BIODIVERSITY MANAGEMENT PLAN

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GLOSSARY OF TERMS

BMP	Biodiversity Management Plan
BNC Act	Brigalow and Nandewar Community Conservation Act
BNC Agreement	Brigalow and Nandewar Community and Conservation Area Agreement
Box Gum Woodland	Refers to the Critically Endangered Ecological Community *White Box, Yellow Box, Blakely's Red Gum Grassy Woodland and Derived Native Grassland*. Includes both woodland and derived grassland forms of the community
CCC	Community Consultative Committee
CEEC	Critically Endangered Ecological Community
CHPP	Coal Handling and Preparation Plant
CL	Coal Lease
CMA	Catchment Management Authority
DP&I	NSW Department of Planning and Infrastructure
DPI	NSW Department of Primary Industries
DRE	NSW Department of Resource and Energy
EA	Environmental Assessment (Part 3A, *Environmental Planning and Assessment Act 1979*)
EARs	Director-General's Environmental Assessment Requirements (NSW DP&I)
EC	The ecological consultant
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EO	The mine environmental officer
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
I&I	NSW Government Industry and Investment
LGA	Narrabri Local Government Area
LM	The land manager
Locality	land within 20 km of the Project Boundary
MCC	Maules Creek Coal Pty Ltd
MNES	Matters of National Environmental Significance (listed matters under the EPBC Act)
NP&W Act	*National Parks and Wildlife Act 1974*
NPWS	NSW National Parks and Wildlife Service
OEH	NSW Office of Environment and Heritage
Offset Strategy	The Project's "Biodiversity Offset Strategy" - the package of compensatory land and associated management actions that will offset the Project impacts on biodiversity
PCO 2010	*Pest Control (1080 Liquid Concentrate and Bait Products) Order 2010*

Project	**"**Maules Creek Coal Project" - the proposed development for which the Biodiversity Management Plan is prepared
Project Boundary	The whole site assessed within the Environmental Assessment as shown in **Figure 1.1**
Project Disturbance Area	The total Project footprint that will require clearing for mining or construction
Region	Refers to the Brigalow Belt South bioregion
ROM	Run of Mine
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
TSC Act	*Threatened Species Conservation Act 1995*
VCA	Voluntary Conservation Agreement

1.0 INTRODUCTION

Cumberland Ecology was commissioned by Hansen Bailey on behalf of Maules Creek Coal Pty Ltd (MCC) to complete a Biodiversity Management Plan (the BMP) for the Maules Creek Coal Project (the Project), which will entail the development of a 21 year open cut coal mining operation and associated infrastructure.

As the Project progresses, there will be a need to ameliorate and manage the impacts to biodiversity within the Project Boundary and to address residual impacts through the provision of biodiversity offsets. The purpose of the BMP is to provide a consolidated plan for the management of flora and fauna within the Project Boundary and the conservation management of a set of offset properties that comprise the Project's Biodiversity Offset Strategy (the Offset Strategy).

The vegetation within the Project Boundary will be progressively cleared but clearing will be gradual. The BMP has provisions to protect habitats up until the time of clearance and to salvage key habitat items such as trees with hollows, so that they can be placed within rehabilitation and some offset areas. As the BMP is implemented, it is intended that forest, woodland and derived native grassland within the offsets will be maintained and improved, with increased areas of *White Box, Yellow Box, Blakely's Red Gum Grassy Woodland and Derived Native Grassland* (Box Gum Woodland) and other affiliated threatened species habitat so that native vegetation within the offsets becomes self sustaining with minimal impacts from feral animals and weeds. The offsets, when combined with rehabilitation within the Project Boundary, are intended to achieve an increase in the quantity and quality of forest and woodland habitat within the locality.

1.1 Background

The ownership of the Project currently lies with MCC, a joint venture between Aston Coal 2 Pty Limited (a wholly owned subsidiary of Whitehaven Coal Limited (Whitehaven)) (75%), ITOCHU Corporation (15%) and J-Power Corporation Pty Limited (10%).

Aston Coal 2 Pty Limited submitted a Project Application to the Department of Planning and Infrastructure (DP&I) in August 2010, for a new project approval under Part 3A of the *Environmental Planning and Assessment Act* (EP&A Act) to enable the construction and operation of the Project.

Project Approval (PA) 10_0138 was granted by the Planning Assessment Commission (PAC) under delegation of the Minister for Planning and Infrastructure on 23 October 2012.

As the Project has been declared a "*controlled action*" under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Commonwealth approval has also been sought concurrently and will be assessed through the accredited assessment pathway under the NSW EP&A Act. On 11 February 2013, the Commonwealth Minister for the Environment granted the *Controlled Action Approval* under the EPBC Act for the Project.

1.1.1 Location

The Project is located in the Gunnedah Coal basin approximately 18 km to the north-east of Boggabri in the north-west region of NSW within the Narrabri Local Government Area (LGA). The landscape around Boggabri is typified by extensive flat plains with the mountain ranges of the Nandewar rising in the east and gently undulating Pilliga country in the west. The main land uses in the region are dry land and irrigation grazing and cropping on freehold land. Several conservation areas and forest reserves occur in the region, one of which is Leard State Forest. This forest consists of a series of ridges and narrow gullies with the steepest areas occurring in the western portion. It is currently used for forestry, coal mining and recreational purposes.

The Project Boundary is approximately 3,551 hectares (ha) in size and includes a portion of the Leard State Forest and some adjacent private landholdings to the north and west (see **Figure 1.1**). Various coal mines exist within close proximity to the Project including Boggabri Coal Mine, Tarrawonga Coal Mine and the Goonbri Exploration Lease located to the south-east of the Project Boundary.

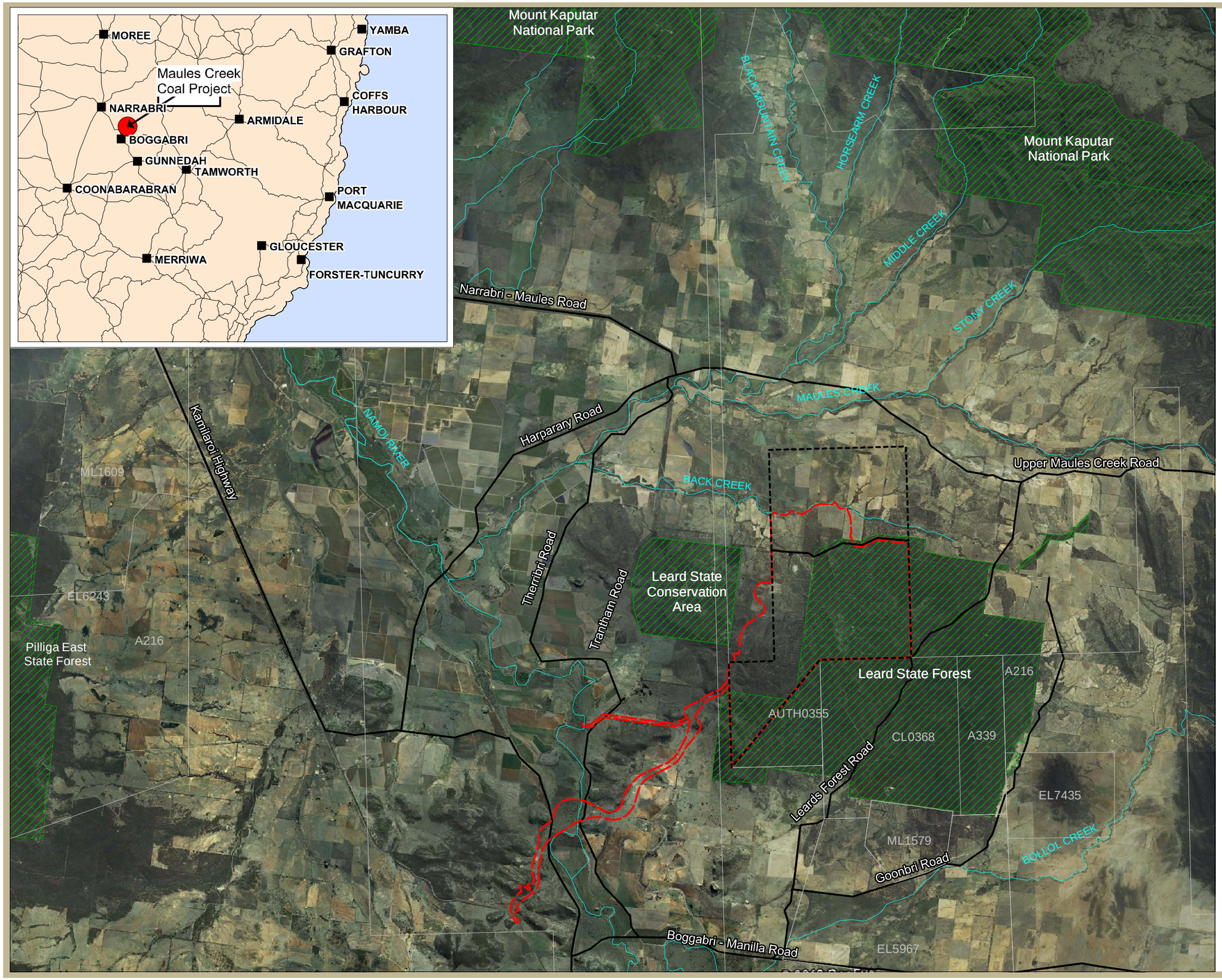
1.1.2 Project Description

The Project entails the development of an open cut coal mining operation and associated infrastructure. The Project is proposed to continue for at least 21 years, commencing in 2013 and specifically seeks approval for the following:

- The construction and operation of an open cut mining operation extracting up to 13 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal to the Templemore Seam;
- Open cut mining fleet including excavator / shovels and fleet of haul trucks, dozers, graders and water carts utilising up to 470 permanent employees;
- The construction and operation of a CHPP with a throughput capacity of 13 Mtpa ROM coal;
- The construction and operation of a Tailings Drying Area;
- The construction and operation of a rail spur, rail loop, associated load out facility and connection to the Werris Creek to Mungindi Railway Line;
- The construction and operation of a Mine Access Road;
- The construction and operation of administration, workshop and related facilities;
- The construction and operation of water management infrastructure including a water pipeline, pumping station and associated infrastructure for access to water from the Namoi River;
- The installation of supporting power and communications infrastructure; and
- The construction and operation of explosive magazine and explosives storage areas.

The Project layout is shown in **Figure 1.2**

Coordinate System:MGA 94 Zone 56



Legend

- Project Boundary
- Mining Tenement Boundary
- State Forest/Conservation Area
- Neighbouring Mining Tenement
- Road
- River

Grid North

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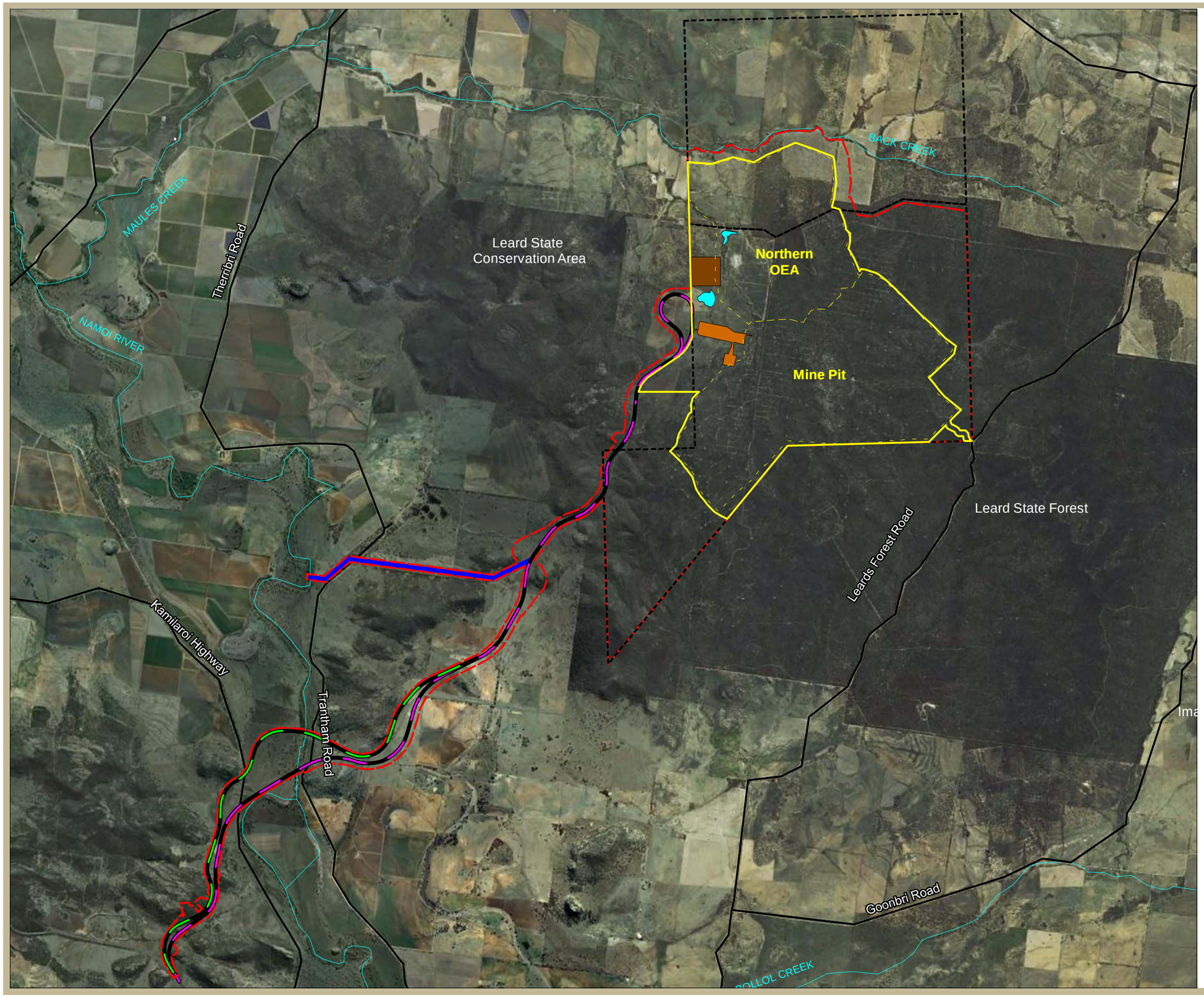
CUMBERLAND ECOLOGY

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Figure 1.1 PROJECT LOCATION

2000 0 2000 4000 6000 8000

Coordinate System:MGA 94 Zone 56



Legend

- Project Boundary
- Mining Tenement Boundary
- Mine Disturbance Boundary
- 21 Year Mining Limit
- Road
- River

Proposed Mine Infrastructure

- Indicative Rail Spur and Loop
- Alternative Rail Alignment
- Pipeline
- Water Storage
- Mine Infrastructure Area
- Coal Handling and Processing Plant

Grid North

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Figure 1.2 PROJECT LAYOUT

1000 0 1000 2000 3000 4000 m

1.2 Aims and Objectives

The aims of this BMP are to:

- Present a comprehensive plan for the management of flora and fauna on the Project Boundary that makes provisions for:
  - Minimising human disturbance to native flora and fauna;
  - Minimising vegetation disturbance or clearing;
  - Minimising impacts to threatened species and communities;
  - Controlling threats to remnant native vegetation in Leard State Forest;
  - Managing the impacts of feral animals and weeds; and
  - Monitoring responses to management actions to assist in adaptive management of flora and fauna;
- Present a comprehensive plan for the conservation management of the offset properties that comprise the Offset Strategy, in order to:
  - Maintain and improve fully viable and self sustaining ecological communities where vegetation will be created in cleared offset areas;
  - Increase the area and quality of Box Gum Woodland by regenerating areas of grassland to woodland;
  - Implement assisted natural regeneration methods to increase the ecological integrity of offset areas and to enhance the native vegetation it contains;
  - Secure land to create and improve wildlife corridors and link to existing conservation reserves (Mount Kaputar National Park and Leard State Conservation Area);
  - Improve the condition of riparian habitat;
  - Reduce weed species and feral animal distribution and abundance; and
  - Create a substantial area of high quality habitat for native fauna that will be protected for conservation in the long-term;
- Describe how the offset properties will be protected in perpetuity;
- Demonstrate that the offset properties are of suitable quality; and
- Demonstrate that a range of management actions and strategies will be put in place to ensure the maximum environmental outcomes of Box Gum Woodland in the longer term.

The management strategies for the offset properties will vary between the individual properties as a result of specific conservation issues and long-term objectives relevant to each site. However, in all cases the strategy is to maximise long-term environmental outcomes through the protection, maintenance and enhancement of the remnant vegetation and specifically Box Gum Woodland occurring on these properties.

1.2.1 Integrated Approach to Biodiversity Management

MCC will implement an integrated approach to biodiversity management via two site-specific management plans, this BMP and the Rehabilitation Management Plan (RMP) to address individual biodiversity issues.

The focus of this BMP is to provide a consolidated plan for the management of flora and fauna within the Project Boundary and the conservation management of a set of offset properties that comprise the Project's Biodiversity Offset Strategy.

The focus of a separate RMP is to provide for the rehabilitation of mining activities in the active pit and emplacement area, and in the case of closure, the rehabilitation of infrastructure areas.

1.3 Structure of the Biodiversity Management Plan

This report has been prepared in consideration of contemporary planning approval conditions, as provided in **Table 2.1** and **Table 2.2**. This BMP firstly presents a summary of the flora and fauna values present in the Project Boundary, followed by an identification of the key Project impacts and existing threats that this BMP seeks to manage (Cumberland Ecology, 2011). This is followed by a detailed description of the Project's Offset Strategy, which includes:

- A detailed description of the land and vegetation to go into offset and rehabilitation areas;
- Maps of proposed offsets and of proposed linkages;
- Details of the agricultural production within offset areas; and
- A summary of the long term security of the offsets.

Subsequent sections provide detailed prescriptions for appropriate management of the offset properties and threats within the Project Boundary, including:

- Minimising human disturbance to native flora and fauna;
- Controlling threats to remnant native vegetation in Leard State Forest;
- Managing the impacts of feral animals and weeds;
- Prescriptions for rehabilitation and conservation management on the offset properties;
- A proposed schedule for the works;
- Milestones and key performance criteria; and
- Details of monitoring that will be undertaken to quantify the efficacy of management measures, including threshold values to enable adaptive management; and
- Details of reporting requirements.

2.0 STATUTORY REQUIREMENTS

Statutory requirements applicable to the Project include any Commonwealth, State or local requirements under any provisions of relevant Acts and regulations, environment planning instruments and any other relevant guidelines.

The following statutory requirements associated with biodiversity impacts have been considered during the development of this BMP.

2.1 Environmental Protection and Biodiversity Conservation Act, 1999

The EPBC Act protects Matters of National Environmental Significance (MNES), including threatened and migratory species and threatened ecological communities.

The *Maules Creek Coal Project Environmental Assessment* (Maules Creek EA) identified that the Project would impact on areas of a Critically Endangered Ecological Community (CEEC) and habitat or potential habitat for species listed under the EPBC Act. These include Box Gum Woodland and potential habitat for the Regent Honeyeater, Swift Parrot and Greater Long-eared Bat which are listed under the EPBC Act.

The Minister for the Environment granted Approval Decision 2010/5566 for the Project under the EPBC Act on 11 February 2013. The conditions that are relevant to this BMP are presented in **Table 2.1**.

Table 2.1 Approval Decision EPBC 2010/5566 Requirements

Condition Number	Requirement	Where Addressed
Condition 9	The person taking the action must register a legally binding conservation covenant over offset areas of no less than	The biodiversity offset strategy is described in Section 4.0 and Appendix B of this BMP.
a)	9,334 ha of equivalent or better quality of habitat for the regent honeyeater, swift parrot and greater long-eared bat; and	
b)	5,532 ha of an equivalent or better quality of the White Box - Yellow Box - Blakely's Red Gum Grassy Wooedland and Derived Native Grassland ecological community.	
	Note: the 5,532 ha of White Box - Yellow Box - Blakely's Red Gum Grassy Wooedland and Derived Native Grassland ecological community may be included within the 9,334 ha of offset area for the threatened species if it meets the listing criteria for the EPBC-listed critically endangered ecological community as definied in rthe EPBC listing advice for that community and the requirements of condition 9.	
Condition 13	The mechanism/s for registering a legally binding covenant must provide protection for the offset areas in perpetuity and be registered within 5 years of the date of this approval.	Section 4.5. To be incorporated into the Revised BMP - see Section 13.1
Condition 17	The person taking the action must submit to the minister for approval, an Offset Management Plan for all the offset areas, specified in condition 9, within 12 months of the date of this approval. The approved Offset management plan must be implemented.	This BMP addresses the requirement to provide an Offset Management Plan for all the offset areas specified in Condition 9
Condition 18	The Offset management plan must include, but not be limited to, the following:	

Condition Number	Requirement	Where Addressed
a)	a text description and a map which clearly defines the location and boundaries of the offset areas. This must be accompanied by the offset attributes and shapefiles.	Section 4.0 and maps within this section
b)	a description of the methodology and results of the surveys measuring the baseline ecological conditions in the offset areas. This must be consistent with the State and Transition Model and include but not be limited to:	Appendix D provides the methodology and summary of ecological surveys conducted on the offset properties. Results are provided in Section 4.0. Further surveys will be undertaken during surveys for the monitoring program.
i.	the extent and condition of all vegetation communities, including a description of the structure, floristics and tree age class representation of each community.	Section 4.7and 4.8, Table 4.20 to Table 4.22, Table D.10.
ii.	The extent and condition class of all areas of the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland ecological community;	The extent of all areas of this community is provided in Table 4.28 and Table 4.29. The condition class of this community is presented in Section 4.10
iii.	Surveys targeting the Regent Honeyeater, Swift Parrot and Greater Long-eared Bat;	Appendix D provides the methodology of fauna surveys conducted on the offset properties. Further surveys will be undertaken during surveys for the monitoring program.
iv.	The extent and quality of all areas of habitat for the Regent Honeyeater, Swift Parrot and Greater Long-eared Bat;	Table 4.29 and Table D.10 in Appendix D
v.	the location of all survey sites (including coordinates);	Figures D.1 and D.2, and Tables D.5 and D.6 in Appendix D
vi.	photo reference points at survey sites.	Photo monitoring points will be established during the pilot study
c)	clearly defined ecological management objectives for the offset areas;	These are provided in Section 5.1and 6.1 for the Northern, and Eastern and Western Offset Areas respectively.
d)	detailed description of all ecological management activities proposed to be undertaken, including maps and/or diagrams showing areas to be managed and the timing of proposed activities;	Section 4.0 and the figures within.

Condition Number	Requirement	Where Addressed
e)	details of ongoing ecological monitoring programs, performance criteria, targets and provisions for adaptive management, including but not limited to:	Section 9.0
i.	a set of measurable ecological indicators for detecting changes to the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland ecological community, including those that may be ascribed to ongoing water stress;	Table 9.2; Section 9.5
ii.	a monitoring plan to assess the success of the management activities measured against the baseline condition. The monitoring must be statistically robust and able to quantify change in the condition of the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland ecological community and habitat for the Regent Honeyeater, Swift Parrot and Greater Long-eared Bat. This should include the use of control sites and periodic ecological surveys to be undertaken by a qualified ecologist.	Section 9.0
iii.	A list of performance criteria based on the ecological management objectives for the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland ecological community and habitat for the Regent Honeyeater, Swift Parrot and Greater Long-eared Bat;	Table 9.1 and Table 9.2
iv.	measures to exclude weeds from all offset areas for the period covered by this approval;	Sections 5.5 and 6.5 specify weed management actions. Section 9.7 specifies weed monitoring.
v.	a description of the potential risks to successful management against the performance criteria, and a description of the contingency measures that would be implemented to mitigate against these risks;	Table 10.1
vi.	a process by which to report to the department the progress of management activities undertaken in the offset areas and the outcome of those activities, including identifying any need for improved management and activities to undertake such improvement.	Section 13.0 contains provision for an annual monitoring report to be submitted to the department
f)	details of all parties responsible for management, monitoring and implementing the management activities, including their position or status as separate contractor.	Section 8.8 and Table 8.1
g)	details of the funding requirements for the ongoing management activities, including an estimate of the costs of the activities and details of the parties responsible for funding the activities.	The full cost to implement the Biodiversity Offset Strategy as per this BMP (excluding land acquisition costs) will be calculated within the revised BMP. See Section 4.5

Condition Number	Requirement	Where Addressed
Condition 19	Unless otherwise agreed to in writing by the department, the baseline surveys for threatened species must be undertaken in accordance with the department's Survey Guidelines for Australia's Threatened Birds and the Survey Guidelines for Australian Threatened Bats. Subsequent monitoring must be carried out annually at the same time of year as the baseline surveys unless otherwise agreed to in writing by the department.	The baseline surveys were undertaken according to these guidelines (see Appendix D). Further baseline surveys will be undertaken a part of the development of benchmarks for the monitoring program.

2.2 Environmental Planning and Assessment Act 1979

Conditions of PA 10_0138 have informed the structure and scope of this BMP. The conditions of PA 10_0138 relevant to biodiversity management are detailed in **Table 2.2**, together with a reference to where these conditions are addressed in this BMP.

Table 2.2 Project Approval 10_0138 Requirements

Condition Number	Condition	Where Addressed
SCHEDULE 2: ADMINISTRATIVE CONDITIONS		
Vegetated Buffer Corridor		
Condition 7	The Proponent shall not clear native vegetation from any land within 250 metres of the adjoining Boggabri Coal Mine mining lease boundary, unless: a) the Proponent has provided an alternative area of equal or better habitat value for the purpose of providing a fully effective east-west movement corridor for native fauna. b) the alternative area is capable of delivering this outcome before clearing commences within 250 m of the lease boundary. c) the alternative area is under tenure arrangements that ensure its maintenance for biodiversity purposes in perpetuity, or there is an enforceable commitment to deliver this outcome. d) the alternative area has been endorsed by the OEH and subsequently approved by the Director-General. *Notes:* *- The alternative area may be provided by way of offset or by way of suitable rehabilitated land within the Boggabri Coal Project site or the Maules Creek Coal Project site.* *- The alternative area may be provided by the Proponent or the Proponent in conjunction with the Proponent of the Boggabri Coal Project.*	A commitment to protecting this vegetation is provided in Section 8.0
SCHEDULE 3: ENVIRONMENTAL PERFORMANCE CONDITIONS		
Biodiversity Offset Strategy		

Condition Number	Condition	Where Addressed
Condition 44	The Proponent shall implement the biodiversity offset strategy described in the EA, summarised in Table 16 and shown conceptually in Appendix 7 [reproduced in Appendix B of this BMP] to the satisfaction of the Director-General.	The biodiversity offset strategy is described in Section 4.0 and Appendix B of this BMP.
Revised Biodiversity Offset Strategy		
Condition 45	The Proponent shall prepare and implement a revised biodiversity offset strategy for the identified offset areas in Table 16 [and reproduced in Appendix B of this BMP] to the satisfaction of the Director-General. The revised Strategy must: a) not reduce the size or quality of the proposed offset areas. b) be consistent (as far as is possible) with the recommendations and objectives of the Leard Forest Mining Precinct Regional Biodiversity Strategy. c) be prepared in consultation with OEH, Namoi CMA, CCC, DPI Catchments and Lands and SEWPaC. d) identify the additional low diversity derived native grassland, cultivated land and pasture improved land to be included in the offset to provide a buffer and connectivity between core remnant habitat. e) identify the additional offset land within the zone of affectation in the Eastern and Western offset areas that has been secured by the Proponent and where properties have not been secured identify substitute areas that would provide an equivalent increase in biodiversity values. f) avoid inclusion of any strategic agricultural land (as defined in the final New England North West Strategic Regional Land Use Plan) in the offset areas, unless it is demonstrated that the inclusion would not have any adverse impacts on agricultural production. g) identify a minimum additional 1,000 ha of offset area targeting habitat for threatened species affected by the project which includes restoration of habitat to provide an improvement in biodiversity values. h) be submitted to the Director-General for approval within 30 months of the date of this approval, or within 6 months of the approval of Stage 2 of the Leard Forest Mining Precinct Regional Biodiversity Strategy (whichever is sooner) for endorsement by OEH and subsequent approval by the Director-General.	A commitment to prepare a revised biodiversity offset strategy is provided in Section 4.1 and Section 13.1. This strategy will be compliant with the following conditions.
Agricultural Production in Offset Areas		
Condition 46	Offset areas are to be managed primarily for the purposes of compensating for biodiversity impacts of the project, and improving regional biodiversity outcomes. However, to the extent that limited agricultural production on the lots purchased for offsets is compatible with these objectives, the Biodiversity Management Plan and other conditions of this approval, the Proponent shall:	Section 4.3

Condition Number	Condition	Where Addressed
a)	include in the Biodiversity Management Plan (see condition 52 below) an agricultural suitability assessment of surplus land on the offset properties, in particular for proposed corridor enhancement zones.	An Agricultural Suitability Assessment of surplus lands will be produced and added to this BMP within 30 months of the Project Approval date.
b)	maintain the agricultural productivity of the surplus areas.	Maintenance of the agricultural productivity of areas outside the biodiversity offset areas is discussed in Section 5.3 and Section 6.3.
Vegetated Corridor between Boggabri Coal and Maules Creek Projects		
Condition 47	For the vegetated buffer corridor required to be retained and protected under condition 7 of schedule 2 of this approval, the Proponent shall:	
a)	use its best endeavours to work cooperatively with the Proponent of the Boggabri Coal Project to enhance the functioning of the area as a biodiversity corridor.	Section 8.0
b)	include in the Biodiversity Management Plan (see condition 52 below) the details as to how impacts on the corridor are to be minimised, to the satisfaction of the Director-General.	Section 8.1.2
Threatened Species		
Condition 48	For the White Box – Yellow Box – Blakely's Red Gum Grassy Woodland Endangered Ecological Community the Proponent shall:	
a)	ensure that the Biodiversity Offset Strategy and site Rehabilitation Strategy is focused on protection rehabilitation, re-establishment and long-term maintenance of viable stands of this community.	The Biodiversity Offset Strategy is outlined in Section 4.1 and is consistent with these aims.
b)	investigate in consultation with OEH and the Namoi CMA, all factors likely to enhance or impede the effective long term restoration of degraded remnants of this EEC in offset areas or regeneration of this EEC on disturbed areas (both offset areas and the site).	To be incorporated into the Revised BMP - see Section 13.1
c)	within 24 months of the date of this approval (and if possible in conjunction with Stage 2 of the Leard Forest Mining Precinct Regional Biodiversity Strategy), submit a report of this investigation and provide an implementation plan to maximise the prospects for rehabilitation and regeneration of this EEC on the offset areas and the site, for approval by the Director-General.	
d)	incorporate the approved implementation plan into the revised Biodiversity Management Plan, required under condition 52.	
Condition 49	For all threatened species on site, the Proponent shall ensure that the Biodiversity Offset Strategy and Rehabilitation Strategy are focused on protection, rehabilitation and long-term maintenance of viable stands of suitable habitat for these species.	The Biodiversity Offset Strategy is outlined in Section 4.1 and is consistent with these

Condition Number	Condition	Where Addressed
	Note: the threatened fauna species on site include: Regent Honeyeater, Fork Tailed Swift, White Throated Needletail, Rainbow Bee-eater, Satin Flycatcher, Speckled Warbler, Swift Parrot, Brown Treecreeper, Diamond Firetail, Grey-crowned Babbler, Hooded Robin, Little Lorikeet, Varied Sittella, White-browed Woodswallow, Black Chinned Honeyeater, Painted Honeyeater, Little Eagle, Spotted Harrier, Black Necked Stork, Square Tailed Kite, Turquoise Parrot, Barking Owl, Masked Owl, Eastern False Pipistrelle, Greater Long-eared Bat, Yellow-bellied Sheath Tail Bat, Eastern Cave Bat, Eastern Bent-wing Bat, Little Pied Bat and Koala.	aims. Revisions to optimise threatened species habitat will be incorporated into the Revised BMP - see Section 13.1
Condition 50	The Proponent shall:	To be incorporated into the Revised BMP - see Section 13.1
a)	investigate, in consultation with OEH and the Namoi CMA, all factors likely to enhance or impede the effective long term provision of suitable habitat(s) for the following species: Regent Honeyeater, Speckled Warbler, Brown Treecreeper, Diamond Firetail, Grey-crowned Babbler, Hooded Robin, Little Lorikeet, Varied Sittella, Black Chinned Honeyeater, Painted Honeyeater, Little Eagle, Spotted Harrier, Turquoise Parrot, Barking Owl, Masked Owl, Eastern False Pipistrelle, Greater Long-eared Bat, Yellow-bellied Sheath Tail Bat and Little Pied Bat.	
b)	within 24 months of the date of this approval (and if possible, in conjunction with Stage 2 of the Leard Forest Mining Precinct Regional Biodiversity Strategy), submit a report of this investigation and provide an implementation plan to ensure delivery of suitable areas of viable habitat for the species included in (a) above, for approval by the Director-General.	
c)	incorporate the approved implementation plan into the revised Biodiversity Management Plan, required under condition 52.	
	Note: the species listed in (a) are those identified in the Director-General's Assessment Report as likely to be significantly impacted by the project.	
Biodiversity Management Plan		
Condition 52	The Proponent shall prepare and implement a Biodiversity Management Plan for the project to the satisfaction of the Director-General. This plan must:	
a)	be prepared in consultation with OEH, SEWPaC, CCC, and the Namoi CMA, and be submitted to the Director-General for approval prior to commencement of construction.	Section 2.4. Note that the CCC is not yet formed at the time of the preparation of this BMP
b)	describe how the implementation of the biodiversity offset strategy would be integrated with the overall rehabilitation of the site.	
c)	describe the short, medium, and long term measures that would be implemented to: - manage the remnant vegetation and habitat on the site and in the offset area/s (if and when applicable); and - implement the biodiversity offset strategy (if and when applicable), including detailed performance and completion criteria.	The vegetation and habitat management measures are provided in Sections 5.0, 6.0 and 8.0. A summary of the Biodiversity Offset Strategy is provided in Appendix B.

Condition Number	Condition	Where Addressed
d)	include detailed performance and completion criteria for evaluating the performance of the biodiversity offset strategy, and triggering remedial action (if necessary).	Section 9.0
e)	include a detailed description of the measures that would be implemented including the procedures to be implemented for: - enhancing the quality of existing vegetation and fauna habitat; - restoring native vegetation and fauna habitat on the biodiversity areas and rehabilitation area through focusing on assisted natural regeneration, targeted vegetation establishment and the introduction of naturally scarce fauna habitat features; - maximising the salvage of resources within the approved disturbance area – including vegetative, top and sub-soils and cultural heritage resources – for beneficial reuse in the enhancement of the biodiversity areas or rehabilitation area; - collecting and propagating seed; - minimising the impacts on fauna on site, including undertaking pre-clearance surveys; - improving the connectivity and corridor function of the offset areas to provide an east/west corridor to the Namoi River and demonstrating that this corridor is enhanced and maintained; - managing any potential conflicts between the proposed restoration works in the biodiversity areas and any Aboriginal heritage values (both cultural and archaeological); - managing salinity; - controlling weeds and feral pests; - controlling erosion; - managing grazing and agriculture on site, including detailed assessment of the suitability of grazing for conservation management outcomes; - controlling access; and - bushfire management.	Sections 5.0, 6.0 and 8.0 of this BMP
f)	include a seasonally-based program to monitor and report on the effectiveness of these measures, and progress against the detailed performance and completion criteria.	Section 9.0
g)	identify the potential risks to the successful implementation of the biodiversity offset strategy, and include a description of the contingency measures that would be implemented to mitigate against these risks.	Section 9.0
h)	include details of who would be responsible for monitoring, reviewing, and implementing the plan. *Note: The Biodiversity Management Plan and Rehabilitation Management Plan need to be substantially integrated for achieving biodiversity objectives for the rehabilitated mine-site.*	Section 8.8
Condition 53	The Proponent shall revise the Biodiversity Management Plan within 30 months of the date of this approval or within 6 months after the completion of Stage 2 of the Leard Forest Mining Precinct Regional Biodiversity Strategy, whichever is sooner. The revised plan must:	Section 13.1
a)	be prepared in consultation with OEH, SEWPaC, Forests NSW, DPI Catchments and Lands, the CCC and the Namoi CMA.	

Condition Number	Condition	Where Addressed
b)	demonstrate consistency with the findings of Leard Forest Mining Precinct Regional Biodiversity Strategy.	
c)	include any implementation plans arising from the studies required under conditions 48 and 50 of this approval.	
	to the satisfaction of the Director-General.	
Long Term Security of the Offset		
Condition 54	The Proponent shall make suitable arrangements to provide appropriate long-term security for the offset areas:	
a)	for the offsets in Table 16 [reproduced in Appendix B of this BMP] that are not subject to final approval as part of the revised Biodiversity Offset Strategy, the long-term security shall be provided by way of: - the Proponent entering into a conservation agreement or agreements pursuant to section 69B of the *National Parks and Wildlife Act 1974*, recording the obligations assumed by the Proponent under the conditions of this approval in relation to these offset areas, and registering the agreement(s) pursuant to section 69F of the *National Parks and Wildlife Act 1974*; or - a tenure of higher conservation status such as a National Park, or Nature Reserve, under the *National Parks and Wildlife Act 1974*.The conservation agreement(s) must be registered by December 2014 unless agreed otherwise by the Director-General after consultation with OEH. The conservation agreements must remain in force in perpetuity.	Section 4.4
b)	within 12 months of the approval of Stage 2 of the Leard Forest Mining Precinct Regional Biodiversity Strategy, unless otherwise agreed by the Director-General, for the offsets in Table 16 [reproduced in Appendix B of this BMP] identified as subject to final approval as part of the revised Biodiversity Offset Strategy.	Section 4.4; to be incorporated into the Revised BMP - see Section 13.1
c)	by the end of December 2034, unless otherwise agreed by the Director-General, for the Rehabilitation Area identified in Table 16 [reproduced in Appendix B of this BMP].	Section 4.4
	to the satisfaction of the Director-General.	
Conservation Bond		
Condition 55	Within 36 months of the date of this approval, or within 6 months of the approval of the revised Biodiversity Management Plan required under condition 52 above (whichever is sooner), the Proponent shall lodge a Conservation and Biodiversity Bond with the Department to ensure that the biodiversity offset strategy is implemented in accordance with the performance and completion criteria of the Biodiversity Management Plan. The sum of the bond shall be determined by:	Section 4.5. To be incorporated into the Revised BMP - see Section 13.1
a)	calculating the full cost of implementing the biodiversity offset strategy (other than land acquisition costs).	
b)	employing a suitably qualified quantity surveyor to verify the calculated costs.	

Condition Number	Condition	Where Addressed
	to the satisfaction of the Director-General. If the offset strategy is completed generally in accordance with the completion criteria in the Biodiversity Management Plan to the satisfaction of the Director-General, the Director-General will release the bond. If the offset strategy is not completed generally in accordance with the completion criteria in the Biodiversity Management Plan, the Director-General will call in all or part of the conservation bond, and arrange for the satisfactory completion of the relevant works. With the agreement of the Director-General, this bond may be combined with rehabilitation security deposit administered by DRE. *Note: Alternative funding arrangements for long term management of the Biodiversity Offset Strategy, such as provision of capital and management funding as agreed by OEH as part of a Biobanking Agreement or transfer to conservation reserve estate can be used to reduce the liability of the conservation and biodiversity bond.*	
Biodiversity Audit		
Condition 56	By the end of December 2017 and then every 5 years, unless the Director-General agrees otherwise, the Proponent shall commission suitably qualified, experienced and independent person/s, whose appointment has been approved by the Director-General, to undertake an audit of the revegetation of the rehabilitation area, management and restoration within the Biodiversity Offset Strategy areas to the satisfaction of the Director-General. This audit must: a) include consultation with OEH, Namoi CMA, DPI Catchments and Lands, SEWPaC, CCC and DRE. b) assess the performance of the revegetation in the rehabilitation area completed to date against the completion criteria in the Rehabilitation Management Plan. c) assess the performance of management and restoration in the off-site Biodiversity Offset Strategy areas completed to date against the completion criteria in the Biodiversity Management Plan. d) identify any measures that should be implemented to improve the performance of rehabilitation, management and restoration within the rehabilitation and biodiversity offset areas. e) if the completion criteria have not been met, or are not adequately trending towards being met, determine the likely ecological value of the rehabilitation and restoration once completed, and recommend additional measures to augment the Biodiversity Offset Strategy to ensure that it adequately offsets the project's impacts on biodiversity. If the audit recommends the implementation of additional measures to augment the Biodiversity Offset Strategy in accordance with (e) above, then within 6 months of the completion of the audit the Proponent shall revise the Biodiversity Offset Strategy, in consultation with the Department, OEH and SEWPaC, and to the satisfaction of the Director-General.	Section 13.3.4

2.3 Plans and Guidelines

Additional plans, guidelines and codes of practice applicable to biodiversity management associated with the Project were considered in the preparation of this BMP and include:

- Draft National Recovery Plan for *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* (DECCW (NSW), 2010);
- Namoi Catchment Action Plan 2010 – 2020 (Namoi CMA, 2011);
- A Guide to Managing Box Gum Grassy Woodlands (Rawlings *et al.*, 2010);
- Restoring Natural Areas in Australia (Buchanan, 2009);
- Threatened species recovery and action plans (Menkhorst *et al.*, 1999; Saunders and Tzaros, 2011; SEWPaC, 2011a);
- Biodiversity guidelines for pre-clearing and construction works (NGH Environmental Consultancy, 2011); and
- Various weed management techniques (see weed management guidelines in **Appendix H**).

This BMP is consistent with the aims and objectives of the recovery plans for Box Gum Woodland, Regent Honeyeater, Swift Parrot and Greater Long-eared Bat. An evaluation of the objectives and actions of this BMP with respect to the above recovery plans is provided in **Appendix C**.

2.4 Stakeholder Consultation

This BMP has been prepared in consultation with the Office of Environment and Heritage (OEH), the Department of Sustainability, Water, Population and Communities (SEWPaC), the Namoi Catchment Management Authority (CMA) and the Maules Creek Coal Community Consultative Committee (CCC) to the satisfaction of the Director-General of DP&I.

The concept for the use of domains was developed in consultation with OEH, as was the concept for measurable outcomes for both vegetation communities and threatened species. The Namoi CMA provided advice regarding monitoring and the use of grazing in the management and restoration of grassy woodlands.

Correspondence with stakeholders in regards to this BMP is included in **Appendix A**.

3.0 EXISTING ENVIRONMENT AND THREATS

This section briefly describes the biodiversity values in the Project Boundary and outlines the main threats to flora and fauna, both those that will occur as a result of the Project, and those that already exist. The impacts of the Project will be addressed through the implementation of this BMP; however the impacts are briefly recapitulated here in order to provide context for the Offset Strategy and the proposed management measures proposed thereafter to manage the remnant flora and fauna values present within the Project Boundary. Threats considered below that are not directly attributable to the Project, however may be exacerbated by the Project, include weeds and feral animals.

3.1 Existing Flora and Fauna Values

The Project Boundary contains significant flora and fauna values, in particular because it includes a substantial proportion of Leard State Forest. The vegetation within Leard State Forest contains several threatened vegetation communities and provides habitat for a range of fauna species, including several threatened species. The majority of threatened species are associated with the box and ironbark woodland communities of Leard State Forest, although small patches of remnant vegetation also occur throughout the predominantly cleared north western portion of the Project Boundary, especially the riparian vegetation along Back Creek. As Leard State Forest and the nearby Leard State Conservation Area are surrounded by heavily cleared agricultural land, it also provides a "stepping stone" corridor for a range of highly mobile species, particularly birds and bats.

3.1.1 Flora

The Project Boundary is predominantly forested by a range of native vegetation communities, although the original character of the vegetation has been altered as a result of previous land uses including agricultural and forestry activities.

i. Threatened Ecological Communities

The Project Boundary contains several ecological communities that are listed under either the TSC Act and/or the EPBC Act. The majority of these are variants on the community known as "*White Box, Yellow Box and Blakely's Red Gum Woodland and Derived Native Grasslands*" (Box Gum Woodland), which is listed as a Critically Endangered Ecological Community (CEEC) under the EPBC Act and as an Endangered Ecological Community (EEC) under the TSC Act. These variants include:

- White Box - Narrow-leaved Ironbark - White Cypress Pine grassy open forest;
- White Box - White Cypress Pine grassy woodland;
- Yellow Box - Blakely's Red Gum grassy woodland;
- White Box - Wilga - Belah woodland;
- White Box - Blakely's Red Gum - Melaleuca riparian forest; and
- Derived Native Grasslands.

One other listed community is present on the Project Boundary; Plains Grassland. This community is consistent with an EEC listed under the TSC Act; "*Native vegetation on cracking clay soils of the Liverpool Plains*". It is also consistent with a CEEC listed under the EPBC Act; "*Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland*".

ii. Threatened Flora Species

The Project Boundary provides habitat for a wide range of flora species, although no threatened species have been recorded. The following threatened flora species have been detected in the vicinity of the Project Boundary, either in Leard State Forest or in Leard State Conservation Area and although they have not been recorded from the Project Boundary, they are considered highly likely to occur:

- *Pomaderris queenslandica* (Scant Pomaderris), listed as Vulnerable under the TSC Act, has been recorded from Leard State Forest;
- *Pultenaea setulosa* is a pea shrub that is listed as Vulnerable under the EPBC Act (Weston, 1991); and
- *Lepidium aschersonii* (Spiny Peppercress), listed as Vulnerable under both the TSC Act and EPBC Act, has been recorded from the Leard State Conservation Area (Carter, 2010).

3.1.2 Fauna

i. Fauna Habitat Values

Vegetation within the Project Boundary provides habitat for a range of native fauna species, including amphibians, reptiles, birds, bats and arboreal and terrestrial mammals. Riparian vegetation along Back Creek may also provide corridor values, particularly for Koalas and other arboreal mammals. Key habitat features present in the Project Boundary include:

- Dense understorey vegetation – which provides shelter and foraging habitat for amphibians, reptiles, small birds and terrestrial mammals;
- Tree hollows suitable as shelter and breeding habitat for a range of hollow-dependant fauna including reptiles, birds, arboreal mammals and microbats;
- Nectar-producing trees and shrubs – which is foraging habitat for insects, blossom dependant birds, arboreal mammals and mega-chiropteran bats (flying-foxes);
- Secondary Koala feed tree species;
- Caves, culverts and other suitable shelter or breeding habitat for a range of cave-dependant fauna;
- Fallen logs, debris and leaf litter – shelter habitat for small terrestrial fauna species including amphibians, reptiles and terrestrial mammals;
- Rocky outcrops – shelter and breeding habitat for amphibians, reptiles and terrestrial mammals;
- Feed trees, shrubs and grasses for a range of species – food for small birds, cockatoos and herbivorous mammals;
- Ecotonal (edge) communities – foraging habitat for many species, particularly birds;
- Ephemeral drainage lines – foraging, shelter and breeding habitat for amphibians, aquatic reptiles, wetland birds and aquatic mammals; and
- Constructed farm dams with aquatic vegetation – foraging and breeding habitat for amphibians, aquatic reptiles and wetland birds.

ii. Threatened Fauna Species

A number of threatened fauna species have been recorded from Leard State Forest and the immediate surrounds, including woodland bird species, raptors, microchiropteran bats and the Koala. These include:

- Speckled Warbler (*Pyrrholaemus saggitatus*);
- Spotted Harrier (*Circus assimilis*);
- Little Eagle (*Hieraaetus morphnoides*);
- Square-tailed Kite (*Lophoictinia isura*);
- Fork-tailed Swift (*Apus pacificus*);
- White-throated Needletail (*Hirundapus caudacutus*);
- White-browed Woodswallow (*Artamus superciliosus*);
- Black-necked Stork (*Ephippiorhynchus asiaticus*);
- Brown Treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*);
- Diamond Firetail (*Stagonopleura guttata*);
- Painted Honeyeater (*Grantiella picta*);
- Black-chinned Honeyeater (eastern subspecies) (*Melithreptus gularis gularis*);
- Rainbow Bee-eater (*Merops ornatus*);
- Satin Flycatcher (*Myiagra cyanoleuca*);
- Varied Sittella (*Daphoenositta chrysoptera*);
- Hooded Robin (*Melanodryas cucullata*);
- Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*);
- Little Lorikeet (*Glossopsitta pusilla*);
- Turquoise Parrot (*Neophema pulchella*);
- Barking Owl (*Ninox connivens*);
- Masked Owl (*Tyto novaehollandiae*);
- Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*);
- Koala (*Phascolarctos cinereus*);
- Little Pied Bat (*Chalinolobus picatus*);
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*);
- Greater Long-eared Bat (*Nyctophilus corbeni*); and
- Eastern Cave Bat (*Vespadelus troughtoni*).

Other species such as the Superb Parrot (*Polytelis swainsonii*), Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Anthochaera phrygia*) have potential to occur in the Project Boundary and the surrounding area from time to time.

3.2 Description of the Impacts

The Project will entail open cut mining activities within Leard State Forest for a period of 21 years and the development of supporting surface infrastructure in its current mining tenements.

3.2.1 Direct Disturbance

i. Vegetation Removal

The Project Disturbance Area is 2178 ha in size, of which approximately 1664.8 ha comprises native forest and woodland habitat. The remaining 513 ha includes various forms of secondary and exotic grassland. The Project will result in the clearance of up to 544 ha of Box Gum Woodland, which is listed as an EEC under the TSC Act and as a CEEC under the EPBC Act.

In addition to the direct removal of these native vegetation communities, the Project will also indirectly impact vegetation that will remain in Leard State Forest by additional fragmentation, edge effects and isolation. Remnant vegetation is already fragmented within the Project Boundary; however the proposed development has potential to increase the level of fragmentation and isolation of forested areas.

ii. Habitat Removal

The open forest, woodland and derived grassland communities of the Project Boundary provide habitat for a range of fauna; including some species that are listed as threatened or migratory under the EPBC Act and/or the TSC Act. Within these vegetation communities, a range of habitat features provide foraging, shelter and breeding opportunities for fauna. The Project will result in the clearance of:

- 1664.8 ha of forest and woodland habitat for TSC Act listed species that have been recorded within the Project Boundary, particularly threatened woodland birds and bats; and
- 1664.8 ha of potential foraging habitat for EPBC Act listed fauna, i.e. Swift Parrot (*Lathamus discolor*), Regent Honeyeater (*Anthochaera phrygia*) and Greater Long-eared Bat (*Nyctophilus corbeni*, which is still recognised as the synonym *N. timoriensis* under NSW legislation).

The quality of habitat is dependent upon location and is very dependent upon past land use. Regrowth areas generally lack many habitat features but areas of good quality habitat were identified at several locations. The habitat features present in the Project Boundary include hollow trees, bushrock, dense understorey vegetation and wetland areas.

Tree hollows are a particularly important habitat component in the Project Boundary. In spite of the history of logging and gathering of timber for firewood within Leard State Forest, many trees remaining within the forest have hollows; particularly within the Box Gum Woodland communities. Of these, it is possible that only a small proportion of available hollows are likely to be functional (Cockle *et al.*, 2008) and so the importance of this limited resource in the Project Boundary is likely to be quite high.

Tree hollows are an essential resource for a number of fauna species that rely on them for refuge and nesting (Newton, 1994; Gibbons and Lindenmayer, 2002; Heinsohn *et al.*, 2003; Cockle *et al.*, 2010). Tree hollows have been shown to be a key limiting resource for hollow-dependent fauna (Brawn and Balda, 1988; Lindenmayer *et al.*, 1990; Newton, 1994; Gibbons and Lindenmayer, 2002; Gibbons *et al.*, 2002; Heinsohn *et al.*, 2003; Cameron, 2006), and the processes of natural decay and primary excavation that produce hollows are time-consuming and energy costly (Marsden and Pilgrim, 2003; Aitken and Martin, 2007; Murphy and Legge, 2007; Aitken and Martin, 2008).

Furthermore, many hollow-dependent species such as the Swift Parrot (*Lathamus discolor*) are hollow specialists (as opposed to hollow generalists) and will only occupy hollows with specific hollow characteristics (Gibbons *et al.*, 2002); this means that many of the available number of hollows in an area of habitat is unlikely to be usable or 'functional', which increases the demand on the remaining suitable hollows. Much of this resource will be lost in the short term and medium term from within the footprint of the Project Boundary. Furthermore, fragmentation and edge effects will have consequences for the integrity of the remaining hollow-bearing forest (e.g. susceptibility to windblow).

The impact of the clearance of vegetation and removal of fauna habitat features will result in several actions considered to be Key Threatening Processes by OEH including Bushrock Removal; Clearing of Native Vegetation; Alteration to the Natural Flow Regimes of Rivers, Streams, Floodplains and Wetlands; Removal of Dead Wood and Dead Trees; and Loss of Hollow-bearing Trees (NSW Scientific Committee, 1999; NSW Scientific Committee, 2001; NSW Scientific Committee, 2002; NSW Scientific Committee, 2004; NSW Scientific Committee, 2007).

3.2.2 Weeds

One of the main threats to vegetation communities and threatened species is weeds, which can result in changes to the structure, species composition, fire frequency and abundance of native communities. Numerous weeds have been recorded from the Project Boundary, and disturbance as a result of the Project has the potential to exacerbate the impact of weeds on areas of retained native vegetation, particularly Leard State Forest. The principal mechanisms for weeds establishing in an area include:

- Elevated nutrients in stormwater runoff;
- Physical disturbances to the soil;
- Increased soil moisture from shading / reduced water infiltration; and
- Increased light at the margins of vegetation.

Weeds have the potential to change the natural diversity and balance of ecological communities and threaten the survival of many plants and animals because they compete with native plants. Weeds may out-compete native plants because they may not be affected by the pests or diseases that would normally control them in their natural habitats or the disturbed environment provides different conditions that better suit the invading weed. As a result the weed may grow faster than native plants and successfully compete for available nutrients, water, space and sunlight; reduce natural diversity by smothering native plants or preventing them from growing back after clearing, fire or other disturbance; or replace the native plants that animals use for shelter, food and nesting. Weeds are often excellent at surviving and reproducing in disturbed environments and are often the first species to colonise and dominate in these conditions.

Recognition of the impact of weeds comes with the listing of several weeds as Key Threatening Processes under the TSC Act; however none of these species has been recorded from the Project Boundary.

For the purposes of this BMP, noxious and environmental weeds that were recorded in the Project Boundary during extensive surveys were considered against the weed lists declared for the Namoi CMA and Narrabri LGA. The key weed species relevant to this BMP are listed below. Any additional significant or declared weed species recorded in the implementation of this BMP will be managed under this BMP where relevant.

In NSW, 'Noxious Weeds' are plants that have been declared under the *Noxious Weeds Act 1993* (NW Act) by the Minister for Primary Industries. Weeds with the potential to impact on agriculture, or animal or human health or damage the environment are potential candidates for declaration as noxious weeds. 'Environmental Weeds' are those plants that are considered to have a significant impact on the natural environment, but have not been declared noxious.

Several of the weeds recorded from the Project Boundary are listed as Noxious Weeds under the NW Act in the Narrabri LGA, including:

- Hemlock (*Conium maculatum*) – Class 4;
- African Boxthorn (*Lycium ferocissimum*) – Class 4;
- Tiger Pear (*Opuntia aurantiaca*) – Class 4;
- Opuntia sp – Class 4;
- Prickly Pear (*Opuntia stricta*) – Class 4;
- Velvet Tree Pear (*Opuntia tomentosa*) – Class 4;
- Creeping Oxalis (*Oxalis corniculata*) – Class 5;
- Blackberry (*Rubus ulmifolius*) – Class 4; and
- Bathurst Burr (*Xanthium spinosum*) – Class 4

The following weed species have not been previously recorded in the Project Boundary but are recognised to be problematic noxious or environmental weeds in the Narrabri LGA or Namoi CMA areas:

- Coolatai Grass (*Hyparrhenia hirta*);
- Alligator Weed (*Alternanthera philoxeroides*) – Class 2;
- Honey locust (*Gleditsia triacanthos*);
- Chilean Needle Grass (*Nassella neesiana*) – Class 4; and
- Devil's Rope Pear (*Cylindropuntia imbricata*) – Class 4.

The characteristics and control requirements of each relevant class of weed can be obtained from the Department of Primary Industries website (http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/noxweed) and are as follows:

Class 2 *Plants that pose a potentially serious threat to primary production or the environment of a region to which the order applies and are not present in the region or are present only to a limited extent. The plant must be eradicated from the land and the land must be kept free of the plant. The weeds are also "notifiable" and a range of restrictions on their sale and movement exist.*

Class 4 *Plants that pose a potentially serious threat to primary production, the environment or human health, are widely distributed in an area to which the order applies and are likely to spread in the area or to another area. The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction. For some species, the plant may not be sold, propagated or knowingly distributed.*

Class 5 *Plants that are likely, by their sale or the sale of their seeds or movement within the State or an area of the State, to spread in the State or outside the State. The weeds are "notifiable" and a range of restrictions on their sale and movement exists.*

Of these, Alligator Weed, Blackberry, Chilean Needle Grass and Devil's Rope Pear are also listed as a Weed of National Significance (WONS). WONS are recognised nationally as part of a National Weed Strategy.

Management Plans have been prepared by the Narrabri Shire Council for African Boxthorn, Blackberry, Chilean Needle Grass, Hemlock, and the species of *Opuntia* (collectively termed "Prickly Pear"). These plans specify the control actions to be implemented for these species and outline the obligations of landholders who have these species on their property (see **Appendix H**).

As described above, weeds are usually pioneer species that do well in disturbed environments and in the interface between natural habitats and disturbed areas. The Project has the potential to impact on intact areas of native vegetation that will not be directly affected by vegetation clearance by facilitating the establishment of weeds. Therefore weed control strategies presented later in this document focus on the interface areas and aim to prevent the establishment and spread of weeds from within the Project Boundary into adjacent areas of native vegetation. Particular attention will be given to the Noxious Weeds identified above as occurring within the Project Boundary.

Weed management of rehabilitation areas will be covered in the separate Rehabilitation Management Plan.

3.2.3 Feral Fauna

Feral fauna can cause problems for native fauna species by preying upon them or by competing with them for food and resources. Leard State Forest supports a significant feral fauna population, notably European Red Fox (*Vulpes vulpes*) and Feral Pig (*Sus scrofa*). These species all have reproducing populations within Leard State Forest and juveniles of both species have been recorded.

Other feral animals recorded from the Project Boundary include the following:

- Black Rat (*Rattus rattus*);
- House Mouse (*Mus musculus*);
- Domestic Cat (*Felis catus*);
- Brown Hare (*Lepus capensis*); and
- European Rabbit (*Oryctolagus cuniculus*).

Although these species are exotic pests, the majority are not considered to be a major threat to the native flora and fauna in the Project Boundary and Leard State Forest. The main species considered to have potential to have a negative impact on these areas are the European Red Fox, Feral Pig, Black Rat and European Rabbit, and these are considered below in subsequent subsections. Although these species already occur in the Project Boundary, disturbance as a result of the Project has the potential to exacerbate the impact of these species through disturbance and alteration of habitat, and the European Rabbit is considered to have potential to impact on rehabilitation works.

i. Feral Pig

Large mobs of up to 25 Feral Pigs have been recorded from within the Project Boundary and regular harvesting of this species takes place within the Leard State Forest (pers.comm. Chris Lauritzen, 2008).

Feral pigs are considered to be an environmental pest, and their major damage is habitat degradation through selective feeding, trampling and rooting for underground parts of plants and invertebrates, as well as predation on, competition with, or disturbance of a range of animals. The most significant environmental damage by feral pigs is caused by their rooting up of soils, grasslands or forest litter,

particularly along drainage lines, moist gullies and around swamps and lagoons, or after rain, when the ground is softer (Choquenot *et al.*, 1996; Threatened Species Scientific Committee, 2001). Disturbance of habitats by feral pigs may also facilitate the invasion and spread of weeds and thus affect the composition of plant communities (DEH, 2005). Feral pigs are also known to prey on frogs, reptiles, birds and small mammals (DEC (NSW), 2005) as well as degrade habitat by feeding selectively on plant communities, creating drainage channels in swamps, and eroding soil and fouling watering points by wallowing.

Predation by the feral pig has been implicated as a major cause of decline in several bird species and direct predation by feral pigs is considered to have contributed to declines in populations of some frog species (Richards *et al.*, 1993).

"Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs" is listed as a Key Threatening Process under both the TSC Act and the EPBC Act, and a Threat Abatement Plan has been prepared (DEH, 2005).

ii. European Red Fox

The European Red Fox is Australia's most significant predator threatening the long-term survival of a range of native wildlife (Saunders *et al.*, 1995). Foxes have a wide dietary range, and are threatened by few natural enemies or few serious diseases in Australia. They also have high reproductive rates and high rates of cub survival, which allows them to rapidly colonise areas although they only breed once a year over a short period. These attributes make the fox a significant threat to biodiversity.

Foxes have direct impacts on a range of native animal species as they prey particularly on small to medium-sized, ground-dwelling and semi-arboreal mammals, and ground-nesting birds (DEWHA, 2008b). The presence of the feral fox is likely to be a key factor in the low numbers and diversity of ground-dwelling fauna in Leard State Forest as they have long been recognised to be a major contributor to the decline of ground-nesting birds, small to medium mammals and reptiles (SEWPaC, 2010).

"Predation by the European Red Fox" is listed as a Key Threatening Process under both the TSC Act and the EPBC Act, and a Threat Abatement Plan has been prepared.

iii. Black Rat

The Black Rat is widespread and abundant in Australia. It is a commensal rodent that is usually found in disturbed or degraded environments. It is the rat most commonly observed in cities and towns, and is often responsible for the infestation of houses, sheds, warehouses and storages of grain. This species competes with native species of rat and native marsupials for resources. Human intervention, in the form of clearing unsuitable habitats and planting cereal and other food crops, increases the optimal habitat and food resources for rats.

Although the Black Rat has been recorded from the Project Boundary, it is in relatively low numbers and natural processes are likely keeping the numbers in check. The Project has the potential to facilitate an increase in the population numbers of this species by disturbance of the environment and an increase in garbage.

iv. European Rabbit

Rabbits are well adapted to climatic conditions in much of Australia and occur in all states and territories. Rabbits are considered to be one of Australia's most serious vertebrate pests, and are the country's most abundant small mammal. They have the capacity to severely affect native flora and fauna, vegetation communities, landforms, geomorphic processes and sensitive sites, as well as primary industries (DEWHA, 2008a).

Rabbits have direct impacts on native flora and fauna; for example, by grazing on native vegetation and thus preventing regeneration, and by competing with native fauna for food and shelter. They also have indirect and secondary effects, such as supporting populations of introduced cats and foxes, denuding vegetation and thereby exposing fauna species (e.g. burrowing petrels) to increased predation, and digging and browsing leading to a loss of vegetation cover and consequent slope instability and soil erosion.

"Competition and grazing by the feral European rabbit" is listed as a Key Threatening Process under the TSC Act, and "Competition and land degradation by rabbits" is listed as a Key Threatening Process under the EPBC Act. A Threat Abatement Plan has been prepared by the Commonwealth Government (DEWHA, 2008a).

The European Rabbit has been recorded from the Project Boundary and it is likely to be widespread in nearby agricultural lands that provide extensive areas of habitat. The Project is unlikely to exacerbate the impact of this species on the natural environment as no additional habitat will be created. The European Rabbit has the potential to impact on areas that are being rehabilitated subsequent to mining, as these areas will initially comprise grassed habitats with young trees. Rabbits are known to pose a risk to regenerating vegetation through browsing the young trees and ringbarking older trees. If this is found to occur, then the control program will be implemented, as described in **Section 8.0.**

3.2.4 Namoi River

A Pump Station is proposed for the Project on the Namoi River, where an existing High Security water licence is held for up to 3000 units of water per annum. No significant impact is predicted as a result of this Pump Station and no aquatic offsets are required for the Project.

3.2.5 Cumulative Disturbance

Aside from the Project, other coal mining associated with the Boggabri Coal Mine is currently taking place in the southern part of Leard State Forest. The Boggabri Coal Mine is also proposing to continue mining for a further 21 years and will eventually mine a high proportion of the southern half of the Leard State Forest. Tarrawonga Mine is further to the south east and will mine additional areas of forest. Collectively, when considered with the Project, a high proportion of the existing Leard State Forest will be subject to mining within the next two to three decades. Notwithstanding this, all of the mines propose to rehabilitate mined areas and return them to forest and woodland. The mined landscape will be progressively returned as flora and fauna habitat in the medium to long term. Additionally, all of the mines have provisions for offsetting ecological impacts. All of the mines will or have purchased additional surrounding lands that contain forest, woodland and derived native grasslands. These will collectively and significantly increase the total areas of native vegetation that exist in the locality in the future and will significantly increase the total area of native vegetation within conservation reserves in the locality and the region.

4.0 BIODIVERSITY OFFSET STRATEGY

The Biodiversity Offset Strategy has been developed to compensate for the biodiversity impacts of the Project and comprises a package of offset properties that will be set aside for conservation and managed in perpetuity. The clusters of offset properties (**Figure 4.1**) are referred to as the "Northern Offsets", in the Barraba district; and the "Eastern and Western Offsets", which are located in the immediate vicinity of the Project. The Eastern and Western Offsets are intended to complement other offsets proposed by Boggabri Coal, forming linkages to the Nandewar Ranges, Leard State Conservation Area and the Namoi River. MCC also has shared ownership of a property located to the south west of the Project Boundary that will be included in the offset package.

The existing environments, vegetation communities and fauna habitats present on the the Northern, Eastern and Western Offset properties included in the Offset Strategy are described in further detail within this Section and include information such as location, landscape context and land use. The properties are also described and discussed.

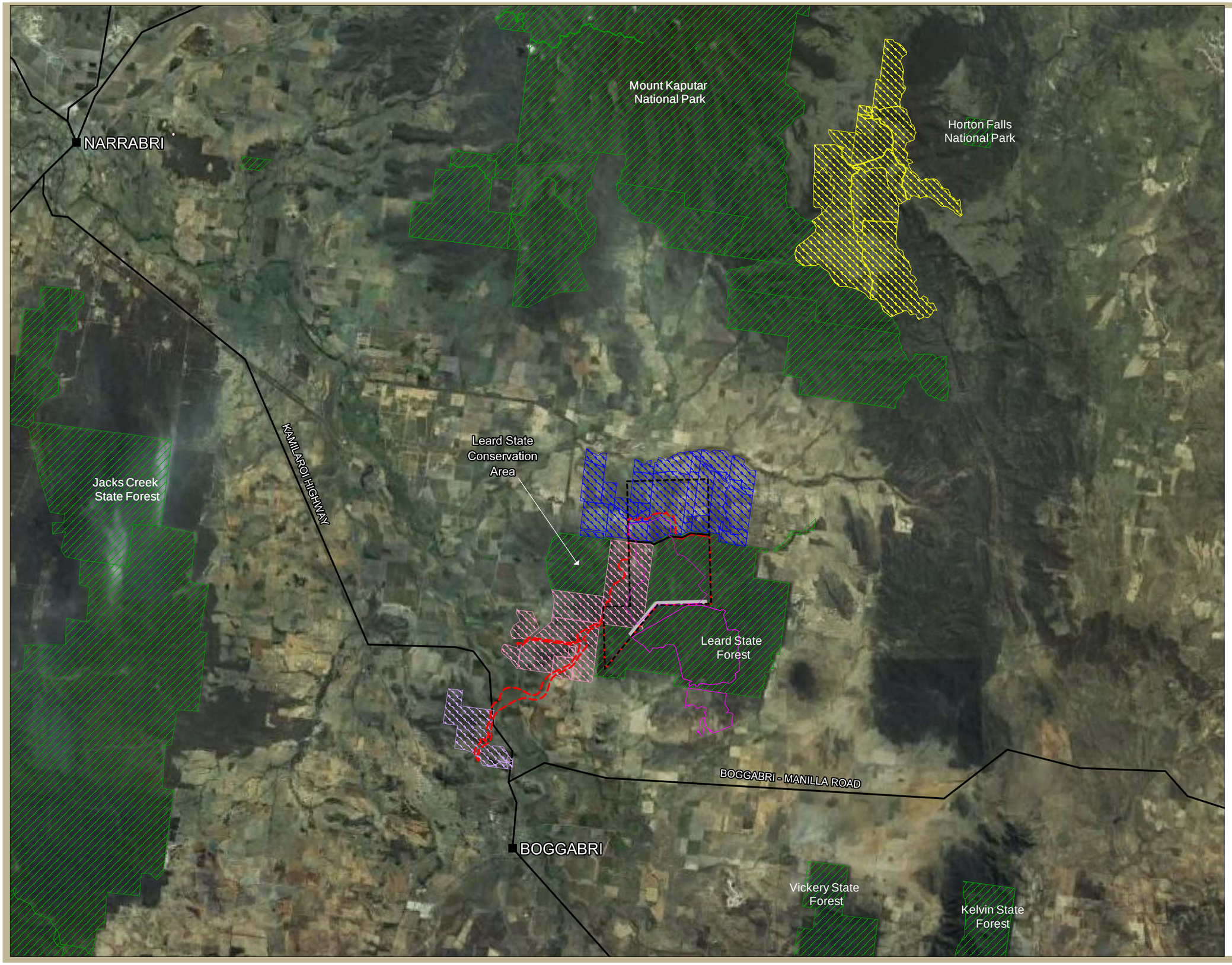
The properties have been divided into various Management Zones and have been described in the relevant management sections. Some Management Zones are designated conservation areas and have been included in the total offset areas. Others are intended to remain as farming areas and have not been included in the total offset areas for the Project. However, the farming areas are still considered within the scope of this BMP as their management will influence the management outcomes in the conservation Management Zones.

The Biodiversity Offset Strategy addresses unavoidable Project impacts on threatened species, populations and communities that are listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act). The Biodiversity Offset Strategy also addresses unavoidable impacts to Matters of National Environmental Significance (MNES) under the EPBC Act, namely clearance of the critically endangered Box Gum Woodland; and foraging habitat for Swift Parrot (*Lathamus discolor*), Regent Honeyeater (*Anthochaera phrygia*) and Greater Long-eared Bat (*Nyctophilus corbeni*, which is still recognised as the synonym *N. timoriensis* under NSW legislation).

The following tables of information are thus provided at the end of this section to summarise the current components of the Offset Strategy. It is consistent with Condition 44 in Schedule 3 of PA 10_0138, which is reproduced in **Appendix B**.

- **Table 4.20** presents the areas of vegetation mapped within the entirety of each property involved in the Offset Strategy for the Project;
- **Table 4.21** itemises the vegetation areas that are to be conserved for biodiversity within each property;
- **Table 4.22** compares the areas of different vegetation communities to be conserved against the direct Project impacts and expresses this comparison as a ratio value;
- **Table 4.27** summarises the areas of habitat within the conservation Management Zones for threatened species that are listed by the TSC Act;
- **Table 4.28** compares only the areas of different Box Gum Woodland communities against the direct Project impacts and again, expresses this comparison as a ratio value; and
- **Table 4.29** is a table summarising the areas of Box Gum Woodland and habitat for threatened species of National Environmental Significance within the conservation Management Zones.

Coordinate System: MGA Zone 56 (GDA 94)



Legend

- Project Boundary
- Mining Tenement Boundary
- Final Rehabilitation
- Conservation and forest reserves
- Towns
- Roads
- Northern Offset Properties
- Eastern Offset Properties
- Western Offset Properties
- Shared Offset Property
- 250 m vegetated biodiversity or "buffer" corridor

Grid North

Image Source:
Image © 2010 GeoEye
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Figure 4.1 The Biodiversity Offset Strategy

3 0 3 6 9 12 km

4.1 Revised Biodiversity Offset Strategy

In addition to the conservation areas within the Northern, Eastern and Western Offset properties, MCC will also locate an additional 1,000 ha of moderate to good condition remnant native vegetation for inclusion in the Offset Strategy (as required by Conditions 44 and 45, Schedule 3 of PA 10_0138) and re-establish 2,078 ha of pre-mining native vegetation as part of the Project's Rehabilitation Management Plan. Further revision to the areas of low diversity derived native grassland areas may also be made.

The additional areas of offset will need to include 500 ha of Box Gum Woodland in addition to the area conserved in the current Offset Strategy to meet the requirements of Condition 9 of the Approval Decision EPBC 2010/5566.

The Offset Strategy will be revised within the first 30 months following Project Approval as required by Condition 53 in Schedule 3 of PA 10_0138 to include these additional areas and revisions. This BMP will then be revised and reissued with updated details about any additional areas according to the requirements of Condition 45 of Schedule 3 of PA 10_0138.

4.2 Research and Indirect Offsetting

The restoration and management of the offset lands as well as the management of the Project Boundary provides a substantial opportunity to support and further ecological research about various ecological issues. These include but are not limited to research into recovery of threatened species populations as habitat is regenerated (e.g. threatened birds and bats), analysis of successional trends in different variants of regenerating Box Gum Woodland and other related vegetation, management of selected weeds within regenerating Box Gum Woodland (e.g. Briar Rose and Box Thorn), and many other topics. The monitoring of offsets will also furnish some data that can potentially be used by research projects and researchers.

A key objective for the monitoring program (**Section 9.0**) and for the BMP will be to explore options for co-operative research projects that provide opportunities for research organisations to conduct ecological research aimed at improving our long term understanding of the ecology of Box Gum Woodland, other vegetation communities and threatened species.

The Pilot Monitoring report will also provide a discussion of opportunities for research within the Offset Properties. Thereafter, further opportunities will be discussed within the Annual Monitoring Report (see **Section 9.3**).

4.3 Agricultural Production within Offset Areas

Although the Biodiversity Offset areas are primarily for conservation, there remain some areas that will be used for agriculture. The management of the offset areas is explained in **Section 5** and **Section 6**, which identify the conservation lands, and the areas that will be subject to agriculture. The management provisions for the offset lands provided within **Section 5** and **Section 6** explain conservation management provisions.

As required by Schedule 3, Condition 46 of PA 10_0138, an Agricultural Suitability Assessment of surplus lands will be produced and added to this BMP within 30 months of the Project Approval date.

4.4 Long Term Security of Offset

The offsets covered by this strategy will be conserved long term by an appropriate mechanism as set out in Schedule 3, Condition 54 of PA 10_0138 and Condition 13 of the Approval Decision EPBC 2010/5566.

MCC will be in ongoing discussions with the National Parks and Wildlife Service (NPWS) and/or OEH in relation to entering agreements in relation to providing long term security for the properties to be included in the offset package.

4.5 Conservation Bond

The full cost to implement the Biodiversity Offset Strategy as per this BMP (excluding land acquisition costs) will be calculated within the revised BMP (due to be updated by 23 October 2015). The costs will include all management measures prescribed within **Section 5.0** to **Section 9.0** of this Plan and include staff costs, fencing, fire management, weed management, feral animal control, seed collection, replanting/revegetation, monitoring, auditing and reporting. The updated costs will also cover any new lands that are to be acquired within the Revised Biodiversity Offset Strategy.

A Conservation Bond Report will be provided to summarise the cost estimates for the Conservation Bond.

The work will be conducted in compliance with Condition 55, Schedule 3 of PA 10_0138.

4.6 Offset Area Descriptions

4.6.1 Northern Offsets

i. Location and Landscape Context

The Northern Offsets are comprised of two large properties; Wirradale and Mt Lindesay (**Figure 4.2**). The Northern Offsets have been acquired or are subject to an acquisition agreement, are located approximately 40 km west of the township of Barraba and are approximately 10 km north east of the Project (**Figure 4.1**). The properties are adjacent to one another and are nestled in a valley within the northern reaches of the Nandewar Ranges. Wirradale is immediately adjacent to the Mount Kaputar National Park.

The Northern Offsets are extensively vegetated and link to each other and to adjacent forest lands, including Mount Kaputar National Park and private properties to the east, which are in turn connected to Horton Falls National Park. The Northern Offset properties contain three permanent streams; Maules Creek, Horton River and Second Water Creek; and many smaller tributaries. They also contain cliffs and rock outcrops that provide excellent habitat for wildlife, including bats.

The inclusion of the Northern Offset properties in the Offset Strategy will protect and improve large areas of Box Gum Woodland and restore large areas of Derived Native Grassland. The Northern Offsets will also buffer and augment the Mount Kaputar National Park from surrounding farming; enhance other nearby conservation areas like the Horton Falls National Park; protect and restore upstream stretches of Maules Creek, Horton River and Second Water Creek; and protect existing areas of good quality habitat for wildlife.

ii. Land Use History

The properties are currently being used as grazing farms for “dorpa” sheep and cattle. Historically, much of the forests and woodland on the properties would have been cleared. The properties are now well vegetated with mature regenerated forest and woodland, however still contain many open grassland areas for pasture. Many areas of the properties are currently grazed infrequently or are subject to low intensity but frequent grazing. As such, much of the grassland areas are dominated by native grass species and a high diversity of native forbs and graminoid species.

Native pastures in more heavily grazed paddocks have been fertilised in the past and contain a moderately high density of weed species, such as thistles and woody weeds. However, seasonal surveys have demonstrated that even these areas support a high diversity of native forb species (see **Appendix D** for floristic data) that could be further encouraged with appropriate management. Tree and shrub regeneration across both properties are evident, particularly on the Wirradale property, demonstrating that the regenerative capacity of the properties is excellent. In combination with grazing management, the restoration opportunities on these properties are positive. Some site photographs are shown below (**Photograph 4.1** to **4.5**).

Coordinate System: MGA Zone 56 (GDA 94)

Grid North

Cotswold Road

HORTON RIVER

Mount Lindsay Road

MIDDLE CREEK

Mt Lindesay

Clonmeen Road

Horton Falls CCA
Zone 1 National Park

HORTON RIVER

Mount Kaputar National Park

Wirradale

MAULES CREEK

Legend

- Northern Offsets
- State Forest/Conservation Areas
- River
- Road

Vegetation Community

- Derived Native Grassland (Box Gum Woodland)
- White Box - stringybark shrubby woodland
- Stringybark - Blakely's Red Gum grassy open forest
- Rough-barked Apple - Blakely's Red Gum riparian grassy woodland
- Tea-tree shrubland in drainage lines
- White Box - stringybark grassy woodland
- Narrow-leaved Ironbark - White Cypress Pine shrubby open forest
- Improved Pastures
- Manna Gum - Yellow Box - Blakely's Red Gum open forest
- Stringybark - Blakely's Red Gum shrubby open forest
- Derived Native Grassland (Low Diversity - Box Gum Woodland)
- Melaleuca riparian forest
- Derived Native Grassland (Non-threatened)
- White Box - White Cypress Pine grassy woodland

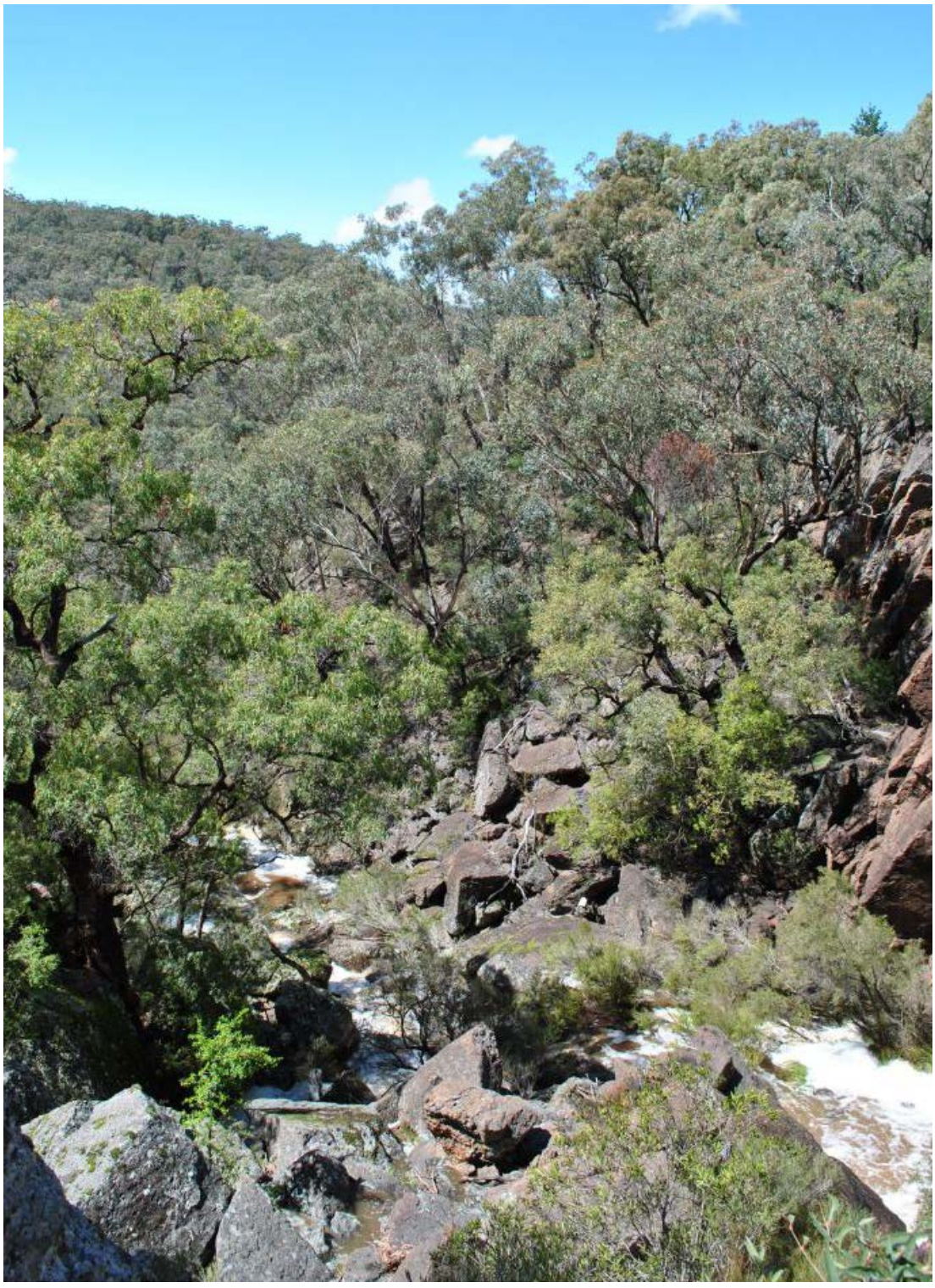
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Image © 2011 GeoEye
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Figure 4.2. Vegetation of the Northern Offset Properties

1000 0 1000 2000 3000 4000 m



Photograph 4.1 Creek habitat and waterfall on Wirradale



Photograph 4.2 **Maules Creek – Wirradale. This is a semipermanent stream that forms excellent habitat for birds, bats and other fauna.**



Photograph 4.3 **Typical grazing paddock on Wirradale with regenerating White Box Grassy woodland.**



Photograph 4.4 **Typical grazing pasture within Yellow Box Grassy Woodland on Mt Lindesay**



Photograph 4.5 ***Poa sieberiana*** **grassland on Mt Lindesay. This is Derived Native Grassland that forms part of the Box Gum Woodland CEEC.**

4.6.2 Eastern and Western Offsets

i. Location and Landscape Context

The Eastern and Western Offsets comprise a selection of properties that are located in the vicinity of the Project Boundary and are adjacent to Leard State Forest to the north and to the west. Much of these areas have been cleared in the past for grazing, although many large patches of remnant vegetation still remain. The role of locating biodiversity offsets in these areas is to conserve existing areas of remnant vegetation in the locality; to buffer and augment the Leard State Conservation Area from the future mining activities; to protect and restore riparian habitats in the vicinity of the Project; to immediately protect habitat for fauna; and to provide habitat improvement opportunities for fauna at the point of disturbance. The Eastern and Western Offset properties are also intended to augment Boggabri Coal's biodiversity offsets to add to the conservation network around the mining developments in the Leard State Forest (see the map in **Appendix B**).

The Eastern Offsets are situated at the northern boundary of Leard State Forest and comprise parts of the following properties: Blue Range, Teston, Tralee, Cattle Plain, Warriahdool and Wallandilly (**Figure 4.3**). These properties contain stretches of Back Creek and Maules Creek that are tributaries of the Namoi River.

The Western Offsets comprises five properties to the west of the Project that include parts of Velyama, Teston and Olivedeen, which are already owned by MCC; parts of Louenville, which is adjacent to the Leard State Conservation Area; and the entirety of Kelso, which is adjacent to Louenville (**Figure 4.3**). Olivedeen and Kelso have frontage to the Namoi River.

All of the remnant vegetation in the Eastern and Western Offsets and select areas of grassland will be included in the offset package. The areas that will be managed for biodiversity conservation are summarised in **Table 4.21** and are shown on the map in **Appendix B**. Some of the Eastern Offset properties lie partly within the Maules Creek exploration lease (A346). It is acknowledged that where these areas fall on land that has been identified to comprise coal resources (the Maules Creek JORC Coal Reserves Pit Shell) they may potentially be considered for mining in the future. These areas have been excluded from the offset. Some site photographs are provided (**Photograph 4.6** to **3.13**).

ii. Land Use History

The Eastern and Western Offset properties are farming properties. They are currently used for dryland cropping in combination with livestock grazing. Nevertheless, significantly large areas of vegetation still remain and would benefit from conservation management. Teston and Kelso have undergone less intense farming in the last few years and thus contain pasture areas that have recovered sufficiently from cultivation and heavy grazing to be categorised as native pastures, albeit with reduced diversity. The regrowth areas on the properties support a number of threatened species that were recorded in Leard State Forest (**Appendix D**); thus the conservation and restoration of the remnant forest and woodland and the restoration of some of the grassland areas on these properties would provide important refugia for threatened species during the operation of the Project.

Coordinate System: MGA Zone 56 (GDA 94)

Cattle Plain
Warriahdool
Wallandilly
Teston
Blue Range
Tralee
Teston
Louenville
Olivedeen
Velyama
Kelso

Legend

- Project Boundary
- Mining Tenement Boundary
- Eastern Offset Properties
- Western Offset Properties

Vegetation Community

- White Box - Narrow-leaved Ironbark - White Cypress Pine grassy open forest
- White Box - Narrow-leaved Ironbark - White Cypress Pine shrubby open forest
- White Box - White Cypress Pine grassy woodland
- White Box - Blakely's Red Gum - Melaleuca riparian forest
- Narrow-leaved Ironbark - White Cypress Pine shrubby open forest
- Dwyer's Red Gum - Ironbark woodland
- Silver-leaved Ironbark heathy woodland
- Weeping Myall grassy open woodland
- Belah woodland
- Pilliga Box - Poplar Box - White Cypress Pine grassy open woodland
- White Box - Wilga - Belah woodland
- Melaleuca riparian forest
- River Red Gum riparian woodland and forests
- Derived Native Grassland (Box Gum Woodland)
- Derived Native Grassland (Poplar Box trees)
- Derived Native Grassland (Low Diversity - Box Gum Woodland)
- Derived Native Grassland (Low Diversity - with scattered Poplar Box trees)
- Derived Native Grassland (Low Diversity - Ironbark Woodland)
- Unclassified vegetation
- Cliff and scree Thickets (Rainforest Species)
- Improved Pastures
- Cultivation

Image Source: © 2011 Cnes/Spot Image
Image © 2011 GeoEye
Image © 2011 DigitalGlobe

CUMBERLAND ECOLOGY

N Grid North

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Figure 4.3 Vegetation of the Eastern and Western Offset Properties

1000 0 1000 2000 3000 4000 m



Photograph 4.6 **Box eucalypts (*Eucalyptus albens*) on the Warriahdool provide habitat for epiphytic orchids (*Cymbidium canaliculatum*)**



Photograph 4.7 **Cultivated fields (foreground) adjacent to significant areas of native remnant woodland (background) on Louenville. The woodland will form part of the Eastern Offset.**



Photograph 4.8 Remnant White Box woodland on Louenville



Photograph 4.9 Remnant Shrubby White Box woodland on Kelso



Photograph 4.10 **Derived Native Grassland with scattered shrubs and trees on Blue Range**



Photograph 4.11 **Remnant White Box – Narrow-leaved Ironbark – White Cypress Pine Grassy woodland on Teston in the Eastern Offsets**



Photograph 4.12 **Remnant White Box – Narrow-leaved Ironbark – White Cypress Pine Grassy woodland on Tralee**



Photograph 4.13 **Extensive native grassland on Velyama. Broad areas of native grassland will be regenerated to woodland within the Eastern and Western Offsets.**

4.6.3 Shared Offset Property

MCC owns property under a joint venture ownership with Boggabri Coal. The shared property is located on the western side of the Kamilaroi Highway to the south west of the Project Boundary (**Figure 4.4**). A small proportion of this land will be utilised by MCC and Boggabri Coal for the proposed rail spur, of which the southern-most section will extend into this shared property. The remainder of the land will be contributed to the Offset Strategy.

MCC intends to dedicate its 50% of the property to the Offset Strategy. As Boggabri Coal also intend to incorporate the remainder of their half of the shared property to the Boggabri Coal Offset Strategy (Parsons Brinckerhoff Australia Pty Ltd, 2010), this would contribute to a regional East-West Corridor strategy comprising various offsetting efforts and conservation/forestry reserves in the locality (**Figure 4.1**). An agreement will be required between MCC and Boggabri Coal regarding the management responsibilities of both parties for the conservation of the shared property.

Coordinate System: MGA Zone 56 (GDA 94)

N
Grid North

Legend

- Project Boundary
- Mining Tenement Boundary
- Boggabri Coal Project Boundary
- Shared Offset Property

Vegetation Community

- White Box - White Cypress Pine grassy woodland (low condition)
- Regrowth - White Cypress Pine
- Dwyer's Red Gum woodland
- Silver-leaved Ironbark heathy woodland
- White Box - Narrow-leaved Ironbark - White Cypress Pine shrubby open Forest

Image Source: © 2011 Cnes/Spot Image
Image © 2011 GeoEye
Image © 2011 DigitalGlobe

CUMBERLAND ECOLOGY

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Figure 4.4 Vegetation of the Shared Offset Property

500 0 500 1000 1500 2000 m

4.7 Vegetation Condition and Conservation Domains

The vegetation within the Offset Properties comprises open forest, woodland and grasslands. The grasslands are artificial, in that they have been created for pastoral use by historic tree clearing. The majority of the grassland is species-rich and has high potential to return to forest or woodland if managed appropriately.

Some grassland areas are highly modified and have been more heavily improved for agriculture. Some areas have been recently or regularly fertilised with phosphate fertilisers and/or sown with subtropical grasses to improve feed for livestock. Such agricultural improvements have significantly reduced the proportion of native plants within such grassland areas. This is particularly the case for some of the grasslands in eastern and western offset properties. However, such highly modified areas will generally not be included within the conservation areas and will continue to be used for agriculture.

The condition of vegetation within conservation areas of the Offset Properties varies from high condition forest and woodland to low condition derived native grassland. As such areas of differing vegetation condition will require varied management. Natural areas in good condition will require less active management than the grasslands that require reafforestation. Highly modified grasslands that are predominantly exotic species are not included in the offset package (refer to **Figure 4.2** to **Figure 4.4**).

The conservation areas within the Offset Properties have been allocated to different "conservation domains", defined here as vegetation condition types requiring specific conservation management. The conservation domains range from "Core Conservation Areas" comprised solely of high condition vegetation needing relatively little active management, to "Active Planting Areas" comprised of grasslands that need extensive replanting of trees and to a lesser extent shrubs, weeding and feral animal control. The domains and their management objectives set out within **Table 4.1** below.

Table 4.1 Land Management Objectives for Conservation Domains

Domain	Description	Current Overall Condition	Objective
Core Conservation Areas	Existing native bushland. Not in zones of active farming.	Good quality vegetation and habitats in benchmark condition as measured against published benchmark values.	Maintain condition of vegetation within benchmark.
Conservation Areas	Existing native bushland. Currently in zones of active farming.	Variable, however generally moderate quality vegetation and habitats as measured against benchmark values. While some benchmark values are met (e.g. numbers of native plant species), other structural variables are not (e.g. understorey cover, number of fallen logs, hollows, etc).	Maintain and improve through assisted natural regeneration. Aim to increase to benchmark condition.
Riparian Areas	Vegetated or future vegetated land buffering creeks and Namoi River.	As above.	Rebuild/improve riparian corridors; protect waterways. Aim to increase to benchmark

Domain	Description	Current Overall Condition	Objective
			conditon.
Active Planting Areas	Cleared to grassland +/- scattered trees. Currently in zones of active farming.	Low condition vegetation in highly modified condition that generally does not meet any benchmark values.	Buffer conservation and core conservation areas from adjacent land use; increase area of existing bushland patches; connect existing bushland patches. Re-establish native plant species to trend towards benchmark values.
Commercial Areas	Commercial farming areas; cleared to grassland +/- scattered trees	Low condition vegetation modified for farming and not to be used for conservation.	No conservation objectives other than to ensure management of farmed areas is done in a way that does not indirectly detract from vegetation within conservation domains.

4.7.1 Measurement of Improvement of Ecological Condition

Ecological improvement of the various domains will be objectively measured against standards taken from high quality examples of representative vegetation types. For most of the vegetation communities known to occur in the offset areas, “benchmark” data is available from the Namoi CMA detailing the proportion of native species of plants, the composition of vegetation strata (layers), tree hollow density and the density of fallen logs. This management plan has been designed to track the progress of vegetation management and the progression of vegetation condition in various domains towards (or in some cases beyond) benchmark condition.

Within **Section 4.8** below, tables of biometric data (refer to **Table 4.2** to **Table 4.19**) are presented for each forest and woodland community to provide examples of benchmark data from published Namoi CMA information. It is proposed that each year, representative vegetation from each domain will be sampled and compared with local benchmark data to be compiled from survey of reference monitoring sites. The method for flora monitoring is set out in **Section 9.0**.

There is no published benchmark data for fauna available for the Namoi CMA or other nearby areas. Therefore, benchmark data for fauna will be derived by sampling faunal assemblages in the Core Conservation Domain, and tracking the recovery of fauna within the less intact domains such as the Active Planting Domain by comparing fauna of such areas to fauna within the Core Conservation Areas. Not all vertebrate fauna will be monitored and the focus will be on birds and bats to provide an indication of the recovery of all vertebrate fauna within the offset areas. The method for fauna montoring is set out in **Section 9.0**.

A range of threatened vertebrate species are known or considered likely to occur in the offsets and they vary in their habitat preferences. In the following sections, lists of threatened species that are considered likely to occur in each vegetation community are set out. These predicted species are based upon literature review and site-specific fieldwork conducted in 2011. The species lists for each community will be refined by further monitoring as work on the offsets proceeds. This is explained within **Section 9.0**.

Derived Native Grasslands are regarded within this BMP as a degraded form of woodland or open forest and the objective will be to restore them to their original structure with their original complement of vertebrate fauna as far as possible. The progress towards this objective will be monitored by comparing the flora and fauna of grassland areas to benchmark data for relevant forests and woodlands.

4.8 Description of the Vegetation Communities in the Offsets

A brief description of each vegetation unit is provided in the following sections.

4.8.1 Open Forests

i. White Box – Narrow-leaved Ironbark – White Cypress Pine grassy and shrubby open forest

This community is generally recorded on mid to lower valley slopes on sedimentary or basaltic soils. It is present in the western offset properties in association with upslope ironbark communities (**Figure 4.3**). The community can be grassy or shrubby; shrubby forms are generally located upslope of grassy areas.

In the offset areas, it comprises semi-mature grassy woodlands as a result of ongoing agricultural activities. It is dominated by *Eucalyptus albens* (White Box) and *E. crebra* (Narrow-leaved Ironbark) and is co-dominated by *Callitris glaucophylla* (White Cypress Pine), particularly in areas of regrowth. The community and has a predominantly grassy understorey with localised patches of shrubs, with *Geijera parviflora* (Wilga), *Notelaea microcarpa var. microcarpa* (Native Olive) and *Callitris glaucophylla* in the small tree stratum.

This community is consistent with the EEC/CEEC Box Gum Woodland listed under the EPBC Act and TSC Act.

This community provides potential habitat for the following threatened species listed under the TSC Act: Little Eagle, Square-tailed Kite, White-browed Woodswallow, Brown Treecreeper, Varied Sitella, Hooded Robin, Little Lorikeet, Barking Owl, Masked Owl, Little Pied Bat, Eastern False Pipistrelle, Eastern Bentwing Bat, Eastern Cave Bat, Yellow-bellied Sheathtail Bat and Scant Pomaderris.

This community also provides potential habitat for the following species listed under the EPBC Act: Regent Honeyeater, Swift Parrot, Greater Long-eared Bat, Koala and *Pultenaea setulosa.*

Table 4.2 Benchmarks for White Box - Narrow-leaved Ironbark - White Cypress Pine grassy open forest

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native ground cover (NGC)	Mosses/ lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
20	5	50	5	30	15	39	2	6	40

Table 4.3 Benchmarks for White Box - Narrow-leaved Ironbark - White Cypress Pine shrubby open forest

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/ lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
30	25	30	5	25	40	32	2	3	40

ii. Stringybark – Blakely's Red Gum grassy and shrubby open forest

This community was recorded in the areas of higher elevation on the Mt Lindesay property. It is either a grassy or shrubby tall open forest or woodland that is dominated by *Eucalyptus macrorhyncha* (Red Stringybark) and *E. blakelyi* in association with a combination of any of the following species: *E. melliodora*, *E bridgesiana*, *Angophora floribunda* and *E. dalrympleana* (Mountain Gum). Where shrubby, the understorey is dominated by *Olearia elliptica* (Sticky Daisy Bush), *Olearia stellulata* (Snow Daisy Bush) and *Pultenaea* sp. G. The groundstorey is rich in herbs and grassy areas are dominated by *Bothriochlora macra* (Red-leg Grass) and *Aristida ramosa* (Purpletop Wiregrass). In less heavily grazed areas, *Poa sieberiana* (Snowgrass) can dominate.

This community is consistent with the EEC/CEEC Box Gum Woodland listed under the EPBC Act and TSC Act.

This community provides potential habitat for the following threatened species listed under the TSC Act: Little Eagle, Square-tailed Kite, White-browed Woodswallow, Brown Treecreeper, Varied Sitella, Hooded Robin, Little Lorikeet, Barking Owl, Masked Owl, Little Pied Bat, Eastern False Pipistrelle, Eastern Bentwing Bat, Eastern Cave Bat, Yellow-bellied Sheathtail Bat, and Scant Pomaderris.

This community also provides potential habitat for the following species listed under the EPBC Act: Regent Honeyeater, Swift Parrot, Greater Long-eared Bat, Koala and *Pultenaea setulosa.*

Table 4.4 Benchmarks for Stringybark - Blakely's Red Gum grassy open forest

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
30	10	40	5	35	20	37	2	3	40

Table 4.5 Benchmarks for Stringybark - Blakely's Red Gum shrubby open forest

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
40	25	30	5	35	30	37	2	3	40

iii. Manna Gum – Rough-barked Apple – Blakely's Red Gum open forest

This community was recorded in the Northern Offsets and can be an open forest or woodland. It is dominated by *Eucalyptus viminalis* (Manna Gum) and *E. blakeyi*. *Eucalyptus melliodora* co-dominates in some areas and *Angophora floribunda* occurs as a sub dominant.

There is a sparse shrub layer of species such as *Olearia stellulata*, *Melichrus urceolatus* (Urn-heath) and Peach Heath (*Lissanthe strigosa*) and *Swainsona galegifolia* (Smooth Darling-pea). The ground layer is dominated by tussock grasses and forbs such as *Poa sieberiana* (Snowgrass), *Themeda australis* (Kangaroo Grass), *Austrodanthonia racemosa* (Wallaby Grass), *Desmodium varians* (Slender Tick-trefoil), *Ranunculus lappaceus* (Common Buttercup), *Echinopogon ovatus* (Forest Hedgehog Grass) and *Aristida ramosa* (Purple Wiregrass).

This community is consistent with the EEC/CEEC Box Gum Woodland listed under the EPBC Act and TSC Act.

This community provides potential habitat for the following threatened species listed under the TSC Act: Little Eagle, Square-tailed Kite, White-browed Woodswallow, Brown Treecreeper, Varied Sitella, Hooded Robin, Little Lorikeet, Barking Owl, Masked Owl, Little Pied Bat, Eastern False Pipistrelle, Eastern Bentwing Bat, Eastern Cave Bat, Yellow-bellied Sheathtail Bat, and Scant Pomaderris.

This community also provides potential habitat for the following species listed under the EPBC Act: Regent Honeyeater, Swift Parrot, Greater Long-eared Bat, Koala and *Pultenaea setulosa.*

Table 4.6 Benchmarks for Manna Gum - Yellow Box - Blakely's Red Gum open forest

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
20	5	50	5	30	15	34	2	5	30

iv. Narrow-leaved Ironbark – White Cypress Pine shrubby open forest

This community is floristically similar to *White Box - Narrow-leaved Ironbark - White Cypress Pine grassy and shrubby open forest*. It generally occurs on upper slopes on skeletal soils over conglomerate. It is dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark). Generally, the subdominant species recorded was *Callitris endlicheri* and/or *C. glaucophylla*, although *E. albens* was recorded in low densities in areas such as drainage heads with locally deeper soils it was observed to be largely absent.

At points of higher relief, the community becomes very shrubby (above 35% projective foliage cover), however can be quite open and grassy on gentler grades. Common shrub species include *Acacia cheelii, Melichrus urceolatus, Canthium odoratum, Dodonea viscosa and Bursaria spinosa*.

This community does not conform to the description of EEC/CEEC Box Gum Woodland Grasslands since *E. albens* occurs as a scattered component and not as a co-dominant species.

This community provides potential habitat for the following threatened species listed under the TSC Act: Little Eagle, Square-tailed Kite, White-browed Woodswallow, Brown Treecreeper, Varied Sitella, Hooded Robin, Little Lorikeet, Barking Owl, Masked Owl, Little Pied Bat, Eastern False Pipistrelle, Eastern Bentwing Bat, Eastern Cave Bat, Yellow-bellied Sheathtail Bat, and Scant Pomaderris.

This community also provides potential habitat for the following species listed under the EPBC Act: Regent Honeyeater, Swift Parrot, Greater Long-eared Bat, Koala and *Pultenaea setulosa.*

Table 4.7 Benchmarks for Narrow-leaved Ironbark - White Cypress Pine shrubby open forest

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
25	25	25	10	25	40	33	-	2	35

4.8.2 Riparian Forests

i. Rough-barked Apple – Blakely's Red Gum riparian grassy forest

This community forms a grassy riparian woodland or open forest and occurs in association with Maules Creek and its tributaries in the Northern Offsets. Dominant tree species include *Eucalyptus blakelyi*, *Angophora floribunda* and *Casuarina cunninghamii* (River Oak), the latter species occurs as a gallery forest. Other tree species that occur include *E. bridgesiana* and *E. blakelyi*. The shrub layer includes *Notelaea microcarpa* (Native Olive) and *Dodenaea viscosa* var. *angustifolia* (Sticky Hop-bush) and *Callistemon sieberi*. The groundcover is species rich, although can be degraded by weeds carried by stock to the Creek. The dominant grass recorded included *Microlaena stipoides* (Weeping Meadow Grass).

This community is consistent with the EEC/CEEC Box Gum Woodland listed under the EPBC Act and TSC Act.

This community provides potential habitat for the following threatened species listed under the TSC Act: Spotted Harrier, Little Eagle, Square-tailed Kite, Black-necked Stork, Painted Honeyeater, Black-chinned Honeyeater, Turquoise Parrot, Masked Owl, Yellow-bellied Sheathtail Bat, Eastern False Pipistrelle and Eastern Bentwing-bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

Table 4.8 Benchmarks for Rough-barked Apple - Blakely's Red Gum riparian grassy woodland

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
30	10	55	0	25	20	25	3	4	40

ii. Melaleuca riparian forest

The riparian areas of Back Creek and its tributaries in the eastern offset properties and also the smaller tributaries of Maules Creek in the Northern Offsets are dominated by *Melaleuca bracteata* over a grassy understorey that is contiguous with the surrounding vegetation communities. This riparian (stream bank) vegetation occurs where the *Melaleuca* can be sustained by extra water from ephemeral flows within these creeks.

Shrub species present include *Geijera parviflora*, *Notelaea microcarpa* and *Pimelea linifolia*, whilst common groundcover species include *Daucus glochidiatus* (Native Carrot), *Calotis lappulacea* (Yellow Burr-daisy), *Vittadinia sulcata*, *Xerochrysum viscosum* (Sticky Everlasting), *Wahlenbergia communis*, *Dichondra repens* (Kidney Weed) and *Geranium solanderi* (Native Geranium). Common grasses recorded were *Austrodanthonia racemosa* (Wallaby Grass), *Austrostipa scabra* (Speargrass), *Austrostipa verticillata* (Slender Bamboo Grass), *Cymbopogon refractus* (Barbed Wire Grass), *Bothriochloa macra* (Red-leg Grass), *Chloris truncata* (Windmill Grass), *Microlaena stipoides* and *Poa sieberiana*.

This community is not listed as a threatened ecological community.

This community provides potential habitat for the following threatened species listed under the TSC Act: Spotted Harrier, Little Eagle, Square-tailed Kite, Black-necked Stork, Painted Honeyeater, Black-chinned Honeyeater, Turquoise Parrot, Masked Owl, Yellow-bellied Sheathtail Bat, Eastern False Pipistrelle and Eastern Bentwing-bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

Table 4.9 Benchmarks for Melaleuca riparian forest

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
20	25	55	0	25	20	22	3	4	40

iii. White Box – Blakely's Red Gum – Melaleuca riparian forest

This community is very similar to *Melaleuca riparian forest*, however contains *Eucalyptus albens* and occasional occurrences of *E. blakelyi* and *Callitris glaucophylla*. It was as recorded along Back Creek, which is a small tributary of Maules Creek to the north of the Leard State Forest. A shrub layer is absent, with a sparse small tree stratum of *Geijera parviflora.* The groundcover is predominantly grassy, although is largely influenced by surrounding agricultural activities.

This community is consistent with the EEC/CEEC Box Gum Woodland listed under the EPBC Act and TSC Act.

This community provides potential habitat for the following threatened species listed under the TSC Act: Spotted Harrier, Little Eagle, Square-tailed Kite, Black-necked Stork, Painted Honeyeater, Black-chinned Honeyeater, Turquoise Parrot, Masked Owl, Yellow-bellied Sheathtail Bat, Eastern False Pipistrelle, Eastern Bentwing-bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

Table 4.10 Benchmarks for White Box - Blakely's Red Gum - Melaleuca riparian forest

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
30	10	55	0	25	20	25	3	4	40

iv. River Red Gum riparian woodlands and forest

Eucalyptus camaldulensis (River Red Gum) forms riverine woodland on floodplains and around billabongs in association with the Namoi River. This community usually suffers from degradation due to trampling and erosion of watercourse banks by livestock and hence, the understorey is largely comprised of a mixture of native and exotic sedges and rushes, pasture weeds and other exotics imported either by livestock or on the water. Very few shrubs are present in this community.

This community occurs in the Western Offsets along the Namoi River frontage and in the lower floodplain areas near the River.

This community is not listed as a threatened ecological community.

This community provides potential habitat for the following threatened species listed under the TSC Act: Spotted Harrier, Little Eagle, Square-tailed Kite, Black-necked Stork, Painted Honeyeater, Black-chinned Honeyeater, Turquoise Parrot, Masked Owl, Yellow-bellied Sheathtail Bat, Eastern False Pipistrelle and Eastern Bentwing-bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

Table 4.11 Benchmarks for River Red Gum riparian woodlands and forests

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
25	10	35	0	35	30	25	2	7	70

4.8.3 Woodlands

i. White Box – White Cypress Pine grassy woodland

This is grassy woodland that is largely restricted to valley floors and floodplain flats, where soils are relatively more fertile. It is present in the Eastern Offset properties on flat country where the majority of the intensive farming occurs, and in the south west paddocks of the Northern Offset in the lower-lying areas of the property. It comprises semi-mature woodlands as a result of ongoing agricultural activities.

It is dominated by *Eucalyptus albens* and supported by a sub canopy of *Callitris glaucophylla*, however is distinguished from the above community by the absence of ironbarks. In areas adjoining Mount Kaputar National Park, the understorey is quite species rich. It contains a sparse shrub stratum of *Geijera parviflora*, *Notelaea microcarpa var. microcarpa* and *Acacia decora.*

This community is consistent with the EEC/CEEC Box Gum Woodland listed under the EPBC Act and TSC Act.

This community provides potential habitat for the following threatened species listed under the TSC Act: Speckled Warbler, Spotted Harrier, Little Eagle, Square-tailed Kite, White-browed Woodswallow, Black-necked Stork, Brown Treecreeper, Diamond Firetail, Painted Honeyeater, Black-chinned Honeyeater, Hooded Robin, Grey-crowned Babbler, Little Lorikeet, Turquoise Parrot, Masked Owl, Eastern Cave Bat, Little Pied Bat and Yellow-bellied Sheathtail Bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

Table 4.12 Benchmarks for White Box - White Cypress Pine grassy woodland

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
20	5	50	5	30	15	39	2	6	40

ii. White Box – Stringybark grassy and shrubby woodland

This grassy or shrubby woodland was present in the Northern Offset properties on higher elevations and is dominated by *Eucalyptus albens*, *E. macrorhyncha* (Red Stringybark) and *Angophora floribunda* (Rough-barked Apple). Other stringybark species may also be present, including *E. laevopina* (Silvertop Stringybark). Co-dominant species were variable across the Northern Offset properties and included *E. melliodora* (Yellow Box), *E. blakelyi* (Blakely's Red Gum) and *Callitris glaucophylla*.

The understorey of this community is very similar to that of other White Box open forest and woodland communities in the wider locality. Shrub species present include *Olearia elliptica* (Sticky Daisy Bush), *Notelaea microcarpa* and *Pimelea linifolia*, whilst common groundcover species include *Daucus glochidiatus* (Native Carrot), *Calotis lappulacea* (Yellow Burr-daisy), *Vittadinia sulcata*, *Xerochrysum viscosum* (Sticky Everlasting), *Wahlenbergia communis*, *Dichondra repens* (Kidney Weed) and *Geranium solanderi* (Native Geranium). Common grasses recorded were *Austrodanthonia racemosa* (Wallaby Grass), *Austrostipa scabra* (Speargrass), *Austrostipa verticillata* (Slender Bamboo Grass), *Cymbopogon refractus* (Barbed Wire Grass), *Bothriochloa macra* (Red-leg Grass), *Chloris truncata* (Windmill Grass), *Microlaena stipoides* (Weeping Meadow Grass) and *Poa sieberiana*.

The grassy component of this community is consistent with the EEC/CEEC Box Gum Woodland listed under the EPBC Act and TSC Act.

This community provides potential habitat for the following threatened species listed under the TSC Act: Speckled Warbler, Spotted Harrier, Little Eagle, Square-tailed Kite, White-browed Woodswallow, Black-necked Stork, Brown Treecreeper, Diamond Firetail, Painted Honeyeater, Black-chinned Honeyeater, Hooded Robin, Grey-crowned Babbler, Little Lorikeet, Turquoise Parrot, Masked Owl, Eastern Cave Bat, Little Pied Bat and Yellow-bellied Sheathtail Bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

Table 4.13 Benchmarks for White Box - stringybark grassy woodland

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
30	5	40	5	40	20	35	2	3	40

Table 4.14 Benchmarks for White Box - stringybark shrubby woodland

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
30	25	30	5	35	30	32	2	3	40

iii. Pilliga Box – Poplar Box – White Cypress Pine grassy open woodland

This is a variable community that occurs as tall woodland to open forests and is co-dominated by *E. populnea* (Poplar Box) and *E. pilligaensis* (Narrow-leaved Grey Box). It is associated with alluvial flats and occurs in the Western Offset in low-lying areas at the south western margins of Leard State Forest (**Figure 4.3**).

On better drained red-brown soils, *Callitris glaucophylla* is usually present as a subdominant tree species along with *Geijera parviflora*. On heavy dark soils, the community exhibits a distinctive assemblage of supporting shrub and small tree species, including *Casuarina cristata*, *Allocasuarina luehmanii* (Bulloak), *Capparis mitchellii* (Native Orange), *Eremophila mitchelli* (Budda), *Alectryon oleifolius* (Western Rosewood) and *Ventilago viminalis* (Supple Jack), which are characteristic species found on the basaltic or rich alluvial cracking clays. Occurrences of this community are generally in good condition with a high proportion of native plant species and few weeds. Many trees within the canopy were found to be young, although substantial numbers of trees with hollows still remain.

This community is not listed as a threatened ecological community.

This community provides potential habitat for the following threatened species listed under the TSC Act: Speckled Warbler, Spotted Harrier, Little Eagle, Square-tailed Kite, White-browed Woodswallow, Black-necked Stork, Brown Treecreeper, Diamond Firetail, Painted Honeyeater, Black-chinned Honeyeater, Hooded Robin, Grey-crowned Babbler, Little Lorikeet, Turquoise Parrot, Masked Owl, Eastern Cave Bat, Little Pied Bat and Yellow-bellied Sheathtail Bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

Table 4.15 Benchmarks for Pilliga Box - Poplar Box - White Cypress Pine grassy open woodland

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
25	10	45	5	20	30	28	2	30	40

iv. White Box – Wilga – Belah woodland

This community is found on heavy black soils on the plains and is associated with alluvial flats. It is floristically very similar to *Pilliga Box - Poplar Box - White Cypress Pine grassy open woodland* where the latter occurs on heavy basalt soils. It occurs within the western offset properties in low-lying areas west of the Leard State Forest (**Figure 4.3**).

Eucalyptus albens dominates the canopy layer and is supported by a number of shrub and small tree species. On better drained red-brown soils, *Callitris glaucophylla* is usually present as a subdominant tree species along with *Geijera parviflora*. On heavy dark soils, the community exhibits a distinctive assemblage of supporting shrub and small tree species, including *Casuarina cristata*, *Allocasuarina luehmanii* (Bulloak), *Capparis mitchellii* (Native Orange), *Eremophila mitchelli* (Budda), *Alectryon oleifolius* (Western Rosewood) and *Ventilago viminalis* (Supple Jack), which are characteristic species found on the basaltic or rich alluvial cracking clays. As with other communities that occur on fertile heavy soils, this community has been extensively cleared for cultivation in the past and current occurrences consist of young trees, largely without tree hollows.

This community is consistent with the EEC/CEEC Box Gum Woodland listed under the EPBC Act and TSC Act.

This community provides potential habitat for the following threatened species listed under the TSC Act: Speckled Warbler, Spotted Harrier, Little Eagle, Square-tailed Kite, White-browed Woodswallow, Black-necked Stork, Brown Treecreeper, Diamond Firetail, Painted Honeyeater, Black-chinned Honeyeater, Hooded Robin, Grey-crowned Babbler, Little Lorikeet, Turquoise Parrot, Masked Owl, Eastern Cave Bat, Little Pied Bat and Yellow-bellied Sheathtail Bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

Table 4.16 Benchmarks for White Box – Wilga - Belah woodland

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
25	10	45	5	20	30	28	2	30	40

v. Belah woodland

This woodland type occurs on heavier soils that are suitable for cropping and has been heavily cleared in the past. It is poorly represented in conservation reserves. In the locality of Leard State Forest, this community occurs on fine-textured black soil associated with basalt or quaternary alluvium geology and is generally in poor condition with a high proportion of weeds in the ground stratum. In better areas, there is up to 25% cover of patchily distributed shrubs, including *Geijera parviflora*, and the original community would have once contained a diversity of shrub and small tree species.

In the Western Offsets, this community is restricted to the flats of Velyama approaching the Namoi River. The main canopy species is *Casuarina cristata* (Belah). The community has been heavily cleared for agriculture and the understorey is now largely part of the crop field matrix.

This community is not listed as a threatened ecological community.

This community provides potential habitat for the following threatened species listed under the TSC Act: Speckled Warbler, Spotted Harrier, Little Eagle, Square-tailed Kite, White-browed Woodswallow, Black-necked Stork, Brown Treecreeper, Diamond Firetail, Painted Honeyeater, Black-chinned Honeyeater, Hooded Robin, Grey-crowned Babbler, Little Lorikeet, Turquoise Parrot, Masked Owl, Eastern Cave Bat, Little Pied Bat and Yellow-bellied Sheathtail Bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

Table 4.17 Benchmarks for Belah Woodland

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
15	2	29	-	-	-	20	-	1	15

vi. Dwyer's Red Gum – Ironbark woodland

This community appears to be an intermediate between *Narrow-leaved Ironbark - White Cypress Pine shrubby open forest* and areas of *Dwyer's Red Gum woodland* and is dominated by a mixture of *E. crebra*, *E. dwyeri* (Dwyer's Red Gum) and possibly occurrences of *E. dealbata* (Tumbledown Red Gum). The red gum species were recorded in variable densities in open woodland areas on fairly skeletal soils.

The small tree stratum ranges from scattered individuals or localised groups of *Acacia cheelii*, *Brachychiton populneus* (Kurrajong) and regenerating canopy trees to dense stands of *Acacia cheelii* and *Dodenaea viscosa*. In some areas there was locally dense regeneration of *E. crebra* and scattered occurrences of *Alphitonia excelsa* (Red Ash), particularly on the volcanics along ridgetops in the south west of the Project Boundary.

This community is not listed as a threatened ecological community.

This community provides potential habitat for the following threatened species listed under the TSC Act: Little Eagle, Square-tailed Kite, White-browed Woodswallow, Brown Treecreeper, Varied Sitella, Hooded Robin, Little Lorikeet, Barking Owl, Masked Owl, Little Pied Bat, Eastern False Pipistrelle, Eastern Bentwing Bat, Eastern Cave Bat, Yellow-bellied Sheathtail Bat and Scant Pomaderris.

This community also provides potential habitat for the following species listed under the EPBC Act: Regent Honeyeater, Swift Parrot, Greater Long-eared Bat, Koala and *Pultenaea setulosa.*

Table 4.18 Benchmarks for Dwyer's Red Gum - Ironbark woodland

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
32	15	35	-	-	-	20	-	2	20

vii. Weeping Myall grassy open woodland

This community occurs on black, brown or red clay soils on flat alluvial plains. It is generally dominated by *Acacia pendula* (Weeping Myall). It is present in the Western Offsets as small stands of *Acacia pendula* in cultivated fields. As these patches are not equal to or greater than 0.5 ha in area, they are not considered to conform to the EPBC Act listing of Weeping Myall Woodlands.

This community provides potential habitat for the following threatened species listed under the TSC Act: Speckled Warbler, Spotted Harrier, Little Eagle, Square-tailed Kite, White-browed Woodswallow, Black-necked Stork, Brown Treecreeper, Diamond Firetail, Painted Honeyeater, Black-chinned Honeyeater, Hooded Robin, Grey-crowned Babbler, Little Lorikeet, Turquoise Parrot, Masked Owl, Eastern Cave Bat, Little Pied Bat and Yellow-bellied Sheathtail Bat.

This community also provides potential habitat for the following threatened species listed under the EPBC Act: Regent Honeyeater, Swift Parrot and Koala.

4.8.4 Shrubland and Grassland

i. Tea-tree shrubland in drainage lines

This shrubland was observed in the small drainages on the Wirradale property. The shrub assemblage was dominated by tea-tree and paperbark species (i.e. *Leptosperum* spp. and *Melaleuca* spp.) and formed a dense shrubby corridor through native pastures. Tree species were generally absent.

Table 4.19 Benchmarks for Tea-tree shrubland in drainage lines

% Native Overstorey Cover (NOS)	% Native mid-storey cover (NMS)	% Native groundcover (NGC)	Mosses/lichen cover (%)	Organic litter cover (%)	Rock/bare ground cover (%)	Native species richness (NPS)	% Canopy recruitment (REG)	Number of trees with hollows (TH)	Total length (m) of fallen logs (FL)
25	30	18	-	-	-	21	-	1	15

ii. Derived Native Grassland – various forms

Various forms of native grassland derived from the clearing of trees and shrubs to create grazing pasture for livestock occur throughout the offset properties. Grasslands that have been recently cultivated, or are currently cultivated, are not included in this category.

Derived grassland (also known as secondary grassland or understorey) can remain relatively intact, however by nature, the floristic composition of these grasslands will vary according to the forest or woodland community from which it originated. The slope, aspect, soil, underlying geology and land use also heavily influences the floristic composition.

Derived Native Grassland – high diversity areas

Native pastures that have not been pasture improved recently or have had little fertiliser applied were found to be rich in forb species and were dominated by native large tussock-forming grass species, such as *Themeda australis* and *Cymbopogon refractus*. Areas of native pasture that were lightly to moderately grazed were also found to be species rich, even if they were fertilised at some time in the past.

Areas with sufficient diversity were referred to as Derived Native Grassland. To be considered sufficiently diverse, at least 12 native forbs with one being a recognised grazing sensitive species must be present within a 0.1 ha area (DEH, 2006).

Native grasslands within the offset properties that were derived from the clearing of grassy communities dominated by White Box, Yellow Box, or Blakely's Red Gum were recognised as being consistent with the EEC/CEEC Box Gum Woodland, which is listed under the EPBC Act and TSC Act (DEH, 2006).

Most occurrences of Derived Native Grassland were recorded in the Northern Offsets, with pasture areas having had less improvement applied to it. In the Eastern and Western Offset areas, Derived Native Grassland was restricted to the fringes of extant woodland and forest vegetation; the diversity of the grassland decreased quite quickly with distance from the forest and woodland margins.

Derived Native Grassland – low diversity areas

Native pastures that have been pasture improved or have had superphosphate fertilisers applied to improve grazing conditions for livestock were generally found to be species poor. Heavily grazed areas, even without pasture improvement, were also found to be species poor. These areas were dominated by grazing resistant native grasses that form low tussocks, such as *Eragrostis brownii*, *Chloris truncata* and *Bothriochloa macra*.

Native pastures (i.e. pastures dominated by native grasses), where the native forb and herb diversity was less than 12 species per 0.1 ha area, were referred to as Derived Native Grassland (Low Diversity) and were ***not*** considered to be consistent with the EEC/CEEC Box Gum Woodland and Derived Grasslands listed under the EPBC Act and TSC Act (DEH, 2006).

iii. Cultivations and Exotic Grasslands

The remaining vegetation within the offset properties comprises cultivated fields and areas of much improved grazing pastures dominated by exotic grass and forb species.

A summary of the types and areas of vegetation present in the offset properties is presented in **Table 4.20** and **Table 4.21**. **Table 4.22** compares the total native vegetation available in the offsets for conservation with the vegetation that will be removed from the Project.

Quadrat data sampled from the offset properties are provided in **Appendix D**.

