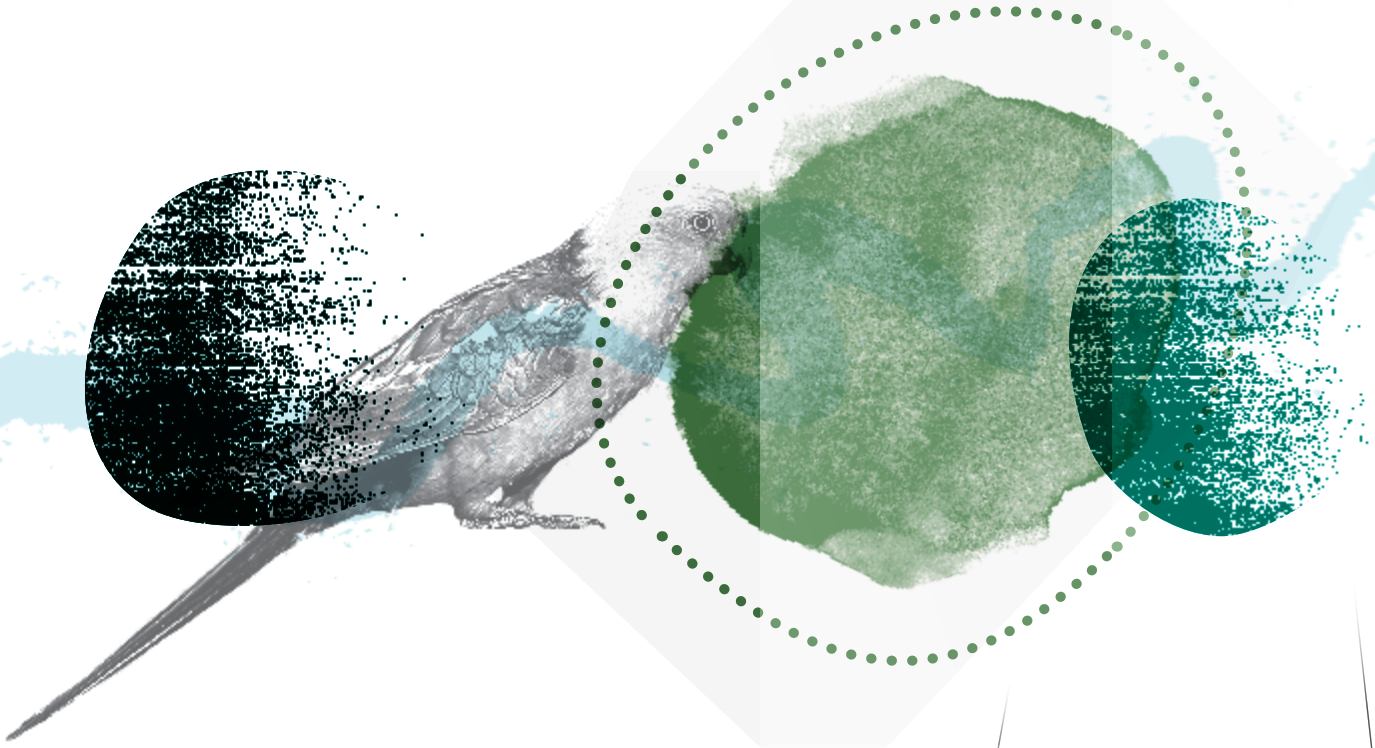
MOLONGLO RIVER RESERVE & OFFSET AREAS

ECOLOGICAL MANAGEMENT GUIDELINES

FEBRUARY 2015



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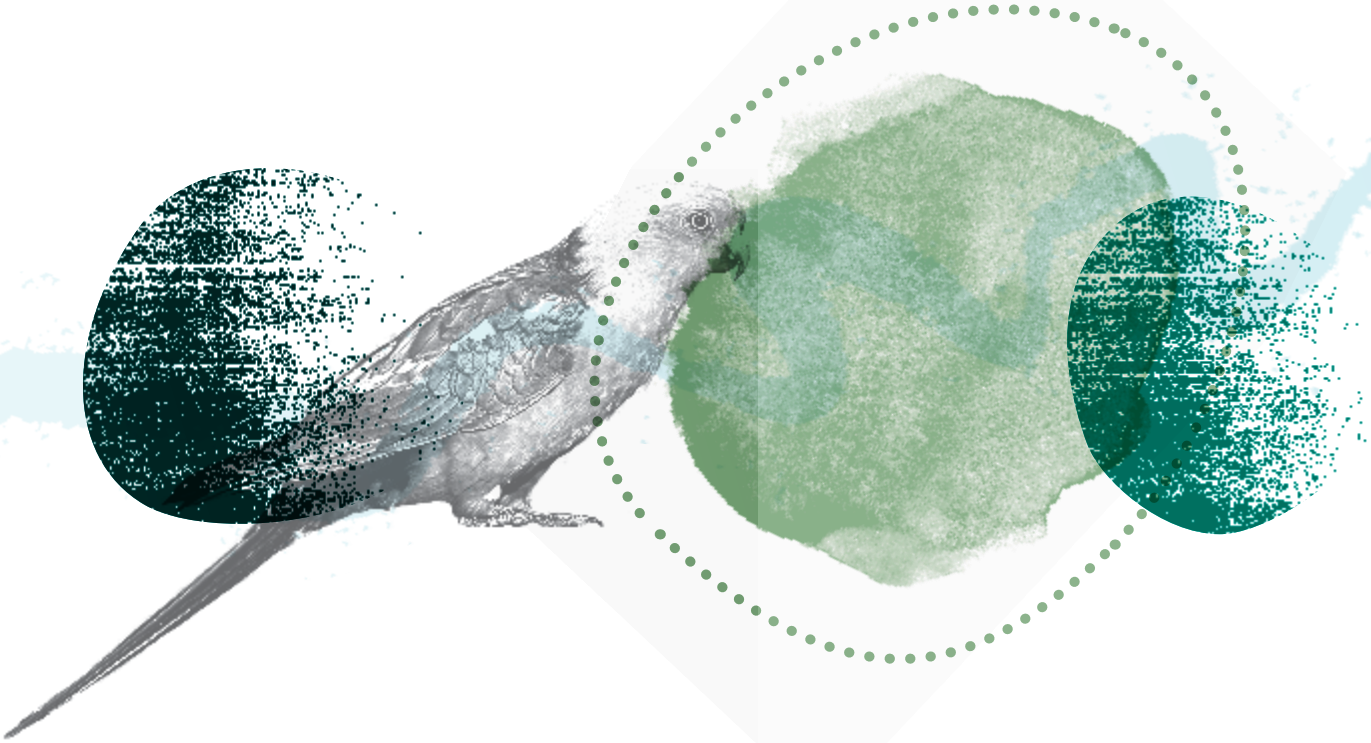

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GLOSSARY

Baseline ecological condition: The condition of an MNES that exists at the time the baseline condition assessment is carried out and the results recorded. Baseline conditions are not necessarily pristine or optimal conditions (ACT Government TAMS 2013).

Critically endangered: At extremely high risk of extinction in the wild in the immediate future.

Ecotone: A transitional area of vegetation between two different defined plant communities, such as woodland and grassland. It has some of the characteristics of each bordering biological community and often contains species not found in either of those overlapping communities. Ecotones also appear at the boundary between the water and the land (e.g. wetlands).

Endangered: At very high risk of extinction in the wild in the near future.

Enhance: Raise the ecological condition of a particular MNES to a level which exceeds the established baseline condition (ACT Government TAMS 2013).

Enhancement: The introduction of additional organisms, genotypes, species or elements of habitat or geodiversity to those that naturally exist in a place). Enhancement should not alter the natural species diversity, genetic diversity or geodiversity of the place if that would reduce its natural significance (Australian Heritage Commission 2002). Enhancement includes revegetation; rehabilitation (ACT Government TAMS 2013).

EPBC Act: Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Maintain: Preserve the ecological condition of a particular MNES at the same level as determined by the baseline condition assessment (ACT Government TAMS 2013).

MNES: Matter of national environmental significance under the EPBC Act. In this report the term refers to Box-Gum Woodland, Natural Temperate Grassland, the Pink-tailed Worm-lizard *Aprasia parapulchella*, the Superb Parrot *Polytelis swainsonii*, and the Swift Parrot *Lathamus discolor*.

Natural regeneration: The natural reproduction of existing plants within a landscape. Natural regeneration requires plants to reach maturity, flower and set seed to be successful. Management that does not allow for full cycling of plants results ultimately in the loss of those species. The Australian Natural Heritage Charter defines regeneration as the natural recovery of natural integrity following disturbance or degradation (Australian Heritage Commission 2002) (ACT Government TAMS 2013).

Obligate seeder: Plant species that are obligate seeders are killed by fire, and the population then renews itself from its previously shed seed, which only germinates after fire. A species can become locally extinct if fire recurs frequently.

Operational plans: The day-to-day management planning tool that will provide detail about on-ground works and activities that will implement the key components of the Adaptive Management Strategy (ACT Government TAMS 2013).

Primary grassland: Grassland that is naturally treeless. Generally, if Natural Temperate Grassland, it is found in low-lying valleys that are subject to cold-air drainage, and has no remnants of trees.

Projective foliage cover: The proportion of ground area hidden from view by foliage when viewed from directly overhead.

Rehabilitation: The re-creation of habitat features in an environment. Generally they include non-living materials, such as logs, rocks, litter or artificial habitat features such as timber, tiles or piles of concrete (ACT Government TAMS 2013).

Reinstatement: Introduction of one or more species or elements of habitat or geodiversity to a place which are known to have existed there naturally at a previous time, but that can no longer be found at that place (Australian Heritage Commission 2002). This may include translocation of threatened species (ACT Government TAMS 2013).

Reserve Management Plans: Management plan required for certain public land zones in the ACT under the *Nature Conservation Act 2014*. Previously termed 'Plan of Management'.

Restoration: Returning existing habitats to a known past state or to an approximation of the natural condition by repairing degradation, by removing introduced species or by reinstatement (Australian Heritage Commission 2002). Restoration is appropriate if such action is consistent with, is necessary for, or contributes to the natural significance of the place (Australian Heritage Commission 2002). Restoration programs may incorporate enhancement of diversity of species and/or structure (ACT Government TAMS 2013).

Revegetation: The establishment of trees, shrubs or herbaceous species, either by direct seeding or planting seedlings (ACT Government TAMS 2013).

Secondary or derived grassland: Woodland that has been cleared of trees. It can be distinguished from grassland by the presence of 'markers' in the form of tree stumps or old fallen timber.

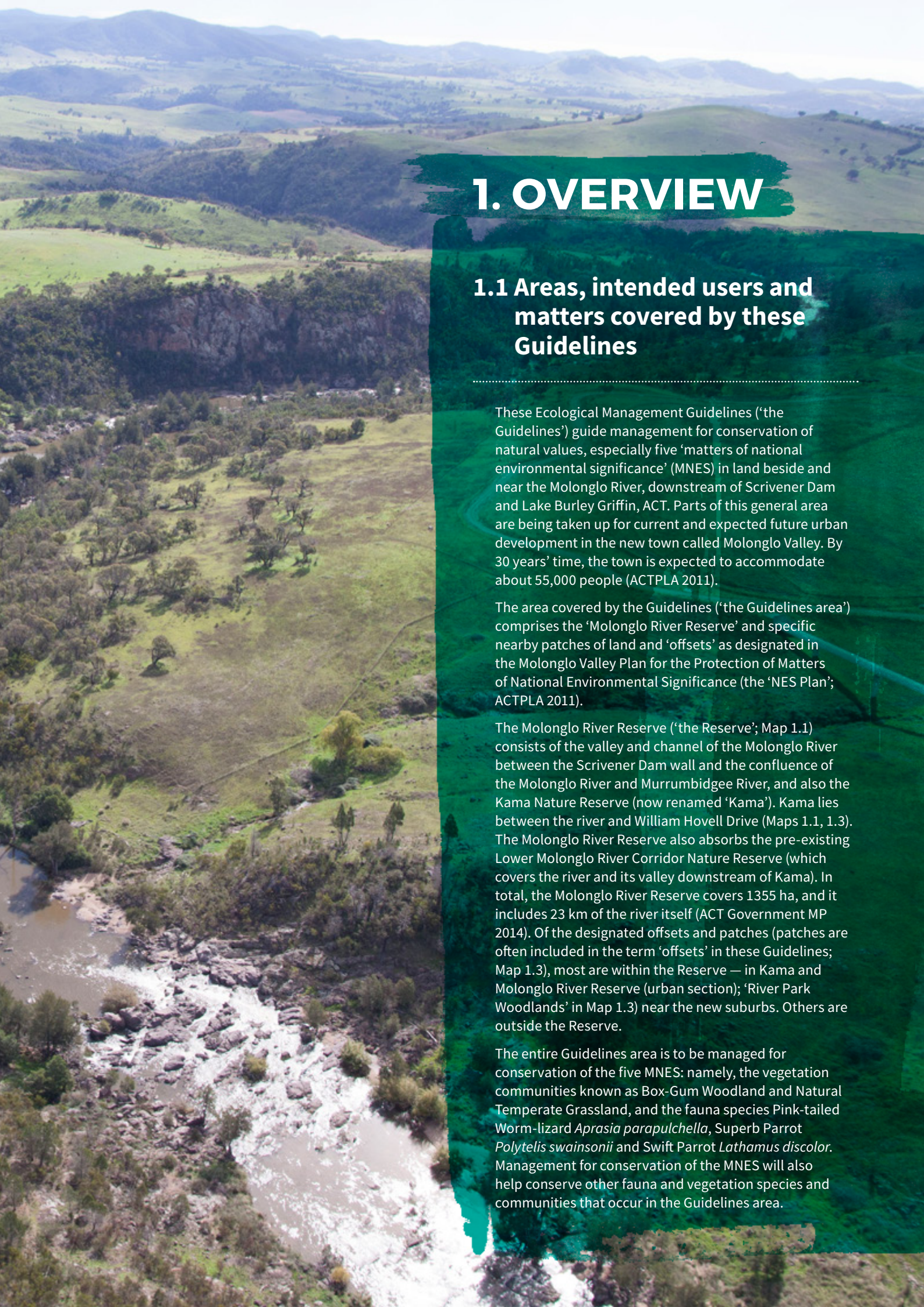
SPS species: A species that has Special Protection Status (SPS) in the ACT.

Strategic Assessment Area: The area of the Molonglo Valley subject to the EPBC Act strategic assessment.

Vulnerable: At high risk of extinction in the medium term future.

Woodland: A group of trees with a crown (canopy) cover of 20–50%, or a projective foliage cover of 10–30%. This means that trees have a crown separation ratio of 0.25– to 1 (Hnatiuk *et al.* 2009). Crown cover is defined as the percentage of the site covered by the projection of the tree canopy onto the ground (if viewed from above). Projective foliage cover is the proportion of a ground area hidden from view by foliage and woody branches (if viewed from directly above) (Hnatiuk *et al.* 2009). Woodland that has a low cover of trees is called open woodland.

Aerial view of Molonglo River Reserve rural section



1. OVERVIEW

1.1 Areas, intended users and matters covered by these Guidelines

These Ecological Management Guidelines ('the Guidelines') guide management for conservation of natural values, especially five 'matters of national environmental significance' (MNES) in land beside and near the Molonglo River, downstream of Scrivener Dam and Lake Burley Griffin, ACT. Parts of this general area are being taken up for current and expected future urban development in the new town called Molonglo Valley. By 30 years' time, the town is expected to accommodate about 55,000 people (ACTPLA 2011).

The area covered by the Guidelines ('the Guidelines area') comprises the 'Molonglo River Reserve' and specific nearby patches of land and 'offsets' as designated in the Molonglo Valley Plan for the Protection of Matters of National Environmental Significance (the 'NES Plan'; ACTPLA 2011).

The Molonglo River Reserve ('the Reserve'; Map 1.1) consists of the valley and channel of the Molonglo River between the Scrivener Dam wall and the confluence of the Molonglo River and Murrumbidgee River, and also the Kama Nature Reserve (now renamed 'Kama'). Kama lies between the river and William Hovell Drive (Maps 1.1, 1.3). The Molonglo River Reserve also absorbs the pre-existing Lower Molonglo River Corridor Nature Reserve (which covers the river and its valley downstream of Kama). In total, the Molonglo River Reserve covers 1355 ha, and it includes 23 km of the river itself (ACT Government MP 2014). Of the designated offsets and patches (patches are often included in the term 'offsets' in these Guidelines; Map 1.3), most are within the Reserve — in Kama and Molonglo River Reserve (urban section); 'River Park Woodlands' in Map 1.3) near the new suburbs. Others are outside the Reserve.

The entire Guidelines area is to be managed for conservation of the five MNES: namely, the vegetation communities known as Box-Gum Woodland and Natural Temperate Grassland, and the fauna species Pink-tailed Worm-lizard *Aprasia parapulchella*, Superb Parrot *Polytelis swainsonii* and Swift Parrot *Lathamus discolor*. Management for conservation of the MNES will also help conserve other fauna and vegetation species and communities that occur in the Guidelines area.

1.1.1 Intended users and relation to Adaptive Management Strategy

These Ecological Management Guidelines ('the Guidelines') are intended for use by land managers, design professionals and planners, to inform conservation planning, design and development activities and continuing land management and nature conservation. The Guidelines must be applied in association with the overarching Adaptive Management Strategy (AMS; see s.1.2.1 below; ACT Government TAMS 2013) endorsed by the Commonwealth Government in August 2013. They reflect the statutory Reserve Management Plan (currently draft, ACT Government MP 2018).

The scope of these Guidelines extends beyond the scope of the AMS. The Guidelines area covers also the ecological management applicable to the former Lower Molonglo River Corridor Nature Reserve, now part of the Molonglo River Reserve (see above).

1.1.2 Significant ecological values in the Reserve and offsets

Users of these Guidelines need to be aware of the numerous significant ecological values, especially the five MNES, that occur within the land area covered by the Molonglo River Reserve and offsets (the Guidelines area).

These MNES vegetation communities and fauna species are declared critically endangered (CE), endangered (E) or vulnerable (V) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC), for this area:

- White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland (known as Box–Gum Woodland) (CE);
- Natural Temperate Grassland of the Southern Tablelands of NSW and the ACT (known as Natural Temperate Grassland) (E);
- *Aprasia parapulchella* (Pink-tailed Worm-lizard) (V);
- *Polytelis swainsonii* (Superb Parrot) (V); and
- *Lathamus discolor* (Swift Parrot) (E).

A range of other significant vegetation communities, flora, fauna (listed below) and fauna habitats are known or thought to occur in the Molonglo River Reserve and offsets, and are listed as threatened or protected under the *ACT Nature Conservation Act 2014* (NC Act), the *NSW Threatened Species Conservation Act 1995* (TSC Act) and/or the EPBC Act, or are considered to be uncommon or declining.

Significant vegetation communities (targeted for conservation; Sharp *et al.* 2007):

- Snow Gum Grassy Woodland,
- River She-oak Forest,
- Black Cypress Pine – Brittle Gum Woodland,
- Tableland Aquatic and Fringing Vegetation Complex.

Significant flora:

- Pale Pomaderris (*Pomaderris pallida*) (V: EPBC Act),
- Hoary Sunray (*Leucochrysum albicans* var. *tricolor*) (E: EPBC Act),
- Mountain Leafless Bossiaea (*Bossiaea grayi*, syn. *B. bracteosa*),
- Birch Pomaderris (*Pomaderris betulina* subsp. *actensis*),
- Australian Anchor Plant (*Discaria pubescens*) (ROTAP: 3RCa), and
- a large number of regionally significant species in the riparan zone and Box-Gum Woodland.

Significant fauna:

- Brown Treecreeper, Little Eagle, Varied Sittella, White-winged Triller, Speckled Warbler and the Gang-gang Cockatoo and a further 20 bird species,
- Perunga Grasshopper,
- regionally significant raptor species,
- significant fauna habitat-connectivity values at the local and regional scales, and
- other native fauna protected under national and Territory legislation.

The following other threatened species or their habitats, as listed in the EPBC Act, the NC Act, or the TSC Act, may also occur within Molonglo River Reserve, although surveys to date have failed to locate them there:

- Austral Toadflax (*Thesium australe*) (V: EPBC Act, NC Act),
- Ginninderra Peppercress (*Lepidium ginninderrense*) (V: EPBC Act),
- Omeo Stork's-bill (*Pelargonium* sp. *striatellum*) (E: EPBC Act, TSC Act, not known from ACT),
- Mauve Burr-daisy (*Calotis glandulosa*) (V: EPBC Act, TSC Act),
- Button Wrinklewort (*Rutidosis leptorrhynchoides*) (E: EPBC Act, NC Act, TSC Act),
- Small Purple Pea (*Swainsona recta*) (E: EPBC Act, NC Act, TSC Act),
- Silky Swainson-pea (*Swainsona sericea*) (V: TSC Act).

Ecological values also include the ecological processes on which these assets depend, including hydrological processes, habitat formation, interactions between organisms, movements of organisms and natural disturbance regimes (Bennett *et al.* 2009).

1.2 General principles for ecological management

- Ecological management is intended to achieve agreed target conditions for communities and species. It is adapted as necessary to improve the likelihood that managed entities will achieve this.
- Adaptive ecological management compares the agreed target condition to the entities' changing condition over time, relative to the condition at the start of the management phase. It is based on initial 'baseline' assessment followed by ongoing well-designed programs of monitoring and evaluation.
- Ecological management (including adaptive management) continually takes into account the actual and expected impacts on the entities being managed (including climatic variation effects, natural hazards and human activities).
- Ecological management should be designed to protect the most valued components of the complex ecosystem of the area, while not putting other components at a disadvantage.

