaeetus leucogaster</i>	White-bellied Sea-eagle	FFG, DSE (v), CAMBA	Breeding at Winton, poss two pairs (Ramsey 2011)
<i>Neophema pulchella</i>	Turquoise Parrot	FFG, DSE (nt)	VBA record (1996)
<i>Chrysococcyx osculans</i>	Black-eared Cuckoo	DSE (nt)	VBA record (1980)
<i>Melanodryas cucullata cucullata</i>	Hooded Robin	FFG, DSE (nt)	Breeding along Northern Shore (Ramsey 2011)
<i>Hirundapus caudacutus</i>	White-throated Needle-tail	JAMBA/CAMBA	200+ birds in 2010/11 (Ramsey 2011)
<i>Coracina maxima</i>	Ground Cuckoo-shrike	FFG DSE (v)	VBA record (1978)
<i>Pomastomus temporalis temporalis</i>	Grey-crowned Babbler	FFG, DSE (e)	Significant new record, two groups at 11 Mile Wetland and along Northern Shore (east end)
<i>Climacteris picumnus victoriae</i>	Brown Treecreeper	DSE (nt)	Common in woodlands, breeding (Ramsey 2011)

Species	Common name	Cons Status	Comment
<i>Chthonicola sagittata</i>	Speckled Warbler	FFG, DSE (v)	VBA record (1990)
<i>Xanthomyza phrygia</i>	Regent Honeyeater	EPBC, FFG, DSE (cr)	Significant new record, heard near car park (Davidson pers com)
<i>Melithripterus gularis</i>	Black-chinned Honey-eater	DSE (nt)	Recorded at boat ramp car park and Duck Pond (Ramsey 2011)
<i>Stagonopleura guttata</i>	Diamond Firetail	FFG, DSE (v)	Common at Winton (Ramsey 2011)

4.3.2.2. Mammals and Monotremes

A total of 21 mammal species and one monotreme (Echidna) has been recorded from Winton Wetlands (Appendix 2). Five of the mammals are introduced (House Mouse, Feral Cat, Red Fox, European Rabbit and European (Brown) Hare).

Native mammal species are apparently all uncommon at the Reserve (Hamilton 2010) although this may have been due to the recent drought and numbers could possibly be expected to increase over time given appropriate conditions. For example, two casual sightings of Yellow-footed Antechinus have been made during 2011, despite not being detected by Hamilton or others, with the most recent record in the Victorian Biodiversity Atlas being 1991.

Hamilton (2010) revealed the diversity of microbats present at the Reserve, recording eight species none of which had previously been recorded at Winton. Again the abundance was found to be extremely low, possibly attributable to low insect abundance that he and co-workers observed during fieldwork.

4.3.2.3. Fish

No formal fish surveys have been undertaken, although there exists considerable anecdotal and observational information on large-bodied native and introduced fish. One small-bodied species (Australian Smelt) is recorded for the site in the Victorian Biodiversity Atlas. It is noted that the wetlands potentially provide suitable habitat for a number of other small-bodied fish (further discussed in Section 5.7.1), but there is minimal data on fish communities prior to Lake Mokoan.

Local sources indicate that Golden Perch and Murray Cod (and possibly Catfish) were present in Winton Swamp prior to the commission of Lake Mokoan. This is supported by an obscure 1897 reference in the Broken Hill (NSW) local newspaper the 'Barrier Miner' (Figure 10). Although the species involved are not mentioned, the weights given suggest Murray Cod and Golden Perch. European Carp was not present in Australia at this time.

Barrier Miner (Broken Hill, NSW : 1888-1954), Monday 15 February 1897, page 2

Victoria.
MELBOURNE, Monday.
Through the gradual drying up of the Winton Swamp, near Benalla, which covers nearly a square mile, thousands of fish from 10 to to 50 pounds in weight are dying, and people daily go to the spot and secure large catches in the muddy shallow water.

National Library of Australia

Figure 10: An excerpt from the 'Barrier Miner' discussing fish salvage in 1897 at Winton Swamp

The construction of the Lake Mokoan wall established a barrier to fish attempting to migrate from the Broken River into the lake. Subsequently, a number of fish species (Redfin, Brown Trout, Golden Perch and Murray Cod) are known to have been introduced for recreational fishing. A large number of the native fish (mostly Golden Perch) were translocated from Winton as it dried out between 2007 and 2010.

In addition, the pest species European Carp, Mosquito-fish and Goldfish have recently established in Winton Wetlands. The large size of Carp observed indicate that adults have entered the system probably from sources higher up in the Catchment, and also across the weir at the outlet during high flows.

4.3.2.4. Reptiles and Amphibians

Records from the Victorian Biodiversity Atlas (VBA) and more recent surveys indicate that 27 species of reptiles (17 spp.) and frogs (ten spp.) have been recorded from the area. Some of these (e.g. Carpet Python) no doubt occur in the nearby hills (the Atlas search includes a 4 km buffer around the Winton Wetlands Reserve), but all could no doubt find at least transitory habitat at the Reserve.

Hamilton (2010) and Carr and Conole (2006) confirmed the presence of 20 species (Appendix 2), including a number of new records for the area (Barking Marsh Frog, Sloan's Froglet, Common Spadefoot Toad, Peron's Tree Frog, Cunningham's Skink, Garden Skink, and Shingleback). A reasonable interpretation of this is that there is a lack of historical data on the faunal values, and further revelations are likely.

Hamilton (2010) reported two species of conservation significance at the state level: Bearded Dragon (data deficient) and Lace Goanna (vulnerable), again in low numbers. The endangered Growling Grass Frog was last recorded from the area in 1970; the return of this species, with its readily identified call, would be significant.

The blue-green algal outbreaks during the Lake Mokoan era may have had a significant impact on amphibious fauna at (now) Winton Wetlands. Carr and Conole (2006) made note of the 'missing fauna' of Lake Mokoan, noting that common frogs were not calling, and there was a general absence of evidence of Long-necked Turtles. During the early 1990s considerable numbers ('thousands') of dead turtle carapaces could be found along the shores of Lake Mokoan (Keith Ward, GBCMA, pers. comm.), thought to be a result of Blue-green algal outbreaks.

Encouragingly, Hamilton (2010) was able to confirm, in much more favourable seasonal conditions, the presence of seven frog species as well as Long-neck Turtle, with a number of nests occurring along the western shore of the Spit.

4.4. Hydrology

Existing information on the hydrology of Winton Swamp is drawn from a model prepared by DSE during decommissioning stages. This model is deduced from the Goulburn Simulation Model (GSM), a REALM-based output, developed and used by agencies to predict irrigation storage volumes according to projected rainfall using long-term data (1891–2004).

A number of outputs can be generated from the data including the approximate area occupied by wetland according to rainfall (Figure 11), and probable changes to this as a result of climate change (Figure 12). While the model has limitations, especially on an unregulated system such as Winton, the periods indicated in Figure 11 when Winton Swamp was dry do accord with anecdotal and historic records.

The probability of a particular wetland area or volume occurring can also be predicted based on long-term data. Figure 13 indicates that according to the model, a wetland area of approximately 1500 ha is likely to be present 90% of the time (years), and overflowing for approximately 15%.

The CSIRO used the model in preparing a report on water availability in the Goulburn Broken catchment under current and future scenarios for land-use development and climate. Impacts of climate change (and projected rainfall declines) were not modelled specifically for Winton, but it is stated that a 15% reduction in rainfall could result in a reduction of runoff of some 40% (CSIRO 2008). Given that Winton Wetlands relies on surface run-off, and to a lesser extent groundwater discharge via a number of small springs, a better understanding of climate change-induced impacts to inflows is clearly required.

With a substantial surface-to-volume ratio, evaporation remains a major hydraulic feature at Winton. CSIRO (2008) presents estimates of 13.5 GL average annual evaporation against average annual inflows of 21.7 GL, with a maximum capacity of approximately 27.7 GL. Thus, with very dry years, there is expected to be a rapid draw-down of the wetland (see the period 2006- 2007 in Figure 14). During such events, it is to be expected that fringing littoral vegetation will not keep pace with the rate that the shoreline recedes, as shown more recently after the dry period between 2006 and 2009 (Roberts *et al.*, 2007, 2008, 2010).

CSIRO used the model to generate 'end-of-May' scenarios which suggests that the median storage at the end of May (taken to be the driest time of the year) is 5GL (equivalent to approximately 1500 ha of surface water), meaning that half the time over the last 100+ years it has been more than 5 GL, and half the time less (CSIRO 2008). Again, climate change impacts need to be incorporated to guide planning.

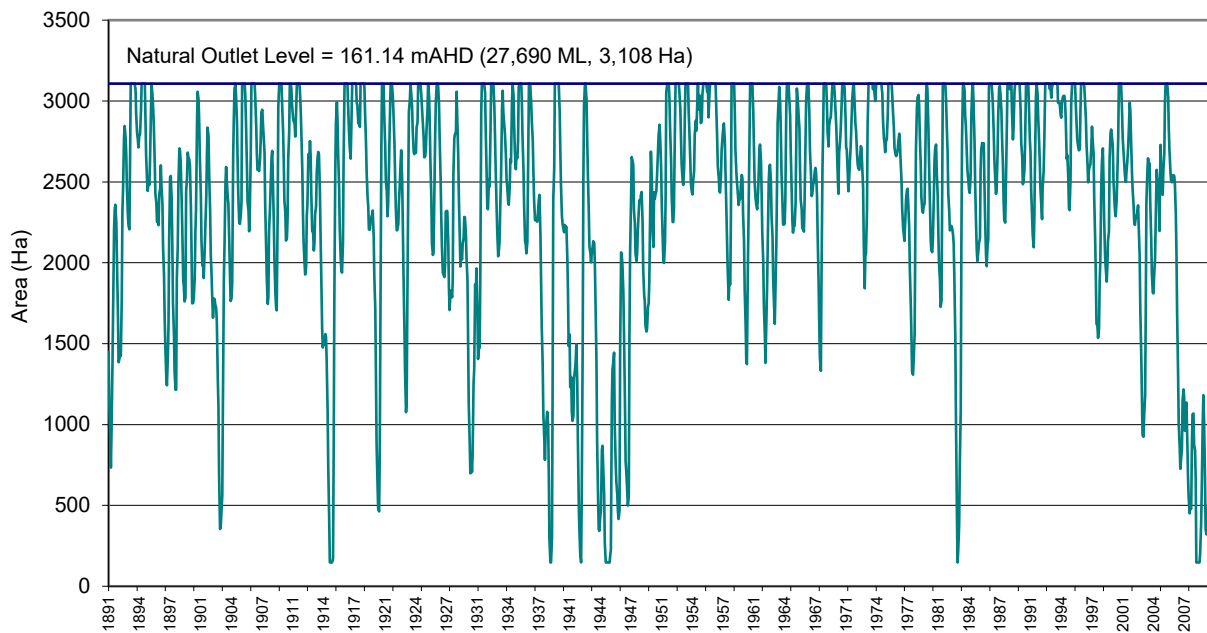


Figure 11: Modelling from the Goulburn Simulation Model illustrating the relationship between wetland area at Winton Wetlands and recorded long-term rainfall (1981–2010). (Source: DSE 2011).

