

MAULES CREEK COAL PROJECT

Biodiversity Offset Management Plan

For:

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Final Draft



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Introduction

1.1 Purpose

This Biodiversity Offset Management Plan (the “BOMP”) has been prepared by Cumberland Ecology, on behalf of Hansen Bailey. The purpose of the BOMP is to provide a plan for the rehabilitation and conservation management of the offset properties that comprise the Maules Creek Coal Project Biodiversity Offset Strategy (the “Offset Strategy”). The Project Location is shown within **Figure 1.1**, while the Project Layout is shown in **Figure 1.2**.

This plan refers to the management of several clusters of properties acquired as conservation offsets. The clusters are the Northern Offsets, in the Barraba district; and the Eastern and Western offsets in the immediate vicinity of the Project. These are shown within **Figure 2.1** and described within **Chapter 2**. 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, as shown within **Figure A1, Appendix A**.

As the BOMP 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 of the mine site, are intended to achieve an increase in the quantity and quality of forest and woodland habitat within the locality (**Figure A1, Appendix A**).

1.2 Background

1.2.1 Assessment and Approval Context

Project Approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) has been sought for the Maules Creek Coal Project (the “Project”). 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.

The Offset Strategy was 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 Offset Strategy has been submitted to the NSW Minister for Planning and Infrastructure (DoPI) for Project Approval as part of the Environmental Assessment (EA) for the Project.

The 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 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).

1.2.2 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.

i. Direct Disturbance

The Project disturbance footprint will be approximately 2178 ha in area, 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 following is a summary of the impact of the Project on threatened biodiversity within the Project Boundary:

- 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;
- Clearance of 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); and
- Clearance of up to 544 ha of Box Gum Woodland, which is listed as an Endangered Ecological Community (EEC) under the TSC Act and as a Critically Endangered Ecological Community (CEEC) under the EPBC Act.

ii. 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.

iii. 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 landscaped 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.

1.2.3 Consistency with Recovery Plans and Conservation Advices

This BOMP 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 BOMP with respect to the above recovery plans is tabulated in **Appendix B**.

1.2.4 Integration with Local Strategies

The Offset Strategy is designed to provide additional conservation areas that complement two conservation reserves, Leard State Conservation Area to the immediate north west of the Project Boundary, and Mount Kaputar National Park, to which the Northern Offsets link. It is also designed to build upon Boggabri Coal's Biodiversity Offset Strategy to provide a network of conservation areas around the Leard State Forest (**Appendix A**).

1.3 Aims and Objectives

The aims of this BOMP are to demonstrate that the acquired lands are of suitable quality and 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 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.

The specific objectives of the BOMP are 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;
- Create a substantial area of high quality habitat for native fauna that will be protected for conservation in the long-term; and
- Describe how the offset properties will be protected in perpetuity.

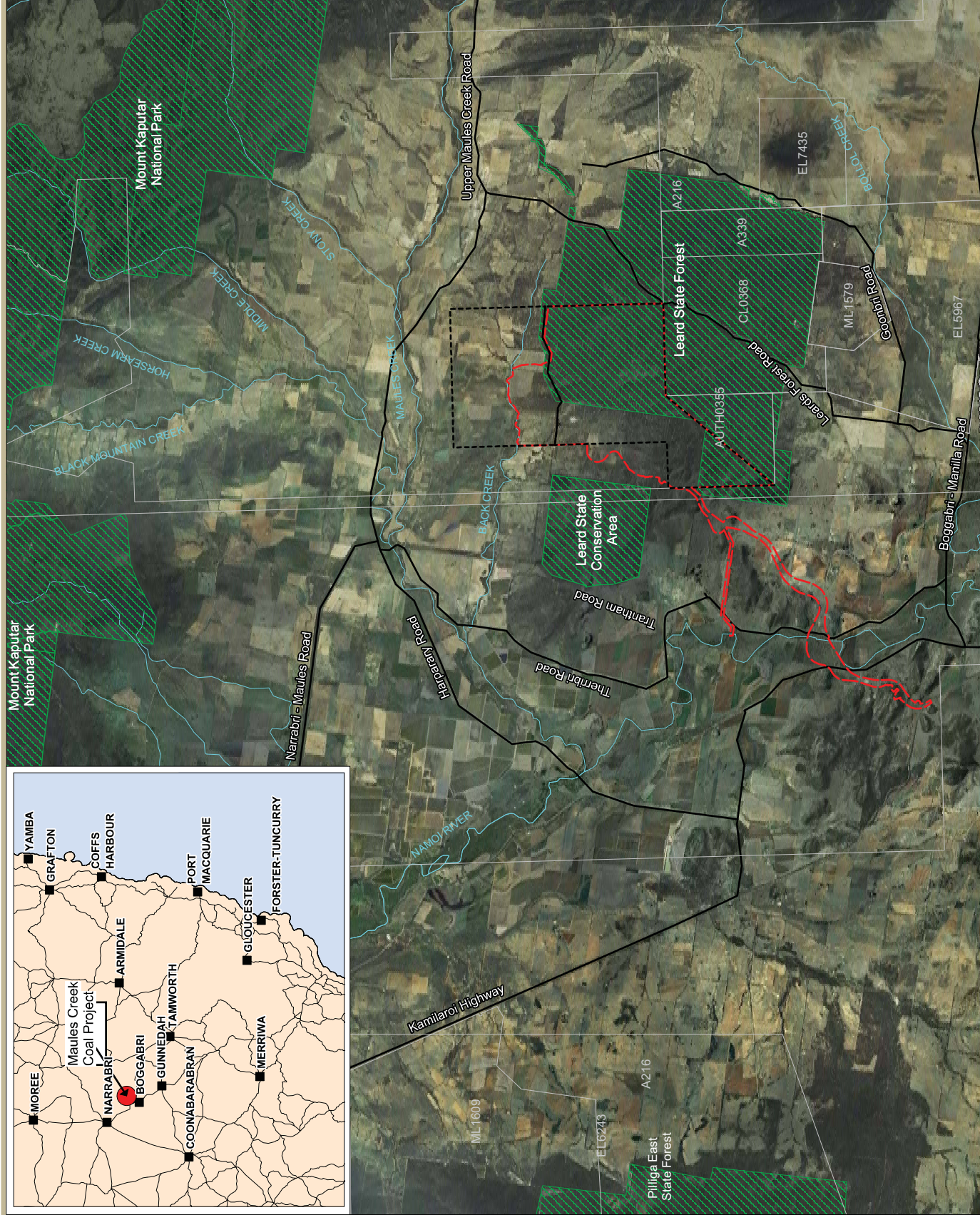
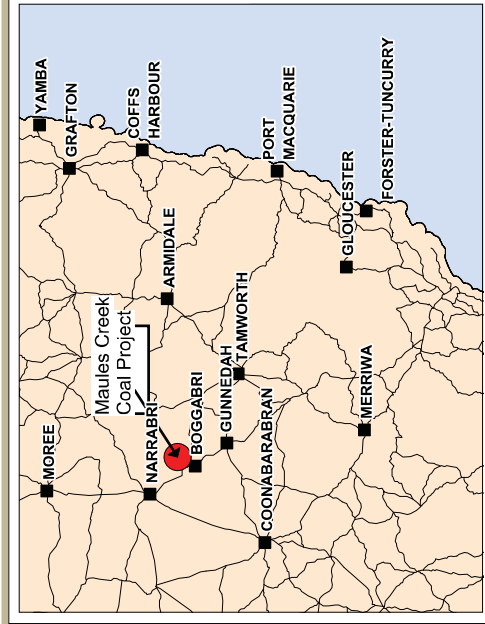
1.4 Structure of the Biodiversity Offset Management Plan

The BOMP includes:

- A detailed description of the land and vegetation to go into offset and rehabilitation areas;
- Maps of proposed offsets, and of proposed linkages;
- Prescriptions for rehabilitation and conservation management;
- A proposed schedule for the works;
- Milestones and key performance criteria; and
- Monitoring and maintenance prescriptions.

1.5 Terms and Abbreviations

Aston	Aston Coal 2 Pty Ltd, a subsidiary of Aston Resources, the Proponent and owner of the offset properties
BOMP	Biodiversity Offset Management Plan
Box Gum Woodland	Short form name referring to the Critically Endangered Ecological Community <i>White Box, Yellow Box, Blakely's Red Gum Grassy Woodland and Derived Native Grassland</i>
CEEC	Critically Endangered Ecological Community
DoPI	NSW Department of Planning and Infrastructure
EA	Environmental Assessment (Part 3A, <i>Environmental Planning and Assessment Act 1979</i>)
EC	The ecological consultant
EEC	Endangered Ecological Community
EO	The mine environmental officer
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
LM	The land manager
MNES	Matters of National Environmental Significance (listed matters under the EPBC Act)
NPWS	NSW National Parks and Wildlife Service
OEH	NSW Office of Environment and Heritage
Offset Strategy	"Maules Creek Coal Project Biodiversity Offset Strategy" - the package of compensatory land and associated management actions that will offset the Project impacts on biodiversity
Project	"Maules Creek Coal Project" - the proposed development for which the Biodiversity Offset Management Plan is prepared
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
TSC Act	<i>Threatened Species Conservation Act 1995</i>
VCA	Voluntary Conservation Agreement



Legend

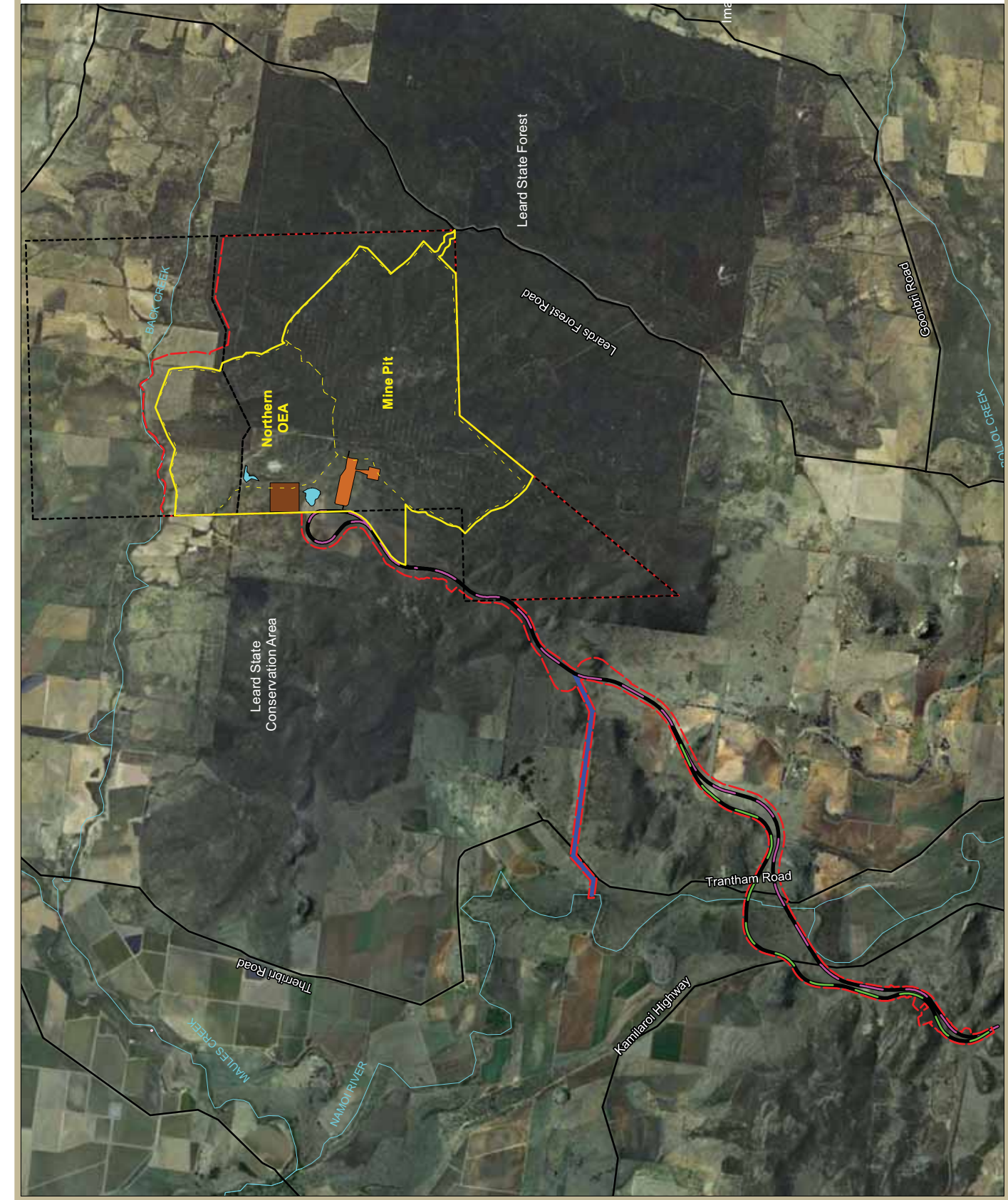
- Project Boundary
- Mining Tenement Boundary
- State Forest/Conservation Area
- Neighbouring Mining Tenement
- Road
- River

Image Source: Image © 2010 GeoEye
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Figure 1.1 PROJECT LOCATION



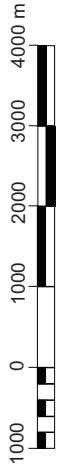


- Legend**
- Project Boundary
 - Mining Tenement Boundary
 - Mine Disturbance Boundary
 - 21 Year Mining Limit
 - Road
 - River
 - Proposed Mine Infrastructure
 - Indicative Rail Spur and Loop
 - Alternative Rail Alignment
 - Pipeline
 - Water Storage
 - Mine Infrastructure Area
 - Coal Handling and Processing Plant

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Figure 1.2 PROJECT LAYOUT



Description of the Offsets

The Offset Strategy comprises properties from three key offset areas: Northern, Eastern and Western Offset Areas (**Figure 2.1**). Aston also has shared ownership of a property located to the south west of the Project Boundary that will be included in the offset package. These are described below.

2.1 General Description

2.1.1 Northern Offsets

i. Location and Landscape Context

The Northern Offsets are comprised of two large properties; Wirradale and Mt Lindesay (**Figure 2.2**). 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 2.1**). 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.

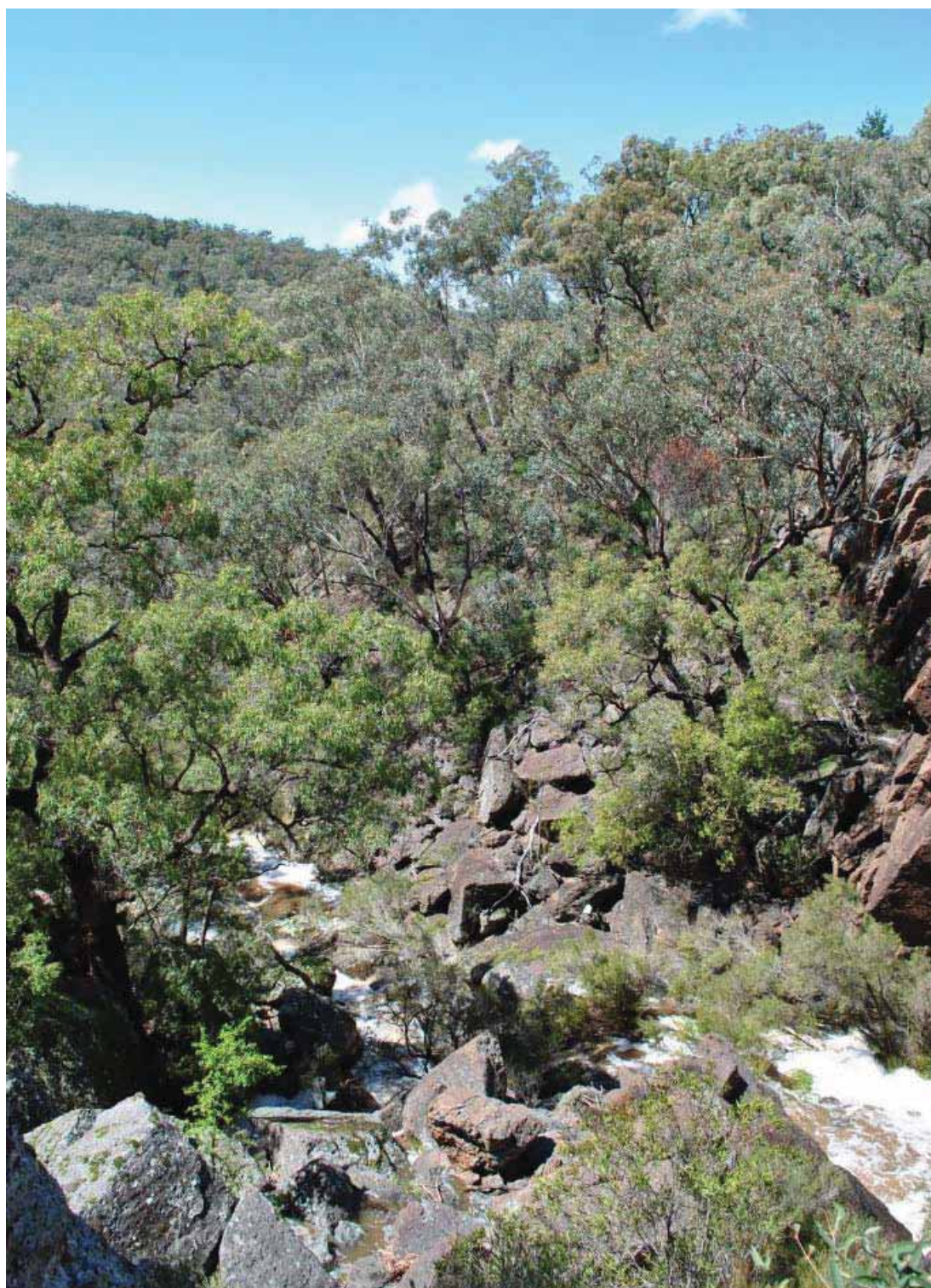
The inclusion of the Northern Offset properties in the Offset Strategy will protect and improve large areas of Box Gum Woodland and restore large areas of Derived Native Grassland. The Northern Offsets will also buffer and augment the Mount Kaputar National Park from surrounding farming; enhance other 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 but 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 C** 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 (**Photographs 2.5**).



Photograph 2.1 **Creek habitat and waterfall on Wirradale**



Photograph 2.2 Maules Creek – Wirradale. This is a semipermanent stream that forms excellent habitat for birds, bats and other fauna.



Photograph 2.3 Typical grazing paddock on Wirradale with regenerating White Box Grassy woodland.



Photograph 2.4 Typical grazing pasture within Yellow Box Grassy Woodland on Mt Lindesay



Photograph 2.5 *Poa sieberiana* grassland on Mt Lindesay. This is Derived Native Grassland that forms part of the Box Gum Woodland CEEC.

2.1.2 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 but 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 A**).

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 2.3**). 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 Aston; parts of Louenville, which is adjacent to the Leard State Conservation Area; and the entirety of Kelso, which is adjacent to Louenville (**Figure 2.3**). 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 2.2** below and are shown on the map in **Appendix A**. 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 (**Photographs 2.6-2.13**).

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 C**); 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.



Photograph 2.6 Box eucalypts (*Eucalyptus albens*) on the Warriahdool provide habitat for epiphytic orchids (*Cymbidium canaliculatum*)



Photograph 2.7 Cultivated fields (foreground) adjacent to significant areas of native remnant woodland (background) on Louenville. The woodland will form part of the Eastern Offset.



Photograph 2.8 **Remnant White Box woodland on Louenville**



Photograph 2.9 **Remnant Shrubby White Box woodland on Kelso**



Photograph 2.10 **Derived Native Grassland with scattered shrubs and trees on Blue Range**



Photograph 2.11 **Remnant White Box – Narrow-leaved Ironbark – White Cypress Pine Grassy woodland on Teston in the Eastern Offsets**



Photograph 2.12 **Remnant White Box – Narrow-leaved Ironbark – White Cypress Pine Grassy woodland on Tralee**



Photograph 2.13 **Extensive native grassland on Velyama. Broad areas of native grassland will be regenerated to woodland within the Eastern and Western Offsets.**

2.1.3 Shared Offset Property

Aston 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 2.4**). A small proportion of this land will be utilised by Aston and Boggabri Coal for the proposed rail spur, of which the southern-most section will extend into this shared property.

Aston intends to dedicate its 50% of the property to the Biodiversity 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 2.1**). An agreement will be required between Aston and Boggabri Coal regarding the management responsibilities of both parties for the conservation of the shared property.

2.2 Vegetation Communities of the Offsets

The vegetation communities of the offsets comprise open forest, woodland and open woodland types. It also includes species-rich native grasslands derived from various vegetation communities. Vegetation units also include low-diversity derived grasslands that currently exist as native pastures. Cultivated fields and more heavily improved pastures (grasslands that have been recently or regularly superphosphated and sown with subtropical grasses) exist on the offset properties (particularly the eastern and western offsets) but are not included in the offset package (refer to **Figures 2.2 to 2.4**).

Table 2.1 presents a summary of the types and areas of vegetation present in the offset properties and **Table 2.2** 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 C**.

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

2.2.1 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 2.3**). 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, which is listed under the EPBC Act and TSC Act.

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, which is listed under the EPBC Act and TSC Act.

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, which is listed under the EPBC Act and TSC Act.

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) but 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.

2.2.2 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 *Dodonea viscosa* var. *angustifolia* (Sticky Hop-bush) and *Callistemon sieberi*. The groundcover is species rich but 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, which is listed under the EPBC Act and TSC Act.

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.

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

This community is very similar to *Melaleuca riparian forest* but 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 but is largely influenced by surrounding agricultural activities.

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

iv. *River Red Gum riparian woodlands and forest*

Eucalyptus camaldulensis (River Red Gum) forms a 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 the creek 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.

2.2.3 **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* but 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, which is listed under the EPBC Act and TSC Act.

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* (Silver-top 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*.

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

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 2.3**).

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.

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 2.3**).

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, which is listed under the EPBC Act and TSC Act.

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.

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 *Dodenaia 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.

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 hectares in area, it is not considered to conform to the EPBC Act listing of Weeping Myall Woodlands.

2.2.4 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. *Leptospermum* spp. and *Melaleuca* spp.) and formed a dense shrubby corridor through native pastures. Tree species were generally absent.

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, but 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 hectare 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 hectare 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, which is 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.

2.3 Habitat for Threatened 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 C** 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. These include the following Vulnerable bird species listed under the TSC Act:

- Spotted Harrier (*Circus assimilis*);
- Little Eagle (*Hieraaetus morphnoides*);

- Square-tailed Kite (*Lophoictinia isura*);
- Barking Owl (*Ninox connivens*);
- Masked Owl (*Tyto novaehollandiae*);
- Speckled Warbler (*Pyrrholaemus saggitatus*);
- White-browed Woodswallow (*Artamus superciliosus*);
- Brown Treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*);
- Diamond Firetail (*Stagonopleura guttata*);
- Painted Honeyeater (*Grantiella picta*);
- Black-chinned Honeyeater (eastern subspecies) (*Melithreptus gularis gularis*);
- Varied Sittella (*Daphoenositta chrysoptera*);
- Hooded Robin (*Melanodryas cucullata*);
- Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*);
- Little Lorikeet (*Glossopsitta pusilla*); and
- Turquoise Parrot (*Neophema pulchella*).

They also include the following Vulnerable bat species listed under the TSC Act:

- Yellow-bellied Sheath-tail Bat (*Saccolaimus flaviventris*);
- Little Pied Bat (*Chalinolobus picatus*);
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) (Vulnerable under TSC Act and EPBC Act);
- Greater Long-eared Bat (*Nyctophilus corbeni*, which is still recognised as the synonym *N. timoriensis* under NSW legislation); and
- Eastern Cave Bat (*Vespadelus troungtoni*).

There are other threatened and migratory species that are known to occur in the locality surrounding the Offset areas. These include the Nationally threatened Spotted-tail Quoll (*Dasyurus 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; these are assessed within the report.

The Namoi River also provides habitat for threatened species and EECs. These include Murray Cod (*Maccullochella 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 2.3 below 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.

2.4 EPBC Act Condition Classes of Box Gum Woodland

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 2.4** provides a summary of the condition classes of Box Gum Woodland and Derived Native Grassland within the Offset Areas.