1.2.1 Adaptive management

Ecological management for the Guidelines area (see Chapter 3) must concord with the overall adaptive management strategy set out in Molonglo Adaptive Management Strategy (AMS; ACT Government TAMS 2013), as follows (p. 11):

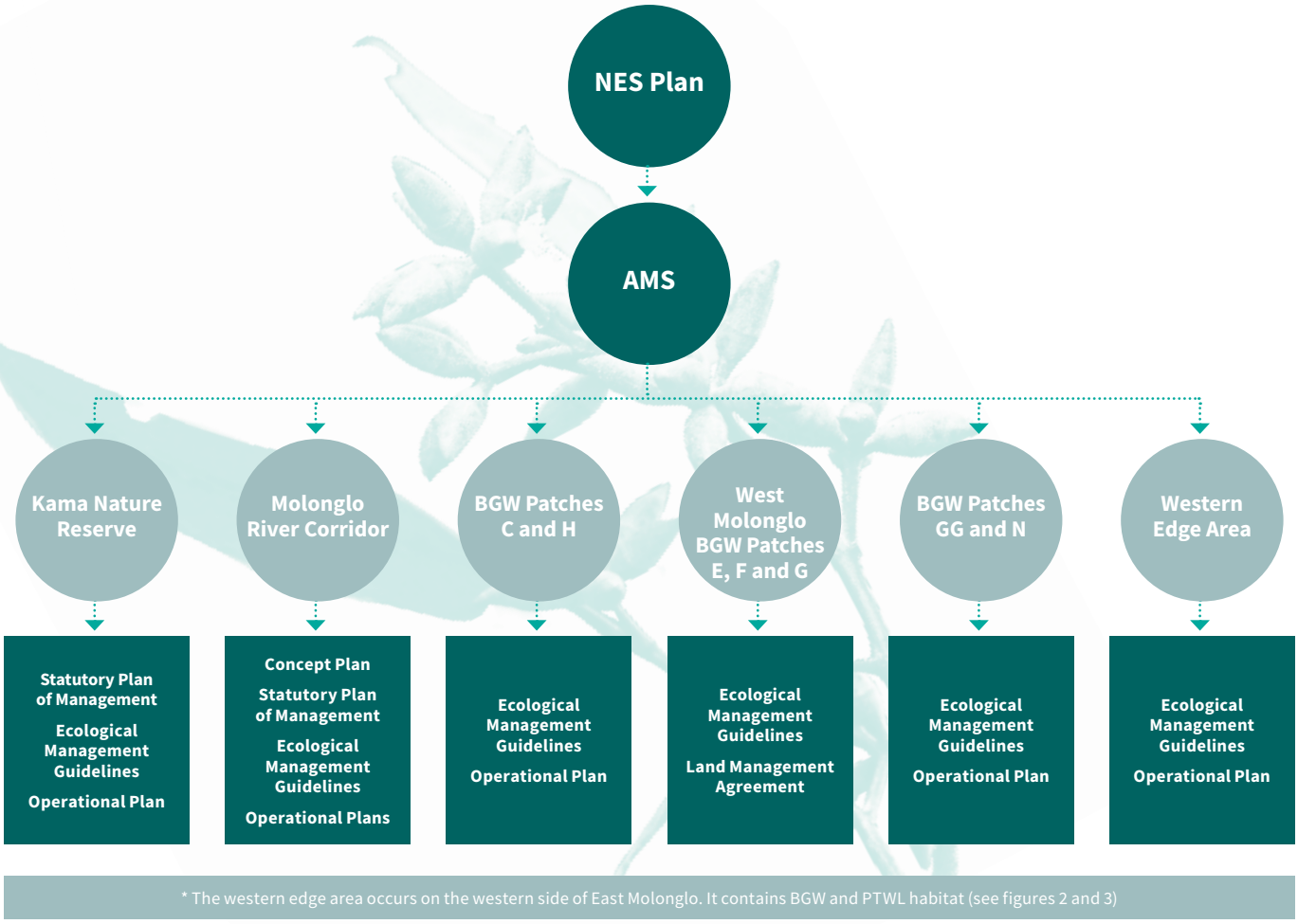
> adaptive management works through the identification of clear objectives, identifying areas of uncertainty and alternative hypotheses, testing assumptions, monitoring to provide feedback about the system and actions, learning from the system as actions are taken to manage it, and incorporating what is learned into future actions … .
>
> In summary adaptive management:
>
> - allows resource managers to maintain flexibility in their decisions, knowing that uncertainties exist;
> - provides managers the latitude to change direction;
> - improves understanding of ecological systems to achieve management objectives; and
> - ensures actions are taken to improve progress towards desired outcomes.

The AMS further distinguishes between adaptive and other management, as follows (p. 20):

> The identification of key threats to the achievement of conservation outcomes and performance targets for MNES is crucial to the AMS [adaptive management strategy]. It is the pre-emptive identification of threats and the subsequent account of them into management planning that distinguishes an adaptive management approach from one of trial and error.
>
> It is important to note the distinction between threats and uncertainties. In the context of the Molonglo AMS, threats refer to pressures on MNES which can be managed with a high degree of certainty to ensure that conservation outcomes and performance targets are met. Uncertainties relate to those areas of MNES ecology where current scientific practices and ecological knowledge is more limited. The achievement of conservation outcomes and performance targets does not necessarily result in the management and resolution of uncertainties. Uncertainties and their management through targeted studies are explained in Section 6 [of ACT Government TAMS 2013].
>
> The key threats to achieving the conservation outcomes and performance targets for the MNES are as follows:
>
> - weeds;
> - pests;
> - fire and fuel suppression;
> - impacts from recreation;
> - soil and water contamination;
> - soil erosion;
> - tree planting in Natural Temperate Grassland and tree planting or revegetation projects in Pink-tailed Worm-lizard habitat; and
> - increased resource competition from both native and exotic species.
>
> The adaptive management of these issues is addressed through the setting of objectives for each threat and through the monitoring of MNES to ascertain where any changes to management may be required.

In relation to the AMS, these Guidelines sit as shown below (Figure 1.1; ACT Government TAMS 2013, p. 31).

Figure 1.1. AMS management planning framework (Diagram 3, p. 31, ACT Government TAMS 2013). The six areas referred to are illustrated in Map 1.2 above; the 'Western edge area' is named Spring Valley Woodlands in Map 1.2.



* The western edge area occurs on the western side of East Molonglo. It contains BGW and PTWL habitat (see figures 2 and 3)

1.3 Outline of these guidelines

The next section (s.1.4) summarises the objectives and conservation targets for ecological management in the Guidelines area particularly for the five MNES; the final section of this chapter presents recommendations for the adaptive ecological management of the Guidelines area.

Chapter 2 describes the vegetation, fauna and other ecological values of the Molonglo River Reserve and offsets.

Chapter 3 explains the aims and recommendations for ecological management and restoration in more detail, including management of weeds, high fuel loads of plant biomass, pest animals, soil and water, and human impacts.

Both Chapters 2 and 3 discuss the whole of the Guidelines area, both non-riparian and riparian. Non-riparian areas comprise woodland and grassland (termed 'threatened habitat' and 'dryland matrix' in the Management Plan for the Reserve; ACT Government MP 2014) in the area's former paddocks and in the river valley. The riparian zone is the land immediately beside and within the Molonglo River and is distinguished by its riparian vegetation.

Chapter 4 outlines baseline assessment, monitoring, evaluation and reporting for all the ecological values: both principles and practice. These are essential elements of the adaptive management of the Guidelines area.

Chapter 5 outlines some points in legislation relating to these Guidelines, lists the zones and jurisdictions of the area, and summarises previous studies made in the Reserve.

The Reference list follows Chapter 5.

1.4 Management summaries for the MNES and other communities and species

Management and restoration are discussed in Chapter 3. The summaries below are for quick reference.

1.4.1 Management objectives

A range of sources give guidance on managing ecological values that occur in the Molonglo River Reserve and offsets (e.g. Rawlings *et al.* 2010; ACT Government TAMS 2011). Based on those sources, the following broad objectives are relevant to protecting ecological values in the Reserve and offsets:

1. Keep soil nutrient levels low (especially nitrogen, phosphorus and sulfur).
2. Maintain groundcover, including large fallen timber, where possible.
3. Prevent the grazing of native seedlings and sensitive species.
4. Minimise edge effects — for example, using buffers, patch shape and patch size.
5. Retain and protect the best vegetation first.
6. Target high productivity areas and critical habitat elements for protection, including standing dead trees, trees with hollows, rock outcrops, streams.
7. Promote the natural regeneration of existing trees, shrubs and groundflora where possible, rather than planting.
8. Retain larger patches which are more resilient and diverse.
9. Increase connectivity and reduce patch isolation and fragmentation to improve population resilience.
10. Manage for vegetation patchiness and heterogeneity.
11. Identify and address threats.
12. Maximise opportunities for community involvement and education.
13. Manage adaptively, responding to the results of monitoring, performance evaluation and unexpected change.

1.4.2 Box-Gum Woodland, other woodlands, Superb Parrot, Swift Parrot

Objectives (woodlands, parrots)

14. Become familiar with the patches of woodland and their characteristic ecological features: native trees (live and dead), native mid- and understorey vegetation, weed types and amounts present, vegetation features likely to support or deter woodland birds including the Superb Parrot and Swift Parrot, pest animals present or likely to be present, soil surface condition including aspects of landscape function, likelihood of human recreational or other non-management activity in each patch.
15. Maintain and increase diversity of characteristic native plants in Box-Gum Woodland areas towards benchmark condition including populations of threatened and significant species.
16. Control threats to the Box-Gum Woodland patches, especially understorey weeds, pest animals, uncontrolled fire and inappropriate human activities.
17. Maintain and improve the extent and quality of specific habitat features of value to Superb Parrot and Swift Parrot, including breeding habitat for the Superb Parrot and foraging habitat for both species.
18. Increase the breeding population of the Superb Parrot in woodlands of the Molonglo River Reserve and offsets.
19. Improve understanding of factors controlling choice of nesting sites by Superb Parrot.
20. Maintain and enhance habitat diversity for other woodland birds, invertebrates and other fauna; e.g. retain or restore fallen timber, hollows, rocks, structural diversity in the groundstorey, midstorey and tree-height vegetation.
21. Maintain or improve diversity of native groundstorey species.
22. Control grassy biomass to benefit native forbs, significant birds, invertebrate prey and fire hazard.
23. Enhance connectivity between patches.
24. Maintain buffer zones around Box-Gum Woodland patches and between urban areas and the riparian zone woodlands, which will assist in fire management, reduce weed spread into the management areas, provide off-reserve areas for activities that may compromise ecological values, reduce movement of feral animals into the management areas, and protect the river and riparian zone from pollution by sediment and other run-off constituents.

25. Communicate with and educate the general public who use or may use these areas so they understand the value of the patches and their ecology, and limits on use of the patches for recreation and waste disposal. Communication should also educate nearby landowners on what they can do to encourage and protect wildlife (eg adherence to cat containment, use of native plants in gardens, keeping dogs on leads)
26. Involve the general public in the management and stewardship of the woodlands.
27. Ensure human access and recreational uses do not compromise conservation values, particularly including breeding success for Superb Parrot.

Conservation targets (woodlands, parrots)

28. Fire fuel and biomass management result in an increase in native species diversity, structure and habitat, including live and dead midstorey vegetation, measured against baseline condition.
29. Fire management is in compliance with the fuel and fire suppression guidelines for threatened ecological communities and species (ACT Government ESDD 2012b).
30. Biomass management and general access do not introduce or support grassy weeds.
31. Native vegetation in the groundcover is >50% (or >70% where native vegetation diversity is high).
32. Bare ground occupies 20% or less of the area of each patch.
33. Kangaroo grazing and other biomass management in each patch maintain a groundlayer biomass ≥2 t/ha on average, never less than 1.5 t/ha, and ≤4 t/ha on average in autumn.
34. Tracks are designed, positioned and maintained so they do not result in erosion, loss of native vegetation diversity or increased weed invasion.
35. Landscape function is maintained at, or better than, baseline condition.
36. There is no active sheet, rill or gully erosion anywhere.
37. Water quality in the Molonglo River and the area's waterbodies is maintained at baseline condition levels or better through management of the quality of inflows.
38. Key habitat areas for Superb Parrot and Swift Parrot are managed, left undisturbed and protected from destruction.
39. Targeted surveys monitor occurrence and species activity of Superb Parrot and Swift Parrot.
40. The extent and quality of Box-Gum Woodland habitat for Superb Parrot and Swift Parrot are increased.
41. Known and potential nest trees for Superb Parrot are protected from destruction.
42. Nesting by Superb Parrots will not be significantly impacted by competiion from non-native fauna such as feral Honeybees , Common Myna and Common Starling.
43. No Swift Parrots die as a result of collisions with human-made structures or vehicles near woodland habitat.
44. Connectivity is maintained between the woodland breeding and/or foraging habitats in Molonglo and Belconnen.
45. Pest animal species are controlled, especially predators (foxes, pigs; cats and dogs are contained by legislation), so the threat within breeding and foraging habitat is reduced.
46. The urban community, including schoolchildren, understands the negative impacts of recreational activity and infrastructure in the areas, including informal tracks and jumps, weed spread, rock removal or disturbance, effects of people and dogs on native wildlife, particularly Superb Parrot and particularly in the breeding seasons.
47. Disturbance from human activity is limited, including at ground level, in bird breeding areas during the breeding season.

1.4.3 Natural Temperate Grassland, other grassland areas and grassy habitat for the Pink-tailed Worm-lizard and other fauna

Objectives (grasslands, fauna habitat)

48. Become familiar with the patches of grassland and their characteristic ecological features: grassland species present, any native trees (live and dead), native mid- and understorey vegetation, weed types and amounts present, vegetation features likely to support or deter grassland birds, pest animals present or likely to be present, soil surface condition including aspects of landscape function, likelihood of human recreational or other non-management activity in each patch.

49. Maintain and increase diversity of characteristic native groundstorey plant species in grassland areas towards benchmark condition including populations of threatened and significant species.

50. Manage threats to grassland areas, especially weeds, excess grassy biomass, pest animals, uncontrolled fire and inappropriate human activities.

51. Maintain and improve habitat diversity and specific habitat features — including fallen timber, hollows, rocks, structural diversity in the vegetation — for significant birds, invertebrates and other fauna, especially rocky grassland areas that are or may be habitat for the Pink-tailed Worm-lizard, and streamside breeding habitat for the Rainbow Bee-eater.

52. Control grassy biomass to benefit native forbs, Pink-tailed Worm-lizard, significant birds, invertebrate prey and fire hazard.

53. Maintain and enhance connectivity between patches.

54. Maintain buffer zones beside Kama, and between urban areas and river valley grassland and Pink-tailed Worm-lizard rocky grassland habitats. Buffers will assist in fire management, reduce spread of weeds and feral animals into the management areas, provide off-reserve areas for activities that may compromise ecological values and protect the areas and the river and riparian zone from pollution by sediment and other run-off constituents.

55. Communicate with and educate the general public who use or may use these areas so they understand the value of the patches and their ecology, and limits on use of the patches for recreation and waste disposal.

56. Involve the general public in the management and stewardship of the grasslands and Pink-tailed Worm-lizard habitat.

57. Manage bushfire operations, general human access (including for management) and recreational uses so they do not compromise conservation values.

Conservation targets (grasslands)

58. Fire fuel and biomass management result in an increase in native species diversity, structure and habitat, measured against baseline condition.

59. Fire management is in compliance with the fuel and fire suppression guidelines for threatened ecological communities and species (ACT Government ESDD 2012b).

60. Patches of low and tall tussock grassland are maintained to increase heterogeneity of the structure and habitat (ACT Government 2004b; McIntyre and Tongway 2005).

61. Native vegetation is maintained at >70% groundcover (or where grassland areas are in lower condition, the proportion of native vegetation in the groundcover is not reduced).

62. Bare ground occupies 20% or less of the area of each patch.

63. Kangaroo grazing and other biomass management in each patch maintain a groundlayer biomass ≥2 t/ha on average, never less than 1.5 t/ha, and ≤4 t/ha on average in autumn.

64. Tracks are designed, positioned and maintained so they do not result in erosion, loss of native vegetation diversity or increased weed invasion. Establishment of new tracks will be minimised and where appropriate existing tracks will be utilised.

65. Landscape function is maintained at or better than baseline condition.

66. There is no active sheet, rill or gully erosion anywhere that is not subject to erosion control measures.

67. Water quality in the dams in Kama and in the river is improved or not worsened from baseline condition.

68. Key habitat areas for Pink-tailed Worm-lizard are managed and left undisturbed, and targeted surveys are undertaken to monitor species numbers.

69. High impact recreation activities occur outside the Reserve.

70. Pest animal species are controlled, especially predators (foxes, pigs; cats and dogs are contained through compliance with legislative instruments) so the threat of predation is reduced within habitat for Pink-tailed Worm-lizard and in breeding and foraging habitat for Superb Parrot and other ground-feeding fauna.

71. The urban community, including schoolchildren, understands the negative impacts of recreational activity and infrastructure in the areas, including informal tracks and jumps, weed spread, removal or disturbance to rocks, effects of people and dogs on native wildlife particularly Pink-tailed Worm-lizard and ground-feeding birds including Superb Parrot.

1.4.4 Pink-tailed Worm-lizard

Objectives (Pink-tailed Worm-lizard)

72. Manage threats to the Pink-tailed Worm-lizard and its habitat.
73. Conserve in perpetuity representative viable populations of the Pink-tailed Worm-lizard in appropriate habitats throughout the Molonglo River Reserve and offsets.
74. Consider mapped habitat in the design of in-reserve infrastructure and in management planning so as to have a minimal impact on the potential habitat.
75. Prevent further fragmentation of populations and habitat.
76. Maintain and enhance potential connectivity between the major areas of habitat.
77. Build community support for habitat conservation.

Conservation targets (Pink-tailed Worm-lizard)

78. Low impact monitoring techniques are developed.
79. Loss of habitat, including removal of rocks from habitat areas, is prevented to avoid further fragmenting existing populations.
80. Rehabilitation techniques are developed and applied, to establish habitat in areas that have been previously disturbed by human activity (e.g. in former pine forests).
81. Management priority is given to areas that increase connectivity along the Molonglo River valley and with adjacent reserved land that supports the species.
82. Management of the species is based on knowledge of the genetic structure of the species in the ACT.
83. The general public's awareness and sense of responsibility for the species are increased.
84. Responsible pet ownership is enforced.
85. There is minimal disturbance to habitat from recreational activities.
86. There is minimal invasion of habitat by weeds.
87. There is minimal disturbance to habitat from deliberately lit fires (both management burning and accidental or deliberately lit fires).

1.5 Recommendations

The recommendations that emerge from the management guidelines are listed below. Much of the management required to maintain condition of the threatened communities, habitat for threatened species and the vegetation communities is similar across all parts of the Guidelines area.

1.5.1 Condition assessment and monitoring (see Chapter 4)

1. Implement existing procedures or develop peer-reviewed standards for survey and monitoring of vegetation communities, habitat and species populations.
2. Undertake strategic baseline condition assessment and mapping of MNES vegetation communities and abundance, and survey the distribution and condition of habitat attributes for fauna species (e.g. hollows, natural regeneration areas and wetlands). Apply benchmark scores for each management area for comparison with scores for high quality sites of that vegetation type.
3. Identify, map and protect areas of other native vegetation, both existing stands and proposed restoration areas that will be managed primarily for conservation; include surveys of selected native and introduced plant and animal species populations to guide management priorities.
4. Undertake baseline condition assessment at optimal times for each community and species, and collate as much quantitative data as possible on each attribute or group of attributes. Measure site attributes, issues and likely impacts (e.g. intensity of visitation by people, encroachment of urban areas, fragmentation of patches, implementation of bushfire mitigation operations).
5. Develop and co-ordinate monitoring programs and identify criteria to be assessed, based on the baseline condition assessment, to measure change resulting from management actions that will be applied and impacts likely to occur from construction, urban encroachment, disturbance.
6. Use monitoring to measure change in condition based on plant species diversity, cover and habitat diversity. Use monitoring also to assess the impacts of fire fuel management, water quality and flow regimes, impacts of grazing, slashing and herbicide use, and pest species impacts.

7. Monitor the MNES in ways that complement existing monitoring programs.

8. Apply a range of techniques, including condition monitoring, aerial photography, landscape function assessment and river health assessment.

9. Encourage and facilitate community groups and research and education institutions to undertake survey and monitoring of non-target vegetation communities and species, such as reptiles, invertebrates, woodland birds and small mammals including bats, and to apply community monitoring programs (e.g. Frogwatch, Waterwatch, Vegwatch and Bird Blitz).

10. Undertake regular inspections of the condition of areas to check for damage to the vegetation and habitat (including rock-rolling or removal). If impacts are detected undertake reparation work soon afterwards to improve condition before the effects of the impacts become major.

11. Maintain records of on-ground actions and significant events that may have impacts on ecological assets.

ASSESSING AND MONITORING PINK-TAILED WORM-LIZARD HABITAT

12. Establish a program of long-term monitoring to measure the response of Pink-tailed Worm-lizards and their habitat to management and impacts of urbanisation. Monitoring will include estimates of lizard abundance as well as measurement of key habitat variables.

ASSESSING AND MONITORING BIRD POPULATIONS

13. Use methods developed for surveying Superb Parrots elsewhere in ACT to monitor the known breeding areas in Spring Valley Farm and Central Molonglo.

14. Follow practices and timing established by the Canberra Ornithologists Group for use in baseline assessment and monitoring of bird fauna in the Molonglo River Reserve and offsets.

15. Monitor Rainbow Bee-eater nesting sites to assess management effectiveness and impacts from urbanisation on breeding activity.

ASSESSING AND MONITORING PEST ANIMALS

16. Use existing standard methods to survey pest animals abundance and distribution.

1.5.2 Protection of ecological values (see Chapters 3, 2, 1)

17. Apply an adaptive management process comprising these steps: assess problem, design management response, implement, monitor outcomes, evaluate, adjust and reassess problem. The aim is to ensure on-ground actions reflect best practice management, using results of monitoring to guide updates of operational plans and their implementation.

18. Prepare operational plans for each NES patch and area of the Reserve, taking into account requirements under the NES Plan, including management of buffers and detailed requirements for monitoring, evaluation and reporting of management outcomes.

19. Review operational programs regularly to update them in relation to new research findings, observations and thinking.

20. Establish a buffer zone[1] to the east of Kama (Kama East) and 20 m wide buffer zones around high- and moderate-quality Pink-tailed Worm-lizard habitat to protect these areas against urban edge effects; use the buffer at Kama East to keep fire fuel management, which may have adverse environmental impacts on threatened species and communities, outside Kama (as required by the NES Plan).

21. Where possible, locate non-conservation related land-uses, including asset protection zones, in places that minimise impacts to natural areas and threatened or significant species. Such land uses could include playing fields, cycling and walking trails, picnic areas or urban parks (Eco Logical Australia 2010a; ACT Government MP 2014).

22. Establish Parkcare or Landcare groups to enhance community awareness and provide community input to support management and monitoring.

1 Buffer width will be determined as part of the final planning and design framework – Stage 3 - EPD

1.5.3 General management recommendations (see Chapter 3)

23. Involve stakeholders, including residents of the new suburbs, other government agencies, research organisations and the wider community, in planning.
24. Ensure people undertaking management actions, research, recreation or other activities are adequately informed about ecological values and issues.
25. Ensure personnel working within patches containing MNES or potential or actual MNES habitat are adequately trained and informed about the ecological values and issues for that patch, so they can act in accordance with best practice standards.
26. Integrate management of patches containing MNES or potential or actual MNES habitat within the broader landscape in which they occur: that is, areas of Molonglo River Reserve should be managed as integral units, whether they contain Box-Gum Woodland and MNES fauna habitat or derived grassland or 'Rocky Natural Grassland' and Pink-tailed Worm-lizard habitat.
27. Manage buffer zones so they function effectively in protecting the NES patches from extreme impacts of fire hazard mitigation, recreation, or other human uses.
28. Maintain and improve a diversity or mosaic of vegetation structure across the landscape, including, where relevant, upperstorey, mid- and groundstorey vegetation, and habitat attributes such as rocks, fallen timber, logs, inter-tussock spaces, and perches for woodland birds, raptors and waterbirds.
29. Increase connectivity between NES patches and other remnant patches of vegetation wherever possible.
30. Develop access tracks, roads and infrastructure away from NES patches and areas containing MNES wherever possible.

1.5.4 Weed control (see Section 3.3)

Planning for weed control

31. Map the weed species of major concern and maintain records of changes, to guide prioritised management of weeds.
32. Stage control and removal of woody weeds so that woody weeds that are providing habitat structure (particularly in highly disturbed areas where the native vegetation has been extensively cleared) can be replaced with suitable native alternatives such as *Acacia* and *Bursaria* species.
33. Control weeds first in the areas that are in better condition, especially those with native groundcover and/or potential for native tree and shrub regeneration.
34. Locate any activities (such as community gardens) that involve cultivating soil, importing soil and organic materials, use of fertilisers and other inputs that will raise soil nutrient levels, more than 100 m away from sensitive natural areas, including moderate- and high-quality Pink-tailed Worm-lizard habitat, watercourses, riparian vegetation, and large grassy woodland and grassland patches that are in good ecological condition.
35. Plan control of water-dispersed weeds such as willows, Blackberry and African Lovegrass in particular, involving all relevant agencies in a whole-of-catchment approach.

Weed control actions

36. Observe strict vehicle hygiene, because there is a very high risk of weed incursions from propagules brought into the Guidelines area on utility, contractor and authorised vehicles.
37. Be vigilant at all times for incursions of highly invasive weeds, and follow guidelines for their removal; report their occurrence to weed control officers promptly. Of special note are Fireweed *Senecio madagascariensis* and any of the exotic needlegrass species *Nassella* spp.
38. Retain management access for weed control throughout the Reserve, while siting access roads and infrastructure where possible outside River She-oak Forest and the flood zone.

39. Prioritise control of weed species so that the first to be removed will be those species that are affecting vegetation diversity and processes in particular sites, and/or those that are out-competing native herbaceous and woody species for moisture and light; remove introduced species sequentially as alternative species are established.