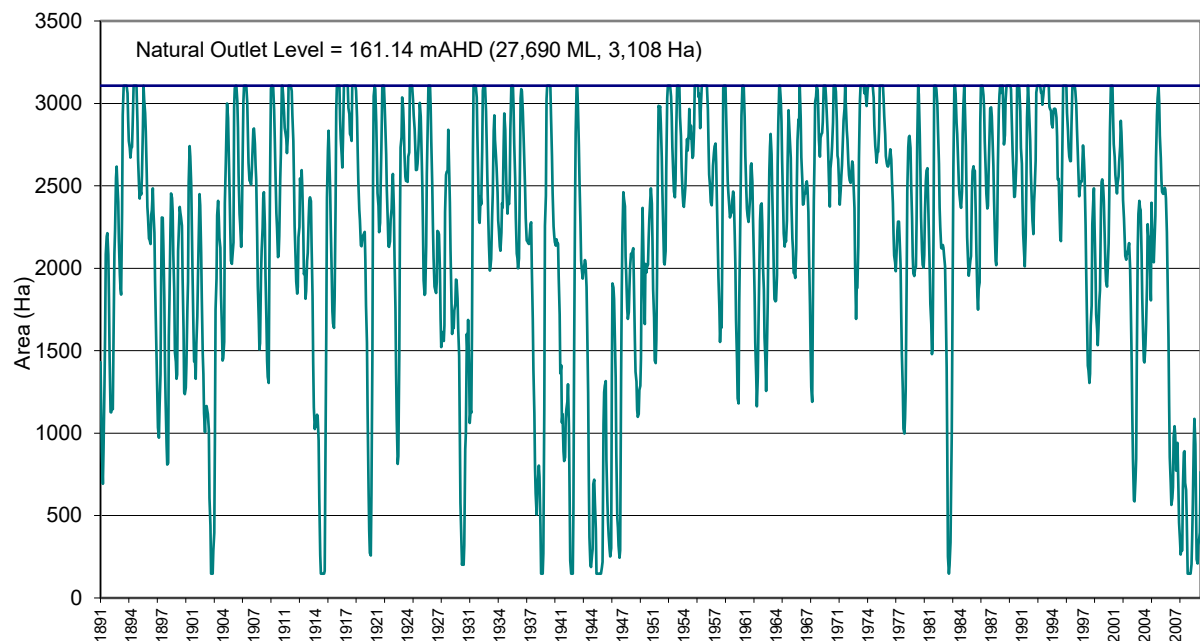


Figure 12: Modelling from the Goulburn Simulation Model illustrating the relationship of wetland area at Winton Wetlands to rainfall using a 2030 median climate change scenario (4% reduction in rainfall, 13% reduction in run-off), i.e. what would have happened at Winton if the predicted future climate applied in the past. Notice the number of times (almost x2) the Swamp is effectively dry (Source: DSE 2011)

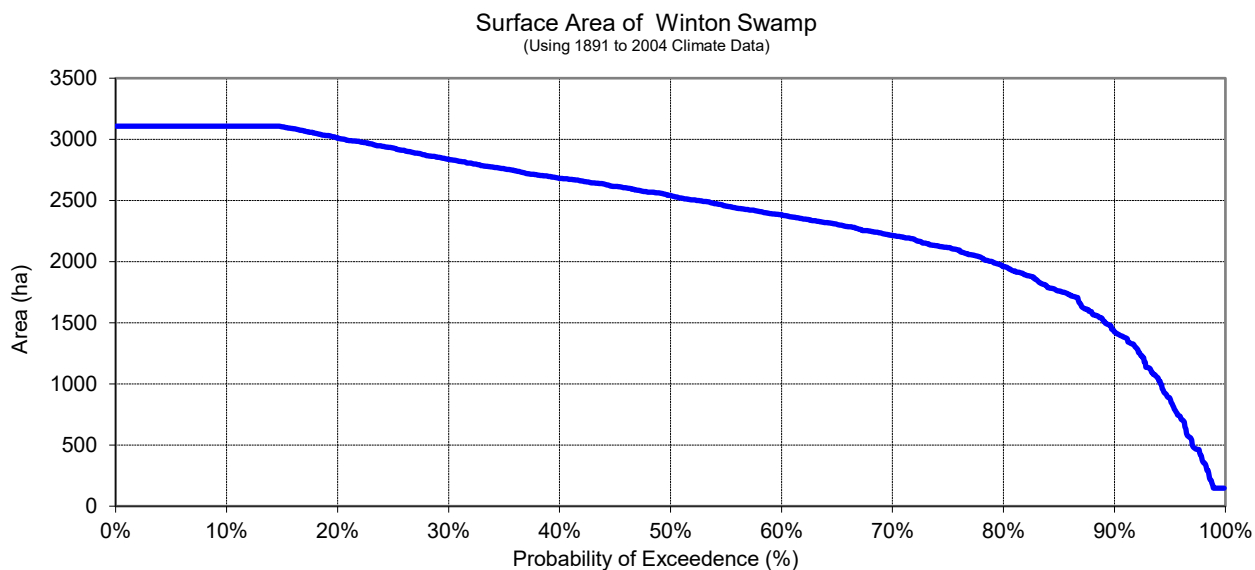


Figure 13: Probability of exceedance for Winton Wetland area (i.e. the likelihood that at any point in time of the area covered by water) (Source: DSE)

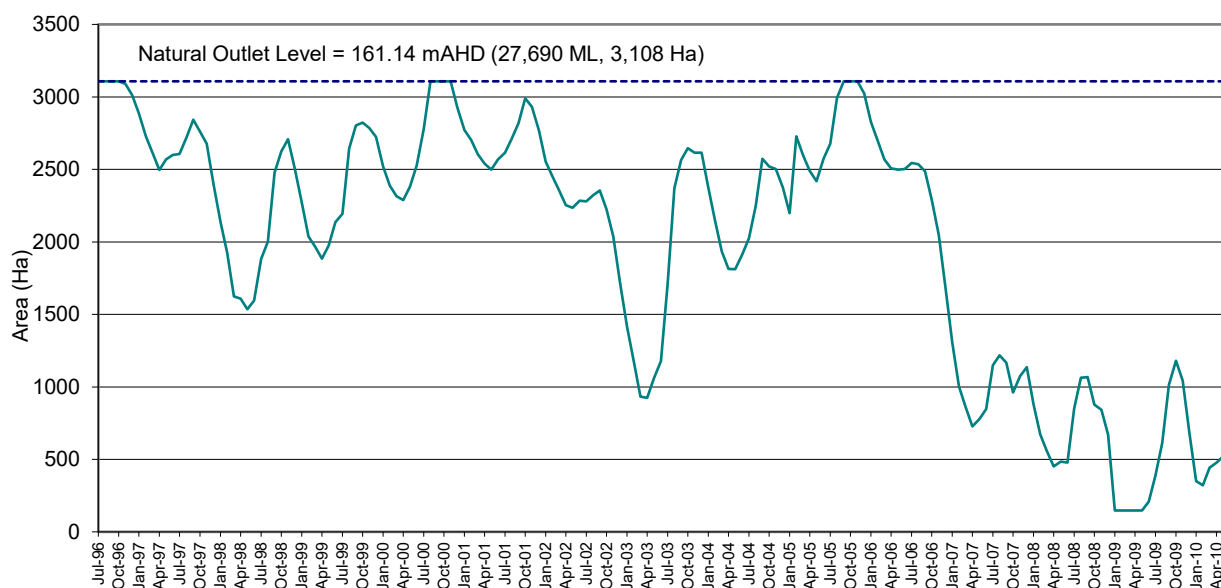


Figure 14: Modelled seasonal variation in wetland area between 1996 and 2010 (Source: DSE 2011)

On a visual level, this modelling suggests for 50% of the time the shoreline at the end of May will be at least 300-400 m out from high water mark when viewed from the car park on Mokoan Road (and of course, closer for the other 50% of the time).

A reduction of approximately 500 ha in wetland area is anticipated for ‘average years’ (Figure 14) (although noting that averages in a climate marked by variability can be deceptive) represents a drop in water level of some 30–40 cm (GMW-provided data). The implications for littoral vegetation requires further investigation, but suggests it will need to be relatively

robust to deal with fluctuating water levels. It is, however, a regime conducive to the development of Southern Cane-grass (*Eragrostis infecunda*), which is well adapted to such conditions and has previously dominated large areas at Winton Wetlands (Aston 1962).

Typically for a much-cleared catchment, creeks and other minor waterways flowing into Winton Wetlands are much scoured due to stock trampling banks and beds, and accelerated run-off velocities. Riparian vegetation is mostly degraded, with only a narrow strip of trees a few metres wide with few shrubs for most of the length. Such conditions continue to compromise water quality entering the Wetlands.

The Inlet Channel which carried water diverted from the Broken River to Lake Mokoan will continue to provide some inflow from the local catchment particularly during flood events. Recent observations indicate that water quality in Winton Wetlands is impacted by turbid water in the Inlet Channel.

4.5. Threat analysis and response

An expert workshop held in April 2011 identified a number of major issues which if left unaddressed could threaten the integrity and maintenance of ecological function of Winton Wetlands. These are listed in Table 4, using a 'likelihood x consequence = risk level' approach. A management response to mitigate the threat is provided, and a second level of risk is then subjectively determined based on the changes in likelihood and/or consequence considered likely as a result of effectively implementing the appropriate response.

Such matrices are not definitive as there is a good deal of subjectivity involved, and it is assumed that management responses have the desired outcome (i.e. ignoring externalities such as weather). This matrix is included here as a point of discussion and it is expected that it will be modified with review.

They do, however, provide a good framework for discussion, and for making rational decisions about priorities for action. For example, even though the likelihood of a major toxic chemical spill entering the wetland is 'rare', the consequences could be catastrophic, and thus presents a 'high risk' to the wetlands. Ensuring that relevant authorities understand the consequences and risk through discussions, and implementing any required works to reduce the chances of a spill entering the system, reduces the risk to very low and is therefore considered to be a very effective course of action.

Table 4: An assessment of major threats to ecological function at Winton Wetlands, and subsequent risk (Risk 2) following mitigation response

Threat	Likelihood	Consequence	Risk 1	Response	Likelihood*	Consequence*	Risk 2*
Invasion and spread of exotic grasses (e.g. Phalaris and Paspalum) displaces native species and reduces habitat diversity	Certain	Major	Extreme	Implement spring grazing in designated 'at risk' areas. Spot control with herbicide and revegetation. Revegetation of problem areas	Likely	Moderate	Moderate
Predation by fox and cat substantially reduces breeding success of fauna	Likely	Major	Very high	Implement fox/cat control programs. Enhance habitat complexity	Occasional	Moderate	Moderate
Toxic chemical spills from rail/road enter waterways	Rare	Catastrophic	High	Work w transport authorities, EPA, CFA to highlight risk; ensure no direct discharge from transport corridors into waterways	Remote	Moderate	Very Low
Over-abundant carp impact biodiversity and water quality	Likely	Major	Very High	Install and maintain carp-trap at Boggy Creek Bridge and Sergeant's Outlet. Survey catchment for source populations. Implement eradication during drought. Introduce native predator/competitor fish species	Occasional	Major	High
Turbid and nutrient-rich water quality entering wetland via Inlet Channel &/or other tributaries	Occasional	Major	High	Minimise acceptance (weir); establish aquatic bio-filtering in channel	Rare	Severe	Moderate
Significant aquatic weed invasion	Likely	Major	Very High	Surveillance and immediate control action	Rare	Major	Moderate
Natural regeneration failure across the landscape	Occasional	Major	High	Research possible causes (e.g. soils); undertake aerial/direct seeding; expand revegetation programs	Rare	Moderate	Low
Excessive wildfire compromises vegetation development	Rare	Major	Moderate	Engage with CFA and DSE. Manage biomass. Implement fire management plans	Rare	Moderate	Low
Lack of connectivity w downstream aquatic systems	Certain	Severe	Very high	Install fish ladder at Sergeant's Swamp Outlet	Occasional	Minor	Low
Structure and diversity of native vegetation compromised by invasion and spread of woody weeds	Certain	Major	Extreme	Implement woody weed control program. Establish indigenous shrubby layer	Moderate	Minor	Moderate
Hares, rabbits and macropopds over-grazing revegetation and natural regeneration	Likely	Major	Very high	Implement rabbit and hare control programs	Occasional	Minor	Low
Overgrazing by native herbivores compromises natural regeneration	Rare	Moderate	Moderate	Monitor populations, control as necessary	Rare	Minor	Very low