Table 4.20 Vegetation Areas within the Eastern, Western, Northern and Shared Properties

Vegetation Communities	Eastern Properties						Northern Properties		Shared Property	Western Properties					SubTotal (ha)
	Blue Range	Cattle Plain	Teston North	Tralee	Wallandilly	Warriahdool	Mt Lindesay	Wirradale	Shared Offset	Kelso	Louenville	Olivedeen	Teston South	Velyama	
Cliff and scree Thickets (Rainforest Species)											0.53				0.53
Manna Gum - Yellow Box - Blakely's Red Gum open forest							139.68	245.85							385.53
Melaleuca riparian forest	9.04	2.68	6.18	14.63	66.55	35.16		4.61							138.85
Narrow-leaved Ironbark - Brown Bloodwood - White Cypress Pine shrubby open forest													0.00		0.00
Narrow-leaved Ironbark - White Cypress Pine shrubby open forest								853.61		270.42	33.70		416.12	79.36	1653.21
River Red Gum riparian woodlands and forests										11.89		8.30			20.19
Stringybark - Blakely's Red Gum grassy open forest							770.30								770.30
Stringybark - Blakely's Red Gum shrubby open forest							84.94								84.94
White Box - Blakely's Red Gum - Melaleuca riparian forest	19.74		10.23	4.49					11.09				4.82		50.37
White Box - Narrow-leaved Ironbark - White Cypress Pine grassy open forest			0.05	0.01	53.29	58.32				16.49	151.10		185.79	23.23	488.28
White Box - Narrow-leaved Ironbark - White Cypress Pine shrubby open forest						0.75			369.43		0.28		34.93	4.13	409.52
Belah woodland													4.21	6.94	11.15
Dwyer's Red Gum - Ironbark woodland			2.84	8.62							3.09		211.64		226.19
Dwyer's Red Gum woodland									176.73				3.59		180.32
Pilliga Box - Poplar Box - White Cypress Pine grassy open woodland				1.75	161.61	16.05				44.01		4.95		6.50	234.87
Regrowth - White Cypress Pine									10.70						10.70
Rough-barked Apple - Blakely's Red Gum riparian grassy woodland							25.34	223.22							248.56
Silver-leaved Ironbark heathy woodland						42.47			69.42						111.89
Weeping Myall grassy open woodland														0.15	0.15
White Box - stringybark grassy woodland							553.72	881.39							1435.11
White Box - stringybark shrubby woodland							139.21	192.30							331.51
White Box - White Cypress Pine grassy woodland	2.26	35.98	48.74	16.96	99.27	91.14		226.75							521.10
White Box - White Cypress Pine grassy woodland (low condition)									72.56						72.56
White Box - Wilga - Belah woodland													85.75	18.26	104.01
Yellow Box - Blakely's Red Gum grassy woodland					0.02										0.02
Total Forest and Woodland	31.04	38.66	68.04	46.46	380.74	243.89	1713.19	2627.73	709.93	342.81	188.70	13.25	946.85	138.57	7489.86
Tea-tree shrubland in drainage lines								69.61							69.61
Total Shrubland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.61	0.00	0.00	0.00	0.00	0.00	0.00	69.61
Derived Native Grassland (Box Gum Woodland)							577.56	1406.40					105.90	71.62	2161.48
Derived Native Grassland (Non-threatened)								74.09						94.10	168.19
Total Derived Native Grassland	0.00	0.00	0.00	0.00	0.00	0.00	577.56	1480.49	0.00	0.00	0.00	0.00	105.90	165.72	2329.67
Derived Native Grassland (Low Diversity - Box Gum Woodland)		103.09	51.69	69.48	0.43	74.87		87.94	2.44	22.12			101.41	126.13	639.60
Improved Pastures							131.98						37.14	62.61	231.73
Low Diversity Native/Exotic Grassland and Cultivation	692.05	139.19	170.77	224.18	1471.60	687.11				134.31	270.19	177.90	81.22	426.16	4474.68
Total Other Grassland	692.05	242.28	222.46	293.66	1472.03	761.98	131.98	87.94	2.44	156.43	270.19	177.90	219.77	614.90	5346.01
Total Vegetation in each Property (ha)	**723.09**	**280.94**	**290.50**	**340.12**	**1852.77**	**1005.87**	**2422.73**	**4265.77**	**712.37**	**499.24**	**458.89**	**191.15**	**1272.52**	**919.19**	**15235.15**
Total Box Gum Woodland (remnant vegetation and derived native grassland) (ha)	**22.00**	**35.98**	**59.02**	**21.46**	**152.58**	**149.46**	**2066.60**	**2983.61**	**11.09**	**16.49**	**151.10**	**0.00**	**382.26**	**113.11**	**6164.76**
Total Vegetation to be protected in Conservation Management Zones (ha)	**127.42**	**154.27**	**204.53**	**103.17**	**822.53**	**202.52**	**2277.55**	**3536.06**	**356.18**	**499.24**	**303.62**	**45.08**	**302.76**	**398.77**	**9333.70**
Total Box Gum Woodland (remnant vegetation and derived native grassland) in Conservation Management Zones (ha)	**21.65**	**35.95**	**57.84**	**17.19**	**98.29**	**64.46**	**2035.89**	**2335.79**	**5.54**	**16.49**	**151.04**	**0.00**	**82.04**	**109.40**	**5031.57**
% Total Vegetation to be conserved from each property	**17.62**	**54.91**	**70.41**	**30.33**	**44.39**	**20.13**	**94.01**	**82.89**	**50.00**	**100.00**	**66.16**	**23.58**	**23.79**	**43.38**	**61.26**
% Total Box Gum Woodland (remnant vegetation and derived native grassland) to be conserved from each property (ha)	**98.41**	**99.92**	**98.00**	**80.10**	**64.42**	**43.13**	**98.51**	**78.29**	**49.95**	**100.00**	**99.96**	**N/A**	**21.46**	**96.72**	**81.62**

Table 4.21 Vegetation to be Conserved within the Eastern, Western, Northern and Shared Properties

Vegetation Communities	Eastern Properties						Northern Properties		Shared Property	Western Properties					SubTotal (ha)
	Blue Range	Cattle Plain	Teston North	Tralee	Wallandilly	Warriahdool	Mt Lindesay	Wirradale	Shared Offset	Kelso	Louenville	Olivedeen	Teston South	Velyama	
Cliff and scree Thickets (Rainforest Species)											0.53				0.53
Manna Gum - Yellow Box - Blakely's Red Gum open forest							139.68	245.85							385.53
Melaleuca riparian forest	9.04	2.68	5.47	9.30	56.17	25.19		4.61							112.46
Narrow-leaved Ironbark - White Cypress Pine shrubby open forest								853.37		270.42	33.70		54.18	56.96	1268.63
River Red Gum riparian woodlands and forests										11.89		8.30			20.19
Stringybark - Blakely's Red Gum grassy open forest							770.30								770.30
Stringybark - Blakely's Red Gum shrubby open forest							84.94								84.94
White Box - Blakely's Red Gum - Melaleuca riparian forest	19.39		10.23	0.23					5.54						35.39
White Box - Narrow-leaved Ironbark - White Cypress Pine grassy open forest			0.05	0.00	10.54					16.49	151.04		10.60	21.69	210.41
White Box - Narrow-leaved Ironbark - White Cypress Pine shrubby open forest									184.71		0.28		28.88	0.85	214.72
Belah woodland														6.94	6.94
Dwyer's Red Gum - Ironbark woodland			2.84	8.62							3.09		81.46		96.01
Dwyer's Red Gum woodland									88.37						88.37
Pilliga Box - Poplar Box - White Cypress Pine grassy open woodland					112.25					44.01		4.95		3.50	164.71
Regrowth - White Cypress Pine									5.35						5.35
Rough-barked Apple - Blakely's Red Gum riparian grassy woodland							1.91	223.22							225.13
Silver-leaved Ironbark heathy woodland									34.71						34.71
White Box - stringybark grassy woodland							546.69	843.02							1389.71
White Box - stringybark shrubby woodland							139.21	192.30							331.51
White Box - White Cypress Pine grassy woodland	2.26	35.95	47.56	16.96	87.75	64.46		205.02							459.96
White Box - White Cypress Pine grassy woodland (low condition)									36.28						36.28
White Box - Wilga - Belah woodland													52.85	16.09	68.94
Total Forest and Woodland	30.69	38.63	66.15	35.11	266.71	89.65	1682.73	2567.39	354.96	342.81	188.64	13.25	227.97	106.03	6010.72
Tea-tree shrubland in drainage lines								35.96							35.96
Total Shrubland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.96	0.00	0.00	0.00	0.00	0.00	0.00	35.96
Derived Native Grassland (Box Gum Woodland)							577.31	818.68					18.59	71.62	1486.20
Derived Native Grassland (Non-threatened)								73.96						57.65	131.61
Total Derived Native Grassland	0.00	0.00	0.00	0.00	0.00	0.00	577.31	892.64	0.00	0.00	0.00	0.00	18.59	129.27	1617.81
Derived Native Grassland (Low Diversity - Box Gum Woodland)		101.59	51.69	38.78				40.07	1.22	22.12				40.36	295.83
Improved Pastures							17.51						36.59	19.87	73.97
Low Diversity Native/Exotic Grassland and Cultivation	96.73	14.05	86.69	29.28	555.82	112.87				134.31	114.98	31.83	19.61	103.24	1299.41
Total Other Grassland	96.73	115.64	138.38	68.06	555.82	112.87	17.51	40.07	1.22	156.43	114.98	31.83	56.20	163.47	1669.21
Total Vegetation to be protected in Conservation Management Zones (ha)	**127.42**	**154.27**	**204.53**	**103.17**	**822.53**	**202.52**	**2277.55**	**3536.06**	**356.18**	**499.24**	**303.62**	**45.08**	**302.76**	**398.77**	**9333.70**
Total Box Gum Woodland (remnant vegetation and derived native grassland) in Conservation Management Zones (ha)	**21.65**	**35.95**	**57.84**	**17.19**	**98.29**	**64.46**	**2035.89**	**2335.79**	**5.54**	**16.49**	**151.04**	**0.00**	**82.04**	**109.40**	**5031.57**

Table 4.22 Summary of Vegetation Areas to be Conserved Against Areas to be Cleared from the Project Boundary

Vegetation Communities	Area to be cleared from Project Boundary (ha) [A]	Area to be conserved in Eastern/ Western/ Northern/ Shared Properties (ha) [B]	Ratio of Offset area to area to be cleared [B]:[A]
Red Gum/Ironbark forests			
Dwyer's Red Gum woodland	0.05	88.37	1767.4
Dwyer's Red Gum - Ironbark woodland	123.56	96.01	0.8
Narrow-leaved Ironbark - White Cypress Pine shrubby open forest	594.83	1268.63	2.1
Silver-leaved Ironbark heathy woodland	334.52	34.71	0.1
RF elements			
Cliff and scree Thickets (Rainforest Species)	0	0.53	n/a
Riparian forests			
Melaleuca riparian forest	0	112.46	n/a
River Red Gum riparian woodlands and forests	1.57	20.19	12.9
Rough-barked Apple - Blakely's Red Gum riparian grassy woodland	0	225.13	n/a
White Box - Blakely's Red Gum - Melaleuca riparian forest	10.12	35.39	3.5
White Box, Yellow Box, Blakely's Red Gum woodlands			
Manna Gum - Yellow Box - Blakely's Red Gum open forest	0	385.53	n/a
Regrowth - White Cypress Pine	0	5.35	n/a
Stringybark - Blakely's Red Gum grassy open forest	0	770.30	n/a
Stringybark - Blakely's Red Gum shrubby open forest	0	84.94	n/a
White Box - Narrow-leaved Ironbark - White Cypress Pine grassy open forest	406.97	210.41	0.5
White Box - Narrow-leaved Ironbark - White Cypress Pine shrubby open forest	136.43	214.72	1.6
White Box - stringybark grassy woodland	0	1389.71	n/a

Vegetation Communities	Area to be cleared from Project Boundary (ha) [A]	Area to be conserved in Eastern/ Western/ Northern/ Shared Properties (ha) [B]	Ratio of Offset area to area to be cleared [B]:[A]
White Box - stringybark shrubby woodland	0	331.51	n/a
White Box - White Cypress Pine grassy woodland	0.8	459.96	575.0
White Box - White Cypress Pine grassy woodland (low condition)	0	36.28	n/a
Yellow Box - Blakely's Red Gum grassy woodland	8.64	0	0
Belah associations			
Belah woodland	4.21	6.94	1.6
Pilliga Box - Poplar Box - White Cypress Pine grassy open woodland	11.69	164.71	14.1
White Box - Wilga - Belah woodland	31.46	68.94	2.2
Total Forest and Woodland	1664.85	6010.72	3.6
Tea-tree shrubland in drainage lines	0	35.96	n/a
Total Shrubland	0.00	35.96	n/a
Derived Native Grassland (Box Gum Woodland)	86.48	1486.20	17.2
Derived Native Grassland (Non-threatened)	0	131.61	
Total Derived Native Grassland	86.48	1617.81	18.7
Derived Native Grassland (Low Diversity - Box Gum Woodland)	210.89	295.83	1.4
Low Diversity Native/Exotic Grassland, Cultivation and Improved Pastures	215.22	1373.38	6.4
Total Other Grassland	426.11	1669.21	3.9
Totals	**2177.44**	**9333.70**	**4.3**

n/a - will not be cleared from the Project Boundary

4.9 Habitat for Threatened Fauna Species

The Offset Properties have been selected partly on the basis that they contain extensive areas of Box Gum Woodland and other habitats found within the Project Boundary, and partly because they have high quality habitat for threatened species. They contain a diversity of open forest, woodland and grassland habitat for native fauna species. They also contain creek and river frontage areas, cliffs and rock outcrops that increase the diversity of habitats and provide refugia for many species.

Fauna surveys completed for birds and bats in September 2011 were successful in detecting many of the threatened species that are predicted to be impacted by the Project. Additionally, the September 2011 surveys included fauna habitat analysis, and this verified that the Northern, Eastern and Western Offsets combined provide substantial habitat for all of the threatened species that are known or likely to occur within the Project Boundary and are predicted to be impacted by the Project (see **Appendix D** for survey results).

The size of the offset areas is substantial and the number of threatened species found is large relative to the survey effort which has been undertaken to date. It is highly probable that more threatened species will be found with further survey effort, particularly in the Northern Offsets, which adjoin Mount Kaputar National Park.

A suite of threatened species is known or predicted to occur in the combined area of the Northern, Eastern and Western Offsets. Different assemblages of threatened species are broadly associated with various woodland, open grassy or shrubby sclerophyll forests or riparian woodland and forests that occur within the Offfset Properties (refer to **Table 4.23** to **Table 4.25**). The species known or predicted to occur in the Offset Properties and their various habitat requirements are detailed in **Table 4.26**.

Table 4.27 provides a summary of the areas of habitat available from the Eastern, Western and Northern Offset properties for threatened species and communities relevant to the Project.

Table 4.23 Assemblage of Threatened Species Associated with Woodland Habitats

Scientific Name	Common Name
BIRDS	
Pyrrholaemus saggitatus	Speckled Warbler
Circus assimilis	Spotted Harrier
Hieraaetus morphnoides	Little Eagle
Lophoictinia isura	Square-tailed Kite
Apus pacificus	Fork-tailed Swift
Hirundapus caudacutus	White-throated Needletail
Artamus superciliosus	White-browed Woodswallow
Ephippiorhynchus asiaticus	Black-necked Stork
Climacteris picumnus	Brown Treecreeper
Stagonopleura guttata	Diamond Firetail
Grantiella picta	Painted Honeyeater
Melithreptus gularis gularis	Black-chinned Honeyeater
Xanthomyza phrygia	Regent Honeyeater
Merops ornatus	Rainbow Bee-eater
Melanodryas cucullata	Hooded Robin
Pomatostomus temporalis temporalis	Grey-crowned Babbler
Glossopsitta pusilla	Little Lorikeet
Neophema pulchella	Turquoise Parrot
Tyto novaehollandiae	Masked Owl
MAMMALS	
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat
Phascolarctos cinereus	Koala
Chalinolobus picatus	Little Pied Bat
Nyctophilus corbeni	Greater Long-eared Bat
Vespadelus troughtoni	Eastern Cave Bat

Table 4.24 Assemblage of Threatened Species Associated with Dry Sclerophyll/Shrubby Woodland/Forest Habitats

Scientific Name	Common Name
BIRDS	
Hieraaetus morphnoides	Little Eagle
Lophoictinia isura	Square-tailed Kite
Apus pacificus	Fork-tailed Swift
Hirundapus caudacutus	White-throated Needletail
Artamus superciliosus	White-browed Woodswallow
Climacteris picumnus	Brown Treecreeper
Myiagra cyanoleuca	Satin Flycatcher
Daphoenositta chrysoptera	Varied Sittella
Melanodryas cucullata	Hooded Robin
Glossopsitta pusilla	Little Lorikeet
Xanthomyza phrygia	Regent Honeyeater
Lathamus discolor	Swift Parrot
Ninox connivens	Barking Owl
Tyto novaehollandiae	Masked Owl
MAMMALS	
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat
Phascolarctos cinereus	Koala
Chalinolobus picatus	Little Pied Bat
Falsistrellus tasmaniensis	Eastern False Pipistrelle
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat
Nyctophilus corbeni	Greater Long-eared Bat

Table 4.25 Assemblage of Threatened Species Associated with Riparian Habitats

Scientific Name	Common Name
BIRDS	
Circus assimilis	Spotted Harrier
Hieraaetus morphnoides	Little Eagle
Lophoictinia isura	Square-tailed Kite
Apus pacificus	Fork-tailed Swift
Hirundapus caudacutus	White-throated Needletail
Ephippiorhynchus asiaticus	Black-necked Stork
Grantiella picta	Painted Honeyeater
Melithreptus gularis gularis	Black-chinned Honeyeater
Xanthomyza phrygia	Regent Honeyeater
Merops ornatus	Rainbow Bee-eater
Myiagra cyanoleuca	Satin Flycatcher
Neophema pulchella	Turquoise Parrot
Tyto novaehollandiae	Masked Owl
MAMMALS	
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat
Falsistrellus tasmaniensis	Eastern False Pipistrelle
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat

Table 4.26 Habitat Requirements for Threatened Species Known or Predicted to Occur in the Eastern, Western, Northern and Shared Properties

Scientific Name	Common Name	Legal Status		Breeding/Foraging Habitat					Nesting/Roosting
		TSC Act	EPBC Act	Vegform	Domin. Canopy	Understorey	Water	Diet	Location
BIRDS - RAPTORS									
Circus assimilis	Spotted Harrier	V		OW		G		M,Bi,R,I,C	Tree (OW)
Hieraaetus morphnoides	Little Eagle	V		OF,W,OW,G,S	E, A, S		X	M,Bi,R,I,C	Tree (OW)
Lophoictinia isura	Square-tailed Kite	V		OF,W	E		X	Bi, I	Tree (An,E)
Ephippiorhynchus asiaticus	Black-necked Stork	E		W, We,G,S			X	F, Cr, Am	Tree
Ninox connivens	Barking Owl	V		F,OW	E		X	Bi,M,I,R	Hollow
Tyto novaehollandiae	Masked Owl	V		F,W			X	Bi,M,I,R	Hollow
BIRDS - FRUGIVORES									
Grantiella picta	Painted Honeyeater	V		OF,OW	E,A,Mi			Fr,I,B	Tree (S,E,P,Mi)
BIRDS - GRANIVORES									
Stagonopleura guttata	Diamond Firetail	V		F,W	E	G, M		S, I	Tree, Shrub
Neophema pulchella	Turquoise Parrot	V		OW	Dead trees	G	X	S,B,Fr,I	Hollow
BIRDS - INSECTIVORES									
Pyrrholaemus saggitatus	Speckled Warbler	V		F,W	E	G		A,S	Ground
Apus pacificus	Fork-tailed Swift		M	IP				I	Cave, Cliff
Hirundapus caudacutus	White-throated Needletail		M	All				I	Tree
Artamus superciliosus	White-browed Woodswallow	V		OF,OW	E, A, S	G, M		A,B,Fr	Tree (V,St,AS)

Scientific Name	Common Name	Legal Status		Breeding/Foraging Habitat					Nesting/Roosting
		TSC Act	EPBC Act	Vegform	Domin. Canopy	Understorey	Water	Diet	Location
Climacteris picumnus	Brown Treecreeper	V		OF,OW	E			I	Hollow
Merops ornatus	Rainbow Bee-eater		M	OF,OW		G, M	X	I	Ground
Myiagra cyanoleuca	Satin Flycatcher		M	F	E		X	A	Tree (E,P,Ba)
Daphoenositta chrysoptera	Varied Sittella	V		F,W	E			A	Tree
Melanodryas cucullata	Hooded Robin	V		OF, OW	E,A			I	Hollow, St
Pomatostomus temporalis temporalis	Grey-crowned Babbler	V		OF, OW,IP		OS, LG, FT, LL		I,S	Tree
BIRDS - NECTARIVORES									
Melithreptus gularis gularis	Black-chinned Honeyeater	V		OF,OW	E		X	A,B,L	Tree
Anthochaera phrygia	Regent Honeyeater	E	E,M	OF,OW	E, Mi			B, I	Tree (E,An,S)
Glossopsitta pusilla	Little Lorikeet	V		OF, OW	E			B	Hollow
Lathamus discolor	Swift Parrot	E	E	F,W	E			B,I,L,S	Hollow
MAMMALS									
Phascolarctos cinereus	Koala	V		F,W	E			Eu	Tree
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat	V		F,OF,W,OW, G				I	Gound, Hollow, AS
Chalinolobus picatus	Little Pied Bat	V		OF,OW				I	Hollow, C,AS
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V		F				I	Hollow, AS
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V		F				I	Cave
Nyctophilus timoriensis	Eastern Long-eared Bat	V	V	OF,OW,S	E			I	Hollow

Scientific Name	Common Name	Legal Status		Breeding/Foraging Habitat					Nesting/Roosting
		TSC Act	EPBC Act	Vegform	Domin. Canopy	Understorey	Water	Diet	Location
Vespadelus troughtoni	Eastern Cave Bat	V		OF, OW	E			I	Cave

KEY:

Vegetation Form (Vegform)

F=Forest
OF=Open Forest
W=Woodland
OW=Open woodland
IP=Inland Plain
We=Wetland
S=Savannah

Dominate (Domin.) Canopy

E=Eucalypt
A=Acacia
An=Angophora
S=Sheoak
P=Paperbark
Mi=Mistletoe
Ba=Banksia
WB=White Box
YB=Yellow Box
BRG=Blakely's Red Gum

Understorey/Ground

G=grassy
M=Malle
OS=Open shrub
LG=Little groundcover
FT=Fallen timber
LL=Leaf litter
TS=Tussock Grass
H=Herbs

Diet

A=Arthropods
S=Seeds
M=Terrestrial mammals
I=Insects
Bi=Birds
R=Reptiles
C=Carrion
B=Blossoms (nectar, flowers, pollen)
Fr=Fruit
F=Fish
Eu=Eucalypt
Cr=Crustaceans
Am=Amphibians
L=Lerp

Nesting/Roosting

C=Caves, crevice, crack
Cl=Cliff
St=Stump
AS=Artifical Structure
V=Vine

Legal Status

V=Vulnerable
E=Endangered
M=Migratory

Table 4.27 Area Condition of Habitat for Threatened Species to be Conserved in the Eastern, Western, Northern and Shared Properties

OFFSETS	[a] HABITAT for Wide-foraging Bird Species (White-throated Needletail, Fork-tailed Swift, Square-tailed Kite, Spotted Harrier, Little Eagle)		[b] HABITAT for Forest and Woodland Species*		[c] Potential HABITAT for Koala		[d] Potential HABITAT for *Pultenaea setulosa*		[e] Potential HABITAT for *Pomaderris queenslandica*	
Property (describe each discrete property separately)	**Good condition vegetation (ha)**	**Low or moderate condition vegetation to be re-vegetated (ha)**	**Good condition vegetation (ha)**	**Low or moderate condition vegetation to be re-vegetated (ha)**	**Good condition vegetation (ha)**	**Low or moderate condition vegetation to be re-vegetated (ha)**	**Good condition vegetation (ha)**	**Low or moderate condition vegetation to be re-vegetated (ha)**	**Good condition vegetation (ha)**	**Low or moderate condition vegetation to be re-vegetated (ha)**
Blue Range	30.69	96.7	0	127.4	0	30.7	0	0	0	28.4
Cattle Plain	38.6	115.6	36.0	118.3	36.0	2.7	0	0	0.0	2.7
Teston (nth)	66.1	138.4	0.1	204.5	0.1	63.3	0.1	2.8	0.0	15.7
Tralee	35	68.1	0.0	103.2	0	26.5	0	8.6	0	9.5
Wallandilly	266.7	555.8	122.8	699.7	122.8	143.9	10.5	0	0.0	56.2
Warriahdool	89.7	112.9	64.5	138.1	64.5	25.2	0	0	0.0	25.2
Mt Lindesay	2260.4	17.5	1456.7	821.2	686.4	1.9	0	0	0.0	226.1
Wirradale	3495.9	40.1	1942.2	1593.7	1088.9	432.9	853.4	0	853.4	420.1
Shared Property	355.0	1.3	124.1	232.1	0	41.8	35.8	183.6	35.8	189.2
Kelso	342.8	156.4	342.8	156.4	72.4	0	286.9	0	282.3	0.0
Louenville	188.6	115.0	188.6	115.0	151.0	0	188.1	0	34.5	0.0
Olivedeen	13.2	31.8	13.2	31.8	13.2	0	0	0	8.3	0.0
Teston (sth)	246.6	56.2	175.1	127.6	10.6	52.9	175.1	0	83.1	0.0
Velyama	116.9	281.9	83.0	315.8	25.2	16.1	79.5	0	57.8	0.0
TOTAL	**7546.3**	**1787.7**	**4549.1**	**4784.8**	**2271.1**	**837.9**	**1629.4**	**195.1**	**1355.1**	**973.1**

Notes:

The habitat estimates that appear in the above table are based on the following assumptions about habitat:

[a] These are wide-foraging species that forage over forest, woodland and grassland areas and are fairly adaptable to modified habitats. These species have been detected, or are likely to occur in the offset areas from time to time.

[b] These are species that rely on forest and woodland areas. These species have been detected, or are likely to occur in the offset areas.

[c] Koalas were not detected within the Project Boundary despite an intensive survey. In spite of this, Koalas are anecdotally known to occur in the Project Boundary but at very low densities. Grassy box woodlands and riparian forests are potential habitat for the Koala in the offset areas.

[d] *Pultenaea setulosa* is known to occur in ironbark forests. Ironbark woodland and forests in the offset areas provide potential habitat for the species.

[e] *Pomaderris queenslandica* has potential habitat in forest and woodlands where there is a shrubby understorey, as well as in creekline vegetation.

Black-necked Stork:

It is difficult to estimate the area of habitat for the Black-necked Stork. The Black-necked Stork has foraging habitat on those properties where there are farm dams and shallow creeks supporting open, still water. Properties in the Eastern and Western offsets with frontage to the Namoi River and Back Creek (such as Kelso, Olivedeen and Warriahdool), containing such water frontages and comprising floodplain areas of the Namoi River, are suitable foraging areas for the species. The Biodiversity Offset Strategy makes provision for the rehabilitation of creekline areas and riparian habitat in offset areas, which is intended to protect and improve the foraging habitat of this species.

**Grey-crowned Babbler, Speckled Warbler, Little Lorikeet, Swift Parrot, Turquoise Parrot, Barking Owl, Masked Owl, Rainbow Bee-eater, Brown Treecreeper, Black-chinned Honeyeater, Regent Honeyeater, Painted Honeyeater, Varied Sittella, White-browed Woodswallow, Satin Flycatcher, Hooded Robin, Diamond Firetail, Yellow-bellied Sheathtail Bat, Little Pied Bat, Eastern False Pipistrelle, Eastern Bentwing-bat, Greater Long-eared Bat and Eastern Cave Bat*

4.10 EPBC Act Box Gum Woodland and Threatened Species in Offset Areas

Surveys completed in September 2011 provided information about the condition classes of Box Gum Woodland in Northern, Eastern and Western Offsets. There are extensive areas of high quality woodland with a relatively intact native grassy understorey. There are also broad areas of Derived Native Grassland that will be able to be regenerated to Woodland in future with appropriate grazing management and some replanting of trees and shrubs in selected areas. **Table 4.28** provides a summary of the areas of Box Gum Woodland in the Offset Areas.

There are other threatened and migratory species that are known to occur in the locality surrounding the Offset areas and include the nationally-threatened Spotted-tail Quoll (*Dasyuris maculatus*). Other Nationally-listed threatened species found within forests and woodlands of the Northern Offsets, and almost certainly the Eastern and Western Offsets is the Vulnerable bat Greater Long-eared Bat (*Nyctophilus corbeni*). The Endangered/Migratory bird species that have potential to occur include Regent Honeyeater and Swift Parrot.

The Namoi River also provides habitat for threatened species and EECs. These include Murray Cod (*Macullochella peelii*) and also the EEC within the Namoi River known as “Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River”.

Table 4.29 represents a summary of the condition classes of Box Gum Woodland and Derived Native Grassland within the Offset Areas.

Table 4.28 Summary of Box Gum Woodland Communities to be Conserved Against Areas to be Cleared from the Project Boundary

Vegetation Communities	Area to be cleared from Project Boundary (ha) [A]	Area to be conserved in Eastern/ Western/ Northern/ Shared Properties (ha) [B]	Ratio of Offset area to area to be cleared [B]:[A]
Riparian forests			
Rough-barked Apple - Blakely's Red Gum riparian grassy woodland	0	225.13	n/a
White Box - Blakely's Red Gum - Melaleuca riparian forest	10.12	35.39	3.5
White Box, Yellow Box, Blakely's Red Gum woodlands			
Manna Gum - Yellow Box - Blakely's Red Gum open forest	0	385.53	n/a
Stringybark - Blakely's Red Gum grassy open forest	0	770.30	n/a
White Box - Narrow-leaved Ironbark - White Cypress Pine grassy open forest	406.97	210.41	0.5
White Box - stringybark grassy woodland	0	1389.71	n/a
White Box - White Cypress Pine grassy woodland	0.8	459.96	575.0
Yellow Box - Blakely's Red Gum grassy woodland	8.64	0	0
Belah associations			
White Box - Wilga - Belah woodland	31.46	68.94	2.2
Total Forest and Woodland	457.99	3545.37	7.7
Derived Native Grassland (Box Gum Woodland)	86.48	1486.20	17.2
Total Derived Native Grassland	86.48	1486.20	17.2
Totals	**544.47**	**5031.57**	**9.2**

n/a - will not be cleared from the Project Boundary

Table 4.29 Summary of EPBC Matters - Condition Areas of Box Gum Woodland and Habitat for Threatened EPBC Fauna to be Conserved in the Eastern, Western, Northern and Shared Properties

OFFSETS						Box Gum Woodland and Derived Grasslands provided (ha)			HABITAT for EPBC Matters of National Environmental Significance (Regent Honeyeater, Swift Parrot and Greater Long-eared Bat)	
Property (describe each discrete property separately)	**Size property (ha)**	**Location property (map coordinates)**		**Current tenure (+security of acquisition)**	**Proposed long-term protection mechanism (covenant, CA, National Parks etc)**	**Condition 'A' (not included in EPBC listing)**	**Condition 'B' (patches of >0.1 ha with more than 12 species)**	**Condition 'C' (patches of >2 ha with at least 20 mature trees per ha**	**Good condition vegetation (ha)**	**Low or moderate condition vegetation to be re-vegetated (ha)**
		LATITUDE	LONGITUDE			*An overstorey of eucalypt trees exists, but there is no substantial native understorey*	*A native understorey exists, but the trees have been cleared*	*Both a native understorey and an overstorey of eucalypts exists in conjunction*		
Blue Range	748	30°31'7.3 S	150°5'47.4 E	Private ownership	CA or other	0	0	21.7	0	127.4
Cattle Plain	284	30°30'57.6 S	150°7'38.1 E	Private ownership	CA or other	0	0	36.0	36.0	118.3
Teston (nth)	292	30°31'58.8 S	150°6'38.7 E	Agreement in Place	CA or other	0	0	57.8	0.1	204.5
Tralee	342	30°32'2.6 S	150°7'26.2 E	MCC Owned	CA or other	0	0	17.2	0	103.2
Wallandilly	1890	30°30'47.9 S	150°9'56.4 E	Private Ownership	CA or other	0	0	98.3	122.8	699.7
Warriahdool	1011	30°31'22.5 S	150°8'40.7 E	MCC Owned	CA or other	0	0	64.5	64.5	138.1
Mt Lindesay	2430	30°19'42.1 S	150°16'57.1 E	MCC Owned	NP, CA or other	0	577.3	1458.6	1456.7	821.2
Wirradale	4321	30°22'54.6 S	150°15'47.8 E	MCC Owned	NP, CA or other	0	818.7	1517.1	1942.2	1593.7
Shared Property	884	30°38'44.7 S	150°1'12.7 E	Boggabri / MCC Owned	CA or other	0	0	5.5	124.1	232.1

OFFSETS						Box Gum Woodland and Derived Grasslands provided (ha)			HABITAT for EPBC Matters of National Environmental Significance (Regent Honeyeater, Swift Parrot and Greater Long-eared Bat)	
Property (describe each discrete property separately)	**Size property (ha)**	**Location property (map coordinates)**		**Current tenure (+security of acquisition)**	**Proposed long-term protection mechanism (covenant, CA, National Parks etc)**	**Condition 'A' (not included in EPBC listing)**	**Condition 'B' (patches of >0.1 ha with more than 12 species)**	**Condition 'C' (patches of >2 ha with at least 20 mature trees per ha**	**Good condition vegetation (ha)**	**Low or moderate condition vegetation to be re-vegetated (ha)**
Kelso	508	30°36'26.1 S	150°3'36.3 E	Private ownership	CA or other	0	0	16.5	342.8	156.4
Louenville	459	30°34'53.3 S	150°4'59.8 E	Agreement in Place	CA or other	0	0	151.0	188.6	115.0
Olivedeen	193	30°35'24.4 S	150°3'9.4 E	MCC Owned	CA or other	0	0	0	13.2	31.8
Teston (sth)	1273	30°34'5.7 S	150°7'0.1 E	MCCOwned	CA or other	0	18.6	63.4	175.1	127.6
Velyama	919	30°36'9.5 S	150°5'5.9 E	MCC Owned	CA or other	0	71.6	37.8	83.0	315.8
TOTAL	**15554**					**0**	**1486.2**	**3545.4**	**4549.1**	**4784.8**

**Note: Verbal agreement has been reached with the property owners. Documents are with the legal practitioners for execution*.

5.0 MANAGEMENT ACTIONS: NORTHERN OFFSETS

5.1 Management Approach

The Northern Offsets comprise the main component of the Offset Strategy. The management objective for the Northern Offsets is to create a conservation property in the long term that is capable of delivering biodiversity objectives whilst maintaining a sustainable grazing enterprise over a small proportion of the land. Income from the farm will help fund the conservation outcome in the long term. If the biodiversity values of the properties are improved and maintained for conservation, it will help provide the ecosystem services that the farm relies on to maintain its productivity (McIntyre *et al.*, 2002) while proceeds from farming can in turn help to fund conservation on the property.

The two properties that constitute the Northern Offsets will be converted from sheep grazing properties to conservation lands that link to and complement the nearby Mount Kaputar National Park and other neighbouring bushland. The majority of the Northern Offset properties will be managed for conservation and a number of management actions will take place to maintain existing woodland and forest, recover woodland from largely cleared native grazing pastures and to improve and maintain a diversity of habitats for native flora and fauna. The management areas that will be managed for conservation are A, B, D, E, F, G on Mt Lindesay, and H, J, K, M, N, O, R, S and U on Wirradale (see **Figure 5.1**). At least 20% of the properties will be managed as core conservation areas (McIntyre *et al.*, 2002) where no further grazing will take place. These areas include the forested blocks I, L, P and Q as these management areas represent intact bushland in excellent condition (**Figure 5.1**).

Commercial livestock grazing will be maintained within core farming areas C on Mt Lindesay and T on Wirradale (**Figure 5.1**) and will not exceed 20% of the total property area. This threshold is considered to be an acceptable upper limit for intense land use to maintain a stable and functional ecosystem (McIntyre *et al.*, 2000).

5.2 Environmental Gains

The Northern Offsets already have high habitat values, however also contain broad areas of partially cleared woodland and derived native grassland that have been used for sheep and cattle pasture prior to purchase for offsetting. Management of the Northern Offsets will aim to maintain and improve the partially cleared woodland and derived native grassland by increasing tree cover in denuded areas and promoting regeneration of the native grassland ground stratum by rotational grazing, weed management and feral animal control.

Regeneration of woodland will increase the total area of woodland habitat within the Northern Offsets and will improve habitat linkages to nearby Mount Kaputar National Park. With a reduction in livestock grazing, it is predicted that the diversity of native grasses and other herbaceous plants will increase, as will wildlife, including threatened fauna. Regeneration of woodland is intended to produce measureable increases in habitat for threatened fauna such as threatened woodland birds, bats, Spotted-tailed Quoll and other species.

The major weed of the Northern Offsets is Briar Rose (*Rosa rubiginosa*), an exotic perennial thorny shrub. Control and reduction of this species will be undertaken in the early years, which will allow for additional growth of native woodland plants and improved habitat for native fauna.

Other weeds will be controlled through avoiding pasture improvement or the use of fertilisers within the conservation zones. This is expected to reduce the densities of other weeds such as various thistle

species in the longer term, as these species proliferate in heavily grazed areas where soil nitrogen is abundant and decline as grazing and nitrogen declines.

There is not expected to be any conflict between the proposed restoration works in the biodiversity areas and any Aboriginal heritage values (both cultural and archaeological). If any artefacts are found or known to occur, then consultation will be undertaken with qualified heritage consultants and an appropriate course of action identified.

Salinity is not known to be an isssue in the Northern Offsets, and the actions specified in this BMP are not likely to increase the level of salinity, and therefore no salinity management measures are proposed to be undertaken in this BMP.

Monitoring of flora and fauna will be conducted to detect and audit environmental gains from the current baseline condition, and will also furnish additional information for adaptive management of the Northern Offsets. The conservation outcomes within the Northern Offsets will be permanently protected by the implementation of a Voluntary Conservation Agreement (VCA) across all management areas, including the core farming areas. The VCA will be registered on the titles to the properties and will provide for long term conservation outcomes. There is also some potential for some areas to be included in the National Parks estate.

MCC has commenced preliminary discussions with the NSW National Parks and Wildlife Service and the OEH in regards to the above agreements.

Coordinate System: MGA Zone 56 (GDA 94)

N
Grid North

Cotswold Road
SECOND WATER CREEK
HORTON RIVER
Mount Lindsay Road
Horton Falls CCA Zone 1
National Park
Clonmeen Road
MIDDLE CREEK
Mount Kaputar
National Park
MAULES CREEK

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U

Legend

- Management Zone
- National Parks and Reserves
- Fence line
- River
- Road

CUMBERLAND ECOLOGY

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Figure 5.1. Management Zones for the Northern Offset Property

1000 0 1000 2000 3000 4000 m

5.3 Grazing Plan

5.3.1 Objectives

The use of grazing to assist with the rehabilitation of grassy woodlands for conservation is part of current best practice (Lunt *et al.*, 2007) and is fundamental for the achievement of the conservation objectives for the Northern Offsets. The objective of this grazing plan for the Northern Offsets is to regulate the intensity and frequency of grazing across the properties to protect core conservation areas and creeklines, and to stimulate natural regeneration of native tree and shrub species in pasture areas. This grazing plan has been developed in consultation with the Namoi CMA, and their recommendations regarding the management of grazing for biodiversity have been incorporated into this Grazing Plan.

Light grazing has been shown to maintain native tussock grasses and grazing sensitive herbs (McIntyre and Lavorel, 2001) and may increase species diversity (Henderson and Keith, 2002; Tasker and Bradstock, 2006; Rawlings *et al.*, 2010) if managed appropriately to avoid overgrazing. Crash grazing is the practice of allowing high densities of livestock graze targeted areas for short periods of time, and is aimed at breaking up mats of perennial grass species to allow room for natural regeneration of trees and shrubs to take place. Crash grazing will also assist to prevent or reduce weedy annual or perennial grass seed production. The crash grazing regime proposed for the offset areas aims to specifically encourage the regeneration of eucalypt species by reducing competition from grassy species that are dominant at the end of summer and early autumn. This approach is less favourable to some native grass species that are seeding at the end of summer; however it will facilitate the germination and early growth of eucalypt seedlings. Once substantial regeneration has occurred, there is likely to be scope to change the grazing regime as appropriate. This may include crash grazing in spring, rather than autumn, which will reduce competition for the early developing exotic weed species and will favour native grasses. As much of the offset areas contain derived native grassland, there are substantial areas available from which recruitment may come, and it is considered a higher priority in the short term to establish canopy tree species, with a later focus on grassy understorey species as appropriate.

Grazing management would be undertaken under strict controls by MCC's Environmental Officer (the 'EO') and the Land Managers (the 'LM'). Both will be suitably qualified and/or will engage the support of suitable consultants/practitioners.

5.3.2 Implementation and Timing

In the first seven years, selected management areas will be systematically subjected to a cycle of crash grazing, resting, and light grazing in accordance with the grazing plan (see **Table 5.1**and **Table 5.2**) to stimulate regeneration of woody plants (trees and shrubs). The minimum paddock size should be 100 ha, which may mean that several paddocks need to be managed together as a single paddock.

Crash grazing will be undertaken in late summer/early autumn to create gaps for eucalypt and canopy seeds to germinate. It will be undertaken for a maximum of 10 days at any one time in each paddock to avoid overgrazing and damage to desirable species.

Crash grazing will be followed by a resting period from grazing to allow tree seedlings to establish. Rest from grazing will also benefit plants when they are flowering, setting seed and establishing. Longer periods of rest will be provided when tree and shrub recruitment is evident. Furthermore, paddocks will be rested when dry matter levels fall below 2,000 kg per hectare, or when groundcover percentage cover falls below 90%.

Light grazing will take place after resting to help maintain the groundcover and litter cover through autumn and winter. This grazing will be with very light stocking rates of no more than 4 Dry Sheep Equivalent

(DSE) per hectare (Dorrough *et al.*, 2008). Stocking rates will be reduced during winter when plant growth rates are slow and stocking rates will also be reduced following good summer and autumn rains to allow plants to recover and encourage seedling establishment.

Light to moderate grazing will also take place in the management areas before the commencement of a cycle (**Table 5.2**) to promote regeneration of woodland vegetation; maintain diversity of habitats; and where necessary, to reduce high levels of grassy fuel.

Monitoring will be undertaken at the beginning, middle and end of the grazing cycle to determine the optimum timing of the next stage of the cycle. As outlined above, several thresholds have been established that require variations to the timing of the grazing cycle. At the end of each grazing cycle, monitoring will take place to determine whether regeneration has taken place and to ascertain the likely trajectory of regeneration. If necessary or appropriate, another grazing cycle will be repeated, and if required, the second crash grazing period will be replaced by light grazing if the results of monitoring indicate that it is appropriate to do so. A flexible approach to the grazing plan will be maintained to take into account varying seasonal conditions from year to year.

It is expected that the grazing plan will undergo small adjustments in consultation with MCC's EO, the LM and an Ecological Consultant (the 'EC') to ensure that grazing objectives continue to be achievable. Further monitoring will be undertaken to check progress of regeneration, and subsequent grazing management will be based on the outcomes of the first seven years of monitoring. As outlined previously, there may be reason to vary the timing of crash grazing after regeneration has occurred in order to facilitate the regeneration of understorey species.

No grazing will occur in forested blocks I, L, P and Q as these management areas contain bushland in good condition.

The following principles will be observed for rotational grazing:

- Livestock to be quarantined in non-weed infested area for 24 hours prior to being put in conservation area to minimise the introduction of weed species;
- Exclude grazing from areas of native pastures during the growing season of target native tussock grass species to facilitate seed set as native tussock grasses are more grazing sensitive at these times;
- Remove stock from paddocks when / if groundcover falls below the acceptable limit to protect the pasture and the soil (see **Section 5.3.3**);
- Livestock are to be excluded by fencing from riparian and sensitive areas;
- Graze strategically so that competition and seed production from pasture weed species is reduced;
- Allow for rest periods to maintain adequate groundcover and litter, particularly at the time of season break of annual broadleaved weeds to reduce their germination; and
- Ensure that overgrazing does not take place.

Conventional livestock grazing will be maintained within core farming areas C on Mt Lindesay and T on Wirradale. The purpose of sheep and cattle grazing will be to provide an income for the Northern Offsets so as to provide funding in the long term for maintenance of the conservation outcomes. Grazing within the core farming areas will be conducted in a sustainable manner, without prolonged overstocking, particularly during drought. Riparian areas such as those in area T will be fenced to exclude livestock and to promote regeneration of riparian corridors (see **Section 5.7**).

Table 5.1 One Grazing Cycle in the Grazing Management of the Northern Offsets

Year	Month	Season	Action
First Year	January	Summer	Crash grazing first 3 months
	February		
	March	Autumn	Exclude grazing three months
	April		
	May		
	June	Winter	Light rotational grazing for 6 months
	July		
	August		
	September	Spring	
	October		
	November		
	December	Summer	
Second Year	January		Monitor. Crash graze if necessary. Otherwise lightly graze
	February		
	March	Autumn	Exclude grazing three months
	April		
	May		
	June	Winter	Light rotational grazing for 6 months
	July		
	August		
	September	Spring	
	October		
	November		
	December	Summer	
Third Year	January		Monitor. Crash graze if necessary. Otherwise lightly graze
	February		
	March	Autumn	Exclude grazing three months
	April		
	May		
	June	Winter	Light rotational grazing for 6 months
	July		
	August		
	September	Spring	
	October		
	November		
	December	Summer	

Table 5.2 Twenty-one Year Indicative Grazing Plan for the Northern Offset Properties

Mgmt Zone	Years during the Ownership of the Proponent																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
A	One grazing cycle			TBD	TBD	TBD	TBD														
B	LRG	One grazing cycle			TBD	TBD	TBD														
C	COMMERCIAL GRAZING																				
D	LRG	LRG	LRG	One grazing cycle			TBD														
E	LRG	LRG	LRG	One grazing cycle			TBD														
F	LRG	LRG	One grazing cycle			TBD	TBD														
G	One grazing cycle			TBD	TBD	TBD	TBD														
H	LRG	One grazing cycle			TBD	TBD	TBD														
I	NO GRAZING																				
J	LRG	LRG	LRG	LRG	One grazing cycle																
K	LRG	LRG	One grazing cycle			TBD	TBD														
L	NO GRAZING																				
M	One grazing cycle			TBD	TBD	TBD	TBD														
N	LRG	One grazing cycle			TBD	TBD	TBD														
O	LRG	One grazing cycle			TBD	TBD	TBD														
P	NO GRAZING																				
Q	NO GRAZING																				
R	LRG	LRG	One grazing cycle			TBD	TBD														
S	LRG	LRG	LRG	One grazing cycle			TBD														
T	COMMERCIAL GRAZING																				

Mgmt Zone	Years during the Ownership of the Proponent																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
U	LRG	LRG	LRG	LRG	One grazing cycle																

LRG - light grazing on rotation.

TBD - To Be Determined subject to monitoring results.

Cells that are highlighted indicate that the grazing plan will be determined in these years based on the results of the first 7 years of the grazing program.

5.3.3 Performance Indicators

The following performance indicators apply to the grazing management of the Northern Offset properties:

- Widespread recruitment (i.e. germination or regrowth from lignotubers) of native trees and shrubs for the first seven years;
- Woodland areas progressing towards a density of 30-40 trees per hectare in the long term (Prober and Brown, 1994; Rawlings *et al.*, 2010). It is acknowledged that this is difficult to assess in the initial establishment years of the management plan but is the benchmark to aim for over the life of the plan;
- Observable increase in growth, abundance and / or maturity of native species such that the survival rate of new recruits is higher than the mortality rate;
- Absence of overly dense stands of regeneration;
- Dominance of large native tussock grasses and erect and twining forbs in the understorey;
- An increase in species diversity of native plants over time, approaching that of nearby reference sites (see monitoring section, **Section 9.0**);
- Bare ground cover no greater than 30-40 % of the cover in pastures (McIvor, 2002). This provides habitat for fauna and native forbs and reticulates surface water flow, thus reducing erosion risk and nutrient leaching; and
- Evidence of mixed-age regeneration taking place.

5.3.4 Potential Corrective Actions

The following corrective actions will be applied as required to the grazing management of the Northern Offset properties:

- Adjust grazing pressure as required and preferentially rotate stock out of stressed paddocks to prevent overgrazing of native pastures;
- Remove stock from paddocks when groundcover falls below the acceptable limit to protect the understorey and the soil;
- Amalgamate or split management areas if necessary or appropriate;
- Apply / increase weed management as necessary;
- Fence off sensitive areas to exclude or control grazing; and
- Continue monitoring and maintain a flexible approach (Lunt *et al.*, 2007).

If regeneration is successful but maturation of the woodland is stunted by prolific growth, then thinning will be undertaken to assist the regeneration (see **Appendix E** for suggested approach and methods). Although woodland stands are capable of self-thinning, this can take up to 50 years to progress (McIntyre *et al.*, 2002). Where regeneration is prolific, selective thinning of regrowth can be beneficial to assist in the development of the woodland. Thinning is also likely to promote the recovery of threatened species habitat (Saunders and Tzaros, 2011). If thinning takes place, the debris will be redistributed as ground cover in woodland areas to provide habitat for fauna (**Appendix E**).

Mosaic burning of overgrown pasture areas within a paddock may be considered in some situations to remove the accumulated rank material, which provides fuel and increases the chance of unplanned grass fires (see **Section 5.8**), as well as to stimulate the growth of fresh, more palatable grass for stock.

5.3.5 Monitoring Parameters and Timing

Monitoring will take place at the beginning of the grazing cycle, once during the cycle and then again at the end of the grazing cycle, for a period of seven years. Subsequent grazing management for the remainder of the life of the plan will be based on the outcomes of the first seven years of monitoring.

Refer to **Section 9.0** for further details.

5.3.6 Responsibility for Carrying out this Action

Refer to **Section 5.11** below.

5.3.7 Reporting and Documentation

Refer to **Section 5.12** below.

5.4 Revegetation Plan

5.4.1 Objectives

Revegetation is an important tool to enhance species and genetic diversity of existing woodland remnants and to provide buffers against adjacent land use (Rawlings *et al.*, 2010). Revegetation is also an important tool to retain the function of over-cleared areas such as creeklines and native pastures (Wilson, 2002; Rawlings *et al.*, 2010) and to reduce stress on scattered paddock trees that are critical habitat components for native wildlife (Gibbons and Boak, 2002; Rawlings *et al.*, 2010).

The objectives of the revegetation plan for the Northern Offsets are to employ low-disturbance revegetation methods to augment natural regeneration; stabilise risk areas such as creeklines; create suitable microhabitat in native pastures to encourage understorey plants; reduce stress on existing scattered paddock trees; and provide a buffer between conservation areas and core grazing areas.

Encouraging natural regeneration is generally favoured over tree planting because natural regeneration conserves the natural genetic diversity of the local vegetation. It is also cheaper and more efficient to encourage natural regeneration than to plant trees over broad areas. Therefore, tree planting efforts will be limited to areas where natural regeneration is likely to be slow or absent.

5.4.2 Implementation and Timing

Revegetation will be undertaken in selected management areas in accordance with the planting plan (see **Table 5.3**). This planting plan provides for the establishment phase of the revegetation works and includes site preparation, planting, and follow-up weeding for a period of two years after the planting. Annual monitoring will also be undertaken to ensure the best chance of success.

No replanting is required for core conservation areas, as it is considered that natural regeneration of forest and woodland will occur. It is predicted that natural regeneration of trees and shrubs will progressively occur and will radiate outwards from existing treed areas, provided that grazing is managed appropriately in these areas. Other areas may be considered for replanting over time, dependant on the results of the monitoring program.

The specific planting objectives for the various management areas are outlined in **Table 5.4** and include the following works:

- Buffer planting;
- Creekline planting;
- Node planting;
- Paddock tree and patch augmentation;
- Weed control (see **Section 5.5**);
- Exclusion fencing; and
- Monitoring (see **Section 5.4.8**).

Buffer planting is important in the management areas adjacent to management areas T and C to reduce transfer of weeds and nutrients from a core grazing area into conservation areas. A buffer of dense trees and shrubs will be planted in native pasture at the boundary interface and around small, vulnerable woodland areas (i.e. less than 5 hectare patches) that are adjacent to more intense land use (Rawlings *et al.*, 2010). Buffer widths will be determined at the time of site preparation in consultation with the EC and LM and will take into account the environmental conditions of the site. Understorey rehabilitation will aim to encourage large native tussock grasses (either through assisted regeneration or planting) to attenuate surface flows and transfer of material (i.e. nutrients, weed seeds etc) from farming areas to the conservation areas.

Tree and shrub planting will take place along creeklines and these areas will be fenced to exclude stock. See **Section 5.7** for more information on creekline restoration.

Planting clumps of trees ("node planting") will provide new sources of seed and expansion points to "infill" gaps in woodland and will provide foci points for regeneration of trees and shrubs in pasture areas in the longer term. Node planting will be configured in clumps and not strips (Montague-Drake, Autumn 2008). Node planting will aim to produce tree patches of no less than 5-10 hectares in size that will be well connected to each other or to existing small patches of trees (Barrett *et al.*, 1994; Freudenberger, 1999).

Tree planting will also take place in selected paddocks to reduce the stress on existing paddock trees and provide scattered tree cover for native woodland birds. Paddock trees will be augmented by planting small numbers of trees and shrubs in clumps.

Temporary exclusion fencing and follow up weed control is critical to the establishment success of planting and will be undertaken routinely at each planting site. Identification and control of potential grazers will also be undertaken before planting to maximise the success of plantings (Rawlings *et al.*, 2010).

Table 5.3 Twenty-one Year Planting Plan for the Northern Offset Properties

Mgmt Zone	Years during the Ownership of the Proponent																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
A																					
B	prep	plant	weed	weed																	
C	COMMERCIAL GRAZING																				
D																					
E																					
F			prep	plant	weed	weed															
G																					
H																					
I	CORE CONSERVATION																				
J																					
K																					
L	CORE CONSERVATION																				
M				prep	plant	weed	weed														
N			prep	plant	weed	weed															
O																					
P	CORE CONSERVATION																				
Q	CORE CONSERVATION																				
R		prep	plant	weed	weed																
S																					
T	COMMERCIAL GRAZING																				

Mgmt Zone	Years during the Ownership of the Proponent																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
U	prep	plant	weed	weed																	

Cells that are highlighted indicate that the planting plan will be determined in these years based on the results of the first 7 years of the planting program.

Note: Monitoring will be undertaken annually for the first seven years of the planting plan.

Table 5.4 Revegetation Objectives for Each Management Area in the Northern Offsets

Mgmt Zone	Buffer Planting	Creekline Planting	Node Planting	Paddock tree and patch augmentation	Weed Control	Exclusion Fencing	Monitor of Planting
A					x		x
B		x	x		x	x	x
C		x			x	x	x
D					x		x
E					x		x
F			x	x	x	x	x
G					x		x
H					x		x
I	No Planting						
J					x		x
K					x		x
L	No Planting						
M	x		x	x	x	x	x
N	x		x	x	x	x	x
O					x		x
P	No Planting						
Q	No Planting						
R	x	x		x	x	x	x
S					x		x
T		x			x	x	x
U	x		x	x	x	x	x

5.4.3 Seed Collection and Seedling Source

Planting material will be preferentially sourced from local provenance and harvested from seed on site if possible to retain genetic diversity. Best practice methods include sourcing seeds with high levels of genetic diversity. Detailed seed collection methods are provided in **Appendix F**. Seed collection should commence as early as possible as large volumes of seeds are likely to be required.

5.4.4 Pre-planting Preparation

Preparation of the planting area will be carried out several months before planting takes place. See **Appendix F** for planting preparation methods.

5.4.5 Planting Techniques

The main planting techniques will be tubestock planting and direct seeding. Methods for these are provided in **Appendix G**. The advantages and disadvantages of each technique is summarised in **Table 5.5** below the most appropriate method will be utilised for each site.

Table 5.5 Advantages (+) and Disadvantages (-) of Tubestock Planting and Direct Seeding

Tubestock Planting	Direct Seeding
(-) Higher establishment costs	(+) Lower establishment costs
(+) Revegetation is quick and visible	(-) May have a 3-5 year lag before results are visible
(-) Often results in rows of plants i.e. unnatural distribution	(+) Natural distribution and more diversely structured
(-) Higher risk of poor root formation due to root spiralling in plant pot	(+) Establishes healthier plants
(-) Adaptation to site depends on seed source	(+) Plants that germinate will be well adapted to site
(+) Uses small quantities of seed	(-) Uses high quantities of seed
(-) More labour intensive	(+/-) Requires moderate labour
(+) Distinct rows can make maintenance easier (e.g. weed control)	(-) Longer establishment times may lead to more maintenance such as weed control
(+) Immediate results	(-) More vulnerable to climate variability
(+/-) Fairly uniform establishment and growth	(-) Ants can take seeds or some areas may be very dense.

Adapted from Rawlings et al. *(2010)*

Low-disturbance planting methods will be employed in the first instance to minimise the risk to existing native vegetation and to reduce the risk of encouraging weed invasion. More intensive planting techniques will be considered in future if the results of monitoring suggest that this is necessary (**Table 5.6**).

Planting season depends largely on germination conditions including stored moisture, soil temperature, humidity and rainfall. Local conditions will be considered before planting; however, general planting seasons for Central Western NSW are at autumn break through to the beginning of spring (Rawlings *et al.*, 2010).

Table 5.6 Low- and High-Disturbance Planting Methods

Planting Technique	Tubestock Planting	Direct Seeding
Low Disturbance	Spot planting with mattock or plug planter	Niche or spot seeding
	Auger planter	Brush mulching
	Small area (node) plantings	Hand broadcast
		Clay balls or coated seeds
		Small area (node) seeding
High Disturbance	Deep ripping	Disc or scalping seeders
	Cultivation	Mouldboard ploughing
	Mounding	Scalping and turf seeding
	Long fallow	
	Mechanical planters	

Adapted from Rawlings et al. *(2010)*

5.4.6 Performance Indicators

The following performance indicators apply to the revegetation of the Northern Offset properties:

- Evidence of recruitment in the direct seeding areas (i.e. germination) within a year of sowing or broadcasting;
- Evidence of successful establishment of seedlings in the first year from planting;
- Observable increase in growth, abundance and / or maturity of native species such that the survival rate of new recruits is higher than the mortality rate;
- Woodland patches attaining a minimum patch size of 5-10 hectares by the end of life of the plan to maintain ecosystem function (Loyn, 1987; Barrett *et al.*, 1994; Freudenberger, 1999);
- Woodland areas progressing towards a density of 30-40 trees per hectare in the long term (Prober and Brown, 1994; Rawlings *et al.*, 2010). It is acknowledged that this is difficult to assess in the initial establishment years of the management plan but will be a benchmark to aim for over the life of the plan;
- Dominance of large native tussock grasses and erect and twining forbs in the understorey;
- Exotic plant cover less than 50%;
- Species diversity of native plants increasing over time and approaching that of nearby reference sites (see monitoring section, **Section 9.0**); and
- Bare ground cover not exceeding 30-40 % of the cover in pastures (McIvor, 2002).

5.4.7 Potential Corrective Actions

The following corrective actions apply to the revegetation of the Northern Offset properties:

- Sow or plant densely to account for inevitable recruitment/seedling loss;
- Additional planting or sowing to replace lost recruits or seedlings if the rate of loss is higher than the rate of establishment;
- Continue monitoring and maintain a flexible approach to revegetation (Lunt *et al.*, 2007);
- Amalgamate or split management areas if necessary or appropriate;
- Fence off areas to exclude or control grazing; and
- Apply / increase weed management as necessary.

If the growth of revegetation is successful but further development is suppressed by high density of plants, then removal of individuals will be undertaken to lower the density of the planting site. Although woodland stands are capable of self-thinning, this can take up to 50 years to progress (McIntyre *et al.*, 2002). Thinning is also likely to promote the recovery of some threatened species habitat (Saunders and Tzaros, 2011). If density reduction takes place, the debris will be redistributed as ground cover in woodland areas to provide habitat for fauna (**Appendix E**).

5.4.8 Monitoring Parameters and Timing

One of the major aims of monitoring will be to monitor the nature, extent and species composition of woody regeneration on the Northern Offset properties. Monitoring should be carried out annually for the collective establishment period, which is for the first seven years of the planting plan (**Table 5.3**)

Review of the planting plan should be completed based on the results of the first seven years of monitoring and follow up works should be developed and implemented for the remainder of the planting plan.

Refer to **Section 9.0** for a detailed description of the monitoring requirements for this action.

5.4.9 Responsibility for Carrying out this Action

Refer to **Section 5.11** below.

5.4.10 Reporting and Documentation

Refer to **Section 5.12** below.

5.5 Weed Management

5.5.1 Objectives

Weeds can have significant detrimental effects on native remnant vegetation and have the potential to compromise rehabilitation efforts. Weed management of the Northern Offset Properties will be aimed at controlling the occurrence and spread of weed species whilst encouraging native species.

The long term objective is to reach a stage where the conservation management areas only require a low level of weed control and where the condition and development of native vegetation is not inhibited by the presence of weeds.

5.5.2 Implementation and Timing

The major weed of the Northern Offsets is Briar Rose (*Rosa rubiginosa*), an exotic perennial thorny shrub. Control and reduction of this species will allow for additional growth of native woodland plants and improved habitat for native fauna species. The shrub will be actively controlled in all core farming and conservation areas using methods outlined within **Appendix H**. Control will occur as necessary for the life of the plan, but major control action to significantly reduce the area covered by the Briar Rose will occur during the first five years of the plan.

Exotic trees such as Elms (*Ulmus* sp) and Weeping Willows (*Salix babylonica*) will be controlled and removed from areas of occurrence, particularly Horton Creek, during the first five years of the plan. This is intended to promote regeneration of native riparian vegetation.

The key consideration for any weed eradication works to be implemented is to limit the secondary damage to surrounding native vegetation, particularly in Box Gum Woodland areas of the offset sites. It is important that weed control measures do not degrade the quality of the existing native vegetation in the Northern Offsets properties.

Below are some recommendations to guide weed removal.

1. *Limit disturbance to surrounding trees, shrubs, and groundcover.*

Mechanical removal of woody weeds, such as bulldozing, use of tractor and chain and deep ripping, are not recommended in environmentally sensitive areas. Localised chemical control, particularly of African Boxthorn growing next to native trees, is the best method to limit inadvertent damage to surrounding native vegetation. For non-woody infestations in sensitive areas, hand removal is preferred over herbicide spraying to minimise spray drift and mortality of desired species.

For small plants of African Boxthorn and Sweet Briar, 'basal bark treatment' is the appropriate control method (see **Appendix H**). After plants are killed with herbicide, the woody material should be removed, not left standing. For larger plants, the 'cut stump treatment' is recommended. These methods are described in more detail in the NSW Industry and Investment (I&I) Primefact sheets on the control of African Boxthorn and Sweet Briar (provided in **Appendix H**).

2. *Stockpile weedy biomatter and dispose of appropriately.*

After physical removal of any plant material, the plant material should be stockpiled well away from sensitive areas and disposed of appropriately. For African Boxthorn, the material should be burnt to prevent further seed production from unripened fruit on the cut branches.

Ensure weed seeds and flowering parts are not transported to other areas of the site on machinery, footwear or other equipment.

3. *Follow up control*

Follow up management is required to treat regrowth or new germinants of woody weeds. Both African Boxthorn and Sweet Briar will sucker from the roots and so regular monitoring for new growth and seedlings is required to prevent new infestations. Grazing management to control seedlings and regrowth is effective for Sweet Briar.

5.5.3 Performance Indicators

The following performance indicators apply to the weed management of the Northern Offset properties:

- A decline in weed densities of all species; and
- No new weed infestations.

5.5.4 Potential Corrective Actions

The following potential corrective actions apply to the weed management of the Northern Offset properties:

- If existing control strategies are not allowing the performance indicators to be met, then additional strategies to control target weed species will be implemented; and
- If required, existing methods will be extended to cover newly occurring weed species.

5.5.5 Monitoring Parameters and Timing

One of the major aims of weed monitoring will be to monitor the distribution and percentage cover of weeds on the Northern Offset properties. The goal of this monitoring will be to determine whether weed control activities have been successful, and whether the control techniques being utilised are appropriate. Monitoring will be carried out annually for the first seven years of this plan (**Table 5.3**). Review of the weed management plan will be completed based on the results of the first seven years of monitoring and follow up works will be developed and implemented for the remainder of the weeding plan based on the results of the monitoring.

Refer to **Section 9.0** for a detailed description of the monitoring requirements for this action.

5.5.6 Responsibility for Carrying out this Action

Refer to **Section 5.11** below.

5.5.7 Reporting and Documentation

Refer to **Section 5.12** below.

5.6 Feral Pest Management

5.6.1 Objectives

Feral Pigs (*Sus scrofa*) and Feral Goats (*Capra hircus*) have been recorded in the Northern Offset Area and these species are known to threaten to the integrity of native woodland vegetation and wildlife habitat. Foxes (*Vulpes vulpes*) are a major threat to native wildlife and are significant predators of small to medium sized native fauna.

Feral animals will be controlled within the Northern Offsets Property with the long term objective being to reach a stage where the conservation management areas only require a low level of feral animal control and where the biodiversity value of native vegetation is not inhibited by the presence of feral animals.

5.6.2 Implementation and Timing

The major feral animal species identified above will be controlled by trapping, poisoning and shooting annually to control numbers of animals and reduce damage. Initially the goal will be to reduce existing populations substantially, with subsequent efforts concentrating on maintaining consistently low levels of feral animals to minimise impacts on native vegetation and fauna.

5.6.3 Performance Indicators

The following performance indicators apply to feral animal management of the Northern Offset properties:

- A decline in feral animal densities of target species;
- Feral animals maintained at low densities such that the EC reports little or no damage to vegetation by feral animals; and
- No new feral animal invasions.

5.6.4 Potential Corrective Actions

The following potential corrective actions apply to feral animal management of the Northern Offset properties:

- If existing control strategies are not allowing the performance indicators to be met, then additional strategies to control target feral animal species will be investigated and implemented as required to reduce the numbers of feral animals to acceptable levels; and
- If required, existing control methods will be extended to cover newly occurring feral animal species such as rabbits, hares or feral cats.

5.6.5 Monitoring Parameters and Timing

One of the major aims of feral animal monitoring will be to monitor the distribution and numbers of feral animals on the Northern Offset properties. The goal of this monitoring will be to determine whether feral animal control activities have been successful, and whether the control techniques being utilised are appropriate. Monitoring will be carried out annually for the first seven years of this plan (**Table 5.3**).

Review of the feral animal management plan will be completed based on the results of the first seven years of monitoring and follow up works will be developed and implemented for the remainder of the plan based on the results of this monitoring.

Refer to **Section 9.0** for a detailed description of the monitoring requirements for this action.

5.6.6 Responsibility for Carrying out this Action

Refer to **Section 5.11** below.

5.6.7 Reporting and Documentation

Refer to **Section 5.12** below.

5.7 Creekline Stabilisation

5.7.1 Objectives

Creeklines are important ecological environments that provide a wide range of ecosystem services such as habitat for flora and fauna, watering sources for fauna, and riparian vegetation also form important habitat corridors for native species. For this reason creekline stabilisation will be undertaken in the Northern Offset Properties to actively manage Horton Creek, Maules Creek and the unnamed tributary of Maules Creek within Management Area J to protect and restore riparian habitat.

The long term objective of creek stabilisation in the Northern Offset Properties is to reduce weed infestations in these creeklines, promote regeneration of native species and to reduce erosion and sedimentation due to stock access, and thereby increase water quality.

5.7.2 Implementation and Timing

Riparian areas such as those in areas J and T will be fenced to exclude livestock and to promote regeneration of riparian corridors. Maules Creek occurs within management areas I and Q and is currently un-grazed. This condition will be maintained.

Exotic trees such as Elms (*Ulmus* sp) and Weeping Willows (*Salix babylonica*) will be controlled and removed from areas of occurrence, particularly Horton Creek, during the first five years of the plan. This is intended to promote regeneration of native riparian vegetation.

Subsequent maintenance will focus on encouraging the regeneration of native species and maintaining weeds at low levels.

5.7.3 Performance Indicators

The following performance indicators apply to creekline stabilisation of the Northern Offset properties:

- Riparian areas fenced;
- Native riparian vegetation regenerating and increasing in density; and
- Weed species controlled, in particular large trees such as Elms and Weeping Willows.

5.7.4 Potential Corrective Actions

The following potential corrective actions apply to creekline stabilisation of the Northern Offset properties:

- If stock damage fences, then these will be repaired to enable their function to be maintained; and
- Ongoing weed control will be conducted within fenced areas.

5.7.5 Monitoring Parameters and Timing

Monitoring of creeklines will take place annually, for a period of seven years. Subsequent creekline management works for the remainder of the life of the plan will be based on the outcomes of the first seven years of monitoring.

5.7.6 Responsibility for Carrying out this Action

Refer to **Section 5.11** below.

5.7.7 Reporting and Documentation

Refer to **Section 5.12** below.

5.8 Fire Management

5.8.1 Objectives

The objective of fire management for the Northern Offsets is to appropriately manage the risk of fire by maintaining low levels of fuel within Asset Protection Zones (APZ), but maintaining sufficient leaf litter and fallen wood in the conservation areas to provide high quality habitat for native species and allow regeneration of native plant species.

5.8.2 Implementation and Timing

Bushfire management of the Northern Offsets will be undertaken as part of the Project's Bushfire Management Plan and will include provisions for the following:

- Perimeter asset protection zones;
- Fuel load reduction where necessary; and
- Maintaining perimeter tracks according to specifications.

The Bushfire Management Plan will prescribe a long term burning plan to ensure that the offset areas are managed safely whilst ensuring the long term viability of the ecological communities. It will contain appropriate performance measures (i.e. to supplement and maintain improvement works) and will be long term. The Bushfire Management Plan has not yet been completed; however it will be completed within six months of the implementation of this BMP.

Fire management will be conducted to reduce grassy fuel in APZs, and within conservation areas. APZs will be established and maintained permanently around the houses on the properties, around the sheds and yards, and along the boundaries of the properties as required under the the NSW Rural Fire Services document *Planning for Bushfire Protection 2006* (RFS (NSW), 2006).

Slashing may be used in selected areas along property boundaries, tracks and around farm infrastructure. However, livestock grazing will also reduce the amount of grassy fuel. Fuel loads within conservation areas will be controlled to both manage fire risk and still promote regeneration of native plants.

There are no plans to conduct control burning on the Northern Offset Properties. However, if fires start naturally and occur within the offset lands, a record of the timing, intensity and extent of each fire will be recorded.

5.8.3 Performance Indicators

The following performance indicators apply to fire management of the Northern Offset properties:

- APZ areas will be relatively weed free;
- Fuel loads will be within prescribed limits;
- No damage has occurred to woodland regeneration in adjacent areas as a result of fuel reduction in APZ areas;
- Fuel within conservation management areas will not be uniformly high.

5.8.4 Potential Corrective Actions

The following potential corrective actions apply to fire management of the Northern Offset properties:

- If required, fuel reduction techniques will be altered if it is found that they do not achieve the performance indicators. This may include more intense grazing or more regular slashing;
- The size and configuration of APZs may be altered if required.

5.8.5 Monitoring Parameters and Timing

Monitoring of APZs and fuel levels will take place annually, for a period of seven years. Subsequent fire management works for the remainder of the life of the plan will be based on the outcomes of the first seven years of monitoring.

5.8.6 Responsibility for Carrying out this Action

Refer to **Section 5.11** below.

5.8.7 Reporting and Documentation

Refer to **Section 5.12** below.

5.9 Schedule of Works

Major works for conservation management will take place during the approval period for the project – 21 years. After this period, the land may be sold into private ownership, or could be put into public ownership within National Parks estate.

Table 5.7 below shows the schedule of works for the major management tasks to be conducted during the first 21 years of the plan.

Table 5.7 Management Schedule for the Northern Offsets

Management Tasks	Years during the Ownership of the Proponent																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Fire Management																					
Track maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Asset Protection Zones around infrastructure	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fuel reduction in management zones	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Grazing Management																					
Core Farming Zone	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG
Conservation Zone (grassland & open woodland)	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG						
Conservation Zone (forest & woodland)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Weed Management - all zones																					
Briar Rose (*Rosa rubiginosa*)	major	major	major	major	major	as req'd							as req'd								
Weeping Willow (*Salix babylonica*)	major	major	major	major	major	as req'd							as req'd								
Elm (*Ulmus sp*)	major	major	major	major	major	as req'd							as req'd								
Thistles	major	major	major	major	major	as req'd							as req'd								
Feral Animal Management																					
Feral Pig (*Sus scrofa*)	major	major	major	major	major	as req'd							as req'd								
Feral Goat (Capra hircus*)*	major	major	major	major	major	as req'd							as req'd								
Fox (*Vulpes vulpes*)	major	major	major	major	major	as req'd							as req'd								
Creek Stabilisation																					
fencing of riparian areas (Areas J and T)	x	x																			
fencing maintenance			as req'd										as req'd								
Weeding of exotic trees (as above)																					
Replanting and Thinning																					
Replanting	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)
Thinnning						potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd
Tenure																					

Key:
CG – Commercial Grazing
RG – Rotational Grazing

5.10 Tenure and Protection Mechanism

Some of the management areas contain high quality forest and woodland that adjoins Mount Kaputar National Park, or is close to it. Ongoing discussions will be held with the OEH and the NPWS to investigate the potential to add areas to National Parks estate. Areas of particular interest for this are A, L, I, P and Q due to the integrity of native vegetation and proximity to other vegetated areas. Preliminary discussions with these agencies have already commenced.

For all lands that cannot be transferred to National Parks estate, the conservation outcomes within the Northern Offsets will be permanently protected by the provision of a Voluntary Conservation Agreement (VCA) across all lands, including the core farming areas. The VCA will be registered on the title and will provide for long term conservation outcomes on this land. Work to register the Northern Offsets as a VCA will commence in year one of the plan.

5.11 Roles and Responsibilities

The work to implement this plan will be the responsibility of the LM, MCC's EO and the EC (**Table 5.8**). The property management staff will be responsible for the day to day management of the site. The EO will be responsible for overseeing this work, for collating monitoring and management data, for arranging the revision and auditing of the BMP and for contracting ecological consultants to conduct the audits and annual monitoring programs.

The EC engaged will be an independent professional ecological consultant who will annually monitor and report on selected areas of the site and who will conduct major audits of the site every five years during the project approval period.

Table 5.8 Roles and Responsibilities for Management Aspect

Management Tasks	Responsibilities		
	Land Manager and Staff	Environmental Officer	Ecological Consultant
Fire Management			
Track maintenance	x		
Asset Protection Zones around infrastructure	x		
Fuel reduction in management zones	x	x	
Grazing Management			
Core Farming Zone	x		
Conservation Zone (grassland & open woodland)	x		
Conservation Zone (forest & woodland)	x		
Weed Management			
Briar Rose (*Rosa rubiginosa*)	x	x	
Weeping Willow (*Salix babylonica*)	x	x	
Elm (*Ulmus* sp)	x	x	
Thistles	x	x	
Feral Animal Management			

Management Tasks	Responsibilities		
	Land Manager and Staff	Environmental Officer	Ecological Consultant
Feral Pig (*Sus scrofa*)	x	x	
Feral Goat (*Capra hircus*)	x	x	
Fox (*Vulpes vulpes*)	x	x	
Creekline Stabilisation			
fencing of riparian areas (Areas J and T)	x	x	
fencing maintenance	x	x	
Weeding of exotic trees (as listed above)	x	x	
Revegetation			
Replanting	x	x	
Thinning	x	x	
Tenure		x	
Monitoring		x	x
Documentation	x	x	

5.12 Documentation

The LM will be required to compile data about the management actions used in each management area during the course of each year. This will include documentation of stocking rates and grazing rotation. Where necessary, management actions will be summarised on maps of the relevant management areas. The resultant documentation will be maintained in a permanent management record for the property and will be subject to audit every three years.

A brief summary report will be sent to Government agencies within the Annual Review to verify that management works are being conducted and the success of the works against the criteria in this BMP.

An ecological monitoring report will also be compiled annually to summarise data collected from each of the target monitoring and reference areas on the subject site. This will be reported on in the Annual Review.

6.0 MANAGEMENT ACTIONS: EASTERN AND WESTERN OFFSETS

6.1 Management Approach

This section describes a management plan for the conservation areas within the properties shown in **Figure 6.1**. The management objective for the Eastern and Western Offsets is to establish conservation areas in perpetuity around Leard State Forest that add to the biodiversity values of the locality. The vision is to create a series of conservation areas in the long term that is capable of delivering biodiversity objectives adjacent to productive farmland areas. If the biodiversity values of the conservation areas are improved and maintained for conservation, the properties will in turn continue to deliver ecosystem services that the farmland relies on to maintain its productivity (McIntyre *et al.*, 2002).

Key objectives for these conservation areas will be:

- To protect existing remnant vegetation in the lands surrounding the Leard State Forest;
- To protect and increase areas of habitat in the surrounding land to provides areas of refuge for threatened species such as birds and bats, that currently use the Leard State Forest;
- To improve corridor values in the locality by restoring and protecting stretches of Back Creek and Maules Creek and by adding to existing offset properties in the area provided by Boggabri Coal;
- To revegetate land with frontage to the Namoi River, so protecting and improving habitat for Murray Cod and also the EEC within the Namoi River known as “Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River”;
- To promote regeneration of Box Gum Woodland and affiliated vegetation near the area of impact; and
- To augment and protect Leard State Conservation Area from surrounding land use by adding to the patch size of Leard State Conservation Area and buffering it from the adjoining properties.

All remnant woodland and forest on the Eastern and Western Offset properties will be retained and protected. Various areas of grassland will also be restored to increase the area of forest and woodland in the long term.

The conservation management zones within the Eastern and Western Offset properties are shown in **Figure 6.1** and are explained below:

- Areas referred to as “A” zones are riparian and creekline restoration areas;
- Areas referred to as “B” zones are areas of existing remnant vegetation that will be protected and improved;
- Areas referred to as “C” zones are areas of significant remnant vegetation that will be protected and improved. These will be core conservation areas; and
- Areas referred to as “D” zones are areas of grassland that will require intensive restoration to provide new areas of woodland to add habitat, establish vegetated corridors and to buffer existing vegetation from surrounding land use.

6.2 Environmental Gains

The Eastern and Western Offsets have experienced more extensive grazing and cropping than the Northern Offset properties. Notwithstanding this, the properties still support valuable areas of native remnant vegetation and fauna habitat. These areas will continue to be at risk and place local native populations of flora and fauna at risk without active conservation management.

Offset management will aim to maintain and improve the partially cleared woodland and derived native grassland by increasing tree cover in denuded areas and promoting regeneration of native grassland ground stratum by rotational grazing, weed management and feral animal control.

Regeneration of woodland is predicted to increase the total area of woodland habitat within the Eastern and Western Offsets and to improve habitat linkages to nearby Mount Kaputar National Park. As livestock grazing will become a secondary use or management tool within these areas, and conservation the prime objective, it is predicted that the diversity of native grasses and other herbaceous plants will increase, as will wildlife, including threatened fauna.

The major weed of the Eastern and Western Offsets is African Boxthorn (*Lycium ferocissimum*), an exotic perennial thorny shrub. Control and reduction of this species will allow for additional growth of native woodland plants and improved habitat conditions.

There is not expected to be any conflict between the proposed restoration works in the biodiversity areas and any Aboriginal heritage values (both cultural and archaeological). If any artefacts are found or known to occur, then consultation will be undertaken with qualified heritage consultants and an appropriate course of action identified.

Salinity is not known to be an isssue in the Eastern and Western Offsets, and the actions specified in this BMP are not likely to increase the level of salinity, and therefore no salinity management measures are proposed to be undertaken in this BMP.

No pasture improvement will be permitted within the conservation zones, or the use of fertilisers. This is expected to contribute to the lowering of the densities of other weeds such as various thistle species, in the longer term, as these species proliferate in heavily grazed areas where soil nitrogen is abundant and decline as grazing and nitrogen declines.

Regeneration of woodland will mean larger areas of higher diversity Box Gum Woodland and this is intended to produce measureable increases in habitat for threatened fauna such as threatened woodland birds, bats, Spotted-tailed Quoll and other species.

The conservation outcomes within the Eastern and Western Offsets will be permanently protected by the provision of a VCA across all lands, including the core farming areas. The VCA will be registered on title and will provide for long term conservation outcomes in this land. There is also some potential for some areas adjacent to Leard State Conservation Area to be included in National Parks estate.

Monitoring of flora and fauna will be designed to detect and audit environmental gains from the current baseline condition, and will also be designed to furnish additional information for adaptive management of the Eastern and Western Offsets.

Coordinate System: MGA Zone 56 (GDA 94)

Grid North

Legend

- Project Boundary
- Mining Tenement Boundary
- Management Zone
- Other Land and Agriculture
- Conservation Reserve
- River
- Road

Image Source: © 2011 Cnes/Spot Image
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CUMBERLAND ECOLOGY

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Figure 6.1 Management Zones of the Eastern and Western Offset Properties

1000 0 1000 2000 3000 4000 m

6.3 Grazing Plan

6.3.1 Objectives

The objective of a strategic grazing plan for the Eastern and Western Offsets is to stop grazing for a period of time to allow native vegetation to recover. Then the objective will be to regulate the intensity and frequency of grazing across the properties to protect core conservation areas and creeklines and to stimulate natural regeneration of native tree and shrub species in pasture areas. Light rotational grazing in areas of conservation can maintain native tussock grasses and grazing sensitive herbs (McIntyre and Lavorel, 2001) and may increase species diversity (Henderson and Keith, 2002; Tasker and Bradstock, 2006; Rawlings *et al.*, 2010) if managed appropriately to avoid overgrazing. This Grazing Plan for the Eastern and Western Offsets has been developed in consultation with the Namoi CMA, and their recommendations regarding the management of grazing for biodiversity have been incorporated into this Grazing Plan.

At the time of preparation of this BMP, the ownership of the Eastern and Western Offset properties have not been finalised and so the following grazing plan is indicative and may change depending on the final properties purchased by MCC.

6.3.2 Implementation and Timing

i. Grazing Exclusion and Light Grazing

All of the conservation management areas within the Eastern and Western Offsets have been subject to disturbance and grazing in the past. The time at which the properties become available for conservation management will be considered “grazing time zero”; at which point grazing will be excluded for five years to allow native vegetation to recover, including trees, shrubs, herbs and grasses.

Where required fencing will be repaired or in some areas newly created to ensure there is no grazing of the conservation areas during this time. The minimum size of management units will be 100 ha, and therefore some paddocks may be combined for management purposes.

After Year 5, vegetation conditions within each management area will be considered on merits and where appropriate limited light grazing may be prescribed to further manage native grassy understorey and regeneration, as described below.

Note that some areas may have regenerated sufficiently to mean that no further grazing by livestock need be prescribed after Year 5.

ii. Strategic Rotational Grazing

After year 5, grazing management is likely to be fundamental for the achievement of objectives for the Eastern and Western Offsets (Lunt *et al.*, 2007). In the first seven years that grazing is reintroduced, selected management areas may be systematically subjected to alternate crash grazing in accordance with the grazing plan (see **Table 6.1**) to stimulate regeneration of woody plants (trees and shrubs). Crash grazing is aimed at breaking up mats of perennial grass species to allow room for natural regeneration of trees and shrubs to take place. Crash grazing will also assist to prevent or reduce weedy annual or perennial grass seed production. If required, crash grazing will be undertaken in late summer/early autumn to create gaps for seeds to germinate. It will be undertaken for a maximum of 10 days at any one time in each paddock to avoid overgrazing and damage to desirable species.

Crash grazing will be followed by a resting period from grazing to allow native grasses, forbs and tree seedlings to establish. Longer periods of rest will be provided when tree and shrub recruitment is evident.

Furthermore, paddocks will be rested when dry matter levels fall below 2,000 kg per hectare, or when groundcover percentage cover falls below 90%,

Light rotational grazing will take place after resting to help maintain the groundcover and litter cover through autumn and winter. This grazing will be with very light stocking rates of no more than 4 DSE per hectare. Stocking rates will be reduced during winter when plant growth rates are slow and stocking rates will also be reduced following good summer and autumn rains to allow plants to recover and encourage seedling establishment.

Monitoring will take place at the beginning of, during and at the end of this resting period and if necessary, crash grazing will take place again prior to another resting period and subsequent light grazing. The second crash grazing will be replaced by light rotational grazing if the results of monitoring indicate that it is appropriate to do so. The above combination of grazing management tasks define a cycle in the grazing plan (**Table 6.1**).

Light to moderate rotational grazing will also take place in these management areas before the commencement of a cycle to promote regeneration of woodland vegetation; maintain diversity of habitats; and where necessary, to reduce high levels of grassy fuel. The following will be observed for rotational grazing:

- Livestock to be quarantined in non-weed infested area for 24 hours prior to being put in conservation area to minimise the introduction of weed species;
- Rotate grazing out of areas of native pastures during the growing season of target native tussock grass species to facilitate seed set and as native tussock grasses are more grazing sensitive at these times;
- Remove stock from paddocks when / if groundcover falls below the acceptable limit to protect the pasture and the soil (see **Section 6.3.3** for groundcover threshold);
- Livestock are to be excluded by fencing from riparian and sensitive areas;
- Graze strategically so that competition and seed production from pasture weed species is reduced;
- Allow for rest periods to maintain adequate groundcover and litter, particularly at the time of season break of annual broadleaved weeds to reduce their germination; and
- Ensure that overgrazing does not take place.

At the end of this cycle, monitoring will take place to determine whether regeneration has taken place and to ascertain the likely trajectory of regeneration. If necessary or appropriate, another cycle will be repeated. A flexible approach to the grazing plan will be maintained to take into account varying seasonal conditions from year to year. It is expected that the grazing plan will undergo small adjustments in consultation with the EO, the LM and the EC to ensure that grazing objectives continue to be achievable.

Further monitoring will be necessary to check progress of regeneration. The grazing plan will be developed for the remainder of the life of the plan and will be informed by the results of the first seven years of monitoring. Subsequent grazing management will be based on the outcomes of the first seven years of monitoring.

Livestock grazing will be maintained within core farming areas. Grazing within the core farming areas will be conducted in a sustainable manner, without prolonged overstocking, particularly during drought. Riparian areas will be fenced to exclude livestock and to promote regeneration of riparian corridors (see **Section 6.7** for more information on creekline restoration).

Table 6.1 An indicative Grazing Cycle in the Grazing Management of the Eastern and Western Offsets (i.e. post year 5)

Year	Month	Season	Action
First Year	January	Summer	Crash grazing first 3 months
	February		
	March	Autumn	Exclude grazing three months
	April		
	May		
	June	Winter	Light rotational grazing for 6 months
	July		
	August		
	September	Spring	
	October		
	November		
	December	Summer	Monitor. Crash graze if necessary. Otherwise lightly graze
Second Year	January		
	February		
	March	Autumn	Exclude grazing three months
	April		
	May		
	June	Winter	Light rotational grazing for 6 months
	July		
	August		
	September	Spring	
	October		
	November		
	December	Summer	Monitor. Crash graze if necessary. Otherwise lightly graze
Third Year	January		
	February		
	March	Autumn	Exclude grazing three months
	April		
	May		
	June	Winter	Light rotational grazing for 6 months
	July		
	August		
	September	Spring	
	October		
	November		
	December	Summer	

6.3.3 Performance Indicators

The following performance indicators apply to the grazing management of the Eastern and Western Offset properties:

- Widespread recruitment (i.e. germination or regrowth from lignotubers) of native trees and shrubs for the first seven years;
- Woodland areas progressing towards a density of 30-40 trees per hectare in the long term (Prober and Brown, 1994; Rawlings *et al.*, 2010). It is acknowledged that this difficult to assess in the initial establishment years of the management plan but should be a benchmark to aim for over the life of the plan;
- Observable increase in growth, abundance and / or maturity of native species such that the survival rate of new recruits is higher than the mortality rate;
- Absence of observable lock up of stands of regeneration;
- Dominance of large native tussock grasses and erect and twining forbs in the understorey;
- Species diversity of native plants increases over time and approaches that of nearby reference sites (see monitoring section, **Section 9.0**);
- Bare ground cover should not exceed 30-40 % of the cover in pastures (McIvor, 2002). This provides habitat for fauna and native forbs and reticulates surface water flow, thus reducing erosion risk and nutrient leaching; and
- Evidence of mixed-age regeneration taking place.

6.3.4 Potential Corrective Actions

The following corrective actions apply to the grazing management of the Eastern and Western Offset properties:

- Continue monitoring and maintain a flexible approach (Lunt *et al.*, 2007);
- Adjust grazing pressure as required and rotate out of stressed paddocks to rest overgrazed native pastures;
- Remove stock from paddocks when the groundcover percentage falls below 90% to protect the understorey and the soil;
- Amalgamate or split management areas if necessary or appropriate;
- Fence off sensitive areas and riparian zones to exclude grazing; and
- Apply / increase weed management as necessary to remove environmental or unpalatable weed species. Weed control is to be conducted in such a way as to minimise impact to native species.

If regeneration is successful but maturation of the woodland is stunted by prolific growth, then thinning measures should be considered to assist the regeneration. Although woodland stands are capable of self-thinning, this can take up to 50 years to progress (McIntyre *et al.*, 2002). Where regeneration is prolific, patch thinning - not wholesale thinning - of regrowth can be beneficial to assist in the development of the woodland (see **Appendix E**). Thinning is also likely to promote the recovery of threatened species habitat (Saunders and Tzaros, 2011). If regrowth thinning takes place, the debris should be redistributed as ground cover in woodland areas to provide habitat for fauna.

Mosaic burning of overgrown or less grazed pasture areas within a paddock should be considered to attract stock away from overgrazed areas and to remove the accumulated rank material, which provides fuel and increases the chance of unplanned grass fires.

6.3.5 Monitoring Parameters and Timing

Monitoring will take place prior to the grazing cycle, once during the grazing cycle and then again at the end of the grazing cycle. Further monitoring will be necessary. The grazing plan will be developed based upon monitoring results after seven years for the remainder of the life of the plan. Subsequent grazing management will be based on the outcomes of the first seven years of monitoring.

Refer to **Section 9.0** for further details.

6.3.6 Responsibility for Carrying out this Action

Refer to **Section 6.11** below.

6.3.7 Reporting and Documentation

Refer to **Section 6.12** below.

6.4 Revegetation Plan

6.4.1 Objectives

The objective of a revegetation plan for the Eastern and Western Offsets is to employ low-disturbance revegetation methods to augment natural regeneration taking place; stabilise risk areas like creeklines; create suitable microhabitat in native pastures to encourage understorey plants; reduce stress on existing scattered paddock trees; and provide a buffer between conservation areas and core grazing areas.

It is acknowledged that natural regeneration is always favoured over tree planting because natural regeneration utilises the natural genetic diversity of the local vegetation. It is also cheaper and more efficient to encourage natural regeneration than to plant trees over broad areas. Therefore, revegetation efforts will be strictly limited to selected areas where natural regeneration is likely to be slow or absent and will be preferentially established next to or near existing remnant woodland and forest.

6.4.2 Implementation and Timing

Revegetation will be undertaken in selected management areas in accordance with the planting plan, which provides for the establishment phase of the revegetation works and includes site preparation, planting, follow-up weeding for a period of two years after the planting and annual monitoring.

No replanting is required for core conservation areas, provided that natural regeneration of forest and woodland occurs. It is predicted that natural regeneration of trees and shrubs will progressively occur and will radiate outwards from existing treed areas, provided that grazing is managed appropriately.

Other areas may be considered for replanting as monitoring progresses.

The specific planting objectives for the various management areas are outlined in **Table 6.2** and include the following works:

- Buffer planting;

- Creekline planting;
- Node planting;
- Paddock tree and patch augmentation;
- Weed control (see **Section 6.5**);
- Exclusion fencing; and
- Monitoring (see **Section 6.4-6.4.8**).

Buffer planting is important in the management areas adjacent to farming areas to reduce transfer of weeds and nutrients from a core grazing area into conservation areas. A buffer of dense trees and shrubs will be planted in native pasture at the boundary interface and around small, vulnerable woodland areas (i.e. less than 5 hectare patches) that are adjacent to more intense land use (Rawlings *et al.*, 2010). Buffer widths will be determined at the time of site preparation in consultation with the EC and LM and should take into account the environmental conditions of the site. Understorey rehabilitation will aim to encourage large native tussock grasses (either through assisted regeneration or planting) to attenuate surface flows and transfer of material (i.e. nutrients, weed seeds etc) from farming areas to the conservation areas.

Tree and shrub planting will take place along creeklines and fenced to exclude grazing. See **Section 6.7** for more information on creekline restoration.

Planting clumps of trees ("node planting") will provide new sources of seed and expansion points to "infill" gaps in woodland and will provide foci points for regeneration of trees and shrubs in pasture areas in the longer term. Node planting will be configured in clumps and not strips (Montague-Drake, Autumn 2008). Node planting will aim to produce tree patches of no less than 5-10 hectares in size and will be well connected to each other or to existing small patches of trees (Barrett *et al.*, 1994; Freudenberger, 1999).

Tree planting will also take place in selected paddocks to reduce the stress on existing paddock trees and provide scattered tree cover for native woodland birds. Paddock trees will be augmented by small numbers of tree and shrub plantings in clumps and not strips.

Temporary exclusion fencing and follow up weed control is critical to the establishment success of planting and will be undertaken routinely at each planting site. Identification and control of potential grazers will also be undertaken before planting to maximise the success of plantings (Rawlings *et al.*, 2010).

Table 6.2 Revegetation Objectives for Each Management Area in the Eastern and Western Offsets

Mgmt Zone	Buffer Planting	Creekline Planting	Node Planting	Paddock tree and patch augmentation	Weed Control	Exclusion Fencing	Monitor
A1		X			x		x
A2		X	x		x	x	x
A3		X			x	x	x
A4		X			x		x
A5		X			x		x
A6		X	x	x	x	x	x
A7		X			x		x

Mgmt Zone	Buffer Planting	Creekline Planting	Node Planting	Paddock tree and patch augmentation	Weed Control	Exclusion Fencing	Monitor
B1			x	x	x	x	x
B2			x	x	x	x	x
B3			x	x	x	x	x
B4			x	x	x	x	x
B5			x	x	x	x	x
B6			x	x	x	x	x
B7	x		x	x	x	x	x
B8			x	x	x	x	x
B9			x	x	x	x	x
C1	x		x	x	x	x	x
C2	x		x	x	x	x	x
C3	x						
D1			x	x	x	x	x
D2			x	x	x	x	x
D3			x	x	x	x	x
D4			x	x	x	x	x

6.4.3 Seed Collection and Seedling Source

Planting material will be preferentially sourced from local provenance and harvested from seed on site if possible. Best practice methods include sourcing seeds with high levels of genetic diversity. Detailed seed collection methods are provided in **Appendix F**.

6.4.4 Pre-planting Preparation

Preparation of the planting area will be carried out at least one year before planting takes place. See **Appendix F** for planting preparation methods.

6.4.5 Planting Techniques

The main planting techniques include tubestock planting and direct seeding. Methods for these are provided in **Appendix G**. The advantages and disadvantages of each technique is summarised in **Table 6.3** and will be considered against each candidate planting site to ascertain the most appropriate method for that site.

Table 6.3 Advantages (+) and Disadvantages (-) of Tubestock Planting and Direct Seeding

Tubestock Planting	Direct Seeding
(-) Higher establishment costs	(+) Lower establishment costs
(+) Revegetation is quick and visible	(-) May have a 3-5 year lag before results are visible
(-) Often results in rows of plants i.e. unnatural distribution	(+) Natural distribution and more diversely structured

Tubestock Planting	Direct Seeding
(-) Higher risk of poor root formation due to root spiralling in plant pot	(+) Establishes healthier plants
(-) Adaptation to site depends on seed source	(+) Plants that germinate will be well adapted to site
(+) Uses small quantities of seed	(-) Uses high quantities of seed
(-) More labour intensive	(+/-) Requires moderate labour
(+) Distinct rows can make maintenance easier (e.g. weed control)	(-) Longer establishment times may lead to more maintenance such as weed control
(+) Immediate results	(-) More vulnerable to climate variability
(+/-) Fairly uniform establishment and growth	(-) Ants can take seeds or some areas may be very dense.

Low-disturbance methods will be employed in the first instance to minimise the risk to existing native vegetation and to reduce the risk of weeds. More intensive techniques will be considered in future if the results of monitoring suggest that this is necessary (**Table 6.4**).

Planting season depends largely on germination conditions including stored moisture, soil temperature, humidity and rainfall. General planting seasons for Central Western NSW are at autumn break through to the beginning of spring (Rawlings *et al.*, 2010).

Table 6.4 Low- and High-Disturbance Planting Methods

Planting Technique	Tubestock Planting	Direct Seeding
Low Disturbance	Spot planting with mattock or plug planter	Niche or spot seeding
	Auger planter	Brush mulching
	Small area (node) plantings	Hand broadcast
		Clay balls or coated seeds
		Small area (node) seeding
High Disturbance	Deep ripping	Disc or scalping seeders
	Cultivation	Mouldboard ploughing
	Mounding	Scalping and turf seeding
	Long fallow	
	Mechanical planters	

Adapted from Rawlings et al. *(2010)*

6.4.6 Performance Indicators

The following performance indicators apply to the revegetation of the Eastern and Western Offset properties:

- Evidence of recruitment in the direct seeding areas (i.e. germination) within a year of sowing or broadcasting;
- Increase in the number of germinants over the first seven years from sowing or broadcasting;
- Evidence of successful establishment of seedlings in the first year from planting;

- Observable increase in growth, abundance and / or maturity of native species such that the survival rate of new recruits is higher than the mortality rate;
- Woodland patches attaining a minimum patch size of 5-10 hectares by the end of life of the plan to maintain ecosystem function (Loyn, 1987; Barrett *et al.*, 1994; Freudenberger, 1999);
- Woodland areas progressing towards a density of 30-40 trees per hectare in the long term (Prober and Brown, 1994; Rawlings *et al.*, 2010). It is acknowledged that this difficult to assess in the initial establishment years of the management plan but should be a benchmark to aim for over the life of the plan;
- Dominance of large native tussock grasses and erect and twining forbs in the understorey;
- Exotic cover is less than 50%;
- Species diversity of native plants increases over time and approaches that of nearby reference sites (see monitoring section, **Section 9.0**); and
- Bare ground cover should not exceed 30-40 % of the cover in pastures (McIvor, 2002). This provides habitat for fauna and native forbs and reticulates surface water flow, thus reducing erosion risk and nutrient leaching.

6.4.7 Potential Corrective Actions

The following corrective actions apply to planting efforts the Eastern and Western Offset properties:

- Sow or plant densely to account for inevitable recruitment/seedling loss;
- Additional planting or sowing to replace lost recruits or seedlings if the rate of loss is higher than the rate of establishment;
- Source more seeds or tubestock seedlings from alternative suppliers or sites;
- Continue monitoring and maintain a flexible approach (Lunt *et al.*, 2007);
- Amalgamate or split management areas if necessary or appropriate;
- Fence off areas to exclude or control grazing; and
- Apply / increase weed management as necessary.

If the growth of revegetation is successful but further development is suppressed by high density of plantings, then removal of individuals will be undertaken to lower the density of the planting site. Although woodland stands are capable of self-thinning, this can take up to 50 years to progress (McIntyre *et al.*, 2002). This is also likely to promote the recovery of some threatened species habitat (Saunders and Tzaros, 2011). If density reduction takes place, the debris should be redistributed as ground cover in woodland areas to provide habitat for fauna (**Appendix E**).

6.4.8 Monitoring Parameters and Timing

One of the major aims of monitoring will be to monitor the nature, extent and species composition of woody regeneration on the Eastern and Western Offset properties. Monitoring should be carried out annually for the collective establishment period, which is for the first seven years of the planting plan.

Review of the planting plan should be completed based on the results of the first seven years of monitoring and follow up works should be developed and implemented for the remainder of the planting plan.

Refer to **Section 9.0** for a detailed description of the monitoring requirements for this action.

6.4.9 Responsibility for Carrying out this Action

Refer to **Section 6.11** below.

6.4.10 Reporting and Documentation

Refer to **Section 6.12** below.

6.5 Weed Management

6.5.1 Objectives

Weeds can have significant detrimental effects on native remnant vegetation and have the potential to compromise rehabilitation efforts. Weed management of the Eastern and Western Offset Properties will be aimed at controlling the occurrence and spread of weed species whilst encouraging native species.

The long term objective is to reach a stage where the conservation management areas only require a low level of weed control and where the condition and development of native vegetation is not inhibited by the presence of weeds.

6.5.2 Implementation and Timing

The major weed of the Eastern and Western Offsets is African Boxthorn (*Lycium ferocissimum*), an exotic perennial thorny shrub. Control and reduction of this species will allow for additional growth of native woodland plants and improved habitat for native fauna species. The shrub will be actively controlled in all core farming and conservation areas using methods outlined within **Appendix H**. Control will occur as necessary for the life of the plan, but major control action to significantly reduce the area covered by the African Boxthorn will occur during the first five years of the plan.

Exotic trees such as Weeping Willows (*Salix babylonica*) will be controlled and removed from areas of occurrence, during the first five years of the plan. This is intended to promote regeneration of native riparian vegetation.

The key consideration for any weed eradication works to be implemented is to limit the secondary damage to surrounding native vegetation, particularly in Box Gum Woodland areas of the offset sites. It is important that weed control measures do not degrade the quality of the existing native vegetation in the Eastern and Western Offsets properties.

Below are some recommendations to guide weed removal.

1. *Limit disturbance to surrounding trees, shrubs, and groundcover.*

Mechanical removal of woody weeds, such as bulldozing, use of tractor and chain and deep ripping, are not recommended in environmentally sensitive areas. Localised chemical control, particularly of African Boxthorn growing next to native trees, is the best method to limit inadvertent damage to surrounding native vegetation. For non-woody infestations in sensitive areas, hand removal is preferred over herbicide spraying to minimise spray drift and mortality of desired species.

For small plants of African Boxthorn and Sweet Briar, ‘basal bark treatment’ is the appropriate control method (see **Appendix H**). After plants are killed with herbicide, the woody material should be removed, not left standing. For larger plants, the ‘cut stump treatment’ is recommended. These methods are

described in more detail in the NSW I&I Primefact sheets on the control of African Boxthorn (provided in **Appendix H**).

2. *Stockpile weedy biomatter and dispose of appropriately.*

After physical removal of any plant material, the plant material should be stockpiled well away from sensitive areas and disposed of appropriately. For African Boxthorn, the material should be burnt to prevent further seed production from unripened fruit on the cut branches.

Ensure weed seeds and flowering parts are not transported to other areas of the site on machinery, footwear or other equipment.

3. *Follow up control*

Follow up management is required to treat regrowth or new germinants of woody weeds. Both African Boxthorn and Sweet Briar will sucker from the roots and so regular monitoring for new growth and seedlings is required to prevent new infestations. Grazing management to control seedlings and regrowth is effective for Sweet Briar.

6.5.3 Performance Indicators

- Weed densities of all species and areas infested decline.

6.5.4 Potential Corrective Actions

- Additional efforts to control target species, or methods extend to cover newly occurring weed species.

6.5.5 Monitoring Parameters and Timing

One of the major aims of weed monitoring will be to monitor the distribution and percentage cover of weeds on the Eastern and Western Offset properties. The goal of this monitoring will be to determine whether weed control activities have been successful, and whether the control techniques being utilised are appropriate. Monitoring will be carried out annually for the first seven years of this plan. Review of the weed management plan will be completed based on the results of the first seven years of monitoring and follow up works will be developed and implemented for the remainder of the weeding plan based on the results of the monitoring.

Refer to **Section 9.0** for a detailed description of the monitoring requirements for this action.

6.5.6 Responsibility for Carrying out this Action

Refer to **Section 6.11** below.

6.5.7 Reporting and Documentation

Refer to **Section 6.12** below.

6.6 Feral Pest Management

6.6.1 Objectives

Feral Pigs (*Sus scrofa*) have been recorded nearby in the Project Boundary and are threats to the integrity of native woodland vegetation. They are known to damage wildlife habitat and can potentially obstruct the restoration works in the conservation management zones. Foxes (*Vulpes vulpes*) are also known from the Project Boundary nearby and are a major threat to wildlife.

The goal of feral fauna management in the Eastern and Western Offset Areas will be to ensure that impacts to native species, existing vegetation and rehabilitation efforts caused by feral fauna are minimised and managed. The long term objective will be to reach a stage where conservation management areas require only minimal control and where rehabilitation efforts and restorations areas are not at high risk from feral fauna.

6.6.2 Implementation and Timing

Sustained and ongoing control will be the key to managing feral populations in the Eastern and Western Offset Areas. Feral Pigs will be controlled by trapping and shooting annually to control numbers of animals and reduce damage. Foxes will be subject to regular control by shooting and poisoning as is routinely done on farms of the locality.

6.6.3 Performance Indicators

The following performance indicators apply to feral animal management of the Eastern and Western Offset properties:

- Feral animal maintained at low densities such that the EC reports little or no damage to vegetation by feral animals;
- A decline in feral fauna diversity and abundance;
- No recruitment of new feral species.

6.6.4 Potential Corrective Actions

The following apply to feral management in the Eastern and Western Offset properties:

- Increase frequency of control;
- Implement feral fauna controls when threatened species of concern are breeding or migrating/ moving to minimise the damage;
- Establish buffer areas to conservation areas or valuable remnant vegetation to limit introduction or reintroduction of feral fauna after controls are implemented;
- Install fencing or some form of physical barrier around rehabilitation areas (effective against feral pigs);
- Additional efforts to control target species or methods extended to cover new feral species.

6.6.5 Monitoring Parameters and Timing

The occurrence and abundance of feral animals will be monitored annually. Refer to **Section 9.0** for a detailed description of the monitoring requirements for this action.

6.6.6 Responsibility for Carrying out this Action

Refer to **Section 6.11** below.

6.6.7 Reporting and Documentation

Refer to **Section 6.12** below.

6.7 Creekline Stabilisation

Back Creek, Maules Creek and the Namoi River will be managed to protect and restore riparian habitat, including habitat for riparian plants, fish, invertebrates and other aquatic and semi-aquatic organisms. Within the property that adjoins the Namoi, the aim will be to revegetate land with frontage to the Namoi River, so protecting and improving habitat for Murray Cod and also the EEC within the Namoi River known as "Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River";

Riparian areas in the "A" zones will be fenced to exclude livestock and to promote regeneration of riparian corridors. Where needed, supplementary planting will be undertaken to control weeds and to increase riparian buffers in a faster timeframe.

Exotic trees such as Weeping Willows (*Salix babylonica*) will be controlled and removed from areas of occurrence, during the first five years of the plan. This is intended to promote regeneration of native riparian vegetation.

6.7.1 Performance Indicators

The following performance indicators apply to creekline stablilisation in the Eastern and Western Offset properties:

- Stock exclusion maintained; and
- Riparian vegetation regenerating and increasing in density.

6.7.2 Potential Corrective Actions

The following corrective actions apply to creekline stablilisation in the Eastern and Western Offset properties:

- Repair fencing; and
- Administer weed control within fenced areas.

6.7.3 Monitoring Parameters and Timing

The condition and extent of creek bank vegetation will be monitored as part of the annual monitoring programme.

6.7.4 Responsibility for Carrying out this Action

Refer to **Section 6.11** below.

6.7.5 Reporting and Documentation

Refer to **Section 6.12** below.

6.8 Fire Management

Bushfire management of the Eastern and Western Offsets will be undertaken as part of the Project's Bushfire Management Plan and will include provisions for the following:

- Perimeter asset protection zones;
- Fuel load reduction where necessary; and
- Maintaining perimeter tracks according to specifications.

The Bushfire Management Plan will prescribe a long term burning plan to ensure that the offset areas are managed safely whilst ensuring the long term viability of the ecological communities. It will contain appropriate performance measures (i.e. to supplement and maintain improvement works) and will be long term. The Bushfire Management Plan has not yet been completed; however it will be completed within six months of the implementation of this Biodiversity Management Plan.

Fire management will be conducted to reduce grassy fuel in APZs, and within the conservation management areas of the offset properties. Slashing may be used in selected areas along property boundaries, tracks and around farm infrastructure. However, livestock grazing will also provide a means by which grassy fuel is to be reduced.

There are no plans to conduct control burning on the Eastern and Western Offsets. However, if fires start naturally and occur within the offset lands, a record of the timing, intensity and extent of each fire will be recorded.

APZs will be established and maintained permanently around the houses on the properties, around the sheds and yards, and along the boundaries of the properties as required under the Bushfires Act. Performance Indicators: fuel reduction will be done efficiently in APZ areas without damaging woodland regeneration in adjacent areas. APZ areas will be relatively weed free.

Fuel within conservation management areas will not be allowed to be uniformly high and will be controlled to both manage fire risk and still promote regeneration of native plants.

6.8.1 Potential Corrective Actions

These could include adjustments to extend or retract APZs or adjust the way fuel is managed in the conservation management areas.

6.9 Schedule of Works

Major works for conservation management will take place during the approval period for the project – 21 years. After this period, the land may be sold into private ownership, or could be put into public ownership within National Parks estate.

Table 6.5 below shows the schedule of works for the major management tasks to be conducted during the first 21 years of the plan.

Table 6.5 Management Schedule for the Eastern and Western Offsets

Management Tasks	Years during the Ownership of the Proponent																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Fire Management																					
Track maintenance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Asset Protection Zones around infrastructure	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fuel reduction in management zones	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Grazing Management																					
Core Farming Zone	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG	CG
Conservation Zone (grassland & open woodland)						RG	RG	RG	RG	RG	RG	RG	RG	RG	RG						
Conservation Zone (forest & woodland)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Weed Management - all zones																					
African Boxthorn (*Lycium ferocissimum*)	major	major	major	major	major	as req'd							as req'd								
Weeping Willow (*Salix babylonica*)	major	major	major	major	major	as req'd							as req'd								
Thistles	major	major	major	major	major	as req'd							as req'd								
Feral Animal Management																					
Feral Pig (*Sus scrofa*)	major	major	major	major	major	as req'd							as req'd								
Fox (*Vulpes vulpes*)	major	major	major	major	major	as req'd							as req'd								
Creek Stabilisation																					
fencing of riparian areas (Areas J and T)	x	x																			
fencing maintenance			as req'd										as req'd								
Weeding of exotic trees (as above)																					
Replanting and Thinning																					
Replanting	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)	Nil (though monitoring may eventually indicate necessity in some areas)
Thinnning						potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd	potentially req'd
Tenure																					

Key:
CG – Commercial Grazing
RG – Rotational Grazing

6.10 Tenure and Protection Mechanism

Areas C1, C2 and C3 contain high quality forest and woodland that adjoins Leard State Conservation Area. Discussions will be held with Office of Environment and Heritage and National Parks and Wildlife Service with a view to arranging to add these areas to National Parks Estate.

For all lands that cannot be transferred to National Parks estate, the conservation outcomes within the Eastern and Western Offsets will be permanently protected by the provision of a VCA across all lands, including the core farming areas. The VCA will be registered on title and will provide for long term conservation outcomes in this land.

Work to register the Eastern and Western Offsets as a VCA should commence in year 1. However, this may need to be staged as some properties in the zone of affectation will not be purchased immediately.

6.11 Roles and Responsibilities

The work to implement this plan will be the responsibility of the LM (farm manager and staff), the EO and EC (**Table 6.6**). The LM will be responsible for day to day actions to manage various things on the site. The EO will be responsible for overseeing this work, for collating management data, for arranging the revision and auditing of the BMP and for contracting ecological consultants to conduct the audits and annual monitoring programs.

The EC will be independent consultants who will annually monitor and report on selected areas of the site and who will conduct major audits of the site every five years during the project approval period.

Table 6.6 Roles and Responsibilities for Management Aspect

Management Tasks	Responsibilities		
	Land Manager and Staff	Environmental Officer	Ecological Consultant
Fire Management			
Track maintenance	x		
Asset Protection Zones around infrastructure	x		
Fuel reduction in management zones	x	x	
Grazing Management			
Core Farming Zone	x		
Conservation Zone (grassland & open woodland)	x		
Conservation Zone (forest & woodland)	x		
Weed Management - all zones			
Weeping Willow (*Salix babylonica*)	x	x	
Blackberry (*Rubus fruticosus*)	x	x	
Thistles	x	x	
Feral Animal Management			
Feral Pig (*Sus scrofa*)	x	x	
Feral Goat (*Capra hircus*)	x	x	
Fox (*Vulpes vulpes*)	x	x	

Management Tasks	Responsibilities		
	Land Manager and Staff	Environmental Officer	Ecological Consultant
Creek Stabilisation			
fencing of riparian areas (A zones)	x	x	
fencing maintenance	x	x	
Weeding of exotic trees (as above)	x	x	
Revegetation			
Replanting	x	x	
Thinning	x	x	
Tenure		x	
Monitoring		x	x
Documentation	x	x	

6.12 Documentation

The LM will be required to compile data about the management actions used in each management area during the course of each year. This will include documentation of stocking rates and grazing rotation. Where necessary, management actions will be summarised on maps of the relevant management areas. The resultant documentation will be maintained in a permanent management record for the property and will be subject to audit every three years.

A brief summary report will be sent to Government agencies within the Annual Review to verify that management works are being conducted and the success of the works against the criteria in this BMP.

An ecological monitoring report will also be compiled annually to summarise data collected from each of the target monitoring and reference areas on the subject site. This will be reported on in the Annual Review.

7.0 MANAGEMENT ACTIONS: SHARED OFFSET PROPERTY

The future management of the Shared Offset Property will be determined in consultation with Boggabri Coal.

The management measures to be implemented for this area will be consistent with measures outlined within the preceding Section for the Eastern and Western Offsets.

8.0 FLORA AND FAUNA MANAGEMENT IN THE PROJECT BOUNDARY

This section outlines the actions to be taken to minimise the impact of the Project on native flora and fauna species and to manage the impacts of exotic flora and fauna. This includes activities to be undertaken on areas to be cleared, prior to the removal of trees in order to minimise the impact to fauna species, and it also includes measures to control the potential impact of weeds and feral animals on the remaining biodiversity within the Project Boundary and in nearby areas of the Leard State Forest. This section does not include prescriptions for vegetation rehabilitation or revegetation; this information will be presented as a separate report, the Rehabilitation Management Plan.

Clearing within the Project Boundary will take place in stages. The first stage of clearing will be the construction phase and will cover clearing for the construction of the rail spur line, pipeline, Mine Infrastructure Area (MIA) and access roads. The remaining stages of clearing will be during the operation of the mine and refers to the staged clearing of the coal mine pit. It is anticipated that some of the management measures will be implemented prior to the commencement of each stage of clearing; however the weed and feral animal control measures will be implemented independently of clearing activities and throughout the life of the Project.

Note that Condition 7 (Schedule 2) and Condition 47 (Schedule 3) of PA 10_0138 require protection of the vegetated corridor between the Project Boundary and that of Boggabri Coal as follows:

Schedule 2; Condition 7

The Proponent shall not clear native vegetation from any land within 250 metres of the adjoining Boggabri Coal Mine mining lease boundary, unless:

a) the Proponent has provided an alternative area of equal or better habitat value for the purpose of providing a fully effective east-west movement corridor for native fauna.

b) the alternative area is capable of delivering this outcome before clearing commences within 250 m of the lease boundary.

c) the alternative area is under tenure arrangements that ensure its maintenance for biodiversity purposes in perpetuity, or there is an enforceable commitment to deliver this outcome.

d) the alternative area has been endorsed by the OEH and subsequently approved by the Director-General.

Notes:

- The alternative area may be provided by way of offset or by way of suitable rehabilitated land within the Boggabri Coal Project site or the Maules Creek Coal Project site.

- The alternative area may be provided by the Proponent or the Proponent in conjunction with the Proponent of the Boggabri Coal Project.

Schedule 3; Condition 47

For the vegetated buffer corridor required to be retained and protected under condition 7 of schedule 2 of this approval, the Proponent shall:

a) use its best endeavours to work cooperatively with the Proponent of the Boggabri Coal Project to enhance the functioning of the area as a biodiversity corridor.

b) include in the Biodiversity Management Plan (see condition 52 below) the details as to how impacts on the corridor are to be minimised, to the satisfaction of the Director-General.

MCC will protect and manage the buffer-corridor required to be retained using methods outlined within this section including methods for marking the limits of clearing, feral animal control and weed control. Where feasible, MCC will work cooperatively with the Proponent of the Boggabri Coal Project to enhance the functioning of the area as a biodiversity corridor. This may include undertaking joint weed control activities, supplementary planting and rehabilitation activities. The condition of the vegetation within the corridor will also be monitored using methods as described in **Section 9.0**.

As part of the process of protecting and managing the aquatic habitats in and adjacent to the Project Boundary, MCC will consult with DPI Fisheries prior to the construction of the permanent Namoi water pipeline and pump station as set out in Condition 51, Schedule 3 of PA 10_0138:

> *Schedule 3; Condition 51*
>
> *Prior to the design and construction of the permanent Namoi water pipeline and pump station, the Proponent must consult with DPI Fisheries regarding the general operation and design of the pump station and screens to minimise entrainment of fish. The Proponent must implement all reasonable and feasible recommendations from DPI Fisheries to the satisfaction of the Director-General.*

8.1 Pre-Clearance and Post-Clearance Activities

8.1.1 Objective

Vegetation clearance will be staged over the life of the mine and therefore pre-clearance and clearance activities will be implemented for each stage of clearing. The following activities will take place prior to each stage of clearing to minimise inadvertent damage and / or adverse impacts to native wildlife and other environmental and regulatory issues. The pre-clearance procedures have been developed with reference to the RTA Biodiversity Guide 1 – Pre-clearance process (NGH Environmental Consultancy, 2011).

A Land Disturbance Protocol (LDP) form has been prepared to manage the clearance process and to ensure all licensing, safety and management requirements are met. The LDP form is provided in **Appendix I** of the BMP and is an environmental checklist that must be completed for each stage of clearing by the person responsible for the clearing activities, the relevant technical expert (eg. Electrical Engineer to confirm no presence of cables etc) and signed off by the EO (or delegate) and final authorisation by the General Manager.

8.1.2 Marking Limits of Clearing

Disturbance of vegetation will be limited to the minimum necessary for each stage of the clearing. Clearance for mining will take place in strips/stages and will occur no more than 12 months in advance of the proposed mine plan during operations.

The current limits of clearing will be marked either by high visibility tape, fencing or an equivalent boundary marker that will be installed any time prior to clearing. To avoid unnecessary or inadvertent vegetation and habitat removal, disturbance must be restricted to the delineated area and no stockpiling of equipment, machinery, soil or vegetation will occur beyond this boundary.

The person responsible for the clearance activities will be responsible for ensuring that the boundary markers are installed to enable the suitable environmental and technical inspections of the proposed disturbance can be undertaken, and ultimately that disturbance can be limited to the marked area approved for disturbance. The completion of this activity will be recorded and signed off in the LDP form.

In order to protect the vegetated buffer corridor, this area will be marked in a similar way to the disturbance area. No disturbance will be permitted to occur in this area; that is, no vehicles or machinery will be permitted enter and general pedestrian traffic will be discouraged.

8.1.3 Pre-Clearance and Clearance Flora and Fauna Surveys

Initially, the environmental assessment will be reviewed to identify known locations of biodiversity features such as hollow bearing trees or bush rocks. An initial inspection will be conducted to identify additional constraints to clearing and access issues by equipment, such as steep topography and rocky outcrops. These will be recorded on the LDP form.

During the pre-clearance process, flora and fauna that have the potential to be disturbed as a result of clearing activities will be identified.

i. Flora Pre-clearing Surveys

Prior to clearing, a pre-clearing flora survey will be conducted to search for threatened plant species that have potential to occur, based on habitat available. These include (but are not limited to):

- *Pultenaea setulosa*;
- *Tylophora linearis*; and
- *Pomaderris queenslandica*.

If a threatened plant species is identified, the numbers of plants will be counted and mapped. Translocation, collection of propagules will be considered. All threatened plant species identified during pre-clearing will be reported to OEH and to SEWPaC (for relevant MNES species).

ii. Fauna Pre-clearing Surveys

Prior to the clearing of any trees, a pre-clearing fauna survey will be conducted by the EC for the presence of fauna species that were identified in the environmental assessment as likely to occur, in order to identify and minimise impacts to resident fauna. Any fauna utilising the area will be recorded, and where possible, these will be encouraged to leave the area.

Habitat features will be identified prior to any clearing activities. These include significant rock outcrops and crevices, large boulders and in particular trees bearing hollows that have potential to contain native species such as bats, gliders, possums, reptiles and birds. All trees observed to contain hollows or nests will be identified, recorded and flagged with fluorescent marking tape, and have a large (>1 m) “H” spray painted with white line marking paint on four sides of the tree. The ground around each tree will be inspected for scats, and the trees for scratch marks. Hollows will be watched in the early evening to see if any arboreal fauna (e.g. gliders, bats) are using them. If necessary (to be recommended by the EC), a burrow scope will be used by the EC to ascertain whether a particular hollow is being used by native fauna. All trees with hollows will be flagged with tape.

For habitat features identified, the following information (where relevant) will be recorded by the EC and submitted to the EO:

- GPS locations;
- Species of tree;
- Number and size classes of hollows; and
- Size and number of boulders.

Prior to clearing, the location of suitable nearby habitat for the release of fauna that may be encountered during the pre-clearing process will be identified and marked on a map. These identified habitats for the release of fauna will be confirmed. Updated maps/plans, pre-determined habitat for the release of fauna, habitat features present in the site and recommended clearing procedures will be submitted to the project manager and/or environment manager (or equivalent).

Twenty-four hours before clearing, licensed wildlife carers and/or ecologists will capture and/or remove fauna that have the potential to be disturbed as a result of clearing activities. These fauna will be relocated into pre-determined habitat identified for fauna release. All fauna handling will be carried out by licensed wildlife carers and/or ecologists. Clearing contractors will then be informed of any changes to the sequence of clearing if required (see below).

Where fauna has been identified and captured for relocation prior to the stage 2 clearing, radio tracking may be used for fauna being relocating into alternate targeted habitat areas. Radio tracking trials and surveys of relocated fauna will be conducted across a number of fauna species as an additional means to measure the success of the relocation program, following further consultation with OEH. Data will be collected and the results analysed. Based on the data analysis from these trials and surveys, updates may be required to the relocation methods. The results and any proposed changes to trials and surveys will be done in consultation with OEH.

The clearing will be conducted using a two-stage clearing process:

1. Clearing will commence following the identification of potential habitat trees by the EC. Trees or habitat features marked as habitat **will not be cleared** during the first stage; however all vegetation around the tree will be so that the tree is isolated.

2. Identified habitat trees will be left to stand for at least 24 hours after stage 1 clearing to allow resident fauna to voluntarily move from the area. Then, the habitat trees will be cleared using the following protocols:

- If possible, trees marked as containing hollows will be shaken by machinery prior to clearing to encourage any animals remaining to leave the hollows and move on;
- Use a bulldozer to start pushing the tree over. Move the bulldozer over the roots and continue *gently* pushing the tree over. The tree should not fall heavily to the ground;
- Remove branches with hollows and sections of trunk and set aside for immediate transfer to a storage area for placement within rehabilitation areas; and
- The EC will investigate all hollows for the presence of fauna following felling of the tree.

The two-stage clearing process enables fauna to feel secure whilst clearing occurs around their tree, and allows them a chance to self-relocate upon nightfall, when foraging typically occurs. Fauna are not likely to re-inhabit trees, as they are not likely to feel secure in their tree with all trees around it cleared.

The EC will be present while clearing to rescue animals injured during the clearance operation. Any fauna found will be captured and relocated to nearby remnant vegetation and released after nightfall to minimise the risk of predation by diurnal predators. Any animals that are inadvertently injured will be taken to the nearest veterinary clinic for treatment, or if the animal is unlikely to survive, it will be humanely euthanized. The closest veterinary clinics to the Project Boundary are recommended below:

Narrabri Veterinary Clinic

Martyn Powell and Michael Read

24 Francis Street

Narrabri NSW 2390

(02) 6792 4388

Gunnedah Veterinary Hospital

14-16 Barber Street, Gunnedah NSW 2380

Telephone (All Hours): 02 6742 1834

Fax: 02 6742 4422

Email: gunvet@bigpond.com

These should be notified prior to the proposed clearing to ensure they are willing to treat injured animals.

All persons working on the vegetation clearing will be briefed about the possible fauna present at the time of construction, and what procedures should be undertaken in the event of an animal being injured or disturbed. A qualified animal rescue person (e.g. WIRES) or the EC will be on call at all times during clearing.

If boulders are to be moved during clearing, the EC will catch any snakes or frogs that may be sheltering under them. These animals will be relocated to suitable habitat elsewhere in the Leard State Forest.

Results and outcomes of pre-clearance and clearance fauna surveys shall be documented by the EC and submitted to MCC's EO. This includes:

- Species and numbers of individuals recorded;
- Incidence of sick or injured animals and the actions taken to care for the fauna; and
- The species and numbers of individuals that were relocated.

If a new threatened species is identified that has not previously been identified as having potential to occur, the occurrence will be surveyed and fully documented. Results will be made available to OEH and to SEWPaC (if it is a species that is a MNES).

8.1.4 Pre-clearance Weed Management

Prior to clearance, infestations of significant weeds (noxious weeds or WONS) will be recorded in the LDP and mapped. If recommended by MCC's EO or EC, control of weeds will be undertaken to minimise the risk of spread of weeds during clearing. Weed control measures will be species specific and will be guided by published control measures (see **Appendix H**).

Any weed materials will need to be carefully removed off site in a manner appropriate to the species so as to prevent the spread of propagules to uncleared areas of native vegetation.

Prior to clearing, all plant equipment entering the site will be inspected and recommended for wash down (in designated wash down areas) as required to ensure weed material from off site locations do not establish or spread into native vegetation within the Project Boundary.

Machinery involved in weed management will also be washed down prior to removal from site to prevent weeds from spreading into off site areas.

8.1.5 Aboriginal Heritage Values

Prior to commencement of pre-clearing and clearing works, the EC will be briefed on the identification of Aboriginal culturally modified trees. Any suspected culturally modified trees identified by the EC during

pre-clearance surveys will be assessed by an archaeologist following the Procedure on the Discovery of Aboriginal Archaeological Objects (refer to Section 6.2.3 of the Aboriginal Heritage Management Plan).