40. When choosing specific weed control methods and timing, base the choice on the type of weed, its density, position in the landscape and the plant species surrounding it, as well as on the impacts control may have on significant fauna in that area.

41. Maintain the biomass of native herbaceous species at greater than 2 t/ha where possible, so that native plant competition can help reduce invasion by weed species such as Serrated Tussock and Paterson's Curse.

42. Apply control methods for the major weeds (including willows, Blackberry and African Lovegrass) in concert with control methods for factors contributing to weed invasion, including rabbits.

43. Revegetate areas left bare from weed control to prevent re-infestation by the same or other weeds and to minimise erosion.

44. Revegetate areas with native shrubs sequentially with removal of woody weeds that are providing habitat for native fauna, so the native shrubs provide alternative habitat.

ACTIONS SPECIFIC TO PINK-TAILED WORM-LIZARD

45. Apply only species-specific spot spraying and cut/paint methods for woody weeds in Pink-tailed Worm-lizard habitat and do not use broad-scale application of herbicides.

ACTIONS SPECIFIC TO RIPARIAN MANAGEMENT

46. Where appropriate consider an alternating strip method for the staged removal of willows and poplars and other woody weeds such as Blackberry, as described in the Molonglo Riparian Strategy (Eco Logical Australia 2011b), to reduce the risks of exposing large areas of streambanks, destabilising them and mobilising bed sediments.

47. Leave stumps and root mats of willows and poplars in place when applying weed control methods, to help stabilise the streambanks over the short to medium term.

48. Where possible, time water releases from Scrivener Dam to occur outside willow seeding times (usually around spring) to minimise the spread of willow seeds downstream into the Lower Molonglo River Valley, consistent with the Lake Burley Griffin Willow Management Plan (Molonglo Catchment Group 2006). Willow seed has a short viability period. (Note: this recommendation will need to be assessed against environmental flow requirements.)

Monitoring weed control outcomes

49. Monitor the distribution and abundance of invasive weeds, especially taking note of new invasions along tracks.

50. Monitor weed control activities and areas to:
(i) determine the success of control measures;
(ii) identify the need for follow-up control; and
(iii) identify whether there has been a change in native plant diversity as a result of weed control.

51. Monitor abundance of bird species in Box-Gum Woodland to determine if their populations have been affected by removal of woody weeds.

52. Correlate the results of monitoring with records of costs, areas treated and herbicides used. By doing this, the most effective means of control will become more apparent, leading to better outcomes (see Adaptive Management Strategy).

1.5.5 Managing plant biomass and fuel loads (see Section 3.4)

Planning for plant biomass management

53. Use biomass manipulation to increase native species diversity, structure and habitat, when measured against baseline condition.

54. Ensure fire management practices do not result in damage to habitat for threatened species or fire-sensitive species.

55. Refer to Table 3.2 to determine the management practices that are likely to achieve the desired outcomes for any particular area.

56. Identify combinations of methods of biomass manipulation that should achieve a diversity of structure, composition and habitat.

57. Consider the requirements of MNES and other species when applying methods to manage biomass.

Planned burns

58. Use planned burns to achieve ecological outcomes and use burns and weed control in preference to grazing by livestock to retain species diversity.
59. Do not conduct prescribed burns during droughts or at times when the soil surface layers (topsoil and surface organic layer) are dry.
60. Use ecological burns to retain groundlayer biomass at approximately 1.5–4 t/ha, on average across the site, measured in autumn in grassy ecosystems.
61. Do not apply regular prescribed burning to reduce fuel hazard in River She-oak Forest and Black Cypress Pine Woodland, in view of the sensitivity of the communities to fire, and generally low natural fuel levels.
62. Do not allow hazard reduction in adjacent communities to impact on the extent or quality of the River She-oak Forest or Black Cypress Pine Woodland communities.

Slashing

63. Develop plans for each site, to ensure weed-free areas are slashed before moving towards the most weed-infested areas, to avoid spreading weed seed and other propagules(Note. this is particularly important for African Lovegrass).

Grazing

64. Identify, map and monitor condition of areas that are under pressure from kangaroo grazing and camping.

Plant biomass management actions

GENERAL ACTIONS

65. Do not remove or disturb habitat when applying biomass management methods; take care not to remove or move rocks in areas that may be Pink-tailed Worm-lizard habitat. The structure and native plant composition of the habitat should be preserved.

Planned burns

66. Apply the Ecological Guidelines of the Bushfire Operations Plan 2011–12 (ACT Government 2011a) relating to fauna habitat, including seasonal restrictions, when undertaking planned burns.
67. Do not burn more often than prescribed in the Ecological Guidelines for each vegetation community or association and species of concern.
68. Apply burns as a mosaic, with no more than 25% of an area burnt at one time, and ensure some habitat remains unburnt for a longer period of time.
69. Vary seasonality of burns, so that the same groups of species are not repeatedly burnt at the same season, which could lead to loss of some species or prevent some species from regenerating; generally avoid burning during key breeding and dispersal periods for MNES and other fauna.
70. Apply burns in such a way that mature trees, saplings or logs are not severely burnt or destroyed, and so that trees with hollows do not collapse. Protect hollow-bearing trees during burns.

Slashing

71. Do not undertake mechanised slashing in wet conditions when the vegetation and structure of the soil could be damaged.
72. Ensure machinery is clean of seeds and seed-bearing soil when entering conservation areas; start mowing in weed-free areas and gradually move to areas with greater weed infestation to prevent spread of weeds.
73. Set slasher blade height to a minimum of 100 mm to prevent permanent damage to vegetation.
74. Remove slashed material (e.g. as hay) after slashing if it is likely to smother established native plants or increase nutrient levels.
75. Apply slashing along tracks and boundaries for reasons of visibility for pedestrians and vehicles and/or provision of fire breaks.
76. Apply slashing to manage biomass if conditions will not permit burning, or if burning could cause damage to some physical or ecological features.
77. Avoid slashing when it may result in loss of seed-bearing vegetation used by ground-feeding fauna including Superb Parrot.

Grazing

78. If an area is to be grazed by livestock, ensure there are opportunities for regeneration of native plant species, no removal of rocks or timber for firewood or to ‘clean up’ the site, that fertiliser is not applied, and that pest plants and animals are controlled.
79. Use rotational or crash grazing (grazing at a high stocking rate over a short period of time) to reduce biomass, to minimise preferential grazing, and to promote breakdown of herbaceous litter through trampling.

80. Take into account the total number of herbivores on a site, including livestock and kangaroos and pest herbivores, and their relative feed requirements, to maintain an average groundlayer biomass at no less than 1.5 t/ha.

81. Ensure stock are removed if the biomass is 1.5 t/ha on average, or less (to prevent exposing the soil surface and consequent erosion, and to avoid damage to vegetation), and if the groundstorey vegetation is not being replenished (for example during a drought).

82. Avoid or limit grazing by livestock (and pest herbivores) in areas where natural regeneration is to be encouraged.

83. Avoid grazing by livestock where revegetation and habitat restoration activities may be compromised.

84. Avoid using livestock grazing until after native seed has set, unless earlier grazing is likely to defoliate and prevent seed-set in exotic plant species in the area, especially annual grasses.

85. Avoid grazing where livestock may trample ground-built nests of species such as the Speckled Warbler or damage habitat for particular species such as the Rainbow Bee-eater.

86. Remove stock if they are causing ring-barking, or browsing on woody native vegetation.

87. Do not use barbed wire for fencing grazed areas, to prevent injury to native fauna.

88. Apply targeted seasonal grazing where soil nutrient levels are high, to remove the biomass of annual grasses, and prevent them from setting seed.

ACTIONS SPECIFIC TO PINK-TAILED WORM-LIZARD HABITAT

89. Do not remove rocks or reshape the ground surface in Pink-tailed Worm-lizard habitat or within their buffer zones. Avoid any activity that dislodges surface rocks or may lead to a potential decrease in native grass cover or introduction of weed species.

90. Maintain biomass below about 4 t/ha.

Planned burns

91. Conduct burns in winter or summer when the lizards are likely to be deeper in their burrows, and avoid burning in the period when the lizards shelter at the immediate underside of rocks.

92. If possible burn during the middle of the day or evening rather than early morning when lizards might be cold and slow moving.

93. Undertake prescribed burns in Pink-tailed Worm-lizard habitat at a maximum rate of once every 7–10 years.

94. Avoid using fire retardant because it increases soil phosphorus and is likely to increase weed infestation.

Slashing

95. Do not undertake mechanised slashing in high- and moderate-quality Pink-tailed Worm-lizard habitat.

96. Slash by hand (e.g. brushcutter) and remove the plant material, to target patches of weeds and tall and dense grass.

Grazing

97. Controlled livestock grazing may at times be required to manage excessive ground cover in high-quality and moderate-quality habitat and buffer zones. However, overgrazing, whether by kangaroos or livestock or pest herbivores, and especially during drought, should be avoided because it damages vegetation, particularly *Themeda* grassland.

98. Timing and intensity of grazing are important and should be monitored.

99. Remove stock if grazing is having an adverse impact on the habitat rocks, grass structure and vegetation.

100. Do not allow grazing to reduce tussocks to less than 20 cm height, to maintain tussock structure and inter-tussock spaces.

ACTIONS SPECIFIC TO THE RIPARIAN ZONE

101. Do not use chemical fire retardant, fire-fighting foam or wetting agents in or near the riparian zone.

102. Use rocky areas and narrow river channels with little floodplain development for fire fuel gaps; these areas are less likely to support either weeds or River She-oak Forest.

103. Ensure slashing activities do not result in slashed material or debris entering waterways, and that slashed material is not left on the streambanks.

104. Do not allow livestock to graze adjacent to the Molonglo River, so avoiding physical damage to the river banks and rocky habitat, and avoiding dung from contaminating the river water.

ACTIONS AT SPECIFIC SITES

105. Within Kama livestock grazing may be applied to achieve ecological outcomes, including control of undesirable plant species (such as annual introduced grasses) or to open up a dense canopy of grasses and provide gaps or niches for herbaceous native species, including rare or threatened species.

ACTIONS SPECIFIC TO SUPERB PARROT

106. Ensure there is no clearing of timber, trees with hollows, or disturbance to foraging areas in Superb Parrot habitat.

107. Avoid biomass manipulation activities during the breeding season in areas where Superb Parrot may be nesting.

Monitoring biomass management outcomes

108. Monitor vegetation communities to measure changes in condition and species diversity, as well as landscape function, to gradually build ecological knowledge and understanding in accordance with the Adaptive Management Strategy.

109. Apply monitoring so as to better understand the outcomes of applying different methods of biomass manipulation on vegetation composition, structure and fauna habitat, and whether goals and targets for the particular management areas are being achieved. Questions for monitoring include: Is biomass manipulation increasing native plant diversity? Is it enhancing particular species abundance or cover? Is it reducing exotic species populations? Is one type of biomass manipulation better than another in a particular site in achieving goals and targets?

110. Monitor slashed areas to pinpoint any invasion by introduced weeds so they can be promptly controlled; African Lovegrass and Chilean Needlegrass are frequently spread by slashers and other machinery, and the latter is likely to spread from peri-urban areas.

111. Monitor biomass quantities regularly in native vegetation at representative sites using standard methods such as the Overall Fuel Hazard Guide or biomass scores.

112. Monitor grazing impacts of kangaroos in selected habitat areas to determine if they can control biomass sufficiently, without additional control by burning, grazing by livestock or slashing.

1.5.6 Managing pest animals (see Section 3.5)

Planning for pest animals management

113. Use surveys and mapping to determine the presence and impacts of pest animals.

114. Bringing soil and organic materials into the Guidelines area and adjacent urban areas risks importing pathogens and introduced invertebrates (such as Portuguese Millipedes and European Wasps). Locate plant nurseries, community gardens and similar intensively managed areas in sites well away from natural parts of the Guidelines area.

115. Consider predator–prey interactions in undertaking pest control activities; for example, rabbit control may increase fox and feral cat predation on native fauna; rabbit control programs should be run in conjunction with control programs for introduced predators.

Pest animals management actions

GENERAL ACTIONS

116. Refer to codes of practice for the humane control of pest species.

117. Undertake pest control within a long-term strategy of control and maintenance and follow up by monitoring of impacts and population abundance.

118. Coordinate management of pest animals across the landscape.

ACTIONS SPECIFIC TO PINK-TAILED WORM-LIZARD

119. Control fauna (such as cats, dogs, foxes) that may prey on Pink-tailed Worm-lizards in and near their habitat.

ACTIONS SPECIFIC TO SUPERB PARROT

120. Control pest animals that compete with the Superb Parrot for use of suitable nesting hollows.

121. Control fauna (such as cats, dogs, foxes) that may prey on Superb Parrots.

ACTIONS SPECIFIC TO RAPTORS

122. Avoid using Pindone to control rabbits because it is known to be particularly toxic to eagle species if ingested.

ACTIONS SPECIFIC TO OTHER VEGETATION COMMUNITIES

123. Erect short–medium term fencing to control grazing pressure by rabbits and other herbivores (deer, goats) in existing and restored River She-oak Forest and Black Cypress Pine Woodland patches, in conjunction with general rabbit control measures.

124. Establish, maintain and monitor exclusion plots to determine their impact on local vegetation where rabbits are suspected of inhibiting regeneration by River She-oak Forest or Black Cypress Pine Woodland.

Monitoring pest animals management outcomes

125. Monitor abundance of pest populations through measuring habitat parameters, regardless of whether or not pest control activities are taking place.

1.5.7 Management of human impacts and benefits (see Section 3.6)

Mitigation against human impacts

126. Undertake community education to increase awareness of ecological values and their requirements in the Guidelines area, and to help limit recreational impact, minimise the risk of weed spread, and gain multiple sources of information on threats that require a response.

127. Encourage residents of nearby suburbs to adopt a stewardship role for areas of native vegetation.

128. Involve the community in the management and care of the areas via existing programs (such as Parkcare, Landcare, Waterwatch, Frogwatch and bird surveys) and new programs (Friends groups).

129. Enforce compliance in keeping cats contained in the suburbs of Molonglo Valley, and dogs out of dog-free areas.

Planning for human impacts

130. Ensure, wherever possible, recreational facilities requiring vegetation clearing or canopy suppression are nodal rather than linear, and located outside identified natural areas of native vegetation (existing and potential restoration areas).

131. Wherever practicable, make sure walking paths, cycle tracks and vehicle roads which cross the river channel are within Asset Protection Zones or Strategic Firefighting Advantage Zones, and preferably in natural firebreak areas such as rock bars, and outside Pink-tailed Worm-lizard habitat, prime River She-oak Forest, and wetland habitats.

132. Design and site any infrastructure so as to avoid damage to the River She-oak Forest and wetland communities in the event of fire or flood.

133. Maintain only low impact and low-use recreational opportunities in areas of high conservation value, including Kama and habitat for Pink-tailed Worm-lizard and Superb Parrot and other bird nesting and foraging areas.

Management actions for human impacts

GENERAL ACTIONS

Community involvement

134. Involve community groups, with assistance from experienced ecologists and rangers, in management, monitoring and other projects.

135. Provide guidelines to encourage complementary planting in gardens and open space, and identify species to be avoided, including the 'sleeper weeds' Chinese Pistachio *Pistacia chinensis*, Chinese Fairy Grass *Miscanthus sinensis* and Coastal Tea-tree *Leptospermum laevigatum*.

136. Ensure domestic animals are kept contained within designated areas or under control when out, and provide information to owners so they can help by active compliance.

Bushfire hazard management

137. Do not undertake routine and regular fuel hazard reduction that is in conflict with recommendations for management to achieve conservation outcomes, unless monitored fuel levels are shown to pose an unacceptable risk to human life and assets.

138. Hazard reduction should only be applied in response to measured fuel levels that exceed defined limits.

139. Control of particularly hazardous weeds such as African Lovegrass will reduce fuel hazard, as well as protecting biodiversity.

140. Apply a strategic and adaptive approach to achieve fuel reduction to reduce bushfire hazard; including by weed control, and use of slashing, burning and/or grazing in accordance with ecological guidelines for MNES and other fauna and flora.

Damage control

141. Enforce prosecution for illegal actions including rubbish dumping (e.g. construction materials and garden waste), collection of firewood or rocks, or arson and vehicle access in the Reserve and offset areas.

142. Use fencing, signage, use-restrictions and environmentally sensitive design of facilities and tracks to help protect ecological values.

ACTIONS SPECIFIC TO PINK-TAILED WORM-LIZARD

Bushfire hazard management

143. If required, aerial water bombing is acceptable over Pink-tailed Worm-lizard habitat as long as this practice does not cause adverse impacts (such as disturbing rocks, grasses, soil).

Damage control

144. Reinforce education aimed at discouraging rock collection and rock-turning and trampling in Pink-tailed Worm-lizard habitat with prosecution for illegal actions if required.

ACTIONS SPECIFIC TO SUPERB PARROT, SWIFT PARROT AND OTHER NATIVE BIRDS

Community involvement

145. Avoid siting public recreation areas within 100 m of existing or potential Superb Parrot nesting sites.

146. Avoid erecting structures with chain-mesh fences or large amounts of glass in the vicinity of Box-Gum Woodland and other potential Swift Parrot foraging sites.

147. Avoid human activities near nesting sites of bird species, within sight of sites frequented by large birds (raptors), and near feeding areas favoured by ground-foraging species.

148. Avoid siting public recreation areas within the vicinity of Rainbow Bee-eater nests.

Bushfire hazard management

149. Plan carefully for fire fuel reduction activities to ensure minimal disruption to nesting Superb Parrots.

ACTIONS SPECIFIC TO RIPARIAN MANAGEMENT

150. Do not allow stock grazing, dog-sledding, horse-riding, trail-bike riding, mountain-bike riding, camping and open wood fires in riparian areas.

Monitoring human impact outcomes

151. Monitor and review outcomes of human impacts on habitat condition and population abundance and distribution of threatened species.

1.5.8 Soil and water management (see Section 3.7)

Planning for soil and water management

152. Rigorously apply soil and water protection principles for construction and urban development within the Molonglo Valley to avoid downstream impacts on MNES and aquatic values and water quality.

153. Protect soil and water by managing frequency and intensity of biomass manipulation and controlling erosion through encouraging strategic restoration. This includes the placement of timber and logs to enhance natural regeneration and to reduce the velocity of water flow across the landscape.

154. Ensure any maintenance, upgrades or construction works at any waterway crossing adheres to guidelines in 'Fish Passage Requirements for Waterway Crossings' (Fairfull and Witheridge 2003), consistent with current Ecological Guidelines for Specified Conservation Actions (ACT Government 2011a), except where the structure prevents upstream colonisation by introduced species such as trout.

Soil and water management actions

GENERAL ACTIONS

155. Map, monitor and remediate active tributary gully and streambank erosion sites before beginning any revegetation works.

156. Apply management against erosion and sedimentation including:

- erosion control techniques, such as diversion banks, surface matting and mulching, cover-cropping, deliberate maintenance of landscape function via plantings, twigs, leaf litter, branches, etc.;
- drainage controls, such as hardened channelling, outlet protection and energy dissipation, check dams, infiltration zones;
- sedimentation controls, such as sediment fences and traps, buffer zones and filter strips, and detention basins.

157. Maintain groundcover and roots to protect soil and streambank stability.

ACTIONS SPECIFIC TO PINK-TAILED WORM-LIZARD

158. Ensure activity or construction or infrastructure upslope of Pink-tailed Worm-lizard habitat does not result in increase in surface flow and sediment movement into Pink-tailed Worm-lizard habitat.

ACTIONS SPECIFIC TO RIPARIAN HABITAT MANAGEMENT

159. Assess the specific river flow regime requirements to maintain condition in River She-oak Forest and identify flow patterns which may be contributing to reduced resilience in the community.

ACTIONS SPECIFIC TO WATER QUALITY IN THE RIVER

160. Pursue opportunities for achieving environmental flows and improved water quality from Scrivener Dam releases.

Monitoring soil and water management outcomes

161. Monitor the effectiveness of the application of soil and water protection actions across the landscape using standard methods such as Landscape Function Analysis and Ephemeral Drainage-Line Assessment (Tongway and Ludwig 2011).

1.5.9 Restoration and connectivity (see Section 3.8)

Planning for restoration and connectivity

162. Develop a strategic restoration plan for the Guidelines area, indicating priorities for revegetation and regeneration, and including Asset Protection Zones, canopy gaps for fire control such as Strategic Firefighting Advantage Zones, fencing and revegetation composition, density and methods. The plan should set out clear, quantified targets and time-frames for restoration.

163. Consider which elements of habitats relevant to MNES and other species can be used to improve habitat and increase connectivity, including planting of native vegetation (trees, shrubs, sub-shrubs and herbaceous species), fencing, ground litter, nest boxes, logs, rocks, tin sheets or tiles, branches, or topsoil translocation.

164. Prioritise restoration programs, beginning with areas identified in the NES Plan as offsets for loss of Box-Gum Woodland.

165. Follow the steps outlined for restoration in the Guidelines area:

- Determine what is to be restored at each site and the outcome(s) to be achieved.
- State desired outcomes as quantitative goals.
- Plan the restoration work around the requirements of particular ecological entities.
- Plan to protect what is already there.
- Make detailed site assessment and recommendations.
- Activate on-ground restoration works.
- Assess the end-product of the work, monitor and evaluate subsequent habitat improvement.

166. Coordinate restoration between different management areas and vegetation communities within the Guidelines area to efficiently use resources in collection of seed, growing plants and planting events, and to optimise connectivity planning.

167. Use planting as an adjunct to, not instead of, natural regeneration.

168. Identify areas for restoration by considering:

- the estimated natural distribution of the vegetation communities in the Guidelines area;
- existing remnant native vegetation, including isolated overstorey dominants (such as River She-oak, Black Cypress Pine and Snow Gums);
- significant features such as vegetation associations and plant populations, and important fauna habitat resources;
- fauna habitat connectivity requirements (riparian and upslope, inside and outside the Guidelines area, at a range of scales);
- potential shading impacts on Pink-tailed Worm-lizard habitat and habitat restoration and extension areas;
- fire protection and management requirements; and
- development plans within Molonglo Valley.

Restoration and connectivity actions

GENERAL ACTIONS

169. Use restoration to increase diversity of plant and animal species, vegetation structure and habitat, and increase patch size and connectivity of native vegetation across the landscape.

170. Ensure revegetation and other restoration is compliant with the Strategic Bushfire Management Plan.

171. Measure soil nutrient concentrations and apply treatments to reduce high concentrations prior to replanting.

172. Apply Florabank guidelines and other more recent guidelines to revegetation programs, including the restoration plan prepared for Barrer Hill (SMEC 2013).

173. Plan for a heterogeneous vegetation structure for each woodland management area: thickets of woody species, open treeless areas, scattered trees, areas of trees with and without a mid-storey of shrubs and trees at all stages of their life — seedlings, saplings, young mature trees, old mature trees with hollows, and dead trees that support a diversity of fauna species, subject to constraints to minimise fire hazard if required.

174. Evaluate the potential for enhancing habitat values in dams through restoration.

175. Identify the habitat features that may be re-introduced into particular NES patches, and where they should be placed for best effect. Ensure introduced features are free from weed seeds, contaminated soil or viable exotic seeds.

176. Give priority to planting herbaceous and sub-shrub species to enhance total composition and structure of woodlands.

177. Investigate opportunities to establish viable populations of threatened plant species into suitable woodland habitat. Following effective threat abatement measures, candidate species for reinstatement in forest, woodland and grassland habitats could include the threatened Pale Pomaderris (*Pomaderris pallida*), Tuggeranong Lignum (*Muehlenbeckia tuggeranong*), Button Wrinklewort (*Rutidosis leptorrhynchoides*) and Small Purple Pea (*Swainsona recta*), the ROTAP Australian Anchor Plant (*Discaria pubescens*) and the recently described rare shrub Mountain Leafless Bossiaea (*Bossiaea grayi*, formerly *B. bracteosa* sens. lat.).