Likelihood	Consequence				
	1 Minor	2 Moderate	3 Severe	4 Major	5 Catastrophic
6 Certain	6 moderate	12 high	18 very high	24 extreme	30 extreme
5 Frequent	5 moderate	10 high	15 very high	20 very high	25 extreme
4 Likely	4 low	8 moderate	12 high	16 very high	20 very high
3 Occasional	3 low	6 moderate	9 moderate	12 high	15 very high
2 Rare	2 very low	4 low	6 moderate	8 moderate	10 high
1 Remote	1 very low	2 very low	3 low	4 low	5 moderate

Likelihood	Descriptor	Consequence	Descriptor
Certain	Event or process is currently occurring, ongoing, or at least annually	Catastrophic	Significant, lethal impact to biota at a large scale (system-wide), recovery to pre-impact conditions likely to take several decades
Frequent	Event or process is expected (Pr>80%) to occur over management time-frame (1–3 years)	Major	Substantial detrimental impact to localised (not system-wide) flora and fauna populations and habitat suitability. Decades to redress impact
Likely	Event or process may (Pr>50<80%) occur over next 1–3 years	Severe	Substantial but short-term impact to localised populations/habitat. Negligible effects detectable within a decade
Occasional	Event or process <50% chance of occurrence over next 1–3 years, but likely (>50%) to occur within next 10 - 15 years	Moderate	Noticeable impacts to populations/habitat; temporary impacts and recovery within 1–2 years
Rare	Event or process <50% chance of occurrence over next 10–15 years	Minor	Impacts detectable; recovery occurs within a year
Remote	Event or process <5% chance of occurrence over next 10–15 years		

5. Restoration and Monitoring Approaches

5.1. Ecological Restoration – Conceptual Models for Winton Wetlands

Conceptual models provide an easily understood means of illustrating the important components of an ecosystem, the interactions involved, and further help to identify meaningful management interventions and important monitoring targets. Conceptual models also help define, in a logical sequence, causal links between ultimate targets (e.g. resource condition), ecosystem processes (or functions) assets, indirect threats, direct threats, opportunities and interventions.

A conceptual model has been developed to guide both woodland and wetland restoration (Figure 15 and Figure 16). Key components of the model are categorised as Drivers (boxes), Stressors (circles), Effects (scrolls) and Attributes (hexagons), following the approach used by Ogden *et al.* (2005) for the Florida Everglades Restoration Program. The model presented depicts the system at the highest/broadest level to guide the overall restoration plan, and can be further refined for sub-systems. For example, there is obviously much more detail that can be described for the relationship between vegetation composition, habitat and fauna populations. A ‘state and transition’ model (Figure 17) drawing on work by Yates and Hobbs (1997) and Rumpff *et al.* (2011) is included to provide an additional means of understanding condition states, stressors and effects on the woodland system, and identifying appropriate management interventions.

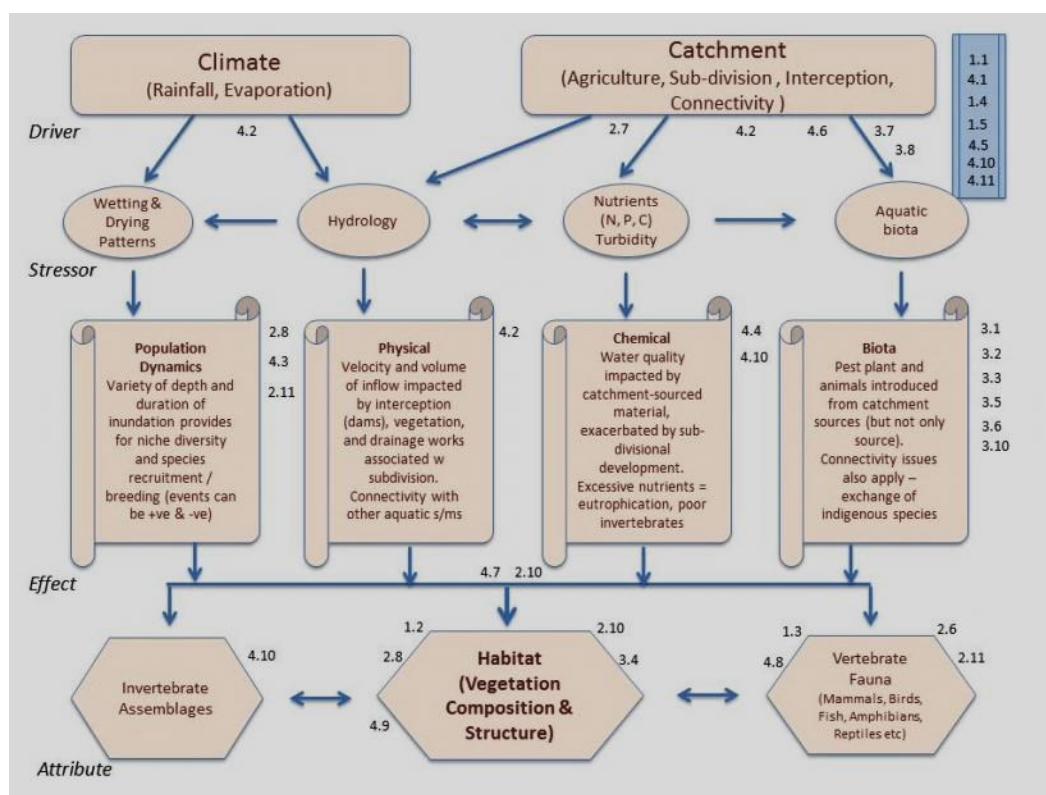


Figure 15: Conceptual model for restoration of ecological function of wetlands at Winton Wetlands Reserve. Objectives, as numbered in the text, are shown where they best sit within the model, thus illustrating the logic between the objective, the restoration program, and ecological attributes. Objectives shown in the blue box (top right) are considered to be ‘global’, and apply right across the models

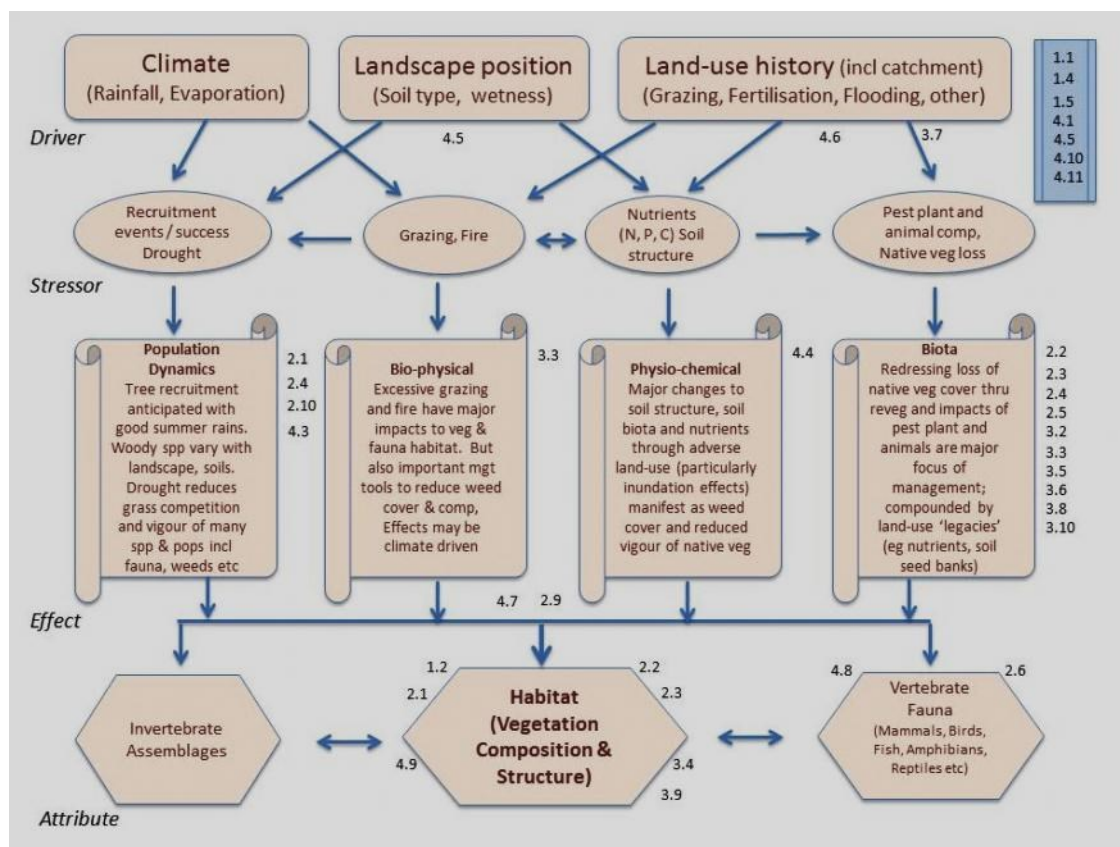


Figure 16: Conceptual model for restoration of ecological function of woodlands at Winton Wetlands Reserve. Objectives, as numbered in the text, are shown where they best sit in the model, thus illustrating the logic between the objective, the restoration program, and ecological attributes. Objectives shown in the blue box (top right) are considered to be ‘global’, and apply right across the models

The state and transition model (Figure 16) is presented to conceptually explain, in a generalised manner, how different ‘condition states’ of vegetation have occurred at Winton Wetlands, and how different recovery pathways may be applied. For example, inundation of the original native vegetation (or vegetation simplified by agricultural use) has resulted in what we are calling ‘Drowned Oldfield’ – areas with a dead overstorey but with a reasonable native understorey. The suggested return pathway for this vegetation is by removal or strategic management of grazing, coupled with some augmentation plantings owing to the relative absence of a seed source.

At the other end of the scale of vegetation degradation is exotic/improved pasture. The model indicates that it is a long route back from this state towards that resembling ‘relatively intact’, and must be initiated with an intensive revegetation program. That is, removal of grazing from these areas will have no positive impact on vegetation condition. For this reason, this plan recommends grazing be continued in such areas. The model also indicates that given a choice, more effective ecological outcomes are achieved if revegetation (or assisted regeneration) is targeted at better quality areas, rather than completely degraded areas. This does not imply however that revegetation of degraded areas is unwarranted.

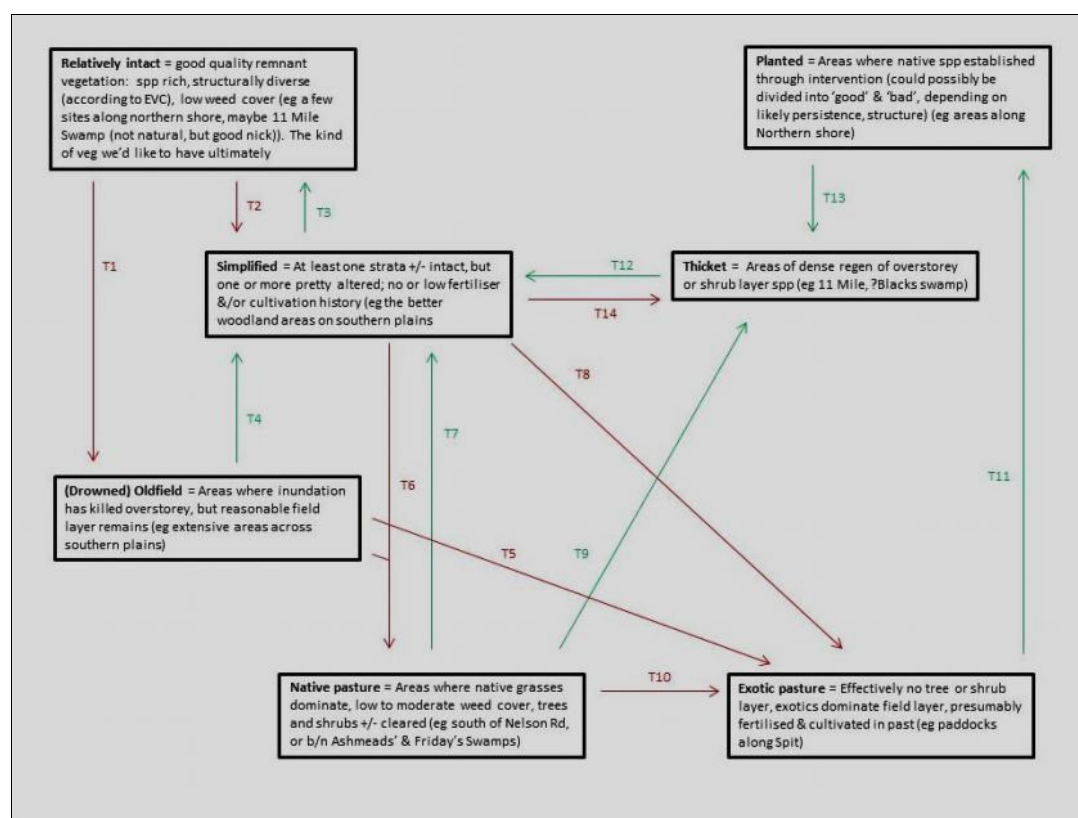


Figure 17: State and transition model illustrating the range of 'condition states' occurring across the woodland zones at Winton, and transition pathways between states (see below). Green pathways designate a positive trend in vegetation condition, red is negative (after Rumpff et al, 2010).