8.1.6 Salvage of Hollow Logs and Rocks

Prior to clearing, 20 x 50 m plots will be surveyed in each vegetation type to quantify the habitat resource. The number of plots per vegetation type will be commensurate with the area of clearing to be undertaken. Within these plots the following information will be recorded as a minimum:

- Photographs;
- GPS location;
- Numbers of tree hollows;
- Size class of tree hollows;
- Species of trees;
- % cover of bush rocks; and
- Length of fallen logs (> 100 mm diameter).

Transportable habitat features such as large logs (> 100 mm diameter), tree stags, tree stags containing hollows (including hollows of a range of diameter sizes), felled timber and boulders will be salvaged to allow their continuation as potential fauna refuge sites. Woody ground debris will also be considered for salvage if it is 100 mm in diameter and 500 mm in length. These habitat features will be fully itemised within the Habitat Resource Recovery Inventory.

Salvage of habitat features will take place during both Stage 1 and Stage 2 of clearing. The salvaged habitat features will be moved to a holding site for storage until a time that they can be emplaced in mine rehabilitation areas and potentially in nearby biodiversity offset areas to allow their continuation as potential fauna refuge sites. This will take place before and after clearing.

A range of hollow logs will also be suspended in trees in areas of retained native vegetation to provide nesting habitat for arboreal mammals and birds. Note: artificial nesting boxes may be established to supplement the use of salvaged hollows. Attention will be paid to the appropriate spacing of hollow logs, both those suspended in the trees and those placed on the ground, to ensure that they are not placed too close together in rehabilitation areas. Too close spacing would limit the number of individuals able to use the hollows due to intraspecific and interspecific competition. A recommended spacing gap is at least 10 m between each hollow log.

A description of the salvage items and the recipient site(s) shall be recorded and signed off in the LDP form.

Vegetation that is not salvaged as a habitat feature will be mulched and applied to rehabilitation areas to provide additional organic matter.

8.1.7 Seed Collection

Seed collection will be synchronised with clearing of vegetation where possible to optimise seed collection – particularly from trees and taller shrubs. This involves ensuring that clearance takes place after key species have flowered and set seed, to allow this seed to be collected.

Collection of available seed will take place for shrubs and groundcover species prior to clearing. Seed collection of canopy species will take place after clearing when the canopy seed bank is accessible from the ground.

The seed that is collected will be propagated for use in rehabilitation areas and other disturbed areas in order to maintain the genetic integrity of the vegetation in the Project Boundary. Seed collection techniques will be prescribed fully in the Rehabilitation Management Plan. Indicative seeding times are discussed in **Section 8.2** below.

A licence or permit is required to collect seeds from threatened species or threatened ecological communities. The EO will ensure that mine staff or appropriate contractors that are engaged to collect seeds hold relevant and valid collection licences.

8.2 Seed Collection / Harvest

Further to collecting seed as part of the pre-clearing and post-clearing protocols, seed harvest of native species in the Project Boundary will be conducted throughout the year and from all areas within the Project Boundary. The seed that is collected will be propagated for use in rehabilitation areas and other disturbed areas in order to maintain the genetic integrity of the vegetation in the Project Boundary.

Seed collection techniques will be prescribed fully in the Rehabilitation Plan. However, suitable seed collection techniques include:

- Brush harvesting, to obtain seeds from a diversity of understorey species;
- Suction or vacuum harvesting of grass species with less persistent seed units (e.g. *Microlaena stipoides*); and
- Hay strewing; this may be appropriate if a recipient site is ready to receive seed at the time of harvest.

Seed should be collected from all strata including grasses and groundcovers. Indicative seed collection times for native species, with particular focus on species characteristic of the threatened Box Gum Woodland, are shown in **Appendix F**. Many species will produce seed in summer and / or autumn (e.g. *Microlaena stipoides*, *Acacia decora*), whilst *Eucalyptus* species can hold their seed in the canopy for up to a year after seed is produced (e.g. *Eucalyptus blakelyi*).

The seed species, location of collection, volume of seed and storage methods shall be documented appropriately as part of the reporting requirements for the Rehabilitation Management Plan.

A licence or permit is required to collect seeds from threatened species or threatened ecological communities. The EO will ensure that mine staff or appropriate contractors that are engaged to collect seeds hold relevant and valid collection licences.

8.3 Rehabilitation and Restoration Works

The procedures, protocols and targets for revegetation of the post-mining rehabilitation areas will be covered in the Rehabilitation Management Plan. The Rehabilitation Management Plan will prescribe methods and procedures relating to the following:

- Planting design and staging;
- Seed collection, storage and propagation;
- Topsoil stockpiling and transfer;

- Site preparation, including primary weeding;
- Planting techniques, including brush matting, tubestock planting and direct seeding;
- Planting densities;
- Maintenance weeding; and
- Performance indicators.

Trials of different regeneration methodologies and strategies will be undertaken as part of the Rehabilitation Management Plan, with a particular emphasis on species that are characteristic of the threatened Box Gum Woodland community.

Monitoring of rehabilitation areas will be undertaken annually by the EC as part of the routine flora and fauna Monitoring Program (**Section 9.0**).

8.4 Timing of Clearing

Clearing of areas for mining will be undertaken predominantly late summer and early autumn periods in order to avoid key breeding/hibernation seasons for threatened bat and bird species known to reside in the Leard State Forest.

Note this restriction will not apply to the construction period of the Project. For the construction phase of the Project, pre-clearing surveys will be undertaken by the EC to identify the presence of any threatened species and recorded/signed off in the LDP as per **Section 8.1.3** above.

For construction areas, tree hollows or nesting sites supporting roosting or torpid bats and/or nesting birds, will be subject to specific measures to protect the relevant species. These measures will be developed by the EC and may include delays in clearing of selected areas or careful translocation of the animals.

8.5 Weed Management Plan

8.5.1 Objective

The Project Boundary is located within the Leard State Forest and also within privately owned lands that contain conservation management areas as identified in **Section 6.0**. For this reason, it is important to ensure that vegetation degradation due to weeds is not introduced or exacerbated in the Leard State Forest and in adjacent private land. The goal of weed management will be to limit and control potential weed incursion into surrounding areas to minimise edge effects. Particular attention will be given to WONS and Noxious Weeds identified previously in this report.

8.5.2 Weed Management Areas

Weed management will be based on best management practice and will focus on weed control at the interface between disturbance and infrastructure areas within the Project Boundary and the adjacent native vegetation to be retained.

Weed management will also include due diligence exercises in the residual native vegetation within the Project Boundary to identify any weed outbreaks and WONS or Noxious Weeds, so that appropriate controls can be implemented.

Various Weed Control Zones have been identified to assist in the implementation of this Weed Management Plan. These are:

- Infrastructure areas, such as the CHPP, tailings dam, rail loop, administration buildings and workshop;
- Undisturbed areas within the Project Boundary adjacent to the linear infrastructure, such as the rail line and water pipeline;
- An approximate 500 metre buffer area around the active disturbance areas. Active disturbance areas include the following:
    - Northern Overburden Emplacement Area;
    - Current mining stage; and
    - Previous mining stages not yet undergoing rehabilitation;
- Any other residual unmined vegetation within the Project Boundary. This includes retained vegetation as well as any undisturbed vegetation in the mine pit area that will be disturbed in future as part of the Project. This is necessary to prevent weeds from spreading beyond these areas into vegetation that will be retained; and
- Rehabilitation in post-mining areas.

For the purposes of this Weed Management Plan, weed management in rehabilitation areas will be covered under the Rehabilitation Management Plan. For the purposes of this Weed Management Plan, any part of the above Weed Control Zones that fall within the Project's Biodiversity Offset Strategy Properties will be managed as part of the BMP and is not covered within the scope of this Weed Management Plan.

8.5.3 Weed Control Strategy

i. Initial Inspection

The Weed Control Zones will be inspected by a suitably qualified person such as an Ecologist or Bush Regenerator to develop a site-specific weeding plan for the primary weeding phase. This site-specific plan will include identification of weeding areas and weed species to target, identification of sensitive areas to avoid, as well as recommendations regarding appropriate weeding techniques to implement.

ii. Primary Weeding

Initially primary weeding will take place targeting the Noxious Weeds and WONS listed previously in **Section 3.2.2**, as well as any other environmental weeds present in the Project Boundary and in the Weed Control Zones. Primary weeding may involve techniques such as but not limited to:

- Selective spraying of weeds, with selective and non-selective herbicide;
- Cutting or scraping deep rooted woody weeds and climbers with hand tools, chainsaws and brush cutters, and painting cut stumps with herbicides containing Glyphosate or Picloram;
- Target drilling and injecting large tree weeds with herbicides such as Glyphosate and a Garlon/diesel mix; and
- Selective hand removal of weeds; and wicker wiping with herbicide of tall weeds in situations where damage to proximate, low growing native plants can be avoided

Recommended techniques for removal of Noxious Weeds that have been published by agencies / organisations such as the NSW I&I or the National Trust are publicly available and will be consulted prior to weed control. Selections of the weed management guidelines available for relevant Noxious Weeds are supplied in **Appendix H**.

After physical removal of any plant material, the plant material should be stockpiled well away from sensitive areas and disposed of in an environmentally sensitive manner to prevent the spread of propagules or further seed production on the cut plant material. Note that some removal guidelines are available for highly invasive weed species such as African Boxthorn.

iii. Follow-Up Weeding

Follow-up or secondary weeding will be undertaken in areas that have received past primary weeding treatments. Follow-up weeding involves the selective removal or treatment of weeds, whilst allowing regenerating or planted native plants to increase in size, abundance and percentage cover. All weeds should be targeted during the follow-up weeding phase. Follow-up weeding is likely to be required at least bi-annually/seasonal for a period of 1.5 years or until weeds are at negligible levels, after which a review will be conducted to determine the on-going maintenance requirements.

iv. Maintenance Weeding

Maintenance weeding will be undertaken annually in the Weed Control Zones for the life of the Project. It is expected that bushland areas and areas within the Project Boundary will always require a certain level of maintenance weeding, as weed seeds and vegetative propagules make their way on site from the soil stored seedbank, and via wind and bird droppings. It is expected that the amount of weeding required will decrease once initial infestations are controlled and areas become more resistant to disturbance and weed colonisation.

Adaptive management/restoration practices will be adopted if weed species increase counter to these expectations.

8.5.4 Erosion Control/Sedimentation Management

Erosion and migration of sediment from the Project Boundary into adjacent vegetation has the potential to facilitate weed invasion through the introduction of weed seeds and nutrients that favour weed species. This potential impact will be avoided through the implementation of appropriate erosion and sediment control measures that will be prescribed in a separate Water Management Plan.

The Water Management Plan will include measures such as:

- Stabilisation of areas of bare soil using jute matting or mulch;
- Stabilisation of areas of bare soil by re-vegetating immediately with appropriate local native plants; and
- Control of sediment by installation of erosion fences around all construction works prior to commencement of any earthworks to avoid potentially nutrient and seed rich run-off entering neighbouring areas of vegetation in the Leard State Forest.

8.5.5 Best Management Practice

Weed removal will have regard to the following, to minimise impacts upon existing vegetation and habitats:

- Avoid over-clearing and remove only targeted species;
- Limit spread of weeds from disturbance areas or off-site areas to weed control areas by washing down vehicles and machinery prior to moving them out of designated disturbance / clearance areas;
- Employ minimal disturbance techniques to avoid soil and surrounding vegetation disturbance, and replacement of disturbed mulch/leaf-litter;
- Remove of fruiting/seeding parts of weeds carefully, to minimise spread of plant propagules;
- Use of chemicals and sprays only during suitable weather conditions (i.e. not during wet or windy conditions), and only during appropriate seasons; and
- Avoid disturbance of native fauna or nesting/breeding sites.

8.5.6 Timing

Weed control activities are independent of the clearing stages and will begin at the commencement of the Project. Weed management will be undertaken in the areas of vegetation to be cleared to prevent weeds from spreading beyond these areas into vegetation that will be retained.

Once mining has ceased in an area and mined areas are rehabilitated, weed control will also be conducted on the rehabilitated land. Further information on weed management of the rehabilitation areas is provided in the Rehabilitation Management Plan.

8.5.7 Performance Indicators

- Measurable decline in weed density and distribution;
- Measurable decline in weed diversity; and
- No recruitment of new weed species.

8.5.8 Potential Corrective Actions

- Increase frequency of control; and
- Additional efforts to control target species or methods extended to cover newly occurring weed species.

8.5.9 Documentation

The EO will ensure that the results and outcomes of weed management are documented for each year. This will include documentation of areas subject to weeding, weeding techniques used, target species controlled, new species identified (if any) and chemicals used. Where necessary, management actions will be summarised on maps of the relevant management areas.

The EO will be responsible for ensuring that all personnel involved in weeding management hold relevant and valid licences / permits for weeding works, including a chemical licence to use herbicides and a chainsaw certificate to operate chainsaws.

8.5.10 Monitoring

Monitoring of the Weed Control Zones will be undertaken bi-annually by the EC as part of the routine flora and fauna Monitoring Program (**Section 9.0**). The monitoring results will be used to inform adaptive management/restoration practices.

8.6 Feral Animal Management

8.6.1 Objective

Feral animal management will focus on the main feral animals recorded from the Project Boundary; the Feral Pig, the European Red Fox, the Black Rat and the European Rabbit. The goal of feral fauna management will be to ensure that impacts to native species and native vegetation caused by feral fauna are not introduced to or increased in the Leard State Forest and adjacent private land.

8.6.2 Feral Control Strategy

Sustained or ongoing management is necessary for protecting the residual habitat within the Project Boundary and the adjacent remnant vegetation from competition or predation by feral fauna. Therefore, the areas of focus for feral management will be in the Project Boundary and in the adjacent remnant vegetation. Feral management also applies to rehabilitation sites and to areas where habitat features such as logs and hollow-bearing timber are relocated.

The appropriate management of the above feral fauna species will require close coordination between monitoring and control activities. Since different feral species can respond differently to control measures, close monitoring is required to respond appropriately to each species. Control measures will be implemented by mine staff or by an appropriate Pest Control Contractor(s) at least once annually.

Prior to the implementation of feral control measures, a population survey will be conducted as part of the annual Monitoring Program (**Section 9.0**) to ascertain the severity and primary areas of infestation. Post-control monitoring will be conducted as part of the annual Monitoring Program to determine whether the controls were effective.

The management of feral fauna is intended to be adaptive and will be informed / reviewed based on the key findings and recommendations of the Monitoring Program. Further control above the routine annual control will be informed by the results of the monitoring survey.

8.6.3 Control Methods

i. European Red Fox Control Measures

A range of control measures are known to be utilised to control the European Red Fox. Government agencies mostly recommend the use of poisons such as strychnine or 1080 to reduce fox populations. Poisons are typically placed into meat baits, or carcasses, for subsequent consumption by the fox. Other control measures include the following:

- Shooting;
- Electric fencing;
- Trapping;
- Fumigation; and

- Fertility control / Biological control.

Within the Project Boundary the most effective control technique for the European Red Fox is baiting with "1080" or monosodium fluoroacetate. Fox poisoning with 1080 is regulated in NSW by the *Pesticides Act 1999* and can be carried out only under the conditions specified in the *Pest Control (1080 Liquid Concentrate and Bait Products) Order 2010* (PCO 2010). In NSW, pest control baits to assist in the management of animal pests are available for purchase through NSW Rural Lands Protection Boards.

Prior to baiting with 1080, it is recommended that bait stations using non-poisoned bait be established. This will allow the bait stations to be monitored for visitation by native fauna by studying tracks in the sand pit. Non-poisoned bait should be buried to a depth of 10-15 cm in the sand pit. When it can be ascertained that foxes are the only fauna regularly taking the bait then baiting with 1080 can commence.

It is recommended that the baits targeting foxes are buried 10-15 cm in the ground to protect native fauna that dig for food. Foxes are able to detect bait buried at depths greater than 10 cm due to their extremely sensitive sense of smell. Baits should be placed at least 500 m apart so that foxes do not cache the bait instead of eating it and to avoid the risk of native fauna eating multiple baits.

After baiting is complete, all untaken baits and carcasses should be recovered and disposed of in accordance with Condition 4.8 of Schedule 2 of the PCO 2010.

ii. Feral Pig Control Measures

Effective feral pig control strategies are underpinned by an understanding of the dynamics of the feral pig problem, such as the population density, movement, habitat conditions, food water resources, and the severity and type of damage all inform the types of techniques that should be used. Various control techniques are best used together in a strategic fashion to manage feral pig populations. In Australia, the most successful efforts to manage feral pigs and the damage they cause have tended to involve the lethal techniques of poisoning, trapping, shooting and hunting.

The main control measure for feral pigs is poisoning, primarily using 1080 poison in grain or meat baits. The fast-acting and more humane poison sodium nitrite, a common human food preservative, is highly lethal to pigs and is currently undergoing registration in Australia. This new toxicant is expected to be available from 2013 (Invasive Animals CRC, 2011). Other control measures include the following (Carritt, 1999):

- Trapping;
- Ground shooting and hunting with dogs;
- Aerial shooting; and
- Fence exclusion.

In common with the recommended European Red Fox control strategy above, within the Project Boundary the most effective control technique for the Feral Pig is baiting with "1080" poison. It requires appropriate free-feeding with non-toxic bait to attract pigs before the poison bait is used and also helps to reduce the risk of loss to non-target animals. This will need to be done separately to Fox control however, as slightly different methods are used, including application of a higher concentration of monosodium fluoroacetate per bait.

Ground baiting is a multistep process:

1. When Feral Pig control is required, an area of Feral Pig activity will be located based on observation of fresh signs such as wallows, faeces, rooting, tracks, watering point activity, and sightings.
2. Bait stations will be established in these areas by placing small piles of grain, fruit or several un-poisoned pre-feed baits every 50 to 100 m for about three to ten days. This free-feeding step, although taking time and effort, is essential for attracting the local feral pig population and increasing bait consumption. Earth or sand pads around bait stations should be swept to allow the prints of animals approaching and consuming baits to be determined. The bait stations should be checked regularly over several days for evidence confirming pig activity and the non-toxic feed replaced with new material at sites where free-feed was taken.
3. Once baits are taken, the number of feeding points will be gradually reduced to draw feral pigs into 'cluster bait' stations or 'feeding hot spots'. This ensures that toxic baits can then be presented across the smallest possible area.
4. Toxic baits will be introduced to cluster bait stations once free-feed bait uptake levels off, and this is continued until toxic bait uptake ceases (1–3 nights). Feral pigs are often killed within the first few nights of the lethal baiting phase.
5. Follow-up monitoring will be undertaken to determine if pigs remain in the area and whether further baiting is needed.

Feral pig poisoning with 1080 is regulated in NSW by the *Pesticides Act 1999* and can be carried out only under the conditions specified in the PCO 2010. In NSW, pest control baits to assist in the management of animal pests are available for purchase through NSW Rural Lands Protection Boards.

Feral pig populations have the capacity to recover rapidly within two years of control. Effective control should therefore aim to maximise population reduction following baiting; a study in western NSW recommended a reduction of 70% of the population following pig control (Giles, 1999). Other techniques can be used in conjunction with baiting to achieve this target in any one control season.

After baiting is complete, all untaken baits and carcasses should be recovered and disposed of in accordance with Condition 4.8 of Schedule 3 of the PCO 2010.

iii. Black Rat Control Measures

The most effective method for controlling Black Rats is to ensure that further food supplies are not provided by the Project. As described below in **Section 8.6.3-**v, strict protocols will be implemented regarding the covering and storing of garbage on the Project Boundary. If numbers are found to increase, then lethal control may be required.

The most common and effective way to control Black Rats is by the use of poison. Several poisons are marketed, including RATTOFF® Zinc Phosphide baits. If significant increases in Black Rat populations are observed during monitoring activities, a poisoning program will be implemented.

iv. European Rabbit Control Measures

It is not expected that control will be required for the European Rabbit as part of this plan. However, during rehabilitation of mined areas, rabbits have the potential to cause a problem by ringbarking trees and browsing on young shoots. One method of controlling the problem, although not the Rabbits, is to place tree guards on all trees planted in rehabilitation areas. This will prevent animals accessing the plants and will increase the survivorship of plants.

The most effective way of controlling rabbits is through a combination of activities such as warren ripping, fumigation, and fencing, poisoning and shooting. If rabbits cause a significant problem in rehabilitating areas, then it may be feasible to fence these areas with rabbit-proof wire. These fences should be buried at least 20 cm deep in the ground and extend for approximately 30 cm at right angles to prevent rabbits from burrowing underneath. Fences should be at least one metre high.

If additional control is required, the most efficient method for use on the Project Boundary is poisoning. The two most common poisons are "1080" and oats coated with Pindone (marketed as RABBAIT®). Usually a trail of poisoned grain is created away from warrens (as rabbits do not usually eat near the warren). It is advantageous to disturb the soil nearby, as rabbits are known to investigate disturbed soil. Pindone is most effective when administered to rabbits in three doses about four days apart over a 10-12 day period.

Monitoring will be conducted and further follow-up control will be undertaken as required based on the results of the Monitoring Program (**Section 9.0**).

v. General Feral Animal Control Measures

Feral animals are known to congregate and breed in windrows of felled trees. For this reason, vegetation cleared from the Project Boundary will not be bulldozed into windrows where it may harbour feral animals. Instead felled trees will be wood chipped and stockpiled in a suitable area away from retained remnant vegetation until it can be used in rehabilitation or appropriately disposed. This will be done after all the salvageable logs with hollows have been removed. Any temporary piles of vegetation will be monitored to determine whether they are being used by feral animals.

Feral animals are known to be attracted by and to feed from garbage, particularly rats and foxes. Accordingly, strict controls will be placed on the disposal and handling of garbage in the Project Boundary. All garbage bins will be constructed from sturdy materials and will be closed at all times to avoid the smell attracting foxes and pigs. Garbage bins will be emptied regularly and the garbage appropriately disposed of offsite by a licensed waste contractor at a suitable facility.

8.6.4 Timing

Feral animal control activities will be conducted at least once yearly or as indicated by the Monitoring Program. Details of the feral animal Monitoring Program to be implemented within the Project Boundary are presented in **Section 9.0**.

8.6.5 Performance Indicators

- Measurable decline in feral fauna abundance;
- Measurable decline in feral fauna diversity;
- Observable reduction in decline of native fauna populations due either to predation by feral fauna; habitat degradation caused by feral fauna; or competition with feral fauna;
- Zero feral fauna in rehabilitation areas; and
- No recruitment of new feral species.

8.6.6 Potential Corrective Actions

- Increase frequency of control;
- Implement feral fauna controls when threatened species of concern are breeding or migrating/ moving to minimise the damage;
- Establish buffer areas to conservation areas or valuable remnant vegetation to limit introduction or reintroduction of feral fauna after controls are implemented;
- Trial fencing or some form of physical barrier around rehabilitation areas (effective against feral pigs);
- Additional efforts to control target species or methods extended to cover new feral species.

8.6.7 Documentation

The EO will ensure that the results and outcomes of feral management are documented for each year. This will include documentation of the techniques used for each feral species, the quantity of bait material purchased and deployed, the areas subject to control, estimates of the numbers of animals culled, new species identified (if any) and any other chemicals used. Where necessary, management actions will be summarised on maps of the relevant management areas.

The EO will be responsible for ensuring that all personnel involved in feral management hold relevant and valid licences / permits, including any relevant chemical licences for pesticide use or a firearms licence for shooting. Note that only an Authorised Control Officer who has received proper accreditation can use 1080 liquid concentrate products.

8.6.8 Monitoring

Monitoring of the feral population in the Project Boundary and adjacent remnant vegetation will be undertaken annually by the EC as part of the routine flora and fauna Monitoring Program (**Section 9.0**). This will include rehabilitation areas. The monitoring results will be used to inform ongoing feral fauna management.

8.7 Other Management Strategies

In addition to the specific management strategies outlined previously, a range of general measures will be implemented to manage the remaining flora and fauna on the Project Boundary and in adjacent areas of Leard State Forest.

8.7.1 Bushfire Management

Bushfire management of the Project Boundary will be undertaken as part of the Project's Bushfire Management Plan and will include provisions for the following:

- Perimeter asset protection zones;
- Fuel load reduction where necessary; and
- Maintaining perimeter tracks according to specifications.

The Bushfire Management Plan will prescribe a long term burning plan to ensure that the offset areas are managed safely whilst ensuring the long term viability of the ecological communities. It will contain appropriate performance measures (i.e. to supplement and maintain improvement works) and will be long term. The Bushfire Management Plan has not yet been completed; however it will be completed within six months of the implementation of this Biodiversity Management Plan.

8.7.2 Inductions and Staff Education

Inductions for staff, contractors and visitors to the site will be conducted to make them aware of the ecological issues present in the Project Boundary and to ensure they know their role and responsibilities to the protection and/or minimisation of impacts to all native biodiversity.

Inductions will address the location of sensitive flora and fauna and the policies being implemented to protect the biodiversity values present in and near the Project Boundary.

Additional targeted and specific inductions/ training will be provided for contract and operational staff directly involved in clearing of native vegetation in relation to the two-staged clearing protocols, exclusions zones, types of flora and fauna in particular threatened species.

8.7.3 Vehicle Driving Policies and Signage

A vehicle driving policy will be implemented with speed restrictions to minimise the risk to fauna, especially collision risks on internal roads due to the extent of woodland habitat. Speeds on internal roads within the Project Boundary should not exceed the sign-posted limits as per the Maules Creek Surface Transport Standard.

Signs will be erected to remind drivers to be alert at known fauna crossings and to signal the speed limit.

8.7.4 Access Control

Measures will be implemented to control public access to the Leard State Forest and to regulate personnel access to areas of the forest during weed or feral control. This is important to limit the disturbance to rehabilitation areas; to limit disturbance and spread of seed propagules during weeding; and to ensure the safety of mine staff during live baiting programs, when feral shooting is taking place or when feral traps are engaged. Signage should be erected in areas where 1080 baiting is taking place in accordance with the Signage must be erected for 1080 baiting in accordance with the requirements of the *Pesticides Act 1999*, the *Pesticides Regulation 2009* and all relevant Pesticide Control Orders..

8.8 Roles and Responsibilities

The work to implement this work will be the responsibility of the EO and EC. The EO will be responsible for overseeing this work, for collating management data, for arranging the revision and auditing of the BMP and for contracting ecological consultants to conduct the audits and annual monitoring programs.

The EC will be independent consultants who will annually monitor and report on selected areas of the site ane who will conduct major audits of the site every five years during the project approval period.

A summary of the actions, responsibilities, frequency of monitoring and reporting requirements is provided in **Table 8.1**.

Table 8.1 Summary of Actions and Responsibilities for the Project Boundary

Control / Action	Timing / Trigger	Responsibility	Monitoring	Reporting
Marking Limits of Clearing	Prior to clearing	EO / Mining Manager	Inspection to be undertaken throughout duration of clearing.	Documented in LDP form and signed off.
Identification of suitable fauna relocation sites	Prior to clearing	EO / Mining Manager	N/A	Documented in LDP form and signed off.
Pre-clearing and clearing surveys, relocation of fauna, care to injured animals	Prior to clearing and during clearing	EC and / or animal rescue person	Inspection to be undertaken throughout duration of clearing.	To be documented in LDP form and signed off. Results to be reported in Annual Review. OEH / SEWPaC notified if new threatened species identified.
Pre-clearing and clearing surveys, threatened flora	Prior to clearing and during clearing	EC	Inspection to be undertaken throughout duration of clearing.	To be documented in LDP form and signed off. Results to be reported in Annual Review. OEH / SEWPaC notified if threatened species identified.
Pre-clearing weed management	Prior to clearing and during clearing	EC and EO	Inspection to be undertaken prior to clearing.	To be documented in LDP form and signed off. Results to be reported in Annual Review.
Relocation of felled timber, stags, bushrock, logs, timber containing tree hollows and other habitat features to rehabilitation areas and / or adjacent vegetation	Before, during and after clearing	Mining Manager / EO	N/A	To be documented in LDP form and signed off. Results to be reported in Annual Review.

Control / Action	Timing / Trigger	Responsibility	Monitoring	Reporting
Inductions and Staff Education	Ongoing as part of the existing induction procedure or as part of toolbox talks prior to commencement of controls	EO / OHS Officer	N/A	As per usual induction procedure
Vehicle Driving Policy and Signage	Ongoing or when wildlife crossing areas are identified	Mining Manager / EO	N/A	N/A
Access Control	As part of existing access protocols	Mining Manager / EO	N/A	N/A
Seed Collection	Throughout year; and before and immediately after clearing	EO	Observations to be made throughout year to check flowering / seeding development of key species.	To be documented as part of the Mine Rehabilitation Plan reporting.
Weed control	Ongoing over life of mine	EO / Qualified Bush Regenerator	Bi-annually in all Weed Control Zones including rehabilitation areas as part of Monitoring Program	Results to be written up and provided to EO. Results to be reported in Annual Review.
Feral control	Ongoing over life of mine	EO / Pest Control Contractor	Bi-annually as part of Monitoring Program	Results to be written up and provided to EO. Results to be reported in Annual Review.
Monitoring Program	Ongoing over life of mine	EC	N/A	Annual Biodiversity Monitoring Report

9.0 MONITORING PROGRAM

9.1 Purpose

This section presents the monitoring strategy that will be implemented under this BMP. The purpose of the Monitoring Program is to monitor the condition of native vegetation, quantify abundance (and investigate risks posed by) exotic weeds and feral animals and to indicate when management actions are required. Progress of ecological restoration and management of the Northern, Eastern, Western and Shared Offset properties will be evaluated against key performance indicators during the life of the Plan so as to provide feedback that can be used to guide and improve management of the offsets.

Monitoring of the remnant native vegetation within the Project Boundary will commence prior to mining and will initially be designed to furnish a baseline of flora and fauna data. Subsequently, as mining and clearing takes place and as rehabilitation commences, the monitoring program will be used to compare native flora, native fauna, weeds and feral animals within undisturbed (i.e. analogue, or reference) sites to rehabilitated mine sites.

Monitoring of the remnant native vegetation within the offset properties will commence prior to conservation works and will also be designed to furnish a baseline of flora and fauna data.

All reference, rehabilitation and conservation sites will be subject to ongoing monitoring over the life of the BMP. The information from the Monitoring Program will be used adaptively to continually improve the outcomes of the BMP. Appropriate data management procedures will be implemented to ensure that all data is collected using appropriate techniques and suitably analysed to allow meaningful spatial and temporal comparisons to be made. Details of the specific monitoring strategies are presented below.

9.2 Completion Criteria

Progress of ecological restoration and management of the Northern, Eastern, Western and Shared Offset properties will be evaluated against key performance indicators. **Table 9.1** below summarises the completion criteria and measurable indicators for each domain covered in this BMP. **Table 9.2** summarises the completion criteria and measurable indicators for specific threatened species and ecological communities to be addressed through the BMP.

The Namoi CMA has publicly available regional vegetation community benchmarks which will also be used initially as reference information for comparison and analysis of the vegetation monitoring data collected.

Vegetative biometric data will be collected annually from reference sites that will be established in the first year of implementation of the management plan. Reference sites will be established in representative areas that will not be impacted by the operation of the mine. The biometric data will be used to develop a database of local benchmark values that will be used to assess the progress of rehabilitation in the Project Boundary and the restoration/conservation management works in the biodiversity offset areas.

Faunal benchmarks will be developed via survey of selected vertebrate fauna groups within representative vegetation communities in the core conservation areas. The fauna occurring within other domains will be compared against the faunal benchmarks from the intact vegetation communities in the core conservation areas.

Table 9.2 provides measurable indicators to quantity and verify improvement in threatened species habitats. Where resident threatened species currently occur in the offsets, the intention is to use detection of the species in the future as a primary measurable indicator, combined with measurements of

increases in preferred habitat. So, for example, the Speckled Warbler, a threatened woodland bird, is resident in many woodland areas of the offsets currently but does not occur in open grassland areas. The measureable indicators for this species would include, ideally, an increased number of annual detections of the species across a wider range of land than occurred in year 1, and measureable increases in grassy woodland area, as woodland habitats would be created in areas that currently have derived native grassland.

For some threatened species, such as Regent Honeyeater, Swift Parrot and Spotted-tailed Quoll, there are no records within either the impact area or the offset areas. Rather, there are potential habitats within these areas. For such species there may be either few or no records during the life of the project. As such the major measureable indicators of success for these species will be measurements that show increased areas of potential habitat.

9.3 Pilot Monitoring Project

In year 1 a Pilot Monitoring Project will be undertaken to formulate the ongoing design and replication of the annual monitoring program.

The Pilot Monitoring Project will determine monitoring locations within all conservation management areas and remnant areas of the Project Boundary; prescribe monitoring techniques; replication; and data analysis. Monitoring of outcomes within these areas will be done in relation to data collected in reference sites comprising intact forest and woodland within or nearby to conservation management areas.

The Pilot Monitoring Project will culminate in the production of an Annual Monitoring Plan that will be implemented for the first ten years of the Project.

9.4 Fixed Monitoring Areas

Within each conservation management area, fixed monitoring areas will be established along zones of greatest potential habitat change, principally within grassland and semi-cleared woodland and open forest areas within selected management areas. The fixed monitoring points will be established during the year when each conservation management area is to be first monitored.

Within each core conservation area (forest, woodland and riparian areas), one fixed monitoring point will be established. Where there are a number of vegetation communities within an area of core conservation then the fixed monitoring point will be established in the dominant vegetation community.

Within each conservation area (woodland and grassland areas), one fixed monitoring point will be established. Where there are a number of separate patches of the same vegetation community within the conservation area then a fixed monitoring point will only be established in the largest patch.

Within the undisturbed areas of the Project Boundary (forest, woodland and grassland areas), one fixed monitoring point will be established within each vegetation community. Where there are a number of separate patches of the same vegetation community within the undisturbed areas within the Project Boundary, then a fixed monitoring point will only be established in the largest patch. Within the rehabilitated areas, one fixed monitoring point will be established.

Reference sites within the offset properties containing high quality forest and woodland that need no further regeneration will be selected within or adjacent to each conservation management area.

Table 9.1 Completion Criteria and Measurable Indicators for each Domain

DOMAIN	Description	Current Overall Condition	Domain Objective	Measurable Indicators	Completion Criteria
Core Conservation	Existing native bushland. Not in zones of active farming.	Good quality vegetation and habitats in benchmark condition as measured against published RVC/BVT benchmark values.	Maintain condition of vegetation within benchmark.	% Native Overstorey Cover (NOS)	Maintenance of current cover
				% Native mid-storey cover (NMS)	Maintenance of current cover
				% Native groundcover (NGC)	Maintenance of current cover
				Mosses/lichen cover (%)	Maintenance of current cover
				Organic litter cover (%)	Maintenance of current cover
				Rock/bare ground cover (%)	Maintenance of current cover
				Total Native species richness (NPS)	Maintenance or increase in average species
				Native species richness (canopy)	Maintenance of species richness
				Native species richness (midstorey)	Maintenance of species richness
				Native species richness (groundcover)	Maintenance or increase in average species
				% Canopy recruitment (REG)	100%
				Number of trees with hollows (TH)	Maintenance or increase in % of trees with hollows.
				Total length (m) of fallen logs (FL)	Maintenance or increase in % of fallen logs
				No. Native Fauna Species	Maintenance of benchmark species richness or increase in known vertebrate fauna found

DOMAIN	Description	Current Overall Condition	Domain Objective	Measurable Indicators	Completion Criteria
					within this domain.
Conservation Area	Existing native bushland. Currently in zones of active farming.	Variable, but generally moderate quality vegetation and habitats as measured against RVC/BVT benchmark values. While some benchmark values are met (e.g. numbers of native plant species), other structural variables are not (e.g. understorey cover, number of fallen logs, hollows, etc).	Maintain and improve through assisted natural regeneration. Aim to increase to benchmark condition.	% Native Overstorey Cover (NOS)	Increase to at least lower benchmark.
				% Native mid-storey cover (NMS)	Increase to at least lower benchmark.
				% Native groundcover (NGC)	Increase to at least lower benchmark.
				Mosses/lichen cover (%)	Increase to at least lower benchmark.
				Organic litter cover (%)	Increase to at least lower benchmark.
				Rock/bare ground cover (%)	Increase to at least lower benchmark.
				Total Native species richness (NPS)	Increase to at least lower benchmark.
				Native species richness (canopy)	Increase to at least lower benchmark.
				Native species richness (midstorey)	Increase to at least lower benchmark.
				Native species richness (groundcover)	Increase to at least lower benchmark.
				% Canopy recruitment (REG)	Increase to at least lower benchmark.

DOMAIN	Description	Current Overall Condition	Domain Objective	Measurable Indicators	Completion Criteria
				Number of trees with hollows (TH)	Maintenance of trees with hollows, and significant increase in trees that can eventually produce hollows.
				Total length (m) of fallen logs (FL)	Statistically significant increase in length of fallen logs.
				No. Native Fauna Species	Increase to at least lower benchmark.
Riparian Areas	Vegetated or future vegetated land buffering creeks and Namoi River.	Variable, but generally moderate quality vegetation and habitats as measured against RVC/BVT benchmark values. While some benchmark values are met (e.g. numbers of native plant species), other structural variables are not (e.g. understorey cover, number of fallen logs, hollows, etc).	Rebuild/improve riparian corridors; protect waterways. Aim to increase to benchmark conditon.	% Native Overstorey Cover (NOS)	Increase to at least lower benchmark.
				% Native mid-storey cover (NMS)	Increase to at least lower benchmark.
				% Native groundcover (NGC)	Increase to at least lower benchmark.
				Mosses/lichen cover (%)	Increase to at least lower benchmark.
				Organic litter cover (%)	Increase to at least lower benchmark.
				Rock/bare ground cover (%)	Increase to at least lower benchmark.
				Total Native species richness (NPS)	Increase to at least lower benchmark.
				Native species richness (canopy)	Increase to at least lower benchmark.

DOMAIN	Description	Current Overall Condition	Domain Objective	Measurable Indicators	Completion Criteria
				Native species richness (midstorey)	Increase to at least lower benchmark.
				Native species richness (groundcover)	Increase to at least lower benchmark.
				% Canopy recruitment (REG)	Increase to at least lower benchmark.
				Number of trees with hollows (TH)	Maintenance of trees with hollows, and significant increase in trees that can eventually produce hollows.
				Total length (m) of fallen logs (FL)	Statistically significant increase in length of fallen logs.
				No. Native Fauna Species	Increase to at least lower benchmark.
Active Planting Areas (includes Rehabilitation Areas)		Low condition vegetation in highly modified condition that generally does not meet any RVC/BVT benchmark values.	Buffer conservation and core conservation areas from adjacent land use; increase area of existing bushland patches; connect existing bushland patches. Re-establish native plant species to trend towards benchmark values.	% Native Overstorey Cover (NOS)	Increase to at least lower benchmark.
				% Native mid-storey cover (NMS)	Increase to at least lower benchmark.
				% Native groundcover (NGC)	Increase to at least lower benchmark.
				Mosses/lichen cover (%)	Increase to at least lower benchmark.
				Organic litter cover (%)	Increase to at least lower benchmark.

DOMAIN	Description	Current Overall Condition	Domain Objective	Measurable Indicators	Completion Criteria
				Rock/bare ground cover (%)	Increase to at least lower benchmark.
				Total Native species richness (NPS)	Increase to at least lower benchmark.
				Native species richness (canopy)	Increase to at least lower benchmark.
				Native species richness (midstorey)	Increase to at least lower benchmark.
				Native species richness (groundcover)	Increase to at least lower benchmark.
				% Canopy recruitment (REG)	Increase to at least lower benchmark.
				Number of trees with hollows (TH)	Maintenance of trees with hollows, and significant increase in trees that can eventually produce hollows.
				Total length (m) of fallen logs (FL)	Statistically significant increase in length of fallen logs.
				No. Native Fauna Species	Increase to at least lower benchmark.

Table 9.2 Completion Criteria and Measurable Indicators for each Threatened Species and Ecological Community Covered in the BMP

Common Name	Scientific Name	TSC Act	EPBC Act	Species Objective	Measurable Indicators	Completion Criteria
White-throated Needletail	*Hirundapus caudacutus*		M	Maintenance of habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Fork-tailed Swift	*Apus pacificus*		M	Maintenance of habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Black-necked Stork	*Ephippiorhynchus asiaticus*	E		Maintenance of potential habitat in limited areas of the Western Offsets.	presence of swamp vegetation around limited wetland areas. Records of Black-necked Stork.	Continued presence of wetland area.
Little Eagle	*Hieraaetus morphnoides*	V		Maintenance of habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Square-tailed Kite	*Lophoictinia isura*	V		Maintenance of habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Spotted Harrier	*Circus assimilis*	V		Maintenance of habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.

Common Name	Scientific Name	TSC Act	EPBC Act	Species Objective	Measurable Indicators	Completion Criteria
Little Lorikeet	*Glossopsitta pusilla*	V		Maintenance of resident species populations within Northern, Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Swift Parrot	*Lathamus discolor*	E	E	Maintenance of potential habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Turquoise Parrot	*Neophema pulchella*	V		Maintenance of resident species populations within Northern, Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Barking Owl	*Ninox connivens*	V		Maintenance of species in at least Eastern and Western Offsets (relevant habitat areas).	Detection of species within Eastern & Western Offsets. Increased areas of forest and woodland habitats, replacing Derived Native Grassland.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Masked Owl	*Tyto novaehollandiae*	V		Maintenance of species in at least Eastern and Western Offsets (relevant habitat areas).	Detection of species within Eastern & Western Offsets. Increased areas of forest and woodland habitats, replacing Derived Native Grassland.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Rainbow Bee-eater	*Merops ornatus*		M	Maintenance of habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.

Common Name	Scientific Name	TSC Act	EPBC Act	Species Objective	Measurable Indicators	Completion Criteria
Brown Treecreeper	*Climacteris picumnus*	V		Maintenance of resident species populations within Northern, Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Speckled Warbler	*Chthonicola sagittata*	V		Maintenance of resident species populations within Northern, Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Regent Honeyeater	*Anthochaera phrygia*	E	E,M	Maintenance of potential habitat for species	Increased cover of forest and woodland communities. Increased condition of forest and woodland communities. Detection of species.	Maintenance of potential habitat for the species including woodland and open forest.
Black-chinned Honeyeater	*Melithreptus gularis gularis*	V		Maintenance of potential habitat for species	Increased cover of forest and woodland communities. Increased condition of forest and woodland communities. Detection of species.	Maintenance of potential habitat for the species including woodland and open forest.
Painted Honeyeater	*Grantiella picta*	V		Maintenance of potential habitat for species	Increased cover of forest and woodland communities. Increased condition of forest and woodland communities. Detection of species.	Maintenance of potential habitat for the species including woodland and open forest.
Grey-crowned Babbler	*Pomatostomus temporalis temporalis*	V		Maintenance of resident species populations within Northern, Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.

Common Name	Scientific Name	TSC Act	EPBC Act	Species Objective	Measurable Indicators	Completion Criteria
Varied Sittella	*Daphoenositta chrysoptera*	V		Maintenance of potential habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.
White-browed Woodswallow	*Artamus superciliosus*	V		Maintenance of habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Satin Flycatcher	*Myiagra cyanoleuca*		M	Maintenance of potential habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Hooded Robin	*Melanodryas cucullata*	V		Maintenance of potential habitat for species	Consistent or increasing detection of species across offsets.	Maintenance of actual and potential habitat for the species including woodland and open forest.
Diamond Firetail	*Stagonopleura guttata*	V		Maintenance of resident species populations within Northern, Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*	V		Maintenance of resident species populations within Northern, Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Koala	*Phascolarctos cinereus*	V		Maintenance of actual and potential habitats	Detection across all offsets during final surveys. Presence	Maintenance of species within conservation areas; spread of

Common Name	Scientific Name	TSC Act	EPBC Act	Species Objective	Measurable Indicators	Completion Criteria
				within Eastern, Western and Northern Offsets.	of maximum potential suitable habitat in all relevant domains.	species into other domains.
Little Pied Bat	*Chalinolobus picatus*	V		Maintenance of actual and potential habitats within Eastern, Western and Northern Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V		Maintenance of actual and potential habitats within Eastern, Western and Northern Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	V		Maintenance of actual and potential habitats within Eastern, Western and Northern Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Eastern Long-eared Bat	*Nyctophilus timoriensis*	V	V	Maintenance of resident species populations within Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains (including parts of Northern offsets).	Maintenance of species within conservation areas; spread of species into other domains.
Eastern Cave Bat	*Vespadelus troughtoni*	V		Maintenance of resident species populations within Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains (including parts of Northern offsets).	Maintenance of species within conservation areas; spread of species into other domains.

Common Name	Scientific Name	TSC Act	EPBC Act	Species Objective	Measurable Indicators	Completion Criteria
	Pultenaea setulosa		V	Maintenance of resident species populations within Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains (including parts of Northern offsets).	Maintenance of species within conservation areas; spread of species into other domains.
Scant Pomaderris	*Pomaderris queenslandica*	E		Establishment of populations within Ironbark forests of Eastern & Western Offsets.	Detection across all offsets during final surveys. Presence of maximum potential suitable habitat in all relevant domains.	Maintenance of species within conservation areas; spread of species into other domains.
Box Gum Woodland and Derived Native Grassland	*Ecological Communities*	CE	CE	Maintenance and improvement of all Box Gum Woodland across its range of occurrence in all offsets: Northern, Eastern & Western. This includes all types of woodland that are part of the Box Gum Woodland complex, and includes regeneration of Derived Native Grassland to Woodland.	% cover of Box Gum Woodland within all offsets. Absence of treeless Derived Native Grassland. Increased native plant species diversity (especially ground stratum) of all Box Gum Woodland.	Conversion of all Derived Native Grassland to woodland. Maintenance of all current woodland cover.

9.5 Vegetation Condition

9.5.1 Purpose

i. Offset Properties

The purpose of monitoring vegetation condition in the offset properties is to track progress of improvement and restoration works in the conservation management areas.

ii. Project Boundary

It is important to maintain the condition of native vegetation within areas to be mined and adjacent areas to be retained so as to maximise the retention of habitat for native flora and fauna at any point in time during mining.

The purpose of monitoring vegetation condition in the Project Boundary is to provide information to guide corrective action (e.g. weed and feral animal control), information about flowering and fruiting of native plants to be used for seed collection and data with which to compare the condition of rehabilitation when it occurs. It is also important to establish a biometric baseline condition of vegetation within and outside the Project Boundary prior to the commencement of mining.

9.5.2 Scope

All monitoring sites within the Project Boundary and the offset properties. Rehabilitation sites will also be added to the monitoring program 18 months after rehabilitation commences.

9.5.3 Target Flora

All vascular plant species within the major forest and woodland types within the Project Boundary. All vascular plant species within the major forest and woodland types within the offset properties.

9.5.4 Frequency

Vegetation condition of quadrats will be monitored annually. Impacts from weeds and feral animals will be monitored no less than annually, and more frequently as required depending upon seasonal conditions, mining work and incidental observations.

9.5.5 Quadrats & Biometric Data

Monitoring sites will be established in representative areas in each type of forest and woodland. Monitoring plots will be located within areas to be mined and areas to be retained in the longer term in Leard State Forest. Reference sites will be established for both the Project Boundary and offset properties. The Namoi CMA has publicly available regional vegetation community benchmarks which will also be used initially as reference information for comparison and analysis of the vegetation monitoring data collected.

Vegetative biometric data will be collected annually from reference sites that will be established in the first year of implementation of the management plan. Reference sites will be established in representative areas that will not be impacted by the operation of the mine. The biometric data will be used to develop a database of local benchmark values that will be used to assess the progress of rehabilitation in the Project Boundary and the restoration/conservation management works in the biodiversity offset areas.

At each monitoring site, a base plot of 20 x 50 m will be permanently marked by placement of a star picket at the eastern end of the midline of each plot and by recording the location of pickets using GPS. This plot will be dissected by a 50 m transect line with each end of the transect line marked with a permanent star picket. Within the base plot a subplot will be established, measuring 20 m x 20 m at the origin end.

Each fixed monitoring point will be monitored on an annual basis. A full floristic monitoring survey (see below) will be undertaken in year 1 (baseline), year 5 and ongoing at 5 year intervals at all fixed monitoring points. A modified monitoring survey (less floristics) will be undertaken in the alternate years, i.e. years 2, 3, 4, 6, 7 etc.

For the full floristic monitoring survey the following measurement will be collected and recorded from within the base plot:

- All vascular flora species present within a 20 m x 20 m subplot;
- The stratum in which each species occurred;
- The relative frequency of occurrence of each plant species.
- Regeneration of canopy species;
- Weeds present;
- Evidence of disturbance by pest animals;
- Number and sizes of hollows and the species of tree in which the hollow occurs;
- Standing dead timber and cumulative length of fallen logs;
- Proximity to water, rocks, caves and overhangs;
- A waypoint to mark the location of the quadrat, using a handheld GPS;
- Photographs of the quadrat; and
- General comments especially on seasonal conditions, past management, etc.

Within the sub plot, measurements will be collected and recorded for:

- All vascular flora species present; and
- The stratum in which each species occurred.

Along the transect line, measurements will be collected and recorded at 5 m intervals including the following:

- Tallest stratum: height, health and projected foliage cover;
- Mid stratum: height, health and projected foliage cover; and
- Groundcover: height, health and projected foliage cover, including
    - grass cover;
    - litter;
    - bare ground;
    - mosses and lichens; and
    - weeds.

For the modified monitoring survey, the above data will be collected, except the sub plot measurements i.e. no recording of the vascular flora species or the stratum in which the species occurs.

The relative abundance and cover of each species within the quadrat was approximated using a scoring system modified from the Braun-Blanquet scoring system (Braun-Blanquet, 1927). The scores used are provided in **Table 9.3**.

Table 9.3 Modified Braun-Blanquet Scores to be used In Quadrat Surveys

Class	Cover-abundance	Notes
1	Less than 5% cover - rare	Herbs, sedges and grasses: less than 3 individuals Shrubs and small trees: less than 3 individuals. Medium - large overhanging tree.
2	Less than 5% cover - occasional	Herbs, sedges and grasses: up to 10 individuals Shrubs and small trees: 3-5 individuals
3	Less than 5% cover – common	Herbs, sedges and grasses: more than 10 individuals but much less than 20 m^2 cover
4	Less than 5% cover – very common	Herbs, sedges and grasses: within 20 m^2 cover
5	5 - less than 25 % cover	-
6	25 - less than 50 % cover	-
75	50 - less than 75 % cover	-
8	75 - 100 % cover	-

9.5.6 Data Storage & Analysis

All quadrat data will be entered on an Excel spreadsheet and stored for later use and analysis. Data will be added to annually so that it will form a data matrix that is amenable to analysis using classification and ordination techniques, and parametric statistics.

Biometric data collected will be analysed and compared with Benchmark data, where available, from other locations within the Namoi Catchment.

A database of plant species will be maintained to provide a baseline of all vascular plants known to occur across the Project Boundary. New species detected during annual surveys will be added to the database and reported on within the annual report.

9.6 Native Fauna

9.6.1 Purpose

It is important to maintain the integrity of native faunal assemblages within areas to be mined and adjacent areas to be retained so as to maximise the retention of native biodiversity at any point in time during mining. Data on faunal assemblages may provide information to guide corrective action (e.g. weed and feral animal control), and data with which to evaluate the extent of success of rehabilitation when it occurs. It is also important to establish a baseline condition of faunal assemblages within the Project Boundary just prior to the commencement of mining, which will represent time zero data.

9.6.2 Scope

All monitoring sites will be located within the Project Boundary at disturbed and undisturbed sites. Rehabilitation sites will also be added to the monitoring program 12 months after rehabilitation has been undertaken in certain areas.

9.6.3 Target Fauna

The fauna to be targeted at each monitoring site will include birds, bats and reptiles. The former two groups will be targeted as they are well represented in the forests and woodlands of the Project Boundary, and because they include the majority of threatened species of fauna known to occur within the Project Boundary. The reptiles will be targeted as they are largely ground dwelling and will provide useful data with which to track recolonisation of rehabilitation areas.

i. Birds

At each monitoring site, bird species will be surveyed using at dawn for two mornings. All species seen or heard calling will be recorded. Any evidence of species from nests, droppings, etc will also be recorded for each monitoring site.

ii. Bats

At each monitoring site, bats will be surveyed using Anabat (or equivalent) ultrasonic call detectors. Anabat units will be installed and left in place for two nights and all species detected via calls will be recorded.

iii. Reptiles

At each monitoring site, reptiles will be surveyed by use of collapsible bait traps installed at intervals along drift fences. At each site, a drift fence with four collapsible traps will be installed. Additionally, reptiles will be searched for by active searches of logs, rocks and leaf litter for approximately half an hour by two people.

iv. Permanent Camera Monitoring Points

Rare native animals (e.g. spotted tailed quolls) will be monitored by automatic cameras at fixed photograph points to be maintained annually.

9.6.4 Frequency

Selected faunal assemblages will be monitored annually at each of the monitoring sites that are to be created for vegetation condition. Additional observations will be made as required depending upon seasonal conditions, mining work and incidental observations.

9.6.5 Data Storage & Analysis

All fauna data will be entered on an Excel spreadsheet and stored for later use and analysis. Data will be added to annually so that it will form a data matrix that is amenable to analysis using classification and ordination techniques, and parametric statistics.

A database of fauna species will be maintained to provide a baseline of all vertebrate fauna known to occur across the Project Boundary. New species detected during annual surveys will be added to the database and reported on within the annual report.

9.7 Weed Monitoring

9.7.1 Purpose

Weeds are a threat to the integrity of forest and woodland within the Project Boundary and may change in distribution and abundance as mining and rehabilitation occurs. Weeds may also change in distribution and abundance seasonally and there is potential for additional weeds to be introduced to the Project Boundary by human activities associated with mining. For these reasons, weed monitoring will be essential.

9.7.2 Scope

Weed monitoring will be undertaken in all monitoring sites within the Project Boundary. Rehabilitation sites will also be added to the monitoring program 12 months after rehabilitation commences.

9.7.3 Target Flora

All weed species within the major forest and woodland types within the Project Boundary.

9.7.4 Frequency

The percentages of weeds within quadrats that are monitored for vegetation condition will be calculated and monitored annually. Weed occurrences will also be routinely noted by the EO and any potential new occurrences mapped.

9.7.5 Annual Quadrat Data

From the quadrat data for vegetation condition, the percentages of all exotic weeds will be calculated and the identity of the main weeds present determined.

9.7.6 Random Meander Transects

In addition to surveying within the quadrats, annual random meander transects will be completed in areas of native vegetation in Leard State Forest adjacent to the Project Boundary to search for weed species, in particular the Noxious Weeds identified in **Section 3.2.2**. Where significant infestations of weeds are found, areas/numbers will be estimated within a 20 x 20 m quadrat, and extrapolated to give overall population size estimates. This information will be used to inform the management actions and trigger control activities.

9.7.7 Fixed Photopoints

Weed management actions and the responses of weed species will be tracked by means of recording where and how weeds were controlled and demonstrating the efficacy of methods by studying information available from fixed photo points.

9.7.8 Incidental Observations

The EO will make incidental observations of any potential new infestations of weeds within the Project Boundary on an opportunistic basis during routine work. Any potentially new species will be noted and collected for identification. Control will be implemented if and when needed.

9.8 Feral Animal Monitoring

9.8.1 Purpose

Feral animals, particularly foxes and pigs, are a threat to the integrity of forest and woodland within the Project Boundary and may change in distribution and abundance as mining and rehabilitation occurs. Feral animals may also change in distribution and abundance seasonally and there is potential for additional species to become prevalent within the Project Boundary as a result of human activities associated with mining. For these reasons, feral animal monitoring will be essential.

9.8.2 Scope

All monitoring sites within the Project Boundary. Rehabilitation sites will also be added to the monitoring program 12 months after rehabilitation commences.

9.8.3 Target Fauna

Major feral animal species within the major forest and woodland types within the Project Boundary. Further details of the proposed Monitoring Program for feral animals are presented below.

i. Feral Pig Monitoring

Monitoring is critical to the success of a campaign and it may be done via visual surveys (ground or aerial), thermal infrared imaging or detection by remote motion cameras in the landscape. Observing water-point activity, counting pig removal, measuring bait uptake, or observing reduction in rooting damage are other ways a control campaign can be monitored. Comparing records from before control activities began with those collected during and after a control campaign will determine the effectiveness of the approach and allow aspects to be adapted where needed.

Several techniques are used to monitor Feral Pig abundance, however many of these are labour intensive and relatively difficult such as aerial spotting and cage trapping. A simpler technique that is applicable for this Project involves determining feral pig abundance using their faeces (dung). The dung of Feral Pigs is often more conspicuous than the animals themselves and therefore provides a good method of detecting the animals' presence or absence.

Dung is usually used to monitor populations using two main approaches: calculating the total amount of dung in a given area, or determining the rate of accumulation of dung in fixed sample plots that are regularly cleared. The simplest method is to use the presence or absence of dung from plots to estimate feral pig abundance. This involves inspecting a number of small permanent plots to initially clear the plot of any dung, and then inspecting the plot again after a given time and counting the amount of dung deposited and estimating the numbers of pigs. This is a relatively qualitative method, but it is appropriate for the Project, as the Feral pig is not considered likely to present a significant problem. This technique will allow an estimation of the number of Feral Pigs present and will allow numbers to be compared between monitoring events. Indirect indicators of Feral Pig numbers such as amount of wallows recorded, or damage to native vegetation should also be recorded during monitoring and factored in to the results. If Feral Pig numbers are found to be increasing, then the control measures described previously will be implemented.

ii. Feral Fox and Rabbit Monitoring

One of the most widely used techniques in Australia for monitoring foxes and rabbits is nocturnal spotlighting. This is considered a practical tool for monitoring the relative size of the rabbit and fox population, especially where the habitat is open grassland or open woodland where trees are sparse. Spotlighting is relatively easy to do, and large areas can be covered in a short amount of time.

To use this technique, a standardised transect should be used that passes through all vegetation types represented in the area and it should be traversable in all weather conditions. If possible, transects will be marked out with reflectors, so surveys can be repeated in the future so that valid comparisons to previous observations can be made.

iii. Permanent Camera Monitoring Points

Feral animals (foxes, pigs and goats) and rare native animals (e.g. spotted tailed quolls) will be monitored by automatic cameras at fixed photograph points to be maintained annually.

9.8.4 Frequency

The abundance of feral animals within the Project Boundary will be monitored to provide the necessary information to trigger management action and to determine the efficacy of management actions undertaken aimed at reducing feral animal abundance. Monitoring should be conducted every 12 months for feral animals using the methods identified above. If levels of feral animals are considered to present a threat, then it may be necessary to monitor more often to determine the results of un-programmed control activities.

In order for monitoring programs to be effective and efficient, reliable estimates of changes in population need to be obtained, and therefore monitoring will be done before, during and after control. Monitoring before the implementation of control measures will establish a benchmark of feral animal abundance will allow objectives and performance indicators to be determined. This initial monitoring should take place prior to the commencement of the Project. Monitoring will be conducted during the life of the Project to determine how feral animal control is operating against set objectives and will provide an opportunity to change the management program if required in response. This adaptive management process will ensure that measurable outcomes are produced within timeframes and budgets. Monitoring after the management program will determine if the management program objectives have been achieved.

Any areas of feral animal damage to vegetation within vegetation condition quadrats will be calculated and monitored annually. Feral animal occurrences (or damage from feral animals) will also be routinely noted by the EO and any potential new occurrences mapped.

9.9 Reporting

After the first 12 months of monitoring has been completed, all monitoring data collected will be analysed within a Pilot Monitoring Report. That report will critically review the efficacy of all methods used and all data collected and provide recommendations to fine tune methods as required. Following the production of the Pilot Monitoring Report, successive annual monitoring will be reported in the Biodiversity Management Plan Annual Reports as outlined in **Section 13.0**.

10.0 RISK ASSESSMENT

An ecological hazard and risk assessment is provided in **Table 10.1** and has been completed for core and other conservation areas, riparian land and active planting areas. The risk matrix presented in **Figure 10.1** and the associated descriptors were utilised to determine the consequence and likelihood of each hazard.

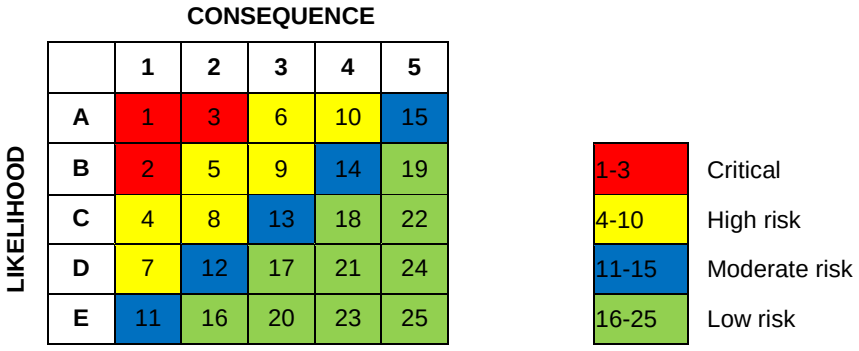


Figure 10.1 Risk Matrix

Consequence	Descriptor	Description
1	Severe	Loss of species, populations or communities in an area
2	Major	Major damage/reduction of species, populations or communities in an area
3	Moderate	Moderate damage to species, populations or communities in an area
4	Minor	Minor damage to individuals/small area
5	Insignificant	Unlikely to affect species, populations or communities

Likelihood	Descriptor	Description
A	Almost certain	Almost certain to happen
B	Likely	Likely to happen at some time
C	Possible	Could potentially happen
D	Unlikely	Not likely to happen
E	Rare	Practically impossible

Table 10.1 Ecological Risk Assessment

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
CORE CONSERVATION AREAS								
Drought	Dieback of plant species	B	3	9	Vegetation monitoring plots.	No controls recommended.	B	9
	Increase severity of bushfire	C	2	8	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	D	12
	Erosion post-drought	C	2	8	Vegetation monitoring plots.	Control numbers of feral animals to reduce net grazing pressure; Maintain ground cover of native vegetation (note: livestock should be excluded from core conservation areas).	D	12
Bushfire	Loss of tree hollows	B	3	9	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	C	13
	Plant mortality	B	2	5	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	C	8

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	Fauna mortality	B	2	5	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	C	8
Flood/major rainfall	Major erosion	C	2	8	Vegetation monitoring plots.	Control numbers of feral animals to reduce net grazing pressure;Maintain ground cover of native vegetation (note: livestock should be excluded from core conservation areas).	D	12
	Loss or decline of plant species	C	3	13	Vegetation monitoring plots.	No controls required.	C	13
Grazing by Feral Pigs	Failure to recruit new plants	C	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	D	12
	Soil disturbance	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8
	Loss or decline of plant species due to herbivory	B	2	5	Vegetation monitoring plots.	Implement feral control program.	D	12
	Introduction of plant diseases	C	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	D	12

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
Grazing by Feral Goats	Failure to recruit new plants	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8
	Loss or decline of plant species due to herbivory	B	2	5	Vegetation monitoring plots.	Implement feral control program.	D	12
	Soil disturbance	B	2	5	Vegetation monitoring plots;Population monitoring of native and feral animals.	Implement feral control program.	C	8
Feral Foxes	Predation on critical weight-range animals	B	1	2	Population monitoring of native and feral animals.	Implement feral control program.	C	4
Existing environmental weeds	Loss or decline of native plant species	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
New environmental weeds	Loss or decline of native plant species	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
Illegal clearing	Loss of tree hollows	C	2	8	Surveillance of property.	Check fencing and restrict access to core conservation	D	12

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
						areas		
	Loss or decline of native plant species	C	2	8	Vegetation monitoring plots.	Check fencing and restrict access to core conservation areas	D	12
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to core conservation areas	D	12
Edge effects from commercial areas	Elevated soil nutrients	B	2	5	Visual inspection; Monitoring plots.	Limit use of fertilisers in commercial areas;Apply in areas with low potential for run-off and away from Core conservation areas.	C	8
	Weed invasion	B	2	5	Visual inspection; Monitoring plots.	Control weeds in commercial areas	D	12
	Feral animal invasion	B	2	5	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to core conservation areas; Implement feral controls.	D	12
	Stock access/grazing	B	2	5	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to core conservation areas.	D	12
CONSERVATION AREAS								
Drought	Loss or decline of native plant	B	2	5	Surveillance of property generally and monitoring plots.	Increase frequency of monitoring and surveillance.	C	8

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	species					If density of woody plants fall below **threshold** levels, supplementary plant and water where possible to maintain density.		
	Increase severity of bushfire	C	2	8	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	D	12
	Erosion post-drought	B	2	5	Surveillance of property generally and monitoring plots.	Remove stock to reduce net grazing pressure;Control feral fauna to reduce net grazing pressure;Maintain ground cover of native vegetation.	D	12
Bushfire	Loss of tree hollows	C	2	8	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	D	12
	Plant mortality	B	2	5	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	C	8
	Fauna mortality	B	2	5	Surveillance of property generally and monitoring plots, mapping and reporting of	Reduce fuel loads as per bushfire management plan.	C	8

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
					bushfires.			
Flood/major rainfall	Major erosion	C	2	8	Surveillance of property generally and monitoring plots.	Remove stock to reduce net grazing pressure; Control feral fauna to reduce net grazing pressure; Maintain ground cover of native vegetation.	D	12
	Loss or decline of plant species	C	3	13	Vegetation monitoring plots.	Supplementary plantings to maintain population numbers;Exclude stock for a period to limit disturbance and allow plants to recover.	D	17
Grazing by Feral Pigs	Failure to recruit new plants	C	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	D	12
	Soil disturbance	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8
	Loss or decline of plant species due to herbivory	B	2	5	Vegetation monitoring plots.	Implement feral control program.	D	12
	Introduction of plant diseases	C	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	D	12

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
Grazing by Feral Goats	Failure to recruit new plants	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8
	Loss or decline of plant species due to herbivory	B	2	5	Vegetation monitoring plots.	Implement feral control program.	D	12
	Soil disturbance	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8
Feral Foxes	Predation on critical weight-range animals	B	1	2	Population monitoring of native and feral animals.	Implement feral control program.	C	4
Existing environmental weeds	Loss or decline of native plant species	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
New environmental weeds	Loss or decline of native plant species	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
Illegal clearing	Loss of tree	C	2	8	Surveillance of property.	Check fencing and restrict access to conservation	D	12

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	hollows					areas		
	Loss or decline of native plant species	C	2	8	Vegetation monitoring plots.	Check fencing and restrict access to conservation areas	D	12
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to conservation areas	D	12
Edge effects from commercial areas	Elevated soil nutrients	B	2	5	Visual inspection; Monitoring plots.	Limit use of fertilisers in commercial areas; Apply in areas with low potential for run-off and away from conservation areas.	C	8
	Weed invasion	B	2	5	Visual inspection; Monitoring plots.	Control weeds in commercial areas	D	12
	Feral animal invasion	B	2	5	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to conservation areas;Implement feral controls.	D	12
	Uncontrolled stock access/grazing	B	2	5	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to conservation areas.	D	12
RIPARIAN AREAS								
Drought	Loss or decline of	B	3	9	Surveillance of property	Increase frequency of	C	13

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	native plant species				generally and monitoring plots.	monitoring and surveillance. If density of woody plants fall below **threshold** levels, supplementary plant and water where possible to maintain density.		
	Fail to establish plants	B	1	1	Survelliance and monitoring	Plant additional as required; consider alternative planting methods	D	7
	Increase severity of bushfire	C	2	8	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	D	12
	Erosion post-drought	A	2	3	Surveillance of property generally and monitoring plots.	Control numbers of feral animals to reduce net grazing pressure; Maintain ground cover of native vegetation (note: livestock should be excluded from riparian areas).	C	8
Bushfire	Loss of tree hollows	B	2	5	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	C	8
	Plant mortality	B	2	5	Surveillance of property generally and monitoring plots,	Reduce fuel loads as per bushfire management plan.	C	8

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
					mapping and reporting of bushfires.			
	Fauna mortality	B	2	5	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	C	8
Flood/major rainfall	Major erosion	A	2	3	Visual inspection after major rainfall or flood events.	Control numbers of feral animals to reduce net grazing pressure; Maintain ground cover of native vegetation (note: livestock should be excluded from riparian areas); Stabilise slopes and creek banks.	C	8
	Loss or decline of plant species	C	3	13	Vegetation monitoring plots.	Supplementary plantings to maintain population numbers.	D	17
Grazing by Feral Pigs	Failure to recruit new plants/failure to establish new plantings	C	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	D	12
	Soil disturbance	B	2	5	Vegetation monitoring plots;Population monitoring of native and feral animals.	Implement feral control program.	C	8

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	Erosion of creek banks and sedimentation of stream	B	2	`5	Surveillance of property generally and monitoring plots.	Control numbers of feral animals to reduce net grazing pressure; Maintain ground cover of native vegetation (note: livestock should be excluded from riparian areas); Stabilise slopes and creek banks.	C	8
	Loss or decline of plant species due to herbivory	B	2	5	Vegetation monitoring plots.	Implement feral control program.	D	12
	Introduction of plant diseases	C	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	D	12
Grazing by Feral Goats	Failure to recruit/establish new plants	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8
	Loss or decline of plant species due to herbivory	B	2	5	Vegetation monitoring plots.	Implement feral control program.	D	12
	Soil disturbance	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8
Feral Foxes	Predation on	B	1	2	Population monitoring of native	Implement feral control	C	4

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	critical weight-range animals				and feral animals.	program.		
Existing environmental weeds	Loss or decline of native plant species	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
	Outcompetes new plantings/Failure to establish new plantings	A	1	1	Routine inspections and vegetation monitoring plots during establishment phase	Implement weed controls and supplementary plant as required.	D	7
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
New environmental weeds	Loss or decline of native plant species	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
	Outcompetes new plantings/Failure to establish new plantings	A	1	1	Routine inspections and vegetation monitoring plots during establishment phase	Conduct soil testing before planting program to determine whether there are any weedy propagules or dormant weed species present; Implement weed controls and supplementary plant as required.	D	7
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
Illegal clearing	Loss of tree hollows	C	2	8	Surveillance of property.	Check fencing and restrict access to riparian areas	D	12
	Loss or decline of native plant species	C	2	8	Vegetation monitoring plots.	Check fencing and restrict access to riparian areas	D	12
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to core conservation areas	D	12
Edge effects from commercial areas	Elevated soil nutrients	B	2	5	Visual inspection; Monitoring plots.	Limit use of fertilisers in commercial areas; Apply in areas with low potential for run-off and away from riparian areas.	C	8
	Weed invasion	B	2	5	Visual inspection; Monitoring plots.	Control weeds in commercial areas	D	12
	Feral animal invasion	B	2	5	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to riparian areas; Implement feral controls.	D	12
	Stock access/grazing	B	2	5	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to riparian areas.	D	12
ACTIVE PLANTING AREAS								
Drought	Loss or decline of native plant	B	3	9	Surveillance of property generally and monitoring plots.	Increase frequency of monitoring and surveillance. If density of woody plants	C	13

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	species					fall below threshold levels, supplementary plant and water where possible to maintain density.		
	Fail to establish plants	B	1	1	Surveliance and monitoring	Plant additional as required; consider alternative planting methods	D	7
	Increase severity of bushfire	C	2	8	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	D	12
	Erosion post-drought	A	2	3	Surveillance of property generally and monitoring plots.	Control numbers of feral animals to reduce net grazing pressure; Stablise bare ground where plants have not yet established.	C	8
Bushfire	Loss of tree hollows	B	2	5	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	C	8
	Plant mortality	B	2	5	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	C	8

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	Fauna mortality	B	2	5	Surveillance of property generally and monitoring plots, mapping and reporting of bushfires.	Reduce fuel loads as per bushfire management plan.	C	8
Flood/major rainfall	Major erosion	A	2	3	Visual inspection after major rainfall or flood events.	Control numbers of feral animals to reduce net grazing pressure; Stablise bare ground where plants have not yet established.	C	8
	Fail to establish plants	B	1	1	Survelliance and monitoring	Control numbers of feral animals to reduce net grazing pressure;Stablise bare ground where plants have not yet established.	D	7
	Loss or decline of plant species	C	3	13	Vegetation monitoring plots.	Supplementary plantings to maintain population numbers.	D	17
Grazing by Feral Pigs	Failure to recruit new plants/failure to establish new plantings	C	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	D	12
	Soil disturbance	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	Loss or decline of plant species due to herbivory	B	2	5	Vegetation monitoring plots.	Implement feral control program.	D	12
	Erosion of creek banks and sedimentation of stream	B	2	`5	Surveillance of property generally and monitoring plots.	Control numbers of feral animals to reduce net grazing pressure; Maintain ground cover of native vegetation (note: livestock should be excluded from active planting areas); Stabilise bare ground.	C	8
	Introduction of plant diseases	C	2	5	Vegetation monitoring plots;Population monitoring of native and feral animals.	Implement feral control program.	D	12
Grazing by Feral Goats	Failure to recruit new plants	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8
	Loss or decline of plant species due to herbivory	B	2	5	Vegetation monitoring plots.	Implement feral control program.	D	12
	Soil disturbance	B	2	5	Vegetation monitoring plots; Population monitoring of native and feral animals.	Implement feral control program.	C	8
Feral Foxes	Predation on critical weight-	B	1	2	Population monitoring of native and feral animals.	Implement feral control program.	C	4

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
	range animals							
Existing environmental weeds	Loss or decline of native plant species	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
	Outcompetes new plantings/Failure to establish new plantings	A	1	1	Routine inspections and vegetation monitoring plots during establishment phase	Implement weed controls and supplementary plant as required.	D	7
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
New environmental weeds	Loss or decline of native plant species	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
	Outcompetes new plantings/Failure to establish new plantings	A	1	1	Routine inspections and vegetation monitoring plots during establishment phase	Conduct soil testing before planting program to determine whether there are any weedy propagules or dormant weed species present; Implement weed controls and supplementary plant as required.	D	7
	Loss of fauna habitat	C	2	8	Surveillance of property generally and monitoring plots.	Implement weed controls.	D	12
Edge effects from commercial areas	Elevated soil nutrients	B	2	5	Visual inspection; Monitoring plots.	Limit use of fertilisers in commercial areas;	C	8

Risk Factor (Hazard)	Impact (Risk)	Likelihood without controls	Consequence	Risk Level	Method of Detection	Action/Control/Risk Mitigation Measure	Residual Likelihood	Residual Risk Level
						Apply in areas with low potential for run-off and away from active planting areas.		
	Weed invasion	B	2	5	Visual inspection; Monitoring plots.	Control weeds in commercial areas	D	12
	Feral animal invasion	B	2	5	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to active planting areas; Implement feral controls.	D	12
	Stock access/grazing	B	2	5	Surveillance of property generally and monitoring plots.	Check fencing and restrict access to active planting areas.	D	12

11.0 ROLES AND RESPONSIBILITIES

MCC will ensure responsibilities for achieving biodiversity objectives are assigned and clearly communicated. General roles and responsibilities for the implementation of this BMP are presented for the Offset Strategy in **Table 11.1** below and for the Project Boundary in **Table 8.1**.

Table 11.1 Summary of the Roles and Responsibilities for the Offset Properties

Management Tasks	Northern Offsets			Eastern and Western Offsets		
	LM	EO	EC	LM	EO	EC
Fire Management						
Track maintenance	x			x		
Asset Protection Zones around infrastructure	x			x		
Fuel reduction in management zones	x	x		x	x	
Grazing Management						
Core Farming Zone	x			x		
Conservation Zone (grassland & open woodland)	x			x		
Conservation Zone (forest & woodland)	x			x		
Weed Management						
Briar Rose (*Rosa rubiginosa*)	x	x				
Weeping Willow (*Salix babylonica*)	x	x		x	x	
Elm (*Ulmus* sp)	x	x				
Thistles	x	x		x	x	
Blackberry (*Rubus fruticosus*)				x	x	
Feral Animal Management						
Feral Pig (*Sus scrofa*)	x	x		x	x	
Feral Goat (*Capra hircus*)	x	x		x	x	
Fox (*Vulpes vulpes*)	x	x		x	x	
Creekline Stabilisation						
fencing of riparian areas (Areas J and T, A zones)	x	x		x	x	
fencing maintenance	x	x		x	x	
Weeding of exotic trees (as listed above)	x	x		x	x	
Revegetation						
Replanting	x	x		x	x	
Thinning	x	x		x	x	
Tenure		x			x	
Monitoring		x	x		x	x
Documentation/Reporting	x	x	x	x	x	x

LM = Land Manager and Staff; EO = Environmental Officer; EC = Ecological Consultant

12.0 CONTACT DETAILS

12.1 Onsite Contact Details

Persons responsible for activities under this BMP are listed in

Table 12.1 Maules Creek Coal Mine Contact Details

Name	Position	Contact Details
Brian Cole	Project Director – Maules Creek	(02) 6749 7821 0418 116 153
Daniel Martin	Environment Manager	Tel: (02) 6749 7804 Mobile: 0438 294 682 24-hour Complaints Hotline: 1800 628 537 (1800 MAULES)
	Environment and Heritage Officer	Tel: (02) 6749 7800 Mobile:
	Land Manager	Tel: (02) 6749 7800 Mobile:

13.0 REVISION, AUDITING AND REPORTING

The BMP will be subject to reporting procedures and regularly audited in order to demonstrate compliancy with approval conditions, review the progress of management actions implemented, and to review the adequacy of the BMP. Recommendations made available through the auditing and reporting procedure will be used to inform scheduled revisions to the BMP. This section summarises the revisions and audits required, and the reporting that will be completed for the BMP.

13.1 Revised Biodiversity Management Plan

The BMP will be revised within 30 months of the date of approval, or within 6 months after the completion of Stage 2 of the Leard Forest Mining Precinct Regional Biodiversity Strategy, whichever is sooner.

The revised BMP will incorporate revisions to the Biodiversity Offset Strategy as required under Condition 45 of PA 10_0138 and will be consistent with the findings of the Leard Forest Mining Precinct Regional Biodiversity Strategy.

The revised BMP will also incorporate the results of the investigations required under Conditions 48 and 50 of PA 10_0138 and threatened species/Box Gum Woodland implementation plans arising from these investigations (see **Section 13.2** below).

The revised BMP will also incorporate an Agricultural Suitability Assessment of the Offset Properties as required under Condition 46 of PA10_0138 (see **Section 4.3**).

13.2 Revisions to Optimise Threatened Biodiversity Management

The measures that are described within this BMP have been prepared in consultation with OEH and Namoi CMA as required under Conditions 48, 49 and 50, Schedule 3 of PA 10_0138. MCC will continue to consult with these regulators to ensure that this BMP and its management measures optimise the way in which Box Gum Woodland and threatened species habitats are managed.

An investigation will be held in accordance with Conditions 48 and 50 of PA 10_0138 for Box Gum Woodland and the threatened species listed in these conditions. Following consultation with the OEH and the Namoi CMA, an investigation report will be prepared within 24 months (and if possible, in conjunction with Stage 2 of the Leard Forest Mining Precinct Regional Biodiversity Strategy); this report will document the findings of this investigation and present an implementation plan to that aims to maximise the prospects for rehabilitation and regeneration of Box Gum Woodland and ensure delivery of suitable areas of viable habitat for the species listed in the above conditions.

As required by Condition 53, Schedule 3 of PA 10_0138, these findings and the implementation plan will be incorporated into a revision of the BMP within 30 months of the date of approval. The revised BMP will also demonstrate consistency with the findings of Leard Forest Mining Precinct Regional Biodiversity Strategy.

13.3 Reporting and Auditing

The following reporting and auditing protocols will take place to assess the quality and compliance of the management of the Offset Properties.

13.3.1 Annual Review

An Annual Review will be submitted by the end of March each year as per Condition 4, Schedule 5 of PA 10_0138, which outlines the environmental performance of the Project over the preceding 12 month period.

The Annual Review will discuss environmental performance, environmental management, and any non-conformance issues. This will include identifying trends in monitoring results, comparisons to EA predictions and statutory requirements, and a description of measures that will be implemented over the following year. One section of the Annual Review will summarise the outcomes of management actions undertaken as part of the BMP and will collate documentation to demonstrate compliancy with the BMP. This section will be prepared as a brief summary report on the BMP to verify that management works are being conducted and the success of the works against the performance criteria outlined above.

The details within this report will be maintained in a permanent management record for the Project and will be subject to audit every three years (see **Section 13.3.4** below). As such, this BMP may be reviewed as a result of the compilation of the Annual Review to improve environmental performance as per Condition 5 in Schedule 5 of PA 10_0138. This review would be conducted within 3 months of submission of the Annual Review.

13.3.2 Biodiversity Management Plan Annual Report

Annual reporting on the BMP will be prepared and a summary report submitted as part of the Annual Review. The Biodiversity Management Plan Annual Report (BMP Annual Report) will assess the performance of management, rehabilitation and restoration actions within the rehabilitation and biodiversity offset areas, and identify any measures that should be implemented to improve the performance of these actions.

After the first 12 months of monitoring has been completed, all monitoring data collected will be presented and discussed within a Pilot Monitoring Report. The Pilot Monitoring Report will critically review the efficacy of all methods used and all data collected and provide recommendations to fine tune methods as required. The report will be submitted to OEH and SEWPaC for review, in accordance with the conditions of PA 10_0138.

Subsequently, in order to document the results of the Monitoring Program and the implementation of this BMP, the BMP Annual Report will be prepared. The BMP Annual Report will be created following the completion of annual monitoring and will provide the results of the year's surveys, and compare them to previous years. Additionally, recommendations will be made which will feed into the management of each area during the coming year. This report will describe the works undertaken, present the findings of the monitoring activities, discuss any problems encountered in implementing the BMP, and will recommend any adaptations or additions to the BMP.

Included in these reports will be:

- Introduction:
  - Description of the offset site;
  - Current Vegetation condition; and
  - Vegetation community descriptions.
- Survey Methods:
  - Flora; and

- Fauna.

- Survey Results:
  - Vegetation condition and regeneration assessment; and
  - Monitoring results.
- Management Recommendations:
  - Flora regeneration;
  - Fauna habitat; and
  - Riparian habitat.

The Annual Report will form a long term record of the flora and fauna management on the Project Boundary and will help determine what the overall impact of the Project has been and will determine the efficacy of the mitigation measures implemented. It is expected that this information will form a valuable base-line data set that will inform future management activities. The BMP Annual Report will be submitted to OEH and SEWPaC for review, in accordance with the conditions of consent.

13.3.3 Website Reporting

The results of the BMP Annual Report will be published on the MCC website by the end of March each year after the commencement of the Project in accordance with Condition 34 of the Approval Decision EPBC 2010/5566. The website reporting will also address compliance with the approval conditions for the BMP over the previous 12 months. Non-compliance with any of the conditions will be reported to the relevant agencies at the same time as the compliance report is published.

13.3.4 Independent Audits

i. Independent Environmental Audit

An Independent Environmental Audit will be conducted every three years and will commence by the end of June 2015, in accordance with Condition 10, Schedule 5 of PA 10_0138. This Environmental Audit will be conducted by a suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Director-General. The Independent Environmental Audit will assess the environmental performance of the Project and the Project's compliance to the conditions of PA 10_0138.

As part of the Independent Environmental Audit, the BMP Annual Reports will be reviewed to assess whether the management of the Offset Properties is generally consistent with the commitments made within the BMP and whether compliance with the relevant conditions of PA 10_0138 has been met.

Recommendations will be made about the management practices and timelines outlined within the BMP based on the compliance or non-compliance of offset areas with the outcomes of the BMP. These reports will consist predominantly of compliance table, where each specific management measure outlined within the BMP is analysed and compared with on-ground data and management actions. Included within these reports will be:

- Introduction:
  - Background;
  - Site description; and
  - Audit Approach and Limitations.

- Compliance tables; and
- Recommendations.

The Independent Environmental Audit will also provide recommendations about whether the management methodologies need to be modified in order to increase their effectiveness. The BMP will review compliance tables to compare the objectives of the BMP with results of surveys. Additionally, data will be compared between years to determine whether changes made as a result of recommendations in the BMP Annual Reports and the Independent Environmental Audits have effectively addressed any non-compliance results.

All reporting will be conducted in accordance with relevant conditions of approval. Reports will be provided to OEH and SEWPaC following each monitoring period.

ii. Biodiversity Audit

An Independent Biodiversity Audit will be conducted throughout the life of the Project in the Northern, Eastern, Western and Shared offset areas in accordance with Condition 56, Schedule 3 of PA 10_0138. This independent audit is additional to the above auditing procedure and intended to specifically address the management, restoration and rehabilitation of biodiversity in the Offset Properties and the rehabilitation areas of the Project Boundary.

It is planned that the first Biodiversity Audit will occur by the end of December 2017 and then every 5 years in the form of independent Biodiversity Audits consistent with Condition 56, Schedule 3 of PA 10_0138.

Audits will be conducted by suitably qualified experts, preferentially those with previous experience in the monitoring of vegetation and fauna habitat rehabilitation. Additionally, experts with previous survey experience within the offset areas would be advantageous, as a first-hand understanding of the constraints and management strategies being undertaken will positively contribute to future management of the offsets.

Consultation will be conducted as required with government agencies and the Namoi CMA during the auditing process.

A summary of the reporting and auditing requirements relating to this BMP is provided in **Table 13.1**.

Table 13.1 Summary of Reporting and Auditing Requirements for the BMP

Review/Auditing Report	Timing	Scope
Revised BMP	Within 30 months of the date of this approval or within 6 months after the completion of Stage 2 of the Leard Forest Mining Precinct Regional Biodiversity Strategy, whichever is sooner.	Findings of threatened species and Box Gum Woodland investigation and implementation plans for these species and CEEC as required by Conditions 48 and 50 in Schedule 3 of PA10_0138 Demonstrate consistency with the findings of Leard Forest Mining Precinct Regional Biodiversity Strategy. Include an Agricultural Suitability Assessment. Revision of Biodiversity Offset Strategy, as required by Condition 45 in Schedule 3 of PA 10_0138. Include details of the costs to implement the Biodiversity Offset Strategy.

Review/Auditing Report	Timing	Scope
Annual Review (Biodiversity Management Plan Annual Report)	By the end of March each year.	Include a comprehensive review of the monitoring results and complaints records of the project over the past year. Identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance; Identify any trends in the monitoring data over the life of the project; Describe what measures will be implemented over the next year to improve the environmental performance of the project. Publish findings on website in accordance with Condition 34 of the Approval Decision EPBC 2010/5566.
Independent Environmental Audit (part of the independent audit of the environmental performance and compliancy of the Project)	By the end of June 2015 and every 3 years thereafter.	Review the adequacy of any approved strategy, plan or program required under the abovementioned approvals. Recommend measures or actions to improve the environmental performance of the project and/or any strategy, plan or program required under these approvals.
Biodiversity Audit (to be conducted by an independent and suitably qualified expert)	Commencing 2017 and every five years from the first Biodiversity Audit.	Assess the performance of the revegetation in the rehabilitation area completed to date against the completion criteria in the Rehabilitation Management Plan. Assess the performance of management and restoration in the off-site Biodiversity Offset Strategy areas completed to date against the completion criteria in the Biodiversity Management Plan. Identify any measures that should be implemented to improve the performance of rehabilitation, management and restoration within the rehabilitation and biodiversity offset areas. If the completion criteria have not been met, or are not adequately trending towards being met, determine the likely ecological value of the rehabilitation and restoration once completed, and recommend additional measures to augment the Biodiversity Offset Strategy to ensure that it adequately offsets the Project's impacts on biodiversity.
Independent Audit of Compliance	Upon the direction of the Minister for the Environment.	Review compliance with the conditions of approval. Audit criteria must be agreed to by the Minister and the audit report must address the criteria to the satisfaction of the Minister.

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APPENDIX A

REGULATORY CORRESPONDENCE

Cecilia Phu

Subject: RE: Maules Creek Biodiversity Management Plan

From: Daniel Martin [mailto:DMartin@whitehavencoal.com.au]
Sent: Friday, 21 December 2012 6:08 PM
To: Nathan Cooper; David Robertson; Cecilia Phu
Subject: Fwd: Maules Creek Biodiversity Management Plan

Begin forwarded message:

> **From:** Todd Soderquist <Todd.Soderquist@environment.nsw.gov.au>
> **Date:** 21 December 2012 5:23:44 PM AEDT
> **To:** Daniel Martin <DMartin@whitehavencoal.com.au>
> **Subject: Maules Creek Biodiversity Management Plan**
>
> Greetings Daniel,
>
> Thank you for providing the Maules Creek Biodiversity Management Plan dated 13 December 2012.
>
> The Biodiversity Conservation Unit staff member who is in charge of this project will not be able to address the BMP comprehensively until late January. However, we have made a rapid perusal of its content and our initial impressions are that major sections of the BMP have not been addressed adequately or are lacking. This may mean that we will be unable to provide meaningful comment on the document without a comprehensive revision. I provide dot points below indicating those areas of the BMP that we highlighted as in need of attention in case you wish to revise the document and send us a new version by late January. Otherwise we will re-examine the current BMP at that time and, if our rapid assessment is correct, are likely to return it for revision before we can comment.
>
> We note the following sections and topics as potentially problematic:
>
> - Poor baseline data is provided with does not clarify biodiversity values
> - Management objectives for biodiversity values are not explicit
> - Quantitative performance measures are lacking
> - Annual quantitative, auditable, SMART targets are absent
> - Risk assessment is lacking or unclear
> - Contingency plans are not fully explained (including explicit triggers if actions or completion criteria are not met)
> - Completion criteria do not detail the quantum of change required over the life of the mine
> - Absence of ecological burning plan over the life of the mine
>
> Please feel free to contact me to discuss this further.
>
> Regards
> Todd

Dr Todd Soderquist

Acting Manager Biodiversity Conservation Unit
Regional Operations Group
Office of Environment and Heritage
NSW Department of Premier and Cabinet
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This email is intended for the addressee(s) named and may contain confidential and/or privileged information.
If you are not the intended recipient, please notify the sender and then delete it immediately.
Any views expressed in this email are those of the individual sender except where the sender expressly and with authority states them to be the views of the Office of Environment and Heritage, NSW Department of Premier and Cabinet.

PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS EMAIL

Maules Creek Coal Project Draft Biodiversity Management Plan
Meeting with OEH regarding Comments on Draft Plan

MEETING MINUTES

Date: 21 January 2013, commencing at 3:30 pm

Venue: Phone Conference.

Attendees:

Todd Soderquist (TS) Office of Environment and Heritage (OEH)
Garry Gerron (GG) – OEH
David Robertson (DR) – Cumberland Ecology
Cecilia Phu (CP) – Cumberland Ecology
Daniel Martin (DM) – Maules Creek Coal
Nathan Cooper (NC) – Hansen Bailey (HB)

Apologies: Nil

Prepared by: NC

---

1. INTRODUCTION

- A summary of actions from these minutes is provided in **Table 3**.
- DR thanked the OEH representatives for their time and explained that the purpose of the meeting was primarily to run through the comments provided by OEH to DM on 21 December 2012 in relation to the Draft Biodiversity Management Plan and ensure that the plan can be revised to address OEHs comments where possible.
- The discussions followed the structure as listed in dot points included within the email dated 21 December.

2. BASELINE DATA

- DR read the comment: ”*Poor baseline data with* {which} *does not clarify biodiversity values*” and explained the baseline data that was collected in September 2011 for the

Maules Creek Biodiversity Offset Properties, including vegetation mapping, fauna surveys, habitat data etc.

- DR further explained that the current Draft Biodiversity Management Plan had considered the completion of pilot studies during the first year of operations to collect any further information that may be required to develop a suitable platform to monitor against throughout the life of the Project. DR explained that such data and the methods used to collect it would be critically reviewed and a formula created (template created) for all subsequent monitoring. DR said that no monitoring data would be provided in the BMP.
- GG and TS agreed and explained that the purpose of the baseline data is to illustrate the principles that will guide the collection of subsequent data about vegetation communities and threatened species. GG went onto explain an example as outlined below.
- GG used Vegetation Communities as the example and explained that the following information could be provided: photos, description of community, habitat attributes, condition class (GG highlighted the Biobanking methodology is the better one to use in their view), resilience of the vegetation community, any other categories, etc.
- GG explained that the above would need to be explained according to a particular management domain.
- DR commented that for the Northern Offset properties (Mt Lindesay and Wirradale) that a lot of information had already been collected and that we had split these properties into management domains. It was the intention of the pilot study to supplement the previous surveys and to set these baselines.
- GG explained a table that could be developed to summarise the baseline values of the biodiversity offset properties.

Vegetation Community	Condition Class (Biobank or some metric)	Description of community	Habitat attributes	GDEs	Tree hollows, etc etc.
Box Gum Woodland					
…					

- GG further highlighted that we need to set out the current values of the offset properties which the targets and objectives of the strategy will be able to achieve into the future.
- GG further explained as an example of the Threatened species known to exist within the offset properties. He explained that we would need to describe: the habitat

requirements for species, including breeding locations, floristic composition etc., nesting locations, foraging locations, etc.

- DR questioned whether we need to describe this across all the offset properties or just generally as attributes across the entire offset properties.
- GG explained that we could explain it across the entire offset properties, however could use specific examples from certain properties to explain the ecological values.
- GG explained that the vegetation communities would need to be by property and highlight the condition classes of the vegetation. Highlighting the condition of the vegetation will identify where further work and conservation will improve the condition of these properties.

3. MANAGEMENT OBJECTIVES

- This section refers to the discussions over the second point within the correspondence dated 21 December, which states: "*Management objectives for biodiversity values are not explicit*".
- GG explained that the purpose of this point is to ensure that the objectives developed for the plan are leading into the improvement of the ecological values of the offset properties. Further that the objectives and targets set for the management plan are measureable and auditable into the long term to demonstrate the improvements over time.
- GG explained that the objectives and targets need to be specific for the life of the mine.
- A possible strategy/goal for vegetation restoration could be to successfully rehabilitate native vegetation communities. The target to achieve could be the restore native vegetation communities to achieve the benchmark data for the particular community by a certain date/link to year of project.
- GG continued to explain that we need to develop performance measures and then complete monitoring consistent with the performance measure.
- GG explained that we need to demonstrate the principles of a system where we can: Describe the Baselines → Set Targets → how to measure performance → reporting on performance.
- TS explained that he understands that we may not have all the data initially for this management plan, however we will need to explain the structure and the high level description of how the system will work.
- DR questioned whether if we include the detail into the management plan that what would be the benefit of including the pilot study.
- TS asked what we meant by a Pilot Study.
- DR explained that due to the extremely large area of offsets required for the Project, that the idea was to explain the values of the overall strategy in one cohesive plan rather than loosing the values within the Biodiversity Management Plan. DR further explained that the Pilot Study would provide a document for reference during ongoing monitoring and standardise the monitoring program.

- TS explained that they would like to see the structure of the general approach and the techniques to be used being described within the management plan, where the Pilot Study will provide the detail on the data.

4. QUANTITATIVE SMART TARGETS

- GG explained that threatened species are able to be quantitatively monitored using number of species identified, biometric tools etc. However there are aspects that are not easily measured, such as how you are going to quantitatively monitor environmental weeds?
- GG explained that the targets that are being measured against need to be SMART targets (i.e. Specific, Measureable, Achievable, Realistic and Timely).
- It was explained that the targets need to be developed at the initial stage, including the process used to measure on an ongoing basis and enable the overall objectives to be achieved.

5. RISK ASSESSMENT AND CONTINGENCY MEASURES

- GG then explained that the possibility of not achieving the targets and objectives should be risk assessed. Risks that may affect the ability of the work program (such as drought, invasive weeds, bushfire etc) to achieve the objectives of the strategy need to be explored. Contingency measures to alleviate the risk need to be identified as well. For example, where tree planting is required, if 75% mortality of plantings occur due to drought, the contingency would be to replant all or part of the area impacted.
- DR agreed that a colour coded risk assessment could be completed using the Australian Standard Risk Matrix. DR questioned whether each property needs to be risk assessed and whether the contingency measures could be in the same table. GG replied that should it become too difficult to combine the risk assessment and contingency measures together that they can be split.
- GG also mentioned about setting interim targets to enable the measurement of progress, particularly for the larger long time items. Further to develop trigger levels should the monitoring show that progress against the targets is not being achieved.
- DR asked whether GG and TS had any examples of any good plans that they could refer us to that efficiently tables what OEH are asking for. TS explained that they did not have any examples, however would get back to us.

6. BUSHFIRE MANAGEMENT

- GG explained that they would like to know more about the long term burning plan to ensure that the offset areas are managed safely whilst ensuring the long term viability of the ecological communities. The plan needs to be developed around the context of

performance measures (i.e. to supplement and maintain performance) and needs to be long term.

- DR explained that we have some high level detail for the Northern Offset properties and have split the properties into management units and we are yet to confirm the location of access tracks that are required throughout the offset properties. This detail would come at a later date and that the Bushfire Management Plan could not be completed until this is finalised.
- TS agreed, but explained that the current draft of the BMP will need to explicitly state that the Bushfire Management Plan will be prescribed within a certain length of time.
- GG explained that the level of detail that DR had explained was what they were looking for the longer term (~12 months time).

7. ADDITIONAL QUERIES

- GG explained that they would request that preclearance surveys be undertaken according to the guidelines that have been put out by the RTA. GG further explained that during the surveys and the identification/capture of any animals should be tracked upon their release to confirm the longevity of these animals.
- DR explained that he was aware of issues relating to the translocation of animals into another area and suggested that the method of release needs to be modified, that rather than capturing them to let them move on to surrounding areas.
- DR stated that this was not feasible to track animals using radio collars that had been captured during preclearance surveys. OEH said that if this was not to be done, a strong justification was to be provided.
- GG explained that we would need to explain how each property was going to be secured into the long term (i.e. what legally binding mechanism would be used).
- GG explained that the education/training of staff and contractors who are to carry out the actions of the plan needs to be specified in the BMP. It needs to indicate the type of contractors and levels of responsibility and frequency of action.
- GG explained the purposes of the action list will be to provide OEH with an indication of the resources that are to be going into the implementation of the plan and the timing that these actions are to be completed.
- GG further explained that we will need to address the reporting requirements under the plan and any legal requirements for reporting. GG mentioned the Annual Review, Project Approval conditions related to biodiversity etc.
- GG also mentioned this section should also indicate the frequency of plan reviews.
- GG indicated that should Cumberland Ecology have any further enquiries to contact him directly.

Meeting close: 4:45pm

8. ACTIONS REQUIRED

Table 1 lists actions by Project, responsibilities and due dates.

Table 1
Actions & Responsibilities

Ref	Details	Who	Due
1.	Review OEHs requirements from email dated 21 December and as discussed during meeting of 21 January and develop a work program to amend management plan to address comments accordingly	DR/CP	30/01/2013
2.	Provide a budget variation for Job 1116 for the update of the management plan according to OEH's comments. Namoi CMA and SEWPaC comments to be provided	DR/CP	30/01/2013
3.	Provide variation request for DM to approve	NC	30/01/2013
4.	Existing BMP is management action focused. To achieve OEHs requirements, the plan needs to be asset (vegetation and threatened species) focused, with the principles of key performance indicators and unambiguous measurable targets throughout	DR/CP	08/02/2013
5.	MNES to be clearly delineated and explained within the revised BMP	DR/CP	08/02/2013

DRAFT

Catchment Management Authority Namoi

Ref No. GAB NAM01766

7 February 2013

Maules Creek Coal Pty Ltd
PO Box 56
BOGGABRI NSW 2382
Attention Mr Daniel Martin, Environment Manager

Dear Daniel

Re Maules Creek Coal Project – Biodiversity Management Plan

Namoi CMA apologises for the late response to the draft Biodiversity Management Plan (BMP). The Plan was received on the 19th December 2012, just prior to the Christmas / New Year holiday break and with absent staff and demands for reviews for other developments and environmental management plans, it has been difficult to meet some deadlines.

As per Project Approval (PA 10_0138) for the above project, Schedule 3 requires Maules Creek Coal Pty Ltd to consult with Namoi CMA under the following conditions:

- Condition 45 - During the preparation of a revised Biodiversity Offset Strategy,
- Condition 48 - Investigate all factors likely to enhance or impede the effective long term restoration of degraded remnants of the Box Gum EEC in offset areas or regeneration of the EEC on disturbed areas (both offset areas and the site),
- Condition 50 - Investigate all factors likely to enhance or impede the effective long term provision of suitable habitat for a number of threatened species, (see Condition 50 in project approval PA 10_0138 for a full list of the threatened species),
- Condition 52 - During the preparation of the Biodiversity Management Plan
- Condition 56 - When undertaking an audit of the revegetation of the rehabilitation, area and the management and restoration within the Biodiversity Offset Strategy areas.

During the project pre-approval phase, Namoi CMA expressed concern with regard to a lack of consideration of the Namoi Catchment Action Plan 2010-2020 and our policies on biodiversity offsets; concerns over the biodiversity assessment; adequacy of offsets and planned security arrangements. Specifically, we expressed concern regarding vegetation condition assessments, regional vegetation community thresholds, net loss of native

All Correspondence - PO Box 546 GUNNEDAH NSW 2380
Tel: 02 6742 9220 - Fax: 02 6742 4022 - Email: glenn.bailey@cma.nsw.gov.au

vegetation, benchmarking and monitoring protocols, land disturbance protocols and agricultural suitability in offset areas.

The following comments are provided with respect to the above conditions and concerns expressed by Namoi CMA. Please note the not all sections of the BMP are commented on, only those where comments are warranted.

Section 1 Introduction

Namoi CMA is aware of the project, structure of the BMP and conditions of approval.

Section 2 Existing Environment and Threats

We are also aware that the project disturbance area is 2178ha including 1665ha of forest and woodland habitat, of which 544ha is Box Gum EEC. Other project impacts include weeds and feral animals.

Section 3 Biodiversity Offset Strategy

Namoi CMA has examined the Biodiversity Offset Strategy and revised Biodiversity Offset Strategy including Tables 3.1 to 3.6 in the BMP. We have always expressed concern that the project would not comply with our Biodiversity Offset Policy in that there would be a net loss of native vegetation from the Catchment, the offset would not be equivalent and there would be time lags with habitat re establishment. We were also concerned with the loss of agricultural land.

Based on Condition of Approval 44 and Tables 3.2 and 3.6 in the BMP, Namoi CMA has attempted to reconcile the land areas within the planned offsets that will be managed for conservation (forests and woodlands), conservation through regeneration (high diversity derived grasslands), conservation through re-establishment (low diversity derived grasslands, etc) and agricultural land. See Appendix 1 for a table that outlines the reconciliation.

Based on the table in Appendix 1, Namoi CMA is satisfied that over 7000ha of existing forests and woodlands will be conserved, while another 4,600ha of derived grasslands will be managed for regeneration and re-establishment of native vegetation. We realise that most of the 4,600ha plus some of the 7,000ha would have been managed in the past for high intensity grazing agricultural land and will in future be managed for woodlands with low intensity grazing. We are satisfied with this level of change in agricultural use.

Furthermore, based on the above we are satisfied that our Biodiversity Offset Policy will be met in that there will be a substantial net gain in native vegetation established even though there are minor lingering concerns regarding equivalence and habitat time lags.

Section 3.5 Vegetation Communities of the Offsets

Namoi CMA is satisfied with the descriptions of the offset vegetation communities in the BMP and their respective classification as Box Gum EEC.

From a Catchment perspective, the Box Gum EEC currently only occupies 27% of its former extent. It is currently under the 30% resilience tipping point and consequently any further

clearing of this community must be avoided and/or mitigated. The project will result in 554ha of Box Gum Woodland being removed which is planned to be offset by 1,486ha of regeneration managed for conservation and 296ha of supplementary planting which will also be managed for conservation. It is realised that the 554ha will also be re-established to Box Gum Woodland in the long term as part of the project site rehabilitation (See Appendix 1).

The areas of regeneration and supplementary plantings represent the real area gain in Box Gum EEC. The 3,545ha of existing Box Gum Woodland does not represent a gain in native vegetation for the Catchment as it already exists and is protected through regulation.

Namoi CMA is satisfied with the proposed regeneration and supplementary planting of Box Gum Woodland ECC even though it does not significantly progress the vegetation community any closer to the 30% resilience threshold.

Section 4 Management Actions: Northern Offsets

Section 4.1 Management Approach

Namoi CMA has examined the management approach and is satisfied with the establishment of core conservation, conservation and commercial areas. It is understood that the grazing will be excluded from the core conservation areas while grazing will be used as a tool to promote regeneration in the conservation areas and conventional grazing will be undertaken in the commercial areas.

Section 4.3 Grazing Plan

Namoi CMA has examined the proposed Grazing Plan for the conservation areas and believes the plan should be more prescriptive to ensure the planned biodiversity objectives are achieved. Many researchers have investigated the best practices to achieve increased biodiversity through grazing with little agreement on a consistent approach.

Namoi CMA has investigated and developed Biodiversity Grazing Management Plans in collaboration with a number of clients over many years. Based on that experience Namoi CMA recommends the following grazing practices to achieve increased biodiversity. We have used the research work by Sue McIntyre and others to assist with the development of our Biodiversity Grazing Management Plans (Dorrough, J., Stol, J. and McIntyre, S. (2008) Biodiversity in the Paddock: a land Managers Guide. Future Farm Industries CRC).

Recommended biodiversity grazing practices:

- Continuous grazing with very light stocking rates (no more than 4 DSE/ha),
- Paddocks should be large at least 100ha, which may require a number of smaller paddocks being managed as one paddock,
- Paddocks should be rested when dry matter levels fall below 2000kg per hectare,
- Paddocks should be rested when groundcover percentage falls below 90%,
- Rest management is triggered by the lowest measurement,
- Stocking rates should be reduced following good summer and autumn rains to allow plants to recover and encourage seedling establishment,

- Stocking rates should be reduced during winter when plant growth rates are slow,
- Properties should be destocked in dry times when the average dry matter levels fall below 2000kg per hectare across the property,
- Rest from grazing is important for providing opportunities for less grazing tolerant plant and animal species,
- Rest from grazing will benefit plants when they are flowering, setting seed and establishing. It is recognised that rest periods can be difficult to coordinate with many native plants flowering, seeding and establishing from early Spring to late Autumn,
- Longer periods of rest should be provided when tree and shrub recruitment is evident,
- Do not use fertilisers in conservation areas,
- Crash grazing should only be used in late summer to early autumn to create gaps for seeds to germinate. Crash grazing should be limited to a maximum of 10days in any paddock,
- Spray and /or remove unpalatable weed species,
- Weed control to be undertaken in such a way to minimise disturbance to native species,
- Livestock to be quarantined in non-weed infested area for 24hours prior to being put in conservation area to minimise the introduction of weed species,
- Livestock are to be excluded by fencing from riparian and sensitive areas.

Namoi CMA realises that many of the above practices are inferred in the grazing plan within the Biodiversity Management Plan, however we believe that more stringent management practices need to be stated in the grazing plan.

Namoi CMA has read the performance indicators, corrective actions and monitoring parameters and is basically satisfied. It is recommended that monitoring be undertaken prior to grazing cycle as well as during and at the end of the cycle.

Section 4.4 Revegetation Plan

Namoi CMA has examined the proposed revegetation plan, objectives, planting plan and methods, performance criteria, corrective actions and proposed monitoring. We are satisfied with the revegetation plan and the proposals to infill plant to improve the regional corridors.

Sections 4.5 Weed Management, 4.6 Feral Pest Management, 4.7 Creek line Stabilisation, 4.8 Fire Management, 4.9 Schedule of Works, 4.10 Tenure and Protection Mechanism, 4.11 Roles and Responsibilities and 4.12 Documentation

Namoi CMA has read and understands these Sections and satisfied with the proposed objectives, implementation, performance indicators and monitoring.

Section 5 Management Actions: Eastern and Western Offsets

Section 5.1 Management Approach

Namoi CMA has examined the proposed management approach for the Eastern and Western Offset areas and is satisfied with the key objectives and the establishment of core conservation areas including riparian areas and significant remnants; conservation areas including existing remnants and grasslands to be revegetated; and the retention of agricultural areas (see Appendix 1).

Section 5.3 Grazing Plan

Namoi CMA agrees with the strategy to exclude livestock from the conservation areas for a period of 5 years to allow these degraded areas to recuperate following long histories of conventional grazing. Also we agree with the proposed management action of permanently excluding stock from the core conservation areas.

It is acknowledged that after 5 years of livestock exclusion then a Biodiversity Grazing Management Plan will commence. Namoi CMA recommends that the same grazing practices as detailed above for the Northern offset area should be adopted for conservation areas in the Eastern and Western Offset areas.

Section 5.4 Revegetation Plan

Namoi CMA has examined the proposed revegetation plan, objectives, planting plan and methods, performance criteria, corrective actions and proposed monitoring. We are satisfied with the revegetation plan and the proposals to enhance and buffer existing remnants, riparian areas and scattered trees.

Sections 5.5 Weed Management, 5.6 Feral Pest Management, 5.7 Creek line Stabilisation, 5.8 Fire Management, 5.9 Schedule of Works, 5.10 Tenure and Protection Mechanism, 5.11 Roles and Responsibilities and 5.12 Documentation

Namoi CMA has read and understands these Sections and satisfied with the proposed objectives, implementation, performance indicators and monitoring.

Section 6 Management Actions: Shared Offset Property

Namoi CMA is satisfied that the management measures proposed for this area will be consistent with measures proposed for the Eastern and Western Offset areas.

Section 7 Flora and Fauna Management in the Project Boundary

It is acknowledged that revegetation principles and practices will be presented in the Rehabilitation Management Plan, which at the time of this review, is in production and not available. Without the Rehabilitation Management Plan it is difficult to provide comprehensive comments on the Biodiversity Management Plan when both plans are inextricably linked.

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Section 7.1 Pre-Clearance and Post Clearance Activities

Namoi CMA has examined the proposed pre and post clearing activities and the land disturbance protocols and procedures and is satisfied with processes that will be adopted.

Sections 7.2 Seed Collection, 7.3 Rehabilitation Works, 7.4 Weed Management Plan, 7.5 Feral Animal Management, 7.6 Other Management Strategies and 7.7 Roles and Responsibilities

Namoi CMA has read and understands these sections and satisfied with the proposed objectives, implementation, performance indicators and monitoring.

Section 8 Monitoring Program

Section 8.1 Purpose

Namoi CMA basically agrees with the monitoring strategy. Monitoring will provide information as to the progress towards ecological restoration while also guiding future management decisions.

We agree that there needs to be baseline monitoring in both the offset properties and within the project boundary, however we have some concerns regarding only monitoring a subset of the conservation management areas and rotating areas for monitoring. We will elaborate further on these concerns in the following sections.

Namoi CMA also agrees that reference sites need to be established to compare progress towards ecological restoration especially for the rehabilitation areas.

Section 8.2 Pilot Monitoring Project

Namoi CMA concurs with the proposal to undertake a pilot monitoring project to determine monitoring point locations, monitoring techniques, replication and data analysis.

Section 8.3 Fixed Monitoring Areas

Namoi CMA has some concerns regarding the establishment of only one fixed monitoring point within each conservation management area.

Based on our experiences and past governmental requirements, Namoi CMA recommends the following with regard to locating fixed monitoring points:

- Within each core conservation area (forest, woodland and riparian areas), 1 fixed monitoring point is to be established within each area. Where there are a number of vegetation communities within an area of core conservation then it is recommended that the fixed monitoring point be established in the dominant vegetation community,
- Within each conservation area (woodland and grassland areas), 1 fixed monitoring point is to be established within each vegetation community. Where there are a number of separate patches of the same vegetation community within the conservation area then it is recommended that a fixed monitoring point only be established in the largest patch,

- Within the undisturbed areas within project boundary (forest, woodland and grassland areas), 1 fixed monitoring point should be established within each vegetation community. Where there are a number of separate patches of the same vegetation community within the undisturbed areas within project boundary then it is recommended that a fixed monitoring point only be established in the largest patch,
- Within the rehabilitated areas, 1 fixed monitoring point should be established within each rehabilitated area.

8.4 Vegetation Condition

Namoi CMA has studied the proposal for the establishment of quadrates and collection of biometric data and is satisfied with the information proposed to be collected and with the quadrate establishment. However, in consideration of the above recommendations for fixed monitoring point establishment it is recommended that an amended assessment methodology be adopted as outlined below:

- Each fixed monitoring point be monitored on an annual basis,
- A full floristic monitoring survey as specified in Section 8.4.5 of the BMP be undertaken in year 1 (baseline), year 5 and ongoing at 5 year intervals at all fixed monitoring points,
- A modified monitoring survey (less floristics) be undertaken in the alternate years, i.e. year 2, 3, 4, 6, 7 etc.

See Appendix 2 for full floristic monitoring survey as per Section 8.4.5 and the recommended modified monitoring survey.

Furthermore, it is recommended that the quadrate be modified so it consists of a base plot measuring 50m x 20m which is dissected by a 50m transect line with each end of the transect line marked with a permanent steel picket. Within the base plot a subplot is established measuring 20m x 20m at the origin end.

Namoi CMA has publicly available regional vegetation community benchmarks which can be used as reference information for comparison and analysis of the vegetation monitoring data collected.

Sections 8.5 Native Fauna, 8.6 Weed Monitoring, 8.7 Feral Animal Monitoring

Namoi CMA has read and understands these sections and satisfied with the proposed purposes and monitoring activities.

Section 10 Revision, Auditing and Reporting

It is a requirement under the conditions of approval that the BMP be revised, audited and reported on at regular intervals.

Under approval Conditions 48-50, Maules Creek Coal Pty Ltd is required to consult with Namoi CMA with regard to the revision and auditing of the BMP and the ongoing management of the Box Gum Woodland and threatened species.

Namoi CMA looks forward to being consulted in the future with regard to the BMP.

Concluding Remarks

Namoi CMA has examined the draft BMP and looks forward to our comments being included in the final copy. If you need further information in regard to the above comments, please contact Glenn Bailey on 6742 9204.

Yours Sincerely



Bruce Brown
General Manager
Namoi Catchment Management Authority

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Appendix 1

Reconciliation of Project Disturbance and Biodiversity Offset Areas

Area	**Property Area**	**Existing Woodland / forest to be conserved**	**Existing high diversity Grassland for regeneration**	**Existing low diversity grassland, pasture and cultivation for establishment**	**Agricultural lands**
Northern Offset Area	6,751ha	4,230ha (2975ha EEC)	1,470ha (1,396ha EEC)	57ha (40ha EEC)	994ha
Eastern offset	4,567ha	526ha (295ha EEC)	0	1,087ha (192ha EEC)	2954ha
Western offset Area including 50% joint venture property	3,778ha	1,234ha (275ha EEC)	148ha (90ha EEC)	524ha (64ha EEC)	1872ha
Eastern Offset area in zone of affectation		336ha		768ha	
Western Offset area in zone of affectation		343ha		156ha	
Additional Offset areas required		500ha		500ha	
Project Disturbance / Rehabilitation area	2,178ha (544ha EEC)			2,078ha (544ha EEC)	
Totals		**7,169ha (3,545ha EEC)**	**1,618ha (1,486ha EEC)**	**3,092ha (296ha EEC)**	**5,820ha**

Notes

1. Table has been derived from table 3.2, 3.6 and B1 in the draft BMP.
2. 2078ha of the project disturbance are will be rehabilitated with 544ha being EEC.

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Appendix 2

Full floristic monitoring survey as specified in section 8.4.5 of the BMP

Within the base plot, measurements are collected and recorded for:

- The relative frequency of occurrence of the tallest stratum (species richness),
- Standing dead timber and cumulative length of fallen logs
- Number and sizes of hollows and the species of tree in which the hollow occurs
- Regeneration of canopy species

Within the sub plot, measurements are collected and recorded for:

- All vascular flora species present,
- The stratum in which each species occurred,

Along the transect line, measurements are collected and recorded at each 5m mark include:

- Groundcover: height, health and projected foliage cover, including
    - Grass cover including perennials vs. annuals, natives vs. exotics
    - Litter
    - Bare ground
    - Mosses and lichens
    - Weeds
- Tallest stratum: height, health and projected foliage cover
- Mid stratum: height, health and projected foliage cover

For each fixed monitoring point, the following information should be collected:

- A waypoint to mark the location of the base plot with the use of a GPS camera,
- Any evidence of disturbance by pest animals
- General comments especially on seasonal conditions, past management, etc
- Proximity to water, rocks, caves and overhangs

Recommended modified monitoring survey; data to be collected:

As above without the sub plot measurements i.e. No recording of the vascular flora species or the stratum in which the species occurs.

Maules Creek Coal Project - Discussion with SEWPAC regarding draft Proposed Decision

MEETING MINUTES

Date: 22 January 2013, commencing 10.30am

Venue: SEWPAC offices, Canberra

Attendees:

- Tessa Bird (TB) – SEWPAC
- Kate Gowland (KG) – SEWPAC (Maules Assessor)
- Peter Irish (PI) – SEWPAC (Maules Assessor)
- Linda ? (L) – SEWPAC (Boggabri Assessor)
- Justin ? (J) – SEWPAC (Boggabri Assessor)
- Brian Cole (BC) – Whitehaven Coal
- Lance Muir (LM) – Maules Creek Coal (Phone in)
- Daniel Martin (DM) – Maules Creek Coal
- David Robertson (DR) – Cumberland Ecology
- Cecilia Phu (CP) – Cumberland Ecology

Apologies: Nil

Prepared by: CP

1. INTRODUCTION

- TB announced that there will be an extension of one week on the date when the assessing team will submit their final recommendation to the Minister. This is not due to any major complications or problems with the Project but is to allow the assessing team to finalise their assessment and complete administrative tasks. This extension date will be posted on the internet and a formal letter of notification will be sent to the Proponent. This will most likely be done this afternoon.

- BC commenced the meeting by stating that the Proponent is generally accepting of most of the conditions in the draft Proposed Decisions but with some small changes. BC stated that the Proponent was interested in not holding up the process but there were some items to discuss.

- TB agreed with BC but noted that whilst the Department was happy to have a discussion about the conditions today, they could not guarantee that any changes discussed would be accepted by the Minister. TB also mentioned that the stakeholder responses and the legal implications of the final Proposed Decision would also have to be considered by the assessing team and the Minister.

- DR asked what the likelihood of a legal challenge was for the Project. TB and KG responded that it is unlikely and difficult for a merit appeal but that a process appeal is possible.

- BC asked what the process for the assessment was from this point onwards. TB replied that if major changes to the draft Proposed Decision was likely, then the Department will reissue a new draft to the Proponent for comment. The final cut off for any comments and responses between the Department and the Proponent is 30th January 2013. If only minor changes were required to the Proposed Decision, then the Department will finalise their recommendations to the Minister without issuing a draft to the Proponent.

- BC asked KG what she thought the key issues are. KG responded that she felt the key issues were (1) the Barrier Coal corridor; and (2) the extent and condition of habitat in proposed offset for trigger species. KG stated that the Department was tasked with providing enough scientific evidence to the Minister to allow the Minister to have confidence that adequate habitat will be provided by the proposed offsets.

- DR asked if key indicators could be conditioned into the Proposed Decision to guarantee that there will be adequate habitat for threatened species. KG said that this is possible but reiterated that the issue is to ensure that the Minister has enough information to confidently sign off on the proposed offset in the first place.

- KG suggested that the conditions be discussed systematically for the remainder of the meeting. KG reiterated that the assessing team could not guarantee or sign off on any changes during the meeting but could provide comments.

2. BARRIER COAL CORRIDOR (CONDITION 3)

- DR explained that the Leard State Forest is a high relief part of the Willow Tree Range. DR explained that in particular, the Barrier Coal corridor is on a high and dry ridgeline and that many native species in the Leard State Forest would most likely be found in the low-lying parts of the forest. He went on to discuss the rationale behind the offset strategy proposal to restore and connect low-lying areas of farmland around the Leard State Forest to each other and to the Namoi River, and that this would provide a better corridor for native fauna in the long term than the Barrier Coal corridor is currently providing.

- DR concluded that the justification behind the State Approval condition concerning the Barrier Coal is to allow some degree of flexibility in the location of the corridor. He then stated that Proponent was not disagreeing with the requirement to establish a corridor, but would like to have the condition changed to be consistent with the State Approval condition, to allow for some flexibility in the ultimate location of the corridor.

- KG said that she wasn't going to dispute the ecology of the issue because she felt that it could result in a protracted discussion back and forth. KG stated that the key factor is the economic value of the corridor. LM and DM stated that the corridor was worth approximately $10 billion in coal revenues. BC estimated that this was about 30% of the value of the Project.

- DR pointed out that of the MNES under assessment by the Department (i.e. Box Gum Woodland, Swift Parrot, Regent Honeyeater and Greater Long-eared Bat) only the Greater Long-eared Bat was considered likely to forage in the habitat within the Barrier Coal corridor and that it is unlikely that the species is dependent on that habitat. Therefore, the question of the Barrier Coal corridor is really a State issue. DR reiterated that regardless, the Proponent is asking for *flexibility* in the condition, not to *remove* the requirement for a corridor.

- TB says the assessing team will consider the discussion put forward in this meeting but notes that the Department has policy considerations to factor in as well. TB mentioned in particular that the Department has difficulty in assessing a Project where the impacts might change (i.e. the Department wants to lock in the Barrier Coal corridor now; the fact that the Barrier Coal corridor may be mined in future if an equivalent future alternative corridor can be found is very difficult for the Department to assess). TB also mentioned that the Department may have differing opinions and interpretations on the habitat requirements of the MNES threatened species in question and may value the corridor differently to what DR explained.

- BC agreed to forward the final PAC report to reiterate some of the responses made previously about the economic value of the corridor. KG assured that the assessing team would be obliged to forward this information onto the Minister as part of their final briefing.

3. ADDITIONAL 500 HA BOX GUM WOODLAND (CONDITION 8)

- KG stated that the Department does not have an opinion on whether the 500 ha like for like Box Gum Woodland is sourced as part of the 1000 ha required by the State Approval conditions or whether it is provided on top of the extra 1000 ha. The purpose of the 500 ha additional like for like Box Gum Woodland is to give the Minister confidence that the impacts to the community can be adequately addressed.

- DR agreed to this in principle but stated that some latitude should be put into the condition to include the restoration of Derived Native Grassland. This would make the condition more realistic and feasible. DR asked that the condition be more specifically worded; for instance, if it could state the minimum area that could be provided as Derived Native Grassland.

- KG generally accepted this reasoning but explained that the Department was cautious because a 20/80 woodland/Derived Native Grassland proposal would be considered unacceptable. KG explained further that the quality and quantity of remnant Box Gum Woodland in the 500 ha is important because the Project is going to have a very large impact on what is a Critically Endangered Ecological Community in the Department's jurisdiction.

- BC stated that he was happy to accept such a condition but notes that DR's comments were important because the condition needs to be achievable. TB agreed that it is the Department's policy that biodiversity offsets need to be feasible and realistic. KG says that the assessing team will review the condition and would be willing to revise it to make it more specific and feasible.

4. FUNDING FOR INDIRECT OFFSETS (CONDITION 10 AND 11)

- TB stated that she would not go into the details of how the Department came up with the funding budget but stated that (a) in principle, indirect funding was required for the Project to demonstrate that there will be an additional gain; and (b) the amount of funding was generally based on the Department's prior experience and what they anticipated was required to deliver outcomes consistent with the recovery objectives in the respective National Recovery Plans.

- TB and KG agreed that they would be willing to change the timeframes to 24 months to be consistent with the State Approval conditions.

5. DATES OF MONITORING (CONDITION 14)

- KG stated that it was acceptable to collect data at different times of the year to account for seasonal surveys and was willing to review the wording of the condition.

6. FUTURE DEVELOPMENT OF PROPOSED OFFSETS (CONDITION 15)

- TB stated that the genesis of this condition was the eastern offsets. There were concerns that the some properties would be proposed for mining in future e.g. the Morse property. TB stated that regardless, NSW offsets are generally not very secure and so this condition would add extra certainty to the proposed offsets.
- TB explained that the ratio of 20:1 is based on precedence.
- TB also mentioned that if another proponent proposes to develop the Project's offsets, then Maules Creek Coal would be liable for the 20:1 offset penalty.
- KG questioned whether land within mining or exploration leases should even be turned into offsets.
- DM asked about a hypothetical scenario where the Proponent puts forward an offset and then a mining / exploration lease is established over the land at a future date. DM asked whether the Proponent be penalised in this instance. TB replied that the Proponent will still be penalised in this instance.
- DR disagreed that the original Proponent should be responsible for another Proponent's proposal to develop their offset.
- TB stated that for this condition, it stands that the Proponent shall be responsible for the 20:1 future offset if the existing offset for the Project is developed, regardless of who the Proponent is.

7. AUDITING AND REPORTING (CONDITION 28-33)

- DM requested that the conditions be revised to be consistent with the State Approval conditions to streamline the auditing and reporting process with the State requirements.
- KG stated this is ok, on the proviso that they check with the Department's auditing department.