Table 2.1 Areas of Vegetation in the Eastern, Western and Northern Offset Properties

Vegetation Community	Area of Vegetation within each Offset Property													
	Mt Lindesay	Wirradale	Kelso	Louenville	Olivedeen	Blue Range	Teston (nrb)	Tralee	Cattle Plain	Wallandilly	Teston (sth)	Velyama	Warriahdool	TOTAL
White Box - Narrow-leaved Ironbark - White Cypress Pine grassy open forest			16.49	84.82						10.54	4.24	23.23		139.31
White Box - Narrow-leaved Ironbark - White Cypress Pine shrubby open forest				66.56							36.94	0.85		104.35
White Box - Blakely's Red Gum - Melaleuca riparian forest						19.76	9.93							29.69
Stringybark - Blakely's Red Gum grassy open forest	770.62													770.62
Stringybark - Blakely's Red Gum shrubby open forest	84.94													84.94
Narrow-leaved Ironbark - White Cypress Pine shrubby open forest		853.61	270.42	33.70							54.27	63.46		1275.46
Manna Gum - Yellow Box - Blakely's Red Gum open forest	160.09	233.10												393.19
River Red Gum riparian woodlands and forests			11.89		8.30									20.19
Melaleuca riparian forest		4.61				9.05	6.04	9.31	2.68	56.17			26.22	114.09
Cliff and scree Thickets (Rainforest Species)				0.53										0.53
White Box - stringybark grassy woodland	477.12	881.46												1358.58
White Box - stringybark shrubby woodland	139.21	192.30												331.51
White Box - White Cypress Pine grassy woodland		226.75				2.26	48.74	16.96	35.98	87.75			65.07	483.49
White Box - Wilga - Belah woodland											52.85	17.05		69.90
Dwyer's Red Gum - Ironbark woodland				3.09			2.84	8.62			81.46			96.02
Belah woodland												6.99		6.99
Pilliga Box - Poplar Box - White Cypress Pine grassy open woodland			44.01		4.95			38.82		112.25		6.49	0.30	206.81
Silver-leaved Ironbark heathy woodland														0.00
Weeping Myall grassy open woodland												0.15		0.15
Rough-barked Apple - Blakely's Red Gum riparian grassy woodland	25.53	223.22												248.75
Tea-tree shrubland in drainage lines		69.61												69.61
Derived Native Grassland (Box Gum Woodland)	508.18	1406.40									18.59	60.75		1993.92
Derived Native Grassland (Low Diversity - Box Gum Woodland)		87.94	21.9928				51.70	48.13	103.09			102.60	15.48	430.93
Derived Native Grassland (Poplar Box trees)												94.10		94.10
Derived Native Grassland (Low Diversity - with scattered Poplar Box trees)			77.7345				1.77	112.13	0.19				14.35	206.17
Derived Native Grassland (Ironbark forest)		74.09												74.09
Derived Native Grassland (Low Diversity - Ironbark forest)			56.57									65.56		122.13
Unclassified grassland					94.89					788.37			89.19	972.45
Improved Pastures	132.06													231.03
Cultivation				270.19	83.01	692.06	168.90		139.96	385.04	19.61	411.29	410.79	2580.84
TOTAL	2297.76	4253.09	499.10	458.89	191.14	723.13	289.92	233.97	281.90	1440.12	304.54	914.90	621.39	12509.85

Table 2.2 Comparison of the Areas to be Conserved in Offset Properties with the Areas of Impact by the Project

Vegetation Community	Total Area of Vegetation within Offsets (ha)	Total Area of Vegetation to be Conserved (ha)	Project Impacts on Vegetation (ha)
White Box - Narrow-leaved Ironbark - White Cypress Pine grassy open forest	139.31	126.65	406.97
White Box - Narrow-leaved Ironbark - White Cypress Pine shrubby open forest	104.35	102.70	136.43
White Box - Blakely's Red Gum - Melaleuca riparian forest	29.69	29.55	10.12
Stringybark - Blakely's Red Gum grassy open forest	770.62	770.30	
Stringybark - Blakely's Red Gum shrubby open forest	84.94	84.94	
Narrow-leaved Ironbark - White Cypress Pine shrubby open forest	1275.46	1268.64	594.83
Manna Gum - Yellow Box - Blakely's Red Gum open forest	0.00	386.64	
River Red Gum riparian woodlands and forests	20.19	20.19	1.57
Melaleuca riparian forest	114.09	56.84	
Cliff and scree Thickets (Rainforest Species)	0.53	0.53	
White Box - stringybark grassy woodland	1358.58	1313.10	
White Box - stringybark shrubby woodland	331.51	331.51	
White Box - White Cypress Pine grassy woodland	483.49	369.56	0.8
White Box - Wilga - Belah woodland	69.90	68.94	31.46
Yellow Box - Blakely's Red Gum grassy woodland			8.64
Dwyer's Red Gum Woodland			0.05
Dwyer's Red Gum - Ironbark woodland	96.02	96.02	123.56
Belah woodland	6.99	6.94	4.21
Pilliga Box - Poplar Box - White Cypress Pine grassy open woodland	206.81	52.45	11.69
Silver-leaved Ironbark heathy woodland	393.19		334.52
Weeping Myall grassy open woodland	0.15		
Rough-barked Apple - Blakely's Red Gum riparian grassy woodland	248.75	225.13	
Tea-tree shrubland in drainage lines	69.61	35.96	

Table 2.2 Comparison of the Areas to be Conserved in Offset Properties with the Areas of Impact by the Project

Vegetation Community	Total Area of Vegetation within Offsets (ha)	Total Area of Vegetation to be Conserved (ha)	Project Impacts on Vegetation (ha)
Derived Native Grassland (Box Gum Woodland)	1993.92	1392.33	86.48
Derived Native Grassland (Low Diversity - Box Gum Woodland)	430.93	305.46	210.89
Derived Native Grassland (Poplar Box trees)	94.10	57.65	
Derived Native Grassland (Low Diversity - with scattered Poplar Box trees)	206.17	116.70	112.67
Derived Native Grassland (Ironbark forest)	74.09	73.96	
Derived Native Grassland (Low Diversity - Ironbark forest)	122.13	84.50	3.74
Unclassified grassland	972.45	113.27	
Improved Pastures	231.03	73.97	24.51
Cultivation	2580.84	458.98	74.3
TOTAL	12509.85	8023.41	2177.44

Table 2.3 Areas of Habitat Available from the Offset Properties for Threatened Species

Family	Scientific Name	Common Name	Status	LGA Count	Detected in Project Boundary	Preferred Habitat	Area of direct Impact on Habitat (ha)	Area of Habitat in Offset Properties
TSC EPBC								
Apodidae	<i>Hirundapus caudacutus</i>	White-throated Needletail	M	30	Yes	F, W, G	2079	7218
Apodidae	<i>Apus pacificus</i>	Fork-tailed Swift	M	1	Yes	F, W, G	2079	7218
Ciconiidae	<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork	E	7	Yes	Wtd	<0.5	<10
Accipitridae	<i>Lophoictinia isura</i>	Square-tailed Kite	V	14	Yes	F, W, G	2079	7218
Accipitridae	<i>Circus assimilis</i>	Spotted Harrier	V	4	Yes	F, W, G	2079	7218
Accipitridae	<i>Hieraaetus morphnoides</i>	Little Eagle	V	19	Yes	F, W, G	2079	7218
Pomatostomidae	<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler	V	130	Yes	F, W, G	2079	7218
Acanthizidae	<i>Pyrholaemus saggitatus</i>	Speckled Warbler	V	136	Yes	F, W	1665	5310
Psittacidae	<i>Glossopsitta pusilla</i>	Little Lorieet	V	38	Yes	F, W	1665	5310
Psittacidae	<i>Lathamus discolor</i>	Swift Parrot	E	0	No	F, W	1665	5310
Psittacidae	<i>Neophema pulchella</i>	Turquoise Parrot	V	114	Yes	F, W	1665	5310
Strigidae	<i>Ninox connivens</i>	Barking Owl	V	129	Yes	F, W	1665	5310

Table 2.3 Areas of Habitat Available from the Offset Properties for Threatened Species

Family	Scientific Name	Common Name	Status	LGA Count	Detected in Project Boundary	Preferred Habitat	Area of direct Impact on Habitat (ha)	Area of Habitat in Offset Properties
TSC EPBC								
Tytonidae	<i>Tyto novaehollandiae</i>	Masked Owl	V	8	Yes	F, W	1665	5310
Meropidae	<i>Merops ornatus</i>	Rainbow Bee-eater	M	75	Yes	F, W	1665	5310
Climacteridae	<i>Climacteris picumnus</i>	Brown Treecreeper	V	92	Yes	F, W	1665	5310
Meliphagidae	<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater	V	4	Yes	F, W	1665	5310
Meliphagidae	<i>Xanthomyza phrygia</i>	Regent Honeyeater	E E,M	7	No	F, W	1665	5310
Meliphagidae	<i>Grantiella picta</i>	Painted Honeyeater	V	21	Yes	F, W	1665	5310
Neositidae	<i>Daphoenositta chrysoptera</i>	Varied Sittella	V	35	Yes	F, W	1665	5310
Artamidae	<i>Artamus superciliosus</i>	White-browed Woodswallow	V	23	Yes	F, W	1665	5310
Monarchidae	<i>Myiagra cyanoleuca</i>	Satin Flycatcher	M	9	Yes	F, W	1665	5310
Petroicidae	<i>Melanodryas cucullata</i>	Hooded Robin	V	22	Yes	F, W	1665	5310
Estrildidae	<i>Stagonopleura guttata</i>	Diamond Firetail	V	17	Yes	F, W	1665	5310
Emballonuridae	<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail Bat	V	46	Yes	F, W	1665	5310
Phascolarctidae	<i>Phascolarctos cinereus</i>	Koala	V	344	Yes	F, W	1665	5310
Vespertilionidae	<i>Chalinolobus picatus</i>	Little Pied Bat	V	6	Yes	F, W	1665	5310

Table 2.3 Areas of Habitat Available from the Offset Properties for Threatened Species

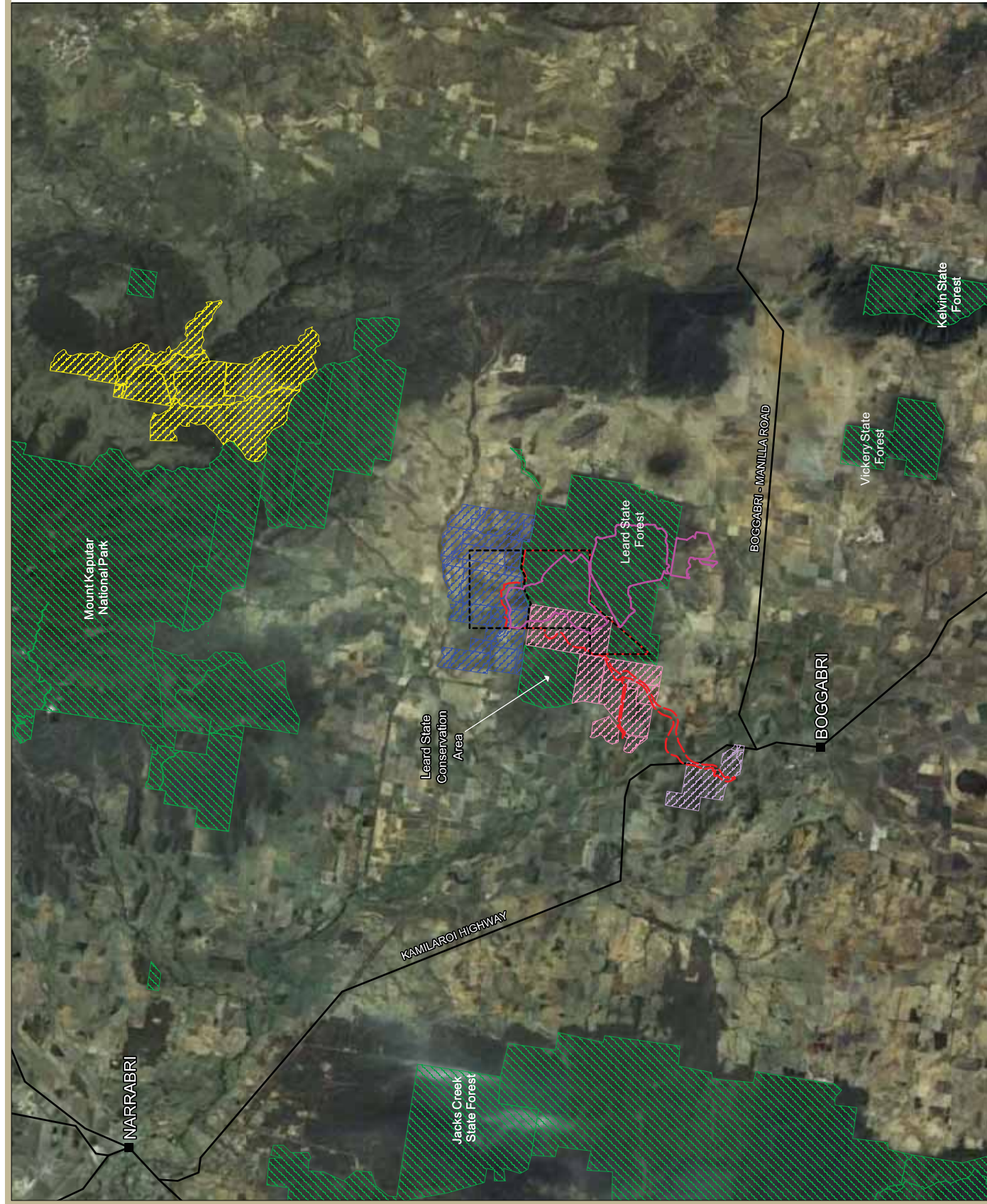
Family	Scientific Name	Common Name	Status	LGA Count	Detected in Project Boundary	Preferred Habitat	Area of direct Impact on Habitat (ha)	Area of Habitat in Offset Properties
TSC EPBC								
Vespertilionidae	<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	0	Yes	F, W	1665	5310
Vespertilionidae	<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-bat	V	7	Yes	F, W	1665	5310
Vespertilionidae	<i>Nyctophilus corbeni</i>	Greater Long-eared Bat	V	52	Yes	F, W	1665	5310
Vespertilionidae	<i>Vespardelus troughtoni</i>	Eastern Cave Bat	V	2	Yes	F, W	1665	5310
Fabaceae (Faboideae)	<i>Pultenaea setulosa</i>		V		Yes	F, W	1665	5310
Rhamnaceae	<i>Pomaderris queenslandica</i>	Scant Pomaderris	E		Yes	F, W	1665	5310
	Box Gum Woodland and Derived Native Grassland		CE	CE	Yes		545	4682
	Plains Grassland		E	CE	Yes		0	0

Table 2.4 Condition Classes of Box Gum Woodland and Derived Native Grassland in the Offsets

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)	Latitude	Longitude	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)	High condition remnant forest and woodland habitat (ha)	Low condition derived native grassland habitat to be re-vegetated to moderate condition habitat in the medium to long term (ha)
Blue Range	723.14	30°31'17.3 S	150°5'47.4 E		Private ownership	CA or other	0	0	21.67	30.69	0
Teston (nth)	291.69	30°31'58.8 S	150°6'38.7 E		Agreement in Place	CA or other	0	0	58.73	66.38	51.61
Tralee	329.76	30°32'2.6 S	150°7'26.2 E		Agreement in Place	CA or other	0	0	17.20	34.89	67.84
Cattle Plain	281.7	30°30'57.6 S	150°7'38.1 E		Private ownership	CA or other	0	0	35.98	38.64	101.62
Wallandilly	1849.7	30°30'47.9 S	150°9'56.4 E		Private ownership	CA or other	0	0	98.99	266.7	0
Kelso	499.02	30°36'26.1 S	150°3'36.3 E		Private ownership	CA or other	0	0	16.49	342.81	156.3
Teston (sth)	1272.5	30°34'5.7 S	150°7'0.1 E		Aston Coal Owned	CA or other	0	18.59	94.03	227.98	18.59
Velyama	909.52	30°36'9.5 S	150°5'5.9 E		Aston Coal Owned	CA or other	0	71.62	41.13	102.53	197.7
Louenville	458.89	30°34'53.3 S	150°4'59.8 E		Agreement in Place	CA or other	0	0	151.38	151.45	0
Olivedeen	193.37	30°35'24.4 S	150°3'9.4 E		Aston Coal Owned	CA or other	0	0	0.00	13.24	0
Warriahdool	1003.91	30°31'22.5 S	150°8'40.7 E		Agreement in Place	CA or other	0	0	65.47	89.23	9.93
Mt Lindesay	2259.1	30°19'42.1 S	150°16'57.1 E		Aston Coal Owned	NP, CA or other	0	1419.98	1331.75	1619.99	494.34
Wirradale	4029.03	30°22'54.6 S	150°15'47.8 E		Under option	NP, CA or other	0	494.59	1272.85	5275.18	932.67
Shared Property	884.47	30°38'44.7 S	150°1'12.7 E		Boggabri / Aston Coal Owned	CA or other	0	0	0	355.34	0

Table 2.4 Condition Classes of Box Gum Woodland and Derived Native Grassland in the Offsets

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)	High condition remnant forest and woodland habitat (ha)	Low condition derived native grassland habitat to be re-vegetated to moderate condition habitat in the medium to long term (ha)	
		Latitude	Longitude								
TOTAL	16835.5					0	2004.79	3304.65	8881.75	2030.6	



Legend

- Project Boundary
- Mining Tenement Boundary
- Final Rehabilitation
- Conservation and Forest Reserves
- Town
- Road
- Northern Offset Properties
- Eastern Offset Properties
- Western Offset Properties
- Shared Offset Property

Image Source:
Image © 2010 GeoEye
Image © 2010 DigitalGlobe
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Figure 2.1. Location of Offset Properties with respect to the Project Location



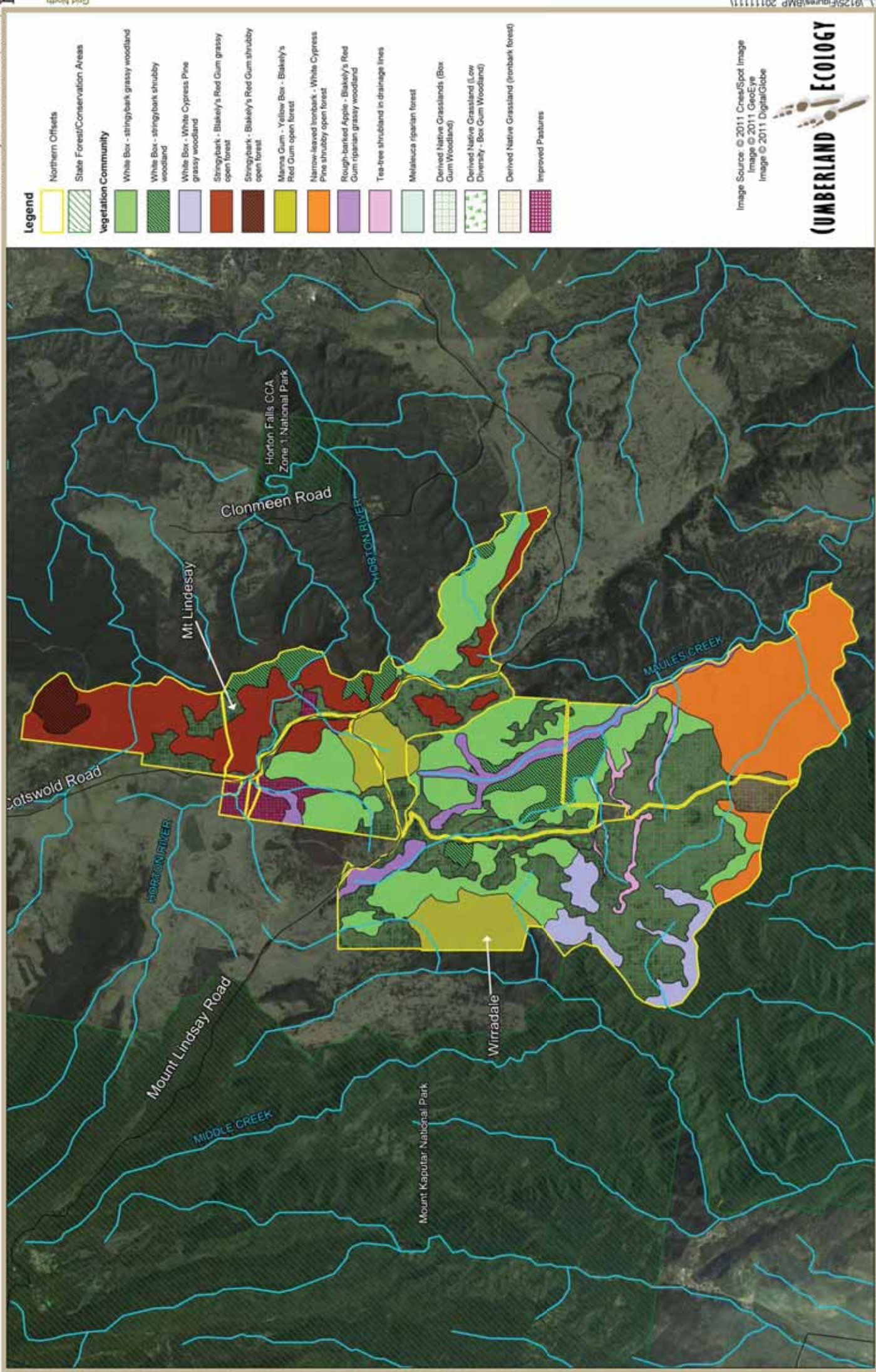


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Image © 2011 GeoEye
Image © 2011 DigitalGlobe



Figure 2.2. Location of the Northern Offset Properties



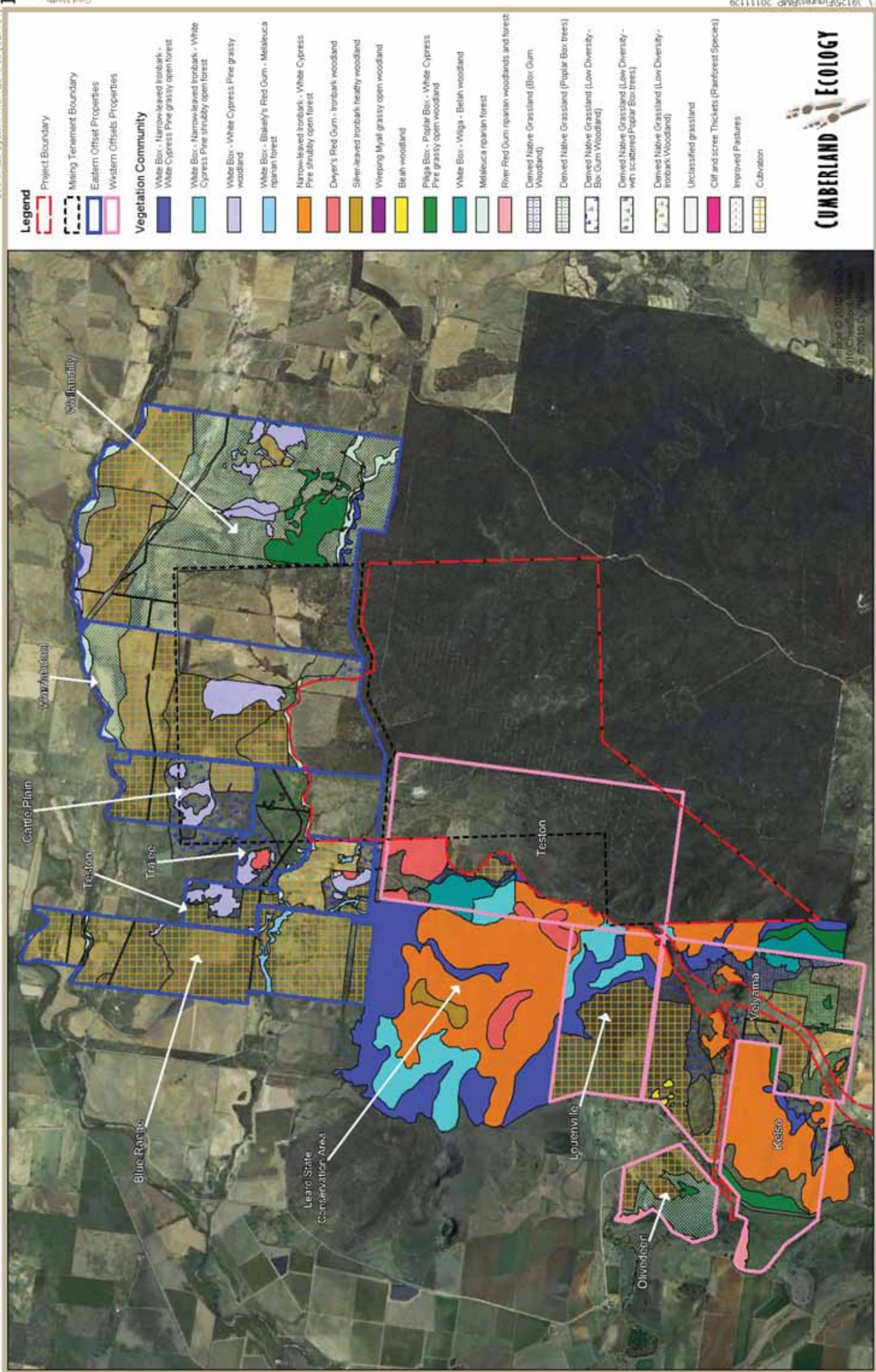
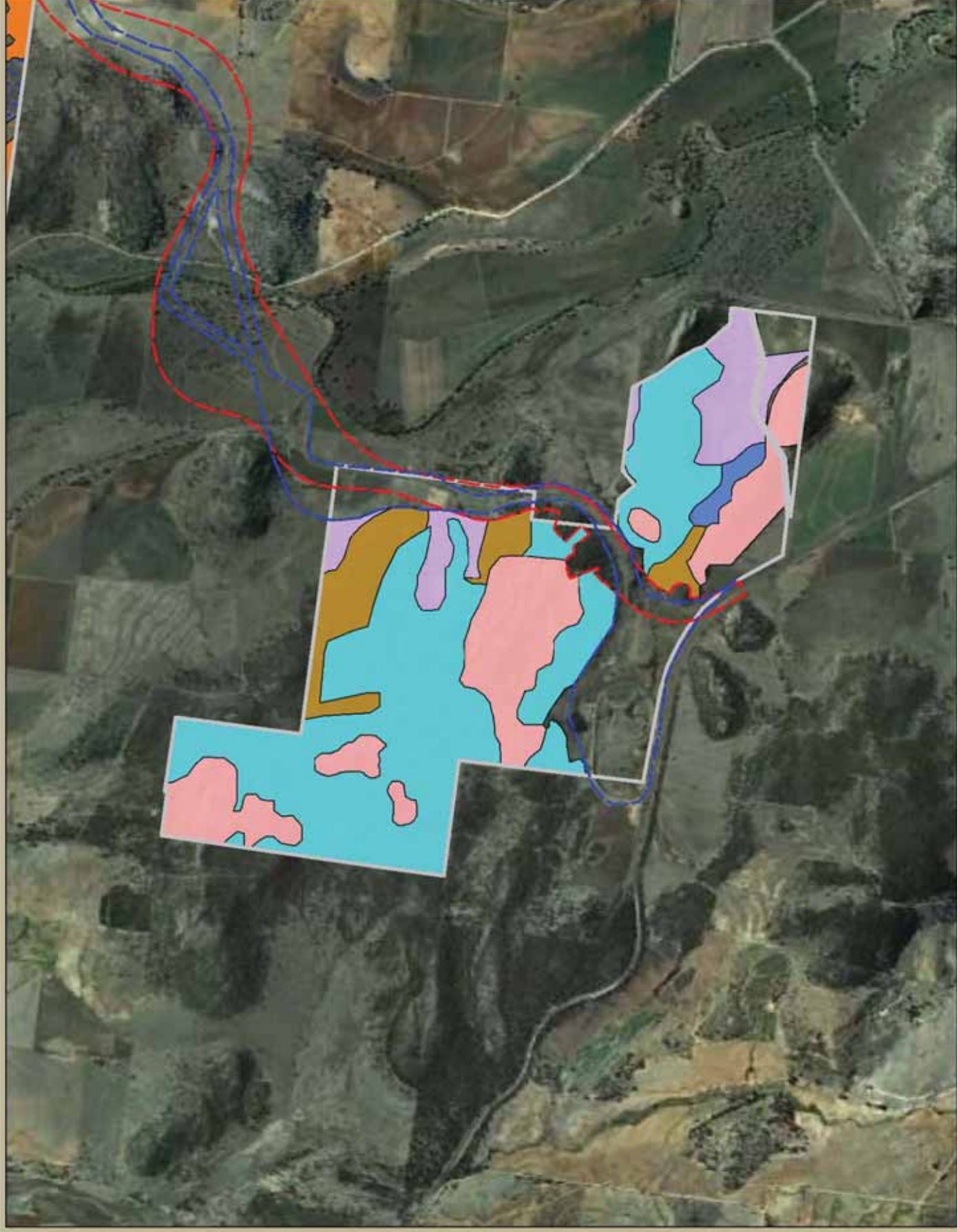


Figure 2.3. Location of the Eastern and Western Offset Properties



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 healthy woodland
- White Box - Narrow-leaved Ironbark - White Cypress Pine shrubby open Forest

Source: Image © 2010 GeoEye
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Figure 2.4. Location of the Shared Offset Property



Management Actions: Northern Offsets

3.1 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 and U on Wirradale (see **Figure 3.1**). 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 3.1**).