Transition pathways:

- T1 +/- permanent flooding of terrestrial and swampy woodlands
- T2 lightly grazed &/or some clearing, no cultivation or fertiliser (at least for many decades)
- T3 Removal or strategic management of grazing to get natural regeneration
- T4 T3 + some augmentative planting as there is likely to be no resource for woody spp.
- T5 cultivation or fertiliser, or lack of grazing where invasive pasture spp. (e.g. Phalaris) present
- T6 tree clearing/senescence, grazing, but no fertiliser
- T7 as per T3 & T4
- T8 T5 + T6
- T9 grazing removal or specific disturbance resulting in mass germination, but possibly 'stall' in growth after a few years
- T10 T5
- T11 Direct seeding & tube-stock planting of native spp.
- T12 Thinning of saplings through either intervention or natural processes to allow recruitment/revegetation of understorey spp.
- T13 T11 typically results in a thicket a few years after planting, followed by thinning as different strata filled
- T14 invasion by exotic woody species

5.2. Ecological Monitoring

Monitoring is the regular assessment of the condition or state of particular attributes/indicators, in this case selected because they are considered to be informative of trends in ecological function at Winton (see section 2.1), and/or provide information relevant to management effectiveness. Monitoring can be considered on a spectrum from 'targeted' or 'surveillance'; the former being associated with a specific management question or testable hypothesis, while the latter is a more general information-gathering exercise, with expected benefits not always predictable beforehand (Wintle *et al.*, 2010). Surveillance monitoring (e.g. recording bird species at Winton Wetlands) is amenable to community involvement. Targeted monitoring (e.g. 'why is species x declining in number?') requires a more rigorous approach to design and implementation.

Monitoring is an essential component of any ecological restoration or management program. Without it there can be no improvement in understanding of the values and function of the system, and no feedback to guide or inform management effectiveness. Despite this, numerous authorities claim that monitoring is rarely done properly for a variety of reasons such as poor design, too coarse (qualitative), poorly targeted, trying to do too much (and therefore poorly due to limited resources), inconsistent approaches and methodologies, loss of key personnel/leadership, and poor data management (Legg and Nagy 2006; Field *et al.*, 2007; Lindenmayer and Likens 2010).

The formulation of conceptual models that attempt to explain our current understanding of the system or issue of concern is an important component of monitoring (e.g. impacts of grazing on vegetation quality, initiation of breeding events, effectiveness of fox control programs). The conceptual models presented in Section 5.1 are not of sufficient resolution to target specific issues, but are intended to be relevant at the system level. Individual conceptual models will be developed to identify key issues and knowledge gaps to be addressed by monitoring as specific monitoring programs are developed (as outlined below).

A relevant model for monitoring at Winton Wetlands is provided by McCarthy *et al.* (2006) for the Barmah Wetland System. They developed monitoring programs, including conceptual models and detailed methods and costs, for a range of indicators (fish, frogs, vegetation, etc.) relevant to management objectives for Barmah. Baldwin *et al.* (2005) provide information on methodologies (including data management), which if adopted at Winton Wetlands, will assist comparisons with other wetlands in the Murray-Darling Basin, and contribute to the greater regional knowledge base.

The following sections provide an overview of restoration approaches for wetland and woodland ecosystems at Winton, and indicate matters to be monitored or where further information is required. Because of the importance of scientific rigour, and the inherent risk of wasting resources on poorly designed monitoring programs, it is recommended that monitoring issues be refined by inviting a specialists in nominated areas to collaboratively develop specific monitoring plans for each issue. A collaborative approach is recommended to produce plans that are consistent, complementary, flexible and efficient.

The WWCoM needs to be able to answer the question: ‘Is ecological function improving?’ To this end, multiple lines of evidence must be derived from the monitoring program. Indicators of improving ecological function will be shown by:

- Water quality parameters (particularly nutrients and turbidity) are within acceptable limits for natural aquatic ecosystems
- Soil nutrients (particularly N and P, and organic Carbon) decrease to within acceptable limits for soils typical of comparable remnant vegetation
- A sustained reduction in the cover and abundance of *Phalaris* and *Paspalum*
- A sustained increase in the cover of indigenous perennial grasses (*Southern Cane-grass* being an indicator species)
- Wetland vegetation adapted to ephemeral conditions, and providing structural diversity for macro-invertebrates
- Recruitment of River Red Gum in appropriate locations
- An increase in the structural diversity of woodland vegetation, indicated by an increase in the diversity and abundance of woodland birds
- An increase in the abundance of frogs, microbats and Rakali Long-necked Turtles
- An appropriate diversity of native fish species, and reduction in exotic fish numbers
- Breeding by colonial water birds

5.3. Hydrology

Key points:

- *Winton Wetlands is a rain-fed ephemeral ecosystem – it will be dry occasionally but flora and fauna will be adapted to this regime*
- *Historical modifications to internal drainage need to be reviewed*
- *Data is required to validate the GSM-derived hydrology model*

The establishment of a new sill level of 161.14 m AHD at the outlet of Sergeant’s Swamp, approximating pre-Mokoan conditions (at least for level, if not for physical form) has been a major initiative for reinstating a more natural hydrological regime at Winton. The above-average rainfall for 2010, and subsequent high volume of inflow has illustrated the capacity for rapid response given adequate conditions (see cover photo).

Winton Wetlands will continue to be a rain-fed system, relying on run-off from the local catchment for in-flows. Outflows will remain unregulated. Available information on the likely hydrological regime is derived from the Goulburn Simulation Model (DSE modelling for Water Supply Demand Strategies, July 2011). This needs to be validated by purpose-specific data to improve the model and provide more accurate guidance for management.

The WWCoM has a Water Right enabling it to purchase 22 ML annually, to be sourced from the Broken River system. This represents less than 0.07% of total storage and will thus have no impact if used to augment water levels in the swamps. The intended use is for amenity servicing around the boat ramp/yacht club area, but if desired some or all could be diverted to the ‘Duck Pond’, where it may have some effect on water levels.

There are a number of instances where internal drainage within the wetlands, particularly in the North East Swamps Unit, has been modified presumably to improve agricultural capability prior to the establishment of Lake Mokoan. This has both increased (e.g. at Friday's Swamp) and decreased (e.g. at Humphries' Swamp) the inundation regime at various ephemeral wetlands and interrupted overland flows to the detriment of wetland vegetation. An assessment of the extent, likely impacts, and restoration possibilities should be conducted by recognised experts in the field of wetland ecology and hydro-engineering.

Restoration:

Internal hydrology

- Assess the extent, impacts, and restoration options (if appropriate) of historical modifications to internal hydrology

Monitoring:

to validate/improve existing hydrology model.

- Data loggers to be installed to provide real-time data on inflows and outflows. Nearest evaporation data is at Dookie (BoM), rainfall at Benalla, rainfall intensity at Wangaratta. Investigate feasibility of re-launching Mokoan weather station recorder.

5.4. Water Quality

Key points:

- *Nutrient and turbidity levels are key drivers of ecological function; elevated levels were previously a problem at Lake Mokoan and catchment sources and influences are likely to still exist*
- *Toxic spills are a remote but potentially catastrophic risk to be addressed*
- *Turbidity in Inlet Channel needs to be addressed*
- *On-going monitoring of water quality parameters, including community-based approaches such as 'Waterwatch'; complex issues will require specialist attention*

Water quality is a key component of wetland ecological function. Poor water quality can reduce biological activity, limit community structure, and influence interdependencies amongst taxa. In some cases, it can lead to lethal conditions through blue-green algae outbreaks and low levels of dissolved oxygen in the water column. In sufficient quantities, high levels of phosphorous and nitrogen in in-flows can cause profound changes to wetland ecology, which can be difficult if not impossible to reverse (e.g. Bachmann *et al.*, 1999; Conley *et al.*, 2009), a situation experienced at Lake Mokoan (Lloyd 1998; Davis and Koop 2006).

The potential effects of elevated nutrient concentrations are compounded by turbid (muddy) water, as less light is transmitted through the water column inhibiting macrophyte

growth. Problematic bacteria are able to move to the high light zones (near the surface) and so are not limited by low light. Furthermore, muddy water warms more quickly than clear water.

The Rural Water Commission, Goulburn Region, precursor of Goulburn Murray Water, established the Lake Mokoan Technical Reference Group in the early 1990's to assist with the management of water quality issues in Lake Mokoan, particularly turbidity and blue-green algae outbreaks. The TRG initiated a number of investigations (eg Anon, 1994; Halliwell, 1997; I.D. & A. P/L and Water ECOscience, 1998) to better understand the sources and resolutions of water quality problems. This work included in the construction of small wetlands (e.g. the 11 Mile Creek Wetland) in an attempt to strip nutrients and/or reduce turbidity, and a Catchment Action Plan (Loone *et al.*, 1996) to mitigate catchment influences on water quality. Work included spot sampling of minor tributaries (Halliwell 1997) to identify the more problematic inputs, with those on the NE & NW sides of the lake considered extremely degraded, although relatively minor terms of total volume inputs.

A review of these investigations, and the efficacy of implemented works, should be a high priority for management. The aim is to develop a comprehensive understanding of the sources, loads, and behaviour of nutrients and turbidity. Winton Wetlands is now a much more 'closed' system than the previous Lake Mokoan where greater through-flow occurred. Thus it is likely that even if nutrient inputs (concentrations and loads) are reduced, they may be accumulating within the wetland system. Where problems within the catchment are identified, WWCoM will need to work with the GBCMA and other land-managers on mitigation.

Turbid water can enter Winton Creek via the old Inlet Channel, which traverses highly dispersive soils. A regulated weir is present at the end of the Channel; this should be managed (opened a fraction) so as to provide gradual drawdown and allow aquatic vegetation to establish in the channel bed. Turbidity is partly being addressed by Benalla City Council, which has initiated a revegetation program on the banks of the Inlet Channel. This program should be expanded to cover both the bed and banks for the length of the Channel to minimise soil/water contact.

There is potential for Benalla Rural City to utilise the Inlet Channel for stormwater discharge from the north-east parts of Benalla. Any plans should consider the feasibility of installing permeable barriers or retention ponds to maximise retention time and improve stormwater quality.

A water quality monitoring program ('Waterwatch') has been recently initiated at Winton Wetlands. Surveillance is required to ensure that nutrient concentrations which led to declines in water quality at Lake Mokoan are not being repeated. It is acknowledged that specialist services will be required for specific water quality monitoring matters (e.g. as part of rigorous scientific investigations).

Three issues require close attention:

- turbid water entering the system via the old Inlet Channel,
- nutrients in the catchment (from crops, sewage etc) mixing with run-off and accumulating in the system, and

- the potential for toxic chemical spills from rail and road transport entering waterways.