8. DEFINITIONS

- KG will review and check for inconsistencies and typos.

9. CLOSING

- BC will forward final PAC report to KG to restate the responses made about the economic value of the Barrier Coal corridor.
- KG will return comments in next couple of days.

- TB reiterated that the notice of extension will be on the website this afternoon and a formal notice sent to the Proponent.
- KG confirmed that she received the draft BMP before Christmas but has not read them yet. PI will get review comments back to DM when they are ready.
- DR noted that a discussion with OEH was undertaken the day before and that changes will be made to address OEH's comments. DR suggested that a copy of the meeting minutes is made available to KG so that the Department could streamline their comments. KG agreed.
- KG said that a clear statement is needed upfront in the BMP about the MNES that are involved, particularly for vegetation communities. This is because the Department still gets confused about equivalency in regional community names, what is EPBC listed and what is not.

Meeting close: 12.00pm

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Minutes of the 1st Meeting of the Maules Creek Coal Community Consultative Committee

Meeting Held: 7th June 2013, 9:30am

Venue: Maules Creek Coal, Finance Office Boardroom, Boggabri

Prior to commencement of the meeting, Daniel Martin advised that Mr John Turner had been approved by the Department of Planning and Infrastructure as an Independent Chair for the Maules Creek Coal Community Consultative Committee.

Present:
Mr John Turner, Chair for CCC
Mr Rod Woolford, Community Rep
Mr Peter Watson, Community Rep
Clr Lloyd Finlay, Narrabri Shire Rep
Mr Daniel Martin, Environment & Heritage Manager
Mr Craig Simmons, Area Manager Services
Mr Brian Cole, Executive General Manager – Project Delivery
Ms Kelly Browning, Work Health & Safety Officer

Apologies:
Mr Jason Davis, Community Rep
Ms Carolyn Nancarrow, Community Rep
Ms Toni Comber, Community Rep
Mr Chris Andrew, Community Rep

1. Introductions

Daniel Martin gave thanks to the persons past and present of the land in which we meet (Gomeroi People).

Participants introduced themselves and gave some personal background.

John gave a brief overview on the Guidelines for establishing and operating community consultative committees for mining projects issued by the NSW Government Department of Planning in June 2007 (a copy was provided to all present). The purpose for the committee is to provide a forum for the community and Maules Creek to exchange information and to engage in consultation on matters affecting the community.
John requested that the representatives of the community should liaise with the community and bring topical items to the CCC for discussion.

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John also asked that members who may have concerns of a personal nature about mining operations affecting them or their property, that they bring those concerns, other than where the wider community might also be interested, to the mining company personally.

In the introductions, Peter Watson made the following points:- he wanted to see that the mine did not affect farming and vice versa. He also stated that he was disappointed that MCC had appointed a chair from outside the area whom was a fly in fly out and not a local.
John Turner advised that the Chair was decided by the DG of Planning and Infrastructure not Maules Creek Coal.

2. Project Background and Project Ownership

Craig Simmons gave a brief overview about the history to the Project.

Mining authorities originally granted in the 1970s. An extensive exploration program was undertaken at the time and a development consent was granted in June 1990. Coal & Allied could have started in 1990 but due to company reasons did not. The original consent would have been valid for 21 years. Aston Coal purchased the project from RTCA in early 2010. The project was 100% owned by Aston, over the last 3 years Aston has sold a 15% share to Itochu Coal Resources Australia (ICRA MC) and another 10% share to J-Power Australia. The project ownership now stands as 75% owned by Aston Coal 2 Pty, 15% ICRA MC and 10% J-Power Australia.

Whitehaven Coal merged with Aston on April 2012 acquiring a share component of the Maules Creek Coal Project. Aston Coal 2 is now a wholly owned subsidiary of Whitehaven Coal

The Maules Creek Coal Project Approval (PA10_0138) was received on 23 October 2012.

3. Project Update

Maules Creek Coal Pty Limited is seeking contemporary project approval under Part 3A of the EP&A Act to allow for the development of a 21 year open cut coal mining operation and associated infrastructure. The key infrastructure items include:

- CHPP with capacity of 13 Mtpa ROM Coal
- Tailings Processing
- Rail Spur, rail loop & load out facility
- Mine access road
- Administration, workshop & related facilities
- Water pipeline & Pumping Station

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- Supporting power and communications infrastructure.

A portion of the Rail Spur will be constructed as part of the Boggabri Coal Expansion approval which was received in July last year. Through consultation and DoPI direction, they did not want to see 2 rail spurs in close proximity across the Namoi River so the first portion of the Rail Spur will be shared infrastructure for Maules Creek and Boggabri Coal.

Peter Watson raised the issue of the design of the rail viaduct. Craig indicated that approval of the design primarily rests under Boggabri Coal's approval. Peter noted that the design has never been made public and that he would like to see some design drawing. Craig said he would seek some information on the design from Boggabri Coal and discussion further with Peter.

A map of the construction activities prior to production was provided to attendees.

The project approvals can be viewed on the company website and approved management plans will be added progressively.

There is a current EPL held for the project.

Approval of management plans are at a stage where construction can commence. Maules Creek Coal is still in discussion with SEWPaC regarding some conditions. Construction is expected to commence in July/August 2013 with construction for approximately 12 to 15 months and the Open Cut to start approximately 3 to 4 months prior to the end of construction.

Construction of the Accommodation Camp has commenced just outside of Boggabri. The MAC Group are constructing this and Maules Creek Coal has rooms allocated.

Following the project update the Chair called for questions.

Peter Watson asked what impact the rail will have on the flood plain and is there a plan available? Where do the community go to obtain this information?

Craig Simmons advised that construction of the rail across the flood plain is covered under Boggabri Coal's project approval, and there is a joint venture in place between Boggabri Coal and Maules Creek Coal to cover commercial arrangements. The design has been subject to extensive flood studies and will be approved by the appropriate agencies.

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Peter Watson enquired whether Maules Creek workers will be utilising the Boggabri or the Narrabri MAC Camp.

Craig Simmons advised that Maules Creek will utilise both camps. It was also stated that during construction Maules Creek is urging contractors to utilise as many local workers as possible, and the MAC accommodation is for the workers with skill sets not readily available in the local community.

Peter Watson asked what the directions for the Narrabri MAC Camp were for traffic. Craig advised that the access to site will be via the Kamilaroi Highway, and over the iron bridge on to Manilla and Therribri Roads, with vehicles over the weight restriction of the iron bridge would utilise Bluevale Road, North of Gunnedah. The Traffic Management Plan will be lodged on the company website and will available for public view. Under the TMP plan most of the workers on site will be transported by bus along designated routes as approved in the Traffic Management Plan.

Peter Watson has been approached by a member of the community (southern side of project) who is concerned about the heavy vehicle in front of his property (dust and impact on the gravel road).

Craig advised that it is a condition for the project that the unsealed section of Manilla Road is to be sealed. Planning for the sealing has commenced.

Peter Watson enquired whether all light vehicles will be using Leards Forest Road and not Therribri Road.

Craig advised that the majority of construction traffic will be via Leards Forest Road and only minimal construction traffic on Therribri Road until the mine access road is commissioned.

Peter Watson asked if the VPA was up for discussion as he understood that it was confidential.

Craig advised that the VPA is not a confidential document and it is included as an appendix in the Project Approval which is available on the company website

Lloyd Finlay also advised Peter Watson that you may request a copy of the Maules Creek VPA at Council

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4. Biodiversity Management Plan

Daniel Martin gave a presentation of the key points from the Biodiversity Management Plan.

See attachment

Questions

Q. Rod Woolford – Is Maules Creek going to employee people for trapping animals like Boggabri?

A. Daniel Martin – The Maules Creek Trapping and Tracking Program, is similar to Boggabri Coal's..

Q. Rod Woolford – Is Maules Creek going to adopt similar practices to Boggabri Coal in regards to rehabilitation? (Point being that Boggabri Coal mulches its timber and mixes it into the top soil and the result is good.)

A. Daniel Martin – Maules Creek have a Rehabilitation Management plan in the draft/consultation phase with DRE. Yes, Maules Creek will adopt similar practices for rehabilitation. Maules Creek is currently in consultation with Boggabri Coal regarding their processes and who they use for their rehabilitation and mulching of timber.

Q. Rod Woolford – Have feral cats been considered to be included in the control of feral animals?

A. Daniel Martin – Yes, and will be included in the BMP.

Q. Lloyd Finlay – Who will maintain Leards forest road?

A. Craig Simmons – Maules Creek's will deal with impacts due to its traffic movements.

Q. Peter Watson – are the Offsets for grazing or for protection of vegetation?

A. Daniel Martin – There are some for both purposes. Grazing management is a tool that can be used with offset management in vegetated areas. The Biodiversity Management Plan shows the different areas for grazing cycles and offset management

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Q. Peter Watson – Agree that grazing can assist with regeneration.

A. Daniel Martin – We invite input from the farming community on what practices have proven to be effective.

Q. Lloyd Finlay – Where Maules Creek leases a property it owns, does Maules Creek take responsibility for control of weeds and feral animals.

A. Daniel Martin – ultimately yes but the lessee will have clear responsibilities under their lease arrangements.

Q. Peter Watson – Under the conditions Maules Creek will be purchasing more offset country?

A. Daniel Martin – Regional Biodiversity Strategy is being developed through consultation with other mines in the precinct and State and Federal agencies. That strategy when developed will guide the purchases.

Q. Peter Watson – Is the rehabilitation of the mine site part of the offsets strategy?

A .Daniel Martin – Rehabilitation of the mine site is heavily regulated under the Rehabilitation Plan and the Mine Operations Plan. Maules Creek has submitted a draft plan to DRE for consultation..

Daniel Martin made note that he has heard back from some of the other CCC members that could not attend this meeting and they had no major comments on the BMP at the time.

Craig Simmons – Management Plans including the BMP are live documents. They will be implemented and monitored and any changes will be reviewed by Government Departments. Trials will be implemented and best practises adopted so it will evolve. This will take place in consultation with the various agencies and the community.

5. General Business

Peter Watson – Would like to have the BMP on the agenda at the next meeting as well.

Biodiversity Management Plan will stay on the agenda for future meetings as it is an important issue

If anyone would like any other items added to the agenda they should contact Daniel Martin by phone or email

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Lloyd Finlay – Can meetings be in the late afternoon,

Daniel Martin will liaise with all members as to suitable times and will advise of a meeting timetable in advance with minimum 4 weeks' notice and will provide an agenda at this time.

Minutes will be developed by the company and sent to John Turner. John Turner will contact committee members for comment on minutes prior to them being uploaded to the internet.

Daniel Martin will send John Turner the committee members contact details and email Peter Watson when Management Plans are uploaded to the internet.

Daniel Martin asked committee members if they are happy for their names and email addressed to be displayed on the Maules Creek Environmental internet page so members of the community can contact them. All in attendance agreed this was a good idea. Daniel to check with members that did not attend this meeting

John Turner – Is everyone satisfied with the arrangements

Attendees – Yes

Rod Woolford – What is the process for letting the community know about what happened at this meeting?

John Turner noted that no one can put out anything on behalf of the committee however you can personally comment.

Craig Simmons – Whitehaven will put out a press release about the first MCC CCC meeting and its purpose, and that minutes of the meeting will be available on the company website.

John Turner requested site visit for next meeting.

Meeting Closed: 11:20am

Craig Simmons

Subject: FW: Maules Ck BMP, consultation

From: Renee Shepherd [mailto:Renee.Shepherd@environment.nsw.gov.au]
Sent: Monday, 17 June 2013 11:59 AM
To: Craig Simmons
Cc: David Coote
Subject: RE: Maules Ck BMP, consultation

Hi Craig,

As discussed a couple of weeks ago on site and as per the phone message that I have just left with you, OEH wishes to see consistency between the Boggabri BMP and the Maules Creek BMP given the proximity of the mines and the current absence of the Regional Biodiversity Strategy.

The statement that you have suggested in the email to Dave Coote is consistent with the Boggabri BMP and is therefore accepted by OEH, with one minor amendment:

"Where fauna has been identified and captured for relocation prior to Stage 2 clearing, radio tracking may be used for fauna being relocating into alternate targeted habitat areas. Radio tracking trials and surveys of relocated fauna will be conducted across a number of fauna species as an additional means to measure the success of the relocation program, following further consultation with OEH. Data will be collected and the results analysed. Based on the data analysis from these trials and surveys, updates may be required to the relocation methods. The results and any proposed changes to trials and surveys will be done in consultation with OEH."

If you have any questions about this please feel free to contact me.

Regards,
Renee.

Renee Shepherd
Regional Operations Group
Office of Environment and Heritage
NSW Department of Premier and Cabinet
PO Box 2111, Dubbo, NSW 2830
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Please note that I work on Mondays and Tuesdays

APPENDIX B

THE BIODIVERSITY OFFSET STRATEGY

B.1. Summary of the Maules Creek Coal Project Biodiversity Offset Strategy

The Project's Biodiversity Offset Strategy is summarised in Condition 44, Schedule 3 of PA 10_0138 and Condition 9 of the Approval Decision EPBC 2010/5566. The Offset Strategy is reproduced below in **Table B. 1** and **Table B. 2**.

The Offset Strategy is intended to complement Boggabri Coal's Biodiversity Offset Strategy to provide a network of conservation areas around the Leard State Forest and form linkages to the Nandewar Ranges, Leard State Conservation Area and the Namoi River, as shown within **Figure B. 1**.

Table B. 1 Summary of the Biodiversity Offset Strategy (Condition 44, Schedule 3 of PA 10_0138)

Area	Offset Type	Minimum Size (ha)
Northern Offset Area currently owned or under option by Proponent	Existing native woodland / forest of 4,286 ha to be protected and enhanced. Additional native vegetation to be established with the restoration of at least 1,470 ha of derived native grassland including 1,396 ha of derived native grassland Box Gum Woodland EEC as listed under the TSC Act. Additional targeted restoration of up to 58 ha of low diversity derived native grassland, pasture improved and cultivated land to provide buffer to offset and connectivity between remnant vegetation. *Note: the final area of restoration of low diversity derived native grassland, pasture improved and cultivated land is subject to completion of the revised offset strategy required in condition 45*.	5,756
Eastern Offset Area currently owned or under option by Proponent	Existing native woodland / forest of 190 ha to be protected and enhanced. Additional targeted restoration of up to 319 ha of adjacent low diversity derived native grassland, pasture improved and cultivated land to provide buffer to offset and connectivity between remnant vegetation. *Note: the final area of restoration of low diversity derived native grassland, pasture improved and cultivated land is subject to completion of the revised offset strategy required in condition 45.*	190
Western Offset Area including 50% Joint Venture property currently owned or under option by Proponent	Existing native woodland / forest of 891 ha to be protected and enhanced. Additional native vegetation to be established with the restoration of at least 148 ha of derived native grassland including 90 ha of derived native grassland Box Gum Woodland EEC as listed under the TSC Act and existing 7ha of Belah Woodland on property 'Velyama' to be enhanced with restoration of at least 5ha of surrounding derived native grassland to Belah Woodland. Additional targeted restoration of up to 368 ha of adjacent low diversity derived native grassland, pasture improved and cultivated land to provide buffer to offset and connectivity between remnant vegetation.	1,039

Area	Offset Type	Minimum Size (ha)
	Note: the final area of restoration of low diversity derived native grassland, pasture improved and cultivated land is subject to completion of the revised offset strategy required in condition 45.	
Eastern Offset Area identified in the zone of affectation	Existing native woodland / forest of 336 ha to be protected and enhanced. Additional targeted restoration of 768 ha of adjacent low diversity derived native grassland, pasture improved and cultivated land to provide buffer to offset and connectivity between remnant vegetation. *Note: the final area of restoration of low diversity derived native grassland, pasture improved and cultivated land is subject to completion of the revised offset strategy required in condition 45*.	336
Western Offset Area identified in the zone of affectation	Existing native woodland / forest of 343 ha to be protected and enhanced. Additional targeted restoration of 156 ha of adjacent low diversity derived native grassland, pasture improved and cultivated land to provide buffer to offset and connectivity between remnant vegetation. *Note: the final area of restoration of low diversity derived native grassland, pasture improved and cultivated land is subject to completion of the revised offset strategy required in condition 45.*	343
Additional offset areas required to be included by the Proponent –	Additional remnant native vegetation of moderate to good condition native forest / woodland and derived native grassland to provide habitat for impacted threatened species, targeting EEC or highly cleared vegetation communities impacted by the project. *Note: Location and type of offset subject to final approval as part of revised Biodiversity Strategy to be prepared by Proponent under condition 45.*	1,000
Rehabilitation Area	Except for the area of the minimised final void, pre-mining native vegetation communities to be re-established (including 544 ha of Box Gum Woodland EEC) for a biodiversity conservation land use objective, with the area subject to finalisation of the rehabilitation management plan as required under this approval. *Note: the final mix and area of native vegetation communities is subject to the approved Biodiversity Management Plan.*	2,078 (less the area of the minimised void approved under the closure plan required under this approval)

Table B. 2 Summary of the Biodiversity Offset Strategy (Condition 9, Approval Decision EPBC 2010/5566)

Condition	Requirement
Offset Management Plan	
Condition 9	The person taking the action must register a legally binding conservation covenant over offset areas of no less than a) 9,334 ha of equivalent or better quality of habitat for the regent honeyeater, swift parrot and greater long-eared bat; and b) 5,532 ha of an equivalent or better quality of the White Box - Yellow Box - Blakely's Red Gum Grassy Wooedland and Derived Native Grassland ecological community. *Note: the 5,532 ha of White Box - Yellow Box - Blakely's Red Gum Grassy Wooedland and Derived Native Grassland ecological community may be included within the 9,334 ha of offset area for the threatened species if it meets the listing criteria for the EPBC-listed critically endangered ecological community as definied in rthe EPBC listing advice for that community and the requirements of condition 9.*

Coordinate System: MGA Zone 56 (GDA 94)

Grid North

Harparary Road
Ellerslie Road
MAULES CREEK
BACK CREEK
MAULES CREEK
Therribri Road
Leard State Conservation Area
NAMOI RIVER
Kamilaroi Highway
Leards Forest Road
Leard State Forest
A1
A2
A3
A4
A5
A6
A7
A8
B1
B2
B3
B4
B5
B6
B7
B8
B9
B10
C1
C2
C3
D1
D2
D3
D4

Legend

- Project Boundary
- Mining Tenement Boundary
- Eastern and Western Offset Management Zone
- Boggabri Coal Biodiversity Offsets
- Mine Disturbance Boundary
- Conservation Areas
- State Forest
- River
- Road

Management

- Habitat Management
- Habitat Restoration
- Corridor Establishment
- Other Land and Agriculture

Source Image: © 2010 Cnes/Spot Image
Image © 2010 DigitalGlobe

Source Data: NPWS, 2010;
Boggabri Coal

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I:\...\9125\Figures\BMP_20111117\

2000 0 2000 4000 6000 8000 m

Figure B.1. Maules Creek and Boggabri Coal Offsets in the vicinity of Leard State Forest

APPENDIX C

EVALUATION OF THE BMP WITH EPBC ACT THREATENED SPECIES RECOVERY PLANS & CONSERVATION ADVICE

Table C. 1 Analysis of BMP Objectives Against Recovery Objectives for Box Gum Woodland

Recovery Objectives	Response
The overall objective of this recovery plan is to promote the recovery and prevent the extinction of the critically endangered ecological community, known as Box-Gum Grassy Woodland.	The BMP aims to protect areas of existing Box Gum Grassy Woodland on the offset properties and to recover areas of Derived Native Grassland to woodland.
The specific objective to be achieved within the life-span of this recovery plan is to minimise the risk of extinction of the ecological community through:	
• *achieving no net loss in extent and condition of the ecological community throughout its geographic distribution;*	The BMP prescribes measures that will *protect and restore* Box Gum Grassy Woodland such that in the long term, there will be a ratio of 8.6 hectares of Box Gum Woodland conserved to every hectare of Box Gum Woodland that will be removed by the Project.
• *increasing protection of sites in good condition;*	The BMP prescribes measures for the protection of good quality Box Gum Woodland and diverse Derived Native Grassland in the Northern Offsets. The BMP prescribes measures to protect Box Gum Woodland in the fertile areas of the landscape in the Eastern and Western Offsets.
• *increasing landscape functionality of the ecological community through management and restoration of degraded sites;*	The BMP aims to restore areas of Derived Native Grassland to woodland. One of the BMP objectives is also to rest and recover areas of low diversity native grasslands to return them to diverse Derived Native Grassland and subsequently restored to woodland.
• *increasing transitional areas around remnants and linkages between remnants; and*	The BMP aims to establish vegetated corridors and increase existing patch sizes to improve the landscape connectivity, particularly around Leard State Forest.
• *bringing about enduring changes in participating land manager attitudes and behaviours towards environmental protection and sustainable land management practices to increase extent, integrity and function of Box-Gum Grassy Woodland.*	The BMP clearly states for the benefit of land managers who will implement the plan that the intent of the BMP is to conserve and improve the extent of Box Gum Woodland on the respective properties.
This objective will be achieved across the geographic distribution of Box-Gum Grassy Woodland and within five years of the adoption of this recovery plan.	Not applicable to this analysis.

Recovery objectives from DECCW (NSW) (2010)

Table C. 2 Analysis of BMP Objectives Against Recovery Objectives for Swift Parrot

Recovery Objectives	Response
To prevent further decline of the Swift Parrot population.	The implementation of the BMP cannot achieve this in itself. However, the BMP is generally consistent with this objective, as it will contribute to the recovery of the species by protecting and improving foraging habitat for the species.
To achieve a demonstrable sustained improvement in the quality of swift parrot habitat to increase carrying capacity.	The BMP aims to increase and improve the existing area of habitat for Swift Parrot in the offset properties. The BMP prescribes regular monitoring to assess and quantify the improvement in Swift Parrot habitat.

Recovery objectives from Saunders and Tzaros (2011)

Table C. 3 Analysis of BMP Objectives Against Recovery Objectives for Regent Honeyeater

Recovery Objectives	Response
1. To ensure that the species persists in the wild.	The BMP aims to assist the conservation of the species in the wild by protecting and improving habitat for the species in a well documented part of its range.
2. To achieve a down-listing from nationally endangered to vulnerable by stabilising the population decline and securing habitat extent and quality in the main areas of occupancy.	The BMP aims to assist the conservation of the species in the wild by protecting and improving habitat for the species in a well documented part of its range.
3. Achieve increasing reporting rates (5% per annum) in areas previously used regularly, eg Munghorn Gap (NSW), Bendigo, north-east Melbourne and the Eildon area (VIC).	Not applicable.

Recovery objectives from Menkhorst et al. *(1999)*

Table C. 4 Analysis of BMP Objectives Against Recovery Objectives for Greater Long-eared Bat

Recovery objectives	Response
Increase understanding of the basic ecology of the species to determine:	The species will be monitored in the offset properties and this will provide additional information about habitat utilisation, including potential roosting or breeding. Revegetation of the offset properties will provide information about how the species recovers from historic habitat clearance, which is a key threatening process.
• *habitat requirements;*	
• *roost and maternity site selection; and*	
• *threatening processes.*	
Clarify the current distribution and abundance of the species.	Monitoring will provide further information about the distribution of the species in the locality.

Recovery objectives from SEWPaC (2011a)

APPENDIX D

BASELINE FLORA AND FAUNA SURVEY METHODS AND DATA

D.1 Introduction

Flora and fauna field surveys were undertaken in September 2011 of the Eastern, Western and Northern Offset properties. This Appendix provides a description of the methodologies used and figures of the sampling locations within these properties. The results of the field surveys are also summarised in tables at the end of this Appendix.

The purpose of the field studies was primarily to collect baseline flora and fauna data from the offset properties and to develop a detailed vegetation map. Of particular focus were fauna groups of relevance to the Project Boundary (i.e. birds, bats) and vegetation conforming to Box Gum Woodland and Derived Native Grassland listed as threatened under both the State and Commonwealth legislation.

Another objective of the additional field studies included collecting data on site specific management issues (e.g. major problem weeds, access, track establishment where required, fencing requirements etc) that would assist in the preparation of the BMP.

D.2 Methods

The existing body of information regarding potential and actual threatened species occurrences in and around the offset properties form a valid component of the baseline information. As such, a review of past surveys of the offset properties (where available) and surrounding land were completed. Threatened species records available from government databases were also examined.

D.2.2. Literature Review

The Leard State Forest and its surrounds have been subject to detailed flora and fauna studies since the late 1970s and are relevant to the Eastern and Western Offset properties. Earlier studies by James B. Croft & Associates (1979) and Dames and Moore (1983; 1984) were considered when assessing the potential occurrence of threatened species in the Eastern and Western Offset properties.

There has also been considerable ecological survey effort within the locality of Leard State Forest in recent times for baseline data by Government and Industry. The contemporary studies completed within Leard State Forest and within the Leard State Conservation Area include those completed by Hunter (2007), ELA (2010), Parsons Brinckerhoff Pty Ltd (2010), Cumberland Ecology (2011) and OEH (NSW) (2011a).

For the Northern Offset properties, we reviewed information regarding the flora and fauna of the Barraba area and Mount Kaputar National Park (2006).

D.2.3. Database Analysis

Threatened species records obtained from the Atlas of NSW Wildlife database (OEH (NSW), 2011b) were examined for an area within a 10 km radius of the offset properties to gain an understanding of the known distribution for species relevant to the Project.

Protected Matters predicted for the offset areas were obtained using the EPBC Protected Matters Search Tool (SEWPaC, 2011b). The Protected Matters Search Tool provides a list of MNES that are predicted to occur based on the presence of suitable habitat, which was useful for informing threatened species searches during field survey.

D.3 Survey Properties and Field Survey Dates

The proposed offset properties that were subject to survey include some of those listed in **Table D. 1** below. The surveys were conducted over two sessions: 12-16 September, 2011; and 26 September-1 October, 2011.

Table D. 1 Properties Subject to Further Field Investigation

Offset Area	Property	Area_ha
Eastern	Blue Range	748.07
	Cattle Plain	284.08
	Teston (north)	292.26
	Tralee	342.14
	Wallandilly	1889.62
	Warriahdool	1010.53
Shared	Shared Offset	884.29
Western	Kelso	507.82
	Louenville	458.89
	Olivedeen	193.37
	Teston (south)	1272.50
	Velyama	919.50
Northern	Mt Lindesay	2429.81
	Wirradale	4321.22

D.4 Flora Surveys

D.4.1. Quadrat Sampling

A total of 43 quadrats were sampled in 20 m x 50 m plots to maintain consistency with the dataset collected from the Project Boundary. The locations of these quadrats were chosen so that sampling was conducted in areas most representative of the condition and composition of the vegetation patch (where access permitted). These quadrat locations are shown in **Figure D. 1** and **Figure D. 2**. In each quadrat, the following information was recorded as a minimum:

- All vascular flora species present within the plot or directly adjacent to the plot;
- The stratum in which each species occurred;
- The relative frequency of occurrence of each plant species;
- Vegetation structural data (i.e. height and percentage cover of each stratum);
- The proportion of weeds in each stratum as a percentage cover;
- A waypoint to mark the location of the quadrat, using a handheld Geographical Positioning System (GPS); and
- Photographs of the quadrat.

The relative abundance and cover of each species within the quadrat was approximated using a scoring system based on the Braun-Blanquet scoring system (Braun-Blanquet, 1927) (Braun-Blanquet, 1927). The scores used are provided in **Table D. 2**.

Table D. 2 Modified Braun-Blanquet Scores

Class	Cover-abundance	Notes
+	Rare (less than 1 % cover)	Herbs, sedges and grasses: within 4 m2
		Shrubs and small trees: less than 5 individuals.
1	Few Individuals (less than 5 % cover)	Herbs, sedges and grasses: within 20 m2
		Shrubs and small trees: 5 or more individuals
		Medium - large overhanging tree.
2	5 - less than 25 % cover	-
3	25 - less than 50 % cover	-
4	50 - less than 75 % cover	-
5	75 - 100 % cover	-

D.4.2. Rapid Grassland Plots

A total of 16 rapid grassland plots were collected to supplement the quadrat dataset. The purpose of collecting rapid plots was to maximise the sampling coverage of large areas of grassland as much as possible in a limited survey timeframe.

Rapid grassland plots were sampled within 20 m x 50 m quadrats exclusively in grassland units dominated by grass species (i.e. shrublands and herbfields would be excluded from rapid sampling if they were present). As a minimum, the following were recorded:

- All vascular species in the ground stratum;
- Percentage ground cover;
- Percentage cover of litter, moss and bare ground;
- The proportion of weeds in the ground stratum as a percentage cover; and
- A waypoint to mark the location of the quadrat, using a handheld GPS.

Although the data collected from rapid plots cannot be analytically compared to the remaining dataset, they provide enough information to determine the condition and composition of grassland areas at their respective locations.

D.4.3. Groundtruthing Transects

The following methods of ground-truthing were undertaken as part of the vegetation mapping exercise:

- Meander transect surveys to obtain information on community distribution in the Project Boundary and surrounds; and
- Detailed walks of vegetation units and recording boundaries using a handheld GPS unit.

The resultant information was synthesised using Geographical Information Systems (GIS) to create a spatial database that was used to interpret and interpolate the data to produce a vegetation map of the offset properties.

Aerial, topographical and geological data were also used to interpret the survey data. Mapping was completed using MapInfo Version 10.5 (Pitney Bowes Software Inc., 2010)(Pitney Bowes Software Inc., 2010) on a Windows XP platform.

D.4.4. Assessing Condition of Box Gum Woodland

The condition classes described in the EPBC Act Listing Advice (Threatened Species Scientific Committee, 2006) was used to map the condition of Box Gum Woodland and Derived Native Grasslands occurring in the offset areas:

- 'A' – An overstorey of eucalypt trees exists, but there is no substantial native understorey;
- 'B' – A native understorey exists, but the trees have been cleared; and
- 'C' – Both a native understorey and an overstorey of eucalypts exists in conjunction.

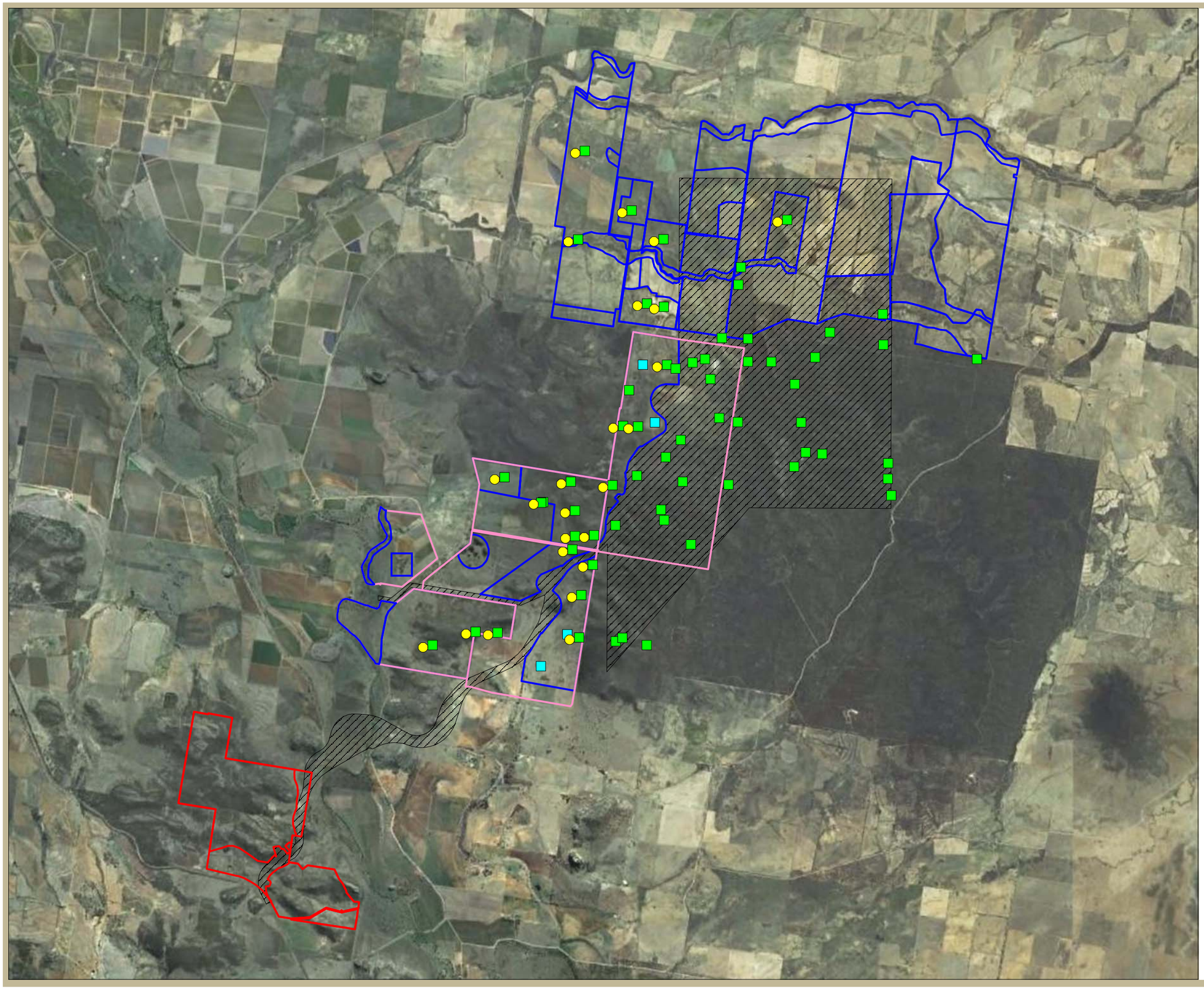
Reference to the identification guidelines published by the NSW National Parks and Wildlife Service was also made (NPWS (NSW), 2005) (**Table D. 3**). Condition class 1 and 2 shown in the table below is considered to be equivalent to the EPBC Act condition class C; condition classes 3 and 4 are considered to be equivalent to the EPBC Act condition class B; and condition class 5 is equivalent to EPBC Act condition class A.

Table D. 3 Identification Guidelines for Box Gum Woodland based on Condition (NPWS (NSW), 2005)

Condition Class	Description
1. Multi-aged overstorey with a grassy herb-rich understorey	Remnants in this condition are very scarce and are generally confined to travelling stock reserves, roadside vegetation, cemeteries, some national parks and the occasional private property
2. Partially cleared/thinned stands with a mixture of native and exotic understorey species	This condition is far more common than the above; however its long-term future is often insecure due to inadequate regeneration of overstorey species. Often current management (e.g. set-stocking) is inconsistent with tree regeneration.
3. Stands where White Box, Yellow Box or Blakely's Red Gum have been killed and other species dominate the canopy	This condition occurs where the characteristic trees occur in conjunction with White Cypress Pine. The understorey is often in reasonable to very good condition.
4. Grasslands (secondary or derived grasslands), where the tree overstorey has been removed and only the Box-Gum Woodland understorey is present	This condition is likely to be reasonably common in some areas and is likely to be relatively easy to rehabilitate if appropriate management strategies are implemented.
5. Degraded remnants that have few, if any, native species in the understorey	This condition is typical of Box-Gum Woodland where agricultural practices have been more intensive (e.g. pasture improvement over long periods).

SEWPaC considers condition class B vegetation to be of low to moderate condition representatives of the ecological community and class C to be a good condition representative of the ecological community. Condition class 5 and condition class C vegetation do not meet the EPBC Act definition for Box Gum Woodland and Derived Native Grasslands, which require a predominantly native understorey.

Coordinate System: MGA Zone 56 (GDA 94)



Legend

Flora Survey Locations
- Quadrat
- Rapid Assessment

Fauna Surveys Locations
- Anabat (4)
- Arboreal Camera (5)
- Diurnal Area Search (14)
- Harp Trap (4)
- Hollow Count (45)
- Nocturnal bird survey (2)
- Terrestrial Camera (5)

Property Boundaries
- Project Boundary
- Eastern Offset
- Western Offset
- Shared Offset

N
Grid North

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I:\...\9125\Figures\RRTS 20120207\Figure C.1 Vegetation South 20120214

Figure D.1 Field Survey Locations within the Project Boundary, Eastern and Western Offset Properties

* Note: Vegetation Communities are listed for the Impact Area and all Offset Areas

1 0 1 2 3 4 km

Coordinate System: MGA Zone 56 (GDA 94)

Legend

Flora Survey Locations

- Quadrat
- Rapid Assessment

Fauna Surveys Locations

Anabat	(4)
Arboreal Camera	(5)
Diurnal Area Search	(14)
Harp Trap	(4)
Hollow Count	(45)
Nocturnal bird survey	(2)
Terrestrial Camera	(5)

Northern Offset

N
Grid North

CUMBERLAND ECOLOGY

I:\...\9125\Figures\RRTS 20120207\Figure C.2 Quadrats North 20120214

Figure D.2 Field Survey Locations within the Northern Offset Properties

* Note: Vegetation Communities are listed for the Impact Area and all Offset Areas

1 0 1 2 3 4 km

D.5 Fauna Surveys

The focus of survey in the Eastern and Western Offset Areas was to confirm the occurrence of habitat that could support the fauna species known to occur in the Leard State Forest. In the Northern Offset Area, fauna surveys aimed to detect the presence of species recorded in the Leard State Forest. The main target fauna groups were woodland bird species and microchiropteran bat species, which were the most prevalent fauna groups in the Leard State Forest.

Specialist ornithologists were engaged to assess the condition of the habitat in the Eastern, Western and Northern offset properties for threatened bird species known to occur in the Project Boundary. Anabat and harp trapping were conducted to detect bat species in the Northern properties where there is little baseline data available. Camera traps were deployed to collect further baseline information of resident species. Habitat data was collected including systematic hollow counts and field notes at each flora and fauna sampling site. These methods are described in further detail below. The locations of survey are shown in **Figure D. 1** and **Figure D. 2**.

D.5.1. Avian Surveys

i. Eastern and Western Properties

The aim of bird surveys of the Eastern and Western properties was to assess the quality of bird habitat. Each property was examined on foot over one to five hours. The duration of each visit was determined by the size of patches of remnant vegetation and habitat complexity. Hence, the method for collected bird data was not standardised.

All species detected by either sight or call, were recorded. The current state of the vegetation cover was noted as well as the current land-use affecting habitat areas on each property. Surveys were also conducted opportunistically within the Leard State Forest so that the types of habitat and the habitat quality on the offsets could be compared with those of the State Forest.

ii. Northern Offsets

Diurnal birds:

An area search by visual and aural cues was conducted at ten sites on Wirradale (26–28 September, sunrise–sunset, 1–2 hours per site for a total of 12 hours) and four sites on Mt Lindesay (26, 29–30 September, mid morning and afternoon, 1–3 hours per sites for a total of 8 hours), coinciding with vegetation survey plots, Anabat, harp trap or camera sites.

The vegetation on each offset property was also assessed subjectively for the presence of potential habitat for threatened birds (NSW TSC Act, EPBC Act) that have been recorded in and around Leard State Forest during surveys completed of the Project Boundary.

Nocturnal birds:

Call-playback of all local owl species' calls at two sites (upper Maules Creek at the waterfall on Wirradale, 26 September; Manna Gum gully on Mt Lindsay Road, 27 September), both at approximately 2030 h, followed by 10 minutes of listening for responses and spotlighting at each site. Each site was surveyed for two nights.

D.5.2. Microchiropteran Bat Surveys

i. Harp Trapping

Harp traps were established at four sites on the Northern Offset properties. Harp trapping was carried out at each site for no less than two consecutive evenings.

ii. Anabat Echolocation Detection

Anabat units were established at four sites on the Northern Offset properties. Anabat units were left out at each site for no less than two consecutive evenings.

D.5.3. Infra-red Camera Traps

Paired arboreal and terrestrial infra-red camera traps were established at five sites in the Northern Offsets.

D.5.4. Hollow Counts

A regularised hollow assessment was conducted at 45 sites. At each sampling point, searches for hollow-bearing trees were made within a 20 m x 50 m quadrat. For each hollow-bearing tree identified the (1) species; (2) height and diameter at breast height (DBH); (3) number of hollows; and (4) size class of hollows were recorded. Hollow size classes are defined in **Table D. 4**. Data obtained was used to determine densities of tree hollows per ha of habitat proposed to be cleared.

Table D. 4 Tree Hollow Class Sizes

Class	Diameter (cm)
1	<5
2	5-10
3	11-15
4	16-20
5	21-25
6	26-30
7	>30

D.5.5. Other

i. Incidental Fauna Observations

Any incidental vertebrate fauna species that were heard calling, observed or otherwise detected on the basis of tracks or signs were recorded.

ii. Habitat Assessment

Notes relating to the presence of key habitat features were taken at each fauna survey site as well as at all flora quadrat locations. Notes were made about the following features as a minimum:

- Dominant overstorey species;
- Presence of flowering eucalypts;
- Presence of She-oak species;
- Recovery potential (signs of regeneration and general diversity of understorey);
- Proximity to wetland/ephemeral or permanent streams/soaks;
- Evidence of disturbance, clearance or fire; and
- Connectivity of the vegetation patch.

D.6 Survey Locations

The locations of the fauna surveys in the offset properties are summarised in **Table D. 5** below.

Table D. 5 Fauna Survey Locations

Zone	Easting	Northing	Property	Site	Trap type
56	240024	6639334	MT LINDESAY	Site 2	Anabat
56	237640	6638828	WIRRADALE	Site 3	Anabat
56	239332	6634646	WIRRADALE	Site 6	Anabat
56	237979	6642278	WIRRADALE	Site 8	Anabat
56	238182	6642740	MT LINDESAY	Site 1	Arboreal Camera
56	240022	6639322	MT LINDESAY	Site 2	Arboreal Camera
56	237634	6638831	WIRRADALE	Site 3	Arboreal Camera
56	237761	6635452	WIRRADALE	Site 4	Arboreal Camera
56	239348	6634650	WIRRADALE	Site 6	Arboreal Camera
56	238214	6642721	MT LINDESAY	Site 1	Harp Trap
56	237771	6635449	WIRRADALE	Site 4	Harp Trap
56	239388	6634644	WIRRADALE	Site 5	Harp Trap
56	236023	6637175	WIRRADALE	Site 7	Harp Trap
56	238189	6642761	MT LINDESAY	Site 1	Terrestrial Camera
56	240041	6639347	MT LINDESAY	Site 2	Terrestrial Camera
56	237639	6638822	WIRRADALE	Site 3	Terrestrial Camera
56	239407	6634644	WIRRADALE	Site 5	Terrestrial Camera
56	237803	6635474	WIRRADALE	Site 4	Terrestrial Camera

Zone	Easting	Northing	Property	Site	Trap type
56	237761	6635452	WIRRADALE	Site 4	Nocturnal bird survey
56	238693	6640116	MT LINDESAY	N-201	Nocturnal bird survey
56	240024	6639334	MT LINDESAY	Site 2	Diurnal Area Search
56	238182	6642740	MT LINDESAY	Site 1	Diurnal Area Search
56	239214	6643707	MT LINDESAY	Q15	Diurnal Area Search
56	238358	6642744	MT LINDESAY	Q14	Diurnal Area Search
56	235213	6636852	WIRRADALE	Q5	Diurnal Area Search
56	235562	6638412	WIRRADALE	Q6	Diurnal Area Search
56	234652	6640097	WIRRADALE	Q7	Diurnal Area Search
56	237634	6638831	WIRRADALE	Site 3	Diurnal Area Search
56	239388	6634644	WIRRADALE	Site 5	Diurnal Area Search
56	236023	6637175	WIRRADALE	Site 7	Diurnal Area Search
56	239348	6634650	WIRRADALE	Site 6	Diurnal Area Search
56	237979	6642278	WIRRADALE	Site 8	Diurnal Area Search
56	239483	6638980	WIRRADALE	Q11	Diurnal Area Search
56	236358	6632286	WIRRADALE	Q4	Diurnal Area Search
56	221260	6621147	BLUE RANGE	Q1	Hollow Count
56	221160	6619159	BLUE RANGE	Q2	Hollow Count
56	219598	6610283	KELSO	Q1	Hollow Count
56	219105	6610286	KELSO	Q2	Hollow Count
56	218143	6609956	KELSO	Q3	Hollow Count
56	221285	6612498	LOUENVILLE	Q1	Hollow Count
56	221264	6613072	LOUENVILLE	Q2	Hollow Count
56	221157	6613721	LOUENVILLE	Q3	Hollow Count
56	220545	6613245	LOUENVILLE	Q4	Hollow Count
56	219655	6613774	LOUENVILLE	Q5	Hollow Count
56	221713	6612531	LOUENVILLE	Q6	Hollow Count
56	222351	6619845	TESTON NTH	Q1	Hollow Count
56	223143	6617706	TESTON NTH	Q2	Hollow Count
56	222757	6617766	TESTON NTH	Q3	Hollow Count
56	223247	6616402	TESTON STH	Q1	Hollow Count
56	222639	6615001	TESTON STH	Q2	Hollow Count

Zone	Easting	Northing	Property	Site	Trap type
56	222296	6615002	TESTON STH	Q3	Hollow Count
56	222100	6613664	TESTON STH	Q4	Hollow Count
56	223090	6619217	TRALEE	Q1	Hollow Count
56	221238	6612194	VELYAMA	Q1	Hollow Count
56	221702	6611868	VELYAMA	Q2	Hollow Count
56	221465	6611176	VELYAMA	Q3	Hollow Count
56	221443	6610230	VELYAMA	Q4	Hollow Count
56	225868	6619738	WARRIAHDOOL	Q1	Hollow Count
56	239483	6638980	MT LINDESAY	Q11	Hollow Count
56	239025	6641153	MT LINDESAY	Q12	Hollow Count
56	238243	6642989	MT LINDESAY	Q13	Hollow Count
56	238358	6642744	MT LINDESAY	Q14	Hollow Count
56	239214	6643707	MT LINDESAY	Q15	Hollow Count
56	238522	6637207	WIRRADALE	Q1	Hollow Count
56	238661	6638099	WIRRADALE	Q2	Hollow Count
56	237725	6637486	WIRRADALE	Q3	Hollow Count
56	236358	6632286	WIRRADALE	Q4	Hollow Count
56	235213	6636852	WIRRADALE	Q5	Hollow Count
56	235562	6638412	WIRRADALE	Q6	Hollow Count
56	234652	6640097	WIRRADALE	Q7	Hollow Count
56	236551	6637911	WIRRADALE	Q8	Hollow Count
56	237178	6636865	WIRRADALE	Q9	Hollow Count
56	238693	6640116	MT LINDESAY	N - 201	Hollow Count
56	238704	6631445	WIRRADALE	D1/IB1	Hollow Count
56	239451	6631438	WIRRADALE	D2	Hollow Count
56	239550	6642707	MT LINDESAY	DR3	Hollow Count
56	243216	6636385	MT LINDESAY	DA1	Hollow Count
56	240836	6637511	MT LINDESAY	DA2	Hollow Count
56	240348	6637786	MT LINDESAY	DA3	Hollow Count

The location of the flora surveys are summarised below in **Table D. 6**. This includes full floristic quadrat data (Q1 to Q43), and rapid assessment plots (RA to RA 16).

Table D. 6 Bird Species Recorded in the Eastern, Western and Northern Offset Properties

Zone	Easting	Northing	Property	ID
56	221260	6621147	BLUE RANGE	Q1
56	221160	6619159	BLUE RANGE	Q2
56	219105	6610286	KELSO	Q3
56	218143	6609956	KELSO	Q4
56	221285	6612498	LOUENVILLE	Q5
56	221264	6613072	LOUENVILLE	Q6
56	221157	6613721	LOUENVILLE	Q7
56	219655	6613774	LOUENVILLE	Q8
56	221713	6612531	LOUENVILLE	Q9
56	243216	6636385	MT LINDESAY	Q10
56	240836	6637511	MT LINDESAY	Q11
56	240348	6637786	MT LINDESAY	Q12
56	239550	6642707	MT LINDESAY	Q13
56	238693	6640116	MT LINDESAY	Q14
56	238370	6642606	MT LINDESAY	Q15
56	239483	6638980	MT LINDESAY	Q16
56	239025	6641153	MT LINDESAY	Q17
56	238243	6642989	MT LINDESAY	Q18
56	238358	6642744	MT LINDESAY	Q19
56	239214	6643707	MT LINDESAY	Q20
56	238324	6642759	MT LINDESAY	Q21
56	240043	6638213	MT LINDESAY	Q22
56	236344	6640133	MT LINDESAY	Q23
56	222351	6619845	TESTON NTH	Q24
56	223143	6617706	TESTON NTH	Q25
56	222757	6617766	TESTON NTH	Q26
56	223247	6616402	TESTON STH	Q27
56	222639	6615001	TESTON STH	Q28
56	222296	6615002	TESTON STH	Q29
56	222100	6613664	TESTON STH	Q30
56	223090	6619217	TRALEE	Q31
56	221465	6611176	VELYAMA	Q32

Zone	Easting	Northing	Property	ID
56	238704	6631445	WIRRADALE	Q33
56	238522	6637207	WIRRADALE	Q34
56	239407	6634644	WIRRADALE	Q35
56	238661	6638099	WIRRADALE	Q36
56	237725	6637486	WIRRADALE	Q37
56	238203	6635314	WIRRADALE	Q38
56	236358	6632286	WIRRADALE	Q39
56	235213	6636852	WIRRADALE	Q40
56	235562	6638412	WIRRADALE	Q41
56	234652	6640097	WIRRADALE	Q42
56	236551	6637911	WIRRADALE	Q43
56	239973	6639381	MT LINDESAY	RA1
56	239102	6639260	MT LINDESAY	RA2
56	222707	6616391	TESTON STH	RA3
56	223011	6615105	TESTON STH	RA4
56	221177	6610290	VELYAMA	RA5
56	220602	6609556	VELYAMA	RA6
56	239196	6636015	WIRRADALE	RA7
56	234469	6633881	WIRRADALE	RA8
56	238469	6637929	WIRRADALE	RA9
56	237426	6637130	WIRRADALE	RA10
56	237982	6631859	WIRRADALE	RA11
56	238273	6633641	WIRRADALE	RA12
56	239062	6634074	WIRRADALE	RA13
56	237230	6633754	WIRRADALE	RA14
56	236067	6634048	WIRRADALE	RA15
56	235091	6633857	WIRRADALE	RA16

D.7 Survey Effort

The survey effort in the offset properties are summarised in **Table D. 7** below.

Table D. 7 Summary of Survey Effort for the Eastern, Western and Northern Properties

Survey Method	Survey Effort
Preliminary survey	
Site inspection and vegetation mapping	5 days (24-25 Nov, 2010; 29 Apr-1 May, 2011)
Flora Sampling	
Quadrats	43 quadrats
Rapid Assessments	16 plots
Diurnal Birds	
Day habitat search (east/west)	approximately 40-50 hours
Area search (northern)	W: 10 hours (12 sites); Mt L: 8 hours (4 sites)
Habitat assessment (northern)	throughout the week.
Nocturnal Birds	
Call playback and Spotlighting	two sites (each surveyed for two nights)
Non-flying Mammals	
Terrestrial Infrared cameras	25 survey nights
Arboreal Infrared cameras	25 survey nights
Microbats	
Harp trapping	15 trap nights
Ultrasonic call recording	15 survey nights
Hollow Counts	**45 sites**

D.8 Survey Limitations

The surveys are considered to be a brief “snap-shot” of the bird assemblage in the area and were not expected to detect spring-summer visitors. Surveys were slightly too early in the season to record most of the spring–summer migrants that are anticipated to arrive (e.g. some cuckoos, Rainbow Bee-eater, Dollarbird). Of these, many are likely to be common species, for instance, the Pallid Cuckoo (*Cacomantis pallidus*) and the Sacred Kingfisher (*Todiramphus sanctus*). However, it is possible that the Painted Honeyeater (*Grantiella picta*) and the Rainbow Bee-eater (*Merops ornatus*) would have been among these arrivals.

The opportunity to survey over an extended period of time and over many seasons would be also more conducive to detecting species that would occur in low densities and/or are rare in the tableland country like at Mt Lindesay and Wirradale, such as Square-tailed Kite (*Lophoictinia isura*) and Spotted Harrier (*Circus assimilis*).

Rain, wind and access-track condition also precluded call-playback at potentially the most conducive site for threatened owls, namely Maules Creek on Wirradale.

The overall length of survey of the offset properties (when considering that the surveys of the Leard State Forest has been surveyed many times over many seasons and years) is relatively short but the bird diversity recorded during the offset surveys is still comparable to the diversity recorded in the Leard State Forest. Many of the threatened species recorded in the Project Boundary were also recorded on one or more of the offset properties.

This indicates that the survey effort was more than adequate to gain information about the resident bird species in the offset properties and to ascertain the likelihood of occurrence of threatened species not detected. The existing bird assemblages and habitat characteristics could be used to suggest which of the possible local threatened bird species could be expected to occur on each of the offset properties.

Table D.8 Bird Species Recorded in the Eastern, Western and Northern Offset Properties

Family	Common Name	Scientific Name	TSC ACT	EPBC ACT	Leard State Forest	Louenville	Kelso	Velyama	Teston (sth)	Blue Range	Teston (nth)	Tralee	Warriahdool	Wirradale	Mt Lindesay	No. of offset properties in which spp was recorded
		No. of Species Detected			**168**	**56**	**50**	**44**	**55**	**28**	**39**	**19**	**18**	**95**	**65**	**125**
		No. of Threatened Birds			**21**	**3**	**4**	**2**	**4**	**2**	**1**	**2**	**1**	**7**	**4**	**9**
Phasianidae	Stubble Quail	*Coturnix pectoralis*			x											0
Phasianidae	Brown Quail	*Coturnix ypsilophora*			x		x	x			x			x		4
Anatidae	Australian Wood Duck	*Chenonetta jubata*			x	x								x	x	3
Anatidae	Grey Teal	*Anas gracilis*			x						x					1
Anatidae	Chestnut Teal	*Anas castanea*			x											0
Anatidae	Pacific Black Duck	*Anas superciliosa*			x						x			x		2
Anatidae	Hardhead	*Aythya australis*									x					1
Podicipedidae	Australasian Grebe	*Tachybaptus novaehollandiae*			x						x			x		2
Columbidae	Common Bronzewing	*Phaps chalcoptera*			x	x	x		x		x	x	x	x		7
Columbidae	Crested Pigeon	*Ocyphaps lophotes*			x	x	x	x	x	x	x		x	x	x	9
Columbidae	Peaceful Dove	*Geopelia striata*			x	x	x	x	x			x		x		6
Columbidae	Bar-shouldered Dove	*Geopelia humeralis*			x	x		x	x							3
Podargidae	Tawny Frogmouth	*Podargus strigoides*			x										x	1
Caprimulgidae	White-throated Nightjar	*Eurostopodus mystacalis*			x											0
Aegothelidae	Australian Owlet-nightjar	*Aegotheles cristatus*			x									x		1
Apodidae	**White-throated Needletail**	***Hirundapus caudacutus***		**M**	**x**											**0**
Apodidae	**Fork-tailed Swift**	***Apus pacificus***		**M**	**x**											**0**
Phalacrocoracidae	Little Pied Cormorant	*Microcarbo melanoleucos*									x					1
Pelecanidae	Australian Pelican	*Pelecanus conspicillatus*			x											0
Ciconiidae	**Black-necked Stork**	***Ephippiorhynchus asiaticus***	**E1**		**x**											**0**
Ardeidae	White-necked Heron	*Ardea pacifica*			x										x	1
Ardeidae	White-faced Heron	*Egretta novaehollandiae*			x									x		1
Threskiornithidae	Straw-necked Ibis	*Threskiornis spinicollis*			x									x		1
Threskiornithidae	Royal Spoonbill	*Platalea regia*			x											0
Threskiornithidae	Yellow-billed Spoonbill	*Platalea flavipes*			x											0
Accipitridae	Black-shouldered Kite	*Elanus axillaris*			x											0
Accipitridae	**Square-tailed Kite**	***Lophoictinia isura***	**V**		**x**											**0**
Accipitridae	Whistling Kite	*Haliastur sphenurus*			x											0
Accipitridae	Brown Goshawk	*Accipiter fasciatus*			x									x	x	2
Accipitridae	Collared Sparrowhawk	*Accipiter cirrhocephalus*			x						x					1
Accipitridae	**Spotted Harrier**	***Circus assimilis***	**V**		**x**											**0**
Accipitridae	Wedge-tailed Eagle	*Aquila audax*			x									x	x	2
Accipitridae	**Little Eagle**	***Hieraaetus morphnoides***	**V**		**x**											**0**
Falconidae	Nankeen Kestrel	*Falco cenchroides*			x		x	x	x					x		4
Falconidae	Brown Falcon	*Falco berigora*			x		x		x		x					3
Falconidae	Australian Hobby	*Falco longipennis*			x	x								x		2
Falconidae	Black Falcon	*Falco subniger*			x											0
Falconidae	Peregrine Falcon	*Falco peregrinus*			x									x		1
Hirundinidae	White-backed Swallow	*Cheramoeca leucosternus*												x		1
Charadriidae	Ringed Plover	*Charadrius hiaticula*			x											0
Charadriidae	Black-fronted Dotterel	*Elseyornis melanops*			x											0
Charadriidae	Masked Lapwing	*Vanellus miles*			x						x			x		2
Turnicidae	Painted Button-quail	*Turnix varius*			x		x									1
Turnicidae	Red-chested Button-quail	*Turnix pyrrhothorax*			x											0
Cacatuidae	Galah	*Eolophus roseicapillus*			x	x	x	x	x	x	x		x	x	x	9
Cacatuidae	Little Corella	*Cacatua sanguinea*			x			x								1
Cacatuidae	Sulphur-crested Cockatoo	*Cacatua galerita*			x	x	x	x		x	x	x	x	x	x	9
Cacatuidae	Cockatiel	*Nymphicus hollandicus*			x	x		x		x						3

Family	Common Name	Scientific Name	TSC ACT	EPBC ACT	Leard State Forest	Louenville	Kelso	Velyama	Teston (sth)	Blue Range	Teston (nth)	Tralee	Warriahdool	Wirradale	Mt Lindesay	No. of offset properties in which spp was recorded
		No. of Species Detected			168	56	50	44	55	28	39	19	18	95	65	125
		No. of Threatened Birds			21	3	4	2	4	2	1	2	1	7	4	9
Psittacidae	Rainbow Lorikeet	*Trichoglossus haematodus*			x											0
Psittacidae	Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*			x											0
Psittacidae	Musk Lorikeet	*Glossopsitta concinna*			x			x						x		2
Psittacidae	**Little Lorikeet**	***Glossopsitta pusilla***	V		x				x					x		2
Psittacidae	Australian King-Parrot	*Alisterus scapularis*			x									x		1
Psittacidae	Red-winged Parrot	*Aprosmictus erythropterus*			x		x	x	x							3
Psittacidae	Crimson Rosella	*Platycercus elegans*			x									x	x	2
Psittacidae	Eastern Rosella	*Platycercus eximius*			x	x	x	x	x	x	x	x	x	x	x	10
Psittacidae	Pale-headed Rosella	*Platycercus adscitus*			x											0
Psittacidae	Australian Ringneck	*Barnardius zonarius*			x											0
Psittacidae	Blue Bonnet	*Northiella haematogaster*			x	x		x	x	x	x		x			6
Psittacidae	Red-rumped Parrot	*Psephotus haematonotus*			x	x	x	x	x	x			x			6
Psittacidae	Budgerigar	*Melopsittacus undulatus*			x											0
Psittacidae	**Turquoise Parrot**	***Neophema pulchella***	V		x	x								x		2
Cuculidae	Eastern Koel	*Eudynamys orientalis*			x											0
Cuculidae	Channel-billed Cuckoo	*Scythrops novaehollandiae*			x										x	1
Cuculidae	Horsfield's Bronze-Cuckoo	*Chalcites basalis*			x											0
Cuculidae	Black-eared Cuckoo	*Chalcites osculans*			x											0
Cuculidae	Shining Bronze-Cuckoo	*Chalcites lucidus*			x	x			x						x	3
Cuculidae	Pallid Cuckoo	*Cacomantis pallidus*			x											0
Cuculidae	Fan-tailed Cuckoo	*Cacomantis flabelliformis*			x									x	x	2
Cuculidae	Brush Cuckoo	*Cacomantis variolosus*			x											0
Strigidae	**Barking Owl**	***Ninox connivens***	V		x											0
Strigidae	Southern Boobook	*Ninox novaeseelandiae*			x										x	1
Tytonidae	**Masked Owl**	***Tyto novaehollandiae***	V		x											0
Tytonidae	Barn Owl	*Tyto alba*			x											0
Alcedinidae	Azure Kingfisher	*Ceyx azureus*			x											0
Halcyonidae	Laughing Kookaburra	*Dacelo novaeguineae*			x	x	x	x						x	x	5
Halcyonidae	Sacred Kingfisher	*Todiramphus sanctus*			x									x	x	2
Meropidae	**Rainbow Bee-eater**	***Merops ornatus***		M	x											0
Coraciidae	Dollarbird	*Eurystomus orientalis*			x											0
Climacteridae	White-throated Treecreeper	*Cormobates leucophaea*			x	x	x	x	x					x	x	6
Climacteridae	**Brown Treecreeper**	***Climacteris picumnus***	V		x				x					x	x	3
Ptilonorhynchidae	Spotted Bowerbird	*Ptilonorhynchus maculatus*			x	x										1
Maluridae	Superb Fairy-wren	*Malurus cyaneus*			x	x	x		x	x	x			x	x	7
Maluridae	White-winged Fairy-wren	*Malurus leucopterus*			x					x						1
Maluridae	Variegated Fairy-wren	*Malurus lamberti*			x	x	x							x	x	4
Acanthizidae	White-browed Scrubwren	*Sericornis frontalis*			x									x	x	2
Acanthizidae	Chestnut-rumped Heathwren	*Calamanthus pyrrhopygius*			x											0
Acanthizidae	**Speckled Warbler**	***Chthonicola sagittata***	V		x	x	x	x	x	x		x		x	x	8
Acanthizidae	Weebill	*Smicrornis brevirostris*			x	x	x	x	x		x	x		x		7
Acanthizidae	Western Gerygone	*Gerygone fusca*			x	x	x		x							3
Acanthizidae	White-throated Gerygone	*Gerygone albogularis*			x									x	x	2
Acanthizidae	Striated Thornbill	*Acanthiza lineata*			x	x			x					x	x	4
Acanthizidae	Yellow Thornbill	*Acanthiza nana*			x	x	x	x	x	x		x		x		7
Acanthizidae	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*			x	x	x	x	x	x	x			x	x	8
Acanthizidae	Chestnut-rumped Thornbill	*Acanthiza uropygialis*			x				x		x					2
Acanthizidae	Buff-rumped Thornbill	*Acanthiza reguloides*			x									x	x	2
Acanthizidae	Inland Thornbill	*Acanthiza apicalis*			x	x	x	x								3
Acanthizidae	Brown Thornbill	*Acanthiza pusilla*			x										x	1
Acanthizidae	Southern Whiteface	*Aphelocephala leucopsis*			x									x		1
Pardalotidae	Spotted Pardalote	*Pardalotus punctatus*			x	x	x	x	x					x	x	6

Family	Common Name	Scientific Name	TSC ACT	EPBC ACT	Leard State Forest	Louenville	Kelso	Velyama	Teston (sth)	Blue Range	Teston (nth)	Tralee	Warriahdool	Wirradale	Mt Lindesay	No. of offset properties in which spp was recorded
		No. of Species Detected			168	56	50	44	55	28	39	19	18	95	65	125
		No. of Threatened Birds			21	3	4	2	4	2	1	2	1	7	4	9
Pardalotidae	Striated Pardalote	*Pardalotus striatus*			x	x	x		x	x	x	x	x	x	x	9
Meliphagidae	Eastern Spinebill	*Acanthorhynchus tenuirostris*												x	x	2
Meliphagidae	Yellow-faced Honeyeater	*Lichenostomus chrysops*			x	x			x					x	x	4
Meliphagidae	Singing Honeyeater	*Lichenostomus virescens*			x	x	x	x	x	x	x			x		7
Meliphagidae	White-eared Honeyeater	*Lichenostomus leucotis*			x		x		x					x	x	4
Meliphagidae	Yellow-tufted Honeyeater	*Lichenostomus melanops*			x									x		1
Meliphagidae	Grey-fronted Honeyeater	*Lichenostomus plumulus*			x											0
Meliphagidae	Fuscous Honeyeater	*Lichenostomus fuscus*			x	x										1
Meliphagidae	White-plumed Honeyeater	*Lichenostomus penicillatus*			x		x	x	x					x	x	5
Meliphagidae	Noisy Miner	*Manorina melanocephala*			x						x	x	x	x	x	5
Meliphagidae	Yellow-throated Miner	*Manorina flavigula*			x	x		x	x	x	x					5
Meliphagidae	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*			x	x	x	x	x	x	x			x	x	8
Meliphagidae	Red Wattlebird	*Anthochaera carunculata*												x	x	2
Meliphagidae	Scarlet Honeyeater	*Myzomela sanguinolenta*			x											0
Meliphagidae	Brown Honeyeater	*Lichmera indistincta*			x	x		x	x					x		4
Meliphagidae	**Black-chinned Honeyeater**	***Melithreptus gularis***	**V**		**x**									**x**		**1**
Meliphagidae	Brown-headed Honeyeater	*Melithreptus brevirostris*			x	x			x					x	x	4
Meliphagidae	White-naped Honeyeater	*Melithreptus lunatus*			x									x	x	2
Meliphagidae	Blue-faced Honeyeater	*Entomyzon cyanotis*			x										x	1
Meliphagidae	Noisy Friarbird	*Philemon corniculatus*			x		x		x	x				x	x	5
Meliphagidae	Little Friarbird	*Philemon citreogularis*			x											0
Meliphagidae	Striped Honeyeater	*Plectorhyncha lanceolata*			x	x	x	x	x	x	x	x		x		8
Meliphagidae	**Painted Honeyeater**	***Grantiella picta***	**V**		**x**											**0**
Pomatostomidae	**Grey-crowned Babbler**	***Pomatostomus temporalis***	**V**		**x**		**x**	**x**		**x (Breeding)**	**x**	**x**	**x**			**5**
Pomatostomidae	White-browed Babbler	*Pomatostomus superciliosus*			x											0
Eupetidae	Spotted Quail-thrush	*Cinclosoma punctatum*					x							x		2
Neosittidae	**Varied Sittella**	***Daphoenositta chrysoptera***	**V**		**x**	**x**								**x**	**x**	**3**
Campephagidae	Ground Cuckoo-shrike	*Coracina maxima*												x		1
Campephagidae	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*			x		x							x	x	3
Campephagidae	White-bellied Cuckoo-shrike	*Coracina papuensis*			x									x		1
Campephagidae	Cicadabird	*Coracina tenuirostris*			x											0
Campephagidae	White-winged Triller	*Lalage sueurii*			x											0
Pachycephalidae	Crested Shrike-tit	*Falcunculus frontatus*			x											0
Pachycephalidae	Golden Whistler	*Pachycephala pectoralis*			x	x	x							x	x	4
Pachycephalidae	Rufous Whistler	*Pachycephala rufiventris*			x	x	x	x	x			x		x	x	7
Pachycephalidae	Grey Shrike-thrush	*Colluricincla harmonica*			x	x			x					x	x	4
Pachycephalidae	Crested Bellbird	*Oreoica gutturalis*			x											0
Oriolidae	Olive-backed Oriole	*Oriolus sagittatus*			x									x		1
Artamidae	Masked Woodswallow	*Artamus personatus*			x				x					x		2
Artamidae	**White-browed Woodswallow**	***Artamus superciliosus***	**V**		**x**		**x**		**x**					**x**	**x**	**4**
Artamidae	Dusky Woodswallow	*Artamus cyanopterus*			x		x							x		2
Artamidae	Grey Butcherbird	*Cracticus torquatus*			x	x	x	x	x		x	x	x	x		8
Artamidae	Pied Butcherbird	*Cracticus nigrogularis*			x		x	x		x	x	x		x	x	7
Artamidae	Australian Magpie	*Cracticus tibicen*			x	x		x	x	x	x		x	x	x	8
Artamidae	Pied Currawong	*Strepera graculina*			x	x		x	x		x			x	x	6
Rhipiduridae	Grey Fantail	*Rhipidura albiscapa*			x	x	x	x	x					x	x	6
Rhipiduridae	Willie Wagtail	*Rhipidura leucophrys*			x	x	x	x	x	x	x	x		x	x	9
Corvidae	Australian Raven	*Corvus coronoides*			x	x		x	x		x	x	x	x	x	8
Corvidae	Little Raven	*Corvus mellori*			x											0
Corvidae	Torresian Crow	*Corvus orru*			x					x				x	x	3
Monarchidae	Leaden Flycatcher	*Myiagra rubecula*			x									x	x	2
Monarchidae	**Satin Flycatcher**	***Myiagra cyanoleuca***	**M**		**x**											**0**
Monarchidae	Restless Flycatcher	*Myiagra inquieta*			x		x		x					x		3

Family	Common Name	Scientific Name	TSC ACT	EPBC ACT	Leard State Forest	Louenville	Kelso	Velyama	Teston (sth)	Blue Range	Teston (nth)	Tralee	Warriahdool	Wirradale	Mt Lindesay	No. of offset properties in which spp was recorded
		No. of Species Detected			**168**	**56**	**50**	**44**	**55**	**28**	**39**	**19**	**18**	**95**	**65**	**125**
		No. of Threatened Birds			**21**	**3**	**4**	**2**	**4**	**2**	**1**	**2**	**1**	**7**	**4**	**9**
Monarchidae	Magpie-lark	*Grallina cyanoleuca*			x		x	x	x		x	x	x	x	x	8
Corcoracidae	White-winged Chough	*Corcorax melanorhamphos*			x	x	x	x	x		x	x	x	x	x	9
Corcoracidae	Apostlebird	*Struthidea cinerea*			x		x	x	x	x	x	x	x			7
Petroicidae	Jacky Winter	*Microeca fascinans*			x	x			x					x	x	4
Petroicidae	Red-capped Robin	*Petroica goodenovii*			x	x	x	x	x		x			x		6
Petroicidae	**Hooded Robin**	***Melanodryas cucullata***	**V**		**x**		**x**									**1**
Petroicidae	Eastern Yellow Robin	*Eopsaltria australis*			x	x	x	x	x		x			x	x	7
Megaluridae	Rufous Songlark	*Cincloramphus mathewsi*			x	x				x				x		3
Megaluridae	Brown Songlark	*Cincloramphus cruralis*			x										x	1
Timaliidae	Silvereye	*Zosterops lateralis*			x	x			x					x	x	4
Hirundinidae	White-backed Swallow	*Cheramoeca leucosterna*			x									x		1
Hirundinidae	Welcome Swallow	*Hirundo neoxena*			x	x	x							x	x	4
Hirundinidae	Fairy Martin	*Petrochelidon ariel*			x										x	1
Hirundinidae	Tree Martin	*Petrochelidon nigricans*			x											0
Sturnidae	Common Starling	**Sturnus vulgaris*			x	x		x		x	x		x	x		6
Sturnidae	Common Myna	**Sturnus tristis*												x		1
Dicaeidae	Mistletoebird	*Dicaeum hirundinaceum*			x	x	x	x	x				x	x	x	7
Estrildidae	Zebra Finch	*Taeniopygia guttata*			x					x						1
Estrildidae	Double-barred Finch	*Taeniopygia bichenovii*			x	x	x		x	x	x			x	x	7
Estrildidae	Plum-headed Finch	*Neochmia modesta*			x											0
Estrildidae	Red-browed Finch	*Neochmia temporalis*			x									x	x	2
Estrildidae	**Diamond Firetail**	***Stagonopleura guttata***	**V**		**x**											**0**
Motacillidae	Australasian Pipit	*Anthus novaeseelandiae*			x			x						x		2

**introduced*

Table D.9 Likelihood of Occurrence of Threatened Birds in the Eastern, Western and Northern Offset Properties

Common Name	Scientific Name	TSC	EPBC	Kelso	Louenville	Velyama	Teston (sth)	Blue Range	Teston (nth)	Tralee	Warriahdool	Wirradale	Mt Lindesay
White-throated Needletail	*Hirundapus caudacutus*		M									x	x
Fork-tailed Swift	*Apus pacificus*		M									x	x
Square-tailed Kite	*Lophoictinia isura*	V		x	x		x					x	x
Spotted Harrier	*Circus assimilis*	V		x	x	x		x				x	x
Little Eagle	*Hieraaetus morphnoides*	V		x	x	x	x	x	x			x	x
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	V											
Little Lorikeet	*Glossopsitta pusilla*	V		x	x	x	**x**		x			**x**	
Swift Parrot	*Lathamus discolor*	E	E	x	x	x	x					x	x
Turquoise Parrot	*Neophema pulchella*	V		x	**x**	x	x	x	x			**x**	
Barking Owl	*Ninox connivens*	V		x	x	x	x					x	
Masked Owl	*Tyto novaehollandiae*	V		x	x	x	x						
Rainbow Bee-eater	*Merops ornatus*		M									x	x
Brown Treecreeper	*Climacteris picumnus*	V		x	x	x	**x**	x	x	x		**x**	**x**
Speckled Warbler	*Chthonicola sagittata*	V		**x**	**x**	**x**	**x**	**x**	x	**x**		**x**	**x**
Regent Honeyeater	*Anthochaera phrygia*	CE	E	x	x		x					x	
Black-chinned Honeyeater	*Melithreptus gularis*	V		x	x		x					**x**	
Painted Honeyeater	*Grantiella picta*	V		x	x		x		x			x	x
Grey-crowned Babbler	*Pomatostomus temporalis*	V		**x**	x	**x**	x	**x**	**x**	**x**	**x**	x	
Varied Sittella	*Daphoenositta chrysoptera*	V		x	**x**		x					**x**	**x**
White-browed Woodswallow	*Artamus superciliosus*	V		**x**			**x**					**x**	**x**
Satin Flycatcher	*Myiagra cyanoleuca*		M									x	x
Flame Robin	*Petroica phoenicea*	V										x	x
Hooded Robin	*Melanodryas cucullata*	V		**x**	x	x	x	x	x	x		x	x
Diamond Firetail	*Stagonopleura guttata*	V		x	x	x	x	x	x	x	x	x	x

Bold and highlighted indicates that the species was detected on site during surveys

Table D.10 Condition of Habitat for Threatened Birds in the Eastern, Western and Northern Offset Properties

Site	Kelso	Louenville	Velyama	Teston (sth)	Blue Range	Teston (nth)	Tralee	Warriahdool	Wirradale	Mt Lindesay
Tree Cover	Continuous to open depending on patch	Continuous	Open	Continuous to open depending on patch	Sparse	Open	Open	Open	Continuous to open depending on patch	Continuous to open depending on patch
Tree Age Structure	Young regeneration with some old growth	Good age structure on upper slopes	Scattered old trees and patches of regeneration	Good mix of different ages	Young regeneration with some old growth	Young regeneration with some old growth	Young regeneration with some old growth	Scattered old trees	Good mix of different ages	Good mix of different ages
		Some clearing on lower slopes							Clearing some some paddocks	Clearing some some paddocks
Shrub Cover	Patchy - small areas of good cover	Generally good within remnants	Mostly absent	Some areas with good cover, others sparse	Some dense patches	Some dense patches	Absent	Absent	Some forest and woodland with good cover, others sparse	Some forest and woodland with good cover, others sparse
Ground Cover										
Grass	Fair in patches	Good	Poor	Good	Very good	Good	Poor	Fair	Good	Good
Forbes	Fair in patches	Good	Poor	Good	Good	Good	Poor	Poor	Good	Good
Litter	Fair in patches	Good	Poor	Good	Fair	Fair	Poor	Poor	Good	Good
Soils	Shallow, rocky	Shallow/rocky upslope and deep on lower slopes	Shallow/rocky upslope and deep on lower slopes	Shallow/rocky upslope and deep on lower slopes	Shallow/rocky upslope and deep on lower slopes	Shallow/rocky in remnants and deep on lower slopes	Shallow/rocky in remnants	Shallow/rocky upslope and deep on lower slopes	Fertile, basaltic	Fertile, basaltic
Habitat Quality	Poor in heavily grazed areas	Good on upper slopes	Poor to fair	Fair to good	Fair	Fair to good	Poor	Poor	Fair to excellent	Fair to excellent
	Good in some patches	Poorer on lower slopes								
No. of Bird Species Detected	50	56	44	55	28	39	19	18	95	65
No. of Threatened Bird Species Detected	4	3	2	4	2	1	2	1	7	4
Potential No. of Threatened Bird Species	18	17	12	17	8	9	5	2	22	16
Current Landuse	Heavily grazed on lower slopes	Not grazed during survey	Heavily grazed on lower slopes	Moderate grazing on lower slopes	Not grazed during survey	Grazed	Moderate grazing	Moderate grazing	Moderate grazing on lower slopes	Moderate grazing on lower slopes

Table D.11 Tree Hollow Data Collected from the Northern, Eastern and Western Offset Properties

	Plot (20 x 50) →	Blue Range 1	Blue Range 2	Kelso 1	Kelso 2	Kelso 3	Louenville 1	Louenville 2	Louenville 3	Louenville 4	Louenville 5	Louenville 6	Teston Nth 1	Teston Nth 2	Teston Nth 3	Teston Sth 1	Teston Sth 2
<5cm	Apple Box																
	Blakely's Red Gum																
	Dwyers Red Gum														2	7	
	Fuzzy Box			1													
	Mountain Gum																
	Native Olive								1								
	NL Ironbark			1	1												
	Poplar Box		1														
	Red Stringybark																
	River Red Gum		3														
	Rough-barked Apple																
	Tumbledown Red Gum					2											
	Unspecified Stag																
	WF Honey Myrtle		11														
	White Box	2			1		6	5	6		2	6	1				4
	White Box Stag				1			1									
	White Cypress Pine								1						1		
	White Cypress Pine Stag					1											
	Wilga																
	Yellow Box													4			
5-10cm	Apple Box																
	Dwyers Red Gum		1												1	1	
	Manna Gum																
	Mountain Gum																
	NL Ironbark																
	Poplar Box			1													
	Red Stringybark																
	River Red Gum		3														
	Rough-barked Apple																
	Unspecified Stag																
	White Box				1		3	5	6			12					
	White Box Stag				5												
	White Cypress Pine Stag					1											
	Yellow Box																
11-15cm	Apple Box																
	Blakely's Red Gum																
	Dwyers Red Gum															1	
	Mountain Gum																
	NL Ironbark			1													
	Poplar Box		1	1													
	Red Stringybark																
	River Oak																
	River Red Gum		2														
	Rough-barked Apple																
	Unspecified Stag																
	WF Honey Myrtle		2														
	White Box	1					2	8	8			10					
	White Box Stag				2			2									
	White Cypress Pine Stag					2											
	Yellow Box													1			

16-20cm	Apple Box																		
	Dwyers Red Gum																3		
	Mountain Gum																		
	NL Ironbark													1					
	Red Stringybark																		
	River Oak																		
	River Red Gum		1																
	Unspecified Stag																		
	White Box	1					2	11	1			2							
	White Box Stag				3														
	Yellow Box														1				
21-25cm	NL Ironbark			2															
	Red Stringybark																		
	River Red Gum		2																
	Unspecified Stag																		
	White Box	1					2	3				1							
	White Box Stag				1														
	Yellow Box														1				
26-30cm	Apple Box																		
	Mountain Gum																		
	Red Stringybark																		
	River Red Gum		3																
	Unspecified Stag																		
	White Box						1												
	White Box Stag				2														
>30cm	Apple Box																		
	Mountain Gum																		
	River Red Gum		2																
	Unspecified Stag																		
	White Box																		
	Total:	5	32	7	17	6	16	35	23	0	2	31	2	7	4	12	4		

Apple Box	*Eucalyptus bridgesiana*
Blakely's Red Gum	*Eucalyptus blakelyi*
Dwyers Red Gum	*Eucalyptus dwyeri*
Fuzzy Box	*Eucalyptus conica*
Manna Gum	*Eucalyptus viminalis*
Mountain Gum	*Eucalyptus dalrympleana*
Native Olive	*Notelaea microcarpa*
NL Ironbark	*Eucalyptus crebra*
Poplar Box	*Eucalyptus populneus*
Red Stringybark	*Eucalyptus macrorhyncha*
River Oak	*Casuarina cunninghamiana*
River Red Gum	*Eucalyptus camaldulensis*
Rough-barked Apple	*Angophora floribunda*
Tumbledown	*Eucalyptus dealbata*
WF Honey Myrtle	*Melaleuca decora*
White Box	*Eucalyptus albens*
White Cypress Pine	*Callitris glaucophylla*
Wilga	*Geijera parviflora*
Yellow Box	*Eucalyptus melliodora*

Table D.11 Tree Hollow Data Collected from the Northern, Eastern and Western Offset Properties (cont.)

	Plot (20 x 50) →	Teston Sth 3	Teston Sth 4	Tralee 1	Velyama 1	Velyama 2	Velyama 3	Velyama 4	Warriahdool 1	Mt Lindesay 11	Mt Lindesay 12	Mt Lindesay 13	Mt Lindesay 14	Mt Lindesay 15	Wirradale 1	Wirradale 2	Wirradale 3	Wirradale 4
<5cm	Apple Box															2		
	Blakely's Red Gum																	
	Dwyers Red Gum			3		2												
	Fuzzy Box																	
	Mountain Gum										5							
	Native Olive																	
	NL Ironbark	1			1													
	Poplar Box																	
	Red Stringybark									13	3					2		3
	River Red Gum																	
	Rough-barked Apple										2							2
	Tumbledown Red Gum																	
	Unspecified Stag					4	1											
	WF Honey Myrtle																	
	White Box	3					2	1	2						1	1	4	2
	White Box Stag																	
	White Cypress Pine			1														
	White Cypress Pine Stag	6																
	Wilga							1										
	Yellow Box											5						
5-10cm	Apple Box															2		
	Dwyers Red Gum			3														
	Manna Gum																	
	Mountain Gum										3							
	NL Ironbark	2																
	Poplar Box																	
	Red Stringybark									12						3		4
	River Red Gum																	
	Rough-barked Apple										2							1
	Unspecified Stag					2	3											
	White Box	3					2	2	1								3	1
	White Box Stag																	
	White Cypress Pine Stag	2																
	Yellow Box											2						
11-15cm	Apple Box															1		
	Blakely's Red Gum																	
	Dwyers Red Gum			1														
	Mountain Gum										3							
	NL Ironbark	1																
	Poplar Box																	
	Red Stringybark									3	1					1		2
	River Oak																	
	River Red Gum																	
	Rough-barked Apple										1							
	Unspecified Stag					2	2											
	WF Honey Myrtle																	
	White Box	4					3									1	3	
	White Box Stag																	
	White Cypress Pine Stag	2																
	Yellow Box											1						

16-20cm	Apple Box															1			
	Dwyers Red Gum			4															
	Mountain Gum										2								
	NL Ironbark																		
	Red Stringybark									3						1		1	
	River Oak																		
	River Red Gum																		
	Unspecified Stag					2													
	White Box	2					3		2										
	White Box Stag																		
	Yellow Box											3							
21-25cm	NL Ironbark																		
	Red Stringybark																		
	River Red Gum																		
	Unspecified Stag					1													
	White Box	1					1										2		
	White Box Stag																		
	Yellow Box											1							
26-30cm	Apple Box															1			
	Mountain Gum										1								
	Red Stringybark															1			
	River Red Gum																		
	Unspecified Stag						1												
	White Box	3					2		1										
	White Box Stag																		
>30cm	Apple Box															1			
	Mountain Gum										1								
	River Red Gum																		
	Unspecified Stag						2												
	White Box	1																	
	Total:	31	0	12	1	13	22	4	6	31	24	12	0	0	1	18	12	16	

Apple Box	*Eucalyptus bridgesiana*
Blakely's Red Gum	*Eucalyptus blakelyi*
Dwyers Red Gum	*Eucalyptus dwyeri*
Fuzzy Box	*Eucalyptus conica*
Manna Gum	*Eucalyptus viminalis*
Mountain Gum	*Eucalyptus dalrympleana*
Native Olive	*Notelaea microcarpa*
NL Ironbark	*Eucalyptus crebra*
Poplar Box	*Eucalyptus populneus*
Red Stringybark	*Eucalyptus macrorhyncha*
River Oak	*Casuarina cunninghamiana*
River Red Gum	*Eucalyptus camaldulensis*
Rough-barked Apple	*Angophora floribunda*
Tumbledown	*Eucalyptus dealbata*
WF Honey Myrtle	*Melaleuca decora*
White Box	*Eucalyptus albens*
White Cypress Pine	*Callitris glaucophylla*
Wilga	*Geijera parviflora*
Yellow Box	*Eucalyptus melliodora*

Table D.11 Tree Hollow Data Collected from the Northern, Eastern and Western Offset Properties (cont.)

	Plot (20 x 50) →	Wirradale 5	Wirradale 6	Wirradale 7	Wirradale 8	Wirradale 9	Mt Lindesay N-201	Wirradale D1	Wirradale D2	Mt Lindesay DR3	Mt Lindesay DA1	Mt Lindesay DA2	Mt Lindesay DA3	Total	Average/plot	Average/ha
<5cm	Apple Box													2	2	20
	Blakely's Red Gum											1		1	1	10
	Dwyers Red Gum													14	4	35
	Fuzzy Box													1	1	10
	Mountain Gum													5	5	50
	Native Olive													1	1	10
	NL Ironbark							2						6	1	12
	Poplar Box													1	1	10
	Red Stringybark											3	4	28	5	47
	River Red Gum													3	3	30
	Rough-barked Apple													4	2	20
	Tumbledown Red Gum													2	2	20
	Unspecified Stag		4					1	1					11	2	22
	WF Honey Myrtle													11	11	110
	White Box	15												64	4	36
	White Box Stag													2	1	10
	White Cypress Pine													3	1	10
	White Cypress Pine Stag													7	4	35
	Wilga													1	1	10
	Yellow Box													9	5	45
5-10cm	Apple Box													2	2	20
	Dwyers Red Gum													6	2	15
	Manna Gum						2							2	2	20
	Mountain Gum													3	3	30
	NL Ironbark							2						4	2	20
	Poplar Box													1	1	10
	Red Stringybark											3	4	26	5	52
	River Red Gum													3	3	30
	Rough-barked Apple						1							4	1	13
	Unspecified Stag							3						8	3	27
	White Box	1												40	3	33
	White Box Stag													5	5	50
	White Cypress Pine Stag													3	2	15
	Yellow Box													2	2	20
11-15cm	Apple Box													1	1	10
	Blakely's Red Gum											1		1	1	10
	Dwyers Red Gum													2	1	10
	Mountain Gum													3	3	30
	NL Ironbark							2						4	1	13
	Poplar Box													2	1	10
	Red Stringybark													7	2	18
	River Oak								3					3	3	30
	River Red Gum													2	2	20
	Rough-barked Apple													1	1	10
	Unspecified Stag							4	1					9	2	23
	WF Honey Myrtle													2	2	20
	White Box													40	4	44
	White Box Stag													4	2	20
	White Cypress Pine Stag													4	2	20
	Yellow Box													2	1	10

16-20cm	Apple Box													1	1	10
	Dwyers Red Gum													7	4	35
	Mountain Gum													2	2	20
	NL Ironbark													1	1	10
	Red Stringybark											2		7	2	18
	River Oak								1					1	1	10
	River Red Gum													1	1	10
	Unspecified Stag							3	2					7	2	23
	White Box													24	3	30
	White Box Stag													3	3	30
	Yellow Box													4	2	20
21-25cm	NL Ironbark													2	2	20
	Red Stringybark											1		1	1	10
	River Red Gum													2	2	20
	Unspecified Stag							2						3	2	15
	White Box													11	2	16
	White Box Stag													1	1	10
	Yellow Box													2	1	10
26-30cm	Apple Box													1	1	10
	Mountain Gum													1	1	10
	Red Stringybark											1		2	1	10
	River Red Gum													3	3	30
	Unspecified Stag							2						3	2	15
	White Box													7	2	18
	White Box Stag													2	2	20
>30cm	Apple Box													1	1	10
	Mountain Gum													1	1	10
	River Red Gum													2	2	20
	Unspecified Stag							1						3	2	15
	White Box													1	1	10
	Total:	16	4	0	0	0	3	22	8	0	0	12	8	**479**	**11**	**106**

Apple Box	*Eucalyptus bridgesiana*
Blakely's Red Gum	*Eucalyptus blakelyi*
Dwyers Red Gum	*Eucalyptus dwyeri*
Fuzzy Box	*Eucalyptus conica*
Manna Gum	*Eucalyptus viminalis*
Mountain Gum	*Eucalyptus dalrympleana*
Native Olive	*Notelaea microcarpa*
NL Ironbark	*Eucalyptus crebra*
Poplar Box	*Eucalyptus populneus*
Red Stringybark	*Eucalyptus macrorhyncha*
River Oak	*Casuarina cunninghamiana*
River Red Gum	*Eucalyptus camaldulensis*
Rough-barked Apple	*Angophora floribunda*
Tumbledown	*Eucalyptus dealbata*
WF Honey Myrtle	*Melaleuca decora*
White Box	*Eucalyptus albens*
White Cypress Pine	*Callitris glaucophylla*
Wilga	*Geijera parviflora*
Yellow Box	*Eucalyptus melliodora*

Table D.12 Quadrat Dataset collected from the Eastern, Western and Northern Offset Properties

Property →		BLUE RANGE	BLUE RANGE	KELSO	KELSO	LOUENVILLE	LOUENVILLE	LOUENVILLE	LOUENVILLE	LOUENVILLE	MT LINDESAY	MT LINDESAY	MT LINDESAY	MT LINDESAY	MT LINDESAY	MT LINDESAY	MT LINDESAY	MT LINDESAY	MT LINDESAY	MT LINDESAY	MT LINDESAY	MT LINDESAY
Family		**Scientific Name**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**Q18**	**Q19**	**Q20**	**Q21**	**Q22**
TREES																								
Apocynaceae		*Alstonia constricta*																						
Casuarinaceae		*Allocasuarina gymnanthera*																						
Casuarinaceae		*Allocasuarina luehmannii*																						
Casuarinaceae		*Allocasuarina stricta*																						
Casuarinaceae		*Casuarina cristata*																						
Casuarinaceae		*Casuarina cunninghamiana*																						
Casuarinaceae		*Casuarina pauper*																						
Cupressaceae		*Callitris endlicheri*																		1				
Cupressaceae		*Callitris glaucophylla*			2	2	2	2	+		1													
Cupressaceae		*Callitris* sp.																						
Fabaceae (Mimosoideae)		*Acacia cheelii*																						
Fabaceae (Mimosoideae)		*Acacia dealbata*																						
Fabaceae (Mimosoideae)		*Acacia implexa*																						
Fabaceae (Mimosoideae)		*Vachellia farnesiana*																						
Loranthaceae		*Amyema cambagei*																						
Loranthaceae		*Amyema lucasii*																						
Loranthaceae		*Amyema maidenii*																						
Loranthaceae		*Amyema miquelii*							+															
Loranthaceae		*Amyema miraculosum*																						
Loranthaceae		*Amyema pendulum*																						
Loranthaceae		*Amyema quandang*																						
Loranthaceae		*Amyema quandang var. bancroftii*																						
Loranthaceae		*Amyema quandang var. quandang*																						
Loranthaceae		*Amyema sp.*																						
Meliaceae		*Melia azedarach*																						
Moraceae		*Ficus ?virens*																						
Moraceae		*Ficus rubiginosa*																						
Myoporaceae		*Eremophila mitchellii*																						
Myrtaceae		*Angophora floribunda*										1				2	3							
Myrtaceae		*Angophora sp*																	2					
Myrtaceae		*Angophora subvelutina*																			2	2		
Myrtaceae		*Corymbia trachyphloia*																						
Myrtaceae		*Eucalyptus albens*	1	1	1		2	2	3	1	3												1	
Myrtaceae		*Eucalyptus bancroftii*																						
Myrtaceae		*Eucalyptus blakelyi*										2	4	+		2	3		1					
Myrtaceae		*Eucalyptus bridgesiana*													2						2		2	
Myrtaceae		*Eucalyptus camaldulensis*		2																				
Myrtaceae		*Eucalyptus chloroclada*																						
Myrtaceae		*Eucalyptus conica*																						
Myrtaceae		*Eucalyptus crebra*			2																			
Myrtaceae		*Eucalyptus crebra (small trees)*			+																			
Myrtaceae		*Eucalyptus dalrympleana ssp. heptantha*																	2		2			
Myrtaceae		*Eucalyptus dealbata*				1																		
Myrtaceae		*Eucalyptus dives*																	3					
Myrtaceae		*Eucalyptus dwyeri*																						
Myrtaceae		*Eucalyptus dwyeri (small trees)*																						
Myrtaceae		*Eucalyptus fibrosa subsp. nubila*																						
Myrtaceae		*Eucalyptus goniocalyx*																				2		
Myrtaceae		*Eucalyptus macrorhyncha*											+	4	3		1			2	2	2		
Myrtaceae		*Eucalyptus macrorhyncha (small trees)*																		1				
Myrtaceae		*Eucalyptus macrorhyncha ssp. macrorhyncha*																4	2					
Myrtaceae		*Eucalyptus sp.*																						
Myrtaceae		*Eucalyptus viminalis*														3								
Myrtaceae		*Melaleuca bracteata*		3																				
Oleaceae		*Notelaea microcarpa var. microcarpa*																						
Pittosporaceae		*Bursaria spinosa*																						
Rhamnaceae		*Alphitonia excelsa*																						
Rhamnaceae		*Pomaderris graniticola*																						
Rhamnaceae		*Pomaderris sp*																						
Rhamnaceae		*Ventilago viminalis*																						
Rutaceae		*Geijera parviflora*		2					+															
Santalaceae		*Exocarpos cupressiformis*																		+				
Sapindaceae		*Alectryon oleifolius subsp. elongatus*		2																				
Sapindaceae		*Alectryon subcinereus*																						
Sapindaceae		*Atalaya hemiglauca*																						
Sapindaceae		*Dodonaea sinuolata subsp. sinuolata*																						
Simaroubaceae		*Ailantus altissima*																						
Sterculiaceae		*Brachychiton populneus*																						
Sterculiaceae		*Brachychiton populneus ssp. populneus*			1																			
Viscaceae		*Notothixos cornifolius*																						
SHRUBS																								
Agavaceae	*	*Agave americana*																						
Apocynaceae		*Carissa ovata*																						
Apocynaceae		*Gompholobium huegelii*																	+					
Asteraceae		*Cassinia aculeata*																						
Asteraceae		*Cassinia arcuata*																						
Asteraceae		*Cassinia leptocephala*																						
Asteraceae		*Cassinia quinquefaria*													+									+
Asteraceae		*Cassinia sp.*																						
Asteraceae		*Olearia elliptica ssp. elliptica*						1	+		+					2		+	1	1	1	1		
Asteraceae		*Olearia sp*												+										
Asteraceae		*Olearia stellulata*												2	2	2		1	1	1	1	1		
Asteraceae		*Olearia viscidula*															1							
Asteraceae	*	*Xanthium spinosum*																						
Boraginaceae		*Ehretia membranifolia*																						
Cactaceae	*	*Opuntia aurantiaca*					+				+													
Cactaceae	*	*Opuntia stricta*					1	1	+		1													

Capparaceae		*Apophyllum anomalum*																					
Capparaceae		*Capparis mitchellii*																					
Caprifoliaceae	*	*Lonicera sp.*																			1		
Celastraceae		*Maytenus cunninghamii*				+	+																
Celastraceae		*Maytenus silvestris*																					
Chenopodiaceae		*Atriplex muelleri*																					
Chenopodiaceae		*Atriplex semibaccata*																					
Chenopodiaceae		*Atriplex* sp.																					
Chenopodiaceae		*Chenopodium auricomum*						+	+		+												
Chenopodiaceae		*Einadia hastata*	1	2			+	+	1		1												
Chenopodiaceae		*Einadia nutans ssp. linifolia*	1		1		1	+		+													
Chenopodiaceae		*Maireana microphylla*																					
Chenopodiaceae		*Rhagodia parabolica*																					
Chenopodiaceae		*Sclerolaena birchii (syn. Bassia birchii)*	1							+													
Chenopodiaceae		*Sclerolaena divaricata*																					
Chenopodiaceae		*Sclerolaena muricata var. semiglabra*		+																			
Chenopodiaceae		*Sclerolaena ventricosa*																					
Chloanthaceae		*Spartothamnella juncea*					1		+														
Cupressaceae		*Callitris endlicheri*																		2			
Cupressaceae		*Callitris glaucophylla*	+			1		1			+												
Dilleniaceae		*Hibbertia obtusifolia*													+				1	1	1	1	
Ericaceae (Styphelioidae)		*Brachyloma daphnoides*															+		1	1			
Ericaceae (Styphelioidae)		*Lissanthe strigosa*													+		+			+	1		
Ericaceae (Styphelioideae)		*Epacris impressa*																					
Ericaceae (Styphelioideae)		*Leucopogon sp.*																					
Ericaceae (Styphelioideae)		*Melichrus urceolatus*													1	+	+	+	1	+	1	1	
Euphorbiaceae		*Beyeria viscosa*					2	1	+		1												
Euphorbiaceae		*Euphorbia tannensis ssp. eremophila var. eremophila*																					
Euphorbiaceae		*Petalostigma quadriloculare*																					
Fabaceae (Caesalpinioideae)		*Cassia barclayana*																					
Fabaceae (Caesalpinioideae)		*Cassia eremophila var. eremophila*																					
Fabaceae (Caesalpinioideae)		*Petalostylis labicheoides*							+														
Fabaceae (Caesalpinioideae)		*Petalostylis labicheoides var. labicheiodes*					+																
Fabaceae (Caesalpinioideae)		*Senna aciphylla*																					
Fabaceae (Caesalpinioideae)		*Senna artemisioides*																					
Fabaceae (Caesalpinioideae)		*Senna artemisioides subsp. coriacea*																					
Fabaceae (Caesalpinioideae)		*Senna artemisioides subsp. petiolaris*																					
Fabaceae (Caesalpinioideae)		*Senna artemisioides subsp. zygophylla*																					
Fabaceae (Caesalpinioideae)		*Senna sp.*																					
Fabaceae (Faboideae)		*Bossiaea sp.*																					
Fabaceae (Faboideae)		*Daviesia genistifolia*																					
Fabaceae (Faboideae)		*Daviesia leptophylla*																					
Fabaceae (Faboideae)		*Daviesia nova-anglica*																					
Fabaceae (Faboideae)		*Daviesia pubigera*																					
Fabaceae (Faboideae)		*Daviesia ulicifolia*																					+
Fabaceae (Faboideae)		*Desmodium brachypodum*				2	1		1		1												
Fabaceae (Faboideae)		*Dillwynia sieberi*																					
Fabaceae (Faboideae)		*Dillwynia sp.*																					
Fabaceae (Faboideae)		*Goodia lotifolia*																					
Fabaceae (Faboideae)		*Hovea lanceolata*																					
Fabaceae (Faboideae)		*Hovea linearis*																					
Fabaceae (Faboideae)		*Hovea sp. (bush)*																					
Fabaceae (Faboideae)		*Indigofera adesmiifolia*			+							1			+			1		+	+	1	
Fabaceae (Faboideae)		*Indigofera australis var. australis*																	1				
Fabaceae (Faboideae)		*Indigofera sp.*																					
Fabaceae (Faboideae)		*Pultenaea cuneata*																					
Fabaceae (Faboideae)		*Pultenaea daphnoides*																					
Fabaceae (Faboideae)		*Pultenaea microphylla*																					
Fabaceae (Faboideae)		*Pultenaea retusa*																					
Fabaceae (Faboideae)		*Pultenaea setulosa*																					
Fabaceae (Faboideae)		*Pultenaea sp*															1						+
Fabaceae (Faboideae)		*Pultenaea sp "G"* (sensu. Weston, 1991)													1				2	1	+		
Fabaceae (Faboideae)		*Swainsona cadellii*					1		1												1		
Fabaceae (Faboideae)		*Swainsona galegifolia*														+	+						+
Fabaceae (Faboideae)		*Swainsona swainsonioides*																					
Fabaceae (Faboideae)		*Templetonia stenophylla*																					
Fabaceae (Mimosoideae)		*Acacia aneura*																					
Fabaceae (Mimosoideae)		*Acacia buxifolia*																					
Fabaceae (Mimosoideae)		*Acacia cheelii*																					
Fabaceae (Mimosoideae)		*Acacia deanei*																					
Fabaceae (Mimosoideae)		*Acacia decora*			+		1																
Fabaceae (Mimosoideae)		*Acacia doratoxylon*																					
Fabaceae (Mimosoideae)		*Acacia excelsa*																					
Fabaceae (Mimosoideae)		*Acacia gladiiformis*																					
Fabaceae (Mimosoideae)		*Acacia hakeoides*																					
Fabaceae (Mimosoideae)		*Acacia harpophylla*																					
Fabaceae (Mimosoideae)		*Acacia homalophylla*																					
Fabaceae (Mimosoideae)		*Acacia leiocalyx*																					
Fabaceae (Mimosoideae)		*Acacia oswaldii*																					
Fabaceae (Mimosoideae)		*Acacia paradoxa*																					
Fabaceae (Mimosoideae)		*Acacia pendula*																					
Fabaceae (Mimosoideae)		*Acacia rubida*																					
Fabaceae (Mimosoideae)		*Acacia salicina*																					
Fabaceae (Mimosoideae)		*Acacia sp.*																					
Fabaceae (Mimosoideae)		*Acacia spectabilis*																					
Fabaceae (Mimosoideae)		*Acacia triptera*																					
Goodeniaceae		*Goodenia ovata*																					
Lamiaceae	*	*Marrubium vulgare*																					
Lamiaceae		*Oncinocalyx betchei*	1		1		1																
Lamiaceae		*Prostanthera cruciflora*																					
Lamiaceae		*Prostanthera granitica*																					
Lamiaceae		*Prostanthera rhombea*																					
Lamiaceae		*Prostanthera* sp.																					

Lamiaceae		*Spartothamnella puberula*																					
Lamiaceae		*Westringia rigida*																					
Loranthaceae		*Lysiana sp.*																					
Loranthaceae		*Lysiana subfalcata*									1												
Malaceae	*	*Cotoneaster pannosus*																	+				
Malvaceae		*Abutilon leucopetalum*																					
Malvaceae		*Abutilon oxycarpum*																					
Malvaceae		*Abutilon oxycarpum var. subsagittatum*		+																			
Malvaceae		*Hibiscus sturtii*																					
Malvaceae	*	*Malva neglecta*																					
Malvaceae	*	*Malva parviflora*																					
Malvaceae		*Malva preissiana*																					
Malvaceae		*Malva* sp.																					
Malvaceae	*	*Malvastrum americanum*		1			1			1													
Malvaceae		*Sida subspicata*	1																				
Myoporaceae		*Eremophila mitchellii*																					
Myoporaceae		*Myoporum deserti*																					
Myoporaceae		*Myoporum montanum*																					
Myrtaceae		*Angophora floribunda*																					
Myrtaceae		*Eucalyptus albens*									1												
Myrtaceae		*Eucalyptus viminalis*														+							
Myrtaceae		*Leptospermum polygalifolium ssp. polygalifolium*																					
Myrtaceae		*Melaleuca bracteata*																					
Myrtaceae		*Melaleuca lanceolata*																					
Myrtaceae		*Melaleuca paludicola*																					
Olacaceae		*Olax stricta*																					
Oleaceae		*Jasminum lineare*																					
Oleaceae	*	*Ligustrum vulgare*					+																
Oleaceae		*Notelaea linearis*																					
Oleaceae		*Notelaea microcarpa*									1		+										
Oleaceae		*Notelaea microcarpa var. microcarpa*		2	1	2	2	2	2			+										+		+
Oleaceae		*Notelaea microcarpa var. subvelutina*																					
Oleaceae		*Notelaea sp.*																					
Phyllanthaceae		*Breynia oblongifolia*																					
Phyllanthaceae		*Phyllanthus virgatus*																+					
Pittosporaceae		*Pittosporum angustifolium*																					
Pittosporaceae		*Pittosporum phillyreoides*																					
Proteaceae		*Grevillea sp.*																					
Rhamnaceae		*Alphitonia excelsa*			+	+	+																
Rhamnaceae		*Cryptandra amara*																					
Rhamnaceae		*Cryptandra sp*										+											+
Rhamnaceae		*Pomaderris andromedifolia*																					
Rosaceae	*	*Rosa rubiginosa*											2					1				+	+
Rosaceae	*	*Rubus fruticosus*																				+	
Rosaceae		*Rubus parvifolius*																					
Rosaceae	*	*Rubus ulmifolius*																					
Rubiaceae		*Canthium odoratum*																					
Rubiaceae		*Canthium sp.*																					
Rubiaceae		*Psydrax odorata*																					
Rubiaceae		*Psydrax oleifolia*				+																	
Rutaceae		*Correa reflexa*																			1		
Rutaceae		*Correa reflexa var. reflexa*																					
Rutaceae		*Geijera parviflora*	2	2	2		+			+	+												
Rutaceae		*Geijera salicifolia*																					
Santalaceae		*Exocarpos cupressiformis*													1							+	
Sapindaceae		*Alectryon diversifolius*																					
Sapindaceae		*Alectryon oleifolius*																					
Sapindaceae		*Alectryon oleifolius subsp. elongatus*																					
Sapindaceae		*Alectryon subdentatus forma. subdentatus*																					
Sapindaceae		*Atalaya hemiglauca*																					
Sapindaceae		*Dodonaea boroniifolia*							+		2												
Sapindaceae		*Dodonaea heteromorpha*																					
Sapindaceae		*Dodonaea multijuga*																					
Sapindaceae		*Dodonaea tenuifolia*																					
Sapindaceae		*Dodonaea truncatiales*																					
Sapindaceae		*Dodonaea viscosa*																					
Sapindaceae		*Dodonaea viscosa ssp angustifolia*				+	2	2	1		1							+				1	
Sapindaceae		*Dodonaea viscosa ssp. cuneata*																					
Solanaceae	*	*Lycium ferocissimum*																					
Solanaceae		*Solanum cinereum*																					
Solanaceae		*Solanum ellipticum*																					
Solanaceae		*Solanum esuriale*																					
Solanaceae		*Solanum ferocissimum*								+													
Solanaceae		*Solanum linearifolium*																					
Solanaceae	*	*Solanum nigrum*																					
Solanaceae		*Solanum parvifolium*							+														
Solanaceae		*Solanum parvifolium ssp. parvifolium*									+												
Sterculiaceae		*Gilesia biniflora*																					
Thymelaeaceae		*Pimelea curviflora*																					
Thymelaeaceae		*Pimelea curviflora var. divergens*				+																	
Thymelaeaceae		*Pimelea linifolia*										2		+								1		+
Thymelaeaceae		*Pimelea linifolia ssp. linifolia*																+		+			
Thymelaeaceae		*Pimelea neo-anglica*			1	+	1	+			1	+	+	+		+		+					
Thymelaeaceae		*Pimelea pauciflora*							1														
Thymelaeaceae		*Pimelea sp.*																					
Thymelaeaceae		*Pimelea stricta*																					
Violaceae		*Melicytus dentatus (=Hymenanthera dentata)*																					
Viscaceae		*Korthalsella rubra ssp geijericola*									+												
HERBS - DICOTS																							
Acanthaceae		*Brunoniella australis*	1	+	+	1			1		+												
Acanthaceae		*Brunoniella pumilio*																					
Acanthaceae		*Pseuderanthemum variabile*																					
Acanthaceae		*Rostellularia adscendens*																					

Acanthaceae		*Rostellularia adscendens var. adscendens*																						
Aizoaceae		*Carpobrotus glaucescens*																						
Aizoaceae	*	*Galenia pubescens*																						
Aizoaceae		*Zaleya galericulata*																						
Amaranthaceae		*Alternanthera denticulata*	+	1																				
Amaranthaceae		*Alternanthera nana*																						
Amaranthaceae	*	*Alternanthera pungens*																						
Amaranthaceae		*Alternanthera sp.*																						
Amaranthaceae	*	*Amaranthus viridis*																						
Anthericaceae		*Tricoryne elatior*										+												
Apiaceae		*Actinotus helianthi*																						
Apiaceae	*	*Ammi majus*																						
Apiaceae		*Centella asiatica*														+								
Apiaceae	*	*Conium maculatum*																						
Apiaceae		*Daucus glochidiatus*	+			1	1	1	1		+													+
Apiaceae	*	*Hydrocotyle bonariensis*											2	2	+									
Apiaceae		*Hydrocotyle laxiflora*														2	+	1			1	1	+	+
Apiaceae		*Hydrocotyle peduncularis*																				1		
Apiaceae		*Hydrocotyle tripartita*																			1			
Apiaceae		*Trachymene sp.*																						
Apocynaceae	*	*Gomphocarpus fruticosus*																						
Apocynaceae		*Marsdenia australis*																						
Apocynaceae		*Marsdenia sp.*																						
Apocynaceae		*Marsdenia viridiflora*																						
Asphodelaceae	*	*Buglossoides arvensis*			+		+		+															
Asteraceae		*Ammobium alatum*										+												
Asteraceae	*	*Arctotheca calendula*																						
Asteraceae	*	*Aster subulatus*																						
Asteraceae	*	*Bidens pilosa*																						+
Asteraceae	*	*Bidens subalternans*																						
Asteraceae	*	*Bidens subalternans var. simulans*		1																				
Asteraceae		*Brachyscome chrysoglossa*																						
Asteraceae		*Brachyscome ciliaris*																						
Asteraceae		*Brachyscome diversifolia var. diversifolia*																	+					
Asteraceae		*Brachyscome gracilis*																						
Asteraceae		*Brachyscome multifida*																						
Asteraceae		*Brachyscome sp*																						
Asteraceae		*Calotis cuneata*																						
Asteraceae		*Calotis cuneifolia*																						
Asteraceae		*Calotis erinacea*																						
Asteraceae		*Calotis hispidula*					1																	
Asteraceae		*Calotis lappulacea*	1	+	+	+	1			+														
Asteraceae		*Calotis sp.*																						
Asteraceae	*	*Carthamus lanatus*	1							1														
Asteraceae		*Cassinia aculeata*																						
Asteraceae		*Cassinia laevis*																						
Asteraceae	*	*Centaurea calcitrapa*								+														
Asteraceae	*	*Centaurea melitensis*																						
Asteraceae	*	*Centaurea solstitialis*					+																	
Asteraceae		*Centipeda minima var. minima*		1																				
Asteraceae	*	*Chondrilla juncea*																						
Asteraceae		*Chondrilla sp.* (seedlings)	+																					
Asteraceae		*Chrysocephalum apiculatum*				+						1			1	+								+
Asteraceae		*Chrysocephalum semipapposum*														+	+							
Asteraceae	*	*Cirsium vulgare*								+						+	adj	+		1		+		+
Asteraceae	*	*Conyza albida*																+	+	1				
Asteraceae	*	*Conyza bonariensis*										+												+
Asteraceae	*	*Conyza sp.*							+															
Asteraceae	*	*Conyza sp. (bonariensis?)*																						
Asteraceae		*Cotula australis*			+				+															
Asteraceae	*	*Cotula coronopifolia*	+																					
Asteraceae		*Cymbonotus lawsonianus*							+			+				1				+	1			+
Asteraceae	*	*Euchiton japonicus*			+																1	1		
Asteraceae	*	*Euchiton japonicus spp. complex*								+	+													
Asteraceae		*Euchiton sp.*																						
Asteraceae		*Euchiton sp. (seedlings)*																						
Asteraceae		*Euchiton sphaericus*							+								+		1				+	
Asteraceae		*Euchtion involucratus*															1						+	+
Asteraceae	*	*Facelis retusa*																						
Asteraceae	*	*Facelis sp.*																						
Asteraceae	*	*Gamochaeta sp*											+			+								
Asteraceae		*Glossocardia bidens*																						
Asteraceae	*	*Gnaphalium japonicum*																						
Asteraceae	*	*Gnaphalium sp.*														+								
Asteraceae		*Gnaphalium sphaericum*																						
Asteraceae	*	*Hedypnois rhagadioloides ssp. cretica*	1																					
Asteraceae		*Helichrysum sp.*																						
Asteraceae	*	*Hypochaeris glabra*	1						+	+										1	1			
Asteraceae	*	*Hypochaeris radicata*										+	+			+		1		1	1		1	
Asteraceae	*	*Hypochaeris sp*												+										
Asteraceae	*	*Lactuca saligna*																						
Asteraceae	*	*Lactuca sp.*																						
Asteraceae		*Lagenophora bellidioides (=Lagenifera stipitata)*																						
Asteraceae		*Leiocarpa panaetioides*																						
Asteraceae		*Leptorhynchos panaetioides*																						
Asteraceae		*Leptorhynchos squamatus*																						
Asteraceae		*Leptorhynchos squamatus ssp squamatus*																						
Asteraceae		*Leptorhynchos tetrachaetus*																						
Asteraceae		*Leucochrysum albicans ssp. albicans var. albicans*																						
Asteraceae		*Microseris lanceolata*																					+	
Asteraceae		*Minuria integerrima*																						
Asteraceae		*Minuria leptophylla*																						
Asteraceae		*Olearia elliptica*													+									

Asteraceae		*Olearia elliptica ssp. elliptica*																						
Asteraceae		*Olearia nernstii*																						
Asteraceae		*Olearia ramulosa*																						
Asteraceae		*Olearia rosmarinifolia*																						
Asteraceae		*Ozothamnus diosmifolius*																						
Asteraceae		*Picris eichleri*																						
Asteraceae		*Podolepis sp.*																						
Asteraceae		*Pseudognaphalium luteoalbum*																						
Asteraceae		*Rhodanthe diffusa ssp. leucactina*																						
Asteraceae	*	*Schkuhria pinnata*																						
Asteraceae	*	*Schkuhria pinnata var. abrotanoides*																						
Asteraceae		*Senecio hispidulus*																						
Asteraceae		*Senecio lautus*										+												
Asteraceae	*	*Senecio madagascariensis*																						
Asteraceae		*Senecio quadridentatus*													+	+								
Asteraceae		*Senecio sp.*					+																	
Asteraceae		*Senecio tenuiflorus*			+			+	1										+	+	1			
Asteraceae		*Sigesbeckia australiensis*																				+		
Asteraceae		*Sigesbeckia sp.*																						
Asteraceae	*	*Silybum marianum*								+														
Asteraceae		*Solenogyne bellioides*																						
Asteraceae		*Solenogyne dominii*																						
Asteraceae	*	*Sonchus asper*	+	1	+		1		1	1									1					
Asteraceae	*	*Sonchus oleraceus*																						
Asteraceae		*Stuartina hamata*																						
Asteraceae		*Stuartina muelleri*																						
Asteraceae		*Stuartina sp.*																						
Asteraceae	*	*Tagetes minuta*																						
Asteraceae	*	*Taraxacum officinale*																				1		
Asteraceae	*	*Tragopogon sp.*																						
Asteraceae		*Triptilodiscus pygmaeus*				1																		
Asteraceae		*Vernonia cinerea*																						
Asteraceae		*Vittadinia cervicularis var. cervicularis*																						
Asteraceae		*Vittadinia cuneata*	1		1	1	1	1	1	1		+				+			+					+
Asteraceae		*Vittadinia dissecta*																						
Asteraceae		*Vittadinia dissecta var. hirta*	+																					
Asteraceae		*Vittadinia muelleri*	+			1																		
Asteraceae		*Vittadinia pterochaeta*																						
Asteraceae		*Vittadinia sulcata*																						
Asteraceae	*	*Xanthium spinosum*		+																				
Asteraceae	*	*Xanthium strumarium*																						
Asteraceae		*Xerochrysum bracteatum*																						
Asteraceae		*Xerochrysum bracteatum ssp bracteatum*																						
Asteraceae		*Xerochrysum palustre*																						
Asteraceae		*Xerochrysum viscosum*																						
Asteraceae	*	*Zinnia peruviana*																						
Boraginaceae	*	*Anchusa arvensis*																						
Boraginaceae		*Cynoglossum australe*																						
Boraginaceae	*	*Echium italicum*																						
Boraginaceae	*	*Echium plantagineum*																						
Boraginaceae	*	*Heliotropium amplexicaule*																						
Brassicaceae	*	*Brassica napus*																						
Brassicaceae	*	*Brassica rapa*																						
Brassicaceae	*	*Brassica* sp.																						
Brassicaceae	*	*Capsella bursa-pastoralis*																						
Brassicaceae	*	*Cardamine hirsuta*																						
Brassicaceae	*	*Hirschfeldia incana*																						
Brassicaceae	*	*Lepidium africanum*	1	1	+		1			+														
Brassicaceae	*	*Lepidium bonariense*																						
Brassicaceae		*Lepidium papillosum*																						
Brassicaceae		*Lepidium pseudohyssopifolium*																						
Brassicaceae		*Lepidium sagittulatum*																						
Brassicaceae		*Lepidium* sp.																						
Brassicaceae		*Lepidium* sp. 2																						
Brassicaceae	*	*Rapistrum rugosum*								2														
Brassicaceae	*	*Sinapsis alba*		+																				
Brassicaceae		*Sisymbrium orientale*		+																				
Cactaceae	*	*Cylindropuntia imbricata*																						
Cactaceae	*	*Cylindropuntia* sp.																						
Cactaceae	*	*Opuntia aurantiaca*																						
Cactaceae	*	*Opuntia* sp.																						
Cactaceae	*	*Opuntia stricta*																						
Cactaceae	*	*Opuntia tomentosa*																						
Campanulaceae		*Wahlenbergia communis*										+			+									
Campanulaceae		*Wahlenbergia fluminalis*																						
Campanulaceae		*Wahlenbergia gracilenta*																			1	1		
Campanulaceae		*Wahlenbergia gracilis*							+								+	1				1	+	+
Campanulaceae		*Wahlenbergia graniticola*																						
Campanulaceae		*Wahlenbergia planiflora*		+					1															
Campanulaceae		*Wahlenbergia planiflora ssp.longipila*																						
Campanulaceae		*Wahlenbergia sp.*	+			1	1			1	1			+						1				
Campanulaceae		*Wahlenbergia* sp. 1																						
Campanulaceae		*Wahlenbergia* sp. 2																						
Campanulaceae		*Wahlenbergia stricta*																						
Caryophyllaceae	*	*Arenaria leptocladus*																						
Caryophyllaceae	*	*Moenchia erecta*																			+			
Caryophyllaceae	*	*Paronychia brasiliana*																						
Caryophyllaceae	*	*Petrorhagia dubia*																						
Caryophyllaceae	*	*Petrorhagia nanteuilii*																				+		+
Caryophyllaceae	*	*Petrorhagia velutina*																						
Caryophyllaceae		*Polycarpaea corymbosa*																						
Caryophyllaceae	*	*Polycarpon tetraphyllum*					+		1															
Caryophyllaceae	*	*Silene gallica*																						

Caryophyllaceae	*	*Stellaria media*		1																				
Caryophyllaceae	*	*Stellaria pallida*			1																			
Caryophyllaceae		*Stellaria sp*																						
Chenopodiaceae		*Chenopodium pumilio*																						
Chenopodiaceae		*Einadia hastata*																						
Chenopodiaceae		*Einadia nutans*																						
Chenopodiaceae		*Einadia nutans ssp. linifolia*																						
Chenopodiaceae		*Einadia polygonoides*																						
Chenopodiaceae		*Einadia* sp.																						
Chenopodiaceae		*Einadia trigonos*																						
Chenopodiaceae		*Enchylaena tomentosa*	+																					
Chenopodiaceae		*Maireana pentagona*																						
Chenopodiaceae		*Maireana sp.*																						
Chenopodiaceae		*Salsola kali*																						
Chenopodiaceae		*Sclerolaena birchii (syn. Bassia birchii)*																						
Chenopodiaceae		*Sclerolaena muricata*																						
Chenopodiaceae		*Sclerolaena muricata var. semiglabra*																						
Chenopodiaceae		*Sclerolaena sp.*																						
Clusiaceae		*Hypericum gramineum*																	+	1		1		
Convolvulaceae		*Convolvulus angustissimus ssp. angustissimus*						+																
Convolvulaceae		*Convolvulus erubescens*																						
Convolvulaceae		*Dichondra repens*											+					1						+
Convolvulaceae		*Dichondra sp.*		1								+		+	+						1	1		
Convolvulaceae		*Dichondra sp. A*	1		1	1	1	1	1		1													
Convolvulaceae		*Evolvulus alsinoides*																						
Crassulaceae		*Crassula sieberiana*	+			1	1		1		1													
Crassulaceae		*Crassula sp.*																						
Dilleniaceae		*Hibbertia obtusifolia*																						
Dilleniaceae		*Hibbertia riparia*																						
Dilleniaceae		*Hibbertia rufa*																						
Dilleniaceae		*Hibbertia sp.*														+								
Droseraceae		*Drosera* sp.																						
Euphorbiaceae		*Chamaesyce drummondii*																						
Euphorbiaceae		*Chamaesyce sp.*					+		+															
Euphorbiaceae		*Chamaesyce sp. A*																						
Euphorbiaceae		*Euphorbia drummondii*																						
Euphorbiaceae		*Euphorbia eremophila*																						
Euphorbiaceae		*Poranthera microphylla*											+				+		+					
Euphorbiaceae		*Poranthera sp*													+									
Euphorbiaceae		*Sauropus ramosissimus*																						
Fabaceae (Faboideae)		*Desmodium brachypodum*			1			2								+	+				+			
Fabaceae (Faboideae)		*Desmodium* sp.																						
Fabaceae (Faboideae)		*Desmodium varians*																1		+	1		+	
Fabaceae (Faboideae)		*Lespedeza juncea ssp. sericea*																			1			
Fabaceae (Faboideae)		*Lotus australis*																				1		
Fabaceae (Faboideae)	*	*Medicago arabica*																						
Fabaceae (Faboideae)	*	*Medicago laciniata*								1														
Fabaceae (Faboideae)	*	*Medicago minima*	1					1		1														
Fabaceae (Faboideae)	*	*Medicago polymorpha*																						
Fabaceae (Faboideae)	*	*Medicago sativa*								1														
Fabaceae (Faboideae)	*	*Medicago sp.*																					+	
Fabaceae (Faboideae)	*	*Medicago sp. (seedlings)*																						
Fabaceae (Faboideae)	*	*Medicago truncatula*	1																					
Fabaceae (Faboideae)		*Pultenaea foliolosa*																						
Fabaceae (Faboideae)		*Swainsona cadellii*						1			1							1				1		
Fabaceae (Faboideae)		*Swainsona galegifolia*										+		+										
Fabaceae (Faboideae)		*Swainsona monticola*																						
Fabaceae (Faboideae)		*Swainsona sp*																						
Fabaceae (Faboideae)	*	*Trifolium arvense*																						+
Fabaceae (Faboideae)	*	*Trifolium dubium*																			+			+
Fabaceae (Faboideae)	*	*Trifolium glomeratum*																						
Fabaceae (Faboideae)	*	*Trifolium repens*																1		1	1			
Fabaceae (Faboideae)	*	*Trifolium sp*					1						2		+									+
Fabaceae (Faboideae)	*	*Trifolium subterraneum*																						
Fabaceae (Faboideae)		*Zornia dyctiocarpa*																						
Fabaceae (Mimosoideae)	*	*Mimosa sp.*																						
Fabaceae (Mimosoideae)		*Neptunia gracilis*																						
Fumariaceae	*	*Fumaria densiflora*																						
Fumariaceae		*Fumaria sp.*		+																				
Gentianaceae	*	*Centaurium erythraea*																						
Gentianaceae	*	*Centaurium sp*																			+			
Gentianaceae		*Schenkia spicata*												+									+	
Geraniaceae		*Erodium crinitum*	+					+		+														
Geraniaceae	*	*Geranium molle*																						
Geraniaceae		*Geranium solanderi*										+	+	1	+	1	+						1	+
Geraniaceae		*Geranium solanderi var. solanderi*																1			1	1		
Geraniaceae		*Geranium sp.*					+	1																
Goodeniaceae		*Goodenia bellidifolia*																						
Goodeniaceae		*Goodenia cycloptera*																						
Goodeniaceae		*Goodenia fascicularis*																						
Goodeniaceae		*Goodenia glabra*																						
Goodeniaceae		*Goodenia hederacea*																	1					
Goodeniaceae		*Goodenia hederacea ssp hederacea*																		1		1		
Goodeniaceae		*Goodenia pinnatifida*																						
Goodeniaceae		*Goodenia rotundifolia*																						
Goodeniaceae		*Goodenia sp.*														+								
Goodeniaceae		*Scaevola spinescens*																						
Haloragaceae		*Gonocarpus sp. aff. elatus*																						
Haloragaceae		*Gonocarpus elatus*																						
Haloragaceae		*Gonocarpus sp.*																						
Haloragaceae		*Gonocarpus tetragynus*																			+			
Haloragaceae		*Gonocarpus teucrioides*																						
Haloragaceae		*Haloragis ?aspera*																						