Commercial livestock grazing will be maintained within core farming areas C on Mt Lindesay and T on Wirradale (**Figure 3.1**) 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).

3.2 Environmental Gains

The Northern Offsets already have high habitat values but 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.

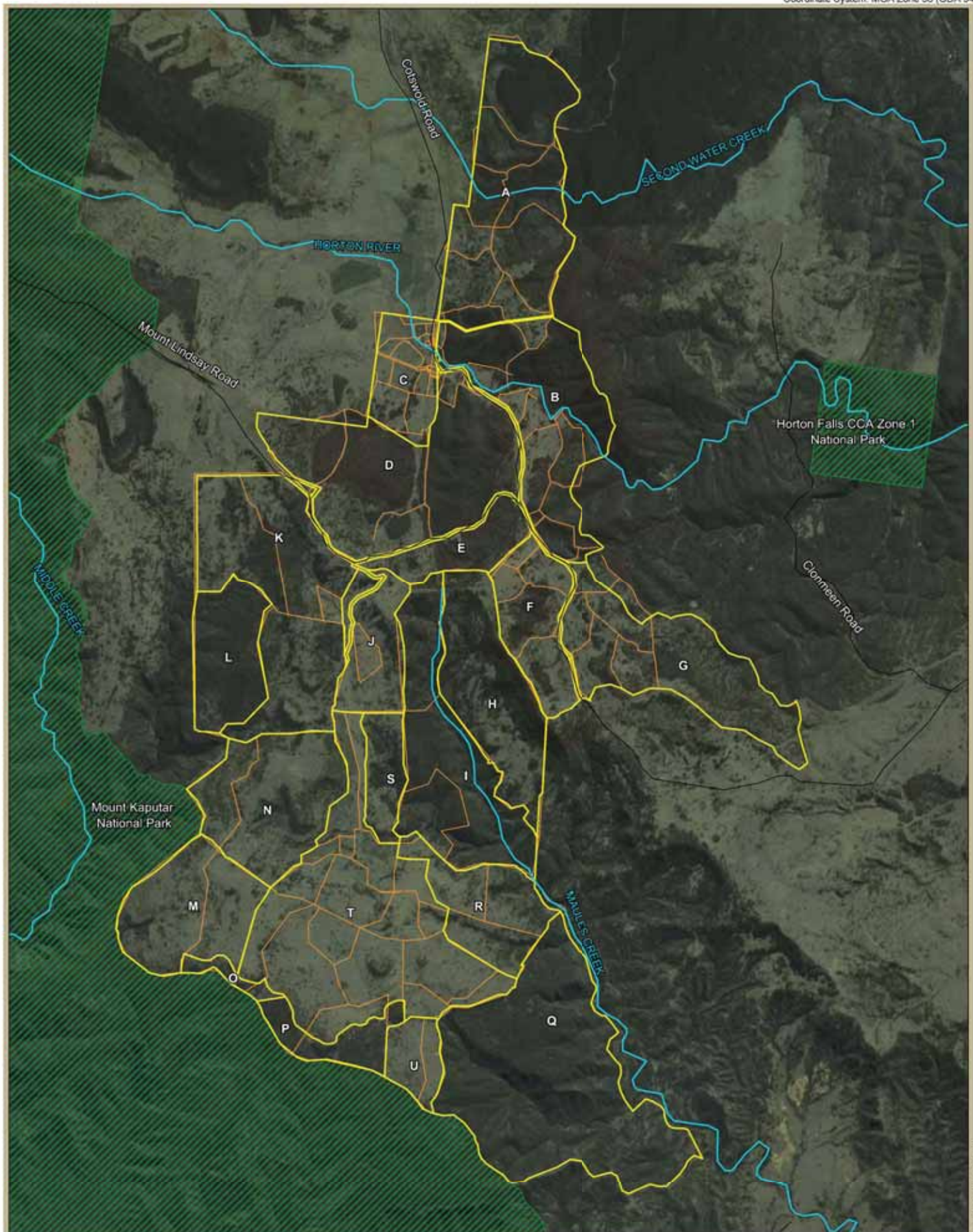
Regeneration of woodland will increase the total area of woodland habitat within the Northern Offsets and will improve habitat linkages to nearby Mount Kaputar National Park. With a reduction in livestock grazing, it is predicted that the diversity of native grasses and other herbaceous plants will increase, 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.

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 National Parks estate.

Aston has commenced preliminary discussions with the NSW National Parks and Wildlife Service and the Office of Environment and Heritage in regards to the above agreements.

**Legend**

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

Figure 3.1. Management Zones for the Northern Offset Property

3.3 Grazing Plan

i. Objectives

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. Grazing management is fundamental for the achievement of the conservation objectives for the Northern Offsets (Lunt *et al.*, 2007). Light rotational grazing has been shown to maintain native tussock grasses and grazing sensitive herbs (McIntyre and Lavorel, 2001) and may increase species diversity (Tasker and Bradstock, 2001; Henderson and Keith, 2002; 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.

ii. Implementation and Timing

In the first seven years, selected management areas will be systematically subjected to a cycle of crash grazing, resting, and light rotational grazing in accordance with the grazing plan (see **Tables 3.1** and **3.2**) to stimulate regeneration of woody plants (trees and shrubs). Crash grazing will be followed by a resting period from grazing to allow native grasses, forbs and tree seedlings to establish. Light rotational grazing will take place after resting to help maintain the groundcover and litter cover through autumn and winter. Light to moderate rotational grazing will also take place in these management areas before the commencement of a cycle (**Table 3.2**) to promote regeneration of woodland vegetation; maintain diversity of habitats; and where necessary, to reduce high levels of grassy fuel.

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 rotational 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 Aston's Environmental Officer, the land manager (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.

No further 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:

- 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 3.3-iii**);
- 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 J & 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 areas J and T will be fenced to exclude livestock and to promote regeneration of riparian corridors (see **Section 3.7**).

Table 3.1 One Grazing Cycle in the Grazing Management of the Northern Offsets

Year	Month	Season	Action
First Year	September	Spring	Crash grazing first 3 months
	October		
	November		
	December		
Second Year	January	Summer	Exclude grazing three months
	February		
	March	Autumn	Light rotational grazing for 6 months
	April		
	May		
	June		
	July		
	August		
	September	Spring	Monitor. Crash graze if necessary. Otherwise lightly graze
	October		
	November		
	December		
Third Year	January	Summer	Exclude grazing three months
	February		
	March	Autumn	Light rotational grazing for 8 months
	April		
	May		
	June		
	July		
	August		
	September	Spring	Monitor
	October		
	November		

Table 3.2 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	TBD														
B	LRG	One grazing cycle		TBD	TBD	TBD	TBD														
C	COMMERCIAL GRAZING																				
D	LRG	LRG	LRG	One grazing cycle		TBD	TBD														
E	LRG	LRG	LRG	One grazing cycle		TBD	TBD														
F	LRG	LRG	One grazing cycle		TBD	TBD	TBD														
G	One grazing cycle		TBD	TBD	TBD	TBD	TBD														
H	LRG	One grazing cycle		TBD	TBD	TBD	TBD														
I	NO GRAZING																				
J	LRG	LRG	LRG	LRG	One grazing cycle		TBD														
K	LRG	LRG	One grazing cycle		TBD	TBD	TBD														
L	NO GRAZING																				
M	One grazing cycle		TBD	TBD	TBD	TBD	TBD														
N	LRG	One grazing cycle		TBD	TBD	TBD	TBD														
O	LRG	One grazing cycle		TBD	TBD	TBD	TBD														

Table 3.2 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
	NO GRAZING																				
P																					
Q																					
R	LRG	LRG	One grazing cycle		TBD		TBD														
S	LRG	LRG	LRG	One grazing cycle		TBD		TBD													
T	COMMERCIAL GRAZING																				
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.

iii. *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, **Chapter 6**);
- 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.

iv. *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 G** 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 (Swift Parrot Recovery Team, 2001). If thinning takes place, the debris will be redistributed as ground cover in woodland areas to provide habitat for fauna (**Appendix G**).

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 3.8**), as well as to stimulate the growth of fresh, more palatable grass for stock.

v. *Monitoring Parameters and Timing*

Monitoring will take place once during the grazing 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 **Chapter 6** for further details.

vi. *Responsibility for Carrying out this Action*

Refer to **Section 3.11** below.

vii. *Reporting and Documentation*

Refer to **Section 3.12** below.

3.4 Revegetation Plan

i. *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; McIntyre *et al.*, 2002).

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.

ii. Implementation and Timing

Revegetation will be undertaken in selected management areas in accordance with the planting plan (see **Table 3.3**). 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 3.4** and include the following works:

- Buffer planting;
- Creekline planting;
- Node planting;
- Paddock tree and patch augmentation;
- Weed control (see **Section 3.5**);
- Exclusion fencing; and
- Monitoring (see **Section 3.4viii**).

Buffer planting is important in the management areas adjacent to management area T 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.

Tree and shrub planting will take place along creeklines and these areas will be fenced to exclude stock. See **Section 3.7** 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, 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 3.3 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																					

Table 3.3 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
P	CORE CONSERVATION																				
Q	CORE CONSERVATION																				
R		prep	plant	weed	weed																
S																					
T	COMMERCIAL GRAZING																				
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 3.4 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

iii. *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 D**. Seed collection should commence as early as possible as large volumes of seeds are likely to be required.

iv. *Pre-planting Preparation*

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

v. *Planting Techniques*

The main planting techniques will be tubestock planting and direct seeding. Methods for these are provided in **Appendix E**. The advantages and disadvantages of each technique is summarised in **Table 3.5** below the most appropriate method will be utilised for each site.

Table 3.5 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 3.6**).

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 3.6 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)

vi. 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, **Chapter 6**); and
- Bare ground cover not exceeding 30-40 % of the cover in pastures (McIvor, 2002).

vii. *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 (Swift Parrot Recovery Team, 2001). If density reduction takes place, the debris will be redistributed as ground cover in woodland areas to provide habitat for fauna (**Appendix G**).

viii. *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 3.3**).

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 **Chapter 6** for a detailed description of the monitoring requirements for this action.

ix. *Responsibility for Carrying out this Action*

Refer to **Section 3.11** below.

x. *Reporting and Documentation*

Refer to **Section 3.12** below.

3.5 Weed Management

i. *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.

ii. *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 F**. 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 F**). 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 and Sweet Briar (provided in **Appendix F**).

2. Stockpile weedy biomass 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.

iii. 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.

iv. 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.

v. *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 3.3**). 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 **Chapter 6** for a detailed description of the monitoring requirements for this action.

vi. *Responsibility for Carrying out this Action*

Refer to **Section 3.11** below.

vii. *Reporting and Documentation*

Refer to **Section 3.12** below.

3.6 Feral Pest Management

i. *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.

ii. *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.

iii. 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 consultant ecologists report little or no damage to vegetation by feral animals; and
- No new feral animal invasions.

iv. 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.

v. 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 3.3**). 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 **Chapter 6** for a detailed description of the monitoring requirements for this action.

vi. Responsibility for Carrying out this Action

Refer to **Section 3.11** below.

vii. Reporting and Documentation

Refer to **Section 3.12** below.

3.7 Creekline Stabilisation

i. 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.

ii. 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.

iii. 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.

iv. 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.

v. *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.

Refer to **Chapter 6** for a detailed description of the monitoring requirements for this action.

vi. *Responsibility for Carrying out this Action*

Refer to **Section 3.11** below.

vii. *Reporting and Documentation*

Refer to **Section 3.12** below.

3.8 Fire Management

i. *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.

ii. *Implementation and Timing*

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*.

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.

iii. *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.

iv. *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.

v. *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.

Refer to **Chapter 6** for a detailed description of the monitoring requirements for this action.

vi. *Responsibility for Carrying out this Action*

Refer to **Section 3.11** below.

vii. *Reporting and Documentation*

Refer to **Section 3.12** below.

3.9 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.

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

Table 3.7 Management Schedule for the Northern Offsets

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	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 (<i>Rosa rubiginosa</i>)	Major	Major	Major	Major	Major	As req'd							As req'd								
Weeping Willow (<i>Salix babylonica</i>)	Major	Major	Major	Major	Major	As req'd							As req'd								
Elm (<i>Ulmus</i> sp)	Major	Major	Major	Major	Major	As req'd							As req'd								

Table 3.7 Management Schedule for the Northern Offsets

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	
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	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	



Table 3.7 Management Schedule for the Northern Offsets

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
Thinning						Poten	Poten	Poten	Poten	Poten	Poten	Poten	Poten	Poten	Poten	Poten	Poten	Poten	Poten	Poten	Poten
						tially	tially	tially	tially	tially	tially	tially	tially	tially	tially	tially	tially	tially	tially	tially	tially
						req'd	req'd	req'd	req'd	req'd	req'd	req'd	req'd	req'd	req'd	req'd	req'd	req'd	req'd	req'd	req'd
Tenure																					

Key:

CG – Commercial Grazing

RG – Rotational Grazing

3.10 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.

3.11 Roles and Responsibilities

The work to implement this plan will be the responsibility of property management staff LM, the mine environmental officer (EO) and EC. The property management staff will be responsible for the day to day management of the site. The Environmental Officer will be responsible for overseeing this work, for collating monitoring and management data, for arranging the revision and auditing of the BOMP and for contracting ecological consultants to conduct the audits and annual monitoring programs.

The ecological consultants will be independent professional ecological 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 3.8 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		

Table 3.8 Roles and Responsibilities for Management Aspect

Management Tasks	Responsibilities		
	Land Manager and Staff	Environmental Officer	Ecological Consultant
Conservation Zone (grassland & open woodland)	x		
Conservation Zone (forest & woodland)	x		
Weed Management			
Briar Rose (<i>Rosa rubiginosa</i>)	x	x	
Weeping Willow (<i>Salix babylonica</i>)	x	x	
Elm (<i>Ulmus</i> sp)	x	x	
Thistles	x	x	
Feral Animal Management			
Feral Pig (<i>Sus scrofa</i>)	x	x	
Feral Goat (<i>Capra hircus</i>)	x	x	
Fox (<i>Vulpes vulpes</i>)	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	

3.12 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 BOMP.

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.

Management Actions: Eastern and Western Offsets

4.1 Management Approach

The Eastern and Western Offsets are not finalised at the time of writing. Whilst some properties are owned by Aston, others have potential to be included in the offsets in the future. This chapter describes an indicative management plan for the conservation areas within the properties shown in **Figure 4.1**. Aston commits to the eventual provision of 1000 hectares of land from the Eastern and Western Offset properties for conservation and management as part of this BOMP.

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 4.1** 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.

4.2 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.

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.

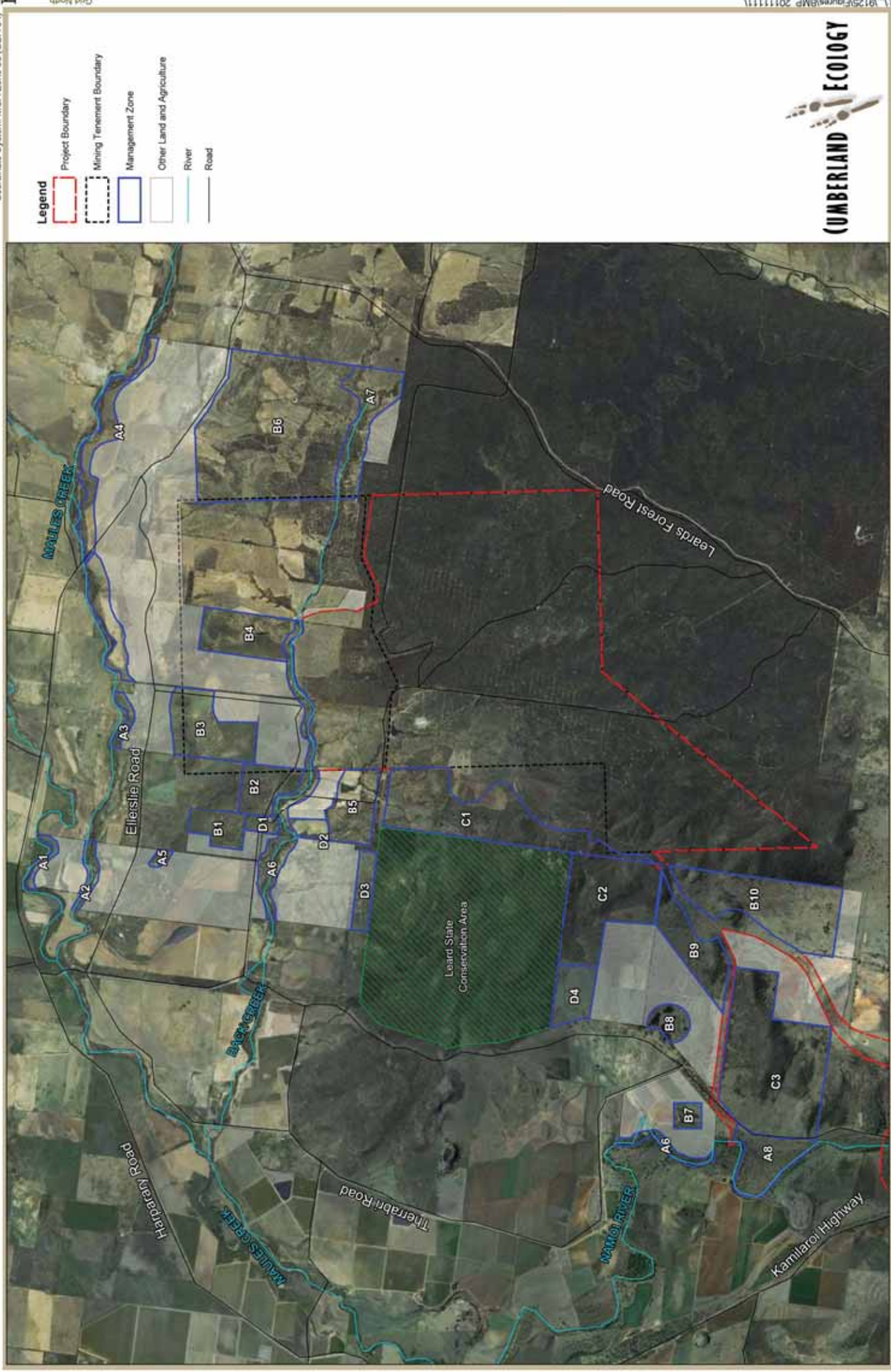


Figure 4.1. Management Zones of the Eastern and Western Offset Properties

4.3 Grazing Plan

i. 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 (Tasker and Bradstock, 2001; Henderson and Keith, 2002; Rawlings *et al.*, 2010) if managed appropriately to avoid overgrazing.

At the time of preparation of this BOMP, 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 Aston.

ii. Implementation and Timing

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.

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.

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 **Tables 4.1**) 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.

Crash grazing will be followed by a resting period from grazing to allow native grasses, forbs and tree seedlings to establish.

Light rotational grazing will take place after resting to help maintain the groundcover and litter cover through autumn and winter.

Monitoring will take place 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 4.1**).

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:

- Promote the growth and dominance of native perennial tussock grasses (McIntyre and Tongway, 2005);
- 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 4.3-iii** for groundcover threshold);
- 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 4.8** for more information on creekline restoration).

Table 4.1 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	September	Spring	Crash grazing first 3 months
	October		
	November		
	December		
Second Year	January	Summer	Exclude grazing three months
	February		
	March	Autumn	Light rotational grazing for 6 months
	April		
	May		
	June	Winter	
	July		
	August		
	September		Spring
	October		
	November		
	December		
Third Year	January		
	February		
	March	Autumn	Light rotational grazing for 8 months
	April		
	May		
	June	Winter	
	July		
	August		
	September	Spring	Monitor
	October		
	November		

iii. *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, Chapter 6);
- 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.

iv. *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 preferentially rotate out of stressed paddocks to rest overgrazed 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;
- Fence off areas to exclude or control grazing; and
- Apply / increase weed management as necessary.

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 G**). Thinning is also likely to promote the recovery of threatened species habitat (Swift Parrot Recovery Team, 2001). 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.

v. *Monitoring Parameters and Timing*

Monitoring will take place 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 **Chapter 6** for further details.

vi. *Responsibility for Carrying out this Action*

Refer to **Section 4.12** below.

vii. *Reporting and Documentation*

Refer to **Section 4.13** below.

4.4 Revegetation Plan

i. *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.

ii. *Implementation and Timing*

Revegetation will be undertaken in selected management areas in accordance with the planting plan (see **Table 4.2**). This planting plan 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 4.4** and include the following works:

- Buffer planting;
- Creekline planting;
- Node planting;
- Paddock tree and patch augmentation;
- Weed control (see **Section 4.6**);
- Exclusion fencing; and
- Monitoring (see **Section 4.5viii**).

Buffer planting is important in the management areas adjacent to management area T 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.

Tree and shrub planting will take place along creeklines and fenced to exclude grazing. See **Section 4.8** 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, 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 4.2 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
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

iii. 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 D**.

iv. Pre-planting Preparation

Preparation of the planting area will be carried out at least one year before planting takes place (**Table 4.4**). See **Appendix D** for planting preparation methods.

v. Planting Techniques

The main planting techniques include tubestock planting and direct seeding. Methods for these are provided in **Appendix D**. The advantages and disadvantages of each technique is summarised in **Table 4.3** and will be considered against each candidate planting site to ascertain the most appropriate method for that site.

Table 4.3 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
(-) 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 4.4**).

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 4.4 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)

vi. *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, Chapter 6); 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.

vii. *Potential Corrective Actions*

The following corrective actions apply to the grazing management of 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 (Swift Parrot Recovery Team, 2001). If density reduction takes place, the debris should be redistributed as ground cover in woodland areas to provide habitat for fauna (**Appendix G**).

viii. *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 **Chapter 5** for a detailed description of the monitoring requirements for this action.

ix. *Responsibility for Carrying out this Action*

Refer to **Section 4.12** below.

x. *Reporting and Documentation*

Refer to **Section 4.13** below.

4.5 Weed Management

i. *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.

ii. *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 F**. 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.

4. *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 F**). 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 F**).

5. *Stockpile weedy biomass 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.

6. *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.

iii. *Performance Indicators*

- Weed densities of all species and areas infested decline.

iv. *Potential Corrective Actions*

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

v. *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 **Chapter 6** for a detailed description of the monitoring requirements for this action.

vi. Responsibility for Carrying out this Action

Refer to **Section 4.12** below.

vii. Reporting and Documentation

Refer to **Section 4.13** below.

4.6 Feral Pest Management

Feral Pigs (*Sus scrofa*) are threats to the integrity of native woodland vegetation. They can also damage wildlife habitat.

These species will be controlled by trapping and shooting annually to control numbers of animals and reduce damage.

Foxes (*Vulpes vulpes*) are a major threat to wildlife and will be subject to regular control by shooting and poisoning as is routinely done on farms of the locality.

Performance Indicators: Feral animal maintained at low densities such that consultant ecologists report little or no damage to vegetation by feral animals.

Potential Corrective Actions:

Additional efforts to control target species, or methods extend to cover newly occurring feral animal species.

i. Monitoring Parameters and Timing

The occurrence and abundance of feral animals will be monitored.

Refer to **Chapter 6** for a detailed description of the monitoring requirements for this action.

ii. Responsibility for Carrying out this Action

Refer to **Section 4.12** below.

iii. Reporting and Documentation

Refer to **Section 4.13** below.

4.7 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.

i. Performance Indicators

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

ii. Potential Corrective Actions

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

iii. Monitoring Parameters and Timing

The condition and extent of creek bank vegetation will be monitored.

Refer to **Chapter 6** for a detailed description of the monitoring requirements for this action.

iv. Responsibility for Carrying out this Action

Refer to **Section 4.12** below.

v. Reporting and Documentation

Refer to **Section 4.13** below.

4.8 Fire Management

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.

i. Potential Corrective Actions

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

4.9 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.

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

Table 4.5 Management Schedule for the Eastern and Western Offsets

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 Box Thorn (<i>Lycium ferocissimum</i>)	Major	Major	Major	Major	Major	As req'd							As req'd									
Weeping Willow (<i>Salix babylonica</i>)	Major	Major	Major	Major	Major	As req'd							As req'd									
Thistles	Major	Major	Major	Major	Major	As req'd							As req'd									

Table 4.5 Management Schedule for the Eastern and Western Offsets

		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
Feral Animal Management																						
Feral Pig (<i>Sus scrofa</i>)	Major	Major	Major	Major	Major	Major	As req'd							As req'd								
Fox (<i>Vulpes vulpes</i>)	Major	Major	Major	Major	Major	Major	As req'd							As req'd								
Creek Stabilisation																						
fencing of riparian areas	x	x																				
fencing maintenance														As req'd								
Weeding of exotic trees (as above)																						
Replanting and Thinning																						
Replanting	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Thinning							Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd	Poten tially req'd
Tenure																						

Key: CG – Commercial Grazing RG – Rotational Grazing

4.10 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.

4.11 Roles and Responsibilities

The work to implement this plan will be the responsibility of the LM (farm manager and staff), the EO and EC. 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 BOMP 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 4.6 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		

Table 4.6 Roles and Responsibilities for Management Aspect

Management Tasks	Responsibilities		
	Land Manager and Staff	Environmental Officer	Ecological Consultant
Conservation Zone (forest & woodland)	x		
Weed Management - all zones			
Weeping Willow (<i>Salix babylonica</i>)	x	x	
Blackberry (<i>Rubus fruticosus</i>)	x	x	
Thistles	x	x	
Feral Animal Management			
Feral Pig (<i>Sus scrofa</i>)	x	x	
Feral Goat (<i>Capra hircus</i>)	x	x	
Fox (<i>Vulpes vulpes</i>)	x	x	
Creek Stabilisation			
fencing of riparian areas (A zones)	x	x	
fencing maintenance	x	x	
Weeding of exotic trees (as above)	x	x	
Replanting and Thinning			
Replanting	x	x	
Thinning	x	x	
Tenure		x	
Monitoring		x	x
Documentation	x	x	

4.12 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 BOMP.



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.

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 Chapter for the Eastern and Western Offsets.