178. Establish other species that have declined in abundance and become rare because of European-style land use.

179. Revegetate wetlands, drainage lines and gullies with indigenous species within Box-Gum Woodland (such as in Kama) to increase habitat values and help reduce erosion and enhance water quality.

180. Thin native tree thickets if growth of the trees is stunted and such thickets are reducing diversity.

ACTIONS SPECIFIC TO PINK-TAILED WORM-LIZARD

181. Do not plant trees and shrubs in the vicinity of rocky habitats or in Natural Temperate Grassland, to avoid shading habitat of Pink-tailed Worm-lizard and other species.

182. Undertake a trial program to enhance existing Pink-tailed Worm-lizard habitat and connect fragmented habitat by adding habitat rock and applying weed control.

ACTIONS SPECIFIC TO AREAS

183. Consider the possibility of planting trees between Box-Gum Woodland patches C and H to increase the combined patch size to more than 10 ha and to enhance bird habitat.

ACTIONS SPECIFIC TO THE RIPARIAN ZONE

184. Assess the Murrumbidgee River and Deep Creek confluences for their suitability for the development of more extensive River She-oak Forest habitat nodes within the river valley.

185. Consider establishing a demonstration site for good condition River She- oak Forest in the large and accessible River She-oak Forest patch at the mouth of the Molonglo River.

186. Revegetate river margins with local emergent aquatic species, especially in areas of high recreational use.

187. Pursue the establishment of environmental flows and improvement of water quality through changing Scrivener Dam water releases, as part of the restoration plan to help the recovery of River She-oak Forest and associated riparian and aquatic communities.

188. Maintain structural habitat in the riparian areas for birds, for foraging, roosting, perching and nesting, with tree branches overhanging the river; ensure that replacement habitat is provided in good time to compensate for removal of introduced species such as willows that currently provide that structural habitat.

Monitoring restoration and connectivity outcomes

189. Monitor abundance of bird species in restored areas to determine if diversity and population abundance have increased.

1.5.10 Potential research projects

190. Research optimal ways to reduce soil nutrient concentrations, building on previous research by Prober *et al.* (2005) and guided by trials being undertaken by Friends of the Pinnacle (Driscoll 2014), to enhance natural regeneration and revegetation and minimise weed establishment.

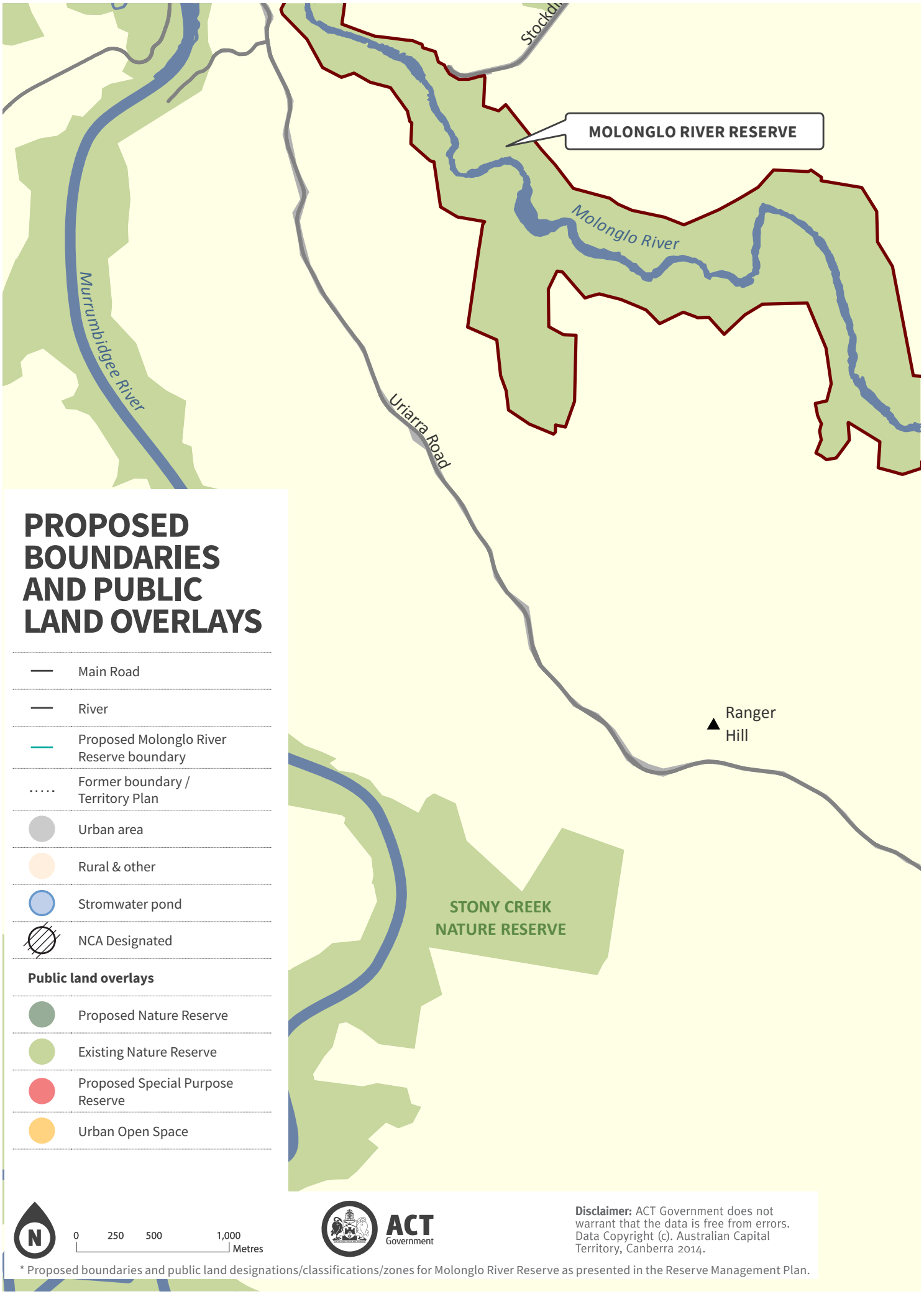
191. Use trials to establish methods for large scale restoration with diverse species.

192. Facilitate research into the fire ecology and post-fire recovery of *Callitris endlicheri* and *Casuarina cunninghamiana* communities, and fire-sensitive species such as *Discaria pubescens* and *Pomaderris pallida*.

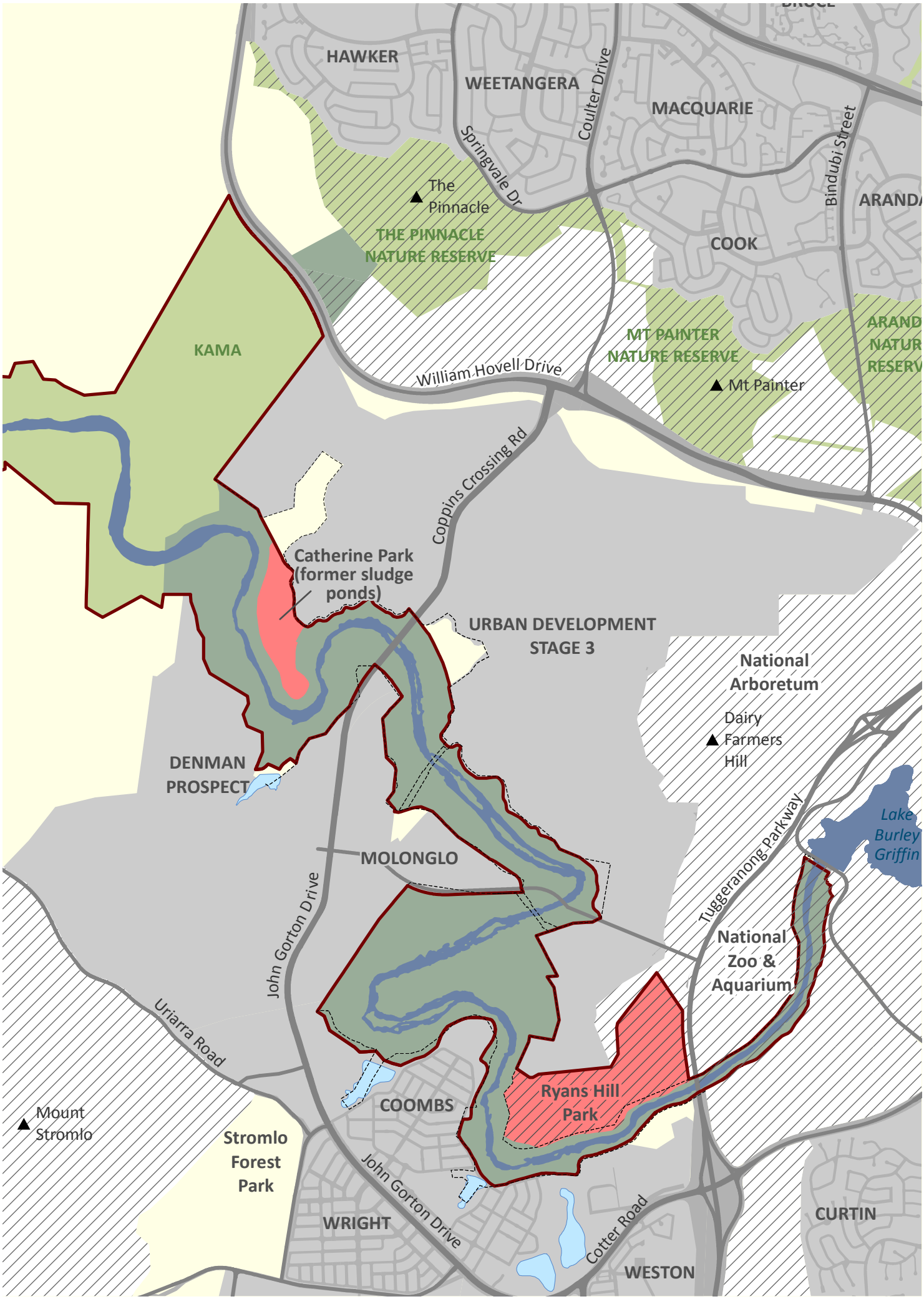
193. Research ways of minimising African Lovegrass invasion (e.g. the effects of shade).

194. Trial alternatives to Pindone for rabbit control, especially where raptors are likely to take treated animals.

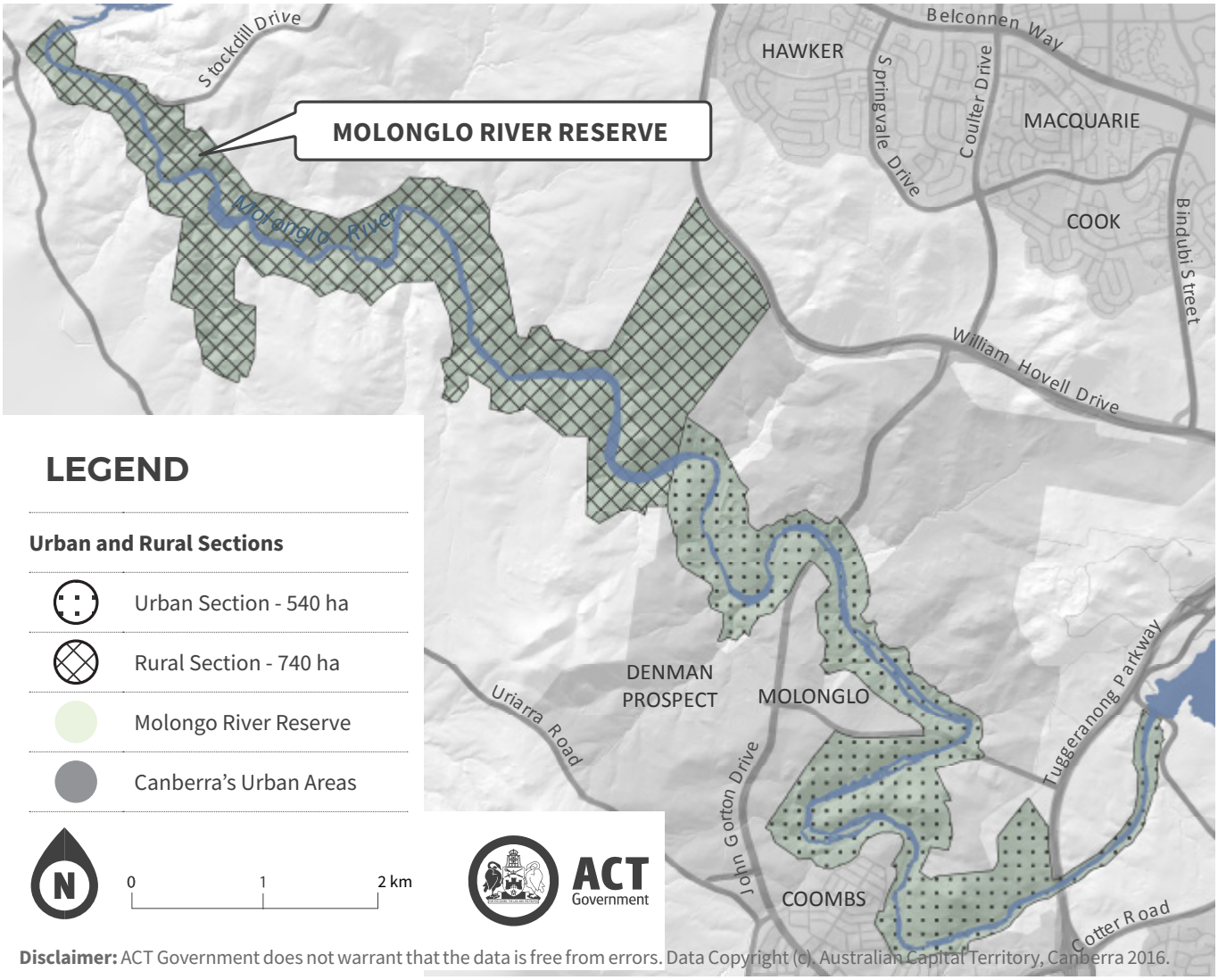
Map 1.1. (From ACT Government MP 2018, Figure 3.1)*



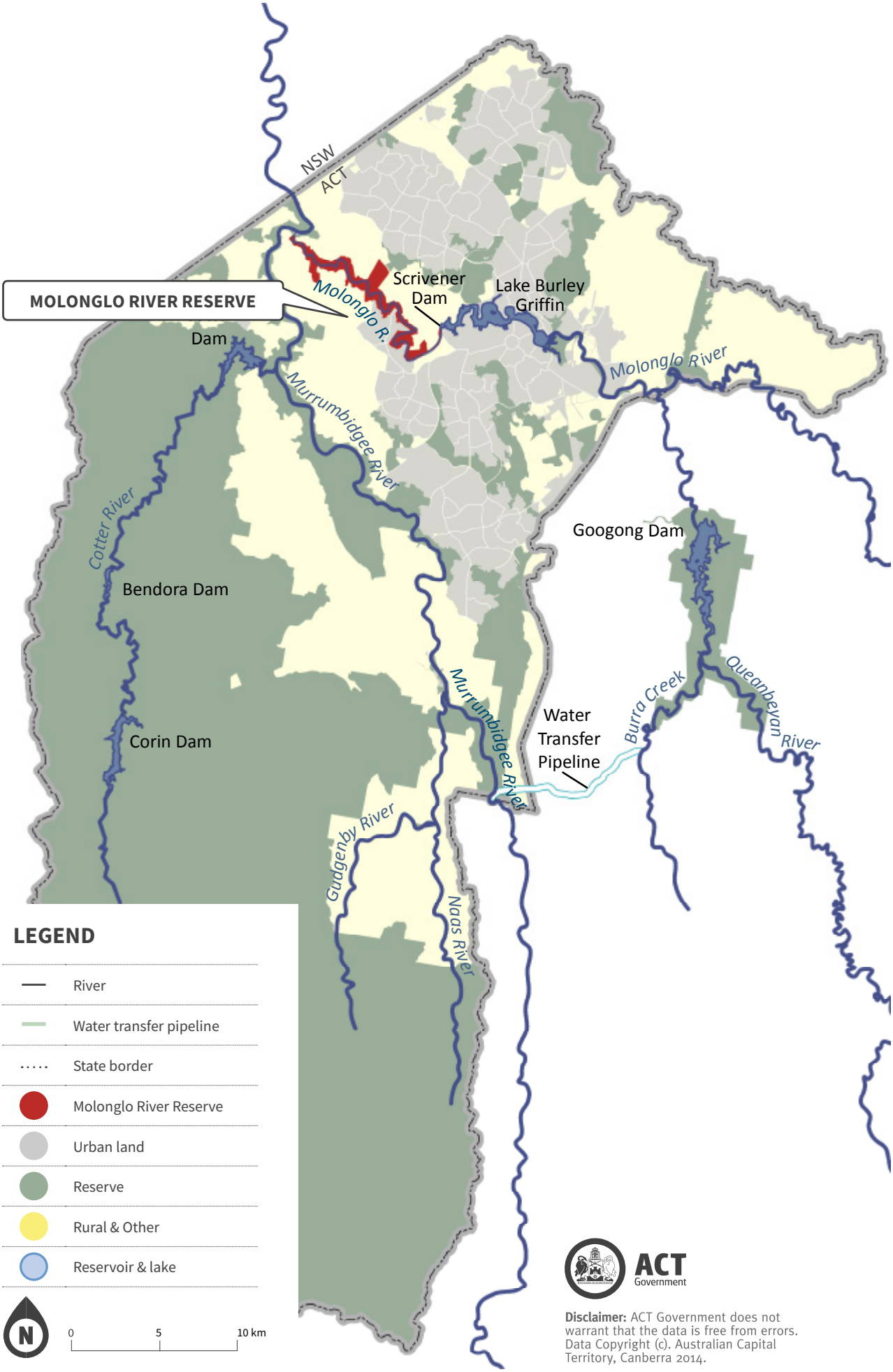
* Proposed boundaries and public land designations/classifications/zones for Molonglo River Reserve as presented in the Reserve Management Plan.


HAWKER
WEETANGERA
Coulter Drive
MACQUARIE
Springvale Dr
Bindubi Street
ARANDA
The Pinnacle
THE PINNACLE NATURE RESERVE
COOK
KAMA
MT PAINTER NATURE RESERVE
Mt Painter
William Hovell Drive
Coppins Crossing Rd
Catherine Park (former sludge ponds)
URBAN DEVELOPMENT STAGE 3
National Arboretum
Dairy Farmers Hill
DENMAN PROSPECT
Lake Burley Griffin
Tuggeranong Parkway
MOLONGLO
John Gorton Drive
National Zoo & Aquarium
Uriarra Road
Ryans Hill Park
COOMBS
Mount Stromlo
Stromlo Forest Park
John Gorton Drive
WRIGHT
Cotter Road
CURTIN
WESTON

Map 1.2 The urban and rural sections of the Reserve



Map 1.3 Molonglo River Reserve in its regional setting



Pink-tail Worm-lizard
Aprasia parapulchella

2. THREATENED AND SIGNIFICANT COMMUNITIES AND SPECIES, HABITATS AND THREATS

This chapter describes the five MNES vegetation communities and fauna species as well as other species that are threatened, protected or significant according

to the ACT Nature Conservation Act (NC Act) and/or the Commonwealth Environment Protection and Biodiversity Conservation Act (EPBC Act) and/or the NSW Threatened Species Conservation Act (TSC Act).

The chapter also discusses the types of habitat offered by the various vegetation communities and land types and the ways in which they are used by fauna, and the threats and threatening processes that need to be managed. Management is discussed in Chapter 3; the management objectives and conservation targets are summarised in s.1.4 above for quick reference.

The Molonglo Valley Plan for the Protection of Matters of National Environmental Significance (the NES Plan) (ACTPLA 2011) defines the areas that are subject to the ACT's commitments to protect the five MNES (as shown on Map 1.2 and outlined in s.1.1 above). These areas are the Molonglo River Reserve and a series of 'offsets' and patches of Box-Gum Woodland set aside to protect woodland and Pink-tailed Worm-lizard habitat in relation to the Molonglo Valley urban development.

The Molonglo River Reserve includes Kama and the Molonglo River and its channel and the river valley, for the whole distance between Scrivener Dam wall and the Murrumbidgee River (s.1.1; Map 1.1). As described in the Molonglo River Reserve Draft Management Plan (ACT Government MP 2014) the Reserve therefore includes both a near-urban section which borders the planned urban development, and a rural section (away from urban development).

2.1 Vegetation communities in Molonglo River Reserve and offsets

Vegetation in the Reserve is 'riparian' in the zone beside and including the river channel; and non-riparian elsewhere. Non-riparian vegetation begins adjacent to the riparian zone but above the influence of flooding and the riverine microclimate (see Map 2.1) and extends to the edge of the management areas.

Non-riparian land in the Reserve is categorised as 'threatened habitat' and 'dryland matrix' in the Reserve Management Plan.

The draft Reserve Management Plan explains the various categories of land in this way (pp. 41, 44, 46), where BGW, NTG and PTWL stand for Box-Gum Woodland, Natural Temperate Grassland and Pink-tailed Worm-lizard, respectively:

> ['Threatened habitat'] comprises the listed threatened vegetation communities and Pink-tailed Worm-lizard habitat above the river. In the urban section, it includes the NES-specified buffers around PTWL habitat. It does not include buffers in the rural section where there is a lower requirement for protection from disturbance. Threatened habitat defined in this way represents 265 ha or about 20% of the Reserve.
>
> …
>
> The dryland matrix consists of the … area of the Reserve that is not river or riparian. This area represents about 65% of the Reserve. It consists of:
>
> - the remaining areas of BGW and NTG that would originally have been classified in these two communities and that is now a mix of modified and weedy grasslands with scattered trees
> - former pine plantations containing mixes of remnant pine trees, self-regenerating pine and native trees with a weedy understorey containing a low proportion of native plants
> - habitat of *Pomaderris pallida*, an ACT threatened plant species scattered along the river banks in the rural section
> - patches of other vegetation communities:
>   – Snow Gum Grassy Woodland,
>   – Black Cypress Pine – Brittle Gum Tall Dry Open Forest,
>   – Broad-leaved Peppermint – Brittle Gum Tall Dry Open Forest.

> These latter communities are not listed as threatened, but Snow Gum Grassy Woodland, where it lies between woodland and grassland, is targeted for protection in the *ACT Lowland Woodland Conservation Strategy* (ACT Government 2004b).
>
> While not meriting protection at the level of threatened communities, this matrix between the less modified patches contains a diversity of native plants, provides important habitat for many species, including threatened species, and acts as crucial connectivity between the scattered areas containing the listed communities inside and outside the Reserve. The dryland matrix also encompasses the two proposed Special Purpose Reserves at Sludge Ponds and Bold Hill/Ryan's Hill. Sludge Ponds and Bold Hill are currently highly modified grassland and Ryan's Hill a former pine plantation.
>
> …
>
> The river and its riparian zone represent the remaining area in the Reserve, about 15%. The riparian zone is that area above the water level where a damper microclimate supports vegetation with different characteristics from adjacent dryland areas (ACT Government 2007). The conservation priority for this area is medium to high. It has fewer threatened species and communities but it is the icon of the Reserve and generally in better base condition for rehabilitation than the dryland matrix.
>
> Conservation goals for the river and riparian zone in the Reserve are already embodied in the ACT Aquatic Species and Riparian Zone Conservation Strategy, Ribbons of Life (ACT Government 2007).

The 'threatened habitat' — native grass associations belonging to the Natural Temperate Grassland threatened community, and woodland areas that can be identified as Yellow Box – Blakely's Red Gum Woodland (known as Box-Gum Woodland) in various condition, and Pink-tailed Worm-lizard habitat — also includes areas used by the Superb Parrot and potentially the Swift Parrot, and a range of other threatened or declining birds and other fauna. The Superb Parrot also uses modified woodland in offset areas in and beyond the 'dryland matrix', and the Swift Parrot could potentially feed in mistletoe found in the River She-oak trees of the riparian zone as well as in Box-Gum Woodland in the Reserve and offsets.