Haloragaceae		*Haloragis heterophylla*													+					1			
Haloragaceae		*Haloragis serra*																		1			
Haloragaceae		*Haloragis sp*											+									+	
Iridaceae	*	*Sisyrinchium sp. A*																					
Lamiaceae		*Ajuga australis*			+													1			1		
Lamiaceae	*	*Marrubium vulgare*		+																			
Lamiaceae		*Mentha satureioides*									+		+		+					+			+
Lamiaceae		*Mentha sp*												1									
Lamiaceae		*Salvia plebeia*																					
Lamiaceae	*	*Salvia verbenaca*																					
Lamiaceae		*Scutellaria humilis*						+		+										1	1		
Lamiaceae	*	*Stachys arvensis*		1	1		1	1	1														
Lamiaceae		*Teucrium racemosum*																					
Linaceae		*Linum marginale*																					
Lobeliaceae		*Isotoma axillaris*				+																	
Lobeliaceae		*Pratia purpurascens*																			1		
Lythraceae		*Lythrum hyssopifolia*																					
Malvaceae		*Hibiscus trionum*																					
Malvaceae	*	*Malva parviflora*		+																			
Malvaceae	*	*Modiola caroliniana*																					
Malvaceae		*Sida corrugata*	1	+	+		+																
Malvaceae		*Sida cunninghamii*	+																				
Malvaceae		*Sida filiformis*																					
Malvaceae	*	*Sida rhombifolia*																					+
Malvaceae	*	*Sida spinosa*	+	1			1	+	1	+	+												
Malvaceae		*Sida subspicata*																					
Myoporaceae		*Eremophila debilis*																					
Myoporaceae		*Eremophila longifolia*																					
Myoporaceae		*Eremophila mitchellii*					+																
Myrsinaceae	*	*Anagallis arvensis*														+						+	
Myrtaceae		*Angophora floribunda*													+								
Myrtaceae		*Eucalyptus viminalis*													+								
Nyctaginaceae		*Boerhavia dominii*																					
Onagraceae		*Epilobium billardierianum subsp. cinereum*																+					
Onagraceae		*Epilobium sp*									+												
Orchidaceae		*Glossodia* sp.																					
Oxalidaceae		*Oxalis chnoodes*																					
Oxalidaceae	*	*Oxalis corniculata*																					
Oxalidaceae		*Oxalis exilis*																					
Oxalidaceae		*Oxalis perennans*											+		+	+							
Oxalidaceae		*Oxalis radicosa*																					
Oxalidaceae		*Oxalis* sp.	+	1	1	1	+	1	1	+		+						1			1		
Phyllanthaceae		*Phyllanthus gunnii*																					
Phyllanthaceae		*Phyllanthus sp.*																					
Phyllanthaceae		*Phyllanthus virgatus*																+					
Phytolaccaceae	*	*Phytolacca octandra*																					
Pittosporaceae		*Pittosporum undulatum* (seedling)																					
Plantaginaceae		*Plantago cunninghamii*																					
Plantaginaceae		*Plantago debilis*							+											+			
Plantaginaceae	*	*Plantago lanceolata*																					
Plantaginaceae		*Plantago sp.*																+					
Plantaginaceae		*Plantago turrifera*	+			1																	
Plantaginaceae		*Plantago varia*										+											
Polygalaceae		*Polygala japonica*																1			1		
Polygonaceae	*	*Fallopia convolvulus*								1													
Polygonaceae		*Persicaria decipiens*																					
Polygonaceae	*	*Polygonum aviculare*	+							1													
Polygonaceae	*	*Polygonum patulum*								+													
Polygonaceae		*Polygonum plebeium*																					
Polygonaceae		*Polygonum sp.*																					
Polygonaceae		*Rumex brownii*									+	+	+	+	+			+		+			
Polygonaceae	*	*Rumex crispus*																					
Polygonaceae		*Rumex sp.*		1																			
Portulacaceae		*Montia fontana ssp. amporitana*																					
Portulacaceae		*Portulaca oleracea*																					
Ranunculaceae		*Ranunculus lappaceus*																		1			
Ranunculaceae		*Ranunculus sessiliflorus*									+												
Ranunculaceae		*Ranunculus sessiliflorus var. sessiliflorus*	+		+		+	1	1														
Rosaceae		*Acaena anserinifolia*										+	+	1	1	2							
Rosaceae		*Acaena anserovina*																				+	+
Rosaceae		*Acaena novae-zelandiae*															+				1		
Rosaceae		*Acaena sp.*																1	1	+	1		
Rosaceae		*Aphanes australiana*																					
Rosaceae		*Aphanes sp.*																					
Rosaceae	*	*Rosa rubiginosa*										2											
Rosaceae		*Rubus sp*													+								
Rubiaceae		*Asperula conferta*										1	+	+	+	+	+				1	+	1	+
Rubiaceae		*Asperula sp.*																					
Rubiaceae	*	*Galium aparine*		1																			
Rubiaceae		*Galium gaudichaudii*																					
Rubiaceae		*Galium gaudichaudii ssp. gaudichaudii*																1	1	1			
Rubiaceae		*Galium leptogonium*			+																		
Rubiaceae		*Galium microlobum*						+	1														
Rubiaceae		*Galium migrans*																					
Rubiaceae	*	*Galium murale*																					
Rubiaceae		*Galium propinquum*											+	+									
Rubiaceae		*Galium* sp.																					
Rubiaceae		*Opercularia aspera*																					
Rubiaceae		*Opercularia diphylla*																					
Rubiaceae		*Opercularia hispida*																					
Rubiaceae		*Opercularia sp.*																					
Rubiaceae		*Pomax umbellata*																					
Rubiaceae	*	*Sherardia arvensis*																					

Santalaceae		*Santalum lanceolatum*																					
Santalaceae		*Santalum sp.*																					
Scrophulariaceae	*	*Linaria arvensis*	1			1	+	1	+														
Scrophulariaceae		*Mimulus gracilis*																					
Scrophulariaceae	*	*Verbascum sp.*																					
Scrophulariaceae	*	*Verbascum thapsus*																					
Scrophulariaceae	*	*Veronica arvensis*																					
Scrophulariaceae		*Veronica calycina*																					+
Scrophulariaceae		*Veronica plebeia*											+			+	1	1	1		1		
Scrophulariaceae		*Veronica sp*												+									
Solanaceae		*Nicotiana sp.*		+																			
Solanaceae		*Solanum aviculare*																					
Solanaceae	*	*Solanum linnaeanum*																					
Solanaceae	*	*Solanum nigrum*																					+
Solanaceae		*Solanum opacum*																					
Solanaceae		*Solanum parvifolium*																					
Solanaceae		*Solanum parvifolium ssp. parvifolium*																					
Solanaceae		*Solanum sp.*																					
Solanaceae		*Solanum stelligerum*																					
Solanaceae		*Solanum tetrathecum*																					
Stackhousiaceae		*Stackhousia sp.*																					
Stackhousiaceae		*Stackhousia viminea*																					
Thymelaeaceae		*Pimelea microcephala*																					
Thymelaeaceae		*Pimelea pauciflora*																					
Urticaceae		*Parietaria debilis*			+				+														
Urticaceae	*	*Urtica dioica*																					+
Urticaceae		*Urtica incisa*		+																			
Verbenaceae	*	*Glandularia aristigera*																					
Verbenaceae	*	*Verbena bonariensis*																					
Verbenaceae		*Verbena gaudichaudii*																					
Verbenaceae	*	*Verbena officinalis*																					
Verbenaceae	*	*Verbena rigida*																					+
Violaceae		*Viola betonicifolia*										+			+	+	+			1	1	1		
Violaceae		*Viola hederacea*																					
Zygophyllaceae	*	*Tribulus terrestris*																					
HERBS - MONOCOTS																							
Amaryllidaceae		*Crinum pedunculatum*																					
Amaryllidaceae		*Crinum sp.*																					
Anthericaceae		*Arthropodium milleflorum*			1		1		+		1										+		
Anthericaceae		*Arthropodium minus*	1					+															
Anthericaceae		*Arthropodium sp.*														+							
Anthericaceae		*Caesia parviflora*																					
Anthericaceae		*Dichopogon fimbriatus*																					
Anthericaceae		*Dichopogon strictus*																					
Anthericaceae		*Laxmannia gracilis*																					
Asphodelaceae		*Bulbine bulbosa*														+							
Asphodelaceae		*Bulbine semibarbata*				1																	
Colchicaceae		*Wurmbea biglandulosa*																					
Colchicaceae		*Wurmbea dioica*																					
Cyperaceae		*Carex appressa*		1																		+	
Cyperaceae		*Carex breviculmis*																		1	1		
Cyperaceae		*Carex incomitata*														+							
Cyperaceae		*Carex inversa*	+	1								+	+	+	+	+						+	
Cyperaceae		*Carex sp.*																					+
Cyperaceae	*	*Cyperus brevifolius*																					
Cyperaceae	*	*Cyperus eragrostis*		+																			
Cyperaceae		*Cyperus exaltatus*																					
Cyperaceae		*Cyperus fulvus*				+																	
Cyperaceae		*Cyperus gracilis*		1	+		1	1	1		+												
Cyperaceae		*Cyperus sp.*																					
Cyperaceae	*	*Cyperus tenellus*																					
Cyperaceae		*Cyperus vaginatus*																					
Cyperaceae		*Eleocharis sp.*																					
Cyperaceae		*Fimbristylis dichotoma*															+					+	
Cyperaceae		*Gahnia aspera*																					
Cyperaceae		*Isolepis hookeriana*																					
Cyperaceae		*Lepidosperma laterale*																+					
Cyperaceae		*Lepidosperma sp.*																					
Cyperaceae		*Lipocarpha microcephala*																					
Cyperaceae		*Schoenus apogon*											+			1		1		+	1	1	
Cyperaceae		*Schoenus sp*															+						
Cyperaceae		*Scirpus sp.*																					
Cyperaceae		*Scleria mackaviensis*			1	+		+	+														
Juncaceae		*Juncus australis*																					
Juncaceae		*Juncus continuus*																					
Juncaceae		*Juncus filicaulis*																		1			
Juncaceae		*Juncus filiformis*																					
Juncaceae		*Juncus homalocaulis*																		1			
Juncaceae		*Juncus kraussii*																					
Juncaceae		*Juncus remotiflorus*																		1			
Juncaceae		*Juncus sp.*	+	+									+										
Juncaceae		*Juncus subsecundus*										+	+		+	+							
Juncaceae		*Juncus usitatus*																				1	
Juncaceae		*Luzula densiflora*															+						
Juncaceae		*Luzula sp.*												+	+	+				1			
Juncaginaceae		*Triglochin procera*																					
Lomandraceae		*Lomandra bracteata*																					
Lomandraceae		*Lomandra confertifolia*																					
Lomandraceae		*Lomandra confertifolia ssp. rubiginosa*																+		1	+	+	
Lomandraceae		*Lomandra filiformis*										+			+								
Lomandraceae		*Lomandra filiformis ssp. filiformis*																1					
Lomandraceae		*Lomandra glauca*																					
Lomandraceae		*Lomandra longifolia*																		+			

Lomandraceae		*Lomandra multiflora*														+							
Lomandraceae		*Lomandra multiflora ssp. multiflora*																	+	1				
Lomandraceae		*Lomandra sp.*			+						+													
Orchidaceae		*Caladenia carnea*													+	+				+				
Orchidaceae		*Cymbidium canaliculatum*																						
Orchidaceae		*Microtis unifolia*															+						+	
Orchidaceae		*Pterostylis boormanii*																						
Orchidaceae		*Pterostylis hamata*																						
Orchidaceae		*Pterostylis mutica*																						
Orchidaceae		*Pterostylis praetermissa*					+																	
Orchidaceae		*Pterostylis revoluta*																						
Orchidaceae		*Pterostylis sp.*																						
Orchidaceae		*Pterostylis sp. (rosettes only)*					+		+															
Phormiaceae		*Dianella longifolia*																						
Phormiaceae		*Dianella revoluta*													+	+								
Phormiaceae		*Dianella* sp.																						
Phormiaceae		*Dianella* sp. (longifolia group)																	+					
Xanthorrhoeaceae		*Xanthorrhoea glauca*																						
Xanthorrhoeaceae		*Xanthorrhoea sp.*																						
FERNS AND ALLIES																								
Adiantaceae		*Adiantum aethiopicum*																						
Adiantaceae		*Adiantum formosum*																						
Adiantaceae		*Cheilanthes austrotenuifolia*																						
Adiantaceae		*Cheilanthes distans*			1	+	1				1													
Adiantaceae		*Cheilanthes lasiophylla*																						
Adiantaceae		*Cheilanthes sieberi*							1				+	+	+		+		1					
Adiantaceae		*Cheilanthes sieberi ssp sieberi*		+		+	+	1												+		1		
Aspleniaceae		*Pleurosorus rutifolius*																						
Dennstaedtiaceae		*Pteridium esculentum*																						
Marsileaceae		*Marsilea drummondii*																						
Ophioglossaceae		*Ophioglossum lusitanicum*																						
Ophioglossaceae		*Ophioglossum lusitanicum ssp coriaceum*																						
Pteridaceae		*Pellaea nana*																						
VINES AND CLIMBERS																								
Apiaceae		*Hydrocotyle geraniifolia*																						
Apocynaceae		*Parsonsia eucalyptophylla*																						
Apocynaceae		*Parsonsia lanceolata*							+															
Apocynaceae		*Rhyncharrhena linearis*																						
Bignoniaceae		*Pandorea pandorana*			+																			
Fabaceae (Faboideae)		*Glycine canescens*																						
Fabaceae (Faboideae)		*Glycine clandestina*												+	+		+	1	1	+	1	1		
Fabaceae (Faboideae)		*Glycine microphylla*																						
Fabaceae (Faboideae)		*Glycine* sp.																						
Fabaceae (Faboideae)		*Glycine tabacina*		+		+						+	+	+		+		1					+	1
Fabaceae (Faboideae)		*Glycine tomentella*																						
Fabaceae (Faboideae)		*Hardenbergia violacea*												+	+			1	1					
Fabaceae (Faboideae)	*	*Vicia sativa ssp .nigra*																						
Lauraceae		*Cassytha pubescens*																						
Luzuriagaceae		*Eustrephus latifolius*																						+
Luzuriagaceae		*Geitonoplesium cymosum*																1						
Oleaceae		*Jasminum sp. (seedlings)*			+																			
Oleaceae		*Jasminum suavissimum*	+	1				+	+															
Ranunculaceae		*Clematis aristata*													+									
Ranunculaceae		*Clematis glycinoides*																						
Ranunculaceae		*Clematis microphylla*		+					1		+													
Ranunculaceae		*Clematis microphylla var. leptophylla*																						
Ranunculaceae		*Clematis sp.* (seedling)																						
Rosaceae		*Rubus moluccanus var trilobus*																					+	
Rununculaceae		*Clematis sp.*																						
GRASSES																								
Poaceae	*	*Anthoxanthum odoratum*											+		+	+		1						
Poaceae		*Aristida behriana*																						
Poaceae		*Aristida benthamii*																						
Poaceae		*Aristida caput-medusae*																						
Poaceae		*Aristida jerichoensis var.jerichoensis*																						
Poaceae		*Aristida leptopoda*																						
Poaceae		*Aristida personata (= Aristida ramosa var. speciosa)*																						
Poaceae		*Aristida ramosa*				1			1	1						1	1						+	
Poaceae		*Aristida sp.*	1				2				+								1	1	2	2		+
Poaceae		*Aristida vagans*											1		3	2	3							
Poaceae		*Austipa aristiglumis*																						
Poaceae		*Austrodanthonia auriculata*																						
Poaceae		*Austrodanthonia bipartita*																						
Poaceae		*Austrodanthonia caespitosa*	1	1																				
Poaceae		*Austrodanthonia eriantha*																						
Poaceae		*Austrodanthonia fulva*																						
Poaceae		*Austrodanthonia induta*																						
Poaceae		*Austrodanthonia monticola*																						
Poaceae		*Austrodanthonia pilosa*																						
Poaceae		*Austrodanthonia racemosa*															+							
Poaceae		*Austrodanthonia racemosa var. obtusata*			+																			
Poaceae		*Austrodanthonia racemosa var. racemosa*																						
Poaceae		*Austrodanthonia richardsonii*																						
Poaceae		*Austrodanthonia setacea*																						
Poaceae		*Austrodanthonia sp.*											+		+			1	1	1	2	2		
Poaceae		*Austrostipa aristiglumis*	1									+												
Poaceae		*Austrostipa bigeniculata*																						
Poaceae		*Austrostipa densiflora*																						
Poaceae		*Austrostipa ramosissima*																						
Poaceae		*Austrostipa scabra*																						
Poaceae		*Austrostipa scabra ssp. scabra*	2		1	1	1	1	1		+													
Poaceae		*Austrostipa setacea*																						
Poaceae		*Austrostipa sp.*																						

Poaceae		*Austrostipa variabilis*																						
Poaceae		*Austrostipa verticillata*	2	2			1		1	+														
Poaceae	*	*Avena fatua*								1														
Poaceae	*	*Avena sp.*																						
Poaceae		*Bothriochloa decipiens*														1								3
Poaceae		*Bothriochloa decipiens var. decipiens*							1															
Poaceae		*Bothriochloa macra*										+	1	2		1					2	1	1	
Poaceae		*Bothriochloa sp.*	1				1			+	+									1				
Poaceae		*Brachiaria milliformis*																						
Poaceae	*	*Briza minor*																						
Poaceae	*	*Bromus catharticus*		1																				
Poaceae	*	*Bromus molliformis*																						
Poaceae	*	*Bromus racemosus*																						
Poaceae		*Capillipedium parviflorum*																						
Poaceae		*Chloris divaricata*																						
Poaceae	*	*Chloris gayana*																						
Poaceae		*Chloris sp.*																						
Poaceae		*Chloris truncata*								1														+
Poaceae		*Chloris ventricosa*	1	1																				1
Poaceae		*Cymbopogon refractus*			+	1	1	2	1		+							1				1		1
Poaceae		*Cymbopogon sp*										2			+									
Poaceae		*Cynodon dactylon*																						
Poaceae	*	*Dactylis glomerata*		+																				
Poaceae		*Dichanthium sericeum*																						+
Poaceae		*Dichanthium sericeum ssp. sericeum*																						
Poaceae		*Dichelachne crinita*																						
Poaceae		*Dichelachne micrantha*																						
Poaceae		*Dichelachne parva*														+							1	+
Poaceae		*Dichelachne siberiana*																1						
Poaceae		*Dichelachne sp.*																			1			
Poaceae		*Digitaria brownii*																						
Poaceae		*Digitaria diffusa*																						
Poaceae		*Digitaria divaricatissima*																						
Poaceae		*Digitaria sp.*		2																				
Poaceae		*Digitaria* sp.1																						
Poaceae		*Digitaria* sp.2																						
Poaceae		*Echinopogon caespitosus*										+	+	2	+	1	1						+	1
Poaceae		*Echinopogon cheelii*																1	1	1	1	2		
Poaceae		*Echinopogon mckiei*																						
Poaceae		*Echinopogon ovatus*																				+		
Poaceae		*Echinopogon sp.*																						
Poaceae	*	*Eleusine indica*																						
Poaceae		*Elymus scaber*		+												+	1	1	1					+
Poaceae		*Elymus scaber var. plurinervis*																						
Poaceae		*Elymus scaber var. scaber*																						
Poaceae		*Elymus sp*																						
Poaceae		*Enneapogon avenaceus*																						
Poaceae		*Enneapogon gracilis*																						
Poaceae		*Enneapogon intermedius*																						
Poaceae		*Enneapogon nigricans*																						
Poaceae		*Enneapogon sp.*	1			+	1				+													
Poaceae		*Enteropogon acicularis*																						
Poaceae		*Entolasia sp.*																						
Poaceae		*Eragrostis brownii*																						
Poaceae	*	*Eragrostis caroliniana*																						
Poaceae	*	*Eragrostis cilianensis*																						
Poaceae	*	*Eragrostis curvula*																						
Poaceae		*Eragrostis elongata*																						
Poaceae		*Eragrostis lacunaria*																						
Poaceae		*Eragrostis laniflora*																						
Poaceae		*Eragrostis leptostachya*																						+
Poaceae		*Eragrostis megalosperma*																						
Poaceae		*Eragrostis molybdea*																						
Poaceae		*Eragrostis sp.*	+											+										
Poaceae		*Eragrostis* sp.1																						
Poaceae		*Eragrostis* sp.2																						
Poaceae		*Eragrostis tenellula*																						
Poaceae		*Eriochloa pseudoacrotricha*		1																				
Poaceae		*Eriochloa sp.*																						
Poaceae		*Glyceria latispicea*																			1			
Poaceae	*	*Hordeum leporinum*								1														
Poaceae		*Imperata cylindrica*													2									
Poaceae		*Joycea pallida*																						
Poaceae		*Lachnagrostis filiformis (=Agrostis avenacea)*												+			1				+		+	
Poaceae	*	*Lamarckia aurea*																						
Poaceae		*Leptochloa decipiens ssp. asthenes*	1	1	1	1	2	2	1															
Poaceae	*	*Lolium perenne*	1							1														
Poaceae	*	*Lolium* sp.													+									
Poaceae		*Microlaena sp*											4	3	1									
Poaceae		*Microlaena stipoides*														1							+	+
Poaceae		*Microlaena stipoides var. stopoides*						+										1		1		1		
Poaceae		*Notodanthonia longifolia*					1	1	1		+													
Poaceae		*Oplismenus aemulus var. aemulus*																						
Poaceae		*Panicum decompositum*																						
Poaceae		*Panicum effusum*																					+	+
Poaceae		*Panicum simile*																						
Poaceae		*Panicum* sp.																						
Poaceae		*Paspalidium caespitosum*																						
Poaceae		*Paspalidium constrictum*																						
Poaceae		*Paspalidium distans*	+	1																				
Poaceae		*Paspalidium gracile*																						
Poaceae		*Paspalidium sp.*																						
Poaceae	*	*Paspalum dilatatum*																		+				

Poaceae	*	*Paspalum urvillei*																					
Poaceae		*Pennisetum alopecuroides*														+				+	+			
Poaceae	*	*Pennisetum clandestinum*																						
Poaceae		*Pennisetum sp.*																						
Poaceae		*Pentapogon quadrifidus*																						
Poaceae	*	*Phalaris aquatica*																						
Poaceae	*	*Phalaris sp.*	+																					
Poaceae		*Phragmites australis*																						
Poaceae		*Poa labillardierei*											2								1		4	+
Poaceae		*Poa sieberiana*										2		2	+	+	+							+
Poaceae		*Poa sp.*																1	1	1		1		
Poaceae		*Setaria sp.*																						
Poaceae		*Sorghum leiocladum*																		+	1	1		
Poaceae		*Sorghum sp.*																						
Poaceae	*	*Sporobolus africanus*					1																	
Poaceae		*Sporobolus caroli*																						
Poaceae		*Sporobolus creber*							+															1
Poaceae		*Sporobolus elongatus*																						
Poaceae		*Sporobolus sp.*																			1			
Poaceae		*Themeda australis*										2											+	
Poaceae		*Tragus australianus*																						
Poaceae	*	*Triticum aestivum*																						
Poaceae	*	*Urochloa advena*																						
Poaceae	*	*Vulpia bromoides*																						
Poaceae	*	*Vulpia muralis*				1																		
Poaceae	*	*Vulpia myuros*																						
Poaceae	*	*Vulpia* sp.	+					+																

** denotes an exotic species*

+ = <1%, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%

Table D.12 Quadrat Dataset collected from the Eastern, Western and Northern Offset Properties (cont.)

Property →		MT LINDESAY	TESTON NTH	TESTON NTH	TESTON NTH	TESTON STH	TESTON STH	TESTON STH	TESTON STH	TRALEE	VELYAMA	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	MT LINDESAY
Family	**Scientific Name**	**Q23**	**Q24**	**Q25**	**Q26**	**Q27**	**Q28**	**Q29**	**Q30**	**Q31**	**Q32**	**Q33**	**Q34**	**Q35**	**Q36**	**Q37**	**Q38**	**Q39**	**Q40**	**Q41**	**Q42**	**Q43**	**RA1**
TREES																							
Apocynaceae	*Alstonia constricta*																						
Casuarinaceae	*Allocasuarina gymnanthera*																						
Casuarinaceae	*Allocasuarina luehmannii*																						
Casuarinaceae	*Allocasuarina stricta*																						
Casuarinaceae	*Casuarina cristata*						1																
Casuarinaceae	*Casuarina cunninghamiana*																						
Casuarinaceae	*Casuarina pauper*																						
Cupressaceae	*Callitris endlicheri*																						
Cupressaceae	*Callitris glaucophylla*				1	3	1			2		3									3		
Cupressaceae	*Callitris* sp.																						
Fabaceae (Mimosoideae)	*Acacia cheelii*				+																		
Fabaceae (Mimosoideae)	*Acacia dealbata*																						
Fabaceae (Mimosoideae)	*Acacia implexa*																						
Fabaceae (Mimosoideae)	*Vachellia farnesiana*																						
Loranthaceae	*Amyema cambagei*																						
Loranthaceae	*Amyema lucasii*																						
Loranthaceae	*Amyema maidenii*																						
Loranthaceae	*Amyema miquelii*						+				+												
Loranthaceae	*Amyema miraculosum*																						
Loranthaceae	*Amyema pendulum*																						
Loranthaceae	*Amyema quandang*																						
Loranthaceae	*Amyema quandang var. bancroftii*																						
Loranthaceae	*Amyema quandang var. quandang*								+														
Loranthaceae	*Amyema sp.*																						
Meliaceae	*Melia azedarach*																						
Moraceae	*Ficus ?virens*																						
Moraceae	*Ficus rubiginosa*																						
Myoporaceae	*Eremophila mitchellii*																						
Myrtaceae	*Angophora floribunda*													2		2	1	2			1		
Myrtaceae	*Angophora sp*																						
Myrtaceae	*Angophora subvelutina*																						
Myrtaceae	*Corymbia trachyphloia*																						
Myrtaceae	*Eucalyptus albens*		2				2	2			3	1	2		adj	2	2	2					
Myrtaceae	*Eucalyptus bancroftii*																						
Myrtaceae	*Eucalyptus blakelyi*														adj				2				
Myrtaceae	*Eucalyptus bridgesiana*	3												2									
Myrtaceae	*Eucalyptus camaldulensis*																						
Myrtaceae	*Eucalyptus chloroclada*																						
Myrtaceae	*Eucalyptus conica*																						
Myrtaceae	*Eucalyptus crebra*		2		1			3		1		2											
Myrtaceae	*Eucalyptus crebra (small trees)*								2														
Myrtaceae	*Eucalyptus dalrympleana ssp. heptantha*																						
Myrtaceae	*Eucalyptus dealbata*																						
Myrtaceae	*Eucalyptus dives*																						
Myrtaceae	*Eucalyptus dwyeri*				2	2				2													
Myrtaceae	*Eucalyptus dwyeri (small trees)*								+														
Myrtaceae	*Eucalyptus fibrosa subsp. nubila*																						
Myrtaceae	*Eucalyptus goniocalyx*																						
Myrtaceae	*Eucalyptus macrorhyncha*																				1		
Myrtaceae	*Eucalyptus macrorhyncha (small trees)*																						
Myrtaceae	*Eucalyptus macrorhyncha ssp. macrorhyncha*											2	2	3		2	2					3	
Myrtaceae	*Eucalyptus sp.*																						
Myrtaceae	*Eucalyptus viminalis*																						
Myrtaceae	*Melaleuca bracteata*																						
Oleaceae	*Notelaea microcarpa var. microcarpa*																						
Pittosporaceae	*Bursaria spinosa*																						
Rhamnaceae	*Alphitonia excelsa*				+			+															
Rhamnaceae	*Pomaderris graniticola*																						
Rhamnaceae	*Pomaderris sp*											+											
Rhamnaceae	*Ventilago viminalis*																						
Rutaceae	*Geijera parviflora*																						
Santalaceae	*Exocarpos cupressiformis*																						
Sapindaceae	*Alectryon oleifolius subsp. elongatus*																						
Sapindaceae	*Alectryon subcinereus*																						
Sapindaceae	*Atalaya hemiglauca*						1																
Sapindaceae	*Dodonaea sinuolata subsp. sinuolata*																						
Simaroubaceae	*Ailantus altissima*																						
Sterculiaceae	*Brachychiton populneus*																						
Sterculiaceae	*Brachychiton populneus ssp. populneus*															+							
Viscaceae	*Notothixos cornifolius*																						
SHRUBS																							
Agavaceae	* *Agave americana*																						
Apocynaceae	*Carissa ovata*																						
Apocynaceae	*Gompholobium huegelii*																						
Asteraceae	*Cassinia aculeata*																						
Asteraceae	*Cassinia arcuata*																						
Asteraceae	*Cassinia leptocephala*																						
Asteraceae	*Cassinia quinquefaria*	+										+	+				1	+			1	+	
Asteraceae	*Cassinia sp.*																						
Asteraceae	*Olearia elliptica ssp. elliptica*												1	2		1	2	+					
Asteraceae	*Olearia sp*																						
Asteraceae	*Olearia stellulata*													2							+	1	
Asteraceae	*Olearia viscidula*																						
Asteraceae	* *Xanthium spinosum*																						
Boraginaceae	*Ehretia membranifolia*																						
Cactaceae	* *Opuntia aurantiaca*																						
Cactaceae	* *Opuntia stricta*									+													

Capparaceae		*Apophyllum anomalum*																					
Capparaceae		*Capparis mitchellii*							+														
Caprifoliaceae	*	*Lonicera sp.*																					
Celastraceae		*Maytenus cunninghamii*							2	1													
Celastraceae		*Maytenus silvestris*																					
Chenopodiaceae		*Atriplex muelleri*																					
Chenopodiaceae		*Atriplex semibaccata*																					
Chenopodiaceae		*Atriplex* sp.																					
Chenopodiaceae		*Chenopodium auricomum*						+	1			+											
Chenopodiaceae		*Einadia hastata*		1	1	1																	
Chenopodiaceae		*Einadia nutans ssp. linifolia*		1							1	1											
Chenopodiaceae		*Maireana microphylla*		+	+	+						1											
Chenopodiaceae		*Rhagodia parabolica*																					
Chenopodiaceae		*Sclerolaena birchii (syn. Bassia birchii)*		1								1											
Chenopodiaceae		*Sclerolaena divaricata*																					
Chenopodiaceae		*Sclerolaena muricata var. semiglabra*																					
Chenopodiaceae		*Sclerolaena ventricosa*																					
Chloanthaceae		*Spartothamnella juncea*				+				+													
Cupressaceae		*Callitris endlicheri*																					
Cupressaceae		*Callitris glaucophylla*		2					1	1									+				
Dilleniaceae		*Hibbertia obtusifolia*																			+	1	
Ericaceae (Styphelioidae)		*Brachyloma daphnoides*																			1		
Ericaceae (Styphelioidae)		*Lissanthe strigosa*																	+		1		
Ericaceae (Styphelioideae)		*Epacris impressa*																					
Ericaceae (Styphelioideae)		*Leucopogon sp.*																					
Ericaceae (Styphelioideae)		*Melichrus urceolatus*	+										+	1	+			1	1		1		
Euphorbiaceae		*Beyeria viscosa*						2	2														
Euphorbiaceae		*Euphorbia tannensis ssp. eremophila var. eremophila*					+			1													
Euphorbiaceae		*Petalostigma quadriloculare*																					
Fabaceae (Caesalpinioideae)		*Cassia barclayana*																					
Fabaceae (Caesalpinioideae)		*Cassia eremophila var. eremophila*																					
Fabaceae (Caesalpinioideae)		*Petalostylis labicheoides*							1														
Fabaceae (Caesalpinioideae)		*Petalostylis labicheoides var. labicheiodes*				1																	
Fabaceae (Caesalpinioideae)		*Senna aciphylla*																					
Fabaceae (Caesalpinioideae)		*Senna artemisioides*																					
Fabaceae (Caesalpinioideae)		*Senna artemisioides subsp. coriacea*																					
Fabaceae (Caesalpinioideae)		*Senna artemisioides subsp. petiolaris*																					
Fabaceae (Caesalpinioideae)		*Senna artemisioides subsp. zygophylla*																					
Fabaceae (Caesalpinioideae)		*Senna sp.*							+														
Fabaceae (Faboideae)		*Bossiaea sp.*																		1			
Fabaceae (Faboideae)		*Daviesia genistifolia*												2			1						
Fabaceae (Faboideae)		*Daviesia leptophylla*																					
Fabaceae (Faboideae)		*Daviesia nova-anglica*																					
Fabaceae (Faboideae)		*Daviesia pubigera*																					
Fabaceae (Faboideae)		*Daviesia ulicifolia*																					
Fabaceae (Faboideae)		*Desmodium brachypodum*									+												
Fabaceae (Faboideae)		*Dillwynia sieberi*																					
Fabaceae (Faboideae)		*Dillwynia sp.*																					
Fabaceae (Faboideae)		*Goodia lotifolia*																					
Fabaceae (Faboideae)		*Hovea lanceolata*																1	1				
Fabaceae (Faboideae)		*Hovea linearis*																			+		
Fabaceae (Faboideae)		*Hovea sp. (bush)*																					
Fabaceae (Faboideae)		*Indigofera adesmiifolia*						+						+			1	1			+		
Fabaceae (Faboideae)		*Indigofera australis var. australis*																					
Fabaceae (Faboideae)		*Indigofera sp.*																					
Fabaceae (Faboideae)		*Pultenaea cuneata*																					
Fabaceae (Faboideae)		*Pultenaea daphnoides*																					
Fabaceae (Faboideae)		*Pultenaea microphylla*												2					1		3		
Fabaceae (Faboideae)		*Pultenaea retusa*																					
Fabaceae (Faboideae)		*Pultenaea setulosa*																					
Fabaceae (Faboideae)		*Pultenaea sp*																					
Fabaceae (Faboideae)		*Pultenaea sp "G"* (sensu. Weston, 1991)											1										
Fabaceae (Faboideae)		*Swainsona cadellii*							1														
Fabaceae (Faboideae)		*Swainsona galegifolia*																					
Fabaceae (Faboideae)		*Swainsona swainsonioides*																					
Fabaceae (Faboideae)		*Templetonia stenophylla*																					
Fabaceae (Mimosoideae)		*Acacia aneura*																					
Fabaceae (Mimosoideae)		*Acacia buxifolia*																					
Fabaceae (Mimosoideae)		*Acacia cheelii*				+	+			2													
Fabaceae (Mimosoideae)		*Acacia deanei*																					
Fabaceae (Mimosoideae)		*Acacia decora*						1															
Fabaceae (Mimosoideae)		*Acacia doratoxylon*																					
Fabaceae (Mimosoideae)		*Acacia excelsa*																					
Fabaceae (Mimosoideae)		*Acacia gladiiformis*																					
Fabaceae (Mimosoideae)		*Acacia hakeoides*																					
Fabaceae (Mimosoideae)		*Acacia harpophylla*																					
Fabaceae (Mimosoideae)		*Acacia homalophylla*																					
Fabaceae (Mimosoideae)		*Acacia leiocalyx*																					
Fabaceae (Mimosoideae)		*Acacia oswaldii*																					
Fabaceae (Mimosoideae)		*Acacia paradoxa*																				+	
Fabaceae (Mimosoideae)		*Acacia pendula*																					
Fabaceae (Mimosoideae)		*Acacia rubida*																					
Fabaceae (Mimosoideae)		*Acacia salicina*																					
Fabaceae (Mimosoideae)		*Acacia sp.*																					
Fabaceae (Mimosoideae)		*Acacia spectabilis*																					
Fabaceae (Mimosoideae)		*Acacia triptera*																					
Goodeniaceae		*Goodenia ovata*																					
Lamiaceae	*	*Marrubium vulgare*																					
Lamiaceae		*Oncinocalyx betchei*		1		1				+	1												
Lamiaceae		*Prostanthera cruciflora*																					
Lamiaceae		*Prostanthera granitica*																					
Lamiaceae		*Prostanthera rhombea*																					
Lamiaceae		*Prostanthera* sp.																					

Lamiaceae		*Spartothamnella puberula*																						
Lamiaceae		*Westringia rigida*																						
Loranthaceae		*Lysiana sp.*																						
Loranthaceae		*Lysiana subfalcata*																						
Malaceae	*	*Cotoneaster pannosus*																						
Malvaceae		*Abutilon leucopetalum*																						
Malvaceae		*Abutilon oxycarpum*																						
Malvaceae		*Abutilon oxycarpum var. subsagittatum*		+	+																			
Malvaceae		*Hibiscus sturtii*																						
Malvaceae	*	*Malva neglecta*																						
Malvaceae	*	*Malva parviflora*										+												
Malvaceae		*Malva preissiana*																						
Malvaceae		*Malva* sp.																						
Malvaceae	*	*Malvastrum americanum*																						
Malvaceae		*Sida subspicata*																						
Myoporaceae		*Eremophila mitchellii*						+																
Myoporaceae		*Myoporum deserti*																						
Myoporaceae		*Myoporum montanum*																						
Myrtaceae		*Angophora floribunda*												1										
Myrtaceae		*Eucalyptus albens*																						
Myrtaceae		*Eucalyptus viminalis*																						
Myrtaceae		*Leptospermum polygalifolium ssp. polygalifolium*																						
Myrtaceae		*Melaleuca bracteata*			+																			
Myrtaceae		*Melaleuca lanceolata*																						
Myrtaceae		*Melaleuca paludicola*																						
Olacaceae		*Olax stricta*																						
Oleaceae		*Jasminum lineare*																						
Oleaceae	*	*Ligustrum vulgare*					+																	
Oleaceae		*Notelaea linearis*																						
Oleaceae		*Notelaea microcarpa*											+											
Oleaceae		*Notelaea microcarpa var. microcarpa*			+	+	+	1	2	1	1	1				+	1	1	+				1	
Oleaceae		*Notelaea microcarpa var. subvelutina*					1	+																
Oleaceae		*Notelaea sp.*																						
Phyllanthaceae		*Breynia oblongifolia*					+			+														
Phyllanthaceae		*Phyllanthus virgatus*																						
Pittosporaceae		*Pittosporum angustifolium*																						
Pittosporaceae		*Pittosporum phillyreoides*																						
Proteaceae		*Grevillea sp.*																						
Rhamnaceae		*Alphitonia excelsa*							+															
Rhamnaceae		*Cryptandra amara*																				+		
Rhamnaceae		*Cryptandra sp*																						
Rhamnaceae		*Pomaderris andromedifolia*																						
Rosaceae	*	*Rosa rubiginosa*	1											+		+	1		1	1	1		1	+
Rosaceae	*	*Rubus fruticosus*																						
Rosaceae		*Rubus parvifolius*																					1	
Rosaceae	*	*Rubus ulmifolius*																						
Rubiaceae		*Canthium odoratum*																						
Rubiaceae		*Canthium sp.*																						
Rubiaceae		*Psydrax odorata*																						
Rubiaceae		*Psydrax oleifolia*								+	+													
Rutaceae		*Correa reflexa*																					1	
Rutaceae		*Correa reflexa var. reflexa*															+	1						
Rutaceae		*Geijera parviflora*		2	1	1	1	1	1	1	+	2												
Rutaceae		*Geijera salicifolia*																						
Santalaceae		*Exocarpos cupressiformis*	+																					
Sapindaceae		*Alectryon diversifolius*																						
Sapindaceae		*Alectryon oleifolius*																						
Sapindaceae		*Alectryon oleifolius subsp. elongatus*																						
Sapindaceae		*Alectryon subdentatus forma. subdentatus*					+		+															
Sapindaceae		*Atalaya hemiglauca*					+																	
Sapindaceae		*Dodonaea boroniifolia*																						
Sapindaceae		*Dodonaea heteromorpha*																						
Sapindaceae		*Dodonaea multijuga*																						
Sapindaceae		*Dodonaea tenuifolia*																						
Sapindaceae		*Dodonaea truncatiales*																						
Sapindaceae		*Dodonaea viscosa*											2											
Sapindaceae		*Dodonaea viscosa ssp angustifolia*	+				+	1	2	3							1		1	1			3	
Sapindaceae		*Dodonaea viscosa ssp. cuneata*																						
Solanaceae	*	*Lycium ferocissimum*																						
Solanaceae		*Solanum cinereum*				+																		
Solanaceae		*Solanum ellipticum*																						
Solanaceae		*Solanum esuriale*																						
Solanaceae		*Solanum ferocissimum*										1												
Solanaceae		*Solanum linearifolium*																						
Solanaceae	*	*Solanum nigrum*		+																				
Solanaceae		*Solanum parvifolium*																						
Solanaceae		*Solanum parvifolium ssp. parvifolium*			+	1																		
Sterculiaceae		*Gilesia biniflora*																						
Thymelaeaceae		*Pimelea curviflora*														+								
Thymelaeaceae		*Pimelea curviflora var. divergens*												1			+		1					
Thymelaeaceae		*Pimelea linifolia*	+																					
Thymelaeaceae		*Pimelea linifolia ssp. linifolia*												1					1				1	1
Thymelaeaceae		*Pimelea neo-anglica*		1		1		+	1	1	1	+	1	1	+			1		+				
Thymelaeaceae		*Pimelea pauciflora*																						
Thymelaeaceae		*Pimelea sp.*																						
Thymelaeaceae		*Pimelea stricta*																						
Violaceae		*Melicytus dentatus (=Hymenanthera dentata)*																						
Viscaceae		*Korthalsella rubra ssp geijericola*							+															
HERBS - DICOTS																								
Acanthaceae		*Brunoniella australis*						+																
Acanthaceae		*Brunoniella pumilio*																						
Acanthaceae		*Pseuderanthemum variabile*																						
Acanthaceae		*Rostellularia adscendens*														+								

Acanthaceae		*Rostellularia adscendens var. adscendens*																					
Aizoaceae		*Carpobrotus glaucescens*																					
Aizoaceae	*	*Galenia pubescens*																					
Aizoaceae		*Zaleya galericulata*																					
Amaranthaceae		*Alternanthera denticulata*																					
Amaranthaceae		*Alternanthera nana*																					
Amaranthaceae	*	*Alternanthera pungens*																					
Amaranthaceae		*Alternanthera sp.*																					
Amaranthaceae	*	*Amaranthus viridis*																					
Anthericaceae		*Tricoryne elatior*												+						1			
Apiaceae		*Actinotus helianthi*																					
Apiaceae	*	*Ammi majus*																					
Apiaceae		*Centella asiatica*																					
Apiaceae	*	*Conium maculatum*																					
Apiaceae		*Daucus glochidiatus*		1		+	+			1	+			+			1	+	+		1	+		+
Apiaceae	*	*Hydrocotyle bonariensis*																					
Apiaceae		*Hydrocotyle laxiflora*												1	1		1	+	1		1	1	1	+
Apiaceae		*Hydrocotyle peduncularis*																						
Apiaceae		*Hydrocotyle tripartita*																						+
Apiaceae		*Trachymene sp.*																						
Apocynaceae	*	*Gomphocarpus fruticosus*															+							
Apocynaceae		*Marsdenia australis*																						
Apocynaceae		*Marsdenia sp.*																						
Apocynaceae		*Marsdenia viridiflora*																						
Asphodelaceae	*	*Buglossoides arvensis*										1												
Asteraceae		*Ammobium alatum*																						
Asteraceae	*	*Arctotheca calendula*																						
Asteraceae	*	*Aster subulatus*																						
Asteraceae	*	*Bidens pilosa*	+																					
Asteraceae	*	*Bidens subalternans*																						
Asteraceae	*	*Bidens subalternans var. simulans*																						
Asteraceae		*Brachyscome chrysoglossa*																						
Asteraceae		*Brachyscome ciliaris*																						
Asteraceae		*Brachyscome diversifolia var. diversifolia*											+		+									
Asteraceae		*Brachyscome gracilis*					1																	
Asteraceae		*Brachyscome multifida*																						
Asteraceae		*Brachyscome sp*																						
Asteraceae		*Calotis cuneata*																						
Asteraceae		*Calotis cuneifolia*																						
Asteraceae		*Calotis erinacea*																						
Asteraceae		*Calotis hispidula*		1			1																	
Asteraceae		*Calotis lappulacea*		1		1					1	1												
Asteraceae		*Calotis sp.*																						
Asteraceae	*	*Carthamus lanatus*										1				+								
Asteraceae		*Cassinia aculeata*																				+		
Asteraceae		*Cassinia laevis*																						
Asteraceae	*	*Centaurea calcitrapa*																						
Asteraceae	*	*Centaurea melitensis*																						
Asteraceae	*	*Centaurea solstitialis*																						
Asteraceae		*Centipeda minima var. minima*																						
Asteraceae	*	*Chondrilla juncea*																						
Asteraceae		*Chondrilla sp.* (seedlings)																						
Asteraceae		*Chrysocephalum apiculatum*	+											+						+	1		+	
Asteraceae		*Chrysocephalum semipapposum*														+								
Asteraceae	*	*Cirsium vulgare*	+											+	+		+						+	
Asteraceae	*	*Conyza albida*												1			1		+		+		1	+
Asteraceae	*	*Conyza bonariensis*	+													+								
Asteraceae	*	*Conyza sp.*							+															
Asteraceae	*	*Conyza sp. (bonariensis?)*																						
Asteraceae		*Cotula australis*				+	+					1												
Asteraceae	*	*Cotula coronopifolia*																						
Asteraceae		*Cymbonotus lawsonianus*										1							+	1		1		
Asteraceae	*	*Euchiton japonicus*													1		1			1				
Asteraceae	*	*Euchiton japonicus spp. complex*												1										
Asteraceae		*Euchiton sp.*																	+					
Asteraceae		*Euchiton sp. (seedlings)*																						
Asteraceae		*Euchiton sphaericus*	+							+				1		1					1		1	+
Asteraceae		*Euchtion involucratus*	+																					
Asteraceae	*	*Facelis retusa*																						
Asteraceae	*	*Facelis sp.*																						
Asteraceae	*	*Gamochaeta sp*																						
Asteraceae		*Glossocardia bidens*																						
Asteraceae	*	*Gnaphalium japonicum*																						
Asteraceae	*	*Gnaphalium sp.*														+								
Asteraceae		*Gnaphalium sphaericum*																						
Asteraceae	*	*Hedypnois rhagadioloides ssp. cretica*										1												
Asteraceae		*Helichrysum sp.*																						
Asteraceae	*	*Hypochaeris glabra*		+		+	+			1		1												
Asteraceae	*	*Hypochaeris radicata*	+												1	+					1	1	1	1	+
Asteraceae	*	*Hypochaeris sp*																						
Asteraceae	*	*Lactuca saligna*																						
Asteraceae	*	*Lactuca sp.*																						
Asteraceae		*Lagenophora bellidioides (=Lagenifera stipitata)*					+															+	1	1
Asteraceae		*Leiocarpa panaetioides*										1												
Asteraceae		*Leptorhynchos panaetioides*																						
Asteraceae		*Leptorhynchos squamatus*																						
Asteraceae		*Leptorhynchos squamatus ssp squamatus*												1										
Asteraceae		*Leptorhynchos tetrachaetus*																						
Asteraceae		*Leucochrysum albicans ssp. albicans var. albicans*																		1				
Asteraceae		*Microseris lanceolata*																						
Asteraceae		*Minuria integerrima*																						
Asteraceae		*Minuria leptophylla*																						
Asteraceae		*Olearia elliptica*											5											

Asteraceae		*Olearia elliptica ssp. elliptica*							1	+														
Asteraceae		*Olearia nernstii*																						
Asteraceae		*Olearia ramulosa*																						
Asteraceae		*Olearia rosmarinifolia*																						
Asteraceae		*Ozothamnus diosmifolius*																						
Asteraceae		*Picris eichleri*												+				1						
Asteraceae		*Podolepis sp.*																						
Asteraceae		*Pseudognaphalium luteoalbum*																						
Asteraceae		*Rhodanthe diffusa ssp. leucactina*																						
Asteraceae	*	*Schkuhria pinnata*																						
Asteraceae	*	*Schkuhria pinnata var. abrotanoides*																						
Asteraceae		*Senecio hispidulus*																						
Asteraceae		*Senecio lautus*											+											
Asteraceae	*	*Senecio madagascariensis*																						
Asteraceae		*Senecio quadridentatus*																						
Asteraceae		*Senecio sp.*																						
Asteraceae		*Senecio tenuiflorus*												1	1		1		1	1			1	
Asteraceae		*Sigesbeckia australiensis*															1							
Asteraceae		*Sigesbeckia sp.*																						
Asteraceae	*	*Silybum marianum*																						
Asteraceae		*Solenogyne bellioides*																						
Asteraceae		*Solenogyne dominii*																		1				
Asteraceae	*	*Sonchus asper*			1	1													+					
Asteraceae	*	*Sonchus oleraceus*																						
Asteraceae		*Stuartina hamata*		+																				
Asteraceae		*Stuartina muelleri*																						
Asteraceae		*Stuartina sp.*										+												
Asteraceae	*	*Tagetes minuta*																						
Asteraceae	*	*Taraxacum officinale*																						+
Asteraceae	*	*Tragopogon sp.*																						
Asteraceae		*Triptilodiscus pygmaeus*					+			+	1									+	1			
Asteraceae		*Vernonia cinerea*																						
Asteraceae		*Vittadinia cervicularis var. cervicularis*																						
Asteraceae		*Vittadinia cuneata*		1			+	1	+	+	1								1					
Asteraceae		*Vittadinia dissecta*																						
Asteraceae		*Vittadinia dissecta var. hirta*																						
Asteraceae		*Vittadinia muelleri*					+							1					1			1		
Asteraceae		*Vittadinia pterochaeta*																						
Asteraceae		*Vittadinia sulcata*																						
Asteraceae	*	*Xanthium spinosum*																						
Asteraceae	*	*Xanthium strumarium*																						
Asteraceae		*Xerochrysum bracteatum*																						
Asteraceae		*Xerochrysum bracteatum ssp bracteatum*																						
Asteraceae		*Xerochrysum palustre*																						
Asteraceae		*Xerochrysum viscosum*																						
Asteraceae	*	*Zinnia peruviana*																						
Boraginaceae	*	*Anchusa arvensis*					+																	
Boraginaceae		*Cynoglossum australe*																						
Boraginaceae	*	*Echium italicum*																						
Boraginaceae	*	*Echium plantagineum*			1																			
Boraginaceae	*	*Heliotropium amplexicaule*																						
Brassicaceae	*	*Brassica napus*																						
Brassicaceae	*	*Brassica rapa*																						
Brassicaceae	*	*Brassica* sp.																						
Brassicaceae	*	*Capsella bursa-pastoralis*			1							+												
Brassicaceae	*	*Cardamine hirsuta*																						
Brassicaceae	*	*Hirschfeldia incana*			1							1												
Brassicaceae	*	*Lepidium africanum*		1		+	+		+			1												
Brassicaceae	*	*Lepidium bonariense*																						
Brassicaceae		*Lepidium papillosum*																						
Brassicaceae		*Lepidium pseudohyssopifolium*																						
Brassicaceae		*Lepidium sagittulatum*																						
Brassicaceae		*Lepidium* sp.																						
Brassicaceae		*Lepidium* sp. 2																						
Brassicaceae	*	*Rapistrum rugosum*										+												
Brassicaceae	*	*Sinapsis alba*																						
Brassicaceae		*Sisymbrium orientale*		1	1							3												
Cactaceae	*	*Cylindropuntia imbricata*																						
Cactaceae	*	*Cylindropuntia* sp.																						
Cactaceae	*	*Opuntia aurantiaca*																						
Cactaceae	*	*Opuntia* sp.																						
Cactaceae	*	*Opuntia stricta*						+	+	+							1					+		
Cactaceae	*	*Opuntia tomentosa*																						
Campanulaceae		*Wahlenbergia communis*											+									+		
Campanulaceae		*Wahlenbergia fluminalis*																						
Campanulaceae		*Wahlenbergia gracilenta*																		1		1		
Campanulaceae		*Wahlenbergia gracilis*		1												+								
Campanulaceae		*Wahlenbergia graniticola*																			1			
Campanulaceae		*Wahlenbergia planiflora*				1					1	1												
Campanulaceae		*Wahlenbergia planiflora ssp.longipila*																						
Campanulaceae		*Wahlenbergia sp.*												1	1			1	1				1	
Campanulaceae		*Wahlenbergia* sp. 1																						
Campanulaceae		*Wahlenbergia* sp. 2																						
Campanulaceae		*Wahlenbergia stricta*	+																					
Caryophyllaceae	*	*Arenaria leptocladus*																						
Caryophyllaceae	*	*Moenchia erecta*																			1			
Caryophyllaceae	*	*Paronychia brasiliana*																						
Caryophyllaceae	*	*Petrorhagia dubia*																						
Caryophyllaceae	*	*Petrorhagia nanteuilii*	+	+		+					1							+				1	+	
Caryophyllaceae	*	*Petrorhagia velutina*																						
Caryophyllaceae		*Polycarpaea corymbosa*																						
Caryophyllaceae	*	*Polycarpon tetraphyllum*		+							1													
Caryophyllaceae	*	*Silene gallica*																						

Caryophyllaceae	*	*Stellaria media*			+						1											1	
Caryophyllaceae	*	*Stellaria pallida*																			1		+
Caryophyllaceae		*Stellaria sp*																					
Chenopodiaceae		*Chenopodium pumilio*																					
Chenopodiaceae		*Einadia hastata*						+	1	1													
Chenopodiaceae		*Einadia nutans*																					
Chenopodiaceae		*Einadia nutans ssp. linifolia*																					
Chenopodiaceae		*Einadia polygonoides*																					
Chenopodiaceae		*Einadia* sp.																					
Chenopodiaceae		*Einadia trigonos*																					
Chenopodiaceae		*Enchylaena tomentosa*																					
Chenopodiaceae		*Maireana pentagona*																					
Chenopodiaceae		*Maireana sp.*																					
Chenopodiaceae		*Salsola kali*																					
Chenopodiaceae		*Sclerolaena birchii (syn. Bassia birchii)*																					
Chenopodiaceae		*Sclerolaena muricata*																					
Chenopodiaceae		*Sclerolaena muricata var. semiglabra*																					
Chenopodiaceae		*Sclerolaena sp.*																					
Clusiaceae		*Hypericum gramineum*	+				+							1					1	1	1	1	
Convolvulaceae		*Convolvulus angustissimus ssp. angustissimus*															+		1				
Convolvulaceae		*Convolvulus erubescens*																					
Convolvulaceae		*Dichondra repens*											+			+			1		1		
Convolvulaceae		*Dichondra sp.*			1	1					1												
Convolvulaceae		*Dichondra sp. A*		1			+	1		2		1											
Convolvulaceae		*Evolvulus alsinoides*																					
Crassulaceae		*Crassula sieberiana*		1		+	+			+	+	1										1	
Crassulaceae		*Crassula sp.*																					
Dilleniaceae		*Hibbertia obtusifolia*																					
Dilleniaceae		*Hibbertia riparia*																					
Dilleniaceae		*Hibbertia rufa*													+							1	
Dilleniaceae		*Hibbertia sp.*																	1				
Droseraceae		*Drosera* sp.																					
Euphorbiaceae		*Chamaesyce drummondii*																					
Euphorbiaceae		*Chamaesyce sp.*					+																
Euphorbiaceae		*Chamaesyce sp. A*																	1				
Euphorbiaceae		*Euphorbia drummondii*																					
Euphorbiaceae		*Euphorbia eremophila*																					
Euphorbiaceae		*Poranthera microphylla*											+			+						1	1
Euphorbiaceae		*Poranthera sp*																					
Euphorbiaceae		*Sauropus ramosissimus*																					
Fabaceae (Faboideae)		*Desmodium brachypodum*						1	1	1			+										
Fabaceae (Faboideae)		*Desmodium* sp.																					
Fabaceae (Faboideae)		*Desmodium varians*	+				+							1	+	+		+	1	1		1	
Fabaceae (Faboideae)		*Lespedeza juncea ssp. sericea*																	1			1	
Fabaceae (Faboideae)		*Lotus australis*																		1			
Fabaceae (Faboideae)	*	*Medicago arabica*																					
Fabaceae (Faboideae)	*	*Medicago laciniata*																					
Fabaceae (Faboideae)	*	*Medicago minima*		1																			
Fabaceae (Faboideae)	*	*Medicago polymorpha*																					
Fabaceae (Faboideae)	*	*Medicago sativa*																					
Fabaceae (Faboideae)	*	*Medicago sp.*										2										+	
Fabaceae (Faboideae)	*	*Medicago sp. (seedlings)*																+					
Fabaceae (Faboideae)	*	*Medicago truncatula*				1																	
Fabaceae (Faboideae)		*Pultenaea foliolosa*																					
Fabaceae (Faboideae)		*Swainsona cadellii*						1			+				1		1	1	1			1	
Fabaceae (Faboideae)		*Swainsona galegifolia*																					
Fabaceae (Faboideae)		*Swainsona monticola*																					
Fabaceae (Faboideae)		*Swainsona sp*																					
Fabaceae (Faboideae)	*	*Trifolium arvense*				+					+								1		1		
Fabaceae (Faboideae)	*	*Trifolium dubium*										1								1	1		
Fabaceae (Faboideae)	*	*Trifolium glomeratum*		1			+																
Fabaceae (Faboideae)	*	*Trifolium repens*												1					1	1	2	+		+
Fabaceae (Faboideae)	*	*Trifolium sp*																					
Fabaceae (Faboideae)	*	*Trifolium subterraneum*																					
Fabaceae (Faboideae)		*Zornia dyctiocarpa*																					
Fabaceae (Mimosoideae)	*	*Mimosa sp.*																					
Fabaceae (Mimosoideae)		*Neptunia gracilis*																					
Fumariaceae	*	*Fumaria densiflora*			+																		
Fumariaceae		*Fumaria sp.*																					
Gentianaceae	*	*Centaurium erythraea*																					
Gentianaceae	*	*Centaurium sp*																			1		
Gentianaceae		*Schenkia spicata*	+									+				1	1		1			1	
Geraniaceae		*Erodium crinitum*								+		+											
Geraniaceae	*	*Geranium molle*																					
Geraniaceae		*Geranium solanderi*	+													+							
Geraniaceae		*Geranium solanderi var. solanderi*		+		1				1	+			1	1		1		1	1		1	1	+
Geraniaceae		*Geranium sp.*										+											
Goodeniaceae		*Goodenia bellidifolia*																					
Goodeniaceae		*Goodenia cycloptera*																					
Goodeniaceae		*Goodenia fascicularis*																					
Goodeniaceae		*Goodenia glabra*																					
Goodeniaceae		*Goodenia hederacea*																					
Goodeniaceae		*Goodenia hederacea ssp hederacea*																				1	
Goodeniaceae		*Goodenia pinnatifida*																					
Goodeniaceae		*Goodenia rotundifolia*																					
Goodeniaceae		*Goodenia sp.*									+												
Goodeniaceae		*Scaevola spinescens*																					
Haloragaceae		*Gonocarpus sp. aff. elatus*				+																	
Haloragaceae		*Gonocarpus elatus*																					
Haloragaceae		*Gonocarpus sp.*																					
Haloragaceae		*Gonocarpus tetragynus*					1																
Haloragaceae		*Gonocarpus teucrioides*																					
Haloragaceae		*Haloragis ?aspera*																					

Haloragaceae		*Haloragis heterophylla*												+						1				+
Haloragaceae		*Haloragis serra*																						
Haloragaceae		*Haloragis sp*																						
Iridaceae	*	*Sisyrinchium sp. A*																						+
Lamiaceae		*Ajuga australis*						+											1	1			1	
Lamiaceae	*	*Marrubium vulgare*			1																			
Lamiaceae		*Mentha satureioides*	+												1	+	1	1	1	1			1	
Lamiaceae		*Mentha sp*																						
Lamiaceae		*Salvia plebeia*																						
Lamiaceae	*	*Salvia verbenaca*																						
Lamiaceae		*Scutellaria humilis*													1		1	1	1				1	
Lamiaceae	*	*Stachys arvensis*		1	1	1				+	1													
Lamiaceae		*Teucrium racemosum*																						
Linaceae		*Linum marginale*																						
Lobeliaceae		*Isotoma axillaris*																						
Lobeliaceae		*Pratia purpurascens*			1																			
Lythraceae		*Lythrum hyssopifolia*																						
Malvaceae		*Hibiscus trionum*																						
Malvaceae	*	*Malva parviflora*			1																			
Malvaceae	*	*Modiola caroliniana*																						
Malvaceae		*Sida corrugata*		1			+				1	1												
Malvaceae		*Sida cunninghamii*				+	+																	
Malvaceae		*Sida filiformis*																						
Malvaceae	*	*Sida rhombifolia*																						
Malvaceae	*	*Sida spinosa*				1		+	+		1	1												
Malvaceae		*Sida subspicata*																						
Myoporaceae		*Eremophila debilis*																						
Myoporaceae		*Eremophila longifolia*																						
Myoporaceae		*Eremophila mitchellii*																						
Myrsinaceae	*	*Anagallis arvensis*								+										+				
Myrtaceae		*Angophora floribunda*																						
Myrtaceae		*Eucalyptus viminalis*																						
Nyctaginaceae		*Boerhavia dominii*																						
Onagraceae		*Epilobium billardierianum subsp. cinereum*															1							
Onagraceae		*Epilobium sp*																						
Orchidaceae		*Glossodia* sp.																						
Oxalidaceae		*Oxalis chnoodes*																						
Oxalidaceae	*	*Oxalis corniculata*																						
Oxalidaceae		*Oxalis exilis*																						
Oxalidaceae		*Oxalis perennans*																						
Oxalidaceae		*Oxalis radicosa*																						
Oxalidaceae		*Oxalis* sp.		1	1		+		+	+		1		1			1	1	1	1	1			+
Phyllanthaceae		*Phyllanthus gunnii*																						
Phyllanthaceae		*Phyllanthus sp.*												1										
Phyllanthaceae		*Phyllanthus virgatus*																						
Phytolaccaceae	*	*Phytolacca octandra*																						
Pittosporaceae		*Pittosporum undulatum* (seedling)																						
Plantaginaceae		*Plantago cunninghamii*																						
Plantaginaceae		*Plantago debilis*																		1	1	1		
Plantaginaceae	*	*Plantago lanceolata*																		1				
Plantaginaceae		*Plantago sp.*										1												
Plantaginaceae		*Plantago turrifera*				+				1	+													
Plantaginaceae		*Plantago varia*																						
Polygalaceae		*Polygala japonica*												+										
Polygonaceae	*	*Fallopia convolvulus*			1																			
Polygonaceae		*Persicaria decipiens*																						
Polygonaceae	*	*Polygonum aviculare*																						
Polygonaceae	*	*Polygonum patulum*																						
Polygonaceae		*Polygonum plebeium*																						
Polygonaceae		*Polygonum sp.*																						
Polygonaceae		*Rumex brownii*			1															+		1		1	+
Polygonaceae	*	*Rumex crispus*																						
Polygonaceae		*Rumex sp.*																						
Portulacaceae		*Montia fontana ssp. amporitana*																						+
Portulacaceae		*Portulaca oleracea*																						
Ranunculaceae		*Ranunculus lappaceus*													1				1					
Ranunculaceae		*Ranunculus sessiliflorus*																						
Ranunculaceae		*Ranunculus sessiliflorus var. sessiliflorus*																		+	1	1		+
Rosaceae		*Acaena anserinifolia*																						
Rosaceae		*Acaena anserovina*	+																					
Rosaceae		*Acaena novae-zelandiae*																	1					
Rosaceae		*Acaena sp.*												1	1		1			1	1	1	1	
Rosaceae		*Aphanes australiana*																						
Rosaceae		*Aphanes sp.*																						
Rosaceae	*	*Rosa rubiginosa*																	1			1		
Rosaceae		*Rubus sp*																						
Rubiaceae		*Asperula conferta*	+											1	1	+	1	1	1	1	2			+
Rubiaceae		*Asperula sp.*																						
Rubiaceae	*	*Galium aparine*																						
Rubiaceae		*Galium gaudichaudii*																						
Rubiaceae		*Galium gaudichaudii ssp. gaudichaudii*		+						+									+			1	1	
Rubiaceae		*Galium leptogonium*												+	1		1	1				+	1	
Rubiaceae		*Galium microlobum*																						
Rubiaceae		*Galium migrans*																						
Rubiaceae	*	*Galium murale*																						
Rubiaceae		*Galium propinquum*																						
Rubiaceae		*Galium* sp.																						
Rubiaceae		*Opercularia aspera*																						
Rubiaceae		*Opercularia diphylla*																						
Rubiaceae		*Opercularia hispida*																						
Rubiaceae		*Opercularia sp.*																						
Rubiaceae		*Pomax umbellata*																						
Rubiaceae	*	*Sherardia arvensis*																						

Santalaceae		*Santalum lanceolatum*																						
Santalaceae		*Santalum sp.*																						
Scrophulariaceae	*	*Linaria arvensis*		1		1	+				1	1												
Scrophulariaceae		*Mimulus gracilis*																						
Scrophulariaceae	*	*Verbascum sp.*																						
Scrophulariaceae	*	*Verbascum thapsus*																				+		
Scrophulariaceae	*	*Veronica arvensis*																			1			
Scrophulariaceae		*Veronica calycina*																						
Scrophulariaceae		*Veronica plebeia*																				1	1	
Scrophulariaceae		*Veronica sp*											+											
Solanaceae		*Nicotiana sp.*																						
Solanaceae		*Solanum aviculare*																						
Solanaceae	*	*Solanum linnaeanum*																						
Solanaceae	*	*Solanum nigrum*																						
Solanaceae		*Solanum opacum*																						
Solanaceae		*Solanum parvifolium*																						
Solanaceae		*Solanum parvifolium ssp. parvifolium*						+																
Solanaceae		*Solanum sp.*																						
Solanaceae		*Solanum stelligerum*																						
Solanaceae		*Solanum tetrathecum*																						
Stackhousiaceae		*Stackhousia sp.*									1													
Stackhousiaceae		*Stackhousia viminea*																						
Thymelaeaceae		*Pimelea microcephala*																						
Thymelaeaceae		*Pimelea pauciflora*																						
Urticaceae		*Parietaria debilis*		+	+	+						1												
Urticaceae	*	*Urtica dioica*																						
Urticaceae		*Urtica incisa*			1																			
Verbenaceae	*	*Glandularia aristigera*																						
Verbenaceae	*	*Verbena bonariensis*																				+		
Verbenaceae		*Verbena gaudichaudii*																						
Verbenaceae	*	*Verbena officinalis*																						
Verbenaceae	*	*Verbena rigida*																						
Violaceae		*Viola betonicifolia*	+											1	1		1			1				
Violaceae		*Viola hederacea*																						
Zygophyllaceae	*	*Tribulus terrestris*																						
HERBS - MONOCOTS																								
Amaryllidaceae		*Crinum pedunculatum*																						
Amaryllidaceae		*Crinum sp.*																						
Anthericaceae		*Arthropodium milleflorum*								1					1			+	+				1	
Anthericaceae		*Arthropodium minus*				1	1			+	1													
Anthericaceae		*Arthropodium sp.*																						
Anthericaceae		*Caesia parviflora*																						
Anthericaceae		*Dichopogon fimbriatus*																						
Anthericaceae		*Dichopogon strictus*																						
Anthericaceae		*Laxmannia gracilis*																						
Asphodelaceae		*Bulbine bulbosa*													+									
Asphodelaceae		*Bulbine semibarbata*				1	+			+														
Colchicaceae		*Wurmbea biglandulosa*																						
Colchicaceae		*Wurmbea dioica*																						
Cyperaceae		*Carex appressa*																						
Cyperaceae		*Carex breviculmis*												1	1		1	1	1	1				
Cyperaceae		*Carex incomitata*												+			1	+						
Cyperaceae		*Carex inversa*	+		1											+	1		1	+				+
Cyperaceae		*Carex sp.*																						
Cyperaceae	*	*Cyperus brevifolius*																						
Cyperaceae	*	*Cyperus eragrostis*																						
Cyperaceae		*Cyperus exaltatus*																						
Cyperaceae		*Cyperus fulvus*																						
Cyperaceae		*Cyperus gracilis*		1		+	+	1	1	1	1	1												
Cyperaceae		*Cyperus sp.*																		1				
Cyperaceae	*	*Cyperus tenellus*																						
Cyperaceae		*Cyperus vaginatus*																+						+
Cyperaceae		*Eleocharis sp.*																						
Cyperaceae		*Fimbristylis dichotoma*	+													+								
Cyperaceae		*Gahnia aspera*																						
Cyperaceae		*Isolepis hookeriana*																						
Cyperaceae		*Lepidosperma laterale*																						
Cyperaceae		*Lepidosperma sp.*																						
Cyperaceae		*Lipocarpha microcephala*																						
Cyperaceae		*Schoenus apogon*												1	1		1		1	2				+
Cyperaceae		*Schoenus sp*																						
Cyperaceae		*Scirpus sp.*																						
Cyperaceae		*Scleria mackaviensis*							1															
Juncaceae		*Juncus australis*																						+
Juncaceae		*Juncus continuus*																						
Juncaceae		*Juncus filicaulis*												1			1			1	1			+
Juncaceae		*Juncus filiformis*																						
Juncaceae		*Juncus homalocaulis*																		1	1			+
Juncaceae		*Juncus kraussii*																						
Juncaceae		*Juncus remotiflorus*																		1				
Juncaceae		*Juncus sp.*																						
Juncaceae		*Juncus subsecundus*	+																					
Juncaceae		*Juncus usitatus*														+								
Juncaceae		*Luzula densiflora*																						
Juncaceae		*Luzula sp.*												1	1			1		1		+		
Juncaginaceae		*Triglochin procera*																						
Lomandraceae		*Lomandra bracteata*																		+				
Lomandraceae		*Lomandra confertifolia*																						
Lomandraceae		*Lomandra confertifolia ssp. rubiginosa*													1		+							
Lomandraceae		*Lomandra filiformis*																						
Lomandraceae		*Lomandra filiformis ssp. filiformis*																+	+			+		
Lomandraceae		*Lomandra glauca*																						
Lomandraceae		*Lomandra longifolia*												1			+		+					

Lomandraceae		*Lomandra multiflora*											+										
Lomandraceae		*Lomandra multiflora ssp. multiflora*				+								2				1					
Lomandraceae		*Lomandra sp.*																					
Orchidaceae		*Caladenia carnea*												+					+			1	
Orchidaceae		*Cymbidium canaliculatum*																					
Orchidaceae		*Microtis unifolia*																		+			+
Orchidaceae		*Pterostylis boormanii*																					
Orchidaceae		*Pterostylis hamata*																					
Orchidaceae		*Pterostylis mutica*																+	1	1			
Orchidaceae		*Pterostylis praetermissa*							+														
Orchidaceae		*Pterostylis revoluta*																					
Orchidaceae		*Pterostylis sp.*																					
Orchidaceae		*Pterostylis sp. (rosettes only)*								+													
Phormiaceae		*Dianella longifolia*																					
Phormiaceae		*Dianella revoluta*																					
Phormiaceae		*Dianella* sp.																					
Phormiaceae		*Dianella* sp. (longifolia group)																					
Xanthorrhoeaceae		*Xanthorrhoea glauca*																					
Xanthorrhoeaceae		*Xanthorrhoea sp.*																					
FERNS AND ALLIES																							
Adiantaceae		*Adiantum aethiopicum*																				1	
Adiantaceae		*Adiantum formosum*																					
Adiantaceae		*Cheilanthes austrotenuifolia*																					
Adiantaceae		*Cheilanthes distans*		1		1	1	1	+	1	2												
Adiantaceae		*Cheilanthes lasiophylla*																					
Adiantaceae		*Cheilanthes sieberi*	+	1		1	1			1	1		+	+		+							
Adiantaceae		*Cheilanthes sieberi ssp sieberi*																+		+		+	
Aspleniaceae		*Pleurosorus rutifolius*																					
Dennstaedtiaceae		*Pteridium esculentum*																				2	
Marsileaceae		*Marsilea drummondii*																					
Ophioglossaceae		*Ophioglossum lusitanicum*																					
Ophioglossaceae		*Ophioglossum lusitanicum ssp coriaceum*																					
Pteridaceae		*Pellaea nana*																+					
VINES AND CLIMBERS																							
Apiaceae		*Hydrocotyle geraniifolia*																					
Apocynaceae		*Parsonsia eucalyptophylla*		1			+				1												
Apocynaceae		*Parsonsia lanceolata*																					
Apocynaceae		*Rhyncharrhena linearis*																					
Bignoniaceae		*Pandorea pandorana*								+													
Fabaceae (Faboideae)		*Glycine canescens*																					
Fabaceae (Faboideae)		*Glycine clandestina*								1			+	1	1		1	1		+		1	1	
Fabaceae (Faboideae)		*Glycine microphylla*	+																				
Fabaceae (Faboideae)		*Glycine* sp.																					
Fabaceae (Faboideae)		*Glycine tabacina*	+		+		+				+					+			1	1			+
Fabaceae (Faboideae)		*Glycine tomentella*																					
Fabaceae (Faboideae)		*Hardenbergia violacea*																1	+			+	
Fabaceae (Faboideae)	*	*Vicia sativa ssp .nigra*																					
Lauraceae		*Cassytha pubescens*																					
Luzuriagaceae		*Eustrephus latifolius*																					
Luzuriagaceae		*Geitonoplesium cymosum*												1	1		1	+				1	
Oleaceae		*Jasminum sp. (seedlings)*																					
Oleaceae		*Jasminum suavissimum*																					
Ranunculaceae		*Clematis aristata*								1													
Ranunculaceae		*Clematis glycinoides*																					
Ranunculaceae		*Clematis microphylla*							1														
Ranunculaceae		*Clematis microphylla var. leptophylla*																					
Ranunculaceae		*Clematis sp.* (seedling)																					
Rosaceae		*Rubus moluccanus var trilobus*																					
Runnunculaceae		*Clematis sp.*													+			+				1	
GRASSES																							
Poaceae	*	*Anthoxanthum odoratum*																1					+
Poaceae		*Aristida behriana*																					
Poaceae		*Aristida benthamii*																					
Poaceae		*Aristida caput-medusae*												1									
Poaceae		*Aristida jerichoensis var.jerichoensis*																					
Poaceae		*Aristida leptopoda*																					
Poaceae		*Aristida personata (= Aristida ramosa var. speciosa)*																					
Poaceae		*Aristida ramosa*	+										+			2							
Poaceae		*Aristida sp.*		1	+		1		1	2	1	2			2		1	1	1	1		1	1	
Poaceae		*Aristida vagans*	+																				
Poaceae		*Austipa aristiglumis*																					
Poaceae		*Austrodanthonia auriculata*																					
Poaceae		*Austrodanthonia bipartita*																					
Poaceae		*Austrodanthonia caespitosa*																					
Poaceae		*Austrodanthonia eriantha*																					
Poaceae		*Austrodanthonia fulva*																					
Poaceae		*Austrodanthonia induta*																					
Poaceae		*Austrodanthonia monticola*																					
Poaceae		*Austrodanthonia pilosa*																				1	
Poaceae		*Austrodanthonia racemosa*	+																				
Poaceae		*Austrodanthonia racemosa var. obtusata*			+	1	1																
Poaceae		*Austrodanthonia racemosa var. racemosa*													2		2						
Poaceae		*Austrodanthonia richardsonii*																					
Poaceae		*Austrodanthonia setacea*																					
Poaceae		*Austrodanthonia sp.*		1							1	1	1	1				1	1	1			1
Poaceae		*Austrostipa aristiglumis*			1																		
Poaceae		*Austrostipa bigeniculata*																					
Poaceae		*Austrostipa densiflora*																					
Poaceae		*Austrostipa ramosissima*																					
Poaceae		*Austrostipa scabra*											1									1	1
Poaceae		*Austrostipa scabra ssp. scabra*		1		2	1	1	1	1	1	1											
Poaceae		*Austrostipa setacea*																					
Poaceae		*Austrostipa sp.*												1									

Poaceae		*Austrostipa variabilis*																						
Poaceae		*Austrostipa verticillata*		+	1	2			+			1												
Poaceae	*	*Avena fatua*																						
Poaceae	*	*Avena sp.*			+																			
Poaceae		*Bothriochloa decipiens*														3								
Poaceae		*Bothriochloa decipiens var. decipiens*																						
Poaceae		*Bothriochloa macra*	1																					
Poaceae		*Bothriochloa sp.*		1	1	2		1			1	1		1			2		1	1	3			+
Poaceae		*Brachiaria milliformis*																						
Poaceae	*	*Briza minor*																						
Poaceae	*	*Bromus catharticus*																						
Poaceae	*	*Bromus molliformis*			1											+								
Poaceae	*	*Bromus racemosus*																						
Poaceae		*Capillipedium parviflorum*																						
Poaceae		*Chloris divaricata*																						
Poaceae	*	*Chloris gayana*																						
Poaceae		*Chloris sp.*																						
Poaceae		*Chloris truncata*																						
Poaceae		*Chloris ventricosa*				1		1																
Poaceae		*Cymbopogon refractus*				1	+	1	1	1	1			2	2		2	1	1			1	2	
Poaceae		*Cymbopogon sp*																						
Poaceae		*Cynodon dactylon*																						
Poaceae	*	*Dactylis glomerata*																						
Poaceae		*Dichanthium sericeum*														1								
Poaceae		*Dichanthium sericeum ssp. sericeum*																						
Poaceae		*Dichelachne crinita*																						
Poaceae		*Dichelachne micrantha*												1	1		1			2	2	1		
Poaceae		*Dichelachne parva*	+																					
Poaceae		*Dichelachne siberiana*																	1					
Poaceae		*Dichelachne sp.*																			2			
Poaceae		*Digitaria brownii*																						
Poaceae		*Digitaria diffusa*																						
Poaceae		*Digitaria divaricatissima*																						
Poaceae		*Digitaria sp.*																						
Poaceae		*Digitaria* sp.1																						
Poaceae		*Digitaria* sp.2																						
Poaceae		*Echinopogon caespitosus*	1																					
Poaceae		*Echinopogon cheelii*													2		2		1					
Poaceae		*Echinopogon mckiei*																						
Poaceae		*Echinopogon ovatus*																						
Poaceae		*Echinopogon sp.*																1		2		+	2	
Poaceae	*	*Eleusine indica*																						
Poaceae		*Elymus scaber*														+		1	1	1	1	1	1	
Poaceae		*Elymus scaber var. plurinervis*												1	2		1							
Poaceae		*Elymus scaber var. scaber*																						
Poaceae		*Elymus sp*																						
Poaceae		*Enneapogon avenaceus*																						
Poaceae		*Enneapogon gracilis*		1					+	1														
Poaceae		*Enneapogon intermedius*																						
Poaceae		*Enneapogon nigricans*																						
Poaceae		*Enneapogon sp.*				1	+	1			1													
Poaceae		*Enteropogon acicularis*															1							
Poaceae		*Entolasia sp.*																						
Poaceae		*Eragrostis brownii*																						
Poaceae	*	*Eragrostis caroliniana*																						
Poaceae	*	*Eragrostis cilianensis*																						
Poaceae	*	*Eragrostis curvula*																						
Poaceae		*Eragrostis elongata*					1					1												
Poaceae		*Eragrostis lacunaria*																						
Poaceae		*Eragrostis laniflora*																						
Poaceae		*Eragrostis leptostachya*	+													1								
Poaceae		*Eragrostis megalosperma*																						
Poaceae		*Eragrostis molybdea*																						
Poaceae		*Eragrostis sp.*		1			+		1			1			1									+
Poaceae		*Eragrostis* sp.1																						
Poaceae		*Eragrostis* sp.2																						
Poaceae		*Eragrostis tenellula*																						
Poaceae		*Eriochloa pseudoacrotricha*																						
Poaceae		*Eriochloa sp.*																						
Poaceae		*Glyceria latispicea*																						
Poaceae	*	*Hordeum leporinum*			1	1																		
Poaceae		*Imperata cylindrica*																						
Poaceae		*Joycea pallida*																						
Poaceae		*Lachnagrostis filiformis (=Agrostis avenacea)*																			1			
Poaceae	*	*Lamarckia aurea*				1																		
Poaceae		*Leptochloa decipiens ssp. asthenes*		1			1	1																
Poaceae	*	*Lolium perenne*			1	1						1												
Poaceae	*	*Lolium* sp.																						
Poaceae		*Microlaena sp*																						
Poaceae		*Microlaena stipoides*	+																					
Poaceae		*Microlaena stipoides var. stopoides*				2									+									
Poaceae		*Notodanthonia longifolia*							1	1														
Poaceae		*Oplismenus aemulus var. aemulus*																						
Poaceae		*Panicum decompositum*																						
Poaceae		*Panicum effusum*	+													+								
Poaceae		*Panicum simile*																						
Poaceae		*Panicum* sp.																						
Poaceae		*Paspalidium caespitosum*																						
Poaceae		*Paspalidium constrictum*																						
Poaceae		*Paspalidium distans*				1					1													
Poaceae		*Paspalidium gracile*																						
Poaceae		*Paspalidium sp.*																						
Poaceae	*	*Paspalum dilatatum*																						+

Poaceae	*	*Paspalum urvillei*																					
Poaceae		*Pennisetum alopecuroides*																					
Poaceae	*	*Pennisetum clandestinum*																					
Poaceae		*Pennisetum sp.*																	+				
Poaceae		*Pentapogon quadrifidus*																					
Poaceae	*	*Phalaris aquatica*																					
Poaceae	*	*Phalaris sp.*																					
Poaceae		*Phragmites australis*																					
Poaceae		*Poa labillardierei*	2																+	1			+
Poaceae		*Poa sieberiana*	+																				
Poaceae		*Poa sp.*											1	1		1	1	1	2	1	1	1	
Poaceae		*Setaria sp.*																					
Poaceae		*Sorghum leiocladum*															1	3	1		1		
Poaceae		*Sorghum sp.*																					
Poaceae	*	*Sporobolus africanus*						1															
Poaceae		*Sporobolus caroli*																					
Poaceae		*Sporobolus creber*	+	1		1						1				1							
Poaceae		*Sporobolus elongatus*	+																				
Poaceae		*Sporobolus sp.*									1												
Poaceae		*Themeda australis*																					
Poaceae		*Tragus australianus*																					
Poaceae	*	*Triticum aestivum*																					
Poaceae	*	*Urochloa advena*																					
Poaceae	*	*Vulpia bromoides*																					
Poaceae	*	*Vulpia muralis*										1											
Poaceae	*	*Vulpia myuros*				1	+			1													
Poaceae	*	*Vulpia* sp.									1									2			+

** denotes an exotic species*

+ = <1%, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%

Table D.12 Quadrat Dataset collected from the Eastern, Western and Northern Offset Properties (cont.)

Property →		MT LINDESAY	TESTON STH	TESTON STH	VELYAMA	VELYAMA	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE	WIRRADALE
Family	**Scientific Name**	**RA2**	**RA3**	**RA4**	**RA5**	**RA6**	**RA7**	**RA8**	**RA9**	**RA10**	**RA11**	**RA12**	**RA13**	**RA14**	**RA15**	**RA16**
TREES																
Apocynaceae	*Alstonia constricta*															
Casuarinaceae	*Allocasuarina gymnanthera*															
Casuarinaceae	*Allocasuarina luehmannii*															
Casuarinaceae	*Allocasuarina stricta*															
Casuarinaceae	*Casuarina cristata*															
Casuarinaceae	*Casuarina cunninghamiana*															
Casuarinaceae	*Casuarina pauper*															
Cupressaceae	*Callitris endlicheri*															
Cupressaceae	*Callitris glaucophylla*															
Cupressaceae	*Callitris* sp.															
Fabaceae (Mimosoideae)	*Acacia cheelii*															
Fabaceae (Mimosoideae)	*Acacia dealbata*															
Fabaceae (Mimosoideae)	*Acacia implexa*															
Fabaceae (Mimosoideae)	*Vachellia farnesiana*															
Loranthaceae	*Amyema cambagei*															
Loranthaceae	*Amyema lucasii*															
Loranthaceae	*Amyema maidenii*															
Loranthaceae	*Amyema miquelii*															
Loranthaceae	*Amyema miraculosum*															
Loranthaceae	*Amyema pendulum*															
Loranthaceae	*Amyema quandang*															
Loranthaceae	*Amyema quandang var. bancroftii*															
Loranthaceae	*Amyema quandang var. quandang*															
Loranthaceae	*Amyema sp.*															
Meliaceae	*Melia azedarach*															
Moraceae	*Ficus ?virens*															
Moraceae	*Ficus rubiginosa*															
Myoporaceae	*Eremophila mitchellii*															
Myrtaceae	*Angophora floribunda*															
Myrtaceae	*Angophora sp*															
Myrtaceae	*Angophora subvelutina*															
Myrtaceae	*Corymbia trachyphloia*															
Myrtaceae	*Eucalyptus albens*															
Myrtaceae	*Eucalyptus bancroftii*															
Myrtaceae	*Eucalyptus blakelyi*															
Myrtaceae	*Eucalyptus bridgesiana*															
Myrtaceae	*Eucalyptus camaldulensis*															
Myrtaceae	*Eucalyptus chloroclada*															
Myrtaceae	*Eucalyptus conica*															
Myrtaceae	*Eucalyptus crebra*															
Myrtaceae	*Eucalyptus crebra (small trees)*															
Myrtaceae	*Eucalyptus dalrympleana ssp. heptantha*															
Myrtaceae	*Eucalyptus dealbata*															
Myrtaceae	*Eucalyptus dives*															
Myrtaceae	*Eucalyptus dwyeri*															
Myrtaceae	*Eucalyptus dwyeri (small trees)*															
Myrtaceae	*Eucalyptus fibrosa subsp. nubila*															
Myrtaceae	*Eucalyptus goniocalyx*															
Myrtaceae	*Eucalyptus macrorhyncha*															
Myrtaceae	*Eucalyptus macrorhyncha (small trees)*															
Myrtaceae	*Eucalyptus macrorhyncha ssp. macrorhyncha*															
Myrtaceae	*Eucalyptus sp.*															
Myrtaceae	*Eucalyptus viminalis*															
Myrtaceae	*Melaleuca bracteata*															
Oleaceae	*Notelaea microcarpa var. microcarpa*															
Pittosporaceae	*Bursaria spinosa*															
Rhamnaceae	*Alphitonia excelsa*															
Rhamnaceae	*Pomaderris graniticola*															
Rhamnaceae	*Pomaderris sp*															
Rhamnaceae	*Ventilago viminalis*															
Rutaceae	*Geijera parviflora*															
Santalaceae	*Exocarpos cupressiformis*															
Sapindaceae	*Alectryon oleifolius subsp. elongatus*															
Sapindaceae	*Alectryon subcinereus*															
Sapindaceae	*Atalaya hemiglauca*															
Sapindaceae	*Dodonaea sinuolata subsp. sinuolata*															
Simaroubaceae	*Ailantus altissima*										+					
Sterculiaceae	*Brachychiton populneus*															
Sterculiaceae	*Brachychiton populneus ssp. populneus*															
Viscaceae	*Notothixos cornifolius*															
SHRUBS																
Agavaceae	* *Agave americana*															
Apocynaceae	*Carissa ovata*															
Apocynaceae	*Gompholobium huegelii*															
Asteraceae	*Cassinia aculeata*															
Asteraceae	*Cassinia arcuata*															
Asteraceae	*Cassinia leptocephala*															
Asteraceae	*Cassinia quinquefaria*															
Asteraceae	*Cassinia sp.*															
Asteraceae	*Olearia elliptica ssp. elliptica*															
Asteraceae	*Olearia sp*															
Asteraceae	*Olearia stellulata*															
Asteraceae	*Olearia viscidula*															
Asteraceae	* *Xanthium spinosum*															
Boraginaceae	*Ehretia membranifolia*															
Cactaceae	* *Opuntia aurantiaca*															
Cactaceae	* *Opuntia stricta*															

Capparaceae		*Apophyllum anomalum*															
Capparaceae		*Capparis mitchellii*															
Caprifoliaceae	*	*Lonicera sp.*															
Celastraceae		*Maytenus cunninghamii*															
Celastraceae		*Maytenus silvestris*															
Chenopodiaceae		*Atriplex muelleri*															
Chenopodiaceae		*Atriplex semibaccata*															
Chenopodiaceae		*Atriplex* sp.															
Chenopodiaceae		*Chenopodium auricomum*															
Chenopodiaceae		*Einadia hastata*															
Chenopodiaceae		*Einadia nutans ssp. linifolia*													+		
Chenopodiaceae		*Maireana microphylla*															
Chenopodiaceae		*Rhagodia parabolica*															
Chenopodiaceae		*Sclerolaena birchii (syn. Bassia birchii)*															
Chenopodiaceae		*Sclerolaena divaricata*				+	+										
Chenopodiaceae		*Sclerolaena muricata var. semiglabra*															
Chenopodiaceae		*Sclerolaena ventricosa*															
Chloanthaceae		*Spartothamnella juncea*															
Cupressaceae		*Callitris endlicheri*															
Cupressaceae		*Callitris glaucophylla*															
Dilleniaceae		*Hibbertia obtusifolia*															+
Ericaceae (Styphelioidae)		*Brachyloma daphnoides*															
Ericaceae (Styphelioidae)		*Lissanthe strigosa*									+						
Ericaceae (Styphelioideae)		*Epacris impressa*															
Ericaceae (Styphelioideae)		*Leucopogon sp.*															
Ericaceae (Styphelioideae)		*Melichrus urceolatus*															
Euphorbiaceae		*Beyeria viscosa*															
Euphorbiaceae		*Euphorbia tannensis ssp. eremophila var. eremophila*															
Euphorbiaceae		*Petalostigma quadriloculare*															
Fabaceae (Caesalpinioideae)		*Cassia barclayana*															
Fabaceae (Caesalpinioideae)		*Cassia eremophila var. eremophila*															
Fabaceae (Caesalpinioideae)		*Petalostylis labicheoides*															
Fabaceae (Caesalpinioideae)		*Petalostylis labicheoides var. labicheiodes*															
Fabaceae (Caesalpinioideae)		*Senna aciphylla*															
Fabaceae (Caesalpinioideae)		*Senna artemisioides*															
Fabaceae (Caesalpinioideae)		*Senna artemisioides subsp. coriacea*															
Fabaceae (Caesalpinioideae)		*Senna artemisioides subsp. petiolaris*															
Fabaceae (Caesalpinioideae)		*Senna artemisioides subsp. zygophylla*															
Fabaceae (Caesalpinioideae)		*Senna sp.*															
Fabaceae (Faboideae)		*Bossiaea sp.*															
Fabaceae (Faboideae)		*Daviesia genistifolia*															
Fabaceae (Faboideae)		*Daviesia leptophylla*															
Fabaceae (Faboideae)		*Daviesia nova-anglica*															
Fabaceae (Faboideae)		*Daviesia pubigera*															
Fabaceae (Faboideae)		*Daviesia ulicifolia*															
Fabaceae (Faboideae)		*Desmodium brachypodum*															
Fabaceae (Faboideae)		*Dillwynia sieberi*															
Fabaceae (Faboideae)		*Dillwynia sp.*															
Fabaceae (Faboideae)		*Goodia lotifolia*															
Fabaceae (Faboideae)		*Hovea lanceolata*															
Fabaceae (Faboideae)		*Hovea linearis*															
Fabaceae (Faboideae)		*Hovea sp. (bush)*															
Fabaceae (Faboideae)		*Indigofera adesmiifolia*															
Fabaceae (Faboideae)		*Indigofera australis var. australis*															
Fabaceae (Faboideae)		*Indigofera sp.*															
Fabaceae (Faboideae)		*Pultenaea cuneata*															
Fabaceae (Faboideae)		*Pultenaea daphnoides*															
Fabaceae (Faboideae)		*Pultenaea microphylla*															
Fabaceae (Faboideae)		*Pultenaea retusa*															
Fabaceae (Faboideae)		*Pultenaea setulosa*															
Fabaceae (Faboideae)		*Pultenaea sp*															
Fabaceae (Faboideae)		*Pultenaea sp "G"* (sensu. Weston, 1991)															
Fabaceae (Faboideae)		*Swainsona cadellii*															
Fabaceae (Faboideae)		*Swainsona galegifolia*															
Fabaceae (Faboideae)		*Swainsona swainsonioides*															
Fabaceae (Faboideae)		*Templetonia stenophylla*															
Fabaceae (Mimosoideae)		*Acacia aneura*															
Fabaceae (Mimosoideae)		*Acacia buxifolia*															
Fabaceae (Mimosoideae)		*Acacia cheelii*															
Fabaceae (Mimosoideae)		*Acacia deanei*															
Fabaceae (Mimosoideae)		*Acacia decora*															
Fabaceae (Mimosoideae)		*Acacia doratoxylon*															
Fabaceae (Mimosoideae)		*Acacia excelsa*															
Fabaceae (Mimosoideae)		*Acacia gladiiformis*															
Fabaceae (Mimosoideae)		*Acacia hakeoides*															
Fabaceae (Mimosoideae)		*Acacia harpophylla*															
Fabaceae (Mimosoideae)		*Acacia homalophylla*															
Fabaceae (Mimosoideae)		*Acacia leiocalyx*															
Fabaceae (Mimosoideae)		*Acacia oswaldii*															
Fabaceae (Mimosoideae)		*Acacia paradoxa*															
Fabaceae (Mimosoideae)		*Acacia pendula*															
Fabaceae (Mimosoideae)		*Acacia rubida*															
Fabaceae (Mimosoideae)		*Acacia salicina*															
Fabaceae (Mimosoideae)		*Acacia sp.*															
Fabaceae (Mimosoideae)		*Acacia spectabilis*															
Fabaceae (Mimosoideae)		*Acacia triptera*															
Goodeniaceae		*Goodenia ovata*															
Lamiaceae	*	*Marrubium vulgare*															
Lamiaceae		*Oncinocalyx betchei*		+	+												
Lamiaceae		*Prostanthera cruciflora*															
Lamiaceae		*Prostanthera granitica*															
Lamiaceae		*Prostanthera rhombea*															
Lamiaceae		*Prostanthera* sp.															

Lamiaceae		*Spartothamnella puberula*															
Lamiaceae		*Westringia rigida*															
Loranthaceae		*Lysiana sp.*															
Loranthaceae		*Lysiana subfalcata*															
Malaceae	*	*Cotoneaster pannosus*															
Malvaceae		*Abutilon leucopetalum*															
Malvaceae		*Abutilon oxycarpum*															
Malvaceae		*Abutilon oxycarpum var. subsagittatum*															
Malvaceae		*Hibiscus sturtii*															
Malvaceae	*	*Malva neglecta*															
Malvaceae	*	*Malva parviflora*		+													
Malvaceae		*Malva preissiana*															
Malvaceae		*Malva* sp.															
Malvaceae	*	*Malvastrum americanum*		+													
Malvaceae		*Sida subspicata*															
Myoporaceae		*Eremophila mitchellii*															
Myoporaceae		*Myoporum deserti*															
Myoporaceae		*Myoporum montanum*															
Myrtaceae		*Angophora floribunda*						+									
Myrtaceae		*Eucalyptus albens*															
Myrtaceae		*Eucalyptus viminalis*															
Myrtaceae		*Leptospermum polygalifolium ssp. polygalifolium*															
Myrtaceae		*Melaleuca bracteata*															
Myrtaceae		*Melaleuca lanceolata*															
Myrtaceae		*Melaleuca paludicola*															
Olacaceae		*Olax stricta*															
Oleaceae		*Jasminum lineare*															
Oleaceae	*	*Ligustrum vulgare*															
Oleaceae		*Notelaea linearis*															
Oleaceae		*Notelaea microcarpa*											+				
Oleaceae		*Notelaea microcarpa var. microcarpa*															
Oleaceae		*Notelaea microcarpa var. subvelutina*															
Oleaceae		*Notelaea sp.*															
Phyllanthaceae		*Breynia oblongifolia*															
Phyllanthaceae		*Phyllanthus virgatus*	+														
Pittosporaceae		*Pittosporum angustifolium*															
Pittosporaceae		*Pittosporum phillyreoides*															
Proteaceae		*Grevillea sp.*															
Rhamnaceae		*Alphitonia excelsa*															
Rhamnaceae		*Cryptandra amara*	+														
Rhamnaceae		*Cryptandra sp*															
Rhamnaceae		*Pomaderris andromedifolia*															
Rosaceae	*	*Rosa rubiginosa*	+					+	+	+			+		+	+	+
Rosaceae	*	*Rubus fruticosus*															
Rosaceae		*Rubus parvifolius*															
Rosaceae	*	*Rubus ulmifolius*															
Rubiaceae		*Canthium odoratum*															
Rubiaceae		*Canthium sp.*															
Rubiaceae		*Psydrax odorata*															
Rubiaceae		*Psydrax oleifolia*															
Rutaceae		*Correa reflexa*															
Rutaceae		*Correa reflexa var. reflexa*															
Rutaceae		*Geijera parviflora*															
Rutaceae		*Geijera salicifolia*															
Santalaceae		*Exocarpos cupressiformis*															
Sapindaceae		*Alectryon diversifolius*															
Sapindaceae		*Alectryon oleifolius*															
Sapindaceae		*Alectryon oleifolius subsp. elongatus*															
Sapindaceae		*Alectryon subdentatus forma. subdentatus*															
Sapindaceae		*Atalaya hemiglauca*															
Sapindaceae		*Dodonaea boroniifolia*															
Sapindaceae		*Dodonaea heteromorpha*															
Sapindaceae		*Dodonaea multijuga*															
Sapindaceae		*Dodonaea tenuifolia*															
Sapindaceae		*Dodonaea truncatiales*															
Sapindaceae		*Dodonaea viscosa*															
Sapindaceae		*Dodonaea viscosa ssp angustifolia*						+									
Sapindaceae		*Dodonaea viscosa ssp. cuneata*															
Solanaceae	*	*Lycium ferocissimum*															
Solanaceae		*Solanum cinereum*															
Solanaceae		*Solanum ellipticum*															
Solanaceae		*Solanum esuriale*															
Solanaceae		*Solanum ferocissimum*															
Solanaceae		*Solanum linearifolium*															
Solanaceae	*	*Solanum nigrum*															
Solanaceae		*Solanum parvifolium*															
Solanaceae		*Solanum parvifolium ssp. parvifolium*															
Sterculiaceae		*Gilesia biniflora*															
Thymelaeaceae		*Pimelea curviflora*															
Thymelaeaceae		*Pimelea curviflora var. divergens*											+				+
Thymelaeaceae		*Pimelea linifolia*															+
Thymelaeaceae		*Pimelea linifolia ssp. linifolia*								+				+			
Thymelaeaceae		*Pimelea neo-anglica*	+					+						+			
Thymelaeaceae		*Pimelea pauciflora*															
Thymelaeaceae		*Pimelea sp.*															
Thymelaeaceae		*Pimelea stricta*															
Violaceae		*Melicytus dentatus (=Hymenanthera dentata)*															
Viscaceae		*Korthalsella rubra ssp geijericola*															
HERBS - DICOTS																	
Acanthaceae		*Brunoniella australis*															
Acanthaceae		*Brunoniella pumilio*															
Acanthaceae		*Pseuderanthemum variabile*															
Acanthaceae		*Rostellularia adscendens*				+	+										

Acanthaceae		*Rostellularia adscendens var. adscendens*															
Aizoaceae		*Carpobrotus glaucescens*															
Aizoaceae	*	*Galenia pubescens*															
Aizoaceae		*Zaleya galericulata*															
Amaranthaceae		*Alternanthera denticulata*															
Amaranthaceae		*Alternanthera nana*															
Amaranthaceae	*	*Alternanthera pungens*															
Amaranthaceae		*Alternanthera sp.*															
Amaranthaceae	*	*Amaranthus viridis*															
Anthericaceae		*Tricoryne elatior*															
Apiaceae		*Actinotus helianthi*															
Apiaceae	*	*Ammi majus*		+	+												
Apiaceae		*Centella asiatica*															
Apiaceae	*	*Conium maculatum*															
Apiaceae		*Daucus glochidiatus*	+				+		+	+	+	+	+	+	+	+	+
Apiaceae	*	*Hydrocotyle bonariensis*															
Apiaceae		*Hydrocotyle laxiflora*	+					+	+	+	+	+		+	+	+	+
Apiaceae		*Hydrocotyle peduncularis*															
Apiaceae		*Hydrocotyle tripartita*															
Apiaceae		*Trachymene sp.*															
Apocynaceae	*	*Gomphocarpus fruticosus*															
Apocynaceae		*Marsdenia australis*															
Apocynaceae		*Marsdenia sp.*															
Apocynaceae		*Marsdenia viridiflora*															
Asphodelaceae	*	*Buglossoides arvensis*		+													
Asteraceae		*Ammobium alatum*															
Asteraceae	*	*Arctotheca calendula*															
Asteraceae	*	*Aster subulatus*															
Asteraceae	*	*Bidens pilosa*															
Asteraceae	*	*Bidens subalternans*															
Asteraceae	*	*Bidens subalternans var. simulans*															
Asteraceae		*Brachyscome chrysoglossa*					+										
Asteraceae		*Brachyscome ciliaris*															
Asteraceae		*Brachyscome diversifolia var. diversifolia*															
Asteraceae		*Brachyscome gracilis*															
Asteraceae		*Brachyscome multifida*															
Asteraceae		*Brachyscome sp*															
Asteraceae		*Calotis cuneata*															
Asteraceae		*Calotis cuneifolia*															
Asteraceae		*Calotis erinacea*															
Asteraceae		*Calotis hispidula*															
Asteraceae		*Calotis lappulacea*				+								+			
Asteraceae		*Calotis sp.*															
Asteraceae	*	*Carthamus lanatus*		3				+	+				+	+	+	+	
Asteraceae		*Cassinia aculeata*															
Asteraceae		*Cassinia laevis*															
Asteraceae	*	*Centaurea calcitrapa*															
Asteraceae	*	*Centaurea melitensis*															
Asteraceae	*	*Centaurea solstitialis*			+												
Asteraceae		*Centipeda minima var. minima*															
Asteraceae	*	*Chondrilla juncea*															+
Asteraceae		*Chondrilla sp.* (seedlings)															
Asteraceae		*Chrysocephalum apiculatum*						+	+		+					+	+
Asteraceae		*Chrysocephalum semipapposum*															
Asteraceae	*	*Cirsium vulgare*						+		+			+		+		
Asteraceae	*	*Conyza albida*								+	+						
Asteraceae	*	*Conyza bonariensis*															
Asteraceae	*	*Conyza sp.*															
Asteraceae	*	*Conyza sp. (bonariensis?)*															
Asteraceae		*Cotula australis*				+	+										
Asteraceae	*	*Cotula coronopifolia*															
Asteraceae		*Cymbonotus lawsonianus*				+		+				+	+	+	+	+	+
Asteraceae	*	*Euchiton japonicus*															
Asteraceae	*	*Euchiton japonicus spp. complex*															+
Asteraceae		*Euchiton sp.*	+						+				+				
Asteraceae		*Euchiton sp. (seedlings)*															
Asteraceae		*Euchiton sphaericus*				+	+				+	+		+	+		+
Asteraceae		*Euchtion involucratus*															
Asteraceae	*	*Facelis retusa*															
Asteraceae	*	*Facelis sp.*															
Asteraceae	*	*Gamochaeta sp*															
Asteraceae		*Glossocardia bidens*															
Asteraceae	*	*Gnaphalium japonicum*															
Asteraceae	*	*Gnaphalium sp.*															
Asteraceae		*Gnaphalium sphaericum*															
Asteraceae	*	*Hedypnois rhagadioloides ssp. cretica*		+													
Asteraceae		*Helichrysum sp.*															
Asteraceae	*	*Hypochaeris glabra*										+					
Asteraceae	*	*Hypochaeris radicata*	+					+	+		+		+			+	+
Asteraceae	*	*Hypochaeris sp*															
Asteraceae	*	*Lactuca saligna*															
Asteraceae	*	*Lactuca sp.*															
Asteraceae		*Lagenophora bellidioides (=Lagenifera stipitata)*										+				+	
Asteraceae		*Leiocarpa panaetioides*															
Asteraceae		*Leptorhynchos panaetioides*															
Asteraceae		*Leptorhynchos squamatus*															
Asteraceae		*Leptorhynchos squamatus ssp squamatus*									+						
Asteraceae		*Leptorhynchos tetrachaetus*															
Asteraceae		*Leucochrysum albicans ssp. albicans var. albicans*											+				
Asteraceae		*Microseris lanceolata*															
Asteraceae		*Minuria integerrima*															
Asteraceae		*Minuria leptophylla*															
Asteraceae		*Olearia elliptica*															

Asteraceae		*Olearia elliptica ssp. elliptica*															
Asteraceae		*Olearia nernstii*															
Asteraceae		*Olearia ramulosa*															
Asteraceae		*Olearia rosmarinifolia*															
Asteraceae		*Ozothamnus diosmifolius*															
Asteraceae		*Picris eichleri*															
Asteraceae		*Podolepis sp.*															
Asteraceae		*Pseudognaphalium luteoalbum*															
Asteraceae		*Rhodanthe diffusa ssp. leucactina*					+										
Asteraceae	*	*Schkuhria pinnata*															
Asteraceae	*	*Schkuhria pinnata var. abrotanoides*															
Asteraceae		*Senecio hispidulus*															
Asteraceae		*Senecio lautus*															
Asteraceae	*	*Senecio madagascariensis*															
Asteraceae		*Senecio quadridentatus*															
Asteraceae		*Senecio sp.*															
Asteraceae		*Senecio tenuiflorus*						+									
Asteraceae		*Sigesbeckia australiensis*															
Asteraceae		*Sigesbeckia sp.*															
Asteraceae	*	*Silybum marianum*		+													
Asteraceae		*Solenogyne bellioides*															
Asteraceae		*Solenogyne dominii*															
Asteraceae	*	*Sonchus asper*		+	+												
Asteraceae	*	*Sonchus oleraceus*															
Asteraceae		*Stuartina hamata*															
Asteraceae		*Stuartina muelleri*							+								
Asteraceae		*Stuartina sp.*															
Asteraceae	*	*Tagetes minuta*															
Asteraceae	*	*Taraxacum officinale*								+							
Asteraceae	*	*Tragopogon sp.*															
Asteraceae		*Triptilodiscus pygmaeus*						+	+		+	+	+	+		+	+
Asteraceae		*Vernonia cinerea*															
Asteraceae		*Vittadinia cervicularis var. cervicularis*															
Asteraceae		*Vittadinia cuneata*		+		+								+			
Asteraceae		*Vittadinia dissecta*															
Asteraceae		*Vittadinia dissecta var. hirta*															
Asteraceae		*Vittadinia muelleri*				+			+					+			+
Asteraceae		*Vittadinia pterochaeta*															
Asteraceae		*Vittadinia sulcata*															
Asteraceae	*	*Xanthium spinosum*															
Asteraceae	*	*Xanthium strumarium*															
Asteraceae		*Xerochrysum bracteatum*															
Asteraceae		*Xerochrysum bracteatum ssp bracteatum*				+											
Asteraceae		*Xerochrysum palustre*															
Asteraceae		*Xerochrysum viscosum*															
Asteraceae	*	*Zinnia peruviana*															
Boraginaceae	*	*Anchusa arvensis*															
Boraginaceae		*Cynoglossum australe*															
Boraginaceae	*	*Echium italicum*				+											
Boraginaceae	*	*Echium plantagineum*															
Boraginaceae	*	*Heliotropium amplexicaule*															
Brassicaceae	*	*Brassica napus*															
Brassicaceae	*	*Brassica rapa*															
Brassicaceae	*	*Brassica* sp.			+												
Brassicaceae	*	*Capsella bursa-pastoralis*		+	+												
Brassicaceae	*	*Cardamine hirsuta*											+	+			
Brassicaceae	*	*Hirschfeldia incana*															
Brassicaceae	*	*Lepidium africanum*		+													
Brassicaceae	*	*Lepidium bonariense*															
Brassicaceae		*Lepidium papillosum*															
Brassicaceae		*Lepidium pseudohyssopifolium*															
Brassicaceae		*Lepidium sagittulatum*															
Brassicaceae		*Lepidium* sp.															
Brassicaceae		*Lepidium* sp. 2															
Brassicaceae	*	*Rapistrum rugosum*		2	+												
Brassicaceae	*	*Sinapsis alba*															
Brassicaceae		*Sisymbrium orientale*		+													
Cactaceae	*	*Cylindropuntia imbricata*															
Cactaceae	*	*Cylindropuntia* sp.															
Cactaceae	*	*Opuntia aurantiaca*															
Cactaceae	*	*Opuntia* sp.								+							
Cactaceae	*	*Opuntia stricta*															
Cactaceae	*	*Opuntia tomentosa*															
Campanulaceae		*Wahlenbergia communis*	+			+	+		+								
Campanulaceae		*Wahlenbergia fluminalis*															
Campanulaceae		*Wahlenbergia gracilenta*												+			+
Campanulaceae		*Wahlenbergia gracilis*															
Campanulaceae		*Wahlenbergia graniticola*									+	+	+				
Campanulaceae		*Wahlenbergia planiflora*		+													
Campanulaceae		*Wahlenbergia planiflora ssp.longipila*															
Campanulaceae		*Wahlenbergia sp.*						+									
Campanulaceae		*Wahlenbergia* sp. 1															
Campanulaceae		*Wahlenbergia* sp. 2															
Campanulaceae		*Wahlenbergia stricta*															
Caryophyllaceae	*	*Arenaria leptocladus*							+		+		+	+			
Caryophyllaceae	*	*Moenchia erecta*															+
Caryophyllaceae	*	*Paronychia brasiliana*														+	
Caryophyllaceae	*	*Petrorhagia dubia*															
Caryophyllaceae	*	*Petrorhagia nanteuilii*							+		+		+	+	+	+	+
Caryophyllaceae	*	*Petrorhagia velutina*															
Caryophyllaceae		*Polycarpaea corymbosa*															
Caryophyllaceae	*	*Polycarpon tetraphyllum*															
Caryophyllaceae	*	*Silene gallica*		+													

Caryophyllaceae	*	*Stellaria media*															
Caryophyllaceae	*	*Stellaria pallida*	+													+	
Caryophyllaceae		*Stellaria sp*															
Chenopodiaceae		*Chenopodium pumilio*															
Chenopodiaceae		*Einadia hastata*															
Chenopodiaceae		*Einadia nutans*															
Chenopodiaceae		*Einadia nutans ssp. linifolia*		+		+											
Chenopodiaceae		*Einadia polygonoides*															
Chenopodiaceae		*Einadia* sp.															
Chenopodiaceae		*Einadia trigonos*															
Chenopodiaceae		*Enchylaena tomentosa*															
Chenopodiaceae		*Maireana pentagona*															
Chenopodiaceae		*Maireana sp.*															
Chenopodiaceae		*Salsola kali*															
Chenopodiaceae		*Sclerolaena birchii (syn. Bassia birchii)*				+											
Chenopodiaceae		*Sclerolaena muricata*															
Chenopodiaceae		*Sclerolaena muricata var. semiglabra*															
Chenopodiaceae		*Sclerolaena sp.*															
Clusiaceae		*Hypericum gramineum*						+	+			+					+
Convolvulaceae		*Convolvulus angustissimus ssp. angustissimus*														+	+
Convolvulaceae		*Convolvulus erubescens*															
Convolvulaceae		*Dichondra repens*	+					+									
Convolvulaceae		*Dichondra sp.*															
Convolvulaceae		*Dichondra sp. A*							+				+	+	+	+	+
Convolvulaceae		*Evolvulus alsinoides*															
Crassulaceae		*Crassula sieberiana*				+			+		+			+		+	
Crassulaceae		*Crassula sp.*															
Dilleniaceae		*Hibbertia obtusifolia*															
Dilleniaceae		*Hibbertia riparia*															
Dilleniaceae		*Hibbertia rufa*															
Dilleniaceae		*Hibbertia sp.*															
Droseraceae		*Drosera* sp.															
Euphorbiaceae		*Chamaesyce drummondii*															
Euphorbiaceae		*Chamaesyce sp.*															
Euphorbiaceae		*Chamaesyce sp. A*															
Euphorbiaceae		*Euphorbia drummondii*															
Euphorbiaceae		*Euphorbia eremophila*															
Euphorbiaceae		*Poranthera microphylla*															
Euphorbiaceae		*Poranthera sp*															
Euphorbiaceae		*Sauropus ramosissimus*															
Fabaceae (Faboideae)		*Desmodium brachypodum*															
Fabaceae (Faboideae)		*Desmodium* sp.															
Fabaceae (Faboideae)		*Desmodium varians*	+						+				+				+
Fabaceae (Faboideae)		*Lespedeza juncea ssp. sericea*															
Fabaceae (Faboideae)		*Lotus australis*															
Fabaceae (Faboideae)	*	*Medicago arabica*															
Fabaceae (Faboideae)	*	*Medicago laciniata*			+												
Fabaceae (Faboideae)	*	*Medicago minima*		+	+												
Fabaceae (Faboideae)	*	*Medicago polymorpha*															
Fabaceae (Faboideae)	*	*Medicago sativa*		+													
Fabaceae (Faboideae)	*	*Medicago sp.*	+							+			+				
Fabaceae (Faboideae)	*	*Medicago sp. (seedlings)*															
Fabaceae (Faboideae)	*	*Medicago truncatula*															
Fabaceae (Faboideae)		*Pultenaea foliolosa*															
Fabaceae (Faboideae)		*Swainsona cadellii*						+									+
Fabaceae (Faboideae)		*Swainsona galegifolia*	+														
Fabaceae (Faboideae)		*Swainsona monticola*															
Fabaceae (Faboideae)		*Swainsona sp*															
Fabaceae (Faboideae)	*	*Trifolium arvense*						+	+					+	+		
Fabaceae (Faboideae)	*	*Trifolium dubium*								+		+					
Fabaceae (Faboideae)	*	*Trifolium glomeratum*															
Fabaceae (Faboideae)	*	*Trifolium repens*	+					+		+		+	+		+	+	
Fabaceae (Faboideae)	*	*Trifolium sp*														+	+
Fabaceae (Faboideae)	*	*Trifolium subterraneum*										+					
Fabaceae (Faboideae)		*Zornia dyctiocarpa*															
Fabaceae (Mimosoideae)	*	*Mimosa sp.*															
Fabaceae (Mimosoideae)		*Neptunia gracilis*															
Fumariaceae	*	*Fumaria densiflora*															
Fumariaceae		*Fumaria sp.*															
Gentianaceae	*	*Centaurium erythraea*															
Gentianaceae	*	*Centaurium sp*															
Gentianaceae		*Schenkia spicata*						+	+				+	+			
Geraniaceae		*Erodium crinitum*					+										
Geraniaceae	*	*Geranium molle*															
Geraniaceae		*Geranium solanderi*															
Geraniaceae		*Geranium solanderi var. solanderi*	+					+	+	+	+		+	+	+		+
Geraniaceae		*Geranium sp.*				+											
Goodeniaceae		*Goodenia bellidifolia*															
Goodeniaceae		*Goodenia cycloptera*															
Goodeniaceae		*Goodenia fascicularis*															
Goodeniaceae		*Goodenia glabra*															
Goodeniaceae		*Goodenia hederacea*															
Goodeniaceae		*Goodenia hederacea ssp hederacea*															
Goodeniaceae		*Goodenia pinnatifida*						+									
Goodeniaceae		*Goodenia rotundifolia*															
Goodeniaceae		*Goodenia sp.*															
Goodeniaceae		*Scaevola spinescens*															
Haloragaceae		*Gonocarpus sp. aff. elatus*															
Haloragaceae		*Gonocarpus elatus*															
Haloragaceae		*Gonocarpus sp.*															
Haloragaceae		*Gonocarpus tetragynus*															
Haloragaceae		*Gonocarpus teucrioides*															
Haloragaceae		*Haloragis ?aspera*															

Haloragaceae		*Haloragis heterophylla*					+					+					
Haloragaceae		*Haloragis serra*															
Haloragaceae		*Haloragis sp*															
Iridaceae	*	*Sisyrinchium sp. A*															
Lamiaceae		*Ajuga australis*															+
Lamiaceae	*	*Marrubium vulgare*															
Lamiaceae		*Mentha satureioides*	+					+		+				+			
Lamiaceae		*Mentha sp*															
Lamiaceae		*Salvia plebeia*															
Lamiaceae	*	*Salvia verbenaca*												+			
Lamiaceae		*Scutellaria humilis*	+														
Lamiaceae	*	*Stachys arvensis*		+	+												
Lamiaceae		*Teucrium racemosum*															
Linaceae		*Linum marginale*															
Lobeliaceae		*Isotoma axillaris*															
Lobeliaceae		*Pratia purpurascens*								+							
Lythraceae		*Lythrum hyssopifolia*															
Malvaceae		*Hibiscus trionum*															
Malvaceae	*	*Malva parviflora*															
Malvaceae	*	*Modiola caroliniana*															
Malvaceae		*Sida corrugata*															
Malvaceae		*Sida cunninghamii*															
Malvaceae		*Sida filiformis*															
Malvaceae	*	*Sida rhombifolia*															
Malvaceae	*	*Sida spinosa*															
Malvaceae		*Sida subspicata*															
Myoporaceae		*Eremophila debilis*															
Myoporaceae		*Eremophila longifolia*															
Myoporaceae		*Eremophila mitchellii*															
Myrsinaceae	*	*Anagallis arvensis*		+													
Myrtaceae		*Angophora floribunda*															
Myrtaceae		*Eucalyptus viminalis*															
Nyctaginaceae		*Boerhavia dominii*															
Onagraceae		*Epilobium billardierianum subsp. cinereum*						+								+	
Onagraceae		*Epilobium sp*															
Orchidaceae		*Glossodia* sp.															
Oxalidaceae		*Oxalis chnoodes*															
Oxalidaceae	*	*Oxalis corniculata*															
Oxalidaceae		*Oxalis exilis*															
Oxalidaceae		*Oxalis perennans*															
Oxalidaceae		*Oxalis radicosa*															
Oxalidaceae		*Oxalis* sp.	+	+		+	+	+			+		+		+	+	+
Phyllanthaceae		*Phyllanthus gunnii*															
Phyllanthaceae		*Phyllanthus sp.*															
Phyllanthaceae		*Phyllanthus virgatus*															
Phytolaccaceae	*	*Phytolacca octandra*															
Pittosporaceae		*Pittosporum undulatum* (seedling)															
Plantaginaceae		*Plantago cunninghamii*															
Plantaginaceae		*Plantago debilis*				+		+	+	+				+	+	+	
Plantaginaceae	*	*Plantago lanceolata*										+	+		+		
Plantaginaceae		*Plantago sp.*	+					+					+				
Plantaginaceae		*Plantago turrifera*		+													
Plantaginaceae		*Plantago varia*															
Polygalaceae		*Polygala japonica*	+														
Polygonaceae	*	*Fallopia convolvulus*			+												
Polygonaceae		*Persicaria decipiens*															
Polygonaceae	*	*Polygonum aviculare*			+												
Polygonaceae	*	*Polygonum patulum*															
Polygonaceae		*Polygonum plebeium*															
Polygonaceae		*Polygonum sp.*															
Polygonaceae		*Rumex brownii*						+	+	+		+	+	+	+		+
Polygonaceae	*	*Rumex crispus*															
Polygonaceae		*Rumex sp.*															
Portulacaceae		*Montia fontana ssp. amporitana*															
Portulacaceae		*Portulaca oleracea*															
Ranunculaceae		*Ranunculus lappaceus*								+							
Ranunculaceae		*Ranunculus sessiliflorus*										+		+			
Ranunculaceae		*Ranunculus sessiliflorus var. sessiliflorus*					+		+		+		+				
Rosaceae		*Acaena anserinifolia*															
Rosaceae		*Acaena anserovina*															
Rosaceae		*Acaena novae-zelandiae*						+		+							
Rosaceae		*Acaena sp.*	+						+			+				+	
Rosaceae		*Aphanes australiana*												+	+	+	
Rosaceae		*Aphanes sp.*															
Rosaceae	*	*Rosa rubiginosa*															
Rosaceae		*Rubus sp*															
Rubiaceae		*Asperula conferta*	+				+	+	+	+		+	+	+	+	+	+
Rubiaceae		*Asperula sp.*															
Rubiaceae	*	*Galium aparine*															
Rubiaceae		*Galium gaudichaudii*															
Rubiaceae		*Galium gaudichaudii ssp. gaudichaudii*															
Rubiaceae		*Galium leptogonium*															
Rubiaceae		*Galium microlobum*															
Rubiaceae		*Galium migrans*															
Rubiaceae	*	*Galium murale*															
Rubiaceae		*Galium propinquum*															
Rubiaceae		*Galium* sp.															
Rubiaceae		*Opercularia aspera*															
Rubiaceae		*Opercularia diphylla*															
Rubiaceae		*Opercularia hispida*															
Rubiaceae		*Opercularia sp.*															
Rubiaceae		*Pomax umbellata*															
Rubiaceae	*	*Sherardia arvensis*													+		

Santalaceae		*Santalum lanceolatum*															
Santalaceae		*Santalum sp.*															
Scrophulariaceae	*	*Linaria arvensis*															
Scrophulariaceae		*Mimulus gracilis*															
Scrophulariaceae	*	*Verbascum sp.*															
Scrophulariaceae	*	*Verbascum thapsus*															
Scrophulariaceae	*	*Veronica arvensis*						+	+		+				+	+	
Scrophulariaceae		*Veronica calycina*															
Scrophulariaceae		*Veronica plebeia*															
Scrophulariaceae		*Veronica sp*															
Solanaceae		*Nicotiana sp.*															
Solanaceae		*Solanum aviculare*															
Solanaceae	*	*Solanum linnaeanum*															
Solanaceae	*	*Solanum nigrum*															
Solanaceae		*Solanum opacum*															
Solanaceae		*Solanum parvifolium*															
Solanaceae		*Solanum parvifolium ssp. parvifolium*															
Solanaceae		*Solanum sp.*															
Solanaceae		*Solanum stelligerum*															
Solanaceae		*Solanum tetrathecum*															
Stackhousiaceae		*Stackhousia sp.*															
Stackhousiaceae		*Stackhousia viminea*															
Thymelaeaceae		*Pimelea microcephala*															
Thymelaeaceae		*Pimelea pauciflora*															
Urticaceae		*Parietaria debilis*															
Urticaceae	*	*Urtica dioica*															
Urticaceae		*Urtica incisa*															
Verbenaceae	*	*Glandularia aristigera*															
Verbenaceae	*	*Verbena bonariensis*															
Verbenaceae		*Verbena gaudichaudii*															
Verbenaceae	*	*Verbena officinalis*															
Verbenaceae	*	*Verbena rigida*															
Violaceae		*Viola betonicifolia*								+							
Violaceae		*Viola hederacea*															
Zygophyllaceae	*	*Tribulus terrestris*															
HERBS - MONOCOTS																	
Amaryllidaceae		*Crinum pedunculatum*															
Amaryllidaceae		*Crinum sp.*															
Anthericaceae		*Arthropodium milleflorum*															
Anthericaceae		*Arthropodium minus*							+				+				
Anthericaceae		*Arthropodium sp.*															
Anthericaceae		*Caesia parviflora*															
Anthericaceae		*Dichopogon fimbriatus*															
Anthericaceae		*Dichopogon strictus*															
Anthericaceae		*Laxmannia gracilis*															
Asphodelaceae		*Bulbine bulbosa*								+							
Asphodelaceae		*Bulbine semibarbata*					+										
Colchicaceae		*Wurmbea biglandulosa*							+								
Colchicaceae		*Wurmbea dioica*															
Cyperaceae		*Carex appressa*								+							
Cyperaceae		*Carex breviculmis*										+	+		+		
Cyperaceae		*Carex incomitata*															
Cyperaceae		*Carex inversa*	+			+	+					+					
Cyperaceae		*Carex sp.*															
Cyperaceae	*	*Cyperus brevifolius*								+							
Cyperaceae	*	*Cyperus eragrostis*															
Cyperaceae		*Cyperus exaltatus*															
Cyperaceae		*Cyperus fulvus*															
Cyperaceae		*Cyperus gracilis*															
Cyperaceae		*Cyperus sp.*											+				
Cyperaceae	*	*Cyperus tenellus*															
Cyperaceae		*Cyperus vaginatus*								+							
Cyperaceae		*Eleocharis sp.*															
Cyperaceae		*Fimbristylis dichotoma*										+					
Cyperaceae		*Gahnia aspera*															
Cyperaceae		*Isolepis hookeriana*															
Cyperaceae		*Lepidosperma laterale*															
Cyperaceae		*Lepidosperma sp.*															
Cyperaceae		*Lipocarpha microcephala*															
Cyperaceae		*Schoenus apogon*								+	+	+					
Cyperaceae		*Schoenus sp*															
Cyperaceae		*Scirpus sp.*															
Cyperaceae		*Scleria mackaviensis*															
Juncaceae		*Juncus australis*															
Juncaceae		*Juncus continuus*															
Juncaceae		*Juncus filicaulis*						+		+	+						
Juncaceae		*Juncus filiformis*														+	
Juncaceae		*Juncus homalocaulis*															
Juncaceae		*Juncus kraussii*															
Juncaceae		*Juncus remotiflorus*										+	+				
Juncaceae		*Juncus sp.*				+	+										
Juncaceae		*Juncus subsecundus*															
Juncaceae		*Juncus usitatus*															
Juncaceae		*Luzula densiflora*															
Juncaceae		*Luzula sp.*															
Juncaginaceae		*Triglochin procera*															
Lomandraceae		*Lomandra bracteata*															
Lomandraceae		*Lomandra confertifolia*															
Lomandraceae		*Lomandra confertifolia ssp. rubiginosa*															
Lomandraceae		*Lomandra filiformis*															
Lomandraceae		*Lomandra filiformis ssp. filiformis*															
Lomandraceae		*Lomandra glauca*															
Lomandraceae		*Lomandra longifolia*															

Lomandraceae		*Lomandra multiflora*															
Lomandraceae		*Lomandra multiflora ssp. multiflora*															
Lomandraceae		*Lomandra sp.*															
Orchidaceae		*Caladenia carnea*															
Orchidaceae		*Cymbidium canaliculatum*															
Orchidaceae		*Microtis unifolia*										+					
Orchidaceae		*Pterostylis boormanii*															
Orchidaceae		*Pterostylis hamata*															
Orchidaceae		*Pterostylis mutica*															
Orchidaceae		*Pterostylis praetermissa*															
Orchidaceae		*Pterostylis revoluta*															
Orchidaceae		*Pterostylis sp.*															
Orchidaceae		*Pterostylis sp. (rosettes only)*															
Phormiaceae		*Dianella longifolia*															
Phormiaceae		*Dianella revoluta*															
Phormiaceae		*Dianella* sp.															
Phormiaceae		*Dianella* sp. (longifolia group)															
Xanthorrhoeaceae		*Xanthorrhoea glauca*															
Xanthorrhoeaceae		*Xanthorrhoea sp.*															
FERNS AND ALLIES																	
Adiantaceae		*Adiantum aethiopicum*															
Adiantaceae		*Adiantum formosum*															
Adiantaceae		*Cheilanthes austrotenuifolia*															
Adiantaceae		*Cheilanthes distans*															
Adiantaceae		*Cheilanthes lasiophylla*															
Adiantaceae		*Cheilanthes sieberi*															
Adiantaceae		*Cheilanthes sieberi ssp sieberi*									+						
Aspleniaceae		*Pleurosorus rutifolius*															
Dennstaedtiaceae		*Pteridium esculentum*															
Marsileaceae		*Marsilea drummondii*															
Ophioglossaceae		*Ophioglossum lusitanicum*															
Ophioglossaceae		*Ophioglossum lusitanicum ssp coriaceum*										+					
Pteridaceae		*Pellaea nana*															
VINES AND CLIMBERS																	
Apiaceae		*Hydrocotyle geraniifolia*															
Apocynaceae		*Parsonsia eucalyptophylla*															
Apocynaceae		*Parsonsia lanceolata*															
Apocynaceae		*Rhyncharrhena linearis*															
Bignoniaceae		*Pandorea pandorana*															
Fabaceae (Faboideae)		*Glycine canescens*															
Fabaceae (Faboideae)		*Glycine clandestina*											+				
Fabaceae (Faboideae)		*Glycine microphylla*															
Fabaceae (Faboideae)		*Glycine* sp.															
Fabaceae (Faboideae)		*Glycine tabacina*									+			+	+	+	+
Fabaceae (Faboideae)		*Glycine tomentella*															
Fabaceae (Faboideae)		*Hardenbergia violacea*															
Fabaceae (Faboideae)	*	*Vicia sativa ssp .nigra*															
Lauraceae		*Cassytha pubescens*															
Luzuriagaceae		*Eustrephus latifolius*															
Luzuriagaceae		*Geitonoplesium cymosum*															
Oleaceae		*Jasminum sp. (seedlings)*															
Oleaceae		*Jasminum suavissimum*															
Ranunculaceae		*Clematis aristata*															
Ranunculaceae		*Clematis glycinoides*															
Ranunculaceae		*Clematis microphylla*															
Ranunculaceae		*Clematis microphylla var. leptophylla*															
Ranunculaceae		*Clematis sp.* (seedling)															
Rosaceae		*Rubus moluccanus var trilobus*															
Rununculaceae		*Clematis sp.*															
GRASSES																	
Poaceae	*	*Anthoxanthum odoratum*															
Poaceae		*Aristida behriana*															
Poaceae		*Aristida benthamii*															
Poaceae		*Aristida caput-medusae*															
Poaceae		*Aristida jerichoensis var.jerichoensis*															
Poaceae		*Aristida leptopoda*															
Poaceae		*Aristida personata (= Aristida ramosa var. speciosa)*															
Poaceae		*Aristida ramosa*															
Poaceae		*Aristida sp.*	+			+			+			+	+	+		+	+
Poaceae		*Aristida vagans*															
Poaceae		*Austipa aristiglumis*															
Poaceae		*Austrodanthonia auriculata*															
Poaceae		*Austrodanthonia bipartita*															
Poaceae		*Austrodanthonia caespitosa*															
Poaceae		*Austrodanthonia eriantha*															
Poaceae		*Austrodanthonia fulva*															
Poaceae		*Austrodanthonia induta*															
Poaceae		*Austrodanthonia monticola*															
Poaceae		*Austrodanthonia pilosa*															
Poaceae		*Austrodanthonia racemosa*															
Poaceae		*Austrodanthonia racemosa var. obtusata*															
Poaceae		*Austrodanthonia racemosa var. racemosa*															
Poaceae		*Austrodanthonia richardsonii*															
Poaceae		*Austrodanthonia setacea*															
Poaceae		*Austrodanthonia sp.*	+			+	+		+					+			+
Poaceae		*Austrostipa aristiglumis*					+										
Poaceae		*Austrostipa bigeniculata*															
Poaceae		*Austrostipa densiflora*															
Poaceae		*Austrostipa ramosissima*															
Poaceae		*Austrostipa scabra*							+				+	+		+	+
Poaceae		*Austrostipa scabra ssp. scabra*				+	+										
Poaceae		*Austrostipa setacea*															
Poaceae		*Austrostipa sp.*															

Poaceae		*Austrostipa variabilis*															
Poaceae		*Austrostipa verticillata*															
Poaceae	*	*Avena fatua*		+	+												
Poaceae	*	*Avena sp.*															
Poaceae		*Bothriochloa decipiens*															
Poaceae		*Bothriochloa decipiens var. decipiens*				+	+										
Poaceae		*Bothriochloa macra*															+
Poaceae		*Bothriochloa sp.*	+	+				1	+	+	+	+	+	+	+	+	
Poaceae		*Brachiaria milliformis*															
Poaceae	*	*Briza minor*										+	+				
Poaceae	*	*Bromus catharticus*															
Poaceae	*	*Bromus molliformis*															
Poaceae	*	*Bromus racemosus*	+										+		+	+	
Poaceae		*Capillipedium parviflorum*															
Poaceae		*Chloris divaricata*															
Poaceae	*	*Chloris gayana*															
Poaceae		*Chloris sp.*															
Poaceae		*Chloris truncata*															
Poaceae		*Chloris ventricosa*	+				+										
Poaceae		*Cymbopogon refractus*						+									+
Poaceae		*Cymbopogon sp*															
Poaceae		*Cynodon dactylon*															
Poaceae	*	*Dactylis glomerata*															
Poaceae		*Dichanthium sericeum*															
Poaceae		*Dichanthium sericeum ssp. sericeum*				+											
Poaceae		*Dichelachne crinita*															
Poaceae		*Dichelachne micrantha*															
Poaceae		*Dichelachne parva*															
Poaceae		*Dichelachne siberiana*															
Poaceae		*Dichelachne sp.*							+								
Poaceae		*Digitaria brownii*															
Poaceae		*Digitaria diffusa*															
Poaceae		*Digitaria divaricatissima*															
Poaceae		*Digitaria sp.*															
Poaceae		*Digitaria* sp.1															
Poaceae		*Digitaria* sp.2															
Poaceae		*Echinopogon caespitosus*															
Poaceae		*Echinopogon cheelii*															
Poaceae		*Echinopogon mckiei*	+														
Poaceae		*Echinopogon ovatus*									+						
Poaceae		*Echinopogon sp.*															
Poaceae	*	*Eleusine indica*															
Poaceae		*Elymus scaber*	+						+			+		+		+	+
Poaceae		*Elymus scaber var. plurinervis*								+							
Poaceae		*Elymus scaber var. scaber*															
Poaceae		*Elymus sp*													+		
Poaceae		*Enneapogon avenaceus*															
Poaceae		*Enneapogon gracilis*															
Poaceae		*Enneapogon intermedius*															
Poaceae		*Enneapogon nigricans*															
Poaceae		*Enneapogon sp.*															
Poaceae		*Enteropogon acicularis*															
Poaceae		*Entolasia sp.*															
Poaceae		*Eragrostis brownii*															
Poaceae	*	*Eragrostis caroliniana*															
Poaceae	*	*Eragrostis cilianensis*															
Poaceae	*	*Eragrostis curvula*															
Poaceae		*Eragrostis elongata*										+					
Poaceae		*Eragrostis lacunaria*															
Poaceae		*Eragrostis laniflora*															
Poaceae		*Eragrostis leptostachya*															
Poaceae		*Eragrostis megalosperma*															
Poaceae		*Eragrostis molybdea*															
Poaceae		*Eragrostis sp.*	+								+	+	+				
Poaceae		*Eragrostis* sp.1															
Poaceae		*Eragrostis* sp.2															
Poaceae		*Eragrostis tenellula*															
Poaceae		*Eriochloa pseudoacrotricha*															
Poaceae		*Eriochloa sp.*															
Poaceae		*Glyceria latispicea*															
Poaceae	*	*Hordeum leporinum*		+	+												
Poaceae		*Imperata cylindrica*															
Poaceae		*Joycea pallida*															
Poaceae		*Lachnagrostis filiformis (=Agrostis avenacea)*															
Poaceae	*	*Lamarckia aurea*															
Poaceae		*Leptochloa decipiens ssp. asthenes*															
Poaceae	*	*Lolium perenne*		+	+												
Poaceae	*	*Lolium* sp.															
Poaceae		*Microlaena sp*															
Poaceae		*Microlaena stipoides*															
Poaceae		*Microlaena stipoides var. stopoides*	+										+				
Poaceae		*Notodanthonia longifolia*					+										
Poaceae		*Oplismenus aemulus var. aemulus*															
Poaceae		*Panicum decompositum*															
Poaceae		*Panicum effusum*									+						
Poaceae		*Panicum simile*															
Poaceae		*Panicum* sp.															
Poaceae		*Paspalidium caespitosum*															
Poaceae		*Paspalidium constrictum*															
Poaceae		*Paspalidium distans*															
Poaceae		*Paspalidium gracile*					+										
Poaceae		*Paspalidium sp.*															
Poaceae	*	*Paspalum dilatatum*	+							+			+		+		

Poaceae	*	*Paspalum urvillei*															
Poaceae		*Pennisetum alopecuroides*															
Poaceae	*	*Pennisetum clandestinum*															
Poaceae		*Pennisetum sp.*															+
Poaceae		*Pentapogon quadrifidus*															
Poaceae	*	*Phalaris aquatica*															
Poaceae	*	*Phalaris sp.*		+													
Poaceae		*Phragmites australis*															
Poaceae		*Poa labillardierei*	+							+							
Poaceae		*Poa sieberiana*															
Poaceae		*Poa sp.*								+			+	+		+	+
Poaceae		*Setaria sp.*															
Poaceae		*Sorghum leiocladum*															
Poaceae		*Sorghum sp.*															
Poaceae	*	*Sporobolus africanus*															
Poaceae		*Sporobolus caroli*															
Poaceae		*Sporobolus creber*				+	+				+	+					
Poaceae		*Sporobolus elongatus*															
Poaceae		*Sporobolus sp.*							+				+				+
Poaceae		*Themeda australis*															
Poaceae		*Tragus australianus*															
Poaceae	*	*Triticum aestivum*															
Poaceae	*	*Urochloa advena*															
Poaceae	*	*Vulpia bromoides*															
Poaceae	*	*Vulpia muralis*															
Poaceae	*	*Vulpia myuros*				+											
Poaceae	*	*Vulpia* sp.						+	+			+	+	+	+	+	

** denotes an exotic species*

+ = <1%, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%

APPENDIX E

REGROWTH THINNING

E.1 Ecological Thinning of Regrowth

Revegetation stands may require thinning at an early stage of the rehabilitation management time frame to encourage greater forest or woodland quantity and quality (Parks Victoria, 2005). Although tree stands have the ability to naturally thin out, it may take up to 50 years for the process to progress (McIntyre *et al.*, 2002). Strategic ecological thinning of selected trees may be required if areas are overstocked with same-age regrowth from the initial revegetation efforts (DSE (VIC), 2009a); the process can increase floristic diversity and structural complexity within a revegetated area and prevent poor or stunted growth of established plants (Bauhus *et al.*, 2001). It also promotes greater access of understorey species, typically herbaceous groundcovers, to resources such as space, light, and nutrients that may otherwise have been restricted by high tree densities. Thinning also increases the amount of woody debris in an area which can provide suitable habitat for ground-dwelling fauna and create microhabitats for flora (Forest Solutions, 2010).