Monitoring Programme

6.1 Purpose

Progress of ecological restoration and management of the Northern, Eastern, Western and Shared Offset properties will be subject to annual monitoring. The aim of monitoring will be to track the progress of key performance indicators, as specified in Chapters 3, 4 and 5 during the life of the Plan so as to provide feedback that can be used to guide and improve management of the offsets.

A subset of conservation management areas from each of the Northern, Eastern, Western and Shared Offset areas will be selected for monitoring annually for the life of the mining Project. Areas to be monitored will be rotated so that different conservation management areas are monitored each year for the life of the Project.

6.2 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 for the Northern, Eastern and Western Offset areas.

The Pilot Monitoring Project will determine monitoring locations within all conservation management areas, prescribe monitoring techniques, replication and data analysis.

Monitoring of outcomes within conservation management 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.

6.3 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.

One fixed monitoring area will be established in each conservation management area.

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.

6.4 Parameters

At a selected subset of monitoring points (conservation management areas and reference areas), the following parameters will be monitored annually in spring:

- Vascular plant species diversity;
- Vegetation structure;
- Woodland and open forest regeneration;
- Weed species;
- Evidence of feral animals;
- Bird census; and
- Bat census.

At each monitoring point, notes will also be made about the general condition of vegetation, prevalent weeds (if present), activities of feral animals, and other potential threats or management issues.

Monitoring methodology for vegetation and faunal habitat will use replicated quadrats and will measure (as a minimum) the following variables:

- Species richness;
- Species frequency and cover abundance;
- Litter Cover (%);
- Ground Percentage Foliage Cover (%) and Height (m);
- Shrub Percentage Foliage Cover (%) and Height (m); and
- Canopy Percentage Foliage Cover (%) and Height (m);

Birds will also be monitored to provide an assessment of the condition (diversity) of avifauna within monitoring versus reference sites.

i. Weed & Feral Animal Research

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.

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.

6.5 Research & Indirect Offsetting

The restoration and management of the offset lands 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 and for the BOMP 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.

6.6 Reporting

An Annual Monitoring Report will be prepared as outlined in the following chapter.

Auditing and Reporting

7.1 Auditing

Auditing will be conducted throughout the life of the Project in the Northern, Eastern, Western and Shared offset areas. Auditing will occur in the form of Independent Environmental Audits.

Independent environmental audits will utilise data collected during the ongoing ecological monitoring to assess whether the management of the offset properties is consistent with the commitments made within this BOMP. Auditing will be undertaken every three years following the completion of each third year of annual monitoring, and will be continued throughout the lifespan of the Project.

In addition to the reporting of annual monitoring results, auditing will also involve interviews with Land Managers to identify any potential land management issues that have the potential to impact upon the effective management of the Offset Areas. Auditing will also involve the identification of deficiencies or shortfalls in management activities such as the maintenance and quality of tracks and fencing and erosion and sediment control in riparian areas.

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.

7.2 Reviews of the BOMP

Reviews of the BOMP will be undertaken every three years. These reviews will use the Independent Environmental Audits to assess whether the Project is meeting the commitments stipulated within the BOMP, and the Project Approval conditions for the Project. If it is found that the management of the offset areas is not meeting the commitments in the BOMP, or conditions of Project Approval, changes will be made to the management practices and timelines outlined within the BOMP. These changes will be based on recommendations within the Independent Environmental Audit, and from stakeholder consultation. Reviews of the BOMP will be undertaken by a suitably qualified expert.

7.3 Reporting

The following reporting will occur to assess the quality and compliance of the management of the Offset Properties. These reports will include:

- Biodiversity Offset Annual Monitoring Report;
- Independent Environmental Audit; and
- Independent BOMP Review.

The Biodiversity Offset Annual Monitoring Report will be created following the completion of annual monitoring. The report will provide the results of the years 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. 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 Independent Environmental Audit will review the documentation of management actions completed to date and compile data collected within the Annual Monitoring to assess and whether the management of the offset properties is consistent with the commitments made within the BOMP. Recommendations will be made based on the compliance or non-compliance of offset areas with the outcomes of the BOMP. These reports will consist predominantly of compliance table, where each specific management measure outlined

within the BOMP 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.

An Independent BOMP Review will be conducted every five years to assess firstly, whether the management actions outlined within the BOMP are being effectively implemented, and secondly whether the management methodologies need to be modified in order to increase their effectiveness. The BOMP will review compliance tables to compare the objectives of the BOMP with results of surveys. Additionally, data will be compared between years to determine whether changes made as a result of recommendations in the Annual Monitoring 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.

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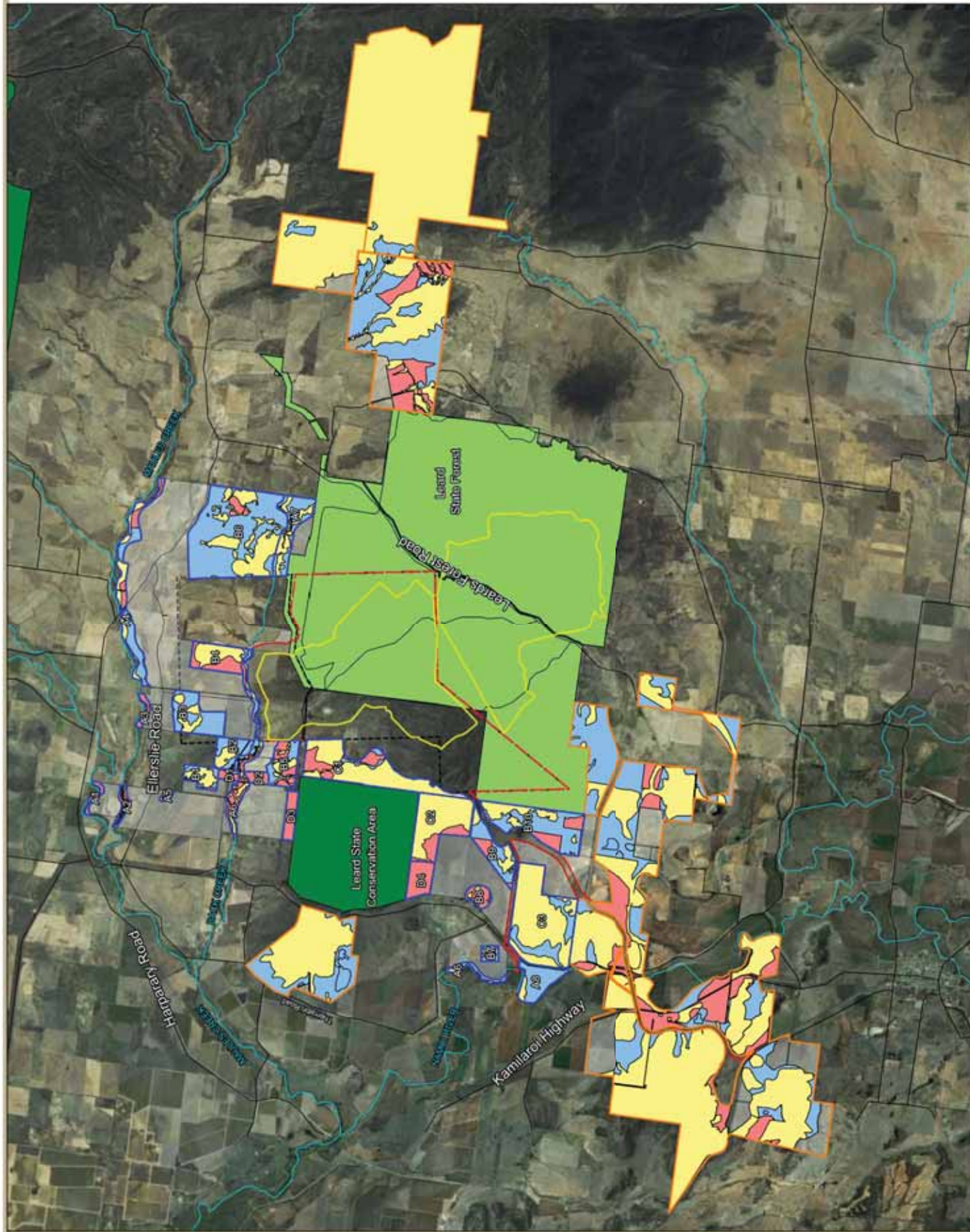
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Appendix A

Eastern and Western Offsets in the Local Context



- 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



Figure A.1. Maules Creek and Boggabri Coal Offsets in the vicinity of Leard State Forest



Appendix B

Evaluation of the BOMP with EPBC Act
Threatened Species Recovery Plans and
Conservation Advices

Table B.1 Analysis of BOMP Objectives Against Recovery Objectives for Box Gum Woodland

Recovery Objectives	Response
<i>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.</i> <i>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:</i> <i>• achieving no net loss in extent and condition of the ecological community throughout its geographic distribution;</i> <i>• increasing protection of sites in good condition;</i> <i>• increasing landscape functionality of the ecological community through management and restoration of degraded sites;</i> <i>• increasing transitional areas around remnants and linkages between remnants; and</i> <i>• 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-</i>	The BOMP 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 BOMP prescribes measures that will <i>protect and restore</i> 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. The BOMP prescribes measures for the protection of good quality Box Gum Woodland and diverse Derived Native Grassland in the Northern Offsets. The BOMP prescribes measures to protect Box Gum Woodland in the fertile areas of the landscape in the Eastern and Western Offsets. The BOMP aims to restore areas of Derived Native Grassland to woodland. One of the BOMP 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. The BOMP aims to establish vegetated corridors and increase existing patch sizes to improve the landscape connectivity, particularly around Leard State Forest. The BOMP clearly states for the benefit of land managers who will implement the plan that the intent of the BOMP is to conserve and improve the extent of Box Gum Woodland on the respective properties.

Table B.1 Analysis of BOMP Objectives Against Recovery Objectives for Box Gum Woodland

Recovery Objectives	Response
<i>Gum Grassy Woodland.</i>	
<i>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.</i>	Not applicable to this analysis.
<i>Recovery objectives from DECCW NSW (2010).</i>	

Table B.2 Analysis of BOMP Objectives Against Recovery Objectives for Swift Parrot

Recovery Objectives	Response
<i>To change the conservation status of the swift parrot from endangered to vulnerable within 10 years.</i>	Not applicable as the recovery plan was initiated in 2001. However, the BOMP is generally consistent with the intent of this objective, which is to provide lasting protection for the species to reduce its risk of extinction.
<i>To achieve a demonstrable sustained improvement in the quality of swift parrot habitat to increase carrying capacity.</i>	The BOMP aims to increase and improve the existing area of habitat for Swift Parrot in the offset properties. The BOMP prescribes regular monitoring to assess and quantify the improvement in Swift Parrot habitat.
<i>Recovery objectives from Swift Parrot Recovery Team (2001)</i>	

Table B.3 Analysis of BOMP Objectives Against Recovery Objectives for Regent Honeyeater

Recovery Objectives	Response
<i>1. To ensure that the species persists in the wild.</i>	The BOMP 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.

Table B.3 Analysis of BOMP Objectives Against Recovery Objectives for Regent Honeyeater

Recovery Objectives	Response
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 BOMP 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 B.4 Analysis of BOMP Objectives Against Recovery Objectives for Greater Long-eared Bat

Recovery objectives	Response
<i>Increase understanding of the basic ecology of the species to determine:</i> • <i>habitat requirements;</i> • <i>roost and maternity site selection; and</i> • <i>threatening processes.</i> <i>Clarify the current distribution and abundance of the species.</i>	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. Monitoring will provide further information about the distribution of the species in the locality.

Recovery objectives from SEWPaC (2011)

Appendix C

Flora and Fauna Survey Data

Figure C.1 Bird Species Recorded in the Eastern, Western and Northern Offset Properties

Family	Common Name	Scientific Name	TSC ACT	EPBC ACT	Leard State Forest	Louenville	Kaloo	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	<i>Coturnix pectoralis</i>														0
Phasianidae	Brown Quail	<i>Coturnix ypsilophora</i>														4
Anatidae	Australian Wood Duck	<i>Chenonetta jubata</i>														3
Anatidae	Grey Teal	<i>Anas gracilis</i>														1
Anatidae	Chestnut Teal	<i>Anas castanea</i>														0
Anatidae	Pacific Black Duck	<i>Anas superciliosa</i>														2
Anatidae	Hardhead	<i>Aythya australis</i>														1
Podicipedidae	Australasian Grebe	<i>Tachybaptus novaehollandiae</i>														2
Columbidae	Common Bronzewing	<i>Phaps chalcoptera</i>														7
Columbidae	Crested Pigeon	<i>Ocyphaps lophotes</i>														9
Columbidae	Peaceful Dove	<i>Geopelia striata</i>														6
Columbidae	Bar-shouldered Dove	<i>Geopelia humeralis</i>														3
Podargidae	Tawny Frogmouth	<i>Podargus strigoides</i>														1
Caprimulgidae	White-throated Nightjar	<i>Eurostopodus mystacalis</i>														0
Aegothelidae	Australian Owlet-nightjar	<i>Aegotheles cristatus</i>														1
Apodidae	White-throated Needletail	<i>Hirundapus caudacutus</i>		M												0
Apodidae	Fork-tailed Swift	<i>Apus pacificus</i>		M												0
Phalacrocoracidae	Little Pied Cormorant	<i>Microcarbo melanoleucos</i>														1
Pelecanidae	Australian Pelican	<i>Pelecanus conspicillatus</i>														0
Ciconiidae	Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>	E1													0
Ardeidae	White-necked Heron	<i>Ardea pacifica</i>														1
Ardeidae	White-faced Heron	<i>Egretta novaehollandiae</i>														1
Threskiornithidae	Straw-necked Ibis	<i>Threskiornis spinicollis</i>														1
Threskiornithidae	Royal Spoonbill	<i>Platalea regia</i>														0
Threskiornithidae	Yellow-billed Spoonbill	<i>Platalea flavipes</i>														0
Accipitridae	Black-shouldered Kite	<i>Elanus axillaris</i>														0
Accipitridae	Square-tailed Kite	<i>Lophoichthya isura</i>	V													0
Accipitridae	Whistling Kite	<i>Haliastur sphenurus</i>														0
Accipitridae	Brown Goshawk	<i>Accipiter fasciatus</i>														2
Accipitridae	Collared Sparrowhawk	<i>Accipiter cirrocephalus</i>														1
Accipitridae	Spotted Harrier	<i>Circus assimilis</i>	V													0
Accipitridae	Wedge-tailed Eagle	<i>Aquila audax</i>														2
Accipitridae	Little Eagle	<i>Hieraaetus morphnoides</i>	V													0
Falconidae	Nankeen Kestrel	<i>Falco cenchroides</i>														4
Falconidae	Brown Falcon	<i>Falco berigora</i>														3
Falconidae	Australian Hobby	<i>Falco longipennis</i>														2
Falconidae	Black Falcon	<i>Falco subniger</i>														0
Falconidae	Peregrine Falcon	<i>Falco peregrinus</i>														1
Hirundinidae	White-backed Swallow	<i>Cherameoca leucosternus</i>														1
Charadriidae	Ringed Plover	<i>Charadrius hiaticula</i>														0
Charadriidae	Black-fronted Dotterel	<i>Elsemyornis melanops</i>														1
Charadriidae	Masked Lapwing	<i>Vanellus miles</i>														2
Trogonidae	Painted Buton-quail	<i>Turnix varius</i>														1
Trogonidae	Red-cheated Buton-quail	<i>Turnix pyrrholorax</i>														0
Cathartidae	Galah	<i>Eolophus roseicapillus</i>														9
Cathartidae	Little Corella	<i>Cacatua sanguinea</i>														1
Cathartidae	Sulphur-crested Cockatoo	<i>Cacatua galerita</i>														9

Figure C.1 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
Cuculidae	Cockatiel	<i>Nymphicus hollandicus</i>			x	x		x		x						3
Psittacidae	Rainbow Lorikeet	<i>Trichoglossus haematodus</i>			x											0
Psittacidae	Scaly-breasted Lorikeet	<i>Trichoglossus chlorolepidotus</i>			x											0
Psittacidae	Musk Lorikeet	<i>Glossopsitta concinna</i>			x			x						x		2
Psittacidae	Little Lorikeet	<i>Glossopsitta pusilla</i>	V		x				x					x		2
Psittacidae	Australian King-Parrot	<i>Alisterus scapularis</i>			x									x		1
Psittacidae	Red-winged Parrot	<i>Aprornis erythropterus</i>			x		x	x								3
Psittacidae	Crimson Rosella	<i>Platycercus elegans</i>			x									x	x	2
Psittacidae	Eastern Rosella	<i>Platycercus eximius</i>			x	x	x	x	x	x	x		x	x	x	10
Psittacidae	Pale-headed Rosella	<i>Platycercus adscitus</i>			x											0
Psittacidae	Australian Ringneck	<i>Barnardius zonarius</i>			x											0
Psittacidae	Blue Bonnet	<i>Northiella haematogaster</i>			x	x		x	x	x	x		x			6
Psittacidae	Red-rumped Parrot	<i>Psephodus haematototus</i>			x	x	x	x	x	x			x			6
Psittacidae	Budgerigar	<i>Melopsittacus undulatus</i>			x											0
Psittacidae	Turquoise Parrot	<i>Neophema pulchella</i>	V		x	x								x		2
Cuculidae	Eastern Koel	<i>Eudynamis orientalis</i>			x											0
Cuculidae	Channel-billed Cuckoo	<i>Scythrops novaehollandiae</i>			x										x	1
Cuculidae	Horsfield's Bronze-Cuckoo	<i>Chalcites basalis</i>			x											0
Cuculidae	Black-eared Cuckoo	<i>Chalcites osculans</i>			x											0
Cuculidae	Shining Bronze-Cuckoo	<i>Chalcites lucidus</i>			x	x			x						x	3
Cuculidae	Pallid Cuckoo	<i>Cacomantis pallidus</i>			x											0
Cuculidae	Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>			x									x	x	2
Cuculidae	Brush Cuckoo	<i>Cacomantis variolosus</i>			x											0
Strigidae	Barking Owl	<i>Ninox connexa</i>	V		x											0
Strigidae	Southern Boobook	<i>Ninox novaeseelandiae</i>			x										x	1
Tyrionidae	Masked Owl	<i>Tyto novaehollandiae</i>	V		x											0
Tyrionidae	Barn Owl	<i>Tyto alba</i>			x											0
Alcedinidae	Azure Kingfisher	<i>Geyx azureus</i>			x											0
Halcyonidae	Laughing Kookaburra	<i>Dacelo novaeguineae</i>			x	x	x	x						x	x	5
Halcyonidae	Sacred Kingfisher	<i>Todiramphus sanctus</i>			x									x	x	2
Meropidae	Rainbow Bee-eater	<i>Merops ornatus</i>		M	x											0
Coraciidae	Dollarbird	<i>Eurystomus orientalis</i>			x											0
Climacteridae	White-throated Treecreeper	<i>Climacteris leucophaea</i>			x	x	x	x	x					x	x	6
Climacteridae	Brown Treecreeper	<i>Climacteris picumnus</i>	V		x				x					x	x	3
Ptilonorhynchidae	Spotted Bowerbird	<i>Ptilonorhynchus maculatus</i>			x	x										1
Maluridae	Superb Fairy-wren	<i>Malurus cyaneus</i>			x		x		x	x	x			x	x	7
Maluridae	White-winged Fairy-wren	<i>Malurus leucopterus</i>			x				x	x						1
Maluridae	Variegated Fairy-wren	<i>Malurus lamberti</i>			x	x	x							x	x	4
Acanthizidae	White-browed Scrubwren	<i>Sericornis frontalis</i>			x									x	x	2
Acanthizidae	Chestnut-rumped Heathwren	<i>Galamanthus pyrrhopygius</i>			x											0
Acanthizidae	Speckled Warbler	<i>Chthonicola sagittata</i>	V		x	x	x	x	x	x		x		x	x	8
Acanthizidae	Weebill	<i>Smicromis brevirostris</i>			x	x	x	x	x			x				7
Acanthizidae	Western Gerygone	<i>Gerygone fusca</i>			x	x	x		x							3
Acanthizidae	White-throated Gerygone	<i>Gerygone olivacea</i>			x									x	x	2
Acanthizidae	Stiated Thornbill	<i>Acanthiza lineata</i>			x	x								x	x	4
Acanthizidae	Yellow Thornbill	<i>Acanthiza nana</i>			x	x	x	x	x	x		x		x		7
Acanthizidae	Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>			x	x	x	x	x	x	x			x	x	8
Acanthizidae	Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>			x				x		x					2

Figure C.1 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	No. of Threatened Birds	168	56	50	44	55	28	39	19	18	95	65	125
Acanthizidae	Buff-rumped Thornbill	<i>Acanthiza reguloides</i>			x											
Acanthizidae	Inland Thornbill	<i>Acanthiza apicalis</i>			x											
Acanthizidae	Brown Thornbill	<i>Acanthiza pusilla</i>			x											
Acanthizidae	Southern Whiteface	<i>Aphelocephala leucopsis</i>			x											
Pardalidae	Spotted Pardalote	<i>Pardalotus punctatus</i>			x											
Pardalidae	Striated Pardalote	<i>Pardalotus striatus</i>			x											
Meliphagidae	Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>			x											
Meliphagidae	Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>			x											
Meliphagidae	Singing Honeyeater	<i>Lichenostomus virescens</i>			x											
Meliphagidae	White-eared Honeyeater	<i>Lichenostomus leucotis</i>			x											
Meliphagidae	Yellow-tufted Honeyeater	<i>Lichenostomus melanops</i>			x											
Meliphagidae	Grey-fronted Honeyeater	<i>Lichenostomus plumulus</i>			x											
Meliphagidae	Fuscous Honeyeater	<i>Lichenostomus fuscus</i>			x											
Meliphagidae	White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>			x											
Meliphagidae	Noisy Miner	<i>Manorina melanoccephala</i>			x											
Meliphagidae	Yellow-throated Miner	<i>Manorina flavigula</i>			x											
Meliphagidae	Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>			x											
Meliphagidae	Red Wattlebird	<i>Anthochaera carunculata</i>			x											
Meliphagidae	Scarlet Honeyeater	<i>Myzomela sanguinolenta</i>			x											
Meliphagidae	Brown Honeyeater	<i>Lichmera indistincta</i>			x											
Meliphagidae	Black-chinned Honeyeater	<i>Meliphaga</i>	V		x											
Meliphagidae	Brown-headed Honeyeater	<i>Meliphaga</i>			x											
Meliphagidae	White-naped Honeyeater	<i>Meliphaga</i>			x											
Meliphagidae	Blue-faced Honeyeater	<i>Entomozon cyanidis</i>			x											
Meliphagidae	Noisy Friarbird	<i>Philemon corniculatus</i>			x											
Meliphagidae	Little Friarbird	<i>Philemon citreogularis</i>			x											
Meliphagidae	Striped Honeyeater	<i>Plectorhyncha lanceolata</i>			x											
Meliphagidae	Painted Honeyeater	<i>Grantia picta</i>	V		x											
Pomatostomidae	Grey-crowned Babbler	<i>Pomatostomus temporalis</i>	V		x											
Pomatostomidae	White-browed Babbler	<i>Pomatostomus superciliosus</i>			x											
Eupetidae	Spotted Quail-thrush	<i>Circosoma punctatum</i>			x											
Neositidae	Varied Sittella	<i>Daphoenositta chrysoptera</i>	V		x											
Campephagidae	Ground Cuckoo-shrike	<i>Coracina maxima</i>			x											
Campephagidae	Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>			x											
Campephagidae	White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>			x											
Campephagidae	Cicadabird	<i>Coracina tenuirostris</i>			x											
Campephagidae	White-winged Triller	<i>Lalage sueurii</i>			x											
Pachycephalidae	Crested Shrike-It	<i>Falcunculus frontatus</i>			x											
Pachycephalidae	Golden Whistler	<i>Pachycephala pectoralis</i>			x											
Pachycephalidae	Rufous Whistler	<i>Pachycephala rufiventris</i>			x											
Pachycephalidae	Grey Shrike-thrush	<i>Colluricincla harmonica</i>			x											
Pachycephalidae	Crested Bellbird	<i>Oreocitta gutturalis</i>			x											
Oriolidae	Olive-backed Oriole	<i>Oriolus sagittatus</i>			x											
Artamidae	Masked Woodswallow	<i>Artamus personatus</i>			x											
Artamidae	White-browed Woodswallow	<i>Artamus leucorhynchus</i>	V		x											
Artamidae	Dusky Woodswallow	<i>Artamus cyanopterus</i>			x											
Artamidae	Grey Butcherbird	<i>Cracticus torquatus</i>			x											
Artamidae	Pied Butcherbird	<i>Cracticus nigricollis</i>			x											

Figure C.1 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
Artamidae	Australian Magpie	<i>Cracticus tibicen</i>			x	x		x	x	x	x		x	x	x	8
Artamidae	Pied Currawong	<i>Strepera graculina</i>			x	x		x	x	x	x		x	x	x	6
Rhipiduridae	Grey Fantail	<i>Rhipidura abiscapa</i>			x	x	x	x	x	x	x		x	x	x	6
Rhipiduridae	Willie Wagtail	<i>Rhipidura leucophrys</i>			x	x	x	x	x	x	x		x	x	x	9
Corvidae	Australian Raven	<i>Corvus coronoides</i>			x	x		x	x	x	x		x	x	x	8
Corvidae	Little Raven	<i>Corvus mellori</i>			x											0
Corvidae	Torresian Crow	<i>Corvus orru</i>			x					x				x	x	3
Monarchidae	Leadend Flycatcher	<i>Myiagra rubecula</i>			x									x	x	2
Monarchidae	Satin Flycatcher	<i>Myiagra cyanoleuca</i>	M		x											0
Monarchidae	Restless Flycatcher	<i>Myiagra inquieta</i>			x		x							x		3
Monarchidae	Magpie-lark	<i>Grallina cyanoleuca</i>			x		x	x	x		x		x	x	x	8
Corcoracidae	White-winged Chough	<i>Corcorax melanoframphos</i>			x	x	x	x	x		x		x	x	x	9
Corcoracidae	Apostlebird	<i>Struthidea chirepa</i>			x		x	x	x	x	x		x			7
Petroicidae	Jacky Winter	<i>Microeca fascians</i>			x	x			x					x	x	4
Petroicidae	Red-capped Robin	<i>Petroica goodenovi</i>			x	x	x	x	x		x			x		6
Petroicidae	Hooded Robin	<i>Melanodryas cucullata</i>	V		x		x									1
Petroicidae	Eastern Yellow Robin	<i>Eopsaltria australis</i>			x	x	x	x	x		x			x	x	7
Megaluridae	Rufous Songlark	<i>Cincloramphus mathewsi</i>			x	x				x				x		3
Megaluridae	Brown Songlark	<i>Cincloramphus cruralis</i>			x										x	1
Timaliidae	Silvereye	<i>Zosterops lateralis</i>			x	x			x					x	x	4
Hirundinidae	White-backed Swallow	<i>Cheramoeca leucosterna</i>			x									x		1
Hirundinidae	Welcome Swallow	<i>Hirundo neoxena</i>			x	x	x							x	x	4
Hirundinidae	Fairy Martin	<i>Petrochelidon arfel</i>			x										x	1
Hirundinidae	Tree Martin	<i>Petrochelidon nigricans</i>			x											0
Sturnidae	Common Starling	<i>*Sturnus vulgaris</i>			x	x		x		x	x		x	x		6
Sturnidae	Common Myna	<i>*Sturnus tristis</i>												x		1
Dicaeidae	Mistletoebird	<i>Dicaeum hirundinaceum</i>			x	x	x	x	x				x	x	x	7
Estrildidae	Zebra Finch	<i>Taeniopygia guttata</i>			x					x						1
Estrildidae	Double-barred Finch	<i>Taeniopygia bichenovii</i>			x	x	x		x	x	x			x	x	7
Estrildidae	Plum-headed Finch	<i>Neochmia modesta</i>			x											0
Estrildidae	Red-browed Finch	<i>Neochmia temporalis</i>			x									x	x	2
Estrildidae	Diamond Firetail	<i>Stagonopleura guttata</i>	V		x											0
Motacillidae	Australasian Pipit	<i>Anthus novaeseelandiae</i>			x			x						x		2