Vegetation in the Reserve areas termed 'dryland matrix' is defined in the draft Reserve Management Plan quote above.

According to the draft Reserve Management Plan (ACT Government MP 2014, p. 41):

> The BGW and NTG remnants that meet the listing criteria are scattered through the Reserve and, together with the scattered patches of grassland that support PTWL, are the areas that have the highest priority for protection and rehabilitation in the MP.

Threatened habitat occurs along the whole length of the Molonglo River Reserve (shown in yellow on Map 2.1 below from ACT Government MP 2014), as also does the dryland matrix (grey in Map 2.1). Much of the threatened habitat (other than in Kama) shown in Map 2.1 is Pink-tailed Worm-lizard habitat. According to surveys, the main areas of Box-Gum Woodland (yellow in Map 2.6 in s.2.3) and Natural Temperate Grassland (pale dove-grey in Map 2.6) in the Reserve are found in Kama. (Most other areas of Box-Gum Woodland covered by these Guidelines are in offsets outside the Reserve area and not covered by the Reserve Management Plan.)

The riparian zone is defined as the stream channel between the low and high water marks, and the adjacent land affected by high water tables, raised soil moisture or distinctive microclimate, which supports vegetation with different structure and/or floristics from that of adjacent terrestrial areas (after Naiman and Décamps 1997 and ACT Government 2004a).

In these Guidelines, the sides of the river are termed 'left' and 'right', relative to a person looking downstream.

Riparian land and vegetation, within and immediately beside the river channel (blue in Map 2.1), is of variable width and will have a different micro-climate from the dryland and its vegetation. In his detailed 1992 survey Barrer considered that where the river runs in an incised corridor or gorge the whole width of the gorge floor is likely to have a different micro-climate from the surrounding plain, supporting a subtly different range of habitat qualities (Barrer 1992 in ACT Government EA 2001). Indeed, Peden *et al.* (2011) note in their report (summarised in s.5.2) that in the upper gorge the stream channel is a 40–50 m wide bedrock floodplain. That floodplain vegetation may all be riparian.

2.2 MNES vegetation communities

2.2.1 Box-Gum Woodland

Box-Gum Woodland is the common name given to ecological communities based on the dominant tree species Yellow Box *Eucalyptus melliodora* and Blakely's Red Gum *E. blakelyi*, occurring in south-eastern Australia on western slopes and tablelands from southern Queensland, through NSW, ACT and Victoria (Australian Government Department of the Environment n.d.-a).

In Commonwealth legislation this community is defined as White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland. It is declared a critically endangered ecological community (CEEC) under the EPBC Act, supporting significant flora and fauna species including the threatened species Superb Parrot *Polytelis swainsonii* and Swift Parrot *Lathamus discolor.* It is estimated that nationally less than 5% of this community remains in good condition.

For an area to be listed as containing the critically endangered ecological community White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Grassland, the following criteria must be met (Australian Government Department of the Environment and Heritage 2006). A patch must:

- have White Box, Yellow Box and/or Blakely's Red Gum as the most common species currently or in the past;
- have a predominantly native understorey where at least 50% of the perennial vegetation cover in the groundlayer is made up of native species (i.e. not counting native or exotic annual plant species);

and either:

- be greater than 0.1 ha in size; and
- contain within the area at least 12 native, non-grass understorey species (including forbs, shrubs and ferns), including at least one important species (as defined in the declaration);

or

- be greater than 2 ha in size with natural regeneration of the overstorey species of 20 or more mature trees (greater than 125 cm circumference at 130 cm height) per hectare.

In the ACT–NSW region Box-Gum Woodland is defined as an endangered ecological community (EEC) under the NC Act and the TSC Act. In the NC Act, the defined name of the listed community is Yellow Box – Red Gum Grassy Woodland and it is distributed on the middle and lower slopes of hills at approximately 600–900 m above sea level, in gently undulating topography (ACT Government 2004b). Mapping indicates that approximately 35% of the estimated pre-1750 distribution remains in a partially or moderately modified condition in the ACT (ACT Government 2004b).

The ACT-listed ecological community also encompasses lower condition woodlands, although there are no quantitative criteria identified in the legislation.

Commonly associated tree species are Apple Box *E. bridgesiana*, Brittle Gum *E. mannifera*, Scribbly Gum *E. rossii* and Red Stringybark *E. macrorhyncha*. Other trees and tall shrubs include Cherry Ballart *Exocarpus cupressiformis*, Silver Wattle *Acacia dealbata*, Black Wattle *A. mearnsii* and Hickory Wattle *A. implexa* (ACT Government 2004b).

Shrubs are typically sparse, temporary (for example following a fire) or non-existent. Shrubs and sub-shrubs less than 0.5 m tall in ACT include Bitter Cryptandra *Cryptandra amara*, Urn Heath *Melichrus urceolatus* and Shrubby Rice Flower *Pimelea glauca*. Acacias may be temporarily common within areas that have been disturbed (such as by fire). Regenerating eucalypt seedlings and saplings form a mid-storey and thickets, particularly after cessation of grazing.

The groundlayer is dominated by native tussock grasses and a high diversity of native forbs. The dominant grasses are Kangaroo Grass *Themeda triandra*, spear grasses *Austrostipa bigeniculata* and *A. scabra*, wallaby grasses *Rytidosperma* spp. (formerly classified as *Austrodanthonia* spp.; Lepschi *et al.* 2012) and Tussock Grass *Poa sieberiana*. Many families of plants are represented in the woodlands, including daisies, sedges, lilies and orchids. Many native forbs are only found in woodlands that have been little disturbed by the introduction of fertiliser and/or ploughing (Dorrough *et al.* 2008).

All Box-Gum Woodland in ACT also contains introduced species, ranging from declared pest plants such as St John's Wort *Hypericum perforatum* to less competitive but widespread species such as Flatweed *Hypochaeris radicata* and Common Centaury *Centaurium erythraea*.

In the Reserve and offsets Box-Gum Woodland occurs in six distinct locations (see Map 1.2, s.1.1):

- Molonglo River Reserve (urban section) which includes Misery Point and Barrer Hill and other NES patches within the Molonglo River valley beside the urban development;
- Kama;
- leased land adjacent to William Hovell Drive;

- land within the Arboretum and adjacent to the Arboretum;
- leased land in Spring Valley Farm; and
- leased land in West Molonglo (to the west of Belconnen, ACT).

Condition of Box-Gum Woodland

Condition of Box-Gum Woodland can range from unmodified to severely modified (see ACT Government 2004b), as follows:

- unmodified lowland woodland: as it was at the time of European settlement; this condition no longer exists in this region;
- partially, moderately, or substantially modified woodlands: these differ in degree of modification to the structure and species of the cover of the trees, shrubs and groundlayer;
- severely modified woodland: contains only scattered trees over a groundlayer dominated by exotic species including weeds.

The more intact the native vegetation the less the modification reflected in the name. The more the disturbance, such as through clearing, soil movement or fertiliser additions, and the lower the proportion of native species in the groundlayer, the more the modification reflected in the name.

Some areas that appear to be grassland may also be regarded as Box-Gum Woodland. In these grassland areas the tree canopy has been removed, but the groundlayer is dominated by native species. The areas are termed 'moderately modified secondary (derived) grassland'.

Remnants that can be identified as 'partially modified' or 'moderately modified' woodland are likely to meet the criteria of the EPBC listed ecological community. The criteria also include 'moderately modified secondary grassland'. That is, under both ACT and Commonwealth legislation, grassland derived from Box-Gum Woodland (i.e. where Yellow Box and Blakely's Red Gum trees would originally have been the dominant tree species present) is part of the listed community.

Since the definitions above were compiled (2004), benchmark condition for Box-Gum Woodland in the ACT has been defined according to criteria developed for the NSW Government BioMetric (NSW DECCW 2011) (ACT Government CPR, unpublished data, March 2013). These values enable areas of Box-Gum Woodland to be compared to determine whether the condition of specific indicators meets or is below the benchmark scores for the community. Table 2.1 shows the benchmark values for high quality Box-Gum Woodland in the ACT (ACT Government CPR, unpublished data, March 2013).

Table 2.1. Benchmark values for Box-Gum Woodland in the ACT (ACT Government CPR, unpublished data).

Attribute	Value
Number of native species/0.04 ha area	35
Native overstorey percentage foliage cover	11–32%
Native mid-storey	0–12.5%
Native understorey percentage foliage cover (grasses)	23–63%
Native understorey percentage foliage cover (shrubs <1 m height)	0–4.5%
Native understorey percentage foliage cover (other — mainly native forbs)	8–16.5%
Number of large trees/0.1 ha area	5
Total length (m) of fallen logs/0.1 ha area	35

The benchmark values are based on criteria obtained by assessing woodland sites that appear to have been least modified by humans since European settlement; i.e. the best remaining sites (Gibbons *et al*. 2008). The criteria help in identifying standard or reference sites (Gibbons *et al*. 2008; NSW DECCW 2011) against which to compare the impacts of development, or for use to show the target condition aimed for in restoration projects.

Habitat features in Box-Gum Woodland

Even where a former Box-Gum Woodland area scores poorly in overall condition relative to the benchmark, it can still have important ecological values (ACT Government 2004b) and provide habitat for a range of species (habitat is discussed in more detail in s.2.7). Scattered trees in a groundlayer of predominantly introduced plant species provide ecological niches. They have positive effects on bird diversity in surrounding woodland patches and offer valuable ecosystem function at the local and landscape scale (Manning and Fischer 2010).

Box-Gum Woodland in the Molonglo River Reserve and offsets provides habitat for both the MNES parrot species (see s.2.4.2, s.2.4.3) and also for other woodland birds (s.2.5) to varying degrees. The following habitat features are particularly relevant to the parrots.

Mature healthy trees: relative to young trees, mature trees have more structure suitable for perching on, and more flowers and fruit and nectar per flower. This means that foraging is more energy-efficient for birds including the Swift Parrot.

- Tree hollows: these are an important resource for breeding and shelter for Superb Parrot, Brown Treecreeper and Southern Whiteface. Large old eucalypts are likely to have valuable hollows. The Superb Parrot in particular is found nesting in the highly modified woodland of scattered paddock trees within Spring Valley Farm (NES Patch M) and adjacent to the high conservation patch in Kama, though it has not been found nesting within Kama itself (Davey 2013a; Eco Logical Australia 2014). All hollow-bearing eucalypts in any vegetation community should be of highest priority to conserve.
- Mistletoe: an important food resource in woodlands, providing nectar for the Swift Parrot and other species.
- A diversity of native grass and forb species in the groundlayer: these provide structural diversity and feed diversity for species such as the Superb Parrot.

Threats to Box-Gum Woodland as an MNES

THREATS TO VEGETATION AND DIVERSITY

Box-Gum Woodland as an MNES is threatened by those factors and processes that would remove or damage the native vegetation components (live or dead, standing or fallen, overstorey or understorey), or lead to loss of structural diversity (physical or botanical) and loss of spatial diversity. Examples are severe disease and insect attack, inappropriate grazing regimes, excess grassy biomass, and illegal felling or removal of trees.

Inappropriate fire regime is another such threat. Box-Gum Woodland has an ecological fire threshold of 10–40 years or possibly longer. That is, a decline in biodiversity is likely if three or more consecutive fires occur with inter-fire intervals of <10 years, and if no moderate to high intensity fires occur within 40–50 years (ACT Government ESDD 2012b).

THREATS TO THE SITE AND HABITAT VALUES

Other important threats and threatening processes include nutrient pollution, active soil erosion and sedimentation and other factors that reduce soil stability at the site; pest plants and animals; and illegal or damaging human activities including removal of fallen wood, rubbish dumping, rock collection, arson and off-track vehicle access. Habitat values for birds are particularly threatened by human activities (noise and visitation, even if passive) and human interference, especially in the breeding season.

Threats to particular fauna species are discussed in those sections, and threats overall are summarised in s.2.8.

2.2.2 Natural Temperate Grassland

Natural Temperate Grassland is the common name for 'Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory', as defined under Commonwealth legislation (EPBC Act). Natural Temperate Grassland is listed as endangered under ACT legislation (NC Act) and in the EPBC Act.

Natural Temperate Grassland occurs in valleys influenced by cold air drainage, and on broad plains where minimum ground temperatures are often below –10°C. This grassland occurs on ridges, crests, hillsides, undulating plains, lower slopes, and near creeks and drainage lines and on river flats. It is usually associated with heavy textured soils with low nutrient levels (Australian Government Department of the Environment n.d.-b; ACT Government 2005; Armstrong *et al*. 2013).

The vegetation community is dominated by dense to open tussock grasses that are moderately tall (25–50 cm) to tall (50–100 cm). They are generally wallaby grasses *Rytidosperma* spp. (formerly named *Austrodanthonia*), spear or corkscrew grasses *Austrostipa* spp., *Bothriochloa*, tussock grasses *Poa* spp. and Kangaroo Grass *Themeda triandra*. Up to 70% of all the plant species in Natural Temperate Grassland may be forbs. The community may be treeless or contain up to 10% canopy cover of trees, shrubs or sedges.

Of the wide range of native forb species associated with Natural Temperate Grassland, the following species are relatively frequently encountered: Sheep's Burr *Acaena ovina*, woodruffs *Asperula* spp., Common Everlasting *Chrysocephalum apiculatum*, Pink Bindweed *Convolvulus angustissima*, cudweeds *Euchiton*, formerly *Gnaphalium* spp., Scaly Buttons *Leptorhynchos squamatus*, matrushes *Lomandra* spp., Variable Plantain *Plantago varia* and Narrow-leaved New Holland Daisy *Vittadinia muelleri*.

Threatened plant species that occur in Natural Temperate Grassland sites in the ACT include Ginninderra Peppercress *Lepidium ginninderrense*, Hoary Sunray *Leuchochrysum albicans* var. *tricolor* (white form) and Button Wrinklewort *Rutidosis leptorrhynchoides* (ACT Government 2005). In the Molonglo River Reserve, however, only Hoary Sunray is known. Although there is suitable habitat for Button Wrinklewort, it has not been found despite extensive surveys.

Until recently all mapping and survey for Natural Temperate Grassland in the ACT was based on descriptions of five distinct vegetation associations (as described in ACT Government 2005). Since then, analyses of extensive survey data from sites across the Southern Tablelands of ACT and NSW have identified eight Southern Tablelands grassland vegetation associations now being described (Armstrong *et al.* 2013).

In the Molonglo River Reserve there are areas of three of the vegetation associations, as follows:

- **r2,** River Tussock – Kangaroo Grass – Rush Wet Tussock Grassland of Footslopes, Drainage Lines and Flats of the South Eastern Highlands Bioregion (likely to be present in frost hollow pockets within the river corridor, and also called Tablelands Wet Tussock Grassland or *Poa labillardieri* Grassland; ACT Government 2005). Its characteristic species is *Poa labillardieri.*
- **r7,** Kangaroo Grass – Wallaby-grass – Snowgrass Moist Tussock Grassland of the South Eastern Highlands Bioregion (Patch A in Kama Nature Reserve). This incorporates Tableland Moist Tussock Grassland (Dry Themeda Grassland; ACT Government 2005). Its characteristic species are *Themeda triandra*, *Rytidosperma* spp., *Austrostipa* spp., *Bothriochloa macra*, *Poa sieberiana*.
- **r8,** Kangaroo Grass – Purple Wire-grass – Wattle Mat-rush Dry Tussock Grassland in the Southern Tablelands region of the South Eastern Highlands Bioregion (or 'Rocky Natural Grassland' occurring on rocky slopes within the river corridor, which may include areas that support Pink-tailed Worm-lizard; Sharp 2014). Its characteristic species are *Themeda triandra*, *Lomandra filiformis*, *Aristida ramosa.* (This was not recognised as a natural grassland type in ACT Government 2005.)

Areas of rocky grassland occur along the slopes of the Molonglo River valley in the Reserve. In previous reports (Biosis Research 2006; Eco Logical Australia 2009, 2010a,b; ngh environmental 2011) it was assumed these areas had been cleared of trees at some stage in the past, and these grasslands were defined as derived grassland, previously dominated by Yellow Box or Blakely's Red Gum (thus forming part of the endangered Box-Gum Woodland community). However, review of survey data against descriptions of the association in Armstrong *et al.* (2013) indicates that it is very likely at least some of these areas are natural grassland (Kangaroo Grass – Purple Wire-grass – Wattle Mat-rush Dry Tussock Grassland in the Southern Tablelands region of the South Eastern Highlands Bioregion, provisionally called 'Rocky Natural Grassland'). There is no evidence of indigenous trees or stumps there to suggest that trees have been cleared (Sharp *et al*. 2013; Sharp 2014).

Exotic species are frequently found in grasslands, and annual grasses and forbs may be especially common (Costin 1954; Sharp 1997), especially following fertiliser applications (Dorrough *et al*. 2008).

For an area to be listed as containing the endangered community, more than 50% of the total perennial plant cover in a grassland patch needs to comprise perennial native grasses, other native graminoids (lilies and sedges) and/or native forbs (that is, herbaceous plants that are not grasses, lilies or sedges) (ACT Government 2005). Beyond this there are no quantitative criteria to use to identify a community as 'endangered' or not, except that officially Natural Temperate Grassland is described as'up to 70% of all species being forbs' (Australian Government Department of the Environment n.d.-b)[2].

Condition of Natural Temperate Grassland

Condition of Natural Temperate Grassland and other native grassland areas has been defined in the ACT (ACT Government 2005) as ranging from unmodified to severely modified, as follows:

- unmodified lowland grassland: estimated to reflect the biological diversity at the time of European settlement; this condition no longer exists in this region;
- partially, moderately, highly, or substantially modified grassland: along this continuum the diversity and cover of native species including forbs and disturbance-sensitive species ranges from high to low, and there are increasing proportions of disturbance-tolerant native species and introduced perennial species;
- severely modified grassland: dominated by exotic annual and/or perennial species, but possibly containing some native species.

Natural Temperate Grassland that meets the definition of the endangered community under the EPBC Act, although not defined by quantitative limits, would be either 'partially modified' or 'moderately modified' grassland.

As noted in s.2.2.1, 'moderately modified secondary (derived) grassland' is Box-Gum Woodland, although it looks like native grassland, having greater than 50% native cover and containing native forbs. In terms of the plant community it is woodland. The groundlayer is similar to that of 'partially modified woodland' or 'moderately modified woodland' (see under 'Condition of Box-Gum Woodland', above), and the tree cover has been totally or partially cleared. At times it is difficult to distinguish such secondary grassland — that is, woodland that has been cleared of trees — from primary grassland that is naturally treeless (as mentioned above in relation to rocky grassland areas). Generally the position in the landscape (in low-lying valleys that are subject to cold-air drainage) and the surrounding vegetation make the distinction clear, as does the presence of 'markers' in the form of stumps or old fallen timber.

2 A draft revision of the national listing for Natural Temperate Grasslands of the Southern Tablelands (NSW and ACT) has been released for public comment. This revision proposes quantitative criteria which would be used to more clearly identify those sites that comprise the threatened community.

Benchmark condition for Natural Temperate Grassland in the ACT has been defined according to criteria developed for the NSW Government BioMetric (NSW DECCW 2011) (ACT Government CPR, unpublished data, March 2013). These values enable comparison of areas of Natural Temperate Grassland, to determine whether the condition of specific indicators is the same as or below the benchmark scores for the community. Table 2.2 shows the benchmark values obtained for high quality Natural Temperate Grassland in the ACT. No benchmark values have yet been identified for Kangaroo Grass – Purple Wire-grass – Wattle Mat-rush dry tussock grassland (**r8**).

Table 2.2. Benchmark values for Natural Temperate Grassland in the ACT (ACT Government CPR, unpublished data).

Attribute	Kangaroo Grass - Wallaby-grass Moist Tussock Grassland scores	River Tussock - Kangaroo Grass Wet Tussock Grassland scores
Number of native species/0.04 ha area	10	16
Native overstorey percentage foliage cover	0–1%	0–1%
Native mid-storey	0%	0%
Native understorey percentage foliage cover (grasses)	40–55%	30–80%
Native understorey percentage foliage cover (shrubs <1 m height)	0%	0–5%
Native understorey percentage foliage cover (other — in Natural Temperate Grassland, mainly native forbs)	3–8%	5–40%
Number of large trees/0.1 ha area	0	0
Total length (m) of fallen logs/0.1 ha area	0	0

Use as habitat

The Pink-tailed Worm-lizard (*Aprasia parapulchella*) occurs in rocky habitat within Natural Temperate Grassland. A range of other fauna species also make use of Natural Temperate Grassland, including kangaroos and birds, reptiles and invertebrates. Waterbodies in grassland areas, such as the dams in Kama, are habitat for waterbirds and amphibians.

Some parts of the Guidelines area would be classified as being highly or substantially modified grassland (sometimes called native pasture) and would not meet the criteria for listing as Natural Temperate Grassland (or Box-Gum Woodland). Nevertheless they provide habitat for a range of species, including threatened species, and play important functional roles. Many of these areas are either habitat for Pink-tailed Worm-lizard or provide buffers to that habitat. Some of them could be restored to enhance their diversity generally and to provide conditions suitable for populations of Pink-tailed Worm-lizard and other species.

Microhabitat characteristics of the Natural Temperate Grassland vegetation community are included in the habitat summaries in s.2.7.

Threats to Natural Temperate Grassland as an MNES

THREATS TO VEGETATION AND DIVERSITY

Threats to Natural Temperate Grassland and modified grasslands, even if severely modified, are those factors and processes that will lessen the condition of the grassland and its soil. They include factors that lead to loss of structural (physical and botanical) diversity and spatial diversity, and clearing of or inappropriate damage to the component native vegetation, whether live or dead including any standing or fallen trees or shrubs.

Examples of threatening factors include: inappropriate fire, severe insect attack, nutrient pollution, active soil erosion and sedimentation, pest plants and animals, inappropriate grazing regimes, excess grassy biomass, and illegal or damaging human activities including felling or removal of any trees and fallen wood, rubbish dumping, rock collection, arson and off-track vehicle access.

THREATS TO SITE AND HABITAT VALUES

Factors and processes that threaten the site, the vegetation community and its function as habitat also threaten fauna that use the ecosystem for habitat. Particular threats to habitat values for birds come from human activities (noise and visitation, even if passive) and human interference, especially in the breeding season. Rock removal or movement, dumping of rubbish and garden waste, runoff from disturbed areas, weed invasion, and predation by urban pets are among additional threats in grassland areas that are habitat for Pink-tailed Worm-lizard.

Threats to particular fauna species are discussed in those sections, and threats overall are summarised in s.2.8.

2.2.3 Ecological values and threats in the NES patches

The NES Plan (ACTPLA 2011) identified patches ('NES patches') totalling 359.1 ha of land containing Box-Gum Woodland for retention and management for ecological values, and 36 ha of Natural Temperate Grassland in Kama to be protected and adaptively managed.

More detailed surveys in 2012–13 identified Box-Gum Woodland in these patches totalling 340.4 ha (Eco Logical Australia 2013; ngh environmental 2012). Further surveys and analysis of existing data may result in a proportion of this Box-Gum Woodland being later redefined as Rocky Natural Grassland (see s.2.2.2); nevertheless the requirements for protection under the NES Plan would remain the same.

The NES patches equate to vegetation units that are relatively homogenous in terms of species composition, structure and condition. They are grouped into management areas (or 'offsets') based on their geographical location (Map 1.2, s.1.1): The urban section, including Barrer Hill) and Kama are within the Molonglo River Reserve and the other four offsets are outside the Reserve. The statistics given below for the vegetation units are based on Eco Logical Australia (2013) and ngh environmental (2012), with new details where they have changed since the NES Plan (ACTPLA 2011).

These patches of land have been set aside specifically to conserve MNES vegetation and fauna. Threats to their ecological values are discussed below. 'The likelihood, extent and severity of these impacts on patches of woodland depend on a number of variables, including size and shape of the patch, its proximity to urban areas and its intended use' (p. 98, Eco Logical Australia 2010a).