E.1.1 Strategies

Large-scale thinning is currently being undertaken in Box-Ironbark communities in Victoria as part of long-term management and research into the viability of these forests and woodlands and as habtiat. Any thinning conducted in rehabilitation areas should refer to strategies implemented by Parks Victoria and the McIntosh Method for ecological thinning (Schirmer and Field, 2000; McIntosh, 2007; McIntosh, 2008). The process should result in *"thinning from 'above' and/or 'below' specifically designed to improve EVC benchmarks and biodiversity including enhancing and speeding the growth and development of the large tree component"* (McIntosh, 2007).

Box-Gum Woodland tree density of 30-40 mature trees per hectare is considered ecologically optimal (McIntyre *et al.*, 2002), with spacing (between mature trees) of half to two crown widths. Woodlands with lower densities were found to be of lower genetic diversity.

Ecological thinning principles in Box-Gum Woodland, as outlined in the 'Ecological thinning of eucalypts' Information sheet 15 from DSE (VIC) (2009a) include:

- Retain mature and senescing trees;
- Retain trees with hollows or that are occupied;
- 'Thin from below' by removing the youngest and smallest trees from a group;
- Thin so remaining trees are distributed as a patchy mosaic over the whole area;
- Retain all felled trees and branches for ground debris to form habitat.

APPENDIX F

PLANTING LISTS, SEED SOURCE AND PROPAGATION

F.1 Selection of Revegetation Stock

F.1.1 Seed Collection

Currently accepted best practice, as described in Rawlings *et al* (2010), (2010), for local provenance seed collection includes:

- Collection of seed from several source sites with similar rainfall, soil, altitude, aspect and slope position to the revegetation site to ensure they are most adapted to the landscape and environmental conditions;
- Collection of seed from between 20-50 plants of each species for genetic diversity; and
- Collection of seed from plants spaced approximately three plant-heights apart to prevent collection of too many closely related seeds.

It is advised that seed from vegetation to be cleared by the Project, particularly canopy trees, be collected and propagated to be used for revegetation and rehabilitation, as they are most adapted to local conditions.

For direct seeding, it is recommended that seed collection allows for approximately 200-500 grams of viable seed per kilometre sown (or, for wattle-rich mixes, 400g/km) (Rawlings *et al.*, 2010). In higher rainfall areas, this can be reduced to 150-300 grams, while in low rainfall Mallee type sites, a rate of 300-500 grams per kilometre may be necessary (Purnell *et al.*, 1999; Bonney, 2000; O'Shea, 2001).

i. Seed Collection Times

The indicative seed collection times for many of the species relevant to the Project are summarised in **Table F. 1** below (Greening Australia, 2011). Further details, including flowering times, collection methods, germination and cultivation tips and additional species can be found at the following website: http://www.florabank.org.au/. Florabank is an online resource for native seed and is funded by Greening Australia. Florabank is an initiative of the Australian Government, Greening Australia and CSIRO.

Table F. 1 Indicative Seed Collection Times for Flora Species Relevant to the Project

Species	Common Name	Summer		Autumn			Winter			Spring			Summer
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TREES AND SHRUBS													
Acacia acinacea	Gold Dust Wattle								x	x	x		
Acacia dealbata	Early Black Wattle	x	x										x
Acacia decora	Western Silver Wattle				x	x	x	x	x	x	x		
Acacia implexa	Lightwood	x	x	x									
Acacia melanoxylon	Blackwood Wattle	x	x	x									x
Acacia paradoxa	Kangaroo Thorn						x	x					
Acacia rubida	Red-Stemmed Wattle	x	x										x
Allocasuarina leuhmanii	Buloke	x											x
Brachychiton populneus	Kurrajong	x	x	x	x	x							x
Bursaria spinosa	Blackthorn	x	x	x	x								
Callitris endlicheri	Black Cypress Pine	x	x	x	x	x	x	x	x	x	x	x	x
Callitris glaucophylla	White Cypress Pine	x	x	x	x	x	x	x	x	x	x	x	x
Cassinia arcuata	Drooping Cassinia	x	x	x	x						x	x	x
Casuarina cunninghamiana	River Oak	x	x	x	x	x	x	x	x	x	x	x	x
Daviesia genistifolia	Broom Bitter Pea	x											x
Daviesia latifolia	Broad-leaved Bitter-pea											x	x
Daviesia mimosoides	-	x									x	x	x
Dilwynia sericea	Showy Parrot-pea	x	x										x
Dodonea viscosa	Hop Bush									x	x	x	

Species	Common Name	Summer		Autumn			Winter			Spring			Summer
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eucalyptus melanophloia	Silverleaf Ironbark	x	x	x	x							x	x
Eucalyptus albens	White Box	x	x	x	x							x	x
Eucalyptus blakelyi	Blakeylis Red Gum	x	x	x	x							x	x
Eucalyptus bridgesiana	Apple Box	x	x	x	x	x	x	x	x	x	x	x	x
Eucalyptus camaldulensis	River Red Gum	x	x	x	x	x	x	x	x	x	x	x	x
Eucalyptus melliodora	Yellow Box	x	x	x	x							x	x
Eucalyptus microcarpa	Inland Greybox	x	x	x	x							x	x
Hibbertia obtusifolia	Grey Guinea Flower	x	x	x								x	x
Indigofera aedesmifolia	Tick Indigo	x	x									x	x
Indigofera australis	Austral Indigo	x	x									x	x
Pimelea glauca	Smooth Rice-flower	x	x								x	x	x
HERBS AND GRASSES													
Austrodanthonia caespitosa	Wallaby Grass	x											x
Austrodanthonia setacea	Wallaby Grass	x											x
Austrostipa scabra	Spear Grass	x	x							x	x	x	x
Bothriochloa macra	Red-leg Grass	x	x	x							x	x	x
Bulbine bulbosa	Bulbine Lily	x	x									x	x
Burchardia umbellata	Milkmaids												
Calocephalus citreus	Lemon Beauty-heads	x	x	x									
Calotis lappulacea	Yellow Burr-Daisy	x	x	x								x	x
Chrysocephalum apiculatum	Golden Buttons	x	x	x							x	x	x

Species	Common Name	Summer		Autumn			Winter			Spring			Summer
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chrysocephalum semipapposum	Clustered Everlasting	x	x	x							x	x	x
Clematis microphylla	Old Man's Beard								x	x	x	x	x
Convolvulus angustissimus	Australian Bindweed								x	x	x	x	
Cymbopogon refractus	Barbed Wire Grass	x	x	x	x					x	x	x	x
Desmodium varians	Slender Tick-trefoil	x	x							x	x	x	x
Dianella longifolia	Smooth Flax Lily	x									x	x	x
Dianella revoluta	Blueberry Lily	x											x
Einatia nutans	Nodding Saltbush	x	x									x	x
Eremophila debilis	Winter Apple	x	x	x									
Geranium solanderi	Austral Cranesbill								x	x	x	x	x
Glycine clandestina	Twining Glycine	x	x								x	x	x
Glycine tabacina	Variable Glycine	x	x	x	x	x	x				x	x	x
Hardenbergia violaceae	False Sarsparilla	x	x										x
Linum marginale	Native Flax	x	x	x	x							x	x
Lomandra filiformis	Wattle Matt-rush	x	x										
Lomandra longifolia	Spiny-headed Mat-rush	x	x										x
Lomandra multiflorus	Many-flowered Matt-rush	x	x										
Lotus australis	Australian Trefoil	x	x										x
Microlaena stipoides	Weeping Grass	x	x							x	x	x	x
Microseris lanceolata	Murnong	x	x	x								x	x
Poa labillardieri	Tussock Grass	x	x							x	x	x	x

Species	Common Name	Summer		Autumn			Winter			Spring			Summer
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sorghum leiocladum	Wild Sorghum	x	x	x								x	x
Themeda australis	Kangaroo Grass	x	x									x	x
Tricoryne elatior	Yellow Rush-lily	x	x	x							x	x	x
Vittadinia cuneata	Burr Daisy	x	x	x							x	x	x
Vittadinia gracilus	Woolly New Holland Daisy	x	x									x	x
Vittadinia muelleri	Narrow-leaf New Holland Daisy	x	x								x	x	x
Wahlenbergia gracilis	Sprawling Bluebell								x	x	x	x	
Wurmbea dioica	Early Nancy							x	x	x	x		
Xerochrysum viscosum	Sticky Everlasting										x	x	x

F.1.2 Commercial Propagation

Revegetation of the scale required should be undertaken by local nurseries that can effectively collect commercial quantities of seed, propagate and grow the seed and harden the seedlings (Florabank). Ensure that:

- Orders in excess of 200 plants are placed at least 12 months in advance;
- The type and number of species required are specified;
- Local provenance is communicated, such that the nursery has enough time to spend collecting from the region; and
- Germination times of species is requested, as is the likely time frames for plants to reach transplantable sizes (e.g. most species require 1 season to be of sufficient size, but other species such as *Xanthorrhoea*, *Callitris* and *Bursaria* can take two or more years).

Examples of commercial tube stock nurseries include:

- Gunnedah Forest Nursery;
- Rural Conservation Service;
- Hastings Tubestock Growers and Planters; and
- Greening Australia.

F.1.3 Propagation Techniques

Native plants can be propagated by seed, cuttings or division, depending on the species. The following techniques and notes (see **Table F. 2**) are taken from the Australian National Botanic Gardens (ANBG, 2012). The website provides details of the best time to collect seeds of particular genus and their treatment requirements.

Optimal propagation times and methods of some native plant genus are provided in **Table F. 3** (ANBG, 2012).

Table F. 2 Propagation Techniques for Tubestock

Propagation Method	Advantages	Disadvantage	Collection and Preparation
Seed	- Seed can be collected and stored for extended periods of time prior to germination; - Suitable for genus such as *Acacia* (wattles), *Banksia*, *Callistemon* (Bottlebrushes), *Allocasuarina* (She Oaks), *Eucalyptus*, *Hakea*, *Hardenbergia* and *Melaleuca.*	- Many species are difficult to grow from seed; some require specific treatments to break dormancy or trigger germination.	- Seed must be fresh, mature, and insect- and disease-free when collected; - Storage in dark, sealed containers in temperatures of 3-5°C and humidity of less than 16%; and - Pre-treatment may be required to make the seed coating permeable to gas and water exchange to break dormancy and encourage germination. Acid treatment; chilling; soaking; boiling water; mechanical scarification; smoke and; smoke water can be used.
Cuttings	- Vegetative propagation method in which all plants are genetically identical to the parent.	- Cuttings should be made as soon as possible after the plant material is collected. However, if kept cool, moist and free of fungus, some plant material can be stored for several days; and - Not all species of plants can be propagated from cuttings. Cuttings taken from species of Eucalyptus do not readily form roots. This is also the case with many Acacia species and most monocotyledons, e.g. grasses.	- Plant material should be semi-mature. Shoot tips should be collected in late spring- early summer; and - Cuttings take 4-10 weeks or longer to root, depending on the species.

Propagation Method	Advantages	Disadvantage	Collection and Preparation
Division	- Often used for grass-like clumps and suckering plants; - Easy to undertake separations; no special equipment required. Plant is already mature and just needs humidity and regular watering; - In warm climates, division can take place at virtually any time of the year; and - Grasses, Dianella, Lomandra, lilies.	- May be time consuming.	- Grassy clumps; and - Plant split into two or more segments, each with root material, leaf shoots and rhizomes attached.

Table F. 3 Optimal Propagation Times and Methods for a Selection of Native Plants

Genus	Propagation Method	Optimal Propagation Time
Acacia	Seed †	Aug-Sept
Allocasuarina	Seed*	Summer and Mar-May
Angophora	Seed	Sept-Nov
Anigozanthos	Division (virus tested stock)	Sept-Nov
Anigozanthos	Seed-fresh	Sept-Nov
Araucaria	Cuttings* seed	Dec-Feb
Asplenium	Spores-2-3 weeks after ripening	Mar - May
Asplenium	Division	Mar - May
Backhousia	Seed	Sept-Nov
Baeckia	Soft tip cuttings	Dec-April
Banksia	Seed	Sept-Nov
Banksia	Soft tip cuttings*	Sept-Nov
Bauera	Soft tip cuttings*	Sept-Oct
Bauera	Seeds 8 weeks to germinate	Sept-Oct
Bauera	Layering	Sept-Oct
Billardiera	Seed-difficult	Mar-May
Billardiera	Division	Mar-May
Billardiera	Soft tip cuttings	Mar-May
Blandfordia	Seed	Sept-Nov
Boronia	Soft tip cuttings	Sept-Nov
Brachychiton	Seeds (wear gloves & mask-often hairs surrounding seeds)	Sept-Nov
Brachychiton	Graft onto seedling understock	Sept-Nov
Brachyscome	Seed*	Sept-Nov
Brachyscome	Soft tip cuttings*	any time
Brachyscome	Division*	Mar-May
Brachysema	Seed	Sept-Nov
Brachysema	Soft tip cuttings*	Mar-Apr
Bracteantha	Seed	all year
Bracteantha	Soft tip cuttings *	all year
Callistemon	Seed from one-year-old woody fruits	Sept-Nov
Callistemon	Soft tip cuttings	Dec-Jun
Callitris	Seed-viable for several years	Mar-May
Calothamnus	Seed-place one-year-old or older	Sept-Nov
Calothamnus	woody fruits	Sept-Nov
Calothamnus	Soft tip cuttings	Sept-Nov
Cassia	Seed †*	Sept-Nov
Cassia	Soft tip cuttings	Dec-Mar

Genus	Propagation Method	Optimal Propagation Time
Clematis	Seed-fresh	Sept
Correa	Soft tip cuttings*	Jan-Mar
Crowea	Soft tip cuttings	Jan-Mar
Cyathea	Spores-2-3 weeks after ripening	Mar-May
Dampiera	Soft tip cuttings*	Sept-Nov
Darwinia	Seeds cuttings	Sept-Nov
Dendrobium	Division	Mar-May
Dianella	Division	Mar-May
Dicksonia	Spores-2-3 weeks after ripening	Mar-May
Dillwynia	Seed †	Dec-Mar
Dillwynia	Soft tip cuttings	Sept-Nov
Dodonaea	Soft tip cuttings	Dec-Mar
Doryanthes	Seed-soak for several hours*	Sept-Nov
Drosera	Division	Mar-May
Drosera	Leaf cuttings	Sept-Nov
Dryandra	Seeds	Sept-Nov
Epacris	Seeds	Sept-Nov
Epacris	Soft tip cuttings	Dec-Mar
Eremophila	Soft tip cuttings*	Sept-Nov
Eriostemon	Soft tip cuttings*	Mar-May
Eucalyptus	Seed	Sept-Mar
Ficus	Seed-fresh cuttings	varies
Gahnia	Seed	varies
Gahnia	Division	Mar-May
Goodenia	Seed	Dec-Feb
Goodenia	Stem cuttings, stolons	Dec-Feb
Grevillea	Soft tip cuttings	Dec-Mar
Hakea	Seed (sun dry woody fruit)	Sept-Nov
Hakea	Soft tip cuttings	Dec-Apr
Hardenbergia	Seeds †*	Sept-Nov
Hardenbergia	Soft tip cuttings	Mar-Apr
Hibbertia	cuttings	Summer
Hovea	Seed †	Summer
Indigofera	Seed †*	Sept-Oct
Isopogon	Seed	Sept-Nov
Isopogon	Soft tip cuttings	Feb-Mar
Jasminum	Seed-pre-treatment	?
Kennedia	Seed †*	Sept-Nov
Kennedia	Soft tip cuttings	Dec-Feb
Kunzea	Soft tip cuttings *	Feb-Apr

Genus	Propagation Method	Optimal Propagation Time
Lambertia	Seed	Sept-Nov
Lambertia	Soft tip cuttings	Feb-Apr
Lechenaultia	Soft tip cuttings	Sept-Nov
Leptospermum	Seeds *	Sept-Nov
Leptospermum	Soft tip cuttings *	May-Jun
Livistonia	Seed	?
Lomandra	Seed	Mar-May
Lomandra	Division	Mar-May
Macadamia	Seed-as soon as ripe	?
Macadamia	(6 months to germinate)	?
Macadamia	Graft	?
Macrozamia	Seed	?
Melaleuca	Seed*	Sept-Nov
Melaleuca	Soft tip cuttings*	Sept-Nov
Melaleuca	Soft wood cuttings	Dec-Mar
Melia	Seed (poisonous)	Sept-Nov
Melia	Soft tip cuttings	Sept-Nov
Myoporum	Soft tip cuttings*	Sept-Mar
Nothofagus	Seed	?
Olearia	Soft tip cuttings	?
Pandorea	Soft tip cuttings	Sept-Mar
Pandorea	Seed	Sept-Mar
Pepperomia	Leaf cuttings*	all year
Persoonia	Seed (difficult)	Sept-Mar
Persoonia	Soft tip cuttings	Sept-Mar
Phebalium	Soft tip cuttings	?
Pimelea	Soft tip cuttings*	Nov-Dec
Pittosporum	Seed	?
Pomaderris	Seed	?
Prostanthera	Soft tip cuttings	Nov-Dec
Pultaneae	Seed cuttings	Sept-Nov
Quandong	Seed (moist, dark, stratification)	?
Scaevola	Soft tip cuttings	?
Sollya	Seed †	Sept-Nov
Sollya	Soft tip cuttings	Sept-Nov
Syzygium	Soft tip cuttings	Dec-Mar
Telopea	Seed	Jun-Jul
Telopea	Soft tip cuttings	Sept
Thryptomene	Soft tip cuttings	Sept-May
Verticordia	Soft tip cuttings	Sept-Nov

Genus	Propagation Method	Optimal Propagation Time
Viola	Division*	all year
Westringia	Soft tip cuttings*	Mar-May
Xanthorrhoea	Seeds	Sept-Nov
Zieria	Soft tip cuttings	Dec-Mar

*† Pre-treatment required. Ease of propagation: *easy; # difficult*

F.2 Recommended Species for Planting

The following species list provided in **Table F.4** is for the EPBC Act-listed threatened ecological community White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland Ecological Community (Box-Gum Woodland). The list is not exhaustive, and not all species are found in all Box-Gum Woodland communities across its distribution. However, the list provides a reference for suitable planting species for rehabilitation and revegetation sites.

Table F. 4 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
Climber	Pittosporaceae	*Billardiera scandens*	Appleberry, Snotberry, Apple Dumplings
	Ranunculaceae	*Clematis microphylla*	Small-leaved Clematis
Dominant tree	Myrtaceae	*Eucalyptus albens*	White Box
Dominant tree	Myrtaceae	*Eucalyptus blakelyi*	Blakely's Red Gum
Dominant tree	Myrtaceae	*Eucalyptus melliodora*	Yellow Box, Yellow Jacket, Honey Box (Qld), Yellow Ironbark (Qld)
Dominant tree (in Nandewar)	Myrtaceae	*Eucalyptus microcarpa*	Grey Box, Narrow-leaved Box, Inland Grey Box, Western Grey Box
Dominant tree (in Nandewar)	Myrtaceae	*Eucalyptus moluccana*	Grey Box, Gum-topped Box
Fern	Aspleniaceae	*Asplenium flabellifolium*	Necklace Fern
	Ophioglossaceae	*Botrychium australe*	Parsley Fern
	Adiantaceae	*Cheilanthes austrotenuifolia*	Rock-fern
	Adiantaceae	*Cheilanthes distans*	Bristly Cloak Fern
	Adiantaceae	*Cheilanthes sieberi*	Narrow Rock Fern
	Dennstaedtiaceae	*Pteridium esculentum*	Common Bracken, Gurgi (Cadigal), Austral Bracken, Bracken
Grass	Poaceae	*Aristida behriana*	Brush Wiregrass, Bunch Wiregrass
	Poaceae	*Aristida calycina*	Dark Wire-grass, Branched Wiregrass
	Poaceae	*Aristida ramosa*	Purple Wiregrass, Kerosene Grass, Prickly Threeawn
	Poaceae	*Austrodanthonia auriculata*	Lobed Wallaby-grass
	Poaceae	*Austrodanthonia bipartita*	Bandicoot Grass, Wallaby Grass, Leafy Wallaby Grass
	Poaceae	*Austrodanthonia caespitosa*	Ringed Wallaby-grass, Common Wallaby-grass
	Poaceae	*Austrodanthonia carphoides*	Short Wallaby-grass
	Poaceae	*Austrodanthonia eriantha*	Hill Wallaby-grass
	Poaceae	*Austrodanthonia laevis*	Wallaby Grass
	Poaceae	*Austrodanthonia monticola*	Small-flower Wallaby Grass
	Poaceae	*Austrodanthonia pilosa*	Velvet Wallaby Grass, Smooth-flowered Wallaby-grass
	Poaceae	*Austrodanthonia racemosa*	Clustered Wallaby-grass, Slender Wallaby Grass

Form	Family	Scientific Name	Common name
	Poaceae	*Austrodanthonia setacea*	Bristly Wallaby Grass
	Poaceae	*Austrofestuca eriopoda*	Snow Fescue
	Poaceae	*Austrostipa bigeniculata*	Tall Speargrass
	Poaceae	*Austrostipa blackii*	Crested Spear-grass
	Poaceae	*Austrostipa densiflora*	Dense Spear-grass
	Poaceae	*Austrostipa nodosa*	Knotty Speargrass
	Poaceae	*Austrostipa rudis*	Veined Speargrass
	Poaceae	*Austrostipa scabra*	Corkscrew, Corkscrew Speargrass, Rough Spear-grass, Rough Needle-grass, Speargrass
	Poaceae	*Bothriochloa macra*	Redgrass, Redleg Grass
	Poaceae	*Chloris truncata*	Windmill Grass
	Poaceae	*Chloris ventricosa*	Tall Windmill Grass
	Poaceae	*Cymbopogon refractus*	Barbed Wire Grass
	Poaceae	*Deyeuxia quadriseta*	Reed Bent-grass
	Poaceae	*Dichanthium sericeum*	Queensland Blue-grass
	Poaceae	*Dichelachne crinita*	Longhair Plumegrass
	Poaceae	*Dichelachne hirtella*	Slender Plumegrass
	Poaceae	*Dichelachne inaequiglumis*	Plume Grass
	Poaceae	*Dichelachne micrantha*	Short-hair Plumegrass
	Poaceae	*Dichelachne parva*	Plume Grass
	Poaceae	*Dichelachne rara*	Plume Grass
	Poaceae	*Echinopogon caespitosus*	Tufted Hedgehog-grass
	Poaceae	*Echinopogon cheelii*	Long-flowered Hedgehog Grass
	Poaceae	*Echinopogon ovatus*	Forest Hedgehog-grass, Hedgehog Grass, Rough-bearded Grass
	Poaceae	*Elymus scaber*	Common Wheat-grass, Wheatgrass, Rough Wheatgrass
	Poaceae	*Enneapogon nigricans*	Black-head Grass
	Poaceae	*Glyceria australis*	Australian Sweetgrass
	Poaceae	*Imperata cylindrica*	Blady Grass
	Poaceae	*Joycea pallida*	Silvertop Wallaby Grass, Redanther Wallaby Grass
	Poaceae	*Microlaena stipoides*	Microlaena, Weeping Grass
	Poaceae	*Panicum effusum*	Hairy Panic, Poison Panic
	Poaceae	*Poa labillardierei*	Tussock Grass
	Poaceae	*Poa meionectes*	Fine-leaved Snow Grass, Fine-leaved Tussock-grass
	Poaceae	*Poa petrophila*	Rock Tussock-grass
	Poaceae	*Poa sieberiana*	Snow Grass, Fine-leaved Tussock-grass
	Poaceae	*Rytidosperma nudiflorum*	Alpine Wallby Grass

Form	Family	Scientific Name	Common name
	Poaceae	*Sorghum leiocladum*	Wild Sorghum
	Poaceae	*Sporobolus creber*	Western Rat-tail Grass, Slender Rat's Tail Grass
	Poaceae	*Sporobolus elongatus*	Slender Rat's-tail Grass
	Poaceae	*Themeda australis (syn. Themeda triandra)*	Kangaroo Grass
	Poaceae	*Themeda triandra (syn. Themeda australis)*	Kangaroo Grass
	Poaceae	*Tripogon loliiformis*	Fiveminute Grass
Grass Tree	Xanthorrhoeaceae	*Xanthorrhoea australis*	Grass Tree
Herb	Rosaceae	*Acaena agnipila*	Sheep's Burr, Bidgee-widgee
	Rosaceae	*Acaena echinata*	Sheep's Burr
	Rosaceae	*Acaena novae-zelandiae*	Bidgee-widgee, Biddy Biddy
	Rosaceae	*Acaena ovina*	Sheep's Burr, Bidgee-widgee
	Lamiaceae	*Ajuga australis*	Australian Bugle, Austral Bugle
	Amaranthaceae	*Alternanthera nana*	Hairy Joyweed, Downy Pigweed
	Asteraceae	*Ammobium alatum*	Tall Ammobium
	Asteraceae	*Ammobium craspedioides*	Yass Daisy
	Rosaceae	*Aphanes australiana*	Australian Piert
	Orchidaceae	*Arachnorchis spp.*	Spider Orchids
	Anthericaceae	*Arthropodium milleflorum*	Vanilla-lily, Pale Vanilla-lily
	Anthericaceae	*Arthropodium minus*	Small Vanilla Lily
	Rubiaceae	*Asperula conferta*	Common Woodruff
	Rubiaceae	*Asperula scoparia*	Prickly Woodruff
	Asteraceae	*Brachyscome aculeata*	Hill Daisy
	Asteraceae	*Brachyscome decipiens*	Field Daisy
	Asteraceae	*Brachyscome diversifolia*	Large-headed Daisy
	Asteraceae	*Brachyscome graminea*	Grass Dairy
	Asteraceae	*Brachyscome heterodonta*	Lobe-seed Daisy
	Asteraceae	*Brachyscome multifida*	Cut-leaved Daisy
	Asteraceae	*Brachyscome rigidula*	Leafy Daisy
	Asteraceae	*Brachyscome scapigera*	Tufted Daisy
	Asteraceae	*Brachyscome spathulata*	Spoon Daisy
	Brunoniaceae	*Brunonia australis*	Pincushion, Blue Pincushion
	Acanthaceae	*Brunoniella australis*	Blue Trumpet
	Asphodelaceae	*Bulbine bulbosa*	Bulbine Lily, Native Onion, Native Leek, Golden Lily
	Asphodelaceae	*Bulbine glauca*	Rock Lily
	Colchicaceae	*Burchardia umbellata*	Milkmaids
	Anthericaceae	*Caesia calliantha*	Blue Grass-Lily
	Asteraceae	*Calocephalus citreus*	Lemon Beautyheads

Form	Family	Scientific Name	Common name
	Orchidaceae	*Calochilus robertsonii*	Purplish Beard Orchid
	Asteraceae	*Calotis cuneifolia*	Purple Burr-daisy
	Asteraceae	*Calotis glandulosa*	Mauve Burr-daisy
	Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy, Yellow Daisy-burr
	Asteraceae	*Calotis scabiosifolia*	Rough Burr-daisy
	Cyperaceae	*Carex inversa*	Knob Sedge, Common Sedge
	Apiaceae	*Centella asiatica*	Pennywort
	Apiaceae	*Centella cordifolia*	Centella
	Centrolepidaceae	*Centrolepis strigosa*	Hairy Centrolepis
	Euphorbiaceae	*Chamaesyce drummondii*	Caustic-weed
	Chenopodiaceae	*Chenopodium pumilio*	Clammy Goosefoot, Small Crumbweed
	Asteraceae	*Chrysocephalum apiculatum*	Yellow Buttons, Common Everlasting
	Asteraceae	*Chrysocephalum semipapposum*	Clustered Everlasting, Yellow Buttons
	Convolvulaceae	*Convolvulus erubescens*	Australian Bindweed, Blushing Bindweed
	Rutaceae	*Correa reflexa*	Common Correa, Native Fuchsia
	Asteraceae	*Cotula australis*	Common Cotula, Carrot Weed
	Asteraceae	*Craspedia canens*	Billy Buttons, Grey Billybuttons
	Asteraceae	*Craspedia variabilis*	Billy Buttons
	Crassulaceae	*Crassula colorata*	Annual Stonecrop, Dense Crassula, Dense Stonecrop
	Crassulaceae	*Crassula helmsii*	Swamp Stonecrop
	Crassulaceae	*Crassula sieberiana*	Australian Stonecrop, Sieber Crassula
	Fabaceae	*Cullen microcephalum*	Dusky Scurf-pea, Mountain Psoralea
	Fabaceae	*Cullen tenax*	Emu-foot, Emu Grass, Tough Scurf-pea
	Asteraceae	*Cymbonotus lawsonianus*	Bear's Ear, Austral Bears-ears, Bears-ears
	Asteraceae	*Cymbonotus preissianus*	Austral Bear's Ear
	Boraginaceae	*Cynoglossum australe*	Australian Forget-me-not, Australian Hound's-tongue
	Boraginaceae	*Cynoglossum suaveolens*	Sweet Hound's-tongue
	Apiaceae	*Daucus glochidiatus*	Australian Carrot, Native Carrot, Austral Carrot
	Fabaceae	*Desmodium brachypodum*	Large Tick-trefoil
	Fabaceae	*Desmodium varians*	Slender Tick-trefoil
	Phormiaceae	*Dianella longifolia*	Smooth Flax Lily
	Phormiaceae	*Dianella revoluta*	Blueberry Lily, Black-Anther Flax Lilly, Spreading Flax Lily
	Convolvulaceae	*Dichondra repens*	Kidney Grass, Kidney Weed
	Anthericaceae	*Dichopogon fimbriatus*	Chocolate Lily, Nodding Chocolate Lily
	Anthericaceae	*Dichopogon strictus*	Chocolate Lily
	Orchidaceae	*Dipodium punctatum*	Hyacinth Orchid, Pink Hyacinth Orchid

Form	Family	Scientific Name	Common name
	Orchidaceae	*Diuris aequalis*	Buttercup Doubletail
	Orchidaceae	*Diuris behrii*	Golden Cowslips
	Orchidaceae	*Diuris chryseopsis*	Common Golden Moths
	Orchidaceae	*Diuris dendrobioides*	Long-tail Purple Diuris, Wedge Diuris
	Orchidaceae	*Diuris maculata*	Leopard Orchid, Nanny Goats, Leopard Diuris, Spotted Doubletail
	Orchidaceae	*Diuris monticola*	Highland Golden Moths
	Orchidaceae	*Diuris ochroma*	Pale Golden Moths
	Orchidaceae	*Diuris pedunculata*	Small Snake Orchid, Two-leaved Golden Moths, Golden Moths, Cowslip Orchid, Snake Orchid
	Orchidaceae	*Diuris punctata*	Purple Donkey-orchid, Purple Double-tails, Purple Diuris, Purple Cowslip, Dotted Double-tails
	Orchidaceae	*Diuris semilunulata*	Donkey-ears
	Orchidaceae	*Diuris sulphurea*	Tiger Orchid, Hornet Orchid
	Droseraceae	*Drosera peltata*	Hairy Climbing Sundew, Pale Sundew
	Droseraceae	*Drosera pygmaea*	Pigmy Sundew, Tiny Sundew
	Chenopodiaceae	*Einadia nutans*	Climbing Saltbush, Nodding Saltbush
	Orchidaceae	*Eriochilus cucullatus*	Parson's Bands
	Geraniaceae	*Erodium crinitum*	Native Crowfoot, Blue Storks-bill, Blue Crowfoot, Blue Herons-bill
	Apiaceae	*Eryngium ovinum*	Blue Devil
	Apiaceae	*Eryngium rostratum*	Blue Devil
	Apiaceae	*Eryngium vesiculosum*	Prostrate Blue Devil, Prickfoot
	Asteraceae	*Euchiton gymnocephalus*	Creeping Cudweed
	Asteraceae	*Euchiton involucratus*	Star Cudweed
	Asteraceae	*Euchiton sphaericus*	Annual Cudweed, Star Cudweed
	Scrophulariaceae	*Euphrasia collina*	Eyebright
	Rubiaceae	*Galium gaudichaudii*	Rough Bedstraw
	Orchidaceae	*Gastrodia sesamoides*	Cinnamon Bells, Potato Orchid
	Orchidaceae	*Genoplesium*	Midge Orchids
	Geraniaceae	*Geranium antrorsum*	Antrorse Geranium
	Geraniaceae	*Geranium graniticola*	Granite Cranesbill
	Geraniaceae	*Geranium neglectum*	Swamp Cranes-bill
	Geraniaceae	*Geranium retrorsum*	Common Cranes-bill
	Geraniaceae	*Geranium solanderi*	Native Geranium
	Orchidaceae	*Glossodia major*	Wax-lip Orchid, Parson-in-the-pulpit
	Fabaceae	*Glycine clandestina*	Twining Glycine
	Fabaceae	*Glycine tabacina*	Glycine Pea, Variable Glycine
	Haloragaceae	*Gonocarpus elatus*	Hill Raspwort

Form	Family	Scientific Name	Common name
	Haloragaceae	*Gonocarpus tetragynus*	Common Raspwort
	Goodeniaceae	*Goodenia bellidifolia*	Daisy-leaved Goodenia, Rocket Goodenia
	Goodeniaceae	*Goodenia hederacea*	Forest Goodenia, Ivy Goodenia
	Goodeniaceae	*Goodenia humilis*	Swamp Goodenia
	Goodeniaceae	*Goodenia pinnatifida*	Scrambled Eggs, Cut-leaf Goodenia
	Goodeniaceae	*Goodenia stelligera*	Spiked Goodenia
	Scrophulariaceae	*Gratiola nana*	Creeping Brooklime
	Scrophulariaceae	*Gratiola pedunculata*	Brooklime
	Scrophulariaceae	*Gratiola peruviana*	Austral Brooklime
	Caryophyllaceae	*Gypsophila tubulosa*	Annual Chalkwort
	Asteraceae	*Helichrysum collinum*	Hill Daisy
	Asteraceae	*Helichrysum scorpioides*	Button Everlasting
	Apiaceae	*Hydrocotyle laxiflora*	Stinking Pennywort
	Orchidaceae	*Hymenochilus bicolor*	Bicolor Greenhood
	Orchidaceae	*Hymenochilus cycnocephalus*	Swan Greenhood
	Orchidaceae	*Hymenochilus muticus*	Midget Greenhood, Blunt Greenhood, Dwarf Greenhood
	Clusiaceae	*Hypericum gramineum*	Small St John's Wort
	Clusiaceae	*Hypericum japonicum*	Small St John's Wort, Matted St John's Wort
	Asteraceae	*Isoetopsis graminifolia*	Grass Cushion
	Lobeliaceae	*Isotoma axillaris*	Rock Isotome
	Fabaceae	*Kennedia prostrata*	Running Postman, Scarlet Running Pea, Scarlet Coral-pea
	Asteraceae	*Lagenophora stipitata*	Blue-bottle Daisy, Common Lagenophora
	Anthericaceae	*Laxmannia gracilis*	Slender Wire-Lily
	Asteraceae	*Leptorhynchos elongatus*	Lanky Buttons, Hairy Buttons
	Asteraceae	*Leptorhynchos squamatus*	Scaly Buttons
	Asteraceae	*Leucochrysum albicans*	Hoary Sunray
	Scrophulariaceae	*Limosella australis*	Australian Mudwort
	Linaceae	*Linum marginale*	Wild Flax, Native Flax
	Lobeliaceae	*Lobelia dentata*	Toothed Lobelia, Wavy Lobelia
	Lobeliaceae	*Lobelia gibbosa*	Tall Lobelia
	Lomandraceae	*Lomandra bracteata*	Mat-rush
	Lomandraceae	*Lomandra filiformis*	Wattle Mat-rush
	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush, Honey Weed
	Lomandraceae	*Lomandra multiflora*	Many-flowered Matrush
	Fabaceae	*Lotus australis*	Austral Trefoil, Australian Trefoil
	Lythraceae	*Lythrum salicaria*	Purple Loosestrife
	Lamiaceae	*Mentha diemenica*	Slender Mint

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	Lamiaceae	*Mentha satureioides*	Creeping Mint, Native Pennyroyal
	Asteraceae	*Microseris lanceolata*	Yam Daisy, Murnong
	Orchidaceae	*Microtis parviflora*	Slender Onion-orchid
	Orchidaceae	*Microtis unifolia*	Common Onion-orchid, Onion-orchid
	Scrophulariaceae	*Mimulus repens*	Creeping Monkey-flower
	Rubiaceae	*Opercularia diphylla*	Stinkweed
	Rubiaceae	*Opercularia hispida*	Hairy Stinkweed
	Ophioglossaceae	*Ophioglossum lusitanicum*	Adder's Tongue
	Apiaceae	*Oreomyrrhis argentea*	Silvery Carraway
	Apiaceae	*Oreomyrrhis eriopoda*	Australian Carraway
	Oxalidaceae	*Oxalis exilis*	Shady Wood Sorrel, Indian Sorrel
	Oxalidaceae	*Oxalis perennans*	Grassland Wood Sorrel, Grass Wood-sorrel, Creeping Yellow Sorrel
	Iridaceae	*Patersonia sericea*	Silky Purple-flag
	Geraniaceae	*Pelargonium australe*	Native Storks-bill, Austral Storks-bill, Wild Geranium
	Geraniaceae	*Pelargonium inodorum*	Scentless Storks-bill
	Geraniaceae	*Pelargonium rodneyanum*	Magenta Storks-bill
	Plantaginaceae	*Plantago debilis*	Shade Plantain, Slender Plantain
	Plantaginaceae	*Plantago euryphylla*	Plantain
	Plantaginaceae	*Plantago gaudichaudii*	Narrow-leaf Native Plantain, Narrow Plantain
	Plantaginaceae	*Plantago varia*	Variable Plantain, Small Plantain, Sago-weed
	Asteraceae	*Podolepis hieracioides*	Tall Copper-wire Daisy
	Asteraceae	*Podolepis jaceoides*	Showy Copper-wire Daisy
	Polygalaceae	*Polygala japonica*	Dwarf Milkwort
	Euphorbiaceae	*Poranthera microphylla*	Small Poranthera, Small-leaved Poranthera
	Portulaceae	*Portulaca oleracea*	Common Pigweed, Common Purslane, Munyeroo
	Orchidaceae	*Prasophyllum petilum*	Tarengo Leek Orchid
	Lobeliaceae	*Pratia purpurascens*	Whiteroot
	Asteraceae	*Pseudognaphalium luteoalbum*	Jersey Cudweed
	Amaranthaceae	*Ptilotus erubescens*	Hairy Tails, Hairy Heads
	Ranunculaceae	*Ranunculus graniticola*	Granite Buttercup
	Ranunculaceae	*Ranunculus lappaceus*	Common Buttercup, Australian Buttercup
	Ranunculaceae	*Ranunculus pachycarpus*	Thick-fruited Buttercup
	Asteraceae	*Rhodanthe anthemoides*	White Sunray, Chamomile Sunray
	Asteraceae	*Rhodanthe pygmaea*	Pigmy Sunray
	Acanthaceae	*Rostellularia adscendens*	Pink-tongues, Bearded Anthem, Dwarf Justicia

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	Polygonaceae	*Rumex brownii*	Swamp Dock, Slender Dock
	Polygonaceae	*Rumex dumosus*	Wiry Dock
	Polygonaceae	*Rumex tenax*	Shiny Dock
	Asteraceae	*Rutidosis leiolepis*	Monaro Golden Daisy
	Asteraceae	*Rutidosis leptorhynchoides*	Button Wrinklewort
	Asteraceae	*Rutidosis multiflora*	Small Wrinklewort
	Caryophyllaceae	*Scleranthus biflorus*	Spiny Mat-plant, Knawel, Cushion-bush, Two-flowered Knawel
	Caryophyllaceae	*Scleranthus diander*	Tufted Knawel
	Lamiaceae	*Scutellaria humilis*	Dwarf Skullcap
	Gentianaceae	*Sebaea ovata*	Yellow Centaury
	Goodeniaceae	*Selliera radicans*	Swamp Weed
	Asteraceae	*Senecio hispidulus*	Hill Fireweed
	Asteraceae	*Senecio quadridentatus*	Cotton Fireweed
	Asteraceae	*Senecio tenuiflorus*	Woodland Groundsel, Narrow Groundsel, Cotton Groundsel, Slender Fireweed
	Malvaceae	*Sida corrugata*	Corrugated Sida
	Asteraceae	*Solenogyne dominii*	Smooth Solenogyne
	Asteraceae	*Solenogyne gunnii*	Hairy Solenogyne
	Orchidaceae	*Spiranthes sinensis*	Austral Ladies' Tresses
	Stackhousiaceae	*Stackhousia monogyna*	Creamy Candles, Creamy Stackhousia
	Stackhousiaceae	*Stackhousia viminea*	Slender Stackhousia
	Caryophyllaceae	*Stellaria angustifolia*	Swamp Starwort
	Caryophyllaceae	*Stellaria filiformis*	Thread Starwort
	Caryophyllaceae	*Stellaria multiflora (Back Creek)*	Back Creek Many Flowered Starwort, Back Creek Rayless Starwort
	Caryophyllaceae	*Stellaria pungens*	Prickly Starwort
	Asteraceae	*Stuartina hamata*	Crooked Cudweed, Hooked Cudweed
	Asteraceae	*Stuartina muelleri*	Spoon Cudweed
	Stylidiaceae	*Stylidium despectum*	Dwarf Triggerplant
	Stylidiaceae	*Stylidium graminifolium*	Grass Triggerplant
	Phormiaceae	*Stypandra glauca*	Nodding Blue Lily
	Fabaceae	*Swainsona behriana*	Behr's Swainson-pea
	Fabaceae	*Swainsona monticola*	Moutain Swainson-pea
	Fabaceae	*Swainsona oroboides*	Variable Swainson-pea
	Fabaceae	*Swainsona queenslandica*	Smooth Darling Pea
	Fabaceae	*Swainsona recta*	Mountain Swainson-pea, Small Purple-pea
	Fabaceae	*Swainsona reticulata*	Kneed Swainson-pea
	Fabaceae	*Swainsona sericea*	Silky Swainson-pea
	Tremandraceae	*Tetratheca spp.*	Black-eyed Susans
	Orchidaceae	*Thelymitra ixioides*	Spotted Sun-orchid, Dotted Sun-orchid

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	Orchidaceae	*Thelymitra malvina*	Mauve-tuft Sun-orchid, Mauve-tufted sun orchid
	Orchidaceae	*Thelymitra pauciflora*	Slender Sun-orchid, Few-flowered Sun-orchid
	Orchidaceae	*Thelymitra rubra*	Pink Sun-orchid, Salmon Sun-orchid, Red Sun-orchid
	Santalaceae	*Thesium australe*	Austral toadflax, Austral Toad-flax, Australian Toadflax
	Anthericaceae	*Thysanotus patersonii*	Twining Fringe-lily
	Anthericaceae	*Thysanotus tuberosus*	Common Fringe-lily
	Apiaceae	*Trachymene humilis*	Alpine Trachymene
	Anthericaceae	*Tricoryne elatior*	Yellow Rush-lily, Yellow Autumn-lily
	Asteraceae	*Triptilodiscus pygmaeus*	Austral Sunray
	Urticaceae	*Urtica incisa*	Stinging Nettle
	Goodeniaceae	*Velleia montana*	Velleia
	Goodeniaceae	*Velleia paradoxa*	Spur Velleia
	Scrophulariaceae	*Veronica calycina*	Hairy Speedwell
	Scrophulariaceae	*Veronica gracilis*	Slender Speedwell
	Scrophulariaceae	*Veronica plebeia*	Trailing Speedwell, Creeping Speedwell
	Violaceae	*Viola betonicifolia*	Showy Violet, Arrow-head Violet, Native Violet, Purple Violet
	Violaceae	*Viola caleyana*	Swamp Violet
	Violaceae	*Viola hederacea*	Native Violet, Ivy-leaf Violet, Ivy-leaved Violet
	Violaceae	*Viola sieberiana*	Diamond Violet
	Asteraceae	*Vittadinia cuneata*	Fuzzweed
	Asteraceae	*Vittadinia muelleri*	Narrow-leaf New Holland Daisy
	Campanulaceae	*Wahlenbergia ceracea*	Waxy Bluebell
	Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell
	Campanulaceae	*Wahlenbergia densifolia*	Fairy Bluebell
	Campanulaceae	*Wahlenbergia gracilenta*	Annual Bluebell
	Campanulaceae	*Wahlenbergia gracilis*	Australian Bluebell, Sprawling Bluebell
	Campanulaceae	*Wahlenbergia graniticola*	Granite Bluebell
	Campanulaceae	*Wahlenbergia littoricola*	Edge Bluebell, Coast Bluebell
	Campanulaceae	*Wahlenbergia luteola*	Yellow-wash Bluebell
	Campanulaceae	*Wahlenbergia multicaulis*	Tadgell's Bluebell
	Campanulaceae	*Wahlenbergia planiflora*	Bluebell
	Campanulaceae	*Wahlenbergia stricta*	Tall Bluebell, Austral Bluebell, Australian Bluebell
	Colchicaceae	*Wurmbea dioica*	Early Nancy
	Asteraceae	*Xerochrysum bracteatum*	Golden Everlasting
	Asteraceae	*Xerochrysum subundulatum*	Orange Everlasting, Alpine Everlasting

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	Asteraceae	*Xerochrysum viscosum*	Sticky Everlasting
	Fabaceae	*Zornia dyctiocarpa*	Zornia
Herb/Shrub	Scrophulariaceae	*Derwentia perfoliata*	Digger's Speedwell
Sedge/Rush	Cyperaceae	*Isolepis cernua*	Nodding Club-rush
	Cyperaceae	*Isolepis hookeriana*	Grassy Club-sedge, Grassy Club-rush
	Cyperaceae	*Isolepis inundata*	Swamp Club-sedge, Swamp Club-rush
	Juncaceae	*Juncus australis*	Austral Rush
	Juncaceae	*Juncus bufonius*	Toad Rush
	Juncaceae	*Juncus flavidus*	Yellow Rush
	Juncaceae	*Juncus fockei*	Slender Joint-leaf Rush
	Juncaceae	*Juncus homalocaulis*	Wiry Rush
	Juncaceae	*Juncus sarophorus*	Broom Rush
	Juncaceae	*Juncus subsecundus*	Finger Rush
	Cyperaceae	*Lepidosperma laterale*	Sword Sedge, Variable Swordsedge
	Juncaceae	*Luzula densiflora*	Dense Woodrush
	Juncaceae	*Luzula meridionalis*	Common Woodrush
	Juncaceae	*Luzula modesta*	Southern Woodrush
	Juncaceae	*Luzula ovata*	Clustered Woodrush
	Cyperaceae	*Schoenus apogon*	Common Bog Sedge, Fluke Bogrush
Shrub	Mimosaceae	*Acacia brownii*	Prickly Moses, Golden Prickly Wattle, Heath Wattle
	Mimosaceae	*Acacia dawsonii*	Poverty Wattle, Dawson's Wattle, Mitta Wattle
	Mimosaceae	*Acacia decora*	Western Silver Wattle, Showy Wattle, Western Golden Wattle, Pretty Wattle
	Mimosaceae	*Acacia falcata*	Sickle Wattle, Burra, Sickle-shaped Acacia, Sally, Hickory Wattle, Silver-leaved Wattle
	Mimosaceae	*Acacia genistifolia*	Spreading Wattle, Early Wattle, Wild Irishman
	Mimosaceae	*Acacia gunnii*	Ploughshare Wattle, Dog's Tooth Wattle
	Mimosaceae	*Acacia paradoxa*	Prickly Acacia, Acacia Hedge, Kangaroo Thorn, Hedge Wattle, Kangaroo Acacia, Prickly Wattle, Paradoxa Wattle
	Mimosaceae	*Acacia siculiformis*	Dagger Wattle
	Mimosaceae	*Acacia ulicifolia*	Prickly Moses, Juniper Wattle
	Epacridaceae	*Acrotriche serrulata*	Honeypots
	Epacridaceae	*Astroloma humifusum*	Native Cranberry, Cranberry Heath
	Araliaceae	*Astrotricha ledifolia*	Common Star-hair
	Rutaceae	*Boronia algida*	Alpine Boronia
	Fabaceae	*Bossiaea buxifolia*	Box-leaved Bitter-pea
	Fabaceae	*Bossiaea prostrata*	Creeping Bossiaea, Prostrate Bitter-pea
	Fabaceae	*Bossiaea riparia*	River Leafless Bossiaea

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	Epacridaceae	*Brachyloma daphnoides*	Daphne Heath
	Myrtaceae	*Calytrix tetragona*	Fringe Myrtle, Common Fringe-myrtle, Heath Myrtle
	Asteraceae	*Cassinia aculeata*	Common Cassinia, Chinese-scrub, Sifton Bush, Dogwood, Dolly Bush
	Asteraceae	*Cassinia arcuata*	Drooping Cassinia, Chinese Tea-scrub, Sifton Bush, Chinese Shrub
	Asteraceae	*Cassinia longifolia*	Shiny Cassinia, Cauliflower Bush, Long-leaf Dogwood
	Asteraceae	*Cassinia quinquefaria*	Rosemary Cassinia
	Pittosporaceae	*Cheiranthera cyanea*	Finger Flower
	Polygalaceae	*Comesperma ericinum*	Heath Milkwort, Heath-leaved False-pea, Pyramid Flower
	Rhamnaceae	*Cryptandra amara*	Bitter Cryptandra
	Fabaceae	*Daviesia genistifolia*	Spiny Bitter-pea, Broom Bitter-pea
	Fabaceae	*Daviesia latifolia*	Hop Bitter-pea
	Fabaceae	*Daviesia leptophylla*	Narrow-leaf Bitter-pea
	Fabaceae	*Daviesia mimosoides*	Narrow-leaf Bitter-pea
	Fabaceae	*Daviesia ulicifolia*	Gorse Bitter-pea
	Fabaceae	*Dillwynia cinerascens*	Grey Parrot-pea
	Fabaceae	*Dillwynia glaucula*	Michelago Parrot-pea
	Fabaceae	*Dillwynia prostrata*	Matted Parrot-pea
	Fabaceae	*Dillwynia retorta*	Heathy Parrot-pea
	Fabaceae	*Dillwynia sericea*	Showy Parrot-pea
	Rhamnaceae	*Discaria pubescens*	Australian Anchor-plant
	Sapindaceae	*Dodonaea procumbens*	Trailing Hop-bush
	Sapindaceae	*Dodonaea viscosa*	Sticky Hop-bush, Giant Hop-bush
	Chenopodiaceae	*Einadia hastata*	Saloop, Berry Saltbush
	Epacridaceae	*Epacris spp.*	Native Heaths
	Myoporaceae	*Eremophila debilis*	Winter Apple, Creeping Boobialla, Amulla
	Santalaceae	*Exocarpos strictus*	Pale Ballart, Pale-fruit Ballart, Dwarf Cherry
	Fabaceae	*Gompholobium huegelii*	Pale Wedge-pea
	Proteaceae	*Grevillea iaspicula*	Wee Jasper Grevillea
	Proteaceae	*Grevillea lanigera*	Woolly Grevillea
	Proteaceae	*Grevillea ramosissima*	Fan Grevillea, Branching Grevillea, Prickly Parsley Bush
	Proteaceae	*Grevillea rosmarinifolia*	Rosemary Grevillea
	Proteaceae	*Grevillea wilkinsonii*	Tumut Grevillea
	Proteaceae	*Hakea microcarpa*	Small-fruit Hakea, Small-fruited Needlebush
	Fabaceae	*Hardenbergia violacea*	False Sarsparilla, Purple Coral-pea, Native Lilac
	Dilleniaceae	*Hibbertia calycina*	Lesser Guinea-flower

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	Dilleniaceae	*Hibbertia obtusifolia*	Hoary Guinea-flower
	Dilleniaceae	*Hibbertia riparia*	Stream Guinea-flower, Erect Guinea-flower
	Fabaceae	*Hovea linearis*	Creeping Hovea
	Violaceae	*Hymenanthera dentata*	Tree Violet
	Fabaceae	*Indigofera adesmiifolia*	Tick Indigo, Leafless Indigo, Broad-leaved Indigo
	Fabaceae	*Indigofera australis*	Austral Indigo, Australian Indigo, Native Indigo, Hill Indigo
	Oleaceae	*Jasminum suavissimum*	Native Jasmine, Sweet Jasmine
	Myrtaceae	*Kunzea parvifolia*	Violet Kunzea, Tickbush
	Myrtaceae	*Leptospermum myrtifolium*	Swamp Myrtle, Swamp Tea-tree, Myrtle-leaved Tea-tree, Grey Tea-tree
	Myrtaceae	*Leptospermum obovatum*	River Tea-tree, Blunt-leaf Tea-tree
	Fabaceae	*Lespedeza juncea*	Perennial Lespedeza
	Epacridaceae	*Leucopogon fletcheri*	Pendant Beard Heath
	Epacridaceae	*Leucopogon fraseri*	Beard Heath
	Epacridaceae	*Leucopogon virgatus*	Common Beard Heath
	Epacridaceae	*Lissanthe strigosa*	Peach Heath
	Chenopodiaceae	*Maireana microphylla*	Eastern Cottonbush, Small-leaf Bluebush, Bluebush
	Epacridaceae	*Melichrus urceolatus*	Urn Heath
	Fabaceae	*Mirbelia oxylobioides*	Mountain Mirbelia
	Polygonaceae	*Muehlenbeckia axillaris*	Wire Plant, Matted Lignum
	Polygonaceae	*Muehlenbeckia tuggeranong*	Tuggeranong Lignum
	Asteraceae	*Olearia elliptica*	Sticky Daisy-bush
	Asteraceae	*Ozothamnus spp.*	Everlastings
	Thymelaeaceae	*Pimelea curviflora*	Curved Rice-flower
	Thymelaeaceae	*Pimelea glauca*	Shrubby Rice-flower
	Thymelaeaceae	*Pimelea pauciflora*	Poison Pimelea, Poison Rice-flower
	Rhamnaceae	*Pomaderris pallida*	Pale Pomaderris
	Fabaceae	*Pultenaea fasciculata*	Bush-pea
	Fabaceae	*Pultenaea microphylla*	Spreading Bush-pea
	Fabaceae	*Pultenaea procumbens*	Heathy Bush-pea
	Fabaceae	*Pultenaea spinosa*	Bush-pea
	Fabaceae	*Pultenaea subspicata*	Low Bush-pea
	Pittosporaceae	*Rhytidosporum procumbens*	White Marianth
	Rosaceae	*Rubus parvifolius*	Small-leaf Raspberry, Small-leaved Rasberry, Native Rasberry
	Sterculiaceae	*Rulingia prostrata*	Dwarf Kerrawang
	Solanaceae	*Solanum linearifolium*	Mountain Kangaroo-apple, Kangaroo-apple
	Epacridaceae	*Styphelia triflora*	Pink Five-corners

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	Fabaceae	*Templetonia stenophylla*	Leafy Templetonia, Leafy Mallee-pea
	Asteraceae	*Vittadinia gracilis*	Woolly New Holland Daisy
	Lamiaceae	*Westringia eremicola*	Slender Westringia
	Convolvulaceae	*Wilsonia rotundifolia*	Round-leaf Wilsonia
Shrub/Tree	Mimosaceae	*Acacia deanei*	Deane's Wattle, Green Wattle
	Mimosaceae	*Acacia decurrens*	Black Wattle, Early Black Wattle, Green Wattle, Queen Wattle, Sydney Green Wattle
	Mimosaceae	*Acacia doratoxylon*	Currawang, Lancewood, Spearwood, Cooriwan, Hickory, Brown Lancewood
	Mimosaceae	*Acacia mearnsii*	Black Wattle, Green Wattle, Late Black Wattle
	Mimosaceae	*Acacia parramattensis*	Sydney Green Wattle, Parramatta Wattle, Parramatta Green Wattle
	Mimosaceae	*Acacia rubida*	Red-stem Wattle, Red-leaved Wattle
	Mimosaceae	*Acacia verniciflua*	Varnish Wattle
	Proteaceae	*Banksia marginata*	Silver Banksia, Honeysuckle Banksia, Dwarf Honeysuckle, Warrock
	Pittosporaceae	*Bursaria spinosa*	Australian Blackthorn, Bursaria, Blackthorn, Native Blackthorn, Sweet Bursaria (Native Box), Whitethorn, Christmas Bush, Prickly Pine, Prickly Box
	Myrtaceae	*Callistemon sieberi*	Alpine Bottlebrush, River Bottlebrush
	Santalaceae	*Exocarpos cupressiformis*	Cherry Ballart, Native Cherry, Wild Cherry, Cherry Wood
	Rutaceae	*Geijera parviflora*	Wilga
	Fabaceae	*Jacksonia scoparia*	Winged Broom-pea, Dogwood, Broom
	Myrtaceae	*Kunzea ericoides*	Burgan, Kanuka
	Myrtaceae	*Melaleuca parvistaminea*	Honey-myrtle
	Rhamnaceae	*Pomaderris spp.*	Pomaderris
Tree	Mimosaceae	*Acacia implexa*	Lightwood, Hickory Wattle, Black Wattle, Hickory, Sally Wattle, Scrub Wattle, Screw-pod Wattle, Bastard Myall, Lignum Vitae, Fish Wattle, Broad-leaf Wattle
	Mimosaceae	*Acacia melanoxlyon*	Blackwood, Black Wattle, Hickory, Mudgerabah, Paluma Blackwood, Sally Wattle
	Mimosaceae	*Acacia obliquinervia*	Mountain Hickory Wattle
	Casuarinaceae	*Allocasuarina littoralis*	Black Sheoak
	Casuarinaceae	*Allocasuarina luehmannii*	Buloke, Bull Oak, Bulloak, Bull Sheoak
	Casuarinaceae	*Allocasuarina verticillata*	Drooping Sheoak, Coast She-oak, Hill-oak, Sheoak
	Myrtaceae	*Angophora floribunda*	Rough-barked Apple, Roughbark Apple, Apple Box (Qld), Apple, Boondah, Gum Myrtle, Rusty Gum

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	Sterculiaceae	*Brachychiton populneus*	Kurrajong
	Cupressaceae	*Callitris endlicheri*	Black Cypress Pine, Black Cypress, Red Cypress, Black Pine, Mountain Pine, Black Callitris, Red Cypress Pine
	Cupressaceae	*Callitris glaucophylla*	White Cypress-pine, White Cypress, White Pine
	Myrtaceae	*Eucalyptus aggregata*	Black Gum
	Myrtaceae	*Eucalyptus amplifolia*	Cabbage Gum
	Myrtaceae	*Eucalyptus bridgesiana*	Apple Box, But-but
	Myrtaceae	*Eucalyptus caliginosa*	New England Stringybark
	Myrtaceae	*Eucalyptus camaldulensis*	River Red Gum, Red Gum, Murray Red Gum, River Gum (WA)
	Myrtaceae	*Eucalyptus cinerea*	Argyle Apple, Silver-leaved Stringybark
	Myrtaceae	*Eucalyptus conica*	Fuzzy Box
	Myrtaceae	*Eucalyptus dalrympleana*	Mountain Gum
	Myrtaceae	*Eucalyptus dives*	Broad-leaved Peppermint, Peppermint, Blue Peppermint (Vic)
	Myrtaceae	*Eucalyptus goniocalyx*	Long-leaved Box, Bundy, Olive-barked Box
	Myrtaceae	*Eucalyptus macrorhyncha*	Red Stringybark
	Myrtaceae	*Eucalyptus mannifera*	Brittle Gum
	Myrtaceae	*Eucalyptus nortonii*	Mealy Bundy, Large-flowered Bundy
	Myrtaceae	*Eucalyptus ovata*	Swamp Gum, Black Gum (southern Tas), White Gum
	Myrtaceae	*Eucalyptus pauciflora*	Snow Gum, Cabbage Gum (Tas), Weeping Gum (Tas), White Sally
	Myrtaceae	*Eucalyptus populnea*	Bimble Box, Poplar Box, Bimbil Box
	Myrtaceae	*Eucalyptus rossii*	Scribbly Gum, Snappy Gum, White Gum, Inland Scribbly Gum
	Myrtaceae	*Eucalyptus rubida*	Candlebark, Ribbon Gum, White Gum
	Myrtaceae	*Eucalyptus sideroxylon*	Red Ironbark, Mugga, Mugga Ironbark
	Myrtaceae	*Eucalyptus viminalis*	Manna Gum, Ribbon Gum
	Oleaceae	*Notelaea microcarpa*	Native Olive
Tree/Mallee	Myrtaceae	*Eucalyptus polyanthemos*	Red Box
	Myrtaceae	*Eucalyptus stellulata*	Black Sally
	Mimosaceae	*Acacia dealbata*	Silver Wattle

APPENDIX G

PLANTING TECHNIQUES

G.1 Revegetation Methods

G.1.1 Pre-planting

i. Site Preparation

Site preparation is essential to provide the best conditions for seedlings and increase planting and growth success in revegetated areas (DSE (VIC), 2009b). Weed control and fencing to exclude stock should be undertaken to minimise threats to the seedlings. Maintaining a weed-free planting zone for at least one year prior to planting has shown to have the best revegetation results (ANBG, 2012). Site preparation allows soil moisture to build up and create an additional reserve for seedlings. This can be achieved by a range of chemical and non-chemical methods, but is dependent on the technique used for planting, the soil type, the weed burden and the desired outcome (Doherty, 1998).

ii. Floristic Requirements

For the purposes of restoring and increasing the extent of wildlife habitat through revegetation, floristic diversity of between 10 to 30 native plant species is generally accepted; of these, a rough guide to attaining structural complexity is by planting 30% tree species, 40% shrubs and 30% groundcovers including grasses (Staubmann and Staubmann, 2004).

iii. Post-seeding Management

Ongoing pest control, of both animals and weeds, is critical for the success of plant growth. Weeds should be kept 1.5 m away from seedlings to maintain access to resources such as light, moisture and nutrients, and minimise seedling exposure to herbicides (O'Shea, 2001). Weed control measures should be undertaken for at least two years after sowing. Should herbicide application be required, a selective chemical should be chosen (refer to manufacture details and MSDS) and shielded sprayers used. Weeds can also be hand removed.

Temporary fencing and tree guards around seedlings may be installed to prevent the young plants being foraged or grazed. Wire or mesh, or thick plastic guards are recommended in sites with rabbits and macropods. Fencing can exclude stock from trampling and browsing in revegetation sites.

G.1.2 Tubestock Planting

Successful planting should entail low-disturbance methods that minimise impacts to existing vegetation and soil and have appropriate planting densities and spacing.

Tubestock refers to seedlings which have been propagated and raised in nursery tubes for the easy transport and planting of already successfully established and conditioned stock. Tubestock is more time consuming, labour intensive and expensive than direct seeding methods; however the preparation and nurturing of plants means revegetation results are immediate and a higher success rate is assured. Due to this, fewer plants are required to be planted and plant placement can be controlled.

Long-stem tubestock is recommended for riparian habitat restoration.

i. Planting of Seedlings

Once seedings are established, the tubestock plants should be gradually 'hardened off', in that while they are still 'tubestock', they are gradually exposed to the environmental conditions of the revegetation site for a few weeks prior to planting to acclimatise and maximise the success of their transfer to non-nursery conditions at the prepared site (Staubmann and Staubmann, 2004).

Methods to plant tubestock include manual planting by hand (hand spot planting), or using mechanical planters. Soil should be broken up to allow seedling roots to take hold, and dense groundcover surrounding the planting areas should be cleared so as not to smother the seedlings. If necessary, mesh plant protectors or fencing can be used to protect the plants from browsing by animals, and tags attached for identification purposes.

Methods referred to below are low-disturbance planting methods that should be employed in revegetation of the Offset areas, as discussed in Rawlings *et al* (2010):

a. Hand spot planting

- Prepare weed-free bare areas;
- Use a mattock, spade, trowel or Hamilton tree planter to dig a hole 1.5 times the depth of the seedling and 2 to 5 times the width;
- Well-water seedlings the day before transplanting seedlings;
- Plant seedling so it sits just below the original ground level. Surrounding soil should be filled in such that rain and water is directed toward the plant;
- Return leaf litter of mulch over the disturbed soil, leaving a gap of approximately 10cm around the stem;
- Water plants immediately (1-2L per plant) to improve contact between roots and soil and remove air pockets; and
- Repeat watering over several weeks is necessary.

b. Mechanical spot planting

Augers (handheld, or tractor-mounted for digging tree holes) can be used to break up compacted soil and increase porosity for root growth and air and water exchange. Fill holes (generally to a depth of 450mm) with water and allow to drain before planting seedling.

G.1.3 Direct Seeding

Direct seeding involves sowing directly into the site to be rehabilitated. The following table provides advantages and disadvantages of direct seeding, using information sources from the Victorian Department of Primary Industries (Purnell *et al.*, 1999).

Table G. 1 Direct Seeding Advantages and Disadvantages

Advantages	Disadvantages
Cheaper (10 - 20% or less of the cost of planting tubestock), and requires minimal labour.	Direct seeding is limited to plants that grow readily from seed (though research is increasing this range).
Higher plant density after germination provides better shelter to new seedlings and reduces weed competition. It also allows natural selection to sort out the stronger	Less reliable method and a large amount of seed is required. Hence, if only minimal seed is available for a particular species, it may be better to raise seedlings for

Advantages	Disadvantages
from the weaker plants without creating gaps to be replanted.	that species in a nursery.
Plants are able to "self select" suitable establishment sites within the revegetation area, particularly if a mixture of species is sown.	Plants germinating under field conditions are extremely vulnerable. Frosts, spring droughts, or flooding of the sowed area can dramatically reduce seedling establishment.
The plants are usually healthier and have stronger, deeper root systems because they are not transplanted and there is no disturbance to root growth. This enables plants to be more tolerant of stressful conditions such as pest attack and drought.	The initial density of plants is harder to control, particularly as many native seedlings do not emerge within the first season after sowing; depending on favourable environmental conditions, it may take up to 3 years for seedlings to emerge. This may create undesirable spacing for quality timber production, but can be overcome by "spot" sowing.
Final plant cover is random, and looks more natural than planting.	
Species such as wattles, peas, some eucalypts, grasses, daisies and pioneer species are best for direct seeding.	
Little maintenance is required after plants are established, apart from ongoing weed control for at least the first season (which ensures no watering).	

i. Low-disturbance direct seeding

Sowing methods include mechanical and manual techniques, the appropriateness of which differs for different revegetation sites and outcomes. For large revegetation sites where extensive seeding is required, machine seeding is recommended. This will allow the quick distribution of seed onto or into the soil bed by simultaneously scalping the top soil, placing the seed and pressing it into the soil (O'Shea, 2001).

Low-disturbance methods (the principles of which were discussed above), for direct seeding are discussed in Rawlings *et al* (2010) and include:

a. Brush mulching

- Best sites are weed-free patches of bare soil which can be roughened with a rake;
- Branches, stems and fruit clusters containing ripe seeds are cut from existing plants and laid on bare sites;
- For shrubs, take less than 10% of the foliage from any individual; for grasses and forbs only harvest in patches, leaving at least 50% of fruiting plants undisturbed;
- Commonly used for wattles, tea trees, bottle brush, eucalypts and daisies;
- Kangaroo grass uses 'lay and spray' technique. When seeds are ripe, the grass is harvested (late January) and spread across site allowing seeds to drop. Herbicide applied to site in winter after the perennial weeds have grown through; hay burnt in early spring allowing new Kangaroo Grass to germinate in November;
- Debris provides shelter and protection to seedlings from browsing.

b. Niche Seeding

- Sow seeds into small niches such as natural gaps between plants in good quality woodland;
- Prepare with hand tools such as rake-hoes or plug-planting tools;
- Roughen or shallow-furrow the soil surface

c. Hand Broadcasting

- Sow seeds in good quality sites where there are few seeds and gaps between tussock grasses;
- Method to reintroduce species that are missing from a woodland community.

d. Node Seeding

- Method for establishing species-rich patches within existing low-diversity pastures that can provide a continuous source of seed for gradual dispersal into surrounding areas;
- Small quantities of seed of a number of species;
- Nodes up to 10 x 10m; seeds sown in moist, turned soil and surface lightly raked over.

APPENDIX H

WEED MANAGEMENT TECHNIQUES

H.1 Common Weed Species for Box Gum Woodland

Box-Gum Woodland occurs on moderately fertile soils in rainfall areas of between 400-1200mm / year; as a result, large extents of this community have historically been cleared for agricultural purposes. The community currently exists as highly modified patchy remnants or scattered paddock trees. Due to ongoing disturbances, the community is subject to weed invasion by exotic groundcovers and shrubs, and pasture-improvement crops.

The most common exotic species are listed in **Table H. 1** below, as provided in the Box-Gum Woodland species list for the Commonwealth listing for the community (DEH, 2006). The key woody weeds include *Ruba rubiginosa* (Sweet Briar) in the Northern Offset properties and *Lycium ferocissimum* (African Boxthorn) in the Eastern and Western Offset properties. *Hyparrhenia hirta* (Coolatai Grass) has also been recorded near the Northern Offset Properties and poses a potential risk for the restoration and ongoing protection of Box Gum Woodland.

Table H. 1 Box-Gum Woodland common weed species

Family	Species	Common Name	Annual/ perennial
Shrubs			
Rosaceae	*Rosa rubiginosa*	Sweetbriar, Briar Rose, Eglantine	perennial
Herbs			
Asteraceae	*Arctotheca calendula*	Cape Weed, African Marigold, Cape Dandelion	annual
Asteraceae	*Carthamus lanatus*	Saffron Thistle	annual
Asteraceae	*Chondrilla juncea*	Skeleton-weed	perennial
Asteraceae	*Cirsium vulgare*	Spear Thistle	annual
Asteraceae	*Hypochaeris glabra*	Smooth Cat's-ear	annual
Asteraceae	*Hypochaeris radicata*	Flatweed, Cat's-ear	perennial
Boraginaceae	*Echium plantagineum*	Paterson's Curse, Salvation Jane, Murrumbidgee Bluebell, Riverina Bluebell	annual
Boraginaceae	*Myosotis discolor*	Yellow and Blue Forget-me-not, Forget-me-not	annual
Brassicaceae	*Lepidium africanum*	Common Pepper-cress, African Pepper-cress, Rubble Pepper-cress	annual
Caryophyllaceae	*Cerastium glomeratum*	Broad-leaved Mouse-ear Chickweed, Sticky Mouse-ear Chickweed	annual
Caryophyllaceae	*Moenchia erecta*	Erect Chickweed, Upright Moenchia	annual
Caryophyllaceae	*Petrorhagia nanteuilii*	Proliferous Pink, Childing pink	annual
Caryophyllaceae	*Silene gallica*	French Catchfly, Five-wounded Catchfly	annual
Clusiaceae	*Hypericum perforatum*	St John's Wort, Perforated St John's Wort	perennial
Fabaceae	*Medicago lupulina*	Black Medic, Hop Medic	annual
Fabaceae	*Trifolium angustifolium*	Narrow-leaved Clover	annual
Fabaceae	*Trifolium arvense*	Hare's-foot Clover	annual
Fabaceae	*Trifolium campestre*	Hop Clover	annual

Family	Species	Common Name	Annual/ perennial
Fabaceae	*Trifolium glomeratum*	Clustered Clover	annual
Fabaceae	*Trifolium scabrum*	Rough Clover	annual
Fabaceae	*Trifolium striatum*	Knotted Clover	annual
Fabaceae	*Trifolium subterraneum*	Subterranean Clover, Sub Clover	annual
Fabaceae	*Vicia sativa*	Common Vetch, Narrow-leaved Vetch	annual
Gentianaceae	*Centaurium erythraea*	Common Centaury	annual
Geraniaceae	*Geranium molle*	Cranes-bill Geranium	annual
Iridaceae	*Romulea rosea*	Onion-grass, Guildford Grass	perennial
Lamiaceae	*Salvia verbenaca*	Wild Sage, Vervain	perennial
Plantaginaceae	*Plantago lanceolata*	Ribwort, Ribgrass, Lamb's Tongue	annual
Polygonaceae	*Acetosella vulgaris*	Sorrel, Sheep Sorrel	perennial
Primulaceae	*Anagallis arvensis*	Scarlet Pimpernel, Blue Pimpernel, Pimpernel	annual
Rubiaceae	*Sherardia arvensis*	Blue Fieldmadder, Field Madder	annual
Scrophulariaceae	*Linaria pelisseriana*	Pelisser's Toadflax	annual
Scrophulariaceae	*Orobanche minor*	Lesser Broomrape, Broomrape, Clover Broomrape	annual
Scrophulariaceae	*Parentucellia latifolia*	Red Bartsia, Common Bartsia	annual
Urticaceae	*Urtica urens*	Small Nettle	annual
Grasses			
Poaceae	*Aira elegantissima*	Delicate Hairgrass	annual
Poaceae	*Anthoxanthum odoratum*	Sweet Vernal Grass, Sweet-scented Vernal-grass, Sweet Vernal	perennial
Poaceae	*Avena barbata*	Bearded Oats	annual
Poaceae	*Briza maxima*	Quaking Grass, Blowfly Grass	annual
Poaceae	*Briza minor*	Shivery Grass, Lesser Quaking Grass	annual
Poaceae	*Bromus diandrus*	Great Brome	annual
Poaceae	*Bromus molliformis*	Silky Brome, Soft Brome	annual
Poaceae	*Dactylis glomerata*	Cocksfoot, Orchard Grass	perennial
Poaceae	*Holcus lanatus*	Yorkshire Fog	perennial
Poaceae	*Hordeum leporinum*	Barley-grass	annual
Poaceae	*Hyparrhenia hirta*	Coolatai Grass	perennial
Poaceae	*Lolium rigidum*	Ryegrass	annual
Poaceae	*Lolium spp.*	Ryegrass	annual
Poaceae	*Nassella neesiana*	Chilean Needle-grass	perennial
Poaceae	*Nassella trichotoma*	Serrated Tussock	perennial
Poaceae	*Phalaris aquatica*	Phalaris	perennial
Poaceae	*Poa bulbosa*	Bulbous Poa	perennial
Poaceae	*Vulpia bromoides*	Squirrel Tail Fescue, Silver Grass	annual
Poaceae	*Vulpia myuros*	Rat's Tail Fescue	annual

Family	Species	Common Name	Annual/ perennial
Poaceae	*Avena fatua*	Wild Oats	annual
Poaceae	*Cynosurus echinatus*	Rough Dogstail	annual
Poaceae	*Lolium perenne*	Perennial Ryegrass	annual
Poaceae	*Paspalum dilatatum*	Paspalum	perennial

H.2 Weed Control Methods

A control program comprising mechanical, herbicide, fire, and if possible, grazing is recommended (SEWPaC, 2007). The following weed control options have been taken from NRRBS (2011), Rawlings *et al* (2010), and the Weeds Australia website.

These are general techniques; site and species-specific techniques should be applied depending on the chemicals used, site conditions, accessibility and environmental conditions. Treatment options depend on the size of the control area, time frame of activities and resourcing and equipment availability. The diagram below details recommended application times for popular herbicides used for common weed species.

Herbicide	Weed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Access	Decidious plants												
	Non-deciduous plants												
Graslan	Brigalow Regrowth												
Grazon DS	Blackberry												
	St John's Wort												
	Sweet Briar												
	Gorse												
	Lantana & Associated weeds												
	Eucalypts / Acacias												
Starane 200	Lantana												
	Acacias												

** Please note this table has been adapted from the RBS website. Further information can be found at* http://www.nrrbs.com.au/chemicalwoodyweedcontrol.htm

Best time to spray/treat
Spray/treat only if conditions are suitable
Do not spray/treat

It is strongly advised that where weeds can be controlled by hand weeding or manual removal, particular in sensitive areas of native vegetation, this should be undertaken over herbicide application. Strategic grazing should also be undertaken before herbicide application to minimise risk to native vegetation. No high disturbance manual removal of woody weeds should be undertaken near native trees, for instance, deep ripping techniques.

H.2.1 Stem Injection / Drill and fill

- Suitable for woody weeds and trees;
- Drill or cut through bark into live sapwood;
- Where low branches are encountered place a cut immediately below the branch;
- Immediately apply herbicide (within 15 seconds) for active uptake by plant;
- Remove plant once dead;
- Do not treat trees with poor sap flow that occurs when plants are stressed.

H.2.2 Cut Stump Application

- Suitable for woody weeds, saplings and trees;
- Put plant off completely at base (no higher than 15cm from ground);
- Use a chainsaw, axe, brush cutter or machete depending on the thickness of the stem/trunk;
- Apply herbicide using knapsack, paint brush, drench gun or a hand-spray bottle;
- Spray or paint herbicide immediately onto the exposed surface of the cut stump (within 15 seconds for water-based herbicides and 1 minute for diesel-soluble herbicides);
- For trees with large circumferences, it is only necessary to place the solution around the edge of the stump in the living tissue. The stump circumference should be bruised with the back of an axe and each successive blow treated with herbicide.

H.2.3 Cut and Swab

- Suitable for vines and multi-stemmed shrubs;
- Similar to cut stump method;
- Herbicide applied via spray or brush;
- In the case of vines with aerial tubers, both ends of the cut stems must be treated with herbicide. Hold both 'bunches' of cut stems in a container of herbicide for 15 seconds after cutting, so that maximum translocation occurs to both ground and aerial tubers.

H.2.4 Stem Scrape

- Suitable for plants and vines with aerial tubers;
- Sharp knife used to scrape a very thin layer of bark from a 10 cm section of stem
- Herbicide immediately applied to the exposed soft underlying green tissue.

H.2.5 Basal Bark Application

- Suitable for thin-barked woody weeds, saplings, regrowth and multi-stemmed shrubs and trees;
- Mix an oil soluble herbicide with diesel;
- Spray (saturate) the full circumference of the trunk or stem of the plant from ground level to 30cm height;
- Best undertaken by contractors.

H.2.6 Foliar Spray Application

- Suitable for shrubs, grasses and dense vines less than 6 m tall and perennial weeds with a small roost system and simple stem;
- Herbicide is diluted with water or diesel at a specific rate, and sprayed over the foliage to point of runoff (until every leaf is wetted, but not dripping);
- Techniques differs depending on size of weed plant or infestation.

H.2.7 Pellet or Granular Soil Application

- Suitable for woody weeds with extensive fine stems and root-suckering plants to 3m in height;
- Apply herbicide pellets evenly to root area (soil under canopy from root crown or stems to 30cm beyond dripline) prior to spring or summer rains.

H.3 Species-Specific Weed Control Methods

The following attachments are recommended weed control methods for pasture weeds and other agricultural weeds published by various Government Departments.

African Boxthorn Class 4 Weed Control Management Plan

Family Name: *Solanaceae*

Scientific Name: *Lycium ferocissimum*

Common Names: African Boxthorn, Boxthorn

Weed status: *The abovementioned weed is a Class 4 noxious weed declared under section Control Order 28 of the Noxious Weeds Act 1993.*

Plan Period

Starting Date: 01 Sept 2011 **Review Date:** 30 June 2016 (Unless otherwise revoked)

Control Requirements:

Under Control Order 28, Noxious Weeds Act 1993 it is required that:

"*The growth of the plant must be managed in a manner that reduces its numbers, spread and incidence and continually inhibits its reproduction and the plant must not be sold, propagated or knowingly distributed".*

Control Methods/Techniques: (Any combination of the following methods is suitable)

Manual/Mechanical: Manual removal (hand pulling) and burning is the most effective method for small infestations, remove bushes in winter when ground is wet making sure to remove as suckering can occur.

Chemical: There are a number of herbicides registered for use on African Boxthorn. Spot spray, cut stump and basal bark methods.

Cultural/Biological: There are no successful biological control agents for use on African Boxthorn.

Revegetation: Plant prickly native bushes such as Rosemary's Grevillia *(Grevillia rosmariifoli),* prickly paperbark *(Melaleuca styphelioides)* or any flowering shrubs eg bottle brush *(Callistemon sp.)* This provides habitat and groundcover as Boxthorns gradually die off.

Area of Operation:

Narrabri Shire Council (NSC) is in the heart of the Namoi Valley with an area of 13,030km² and population of 13,507. NSC includes the towns of Baan Baa, Bellata, Boggabri, Edgeroi, Gwabegar, Narrabri, Pilliga and Wee Waa. The shire's largest town of Narrabri is positioned on the crossroads of the Newell and Kamilaroi highways.

References:

DPI Primefacts, Noxious and Environment Weed Control Handbook 5th edition, 2011 NSW DPI.

Registered Herbicide Application Rates:

Access® 1L per 60L Diesel (cut stump & Basal

Glyphosate 360g/L (various trade names) at 700ml/100L water. (spot spraying)
Triclopyr 300g/L + Picloram 100g/L + Aminipyralid 8g/L (Grazon ®Extra) at 500ml/100L water. (spot spraying) Only apply to plants less than 2m tall.
Triclopyr 300g/L + Picloram 100g/L (various trade names) at 500ml/100L water. (spot spraying) Only apply to plants less than 2m tall.

Optimum months for control:

J	F	M	A	M	J	J	A	S	O	N	D
☐	☐	☐	☑	☑	☑	☑	☑	☑	☑	☐	☐

Critical Comments:

- Apply when bushes have good leaf cover, growth and no leaf fall.
- Consult your weeds officer for application tips.
- Read MSDS and Label of respective herbicides

Linkages to other Plans / Strategies

National Weed Strategy and control plans, NSW Weed Strategy and control plans. NIWAC Regional Weed Strategy and control plans. However, in some instances it is also important for a land manager to consider other strategies.

For further information contact:
Narrabri Shire Council
Phone: (02) 6799 6702 Fax: (02) 6799 6888
Email: council@narrabri.nsw.gov.au
Website: www.narrabri.nsw.gov.au

Northern Inland Weeds Advisory Committee:
Website: www.niwac.org

African Boxthorn Weed Profile Sheet

Family Name: Solanaceae

Scientific Name: *Lycium ferocissimum*

Common Names: African Boxthorn, Boxthorn

Country of Origin: Africa (Southern Coast). Imported in the mid 1800's and commonly used as a hedge plant.

Habit

Life Span: Perennial

Life Form: Erect shrub to 5m tall and 3m wide.

Habitat Sub humid and semi arid subtropical regions, occurring in drier soils. It grows well in all soil types, but prefers lighter soils particularly along dry creek beds.

Environmental Impact:

Existing: An escaped garden hedge plant in Australia where it has spread into pastures, natural bush-land neglected areas, roadsides and waterways.
Plants compete against local native plants for light, water, nutrients and space.

Potential: Due to the impenetrable barrier the plant creates it forms dense stands restricting access by native fauna and humans. Can impact heavily on both agriculture and the environment through reduced carrying capacity and the plant's sharp thorns have been known to damage the eyes of grazing animals.







Reproduction

Flower: Fragrant, 5 petals, white with purple or lilac marks in the throat, about 1cm in diameter, formed singly or in pairs on short stalks in the leaf axils.

Fruit: Green ripening to orange/red, shiny, globular or ovoid berry about 1cm in diameter borne on short stalks, drooping from leaf axils with prominent Calyx.

Seed: Light brown or yellow, numerous, ovoid or irregularly flattened, 2.5mm long by 1.5mm wide, smooth, dull with small raised dots on the surface.

Characteristics

Leaves: Glabrous, fleshy 3.5cm long, 2cm wide, ovate to elliptical formed on short stalks in clusters at the numerous nodes.

Stem/Branches: Light brown when young, grey or brown when mature, erect and much branched. Spines to 15cm long are borne on the main stems, smaller spines on the numerous branchlets

Underground Structures: Extensive deep branched taproot producing new growth when damaged. (suckering)

Dispersal: By seed, fruit commonly eaten by birds and foxes and later void in faeces.
(Bird lollies)

African boxthorn is an aggressive invader of pastures, roadsides, reserves, remnant bushland and waterways. It forms an impenetrable, spiny thicket that inhibits the movement of stock and provides a haven for feral animals.

Many insects, including fruit fly, the common house fly and the tomato fly, breed in the fruit of this weed.

Confusing Species

Cockspur, Bursaria (Black thorn), Pyracantha

Blackberry Class 4 Weed Control Management Plan

Family Name: Rosaceae

Scientific Name: *Rubus fruticosus aggregate species*

Common Names: Blackberry

Weed status: *The abovementioned weed is a Class 4 noxious weed declared under section Control Order 28 of the Noxious Weeds Act 1993.*

Plan Period

Starting Date: 01 Sept 2011 **Review Date:** 30 June 2016 (Unless otherwise revoked)

Control Requirements:

Under Control Order 28, Noxious Weeds Act 1993 it is required that:

"*The growth of the plant must be managed in a manner that reduces its numbers, spread and incidence and continually inhibits its reproduction and the plant must not be sold, propagated or knowingly distributed*".

The New England Weeds Authority will control Blackberry growing on all land for which it has the responsibility to control weeds under the *Noxious Weeds Act 1993,* using herbicides registered for the control of Blackberry.

Control Methods/Techniques: (Any combination of the following methods is suitable)

Manual/Mechanical: Slashing of juvenile bushes, hoed grubbed or ploughed to remove the crowns, or otherwise cut.

Chemical:

The Blackberry is to be treated with a herbicide registered for the control of Blackberry, in the manner specified on the label;

Cultural/Biological:

The Blackberry is to be grazed with either sheep or goats, to consistently defoliate the plants and control emerging seedlings. Biological control agents also available.

Area of Operation: Narrabri Shire Council (NSC) is in the heart of the Namoi Valley with an area of 13,030km² and population of 13,507. NSC includes the towns of Baan Baa, Bellata, Boggabri, Edgeroi, Gwabegar, Narrabri, Pilliga and Wee Waa. The shire's largest town of Narrabri is positioned on the crossroads of the Newell and Kamilaroi highways.

References:

DPI Primefacts, Noxious and Environmental Weed Control Handbook 5th edition, 2011 NSW DPI.

Registered Herbicide Application Rates:

Triclopyr 200g/L + Picloram 100g/L (Tordon®DSH) 500ml per 100L water

Grazon Extra - at 350 or 500ml/100L water. Use the higher rate on plants that have been damaged or difficult to kill blackberry. Treat in late spring to autumn.

Metsulfuron methyl 63.2g/kg + glyphosate 760.5g/kg (Cut-out®) 1 measured pack (95g) per 100L of water (apply between Jan and April when bushes are actively growing)

(Note: Not all herbicides registered for these purposes may be listed. Consult weeds officer for more options.)

Optimum months for control:

J	F	M	A	M	J	J	A	S	O	N	D
✓	✓	✓	☐	☐	☐	☐	☐	☐	☐	☐	✓

Critical Comments:

- Apply between December to March when bushes are actively growing.
- Do not apply to bushes with mature fruit.

As a general rule of thumb:

- First, protect blackberry-free areas at risk of becoming infested
- Second, deal with areas where blackberry is present in a few well-defined populations
- Finally, tackle large, well-defined areas of infestations, starting with the smaller outlying populations.

For further information contact:
Narrabri Shire Council
Phone: (02) 6799 6702 Fax: (02) 6799 6888
Email: council@narrabri.nsw.gov.au
Website: www.narrabri.nsw.gov.au

Northern Inland Weeds Advisory Committee:
Website: www.niwac.org

Blackberry Weed Profile Sheet

Family Name: Rosaceae

Scientific Name: *Rubus fruticosus aggregate species*

Common Names: Blackberry, European Blackberry

Country of Origin: Europe, North America & Asia. Blackberries were deliberately introduced to Australia for fruit around the time of European settlement in the 1830s.

Habit

Life Span: Summer active woody perennial.

Life Form: Blackberry is a perennial, semi deciduous shrub with prickly canes that take root where they touch the ground. It varies from sprawling to almost erect. Stems grow up to 7m long and can be green, purplish or red and are usually thorny.

Habitat Blackberry is mostly restricted to areas with temperate climates (warm summers, cool winters) with an annual rainfall of at least 700mm (regardless of altitude), but plants can grow in lower rainfall areas when other environmental conditions are favourable (such as along the banks of watercourses).

Environmental Impact: Recognised as one of the worst weeds in Australia.

Existing: Declared a Weed of National Significance (WoNS) in 1999.

Potential: Blackberry grows vigorously and can infest large areas quickly due to its invasiveness, potential to spread and its environmental and economic impacts.



Fruit from a species in The R. fruiticosus agg.



Blackberry can dominate other Vegetation.

Reproduction

Flower: White or pink flowers 2-3cm in diameter occur at the end of floricanes from late Nov to late Feb. Clusters are either cylinder or pyramid shaped, and may change colour between budding and opening.

Fruit: Berries (fruit) are 1-3cm in diameter, and occur from late Dec to April, changing colour from green to red to black as they mature. Each berry consists of a number of fleshy segments (druplets), and each druplet holds one seed.

Seed: The seeds are light to dark brown, oval, 2-3mm long & deeply & ireegularly pitted. One berry may contain as many as 80 seeds which are easily spread by birds, mammals and water.

Characteristics

Leaves: Generally occur alternately along canes, are compound (with 3 to 5 leaflets), and are dark green on top with a lighter green underside. Most leaves shed during winter.

Stem/Bark: Stems are known as canes and can grow up to 7m long. They can be erect, semi-erect, arched or trailing. The canes are covered in sharp prickles.

Underground Structures: The root system is the perennial part of the plant. It comprises a woody crown that can grow up to 20cm wide with a main root depth up to 4m.

Dispersal: Mainly by animals such as birds eating the fleshy fruit and passing them in faeces, but also by water or just falling from the bush.

Problems associated with Blackberries

- Reducing productivity of primary industries
- Degrading the natural environment and affecting biodiversity
- Restricting access to land and water
- Harbouring vermin
- Creating fire hazards

Chilean Needle Grass Class 4 Weed Control Management Plan

Family Name: *Poaceae*

Scientific Name: *Nassella neesiana*

Common Names: Chilean Needle Grass

Weed status: *The abovementioned weed is a Class 4 noxious weed declared under section Control Order 28 of the Noxious Weeds Act 1993.*

Plan Period

Starting Date: 01 Sept 2011 **Review Date:** 30 June 2016 (Unless otherwise revoked)

Control Requirements:

Under Control Order 28, Noxious Weeds Act 1993 it is required that:

"*The growth of the plant must be managed in a manner that reduces its numbers, spread and incidence and continually inhibits its reproduction and the plant must not be sold, propagated or knowingly distributed".*

Control Methods/Techniques: (Any combination of the following methods is suitable)

Manual/Mechanical: Physical removal is recommended for single plants and small infestations. Larger infestations require pasture improvement involving rotational cropping combined with a rotational grazing strategy utilising short duration-high intensity grazing. Once established Chilean Needle Grass is difficult to control, so early detection and control is the key.

Chemical: There are a number of herbicides registered for use on this plant.

Biological: Research is being conducted in Argentina on a rust fungus *Puccinia nassellae*

Area of Operation:

Narrabri Shire Council (NSC) is in the heart of the Namoi Valley with an area of 13,030km² and population of 13,507. NSC includes the towns of Baan Baa, Bellata, Boggabri, Edgeroi, Gwabegar, Narrabri, Pilliga and Wee Waa. The shire's largest town of Narrabri is positioned on the crossroads of the Newell and Kamilaroi highways.

References:

DPI Primefacts, Noxious and Environmental Weed Control Handbook 5th edition, 2011 NSW DPI.

Registered Herbicide Application Rates:

Glyphosate 360g/L (various trade names) 1 L per 100L water (spot spray)
1L /ha (boom)

Flupropanate 745g/L (various trade names) 1.5 - 3L/ha (boom)
200ml flupropanate plus 150ml glyphosate 360g/L per100L water (spot spray)

(Note: Not all herbicides registered for these purposes may be listed. Consult weeds officer for more options.)

Optimum months for control:

J	F	M	A	M	J	J	A	S	O	N	D
✓	✓	✓						✓	✓	✓	✓

Critical Comments:

- Apply to actively growing plants from Spring to Autumn
- Incorporate chemical control with pasture improvement and grazing strategies.
- Read off label permit 792
- Read MSDS and label of respective herbicides.

Linkages to other Plans / Strategies

National Weed Strategy and control plans, NSW Weed Strategy and control plans. NIWAC Regional Weed Strategy and control plans, WONs Chilean Needle Grass Strategic Plan.

For further information contact:
Narrabri Shire Council
Phone: (02) 6799 6702 Fax: (02) 6799 6888
Email: council@narrabri.nsw.gov.au
Website: www.narrabri.nsw.gov.au

Northern Inland Weeds Advisory Committee:
Website: www.niwac.org

Chilean Needle Grass
Weed Profile Sheet

Family Name: Poaceae

Scientific Name: *Nassella neesiana*

Common Names: Chilean Needle Grass

Narrabri SHIRE
Heart of the North West

Country of Origin: South America (Argentina, Chile, Bolivia, Equador, Southern Brazil & Uraguay)

Life Form: Perennial tussock forming grass which grows in dense clumps. Without grazing it can grow to 1m in height. An unusual feature of the grass is that, in addition to normal flower seeds, it produces hidden seeds which are formed in the nodes and bases of the flowering stems. The "stem seeds" are self-fertilised and account for about 1/4 of total seed production. They enable the plant to reproduce despite grazing, slashing and fire.

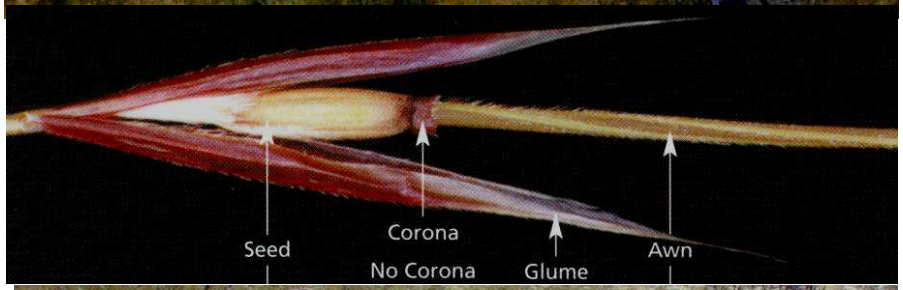
Habitat Temperate, subtropical and tropical regions, where it occurs commonly in wet places, Particularly along field boundaries, roadsides, creeks, and canal banks, from where it readily invades cultivated and irrigated paddocks.

Environmental Impact:

Existing: Chilean Needle Grass, named for its sharp, pointed seeds, is relatively unpalatable. It causes injury to stock and downgrades wool, skins and hides with its long, sharp seeds. It is listed as a Weed of National Significance (WONs).

Potential: Chilean Needle Grass can decrease pasture productivity by up to 50% during summer, and reduces biodiversity in native grasslands. It has the potential to invade both sown pastures and native grass lands throughout south east Australia







Reproduction

Inflorescence: Panicle to 40cm long; lemma (excluding corona) to 1cm long, hard point at base of lemma with hairs; awns twice bent, 4-9cm long. Flowers in spring and summer. The flowering seed heads are a distinctive purplish colour & the seeds are very sharp at the point.

Seed: In a dense, ungrazed infestation, panicle seed production ranges from 1,600 to 22,000 seeds per square metre. As well as the panicle seed, the stem nodes and base of the plant bear cleistogenes, which also account for a considerable amount of the total seed production.

Characteristics

Leaves: Leaves are 1-5mm wide, flat and strongly ribbed on their upper surface, with leaf edges that are rough to touch.

Underground Structures: Fibrous and freely branching to depths of 1.2m.

Dispersal: Chilean Needle Grass has been known to be sold in nurseries and used in landscaping projects. Spread is principally by seed. The seeds are very effectively spread attached to farm machinery, clothing or livestock. Seed has also been spread along roadsides and other grassy areas by the used of mowing and earthmoving equipment, or as a contaminant in hay or grain.

,

Confusing Species

Cockspur, Bursaria (Black thorn), Pyracantha

Hemlock Class 4 Weed Control Management Plan

Family Name: *Apiaceae*

Scientific Name: *Conium maculatum*

Common Names: Hemlock, Carrot Fern

Weed status: *The abovementioned weed is a Class 4 noxious weed declared under section Control Order 28 of the Noxious Weeds Act 1993.*

Plan Period

Starting Date: 01 Sept 2011 **Review Date:** 30 June 2016 (Unless otherwise revoked)

Control Requirements:

Under Control Order 28, Noxious Weeds Act 1993 it is required that:

"*The growth of the plant must be managed in manner that reduces its numbers, spread and incidence and continuously inhibits its reproduction.*"

Control Methods/Techniques: Control methods are effective if used in a combination with all methods.

Manual/Mechanical:

Hemlock does not persist under cultivation. Individual plants and localised patches should be hand pulled or hoed before flowering. Slashing just prior to flowering may provide effective control, but sometimes new growth is produced, requiring further treatment.

Chemical:

Spot spray actively growing young plants before they elongate into the flowering stage, preferably with a woody weed herbicide.

Biological:

No biological control available.

Area of Operation:

Narrabri Shire Council (NSC) is in the heart of the Namoi Valley with an area of 13,030km² and population of 13,507. NSC includes the towns of Baan Baa, Bellata, Boggabri, Edgeroi, Gwabegar, Narrabri, Pilliga and Wee Waa. The shire's largest town of Narrabri is positioned on the crossroads of the Newell and Kamilaroi highways.

References:

DPI Primefacts, Noxious and Environmental Weed Control Handbook 5th edition, 2011 NSW DPI.

Registered Herbicide Application Rates:

MCPA 340g/L + Dicamba (various trade names)	80ml/L 80ml per 15L of water - knapsack spray 350ml per 100L of water - high volume spot spray 5.2L/ha - boom spray rate. Young active growth, repeat treatments may be necessary

(Note: Not all herbicides registered for these purposes may be listed. Consult Weed Officers for more options).

Optimum months for control:

J	F	M	A	M	J	J	A	S	O	N	D
☐	☐	☐	☐	✓	✓	✓	✓	✓	☐	☐	☐

Critical Comments:

- Read MSDS and label of respective herbicides.

Linkages to other Plans / Strategies

National Weed Strategy and control plans, NSW Weed Strategy and control plans.
NIWAC Regional Weed Strategy and control plans.

For further information contact:

Narrabri Shire Council
46-48 Maitland St, Narrabri NSW 2390
Phone: (02) 6799 6702 Fax: (02) 6799 6888
Email: council@narrabri.nsw.gov.au
Website: www.narrabri.nsw.gov.au

Northern Inland Weeds Advisory Committee:
Website: www.niwac.org

Hemlock Weed Profile Sheet

Family Name: *Apiaceae*

Scientific Name: *Conium maculatum*

Common Names: Hemlock, Carrot Fern

Country of Origin: Europe, Western Asia and North America.

Habit

Life Span:

Life Form: Robust biennial or occasionally an annual herb 1 to 2m high with zigzagging stems, which have whitish bloom, are finely blotched brown or purple, and are hollow.

Habitat

Usually found on waste ground in moist conditions, such as river banks and around edges of pasture. It prefers moist, neglected situations.

Environmental Impact:

Existing: It seldom forms large stands, but is a significant weed because all parts of the plant are poisonous to humans and livestock if eaten. It causes death by respiratory paralysis. It is rarely eaten green by stock, but may be eaten when incorporated into hay or silage.

Potential: As an environmental weed it has invaded lowland grassland and grassy woodland, riparian vegetation and warm temperate rainforest. It grows rapidly after autumn rains and on disturbed soils can exclude most other vegetation.

Reproduction

Flowers: Small, white 2 to 4mm diameter with five petals; numerous, and carried in branching umbrella-shaped heads. Present in Spring to early summer.

Seeds: Dark grey to brown, 3mm long, globular with 5 prominent wavy ridges.

Characteristics

Leaves: Fern or carrot like, 12 to 25cm long but up to 50cm, hairless, alternate, emitting a strong mousy odour.

Stem/Bark: Erect, up to 3m high but often less than 2m; strong, hairless, hollow except at nodes, pale green, blotched with purple and emitting an offensive odour when damaged.

Underground Structures: Long white tap root which may be branched.

Dispersal: seed is spread by water, machinery or vehicles, or in contaminated soil or by wind over short distances.

Confusing Species: Wild Carrot (*Daucus carota*) has a similar head but narrower leaf segments and yellow flowers.





Prickly Pears Class 4 Weed Control Management Plan

Family Name: *Cactaceae*

Scientific Name: *Opunta stricta*

Common Names: Prickly Pears, Common Pest Pear

Weed status: *The abovementioned weed is a Class 4 noxious weed declared under section Control Order 28 of the Noxious Weeds Act 1993.*

Plan Period

Starting Date: 01 Sept 2011 **Review Date:** 30 June 2016 (Unless otherwise revoked)

Control Requirements:

Under Control Order 28, Noxious Weeds Act 1993 it is required that:

"*The growth of the plant must be managed in a manner that reduces its numbers, spread and incidence and continuously inhibits its reproduction and the plant must not be sold, propagated or knowingly distributed.*

Control Methods/Techniques: Individual plants and small infestations must be totally controlled.

Manual/Mechanical: Manual/mechanical removal and burning of plants is the most effective method of control, taking care to remove all plant segments and fruit. As much of the root system as possible should be removed to prevent suckering.

Chemical: There are a number of herbicides registered for use on these Cactus species.

Biological: There are a number of biological agents available for use on these cacti. They are all generally species specific. The most well known are Cactoblastis moth, and Cochineal insects. (consult your Weeds Officer for more details).

Area of Operation:

Narrabri Shire Council (NSC) is in the heart of the Namoi Valley with an area of 13,030km² and population of 13,507. NSC includes the towns of Baan Baa, Bellata, Boggabri, Edgeroi, Gwabegar, Narrabri, Pilliga and Wee Waa. The shire's largest town of Narrabri is positioned on the crossroads of the Newell and Kamilaroi highways.

References:

DPI Primefacts, Noxious and Environmental Weed Control Handbook 5th edition, 2011 NSW DPI.

Registered Herbicide Application Rates:

Triclopyr 300g/L & Picloram 100g/L (various trade names) at 500ml per 100ml water
Triclopyr 600g/L (Various trade names) 1L in 75L distillate or 3L in 100L water (foliar spray)
Triclopyr 240g/L + Picloram 120g/L (Access®) 1 L in 60L of distillate (foliar application)
(Thoroughly wet plants)

(Note: Not all herbicides registered for these purposes may be listed. Consult Weed Officers for more options).

Optimum months for control:

Common pears can be treated anytime during the year, although best time is when plants are actively growing.

J	F	M	A	M	J	J	A	S	O	N	D
✓	✓							✓	✓	✓	✓

Critical Comments:

- Specific herbicide registrations apply for different species.
- Apply as a thorough foliar spray, being careful under desirable species
- Consult your weeds officer for application tips
- Read MSDS and label of respective herbicides.

Linkages to other Plans / Strategies

National Weed Strategy and control plans, NSW Weed Strategy and control plans.
NIWAC Regional Weed Strategy and control plans.

For further information contact:

Narrabri Shire Council
Phone: (02) 6799 6702 Fax: (02) 6799 6888
Email: council@narrabri.nsw.gov.au
Website: www.narrabri.nsw.gov.au

Northern Inland Weeds Advisory Committee:
Website: www.niwac.org

Prickly Pear Weed Profile Sheet

Family Name: *Cactaceae*

Scientific Name: *Opuntia stricta*

Common Names: Prickly Pears, Common Pest Pear

Country of Origin: North, Central and Tropical America (this sheet is for Prickly Pear, but all other cacti spp are very similar and their particular control requirements are the same).

Habit

Life Span: Perennial succulent shrubs.

Life Form: Erect succulent shrubs, growing from 0.5m to 5m tall varying by species. All species reproduce by seed and branch segments.

Habitat Semi arid savannas in warm temperate, subtropical and tropical regions, growing well in both exposed and semi arid shade situations. Before the introduction of biological control agents it was the most serious weed in Australia and capable of growing in most parts of the continent.

Environmental Impact:

Existing: Escaped ornamental shrubs, food or fodder plants. Although slow growing these Cactus spp can form large impenetrable hedges and have the capacity to cover hundreds of hectares if left unchecked competing for light, water, nutrients and space.

Potential: Due to the impenetrable barrier the plant creates it forms dense stands restricting access by animals and humans. Can impact heavily on both agriculture and the environment.

Prickly Pear







Reproduction

Flower: Lemon yellow with greenish or pinkish markings on the back, 6-8cm in diameter, sessile, each with a fleshy base which becomes the fruit, borne mostly on the margins of the segments.

Fruit: Skin reddish purple, flesh reddish, somewhat pear shaped, 4-6cm long, bearing tufts of fine barbed bristles in areoles.

Seed: Yellow or pale brown, rounded, 5mm in diameter, numerous embedded at the centre of the fruit.

Characteristics

Leaves: Small scale like, produced beneath the areoles, on young segments only and are shed as segments mature.

Stem/Branches: Often dull or bluish green, glabrous, consisting of a series of fleshy segments each to 30cm long, 15cm wide and 1-2cm thick, each areole contains tufts of short, very finely barbed bristles, and occasionally 1 or 2 stout yellow spines about 2-4cm long.

Underground Structures: Fibrous shallow roots.

Dispersal: Initially distributed because of its use as an ornamental or edible spp, but also through careless dumping of plants and dispersal of seeds in faeces when fruit is eaten by birds, pigs and cattle. New plants from when plants segments of fruiting bodies touch the ground. Seeds can germinate at any time.

Confusing Species:

Other cactuses, Opuntia and Harrisia spp.

North West Weeds

NOXIOUS WEED CONTROL UNIT FOR GWYDIR AND INVERELL SHIRES

Please address all correspondence to the General Manager, Gwydir Shire Council, Locked Bag 5, BINGARA, NSW, 2404 - Phone 02 6729 1016, facs 02 6729 1400, email tannerl@northnet.com.au

Tiger Pear

Tiger pear *(Opuntia aurantiaca)* is a native of South America. It's believed to have been introduced into Australia as a garden plant during the very early 1800s.



IDENTIFICATION

Tiger pear is a low-growing, jointed, cactus plant. A typical tiger pear plant is made up of many joined "segments", each covered in sharp, 25mm spines.

The segments easily detach from parent plants and attach to passing animals, humans, tyres of motor vehicles etc. Dislodged tiger pear segments are very hardy – they can lie on top of the ground for months before eventually taking root and establishing as a new plant.

Floodwaters carry tiger pear segments over long distances. Animals then carry the segments back into the hills. Some NSW river systems such as the Turon, Peel, Namoi, Gwydir and Horton have become infested in this way. (And, in most cases the source was traced back to a house garden!)

Tiger pear plants average around 60cm high. New plants start from segments, not seeds. The two main growing periods are Feb and Oct when new, bright green shoots appear. These shoots can grow as long as 10cm in a couple of weeks.



THE PROBLEM

Sharp thorns on each segment contain tiny barbs. The thorns enter easily but are very difficult (and painful) to remove. Tiger pear can cause painful injury to animals or humans who come into contact with a plant. Dogs, for example, try to use their teeth to remove segments from their paws, and often end up with thorns stuck in their gums, roof of the mouth, even right through their tongues! Other examples include lactating cows rejecting their calves because the calves have a piece of tiger pear stuck on their noses. There are also sad stories of koalas dying as a result of being completely tangled in thick tiger pear.

Although kangaroos and most mature stock learn to "live with" tiger pear, they continue to spread the small segments all over the property. Unless controlled, tiger pear will seriously impact on a property's grazing potential.

MORE INFORMATION? PLEASE CONTACT YOUR LOCAL WEEDS OFFICER:

Stephen Kneller Bingara 0427 240 061	Clem McLeod Inverell 0427 453 052	Doug Stieger Warialda 0427 291 912	Les Tanner Head Office 0427 241 806
OR check out our website on www.northwestweeds.nsw.gov.au			

TIGER PEAR (CONT)

CC4(C) MANAGEMENT PLAN – Legal requirements within the Shires of Gwydir & Inverell
The growth and spread of the plant must be controlled by conducting an on-going and effective treatment program to reduce plant numbers and to minimise the plant's negative impact on the land. Any biological control or other control program directed by the local control authority must be implemented. All reasonable measures are to be taken to ensure vehicles, machinery and livestock moved off the property are free of the plant. Plant must not be sold, propagated or knowingly distributed.

CONTROL METHODS

Ploughing, where possible, is probably the only way to totally eradicate an area of tiger pear. It cannot survive on lands under constant cultivation [NB. ploughing is subject to compliance with Native Veg. Act].
Burning. Tiger pear can be destroyed by fire. Tops of plants are easily killed, butts require extra heat. Take care when collecting plants or stacking wood on top – the small segments are easily scattered. Burning is really only appropriate for small infestations. [NB. subject to local fire restrictions].
Burying tiger pear is another option for small infestations. Plants only have to be buried to the extent that the air supply is cut off. Take care because the small segments are easily scattered.
Chemical treatment is recommended for small/isolated infestations, in paddocks used for intensive grazing/horse/cattle studs etc, or where containment is otherwise essential eg river frontages and property boundaries, or in areas where biological control has proven ineffective because of climatic conditions. According to NSW DPI's excellent booklet "*Noxious and Environmental Weed Control Handbook 2004/2005*", herbicide treatments include:

Chemical	Rate	Comments
Triclopyr eg Garlon 600®	3.0 L in 100 L **water OR** 1.0 L in **75 L diesel**	Apply as a thorough foliar spray
Triclopyr + Picloram eg Access®	1.0 L in 60 L diesel	Folia application, thoroughly wet plants

Remember, it's not hard to kill a single tiger pear plant BUT finding all the small plants and loose segments scattered around the ground is the real challenge! Spraying tiger pear is a job that just cannot be rushed. Repeated, thorough treatments are necessary.

IMPORTANT: USE OF PESTICIDES - ALWAYS READ THE LABEL
Pesticides must only be used for the purpose for which they are registered and must not be used in any other situation or in any manner contrary to the directions on the label. Never use a herbicide in any way contrary to label recommendations. Always observe withholding periods.

Biological control is a practical and cost-effective control option for large and/or inaccessible areas of pear, especially in north-west NSW. Cactoblastis sometimes attacks tiger pear, but **cochineal** (photo, right) is more effective in the long term, especially if the landholder gives them some help by simply moving them into new plants. All it takes to do the job is an hour here and there, a bucket and a pair of tongs! For more information on when and how to get best results from biological control please visit the websites listed below.



USE THE RIGHT COCHINEAL…. Tiger pear, common pear and rope pear cochineal all appear the same. But, they're each specific to their host plants. Only tiger pear cochineal – *Dactylopious austrinus* - works on tiger pear!

MORE INFORMATION
www.northwestweeds.nsw.gov.au/cochineal.htm
www.northwestweeds.nsw.gov.au/cactoblastis.htm

DISCLAIMER: The information contained herein is based on knowledge and understanding at the time of writing. However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of North West Weeds or the user's independent adviser. (LRT 10/07/06)

North West Weeds

Your local guide to local noxious weed control (E. Australia)

Rope pear

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NSW 2404

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About this website

Identification | The problem | More information | Control methods | Using pesticides | Disclaimer



A native of Mexico and the United States, ***Cylindropuntia imbricata* - rope pear** (also known as Devil's rope) has been widely distributed in New South Wales as a garden plant. An easy plant to grow, and one that requires very little moisture, rope pear survives well in the western areas of the State.