*Introduced

Table C.2 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)	Tralea	Warriahdool	Wirradale	Mt Lindesay
White-throated Needle-tail	<i>Hirundapus caudacutus</i>		M									x	x
Fork-tailed Swift	<i>Apus pacificus</i>		M									x	x
Square-tailed Kite	<i>Lophoictinia isura</i>	V		x	x		x					x	x
Spotted Harrier	<i>Circus assimilis</i>	V		x	x	x		x				x	x
Little Eagle	<i>Hieraetus morphnoides</i>	V		x	x	x	x	x	x			x	x
Glossy Black-Cockatoo	<i>Calyptorhynchus lathami</i>	V											
Little Lorikeet	<i>Glossopsitta pusilla</i>	V		x	x	x	x		x			x	
Swift Parrot	<i>Lathamus discolor</i>	E	E	x	x	x	x					x	x
Turquoise Parrot	<i>Neophema pulchella</i>	V		x	x	x	x	x	x			x	
Barking Owl	<i>Ninox connivens</i>	V		x	x	x	x					x	
Masked Owl	<i>Tyto novaehollandiae</i>	V		x	x	x	x						
Rainbow Bee-eater	<i>Merops ornatus</i>		M									x	x
Brown Treecreeper	<i>Climacteris picumnus</i>	V		x	x	x	x	x	x	x		x	x
Speckled Warbler	<i>Chthonicola sagittata</i>	V		x	x	x	x	x	x	x		x	x
Regent Honeyeater	<i>Anthochaera phrygia</i>	CE	E	x	x		x					x	
Black-chinned Honeyeater	<i>Melithreptus gularis</i>	V		x	x		x					x	
Painted Honeyeater	<i>Grantia picta</i>	V		x	x		x		x			x	
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>	V		x	x	x	x	x	x	x		x	
Varied Sittella	<i>Daphoenositta chrysoptera</i>	V		x	x		x					x	x
White-browed Woodswallow	<i>Artamus leucorhynchus</i>	V		x			x					x	x
Satin Flycatcher	<i>Myiagra cyanoleuca</i>		M									x	x
Flame Robin	<i>Petroica phoenicea</i>	V										x	x
Hooded Robin	<i>Melanodryas cucullata</i>	V		x	x	x	x	x	x	x		x	x
Diamond Firetail	<i>Stagonopleura guttata</i>	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 C.3 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 Lindsey
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 Some clearing on lower 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
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	Clearing some some paddocks	Clearing some some paddocks
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	Shallow/rocky in remnants	Shallow/rocky upslope and deep on lower slopes	Fertile, basaltic	Fertile, basaltic
Habitat Quality	Poor in heavily grazed areas Good in some patches	Good on upper slopes Poorer on lower slopes	Poor to fair	Fair to good	Fair	Fair to good	Poor	Poor	Fair to excellent	Fair to excellent
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 C.4 Tree Hollow Data Collected from the Northern, Eastern and Western Offset Properties

	Plot (20 x 50) →	Blue Range		Kelso 1	Kelso 2	Kelso 3	Louenville 1	Louenville 2	Louenville 3	Louenville 4	Louenville 5	Teston Nth		Teston Nth	Teston Sth	Teston Sth
		1	2									1	2			
<5cm	Apple Box															
	Blakely's Red Gum															
	Dwyers Red Gum															
	Fuzzy Box			1										2	7	
	Mountain Gum								1							
	Native Olive															
	NL Ironbark			1	1											
	Poplar Box															
	Red Stringybark		1													
	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
5-10cm	White Box Stag			1				1								
	White Cypress Pine															
	White Cypress Pine Stag					1								1		
	Wilga															
	Yellow Box												4			
	Apple Box															
	Dwyers Red Gum		1											1	1	
	Manna Gum															
	Mountain Gum															
	NL Ironbark															
	Poplar Box															
	Red Stringybark			1												
	River Red Gum		3													
	Rough-barked Apple															
	Unspecified Stag															
11-15cm	White Box															
	White Box Stag			1	5		3	5	6				12			
	White Cypress Pine Stag					1										
	Yellow Box															
	Apple Box															
	Blakely's Red Gum															
	Dwyers Red Gum															
	Mountain Gum														1	
	NL Ironbark			1												
	Poplar Box		1													
	Red Stringybark															
	River Oak															
	River Red Gum		2													
	Rough-barked Apple															
	Unspecified Stag															
	WF Honey Myrtle	1	2				2	8	8				10			
	White Box				2											
	White Box Stag															
	White Cypress Pine Stag					2										
	Yellow Box														1	

[illegible]

MAULES CREEK COAL PROJECT

C.9

FINAL DRAFT HANSEN BAILEY
1 DECEMBER 2011

16-20cm	Apple Box Dwyers Red Gum Mountain Gum NL Ironbark Red Stringybark River Oak River Red Gum Unspecified Stag White Box White Box Stag Yellow Box	4	2	3	2	3										1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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Table C.4 Tree Hollow Data Collected from the Northern, Eastern and Western Offset Properties

Plot (20 x 50) →	Wirradale 5Wirradale 6Wirradale 7Wirradale 8Wirradale 9										Total	Average/plot	Average/ha
	Mt 201	Wirradale D1	Wirradale D2	Mt Lindesay DR3	Mt Lindesay DA1	Mt Lindesay DA2	Mt Lindesay DA3						
<5cm	Apple Box Blakely's Red Gum Dwyers Red Gum Fuzzy Box Mountain Gum Native Olive NL Ironbark Poplar Box Red Stringybark River Red Gum Rough-barked Apple Tumbledown Red Gum Unspecified Stag WF Honey Myrtle White Box White Box Stag White Cypress Pine White Cypress Pine Stag Willga Yellow Box					1					2	2	20
											1	1	10
											14	4	35
											1	1	10
											5	5	50
											1	1	10
		2									6	1	12
											1	1	10
											28	5	47
										3	3	30	
										4	2	20	
										2	2	20	
										11	2	22	
										11	11	110	
	15									64	4	36	
										2	1	10	
										3	1	10	
										7	4	35	
										1	1	10	
										9	5	45	
5-10cm	Apple Box Dwyers Red Gum Manna Gum Mountain Gum NL Ironbark Poplar Box Red Stringybark River Red Gum Rough-barked Apple Unspecified Stag White Box White Box Stag White Cypress Pine Stag Yellow Box										2	2	20
											6	2	15
		2									2	2	20
											3	3	30
											4	2	20
			2								1	1	10
										3	4		
											26	5	52
											3	3	30
		1									4	1	13
			3								8	3	27
	1										40	3	33
											5	5	50
											3	2	15
											2	2	20
11-15cm	Apple Box Blakely's Red Gum Dwyers Red Gum Mountain Gum NL Ironbark Poplar Box Red Stringybark River Oak River Red Gum Rough-barked Apple Unspecified Stag WF Honey Myrtle White Box White Box Stag White Cypress Pine Stag Yellow Box										1	1	10
										1	1	1	10
											2	1	10
											3	3	30
											4	1	13
			2								2	1	10
											7	2	18
										3	3	3	30
											2	2	20
											1	1	10
										1	9	2	23
										2	2	2	20
											40	4	44
											4	2	20
											4	2	20
											2	1	10

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MAULES CREEK COAL PROJECT

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+ = <1%, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100% denotes an exotic species

+ = <1%, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100% denotes an exotic species

MAULES CREEK COAL PROJECT

FINAL DRAFT	HANSEN E	1 DECEMBER
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+ = <1%, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%

SHRUBS

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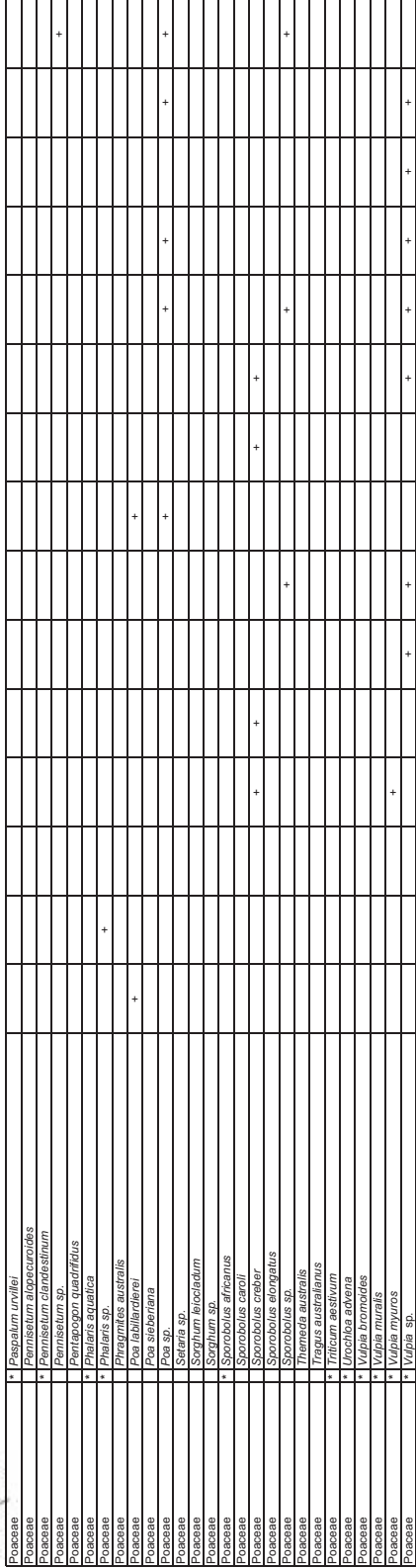
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+ = <1%, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100% denotes an exotic species

$$+ = 1/0, \quad 1 = 1-0/0, \quad z = 0-z/0, \quad y = 20-z/0, \quad x = 0-1/0, \quad v = 10-10/0$$

Appendix D

Planting Lists, Seed Source and Propagation

D.1 Selection of Revegetation Stock

D.1.1 Seed Collection

Currently accepted best practice, as described in Rawlings *et al* (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 (Bonney, 2000; O'Shea, 2001, Purnell *et al*, 1999).

D.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.

D.1.3 Propagation Techniques

Native plants can be propagated by seed, cuttings or division, depending on the species. The following techniques and notes are taken from the Australian National Botanic Gardens (ANPC, 2011). The website provides details of the best time to collect seeds of particular genus and their treatment requirements.

Table D.1 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%. 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

Table D.1 Propagation Techniques for Tubestock

Propagation Method	Advantages	Disadvantage	Collection and Preparation
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.	be used. Plant material should be semi-mature. Shoot tips should be collected in late spring- early summer.
		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.	Cuttings take 4-10 weeks or longer to root, depending on the species
Division	Often used for grass-like clumps and suckering plants.	May be time consuming.	Grassy clumps
	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. Grasses, Dianella, Lomandra, lilies,		Plant split into two or more segments, each with root material, leaf shoots and rhizomes attached.

Optimal propagation times and methods of some native plant genus are provided below (ANPC, 2011).

Table D.2 Optimal Propagation Times and Methods for a Selection of Native Plants

Genus	Propagation Method	Optimal Propagation Time
<i>Acacia</i>	Seed †	Aug-Sept
<i>Allocasuarina</i>	Seed *	Summer and Mar-May
<i>Angophora</i>	Seed	Sept-Nov
<i>Anigozanthos</i>	Division (virus tested stock)	Sept-Nov
	Seed-fresh	Sept-Nov
<i>Araucaria</i>	Cuttings * seed	Dec-Feb
<i>Asplenium</i>	Spores-2-3 weeks after ripening	Mar - May
	Division	
<i>Backhousia</i>	Seed	Sept-Nov
<i>Baeckia</i>	Soft tip cuttings	Dec-April
<i>Banksia</i>	Seed	Sept-Nov
	Soft tip cuttings •	
<i>Bauera</i>	Soft tip cuttings*	Sept-Oct
	Seeds 8 weeks to germinate	
	Layering	
<i>Billardiera</i>	Seed-difficult	Mar-May
	Division	
	Soft tip cuttings	
<i>Blandfordia</i>	Seed	Sept-Nov
<i>Boronia</i>	Soft tip cuttings	Sept-Nov
<i>Brachychiton</i>	Seeds (wear gloves & mask- often hairs surrounding seeds)	Sept-Nov
	Graft onto seedling understock	Sept-Nov
<i>Brachyscome</i>	Seed *	Sept-Nov
	Soft tip cuttings*	any time
	Division *	Mar-May
<i>Brachysema</i>	Seed	Sept-Nov
	Soft tip cuttings *	Mar-Apr
<i>Bracteantha</i>	Seed	all year

Table D.2 Optimal Propagation Times and Methods for a Selection of Native Plants

Genus	Propagation Method	Optimal Propagation Time
	Soft tip cuttings *	
<i>Callistemon</i>	Seed from one-year-old woody fruits	Sept-Nov
	Soft tip cuttings	Dec-Jun
<i>Callitris</i>	Seed-viable for several years	Mar-May
<i>Calothamnus</i>	Seed-place one-year-old or older woody fruits	Sept-Nov
	Soft tip cuttings	
<i>Cassia</i>	Seed †*	Sept-Nov
	Soft tip cuttings	Dec-Mar
<i>Clematis</i>	Seed-fresh	Sept
<i>Correa</i>	Soft tip cuttings *	Jan-Mar
<i>Crowea</i>	Soft tip cuttings	Jan-Mar
<i>Cyathea</i>	Spores-2-3 weeks after ripening	Mar-May
<i>Dampiera</i>	Soft tip cuttings*	Sept-Nov
<i>Darwinia</i>	Seeds cuttings	Sept-Nov
<i>Dendrobium</i>	Division	Mar-May
<i>Dianella</i>	Division	Mar-May
<i>Dicksonia</i>	Spores-2-3 weeks after ripening	Mar-May
<i>Dillwynia</i>	Seed †	
	Soft tip cuttings	Dec-Mar
<i>Dodonaea</i>	Soft tip cuttings	Sept-Nov
		Dec-Mar
<i>Doryanthes</i>	Seed-soak for several hours *	Sept-Nov
<i>Drosera</i>	Division	Mar-May
	Leaf cuttings	Sept-Nov
<i>Dryandra</i>	Seeds	Sept-Nov
<i>Epacris</i>	Seeds	Sept-Nov
	Soft tip cuttings	Dec-Mar
<i>Eremophila</i>	Soft tip cuttings *	Sept-Nov
<i>Eriostemon</i>	Soft tip cuttings *	Mar-May
<i>Eucalyptus</i>	Seed	Sept-Mar
<i>Ficus</i>	Seed-fresh cuttings	varies

Table D.2 Optimal Propagation Times and Methods for a Selection of Native Plants

Genus	Propagation Method	Optimal Propagation Time
<i>Gahnia</i>	Seed	
	Division	Mar-May
<i>Goodenia</i>	Seed	Dec-Feb
	Stem cuttings, stolons	
<i>Grevillea</i>	Soft tip cuttings	Dec-Mar
<i>Hakea</i>	Seed (sun dry woody fruit)	Sept-Nov
	Soft tip cuttings	Dec-Apr
<i>Hardenbergia</i>	Seeds †*	Sept-Nov
	Soft tip cuttings	Mar-Apr
<i>Hibbertia</i>	cuttings	Summer
<i>Hovea</i>	Seed †	Summer
<i>Indigofera</i>	Seed †*	Sept-Oct
<i>Isopogon</i>	Seed	Sept-Nov
	Soft tip cuttings	Feb-Mar
<i>Jasminum</i>	Seed-pre-treatment	.
<i>Kennedia</i>	Seed †*	Sept-Nov
	Soft tip cuttings	Dec-Feb
<i>Kunzea</i>	Soft tip cuttings *	Feb-Apr
<i>Lambertia</i>	Seed	Sept-Nov
	Soft tip cuttings	Feb-Apr
<i>Lechenaultia</i>	Soft tip cuttings	Sept-Nov
<i>Leptospermum</i>	Seeds *	Sept-Nov
	Soft tip cuttings *	May-Jun
<i>Livistonia</i>	Seed	.
<i>Lomandra</i>	Seed	Mar-May
	Division	
<i>Macadamia</i>	Seed-as soon as ripe	.
	(6 months to germinate)	
	Graft	
<i>Macrozamia</i>	Seed	.
<i>Melaleuca</i>	Seed*	Sept-Nov
	Soft tip cuttings *	Sept-Nov

Table D.2 Optimal Propagation Times and Methods for a Selection of Native Plants

Genus	Propagation Method	Optimal Propagation Time
	Soft wood cuttings	Dec-Mar
<i>Melia</i>	Seed (poisonous)	Sept-Nov
	Soft tip cuttings	
<i>Myoporum</i>	Soft tip cuttings *	Sept-Mar
<i>Nothofagus</i>	Seed	.
<i>Olearia</i>	Soft tip cuttings	.
<i>Pandorea</i>	Soft tip cuttings	Sept-Mar
	Seed	
<i>Pepperomia</i>	Leaf cuttings*	all year
<i>Persoonia</i>	Seed (difficult)	Sept-Mar
	Soft tip cuttings	
<i>Phebalium</i>	Soft tip cuttings	.
<i>Pimelea</i>	Soft tip cuttings*	Nov-Dec
<i>Pittosporum</i>	Seed	.
<i>Pomaderris</i>	Seed	.
<i>Prostanthera</i>	Soft tip cuttings	Nov-Dec
<i>Pultaneae</i>	Seed cuttings	Sept-Nov
<i>Quandong</i>	Seed (moist, dark, stratification)	.
<i>Scaevola</i>	Soft tip cuttings	.
<i>Sollya</i>	Seed †	Sept-Nov
	Soft tip cuttings	
<i>Syzygium</i>	Soft tip cuttings	Dec-Mar
<i>Telopea</i>	Seed	Jun-Jul
	Soft tip cuttings	Sept
<i>Thryptomene</i>	Soft tip cuttings	Sept-May
<i>Verticordia</i>	Soft tip cuttings	Sept-Nov
<i>Viola</i>	Division*	all year
<i>Westringia</i>	Soft tip cuttings*	Mar-May
<i>Xanthorrhoea</i>	Seeds	Sept-Nov
<i>Zieria</i>	Soft tip cuttings	Dec-Mar

† Pre-treatment required. Ease of propagation: *easy; # difficult

D.2 Recommended Species for Planting

The following species list 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 D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
Climber	Pittosporaceae	<i>Billardiera scandens</i>	Appleberry, Snotberry, Apple Dumplings
	Ranunculaceae	<i>Clematis microphylla</i>	Small-leaved Clematis
Dominant tree	Myrtaceae	<i>Eucalyptus albens</i>	White Box
Dominant tree	Myrtaceae	<i>Eucalyptus blakelyi</i>	Blakely's Red Gum
Dominant tree	Myrtaceae	<i>Eucalyptus melliodora</i>	Yellow Box, Yellow Jacket, Honey Box (Qld), Yellow Ironbark (Qld)
Dominant tree (in Nandewar)	Myrtaceae	<i>Eucalyptus microcarpa</i>	Grey Box, Narrow-leaved Box, Inland Grey Box, Western Grey Box
Dominant tree (in Nandewar)	Myrtaceae	<i>Eucalyptus moluccana</i>	Grey Box, Gum-topped Box
Fern	Aspleniaceae	<i>Asplenium flabellifolium</i>	Necklace Fern
	Ophioglossaceae	<i>Botrychium australe</i>	Parsley Fern
	Adiantaceae	<i>Cheilanthes austrotenuifolia</i>	Rock-fern
	Adiantaceae	<i>Cheilanthes distans</i>	Bristly Cloak Fern
	Adiantaceae	<i>Cheilanthes sieberi</i>	Narrow Rock Fern
	Dennstaedtiaceae	<i>Pteridium esculentum</i>	Common Bracken, Gurgi (Cadigal), Austral Bracken, Bracken
Grass	Poaceae	<i>Aristida behriana</i>	Brush Wiregrass, Bunch Wiregrass
	Poaceae	<i>Aristida calycina</i>	Dark Wire-grass, Branched Wiregrass
	Poaceae	<i>Aristida ramosa</i>	Purple Wiregrass, Kerosene Grass, Prickly Threeawn
	Poaceae	<i>Austrodanthonia auriculata</i>	Lobed Wallaby-grass
	Poaceae	<i>Austrodanthonia bipartita</i>	Bandicoot Grass, Wallaby Grass,

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
			Leafy Wallaby Grass
	Poaceae	<i>Austrodanthonia caespitosa</i>	Ringed Wallaby-grass, Common Wallaby-grass
	Poaceae	<i>Austrodanthonia carphoides</i>	Short Wallaby-grass
	Poaceae	<i>Austrodanthonia eriantha</i>	Hill Wallaby-grass
	Poaceae	<i>Austrodanthonia laevis</i>	Wallaby Grass
	Poaceae	<i>Austrodanthonia monticola</i>	Small-flower Wallaby Grass
	Poaceae	<i>Austrodanthonia pilosa</i>	Velvet Wallaby Grass, Smooth-flowered Wallaby-grass
	Poaceae	<i>Austrodanthonia racemosa</i>	Clustered Wallaby-grass, Slender Wallaby Grass
	Poaceae	<i>Austrodanthonia setacea</i>	Bristly Wallaby Grass
	Poaceae	<i>Austrofestuca eriopoda</i>	Snow Fescue
	Poaceae	<i>Austrostipa bigeniculata</i>	Tall Speargrass
	Poaceae	<i>Austrostipa blackii</i>	Crested Spear-grass
	Poaceae	<i>Austrostipa densiflora</i>	Dense Spear-grass
	Poaceae	<i>Austrostipa nodosa</i>	Knotty Speargrass
	Poaceae	<i>Austrostipa rudis</i>	Veined Speargrass
	Poaceae	<i>Austrostipa scabra</i>	Corkscrew, Corkscrew Speargrass, Rough Spear-grass, Rough Needle-grass, Speargrass
	Poaceae	<i>Bothriochloa macra</i>	Redgrass, Redleg Grass
	Poaceae	<i>Chloris truncata</i>	Windmill Grass
	Poaceae	<i>Chloris ventricosa</i>	Tall Windmill Grass
	Poaceae	<i>Cymbopogon refractus</i>	Barbed Wire Grass
	Poaceae	<i>Deyeuxia quadriseta</i>	Reed Bent-grass
	Poaceae	<i>Dichanthium sericeum</i>	Queensland Blue-grass
	Poaceae	<i>Dichelachne crinita</i>	Longhair Plumegrass
	Poaceae	<i>Dichelachne hirtella</i>	Slender Plumegrass
	Poaceae	<i>Dichelachne inaequiglumis</i>	Plume Grass
	Poaceae	<i>Dichelachne micrantha</i>	Short-hair Plumegrass
	Poaceae	<i>Dichelachne parva</i>	Plume Grass
	Poaceae	<i>Dichelachne rara</i>	Plume Grass
	Poaceae	<i>Echinopogon caespitosus</i>	Tufted Hedgehog-grass
	Poaceae	<i>Echinopogon cheelii</i>	Long-flowered Hedgehog Grass

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Poaceae	<i>Echinopogon ovatus</i>	Forest Hedgehog-grass, Hedgehog Grass, Rough-bearded Grass
	Poaceae	<i>Elymus scaber</i>	Common Wheat-grass, Wheatgrass, Rough Wheatgrass
	Poaceae	<i>Enneapogon nigricans</i>	Black-head Grass
	Poaceae	<i>Glyceria australis</i>	Australian Sweetgrass
	Poaceae	<i>Imperata cylindrica</i>	Blady Grass
	Poaceae	<i>Joycea pallida</i>	Silvertop Wallaby Grass, Redanther Wallaby Grass
	Poaceae	<i>Microlaena stipoides</i>	Microlaena, Weeping Grass
	Poaceae	<i>Panicum effusum</i>	Hairy Panic, Poison Panic
	Poaceae	<i>Poa labillardierei</i>	Tussock Grass
	Poaceae	<i>Poa meionectes</i>	Fine-leaved Snow Grass, Fine- leaved Tussock-grass
	Poaceae	<i>Poa petrophila</i>	Rock Tussock-grass
	Poaceae	<i>Poa sieberiana</i>	Snow Grass, Fine-leaved Tussock-grass
	Poaceae	<i>Rytidosperma nudiflorum</i>	Alpine Wallby Grass
	Poaceae	<i>Sorghum leiocladum</i>	Wild Sorghum
	Poaceae	<i>Sporobolus creber</i>	Western Rat-tail Grass, Slender Rat's Tail Grass
	Poaceae	<i>Sporobolus elongatus</i>	Slender Rat's-tail Grass
	Poaceae	<i>Themeda australis</i> (syn. <i>Themeda triandra</i>)	Kangaroo Grass
	Poaceae	<i>Themeda triandra</i> (syn. <i>Themeda australis</i>)	Kangaroo Grass
	Poaceae	<i>Tripogon loliiformis</i>	Fiveminute Grass
Grass Tree	Xanthorrhoeaceae	<i>Xanthorrhoea australis</i>	Grass Tree
Herb	Rosaceae	<i>Acaena agnipila</i>	Sheep's Burr, Bidgee-widgee
	Rosaceae	<i>Acaena echinata</i>	Sheep's Burr
	Rosaceae	<i>Acaena novae-zelandiae</i>	Bidgee-widgee, Biddy Biddy
	Rosaceae	<i>Acaena ovina</i>	Sheep's Burr, Bidgee-widgee
	Lamiaceae	<i>Ajuga australis</i>	Australian Bugle, Austral Bugle
	Amaranthaceae	<i>Alternanthera nana</i>	Hairy Joyweed, Downy Pigweed