Restoration:

Inlet Channel:

- Work with Benalla Rural City to revegetate aquatic zone within the Channel, noting that the banks for part of the length have been reshaped and revegetated.
- Keep the outlet valve on the Channel regulated so as to allow gradual drawdown between storm events to facilitate the establishment of appropriate aquatic vegetation.
- Investigate feasibility of modifying the Inlet Channel with a series of vegetated retention ponds to allow for improvements in water quality prior to entering the wetlands.

Catchment nutrients:

- Review work conducted for GMW in the 1990's on catchment influences on water quality, and the efficacy of mitigation measures.
- Work with the GBCMA to prioritise riparian vegetation in the catchment to provide nutrient buffers and control stock access
- Identify and redress potential point sources of nutrients such as septic outfalls that may be entering waterways
- Engage with catchment farming community to increase understanding of risks to aquatic systems from nutrient inputs.

Chemical spills:

- Commission a survey to map relationships between local streams and runoff from road and rail networks, with a view to understanding the potential for high-risk toxic spills into waterways
- Work with relevant agencies (EPA, Benalla City, VicRoads, V-line, CFA, etc.) to identify and understand risks, and develop emergency response protocols designed to protect Winton Wetlands.

Monitoring:

To better understand the water quality profile of tributaries, including macrophyte and macroinvertebrate communities, and risk of potential negative outcomes (e.g. blue green algal outbreaks, include data on:

- macroinvertebrates
- macrophytes
- Turbidity
- Electrical Conductivity (salinity)
- Dissolved Oxygen
- pH
- Phosphorus and nitrogen
- Temperature.

5.5. Wetland (aquatic and littoral) Vegetation

Key points:

- *Regenerating wetland vegetation is an expression of the seasonal wetting and drying regime, and may take some time to 'stabilise', or exhibit clear patterns.*
- *It is anticipated that Southern Cane-grass will eventually be a feature of aquatic vegetation*
- *Invasion by aquatic weeds is an on-going risk requiring surveillance.*

Wetland vegetation provides a host of ecosystem services to the wetland system: oxygenation of water, nutrient uptake, wave dampening to limit shore erosion and sediment re-suspension, and of course habitat and food for a wide range of invertebrate and vertebrate fauna.

As predicted by Carr and Conole (2006), there appears to be little need for extensive intervention to restore wetland vegetation, as demonstrated over the past year where filling of the wetland has enabled extensive areas of a number of Ecological Vegetation Classes to develop. These EVCs are Plains Rushy Wetland, Tall Marsh, Aquatic Herbfield, Red Gum Swamp, Cane-grass Wetland and Plains Grassy Wetland. Collectively, these EVCs, particularly the more aquatic/littoral ones, have been described as 'high-speed temporal mosaics' (Doug Froot, pers. comm), shifting in space and composition in response to the depth and periodicity of flooding.

The dynamic nature of this vegetation will continue with the fluctuation in water levels expected over time (Section 5.1). The composition of wetland vegetation will be an expression of the varying hydrology. It is noted, however, that this harsh wetting and drying regime is conducive to the establishment of Cane-grass; Cane-grass Wetland being a major EVC at Winton prior to the establishment of Lake Mokoan (Aston, 1962).

Roberts *et al.* (2010) developed a monitoring program, subsequent to a review of earlier monitoring (2007–2009) to document dynamics of littoral vegetation at Winton, in particular recruitment of Southern Cane-grass and River Red Gum, two species of major structural importance at Winton, as well as quantitatively recording cover and abundance of all species occurring within 10m x 10m quadrats. This program should be continued, modified according to the requirements of the collaborative monitoring program mentioned in Section 5.2.

Augmentation of the composition of some EVCs through the planting of absent or impoverished species (e.g. *Alisma plantago-aquatica*, *Eleocharis sphacelata*, *Triglochin procera/multifructa*) may be desirable. This matter requires further investigation to compile an inventory of what should be, but isn't present.

The scarcity of live, seed-bearing River Red Gum trees throughout the system suggests that seed availability will limit recruitment, and should be augmented through tube-stock planting and aerial seeding in strategic locations (see Section 5.6). It is noted that natural regeneration is already occurring, sparsely, across the site.

As a general rule, wetland plants are readily dispersed by a number of agents (water, wind, birds, etc). These dispersal modes will assist the introduction of both indigenous and exotic

species. In comparison to terrestrial vegetation, there are relatively few wetland/aquatic weeds but those that do exist are extremely problematic with few control options available, especially at a large scale. Cabomba (**Cabomba caroliniana*), Arrowhead (**Sagittaria platyphylla*), Elodea (**Elodea canadensis*) and Egeria (**Egeria densa*) are four major aquatic weeds which have known populations within c.50 km of Winton and management will need to maintain diligent surveillance to ensure that populations do not establish at Winton. Woody weeds such as Willows (**Salix spp.*), Poplars (**Populus spp.*), and River She-oak (**Allocasuarina cunninghamiana*) occur sporadically around wetland margins and require management. Phalaris (**Phalaris aquatica*) remains the most insidious threat to wetland ecology. Currently, there are isolated patches around swamp margins and these should be eradicated as a matter of priority. Note that these issues are dealt with in detail in the Winton Wetlands Pest Plant Management Plan (GreenAcres 2011).

Restoration:

Species enrichment:

- Develop an inventory of desirable but currently absent wetland flora with a view to reintroduction at Winton Wetlands as appropriate
- Undertake tube-stock planting of River Red Gum around accessible swamp margins (Friday, Ashmead's and Humphries') and aerial seeding in larger areas (e.g. Green's Swamp, Boggy Bridge Swamp, North east Swamps, Winton Swamp (margins only).

Pest Plants:

- Develop a list of 'extreme threat' aquatic weed species and initiate control actions as soon as any populations are detected.
- Implement on-going control of wetland woody weeds as per Winton Wetland Pest Plant Management Program.

Monitoring:

To better understand development in vegetation composition in Red Gum Swamps and littoral vegetation; to document recruitment of River Red Gum and Southern Cane-grass; to detect weed invasions

- Establish permanent transects and photo-points at selected locations on the littoral zone and in Red Gum swamps to record cover and abundance of wetland vegetation on an annual basis (e.g. November each year), particularly recruitment of Southern Cane-grass and River Red Gum.
- Conduct seasonal surveillance monitoring to identify and document any incursions of designated high priority aquatic and terrestrial weeds.

5.6. Terrestrial Vegetation

Key points

- *Restoring woodland and grassland vegetation is a major long-term challenge; the issue is discussed below in 9 sub-sections*
- *Guiding principles are provided*
- *The challenge is of a magnitude requiring a dedicated vegetation officer to plan and co-ordinate implementation*
- *A GIS is to be developed to provide small-scale detail on vegetation restoration (where, what, when, resources).*

Restoration of the terrestrial vegetation at Winton Wetlands is one of the major challenges facing management. Owing to a history of firstly agricultural use (grazing and occasional cropping in parts) and subsequently inundation to varying depths and frequency during the life of Lake Mokoan, there is substantial degradation in edaphic conditions and indigenous vegetation quality across much of the site. The impacts of this, and possible return pathways, on terrestrial vegetation are represented in the woodland state and transition model (Figure 17).

A number of approaches to restore terrestrial native vegetation are described below. Specific details on species suites for specific sites according to the appropriate Ecological Vegetation Class, and including timing and costs, are provided in a dedicated GIS to be developed forthwith. Corr (2003) provides detailed information in a technical manual of revegetation techniques should this be required for implementation purposes, however it is strongly recommended that revegetation programs be led by an experienced practitioner. Similarly, Rawlings *et al.* (2010) provide an excellent resource for understanding the principles and practices of managing and restoring woodlands. They highlight the importance of utilising different approaches according to site quality (e.g. natural regeneration will not occur in a sea of *Phalaris*)

The following over-arching principles are provided to guide restoration of terrestrial vegetation:

- Focus on improving the quality, structural diversity and extent of better quality vegetation as a priority
- Manage to enhance potential for natural regeneration where practical
- Use the relevant EVC as a reference for species selection in revegetation
- Emphasise use of ‘pioneering’ and structurally important species in initial revegetation work
- ‘Untidy’ habitat is good habitat: retain litter, and fallen branches
- Develop techniques to reduce soil nutrient levels to limit the competitive advantage of weeds
- As a general rule, minimise soil disturbance to limit opportunities for weed invasion
- Always follow-up weed control with direct seeding and/or hand-planting of appropriate native vegetation.

5.6.1. Natural regeneration

Key points:

- *Natural regeneration is the preferred approach given the area involved, but will need to be augmented with additional approaches given relative absence of seed-bearing trees.*

Natural regeneration (recruitment) is the preferred approach for re-establishing vegetation cover across the site. Although lacking the immediate visual impact of direct seeding or tube-stock planting, it has the following advantages:

- A diversity of age-classes is established – important for structural and habitat diversity, future recruitment potential and landscape aesthetics
- Plants establishing are obviously adapted to local conditions (genetically appropriate) and usually growing vigorously
- It's cheap and requires little to no labour, and is often the most viable approach across large areas.

But there are limitations:

- Regeneration is limited by inadequate seed supply (lack of source populations/species)
- Dry summers and grass competition have strong negative effects on establishment success
- Grazing of seedlings, or destruction of seed, by stock or other herbivores, including invertebrates
- All favourable factors - flowering, seed dispersal, conditions at receival sites (especially soil moisture and competition for space), season and rainfall - must align to produce a 'recruitment event' (i.e., not often).

The substantial rains of 2010 followed a prolonged dry spell. This meant River Red Gum seedlings had less competition for space and other resources with grasses and accumulated litter. These circumstances have enabled a recruitment event and young River Red Gum seedlings are evident in a number of areas, particularly in littoral zones. While obviously welcome, such recruitment is not expected to occur on an annual basis. Furthermore, the relative absence of parent trees across the site is a substantial limitation on natural recruitment.

Grazing is restricted to existing grazing licensed areas. Short-term, high intensity grazing can be used to assist opportunities for recruitment by reducing plant competition and should be considered as an appropriate management tool for ecological outcomes (further discussed in Section 5.6.7). Set-stocking (continuous grazing), however, is an anathema to natural regeneration and the persistence of perennial forbs and grasses (Dorrrough *et al.*, 2004).

In addition to difficulties predicting the timing of natural regeneration events, it is also difficult to predict where suitable conditions will occur spatially. As a general rule, native plant regeneration is highly unlikely to occur in thick grassy swards, suggesting that at Winton it is more likely to occur in open areas along the Northern Shore, Southern Plains (particularly on lighter soils), Green's Ridge, and areas around 11 Mile Wetland. The tussocky nature of Plains Rush stands around the margins of Winton and Sergeant's Swamps, and Green's Swamp, appear to also afford opportunities for recruitment of River Red Gum, based on current observations.

5.6.2. Direct Seeding (aerial and ground-based)

Key points:

- *Use to augment natural regeneration: a number of techniques are suggested, depending on site context.*

Direct seeding either by aerial (e.g. helicopter) or ground-based machine or hand-based approaches can be used to augment limited seed supplies for natural regeneration, although success will still be dependent on other establishment factors.

Direct seeding by helicopter is a well-established silvicultural practice: experienced operators are able to place known amounts of seed in exact locations. It is usually limited to application of eucalypt seed, but other seed can be dispersed manually from the helicopter where seeding rates and locations aren't as critical.

It is recommended that heli-seeding approaches be trialled in remote areas at Winton, for example at Green's Swamp, the southern shores of Winton and Sergeant's Swamps, and northern parts of the Southern Plains. Seeding should aim for low woodland densities of c. 50 plants per ha to allow space for future recruits and bough formation (Vesk *et al.*, 2008). Seeding should be timed to occur during strong *La Nina* weather patterns when the chance of summer drought-stress on young seedlings are less (Huth *et al.*, 2008), in either late spring or early autumn.

Mechanical direct-seeding using vehicle-towed seeders is widely used in moderate-sized revegetation projects and has good potential for deployment at Winton where vehicle access is possible. Customised seed mixes can be placed with a high degree of accuracy into prepared sites (preparatory weed control being essential). A good success rate can be achieved if follow-up rains and weed control are provided. Techniques are well-understood by practitioners and are not further discussed here.