Rope pear spreads by fruit and segments that break off the parent plant and wash along waterways. This photo taken in 1988 shows a major patch of rope pear near the McIntyre River, in the Elsmore area near Inverell, New South Wales.

THE PROBLEM





Rope pear is a very thorny cactus which can cause injury to humans and to animals. Segments are mainly spread by floodwaters, and in some cases by being rolled along bare ground by strong winds. These segments form into new plants. Rope pear is comparatively slow-growing, but as shown in the above photograph, it can eventually become thick enough to impede access and to reduce stock-carrying capacity.

[CLICK ON PHOTOS FOR A LARGER VIEW]

IDENTIFICATION





This cactus is commonly called "rope pear" because of its rope-like appearance. The plant grows to a height of 2 to 3 metres. It is made up of strong, woody segments – the outer segments (and fruit pods) break off easily to form new plants. The plant has 2-3 cm thorns, enclosed in yellowy sheaths. Rope pear produces very attractive purple flowers – no doubt one of the reasons for its appeal as a garden plant. The main growing period for the plant is in October each year.

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CONTROL METHODS

Chemical treatment of rope pear is effective, because the plants are relatively easy to find. Biological control is another practical and cost-effective means of control, especially in the warmer and drier areas of western New South Wales. Repeated ploughing/cultivation destroys rope pear (the pieces eventually give up if damaged and/or disturbed often enough). Burying or burning is an option for small infestations.

HERBICIDES – Current registrations for Cactaceae family:

Chemical	Rate	Comments
Triclopyr + Picloram eg Grazon DS®/Extra®	High volume 500 ml + 500 mL Uptake spray oil in 100 L water or knapsack application 50mL plus 50mL Uptake spray oil in 10L of water	Apply to actively growing plants - see **permit PER10544** for more details [??? Very slow acting - especially on larger plants ... LT - 23/11/08]
Triclopyr eg Garlon 600®	High volume 500 ml + 500 mL Uptake spray oil in 100 L water or knapsack application 50mL plus 50mL Uptake spray oil in 10L of water **OR** 1L in 75L **diesel**	Apply to actively growing plants - see **permit PER10544** for more details **NB PER10544 covers the entire *Cactaceae* family**
Triclopyr + Picloram Access®	1.0 L in 60 L **diesel**	Folia application, thoroughly wet plants

STOP PRESS: The botanical name for rope pear has been changed from *Opuntia imbricata* to *Cylindropuntia imbricata*. Not all herbicide labels have been updated by the manufacturers to reflect this change. So, please check the labels on any new herbicide containers to ensure registration applies.

IMPORTANT: USE OF PESTICIDES - ALWAYS READ THE LABEL

Pesticides must only be used for the purpose for which they are registered and must not be used in any other situation or in any manner contrary to the directions on the label. Never use a herbicide in any way contrary to the label recommendations.

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BIOLOGICAL – not recommended for small or isolated areas (you're much better off to get rid of the plants by chemical or manual means) but cochineal insects are very useful for controlling thick patches - especially in dry and warmer areas:





Cochineal insects (*Dactylopious tomentosus*) are slow, but they can achieve an acceptable level of control if they are given some assistance. Once established on individual plants, the adults provide a continuous supply of new insects to attack new growth and surrounding plants. This photograph (**left**) shows cochineal at work on rope pear - the white material is the protective cover for the adult cochineal - dozens of tiny (red) "crawlers" (young cochineal) can be clearly seen against the plant's green

background.

The use of cochineal insects simply involves the manual transfer of cochineal-infested segments, like the one in the photo, into plants that do not contain cochineal insects! All you need is a bucket and a pair of tongs...

Assisting the further distribution of cochineal? Cochineal start their lives as tiny, crawling insects, venturing off to locate a new food source. Sometimes they climb to the top of a blade of grass and wait for the wind to blow them to a new area. They can travel some kilometres in this way, but of course they don't always find the target!

Cochineal insects can only crawl along the ground for about 4 or 5 metres (or to the first large crack in the ground, eg as in black soil situations. Generally, they need our assistance to get them into new pear areas. A bucket and a pair of tongs, and the simple transfer of infected segments into new plants is the answer.

Tips to help the cochineal?

- Always remember that cochineal insects are very delicate. They don't like cold and wet weather. When you put the insects into a new plant (especially in the approach to winter) give them some protection from the elements. Cover the infected segments with parts of the plant, or branches, bark, cow pads etc.

- Covering newly-infected plants with cardboard, plywood or even a bit of old corrugated iron will offer the cochineal insects useful protection from the weather. You'll be surprised how well the insects build up in this situation.

- Another trick is to breed the insects indoors, in readiness for release in early summer, the optimum time for release. Store infected plant material in cardboard boxes in a dry, warm area. Over a period of 6 to 8 weeks, you'll have good supplies to put out when the weather warms up.

- After cochineal insects become established on the plants, CUT SOME OF THE LARGER PLANTS DOWN - **CAREFULLY**. Cutting the plant off at or near ground level severs the plant's food supply and reduces its resistance to the tiny cochineal insects. Stack the severed plant parts around the base of the plants to keep the material and the insects together.

WARNING: The process of cutting down rope pear plants can transform thorny segments into dangerous projectiles. Take care, and always wear appropriate protective clothing!

USE THE RIGHT COCHINEAL… Tiger pear, common pear and rope pear cochineal all look the same. But, they're each specific to their host plants. Only rope pear cochineal – *Dactylopious tomentosus* - works on rope pear!

MORE INFORMATION

Cochineal.htm on this website. Information on individual prickly pear species is also included in this website. Return to Weeds List for harrisia cactus, velvety tree pear, prickly pear history etc.

Return to top of the page

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LRT - 7/9/02

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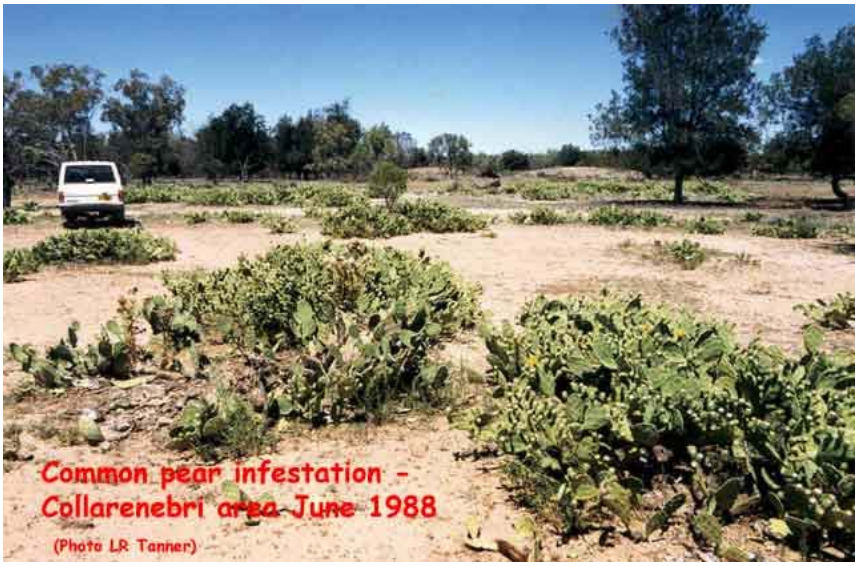
NOXIOUS WEED CONTROL UNIT FOR GWYDIR AND INVERELL SHIRES

Please address all correspondence to the General Manager, Gwydir Shire Council, Locked Bag 5, BINGARA, NSW, 2404 - Phone 02 6729 1016, facs 02 6729 1400, email tannerl@northnet.com.au

Common Prickly Pear

"Common pest pear" or "prickly pear" (*Opuntia stricta* and sub species) was the variety of pear that caused such widespread devastation in eastern Australia during the late 1800s and early 1900s.

Originally imported from the Americas during the early 1800s, prickly pear was widely promoted and grown as a source of stock fodder during periods of drought. It didn't take long for prickly pear to become established over large areas of New South Wales and Queensland. The perfect climate and lack of natural enemies accounted for its amazing spread - still considered by many experts to be one of the botanical wonders of the world.



Common pest pear is still present throughout New South Wales. Biological control agents (cactoblastis and cochineal) generally keep this pest under control - especially with a little bit of help from the land holder…



IDENTIFICATION

Common pest pear is a flat-leaved cactus plant, usually around 60 cm high but up to 1 metre. The leaves, or pads, grow to about "the size of a man's hand". Flowers are yellow, the prolific fruit purple when ripe. Birds, foxes and pigs eat the fruit and spread seed over large areas. New plants grow from seed or from pieces of the plant. The two main growing periods for the plant are in February and October each year.

THE PROBLEM

Common pest pear is an invasive plant. It spreads quickly if not controlled and can completely take over a paddock. The plant is "armed" with two sets of thorns: the 25mm ones are very sharp, but they aren't really significant. The clusters of small, golden thorns are the ones that cause the problem. The pattern on the leaf (*Photo of leaf, courtesy NSW Dept of Primary Industries*) marks the clusters of thorns.

These tiny thorns penetrate tongues and mouths of animals choosing to eat the plant, as cattle and sheep often do when feed is scarce. The thorns cause irritation and inflammatory sores. Sheep brushing amongst the pear accumulate numerous thorns in their wool and hides, causing

MORE INFORMATION? PLEASE CONTACT YOUR LOCAL WEEDS OFFICER:

Stephen Kneller Bingara 0427 240 061	Clem McLeod Inverell 0427 453 052	Doug Stieger Warialda 0427 291 912	Les Tanner Head Office 0427 241 806
OR check out our website on www.northwestweeds.nsw.gov.au			

COMMON PEST PEAR (CONT)

downgrading of the wool and discomfort to the sheep. Of course, shearers are not impressed with the thorns either!

CC4(C) MANAGEMENT PLAN – Legal requirements within the Shires of Gwydir & Inverell
The growth and spread of the plant must be controlled by conducting an on-going and effective treatment program to reduce plant numbers and to minimise the plant's negative impact on the land. Any biological control or other control program directed by the local control authority must be implemented. All reasonable measures are to be taken to ensure vehicles, machinery and livestock moved off the property are free of the plant. Plant must not be sold, propagated or knowingly distributed.

CONTROL METHODS

Ploughing and cultivation takes care of prickly pear, but plants need to broken up and disturbed a number of times before they give up. One run with a plough will multiply each plant by the number of leaves left lying on top of the ground! The plant pieces need to be buried or badly damaged before they rot away completely. [NB. State laws apply in respect of land clearing.]

Burning. It takes a lot of heat to kill a plant, especially one with a large butt still under the ground. Plants pulled out of the ground are easier to kill. Burning is really only appropriate for small infestations. [NB. Subject to compliance with local bushfire restrictions].



Biological control is a good control option for large areas of pear, especially in the area covered by North West Weeds. There are two entirely different agents for common pear – **cochineal (right)** and **cactoblastis (left)**. Biological control is a practical and cost-effective means of keeping this pear in check, provided the insects are given a bit of help. Please check out www.northwestweeds.nsw.gov.au for more information on best results for biological control.



USE THE RIGHT COCHINEAL… Tiger pear, common pear and rope pear cochineal all look the same. But, they're each specific to their host plants. Only common pear cochineal – *Dactylopious opuntiae* - works on common pear!

Chemical treatment of common pest pear is effective, because the plants are easy to find. According to NSW Dept of Primary Industries' excellent booklet "***Noxious and Environmental Weed Control Handbook 2004/2005***", herbicide treatments include:

Chemical	Rate	Comments
Triclopyr Garlon 600®	3.0 L in 100 L water **or** 1.0 L in 75 L distillate	Apply as a thorough foliar spray
Triclopyr + Picloram Grazon DS®	500 ml in 100 L water	Apply when with active leaf growth
Triclopyr + Picloram Access®	1.0 L in 60 L diesel	Folia application, thoroughly wet plants

IMPORTANT: USE OF PESTICIDES – ALWAYS READ THE LABEL
Pesticides must only be used for the purpose for which they are registered and must not be used in any other situation or in any manner contrary to the directions on the label. Never use a herbicide in any way contrary to label recommendations. Always observe withholding periods.

MORE INFORMATION

www.northwestweeds.nsw.gov.au/cochineal.htm
www.northwestweeds.nsw.gov.au/cactoblastis.htm

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North West Weeds

Your local guide to local noxious weed control (NSW, Australia)

Velvety tree pear

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Related Weed Sites
Prickly Pear History

This website is proudly sponsored by QuikCorp, supplier of "reel" equipment for spraying weeds!



Suppliers of quality spray equipment

North West Weeds
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20 Dinoga Street
BINGARA
NSW 2404



Velvety tree pear *(Opuntia tomentosa)* also known as velvet tree pear is a native of Central Mexico. The story behind its introduction into Australia is not known, but it would be safe to assume it was brought out here as a garden plant. It is now locally established over thousands of hectares of land in inland Queensland and northern New South Wales.



Photo, right: An example of how large velvety tree pear can grow - former Prickly-pear Destruction Commission officer Kevin Whitton standing underneath a patch of velvety tree pear on the property "Monkstadt", located between Bonshaw and Tenterfield, NSW - circa 1985.



THE PROBLEM

The plentiful seeds of velvety tree pear are spread over long distances by birds. Plants grow into large trees up to 5m high, and groups of plants become so thick they impede stock movement and eliminate useful grasses. On the credit side, however, velvety tree pear has some value as supplementary fodder during dry times. Although the plant certainly has plenty of thorns, they are not as severe as those on most other cactus species.

IDENTIFICATION





Most dominant feature is the actual size/height of the plant. It grows way beyond the normal, common prickly pear. Young leaves are shiny but take on a "velvety" appearance as they mature. Flowers are a beautiful orange colour.

CONTROL METHODS

Biological control

Cochineal insects (***Dactylopious opuntiae***) can be very effective. BUT, the insects have limited mobility and sometimes need to be manually transferred into new areas and/or isolated plants. They can be carried long distances by strong winds but on their own the tiny insects can only travel 3-4 metres. Thick ground cover hinders them, and cracked ground (eg black soil country) is fatal because they drop into the cracks! They travel best on hard, reasonably bare ground.



The insects work better if they are given shelter from the elements. After the insects are established on the plant itself, the biocontrol program can be further assisted by cutting some of the main plants down (about 300mm above ground level). Ideally, try to land these plants on rocks/logs to minimise their contact with the soil and their ability to take root. Those parts of the plant that break away when the plant hits the ground should be stacked back around the base of the main plant - especially if they landed on good soil.

Cutting cochineal-infected tree pear down does three things;
(1) it severs the plant's own food supply,
(2) it reduces the plant's resistance to the effects of the tiny cochineal insects, and



(3) it provides a sheltered environment (the underside of the leaves) for the cochineal insects to flourish in.
(Pushing the plants over with a tractor or 4WD seldom severs the plants food supply, but it certainly helps to provide a sheltered environment for the insects! - see photo, right)



It's always important to note that while ever the insects are present on the main plants, their offspring are wandering around the ground in search of new plants. They are particularly useful for locating and wiping out new seedlings - photo, left, shows new-established cochineal on a cluster of tree pear seedlings ...

Maintaining supplies of biocontrol agents for the future?

The ongoing presence of velvety tree pear provides host material for cochineal (the same species also attacks the more aggressive common pest pear). It also provides an option for desperate cactoblastis moths unable to locate their favoured common pear on which to lay their eggs - the young leaves are soft enough for the cactoblastis to enter and eventually complete their life cycle, thus paving the way for their next generation. While cactoblastis larvae will demolish thousands of young seedlings in some seasons, they have zero impact on large plants because the basic material is too hard.

Chemical treatment of velvety tree pear is effective, because the plants are easy to find. Unfortunately the work can be costly because of the volume of herbicide needed to cover the plants. According to NSW DPI's excellent booklet "*Noxious and Environmental Weed Control Handbook 3rd Edition*", and other sources, herbicide treatments include:

Chemical	Rate	Comments
Triclopyr 600 g/L eg *Garlon 600*®	High volume 3L in 100L water + 0.5% (500 mL) uptake spray oil or knapsack application 50mL in 10L of water plus 50mL Uptake spray oil **OR** 1L in 75L **diesel**	Apply to actively growing plants - see APVMA **permit PER10544** for more details
Triclopyr 300 g/L**+ picloram** 100 g/L eg *Grazon DS*® *or* **Triclopyr** 300 g/L**+ picloram** 100 g/L + eg *Grazon Extra*®	High volume 500 ml in 100 L water + 0.5% (500 mL) uptake spray oil **OR** knapsack application 50mL in 10L of water plus 50mL Uptake spray oil (Essential to use spray oil or similar to help the spray "stick" to the leaves)	Apply to actively growing plants - see APVMA **permit PER10544** for more details [Editor's note: Water-based sprays are very slow acting, especially on larger plants. The process can take 12 months or more, but this is an important advantage if cochineal insects are present; the adults will persist and continue to produce offspring; the new insects will help to control re-growth and the inevitable new plant seedlings... LT - 2/10/2011]
Triclopyr + Picloram eg Access®	1.0 L in 60 L **diesel**	Folia application, thoroughly wet plants
Amitrole + Ammonium thiocyanate Nufarm Amitrole T®	1mL injected into cuts at 3cm spacings around lower trunks of mature plants	Tree pears may take up to 12 months to die. Re-spraying may be necessary in some cases. **Registered for use in Qld only...**
Amitrole + Ammonium thiocyanate Nufarm Amitrole T®	Apply a mix of 1 part Amitrole T in 25 parts water liberally to small plants and regrowth	Tall plants may be lopped before spraying. Apply the spray liberally over the entire plant and on adjacent soil. **Registered for use in Qld only.**

IMPORTANT: USE OF PESTICIDES - ALWAYS READ THE LABEL

Pesticides must only be used for the purpose for which they are registered and must not be used in any other situation or in any manner contrary to the directions on the label. Never use a herbicide in any way contrary to the label recommendations.

MORE INFORMATION

Cochineal.htm on this website. Information on other individual prickly pear species is also included in this website. Return to **Weeds List** for rope pear, harrisia, prickly pear history etc.

Return to top of the page

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LRT 0/09/09

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FOR PROFITABLE, ADAPTIVE AND SUSTAINABLE PRIMARY INDUSTRIES

SEPTEMBER 2009 | PRIMEFACT 654 | 2ND EDITION

African boxthorn

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Introduction

African boxthorn (*Lycium ferocissimum*) is a member of the family Solanaceae, which also includes silver-leaf nightshade, tobacco and tomatoes.

It was introduced into Australia from South Africa in the mid 1800s and was commonly used as a hedge plant.

It is now a serious weed threat in all States and is one of the major weed threats to the semi-arid rangelands of western NSW.

Consequently, it is a declared noxious weed in most parts of NSW. (See map)



A close up of a mature African boxthorn shrub. Note the fleshy leaves, immature fruit (green berries), mature fruits (red berries) and spines at the end of the branchlets. Photo: Brian Worboys, Maitland City Council.

The problem

African boxthorn is an aggressive invader of pastures, roadsides, reserves, remnant bushland and waterways. It forms an impenetrable, spiny thicket that inhibits the movement of stock and provides a haven for feral animals.

Many insects, including fruit fly, the common house fly and the tomato fly, breed in the fruit of this weed.

Distribution

In NSW, African boxthorn is more prevalent on the well drained soils of the slopes and plains. Often, it has spread from around old homesteads and urban areas. It grows on all soil types but establishes best on lighter soils, particularly along dry creek beds.

The plant

African boxthorn is an erect perennial shrub. It can grow up to 5 m high and 3 m across but usually reaches only 2 or 3 m in height. It is characterised by its woody, thorny growth. The stems are rigid and very branched, and the main stems have spines up



An African boxthorn infestation. Commonly found under trees because the seeds remain viable when excreted by birds. Photo: Brian Worboys, Maitland City Council.

NSW GOVERNMENT Industry & Investment

to 15 cm long. Each smaller spiny branchlet ends in a stout spine.

The leaves are smooth, fleshy and up to 3.5 cm long. They can be larger and more succulent on regrowth from damaged roots. The plant is drought resistant and in times of moisture stress can shed its leaves, making it look dead. In some locations plants can be deciduous, losing their leaves in winter.

Plants are at least two years old when they flower, and although this generally occurs in spring and early summer it may occur at any time of the year provided the conditions are right. The flowers are white with pale blue markings and fragrant. They have five petals.

Fruit set generally occurs in autumn, but, again, it can occur at any time of the year depending on conditions.

The berries are green when young and succulent, round, 5 to 10 mm in diameter, contain 35 to 70 seeds and are orange-red when ripe. Seeds can germinate at any time of the year if there is adequate moisture and warmth.

The plant has an extensive, deep, branched taproot that will sucker and produce new growth if broken. Early root growth is rapid to allow seedlings to compete with other plants.

Dispersal

The seeds are readily eaten by birds and animals and remain viable when excreted. Consequently, new infestations are commonly found under trees, along fences and under powerlines. Spread can also occur if seeds contaminate agricultural produce, gravel or mud. The roots also have the ability to produce new growth from broken pieces, so care must be taken in removing and destroying all root matter when undertaking mechanical control.

Methods of control

The effective, long-term control of this weed will generally require the integration of a number of techniques, including mechanical removal, cultivation, herbicide application, replacement with appropriate plants and regular monitoring.

For invasive woody weeds such as African boxthorn, control is more effective and economical if done when the plants are young.

The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult your local agronomist or council weeds officer.

Mechanical removal

The most cost effective way of controlling mature bushes forming thickets is to physically remove the top growth and as many of the roots as possible. The removed plant material should then be burnt. Removal of the roots is much easier and more effective when the soil is moist.

It is important to destroy all plant material after physical removal because:



Areas of NSW where African boxthorn is declared a noxious weed. Alan Maguire, 2007.

- dead branches still pose a problem because of their thorns and the fact that they can harbour vermin;
- unripened fruit on cut branches can still ripen and produce seed; and
- broken root fragments may sucker and produce new growth.

Cultivation

After physical removal of the mature plants, suitable sites can be deep ripped, bringing most remaining root fragments to the surface to be raked and burned. In some instances cultivation may result in the deeper root fragments shooting. In this case, follow-up treatment will need to be directed at the regrowth.

It is essential that you perform follow-up treatment as new plants become established.

Do not treat regrowth with a foliar herbicide until the plants are at least 50 cm high (approximately 18 months old).

Chemical control

Only a registered herbicide used according to the directions on the label should be used to control this weed. Refer to the Department of Industry & Investment NSW publication *Noxious and Environmental Weed Control Handbook* for the chemicals recommended for the control of African boxthorn.

Herbicides can be applied to African boxthorn in many different ways. At times, the plant will lose its leaves and appear dead after the application of a herbicide, but later new leaves appear and the plant appears to recover. This cycle may happen several times before the plant eventually dies. The most appropriate form of herbicide application will depend on the location, size and maturity of the infestation.

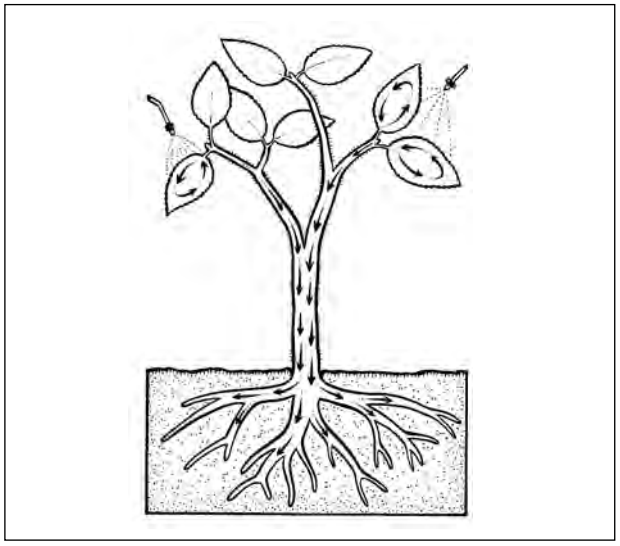


Figure 1: Applying chemicals through foliar spraying is more effective if the plant is actively growing. Queensland Natural Resources and Mines.

Foliar spray

Foliar spraying is the most commonly used method of control. Its effectiveness depends on adequate soil moisture to allow active growth of the bush. For effective control by this application method, spray the whole bush thoroughly during a time when the plant is actively growing (Figure 1). This will vary depending on the location but is generally during spring after rain. For large bushes it is very costly and difficult to obtain good coverage with the herbicide. It may be more cost effective to bulldoze thickets of large bushes and spray the regrowth. The uptake of foliar-applied herbicides is dependent on total leaf area, so foliar spraying should not be done until the regrowth is at least 50 cm high (approximately 18 months old). For effective results, do not treat infestations during hot, dry, summer periods or when the plant is stressed from drought, water logging or cold.

Basel bark treatment

This technique is appropriate for infestations in environmentally sensitive locations. It is most suited for small bushes with stem diameters up to 5 cm. Spray a herbicide registered for this activity around the complete base of every stem to a height of 30 to 40 cm above the soil surface (Figure 2).

Cut stump treatment

This technique is also appropriate for small infestations in environmentally sensitive locations. It is most suitable for large plants with stem diameters greater than 5 cm.

Cut each stem off 15 cm above the soil surface. Liberally apply a herbicide registered for this activity to the cut surface within 30 seconds of the cut being made (Figure 3). This can be done by paintbrush or by spraying.

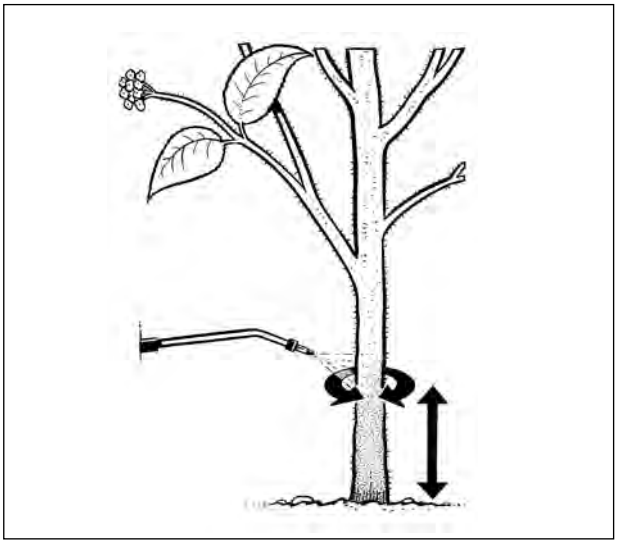


Figure 2: Basel bark application of chemicals should be around the complete base of every stem to a height of 30–40cm above the ground. Queensland Natural Resources and Mines.

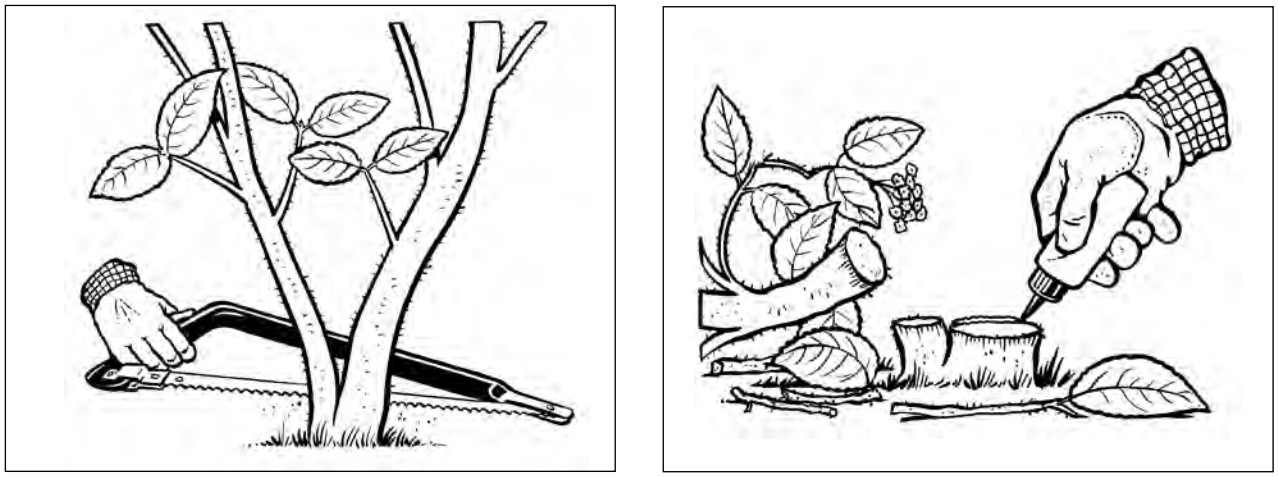


Figure 3. In cut stump applications it is important to apply the chemical immediately to the cut stem. Queensland Natural Resources and Mines.

If the herbicide is not applied immediately, the plant will heal the cut, the chemical will not be translocated through the plant, and control will not be effective.

Root application

Take great care when using this technique.

Many desirable trees, in particular eucalypts, are susceptible to the residual herbicides used for this control method. Do not use these chemicals within a distance of at least twice the height of adjacent desirable trees or shrubs.

To control African boxthorn, apply an appropriate registered residual herbicide directly under the plant towards the edge of the foliage (drip line). The herbicide should preferably be applied under the soil to prevent degradation by sunlight and possible contamination of surface run-off after rain. It is most effectively applied when the soil is moist—usually in spring or autumn.

These herbicides have the advantage of being easy to apply, and the timing of the application is not as critical as for other application methods. The residual effect of these herbicides may also give control of seedling regrowth for some time after application.

Replacement with appropriate plants

Like most weeds, African boxthorn seedlings are susceptible to competition from other plants. It is essential for the long-term control of this weed that, once removed, it is replaced with other suitable vegetation.

The vegetation you use will depend on your site. It can include the establishment of native vegetation or perennial pastures.

Native vegetation

If the weed infestation is providing a valuable habitat for native fauna, use a staged control program. This will allow the gradual replacement of the weed habitat with suitable indigenous vegetation. Consult a local vegetation expert for advice on suitable local species and their establishment and management.

Pastures

Vigorous perennial pastures provide competition to prevent the invasion of African boxthorn. At suitable sites they should be established as soon as possible after the removal of the weed infestation but not after the application of residual herbicides. Consult your local agronomist for advice on pasture establishment and appropriate pasture management. For further information refer to the range of publications available at any Industry & Investment NSW office or at www.dpi.nsw.gov.au

Regular monitoring

All control methods will require follow up treatment for long-term management of African boxthorn. Once the initial infestation is removed, regular monitoring of the site for regrowth from root fragments or germinating seedlings should be carried out. Control of these small plants is easy if you use cultivation or apply an appropriate registered herbicide.

Who is responsible?

African boxthorn is a declared noxious weed in many areas of NSW. See www.dpi.nsw.gov.au/weeds. For a complete list of declared noxious weeds for each control area.

African boxthorn has been declared as a Class 4 weed in NSW. A Class 4 weed poses a threat to agriculture, the environment or the community and has the ability to spread to other areas. The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority.

The Noxious Weeds Act 1993 is enforced by the local control authority (usually local government).

The responsibility for control of noxious plants and appropriate disposal of weed plant material on private land rests with the owner or occupier of the land. Failure to do so could result in the local control authority issuing a weed control notice, a fine or taking court action.

Local control authorities must adequately control noxious weeds on land under their control to prevent the infestation of adjoining land. The community can help control this weed by notifying the local control authority of any known infestation of African boxthorn on public land.

Further information

For further information on the management of African boxthorn contact your local council Weeds Officer or Industry & Investment NSW District Agronomist.

Publications available

For a complete list of Industry & Investment NSW publications, please see www.dpi.nsw.gov.au, or contact the Industry & Investment NSW Bookshop on 1800 028 374 or by email bookshop@dpi.nsw.gov.au.

Acknowledgements

Information for this Primefact was taken from:

African boxthorn Agfact P7.6.31, first edn

WT Parsons and EG Cuthbertson 2001, Noxious weeds of Australia, second edn, CSIRO Publishing, Collingwood, Melbourne.

African boxthorn (*Lycium ferocissimum*) 2002, DPIWE Information sheet, Department of Primary Industries, Water and Environment, Tasmania or www.dpiwe.tas.gov.au/inter.nsf/WebPages/RPIO-523VU9

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Replaces Primefact 654 1st edition

Prepared by Alyssa Schembri, Orange Agricultural Institute, Orange.

Updates of this Primefact are available at www.dpi.nsw.gov.au/primefacts

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Suppression of alligator weed in pastures

For areas of NSW where alligator weed is declared a Class 3 noxious weed

Tony Cook
Technical Officer (Weeds),
Tamworth

Elissa van Oosterhout
Best Practice Officer (Aquatic Weeds),
Grafton

Introduction

Alligator weed (*Alternanthera philoxeroides*) is a highly invasive weed that grows both on land and in water. Due to its ability to tolerate herbicides and spread easily by fragments, it is a serious weed of waterways, wetlands and floodplains in Australia[1].





Figures 1 and 2. Alligator weed. Photos: B. Auld and B. Worboys.



Figure 3. Alligator weed infested pastures in the Hunter region. Photo: E. van Oosterhout.

Irrigated and floodplain-based farming is threatened by alligator weed and the worst infestations currently affect grazing lands in the Hunter region of NSW.

The pasture management technique presented in this Primefact is for the ongoing suppression of extensive alligator weed infestations occurring in pastures and grazing lands in areas of NSW where alligator weed is declared a Class 3 noxious weed.

The technique is not appropriate for areas of NSW where alligator weed is declared a Class 2 noxious weed due to the requirement for Class 2 plants to be eradicated and because of the risks of spread associated with slashing and grazing (See page 5).

The application of this technique will enable graziers to change alligator weed dominated pastures into pastures dominated by desirable species, and maintain long term suppression of alligator weed through careful grazing management and strategic control on a year to year basis.

[1] In high rainfall areas alligator weed can persist and grow above a floodplain. Please refer to the publications listed under 'Further reading' on page 6 for advice on the identification and profile of alligator weed.

The pasture management technique

This technique is based on two to three applications of the selective herbicide metsulfuron-methyl 600 g/kg each year, with the height of the pasture canopy reduced either by slashing or grazing prior to each herbicide application, combined with careful pasture management.

The research supporting this technique was done in a pasture comprising 90% alligator weed and 10% kikuyu. In the research trial the pasture composition changed from 90% alligator weed to 10% alligator weed and correspondingly 80–90% kikuyu 1 month after the first spray treatment.

Very good results can be obtained after the first season but it will take two to three seasons of treatment and ongoing pasture management to achieve significant long term suppression.

How does it work?

The selective herbicide will suppress alligator weed and allow viable pasture grasses to compete and dominate. However, small alligator weed plants persist beneath the pasture canopy, and as the grass becomes dominant, it becomes difficult to apply follow-up treatments to the remaining alligator weed as the thick pasture canopy prevents contact of the herbicide with the alligator weed. The pasture canopy must be reduced either by slashing or grazing prior to every herbicide application. This promotes alligator weed regrowth and allows better contact of the herbicide with the alligator weed foliage.

Once alligator weed levels have been reduced, grazing must be managed so that the pastures provide a high level of ground cover and a very competitive canopy. This helps with further suppression of alligator weed and lowers the risk of the infestation spreading throughout the pasture by preventing the establishment of new plants from stem fragments.

The continual pressure applied to the alligator weed gradually depletes the weed's below-ground storage tissues. After long term application of this technique there may be situations where plant numbers are reduced to the point that eradication strategies could be successful over small areas (see the *Alligator Weed Control Manual* listed in 'Further reading' on page 6 for information on eradication). In most cases alligator weed will always be present but at much reduced and suppressed levels.



Figure 4. An infested pasture (90% alligator weed) before application of the pasture management technique. Photo: T. Cook.



Figure 5. After treatment, the proportion of alligator weed was reduced to 10% and the kikuyu increased to 90%. Photo: T. Cook.

Applying the technique

The steps involved in applying the technique are described below. The main consideration for the timing of the first herbicide treatment is that the alligator weed is actively growing and has reached the required height or leaf stage for herbicide treatment (10 to 20 cm; six to eight pairs of leaves). Best results occur after heavier rains, particularly following dry periods.

1. Check pasture composition

Success depends on the presence of competitive pasture grasses (no less than 10% of the ground cover). Make sure that some competitive pasture grass species are present in the infested pastures.

Species that grow by stolons or runners, or summer active grasses that grow to at least 30 cm high, will provide strong competition (i.e. kikuyu, Swazi grass, Rhodes grass). Tussocky plants such as Setaria and some sedges and rushes can achieve the required heights, but provide too much light and space, allowing the alligator weed to compete easily. Other stoloniferous grasses do not grow tall enough to dominate alligator weed.

Seek agronomic advice on pasture species with the required height and running habit.

If a competitive grass needs to be introduced, oversow in mid-autumn, at least 3 months after any metsulfuron-methyl application. This will allow the pasture to establish before the following spring when the herbicide program is repeated. It also allows enough time in more acidic soils for the metsulfuron-methyl residues to break down.

2. Slash or crash graze and then remove the stock

If alligator weed is dominant there may be no need to slash or crash graze in order to get good herbicide contact. In this case remove the stock (see 'Grazing as part of this technique') and go straight to step 3.

If alligator weed is in amongst grasses and other weeds, slash or crash graze the area. Then keep the area destocked until after the spray program has finished for the season (crash grazing can be used for the subsequent pasture height reductions in step 4).

If slashing, cut to 10 cm (no higher) and make sure the blades are kept above ground level to reduce the risk of soil or root fragment spread. Use standard machinery hygiene practices for slashers, tractors and mowers to prevent the spread of alligator weed between paddocks or properties (refer to the *Alligator Weed Control Manual* listed in 'Further reading' on page 6).



Figure 6. Alligator weed is exposed after slashing pasture to 10cm. Photo: T. Cook.



Figure 7. Alligator weed regrowth is obscured by grass when the pasture is slashed any higher than 10cm (this site was slashed to 20cm). Photo: T. Cook.

3. Spray when the alligator weed regrowth reaches 10–20cm or has six to eight pairs of leaves

This should take around 2 weeks during the growing season and 4 weeks in the cooler months. Apply the first treatment of metsulfuron methyl 600 g/kg at the registered rate.

4. Allow the herbicide to take effect, then slash or crash graze again

Alligator weed will take at least 1 to 2 months to die back. Yellowing may occur in some pasture grasses (particularly kikuyu) but established grasses will recover 2–4 weeks after treatment. All legumes will be killed.

Allow time for the herbicide to take effect on the alligator weed and for the pasture grass growth to increase. Slash or crash graze again to no higher than 10 cm.

5. Spray again when alligator weed regrowth reaches 10–20cm or has six to eight pairs of leaves

Wait for the alligator weed regrowth to reach the required level of growth and then apply the second treatment of metsulfuron-methyl 600 g/kg at the registered rate.



Figure 8. Alligator weed regrowth ready to spray. Photo: T. Cook.

6. Repeat steps 4 and 5 in accordance with alligator weed growth

Always carry out pasture height reductions prior to any further herbicide applications.

7. Manage grazing

Once the pastures have been re-established some grazing pressure is acceptable, but the pasture must be left with a competitive canopy. Only graze for short periods (up to 1 month), and allow pastures to rest for longer periods between grazing (2 to 3 months). Grazing pastures to below 10 cm for longer than 1 month at a time will encourage rapid regrowth and dominance by alligator weed.



Figure 9. Heavy grazing will promote domination of the pasture by prostrate alligator weed. Photo: B. Worboys

Grazing as part of this technique

There is no withholding period for metsulfuron-methyl. Stock can be used for the pasture height reductions before each herbicide application but they should not be constantly grazing areas undergoing treatment. Trials show that immediate grazing after the herbicide applications resulted in lower levels of alligator weed suppression.

The grazing of alligator weed itself has been associated with photosensitivity and resultant skin lesions, liver damage and death in cattle, calves and lambs in Australia and New Zealand. Research in India has shown that alligator weed should not make up more than 15% of a ruminant's diet in order to avoid malnutrition from a lack of essential amino acids. Always monitor stock grazing in infested paddocks and avoid grazing alligator weed wherever possible.

Apply the technique carefully

Trials have shown that slashing and grazing promote alligator weed growth. Slashing or grazing alone will allow alligator weed to dominate and will promote a prostrate growth habit, which is then harder to suppress with herbicide. This technique uses slashing or grazing to increase the effectiveness of selective herbicide treatments.

Flooding can kill pastures and allow alligator weed to dominate. As long as some competitive pasture species are present or have been reintroduced after flooding, this pasture management technique can be used again for ongoing suppression.

Never use glyphosate herbicides or other non-selective herbicides in association with slashing or grazing, as removal of competitive grasses will worsen infestations.

Risks of spread

There are very high risks of spread associated with stock and machinery movements from infested areas. Grazing stock can carry stem fragments in their hooves and mouths. It is extremely important that proper hygiene protocols for stock and machinery are followed.



Figure 10. Grazing alligator weed has been associated with photosensitivity and resultant skin lesions, liver damage and death in cattle, calves and lambs. Photo: A. Storrie.

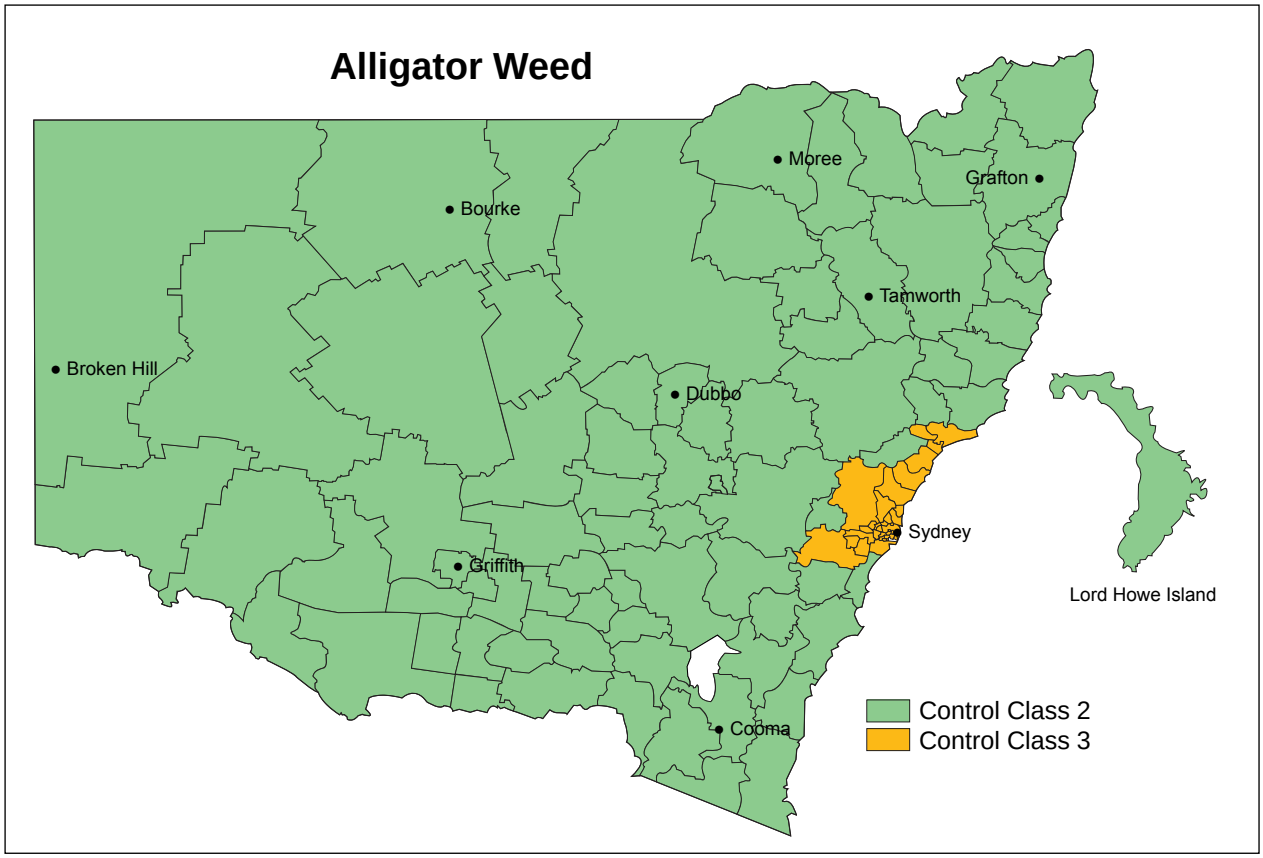


Figure 11. Declarations for alligator weed in NSW. A. Maguire.

Legislation

Alligator weed is declared a Class 2 or Class 3 noxious weed under the NSW *Noxious Weeds Act 1993* (see Table 1 and Figure 11).

The responsibility for the control of noxious weeds on private land rests with the land owner or occupier of the land. This responsibility extends to the middle line of any adjacent watercourse, river or inland water (tidal or non-tidal).

This plant must not be sold anywhere within NSW.

A full list of noxious weeds and requirements under the Noxious Weeds Act can be found at www.dpi.nsw.gov.au/weeds

Table 1. Declaration of alligator weed by local government area.

Class	Local Government Areas
Class 3 Control requirements for Class 3 noxious weeds are that 'the plant must be fully and continuously suppressed and destroyed'	Auburn, Bankstown, Baulkham Hills, Blacktown, Burwood, Camden, Campbelltown, Canterbury, Sydney, Fairfield, Gosford, Hawkesbury, Hawkesbury River County Council, Holroyd, Hurstville, Kogarah, Ku-ring-gai, Lake Macquarie, Lane Cove, Leichhardt, Liverpool, Maitland, Manly, Marrickville, Mosman, Newcastle, North Sydney, Parramatta, Penrith, Pittwater, Port Stephens, Randwick, Rockdale, Ryde, Strathfield, Sutherland, Botany, Ashfield, Hunters Hill, Hornsby, Warringah, Waverly, Willoughby, Wollondilly, Woollahra, Wyong.
Class 2 Class 2 noxious weeds must be eradicated from the land and the land must be kept free of the plant. As a notifiable weed, all outbreaks must be reported to the local council within three days.	Throughout the State except for the Local Government Areas where alligator weed is declared a Class 3 noxious weed.

References

Cook, T. and Storrie, A. (in press), Tactics for the control and possible eradication of terrestrial alligator weed (*Alternanthera philoxeroides*), *Proceedings of the 16th Australian Weeds Conference*, 2008, Cairns.

Storrie, A. and Cook, T. (2006), 2006 Research Update: Herbicides and alligator weed, NSW Department of Primary Industries, Tamworth.

Bhatta, R. and Das, T.K. (1995), Utility of alligator weed in the ration of growing calves, *Indian Journal of Animal Nutrition*, 12(4):237–240.

Further reading

Alligator weed control manual: Eradication and suppression of alligator weed (*Alternanthera philoxeroides*) in Australia, (2008), NSW DPI, Orange. Available from DPI Bookshop, phone 1800 028 374, or www.dpi.nsw.gov.au/weeds

Alligator weed – Don't let it drag you under: An early detection guide for farmers (2008), Brochure, NSW DPI, Orange. Available from DPI Bookshop, phone 1800 028 374, or www.dpi.nsw.gov.au/weeds

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Disclaimer
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Product names
The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended and that the inclusion of a product does not imply endorsement by NSW Department of Primary Industries over any other equivalent product from another manufacturer.

Always read the label
Users of agricultural chemicals products must always read the label, and any permit before using the product, and strictly comply with the directions on the label and any permit.

Users are not absolved from compliance with the directions on the label or the conditions of the permit by reason of any statement made or omitted to be made in this publication.

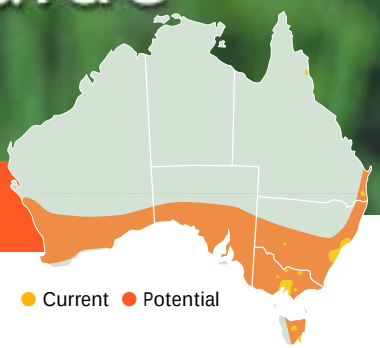
Warnings: Pasture improvement may be associated with an increase in the incidence of certain livestock health disorders. Livestock and production losses from some disorders are possible. Management may need to be modified to minimise risk. Consult your veterinarian or adviser when planning pasture improvement.

Legislation covering conservation of native vegetation may regulate some pasture improvement practices where existing pasture contains native species. Contact your Catchment Management Authority office for further information.

Job number 8378

Weed Management Guide

Alligator weed –
Alternanthera philoxeroides



Alligator weed (*Alternanthera philoxeroides*)

The problem

Alligator weed is a *Weed of National Significance.* It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts. It is an especially troublesome weed because it invades both land and water, and is very hard to control.

When growing on land it displaces other more favourable plants such as crops or native vegetation, and can be harmful to animals. When growing in fresh water, alligator weed can cover the entire water surface, preventing flow, blocking up drainage channels and potentially increasing flood damage. Weed mats can also reduce oxygen exchange, affecting instream plants and animals and reducing water quality.

Alligator weed caused the failure of small crop and turf farms in parts of the lower Hunter region in New South Wales. Another infestation, in Barren Box Swamp, would have cost irrigation farmers in the Murrumbidgee Irrigation Area up to $250 million annually if left unchecked. So far, more than $3 million has been spent controlling this infestation alone.

The weed

Alligator weed can grow with roots embedded in the bank or on the bottom of shallow water bodies, or float freely on the water surface. It spreads its leaves across the water surface, forming dense mats. The long spreading stems are hollow, helping it to float. The roots are thin and stringy, and trail in the water from the joints between plant segments (the nodes).

When growing on land alligator weed is quite different in structure. The stems are shorter and barely hollow. Reddish-brown tap roots can reach depths exceeding 500 mm.

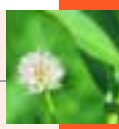
Whether it grows in water or on land, the shiny, dark green leaves occur in opposite pairs along the stem. The leaves are 20–70 mm long and 5–40 mm wide, with smaller veins almost perpendicular to a characteristic mid-line along the length of the leaf. The silvery-white flower is small (12–14 mm wide) and papery, with a short stalk growing from either the axil (where the leaf joins the stem) or the very end of the stem.



Infestations can take over wetlands such as creeks and drainage channels and spread onto adjacent land.
Photo: Mic Julien

Key points

- Alligator weed poses a significant economic and environmental threat.
- It can grow in water or on land, and has been mistakenly grown in the past as a food.
- Prevention is the most cost-effective form of weed control. Quarantine, early detection and good hygiene within infestations will prevent its spread.
- Mechanical and chemical control, integrated with biological control, is effective on established aquatic growth forms.
- However, care must be taken because it spreads easily from fragments.
- Ongoing follow-up control will be required.



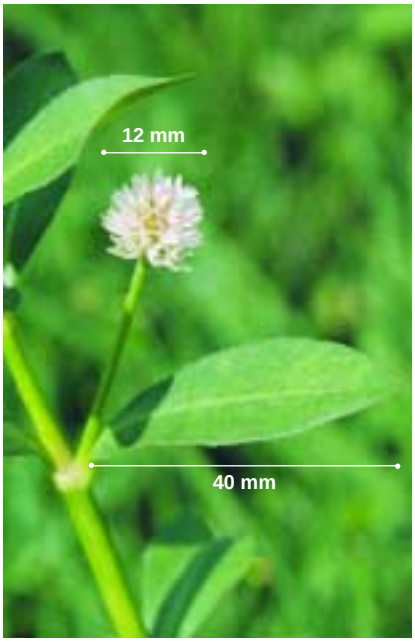
Natural Heritage Trust
Helping Communities Helping Australia
An Australian Government Initiative

Growth calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
New growth									■	■	■	
Active growth	■	■	■						■	■	■	■
Flowering	■	■	■									
Seed formation	No viable seed yet found in Australia											
Seed drop												
Germination												

■ General growth pattern

Growth in alligator weed commences during spring and continues in the warmer weather. New stems formed in spring grow quickly during summer, producing flowers by mid-summer. Flowering continues until the weather becomes cooler and the days shorter. In cooler climates leaves drop off and frost kills off most of the exposed vegetation during winter. However, some roots, rhizomes and protected stems survive and recommence growth during the following spring.



Silvery-white flowers are borne on short stalks during mid-summer.
Photo: Colin G. Wilson

How it spreads

Alligator weed does not produce viable seed in Australia, although it can in its native range. It spreads in Australia through vegetative reproduction, when fragments containing at least one node are moved from one place to another and take root in suitable habitat. It is commonly spread downstream when the plant is broken up into smaller fragments (eg by floods, or following mechanical or chemical control). Movement between river catchments is most commonly due to human activities. It has been spread in garden mulch and landfill, and attached to machinery and vehicles (eg bulldozers, trailers, boats and other watercraft). Animals may also spread the fragments (eg by transport of nesting material by ducks or in cows' hooves).



In water fine roots grow from the nodes.
Photo: Rebecca Coventry

It is believed that alligator weed first reached Australia near Newcastle in the 1940s in ballast. It has since spread to infest many waterways in New South Wales, including the lower Hunter region, Barren Box Swamp, the Sydney region, Griffith, Albury (which threatens the Murray River) and infestations in Brisbane, Cairns and Canberra.

Where it grows

One of the reasons that alligator weed poses such a dramatic threat is its ability to live in both aquatic and terrestrial habitats. It can tolerate brackish (slightly salty) water but thrives in nutrient-rich water. Ideal terrestrial habitats include places that are regularly inundated or that have high rainfall or irrigation. Alligator weed can survive in tropical and sub-tropical regions such as Darwin and Brisbane, and also cooler climates such as Victoria and Tasmania where the survival of some stems and rhizomes over winter allows it to regenerate during the warmer months.

Alligator weed is native to temperate regions of South America, especially Argentina. It is now found as a serious weed throughout tropical and warm-temperate regions, including the US, China, India, South-East Asia and New Zealand.

Potential distribution

The potential range of alligator weed, based on climate, includes waterways throughout most of southern Australia, extending south from Bundaberg in Queensland, through New South Wales, Victoria, Tasmania and South Australia, and north to Kalbarri in Western Australia. However, a different model predicts that alligator weed could also survive in the tropics, which may explain an infestation surviving in Cairns.

What to do about it?

Early detection is most cost-effective

Alligator weed has rarely, if ever, been successfully eradicated once it has infested a water body, despite numerous costly attempts. For this reason, the highest priority for the management of alligator weed in Australia is an effective system of early detection and eradication before infestations become established.



In the past alligator weed was mistaken as a traditional Sri Lankan herb and planted in gardens around Australia.
Photo: Lalith Gunasekera

The success of an early detection and eradication program depends on:

- maintenance of quarantine to prevent further introductions
- enhanced awareness and education to reduce the risk of spread
- the identification and monitoring of high-risk sites
- adherence to weed hygiene protocols (eg not removing material from infestations, carefully washing down equipment after contact with alligator weed)
- coordination between stakeholders and local and state/territory governments.

Some successes with small infestations

Much of this work is ongoing but significant inroads have recently been made. For example, alligator weed was being cultivated in backyards and mistakenly used in traditional Sri Lankan cooking instead of another herb known as 'mukunewenna' or 'pononcarni'. A campaign was initiated to educate the Sri Lankan community about the dangers of alligator weed, to eradicate infestations and to replace it with a less weedy species. In Victoria 784 backyard infestations were identified following an awareness campaign that included newspaper articles, radio segments, leaflets and fridge magnets. By working closely with the Sri Lankan community, the infestations have been controlled via repeated herbicidal treatments. An Australian native species, common joy weed *Alternanthera denticulata*, has been accepted as a suitable replacement.

Don't try and treat alligator weed on your own

The successful control of alligator weed in backyard situations has been achieved using the considerable experience and resources of local councils and state/territory weed management agencies. However, there is still much that is unknown about alligator weed. For example, the effectiveness of different herbicides in different environments is still being examined. For these reasons, and because it can spread so easily from small fragments, you must contact your local council or state/territory weed management agency to help you control alligator weed.



In aquatic situations the hollow stem helps floatation.
Photo: Rebecca Coventry

It is extremely difficult to control alligator weed in aquatic situations

In some aquatic habitats, alligator weed infestations can be reduced with weed harvesters or by manual removal, but small fragments are inevitably left behind or dislodged. These fragments readily create new infestations. Therefore, any living plant material must be very carefully disposed of to prevent further spread.

In water alligator weed can be treated with a registered herbicide. However, this rarely kills the entire plant, which often breaks up into smaller pieces. These smaller pieces can drift downstream and lead to new infestations. Additionally, there are restrictions on the use of herbicides in waterways, including concerns about impacts to non-target plants and the environmental health of waterways.

Therefore, both the chemical and mechanical control of alligator weed in aquatic habitats is extremely difficult and can lead to further downstream infestations.



Alligator weed has an extensive root system when growing on land.
Photo: Graham Prichard

Weed control contacts

State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
NT	Dept of Infrastructure, Planning and Environment	(08) 8999 5511	weedinfo.ipe@nt.gov.au	www.nt.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.tas.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au
Australia wide	Australian Pesticides and Veterinary Medicines Authority	(02) 6272 5852	contact@apvma.gov.au	www.apvma.gov.au

For up-to-date information on which herbicides are registered to control alligator weed and the best application methods and dosages, contact your state or territory weed management agency or local council. This information varies from state to state and from time to time. Contact details are listed above, including contacts for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

When using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed directly onto water.

…and on land

When it grows on land, alligator weed can be controlled with repeated herbicide treatments. The Queensland Department of Natural Resources and Mines suggests three treatments during the growing season, each consisting of two applications separated by one week. Ideally, the last treatment should be undertaken close to the start of winter to target the rhizomes, which would otherwise allow the weed to survive through winter.

However, there are problems in this approach, including concerns about using herbicides near waterways, expense, and the difficulty of targeting alligator weed when other desirable species are also present.

Physical removal is also difficult because of the depth that roots and rhizomes can reach. It is recommended that all weed material be removed to a depth of one metre, and then be disposed of by deep burial. This is obviously a difficult and time-consuming task requiring mechanical assistance.



Flowering alligator weed in paddocks of the Lower Hunter, NSW, in February.
Photo: Mic Julien

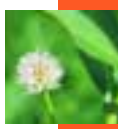


Adult biocontrol agents (the alligator weed flea beetle *Agasicles hygrophila*) feed on leaves and stems.
Photo: Graham Prichard

Biological control can help manage alligator weed

Three insects have been released in Australia to control alligator weed. The aquatic alligator weed flea beetle *Agasicles hygrophila*, has been quite successful in controlling alligator weed growing in the water. It was first released in 1977 in New South Wales. The adults and larvae reduce the growth of alligator weed by feeding on the underside of the leaves and aerial parts of the plant.

Unfortunately, biological control does not yet offer a cure to the alligator weed problem. The flea beetle is only effective in warm, temperate areas that allow it to breed up to high numbers in early summer, and it does not attack alligator weed growing on land. Therefore, the search continues for new biological control agents in alligator weed's native range, particularly for agents to control the weed in cooler climates and when it grows on land.





Mechanical removal of alligator weed requires careful hygiene to prevent the spread of small fragments.
Photo: Brian Worboys

Given the difficulties and expense associated with chemical and mechanical control, biological control agents are an attractive option to tackle alligator weed in the long term. However, biological control is a complex process, requiring success at a number of separate stages. Once identified, suitable agents must be approved for release, reared in captivity and then become established in the field. The hope for future biological control agents must therefore be balanced by the possibility that they may not be available or successful.

Legislation

In all states and territories, landholders are obliged by law to control or eradicate alligator weed and to limit its spread and impacts. Most regions restrict its importation. Check with your local council or state/territory government agency about its requirements for alligator weed control.

Acknowledgments

Information and guide revision: Mic Julien (CSIRO/Weeds CRC), Rebecca Coventry (NSW Dept of Agriculture), Richard Carter (NSW Dept of Agriculture/ Weeds CRC), John Wilson (CSIRO/Weeds CRC), Nimal Chandrasena (Sydney Water), Andrew Storrie (NSW Dept of Agriculture/ Weeds CRC) and John Thorp (National Weeds Management Facilitator).

Maps: Australian Weeds Committee.

...case study

Integrated management of alligator weed in Botany Wetlands in Sydney

Sydney Water provides drinking water and wastewater services to over four million people in the Sydney, Blue Mountains and Illawarra areas, including the Botany Wetlands which are situated within the metropolitan area of Sydney.

The Botany Wetlands are ecologically and aesthetically significant, but are also historically important as they served as a drinking water supply for Sydney in the mid 1800s. Alligator weed was first noted in waterways around 1985, but only occasionally treated with herbicides until the mid 1990s, by which time the infestation was out of control and posed a significant threat to the wetlands.

Sydney Water has since introduced an integrated weed management approach to deal with alligator weed. This combines vigilant and systematic monitoring for any new infestations, with regular application of suitable herbicides for both terrestrial and aquatic infestations and manual removal of floating masses. Other active management strategies include the lowering of water levels to allow better control, the large scale planting of native water plants in treated areas, and the controlled burning of sedges and rushes in selected infested areas. Additionally, in order to minimise environmental damage from chemicals, herbicides are not applied when the biological control agents are most active.

In terms of actual control efforts, herbicides are applied as spot-treatments to persistent patches at monthly intervals during cooler months, and more frequently in the warmer months (September–May). New infestations are treated with herbicides or are removed by hand picking as soon as practicable, with the ultimate aim of preventing further downstream spread. Disposal of collected live plant material is by burial in the sand in selected locations, following drying and herbicide treatment.

It is estimated that, on average, 90–95% of the previous alligator weed infestation has been controlled and removed since the adoption of the new integrated management plan in 1997. Although this is a relatively successful result, the inability to completely eradicate the weed from the wetlands reflects its resilience to current control measures and its ability to spread even when being carefully managed. It must also be recognised that the current gains made on alligator weed in the Botany Wetlands have been achieved through diligent and committed action, continual assessment, persistent management intervention and investment of labour and other resources.



Impacts of alligator weed include flooding due to blocked drains.
Photo: Rebecca Coventry



How to control alligator weed

Quick reference guide

Preventing spread

The main aim of alligator weed management in Australia is to prevent its spread from core infestations into new areas by:

- preventing new plant material entering Australia
- using weed hygiene protocols, such as washing contaminated equipment
- educating people to recognise it and respond to outbreaks.

The importance of monitoring

Early detection offers the only likelihood of finding infestations that are small enough to hope to eradicate. Monitoring of likely areas is therefore crucial to successful alligator weed management.

The limitations of current control techniques

Available management techniques for controlling alligator weed include:

- mechanical (eg weed harvesters in water bodies)
- physical (eg digging all material out to a depth of one metre)
- chemical (several herbicides registered for use on land or water)
- biological (eg the flea beetle attacks alligator weed growing in water).

Unfortunately each of these techniques has its limitations. Mechanical, physical and chemical control can all leave small fragments behind and actually increase the spread of alligator weed. These techniques therefore require a great deal of care and should only be conducted with the assistance of experts.

Other issues with these techniques include expense, the intensity of work required (eg spraying land infestations requires three treatments of two sprayings each), concern over residual herbicides in and around waterways and effects on non-target plants and animals, the difficulty of disposing of collected material and the need for continual follow-up work.



This simple screen has effectively prevented the spread of alligator weed into nearby wetlands. Photo: Graham Prichard



Control options

Type of infestation	Best way to control
Backyard infestations	Backyard infestations should be reported to your local council or state/territory weed management agency. Herbicides have been used successfully in different regions, but will require many repeated treatments. Care must be taken to prevent the spread of weed through fragments escaping from the garden.
In a waterway	Alligator weed in waterways should be reported to your local council or state/territory weed management agency. Herbicides are most effective when above water vegetation is greatest. Manual or mechanical removal may also be possible. If not already present, flea beetles should be introduced. Integration of all of these techniques will ultimately provide the best results.
On land	Alligator weed on land should be reported to your local council or state/territory weed management agency. Effective herbicides are available; however, treatments must be repeated frequently during the growing season. Biological control does not yet impact on land infestations, but other management techniques such as revegetation or physical removal are useful.

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CRC Weed management

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Blackberry

Invasive Species Unit

Introduction

Recognised as one of the worst weeds in Australia, blackberry was declared a Weed of National Significance (WoNS) in 1999. Blackberries belong to a large genus (group of species) called *Rubus* which includes other berry plants such as raspberries (*R. idaeus*), dewberries (*R. roribaccus*), and loganberries (*R. loganobaccus*).

In NSW the group of blackberries that are considered to be noxious weeds are referred to as the *Rubus fruticosus* aggregate (*R. fruticosus* agg.) or, commonly, as European blackberries.

Currently there are 16 species in the *R. fruticosus* aggregate that occur in Australia, with the following nine species occurring in NSW:

- *R. anglocandicans*
- *R. leucostachys*
- *R. polyanthemus*
- *R. laciniatus*
- *R. ulmifolius var. ulmifolius*
- *R. ulmifolius var. anoplothyrsus*
- *R. vestitus*
- *R. leightonii*
- *R. phaeocarpus*



Figure 1: Blackberries are semi-deciduous, scrambling shrubs that form dense thickets.

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There are a number of other introduced weedy *Rubus* species that are often referred to as blackberry but are not declared noxious in NSW, including:

- *R. laudatus*
- *R. philadelphicus*
- *R. roribaccus* (dewberry, youngberry, boysenberry)
- *R. loganobaccus* (loganberry)
- *R. ellipticus* (yellow Himalayan raspberry)
- *R. rugosus* (keriberry)
- *R. niveus*
- *R. idaeus* (raspberry)

There are also a number of native *Rubus* species in Australia, with *R. pavifolius* growing most commonly in association with *R. fruticosus* agg. species.

This Primefact provides information specific to the *R. fruticosus* aggregate in NSW.

Habitat and distribution

Blackberry infests about 9 million hectares of land in Australia. It is mostly restricted to areas with temperate climates (warm summers, cool winters) with an annual rainfall of at least 700 mm (regardless of altitude), but plants can grow in lower rainfall areas when other environmental conditions are favourable (such as along the banks of watercourses).

The *R. fruticosus* agg. has probably reached its climatic limit of distribution; however, individual species in the aggregate may not have done so. The *R. fruticosus* agg. species in NSW currently occur in the following distribution:

- *R. anglocandicans* – most common species occurring in all wetter areas of the state
- *R. leucostachys* – widespread
- *R. polyanthemus* – recorded in Kosciuzsko National Park
- *R. laciniatus* – recorded in wetter areas of the state
- *R. ulmifolius* var. *ulmifolius* – widespread
- *R. ulmifolius* var. *anoplothyrsus* – possibly present in NSW
- *R. vestitus* – recorded but not common
- *R. leightonii* – recorded
- *R. phaeocarpus* – Kowmung River area

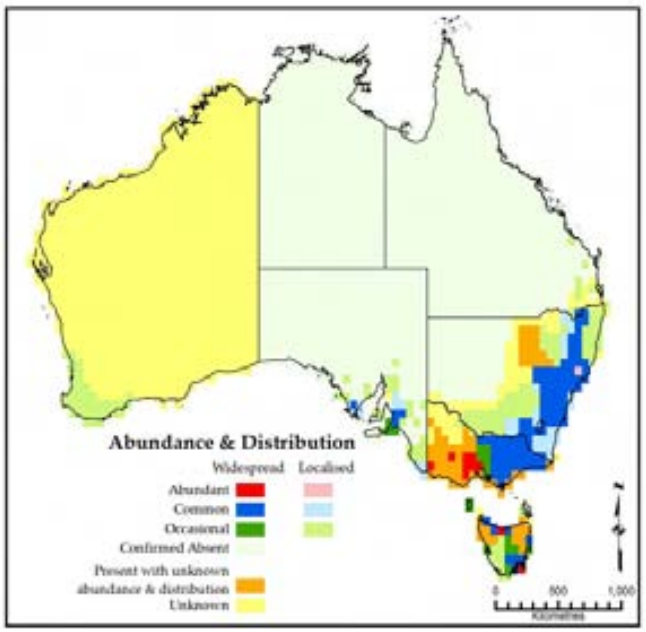


Figure 2: Distribution of the R. fruticosus *agg.*

Impact

Blackberry grows vigorously and can infest large areas quickly. Negative impacts include:

- reduced available grazing land (most livestock find blackberry unpalatable) and restricted livestock access to water (when growing densely around waterbodies)
- reduced productivity of land caused by shading out of pastures and crops, and competition for soil moisture and nutrients
- problems in forestry such as the prevention of regeneration of hardwood forests and reduced capacity of plantation softwood and hardwood seedlings to establish and grow. Thickets of blackberry also hinder access for forest operations
- degradation of natural environments by displacing native plants and reducing habitat for native animals
- devaluation of visual and recreational aspects of public land, parks and reserves
- provision of harbour for vermin such as rabbits and foxes, and seasonal food for exotic animals such as starlings, blackbirds and foxes. These pest species also disperse blackberry seed, acting as vectors that spread blackberry infestations
- increased fire hazard caused by dead blackberry material and obstruction of access to fire trails and water for controlling fires.

On the positive side, blackberry produces:

- fruit (berries) which is favoured by many people and which can be eaten fresh, or used in cooking and preserves
- blackberry flowers which produce nectar for bees to make honey
- leaves that can be used to make herbal teas, medicinal products for chest ailments, and astringents for skin care
- food and protection from predators for a number of native animals and birds, such as bandicoots and blue wrens.

Blackberry has been estimated to result in a loss of production and cost of control of between $95.1 million and $102.8 million in Australia. In comparison, the aggregated benefits of blackberry have been estimated to be approximately $1.5 million per annum, indicating that the negative impacts of blackberry vastly outweigh the positive impacts (CRC, 2006).

Description

Blackberries are semi-deciduous, scrambling shrubs with tangled, prickly stems that form impenetrable thickets several metres high.

Due to a large amount of variation between species, the best way to correctly identify a blackberry species is to send samples to a herbarium. The best time to collect samples for herbarium identification is when the plant is flowering. Include segments of both the primocane (first year cane) and the floricane (flowering cane) (see Figure 3). Keep one specimen for reference and send two to the herbarium. For more information on collecting samples see the Primefact *Collecting and preparing plant specimens for identification* and the *Blackberry Control Manual* (see 'Publications available' below), or contact your local weeds officer.

Root system

The root system is the perennial part of the plant. It comprises a woody crown that can grow up to 20 cm wide with a main root that can grow to a depth of 4 m. Secondary roots grow horizontally from the crown for 30-60 cm, then grow down and shoot thin roots in all directions.

Stems

Stems are known as canes and can grow up to 7 m long. They can be erect, semi-erect, arched or trailing. With the exception of *R. ulmifolius* var. *anoplothyrsus*, the canes are covered in sharp prickles. Canes generally live for two years

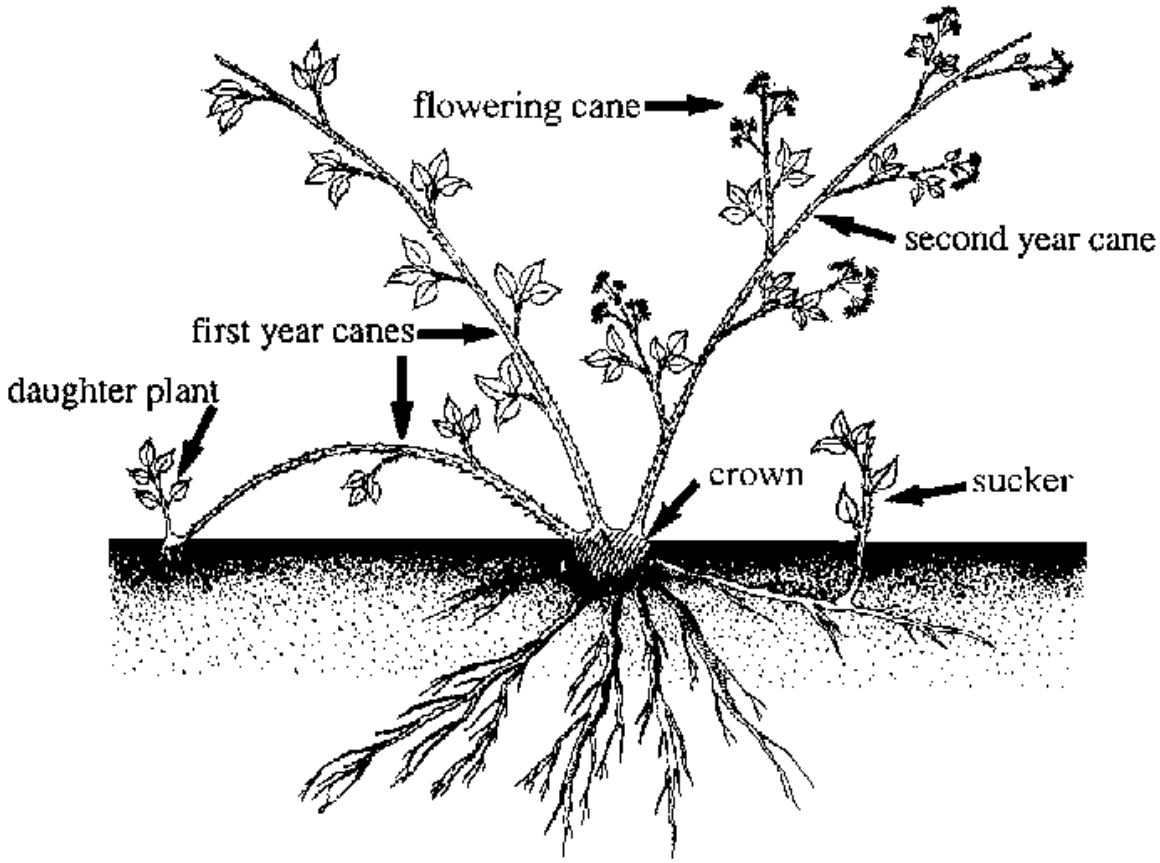


Figure 3. Growth pattern of the R. fruiticosus *aggregate.*

(biennial) but may live for longer. They may be green, purplish or red depending on their exposure to light. The first year canes (primocanes) root where they touch the ground, producing a daughter plant. In their second year, primocanes form buds which sprout in spring to produce short canes (floricanes) that terminate in a branched cluster (panicle) of flowers and fruit.

Leaves

Leaves generally occur alternately along canes, are compound (with three to five leaflets), and are dark green on top with a lighter green underside. Leaflet veins and stalks are covered with short, curved prickles. Most leaves shed from the canes during winter except in warmer climates.



Figure 4: Leaves are compound (three to five leaflets,) light green on the underside and dark green on top.

Flowers

White or pink flowers 2-3 cm in diameter occur at the end of floricanes from late November to late February. Clusters of flowers are either cylinder or pyramid-shaped, and may change colour between budding and opening depending on the species.



*Figure 5: Blackberry flower (*R. anglocandicans*).*

Fruit and seeds

Berries (fruit) are 1-3 cm in diameter, and occur from late December to April, changing colour from green to red to black as they mature. Each berry consists of a number of fleshy segments (druplets), and each druplet holds one seed.



*Figure 6: Blackberry fruit (berry), showing druplets (*R. anglocandicans*).*

Lifecycle reproduction and spread

All blackberries can reproduce both vegetatively and by seed. The following describes these two methods of reproduction for the *R. fruticosus* agg.

Reproduction by seed

Apart from *R. ulmifolius*, the *R. fruticosus* agg. species are opomictic plants; that is, the plant's embryo is stimulated but not fertilised by pollen, producing a clone. Where hybridisation occurs, one parent is likely to be the sexually reproducing *R. ulmifolius.* Each berry can contain from 20 to 30 seeds. At the end of the blackberry season, there may be up to 13,000 seeds/m^2 under a blackberry bush. Plants in dense shade will produce fewer seeds than those in open areas. Seedling survival rate is also considerably lower in shaded areas compared to areas with full sun.

Vegetative reproduction

Where the tips of the primocanes touch the ground, roots may sprout in autumn and become new plants. These 'daughter plants' will then produce a primocane in the following spring. When the second year primocanes die, the daughter plant continues as an independent plant. *R. fruticosus* agg. species can also produce sucker plants and can reproduce from root fragments and other plant parts.

Birds, mammals (including foxes and humans), water and contaminated soil can all act as vectors for blackberry seeds, sometimes spreading them a long way from the mother plant.

Management and control

Detailed information about the control and management of blackberry is provided in the Blackberry Control Manual (see 'Publications available' below).

Maintaining control of blackberry is an ongoing process. It cannot be achieved with a one-off effort, especially with larger infestations. The best way to manage blackberry is to develop a plan that details the factors to be considered, the control methods to be used, and the monitoring and rehabilitation regimes to be implemented. Develop a management plan using the following steps:

- Step 1 – Assess the problem (likely impacts of control methods; characteristics of infestation such as size, density, access); record the assessment on a topographic map; take photographs of the infestation.
- Step 2 - Prioritise the areas for management; set up treatment zones (see Table 1 below); note where the infestation appears to have come from.
- Step 3 – Develop the management plan; set a short term (first year), medium term (2-3 years) and long term (5 years) goal for each action; choose appropriate control methods; allocate financial resources and time for control as well as for follow-up and monitoring.
- Step 4 – Implement the plan; monitor, record, re-treat, rehabilitate; keep records and review progress.

Table 1 – Treatment zones for prioritising blackberry control.

Zone	Characteristics	Actions
Exclusion zone	Area free of blackberry	Monitor and eradicate new plants
Eradication zone	A few well-defined thickets	Eradicate infestations Monitor for new plants and eradicate
Containment zone	A few large well-defined infestations with outlying thickets	Start control where spread is most rapid Work from outer edges in Control to prevent reproduction Protect high value assets
Protection zone	Infestations widespread and scattered	Control to reduce impacts and prevent spread

Herbicides

Herbicides are the most reliable method for achieving local eradication of blackberry. For best results they should be used in combination with other control methods. A number of herbicides are registered for use on blackberry, each with advantages and disadvantages. Table 2 below briefly summarises some of these. See the Noxious & Environmental Weed Control Handbook for a complete list of herbicides registered for blackberry control in NSW (see *Publications available* below).

Table 2 – Herbicides for blackberry control

Herbicide (active ingredient)	Characteristics
Metsulfuron-methyl	Absorbed through foliage and root system; recommended for initial treatment of large, dense infestations
Glyphosate	Absorbed through foliage; recommended for small infestations that are easy to check and re-treat and areas where other herbicides cannot be used, such as in or near watercourses
Triclopyr	Absorbed mostly through foliage; recommended for initial treatment of large infestations
Picloram	Absorbed through foliage and roots; persistent in the soil; useful where pellet formulations are considered the most appropriate technique
Picloram + Triclopyr** **with or without aminopyralid	Recommended for most infestations, both large and small; usually provides highest levels of control

Consider the following when selecting a herbicide for blackberry control:

- proximity of the site to water – this affects the choice of registered herbicides
- selectivity of the herbicide – it is usually best to retain desirable vegetation and groundcover where possible
- cost of herbicides - at their highest application rates, the relative costs of the afore-mentioned herbicides from lowest to highest is: metsulfuron-methyl; triclopyr; picloram; glyphosate; picloram + triclopyr
- level of control - experience has shown that a mixture of triclopyr + picloram used with or without aminopyralid will give the greatest long-term control
- application costs – for large infestations the cost of treatment is often underestimated. The costs of retreatment also need to be considered.

The success of any herbicide application will depend on:

- variation in herbicide application – large bushes are commonly under-sprayed. Foliar treatments must ensure that the inner leaves and canes of bushes are sufficiently wetted along with the outer canopy
- seasonal timing of application – optimal time for treatment is during the active growth stage from flowering to fruiting (usually December to March). Translocated herbicides applied in autumn can achieve better kill rates as long as the plants are actively growing
- the condition of the plant being treated – plants must be free of moisture stress or disease. Check that tips of canes have new, soft leaves
- weather conditions at the time of treatment – temperatures over 30^{o}C can cause heat stress to plants, limiting uptake of herbicide, particularly when humidity is also high
- the age of the plant – plants in their first year of growth are easier to kill with herbicides. Old, well-established thickets may require a number of treatments. At least 1 m of growth on canes is required for successful treatment
- pre-control activities (e.g. slashing or burning) – after slashing or burning ensure enough regrowth, prior to herbicide applications
- the species of blackberry – some species are more resistant to certain herbicides than others. Correct identification of the species and monitoring the results of the treatment are critical for successful control
- the quality of the water used to mix herbicide – pH, water hardness and dirty water can all affect the results of a herbicide treatment. Use the best quality water available.

There are various ways of applying herbicides to blackberry infestations, depending on the size of the infestations and other aspects such as accessibility and proximity to waterways. For detailed information on selecting and applying herbicides for blackberry control, see the Blackberry Control Manual (see 'Publications available' below).

Physical control

Physical control alone is rarely successful because of the root structure of blackberry. These techniques are best used in combination with herbicides. The various methods of physical control are:

- hand removal of top growth and digging up of roots - this method may be suitable for small and isolated infestations. Combining hand removal with cut stump herbicide application gives better results
- mechanical grubbing and scalping - this method can be successful if the hoe or root rake completely removes the plant, including all roots
- cultivation of the ground - because blackberry can reproduce vegetatively as well as sucker, cultivation can simply spread blackberry. However this method may be suitable if it is carried out frequently enough
- using earthmoving equipment or slashing - this method is unlikely to remove root material and may even promote growth but can be useful to gain initial access to heavy infestations for further treatments.

Biological control

Biological control methods use natural enemies of blackberry to suppress and weaken plants. Currently the only deliberately released biological control agent in Australia is the leaf rust fungus *Phragmidium violaceum*. The fungus is only effective on the *R. fruticosus* agg., attacking the leaves and causing defoliation. It also infects flower buds and unripe fruit. The tips of infected canes die back, preventing the production of daughter plants. Overall the fungus reduces a plant's ability to grow and reproduce.

Phragmidium violaceum spores need dew, rain or high humidity to germinate. It is most effective when most of the plant's canopy is young leaves, in areas where annual rainfall is greater than 750 mm and evenly spread over the year, and where January temperatures average about 20ºC.

There is currently an active program of releasing *Phragmidium violaceum* into new areas, as well as trialling other strains of fungus to specifically target other species of blackberry.



Figure 7: Blackberry leaf rust fungus. Heavily infected leaves turn brown, shrivel and fall from canes.

Grazing

Goats preferentially graze blackberry over improved pasture species. They may be useful as an initial control to reduce heavy infestations but follow-up treatment will be required after the goats are removed. The Meat & Livestock Australia publication *Weed Control Using Goats: a guide to using goats for weed control in pastures* provides useful information on the use of goats (see 'Publications available' below).

Cattle will not control blackberry infestations but will reduce tip rooting and the establishment of daughter plants.

Sheep graze blackberry seedlings depending on availability of other (more palatable) feed.

Pasture management

Pasture management or re-establishment can be an important component of a management program. Strong, actively growing pasture will help to prevent invasion from weeds.

Burning

Burning will not kill blackberry but it can be used to make infestations more accessible for follow-up treatment. Always allow sufficient regrowth before applying follow-up herbicide treatments.

Legislation

In NSW, all *R. fruticosus* agg. species are declared Class 4 weeds under the *Noxious Weeds Act 1993* (NSW).

As a Class 4 weed, the growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority, and the plant may not be sold, propagated or knowingly distributed.

All species in the *R. fruticosus* agg. (European blackberry) are banned from sale in Australia, and are prohibited entry to Australia. There are, however, a number of cultivars that can still be sold including Black Satin, Chehalem, Chester Thornless, Dirksen Thornless, Loch Ness, Murrindindi, Silvan, Smoothstem and Thornfree.

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Images

Figure 1. Bruce Auld

Figure 2. Australian Government National Land and Water Resources Audit (2009)

Figure 3. Birgitte Verbeek

Figure 4. Birgitte Verbeek

Figure 5. Alyssa Fitzgerald

Figure 6. Bruzzese and Lane (1996)

Figure 7. Courtesy of CSIRO Entomology

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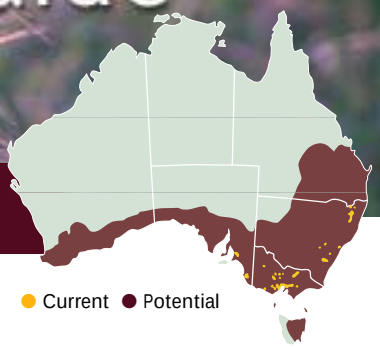
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Weed Management Guide

Chilean needle grass
Nassella neesiana



Chilean needle grass (*Nassella neesiana*)

The problem

Chilean needle grass is a *Weed of National Significance*. It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts. It is closely related to another *Weed of National Significance*, serrated tussock (*Nassella trichotoma*).

Chilean needle grass affects both sown pasture and native grasslands of southeastern Australia. It is relatively unpalatable and reduces farm productivity by displacing more desirable pasture species. Heavy infestations can decrease productivity by as much as 50% during summer. It also causes injury to stock and downgrades wool, skins and hides with its long, sharp seeds.

As an environmental weed it reduces biodiversity in native grasslands, where it outcompetes indigenous species.

A survey of landholders in Victoria, New South Wales and the Australian Capital Territory estimated the average annual cost of controlling Chilean needle grass was between $60 and $120 per ha, depending on whether the infestation was scattered or dense.

The weed

Chilean needle grass, named for its sharp, pointed seeds, is a perennial tussock-forming grass which grows in dense clumps. Without grazing it can grow to 1 m in height. An unusual feature of the grass is that, in addition to normal flower seeds, it produces hidden seeds which are formed in the nodes and bases of the flowering stems. These 'stem seeds' are self-fertilised and account for about one-quarter of total seed production. They enable the plant to reproduce despite grazing, slashing and fire.

The flowering seed heads are a distinctive purplish colour and the seeds are very sharp at the point.

The seedlings grow quite slowly but have a very high survival rate and can produce flowers in their first season. The adult plant is long-lived and very hardy. Its leaves are 1–5 mm wide, flat and strongly ribbed on their upper surface, with leaf edges that are rough to touch.



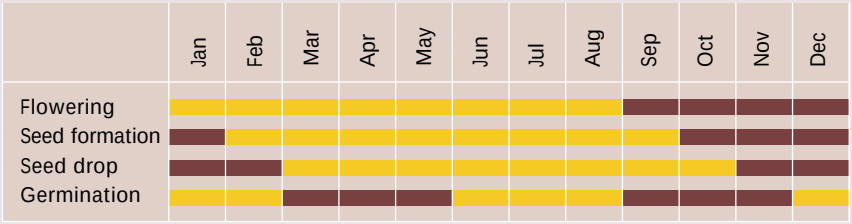
Heavy Chilean needle grass infestations can reduce pasture productivity by up to 50%, contaminate produce and cause injury to stock.
Photo: DPI Vic

Key points

- Chilean needle grass is highly invasive in native grasslands.
- It builds up a large and persistent seedbank in the soil.
- Rehabilitation of infested land is very difficult.
- If you are not sure about the identification of a plant, have the specimen identified by a herbarium, local agronomist or weeds officer.
- Chemical application alone will not control Chilean needle grass.
- For best results, combine herbicide application with physical removal, crop rotation, pasture sowing and grazing management.

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Growth calendar



Chilean needle grass flowers mainly from September to December but it can potentially flower year round. Seed is formed about one month after flowering and most seed has been dropped by February. Seeds mainly germinate in autumn and spring, but germination can occur at other times of the year given adequate moisture and suitable temperature.



Chilean needle grass occurs in disturbed areas such as pastures and roadsides, and in native grasslands.
Photo: Steve Smithyman

How it spreads

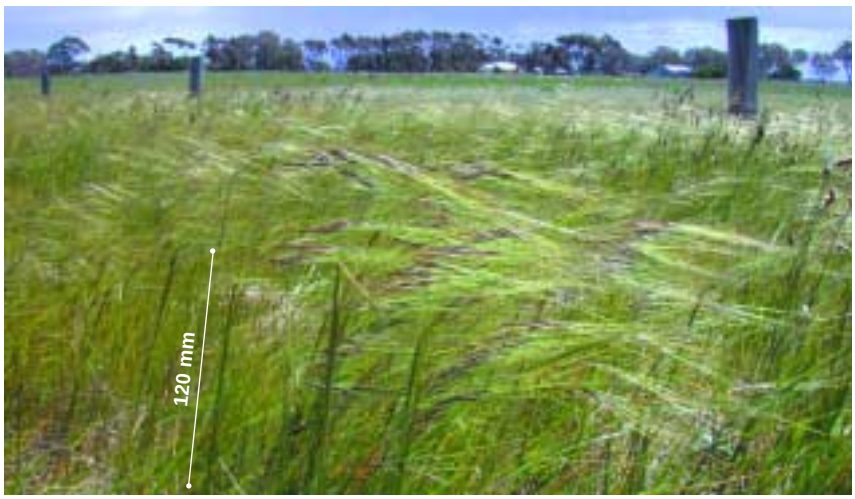
Depending on the availability of moisture, Chilean needle grass can produce more than 20,000 seeds per square metre. The resulting seedbank can persist for many years even if further seed input is prevented. The seeds are very effectively spread attached to farm machinery, clothing or livestock. Seed has also been spread along roadsides and other grassy areas by the use of mowing and earthmoving equipment. Floodwater will move seed downstream.

Chilean needle grass is a South American species. Although it was first identified in Australia in 1934, it appears to have spread very slowly until the late 1970s and has only recently been recognised as a serious weed.

Where it grows

In Australia, Chilean needle grass grows in temperate regions with annual rainfall greater than 500 mm. It can thrive in a wide range of soils and conditions and has the potential to be very invasive over a large part of the country in both pasture and native vegetation. It tolerates drought and heavy grazing.

Its known range extends from the Northern Tablelands of New South Wales, along the Great Dividing Range and through Victoria to southeastern South Australia. It is well established in large areas of New South Wales, the Australian Capital Territory and Victoria. Isolated infestations have been recorded in South Australia, southern Tasmania and the Darling Downs Region of southern Queensland.



Chilean needle grass mainly flowers from November to February but under certain conditions it can also flower at other times.
Photo: Donna Smithyman

Although Chilean needle grass occurs mainly in pastures and grassy woodlands, on roadsides, and along creeks and rivers, it is increasingly invading native grasslands.

Potential distribution

Chilean needle grass could expand its range and invade grasslands throughout much of southern and southeastern Australia. Based on climate, it could spread further in areas such as southeastern Queensland and into new areas such as southwestern Western Australia.

What to do about it

Once a paddock has developed a high level of infestation with Chilean needle grass, the large and persistent seedbank will make management difficult. Small, newly established infestations may be controlled with a great deal of persistence.

Chilean needle grass is extremely vigorous and competitive. Land managers need to know how to identify it and take prompt action if it is discovered.

Management options in established infestations will depend on land use and may include crop rotation, pasture sowing, herbicide control and grazing management. For best results a combination of options needs to be used.

The aim is to minimise Chilean needle grass in pasture by creating conditions that hinder its growth and reduce the soil seedbank. It needs bare ground to establish so it is most important to maintain a cover of competitive perennial pasture.

Check with local contacts for advice on herbicides

Although no herbicides are registered for Chilean needle grass control in Australia yet, herbicide use under permit is allowed in New South Wales. Check with weed control contacts (see table, p. 4), local councils or the Australian Pesticides and Veterinary Medicines Authority for details of current herbicides.

A drawback of herbicide control is that it may also kill desirable species and leave bare ground where seed reserves of Chilean needle grass will germinate. If there are only a few plants, it is probably better to remove them by hand than to create a bare area with spot spraying.

Use short duration, high intensity grazing

Chilean needle grass can produce good feed in its vegetative state during winter, but is less palatable once it flowers in summer.

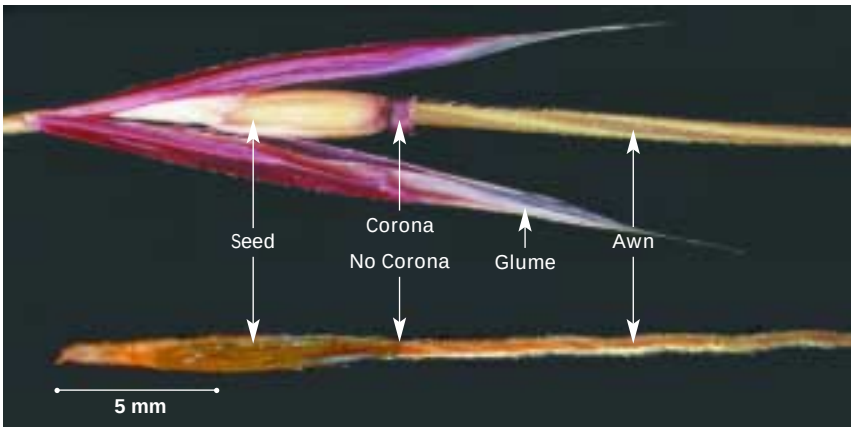
In well-established and large infestations, grazing strategies aimed at making Chilean needle grass a more productive component of pastures and reducing its abundance are the only practical alternatives. Short duration, high intensity grazing, followed by long rest periods designed to favour faster growing competing grasses, may achieve this end. This will help the faster growing desirable species such as fescue to slow the growth of Chilean needle grass through shading and competition for moisture.

Regular paddock inspection and appropriate action to eliminate newly emerged plants are vital to maintaining clean areas.

Making paddocks smaller and increasing mob sizes involves a greater capital outlay for fencing and watering points and a change to the way stock are handled. It also requires spending more time in decision making/management when compared with traditional low intensity set stocking. However, the benefits are better pasture, fewer weeds and better livestock returns.



Hand weeding or chipping is effective on small patches but plants cannot be left to dry out in the paddock because of the basal and stem seeds.
Photo: Kate Blood



The seeds of Chilean needle grass (*top*) have a raised crown (corona) between the body of the seed and the awn or 'tail' of the seed. The seeds of native spear grasses (*Austrotipa* species, *bottom*) are similar except that they lack the corona. Note, the outer glume of the native spear grass has been removed.
Photo: DPI Vic

Look-alike species of grasses

Chilean needle grass is similar in appearance to the native spear grasses (*Austrostipa* species). They all have sharp seeds with a long curved or bent awn and hairy tip, and may appear red before drying to a straw colour. The most distinctive feature of Chilean needle grass seed is the corona at the join of the seed body and the seed awn.

Before flowering, green leafy plants of Chilean needle grass can be mistaken for many other winter green species, especially *Austrodanthonia* and *Festuca*. If you look closely, you can see hairs along the leaf surface of Chilean needle grass, in contrast with the hairless leaves of fescue. Chilean needle grass also has a small tuft of hairs at the junction of the leaf blade and the leaf sheath which fescue does not have. The leaves of Chilean needle grass are much coarser and wider than those of *Austrodanthonia*.

Weed control contacts

State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.tas.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au
Australia wide	Australian Pesticides and Veterinary Medicines Authority	(02) 6272 5852	contact@apvma.gov.au	www.apvma.gov.au

For up-to-date information on which herbicides are registered to control Chilean needle grass and the best application methods and dosages, contact your state or territory weed management agency or local council. This information varies from state to state and from time to time. Contact details are listed above, including contacts for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

When using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed on riverbanks.



Chilean needle grass is highly invasive and tolerates drought and heavy grazing.
Photo: Weeds CRC

Rotational cropping

On arable land, planting crops may help control Chilean needle grass. Where ploughing is possible, planting a sequence of fodder crops for a number of years may reduce the seedbank. Summer grain cropping can also be used. With any of the cropping programs it is vital to ensure, by using either chemical control or cultivation, that any Chilean needle grass seedlings are prevented from flowering.



Slashing may reduce seed set in the flower heads but it can actively disperse stem seeds if machinery is not kept clean.
Photo: DPI Vic

Physical control is suited to small infestations

Hand weeding or chipping is very effective on single plants or small patches. Plants cannot be left to dry in the paddock because of the basal and stem seeds. The whole plant needs to be destroyed.

Slashing may reduce seed set in the flower heads but it can actively disperse stem seeds if machinery is not kept clean.

Mowing with a catcher mower during flowering will reduce set seed but, once again, it will not remove the basal and stem seeds. Clippings must be burnt and the mower must be thoroughly cleaned before it is used anywhere else.

A biological control program has recently commenced

A biological control program has identified agents in the countries of origin of Chilean needle grass that attack the weed. Research on the rust fungus *Puccinia nassellae* is being conducted in Argentina to ensure that it is safe and will not attack any other species if released in Australia. It may prove to be the first successful biocontrol program of a perennial grass anywhere in the world.



...case study

Rotational grazing at Ashley Park, NSW Northern Tablelands

Adopting management practices that encourage competitive plant species is an effective way to control weeds in grazing situations. A rotational grazing trial has been conducted by Dr Mark Gardener and A/Prof Wal Whalley of the University of New England at the 'Ashley Park' property near Glen Innes on the New South Wales Northern Tablelands. The results of the trial show that strategic grazing management can encourage desirable perennial grasses in pasture densely infested with Chilean needle grass.

Taking advantage of the relatively slow growth rate of Chilean needle grass, the researchers and the landholder used rotational grazing (grazing at high stocking rates over short periods of time) to heavily graze the pasture and give the faster-growing perennial grasses an advantage during the subsequent rest periods.

The estimated contribution by dry weight of Chilean needle grass in the spring fell from 55% to about 30%, with a corresponding increase in other perennial grasses such as cocksfoot, tall fescue and paspalum.

The Chilean needle grass changed from rank, unpalatable tussocks to a shorter, green and apparently more acceptable grass. The pasture was no longer completely dominated by Chilean needle grass but included a higher proportion of palatable exotic grasses, particularly cocksfoot and tall fescue.

Previous attempts to control Chilean needle grass on the property using herbicides, cultivation and pasture establishment had failed because of the weed's large and persistent seedbank.



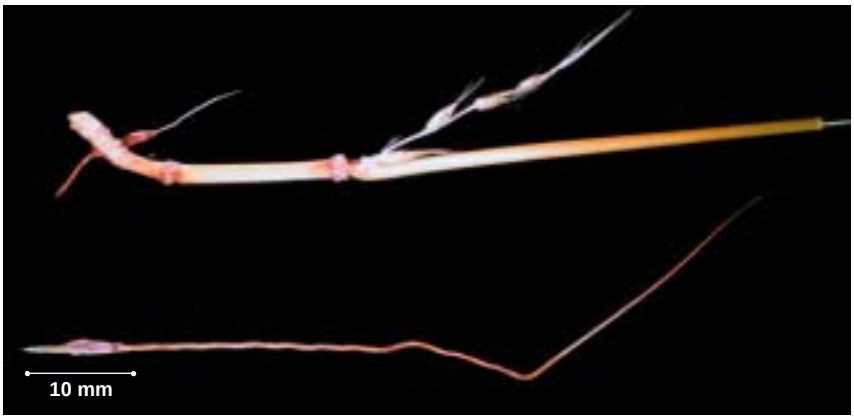
Preventing seed movement to uninfested areas

Movement of stock, machinery and forage contaminated with seed are the main ways by which Chilean needle grass is spread. Cleaning of plant, equipment and material are very important in preventing further spread, as is controlling the movement of livestock from infested to clean areas. Stopping seed movement within the property is also important. Check machinery (including the interior of the vehicle) moving onto your property and drive visitors around in your own vehicle. Always wash down vehicles and machinery in the same area to allow easy follow-up control of any seeds that may germinate. Ensure that service provider vehicles (eg telephone, electricity, gas) are free of Chilean needle grass seed.

When you are buying hay, stock feed, and crop and pasture seed, make enquiries about where it was produced to ensure it did not come from areas known to be infested with Chilean needle grass. Feed stock in the same areas to minimise the risk of seed spread and to limit the area requiring control.

Control in native grasslands

Chilean needle grass is a difficult weed to manage in native grasslands. To minimise damage to native vegetation, early detection is essential and careful physical removal of isolated plants is recommended. Revegetation with indigenous species is needed to prevent reinfestation. Larger infestations need to be contained using a combination of available methods to minimise the spread of Chilean needle grass into native grasslands.



The stem seeds (*top*) are located at the nodes (or joins) on the stems and at the base of the flowering stems. They are normally concealed by the leaf sheath, which has been removed in this instance. A normal flower seed (*bottom*) is sharp, with a hairy tip and a long curved or bent awn.
Photo: DPI Vic

Legislation

Chilean needle grass is a prohibited species under the *Quarantine Act 1908* and is therefore not allowed to be brought into or sold in Australia. Few regions have declared it as a noxious weed, as enforcement would be difficult. It is declared as a pest plant in the Australian Capital Territory and parts of New South Wales, meaning that landholders are required to control it.

Acknowledgments

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Maps: David McLaren (DPI Vic/ Weeds CRC).



How to control Chilean needle grass

Quick reference guide

Chilean needle grass – *Nassella neesiana*

Preventing new infestations

Maintaining weed-free machinery and equipment is very important in preventing further spread of Chilean needle grass. Check machinery moving onto your property and wash down vehicles and machinery in the same area to allow easy follow-up control of any seeds that may germinate. Don't buy hay, stock feed, or crop and pasture seed from infested areas.

In pasture

When there are only a few plants, remove them by hand weeding rather than spot spraying to prevent creating a bare area.

The use of smaller paddocks and larger mobs offers the benefit of better pasture, fewer weeds and better livestock returns.

On arable land

Control may be achieved using an integrated approach involving rotational cropping and a mix of cultivation and herbicide application to prevent seeding.



The flowering seed heads of Chilean needle grass are a distinctive purplish colour.
Photo: DPI Vic

Control options

Type of infestation	Chemical	Grazing management	Physical	Rotational cropping
Small infestation in pasture	Spot spray with registered herbicide.	Maintain good pasture cover by carefully managing pasture and not overgrazing.	Remove by hand weeding or chipping; whole plant needs to be removed.	Not suitable.
Well-established and large infestations in pasture	Not suitable.	Use short duration, high intensity grazing followed by long rest periods.	Mowing will reduce seed set but will not remove stem seeds.	Not suitable.
Arable land, moderate to heavy infestation	Not suitable.	Not suitable.	Not suitable.	Plant crops, and use chemical control or cultivation to ensure that seedlings do not flower.

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National Chilean Needle Grass Taskforce

CRC Weed management

Disclaimer

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Chilean needle grass

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BACKGROUND

Chilean needle grass (*Nassella neesiana* formerly *Stipa neesiana*) is a serious weed on the Northern Tablelands and north-west slopes of New South Wales. According to records at the National Herbarium, it was first identified in NSW during the early 1940s in the Glen Innes region.

It is thought to have spread very slowly until the late 1970s. Identifications of this species from the Guyra - Glen Innes area since the mid 1970's have increased indicating its ability to spread. In 1996 a major infestation was identified near Tamworth in the Reedy Creek catchment. Chilean needle grass is also well established on the Southern Tablelands and southwest slopes of NSW and in southern and central Victoria.

Chilean needle grass is a native of South America occurring in Argentina, Uruguay, Chile and Brazil. It has become naturalised in New Zealand, South Africa and several European countries. In Australia, Chilean needle grass is considered a weed because it is very invasive and is less productive/lower quality than introduced pasture, causing a reduction of carrying capacity.

WHY IS IT SO SUCCESSFUL?

Research on the Northern Tablelands of NSW by the University of New England has shown that the main reason for the success of Chilean needle grass is its large, long-lived reserve of viable seed in the soil seed bank. This seed bank can persist for many years even if further seed input is prevented. It is a prolific seeder, with the potential to produce more than 20,000 seeds per square metre in a good season. It also has hidden seeds under the leaf sheaths at each of the nodes on the flowering stems that mature even if the seed head has been removed.

Chilean needle grass germinates in autumn and spring and at other times of the year given adequate moisture and temperature. Its main requirement for establishment is bare ground that can be created by over grazing or indiscriminate herbicide application. The seedling grows quite slowly but has a very high survival rate and can produce flowers in the first season. The adult plant is long-lived and very hardy, surviving heavy grazing and drought.

Seed heads emerge during late spring, and when mature have a very distinctive purplish colour. The individual seeds are very sharp at the apex (hence the name) as shown in Figure 1. By late February, most of the seed has been shed from the plant and can be found on the ground. Wind dispersal of seed appears to be almost negligible. Most of the spread is by attachment to animals (both domestic and wildlife) or machinery, particularly motor vehicles. The backward pointing hairs on the apex of the seed anchor firmly in the wool of sheep. These seeds may fall from the fleece several months later, spreading the seed to new regions. Sometimes, Chilean needle grass seed will penetrate the skin of sheep reducing their hide value and may irritate individual animals.

IDENTIFICATION

Chilean needle grass appears very similar to the native spear grasses (*Austrostipa* spp.). The most diagnostic feature of Chilean needle grass (and only found in this species) is the corona — a raised crown of small teeth, at the junction



Figure 1. Seedhead (L) and seed showing bent awns (R) of Chilean needle grass. Photos: A Storrie

of the seed body and the seed awn. The awn twists when dry and often has two bends in it.

Vegetative (green leafy) plants of Chilean needle grass can be mistaken for many other winter green species, especially *Danthonia* and fescue. Close examination reveals the presence of hairs along the leaf surface of Chilean needle grass by contrast with the hairless leaves of fescue and the much coarser feel of needle grass leaves compared with *Danthonia*. Chilean needle grass also has a small tuft of hairs at the junction of the leaf blade and the leaf sheath, which most other grasses do not have.

Chilean needle grass forms a robust tussock but is variable and not as clumpy as *Poa* or many *Eragrostis* species.

MANAGEMENT METHODS

Once established in an area and allowed to set seed, it is unlikely Chilean needle grass can be eradicated. This is because established populations have a persistent seed bank that will enable reinfestation even if adult plants have been killed. Small newly establishing infestations may be eradicated with a great deal of persistence.

The management options of established Chilean needle grass populations depend on the land use. These options include crop rotation, pasture sowing, herbicide control and grazing management with best results where a combination of options is used. The management goals should aim to reduce the soil seed bank and minimise the Chilean needle grass component of the pasture by creating conditions that hinder its growth. The most important of these conditions is the maintenance of good ground cover through competitive perennial pastures and grazing management.

1. Arable Areas

On arable lands timely planting of crops can keep Chilean needle grass populations to a minimum. Where ploughing is possible, planting a sequence of fodder crops for two or three years will reduce the weed seed bank. However seeds buried as a result of deep cultivation will remain viable for longer periods than those near the surface.

Winter or summer forage cropping or summer grain cropping programs can be used. The important issue with any of the cropping programs is to make sure that any seedlings that germinate and go through winter are prevented from flowering and seeding in late spring/early summer either by chemical, cultivation or very heavy grazing.

Following the cropping phase establishment of a perennial pasture will provide competition for remaining Chilean needle grass seedlings. The pasture must be allowed to properly establish and maintain good ground cover all year-round and develop height plus bulk from November to February to have a smothering effect against Chilean needle grass seedlings. In addition, regular paddock inspection and spot spraying to eliminate newly emerged plants is vital to maintain clear areas.

2. Non Arable Areas

The same principles apply as those for arable areas. The seed bank should be reduced by a succession of short-term pasture or annual fodder crops established by direct drilling. In many locations, steep or stony country causes great difficulty, even for direct drilling. In these areas, aerial application of herbicide, seed and fertiliser would be necessary, but, where possible, ground application of herbicide is preferred to reduce off-target damage.

Pasture management of these areas is vital to ensure plenty of competition to needle grass seedlings. Strategic grazing and resting of pasture should aim to maintain comprehensive ground cover, particularly during spring and autumn germination of Chilean needle grass seeds.

For specific pasture species and management recommendations for your area refer to the appropriate pasture management guides.

3. Chemical Control

Several years' research conducted by NSW Agriculture's Weed Research and Demonstration Unit has provided guidelines for chemical control. In summary, glyphosate gave 90% control at 1.5 L/ha when applied in autumn, but was significantly less effective from a spring application. By contrast fluproponate was equally effective from a spring or autumn application. Figures 2 and 3 detail rates and level of control with glyphosate and fluproponate.

Chemical control is a useful tool to be used in a management program. Herbicide application before direct drilling is essential. Later in a program, spot spraying of re-invading seedlings will also be vital to reduce pasture degradation.

Glyphosate will generally be preferred to fluproponate for initial boom spraying in autumn where the area is to be resown because of the high cost of fluproponate. Glyphosate is used for or to assist in seedbed preparation prior to direct drilling, conventional preparation or aerial seeding.

Fluproponate would be preferred for smaller infestations, spot spraying or removing Chilean needle grass from an established pasture where the infestation is large enough to warrant boom spraying. At registered boom spraying rates fluproponate has reasonable selectivity, leaving behind pasture species such as fescue and cocksfoot.

However some pasture species are sensitive to fluproponate depending on timing — for example phalaris is sensitive to autumn applications but has little effect when applied in summer. Label information on selectivity should be carefully read. Manufacturers should be contacted if in doubt.

Figure 2: *Nassella neesiana* control with glyphosate

Spring - applied 28/11/89 assessed 10 Months after Treatment Autumn - applied 8/3/90
7 Months After Treatment
Source: Northern WRDU

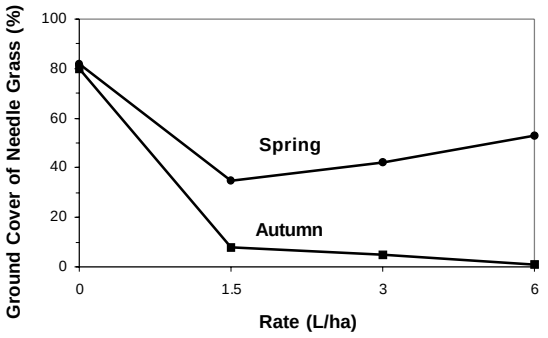
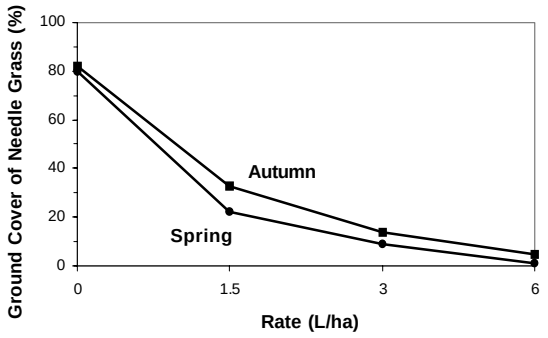


Figure 3: *Nassella neesiana* control with fluproponate

Spring - applied 28/11/89 assessed at 10 Months afterTreatment
Autumn - applied 8/3/89 assessed at 7 Months after Treatment
Source: Northern WRDU



Under some circumstances, usually at flowering, low rates of glyphosate can be added to the slower acting fluproponate to provide a quicker desiccation and reduce seed production. Pesticide permits are available for both fluproponate and Roundup® Biactive.

Weed wipers using glyphosate have been used on Chilean needle grass with varying success. If plants are wiped between flowering and milky-dough stage (usually November to early December) panicle seed set is prevented. This overcomes seed problems when grazing (wool vegetable fault and eye/carcass injuries). Wiping to kill plants has not been highly successful, with less than 60% kill.

Pasture topping is a useful technique for seed sterilisation in spring/early summer. For sheep producers this allows Chilean needle grass paddocks to be grazed (after complying with chemical withholding periods) without the panicle seed causing significant problems with wool vegetable fault or eye/carcass injuries. It also significantly reduces the amount of seed going to the soil seed bank.

Chemical control has its drawbacks. The non-selectivity of most herbicides result in the death of both desirable and target species. Since Chilean needle grass has a large seed bank and a requirement for bare ground to establish, the resulting vegetation after herbicide application may actually have a greater proportion of the weed. Bare ground resulting from herbicide application should be re-seeded to provide the germinating Chilean needle grass with competition. If there are only a few plants it is probably better to remove them by hand than create a bare area with spot spraying.

It must be emphasised that chemical application alone will not control Chilean needle grass.

4. Grazing Management

One inexpensive and adaptable tool available to most landholders is grazing management. Although Chilean needle grass is less palatable than other introduced pasture plants, research has shown that during winter it produces a reasonable quantity of average quality feed (up to 16.6% crude protein and digestibility of approximately 60% — in comparison the temperate pasture grass fescue had crude protein up to 18.8% and digestibility of approx. 65%). In extensive areas of Chilean needle grass where it is uneconomical or impractical to control, consideration should be given to utilisation in winter in combination with pasture topping or weed wiping in spring. In South America it is considered an important winter growing pasture grass. However, during summer it produces little green leaf and a large amount of unpalatable flower stalk.

Because of its lower palatability compared to other pasture species, a high density –short duration strategic grazing management system is preferable. This allows better utilisation of the pasture as well as allowing the faster growing desirable species such as fescue to slow the growth of Chilean needle grass through shading.

A heavy grazing with cattle in spring, when the flower heads were developing, reduces the number of flower stalks produced and made the grass more palatable to stock. Landholders have made Chilean needle grass dominated pastures more productive by using heavy stock densities for a short duration during the flowering period. Spraytopping of the pasture in the early flowering period with very low herbicide rates is also said to increase palatability.

The most important thing in any system of grazing management is to maintain good ground cover and favourable conditions for the faster growing desirable pasture species.

Permits currently available for Chilean needle grass control can be found at http://www.apvma.gov.au/permits/permits.shtml. Check expiry date of permit before use.

PER4843 – Pasture - 3 L/ha fluproponate or Spot treatment - 200 mL fluproponate + 150 mL Roundup® Biactive per 100 L water. Expires 30 September, 2006

PER5894 – Pasture spray-topping – Spot – 1 L in 100 L water glyphosate (360 g a.i. /L). Boom – 0.8 L glyphosate (450 g a.i.) /ha or 1 L glyphosate (360 g a.i.) /ha Expires 30 September, 2004

PER5895 – legume pasture and lucerne – 1–2 L/ha Fusilade® 212 plus 1% Supercharge® applied at flowering before milky dough stage of CNG, prior to hay cutting. Expires 30 September, 2004

5. The Future

Chilean needle grass is a widespread naturalised species in Australia. Control using conventional methods has proven difficult. Control can be achieved using an integrated approach of cropping, herbicide application and grazing management. If Chilean needle grass has become widespread on your property, then viewing Chilean needle grass as a permanent part of your farming system is likely to be more fruitful than attempting its eradication.

However, it is important to act promptly when an infestation is recognised as small infestations may be controlled. Where any doubt exists as

to the identification of the plant, have the specimens identified by a local agronomist.

Biological agents are being investigated by organisations such as the CSIRO. However biological agents for weed control are rarely successful when used alone.

ACKNOWLEDGMENTS

Thanks to Dr Mark Gardener, formerly of UNE for help with the previous edition, M. Duncan for the first edition of this Agnote and M. Michelmore for comments.

Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (June 2003). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of the New South Wales Department of Agriculture or the user's independent adviser.

Always Read the Label

Users of agricultural (or veterinary) chemical products must always read the label and any Permit, before using the product, and strictly comply with the directions on the label and the conditions of any Permit. Users are not absolved from compliance with the directions on the label or the conditions of the permit by reason of any statement made or omitted to be made in this publication.

Pesticide Residues may accumulate in animals treated with any pesticide or fed any crop product, including crop residues, which have been sprayed with pesticides. In the absence of any specific grazing withholding period(s), grazing of any treated crop is at the owner's risk. Withholding periods for stock treated with any pesticide or fed on any pesticide treated plant matter must also be observed. Pesticide residues may also contaminate grains, oils and other plant products for human use and consumption. Growers should observe harvest withholding periods on the pesticide label and should not assume that in the absence of a withholding period or after the expiry of a withholding period that the plant will be free of pesticide residues.

Pasture Improvement

Pasture improvement may be associated with an increase in the incidence of certain livestock health disorders. Livestock and production losses from some disorders is possible. Management may need to be modified to minimise risk. Consult your veterinarian or adviser when planning pasture improvement.

The Native Vegetation Conservation Act (1997) restricts some pasture improvement practices where existing pasture contains native species. Inquire through your office of the Department of Land and Water Conservation for further details.

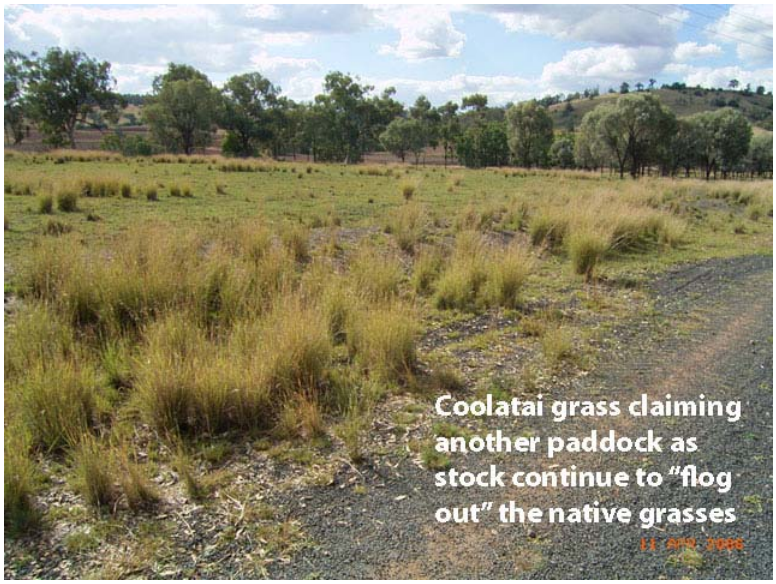
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Information Delivery Unit
Job No. 4246
Agdex 641

North West Weeds

NOXIOUS WEED CONTROL UNIT FOR GWYDIR AND INVERELL SHIRES
Please address all correspondence to the General Manager, Gwydir Shire Council, Locked Bag 5, BINGARA, NSW, 2404 - Phone 02 6729 1016, facs 02 6729 1400, email tannerl@northnet.com.au

Coolatai Grass



Coolatai grass (*Hyparrhenia hirta*) has taken over large areas of the north west and is still spreading. Generally regarded as a weed, it is usually avoided by stock because of its low digestibility. During drought conditions, however, it can and does supplement stock feeding programs.

According to research being carried out by NSW Dept of Primary Industries, grazing management, soil nutrition and legume species can improve the value of Coolatai grass.

For information on these management options contact NSW Dept of Primary Industries agronomists at Tamworth (Lester McCormick) or at Inverell (Bob McGufficke). Or, go to the NSW Dept of Primary Industries weeds website to download a copy of *Management of Coolatai Grass on the North West Slopes of NSW*



Photo (right) shows seed attached to the front number plate of a motor vehicle driven 50 metres along a track covered with (wet) Coolatai grass!

Coolatai grass can spread to new areas very quickly!

Coolatai grass has an amazing capacity to spread. During its seeding phase, the plant produces thousands of tiny, sticky seeds which adhere readily to animals, farm machinery and motor vehicles.



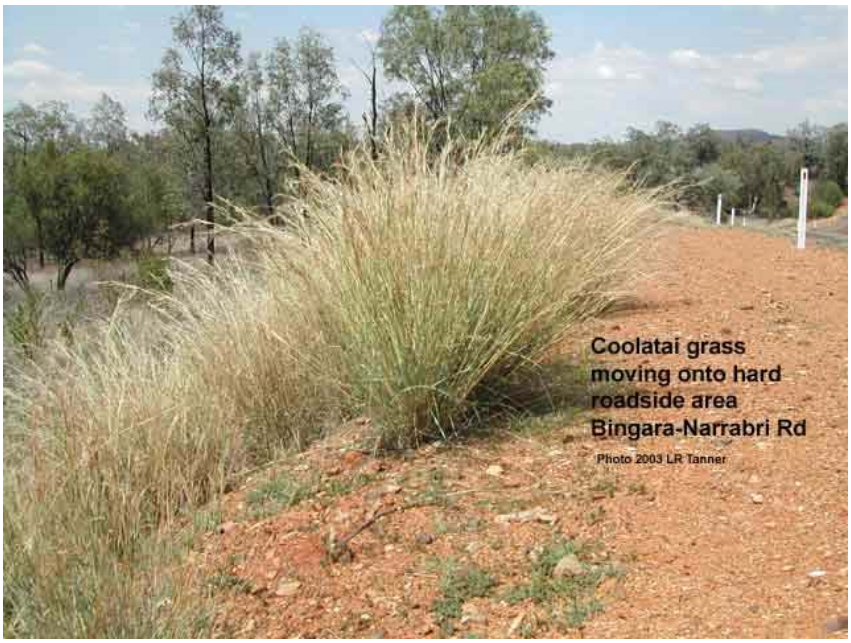
MORE INFORMATION? PLEASE CONTACT YOUR LOCAL WEEDS OFFICER:

Stephen Kneller Bingara 0427 240 061	Clem McLeod Inverell 0427 453 052	Doug Stieger Warialda 0427 291 912	Les Tanner Head Office 0427 241 806
OR check out our website on www.northwestweeds.nsw.gov.au			

Control methods:

Coolatai grass is NOT a declared noxious weed within Inverell and Gwydir Shires. However, all landholders are urged to discourage entry of this invasive plant onto their properties!

Every effort should be made to prevent Coolatai grass from becoming established in new areas. It doesn't take long for one plant to contaminate a roadside or an individual property.



Treatment - either manual removal or herbicide application - should be carried out before the plant has a chance to produce seed. Regular follow-up is essential to prevent further establishment.

Herbicides?

No herbicides are registered in NSW for **boom spraying** of Coolatai grass. There is one permit for **spot spraying** of Coolatai grass (NSW)

Permit PER7883
In force 25 Oct 2004 to 30 September 2009

PLEASE READ AND FOLLOW PERMIT DIRECTIONS
The permit sets out conditions for the use of glyphosate and flupropanate products for treatment of Coolatai grass in native pastures and non-crop situations including rights-of-way, bushland, forests, reserves and roadsides.

Chemical	Rate: Spot	Comments
Glyphosate 360 g/L various trade names	2.0 L in 100 L of water	Apply to actively growing plants before flowering. Wet to run-off, ie. 1000-2000 L/ha. Spray 2 - 3 times Sep to May Only use the tankmix once per season.
Glyphosate 360 g/L Various trade names **PLUS** **Flupropanate 745 g/L** eg Tussock Herbicide®	2.0 L glyphosate **PLUS** 200 mL flupropanate in 100 L of water	Apply to actively growing plants before flowering. Wet to run-off, ie. 1000-2000 L/ha. Spray Jul to Oct (addition of flupropanate is most effective during spring). Only use the tankmix once per season.

DISCLAIMER: The information contained herein is based on knowledge and understanding at the time of writing. However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of North West Weeds or the user's independent adviser.

(LRT 15/06/06)



NSW Agriculture

Management for Coolatai Grass on the North West Slopes of NSW

MEAT & LIVESTOCK AUSTRALIA

SGS

Coolatai grass (*Hyparrhenia hirta*) is a native of South Africa and the Mediterranean region.

Since its introduction to northern New South Wales in the 1940's it has spread along roadsides and stock routes and invaded grazing lands on many properties. It grows on a range of soil types from light textured granites to heavy black earths, but prefers the lighter textured soils where it can dominate.

It is a tall, tufted, summer active perennial growing to more than one metre in height. The species is distinguished by paired seedheads, and leaves which are typically grey-green and harsh to touch. When heavily grazed the basal stems form a dense, hard tuft that successfully protects it from close grazing by sheep and makes it resistant to fire.

Coolatai grass grows prolifically during the warm months but, being frost sensitive, it hays off in winter. Although a tropical grass, it grows in temperate environments and is extremely drought resistant.

Coolatai grass is invasive, can make growth on small falls of rain, grows longer into the cooler months than most other summer growing native grasses and, because of its low digestibility, is avoided by livestock and can dominate native pastures. Many producers consider it a weed, but attention to grazing management, soil nutrition and use of legume species can significantly improve its value.



Research *1989 to 2001*

A research site on the 'Springmount' Tamworth Rural Lands Protection Board reserve, Upper Manilla, was established in 1990. Initially the research aimed at controlling Coolatai grass with grazing or herbicides, but evolved into a study to investigate management of Coolatai grass. The average annual rainfall at the site is 650 mm. Soil type was hard setting red soil and the pasture was completely dominated by Coolatai grass.



Three pre-herbicide application treatments (back to front) untreated, slashed and burnt



Fleabane invading plot following herbicide application

Herbicide Treatments

- Three herbicides: Glyphosate (Roundup®), 2,2-DPA (Dalapon®) and fluproponate (Frenock®).
- Two times of application: Spring 1990, Autumn 1991
- Three rates of each chemical
- Three pre-herbicide application treatments: burning, slashing or untreated.

Grazing Treatments

- Two grazing pressures: 7 and 37 wethers per hectare.
- The grazing treatments occurred in half-hectare plots.
- Three pre-grazing treatments: burning, slashing or untreated.

Pasture Improvement

- Legumes and superphosphate were introduced and tactical grazing was employed.
- Subterranean clover, arrowleaf clover and woolly pod vetch were introduced by sod seeding.

Results

Herbicides

None of the herbicides completely eradicated Coolatai grass. Glyphosate applied in autumn and fluproponate applied in autumn or spring were the most effective. Initially, Coolatai grass was replaced by other weedy species and then it reinvaded so that within two years it was again dominant. For herbicides to be effective competitive species need to be introduced into the pasture.

Cost of herbicide control was in excess of $360 per hectare.