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Asteraceae	<i>Ammobium alatum</i>	Tall Ammobium
	Asteraceae	<i>Ammobium craspedioides</i>	Yass Daisy
	Rosaceae	<i>Aphanes australiana</i>	Australian Piert
	Orchidaceae	<i>Arachnorchis spp.</i>	Spider Orchids
	Anthericaceae	<i>Arthropodium milleflorum</i>	Vanilla-lily, Pale Vanilla-lily
	Anthericaceae	<i>Arthropodium minus</i>	Small Vanilla Lily
	Rubiaceae	<i>Asperula conferta</i>	Common Woodruff
	Rubiaceae	<i>Asperula scoparia</i>	Prickly Woodruff
	Asteraceae	<i>Brachyscome aculeata</i>	Hill Daisy
	Asteraceae	<i>Brachyscome decipiens</i>	Field Daisy
	Asteraceae	<i>Brachyscome diversifolia</i>	Large-headed Daisy
	Asteraceae	<i>Brachyscome graminea</i>	Grass Dairy
	Asteraceae	<i>Brachyscome heterodonta</i>	Lobe-seed Daisy
	Asteraceae	<i>Brachyscome multifida</i>	Cut-leaved Daisy
	Asteraceae	<i>Brachyscome rigidula</i>	Leafy Daisy
	Asteraceae	<i>Brachyscome scapigera</i>	Tufted Daisy
	Asteraceae	<i>Brachyscome spathulata</i>	Spoon Daisy
	Brunoniaceae	<i>Brunonia australis</i>	Pincushion, Blue Pincushion
	Acanthaceae	<i>Brunoniella australis</i>	Blue Trumpet
	Asphodelaceae	<i>Bulbine bulbosa</i>	Bulbine Lily, Native Onion, Native Leek, Golden Lily
	Asphodelaceae	<i>Bulbine glauca</i>	Rock Lily
	Colchicaceae	<i>Burchardia umbellata</i>	Milkmaids
	Anthericaceae	<i>Caesia calliantha</i>	Blue Grass-Lily
	Asteraceae	<i>Calocephalus citreus</i>	Lemon Beautyheads
	Orchidaceae	<i>Calochilus robertsonii</i>	Purplish Beard Orchid
	Asteraceae	<i>Calotis cuneifolia</i>	Purple Burr-daisy
	Asteraceae	<i>Calotis glandulosa</i>	Mauve Burr-daisy
	Asteraceae	<i>Calotis lappulacea</i>	Yellow Burr-daisy, Yellow Daisy-burr
	Asteraceae	<i>Calotis scabiosifolia</i>	Rough Burr-daisy
	Cyperaceae	<i>Carex inversa</i>	Knob Sedge, Common Sedge
	Apiaceae	<i>Centella asiatica</i>	Pennywort
	Apiaceae	<i>Centella cordifolia</i>	Centella

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Centrolepidaceae	<i>Centrolepis strigosa</i>	Hairy Centrolepis
	Euphorbiaceae	<i>Chamaesyce drummondii</i>	Caustic-weed
	Chenopodiaceae	<i>Chenopodium pumilio</i>	Clammy Goosefoot, Small Crumbweed
	Asteraceae	<i>Chrysocephalum apiculatum</i>	Yellow Buttons, Common Everlasting
	Asteraceae	<i>Chrysocephalum semipapposum</i>	Clustered Everlasting, Yellow Buttons
	Convolvulaceae	<i>Convolvulus erubescens</i>	Australian Bindweed, Blushing Bindweed
	Rutaceae	<i>Correa reflexa</i>	Common Correa, Native Fuchsia
	Asteraceae	<i>Cotula australis</i>	Common Cotula, Carrot Weed
	Asteraceae	<i>Craspedia canens</i>	Billy Buttons, Grey Billybuttons
	Asteraceae	<i>Craspedia variabilis</i>	Billy Buttons
	Crassulaceae	<i>Crassula colorata</i>	Annual Stonecrop, Dense Crassula, Dense Stonecrop
	Crassulaceae	<i>Crassula helmsii</i>	Swamp Stonecrop
	Crassulaceae	<i>Crassula sieberiana</i>	Australian Stonecrop, Sieber Crassula
	Fabaceae	<i>Cullen microcephalum</i>	Dusky Scurf-pea, Mountain Psoralea
	Fabaceae	<i>Cullen tenax</i>	Emu-foot, Emu Grass, Tough Scurf-pea
	Asteraceae	<i>Cymbonotus lawsonianus</i>	Bear's Ear, Austral Bears-ears, Bears-ears
	Asteraceae	<i>Cymbonotus preissianus</i>	Austral Bear's Ear
	Boraginaceae	<i>Cynoglossum australe</i>	Australian Forget-me-not, Australian Hound's-tongue
	Boraginaceae	<i>Cynoglossum suaveolens</i>	Sweet Hound's-tongue
	Apiaceae	<i>Daucus glochidiatus</i>	Australian Carrot, Native Carrot, Austral Carrot
	Fabaceae	<i>Desmodium brachypodium</i>	Large Tick-trefoil
	Fabaceae	<i>Desmodium varians</i>	Slender Tick-trefoil
	Phormiaceae	<i>Dianella longifolia</i>	Smooth Flax Lily
	Phormiaceae	<i>Dianella revoluta</i>	Blueberry Lily, Black-Anther Flax Lilly, Spreading Flax Lily

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Convolvulaceae	<i>Dichondra repens</i>	Kidney Grass, Kidney Weed
	Anthericaceae	<i>Dichopogon fimbriatus</i>	Chocolate Lily, Nodding Chocolate Lily
	Anthericaceae	<i>Dichopogon strictus</i>	Chocolate Lily
	Orchidaceae	<i>Dipodium punctatum</i>	Hyacinth Orchid, Pink Hyacinth Orchid
	Orchidaceae	<i>Diuris aequalis</i>	Buttercup Doubletail
	Orchidaceae	<i>Diuris behrii</i>	Golden Cowslips
	Orchidaceae	<i>Diuris chryseopsis</i>	Common Golden Moths
	Orchidaceae	<i>Diuris dendrobioides</i>	Long-tail Purple Diuris, Wedge Diuris
	Orchidaceae	<i>Diuris maculata</i>	Leopard Orchid, Nanny Goats, Leopard Diuris, Spotted Doubletail
	Orchidaceae	<i>Diuris monticola</i>	Highland Golden Moths
	Orchidaceae	<i>Diuris ochroma</i>	Pale Golden Moths
	Orchidaceae	<i>Diuris pedunculata</i>	Small Snake Orchid, Two-leaved Golden Moths, Golden Moths, Cowslip Orchid, Snake Orchid
	Orchidaceae	<i>Diuris punctata</i>	Purple Donkey-orchid, Purple Double-tails, Purple Diuris, Purple Cowslip, Dotted Double-tails
	Orchidaceae	<i>Diuris semilunulata</i>	Donkey-ears
	Orchidaceae	<i>Diuris sulphurea</i>	Tiger Orchid, Hornet Orchid
	Droseraceae	<i>Drosera peltata</i>	Hairy Climbing Sundew, Pale Sundew
	Droseraceae	<i>Drosera pygmaea</i>	Pigmy Sundew, Tiny Sundew
	Chenopodiaceae	<i>Einadia nutans</i>	Climbing Saltbush, Nodding Saltbush
	Orchidaceae	<i>Eriochilus cucullatus</i>	Parson's Bands
	Geraniaceae	<i>Erodium crinitum</i>	Native Crowfoot, Blue Storks-bill, Blue Crowfoot, Blue Herons-bill
	Apiaceae	<i>Eryngium ovinum</i>	Blue Devil
	Apiaceae	<i>Eryngium rostratum</i>	Blue Devil
	Apiaceae	<i>Eryngium vesiculosum</i>	Prostrate Blue Devil, Prickfoot
	Asteraceae	<i>Euchiton gymnocephalus</i>	Creeping Cudweed
	Asteraceae	<i>Euchiton involucratus</i>	Star Cudweed

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Asteraceae	<i>Euchiton sphaericus</i>	Annual Cudweed, Star Cudweed
	Scrophulariaceae	<i>Euphrasia collina</i>	Eyebright
	Rubiaceae	<i>Galium gaudichaudii</i>	Rough Bedstraw
	Orchidaceae	<i>Gastrodia sesamoides</i>	Cinnamon Bells, Potato Orchid
	Orchidaceae	<i>Genoplesium</i>	Midge Orchids
	Geraniaceae	<i>Geranium antrorsum</i>	Antrorse Geranium
	Geraniaceae	<i>Geranium graniticola</i>	Granite Cranesbill
	Geraniaceae	<i>Geranium neglectum</i>	Swamp Cranes-bill
	Geraniaceae	<i>Geranium retrorsum</i>	Common Cranes-bill
	Geraniaceae	<i>Geranium solanderi</i>	Native Geranium
	Orchidaceae	<i>Glossodia major</i>	Wax-lip Orchid, Parson-in-the-pulpit
	Fabaceae	<i>Glycine clandestina</i>	Twining Glycine
	Fabaceae	<i>Glycine tabacina</i>	Glycine Pea, Variable Glycine
	Haloragaceae	<i>Gonocarpus elatus</i>	Hill Raspwort
	Haloragaceae	<i>Gonocarpus tetragynus</i>	Common Raspwort
	Goodeniaceae	<i>Goodenia bellidifolia</i>	Daisy-leaved Goodenia, Rocket Goodenia
	Goodeniaceae	<i>Goodenia hederacea</i>	Forest Goodenia, Ivy Goodenia
	Goodeniaceae	<i>Goodenia humilis</i>	Swamp Goodenia
	Goodeniaceae	<i>Goodenia pinnatifida</i>	Scrambled Eggs, Cut-leaf Goodenia
	Goodeniaceae	<i>Goodenia stelligera</i>	Spiked Goodenia
	Scrophulariaceae	<i>Gratiola nana</i>	Creeping Brooklime
	Scrophulariaceae	<i>Gratiola pedunculata</i>	Brooklime
	Scrophulariaceae	<i>Gratiola peruviana</i>	Austral Brooklime
	Caryophyllaceae	<i>Gypsophila tubulosa</i>	Annual Chalkwort
	Asteraceae	<i>Helichrysum collinum</i>	Hill Daisy
	Asteraceae	<i>Helichrysum scorpioides</i>	Button Everlasting
	Apiaceae	<i>Hydrocotyle laxiflora</i>	Stinking Pennywort
	Orchidaceae	<i>Hymenochilus bicolor</i>	Bicolor Greenhood
	Orchidaceae	<i>Hymenochilus cynnocephalus</i>	Swan Greenhood
	Orchidaceae	<i>Hymenochilus muticus</i>	Midget Greenhood, Blunt Greenhood, Dwarf Greenhood

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Clusiaceae	<i>Hypericum gramineum</i>	Small St John's Wort
	Clusiaceae	<i>Hypericum japonicum</i>	Small St John's Wort, Matted St John's Wort
	Asteraceae	<i>Isoetopsis graminifolia</i>	Grass Cushion
	Lobeliaceae	<i>Isotoma axillaris</i>	Rock Isotome
	Fabaceae	<i>Kennedia prostrata</i>	Running Postman, Scarlet Running Pea, Scarlet Coral-pea
	Asteraceae	<i>Lagenophora stipitata</i>	Blue-bottle Daisy, Common Lagenophora
	Anthericaceae	<i>Laxmannia gracilis</i>	Slender Wire-Lily
	Asteraceae	<i>Leptorhynchus elongatus</i>	Lanky Buttons, Hairy Buttons
	Asteraceae	<i>Leptorhynchus squamatus</i>	Scaly Buttons
	Asteraceae	<i>Leucochrysum albicans</i>	Hoary Sunray
	Scrophulariaceae	<i>Limosella australis</i>	Australian Mudwort
	Linaceae	<i>Linum marginale</i>	Wild Flax, Native Flax
	Lobeliaceae	<i>Lobelia dentata</i>	Toothed Lobelia, Wavy Lobelia
	Lobeliaceae	<i>Lobelia gibbosa</i>	Tall Lobelia
	Lomandraceae	<i>Lomandra bracteata</i>	Mat-rush
	Lomandraceae	<i>Lomandra filiformis</i>	Wattle Mat-rush
	Lomandraceae	<i>Lomandra longifolia</i>	Spiny-headed Mat-rush, Honey Weed
	Lomandraceae	<i>Lomandra multiflora</i>	Many-flowered Matrush
	Fabaceae	<i>Lotus australis</i>	Austral Trefoil, Australian Trefoil
	Lythraceae	<i>Lythrum salicaria</i>	Purple Loosestrife
	Lamiaceae	<i>Mentha diemenica</i>	Slender Mint
	Lamiaceae	<i>Mentha satureioides</i>	Creeping Mint, Native Pennyroyal
	Asteraceae	<i>Microseris lanceolata</i>	Yam Daisy, Murnong
	Orchidaceae	<i>Microtis parviflora</i>	Slender Onion-orchid
	Orchidaceae	<i>Microtis unifolia</i>	Common Onion-orchid, Onion-orchid
	Scrophulariaceae	<i>Mimulus repens</i>	Creeping Monkey-flower
	Rubiaceae	<i>Opercularia diphylla</i>	Stinkweed
	Rubiaceae	<i>Opercularia hispida</i>	Hairy Stinkweed
	Ophioglossaceae	<i>Ophioglossum lusitanicum</i>	Adder's Tongue

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Apiaceae	<i>Oreomyrrhis argentea</i>	Silvery Carraway
	Apiaceae	<i>Oreomyrrhis eriopoda</i>	Australian Carraway
	Oxalidaceae	<i>Oxalis exilis</i>	Shady Wood Sorrel, Indian Sorrel
	Oxalidaceae	<i>Oxalis perennans</i>	Grassland Wood Sorrel, Grass Wood-sorrel, Creeping Yellow Sorrel
	Iridaceae	<i>Patersonia sericea</i>	Silky Purple-flag
	Geraniaceae	<i>Pelargonium australe</i>	Native Storks-bill, Austral Storks-bill, Wild Geranium
	Geraniaceae	<i>Pelargonium inodorum</i>	Scentless Storks-bill
	Geraniaceae	<i>Pelargonium rodneyanum</i>	Magenta Storks-bill
	Plantaginaceae	<i>Plantago debilis</i>	Shade Plantain, Slender Plantain
	Plantaginaceae	<i>Plantago euryphylla</i>	Plantain
	Plantaginaceae	<i>Plantago gaudichaudii</i>	Narrow-leaf Native Plantain, Narrow Plantain
	Plantaginaceae	<i>Plantago varia</i>	Variable Plantain, Small Plantain, Sago-weed
	Asteraceae	<i>Podolepis hieracioides</i>	Tall Copper-wire Daisy
	Asteraceae	<i>Podolepis jaceoides</i>	Showy Copper-wire Daisy
	Polygalaceae	<i>Polygala japonica</i>	Dwarf Milkwort
	Euphorbiaceae	<i>Poranthera microphylla</i>	Small Poranthera, Small-leaved Poranthera
	Portulacaceae	<i>Portulaca oleracea</i>	Common Pigweed, Common Purslane, Munyeroo
	Orchidaceae	<i>Prasophyllum petilum</i>	Tarengo Leek Orchid
	Lobeliaceae	<i>Pratia purpurascens</i>	Whiteroot
	Asteraceae	<i>Pseudognaphalium luteoalbum</i>	Jersey Cudweed
	Amaranthaceae	<i>Ptilotus erubescens</i>	Hairy Tails, Hairy Heads
	Ranunculaceae	<i>Ranunculus graniticola</i>	Granite Buttercup
	Ranunculaceae	<i>Ranunculus lappaceus</i>	Common Buttercup, Australian Buttercup
	Ranunculaceae	<i>Ranunculus pachycarpus</i>	Thick-fruited Buttercup
	Asteraceae	<i>Rhodanthe anthemoides</i>	White Sunray, Chamomile Sunray
	Asteraceae	<i>Rhodanthe pygmaea</i>	Pigmy Sunray
	Acanthaceae	<i>Rostellularia adscendens</i>	Pink-tongues, Bearded Anthem,

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
			Dwarf Justicia
	Polygonaceae	<i>Rumex brownii</i>	Swamp Dock, Slender Dock
	Polygonaceae	<i>Rumex dumosus</i>	Wiry Dock
	Polygonaceae	<i>Rumex tenax</i>	Shiny Dock
	Asteraceae	<i>Rutidosis leiolepis</i>	Monaro Golden Daisy
	Asteraceae	<i>Rutidosis leptorhynchoides</i>	Button Wrinklewort
	Asteraceae	<i>Rutidosis multiflora</i>	Small Wrinklewort
	Caryophyllaceae	<i>Scleranthus biflorus</i>	Spiny Mat-plant, Knawel, Cushion-bush, Two-flowered Knawel
	Caryophyllaceae	<i>Scleranthus diander</i>	Tufted Knawel
	Lamiaceae	<i>Scutellaria humilis</i>	Dwarf Skullcap
	Gentianaceae	<i>Sebaea ovata</i>	Yellow Centaury
	Goodeniaceae	<i>Selliera radicans</i>	Swamp Weed
	Asteraceae	<i>Senecio hispidulus</i>	Hill Fireweed
	Asteraceae	<i>Senecio quadridentatus</i>	Cotton Fireweed
	Asteraceae	<i>Senecio tenuiflorus</i>	Woodland Groundsel, Narrow Groundsel, Cotton Groundsel, Slender Fireweed
	Malvaceae	<i>Sida corrugata</i>	Corrugated Sida
	Asteraceae	<i>Solenogyne dominii</i>	Smooth Solenogyne
	Asteraceae	<i>Solenogyne gunnii</i>	Hairy Solenogyne
	Orchidaceae	<i>Spiranthes sinensis</i>	Austral Ladies' Tresses
	Stackhousiaceae	<i>Stackhousia monogyna</i>	Creamy Candles, Creamy Stackhousia
	Stackhousiaceae	<i>Stackhousia viminea</i>	Slender Stackhousia
	Caryophyllaceae	<i>Stellaria angustifolia</i>	Swamp Starwort
	Caryophyllaceae	<i>Stellaria filiformis</i>	Thread Starwort
	Caryophyllaceae	<i>Stellaria multiflora (Back Creek)</i>	Back Creek Many Flowered Starwort, Back Creek Rayless Starwort
	Caryophyllaceae	<i>Stellaria pungens</i>	Prickly Starwort
	Asteraceae	<i>Stuartina hamata</i>	Crooked Cudweed, Hooked Cudweed
	Asteraceae	<i>Stuartina muelleri</i>	Spoon Cudweed
	Stylidiaceae	<i>Stylidium despectum</i>	Dwarf Triggerplant

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Stylidiaceae	<i>Stylidium graminifolium</i>	Grass Triggerplant
	Phormiaceae	<i>Stypandra glauca</i>	Nodding Blue Lily
	Fabaceae	<i>Swainsona behriana</i>	Behr's Swainson-pea
	Fabaceae	<i>Swainsona monticola</i>	Mountain Swainson-pea
	Fabaceae	<i>Swainsona oroboides</i>	Variable Swainson-pea
	Fabaceae	<i>Swainsona queenslandica</i>	Smooth Darling Pea
	Fabaceae	<i>Swainsona recta</i>	Mountain Swainson-pea, Small Purple-pea
	Fabaceae	<i>Swainsona reticulata</i>	Kneed Swainson-pea
	Fabaceae	<i>Swainsona sericea</i>	Silky Swainson-pea
	Tremandraceae	<i>Tetradlea spp.</i>	Black-eyed Susans
	Orchidaceae	<i>Thelymitra ixioides</i>	Spotted Sun-orchid, Dotted Sun-orchid
	Orchidaceae	<i>Thelymitra malvina</i>	Mauve-tuft Sun-orchid, Mauve-tufted sun orchid
	Orchidaceae	<i>Thelymitra pauciflora</i>	Slender Sun-orchid, Few-flowered Sun-orchid
	Orchidaceae	<i>Thelymitra rubra</i>	Pink Sun-orchid, Salmon Sun-orchid, Red Sun-orchid
	Santalaceae	<i>Thesium australe</i>	Austral toadflax, Austral Toad-flax, Australian Toadflax
	Anthericaceae	<i>Thysanotus patersonii</i>	Twining Fringe-lily
	Anthericaceae	<i>Thysanotus tuberosus</i>	Common Fringe-lily
	Apiaceae	<i>Trachymene humilis</i>	Alpine Trachymene
	Anthericaceae	<i>Tricoryne elatior</i>	Yellow Rush-lily, Yellow Autumn-lily
	Asteraceae	<i>Triptilodiscus pygmaeus</i>	Austral Sunray
	Urticaceae	<i>Urtica incisa</i>	Stinging Nettle
	Goodeniaceae	<i>Velleia montana</i>	Velleia
	Goodeniaceae	<i>Velleia paradoxa</i>	Spur Velleia
	Scrophulariaceae	<i>Veronica calycina</i>	Hairy Speedwell
	Scrophulariaceae	<i>Veronica gracilis</i>	Slender Speedwell
	Scrophulariaceae	<i>Veronica plebeia</i>	Trailing Speedwell, Creeping Speedwell
	Violaceae	<i>Viola betonicifolia</i>	Showy Violet, Arrow-head Violet,

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
			Native Violet, Purple Violet
	Violaceae	<i>Viola caleyana</i>	Swamp Violet
	Violaceae	<i>Viola hederacea</i>	Native Violet, Ivy-leaf Violet, Ivy-leaved Violet
	Violaceae	<i>Viola sieberiana</i>	Diamond Violet
	Asteraceae	<i>Vittadinia cuneata</i>	Fuzzweed
	Asteraceae	<i>Vittadinia muelleri</i>	Narrow-leaf New Holland Daisy
	Campanulaceae	<i>Wahlenbergia ceracea</i>	Waxy Bluebell
	Campanulaceae	<i>Wahlenbergia communis</i>	Tufted Bluebell
	Campanulaceae	<i>Wahlenbergia densifolia</i>	Fairy Bluebell
	Campanulaceae	<i>Wahlenbergia gracilentia</i>	Annual Bluebell
	Campanulaceae	<i>Wahlenbergia gracilis</i>	Australian Bluebell, Sprawling Bluebell
	Campanulaceae	<i>Wahlenbergia graniticola</i>	Granite Bluebell
	Campanulaceae	<i>Wahlenbergia littoricola</i>	Edge Bluebell, Coast Bluebell
	Campanulaceae	<i>Wahlenbergia luteola</i>	Yellow-wash Bluebell
	Campanulaceae	<i>Wahlenbergia multicaulis</i>	Tadgell's Bluebell
	Campanulaceae	<i>Wahlenbergia planiflora</i>	Bluebell
	Campanulaceae	<i>Wahlenbergia stricta</i>	Tall Bluebell, Austral Bluebell, Australian Bluebell
	Colchicaceae	<i>Wurmbea dioica</i>	Early Nancy
	Asteraceae	<i>Xerochrysum bracteatum</i>	Golden Everlasting
	Asteraceae	<i>Xerochrysum subundulatum</i>	Orange Everlasting, Alpine Everlasting
	Asteraceae	<i>Xerochrysum viscosum</i>	Sticky Everlasting
	Fabaceae	<i>Zornia dyctiocarpa</i>	Zornia
Herb/Shrub	Scrophulariaceae	<i>Derwentia perfoliata</i>	Digger's Speedwell
Sedge/Rush	Cyperaceae	<i>Isolepis cernua</i>	Nodding Club-rush
	Cyperaceae	<i>Isolepis hookeriana</i>	Grassy Club-sedge, Grassy Club-rush
	Cyperaceae	<i>Isolepis inundata</i>	Swamp Club-sedge, Swamp Club-rush
	Juncaceae	<i>Juncus australis</i>	Austral Rush
	Juncaceae	<i>Juncus bufonius</i>	Toad Rush
	Juncaceae	<i>Juncus flavidus</i>	Yellow Rush

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Juncaceae	<i>Juncus fockei</i>	Slender Joint-leaf Rush
	Juncaceae	<i>Juncus homalocaulis</i>	Wiry Rush
	Juncaceae	<i>Juncus sarophorus</i>	Broom Rush
	Juncaceae	<i>Juncus subsecundus</i>	Finger Rush
	Cyperaceae	<i>Lepidosperma laterale</i>	Sword Sedge, Variable Swordsedge
	Juncaceae	<i>Luzula densiflora</i>	Dense Woodrush
	Juncaceae	<i>Luzula meridionalis</i>	Common Woodrush
	Juncaceae	<i>Luzula modesta</i>	Southern Woodrush
	Juncaceae	<i>Luzula ovata</i>	Clustered Woodrush
	Cyperaceae	<i>Schoenus apogon</i>	Common Bog Sedge, Fluke Bogrush
	Mimosaceae	<i>Acacia brownii</i>	Prickly Moses, Golden Prickly Wattle, Heath Wattle
	Mimosaceae	<i>Acacia dawsonii</i>	Poverty Wattle, Dawson's Wattle, Mitta Wattle
	Mimosaceae	<i>Acacia decora</i>	Western Silver Wattle, Showy Wattle, Western Golden Wattle, Pretty Wattle
	Mimosaceae	<i>Acacia falcata</i>	Sickle Wattle, Burra, Sickle- shaped Acacia, Sally, Hickory Wattle, Silver-leaved Wattle
	Mimosaceae	<i>Acacia genistifolia</i>	Spreading Wattle, Early Wattle, Wild Irishman
Shrub	Mimosaceae	<i>Acacia gunnii</i>	Ploughshare Wattle, Dog's Tooth Wattle
	Mimosaceae	<i>Acacia paradoxa</i>	Prickly Acacia, Acacia Hedge, Kangaroo Thorn, Hedge Wattle, Kangaroo Acacia, Prickly Wattle, Paradoxa Wattle
	Mimosaceae	<i>Acacia siculiformis</i>	Dagger Wattle
	Mimosaceae	<i>Acacia ulicifolia</i>	Prickly Moses, Juniper Wattle
	Epacridaceae	<i>Acrotriche serrulata</i>	Honeypots
	Epacridaceae	<i>Astroloma humifusum</i>	Native Cranberry, Cranberry Heath
	Araliaceae	<i>Astrotricha ledifolia</i>	Common Star-hair