The mechanical direct seeding approach is most applicable in weedier sites where weed control is unlikely to impact native understorey, and potential for more natural means of establishment are minimal. The Warby Range Landcare Group has undertaken a direct-seeding trial in the vicinity of 11 Mile Wetland. This was initially thought to be a failure due to drought, but plant establishment since the rains of 2010 is now quite noticeable. Areas most suited to mechanical direct-seeding are weedier areas of the Southern Plains, Northern Shore, Green's Ridge, The Spit and the Eastern Rises.

A second approach involves sowing native grass seed onto grassland areas in moderate condition to augment abundance and/or diversity. This involves either broadcast or disc-drilling techniques to minimise soil disturbance. This is not a well-established technique and requires research to improve effectiveness. The Southern Plains and Eastern Rises are amenable to this technique.

Manual direct-seeding (e.g. 'niche' seeding, Corr 2003) involves the placement of small quantities of 'primed' seed mix into holes made by a pottiputki in areas <1 m² prepared with a rake-hoe or similar implement. The costs of plant propagation, nursery care and transport are negated yet it can still be a community-based activity. It is useful in areas where mechanical seeder access isn't possible or appropriate, for example, enhancing remnants

with understorey shrubs, forbs and grasses, and also for re-establishing native plants where spot weed control has been undertaken. Providing follow-up rains occur, this is an efficient means of establishing new plants into existing vegetation with minimal disturbance and cost. A number of areas on the Northern Shore are ideally suited to this method. Introducing appropriate shrubs and other understorey species and extending the Grassy Woodland will have a marked improvement on aesthetics and fauna habitat.

5.6.3. Tube-stock planting

Key points

- *Ideal community involvement activity, to be targeted at accessible areas.*

Tube-stock planting is the traditional method deployed in small-scale revegetation projects, although substantial areas can be covered with enough people over a number of years. It is particularly useful for generating community interest and involvement, although care must be taken to avoid 'reveg burn-out'. Low success rates due to poor weed control or lack of follow-up rain can be demoralising. It is also the most resource-hungry technique involving substantial cost, materials and human effort.

This method is most appropriate where community access and facilities are reasonably available (there should be as much emphasis on enjoying the activity as a social event as completing it as a land management exercise when community involvement is utilised). The Northern Shore woodlands, The Spit, and parts of the Eastern Rises (e.g. around Ashmead's and Friday's Swamps), and accessible drainage lines are recommended sites.

5.6.4. Seed collection

Key points:

- *Considerable indigenous seed supply for the short-term needs has already been secured*
- *Seed production areas should be established to provide on-going, fresh, secure supply.*

A substantial seedbank to support revegetation has been established thanks to generous support from the Warby Range Landcare Group and the Goulburn Broken Indigenous Seedbank. Further seed is likely to be required, particularly of more difficult-to-collect and/or rare species.

Many plant species targeted for revegetation are either absent from the site or present in low numbers. This presents a challenge to ensure that re-established populations have a genetically diverse, but never-the-less indigenous, provenance. Target populations should be sourced from the Warby Ranges and Chesney Hills for Grassy Woodland taxa, and the (northern) Riverine Plains for other EVCs. Where possible, seed should be sourced from lower rainfall zones to improve adaptability to climate change.

It would be desirable to establish a number of 'seed production areas' at Winton Wetlands to provide a readily accessible seed source for future restoration work, especially of field-layer grasses and forbs.

A formal arrangement needs to be established with the Goulburn Broken Indigenous Seedbank to secure on-going storage of seed.

5.6.5. Soil nutrient management

Key points:

- *Limiting nutrient availability reduces competitive advantage of weeds*
- *Soil nutrients at Winton are relatively high (for 'remnant soils')*
- *No fertiliser to be used at Winton Wetlands*
- *No-kill cropping and soil scalping are suggested as techniques to reduce nutrients and assist recruitment and establishment of indigenous species.*
- *Requires targeted monitoring to document effects on nutrient levels and vegetation responses.*

It has been shown that a direct relationship exists between vegetation degradation and altered soil nutrient characteristics (Prober *et al.*, 2002) and that high nitrate levels facilitate the competitive advantage of weeds over native understorey plants in woodlands (Prober *et al.*, 2005). Field trials have shown that the application of carbon (in the form of sugar) can assist the reduction of soil nitrates and thus help reduce weed biomass and competitiveness (Prober *et al.*, 2005). Alternative strategies are required for use at a large scale due to the cost of the sugar (and repeated applications) .

The chemical (nutrients) and physical properties of the soils at Winton have been documented by Wrigley and Dillon (2006). They found that soil structure (in areas accessible at the time) had not been substantially modified as a result of occasional inundation (in the more elevated areas) and remained comparable to surrounding farmland. Total soil nitrogen was found to be low to moderate in the context of capability for agricultural purposes, with higher concentrations found in lake sediments. Soil phosphorous was also considered low, and again higher concentrations were found in sediments. Olsen P in sediments ranged from 3 to 14.4 mg/kg, with an average of 8.4 mg/kg. While marginal from an agricultural perspective, both N and P levels are considered approximately twice what would be found within similar soil types in remnant vegetation. Thus, elevated nutrient levels at Winton Wetlands are likely to be assisting the competitive advantage of many introduced species. A reduction in available N and P and an increase in total carbon (as an indicator of soil biological activity) over time is considered to be an indicator of improving ecological function.

Nutrient reduction or export will only benefit vegetation where native perennial grasses are present, or are introduced, to take advantage of the reduced vigour of weeds. Reduction strategies include crash grazing, hay-making, and high-intensity burning. An emerging technique in grassland management is known as 'no-kill' cropping and its potential at Winton could be explored. No-kill cropping is analogous to traditional direct drilling with no soil disturbance, except that cereal crops are sown instead of native seed. The theory is the cereal crop competes with cool-season grasses whilst growing and is cut for hay or harvested in the normal manner, thus freeing up resources for growth of summer-active grasses. It is a technique that could be further researched in selected areas at Winton. So far, it has only been trialled from a primary production perspective, but has been shown to improve ecological function in the form of soil health (fungi and filamentous bacteria – important for

soil structure and nutrient cycling), water infiltration, soil carbon and perennial grass cover (Ampt and Doornbos, 2010) and so its application in grassland restoration is of interest.

Under no circumstances are nitrogen or phosphorous fertilisers to be applied at Winton Wetlands as this would favour introduced plants over natives and possibly 'leak' to the wetlands system.

The removal of topsoil ('scalping') can be an effective means of reducing nutrients and the source of exotic seed stored within that soil. This approach has been demonstrated to be an effective technique for grassland restoration by Greening Australia (Vic), led by researchers from the University of Melbourne, (known as the 'Grassy Groundcover Restoration Project'³). This technique would be suitable for the establishment of seed production areas, and potentially for sequential restoration of larger, degraded areas.

5.6.6. Pest plant management

Key points:

- *A separate pest plant management plan has been prepared*
- *Winton wetlands will never be 'weed-free' but serious invasive weeds will be managed to minimise impact*
- *Pest plant control work to be followed up with revegetation.*

A Pest Plant Management Plan has been prepared for Winton Wetlands (GreenAcres 2010), including a comprehensive GIS detailing locations, population size, recommended control methods, implementation data and other information in an extensive attribute table. It will be necessary to update this GIS on an on-going basis.

The GIS focuses on 27 of the most problematic weeds present at Winton, including African Love-grass, Bathurst Burr, Blackberry, Pampas Grass, Paspalum, Phalaris, Patterson's Curse, Spiny Rush, St John's Wort, and Willows. Other weeds (particularly pasture grasses) that are relatively widespread or dispersed cannot be effectively eliminated by management intervention. The reduction in cover and abundance of these species will be achieved only by increasing the presence and competitive advantage of native plant species as described in various sections of this document.

It is important that any weed control work does not leave bare ground able to be colonised by another suite of weeds, and that treated sites are revegetated in a timely manner.

The reality is there will always be exotic flora present at Winton: the challenge for management is to ensure that pest plants do not overwhelm other ecological objectives and attributes.

5.6.7. Biomass management

Key points:

- *Ungrazed Phalaris provides excessive biomass, counter-productive to biodiversity and fire-management objectives*
- *Grazing management strategy to be developed*

³ http://www.greeningaustralia.org.au/uploads//General%20pdfs/VIC_GG_march_2010.pdf

- *Grazing is to continue on current licenses, and new licences established for designated high biomass areas*
- *Licenses to be longer-term with performance based criteria.*

Excessive biomass accumulation (of exotic grasses, especially Phalaris and Wild Oats) is counterproductive to improving biodiversity values at Winton Wetlands. It inhibits natural regeneration and revegetation success, can harbour vermin, and increases production of exotic seed for further invasion. It also reduces landscape aesthetics and increases the overall fire hazard.

Current biomass levels have been mapped based on visual assessment by Davidson (2011) (Figure 19) for the purposes of identifying priorities for grazing or other load reduction techniques without compromising existing biodiversity values. Tree canopy (dead or alive) and wetland vegetation are not included in the biomass assessment.

The biomass assessment was undertaken when district stock numbers were low and grass growth prolific. Appropriate grazing is the preferred method of managing exotic grass biomass against available alternatives (slashing, fire, herbicide, etc). In particular, grazing can be effective tool in controlling Phalaris (Williams *et al.*, 2009) and Wild Oats. It is also apparent that existing biodiversity values on licensed land are compatible with appropriately managed grazing (Figure 18).

Numerous examples exist of such values being lost when grazing is removed from already degraded vegetation in productive landscapes (i.e. the weeds get worse once grazing is removed).



Figure 18: A cross-fence comparison of grazing impacts on vegetation: the sheep-grazed foreground is dominated by indigenous Wallaby-grasses, whereas the un-grazed vegetation in the background is dominated by the invasive Phalaris (Photo: Geoff Carr, Jan 2006)