Legume & coolatai grass



Light and heavily grazed plots

Grazing Treatments

In the light grazing treatment stock only grazed 20% of the area and large amounts of dead feed accumulated. When conditions turned dry, stock rapidly lost weight.

Sheep grazed at 37 wethers per hectare utilised the entire area. They were removed whenever all green feed was eaten. Coolatai grass, when kept short, provided maintenance feed for dry stock during spring and summer. Feed quality peaked in summer but dropped quickly with flowering and frosting.

After seven years the heavily grazed plots remain dominated by Coolatai grass. The measured growth rates for Coolatai grass were less in the heavily grazed plots.

Heavily grazed plots from November 1990 to mid November 1997 provided 77% more grazing days (an extra 2948 wether grazing days) than the lightly grazed treatment.

Sheep on heavily grazed plots maintained good condition, but were removed when feed became short. Wool cuts from these sheep averaged 6 kg/hd compared with the flock average of 5.5 kg/hd.

The effect of the pre-grazing treatments (slashing, burning and untreated) was short lived. The main benefit was removal of dead rank growth, which encouraged growth of better quality green, leafy feed.

These results were obtained in mainly dry years that did not favour the growth of Coolatai grass. But the research showed that when it is kept short it could provide valuable feed in dry times.

Introducing Legumes

Legumes can be successfully grown with Coolatai grass to improve winter feed quality of these pastures. However, legume growth and the resultant increased growth of Coolatai grass requires a higher level of grazing management.

The best legumes in this demonstration were arrowleaf and subterranean clover.

Key points for Coolatai grass management

- Coolatai grass produces a large bulk of feed even in dry years. This extra growth must be utilised to maintain feed quality and to prevent Coolatai grass from dominating the pasture.
- Burn or slash to reduce the bulk of poor quality dead material prior to grazing to increase green leaf for strategic livestock needs.
- High stocking pressures are needed to keep Coolatai grass short, and to maintain higher pasture quality.
- Legumes can increase winter-feed quality, providing nitrogen for grass growth and increasing ground cover and litter.

Conclusions

Grazing or herbicide use is unlikely to reduce the presence of Coolatai grass in Coolatai grass dominant pastures.

Coolatai grass can be managed to provide a maintenance diet for dry stock in spring and summer, using heavy grazing after slashing or burning. This system of heavy grazing should only be maintained for 2 to 3 years before moving stock to a different area.

Moving stock allows ground cover, litter and pasture vigour to be restored. The pasture should be monitored for signs of degradation during periods of heavy grazing.

Tactical grazing improves pasture quality over spring and summer. Correcting soil nutrient deficiencies and growing a legume with Coolatai grass provides higher quality feed during winter and nitrogen for grass growth during summer.

Further on-farm research needs

The management of Coolatai grass in whole farm situations should be investigated. Questions which need answering include:

- What grazing strategies can be applied to the whole farm system, to better manage the potentially large bulk of growth?
- How does management prevent Coolatai grass becoming tall and rank in larger paddocks?
- What options are available to manage growth that cannot be controlled?
- How is ground cover and litter maintained under a high utilisation regime?



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Information prepared by Lester McCormick, Greg Lodge and Bob McGufficke, August 2002.

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Dubbo and Orange
November 2002

Job No 3573

Coolatai Grass

Invasive Species Unit

Coolatai grass (*Hyparrhenia hirta*) is an invasive drought, fire and herbicide tolerant tussock forming perennial grass. It has become a major invasive species in northern New South Wales (NSW) and southern Queensland, dominating pastures over a range of soil types and conditions. It is also one of the few perennial grasses capable of invading undisturbed natural ecosystems and is a major threat to natural biodiversity in stock routes, nature reserves and National Parks. Pasture dominated by Coolatai grass can be productive, although the management requirements are higher than that commonly employed.

Coolatai grass continues to expand its range across southern Australia, which will be enhanced by the predicted increases in summer rainfall and milder winters due to global warming.

Distribution

Coolatai grass is a native of tropical and temperate Africa, the Mediterranean region, Oman, Saudi Arabia, Yemen, Turkey, Iraq, Iran, Afghanistan, Pakistan and India.

It is naturalised in Australia, Mexico, the Caribbean and parts of South America.

The plant was thought to have been first introduced from southern Africa to Queensland and northern NSW in the late 1800's. The CSIRO and some State Government departments also introduced a range a material in the 1950's and 1960's in an effort to find a hardy perennial grass that would survive heavy grazing and grow in a winter dominant rainfall zone.

It is found in all Australian states and territories.

Figure 1. Coolatai grass dominated pasture Inverell district of NSW



Main infestations are found in south-eastern Queensland, north eastern NSW, north eastern Victoria, the Adelaide basin and the upper Yorke Peninsula in South Australia. In Western Australia it is found around Geraldton, Perth to Augusta and Esperance.

Coolatai grass continues to expand its range in southern NSW where isolated infestations are often identified.

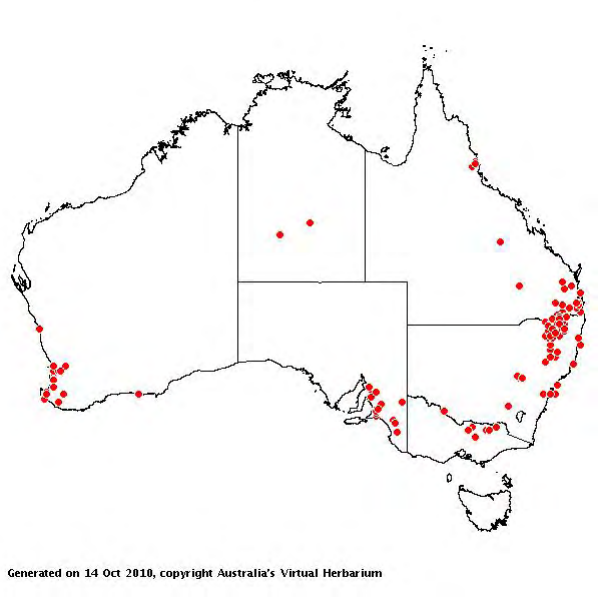


Figure 2. Distribution of verified infestations of Coolatai grass in Australia

Habitat

Coolatai grass will grow on a range of soils but is most active on light to medium textured soils and will grow and increase on heavy clay soils if not waterlogged. Studies in South Africa and the Middle East show that Coolatai grass prefers growing on slopes that face the sun.

It is cold tolerant and is found from sea level to 1500 m altitude. In South Africa Coolatai grass is found up to 2400 m above sea level.

It thrives in both sub-tropical and temperate conditions however the seedlings are sensitive to heavy frosts. Currently in Australia, it is found in areas receiving 400 to 800 mm annual rainfall, with a distribution pattern ranging from winter dominant to summer dominant.

Tussocks can easily survive hot fires and regular burning has been shown to have no negative impact on plant numbers.

Coolatai grass will readily invade disturbed areas such as roadsides and pastures, forming monocultures and out-competing most other species. It also has the ability to invade relatively pristine remnant native vegetation, making it a significant threat to the conservation of these areas.

Coolatai grass is also expanding its range in southern Africa, outcompeting taller *Hyparrhenia* species, which are preferred thatching grasses. The likely cause is an increase in frequency of pasture burning followed by heavy grazing with cattle.

Impact

In 2004 it was estimated that Coolatai grass already infested 1 million hectares in NSW. It has continued to expand its range across Australia.

Coolatai grass presents a dilemma in that it is able to invade relatively undisturbed natural ecosystems, yet can be a resilient productive pasture species if managed correctly.

Coolatai grass is also highly tolerant of most herbicides making control on a large scale difficult, particularly where the treatment cost will exceed the productive value of the land.

The agricultural landscape

Coolatai grass readily invades pastures and dominates them, particularly where ground cover is low (less than 70%) due to the grazing regime (set stocking) and low soil fertility. Failure to appropriately manage a Coolatai grass dominated pasture will see a monoculture of tall rank growth of low digestibility (<40%) and protein (<7%). Sheep production will be poor and cattle will need supplementary nitrogen or protein to be able to utilise the feed.

Most graziers feel that if you don't already have Coolatai grass you don't want it as there are more easily managed perennial and annual pasture options available.



Figure 3. Coolatai grass spreads readily along roadsides, this adjacent native pasture is being infested from the roadside.

On the other hand, studies have shown that with significant management inputs where Coolatai grass is kept short, it can be a highly productive pasture and meet the feed requirement of dry stock. Coolatai grass also has the benefit of not having damaging seeds like wiregrasses (*Aristida* spp.) and corkscrew grass (*Austrostipa* spp.), however there are other more easily managed tropical perennial pasture species available that also have benign seed.

If large areas have been dominated by Coolatai grass, management strategies of rotational grazing, spring burning and/or slashing will be essential. The maintenance of a legume component in a Coolatai grass dominated pasture is difficult.

Natural ecosystems – remnant vegetation

Coolatai grass poses a huge risk to the biodiversity of the fragmented areas of native ecosystems remaining across NSW as it easily invades relatively undisturbed ecosystems. The mechanisms of how this occurs are still not fully understood but Coolatai grass has a number of characteristics that allow it to invade a range of ecosystems:

- plants are long lived
- able to produce fertile seed from a single plant
- seed is mobile – wind, water, animals, vehicles
- seed will germinate over a wide range of temperatures
- seeds are able to germinate and establish at the soil surface in the presence of leaf litter
- established plants are tolerant of drought, fire and herbicides

Studies in northern NSW have shown that Coolatai grass infestations have reduced the number of plant, invertebrate and frog species in threatened white box, yellow box and Blakeley's red gum communities.

Description

Coolatai grass is a long lived summer active perennial grass that forms a dense tussock and grows to 1.5 m. It has greyish-green leaves that turn orangey-red in winter, particularly after frost. The leaves are harsh to touch. Leaf sheaths are usually hairless and keeled. The leaf blade is flat and 2-3 mm wide with the ligule 2-3 mm long and minutely toothed.



Figure 4. Coolatai grass tussock

The seedhead is a 'false panicle' consisting of paired racemes with 5-8 awns per raceme. The paired racemes are up to 35 mm long and arise from 3-8 cm long flower bracts. Half the flowers are male and therefore sterile.

Table 1 Characteristics of Hyparrhenia species found in Australia

Name	Coolatai Grass (*H. hirta*)	Tambookie grass (*H. filipendula*)	Thatch grass *H. rufa*
Origin	Introduced	Native	Introduced
Habit	dense tussock to 1.5 m	tussock to 1.5 m	tussock to 2.5 m
Seedheads	Paired racemes 15-50 mm long, whitish or greyish	Paired racemes 15-25 mm long	Paired racemes 20-50 mm long, bases hairy
Awns per raceme	5-8	1-3	9-10
Distribution in Australia	All mainland states and territories.	Coastal northern NSW & Queensland.	Newcastle, Upper Hunter and Werris Creek in NSW; north coast of Queensland.

Related species in Australia

In addition to Coolatai grass there are two other species of the *Hyparrhenia* genus in Australia, *H. filipendula* and *H. rufa*. *Hyparrhenia filipendula* is a native of Australia and has a coastal distribution. *Hyparrhenia rufa* is introduced and is currently found in small infestations around Quirindi and along the coast from Newcastle to northern Queensland (see Table 1).

Native species that might be confused with Coolatai grass

Grasses not in flower can be very difficult to identify, particularly when seedlings. The best method to identify a grass is to collect specimens when flowering, press till dry and send to the National Herbarium of NSW. See Primefact 919 “Collecting and preparing plant specimens for identification” (see below under Publications available).

The most obvious distinguishing characteristic of Coolatai grass is the paired racemes with 5-8 brown awns per raceme. The racemes are soft to touch compared with barb wire grass and kangaroo grass.



Figure 5. Paired racemes of Coolatai grass are a key distinguishing feature.



Figure 6. Redgrass seedheads do not have paired racemes but have 3-6 racemes arising from a single point

Table 2. Characteristics of summer growing native grasses that could be confused with Coolatai Grass

Name	**Coolatai grass** ***Hyparrhenia hirta***	**barbed wire grass** ***Cymbopogon refractus***	**kangaroo grass** ***Themeda australis***	**redgrass** ***Bothriochloa macra***
Habit	Dense tussock to 1.5 m.	Aromatic perennial to 1 m.	Dense tussocky perennial to 1.5 m, blue to pale green growth turning reddish-brown at maturity.	Straggly perennial to 1 m.
Seedheads	Paired racemes 15-50 mm long, whitish or greyish.	Paired racemes with sparse hairs, bending downward as they mature. Firm to touch.	Loose interrupted panicle to 25 cm long, spikelets single or in pairs. Papery to touch.	3-6 racemes arising from a single point, upright and close packed. Soft to touch.
Distribution and Habitat	Common in Northern NSW and increasing infestations in southern NSW especially on roadsides.	Common in the eastern half of NSW, widespread on low fertility soils.	Widespread across NSW Heavily grazed when young. Can form dense stands of coarse material not readily grazed.	Common in the eastern half of NSW. Common in heavily grazed pastures.



Figure 7. Kangaroo grass seedhead



Figure 8. Barbed wire grass seedhead

Life cycle

Coolatai grass is a long lived perennial that produces short rhizomes that form dense tussocks. Being drought tolerant, it has the ability to rapidly respond to rain, producing new culms from the tussock base and flowering in a matter of weeks. It is well adapted to fire, with tussocks surviving hot burns.

Both these characteristics give the species the ability to quickly flower and set seed when environmental conditions are favourable.

Its sole means of reproduction is by seed. Seed yields are low compared to many grass species with 4 to 10% of the florets producing viable seed. Seed is produced both sexually (with pollen) and asexually (without pollen - apomixis). Asexual seed formation allows Coolatai grass to produce viable seed in the absence of pollen.

Although Coolatai grass seed will germinate at temperatures between 5° and 40° C, its optimum temperature range for germination is from 20-30°C. Seedlings are small, weak and killed by heavy frost and temperatures below 10° C. This pattern is common in tropical grasses.

The main recruitment period for seedlings is therefore in spring for much of southern Australia.

Coolatai grass will flower and set seed from spring to autumn, however it will flower all year if conditions are suitable. This demonstrates that the plants in Australia have no photoperiod requirement (i.e. day neutral) or cold requirement (vernalisation) to promote flowering.

The period from germination to flowering is approximately 90 days.

Seedheads mature unevenly and the seed is shed quickly on maturity.

There is no data on the presence or absence of post ripening dormancy of the seed or persistence and size of the seedbank.

Spread

The predicted increase in summer rainfall and milder winter temperatures in southern NSW with the onset of global warming will favour the spread and establishment of Coolatai grass in these areas. Coolatai grass has the characteristics that allow it to benefit from the increased spring/summer rainfall events and milder winter temperatures.

Seed sheds quickly on maturity. The hairy, awned seeds readily adhere to the hair and wool of animals, clothing and is easily caught on and in vehicles.

Along roadsides the seed is spread by the common practice of slashing for ‘road safety’. The light weight of the seed also facilitates the spread by air movement by passing vehicles, particularly trucks.

Cattle are known to graze the heads of Coolatai grass. Research on the viability of annual ryegrass (*Lolium rigidum*) passing through cattle shows that around 12% of seed consumed remains viable. Therefore it would be reasonable to assume that some Coolatai grass seed will survive the digestive track of cattle.

Control and management

The greatest problem with invasive species is the lack of early detection and management. Grasses are particularly difficult because they look innocuous and rarely raise land managers’

attention until the species is well established. This is because most grasses look much the same to the untrained eye and unless they have a particularly acute affect, such as stock poisoning or produce damaging seed, they do not pose an immediate threat. Coolatai grass is a prime example of this.

The general public and land managers need to know that Coolatai grass is an invasive undesirable species and new occurrences must be correctly identified and controlled.

In any management program, infestations should be mapped and early efforts directed at lightly infested areas, working back toward more heavily infested areas.

Prevention – quarantine

Coolatai grass is easily spread by stock, machinery, fodder and seed. Land managers must ensure stock, fodder, grain and machinery coming onto their land has not come from a Coolatai grass infested area.

New or stock returning from agistment must be quarantined in a small paddock for at least a week. This quarantine paddock needs to be monitored for Coolatai grass establishment for the next 2 summers. Also stock grazed on Coolatai grass during flowering and seed set should not be moved to 'clean' paddocks without some quarantine period.

Early detection and control

Coolatai grass will usually start from one or two plants near the front gate, driveway, track or farm buildings. These plants must be identified and removed before viable seed has been set.



Figure 9. Individual plants should be dug up and disposed of taking care not to disperse seed

Remove plants, bag and burn, try to stop seed being dropped in the process. It may be useful to sow some replacement competitive pasture species in disturbed areas to compete with new germination of Coolatai grass.

Spot spraying with knockdown herbicides will require 2-3 applications for complete control.

Roadside management

The lighter textured soil used in road construction and regular applications of glyphosate to control vegetation combined with the water-harvesting of the road surface creates an ideal environment for establishment and growth of Coolatai grass. Road maintenance and construction along with slashing grass with mature seed, stock, water and wind all move the seed to new areas.

Roadside vegetation should be mapped and areas with Coolatai grass 'flagged' and treated. These areas must not be slashed, or should be slashed last and then the machines thoroughly cleaned before moving to a new area.

Construction and maintenance crews must be made aware of infestations and no unnecessary machinery movement or "cleaning up" of the roadside should be conducted.



Figure 10. Roadsides are an ideal environment for establishment and growth of Coolatai grass

Herbicides

Coolatai grass is tolerant of most commonly used herbicides and suppression of growth is the most likely outcome.

There is an Australian Pesticides & Veterinary Medicines Authority (APVMA) permit 'Control of tussock grasses' (PER9792 which expires on 30th November 2015) which outlines the allowed use of glyphosate and flupropanate for the suppression of Coolatai grass (Page 8, Table 5). Copies of the permit can be downloaded from the APVMA website www.apvma.gov.au.

Research has shown that pre-treatments of burning and slashing can reduce control as it suppresses the active growth of Coolatai grass

which should have sufficient green leaf and be actively growing for the highest levels of control.

Regardless of application method, up to three applications of glyphosate in the same growing season will be required. The repeat application timed for when there is sufficient regrowth of fresh leaves.

Cropping

In areas suitable for cropping, 2 - 3 years of crop will control Coolatai grass. A competitive pasture should then be re-established.

Competitive pastures and grazing management

Coolatai grass seedlings are small and weak, and plants produce relatively smaller quantities of seed compared to many other invasive perennial grasses. These characteristics highlight that competitive pastures (where ground cover is maintained at >70%) will resist Coolatai grass invasion.

Rotational grazing is also important. Research conducted in northern NSW has shown that pastures that are rotationally grazed have higher ground cover and litter, more soil organisms, more pasture growth, reduced runoff and evaporation all with less supplementary feeding compared with 'year-long' grazed pastures. Where 90% groundcover was maintained there was little runoff, summer soil temperatures and evaporation were lower, all leading to higher pasture growth.

Growing tropical perennial grasses in northern NSW will effectively compete with Coolatai grass for resources. In southern NSW competitive pastures in spring, maintaining high levels of ground cover over summer will resist Coolatai grass invasion. Small numbers of surviving plants in autumn will be obvious and can be hand pulled and burnt.

Maintaining adequate levels of soil nutrients for your level of stocking will be essential to maintain competitive pastures.

Legislation

In various areas of NSW (see Figure 11) Coolatai grass is declared a Class 3 noxious weed under the *NSW Noxious Weeds Act 1993*. Class 3 control requirements are 'that the plant must be continuously suppressed and destroyed'. For further information contact your local council weeds officer or refer to the Industry and Investment NSW website www.dpi.nsw.gov.au/weeds.

The responsibility for control of noxious plants and appropriate disposal of weed plant material on private land rests with the owner or occupier of the land.



Figure 11. Declaration of Coolatai grass in NSW

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Figure 2 – Australia's Virtual Herbarium

Figure 6 – Harry Rose

Figures 4, 7, 10 – Andrew Storrie

Figure 8 – Lachlan Rowling

Figure 11 – Alan Maguire

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NSW Industry & Investment – Collecting and preparing plant specimens for identification. http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/publications/collecting-preparing-specimens

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Honey Locust

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About this website





Honey locust (*Gleditsia triacanthos*) is a native of eastern and central North America. In was apparently introduced into Australia and planted for its value as a source of stock fodder. The photo, right, shows an example of an "orchard" of honey locust trees planted some years ago in a paddock near Bingara, NSW. Note the number of seed pods on each plant!

Honey locust's efficient means of spread, firstly through deliberate plantings and then through its floating seed pods (photo right), has allowed the plant to establish in many areas of parts of eastern Australia. It is quite common along a number of inland river systems, including the McIntyre and Severn Rivers in Inverell Shire.



Honey locust grows to a height of 20 metres or more. The trees are armed with long and very tough spines, forming a formidable barrier to animals and humans as the trees become larger and more densely populated along watercourses etc. The seed pods grow to a length of up to 20 cm. each containing 20 to 30 seeds.



Photo (above, left) Clem McLeod amongst large honey locust trees at Wells Crossing, Severn River near Ashford, NSW - circa 2002 - before Ashford Landcare Group commenced their effective treatment work on this problem infestation.



To quote directly from www.weeds.org.au Notes: Introduced as a fodder tree and cultivated as an ornamental. Pods are first produced when trees are 3-5 years old. Trunk is protected by thorns. Found in dense thickets along watercourses on the central coast, western slopes and tablelands of northern NSW and in south eastern Queensland. Introduced by William Macarthur to 'Camden Park', Camden NSW in mid 1800s and now widespread on the floodplain of the Hawkesbury-Nepean river system.



CONTROL METHODS

Chemical Options: According to NSW DPI's excellent booklet *"Noxious and Environmental Weed Control Handbook 5th Edition"*, treatments **include:**

Non-Chemical Options: Mechanical control is possible but will require follow-up treatments.

Chemical Options:

Chemical options	Rate: Spot/Boom	Comments
Triclopyr + Picloram Access ®	1.0 L in 60 L of diesel	**Basal bark application** for basal diameter less than 5 cm or cut stump application for above 5 cm.
Fluroxypyr 333 g/L Starane Advanced ®	300 mL per 100L of water 900 mL per 100 L of diesel 1.8 L per 100 L of diesel 3.0 L per 100 L of diesel 3.0 L per 100 L of diesel	**Foliar application**, seedlings & young plants up to 2 m in height. **Basal bark application** Plants up to 10 cm basal diameter. Plants 10-20 cm basal diameter. Plants above 20 cm basal diameter. **Cut stump application.**
Picloram 45 g/kg Vigilant®	Undiluted	Cut stump/stem injection application. Apply a 3-5 mm layer of gel for stems less than 20 mm. Apply 5 mm layer on stems above 20 mm (see label).

MPORTANT: USE OF PESTICIDES – ALWAYS READ THE LABEL

Pesticides must only be used for the purpose for which they are registered and must not be used in any other situation or in any manner contrary to the directions on the label. Never use a herbicide in any way contrary to the label recommendations**.**

Return to top of the page

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LRT 233/06/2010

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Fact sheet

DECLARED CLASS 1 PEST PLANT

Honey locust

Gleditsia spp.







Honey locust is a large, rapidly growing tree. In the past it has been deliberately promoted and planted in Australia as a fodder tree and garden ornamental.

Although beneficial in the short term as stockfeed, the long-term consequences of its growth and spread are counter productive.

Honey locust tree is considered a serious pest due to its invasiveness and environmental, economic and social impacts.

Environmental impacts

Honey locust is an invasive tree capable of out-competing and replacing native vegetation. It can often create dense monocultures and hence provide restricted habitat for native fauna. The sharp barbs on its branches can also injure wildlife. Honey locust can also provide a haven for introduced pest animals such as foxes, cats and rabbits.

PP47 September 2011

Queensland Government

Agricultural impacts

Honey locust spreads rapidly from seed. If not controlled, it can destroy pastures by smothering the more desirable grass species. The plant can form dense thickets, particularly along waterways, preventing stock access to water.

Safety

The plant's long, strong spines can inflict serious injuries and infections to humans and livestock. They can also cause damage to tractor, quad bike and other vehicle tyres, restricting vehicle movement near infestations. Even when the plant has died, spines can continue to inflict injury.

Declaration details

Honey locust (*Gleditsia* spp.) is a Class 1 declared plant under the *Land Protection (Pest and Stock Route Management) Act 2002*. This includes all ornamental cultivars and 'thornless' varieties.

Class 1 pests established in Queensland are subject to eradication from the state. Landowners must take reasonable steps to keep land free of Class 1 pests. It is a serious offence to introduce, keep or supply a Class 1 pest without a permit issued by Biosecurity Queensland. Penalties of up to $80 000 apply.

Description and general information

Honey locust is a deciduous, leguminous tree growing to 20 m tall. From spring to autumn, it bears prolific green leaves (10 cm long), with about 12 opposite paired leaflets per leaf. In October–November it bears creamy, yellow hanging flower stalks (10 cm long) that develop into 20–30 cm long brown pods. Some varieties have separate male and female plants, while other varieties are bisexual. The plant seeds prolifically every 1–2 years and the pods are relished by stock.

The trunk and limbs of 'wild' trees bear very large crucifix-like spines that can grow to more than 50 mm. In the past, nurseries have sold grafted ornamental thornless varieties of honey locust. There are many ornamental varieties of honey locust, including Rubylace, Sunburst, Moraine, Shademaster and Inermis. These so-called thornless varieties produce thorns at a later date or throw thorny progeny. This means that these varieties are subject to the same controls as the wild type. All varieties must be destroyed and cannot be sold anywhere in Queensland.



Basal barking

Habitat and distribution

History

Honey locust was originally introduced from North America and planted in Queensland in 1907 as a fodder and ornamental tree. It was first reported as a pest in 1955 at Cressbrook Creek (Esk Shire). Honey locust exists naturally across the United States from Mexico in the south to Ontario, Canada, in the north.

Present distribution

Honey locust can grow in most soil types but prefers alluvial flood plains along river systems. Impenetrable thickets of this thorny weed have smothered large areas of highly productive alluvial grazing land near Toogoolawah.

Heavy infestations occurred on the Darling Downs in the Clifton/Allora area and at Toogoolawah. Scattered infestations and individual ornamental plants are found around Monto, on the eastern Darling Downs from Toowoomba to New South Wales, and in the Arcadia, Stanley, Bremer and Logan valleys.

An eradication project in 1993 involving departmental staff, local governments and landholders. All major infestations have now been treated. Follow-up programs through local government and landholders continue to control isolated infestations and regrowth from new seedlings. As new seedlings take up to two years to set seed, there is adequate time for follow-up control and possible eradication.

Potential distribution

Honey locust is an extremely drought tolerant, adaptable species and is presently free of insects and disease. Its potential for spread over large areas is enormous.

There are no reasons, climatic or otherwise, why honey locust should not spread throughout south-east Queensland, especially on alluvial soils in the Brisbane Valley and Darling Downs. Seed is spread by:

- grazing stock eating pods and passing seed in dung
- floodwaters transporting floating pods
- people planting it as an ornamental or for fodder.

Control

The spread of weeds threatens the sustainability of agriculture and other land uses. Weeds also devastate native plants and animals.

The best approach is usually to combine different control methods. These may include chemical and mechanical control methods combined with land management practices. The control methods chosen should suit the specific weed and your particular situation.

Management strategies

Although honey locust is a useful fodder tree when young, older trees can reproduce at an uncontrollable rate. If left uncontrolled, a population explosion may occur, threatening sustainable pasture production and the environment. This has been evident in established infestations near Esk and Warwick. Eradication of isolated trees can prevent this situation occurring elsewhere.

Grazing

Continual grazing suppresses seedlings but can also assist in spreading seeds into new areas. Grazing can be a useful follow-up control method after herbicide treatment to control seedlings and regrowth, providing the plants do not bear seed pods.

For the control of dense infestations on grazing land, burning followed by spot spraying is an economical control method.

Mechanical control

Bulldozing

This method breaks plants at or above ground level. Once broken, honey locust will vigorously produce regrowth from broken bases and roots. Follow-up with some other form of control such as cultivation or herbicide is necessary.

Cultivation

On arable land, dozing followed by deep ploughing can control dense infestations, but only if followed by regular cropping and/or spot spraying of regrowth. If cultivation is abandoned, reseeding from nearby trees can be a problem.

Herbicide control

Table 1 shows the herbicides registered for honey locust control. Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label.

Once a honey locust tree has been killed by herbicides, it is quickly invaded by borers. By the time the tree falls, the borers have reduced it to a shell and it will shatter. Blockages of watercourses are of minimal concern. The thorns do not break down as quickly and remain a danger to humans and other animals walking through the area where the trees were. As safety is a concern, removal of the dead trees will help to eliminate these problems.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).



Basal barking honey locust

Table 1 Herbicides registered for the control of honey locust

Situation	Herbicide active ingredient	Rate	Comments[2]
Agricultural land – non-crop Forests – timber production Land – commercial or industrial or public Rights of way Pastures	fluroxypyr as mhe (200 g/L)[1] (e.g. Starane 200®)	1.5 L/100 L diesel	Basal bark for plants up to 10 cm basal diameter. Treat circumference of stem to a height of 45 cm from the ground
		3 L/100 L diesel	Basal bark for plants 10–20 cm basal diameter. Treat circumference of stem to a height of 45 cm from the ground
		5 L/100 L diesel	Basal bark for plants greater than 20 cm basal diameter. Treat circumference of stem to a height of 45 cm from the ground
		0.5 L/100 L water	High-volume spraying. Apply to plants to 2 m high
		75 ml/15 L water	Knapsack spraying. Apply to plants to 2 m high
	triclopyr as butotyl (240 g/L) + picloram as ioe (120 g/L) (e.g. Access®)	1 L/60 L diesel	Basal bark stems up to 5 cm thick Cut stump treatment for larger plants. Cut plant as close to ground as possible and apply herbicide mixture immediately (within 15 seconds) after cut is made

Notes:
[1] Do not graze treated pastures for 7 days after application.
[2] Honey locust trees can be successfully controlled when basal barking in both actively growing and dormant stages.

Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.

Fact sheets are available from Department of Employment, Economic Development and Innovation (DEEDI) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DEEDI does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

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Noogoora burr, Californian burr, Italian cockleburr and South American burr

Weed Management Unit

Introduction

Xanthium species are common summer growing weeds of crops and pastures in New South Wales (NSW). There are 6 related *Xanthium* species in NSW.

The six species are:

- Italian cockleburr or Hunter burr (*X. italicum*) (see Figure 1)
- Noogoora burr (*X. occidentale*) (see Figure 2)
- Californian burr (*X. orientale*) (see Figure 3)
- South American burr (*X. cavanillesii*)
- Bathurst burr (*Xanthium spinosum*) and
- *X. ambrosioides*, a hairy form of Bathurst burr.

The four *Xanthium* species covered in this publication are very similar and are often confused. Hybrids of these species have been found where there are mixed populations. Some experts consider them as one species (*X. strumarium*). The biology and management of these species are similar.

Xanthium species are also commonly referred to as cockleburr or burrweed.



Figure 1. Italian cockleburr. S. Johnson.

Noogoora and Italian cockleburr are native to the southern United States of America, Mexico and West Indies. Californian burr is native to northern California. South American burr is native to Argentina, Chile and Uruguay.

Impact

These weeds compete with summer crops and pastures. They are especially a problem when they grow in dense stands. In crops such as cotton, corn and soybeans, these weeds can out-compete crops



Figure 2. Noogoora burr. S. Johnson.



Figure 3. Californian burr. S. Johnson.

NSW GOVERNMENT Industry & Investment

for moisture and nutrients. Left untreated, infestations result in reduced yields and downgrading of grain due to contamination. In cotton and wool production, masses of the fruit or burrs can get tangled in the fibres, resulting in price penalties.

These weeds also cause problems in livestock production. Large plants can create barriers for livestock and people around watercourses and in irrigation areas. The burrs can cling to livestock, making handling difficult and causing physical injury to people and the livestock. Noogoora burr is also a host plant for various plant pathogens that affect crop plants, for example the disease of cotton crops verticillium wilt (*Verticillium dahliae*).

Burr plants can cause allergies and contact dermatitis reactions in some people.

Toxicity

Xanthium species are toxic to most livestock at the seedling stage while the cotyledon (first two) leaves are still present. Mature plants are not toxic but are unpalatable to grazing animals.

Habitat

Plants are commonly found in riparian areas, along roadsides, in wasteland and in pastures or cultivated areas that are low lying or subject to periodic flooding. They are capable of forming extensive dominant stands in wet summers.

These species grow in a variety of climates. They grow best in deep fertile soils but are found on a variety of soil types.

Distribution

The distribution and abundance of these species in NSW varies with seasonal conditions.

Noogoora burr is the most widespread. It is found in most parts of NSW, except for the southern tablelands.

Californian burr is generally confined to the south-western areas of NSW.

Italian cockleburr was first found in the Hunter Valley but has now been found on the central, south and most commonly the northwest slopes and plains.

South American burr is found around Sydney, Windsor and upper Hunter areas.

Description

Noogoora burr, California burr, Italian cockleburr and South American burr are stout, erect, single stem or many branched annual plants with large leaves similar to those on grapes. They usually grow to one metre in height but can reach four metres.

These plants are very similar and often confused. However, there is extensive variation between these species, especially in the number and length of the burrs and the spines on the burrs. Plant height can vary, as can leaf size and shape.

Hybrids between these species can occur in mixed populations. The main features of these species are outlined in Table 1.

Stems

Plants tend to be single stemmed when growing in dense patches. Isolated plants have branched and spreading stems.

Leaves

Plants have large grapevine-like leaves that grow alternately on the stems. They are 5–15 cm in diameter and have prominent veins.

Roots

Plants have a stout taproot and a very extensive root system.

Flowers

The flowers are small, green and inconspicuous. They form in clusters containing separate male and female flowers along slender branchlets and in leaf axils. Female flowers develop to become the fruit (burr).

Fruit

The fruit or burr is hard and woody, more or less egg-shaped, densely covered with hooked spines and ending in longer terminal spines (or beaks). The burr is green when immature and brown when mature. The main way of distinguishing between burr species is by the burr shape and size (see Figure 4). The burr of the South American burr is the largest (heaviest) of these species. The burrs of the Californian, Italian and Noogoora burr decrease in size respectively (Table 1 and Figure 4).

Seed

There are two seeds in each burr, one slightly larger than the other. They are brown, grey or black, boat-shaped and flat on one side.

Lifecycle

Noogoora, Californian, Italian cockle and South American burr are annual plants that reproduce by seed.

Seeds germinate when the soil is moist in late winter to summer. Flushes of germination can occur after summer storms or irrigation events. On flood prone areas large germination events are common after floods.

The seedlings (see Figure 5) have a rapid growth rate. These species are short day-length plants meaning that flowering begins as the days shorten in January to early March regardless of plant age or size. Californian burr can germinate earlier and mature one month earlier than the other species.

Plants have separate male and female flowers. The male flower is just above the female on the stem and branches. Plants can be self pollinated or wind pollinated from nearby plants.

The fruit (burrs) continue to grow and mature from March until the cool temperatures or a lack of moisture stops plant growth. These weeds can produce hundreds of burrs per plant which may result in 2000–3000 seeds produced per square metre.

Burrs are usually dispersed from the plant in autumn and winter but they may remain attached on undisturbed plants until the following spring.

Each burr contains two seeds, each with a different dormancy. Moisture is required to break the dormancy. The large lower seed usually germinates in the season following production but the smaller seed does not usually germinate until at least a year later.



*Figure 4. A comparison of the seed capsules of the main Xanthium species (left to right): South American burr (*X. cavanillesii*), Italian cockleburr (*X. italicum*), Californian burr (*X. orientale*), Noogoora burr (*X. occidentale*) and Bathurst burr (*Xanthium spinosum*). Auld & Medd.*

Spread

The burrs of the four species, with their hooked spines, are easily spread by people and animals. The burrs can also float and are often spread in floodwater and along watercourses.

Sheep, cattle and horses spread the burrs. Populations can also be spread by seed contamination in grain and machinery.

Control and management

Integrated weed management

Prevention of seed set is the most important part of managing these plants and eliminating infestations. Trials have shown that six years prevention of seed set leads to a decline in populations to 1% of previous populations.



Figure 5: Noogoora burr seedling. S. Johnson.

Table 1. Characteristics of burr plants.

	Noogoora burr (*X. occidentale*)	Californian burr (*X. orientale*)	Italian cockleburr (*X. italicum*)	South American burr (*X. cavanillesii*)
Distribution in NSW	Widespread	Southwest regions	Hunter and north west regions	Sydney and upper Hunter regions
Common height	To 2 m	To 2 m	To 1 m	To 1 m
Stems	Purple/green mottling and hairy	Green to reddish-brown with a rough surface	Green with a rough surface	Green with a rough surface
Leaves	Green rough surface, upper darker, purplish veins	Both surfaces green and rough	Both surfaces green and rough	Both surfaces green and rough
– Shape	Broad ovate to triangular	Ovate to triangular	Broad ovate or triangular	Broad ovate or triangular
– Size	5–15 cm long 5–15 cm wide 3–5 lobed	5–14 cm long 5–15 cm wide 3 lobed	6–9 cm long 6–12 cm wide 3 lobed	5 –12 cm long 5–12 cm wide Lobes barely developed
Fruit (burrs) – Length	16–22 mm	15–25 mm	25–30 mm	15–30 mm
– Spines	Hooked 1–3 mm	Hooked 2–4 mm, diverging	Hooked 3–4 mm	Thin, hooked 4–7 mm
– Terminal spines (beak)	Straight almost parallel (sometimes divergent) 3–5 mm	Hooked 4–6 mm long curving inward at the tips	Diverging 5–7 mm long, curving inward at the tips	Straight, hooked and diverging 6–8 mm long. Not hooked at tips.

Repeated control is often needed as many germination events can occur from late winter to summer. Early control can prevent competition with crops and pastures, and later control can prevent seed set of plants that may have been missed by earlier control efforts.

Large populations can be treated with herbicides, cultivation or slashing; follow-up control of smaller populations may include spot spraying, chipping (or hand-hoeing) or inter-row cultivation in crops.

Herbicides

These plants are susceptible to a range of foliar and residual herbicides. For a full list of registered herbicides see the Industry & Investment NSW publications *Noxious and environmental weed control handbook* and *Weed control in summer crops*.

Foliar herbicides are most effective if the plants are young and actively growing. Plants suffering from moisture stress are difficult to kill. Older plants may require repeat applications. Late control with some herbicides, when the burrs are green, can result in seed sterility – however this is not recommended as the primary form of control.

In crops, residual pre-emergent herbicides are useful, although there are sometimes problems as the burr can germinate and emerge from relatively deep in the soil, below the residual herbicide band. Follow-up control in the form of chipping or inter-row cultivation may be required. Spot spraying is an important tool for areas that are difficult to access and for scattered plants.

Cultivation

Cultivation is an effective method of controlling the seedlings of these weeds. Successive flushes of seedlings during the summer may require follow up control.

Inter-row cultivation is commonly used in row cropping such as sorghum, corn and cotton to control seedlings that have germinated after irrigation events.

Slashing

Slashing or mowing are useful in clean-up operations after spraying with herbicide or if infestations are small and scattered. Any burrs from the plant should be removed from the equipment to prevent spread.

Chipping

Chipping or hand hoeing is only economical for small areas, individual plants or isolated populations. It is an effective follow up control method for plants not controlled by other methods to prevent seed set.

Surveillance

After controlling burr plants it is important to monitor these sites for further germination events. High risk areas for new infestations include flood prone areas or areas where stock from burr infested areas have been.

Pasture management

Maintaining ground cover in pastures is vital. Pasture gaps result in an increase in burr germination and seedling survival. It is important to ensure that pastures are not overgrazed in spring and summer to reduce the potential for the establishment of burrs and other weeds.

Grazing

Adult plants are not easily eaten by livestock, due to the roughness of the leaves and stems. Care needs to be taken when grazing to ensure there are no seedling plants, which are toxic to animals and could result in death.

Biological control

Four species of insects and one rust fungus have been released in Australia for the biological control of Noogoora burr. These agents have had little or no effect in NSW, mainly due to the agents' inability to tolerate the uncertain climatic conditions where Noogoora burr is found.

Legislation

Xanthium species are class 4 noxious weeds under the *NSW Noxious Weeds Act 1993* in many areas of NSW (see Figure 6).

Class 4 control requirements are that 'the growth and spread of the plant must be controlled according to the measures specified in a management plan published by the Local Control Authority.'

The responsibility for the control of noxious weeds on private land rests with the land owner or occupier of the land. This responsibility extends to the middle line of any adjacent watercourse, river or inland water (tidal or non-tidal).

A full list of noxious weeds and requirements under the Act can be found at www.dpi.nsw.gov.au/weeds



Figure 6. Declaration of Xanthium species in NSW. A. Maguire.

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Publications available

A complete list of Industry & Investment NSW weed publications can be found at www.dpi.nsw.gov.au/weeds. Printed copies are available – contact the Industry & Investment NSW bookshop on 1800 028 374 or visit www.dpi.nsw.gov.au/bookshop

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Scotch, Illyrian and stemless thistle

Weed Management Unit, NSW DPI

Introduction

There are four *Onopordum* species thistles present in Australia. Three are major weeds of pastures in some areas of New South Wales (NSW). These are

- Scotch thistle (*Onopordum acanthium*),
- Illyrian thistle (*Onopordum illyricum*) and
- Stemless thistle (*Onopordum acaulon*).

The fourth species, Taurian thistle (*Onopordum tauricum*), is recorded only in two isolated areas of Victoria.

An additional species, *Onopordum nervosum*, was detected in NSW. It was promoted as an 'cottage garden' plant and was purchased by mail order via the internet. Populations of this species were destroyed.

These thistles are all members of the Asteraceae (daisy) family and originate from Europe and Asia.

Distribution

In NSW, Scotch thistle and Illyrian thistle are major weeds of pastures on the Central and Southern Tablelands and the Central and South-West Slopes. They are also present to a much lesser extent on the coast, Northern Tablelands and North-West Slopes.



Figure 1. Illyrian thistle flower. Photo: J. Dellow.

Stemless thistle is a troublesome annual weed of pastoral areas of South-West Plains. It is the most widespread of the *Onopordum* species in Australia.

All three *Onopordum* species are still extending their range in NSW.

Habitat

Onopordum thistles grow well in the warm temperate regions. They are typically found in cultivated areas, on disturbed ground such as roadsides, rocky slopes and wasteland. They are often a problem on non-arable pastures. Thistles tend to favour the more fertile soils and those sown to introduced pastures.



Figure 2. Stemless thistle. Photo: J. Dellow.

Scotch and Illyrian thistle flourish on soils that are well drained and of moderate to high fertility and are particularly common on high fertile soils associated with introduced perennial pastures in the winter dominant rainfall zone. They prefer moderate to high rainfall. In contrast stemless thistle is found in areas of less than 450 mm of rainfall such as the pastoral areas of south-western NSW and can grow on a wide range of soils from sandy soils to the heavier, more fertile soils.

Impact

Thistles compete with pastures and reduce their carrying capacity. Rosette leaves smother desirable pasture species in spring reducing their early growth.

Dense stands of mature thistles create barriers that hinder livestock movement. Parts of the plant can break off causing vegetable fault and thus a loss in value for the wool. Thistles can cause injury to livestock and people handling the livestock or fleece.

Thistles are prolific seeders and can spread quickly if not controlled. Once established thistles are difficult and expensive to control. Dense thistle populations can reduce property values.

Description

Scotch and Illyrian thistles are often confused with each other and are sometimes identified as the same species.

There is a large variation within each species due to hybridisation between Scotch and Illyrian thistles. These two species have the same weediness and control methods.

The major differences between the three *Onopordum* species present in NSW are summarised in Table 1.

Scotch thistle

Onopordum acanthium is also known as heraldic thistle, cotton thistle and woolly thistle.

The plant has a whitish-grey appearance with woolly stems and leaves. The flower heads are purple and round with spiny bracts. These bracts, surrounding the flowers, are the main distinguishing feature. They are sharp, needle-like and less than 3 mm broad at the base, yellow in colour, and only the outer bracts are reflexed (bent sharply backwards). The plant can grow to over two metres in height.

Illyrian thistle

Onopordum illyricum is also known as Scotch thistle and woolly thistle.



Figure 3. Scotch thistle flower. Photo: J. Dellow.

It has the same whitish-grey, woolly appearance as Scotch thistle. Its main distinguishing feature is the configuration of the flower head. The flowers are purple and protrude slightly more from the head than they do with Scotch thistle. The bracts surrounding the flower are much broader than 3 mm at the base, are reddish-purple in colour and are all reflexed. The rosette leaves are more deeply lobed and the mature plant looks more skeletal and angular.



Figure 4. Mature Illyrian thistle. Photo: J. Dellow.

Stemless thistle

Onopordum acaulon is very similar to the other two species during the seedling and rosette stages. The rosette leaves are woolly, but are less lobed and broader than the other two species. The mature flowering plant is readily identified as it is stemless and prostrate with a 'wreath'-like appearance. It grows up to 60 cm in diameter and has the round flower heads in the centre of the rosette.



Figure 5. Mature stemless thistle. Photo: J. Dellow.



Figure 6. Seedlings of Scotch thistle (left), stemless thistle (centre) and Illyrian thistle (right). Photos: J. Dellow.

Table 1. Comparison of *Onopordum* species thistles

	Scotch thistle *O. acanthium*	Illyrian thistle *O. illyricum*	Stemless thistle *O. acaulon*
Lifecycle	**Annual to biennial**	**Annual to biennial**	**Annual**
Seeds	species similar – rectangular, 4–5 mm long, greyish-brown		
Seedlings	cotyledons and seedlings all very similar (see Figure 6)		
Colour and texture	whitish-grey with woolly stems and leaves	whitish-grey with woolly stems and leaves (less woolly than Scotch and stemless thistles)	whitish-grey with woolly leaves
Rosette leaves	lobed with spiny margins	deeply lobed to main rib (more deeply lobed than scotch and stemless thistles)	lobed with spiny margins (broader than Scotch and Illyrian thistles)
Stems	erect with spiny wings extending from leaves	erect with spiny wings extending from leaves (more skeletal, angular appearance than scotch thistle)	stemless and prostrate
Flower heads	purple, globular with long, slender bracts less than 3 mm with only outer bracts reflexed	purple, globular with broad bracts wider than 3 mm, bracts reddish-purple and all reflexed (flowers protrude more from head than scotch thistle)	white to purple clusters of globular heads in centre of rosette, sharp bracts
Flowering time	August–December	December–Feburary	October–December
Distribution in NSW	mainly Central and Southern Tablelands and Slopes	mainly Central and Southern Tablelands and Slopes	mainly south-western pastoral areas but scattered populations are present on the Northern Tablelands



Figure 7. Rosette leaves of Scotch (left), stemless (centre) and Illyrian thistle (right). Photo: J. Dellow.

Life cycle

Scotch and Illyrian thistles are annual or biennial but can be behave as short-lived perennials when stressed (e.g. during drought or when they are slashed or mowed prior to flowering). Stemless thistle is mostly an annual plant.

Seeds can germinate at any time of year, however rain in summer and autumn often result in establishment events. Seedling survival is highest when there is little ground cover or competition from other pasture plants. Plant growth is dependent on rainfall.

Thistles form rosettes in their first year and develop a thick tap root that supports the development of an erect flowering stem one to two metres (rarely to three metres) in height later in the lifecycle. Stemless thistle has no stems.

Plants that germinate in autumn can flower in the following spring or summer and then die (annuals). Plants that germinate later in winter or spring/summer can be biennials, that is, if the summer is favourable the plants remain as rosettes until the following spring and then flower. This is because the plants need a winter chilling period before they flower. A proportion of the thistle population may persist in the rosette stage for several years before flowering as a response to stress (perennial).

The variable germination and biennial growth habit increases the difficulty in controlling these thistles as there is always a mixed age population, from seedlings through to mature plants.

Thistle seed production can vary from a few hundred per plant in a poor season to over 10 000 per square metre in a good season. Seed is long-lived and can remain viable in the soil for more than eight years.

Spread

The main form of spread is by seed. The seeds have fine hairs which can easily attach to stock and clothing. The seed is often spread in hay, on machinery or vehicles. The seed can also survive the digestive tract of sheep.

The seed of stemless and Illyrian thistles are well suited for wind and water dispersal. The Scotch thistle seeds are poorly spread by wind except when the seed head breaks off the plant and is blown about by strong winds.

Scotch thistle may be spread when root fragments are moved by cultivation equipment. This is rare as plants will only survive if the fragments are fresh and the ground is moist and soft.



Figure 8. Scotch thistles grow to two metres. Dense infestations can prevent movement of vehicles or stock. Photo: J. Dellow.

Control and management

The control and management of all three species is similar.

Integrated weed management

An integrated management program is the key to successful thistle management. The use of a range of tools such as the maintenance of a strong perennial pasture, strategic herbicide application, chipping by hand and use of biological control agents where appropriate is the best strategy for long term control.

The key to managing thistles is control of seed set. By preventing plants from ripening seed the following year's population will be greatly reduced. Dense populations of thistles may have to be controlled in stages.

Consistency of control is also important. Trials show that preventing seed set for five years reduced a large thistle population, however plant numbers returned to pre-trial levels after only two years when no control was undertaken.

Preventing spread

Control isolated patches before they have a chance to spread. If transporting hay from areas where these weeds occur, monitor the area where the hay was spread out for thistle seedlings and kill them before they set seed

Quarantine sheep in holding paddocks if moving from infested to uninfested areas to allow seed to pass through the digestive tract. A minimum of five days is recommended. Monitor and kill any thistles before they set seed in quarantine paddocks.

Pasture management

The most important part of any thistle control program is maintaining a dense, vigorous and competitive pasture. A vigorous perennial grass pasture provides competition for germinating thistles reducing seedling establishment.

Gaps in the pasture result in an increase in thistle germination and seedling survival so maintaining excellent ground cover at all times is desirable. Maintenance of adequate ground cover especially in summer and early autumn is essential to reduce the potential for the establishment of thistles.

Establishing a new pasture

Establishing introduced perennial pastures is expensive so thorough preparation and research into suitable species and varieties is required. The establishment of adequate plant numbers is the first step to a successful pasture. Seek advice from your agronomist on the best pasture establishment steps for your situation. Some perennial grasses, particularly

phalaris, compete strongly with Scotch and Illyrian thistles. Lucerne competes well with stemless thistle.

Sown perennial pastures also require regular maintenance fertiliser applications (as dictated by a soil test) to maintain their vigour and competitiveness. Grazing management and ground cover is a critical factor to the maintenance of adequate perennial plant density in the years following pasture establishment.

Maintaining the current pasture

Management of existing native and naturalised pastures should aim to maintain perennial grass content and ground cover. Identify the species present, their growth cycles and their response to grazing, and fertiliser to formulate a management regime that is most suitable to maximising their competitive behaviour. The addition or dominance of too many legumes, combined with fertiliser and a trend towards an annual pasture system can lead to instability in the pasture and potential for thistle invasion.

While thistles respond to increases in soil fertility (and in particular nitrogen), management of all pasture types should aim to maintain pastures that have a good balance of perennial grass to legume content.

Fertilisers

Fertiliser application (as determined by a soil test) will improve the vigour of annual and perennial introduced grasses, increasing ground cover and reducing future thistle establishment.

Grazing management

Thistles are generally avoided by stock. However goats eat thistles at both the rosette and flowering stage as well as post-flowering. Horses, and sometimes cattle graze the flower which can reduce the amount of seed. The amount eaten depends on the grazing pressure and the amount of other feed available.

Physical removal

Isolated plants should be removed using a hoe or mattock (chipping or grubbing). Remove as much of the taproot as possible so that regrowth does not occur.

Cultivation is effective on seedlings or young rosettes if they are uprooted. Older rosettes are damaged by cultivation but are able to regrow, especially if the soil is moist.

Slashing or mowing is not usually effective as plants develop new growth from the base. Immature seed heads that are cut and left lying on the ground can contain viable seed.

Herbicides

Herbicide control can be very effective and is an essential part of the overall management of these thistles. When there is a low density of thistles, spot spraying or chipping is preferred.



Figure 9. Illyrian thistle grazing trial. Goats eat thistles at the rosette and flowering stages. Photo: NSW DPI.

Onopordum thistles can be difficult to kill, and a number of critical factors should be taken into consideration when using herbicides. These include:

- Correct rate and timing of application – herbicides are most effective on seedlings and young rosettes however once plants begin stem elongation herbicides may be less effective.
- The hairy leaves of the thistles can reduce herbicide effectiveness through reduced absorption. Therefore it is important to follow the herbicide label and use the recommended rate, application volume and adjuvant.
- Control will be reduced if plants are stressed.

Always read the herbicide label prior to applying herbicides.

For populations of thistles where there is a mixture of sizes, spray in the spring before the flowering stem develops. If there is a flush of seedlings in the autumn an early spray can prevent the rosettes from colonising the ground and competing with the pasture.

Take care in selecting the herbicide product, as many registered and effective herbicides for control will damage pasture legumes leaving room for other weeds to establish. Regular herbicide use affects the long term composition of the pasture. For lists of herbicides registered for these thistles see the *Noxious and Environmental Weed Control Handbook*, *Weed Control in Lucerne and Pastures* or *Weed Control in Winter Crops* available from NSW DPI or www.dpi.nsw.gov.au/weeds

Resistance

In New Zealand the total reliance on 2,4-D ester (MOA Group I) for the control of nodding and slender thistles for many years has lead to the development of herbicide resistance, however this has not yet been recorded in Australia.

Dense thistle populations with large seed banks are a higher risk to develop resistance compared with sparse weed populations.

Herbicides should only be used as part of an overall management strategy.



Figure 10. Illyrian thistle infestation. Photo: J. Dellow.

Spray grazing

Spray grazing is the use of a sub-lethal rate of herbicide to 'sweeten' the weeds, making them palatable to livestock. Only use this method when there are low levels of the weeds present and there is plenty of alternative feed available. Weeds must be in the early rosette stage. For spray grazing to be effective sheep stocking rates must be increased to 8–10 times the normal rate. Grazing should be continued until the weeds have had the growing points eaten but not to the point where the pasture species are at risk. Spray grazing is only effective if there is a competitive pasture to replace the weed.

Observe the stock health warnings on the herbicide label when using the spray grazing technique. There is a risk of stock poisoning if a large proportion of the pasture consists of other weeds such as Paterson's curse (*Echium plantagineum*) or variegated thistle (*Silybum marianum*).

Biological control

Biological control of thistles is a long term tactic and should only be seen as part of an effective integrated weed program.

Up to ten insect species were trialled for released for the biological control of *Onopordum* thistles. The successfully established species shown below were released several years ago and are now present in most areas affected by *Onopordum* thistles. There should be no need for redistribution of these species.

These biological control agents have a direct impact on the seed set of thistles. This is important for the long term control of thistles.

Seed-head weevil

The seed-head weevil, *Larinus latus*, was released in spring 1992. The adult weevil is up to 25 mm long, 10 mm wide and is black with a yellow waxy coating. Adults hibernate over winter until mid to late spring when they become active and mate. Each lay up to 30 eggs on the thistle flower head. Larvae hatch and tunnel into the flower head where they feed on the tissue supporting developing seeds. After feeding for about six weeks the larvae pupate.

A single larva is capable of destroying all the seed in a flower head of 3 cm diameter or less and more than one larva may develop in larger heads. This weevil has only one generation per year so it has taken a number of years for populations to grow large enough to destroy most of the seed in a flower head. At some NSW sites this insect has reduced seed production by more than 80 per cent.



Figure 11. Clockwise from top left. The crown moth (*Eublemma amoena*). The rosette weevil (*Trichosirocalus briesei*). The seed-head weevil (*Larinus latus*) attacking Illyrian thistle. The stem-boring weevil (*Lixus cardui*). Photos: CSIRO Entomology.

Stem-boring weevil

The stem-boring weevil, *Lixus cardui*, was first released in November 1993 and is now widely established. Adults grow up to 15 mm long and are brown in colour. They emerge from stems in early spring and chew holes in the leaves of thistle rosettes. Females lay eggs into the flowering stems then larvae bore into the plant. Adults continue to feed on the leaves. Combined heavy adult and larval feeding can reduce plant growth and subsequent seed production.

The stem-boring weevil is not capable of killing *Onopordum* thistles. Its activity weakens the plant, makes it less competitive and reduces seed production. This action allows insects such as the seed head weevil to have a greater impact on the plant.

Crown moth

The crown moth, *Eublemma amoena*, was first released in 1998. Adult moths are mottled, light brown and white and up to 15 mm in length. There are three adult generations per year, commencing in spring when adults emerge from pupal cells in thistle rosettes. Females lay eggs on leaves and larvae feed in the leaf petioles, causing leaves to shrivel and die. Larvae can also bore into the crown and root of the plant. This may lead to the death of smaller plants. Larvae of subsequent generations feed in the leaves of stems, causing similar leaf shrivelling, reducing plant vigour.

Rosette weevil

The rosette weevil, *Trichosirocalus briesei*, was first released in 1997. It is now established in many areas and is starting to have an impact on thistle populations. Adults are 3–5 mm long and a mottled brown colour. There is one generation per year. Adults emerge from a summer dormancy period following autumn rains and commence feeding on rosette leaves. Females lay eggs near the base of the rosette leaves. After hatching, larvae destroy the growing point of the rosette either killing the plant or severely reducing its vigour.

Legislation

In some areas of NSW Scotch thistle, stemless thistle, Illyrian thistle and Taurian thistle are declared as Class 4 noxious weeds under the *NSW Noxious Weeds Act 1993* (Figure 12).

Class 4 control requirements are that ‘the growth and spread of the plant must be controlled according to the measures specified in a management plan published by the Local Control Authority.’

The responsibility for control of noxious weeds on private land rest with the landowner or occupier of the land.

A full list of noxious weeds and requirements under the Noxious Weeds Act can be found at www.dpi.nsw.gov.au/weeds



Figure 12. Areas of NSW where *Onopordum* species are declared a Class 4 noxious weed.

Acknowledgements

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Warnings: Pasture improvement may be associated with an increase in the incidence of certain livestock health disorders. Livestock and production losses from some disorders are possible. Management may need to be modified to minimise risk. Consult your veterinarian or adviser when planning pasture improvement.

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St John's wort

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Introduction

St John's wort (*Hypericum perforatum*) was brought to Australia in 1875 as a garden plant and is now a serious weed on the tablelands and slopes of New South Wales. It is found in pastures, water catchment reserves, forests and national parks.

St John's wort is a declared noxious plant in many local government areas in New South Wales (see page 11).

The problem

St John's wort contains the toxin hypericin, which causes photosensitisation in sheep, cattle, horses and goats. The skin damage associated with this problem leads to weight loss, reduced productivity and, in extreme cases, death. St John's wort also adds vegetable fault to wool.

St John's wort competes with useful plants in pastures, and large infestions reduce property values.

Distribution

St John's wort is a native of Europe, Asia and North Africa, and is a weed in 21 countries.

In Australia, Victoria was first to record St John's wort as a weed, in 1893.

St John's wort now infests large areas in NSW, Victoria and South Australia. The most heavily infested areas are the central and southern tablelands and slopes of New South Wales and north-eastern Victoria.

It is most suited to areas receiving more than 600 mm annual rainfall and above 500 m altitude.

Identification

Key Points for Identification

- Yellow flowers in October to January, about 22 mm across, with five petals.
- Leaves and branches always opposite one another on the stem.
- Leaves appear perforated when held up to the light.



St John's wort plant and flower. Photo: B. Trounce.

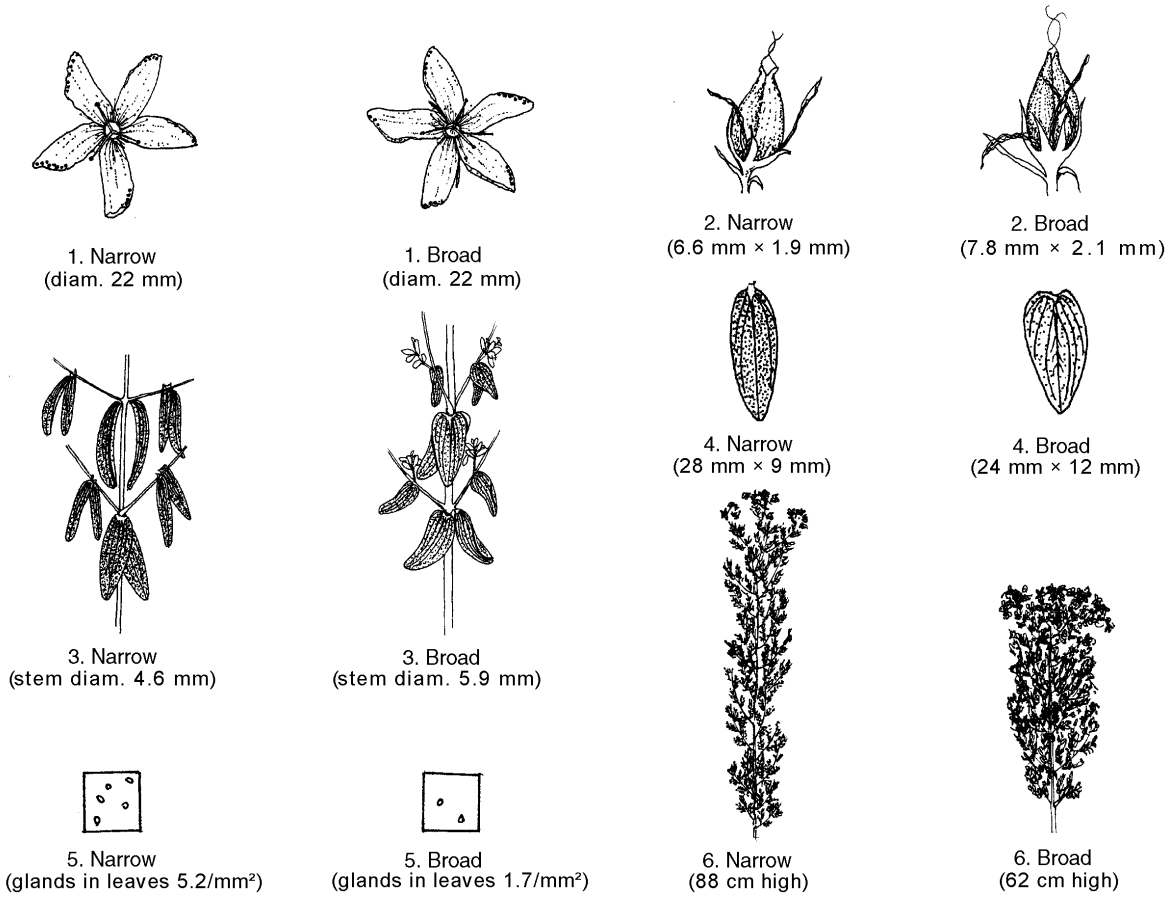


Figure 1. Comparison between narrow- and broad-leaf strains of St John's wort. J. Peacock.

Strains

There are two main strains of St John's wort in NSW (Figure 1). Knowing which strain of St John's wort you are dealing with is essential, as toxic properties and management options will depend on the strain present.

The **narrow-leaf strain** is more widespread and contains more oil glands in the leaves, resulting in higher levels of hypericin. The plants are late-flowering and tall, with thin stems and small seed capsules.

The **broad-leaf strain** contains fewer oil glands in the leaves, resulting in lower levels of hypericin. It is early-flowering and short, with thick stems and large seed capsules.

Leaves

Leaf width is the most reliable characteristic to use to distinguish between the broad-leaf and narrow-leaf strains. Leaf width is measured at the 6th node (bump) on the flowering stem when the plant is growing well in spring.

The **narrow-leaf strain** has leaves 7– 9 mm wide.

The **broad-leaf strain** has leaves 10–12 mm wide.

Leaves are paler green on the lower surface and have translucent oil glands, which give them a perforated appearance when held against strong light. They are opposite one another on the stem and have no stalk.



The translucent oil glands in the leaf. The leaf width – narrow (top) and broad (bottom) – allows for easy identification. Photo: NSW DPI

Flowers

St John's wort flowers from late October to January. The flowers are bright yellow. They grow in dense clusters at the ends of the branches. The flowers are about 22 mm in diameter, and have five petals.

Fruit and Seed

The fruit, a sticky three-celled capsule, is about 8 mm long. The fruit splits open on ripening in summer, to release seeds in the following autumn and winter.

The seed is small (0.5–1 mm), cylindrical and light to dark brown or black, with a pitted seed coat. Seeds need mild temperatures, light and rainfall (to wash off an inhibitor) before they will germinate. Seeds can remain viable for 12 years.

A plant may produce up to 33 000 seeds per year.



The flower bud, flower and seed capsule of St John's wort. Photo: NSW DPI

Stems

Non-flowering stems grow from the crown in autumn and winter, and can form tangled thickets if not grazed.

Erect, woody, flowering stems are produced from the crown in spring. These stems sometimes have a reddish tinge, branch near the top and have two opposite longitudinal ridges.

The broad-leaf strain grows to a height of about 60 cm, while the narrow-leaf strain grows to a height of about 90 cm.

Roots

St John's wort has one set of roots that grow vertically to about 1 m deep into the soil, and another set that grow horizontally and produce buds that form new aerial growth.

Deep soils favour the development of vertical roots and long-term survival of the crown. In shallow soils, the life of the crown is shorter and roots generally grow laterally and sucker more readily than vertical roots.



The broad-leaf strain of St John's wort (left) is short and early flowering, while the narrow-leaf strain (right) is tall and late flowering. Photo: NSW DPI

Life cycle

St John's wort is a perennial plant. A single plant increases in size by growing outwards from the roots in concentric circles.

Seeds can germinate from autumn to spring, but new plants do not flower in the first year.

It has non-flowering stems that grow from the crown during autumn and winter and die in late spring, and flowering stems that grow from the crown each spring and die in the following autumn.

Viewed from a distance, an infestation of the weed appears yellow from November to January, a mixture of dark green, brown and yellow from February to April and brownish-red in winter.



St John's wort can spread by suckers growing from lateral roots. Photo: NSW DPI

Dispersal

St John's wort spreads by seeds and lateral roots.

The sticky seed capsules adhere to animals – hence its spread along roads, travelling stock reserves and animal tracks. Seeds are also carried in the digestive tracts of animals, and seedlings have been observed in cattle dung. Seed is spread over short distances by wind, but over long distances by water, machinery, humans, livestock or feral animals.

The roots of St John's wort sucker and grow from fragments; therefore, cultivation can spread the weed unless the roots are brought to the surface and dried out.

Toxic properties

St John's wort contains the toxin hypericin. Stock will only eat St John's wort when other feed is scarce; however, it is quite poisonous, particularly to animals not accustomed to it.

When animals ingest hypericin, it passes from the stomach to the bloodstream. When hypericin enters the blood vessels in the skin of an animal it is activated by bright sunlight. Sunlight alters the chemical structure of hypericin, making the compound potentially poisonous.

Variations in hypericin production

Plant parts and season

Production of hypericin by St John's wort is strongly associated with the growth and development of its flower stems; consequently, hypericin levels display a large seasonal variation (Table 1).

Hypericin levels rise rapidly in spring once the new season flower shoots exceed a height of 5–10 cm. Levels continue to rise as the flowering heads develop further and reach a maximum when the plant is in full flower. Hypericin levels then decrease as flowers are lost and capsules mature over summer. In late autumn, when the growth of prostrate winter stems begins, only low to moderate levels of hypericin are present; these levels reach a minimum for the year from late July to late August. With spring, the hypericin levels rapidly rise and the cycle begins again.

Strains

St John's wort occurs as narrow-leaf and broad-leaf strains, the narrow-leaf strain containing about twice the concentration of hypericin as the broad-leaf strain. However, in both strains the hypericin production level changes as the growth stage of the plant changes (Table 1).

Climatic factors

Little is known about the influence of climatic factors on the production of hypericin in St John's wort.

Research was conducted by NSW Department of Primary Industries over two consecutive years (Figure 2). The first year was a lower than average rainfall year, and the second a higher than average rainfall year.

Results indicated that peak hypericin production in the year of above-average rainfall was found to be 20% higher than that for the year of below-average rainfall. This demonstrates that hypericin is not enhanced by water stress.

Grazing

When new season flowering stems appear in spring, continued heavy grazing significantly suppresses their rate of growth. This in turn suppresses hypericin production.

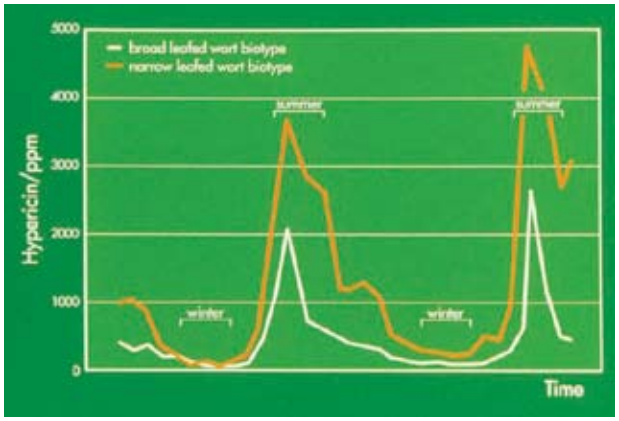


Figure 2. Seasonal hypericin variation over two consecutive years between broad-leaf and narrow-leaf St John's wort. Source: C. Bourke.

Table 1. Variation in hypericin production levels between strains and growth stages of St John's wort

Growth stage	Time of year	Narrow-leaf	Broad-leaf
Growth of upright flower spikes	Sept–Nov	300–600 ppm	100–500 ppm
Full flowering	Nov–Dec	1000–5000 ppm	500–2500 ppm
Development of fruiting capsules	Jan–March	3000–1500 ppm	1000–400 ppm
Growth of prostrate winter stems	March–June	1500–300 ppm	400–100 ppm
Winter stem growth	June–Sept	100–300 ppm	50–100 ppm

For example, in spring the broad-leaf strain was continously grazed. In early January, regrowth contained hypericin at 350 ppm. St John's wort which was not continuously grazed during spring contained 1400 ppm of hypericin.

Effects on livestock

On sunny days, livestock grazing on pastures heavily infested with flowering St John's wort can develop clinical signs of hypericin poisoning in less than five hours.

Early symptoms of hypericin poisoning include agitation, head-rubbing, intermittent hind limb weakness with knuckling over, panting, confusion and depression. Some animals may develop mild diarrhoea.

This is followed by inflammation and swelling of the skin around the forehead and eyes. Affected animals also have abnormally high body temperatures (hyperthermia).

If affected animals continue to graze St John's wort, the reddish inflammation and fluid-associated swelling of the head and ears will worsen.

Affected animals will then rub their irritated heads or ears against fixed objects. Raw, weeping, bleeding areas of skin will develop, and eventually dry to form scabs.

Production losses

The animal production losses associated with grazing St John's wort pastures include:

- weight loss and failure to gain weight associated with a reduction in eating ability or interest in eating
- less wool produced in sheep, and less milk produced in sheep and cattle
- fewer lambs and calves born alive and less surviving to weaning



Photosentisation causes swelling and scab formation on the face. Photo: C. Bourke.

- fewer ewes or cows that are sufficiently heavy or healthy to conceive in the first place.

Treatment

Animals affected by hypericin poisoning must be removed from direct sunlight as soon as clinical signs develop, and held in full shade. Animals will need to remain protected by shade for at least four to seven days.

Once animals have excreted all accumulated hypericin they can be returned to sunlight and, provided they have access to good feed and water, should not show any further clinical response.

Tolerance in animals

Since hypericin only becomes poisonous after it has been activated by sunlight, an animal's hypericin tolerance is influenced by the amount of skin protection it has. Therefore, characteristics that will increase animals' tolerance of hypericin are:

- pigmentation rather than non-pigmentation
- wool cover rather than hair cover
- wool cover rather than shorn wool
- dense, fine fleece or hair rather than open, coarse fleece or hair
- long rather than short wool or hair
- tough rather than soft skin.

In addition, an animal's tolerance of hypericin is increased in the absence of direct sunlight. For example, in trials conducted by NSW Department of Primary Industries, sheep were dosed with twice the daily intake tolerance amount of hypericin, while one group of sheep was kept indoors (out of direct sunlight) and another group outdoors (bright sunlight exposure). Only the sheep kept outdoors in bright sunlight developed clinical signs of hypericin poisoning.

This shows that preventing an animal's exposure to sunlight will increase its tolerance to hypericin. Since it is not practical to keep animals indoors, providing good shade cover in a St John's wort-infested paddock is the most practical way to minimise sunlight exposure and hence improve an animal's hypericin tolerance.

Pregnant and lactating animals should always be removed from St John's wort-infested pastures. Hypericin can cross from the mother into the blood circulation of her foetus or into her milk. This can result in the birth of weak or dead progeny, and poor performance in suckling young.

Adult animals are more hypericin-tolerant than suckling or young weaner animals. The softer, thinner skin of young animals, together with lighter fleece or hair cover, reduces their hypericin tolerance. Also, suckling young ingest hypericin from two sources: the

St John's wort in the pasture and the hypericin in their mother's milk.

Different animal species vary in their tolerance of hypericin, and there are significant differences within an animal species.

Sheep

Sheep hypericin tolerance is influenced by their amount of wool coverage. For example, research conducted by NSW Department of Primary Industries indicated that the majority of Merino sheep with at least four months wool growth will not be poisoned by a single hypericin dose of 3 mg/kg live weight per day. However, 94% of recently shorn Merino sheep will develop early signs of poisoning, even at this low dose.

There are also small differences in hypericin tolerance between different bloodlines of sheep. Fine and superfine bloodline sheep, with at least four months wool growth, are more tolerant of hypericin than sheep from medium wool bloodlines. Studies show that superfine Merinos are more than twice as well protected against St John's wort poisoning than medium wool Merinos.

The difference in performance of different wool types reflects the greater crimp frequency and fibre density of the finer types, contributing to a tighter fleece with more skin protection from sunlight. Individual variation in hypericin tolerance also exists between sheep within the same bloodline.



Sheep affected by St John's wort showing swollen head and signs of depression. Photo: C. Bourke.

Cattle

Until recently, it was believed that cattle were more sensitive to hypericin than sheep and goats. However, recent research by NSW Department of Primary Industries indicates that cattle may actually be much more tolerant of hypericin then previously suspected.

For example, the toxic dose of hypericin for yearling Hereford steers (approximately 300 kg) is about 10.5 mg/kg liveweight per day. Therefore, Hereford cattle are at least three times more tolerant of St John's wort than Merino sheep protected by white wool.

Based on this, fully pigmented cattle may be as much as four to six times more tolerant of hypericin. Further research needs to be conducted to more accurately assess the minimum toxic dose of hypericin for cattle.

Goats

Anecdotal reports suggest that goats are more tolerant of hypericin than sheep and cattle. However, this may not necessarily stand up to scientific scrutiny. Genetic differences between groups of sheep in their sensitivity to St John's wort poisoning appear to relate to the exclusion of light from the skin rather than the capacity of sheep to metabolise and excrete hypericin. Therefore, it is possible that the same trend will apply to other ruminant species.

For example, a white, coarse-haired Saanen doe may be less tolerant of hypericin than a white, superfine, wool-protected Merino wether. A fully pigmented Angus steer may be more tolerant than either of these. Further research needs to be conducted to assess the minimum toxic dose of hypericin for goats.

Control techniques

The most cost-effective and practical control techniques to use will depend on the scale of the St John's wort infestation and the topography of the infested land. All techniques should aim to remove the weed and replace it with introduced or native pastures.

Prevention of spread

Preventing the invasion of St John's wort is the cheapest and most effective way of controlling it. Learn to identify the weed, and regularly check for it in October or November along boundary fences, roadsides, stock routes or reserves adjoining your property. If found, act immediately to remove it.

If purchasing livestock from areas contaminated with St John's wort, hold them in a small paddock for five weeks before releasing them, to allow seed on or inside the animal to be released. Later, inspect this paddock and treat any infestations. If you have infested paddocks on your property, minimise stock movements from infested to clean paddocks and clean any vehicles that have passed through infested areas.

Buy only certified seed. If purchasing fodder, obtain as much detail about the source of the fodder as possible. When feeding, restrict the feeding area, preferably to flat, arable areas, as they allow easy access and the opportunity to use a variety of control options; or, feed in paddocks where there is a strong perennial grass pasture, as this will provide good competition against establishing weeds.

Regularly check the feeding areas and treat any new infestations.

Establish a competitive perennial pasture, such as a phalaris pasture, along boundaries of infested paddocks, to create a buffer against the further spread of St John's wort.

Burning

Burning checks the growth of St John's wort and destroys seeds on the plant, but has a more detrimental effect on the associated pasture than on the St John's wort.

Hand-weeding

Hand-weeding, either by pulling plants out by hand or digging plants out using a hoe or shovel, is not an effective method of controlling St John's wort.

St John's wort can reproduce from buds produced on its roots; therefore, new plants will grow unless the entire root structure is removed.

Herbicides

Herbicides registered for control of St John's wort include fluroxypyr, triclopyr + picloram and glyphosate. For a full list of registered herbicides for St John's wort refer to the NSW DPI publication *Noxious and environmental weed control handbook.*

Applied during flowering, fluroxypyr will selectively remove St John's wort while minimising damage to grasses or clovers, triclopyr + picloram will kill all legumes, and glyphosate will kill or severely damage all species growing with the weed.

Spot-spraying

Spot-spraying is an appropriate control strategy to use on isolated St John's wort infestations. Triclopyr + picloram and glyphosate are both registered for the control of St John's wort using spot-spraying equipment.

Spot-spraying is best carried out when the St John's wort is in flower (November to January), because at this time it is easily seen and most sensitive to herbicides (Figure 3). Start spraying when the St John's wort reaches the 50% open flower stage and finish before it advances to the 50% green capsule stage. Avoid spraying plants when the flowers have turned brown. For best results when spot-spraying, spray to thoroughly wet foliage.

Do not spray St John's wort that has been defoliated by insects, grazing or cutting, or is moisture stressed, as herbicide effectiveness is reduced under these circumstances.

Boom-spraying

Fluroxypyr, triclopyr + picloram and glyphosate are all registered for the control of St John's wort using boom-spray equipment. Boom-spraying St John's wort should be carried out from bud to full flowering (November to early January).

Patches of St John's wort can be treated with fluroxypyr or triclopyr + picloram using a small boom. Research conducted by NSW Department of Primary Industries indicates that two boom-spray applications of fluroxypyr or triclopyr + picloram one year apart at flowering can result in 100% kill of the weed.

Boom-spraying medium St John's wort infestations can be effective if the existing pasture can be salvaged. A chemical such as fluroxypyr will selectively remove St John's wort in the pasture while minimising damage to clovers or grasses.

If the existing pasture cannot be salvaged, boom-spraying with glyphosate in November/December as part of a pasture resowing program is the best option (see 'pasture competition' section).

Rotary wiper

A rotary wiper can be effective for treating patches of St John's wort. Trials conducted by the Mid Western County Council near Mudgee resulted in a 90% kill of St John's wort one year after wiping. The St John's wort was treated at full flower with 1 L glyphosate per 20 L water (plus 200 mL wetting agent) by wiping the top two-thirds of the plants one way. It is important to graze any associated useful plants to below the wiper height before treatment.

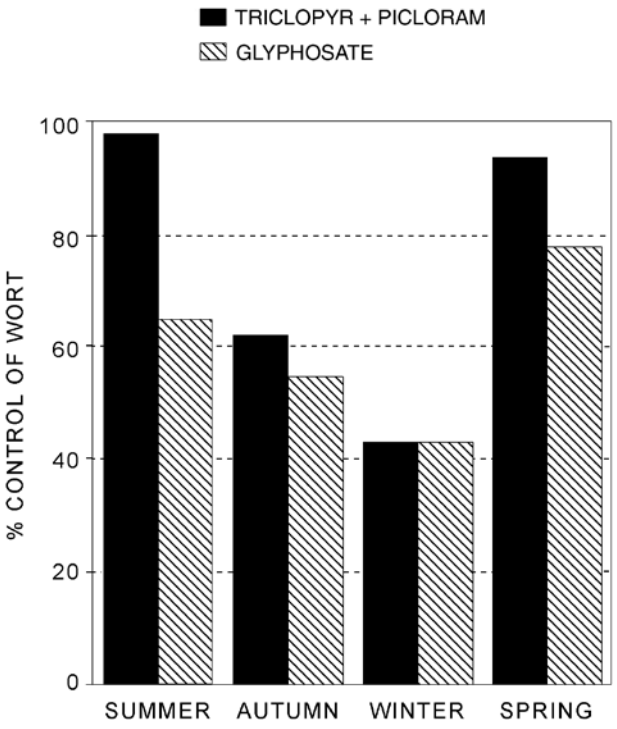


Figure 3. The best time to spray St John's wort is late spring to early summer. Source: Campbell et al. 1991.

Pasture competition

Competition from perennial pastures is essential for the long-term control of St John's wort. Pasture competition prevents the germination and establishment of St John's wort seedlings by reducing space, light, moisture and nutrient availability. Maintaining pasture cover at the autumn break is particularly effective in reducing germinating St John's wort seedlings, which are highly susceptible to competition early in their life cycle.

In light to medium St John's wort infestations (where the existing pasture can be salvaged) pasture competition can be improved by appropriate grazing management (for example, allowing pastures to occasionally set seed and resting paddocks) and by fertilising regularly and controlling pests.

On fertile country, medium to heavy St John's wort infestations (where the existing pasture cannot be salvaged) can be controlled by sowing a perennial pasture. See below for examples of pasture establishment methods.

Cropping and pasture sowing on arable land

On arable land, St John's wort can be controlled by cultivation and cropping to remove the St John's wort and reduce seed reserves before sowing a perennial pasture.

For example:

- Year 1 – boom-spray with glyphosate in November/December to obtain an initial kill or plough in summer to expose and dry out the roots of the St John's wort.
- Year 2 – cultivate to prepare a seedbed and sow a winter cereal crop in autumn. Repeat ploughing or glyphosate herbicide application in the summer.



Phalaris and sub clover (green plot) replacing St John's wort two years after using a simulated aerial spray-sow technique at Cassilis. Photo: NSW DPI

- Year 3 – sow a second cereal crop in autumn and repeat ploughing or glyphosate herbicide application in summer, before sowing a perennial pasture in the following autumn.

Perennial grass pastures are the most competitive for St John's wort control. As pasture varieties and sowing requirements vary, consult your local agronomist for recommendations for your property.

Pasture sowing on non-arable land

Infestations of St John's wort on non-arable fertile hill country can be controlled by replacing it with a direct-drilled or aerially sown perennial pasture.

The direct-drilling/aerial sowing program involves spraying glyphosate in November to January, and again after the autumn break, to control annual weeds before sowing the pasture mix.

New pastures should be allowed to set seed in the year of establishment, and any reinfesting St John's wort can be controlled by spot-spraying.

Grazing management

Grazing St John's wort offers a cost-effective, long-term control method in all situations; however, it is often the only practical method for steep, inaccessible hill country. Care needs to be taken to avoid poisoning when grazing St John's wort. The following are some guidelines for the grazing management of St John's wort.

Animals to use

Superfine or fine-wool adult Merino wethers or dry, non-pregnant ewes with at least four months' wool growth are recommended for grazing of St John's wort infestations. Animals with this wool type and amount of wool growth have the most protection against sunlight, and are also effective defoliators of St John's wort.

Cattle can also be used, either exclusively or to supplement the role of sheep. Cattle are less effective defoliators of St John's wort than sheep (sheep graze more closely than cattle) but they are more tolerant of hypericin. Fully coloured (pigmented) cattle, either 100% black or red, will be the most tolerant.

Cattle can be put onto St John's wort pastures about six weeks earlier than sheep, and the pasture can be used to knock down heavy infestations and open it up for subsequent grazing by sheep. Cattle can also remain on St John's wort pastures much longer than sheep in spring.

Timing of grazing

St John's wort should only be grazed when the hypericin levels in the plant are low. For broad-leaf infestations, start grazing (with sheep) in early May and continue through to mid-October. For narrow-leaf

infestations, start grazing (with sheep) in early July, and continue through to mid-September.

Variations in yearly climatic conditions can influence these recommended grazing periods. For example, the grazing period may be extended for a few weeks in years in which dry conditions occur, but reduced during wet years, as hypericin levels become elevated during wet conditions.

During these safer grazing periods, the flowering stems, which are high in hypericin, are dead, but at the base of each plant there are many soft, green, prostrate-growing shoots. These shoots are low in hypericin, and by eating them stock will significantly depress the weed's ability to re-grow the following season. Grazing these shoots will allow competing vegetation to progressively outgrow them. The reduction in St John's wort density in pastures following successive years of grazing will allow the safe grazing period to begin earlier in autumn and continue longer through spring, because it will decrease the potential daily hypericin intake of grazing livestock.

Grazing hard in spring can also delay the growth of hypericin-rich flower stems for several months, and thereby extend the safe grazing period. In spring, always make sure that livestock are moved off St John's wort pastures before the new season flowering stems reach a height of 5–10 cm, because poisonous levels of hypericin will rapidly develop.

Grazing methods

Several shorter periods of grazing using high stocking rates will be more effective than one long period using a lower stocking rate. Higher stocking rates will allow stock to defoliate St John's wort and shorter grazing periods allow stock to be removed to protect their health and maintain the competitive nature of the pasture. If possible, fence off heavy St John's wort infestations, to reduce the size of the area to be grazed and thereby facilitate this repeated heavy grazing.

Grazing must be carried out every year to achieve long-term control. The retention of good tree shade in St John's wort-infested paddocks is recommended, to minimise the effect of sunlight on livestock.

Biological control

Currently, only six of the twelve agents released as biological control agents for St John's wort have become established in Australia. These agents can reduce the spread and density of St John's wort infestations, and in some cases control is achieved to the level where the weed is no longer of concern and no other control is necessary. More commonly, other methods are still required to achieve the desired level of control; however, these need not be used so frequently or intensively.

Contact your local NSW DPI office to arrange an assessment of the suitability of your site and information on release sites for biological agents.



Large infestations of St John's wort can reduce property values. Photo C. Bourke

Chrysolina beetles

Two species have established in Australia: *Chrysolina hyperici* and *C. quadrigemina*. They are black with bronze, dark-blue or purple reflections, and are oval in shape. *Chrysolina quadrigemina* is slightly larger (6.0 to 7.1 mm) than *C. hyperici* (5.3 to 6.1 mm). Some individuals of *C. quadrigemina* are distinctly bluish.

The Chrysolina larvae and beetles feed on the leaves of St John's wort. The larvae attack the winter growth and the adult beetles attack the spring growth. At favourable sites, beetles may reach densities high enough to cause complete defoliation, and this suppresses flowering and seed production. The best control is achieved when the beetles and larvae attack the weed in the same or consecutive years. The damage produced by the beetles can appear spectacular, but the impact tends to be sporadic and inconsistent. They can provide effective control in open, unshaded situations, but without follow-up pasture improvement the weed frequently re-establishes. The beetles are not effective in timbered country, as they mate only in sunlight.

Chrysolina beetles have low mobility, and therefore it may be worthwhile to assist their movement by collecting batches in spring and transferring them to new infestations.



Black Chrysolina beetles stripping St John's wort of leaves. Photo: NSW DPI.

Do not use herbicides as an additional method of control when high numbers of Chrysolina beetles are present, because partially defoliated plants are unlikely to absorb enough herbicide to kill them.

Agrilus hyperici

The adults of this beetle are bronze in colour and 5 mm x 2 mm in size. They lay their eggs in the crown of St John's wort plants in summer; when the larvae hatch, they bore into the roots and kill the plants. While able to cause significant damage to St John's wort, this beetle is restricted to one or two isolated sites near Mudgee and Tuena.

Gall midge (Zeuxidiplosis giardi)

This small fly lays eggs in the terminal buds of St John's wort plants. When the larvae hatch, they form galls by feeding on the leaf buds, thus reducing seed production. Although relatively widespread and common, the gall midge does not generally reach sufficient levels to cause a significant impact on St John's wort infestations. However, the gall midge does help to control St John's wort in shady country where other insects are not active.

Aphis chloris

This green aphid attacks flowering stems of St John's wort in summer, when the Chrysolina beetles are inactive, reducing seed production and weakening the plant. Like the gall midge, this aphid is relatively widespread and common, but also does not generally reach sufficient levels to cause an impact on St John's wort infestations.

St John's wort stunt mite (Aculus hyperici)

This mite is almost invisible to the naked eye and all life stages are present during the whole year. The mite has established well but it only seems to affect the narrow-leaf form of St John's wort.

The mites feed on the growing tips of plants. Damaged leaves often have yellow streaks or mottling. The mite stunts the growth of rosettes and flowering stems, gradually weakening plants and reducing vigour and seed production. Over a two to three year period mites can exhaust the root reserves and kill narrow-leaf St John's wort plants.

Legislation

St John's wort is declared a noxious weed under the *NSW Noxious Weeds Act 1993* (Figure 4).

Class 3 control requirements are that 'the plant must be fully and continuously suppressed and destroyed'.

Class 4 control requirements are that 'the growth and spread of the plant must be controlled according to the

measures specified in a management plan published by the local control authority'.

The responsibility for control of noxious weeds on private land rests with the landowner or occupier of the land.

A full list of noxious weeds and requirements under the *NSW Noxious Weeds Act 1993* can be found at www.dpi.nsw.gov.au/weeds



St John's wort. Photo: L. Ayres.

Further information

For further information contact your local office of NSW Department of Primary Industries.

A complete list of NSW DPI weed publications can be found at www.dpi.nsw.gov.au/weeds

Printed copies can be arranged by contacting the NSW DPI Bookshop, Orange Agricultural Institute, Forest Rd, Orange 2800 on 1800 028 374.

Further reading

Bourke, CA 1999, 'Control of *Hypericum perforatum* (St John's wort) by grazing management system that uses Merino sheep', *Proceedings 12th Australian Weeds Conference, Hobart,* pp. 4–7.

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Bourke, CA, Southwell, IA & Mayo, GM 2002, 'Sheep as biological control agents against St John's wort (*Hypericum perforatum* L.): Factors affecting hypericin variation and hypericin tolerance', *Proceedings 13th Australian Weeds Conference, Perth*, pp. 398–401.

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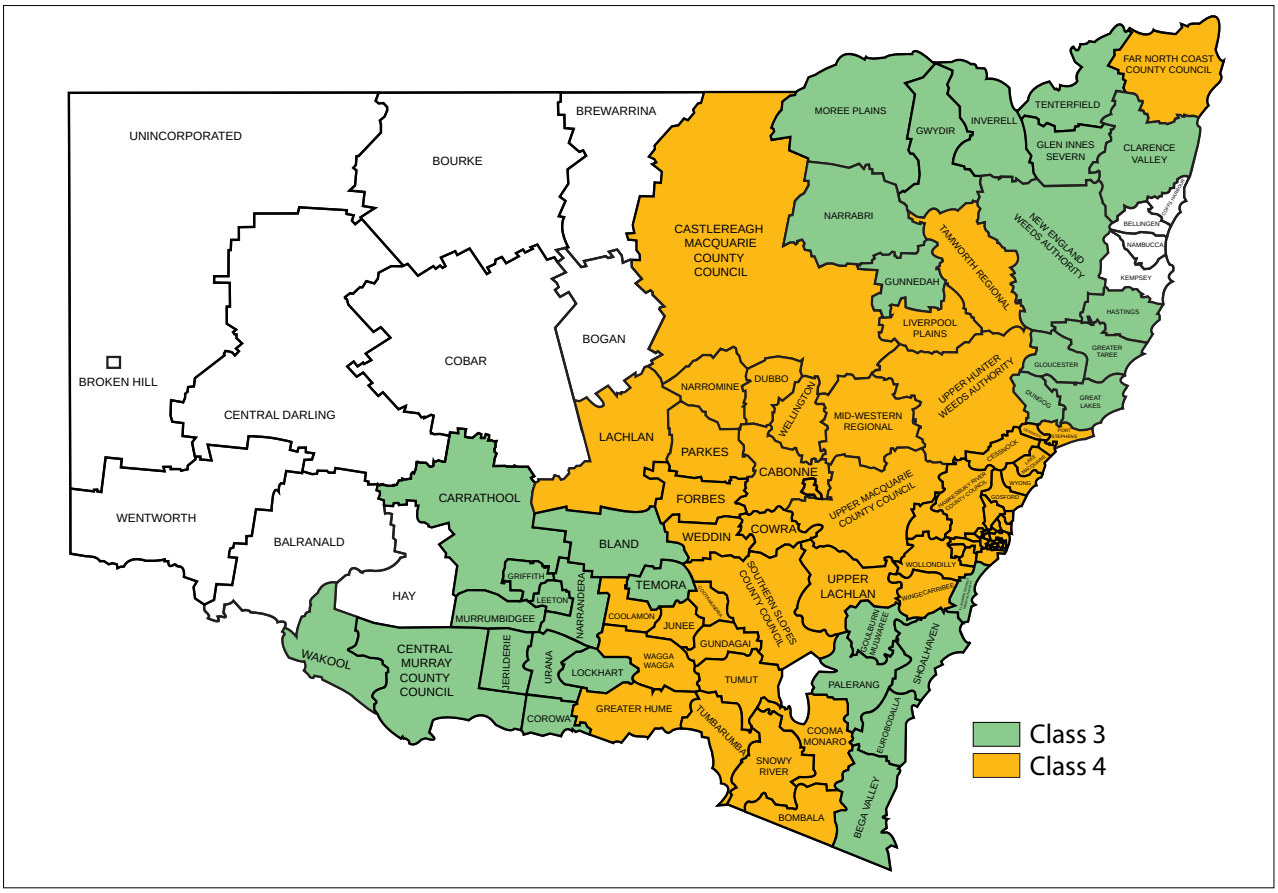


Figure 4. Area of NSW where St John's wort is declared a Class 3 or 4 noxious weed. A. Maguire.

Campbell, MH, May, CE, Southwell, IA, Tomlinson, JD & Michael, PW 1997, 'Variation in *Hypericum perforatum* L. (St John's wort) in New South Wales', *Plant Protection Quarterly*, vol. 12, pp. 64–66.

Campbell, MH & Nicol HI 2000, 'Effect of split applications of herbicides on the control of *Hypericum perforatum* L. (St John's wort) and regeneration of native grasses and annual clovers on non-arable land', *Plant Protection Quarterly*, vol. 15, pp. 119–122.

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Warnings: Pasture improvement may be associated with an increase in the incidence of certain livestock health disorders. Livestock and production losses from some disorders are possible. Management may need to be modified to minimise risk. Consult your veterinarian or adviser when planning pasture improvement.

Legislation covering conservation of native vegetation may regulate some pasture improvement practices where existing pasture contains native species. Contact the nearest Catchment Management Authority office for further information.

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Sweet briar

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INTRODUCTION

Sweet briar (*Rosa rubiginosa*) is a native of Europe that now grows throughout the world. The fruit or hips are rich in vitamin C and have been used in making syrups.

The plant is widespread in NSW but is more common in the cooler, high rainfall areas. The worst infestations are usually found on the tablelands and cooler slopes.

Sweet briar can reduce the carrying capacity of land, harbour rabbits, restrict vehicle access and restrict stock movements, especially where it occurs in clumps or patches.

HABITAT

Sweet briar often invades unimproved grasslands and disturbed bushland. It prefers well-drained areas of moderate fertility with little competition and light grazing. The weed can grow on most soil types.

Generally, it is confined to areas in NSW with an annual rainfall greater than 600 mm. However, in lower rainfall areas, infestations can still occur in moist gullies and protected sites.

Infestations are often heaviest in hilly and rocky country around trees on creek banks and along fence lines.

DESCRIPTION

Sweet briar is an erect perennial shrub, commonly growing 1.5 to 2 m high but can be up to 3 m. Many stems arise from a shallow, perennial rootstock. They are smooth when young and become rough and woody as the plant ages. They



Photo: J.J. Dellow

1: A mature sweet briar (*Rosa rubiginosa*) bush



Photo: J.J. Dellow



Photo: J.J. Dellow

3 (above): The fruits of sweet briar (*Rosa rubiginosa*) are orange-red in colour and are attractive to birds.

2 (left): The attractive flowers of sweet briar (*Rosa rubiginosa*).

arch towards the top and have numerous backward curving flat thorns up to 1.5 cm long.

The leaves are pinnate and have an apple-like fragrance. They consist of 2 to 4 pairs of oval leaflets plus one terminal leaflet. The leaflets have serrated margins and short prickles on the leaf stems.

Flowers usually appear in late spring and are pink or white with 5 petals and long green sepals or leaflike structures at the flower base. They form in loose clusters at the ends of the branches and are also fragrant.

The fruits are orange-red in colour, oval shaped with short spines and contain numerous, yellow, irregularly shaped seeds. The sepals remain attached to the fruit.

The extensive roots are at least 1 m long and are usually confined to the top 30 cm of soil.

LIFE CYCLE

The seeds of sweet briar can germinate at almost any time of the year. Young seedlings are not very competitive and few survive grazing or competition from other plants.

Plants generally begin to flower after three years. This is usually in November and can continue until early summer.

Sweet briar is a deciduous plant and sheds its leaves in autumn, with new leaf and cane growth starting in spring.

Figure 1: The lifecycle of sweet briar

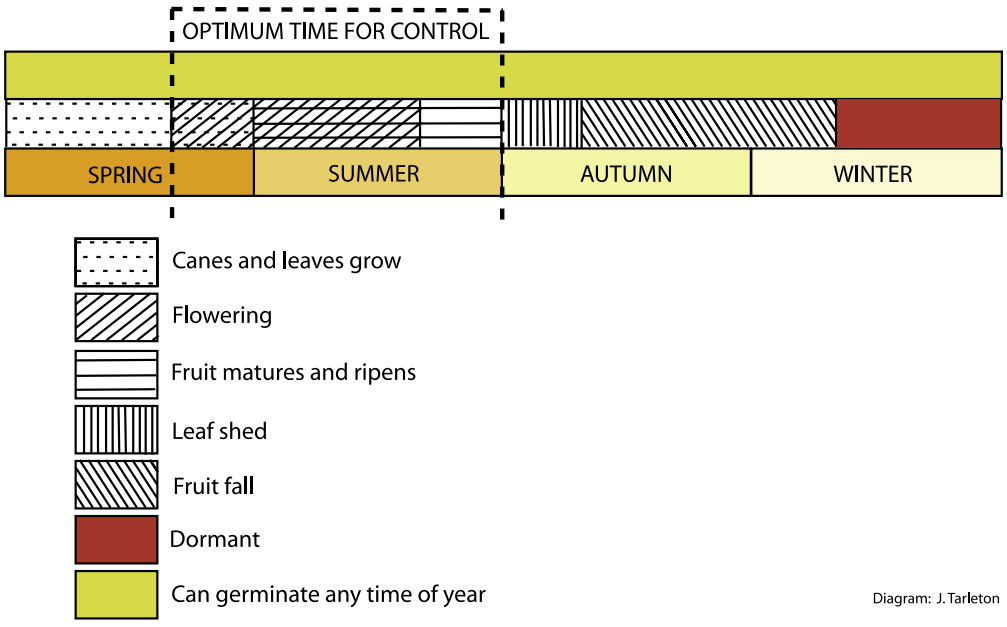


Diagram: J. Tarleton

Fruits mature during summer and are shed in autumn/winter after leaf fall.

SPREAD

Sweet briar is spread mainly by birds or animals eating the fruit and distributing the viable seed. Fruits and seeds can also be spread by run-off in steep country along creeks and streams. The seeds can remain viable in the soil for up to 4 years.

Root pieces and disturbed crowns of sweet briar can also produce new growth or suckers.

METHODS OF CONTROL

The effective, long-term control of this weed may require the integration of a number of techniques including mechanical removal, pasture management, grazing management, herbicide application, regular monitoring and replacement with appropriate plants.

For invasive, woody weeds such as sweet briar, control is more effective and economical if done when the plants are young.

The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult your local agronomist or council weeds officer.

Mechanical removal

Established plants can be removed by hand grubbing, bulldozing or tractor and chain. This is easier and more effective when the ground is wet.

Deep cultivation can be effective on arable land as it exposes and kills the bulk of the root system. However, it can be difficult if the bushes are large or dense. After the initial removal, further cultivations in summer will ensure the remaining root system is exposed and killed. Normal autumn cultivations before sowing pastures or crops will kill any remaining seedlings.

The site should be monitored regularly and any regrowth should be treated with repeat cultivations or by spraying with an appropriate herbicide once it is a sufficient size (refer to the chemical label).

Pasture management

Vigorous perennial pastures provide competition to reduce the invasion of sweet briar. In suitable sites, they should be established as soon as possible after the removal of the weed infestation but not after the application of residual herbicides.

Consult your local agronomist for advice on pasture establishment and appropriate pasture management. For further information refer to a range of NSW Department of Primary Industries (NSW DPI) publications available at any NSW DPI office or www.dpi.nsw.gov.au/agriculture.

Grazing management

Grazing management is also useful in controlling sweet briar. Sheep will readily graze young seedlings and help prevent their establishment. Cattle are not as good at preventing seedling establishment and an increase in sweet briar infestations is often noticed after graziers switch from sheep to cattle.

Sweet briar is highly palatable to goats so they can be very successful in controlling infestations. They will readily graze both established plants and seedlings, continually defoliating all accessible stems and eventually ringbarking them. This kills established plants and prevents seedlings from establishing.

Chemicals

Refer to the NSW DPI publication, *Noxious and Environmental Weed Control Handbook*, for a guide to the recommended chemicals to control sweet briar.

Only use registered herbicides according to the label directions.

Herbicides can be applied to sweet briar in many different ways. The most appropriate form of herbicide application will depend on the location, size and maturity of the infestation.

Treated infestations should be regularly monitored for regrowth because seedlings, spray errors and root shoots (suckers) can occur over a period of years. Regrowth should not be treated with an appropriate herbicide until it is of sufficient size (refer to the chemical label).

Foliar Spray

Foliar spraying is the most commonly used method of control. For effective control spray the whole bush thoroughly when soil moisture is adequate and the plant is actively growing (see Figure 2). This will vary depending on location but is generally during late spring to early autumn. The plant should be in full leaf, prior to leaf fall (refer to the chemical label for the most appropriate time). See Figure 1.

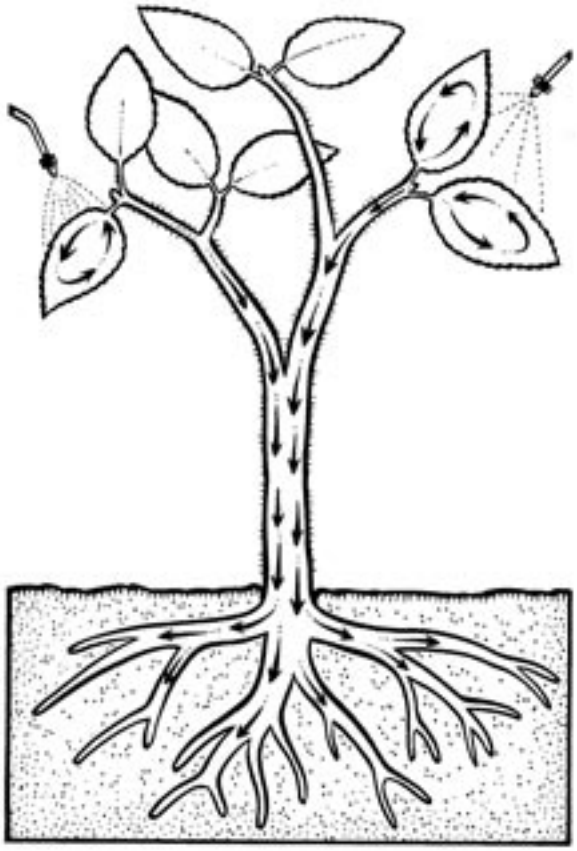


Diagram: Queensland Natural Resources and Mines

Figure 2: Applying chemicals through foliar spraying is more effective when the plant is actively growing.

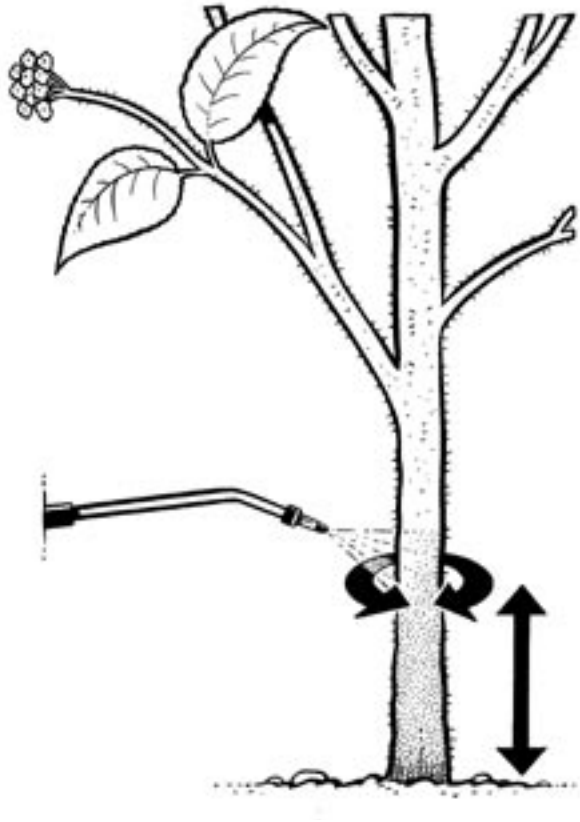


Diagram: Queensland Natural Resources and Mines

Figure 3: Basal bark application of chemicals should be to the complete base of every stem to a height of 30–40 cm above the ground.

Insufficient herbicide coverage is a common mistake and is probably the largest cause of survival.

A systematic approach is required when spraying. Spraying should commence at the top of the bush and work down to the base. Seedlings and suckers around the drip zone of the plant also need to be treated.

For effective results, DO NOT treat infestations during hot, dry, summer periods or when the plant is stressed from drought, waterlogging, cold or without leaf.

Basal Bark Treatment

This technique is less effective but is appropriate for infestations in environmentally sensitive locations. It is most suited for small bushes with stems less than 5 cm in diameter.

Spray an appropriate herbicide mixed with diesel around the COMPLETE BASE OF EVERY STEM to a height of 30–40 cm above the soil surface (see Figure 3). Check the chemical label for the correct mixing ratio.

Ensure that stems and bark are not wet at the time of application as water will repel the diesel mixture. Basal bark treatments also work best if plants are actively growing.

Cut Stump Treatment

This technique is labour intensive but is also appropriate for small infestations in environmentally sensitive locations. It is most suitable for large plants with a stem diameter greater than 5 cm.

Cut each stem off 15 cm above the soil surface. Liberally apply an appropriate herbicide mixed with diesel (check the chemical labels for the correct mixing ratio) to the cut surface within 30 seconds of the cut being made (see Figure 4).

If the herbicide is not applied immediately, the plant will heal the cut, the chemical will not be translocated through the plant and control will not be effective.

Root Application

Great care must be taken when using this technique.

Many desirable trees, in particular eucalypts, are susceptible to the residual herbicides used for this control method. DO NOT use these chemicals within a distance of at least twice the height of adjacent desirable trees or shrubs.



Diagram: Queensland Natural Resources and Mines



Diagram: Queensland Natural Resources and Mines

Figure 4: In cut stump applications it is important to apply the chemical immediately to the cut stem.

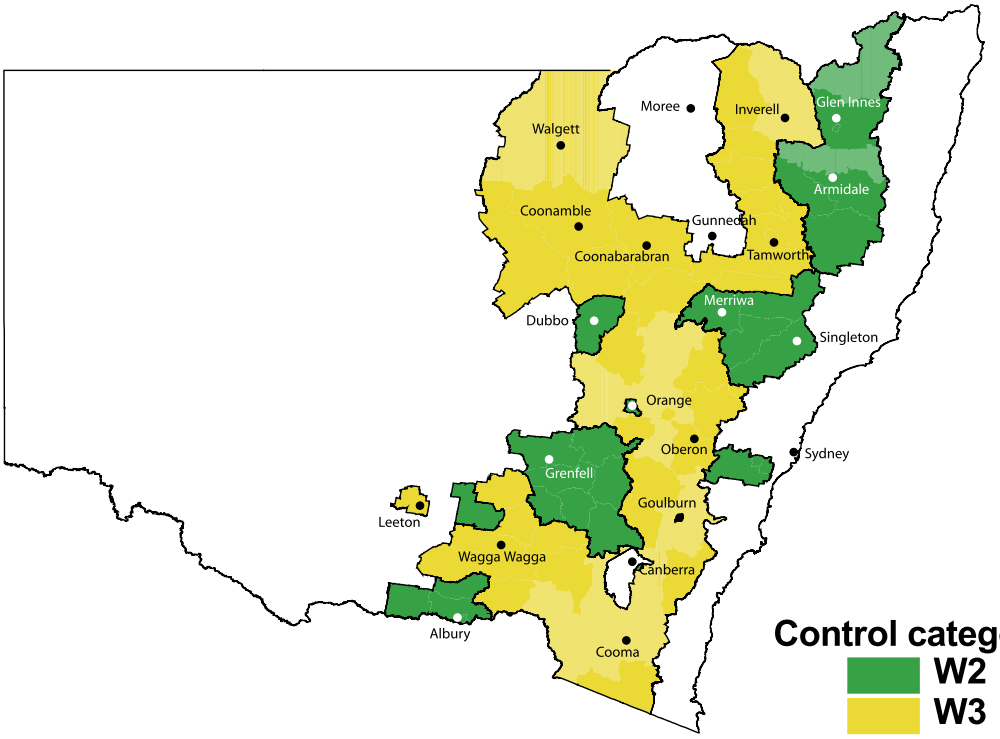
To control sweet briar, apply an appropriate residual herbicide directly under the plant near the base. The herbicide should be applied under the soil to prevent degradation by sunlight and possible contamination of surface run-off after rain. It is most effectively applied when the soil is moist.

Deep-rooted plants may need to be retreated after 2 years if they are still partially green.

WHO IS RESPONSIBLE

Sweet briar is a declared noxious weed in many areas of NSW. See www.agric.nsw.gov.au/noxweed/ for a complete list of declared noxious weeds for each control area.

It has a W2 or W3 Weed Control Category depending on the infestation and control area. A W2 weed poses a threat to agriculture, the environment or the community and has the ability



Map: A Maguire

Areas of NSW where sweet briar is declared a noxious weed, January 2003

to spread to other areas. Infestations must be continually suppressed and destroyed. A W3 weed is the same but also so widespread that total suppression or destruction is impractical.

The *Noxious Weeds Act, 1993* is enforced by the local control authority, usually local government.

The responsibility for control of noxious plants and appropriate disposal of weed plant material on private land rests with the owner or occupier of the land. Failure to do so could result in the local control authority issuing a weed control notice, court action and a fine.

Local control authorities must control noxious weeds on land under their control adequately to prevent the infestation of adjoining land. The community can assist the control of this weed by notifying the local control authority of any known infestation of sweet briar on public land.

WARNINGS

Pasture improvement may be associated with an increase in the incidence of certain livestock health disorders. Livestock and production losses from some disorders are possible. Management may need to be modified to minimise risk. Consult your veterinarian or adviser when planning pasture improvement.

Legislation covering conservation of native vegetation may regulate some pasture improvement practices where existing pasture contains native species. Inquire through you office of the Department of Natural Resources for further information.

ACKNOWLEDGEMENTS

Information for this Primefact was taken from:

Sweetbriar. Second Edition. AgFact P7.6.19.

Parsons W.T. and Cuthbertson E.G. (2001). *Noxious Weeds of Australia*. 2nd Edition.

Sweet Briar (*Rosa rubiginosa* L.). DPIWE Information Sheet. Agdex 647.

The authors would like to acknowledge the comments made by Tony Cook and Clare Edwards regarding the technical content of this publication.

DISCLAIMER

The information contained in this publication is based on knowledge and understanding at the time of writing (October, 2005). Because of advances in knowledge, the currency of the information should be checked with the appropriate officer of NSW DPI or your independent adviser.

ALWAYS READ THE LABEL

Users of agricultural (or veterinary) chemical products must always read the label and any Permit before using the product, and strictly comply with the directions on the label and the conditions of any Permit. Users are not absolved from compliance with the directions on the label or the conditions of the permit by reason of any statement made or not made in this publication.

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APPENDIX I

LAND DISTURBANCE PROTOCOL

MAULES CREEK COAL MINE

LAND DISTURBANCE PROTOCOL FORM

LDP Number: (Env. Department only)	

FOR COMPLETION & STAGED SIGN-OFF PRIOR TO UNDERTAKING ANY DISTURBANCE, THEN FINAL SIGNOFF AT COMPLETION OF WORKS

Note: the form that is completed with details of the activity should be submitted to the Environmental Manager, at least two weeks prior to the proposed disturbance activities being scheduled to commence to enable Environment Department input and to assist in identifying various management and mitigation measures to be applied prior to, during and following proposed activities.

Name of Operator /Contractor	
Position/s	
Name/s of Person Responsible	
Company	

Description of Work to be Undertaken	
Describe any access constraints that require consideration	
Date Scheduled to Commence	/ /
Scheduled Date of Completion	/ /
Duration of Works	

ATTACHMENTS

Please check the following has been attached as required:

Design Plans

Risk Assessment

Map(s) clearly indicating:
- Exclusion zones/limit of disturbance;
- Sensitive features considered in the risk assessment;
- Proposed fauna relocation sites;
- Flora Boundaries;
- Location on project, tenements/property;
- Previously identified Aboriginal sites (including scar trees identified by pre-clearance surveys); and
- Location of habitat trees, boulders and other habitat resources which will be salvaged for use in rehabilitation/restoration activities.

Erosion and Sediment Control Plan for the proposed Disturbance Area

A map for use by the contractors completing the topsoil stripping that illustrates soil type and stripping procedures.

Please list any other supporting documentation or attachments in the order provided

FINAL SIGNOFF (by Environmental Manager) – not to signed until all works associated with this LDP are completed to the satisfaction of the Environmental Manager

Name	
Signature	
Date	

1.0 PROPOSED DISTURBANCE ACTIVITY

This section is to be completed by the Construction Supervisor/Site Manager(s) responsible for the clearing activity as relevant to the information required

1.1 LOCATION

Please mark the proposed disturbance activity on Figure(s) required above

GPS Coordinates		Disturbance Area (Ha)	
Landholder Name		Lot / Plan/Tenement	
Property Name		Local Council	
Tenure	Freehold / Leasehold / MCC Owned / Crown Owned / State Forest / Other		
Is a risk assessment (including environmental issues) and necessary documentation (where necessary) attached for the work to be undertaken?			Y / N
Is the area to be disturbed clearly demarcated for site inspections to be undertaken?			Y / N

Please attach any relevant design plans for the proposed activities
Note: the Environmental Manager may require further items included on the plan to check against the relevant approvals

Name	
Company/Position	
Signature	
Date	

2.0ELECTRICAL/COMMUNICATIONS

This section is to be completed by a Registered Surveyor

Are you satisfied that the proposed works will not interfere with any existing power, water or telecommunication lines? Y / N

If no, please provide details on items that may be impacted by the proposed disturbance activities and attach a map showing services:

List any mitigation measures to be implemented to avoid risks involved with nearby power or telecommunication lines:

Name	
Company	
Signature	
Date	

Secondary Signoff: Person responsible for activity to arrange the registered surveyor to complete an inspection of the site to confirm that the mitigation measures listed above have been implemented to registered surveyor's satisfaction (Need to signoff if no mitigation measures are listed above):

Name	
Company	
Signature	
Date	

3.0 PLANNING APPROVALS / ENVIRONMENTAL

This section is to be completed by the Environmental Manager:

3.1 Introduction

Are access arrangements in place with the Landholder? Y / N / NA

If no, then works cannot commence until arrangements are in place. Advise person responsible for activity. What action(s) need to be taken?

Do the proposed works adhere to the conditions of the Occupation Agreement (Forests NSW)? Y / N / NA

If no, then works cannot commence until works meet conditions of Occupation Agreement. Advise person responsible for activity. What action(s) need to be taken to meet Occupation Agreement conditions?

Are the proposed works in accordance with the Project Approval? Y / N

If no, then works cannot commence until works meet conditions of Project Approval. Advise person responsible for activity. What action(s) need to be taken to meet Project Approval conditions?

Are the proposed works in accordance with the approved Environmental Management Plans? Y / N

If no, then works cannot commence until works meet requirements of approved Environmental Management Plans. Advise person responsible for activity. What action(s) need to be taken to meet requirements of Environmental Management Plans?

Are the proposed works in compliance with the MOP? Y / N

If no, then works cannot commence until works meet requirements of MOP. Advise person responsible for activity. What action(s) need to be taken to meet requirements of MOP?

Are there any outstanding complaints in regards to this disturbance activity? Y / N

If yes, then works cannot commence until complaints have been responded to. Advise person responsible for activity. What action(s) need to be taken?

If any of the above questions require further action, the Environmental Manager is to advise the person responsible for the activity that actions are required prior to the LDP being signed off. The Environmental Manager may refuse the application, with a new Land Disturbance Protocol Form to be completed for the activity with the required information.

3.2 Flora and Fauna

This section is to be undertaken by the Environmental Manager. Please ensure a field survey of the proposed disturbance area is undertaken by the chosen specialist.

Please reference the specialists report and any supporting documentation

If relevant, detail the management strategy which describes how harm will be minimised:

Has a pre-clearance survey been completed? Y / N

Trees:

Key Native Species

Number to be cleared (approx.)

How many habitat trees were identified?

Have habitat trees been clearly marked throughout the area to be cleared? Y / N

Shrubs:

Key Native Species

Cover Continuous / Scattered / Sparse

Groundcover:

Description Exotic / Native

Cover Continuous / Scattered / Sparse

Key Native Species

Remnant

Boulders/Other Features:

Number in area to be cleared (approx.)

How many boulders/other features with habitat potential were identified?

Have items of potential habitat value been clearly marked throughout the area to be cleared? Y / N

Have signs of breeding by native fauna been recorded? Y / N

Have any potential trees, shrubs or grasses with a potential for seed collection and recommended timing for these works. If yes, when should seed collection take place? Y / N

Describe how the felled timber should be managed:

Identify any transportable fauna habitat features that can be salvaged for reuse in rehabilitation areas (illustrate on a map)

Identify where any recovered fauna habitat features are to be stored or reused within rehabilitation activities (illustrate on a map)

Identify any Management strategies or plans which detail mitigation techniques and methods to minimise harm.

Preliminary Signoff: Environmental Manager to complete an inspection of the site to be disturbed and storage area to confirm that the above identified fauna habitat features have been labelled? *If yes, Stage 1 clearing activities can proceed (i.e. clearing of vegetation around labelled fauna habitat features), otherwise advise person responsible of remaining actions prior to signoff*:

Y / N/A (no fauna habitat features identified)

Name	
Company	
Signature	
Date	

On the day following Stage 1 clearing activities, identified habitat features are to be cleared using the procedure(s) described within the Biodiversity Management Plan.

Environmental Manager to record the details of the recovered habitat features and where they are stored within the Habitat Resource Recovery Inventory to track reuse within rehabilitation/restoration activities. Has this been undertaken?

Y / N

Name	
Company	
Signature	
Date	

Please attach a map indicating:

- *Survey area;*
- *Areas where seed collection will be/has been undertaken; and*
- *Fauna Habitat features to be recovered for reuse in rehabilitation.*

3.3 Water Management

Identify any nearby creaks, drainage lines or water bodies which may be impacted (illustrate on a map)

Describe any potential impacts

Detail any mitigation measures to manage the possible impacts:

3.4 Sediment Control and Erosion

Please attach Erosion and Sediment Control Plan for the proposed Disturbance Area

Confirm plan has been developed according to the requirements of the Water Management Plan? Y / N

Are there any potential issues associated with sediment and erosion prior to clearance? Y / N

Describe these issues:

a) Analysis of the drainage of the site to be cleared:

b) Potential for soil dispersivity/ erosivity:

c) Identify potential impacts to nearby creeks or drainage lines that may be impacted:

d) Other

Have the clean water diversion banks been included in the Erosion and Sediment Control Plans for catchments upslope of proposed disturbance? Y / N

Are these diversion banks/structures considered adequate for the works being undertaken? Y / N

Please detail the mitigation measures to be put in place to avoid erosion and sediment impacts:

Have all mitigation measures been completed and in working order prior to disturbance activity e.g. sediment dams, silt fencing, culverts Y / N

Preliminary Signoff: Environmental Manager to complete an inspection of the site and confirm erosion and sediment control mitigation and management measures have been completed to a satisfactory standard prior to any clearing commencing? *If yes, clearing activities can proceed, otherwise advise person responsible of remaining actions that need to be completed prior to signing off*:

Y

Name	
Company	
Signature	
Date	

3.5 Soil Management

Soil Type(s)

Please describe any existing land degradation issues:

Identify the soil resources to be separately stripped and stockpiled for reuse in rehabilitation.

Please attach a map for use by the contractors completing the stripping activities which identifies Soil type and stripping procedures.

Can topsoil be utilised directly on rehabilitation areas? Y / N

If no, provide details for topsoil stockpiling and any resources to be transported in accordance with the soil stripping and stockpiling strategy detailed in the Rehabilitation Management Plan.

Please detail any proposed mitigation measures to manage the possible impacts:

3.6 Air Quality Management

Is a water cart readily available during disturbance activities? Y / N

Where will the water be sourced from?

Identify any potential impacts on air quality that may result because of land clearance and disturbance:

List mitigation measures to manage possible impacts:

3.7 Acoustics Management

Are all works scheduled within approved work hours? Y / N

Has all the plant machinery and tools to be used onsite been serviced (or tagged) and fitted with the necessary attenuation equipment (e.g. exhaust silencers)? Y / N

If yes, please reference relevant documentation and details to the end of the LDP:

Identify any potential environmental impacts on acoustics that may result because of land disturbance:

List mitigation measures to manage the possible impacts:

3.8 Traffic Management

Will the proposed works impact upon the capacity of the public traffic network? (if no please skip to next section) Y / N

If yes, has a Traffic Control Plan been prepared to the satisfaction of the relevant roads authority (Narrabri Shire Council and / or Roads and Maritime Services)? Y / N

Please detail any mitigation measures that have been put in place to minimise impacts to other workers:

Have any possible driving hazards been removed or suitability demarcated with highly reflective tape? Y / N

Identify any other potential impacts as a result of increased traffic to sites of disturbance:

List mitigation measures to manage the possible impacts:

3.9 Aboriginal and Cultural Heritage

Are the works to be undertaken within the vicinity of Significant Heritage Areas or culturally sensitive heritage areas (refer to Aboriginal Cultural Heritage Management Plan)? Y / N

If yes please notify the Environmental Manager and arrange a site inspection

If there is a listed artefacts in the disturbance area, has the required salvage program been undertaken? Y / N

If yes, Environmental Manager to attach the completed Archaeological Clearance Works Sign Off Form. Clearing activities can then proceed. Otherwise advise person responsible of remaining actions that need to be completed prior to signing off:

Name	
Company	
Signature	
Date	

Have all listed artefacts or culturally significant areas either been collected (as above) or adequately fenced off and is signage provided to limit disturbance? Y / N

If a relic was found has this been reported to the Heritage Council compliant with *Section 146* of the *Heritage Act?* Y / N

Identify any potential environmental impacts on Aboriginal and Cultural Heritage that may result because of land clearance and excavation:

List mitigation measures to manage the possible impacts

3.10 Rehabilitation

Describe rehabilitation tasks that are required to be carried out in order to restore the land to previous conditions:

Signoff: Environmental Manager to complete an inspection of the site to confirm that rehabilitation tasks have been completed to a satisfactory standard? *If yes, the LDP can be closed out in Section 5.0, otherwise advise person responsible of remaining actions that need to be completed prior to signing off*:

Name	
Signature	
Date	

4.0 AUTHORISATION SIGNOFF TO COMMENCE ACTIVITY

This section is to be completed by the Environmental Manager and Construction Supervisor/Site Manager:

The Environmental Manager and Construction Supervisor/Site Manager to complete an inspection of the site and review the contents of this LDP (including preliminary signoff sections in green that must be completed) to confirm that activities within this LDP can commence.

Recommendations/Outcomes from the LDP that need to be addressed during conduct of activities

Can the proposed works proceed according to the Information and Plans presented in this LDP? Y / N

If no, Environmental Manager to refuse application, with a new LDP to be completed for the activity with the required information.

Environmental Manager name:	
Signature:	
Date:	
General Manager name:	
Signature:	
Date:	

5.0WORKS COMPLETED

This section is to be completed by the Person Responsible for the proposed works and final signoff and filing by the Environmental Manager:

Outcomes from clearing activity:

Works associated within this LDP were completed in accordance with the Information and Plans presented:	
Person Responsible name:	
Signature:	
Date:	
Environmental Manager name:	
Signature:	
Date:	