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Rutaceae	<i>Boronia alida</i>	Alpine Boronia
	Fabaceae	<i>Bossiaea buxifolia</i>	Box-leaved Bitter-pea
	Fabaceae	<i>Bossiaea prostrata</i>	Creeping Bossiaea, Prostrate Bitter-pea
	Fabaceae	<i>Bossiaea riparia</i>	River Leafless Bossiaea
	Epacridaceae	<i>Brachyloma daphnoides</i>	Daphne Heath
	Myrtaceae	<i>Calytrix tetragona</i>	Fringe Myrtle, Common Fringe-myrtle, Heath Myrtle
	Asteraceae	<i>Cassinia aculeata</i>	Common Cassinia, Chinese-scrub, Sifton Bush, Dogwood, Dolly Bush
	Asteraceae	<i>Cassinia arcuata</i>	Drooping Cassinia, Chinese Tea-scrub, Sifton Bush, Chinese Shrub
	Asteraceae	<i>Cassinia longifolia</i>	Shiny Cassinia, Cauliflower Bush, Long-leaf Dogwood
	Asteraceae	<i>Cassinia quinquefaria</i>	Rosemary Cassinia
	Pittosporaceae	<i>Cheiranthra cyanea</i>	Finger Flower
	Polygalaceae	<i>Comesperma ericinum</i>	Heath Milkwort, Heath-leaved False-pea, Pyramid Flower
	Rhamnaceae	<i>Cryptandra amara</i>	Bitter Cryptandra
	Fabaceae	<i>Daviesia genistifolia</i>	Spiny Bitter-pea, Broom Bitter-pea
	Fabaceae	<i>Daviesia latifolia</i>	Hop Bitter-pea
	Fabaceae	<i>Daviesia leptophylla</i>	Narrow-leaf Bitter-pea
	Fabaceae	<i>Daviesia mimosoides</i>	Narrow-leaf Bitter-pea
	Fabaceae	<i>Daviesia ulicifolia</i>	Gorse Bitter-pea
	Fabaceae	<i>Dillwynia cinerascens</i>	Grey Parrot-pea
	Fabaceae	<i>Dillwynia glaucula</i>	Michelago Parrot-pea
	Fabaceae	<i>Dillwynia prostrata</i>	Matted Parrot-pea
	Fabaceae	<i>Dillwynia retorta</i>	Heathy Parrot-pea
	Fabaceae	<i>Dillwynia sericea</i>	Showy Parrot-pea
	Rhamnaceae	<i>Discaria pubescens</i>	Australian Anchor-plant
	Sapindaceae	<i>Dodonaea procumbens</i>	Trailing Hop-bush
	Sapindaceae	<i>Dodonaea viscosa</i>	Sticky Hop-bush, Giant Hop-bush
	Chenopodiaceae	<i>Einadia hastata</i>	Saloop, Berry Saltbush
	Epacridaceae	<i>Epacris spp.</i>	Native Heaths

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Myoporaceae	<i>Eremophila debilis</i>	Winter Apple, Creeping Boobialla, Amulla
	Santalaceae	<i>Exocarpos strictus</i>	Pale Ballart, Pale-fruit Ballart, Dwarf Cherry
	Fabaceae	<i>Gompholobium huegelii</i>	Pale Wedge-pea
	Proteaceae	<i>Grevillea iaspicula</i>	Wee Jasper Grevillea
	Proteaceae	<i>Grevillea lanigera</i>	Woolly Grevillea
	Proteaceae	<i>Grevillea ramosissima</i>	Fan Grevillea, Branching Grevillea, Prickly Parsley Bush
	Proteaceae	<i>Grevillea rosmarinifolia</i>	Rosemary Grevillea
	Proteaceae	<i>Grevillea wilkinsonii</i>	Tumut Grevillea
	Proteaceae	<i>Hakea microcarpa</i>	Small-fruit Hakea, Small-fruited Needlebush
	Fabaceae	<i>Hardenbergia violacea</i>	False Sarsparilla, Purple Coral-pea, Native Lilac
	Dilleniaceae	<i>Hibbertia calycina</i>	Lesser Guinea-flower
	Dilleniaceae	<i>Hibbertia obtusifolia</i>	Hoary Guinea-flower
	Dilleniaceae	<i>Hibbertia riparia</i>	Stream Guinea-flower, Erect Guinea-flower
	Fabaceae	<i>Hovea linearis</i>	Creeping Hovea
	Violaceae	<i>Hymenanthera dentata</i>	Tree Violet
	Fabaceae	<i>Indigofera adesmiifolia</i>	Tick Indigo, Leafless Indigo, Broad-leaved Indigo
	Fabaceae	<i>Indigofera australis</i>	Austral Indigo, Australian Indigo, Native Indigo, Hill Indigo
	Oleaceae	<i>Jasminum suavissimum</i>	Native Jasmine, Sweet Jasmine
	Myrtaceae	<i>Kunzea parvifolia</i>	Violet Kunzea, Tickbush
	Myrtaceae	<i>Leptospermum myrtifolium</i>	Swamp Myrtle, Swamp Tea-tree, Myrtle-leaved Tea-tree, Grey Tea-tree
	Myrtaceae	<i>Leptospermum obovatum</i>	River Tea-tree, Blunt-leaf Tea-tree
	Fabaceae	<i>Lespedeza juncea</i>	Perennial Lespedeza
	Epacridaceae	<i>Leucopogon fletcheri</i>	Pendant Beard Heath
	Epacridaceae	<i>Leucopogon fraseri</i>	Beard Heath
	Epacridaceae	<i>Leucopogon virgatus</i>	Common Beard Heath

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
Shrub/Tree	Epacridaceae	<i>Lissanthe strigosa</i>	Peach Heath
	Chenopodiaceae	<i>Maireana microphylla</i>	Eastern Cottonbush, Small-leaf Bluebush, Bluebush
	Epacridaceae	<i>Melichrus urceolatus</i>	Urn Heath
	Fabaceae	<i>Mirbelia oxylobioides</i>	Mountain Mirbelia
	Polygonaceae	<i>Muehlenbeckia axillaris</i>	Wire Plant, Matted Lignum
	Polygonaceae	<i>Muehlenbeckia tuggeranong</i>	Tuggeranong Lignum
	Asteraceae	<i>Olearia elliptica</i>	Sticky Daisy-bush
	Asteraceae	<i>Ozothamnus spp.</i>	Everlastings
	Thymelaeaceae	<i>Pimelea curviflora</i>	Curved Rice-flower
	Thymelaeaceae	<i>Pimelea glauca</i>	Shrubby Rice-flower
	Thymelaeaceae	<i>Pimelea pauciflora</i>	Poison Pimelea, Poison Rice-flower
	Rhamnaceae	<i>Pomaderris pallida</i>	Pale Pomaderris
	Fabaceae	<i>Pultenaea fasciculata</i>	Bush-pea
	Fabaceae	<i>Pultenaea microphylla</i>	Spreading Bush-pea
	Fabaceae	<i>Pultenaea procumbens</i>	Heathy Bush-pea
	Fabaceae	<i>Pultenaea spinosa</i>	Bush-pea
	Fabaceae	<i>Pultenaea subspicata</i>	Low Bush-pea
	Pittosporaceae	<i>Rhytidosporum procumbens</i>	White Marianth
	Rosaceae	<i>Rubus parvifolius</i>	Small-leaf Raspberry, Small-leaved Raspberry, Native Raspberry
	Sterculiaceae	<i>Rulingia prostrata</i>	Dwarf Kerrawang
	Solanaceae	<i>Solanum linearifolium</i>	Mountain Kangaroo-apple, Kangaroo-apple
	Epacridaceae	<i>Styphelia triflora</i>	Pink Five-corners
	Fabaceae	<i>Templetonia stenophylla</i>	Leafy Templetonia, Leafy Mallee-pea
	Asteraceae	<i>Vittadinia gracilis</i>	Woolly New Holland Daisy
	Lamiaceae	<i>Westringia eremicola</i>	Slender Westringia
	Convolvulaceae	<i>Wilsonia rotundifolia</i>	Round-leaf Wilsonia
	Mimosaceae	<i>Acacia deanei</i>	Deane's Wattle, Green Wattle
	Mimosaceae	<i>Acacia decurrens</i>	Black Wattle, Early Black Wattle, Green Wattle, Queen Wattle, Sydney Green Wattle

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
Tree	Mimosaceae	<i>Acacia doratoxylon</i>	Currawang, Lancewood, Spearwood, Cooriwan, Hickory, Brown Lancewood
	Mimosaceae	<i>Acacia mearnsii</i>	Black Wattle, Green Wattle, Late Black Wattle
	Mimosaceae	<i>Acacia parramattensis</i>	Sydney Green Wattle, Parramatta Wattle, Parramatta Green Wattle
	Mimosaceae	<i>Acacia rubida</i>	Red-stem Wattle, Red-leaved Wattle
	Mimosaceae	<i>Acacia verniciflua</i>	Varnish Wattle
	Proteaceae	<i>Banksia marginata</i>	Silver Banksia, Honeysuckle Banksia, Dwarf Honeysuckle, Warrock
	Pittosporaceae	<i>Bursaria spinosa</i>	Australian Blackthorn, Bursaria, Blackthorn, Native Blackthorn, Sweet Bursaria (Native Box), Whitethorn, Christmas Bush, Prickly Pine, Prickly Box
	Myrtaceae	<i>Callistemon sieberi</i>	Alpine Bottlebrush, River Bottlebrush
	Santalaceae	<i>Exocarpos cupressiformis</i>	Cherry Ballart, Native Cherry, Wild Cherry, Cherry Wood
	Rutaceae	<i>Geijera parviflora</i>	Wilga
	Fabaceae	<i>Jacksonia scoparia</i>	Winged Broom-pea, Dogwood, Broom
	Myrtaceae	<i>Kunzea ericoides</i>	Burgan, Kanuka
	Myrtaceae	<i>Melaleuca parvistaminea</i>	Honey-myrtle
	Rhamnaceae	<i>Pomaderris spp.</i>	Pomaderris
	Mimosaceae	<i>Acacia implexa</i>	Lightwood, Hickory Wattle, Black Wattle, Hickory, Sally Wattle, Scrub Wattle, Screw-pod Wattle, Bastard Myall, Lignum Vitae, Fish Wattle, Broad-leaf Wattle
	Mimosaceae	<i>Acacia melanoxylon</i>	Blackwood, Black Wattle, Hickory, Mudgerabah, Paluma Blackwood, Sally Wattle
	Mimosaceae	<i>Acacia obliquinervia</i>	Mountain Hickory Wattle

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
	Casuarinaceae	<i>Allocasuarina littoralis</i>	Black Sheoak
	Casuarinaceae	<i>Allocasuarina luehmannii</i>	Buloke, Bull Oak, Bulloak, Bull Sheoak
	Casuarinaceae	<i>Allocasuarina verticillata</i>	Drooping Sheoak, Coast She-oak, Hill-oak, Sheoak
	Myrtaceae	<i>Angophora floribunda</i>	Rough-barked Apple, Roughbark Apple, Apple Box (Qld), Apple, Boondah, Gum Myrtle, Rusty Gum
	Sterculiaceae	<i>Brachychiton populneus</i>	Kurrajong
	Cupressaceae	<i>Callitris endlicheri</i>	Black Cypress Pine, Black Cypress, Red Cypress, Black Pine, Mountain Pine, Black Callitris, Red Cypress Pine
	Cupressaceae	<i>Callitris glaucophylla</i>	White Cypress-pine, White Cypress, White Pine
	Myrtaceae	<i>Eucalyptus aggregata</i>	Black Gum
	Myrtaceae	<i>Eucalyptus amplifolia</i>	Cabbage Gum
	Myrtaceae	<i>Eucalyptus bridgesiana</i>	Apple Box, But-but
	Myrtaceae	<i>Eucalyptus caliginosa</i>	New England Stringybark
	Myrtaceae	<i>Eucalyptus camaldulensis</i>	River Red Gum, Red Gum, Murray Red Gum, River Gum (WA)
	Myrtaceae	<i>Eucalyptus cinerea</i>	Argyle Apple, Silver-leaved Stringybark
	Myrtaceae	<i>Eucalyptus conica</i>	Fuzzy Box
	Myrtaceae	<i>Eucalyptus dalrympleana</i>	Mountain Gum
	Myrtaceae	<i>Eucalyptus dives</i>	Broad-leaved Peppermint, Peppermint, Blue Peppermint (Vic)
	Myrtaceae	<i>Eucalyptus goniocalyx</i>	Long-leaved Box, Bundy, Olive-barked Box
	Myrtaceae	<i>Eucalyptus macrorhyncha</i>	Red Stringybark
	Myrtaceae	<i>Eucalyptus mannifera</i>	Brittle Gum
	Myrtaceae	<i>Eucalyptus nortonii</i>	Mealy Bundy, Large-flowered Bundy
	Myrtaceae	<i>Eucalyptus ovata</i>	Swamp Gum, Black Gum (southern Tas), White Gum

Table D.3 Box-Gum Woodland Species and Planting List

Form	Family	Scientific Name	Common name
Tree/Mallee	Myrtaceae	<i>Eucalyptus pauciflora</i>	Snow Gum, Cabbage Gum (Tas), Weeping Gum (Tas), White Sally
	Myrtaceae	<i>Eucalyptus populnea</i>	Bimble Box, Poplar Box, Bimbil Box
	Myrtaceae	<i>Eucalyptus rossii</i>	Scribbly Gum, Snappy Gum, White Gum, Inland Scribbly Gum
	Myrtaceae	<i>Eucalyptus rubida</i>	Candlebark, Ribbon Gum, White Gum
	Myrtaceae	<i>Eucalyptus sideroxylon</i>	Red Ironbark, Mugga, Mugga Ironbark
	Myrtaceae	<i>Eucalyptus viminalis</i>	Manna Gum, Ribbon Gum
	Oleaceae	<i>Notelaea microcarpa</i>	Native Olive
	Myrtaceae	<i>Eucalyptus polyanthemos</i>	Red Box
	Myrtaceae	<i>Eucalyptus stellulata</i>	Black Sally
	Mimosaceae	<i>Acacia dealbata</i>	Silver Wattle

Appendix E

Planting Techniques

E.1 Revegetation Methods

E.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), 2009). 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 (ANPC, 2011). 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 (Habitat Plants, 2011).

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.

E.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 seedlings 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 (Habitat Plants, 2011).

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 or 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.

E.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 E.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 from the weaker plants without creating gaps to be replanted.	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 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 F

Weed Management Techniques

F.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 below, as provided in the Box-Gum Woodland species list for the Commonwealth listing for the community (SEWPaC, 2011). 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 F.1 Box-Gum Woodland common weed species

Family	Species	Common Name	Annual/ perennial
Shrubs			
Rosaceae	<i>Rosa rubiginosa</i>	Sweetbriar, Briar Rose, Eglantine	perennial
Herbs			
Asteraceae	<i>Arctotheca calendula</i>	Cape Weed, African Marigold, Cape Dandelion	annual
Asteraceae	<i>Carthamus lanatus</i>	Saffron Thistle	annual
Asteraceae	<i>Chondrilla juncea</i>	Skeleton-weed	perennial
Asteraceae	<i>Cirsium vulgare</i>	Spear Thistle	annual
Asteraceae	<i>Hypochaeris glabra</i>	Smooth Cat's-ear	annual
Asteraceae	<i>Hypochaeris radicata</i>	Flatweed, Cat's-ear	perennial
Boraginaceae	<i>Echium plantagineum</i>	Paterson's Curse, Salvation Jane, Murrumbidgee Bluebell, Riverina Bluebell	annual
Boraginaceae	<i>Myosotis discolor</i>	Yellow and Blue Forget-me-not, Forget-me-not	annual
Brassicaceae	<i>Lepidium africanum</i>	Common Pepper-cress, African Pepper-cress, Rubble Pepper-cress	annual
Caryophyllaceae	<i>Cerastium glomeratum</i>	Broad-leaved Mouse-ear Chickweed, Sticky Mouse-ear Chickweed	annual

Table F.1 Box-Gum Woodland common weed species

Family	Species	Common Name	Annual/ perennial
Caryophyllaceae	<i>Moenchia erecta</i>	Erect Chickweed, Upright Moenchia	annual
Caryophyllaceae	<i>Petrorhagia nanteuilii</i>	Proliferous Pink, Childing pink	annual
Caryophyllaceae	<i>Silene gallica</i>	French Catchfly, Five-wounded Catchfly	annual
Clusiaceae	<i>Hypericum perforatum</i>	St John's Wort, Perforated St John's Wort	perennial
Fabaceae	<i>Medicago lupulina</i>	Black Medic, Hop Medic	annual
Fabaceae	<i>Trifolium angustifolium</i>	Narrow-leaved Clover	annual
Fabaceae	<i>Trifolium arvense</i>	Hare's-foot Clover	annual
Fabaceae	<i>Trifolium campestre</i>	Hop Clover	annual
Fabaceae	<i>Trifolium glomeratum</i>	Clustered Clover	annual
Fabaceae	<i>Trifolium scabrum</i>	Rough Clover	annual
Fabaceae	<i>Trifolium striatum</i>	Knotted Clover	annual
Fabaceae	<i>Trifolium subterraneum</i>	Subterranean Clover, Sub Clover	annual
Fabaceae	<i>Vicia sativa</i>	Common Vetch, Narrow-leaved Vetch	annual
Gentianaceae	<i>Centaurium erythraea</i>	Common Centaury	annual
Geraniaceae	<i>Geranium molle</i>	Cranes-bill Geranium	annual
Iridaceae	<i>Romulea rosea</i>	Onion-grass, Guildford Grass	perennial
Lamiaceae	<i>Salvia verbenaca</i>	Wild Sage, Vervain	perennial
Plantaginaceae	<i>Plantago lanceolata</i>	Ribwort, Ribgrass, Lamb's Tongue	annual
Polygonaceae	<i>Acetosella vulgaris</i>	Sorrel, Sheep Sorrel	perennial
Primulaceae	<i>Anagallis arvensis</i>	Scarlet Pimpernel, Blue Pimpernel, Pimpernel	annual
Rubiaceae	<i>Sherardia arvensis</i>	Blue Fieldmadder, Field Madder	annual
Scrophulariaceae	<i>Linaria pelisseriana</i>	Pelisser's Toadflax	annual
Scrophulariaceae	<i>Orobanche minor</i>	Lesser Broomrape, Broomrape, Clover Broomrape	annual
Scrophulariaceae	<i>Parentucellia latifolia</i>	Red Bartsia, Common Bartsia	annual
Urticaceae	<i>Urtica urens</i>	Small Nettle	annual
Grasses			
Poaceae	<i>Aira elegantissima</i>	Delicate Hairgrass	annual
Poaceae	<i>Anthoxanthum odoratum</i>	Sweet Vernal Grass, Sweet-scented Vernal-grass, Sweet Vernal	perennial
Poaceae	<i>Avena barbata</i>	Bearded Oats	annual

Table F.1 Box-Gum Woodland common weed species

Family	Species	Common Name	Annual/ perennial
Poaceae	<i>Briza maxima</i>	Quaking Grass, Blowfly Grass	annual
Poaceae	<i>Briza minor</i>	Shivery Grass, Lesser Quaking Grass	annual
Poaceae	<i>Bromus diandrus</i>	Great Brome	annual
Poaceae	<i>Bromus molliformis</i>	Silky Brome, Soft Brome	annual
Poaceae	<i>Dactylis glomerata</i>	Cocksfoot, Orchard Grass	perennial
Poaceae	<i>Holcus lanatus</i>	Yorkshire Fog	perennial
Poaceae	<i>Hordeum leporinum</i>	Barley-grass	annual
Poaceae	<i>Hyparrhenia hirta</i>	Coolatai Grass	perennial
Poaceae	<i>Lolium rigidum</i>	Ryegrass	annual
Poaceae	<i>Lolium spp.</i>	Ryegrass	annual
Poaceae	<i>Nassella neesiana</i>	Chilean Needle-grass	perennial
Poaceae	<i>Nassella trichotoma</i>	Serrated Tussock	perennial
Poaceae	<i>Phalaris aquatica</i>	Phalaris	perennial
Poaceae	<i>Poa bulbosa</i>	Bulbous Poa	perennial
Poaceae	<i>Vulpia bromoides</i>	Squirrel Tail Fescue, Silver Grass	annual
Poaceae	<i>Vulpia myuros</i>	Rat's Tail Fescue	annual
Poaceae	<i>Avena fatua</i>	Wild Oats	annual
Poaceae	<i>Cynosurus echinatus</i>	Rough Dogstail	annual
Poaceae	<i>Lolium perenne</i>	Perennial Ryegrass	annual
Poaceae	<i>Paspalum dilatatum</i>	Paspalum	perennial

F.2 Weed Control Methods

A control program comprising mechanical, herbicide, fire, and if possible, grazing is recommended. 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	Deciduous plants												
	Non-deciduous plants												
Graslan	Brigalow Regrowth												
Grazon DS	Blackberry												
	St John's Wort												
	Sweet Briar												
	Gorse												
	Lantana & Associated weeds												
Starane 200	Eucalypts / Acacias												
	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.

F.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.

F.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.

F.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.

F.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.

F.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.

F.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.

F.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.

F.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.

St John's wort

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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.

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 infestations 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.

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.



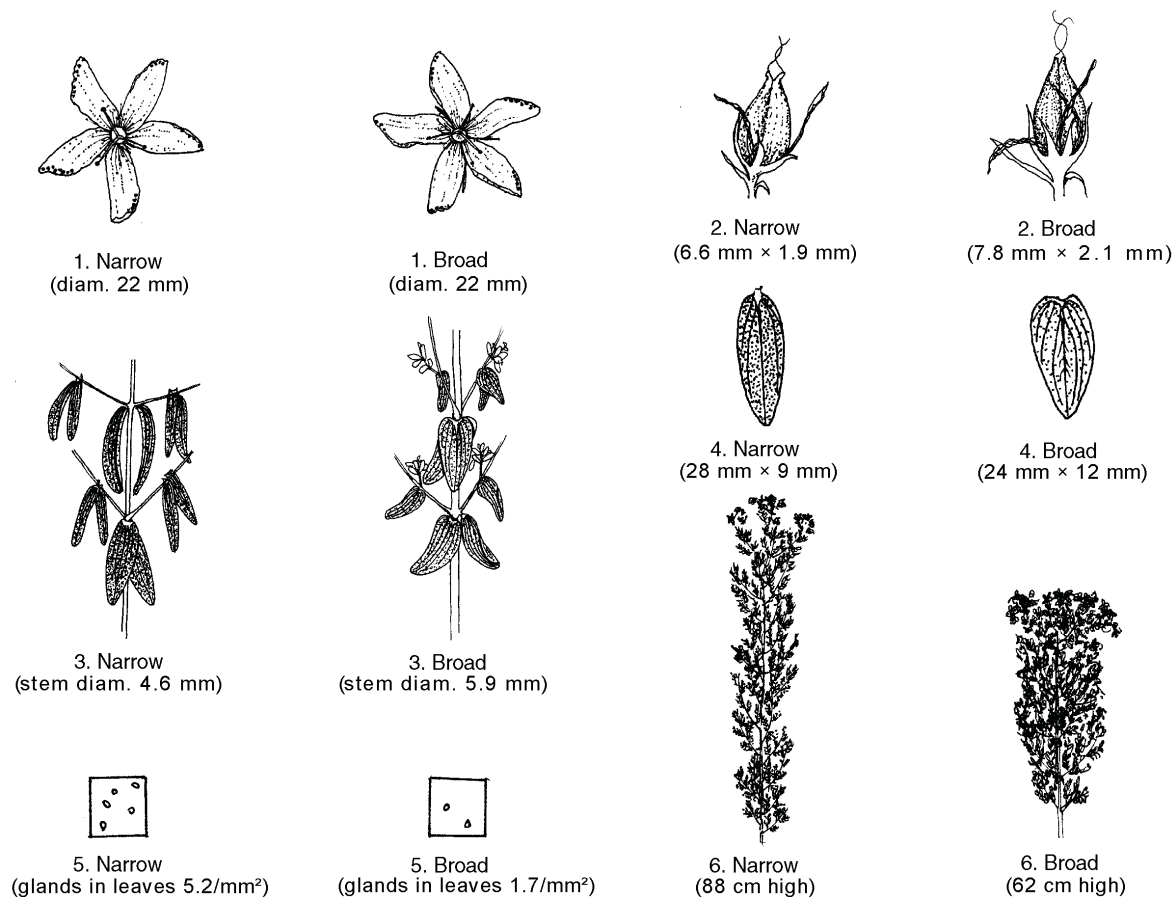


Figure 1. Comparison between narrow- and broad-leaf strains of St John's wort. J. Peacock.

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.

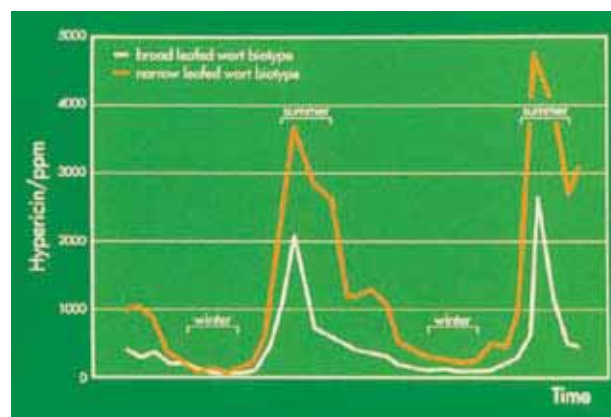


Figure 2. Seasonal hypericin variation over two consecutive years between broad-leaf and narrow-leaf St John's wort. Source: C. Bourke.

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 continuously 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



Photosensitisation 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 than 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.

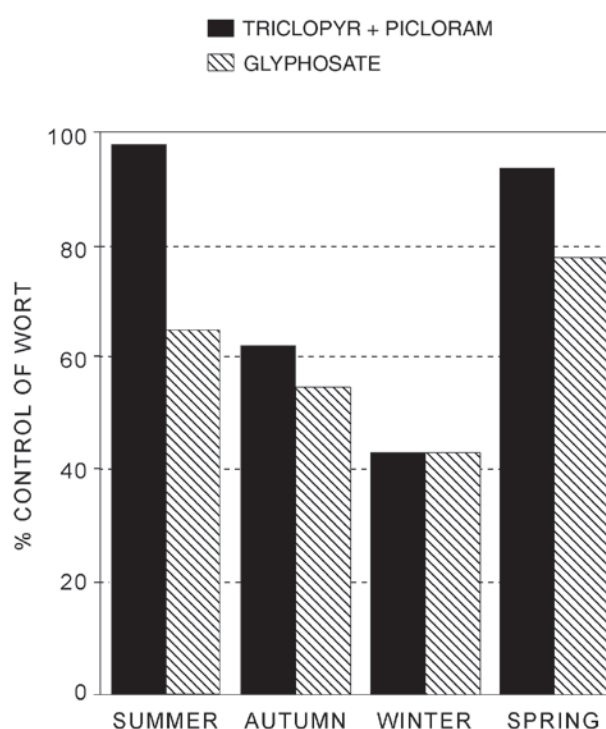


Figure 3. The best time to spray St John's wort is late spring to early summer. Source: Campbell et al. 1991.