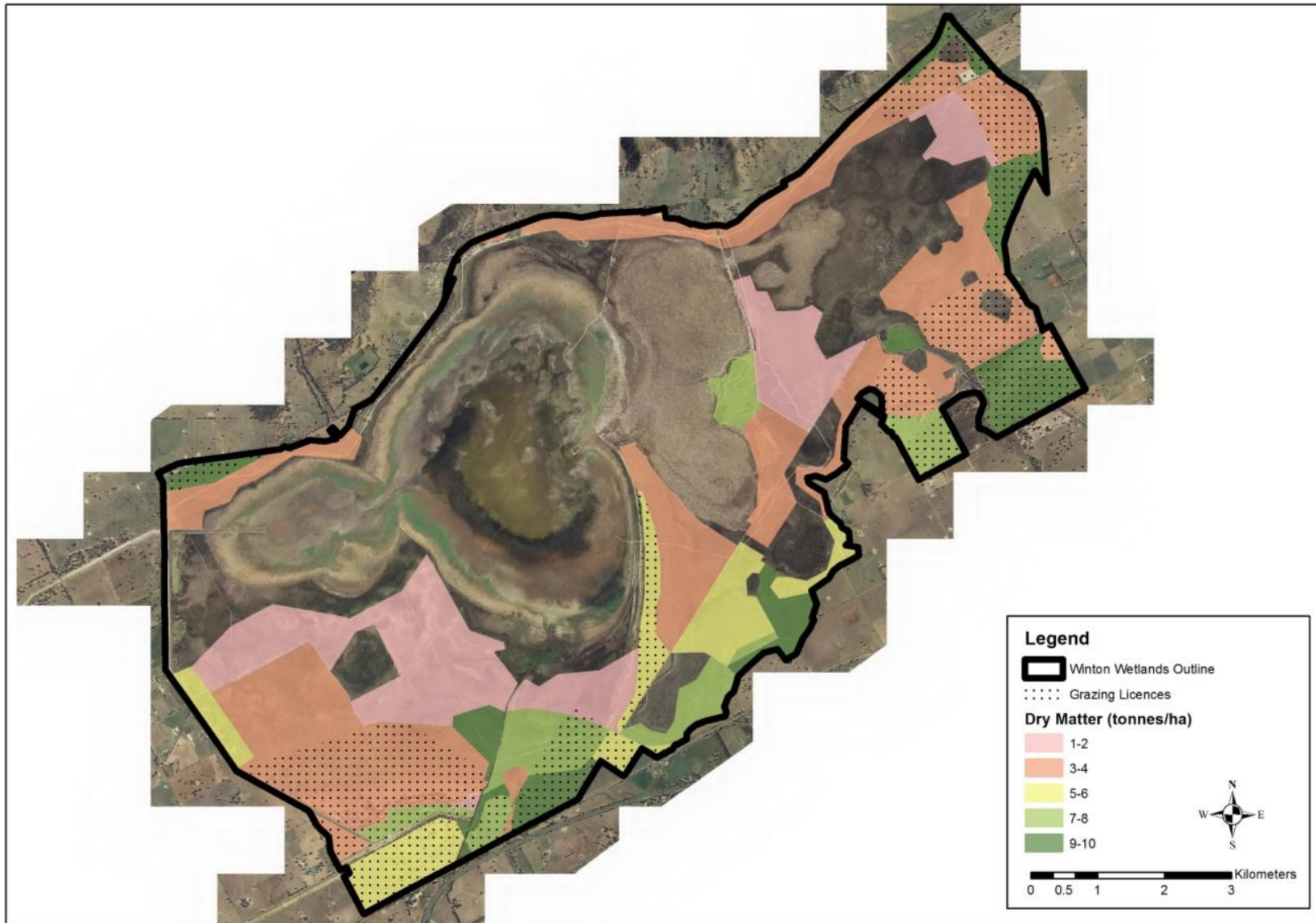


Figure 19: Distribution of biomass levels and existing grazing licenses at Winton (biomass in wetlands not included)

Figure 19 reveals a good overlap between areas under license and those requiring biomass management. Unless or until the areas are revegetated, additional grazing licenses should be established over high biomass pasture to the east and west of Winton Creek, and between Friday's and Ashmead's Swamps, with an ungrazed 100 m nutrient filter buffer to be revegetated.

Grazing may be deployed on non-leased areas where specific ecological outcomes are desired, including control of Phalaris (e.g. eastern parts of North East Swamps) and Wild Oats (e.g. The Spit, adjacent to Green's Swamp). In such cases, temporary electric fencing should be used to concentrate stock and allow for easy relocation/removal. The further development and application of 'virtual fencing'⁴ has great potential in this regard.

Leases should be performance based with the purpose of grazing to manage the biomass and seeding of Phalaris and other exotic plants. Suggested criteria are:

- Biomass should be greater than 1.5 and less than 4 tonnes/ha by Nov 30
- If grazing can't achieve this figure, pasture should be cut for hay or burnt
- Biomass should not be below 1 tonne/ha during summer
- Grazing should be timed to late autumn/early winter, spelled during wetter parts of winter, and grazed again in spring through to early summer
- Remnant woodland and creek zones to be protected from grazing

Grazing arrangements need to be documented through the development of a grazing management strategy, involving collaboration between ecologists and licensed graziers. Ideally, licenses should be applicable for c. 5 years to provide some surety and on-going co-operation between management and licensees.

5.6.8. Fire Management

Key points:

- *Planning and strategic issues addressed in Fire Management Plan*
- *Fire is not the preferred tool for fuel hazard reduction due to impacts on fire-sensitive vegetation*
- *Burning for specific ecological outcomes to be tightly controlled*

The WWCoM prepares a Fire Management Plan, reviewed annually, that addresses fire management from a strategic perspective and addresses a range of objectives relating to fire protection and suppression. The Committee takes seriously the need to prevent wildfires entering and/or escaping from the Reserve and liaises with regional agencies and local landholders to achieve this. Under DSE's (Draft) Fire Operations Plan, Winton Wetlands is currently zoned as an 'Ecological Management Zone' which allows for fire to be used as a tool for ecological outcomes.

⁴ <http://www.csiro.au/science/Virtual-Fencing-Project.html>

Prescribed burning for fuel hazard reduction across large areas is not recommended at Winton Wetlands although it is acknowledged that use of fire may have a role in biomass management (see above) in zones dominated by Phalaris or Wild Oats. As a general rule, fire is not considered appropriate for wetland vegetation, and in drier areas will kill young River Red Gum, injure mature trees, and burn dead standing trees (and in which underground smouldering can continue for months, creating a potential source of ignition in summer months).

Ecological burning to improve understorey condition must be highly targeted and used with extreme care. For example, use of hand-held, gas-powered weed burners can be used to limit seed-set of annual grasses, but should only be used in 'green' (non-cured) vegetation.

All proposals for burning must be logged with the Department of Sustainability and Environment's annual Fire Operations Plan. The WWCoM should approach DSE for assistance with implementation of any burning.

5.6.9. Revegetation for Carbon sequestration/community woodlots

Key points:

- *Inviting third parties to undertake biodiverse carbon sequestration or community woodlot plantings provides an opportunity to reduce restoration costs to WWCoM.*

Carbon sequestration through revegetation by third parties could potentially allow the WWCoM to achieve revegetation over large areas at minimal cost. Any such activity must firstly focus on establishing appropriate habitat through the reinstatement of relevant EVCs, not high density species-poor plantations. General principles as described above (minimal disturbance, genetic diversity, diversity of age-classes and structure) should be followed.

The establishment of a community woodlot offers the potential for Winton Wetlands to provide an additional service to the local community. A manageable woodlot is likely to occupy a relatively small area, but as it is not a priority objective for the WWCoM expressions of interest should be sought from community groups to undertake the establishment and management of any woodlot.

Management Units suitable for these activities are the southern parts of the Southern Plains and areas requiring revegetation within the Eastern Rises.

Terrestrial vegetation summary

Restoration:

Strategies:

- The preferred strategy for re-establishing native vegetation cover is to manage for natural regeneration
- A GIS is to be developed that provides fine-scale detail on locations, species suites, recommended techniques, timing, and a monitoring database
- Natural regeneration is to be augmented by heli-seeding, niche planting, direct seeding (machine-based) and tube-stock planting

- Enhance understorey vegetation in Grassy Woodland and Plains Grassy Woodland remnants with additional plantings of shrub and field layer species
- Explore use of nutrient-limiting techniques to improve competitiveness of native perennial grasses
- Revegetation is to align with the relevant EVC; seed to be sourced from adjacent Grassy Woodland in the Warby Ranges and Chesney Hills, other EVCs to be sourced from the northern Victorian Riverine Plain
- Biomass management where exotic grasses dominate is to be conducted via grazing as far as practical; other techniques that may be deployed include haying and fire; grazing licenses to include outcome-based criteria
- Grazing arrangements need to be documented through the development of a grazing management strategy
- Ecological burning is to be targeted to specific activities with extreme care; broad-acre fuel hazard reduction burning is to be deployed only in areas dominated by exotic grasses.

Resourcing:

- A vegetation manager should be employed to undertake detailed planning, co-ordination, implementation and monitoring of the restoration of terrestrial vegetation given the magnitude of tasks involved. Responsibilities would include:
 - Preparing active revegetation sites
 - Leading community involvement in revegetation activity (e.g. tube-stock planting, niche planting)
 - Planning and co-ordinating seed collection and plant propagation
 - Planning direct seeding schedules
 - Managing direct seeding contracts
 - Co-ordinating weed control and follow-up revegetation works
 - Identifying weed incursions for early control works
 - Managing Pest Plant GIS
 - Monitoring grazing impacts
- WWCoM should develop partnerships with third parties for the following:
 - Research into the role of no-kill cropping to investigate its potential to assist with understorey restoration
 - Implementation of heli-seeding
 - Seed collection and storage
 - Biomass management through grazing (leaseholders)
 - Pest plant management
 - Potential carbon sequestration or woodlot plantings.

Monitoring:

Regeneration/recruitment

- Recruitment of River Red Gum trees should be monitored by conducting annual walks along a GPS-defined route (e.g. Northern Shore) recording the location and height of each tree (or representative sample if densely clumped) observed within (say) 50 m of the route (ideal community involvement exercise)

- A patch of Southern Cane-grass be identified for permanent (annual) monitoring of extent and cover (suggested site on southern shore of Sergeant's Swamp, northern parts of Southern Plains)
- Revegetation activity (e.g. heli-seeding) be monitored using before-after-control-impact methods
- Permanent quadrats be established in Grassy Woodland (Northern Shore), Plains Grassy Woodland, and Riverine Swampy Woodland (Southern Plains) to monitor composition and condition (these quadrats to be kept 'treatment free' as reference controls).

Pest Plant Management

- Continual surveillance monitoring to identify new and emerging pest plants
- Treatment and effectiveness of pest plant management to be documented in Pest Plant GIS.

Soil Health

- A protocol be developed in conjunction with a recognised expert(s) to monitor trends in soil health, nutrient cycling, and dynamics of exotic and native grasses.

Grazing, Phalaris and Biomass Management

- Grazing leases to be monitored annually to ensure biomass is between 1 and 4 tonnes/ha by Nov 30, and that Phalaris seeding is limited as far as possible.

5.7. Fauna

Restoration of wildlife populations is firstly achieved by restoration of habitat. As a general rule, mobile species can be expected to occupy habitat as it becomes available providing of course it is physically accessible.

Deliberate introduction of fauna should only be considered for specific cases, and include a cost-benefit analysis: the effort to maintain fauna in sub-optimal habitat can be considerable. If the habitat is considered appropriate, management should focus on related issues such as predator control to enhance suitability for existing or new fauna populations.

All purposeful manipulation of *any* fauna population must be directed and overseen by relevant authorities within the Department of Sustainability and Environment.

The establishment of captive populations of fauna is considered incompatible with the objective of improving ecological function and will divert considerable resources away from more relevant management priorities.

5.7.1. Fish

Key points:

- *A Fish Management Plan is to be developed to resolve issues around exotic fish control and enhancement of native fish communities*
- *The Plan should include investigation of feasibility of installing a fish ladder at Winton Wetlands outlet to provide connectivity for aquatic biota; installation of a carp trap at*

Boggy Creek Bridge and Winton Outlet; and appropriateness of native fish introductions.

A Fish Management Plan needs to be developed for Winton Wetlands. Currently, larger-bodied native fish (e.g. Murray Cod, Golden Perch) are unable to enter or exit Sergeant's Swamp from the Broken River due to the barrier presented at the outlet channel. Fish ladder installation (incorporating a Carp trap) should be investigated, as the lack of escape is problematic given the ephemeral nature of the wetlands.

Other native fish suited to habitat at Winton Wetlands include Australian Smelt, Murray-Darling Rainbow-fish, Flat-headed Gudgeon, Carp Gudgeons, Golden Perch, Southern Pygmy Perch, Flat-headed Galaxias. A fish census should be conducted as part of the management planning process to identify which of these are present, or if not, ascertain the suitability of available habitat. Expert advice should be sought concerning re-introducing populations of these small-bodied fish, if appropriate, while European Carp and Mosquito-fish are at current levels.

European Carp pose a major management issue at Winton Wetlands. Carp consume and compete with native fish for resources, graze and uproot littoral vegetation, and increase turbidity that further limits plant growth and habitat development for vertebrate and invertebrate fauna. In 2010-11, there is ample preferred habitat (shallow vegetated wetlands) at Winton Wetlands favoured by European Carp for breeding. It is unlikely European Carp can be eliminated from Winton Wetlands in the near future, and management must aim to limit impact (although there is some potential for biological control through initiatives such as daughterless carp and the koi virus). One initiative that could be considered is the installation of a carp trap at Boggy Bridge Road (between Green's and Boggy Bridge Swamps) that would intercept carp migrating into shallow waters to breed.