Molonglo River Reserve (urban section) The Molonglo River Reserve (urban section; Maps 2.2, 2.3a) extends from the Scrivener Dam wall to the eastern edge of the former Lower Molonglo River Nature Reserve. It includes the valley at the southern edge of Kama, and the southern end of Deep Creek and its valley.

The urban section is part of an important corridor linking the Murrumbidgee River valley (and the Brindabella Ranges beyond) to the Belconnen Woodlands and the central urban parklands around Lake Burley Griffin. Between Scrivener Dam and Barrer Hill ('Misery Hill' in Map 2.2a) the riparian zone has been severely disturbed and invaded by willows and other weeds (which nevertheless provide waterbird habitat, see s.2.5.8), but is less degraded further downstream.

Threatened habitat in the urban section is within a dryland matrix of mixed woodland, shrubland and grassland which needs to be managed as a whole. Threatened habitat in the urban section), based on baseline assessment in 2011–13 (ngh environmental 2012; Eco Logical Australia 2013), comprises:

- 17.2 ha of Box-Gum Woodland in patch D1 (Map 2.2);
- 54.3 ha of derived grassland (Box-Gum Woodland) in patches Q, R, S, K1 and T, identified in 2011–13 surveys. Further surveys may result in redefinititon of some or all of these areas identified as Rocky Natural Grassland (Sharp *et al*. 2013);
- 68.7 ha of high- and moderate-quality habitat for the Pink-tailed Worm-lizard that includes potential Rocky Natural Grassland patches (see above) in the urban section.

The NES plan identified 73 ha of Box-Gum Woodland and derived grassland (Box-Gum Woodland). There is dryland matrix totalling 16.8 ha in patches T (4.3 ha), K2 (10.2 ha exotic pasture) and D2 (2.3 ha native pasture). These were deemed in 2012–13 to no longer meet the criteria for endangered Box-Gum Woodland (Eco Logical Australia 2013), but nevertheless are likely to contain habitat for a range of native species.

Apart from its vegetation, Molonglo River Reserve (urban section) supports known and potential habitat for all three MNES fauna species: Pink-tailed Worm-lizard (as above); Swift Parrot potentially for feeding; and Superb Parrot and other threatened or significant woodland and waterbird species for feeding and breeding (see Table 2.12 and Map 2.6).

Note that the Rainbow Bee-eater (described in s.2.5.6) is known to nest within the urban section, specifically near the river in the vicinity of patches Q, R and S and near T1 (Barrer Hill) (see Map 2.2). This significant migratory bird species, which is listed in the EPBC Act and internationally, is not an MNES for Molonglo but has limited breeding habitat elsewhere in the ACT.

The Perunga Grasshopper *Perunga ochracea* (listed as vulnerable in the ACT Nature Conservation Act) has been recorded in native grassland in the Molonglo River Reserve (urban section; D. Wong pers.comm. 2009).

Table 2.3 summarises the current assessment of vegetation in the Molonglo River Reserve (urban section) patches. The area of each identified patch is based on 2012–13 surveys.

Table 2.3. Molonglo River Reserve (urban section) vegetation attributes (Eco Logical Australia 2013; ngh environmental 2012)

Patch	Vegetation	Average native plant species richness/0.04 ha	Native understorey cover	Floristic diversity	Habitat diversity
D1	Box-Gum Woodland (17.2 ha)	11	63%	Low	Low
D2	Low quality Box-Gum Woodland (not EEC) (2.3 ha)	11	30%	Low	High
K1	Box-Gum Woodland (derived grassland) or possibly Rocky Natural Grassland (33.2 ha)	17	85%	Moderate	Moderate
K2	Low quality Box-Gum Woodland (derived grassland) or possibly Rocky Natural Grassland (10.2 ha) (not EEC)	11	14%	Low	Very Low
Q	Box-Gum Woodland (derived grassland) or possibly Rocky Natural Grassland (6.0 ha)	19	64%	Moderate	Very high
R	Box-Gum Woodland (derived grassland) or possibly Rocky Natural Grassland (2.5 ha)	14.5	67%	Low	Moderate
S	Box-Gum Woodland (derived grassland) or possibly Rocky Natural Grassland (5.6 ha)	23	81%	Moderate	High
T	Box-Gum Woodland (derived grassland) or possibly Rocky Natural Grassland (7.0 ha)	No data	No data	No data	No data

THREATS IN MOLONGLO RIVER RESERVE (URBAN SECTION)

All the patches of woodland, shrubland and grassland in the urban section are close to residential areas and the river, and are likely to attract a range of recreational uses. In these patches and the riparian zone there is not only Box-Gum Woodland but also all the other significant vegetation communities and habitats found in Molongo (Table 2.9, Map 2.6, s.2.3, s.2.7).

Threats to the ecological values of Box-Gum Woodland and other woodland in NES patches D, K, Q, R and S on the left side, and T on the right and left sides of the Molonglo River between Barrer Hill and Coppins Crossing are of greatest concern. The patches are close to residential areas and the river is likely to attract a range of recreational uses. Habitats in these areas will be threatened by noise and human activity, not only from construction but also from continuing traffic and recreation. In addition, built elements such as fences and large panes of glass pose hazards to Swift Parrots and other birds. For example, up to 2% of the Swift Parrot population is thought to die each year from collisions (Pfenningwerth 2008).

Human activity (even passive) nearby is likely to threaten the success or continuation of breeding by significant waterbird species and the Rainbow Bee-eater, and may also threaten the presence of the Perunga Grasshopper.

Pink-tailed Worm-lizard habitat may be threatened by human recreation near its habitat (for example, by general bicycle and foot traffic, children's play, removal of rocks, picnicking, fishing) and dumping of rubbish or garden waste. Effects on the ground resulting from constuction are also potential threats to the lizard habitat. Damage from human activities that impact on the habitat of the Pink-tailed Worm-lizard is likely to accumulate over time unless there is an effective management response.

Threats that apply to all the types of woodland (see s.2.3) as well as to the derived and rocky grassland in these patches include: inappropriate fire, disease, insect attack, nutrient pollution, active soil erosion and sedimentation, pest plants and animals, inappropriate grazing regimes, excess grassy biomass, and illegal or damaging human activities including felling or removal of trees and fallen wood, rubbish dumping, rock collection, arson and off-track vehicle access.

Important threats particularly to the Black Cypress Pine Woodland (see s.2.3.1) include grazing of the seedlings by rabbits, and soil erosion because this community typically occurs on steep slopes. The River She-oak Forest (see s.2.3.3) in the river valley is fire-sensitiveand still recovering from the 2003 wildfire. Threats to this woodland community's recovery and conservation include inappropriate fire, weeds and rabbits.

Kama

Kama occupies 154.6 ha in the rural section of the Molonglo River Reserve (Maps 2.3a,b), with connectivity to Belconnen Hills and to the Molonglo River valley providing key habitat for Superb Parrot, Swift Parrot and other declining woodland birds.

Threatened habitat in Kama comprises both Box-Gum Woodland (118 ha as surveyed in 2012–13, rather than the 117 ha noted in the NES Plan) and Natural Temperate Grassland (~36.6 ha), as follows:

- patches A1 (22.1 ha) and A2 (14.5 ha), partially modified Natural Temperate Grassland;
- patches B1 (51.2 ha), B2 (42.7 ha), B3 (12.1 ha) and O1 (12.1 ha), Box-Gum Woodland;
- 3.4 ha of Pink-tailed Worm-lizard habitat within patches A1 and A2.

There is 'dryland matrix' in Kama East where the woodland does not meet the criteria for endangered Box-Gum Woodland or Natural Temperate Grassland. Kama East was designated in the NES Plan as a buffer to protect Kama from detrimental impacts resulting from fire fuel management, and from urban edge effects (ACTPLA 2011). Kama East comprises:

- patches O2–O4 (38.2 ha), which have 7.1 ha of woodland with a predominantly introduced groundlayer, contiguous with patch B, and other extensions of patch O. The lower section of patch O4 would have been Natural Temperate Grassland contiguous with patches A1 and A2, prior to extensive disturbance.

Table 2.4 summarises the assessment of vegetation in Kama and Kama East.

THREATS IN KAMA

In patches A, B and O, threats are of low concern, because of the size of the Kama area, its status as part of the Reserve and its protection by a buffer between the Reserve and future urban areas. The main threats are human interference, noise and recreational activity (even if passive) affecting habitat for the Superb Parrot and woodland birds (J. Bounds pers.comm. July 2012), and weed invasion. All other threats that affect the ecological values of woodland and grassland are also relevant in Kama. Fire mitigation actions that may compromise ecological values within Kama are to be kept outside the Reserve (ACTPLA 2011).

Table 2.4. Kama vegetation attributes (Eco Logical Australia 2013).

Patch	Vegetation	Average native plant species richness/0.04 ha	Native understorey cover	Floristic diversity	Habitat diversity
B1	Box-Gum Woodland	22	85%	Moderate	High
B2	Box-Gum Woodland	26	61%	Moderate	Very high
B3	Box-Gum Woodland	22	90%	Moderate	Very high
O1	Box-Gum Woodland	18	90%	Moderate	Low
A1	Natural Temperate Grassland	14.5	77%	High	Low
A2	Natural Temperate Grassland	27	86%	High	High
O2–4	Exotic pasture, some woodland; not EEC	8.5	23%	Low	Low

Arboretum woodland

Offsets beside the National Arboretum Canberra are designated patches GG and N in the NES Plan (ACTPLA 2011; Map 2.3). These patches are to be incorporated into the National Arboretum and extensively revegetated to restore habitat values.

MNES habitat in Arboretum woodland, based on baseline assessment in 2012–13 (Eco Logical Australia 2013), comprises:

- Box-Gum Woodland in patch GG1 (~44 ha) and patch N2 (7.8 ha), and an additional area of derived Box-Gum Woodland (patch GG2, 3.7 ha) that will not be developed.

The remaining parts were deemed in 2012–13 to no longer meet the criteria for endangered Box-Gum Woodland (Eco Logical Australia 2013). They contain depauperate native pasture derived from Box-Gum Woodland, in patches N1 (10.2 ha) and N3 (3.1 ha).

Early surveys were made during the severe drought while the patches were still leased and being grazed, and at that time patch GG1 did not meet the criteria as endangered Box-Gum Woodland. Since then the land has become unleased and ungrazed by livestock, and in 2012–13 Eco Logical Australia found patch GG1 to be entirely Box-Gum Woodland in varying condition.

Table 2.5 summarises the attributes recorded for the Aboretum woodland patches.

THREATS IN ARBORETUM WOODLAND

Ecological values of Box-Gum Woodland in NES patches GG and N are likely to be affected by weed invasion and wildfire, and later by urban edge effects and other threats that affect woodland as habitat (e.g. see Molonglo River Reserve (urban section), above).

Table 2.5. Arboretum woodland vegetation attributes (Eco Logical Australia 2013).

Patch	Vegetation	Average native plant species richness/0.04 ha	Native understorey cover	Floristic diversity	Habitat diversity
GG1	Box-Gum Woodland	19	85%	Moderate	High
GG2	Box-Gum Woodland	17	100%	Low	Low
N1	Depauperate native pasture	11.5	44%	Low	Low
N2	Box-Gum Woodland	13	99%	Low	Low
N3	Depauperate native pasture	6	60%	Low	Very low

William Hovell woodland

Two patches of rural leasehold land to be protected and adaptively managed under the NES Plan are adjacent to William Hovell Drive, with connectivity to the Belconnen Hills (patches C and H, Map 2.3). These patches are separated from each other by an intervening area of woodland of lower conservation value. If managed as one unit together with the connecting area, the viability and ecological value of the two patches would be enhanced.

MNES habitat in William Hovell woodland, based on baseline assessment in 2012–13 (Eco Logical Australia 2013), comprises:

- 6.9 ha of Box-Gum Woodland (patch C).

Patch H (8.6 ha) was deemed in 2012–13 to no longer meet the criteria for endangered Box-Gum Woodland (Eco Logical Australia 2013), and contains substantially modified woodland.

Table 2.6 summarises the attributes recorded for the William Hovell woodland patches.

Table 2.6. William Hovell woodland vegetation attributes (Eco Logical Australia 2013).

Patch	Vegetation	Average native plant species richness/0.04 ha	Native understorey cover	Floristic diversity	Habitat diversity
C	Box-Gum Woodland	13.5	60%	Low	Low
H	Low quality Box-Gum Woodland (not EEC)	8.5	60%	Low	Low

THREATS IN WILLIAM HOVELL WOODLAND

Ecological values of Box-Gum Woodland in NES patches H and C are likely to be affected by weed invasion and wildfire, and later by urban edge effects and other threats that affect woodland as habitat (e.g. see Molonglo River Reserve (urban section), above).

Spring Valley Farm

Four patches identified in the NES Plan are partly in the Spring Valley Farm rural lease held by the Australian National University, and partly in the former Bluett's pine plantation. These patches are contiguous with each other and with other woodland on the property and with the Molonglo River Reserve. They have connectivity through the river valley to Kama and Belconnen Hills, and should be managed as one area, together with other woodland within the property.

This management area may be particularly susceptible to impacts from fire hazard management (Eco Logical Australia 2011a), reflected in the proviso that if the condition is compromised a further offset site of 90.8 ha of Box-Gum Woodland will be protected elsewhere (NES Plan, see s.5.1.2).

MNES habitat in this area comprises Box-Gum Woodland (based on baseline assessment in 2012–13; Eco Logical Australia 2013). There is adjacent Pink-tailed Worm-lizard habitat extending north towards the river, through the Reserve (Map 2.4):

- 37.4 ha of Box-Gum Woodland in patches I (20.7 ha), L (2.2 ha), M1 (6.7 ha) and P1 (7.8 ha);
- 27.5 ha of habitat for Pink-tailed Worm-lizard (Osborne and Wong 2010).

The 8.0 ha of the Spring Valley Farm offset not occupied by Box-Gum Woodland contains other native vegetation communities or is dominated by exotic pines (Eco Logical Australia 2013). Table 2.7 summarises the attributes recorded for the Spring Valley Farm patches.

Table 2.7. Spring Valley Farm woodland vegetation attributes (Eco Logical Australia 2013).

Patch	Vegetation	Av. native plant species richness /0.04 ha	Native understorey cover	Floristic diversity	Habitat diversity
I	Box-Gum Woodland derived grassland	19	71%	Moderate	High
L	Box-Gum Woodland	28	70%	Moderate	High
M1	Box-Gum Woodland	21	86%	Moderate	High
M2	Red Stringybark – Scribbly Gum Dry Forest	No data	No data	Moderate	High
P1	Box-Gum Woodland	23	74%	Moderate	Very high
P2	Regenerating *Pinus radiata* wildings	No data	No data	Low	Low
P3	Bundy – Red Stringybark forest	No data	No data	Moderate	Very high

THREATS TO SPRING VALLEY FARM

In NES patches I, L, M and P fire mitigation actions (to protect future adjacent urban areas), wildfire and changes to current grazing practices may reduce the ecological values of the Box-Gum Woodland to the extent that the areas cease to be representative under the NES Plan.

The habitat values of the patches and adjacent Pink-tailed Worm-lizard habitat may be affected by threats from human activity which may deter Superb Parrot from breeding, and by factors affecting the groundstorey species composition.

West Molonglo woodland

West Molonglo woodland (in western Belconnen) is rural leasehold separated from the rest of the Molonglo Valley (see Map 2.4). There are several NES patches in this offset (see Table 2.8), which is contiguous with woodland within the Murrumbidgee River corridor.

The NES Plan identifies that land here will be adaptively managed to maintain and enhance the ecological condition of its Box-Gum Woodland. If this area west of Belconnen is developed for broadacre uses or residential development (the proposed 'West Belconnen') the NES Plan requires that the Box-Gum Woodland will be set aside as a nature reserve, subject to confirmatory ecological assessment (ACTPLA 2011).

Rather than the 64.2 ha designated in the NES Plan, MNES habitat here comprises:

- 38.8 ha of Box-Gum Woodland, based on baseline assessment in 2012 (Nash andHogg 2013).

The remaining 25.4 ha does not qualify as Box-Gum Woodland though previously identified as that community. It comprises exotic pasture, substantially modified Box-Gum Woodland and other vegetation communities.

Table 2.8. West Molonglo woodland vegetation attributes (Nash and Hogg 2013).

Patch	Vegetation	Average native plant species richness/0.04 ha	Native understorey cover	Floristic diversity	Habitat diversity
1A	Box-Gum Woodland	16	85%	Low	High
1B	Exotic pasture	3	0%	Very low	Low
1C	Box-Gum Woodland	15	92%	Low	High
2	Box-Gum Woodland	20.1	75%	Moderate	Moderate
3A	Box-Gum Woodland	10	88%	Low	Low
3B	Exotic pasture	11.5	28%	Low	Low

THREATS IN WEST MOLONGLO

NES patches E, F and G (now modified and called 1A, 1B, 1C, 2, 3A and 3B) are likely to be threatened by human activities if plans proceed for extensive development in this general area. In that case, the woodland will be subject to threats similar to those in the patches above which directly abut proposed urban areas. Threats to ecological values of Box-Gum Woodland apply here.

Summary

In summary, MNES vegetation (termed 'threatened habitat' or 'dryland matrix' where it occurs within the Reserve; ACT Government MP 2014) occurs in the Guidelines area as shown in Table 2.9. Amounts of 'Rocky Natural Grassland', as distinct from derived grassland, are not yet clarified. The Guidelines area also carries MNES vegetation in lower condition, other vegetation communities (s.2.3, Map 2.6), and weedy grassy areas. The physical areas (in hectares) of MNES vegetation and habitat in the part of the Reserve formerly named Lower Molonglo River Corridor Nature Reserve are still to be spatially defined.

Table 2.9. MNES vegetation and habitat in the offsets and NES patches (ngh environmental 2012; Eco Logical Australia 2009, 2011a, 2013; Nash and Hogg 2013).

Vegetation type	Molonglo River Reserve			Other offset areas				
	Urban section (ha)	Barrer Hill (ha)	Kama (ha)	Arboretum (ha)	William Hovell (ha)	Spring Valley Farm (ha)	West Molonglo (western Belconnen) ha)	Total (ha)
Box-Gum Woodland	17.2		118	55.4	6.9	37.4	38.8	280.2
Degraded Box-Gum Woodland (not EEC)	2.3	1.5		13.3	8.6			25.7
Derived Box-Gum Woodland or possibly Natural Temperate Grassland	47.3*	7						54.3
Natural Temperate Grassland			36.6					36.6
Degraded derived Box-Gum Woodland or possibly Natural Temperate Grassland (not EEC)	10.2	1.8						12
Pink-tailed Worm-lizard high and medium quality habitat	60.0	8.7	3.4	Yes		27.5		
Superb Parrot habitat			Yes (feeding)			Yes (nesting)		
Swift Parrot habitat	Yes (feeding)		Yes (feeding)					

2.3 Other vegetation communities

Apart from the MNES vegetation communities, seven other vegetation communities occur in the Molonglo River Reserve dryland matrix and riparian zone, including the former Lower Molonglo River Corridor Nature Reserve and Barrer Hill. Also there is Red Stringybark – Scribbly Gum Forest and exotic woodland (pines) in the Spring Valley Farm offset area (NES patches M, P). Map 2.6 shows the distribution of vegetation communities in the Molonglo River Reserve as identified in the draft Reserve Management Plan (ACT Government MP 2014).

For each community in this list the short name is followed by the full referenced name based on Armstrong *et al*. (2013):

- Black Cypress Pine Woodland (Black Cypress Pine – Brittle Gum tall dry woodland),
- Snow Gum Grassy Woodland (Snow Gum – Candle Bark tall grassy woodland),
- Apple Box – Broad-leaved Peppermint Shrubby Woodland (Apple Box – Broad-leaved Peppermint tall shrub-grass woodland),
- Red Stringybark – Scribbly Gum Forest (Red Stringybark – Scribbly Gum – Redanther Wallaby Grass tall grass-shrub dry sclerophyll woodland to open forest);

and in the moist or wet riparian zone beside and within the river channel:

- River She-oak Forest (River She-oak dry forest),
- Rocky Riparian Shrubland (River Bottlebrush – Burgan rocky riparian shrubland),
- Tableland Aquatic and Fringing Aquatic Vegetation Complex.

Barrer (1992) identified and mapped 11 open forest and woodland associations, seven riverine shrubland associations, five native grassland associations, eight wetland associations and the regionally significant fernland (*Pellaea falcata*) in the river valley between Kama and the Murrumbidgee confluence in both the non-riparian and the riparian zones (the former Lower Molonglo River Corridor Nature Reserve). Recent analyses of vegetation communities in the ACT have incorporated these associations into the communities listed above (Armstrong *et al.* 2013; ACT Government CPR, unpublished).

Relatively recent surveys have concentrated on determining the extent of threatened vegetation communities and threatened species (Eco Logical Australia 2008, 2009), and there has been only limited mapping and survey of vegetation communities other than Box-Gum Woodland and Natural Temperate Grassland. Apart from the Barrer study (1992), Peden *et al.* (2011) undertook photo-interpretation of the river valley, backed by point-based on-ground survey, but the actual extent and condition of each community were not identified.

All the types of native woodlands and open-forest in the Molonglo River Reserve and offsets are used by most of the significant woodland bird species, particularly those that require denser tree cover or shrubbier habitats than can be found in Box-Gum Woodland.

There are two vegetation-related significant heritage sites in the river valley identified by NCDC (1988):

- the Lower Molonglo Gorge — 80 metres incised river channel with hanging side valleys and river terraces that border the river and stands of Black Cypress Pine (*Callitris endlicheri*); of geomorphological, botanical and zoological significance; and
- bluffs and terraces — distinctly banded tuff rock face and narrow sandy terraces with River She-oaks (*Casuarina cunninghamiana*).

Note that there are no stands of Drooping She-oak *Allocasuarina verticillata* in the Reserve.

2.3.1 Black Cypress Pine Woodland

Black Cypress Pine Woodland (Black Cypress Pine – Brittle Gum tall dry woodland on hills primarily in the Cooma Region, NSW; u191 in Armstong *et al*. 2013) characteristically comprises *Callitris endlicheri*, *Eucalyptus mannifera*, *E. nortonii*, *E. macrorhyncha*, *E. blakelyi* and *Allocasuarina verticillata*.

Black Cypress Pine Woodland is a vegetation community targeted for conservation in the ACT (Sharp *et al*. 2007). Barrer identified the *Callitris endlicheri – Eucalyptus macrorhyncha* association in the lower Molonglo River corridor as rare, and of regional and possibly national significance because of its extent (Barrer 1992).

Black Cypress Pine itself is fire-sensitive and an obligate seeder[3]. It is eliminated by frequent intense fire (England *et al.* 2004 in ACT Government 2007). Trees that were 100% scorched in the 2003 fires have died. Much of the community was severely burnt in the January 2003 bushfires, though there has been regeneration from seed following the fire.

Since the 2003 fires, surveys have found the community in several places in the Molonglo River Reserve. Eco Logical Australia (2008) found Black Cypress Pine Woodland on the dry rocky steep slopes in the lower reaches of the Molonglo River, on both sides of the river, but more commonly on the lefthand side. The community was mostly in moderate condition, with two small sections (right and left bank) assessed as high condition. In 2011, Peden *et al.* noted that the Black Cypress Pine Woodland was destroyed by the 2003 bushfire on shallow soils but has survived on the deeper soils persisting at the bases of gullies.

One of three sites established in 2004 for long-term post-fire monitoring of the recovery of the community is in the Molonglo River Reserve, and monitoring results show some seedling recovery (ACT Government 2007). Sites on steeper land provide a degree of protection from fire and grazing, although the community is likely to have greatly contracted in range since European settlement (ACT Government EA 2001).