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 Tuenah.

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.

Bourke, CA 2003, 'The effect of shade, shearing and wool type in the protection of Merino sheep from *Hypericum perforatum* (St John's wort) poisoning', *Australian Veterinary Journal*, vol. 81, pp. 494–498.

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Bourke, CA & White, JG 2004 (Nov), 'Reassessment of the toxicity of *Hypericum perforatum* (St John's wort) for cattle', *Australian Veterinary Journal*, vol. 82.

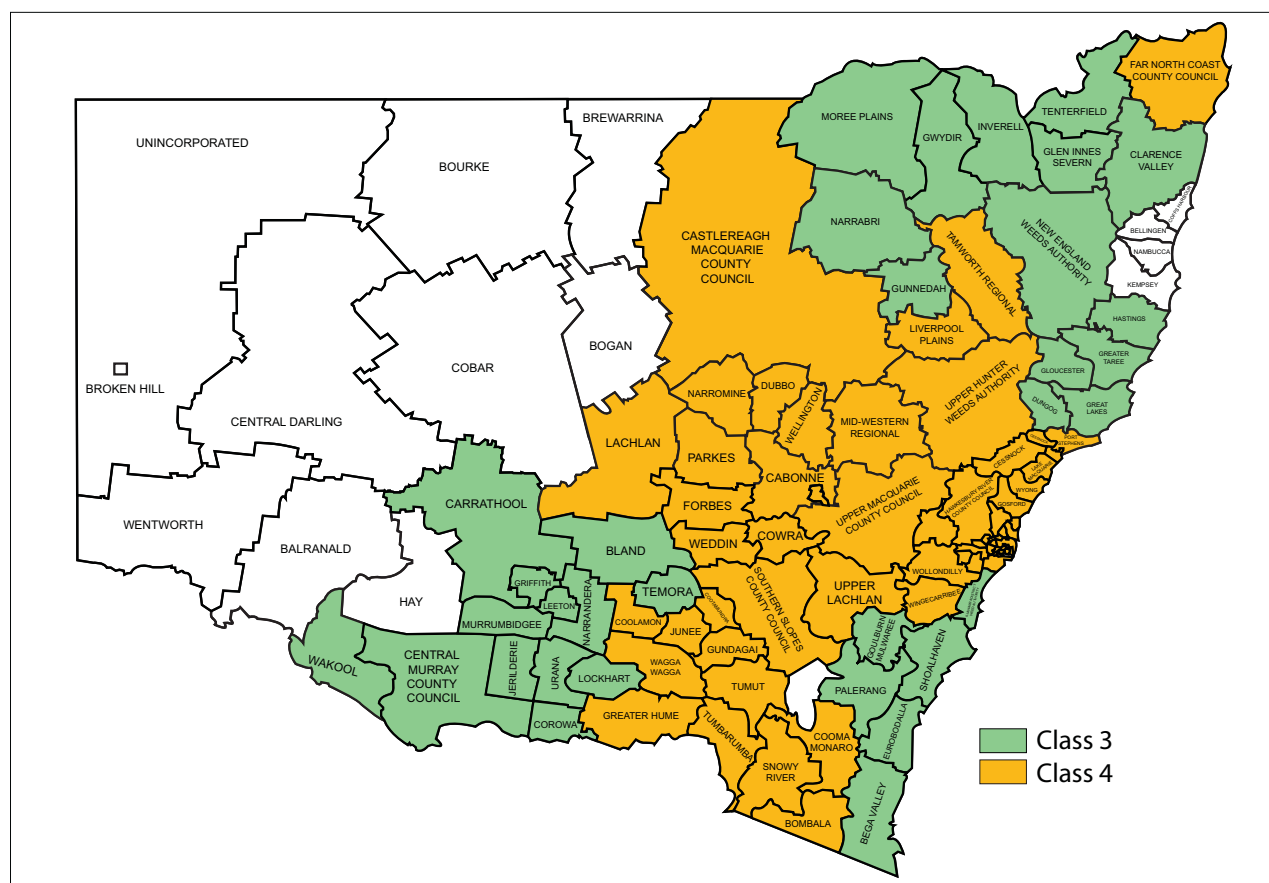


Figure 4. Area of NSW where St John's wort is declared a Class 3 or 4 noxious weed. A. Maguire.

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.

Southwell, IA & Bourke, CA 2001, 'Seasonal variation in hypericin content of *Hypericum perforatum* L. (St John's wort)', *Phytochemistry*, vol. 56, pp. 437–441.

ACKNOWLEDGEMENTS

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Replaces Agfact P7.6.1.

Updates of this Primefact are available at www.dpi.nsw.gov.au/primefacts

Disclaimer: The information contained in this publication is based on knowledge and understanding at the time of writing (October 2007). 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 New South Wales Department of Primary Industries or the user's independent adviser.

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 the nearest Catchment Management Authority office for further information.

Job number 8140

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 <i>O. acanthium</i>	Illyrian thistle <i>O. illyricum</i>	Stemless thistle <i>O. acaulon</i>
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–February	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 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 led 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 release 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 lays 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 latius*) 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

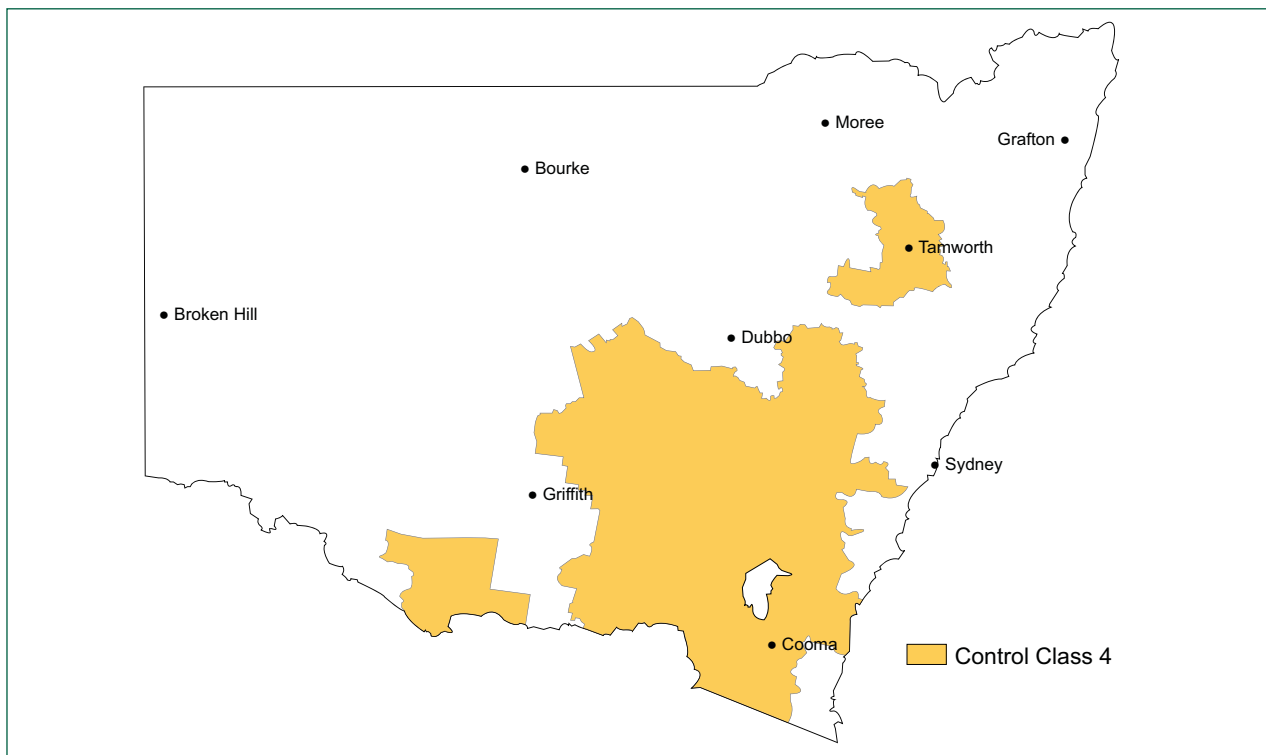


Figure 12. Areas of NSW where *Onopordum* species are declared a Class 4 noxious weed.

Acknowledgements

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Publications Available

A complete list of NSW DPI weed publications can be found at www.dpi.nsw.gov.au/weeds

Printed copies are available by contacting the NSW DPI Bookshop, on 1800 028 374 or visit www.dpi.nsw.gov.au/bookshop

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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 8220

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.

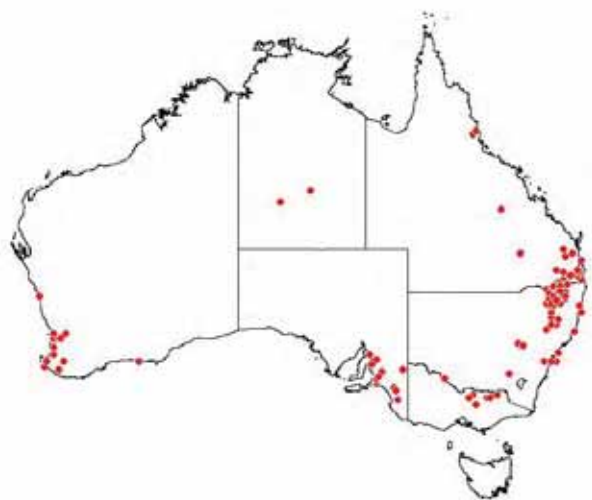
It is found in all Australian states and territories.

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.



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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 (<i>H. hirta</i>)	Tambookie grass (<i>H. filipendula</i>)	Thatch grass <i>H. rufa</i>
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 <i>Hyparrhenia hirta</i>	barbed wire grass <i>Cymbopogon refractus</i>	kangaroo grass <i>Themeda australis</i>	redgrass <i>Bothriochloa macra</i>
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

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 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/publications/collecting-preparing-specimens>

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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.

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.

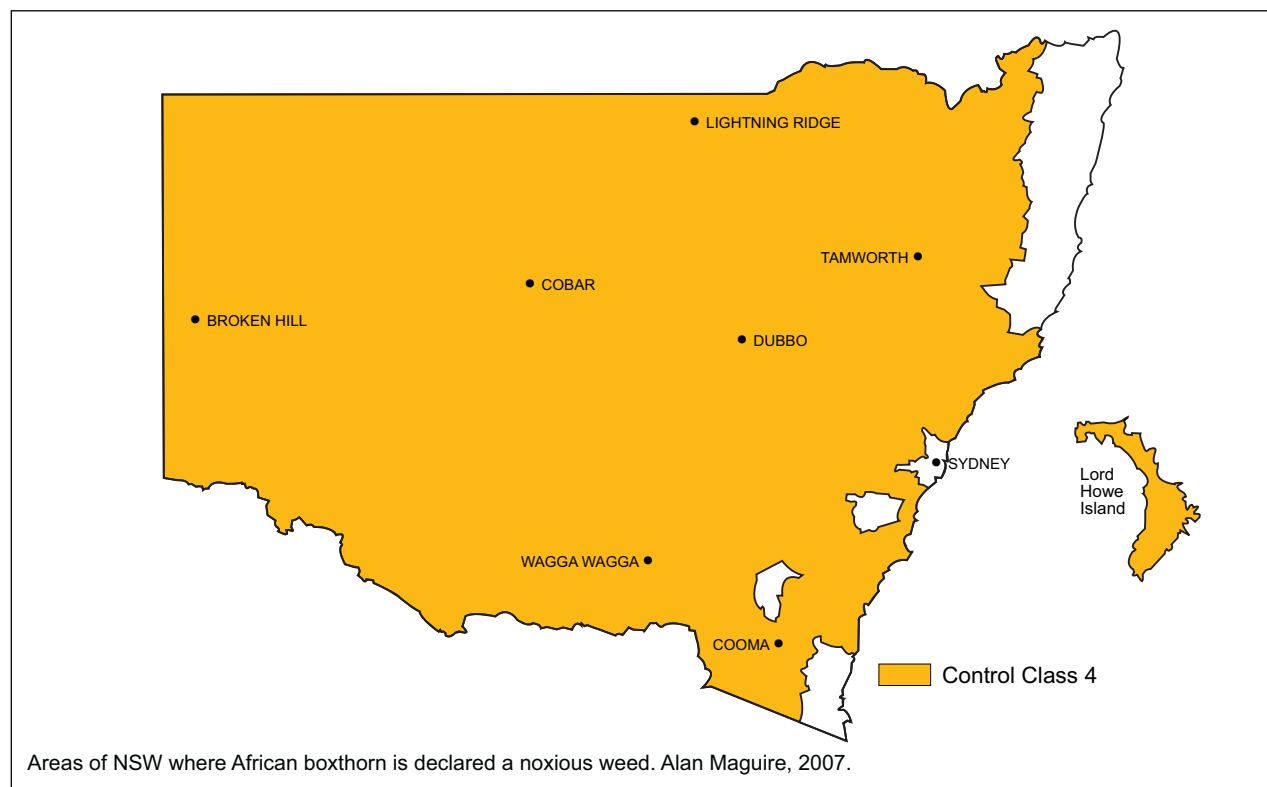
For invasive woody weeds such as African boxthorn, control is more effective and economical if done when the plants are young.

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:



- 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.

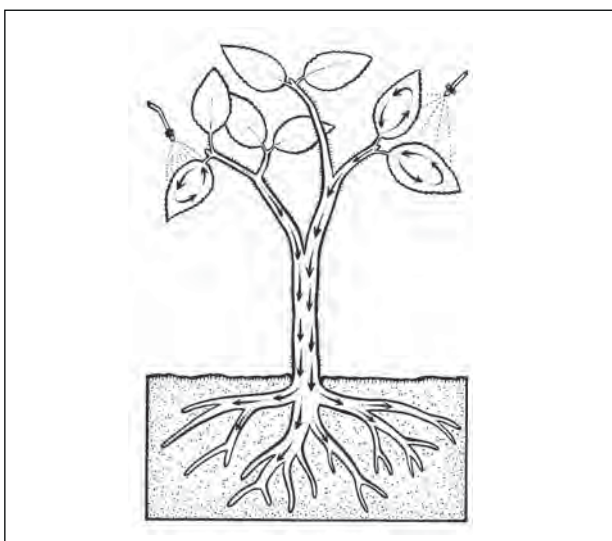


Figure 1: Applying chemicals through foliar spraying is more effective if the plant is actively growing. Queensland Natural Resources and Mines.

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.

Basal 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.

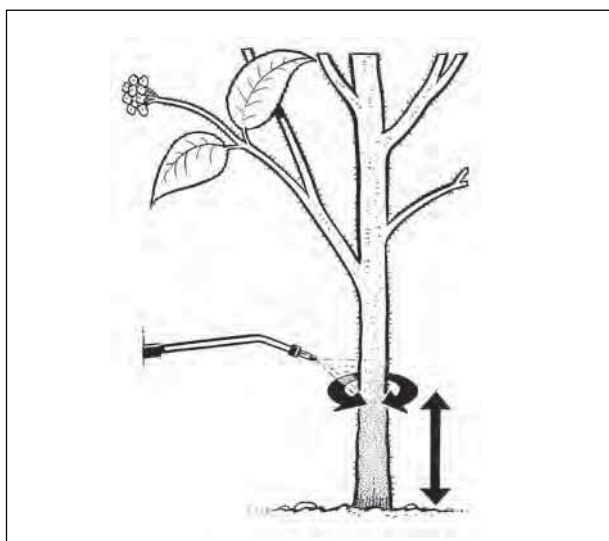


Figure 2: Basal bark application of chemicals should be around the complete base of every stem to a height of 30–40cm above the ground. Queensland Natural Resources and Mines.

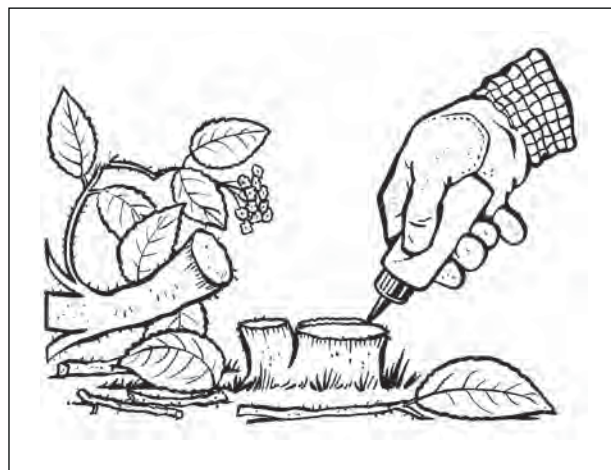
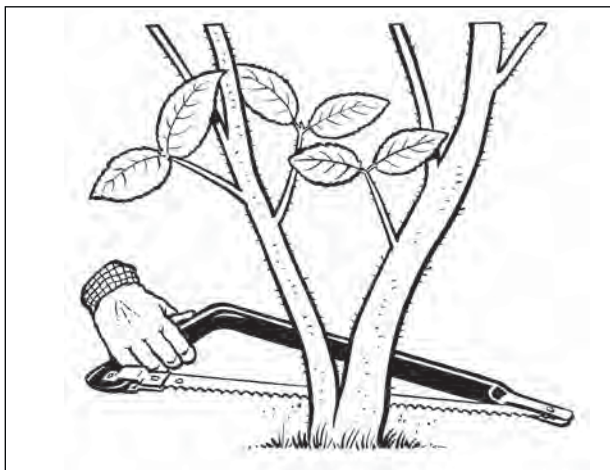


Figure 3. In cut stump applications it is important to apply the chemical immediately to the cut stem. Queensland Natural Resources and Mines.

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

The authors would like to acknowledge the comments made by Peter Gorham, Jim Dellow and Stephen Johnson regarding the technical content of this publication.

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Prepared by Alyssa Schembri, Orange Agricultural Institute, Orange.

Updates of this Primefact are available at www.dpi.nsw.gov.au/primefacts

Disclaimer: The information contained in this publication is based on knowledge and understanding at the time of writing (August 2007). 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 Industry & Investment NSW or the user's independent adviser.

Job number 9608



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

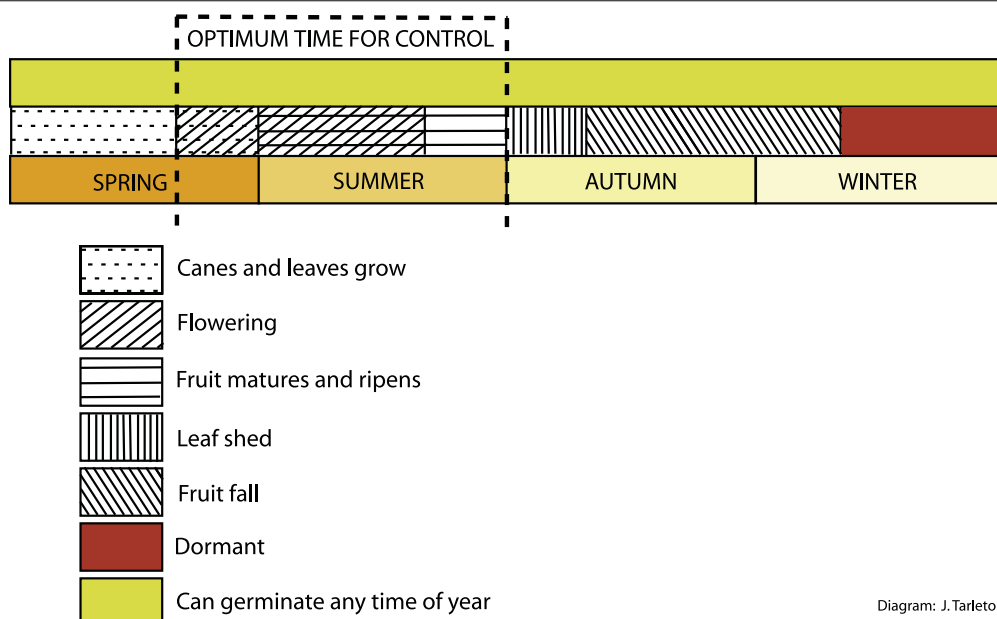


Diagram: J. Tarleton

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.

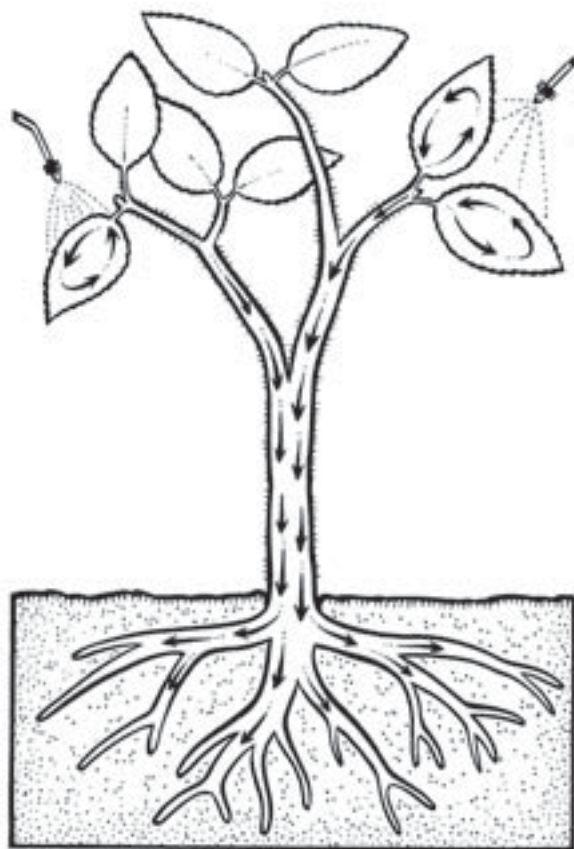


Diagram: Queensland Natural Resources and Mines

Figure 2: Applying chemicals through foliar spraying is more effective when the plant is actively growing.

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.

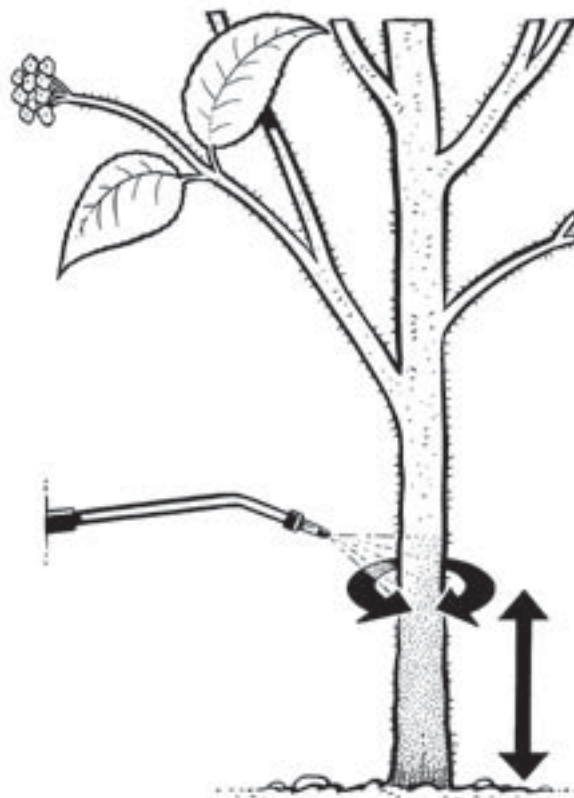


Diagram: Queensland Natural Resources and Mines

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.

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.

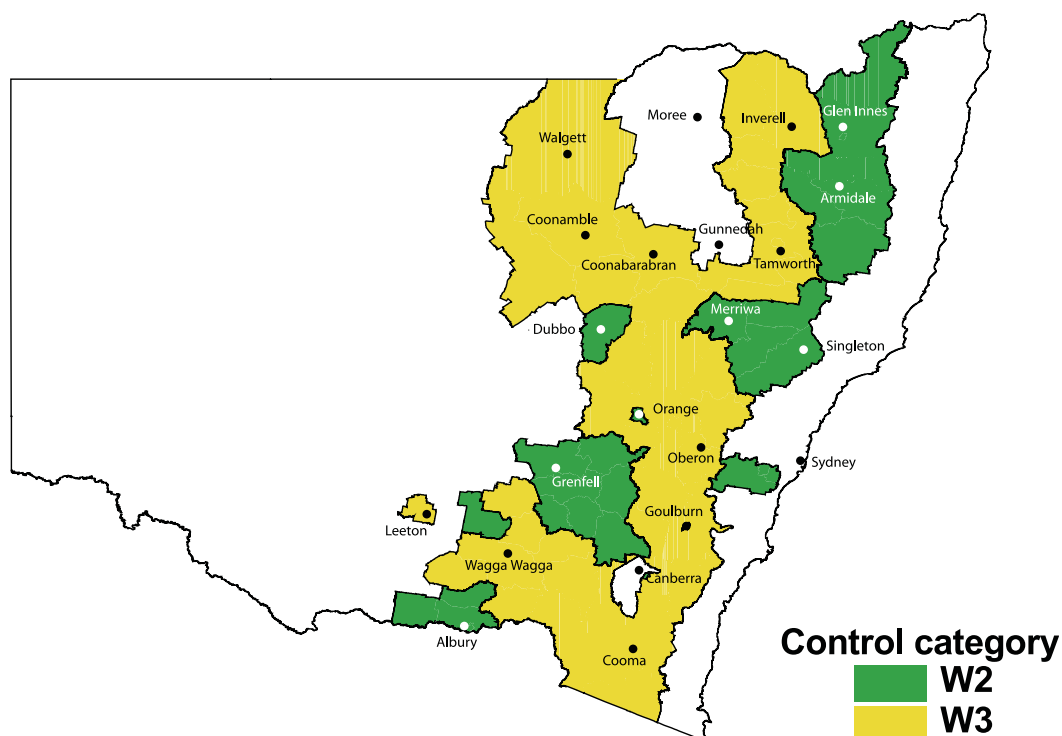
To control sweet briar, apply an appropriate residual herbicide directly under the plant near the base. The herbicide should be applied under the soil to prevent degradation by sunlight and possible contamination of surface run-off after rain. It is most effectively applied when the soil is moist.

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.

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.

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 your office of the Department of Natural Resources for further information.

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Job number 6012

Appendix G

Regrowth Thinning

G.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. 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), 2009); 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).

G.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 habitat. Any thinning conducted in rehabilitation areas should refer to strategies implemented by Parks Victoria and the McIntosh Method for ecological thinning (McIntosh, 2007, 2008; Schirmer and Field, 2000). 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. Woodland 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) (2009) 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.