Commercial Carp fishing is not viable given the relative difficulty of access through marshy vegetation compared to open lakes. Although the outlet was thought to limit access for European Carp, over-topping during heavy discharge (when the Swamp was 150% capacity) may have enabled European Carp access. Presumably, European Carp can also access the Wetlands from higher in the catchment (e.g. farm dams). A survey of dams in the catchment should be undertaken to identify high-risk sites and sites for control. Carp traps installed at the outlet (if a fish ladder is installed) and the Boggy Creek Bridge offer potential to put some pressure on European Carp populations and impacts.

Red Fin Perch and Brown Trout are both predators of young or small fish, and can carry the contagious Epizootic Haematopoietic Necrosis (EHN) disease, and should not be introduced to the Wetlands.

Restoration:

- Subject to the development of a Fish Management Plan, consideration should be given to the following:
 - Installation of a fish ladder at the outlet to provide connectivity between the wetlands and downstream ecosystems
 - Installation of a carp trap at Boggy Bridge Road crossing.

Monitoring:

- Impacts of carp on littoral vegetation be monitored to, for example, with the construction of a carp exclusion fence in suitable area
- A monitoring protocol be established to document population trends in all fish species present at Winton Wetlands.

5.7.2. Birds

Key Points:

- *Targeted monitoring to assess value of Winton Wetlands for Latham's Snipe is required*
- *Nesting by colonial water birds to be monitored and documented*
- *Status of threatened bird species to be documented.*

Like other fauna, ongoing efforts to restore and enhance habitat is the recommended approach for increasing the diversity and abundance of bird populations. Monitoring of the Latham's Snipe population should be conducted over a number of years (5+) when habitat conditions are suitable to ascertain the value of Winton Wetlands for this species. This is achieved by conducting transects through marshy vegetation three to four times over summer and counting birds flushed. Further details are provided in Conole (2007). The populations and breeding success of colonial breeding species (e.g. Intermediate Egret, Great Egret, Nankeen Night-heron, Pied Cormorant and Little Black Cormorant) should also be documented on an annual basis to determine the importance of Winton Wetlands as a breeding site for colonial waterbirds. Monitoring of the status of state or nationally threatened bird fauna should also be undertaken to provide evidence supporting the value of Winton Wetlands. These include the White-bellied Sea-eagle, the Australasian Bittern, Freckled Duck (both nationally endangered), Australasian Shoveler and the Hardhead, two species of duck listed as vulnerable in Victoria.

Winton Wetlands will, if not already, become a popular venue for bird watching enthusiasts. In consultation with one local bird observer (Michael Ramsey), a list of sites has been mapped (Figure 20) that provides the best bird watching opportunities at Winton Wetlands.

Restoration:

- Focus on maintaining, restoring and maintaining habitat to increase diversity and abundance of bird populations.

Monitoring:

- In consultation with recognised experts, develop and implement monitoring programs to:
 - Ascertain population of Latham's Snipe over-summering at Winton Wetlands
 - Document breeding by colonial waterbirds (Intermediate Egret, Great Egret, Nankeen Night-heron, Pied Cormorant and Little Black Cormorant) and other significant species (e.g. White-bellied Sea-eagle, Hooded Robin, Diamond Firetail, Grey-crowned Babbler, Brown Treecreeper, Painted Button-quail)

- Document utilisation of the site by state and nationally threatened bird species (especially Australasian Bittern, Little Bittern, Freckled Duck, Blue-billed Duck) – season, location/habitat, population size, breeding etc
- Surveillance monitoring to document use of Winton Wetlands by all bird fauna is encouraged and provides an ideal involvement and educational opportunity for the broader community.

5.7.3. Other fauna

Key points:

- *Macropod populations to be monitored to identify potential for over-grazing on-site*
- *Increases in the abundance of Long-necked Turtle and microbats, the diversity and abundance of frog species, and/or return of Rakali, would suggest improvements in ecological function.*

Although the current population of Eastern Grey Kangaroo is not known, various estimates have put it between 200 and 500 animals. Eastern Grey Kangaroos may eventually increase in numbers sufficient to provide excessive grazing pressure on native vegetation, and/or be of sufficient nuisance value to neighbouring landholders that some control measures may be required. This must be done under the direction of DSE. It will be prudent to formulate a monitoring protocol (e.g. a spotlighting transect along Winton North Road conducted annually) to track trends in kangaroo numbers and so anticipate any likely issues. The opinions of landholders concerning trends in kangaroo numbers should also be regularly ascertained as part of this process.

Long-necked Turtles (*Chelodina longicollis*) were once very common at Lake Mokoan (and presumably also prior to that) but apparently suffered dramatic declines during the 1990s possibly due to blue-green algae outbreaks. The nesting areas along the southern shores of Sergeants and Winton Swamps should be targeted for fox control to assist recovery of the local population, as foxes are digging up many nests (Ian Davidson pers. comm.).

Rakali (*Hydromys chrysogaster*) have not been recorded as occurring at Winton Wetlands/Lake Mokoan since 1980 (App 2), nor have they been observed by locals in recent decades (Doug Bain pers. comm., Russell Ellis pers. comm.). The diet includes small fish, freshwater mussels and other macro-invertebrates (Dytiscidae and Hemiptera) considered indicative of better quality aquatic environments (ANGB, undated). They have good dispersal capabilities and thus their re-appearance at Winton Wetlands would be a strong indicator of improving ecological condition.

Frog species are considered to be important indicators of ecological function owing to their high sensitivity to ecological stress, although variations in local populations may be difficult to attribute to local stresses as opposed to more global factors such as UV radiation. Nevertheless, an increase in frog diversity and abundance detected through a rigorous monitoring protocol would be a strong indicator of improving ecological function.

Aquatic macro-invertebrates are important components of wetlands because they are common, abundant, diverse and complete their life cycle within wetlands. They are an

important component of aquatic food webs and respond to a range of physical and chemical stressors. As such they are good indicators of ecological function (Baldwin *et al.*, 2005).

There are a number of monitoring programs that utilise macroinvertebrates particularly in rivers that use rapid assessment techniques, but these are not generally applicable to wetlands. A program for monitoring wetlands of the Swan River (WA) (AUSWAMP – Davis *et al.*, 1999) could be adopted or alternatively a monitoring program designed for wetlands in Living Murray Icon sites within the Mallee CMA could be adapted (Sholtz *et al.*, 2005). Whichever method is used, monitoring will be in the form of 'site condition monitoring' where surveillance monitoring occurs at a number of sites to reveal the environmental condition of those sites over time. This type of monitoring does not establish cause and effect due to lack of experimental control sites. As such, any improvement in the asset due to the management intervention or other factors that are not controlled for cannot be attributed with certainty (McCarthy *et al.*, 2006).

Hamilton (2010) detected eight species of microbats at Winton Wetlands, all in extremely low numbers. Being insectivorous, microbats are thought to play an important role in regulating insect numbers, for example, mosquitoes (one bat can consume 600 mosquitoes per hour) and thus play an important role at Winton Wetlands. Monitoring using ultrasonic call detection to detect population trends will assist and inform progress towards improving ecological function.

5.7.4. Habitat enhancement

The most constructive way of assisting the restoration of fauna populations is to enhance the diversity and quality of habitat. Restoring appropriate native vegetation is the principal means of enhancing habitat and includes the removal of introduced species that are likely to simplify the structure and/or composition of existing habitat.

Reducing predator pressure is part of habitat enhancement. A separate Pest Animal Management Plan is currently being prepared under the direction of the WWCoM that details target species, control strategies and monitoring requirements.

Other measures that can be deployed include increasing the amount of fallen timber on the ground, particularly in newly establishing vegetation (revegetation and regeneration) to provide a resource for fauna otherwise unlikely to develop for many decades. Dead trees across the Reserve could be strategically relocated to areas devoid of ground timber. Care should be taken to ensure soil disturbance is minimised during such operations (e.g. avoiding wet areas or dragging timber along the ground).

The construction and installation of nest boxes is a great way to involve the community in habitat enhancement. A number of designs are available from various sources for a range of fauna, and community groups can be involved in the construction, installation and monitoring of these boxes. A considerable proportion of live trees present at Winton Wetlands are decades younger than the age of hollow-bearing trees, and the installation of nest boxes of various designs will enhance the availability of shelter and breeding sites.

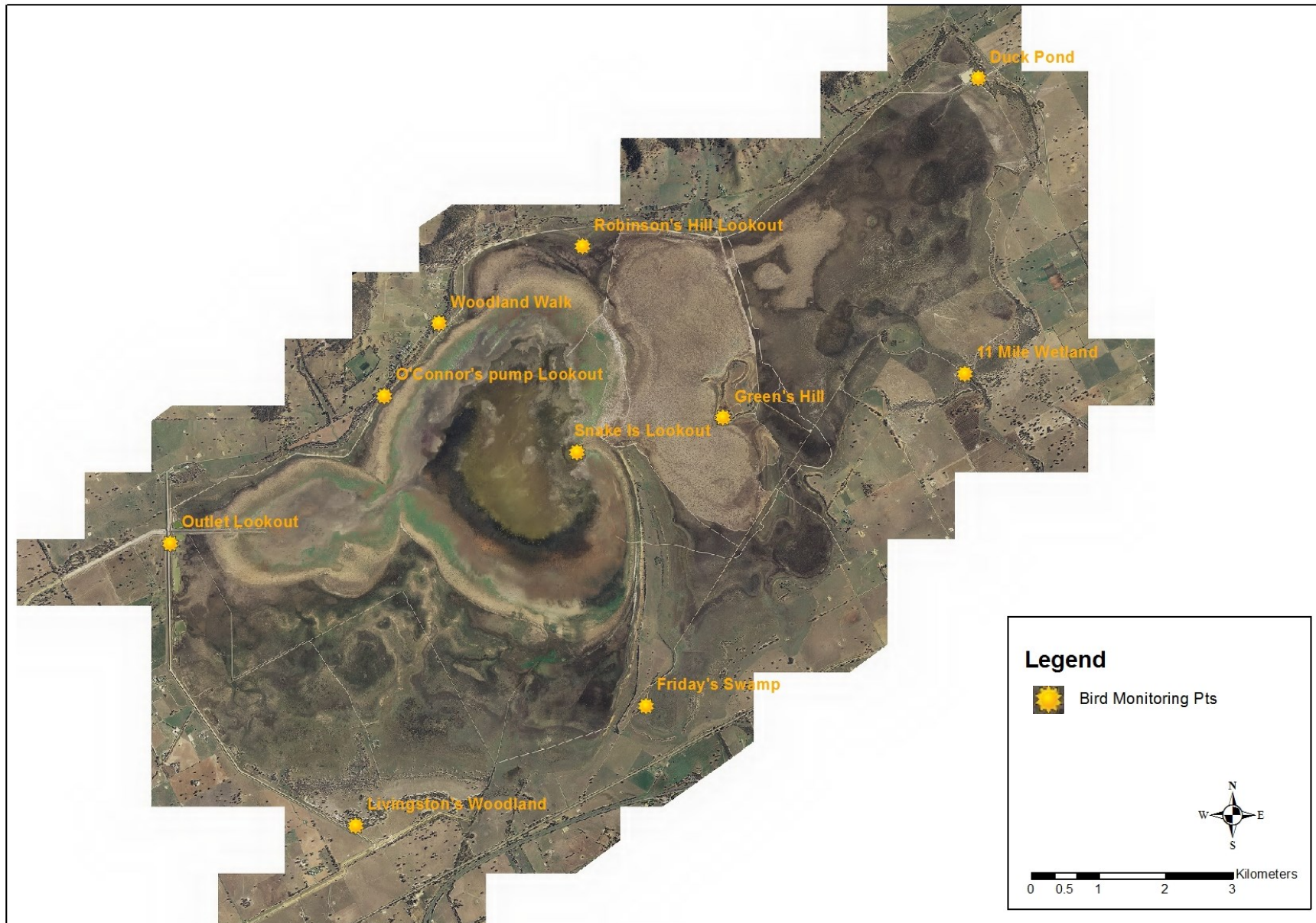


Figure 20: Suggested vantage points for bird observation activities at Winton Wetlands

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