THREATS TO BLACK CYPRESS PINE WOODLAND

Wildfire, weed invasion and factors similar to those that affect Box-Gum Woodland are the main threats to this woodlandin the Molonglo River Reserve. Important threats particular to the Black Cypress Pine woodland include inappropriate burning, grazing of seedlings by rabbits, and soil erosion because this community typically occurs on steep slopes of the valley. Other threats may include nutrient pollution and felling or removal of trees and fallen wood. Although the species is an obligate seeder, the Ecological Guidelines for Fire and Fuel Management Operations (ACT Government ESDD 2012b) recommend that as far as possible this species should not be burnt.

Nearby urban development (see s.2.2.3) could threaten this community's value as habitat, through noise and human activity (recreational or otherwise) and rubbish dumping.

2.3.2 Snow Gum Grassy Woodland

Snow Gum Grassy Woodland (Snow Gum – Candlebark tall grassy woodland in frost hollows and gullies primarily of the Namadgi Range; u27 in Armstrong *et al*. 2013) is targeted for conservation in the ACT (ACT Government 2005; Sharp *et al*. 2007) and listed as an endangered ecological community in NSW under the TSC Act.

The community characteristically comprises *Eucalyptus pauciflora*, *E. rubida*, *E. dives*, *Daviesia mimosoides*, *Acacia dealbata*, *Poa sieberiana* and occurs in the South Eastern Highlands Bioregion. It occurs in the river valley of the Molonglo River Reserve (see Map 2.6).

Barrer (1992) and Eco Logical Australia (2008) in total recorded 104.8 ha of the community along the river valley that is now part of the Molonglo River Reserve.

3 Obligate seeders are plant species that are killed by fire, and the population then renews itself from previously shed seed, which only germinates after fire. Species can become locally extinct if a fire occurs before the vegetation has sufficient time to establish a large enough seedbank (BFCRC 2009).

Snow-Gum Grassy Woodland was noted in the upstream section of the Molonglo River Reserve in 2008, between Scrivener Dam and the beginning of the gorge, on both sides of the river valley, but more commonly on the righthand side of the river. The community was in poor condition between Scrivener Dam and just past Coppins Crossing, and in moderate condition in areas past Coppins Crossing (Eco Logical Australia 2008). The general loss of overstorey trees on land formerly used for grazing and pine plantations presents a challenge in determining the original distribution of the Snow Gum Grassy Woodland in the Reserve.

The community has an ecological fire threshold of 12–50 years. That is, its biodiversity is likely to decline both if there are three or more consecutive fires with inter-fire intervals of <12 years, and if there are no moderate to high intensity fires within 50–100 years (ACT Government 2012b).

THREATS TO SNOW GUM GRASSY WOODLAND

Threats identified for Box-Gum Woodland (see s.2.2.1) are generally applicable to this community, particularly in Molonglo River Reserve (urban section; s.2.2.3). Potential threats to the vegetation include inappropriate fire, disease, insect attack, nutrient pollution, active soil erosion and sedimentation, pest plants and animals, felling or removal of trees and fallen wood.

The value of the woodland as habitat is likely to be threatened by noise and human activity nearby.

2.3.3 River She-oak Forest

River She-oak Forest (River She-oak dry forest on sand/gravel alluvial soils along major watercourses; p32d in Armstrong *et al*. 2013) is a riparian vegetation community targeted for conservation in ACT (River She-oak Tableland Riparian Woodland in Sharp *et al.* 2007). This community typically comprises *Casuarina cunninghamiana*, *Acacia dealbata*, *Microlaena stipoides* and *Lomandra longifolia*, and grows on sand/gravel alluvial soils along major watercourses of the South Eastern Highlands and upper South Western Slopes Bioregions.

Within the Molonglo River Reserve (urban section) alone, River She-oak Forest occupies over 200 ha. Several River She-oaks have been identified as Exceptional Trees (defined as trees >12 m in height, >0.5 m diameter at 1 m above ground level, or at least 12 m in crown width; Eco Logical Australia 2008).

In 1992 Barrer had mapped River She-oak Forest community as occurring more or less continuously through the gorges section of the Molonglo River and upstream as far as Misery Point, beyond which willows dominated.

Most of this River She-oak Forest is currently considered to be in low and moderate condition: low and very low, in the urban section and near the confluence with the Murrumbidgee River, and moderate in the gorge section of the river, downstream of Kama (rural section; Eco Logical Australia 2008). Small sections in the gorge and closer to Scrivener Dam are considered to be in better condition. Near the Deep Creek confluence some areas are in excellent condition with plenty of mature and regenerating River She-oaks, some with mistletoe (Peden *et al.* 2011).

In general the community is largely dominated by weeds and has been significantly affected by the 2003 fires, as is evident by remaining dead standing trees. River She-oak Dry Riparian Forest has an ecological fire threshold of 25–100 years. This means that its biodiversity is likely to decline if there are two or more consecutive fires within 25 years of each other (i.e. before 2028), and also if there are no high intensity fires within 50–100 years.

THREATS TO RIVER SHE-OAK FOREST

Apart from inappropriate burning regimes for this fire-sensitive community, threats include weed invasion and rabbits, as well as threats specific to riparian areas such as soil and bank erosion and sedimentation, nutrient pollution of the water, and flood.

Where River She-oak Forest occurs in Molonglo River Reserve (urban section) the river valley is likely to be popular for recreation, which potentially will threaten this woodland's value as habitat, through noise and human activity nearby.

2.3.4 Apple Box – Broad-leaved Peppermint Shrubby Woodland

Apple Box – Broad-leaved Peppermint Shrubby Woodland (Apple Box – Broadleaved Peppermint tall shrub grass woodland; u29 in Armstrong *et al*. 2013) is mainly found on granitoids in the South Eastern Highlands Bioregion. Characteristic species are *Eucalyptus dives*, *E. bridgesiana*, *E. nortonii*. This community has been identified on 4.78 ha of the river valley in the urban section, as well as elsewhere in the Reserve downstream of Kama (rural section). Its ecological fire threshold is 12–40 years.

THREATS TO APPLE BOX – BROAD-LEAVED PEPPERMINT SHRUBBY WOODLAND

Threats identified for Box-Gum Woodland (see s.2.2.1) are generally applicable to this community. They include: inappropriate fire, disease, insect attack, nutrient pollution, active soil erosion and sedimentation, pest plants, and felling or removal of trees and fallen wood. Like other communities occurring in the Molonglo River Reserve, this woodland's value as habitat may be threatened by human activity and noise nearby.

2.3.5 Red Stringybark – Scribbly Gum Tall Dry Forest

Red Stringybark – Scribbly Gum Tall Dry Forest (Red Stringybark (*Eucalyptus macrorhyncha*) – Scribbly Gum (*E. rossii*) – Redanther Wallaby Grass (*Rhytidosperma pallidum*) tall grass shrub dry sclerophyll woodland to open forest; p14 in Armstrong *et al*. 2013) is typically found on loamy ridges of the central South Eastern Highlands Bioregion.

This woodland characteristically comprises *Eucalyptus macrorhyncha*, *E. rossii* and *E. mannifera* with an understorey dominated by *Rytidosperma pallidum.*

In the Molonglo River valley, Eco Logical Australia (2008) and Barrer (1992) between them noted Red Stringybark – Scribbly Gum Tall Dry forest occupying 24.9 ha, near the Murrumbidgee confluence as well as in the Spring Valley Farm area and West Molonglo (western Belconnen). Peden *et al.* (2011) noted a few patches of heavily fire-affected *E. macrorhyncha*, remnants of Red Stringybark – Scribbly Gum Forest, above the gorge.

An ecological fire threshold of 10–50 years is recommended for this community. The community's biodiversity is likely to decline if three or more consecutive fires occur within 10 years of each other, and if no moderate to high intensity fires occur within 50–100 years.

THREATS TO RED STRINGYBARK – SCRIBBLY GUM TALL DRY FOREST

Threats identified for Box-Gum Woodland (see s.2.2.1) are generally applicable to this community, in the urban section, the Reserve as a whole, and in the Spring Valley Farm offset areas. Its value as habitat may be threatened by human activity nearby.

Wildfire mitigation activity is noted as a particular threat at Spring Valley Farm, and otherwise threats to the vegetation include inappropriate burning, disease, insect attack, nutrient pollution, active soil erosion and sedimentation, pest plants, inappropriate grazing regimes, excess grassy biomass, felling or removal of trees and fallen wood, rubbish dumping and rock collection.

2.3.6 Rocky Riparian Shrubland

Rocky Riparian Shrubland (River Bottlebrush – Burgan Rocky Riparian Shrubland; u181 in Armstong *et al*. 2013) is also called 'Burgan Tableland Shrubland – riparian and dryland' (Eco Logical Australia 2008, 2011b). It occupies 25.33 ha in the riparian zone of the urban section, and also occurs elsewhere in the Reserve downstream of Kama (rural section).

This community occurs in the South Estern Highlands and upper South Western Slopes Bioregions, and characteristically comprises *Kunzea ericoides*, *Melaleuca paludicola* syn. *Callistemon sieberi*, *Bursaria spinosa*, *Pomaderris angustifolia*, *Cryptandra propinqua*, *Dodonaea viscosa*, *Acacia rubida*, *A. dealbata*, *Leptospermum obovatum* and *A. mearnsii.*

Peden *et al*. (2011) noted: 'in the upper gorge at the foot of the slope on the left side, there is a River Bottlebrush – Burgan Rocky Riparian Shrubland containing *A. mearnsii, K. ericoides* and occasional *M. paludicola*'. The shrubland was also seen downstream of the gorge where the Molonglo River forms a series of large pools.

The Rocky Riparian Shrubland community has an ecological fire threshold of 10–30 years. That is, a decline in biodiversity is likely if three or more consecutive fires occur with inter-fire intervals of <10 years, and if no high intensity fires occur within 30–40 years.

THREATS TO ROCKY RIPARIAN SHRUBLAND

Potential threats include weed invasion and pest animals, as well as threats specific to riparian areas such as soil and bank erosion and sedimentation, nutrient pollution of the water, and flood. Other threats could be inappropriate grazing regimes, excess grassy biomass, and rubbish dumping, as well as damage by human activity including access for fishing.

2.3.7 Tableland Aquatic and Fringing Vegetation Complex

Tableland Aquatic and Fringing Vegetation Complex characteristically comprises *Typha* spp., *Phragmites australis*, *Carex appressa*, *Juncus australis*, *Isolepis fluitans*, *Cyperus* spp., *Schoenoplectus validus* and *Eleocharis acuta*. This riparian community occurs in patches along the banks of, and in, the river, mostly near Scrivener Dam (Eco Logical Australia 2008).

In 2011 elements of this vegetation complex were seen on the banks of the river at the floodplain below Barrer Hill, namely *Phragmites australis*, *Persicaria* sp., *Bolboschoenus* sp., *Schoenoplectus* sp. and *Juncus* sp. (Peden *et al*. 2011). Also in 2011 the complex was evident near Scrivener Dam, where there was a high cover and abundance of native semi-aquatic fringing vegetation in the backed-up water created by the willows and low flows caused by Scrivener Dam, including *Typha domingensis*, *Schoenoplectus validus* and *Lythrum salicaria*. The native *Hydrocotyle tripartita*, *Ranunculus amphitrichus* and *Acaena agnipila* were growing abundantly on the raised moist rocky areas above the low base-flow level (Peden *et al*. 2011).

Further downstream, west of the Tuggeranong Parkway the aquatic fringing species still had a high native component and included *Schoenoplectus* sp., *Bolboschoenus* sp., *Cyperus* sp., *Persicaria* sp. and algal species (*Spirogyra* spp.) typical of the Tableland Aquatic and Fringing Vegetation Complex (Peden *et al*. 2011). Also, ngh environmental (2011) noted there was a small patch of wet grassland dominated by the native River Tussock (*Poa labillardierei*) on valley floor alluvium at the south-eastern end of Molonglo River Reserve (urban section).

At Coppins Crossing Peden et al. (2011) described the margins of the river as having patches of Tableland Aquatic and Fringing Vegetation Complex in good condition, containing *Persicaria lapathifolia*, *Juncus usitatus* and *Cyperus eragrostis*. As the river spread out among the boulders in the flat-bottomed but quite narrow valley floor, there were *C. cunninghamiana* with *A. mearnsii* on the terraces and in the river-line. The instream vegetation included extensive patches of *Myriophyllum verrucosum* and emergent *Phragmites australis, Persicaria lapathifolia, Juncus usitatus* and *Cyperus eragrostis*.

Close to the Deep Creek confluence, Peden *et al*. (2011) noted that the floodplain also included some *Typha* beds. Deep Creek, running under the aqueduct, was noted as a base-flow creek with *Crassula helmsii, Nasturtium officinale, Juncus articulatus* and similar plants in the riparian zone. The stream channel was braided in parts of the floodplain and wetlands had formed in some subsidiary channels.

In the upper gorge (Peden *et al.* 2011), there were occasional sandbars containing *Myriophyllum verrucosum* across the floodplain marking the ends of pools in dry periods. Also in the upper gorge at the foot of the slope on the left side, there were marginal beds of stranded *Schoenoplectus validus*. Downstream of the gorge the river formed a series of large pools. The fringing emergent vegetation included some *Schoenoplectus validus* and *Persicaria lapathifolia* (Peden *et al.* 2011).

THREATS TO TABLELAND AQUATIC AND FRINGING VEGETATION COMPLEX

This riparian community may be threatened by weed invasion and pest animals, as well as threats specific to riparian areas such as soil and bank erosion and sedimentation, nutrient pollution of the water, and flood. Other threats could be inappropriate grazing, excess grassy biomass, and rubbish dumping, as well as damage by human activity including access for fishing.

2.3.8 Other vegetation associations and species

The ACT Flora and Fauna Committee (ACT Government n.d.) has listed rare or biogeographically significant plants recorded in the Molonglo River valley. Table 2.10 shows species recorded in the Molonglo River Reserve, the locations, and important microhabitat characteristics, including:

- *Pellaea falcata* fernland, a regionally significant vegetation association that was recognised by Barrer (1992) in the river valley;
- Australian Anchor Plant *Discaria pubescens* and Birch Pomaderris *Pomaderris betulina* ssp. *actensis*, both of which are listed in the ROTAP register (Briggs and Leigh 1996) or have been rated as significant under ROTAP criteria;
- Hoary Sunray *Leucochrysum albicans* var. *tricolor*, which is listed as threatened under the EPBC Act but is not listed in the NC Act; it is found in the river valley opposite Misery Point;
- Pale Pomaderris *Pomaderris pallida*, which is listed as threatened under the EPBC Act but is not listed in the NC Act; it is present downstream of Coppins Crossing;
- 14 species listed as Protected under the NC Act;
- Mountain Leafless Bossiaea *Bossiaea grayi*, syn. *B. bracteosa* sens. lat., a recently described rare species; it occurs at the downstream end of the Reserve, and although it could not be found at recorded locations during surveys in 2006 and 2007 (McDougall 2009) three small populations have since been located (Luke Johnston pers.comm. in McDougall 2009). This species is restricted to the ACT and, like Pale Pomaderris, is fire sensitive. All known sites were burnt in 2003.

In the Molonglo River Reserve, protection from overgrazing, damaging fire, weed and pest invasion and excessive soil fertility should maintain conditions that allow native plant recruitment, ongoing recovery from wildfire damage, and spreading of rock refuge species such as Australian Anchor Plant and Blue Flax-lily into surrounding grassland.

The following threatened and protected plant species could also potentially occur in the Molonglo River Reserve in suitable habitat, although surveys to date have failed to find them (Eco Logical Australia 2010a):

- Button Wrinklewort *Rutidosis leptorrhynchoides*,
- Austral Toadflax *Thesium australe*, and
- Small Purple Pea *Swainsona recta*.

(A population of *Swainsona recta* is located in the Aranda Bushland and it is also known from Mt Taylor; ACT Government 2004b.)

Table 2.10. Significant vegetation species, habitats and locations recorded in the Molonglo River Reserve and offsets.

Species	Status	Habitat	Location
Trees			
Shrubs			
Bertia *Bertya rosmarinifolia*	Proposed Protected Plant (NC Act)		Barrer (1992)
Scaly Bossiaea, Mountain Leafless Bossiaea *Bossiaea grayi* (syn. *B. bracteosa* sens. lat.)	Proposed Protected Plant (NC Act) *B. bracteosa* sens. lat. indicated as 'rare' in RBG Plantnet	Grows in sand amongst boulders on river banks dominated by *Casuarina cunninghamiana* or occasionally in shrubland of rock outcrops close to the river (McDougall 2009). On rock outcrops at or a little above high flood level, and further from the river, on a protected south-facing gully slope amongst Burgan (Barrer 1992).	Directly south of LMWQCC (McDougall 2009). At least 4 mid-size populations in the downstream part of the corridor — 148° 58' 51" E/35° 15' 36" S: 148° 59' 13" E/35° 15' 49" S: 148° 59' 22" E/35° 15' 49" S: 148° 59' 50" E/35° 15' 36" S (Barrer 1992). All known sites burnt in 2003.
Australian Anchor Plant *Discaria pubescens*	Protected (NC Act) ROTAP 3RCA	Woodland, forest, among rocks and on deeper soils (Barrer 1992). Low cliff face among rocks (ngh environmental 2011).	Small to large populations scattered along length of Nature Reserve corridor (Barrer 1992). Left bank at MGA 685982 6089984 in Coombs Interface (7 plants) (ngh environmental 2011).
Tick Indigo *Indigofera adesmiifolia*	Proposed Protected Plant (NC Act)	Rocky places, mostly on volcanics. Widespread in woodland.	Left bank opposite Misery Point at MGA 685348 6090590 (ngh environmental 2011). Lower Molonglo Nature Reserve (Barrer 1992).
Birch Pomaderris *Pomaderris betulina* ssp. *actensis*	ROTAP 2R (PlantNet)	Shrubland, woodland and forest on ridges, cliff lines and dry gullies, usually on skeletal or shallow soils (Plantnet).	Very sparsely scattered on rocky slopes in the Coombs interface section, including at MGA 686010 6089719 (ngh environmental 2011).
Pale Pomaderris *Pomaderris pallida*	Protected (NC Act) ROTAP 2VCi Threatened (NSW) — V Threatened (Cwlth) — V	Often shallow woodland soils on rocky WSW-facing slopes (Barrer 1992).	Five populations recorded in Nature Reserve section, four on the right bank, one on the left bank (148° 58' 44" E/35° 15' 37" S: 148° 58' ll" E/35° 15' 1" S: 148° 58' 13"E/35° l5' 6"S: 148° 58' 18"E/35° l5' 14"S: 148° 59' 28" E/35° 15' 57" S). Two right bank populations were burned in 1990, in one population approximately 13 plants of an estimated 150 individuals survived to sucker from the base of the stem, but most died subsequently. Some seedlings have appeared following the fire. The other population of approximately 32 mature individuals survived with few casualties. The left bank population comprises approximately 90 plants of various ages (Barrer 1992).
Forbs			
Stiff Woodruff *Asperula ambleia*	Protected (NC Act)		Barrer (1992)
Milkmaids *Burchardia umbellata*	Protected (NC Act)	Recorded in a high slope seepage area, colonised by Burgan (Barrer 1992).	Recorded at one site in the Nature Reserve section (Barrer 1992).
Blue Flax Lily *Dianella longifolia* var. *longifolia*	Protected (NC Act) (as *D. laevis*)	Appears to prefer such steep protected south or south-east facing sites, apparently inaccessible to sheep, although a plant was noted on the north-eastern side of a limestone outcrop (Barrer 1992). Native grassland (Kangaroo Grass dominant) (ngh environmental 2011).	Mid-north (left bank) transect T31 and south (right bank) transect 24 in River Park (Eco Logical Australia 2009). In north of Coombs interface (left bank) at MGA 685348 6090590 and south of interface (left bank) upslope of MGA 686382 6089680 (ngh environmental 2011). Very occasionally along the length of the Nature Reserve section (Barrer 1992).

Species	Status	Habitat	Location
Hoary Sunray *Leucochrysum albicans* var. *tricolor*	Proposed Protected Plant (NC Act) Threatened (Cwlth) — E	Woodland and grassland.	Mid-north (left bank) transect T31 in River Park (Eco Logical Australia 2009) — note: record included survey data but not included in report findings in Eco Logical Australia (2009). Variety not specified.
Yam Daisy, Murnong *Microseris lanceolata*	Proposed Protected Plant (NC Act)		Barrer (1992) — as *M. scapiger.*
All orchids, including: Needle-point Rustyhood *Oligochaetochilus aciculiformis*	Protected (NC Act)	*Oligochaetochilus aciculiformis* (syn. *Pterostylis rufa* ssp. *aciculiformis*) grows in shallow rocky soils in a variety of habitats (Barrer 1992).	*Oligochaetochilus aciculiformis* (syn. *Pterostylis rufa* ssp. *aciculiformis*) is common and widespread within the Gorges in the Nature Reserve section (Barrer 1992).
Notched Swainson-pea *Swainsona monticola*	Proposed Protected Plant (NC Act)	Grassy woodland.	Left bank opposite Misery Point (Barrer 1992).
Graminoids			
Blady Grass *Imperata cylindrical* var. *major*	Proposed Protected Plant (NC Act)		Eco Logical Australia (2009) — Transect T23.
Ferns			
Bristly Cloak Fern *Cheilanthes distans*	Proposed Protected Plant (NC Act)	Steep rocky timbered north-facing slopes (Barrer 1992).	Not uncommon in Nature Reserve section (Barrer 1992).
Necklace Fern *Asplenium flabellifolium* Rough Maiden hair Fern *Adiantum hispidulum* Gristle Fern *Blechnum cartilagineum* Rasp Fern *Doodia aspera* Sickle Fern *Pellaea falcata* var. *falcata* Bristly Cloak Fern *Pleurosorus rutifolius* Tender Brake *Pteris tremula*	Protected (NC Act) – all ferns except Bracken and *Cheilanthes* spp.	Variety of rocky and sheltered habitats (Barrer 1992). Rocky knoll in Kangaroo Grass grassland (ngh environmental 2011).	Recorded in the Nature Reserve section (Barrer 1992). Necklace Fern recorded in north of Coombs interface at MGA 685348 6090590 (survey site 1) (ngh environmental 2011).

2.4 MNES fauna species

As noted in s.1.1, three fauna species are among the five MNES declared under the EPBC Act for the Molonglo River Reserve:

- *Aprasia parapulchella* (Pink-tailed Worm-lizard),
- *Polytelis swainsonii* (Superb Parrot), and
- *Lathamus discolor* (Swift Parrot).

This section discusses these three species. Sections 2.5 and 2.6 below (s.2.5, s.2.6) discuss other birds and other significant fauna known or thought to occur in the Guidelines area. Section 2.7 (s.2.7) then draws together information on characteristics of vegetation as habitat for fauna, and section 2.8 (s.2.8) summarises threats to the ecological values as a whole.

2.4.1 Pink-tailed Worm-lizard

The Pink-tailed Worm-lizard (or Granite Worm Lizard) *Aprasia parapulchella* is a member of the legless lizard family Pygopodidae (flap-footed or legless lizards), a family in which all species completely lack legs. Although somewhat similar in appearance to a very small snake, the Pink-tailed Worm-lizard does not have a bifurcated tongue nor the broad ventral scales characteristic of most snakes. It could be mistaken for a worm snake *Ramphotyphlops* but Pink-tailed Worm-lizards have prominent eyes unlike the eyes of worm snakes which are reduced to a dark spot under the scales of the head.

Pink-tailed Worm-lizards are grey or brown in dorsal colour, with a darker head and nape. The tail colour is a distinctive pinkish- or reddish-brown. Dark dots or longitudinal bars on the centre of each dorsal scale give the appearance of faint longitudinal lines running down the body and tail. The body is slender and round, the head is blunt and the tail is relatively short and round-tipped. Adults may reach a length (snout to vent) of approximately 150 mm, and can grow to a total length of about 240 mm (Jones 1999). In the ACT region the Pink-tailed Worm-lizard cannot readily be confused with any other species.

The Molonglo River Reserve has the largest known population of the lizard, nationally, particularly on the hill slopes near the Molonglo River (Wong *et al.* 2011), from near Misery Point to the confluence with the Murrumbidgee River 10 km to the west. In fact, most records of the species in Australia are from the ACT and adjacent region (Osborne *et al.* 1991; Wong *et al.* 2011). Effective conservation of this region's populations therefore will also protect the future survival of the species nationally. For details of the life-history and ecology of the Pink-tailed Worm-lizard, see Wong *et al*. (2011).

The Pink-tailed Worm-lizard as an MNES is listed as vulnerable under the EPBC Act. It is also listed as threatened in each state in which it occurs: vulnerable in the ACT (NC Act) and in NSW (TSC Act), and threatened in Victoria (Flora and Fauna Guarantee Act 1988) (Australian Government Department of the Environment n.d.-c).

Under the EPBC Act, actions that have, or are likely to have, significant impacts on the Pink-tailed Worm-lizard — an MNES — require approval from the Australian Government Minister for the Environment, because impact on nationally listed species is considered to be of national conservation significance. Therefore, Commonwealth approval is required to disturb or destroy habitat of the Pink-tailed Worm-lizard in the ACT. The species also has Special Protection Status (SPS species) in the ACT. This is the highest level of statutory protection that can be given; licensing is required for activities likely to impact on the habitat of the species (NC Act, Chapter 16).

Pink-tailed Worm-lizard behaviour

The Pink-tailed Worm-lizard lives largely underground. It co-inhabits the burrows of small ants and feeds almost exclusively on their eggs and larvae (Webb and Shine 1994; Jones 1999). It can be very difficult to see, even if present at a site, and is generally only found, occasionally, beneath partially embedded rocks. Such rocks are commonly about 10 cm to 30 cm in diameter.

In the ACT, Pink-tailed Worm-lizards have mainly been found in areas underlain by acid volcanic rock types — late Silurian acid volcaniclastic deposits (e.g. rhyodacite, rhyolite, dacite and quartz). Some lizards have also been found under sandstone rocks (a single site on Black Mountain) and metamorphosed shales (sites near Googong). They have also been found at times under fallen fenceposts (R. Bennett pers.comm.) and bricks (T. Baker pers.comm.).

The lizards are dependent on the temperature of their surroundings for regulating their body temperature (Jones 1999). It is thought that during cold weather when soil temperatures are relatively low, the lizards move to the upper edges of the ant burrows that they live in so that they can bask against the warm underside of the rocks that cover the ant nests (Osborne *et al.* 1991; Jones 1999). Osborne *et al.* (1991) also suggest that during unfavourable weather (too hot or too cold) the lizards retreat deeper into the ant burrows.

Pink-tailed Worm-lizards are not known to occur in tree-covered sites in the ACT; it is thought that shade from tree foliage might influence the ground temperature and thereby thermoregulation. In addition, groundcover changes substantially following establishment of trees.

Habitat

Most sites where this lizard is found are within primary and secondary native grassland or pasture, where there are numerous scattered surface rocks which are well-weathered and partially embedded in the soil and grass (see Map 2.6 and Table 2.12 for presumed habitat sites).

These grasslands usually have no or very little tree cover, and little or no leaf litter, and the vegetation is mainly native grasses, particularly Kangaroo Grass *Themeda triandra*, Barbed-wire Grass *Cymbopogon refractus* and Wattle Matrush *Lomandra filiformis*. Redleg Grass *Bothriochloa macra* predominates at more disturbed sites (Osborne *et al.* 1991; Osborne and McKergow 1993; Jones 1992, 1999; Wong *et al.* 2011).

In the Molonglo River Reserve and offsets, the Pink-tailed Worm-lizard is associated with the following vegetation types:

- Natural Temperate Grassland at Kama (type r7) and in the river valley (type r8);
- cleared unimproved native pasture (secondary grassland);
- low shrubland and relatively small natural or artificial clearings in woodland;
- clearings in Yellow Box – Blakely's Red Gum tall grassy woodland;
- clearings in Yellow Box – Apple Box grassy woodland;
- clearings in Red Stringybark – Scribbly Gum Tall Dry Forest (several sites in the Molonglo River Reserve downstream from Kama);
- Kangaroo Grass – Purple Wire grass – Wattle Mat-rush Dry Tussock grassland; and
- Tall Speargrass – Corkscrew Grass – Wallaby Grass disclimax grassland.

As a general rule, the greater the proportion of Kangaroo Grass and other species indicative of little disturbance at a site, the greater the likelihood of Pink-tailed Worm-lizards occurring there (Wong *et al.* 2011).

Recent survey and mapping of the habitat of Pink-tailed Worm-lizard in the ACT has been based on qualitative descriptions of habitat condition followed up by searches for the species to confirm its occurrence within the mapped areas. Mapping is reasonably straightforward. It involves delineating a particular type of outcropping geology and recognising the presence of a particular suite of native grass plant species (Wong *et al*. 2011; Wong 2013). The technique is outlined in s.4.2.6. Monitoring for Pink-tailed Worm-lizard also involves measuring key habitat variables and making estimates of lizard abundance (s.4.2.6).

Habitat is typically ranked as being High Quality (least disturbed), Moderate Quality (intermediate disturbance) or Low Quality (most disturbed, and likely to no longer support the lizards).

High quality potential habitat consists of suitable rocky areas generally dominated by or having a good cover of large tussock-forming grasses such as Kangaroo Grass *Themeda triandra* or Purple Wiregrass *Aristida ramosa* and also often containing *Poa sieberiana* and a range of disturbance-sensitive native forbs, geophytes, subshrubs, or graminoides such as *Lomandra* spp. Table 4.7 (s.4.2.6) lists plant species associated with low disturbance.

Alternative high quality potential habitat, in suitable rocky areas that may not necessarily be dominated by large tussock-forming grasses, will carry a high proportion of disturbance-sensitive species of forbs, graminoids, subshrubs or geophytes indicative of lower disturbance levels. Examples are Creamy Candles *Stackhousia monogyna*, Scaly Buttons *Leptorhynchos squamatus* and Early Nancy *Wurmbea dioica*. Exotic annual species such as Haresfoot Clover *Trifolium arvense* and *Vulpia* spp. may be present even in the least disturbed sites.

Moderate quality potential habitat consists of suitable rocky areas usually dominated by speargrasses *Austrostipa* spp. and wallaby grasses *Rytidosperma* spp. with few or no native forb species present. Disturbance-tolerant native forb species including Common Everlasting *Chrysocephalum apiculatum* and Pink Bindweed *Convolvulus angustissimus* syn. *C. erubescens* and exotic annual species such as Haresfoot Clover *Trifolium arvense*, Wild Oats *Avena* sp., and Saffron Thistle *Carthamus lanatus* may also be present.

Low quality potential habitat consists of suitable rocky areas that have been subject to high levels of disturbance in the recent past. These areas can be seen to have had much disturbance to the soil layer or they are dominated by sown pasture grasses, other agronomic species and weeds. Former sheep camps that no longer support native groundcover are examples of low quality potential habitat.

Threats

THREATS TO THE LIZARD

The lizards are threatened by predation and particularly by threats to their habitat (Brown 2009; Wong *et al.* 2011).

THREATS TO LIZARD HABITAT AND POTENTIAL HABITAT

Threats to grassland ecological values (s.2.2.2) threaten lizard habitat. Examples include: pasture improvement, inappropriate grazing regimes, nutrient pollution, active soil erosion or other disturbance to the soil, pest plants and animals, excess grassy biomass, and illegal or damaging human activities including removal of rocks or of any fallen wood and logs, rubbish dumping, arson and off-track vehicle access.

Threats to the habitat, such as from an influx of weeds, pollutants, sediments and the potential for trampling and other disturbances such as inappropriate fire, fire management and recreation, can be reduced by use of buffer zones.

Threats are summarised in s.2.8.

2.4.2 Superb Parrot

The Superb Parrot *Polytelis swainsonii* is a bright green medium-size parrot with a long tail and distinctive shape in flight. The male has a yellow face and throat separated from the green of the chest by a red band. The female and immature birds are a duller green colour.

The Superb Parrot occurs in central and southern inland NSW, northern ACT and north-central Victoria. Within the ACT, until 2005–06 the Superb Parrot was considered to be a rare breeding migrant (Davey 2013a,b) and was usually seen only in the northern Belconnen and Gungahlin areas. Since the 2005 breeding season the species has become increasingly common throughout Belconnen, Gungahlin and more recently the Molonglo Valley. Overwintering of this usually migratory species has been reported, and breeding has been recorded in Gungahlin and the Molonglo Valley (Davey 2013a,b; Eco Logical Australia 2014).

In the Molonglo River Reserve and offsets the Superb Parrot has been recorded regularly in Kama although there are no breeding records from here. It is known to breed in Spring Valley Farm (Eco Logical Australia 2013). Occasionally birds are reported flying over the Molonglo River but the species has not been recorded in the riparian corridor (Canberra Ornithologists Group database). It is frequently recorded in the Central Molonglo woodlands (to the west of Kama extending through to the Murrumbidgee River), and may occur in the West Molonglo (western Belconnen) woodland but has not been reported from there.

Habitat

In the ACT, Box-Gum Woodland is the main breeding habitat of the Superb Parrot. Nests are made in tree hollows, the most suitable of which form in trees of large diameter. In the Box-Gum Woodlands the largest trees are usually *Eucalyptus blakelyi* and they are often in poor health or dead.

Superb Parrots feed mostly on seeds of grasses and forbs, fruits, nectar, lerps and occasionally insects (Higgins 1999). Food sources are usually reported to be plants associated with Box-Gum Woodland (ACT Government 2004b), but as the species has become more common in the suburbs it has been reported as feeding on a greater range of plants. The list now includes non-indigenous native trees and shrubs (*Acacia baileyana*, *A. boormannii*, *A. cultriformis*); exotic trees (*Ulmus* sp., *Betula pendula*); introduced grasses (*Avena* spp., *Hordeum leporinum*) and forbs (*Polygonum aviculare*, *Trifolium* sp.) (Taws 2001; Blemings 2005; Lashko 2006; G. Dabb pers. comm.). Urban planners should ensure that consideration is given to planting known Superb Parrot feed species within new suburbs.

In many of the highly modified woodlands of the ACT region where Superb Parrots breed there is little native groundcover, and introduced grasses appear to be a major food source. Barley Grass (*Hordeum leporinum*) is a dominant species in the nutrient-enriched soils of former sheep camps under paddock trees, and Superb Parrots have been frequently observed feeding on this grass under trees where the branches reach low to the ground and offer immediate refuge for the birds if they are disturbed (Taws 2001).

Threats

LOSS OF WOODLAND HABITAT AND MOVEMENT CORRIDORS

The most significant threat to the Superb Parrot is the loss of woodland habitat for breeding and feeding. Even in the ACT region where widespread clearing of woodlands no longer occurs, there are still incremental losses of trees through old age, firewood removal, agricultural intensification and urban expansion. The same nest hollows are used in successive years (Webster and Ahern 1992; Manning *et al.* 2004) so nesting trees assume particular significance and their loss cannot be offset by the birds just moving to another hollow. Breeding habitat is usually located within 10 km of foraging habitat (Webster 1988).

A loss of foraging habitat can lead birds to abandon breeding areas even when suitable nest trees remain (Webster 1988). However, this is unlikely to be a threat in the ACT where the Superb Parrot appears to be able to use many food resources within the established suburbs (Lashko 2006).

The Superb Parrot requires wooded movement corridors between breeding and foraging habitat. It rarely crosses extensive areas of open ground (Webster 1988). This is apparent from the maps of flight direction in Davey (2013a,b) and Eco Logical Australia (2014), where the Superb Parrot was nearly always observed flying over woodland or scattered trees and avoiding treeless areas.

COMPETITION FROM OTHER SPECIES

Competition for nesting sites is a threat posed by a range of native and introduced fauna, because of the dependence of the Superb Parrot on particular tree hollows. Inter-specific aggression in the vicinity of nest hollows has been observed between Superb Parrots and Eastern Rosellas, Crimson Rosellas, Red-rumped Parrots, Nankeen Kestrel and Common Starling, with both rosella species being particularly successful 'winners' of aggressive interactions (Taws 2001; Davey 2013a,b). Galah, Little Corella and Long-billed Corella are also potential competitors because Superb Parrots often use hollows with entrances large enough to permit access by these cockatoos (Manning *et al.* 2004). Feral Honeybees have been found occupying hollows in Superb Parrot nest trees or in trees that Superb Parrots were investigating (Taws 2001) but the overall impact of feral Honeybees is unknown (Baker-Gabb 2011).

The Common Myna is a potential threat if its population increases and expands with the new urban developments, although competition with this species for hollows has not been reported (Davey 2014).

HUMAN ACTIVITY

Where breeding areas coincide with public recreation areas such as picnic and camping sites, Superb Parrots have been observed to become agitated and avoid entering the nest hollow when people are near the nest tree (Baker-Gabb 2011). Restrictions on public access and human activity within 100 m of known colonies are applied in some areas to avoid disturbance to breeding Superb Parrots (Webster and Ahern 1992).

2.4.3 Swift Parrot

The Swift Parrot *Lathamus discolor* is a small bright green parrot with patches of bright red on the forehead, throat, shoulders and underwing, and softer red along the tail.

The Swift Parrot breeds in Tasmania in summer and migrates to the mainland to spend winter in flowering Box-Ironbark forests anywhere from south-eastern South Australia through coastal and inland Victoria and NSW to south-eastern Queensland. The birds are highly nomadic on the mainland depending on food availability. Food sources are primarily nectar from flowering eucalypts and lerps, as well as pollen, seed and insects (Forshaw and Cooper 1981).

In the ACT the species is recorded only a few times a year, mostly between March and October (Canberra Ornithologists Group (COG) database). Most records are from suburban areas or nature reserves where the birds have been observed foraging on indigenous vegetation species but also on planted non-local native species such as Mugga Ironbark (*Eucalyptus sideroxylon*) (Taws and Saunders 2005). There is only one record from the Molonglo River Reserve and offset areas, in Kama in 2008 when there were two sightings of one bird (probably the same bird) on the same day.

Habitat

The main melliferous (honey-producing) eucalypt native to the ACT is Yellow Box *E. melliodora*, but it flowers primarily in spring–summer (Birtchnell and Gibson 2006). Other melliferous eucalypts of the ACT which flower in autumn–winter are *E. goniocalyx* and *E. polyanthemos*. Swift Parrots have been observed feeding in flowering *E. goniocalyx* (COG archive 2005–04).

Red Box *E. polyanthemos* appears to be a source of lerps for the Swift Parrot rather than nectar (Taws and Saunders 2005).

Swift Parrots will often show fidelity to foraging habitat and will return to specific areas or even certain stands of trees if they are providing resources (flowers or lerps) in that year.

Threats

LOSS OF FORAGING HABITAT

The main threat to the Swift Parrot in its winter habitat is the ongoing loss of foraging habitat, primarily winter-flowering eucalypts. The loss of large mature trees is particularly significant because they produce more flowers and flower more reliably than small young trees (Law and Chidel 2007). The loss of mature trees through senescence, firewood collection, agricultural intensification and urban expansion reduces the nectar resource and increases competition between nectarivorous species.

COMPETITION FROM OTHER SPECIES

Competition with the large honeyeaters Noisy Miner and Red Wattlebird is a particular threat because they aggressively defend nectar sources against Swift Parrots and other nectarivores (Taws and Saunders 2005). These two honeyeaters are resident year-round, and very common in the urban area and adjacent woodlands (COG 2014). Another potential competitor is the Rainbow Lorikeet which is present in the suburbs in small but increasing numbers (COG 2014).

STRUCTURES NEAR FORAGE TREES

Additional threats to the Swift Parrot are human-made structures such as fences (especially chain-link fences), windows and vehicles, because the parrots collide with them in flight. Up to 2% of the population is thought to die each year in such collisions (Pfenningwerth 2008).

It is important to avoid impinging on the Swift Parrots' known foraging sites in winter-flowering eucalypts, especially when planning any developments that need structures with chain-mesh fences (e.g. tennis courts) or large amounts of glass (e.g. large buildings).

If avoidance is impossible, it is important to carefully consider the design and placement of such structures to minimise the threat to this MNES parrot species' feeding habitat (Pfennigwerth 2008). Shade cloth has been used effectively to deter Swift Parrots from flying into chain-link fences (Brereton 1999).

Where potentially hazardous structures are already in place, winter-flowering eucalypts that attract Swift Parrots should not be planted nearby or used in landscaping nearby. Such planting can be sited at good distance away, or alternative species used (D. Saunders pers.comm. 2014).

2.5 Birds other than Superb and Swift Parrots

Twenty-nine bird species of significance, other than the MNES Superb and Swift Parrots, have been recorded or could potentially be recorded in the Molonglo River Reserve and offsets.

These Guidelines group the 29 species into four categories: Woodland birds (21), Raptors (3), Migratory birds (1) and Waterbirds (4). Table 2.11 lists the individual bird species in each category with their threat status in Commonwealth, ACT and NSW legislation, and it shows the status of the individual species within the Guidelines area, based on records kept by the Canberra Ornithologists Group (COG).

The descriptions below, and the listing in Table 2.11, are arranged first by threat status in ACT and NSW (though preceded by the MNES parrots), and then alphabetically by the first letter of the common name. Threats are noted in many of the species' descriptions below and also in the summary descriptions of the four categories (s.2.5.3, s.2.5.5, s.2.5.7, s.2.5.9).

Table 2.11. Bird species considered in the Guidelines; their threat status in Commonwealth, ACT and NSW legislation, and species status within the Guidelines area. W = Woodland-dependent species thought to be declining in ACT. A = Waterbird breeding in ACT.

Bird species	Common name	Common-wealth	ACT	NSW	Status			
					Dryland	Riparian	Breeding	Migrant
Woodland birds								
Polytelis swainsonii	Superb Parrot	Vulnerable, NES	Vulnerable, NES	Vulnerable	Uncommon	Rare	✓	Summer
Lathamus discolor	Swift Parrot	Endangered, NES	Vulnerable, NES	Endangered	Rare, two records in 2009, probably same bird	Not recorded		Winter
Xanthomyza phrygia	Regent Honeyeater	Endangered	Endangered	Critically endangered	Not recorded	Not recorded		Summer
Climacteris picumnus	Brown Treecreeper		Vulnerable	Vulnerable	Rare, resident in Kama, rare in Spring Valley	Rare	✓	
Calyptorhynchus lathami	Glossy Black-Cockatoo		Vulnerable	Vulnerable	Rare, only one record			
Melanodryas cucullata	Hooded Robin		Vulnerable	Vulnerable	Not recorded	Not recorded		
Grantiella picta	Painted Honeyeater		Vulnerable	Vulnerable	Not recorded	Rare		Summer
Daphoenositta chrysoptera	Varied Sittella		Vulnerable	Vulnerable	Uncommon	Uncommon	✓	
Lalage tricolor	White-winged Triller		Vulnerable		Common	Common	✓	Summer
Stagonopleura guttata	Diamond Firetail		W	Vulnerable	Uncommon	Uncommon	✓	
Petroica phoenicea	Flame Robin		W	Vulnerable	Uncommon	Uncommon		Winter
Callocephalon fimbriatum	Gang-gang Cockatoo		W	Vulnerable	Uncommon	Rare		
Petroica multicolor	Scarlet Robin		W	Vulnerable	Uncommon	Uncommon		Winter
Chthonicola sagittata	Speckled Warbler		W	Vulnerable	Uncommon	Uncommon		
Epthianura albifrons	White-fronted Chat		W	Vulnerable	Uncommon, localised at Stromlo Forest Park	Uncommon, occasional records from Coppins Crossing and sewage ponds.	✓	

Bird species	Common name	Common-wealth	ACT	NSW	Status		Breeding	Migrant
					Dryland	Riparian		
Falcunculus frontatus	Crested shrike-tit		W		Rare, Kama	Not recorded		
Taeniopygia bichenovii	Double-barred Finch		W		Uncommon	Common	✓	
Artamus cyanopterus	Dusky Wood-swallow		W		Common	Common	✓	Summer
Microeca fascinans	Jacky Winter		W		Rare	Rare		
Myiagra inquieta	Restless Flycatcher		W		Rare	Rare		
Aphelocephala leucopsis	Southern Whiteface		W		Uncommon	Uncommon		
Raptors								
Hieraaetus morphnoides	Little Eagle		Vulnerable	Vulnerable	Uncommon	Uncommon	✓	
Aquila audax	Wedge-tailed Eagle				Common	Common	✓	
Haliaeetus leucogaster	White-bellied Sea-Eagle	Migratory. EPBC Act. International listing			Rare	Rare	Possibly[4] breeding	
Migratory birds								
Merops ornatus	Rainbow Bee-eater	Migratory. EPBC Act. International listing			Uncommon	Common	✓	Summer
Waterbirds								
Anhinga novaehollandiae	Australasian Darter		A		Not recorded	Common	✓	
Phalacrocorax carbo	Great Cormorant		A		Not recorded	Uncommon		
Phalacrocorax sulcirostris	Little Black cormorant		A		Not recorded	Uncommon		
Microcarbo melanoleucos	Little Pied Cormorant		A		Rare	Common	✓	

Commonwealth — Listing under EPBC Act (Australian Government Department of the Environment n.d.-d).

ACT — Listing under NC Act (ACT Government 2012a).

NSW — Listing under TSC Act (NSW OEH n.d.).

4 Olsen & Fuentes 2004

2.5.1 Woodland birds listed as threatened

Threatened woodland birds include the two species listed as MNES — the Superb Parrot and Swift Parrot — already decribed above. Most of the conservation actions which will benefit the Superb and Swift Parrots will also benefit other woodland birds and woodland habitat.

Woodland-dependent birds are primarily associated with woodland or forest habitat for their regular daily activities (foraging, roosting and nesting) and are seldom observed in highly modified environments (Radford *et al.* 2005).

These Guidelines consider the woodland species listed under the NC ACT (ACT Government 2012a) and the species that are suspected to be declining within the ACT. Several species in this latter group are listed as Vulnerable within NSW (see Table 2.11).

- The Regent Honeyeater is listed as Endangered nationally and in the ACT. It has not been recorded in the Molonglo River Reserve but is included in the Guidelines because it uses Box-Gum Woodland and River She-oak Dry Forest as habitat.
- Six woodland bird species (described below) are listed as Vulnerable in the ACT: the Brown Treecreeper, Glossy Black-Cockatoo, Hooded Robin, Painted Honeyeater, Varied Sittella and White-winged Triller. Of the 13 species described below, 11 are listed as Vulnerable in NSW.
- The Hooded Robin has not been recorded in the Molonglo River Reserve but has been recorded once at Shepherd's Lookout (Map 2.6) and suitable habitat is found in the Box-Gum Woodland of the Molonglo River Reserve.
- The Glossy Black-Cockatoo has only been recorded once in the Molonglo River Reserve and there is none of its food source, the Drooping She-oak.
- The Painted Honeyeater has only been recorded once in the Molonglo River Reserve (Taws 2014) but the species has bred in the past at Uriarra Crossing, not far upstream of the confluence of the Molonglo and Murrumbidgee Rivers, and suitable habitat occurs in the Reserve along the Molonglo River and in the Box-Gum Woodland.

Woodland bird species can be found in the variety of habitats present in the Molonglo River Reserve including: Box-Gum Woodland, River She-oak Dry Forest, other woodland and dry forest communities, modified woodlands, shrubland and open forest and, to a lesser extent, Natural Temperate Grassland and other grasslands. Characteristics of habitats are summarised in s.2.7.

Regent Honeyeater (*Anthochaera phrygia*)

The Regent Honeyeater is listed as threatened (Endangered) at the national level and in every state in which it has been recorded (Critically Endangered in NSW and Victoria; Endangered in South Australia, ACT and Queensland).

The Regent Honeyeater is a predominantly black and yellow bird. Surrounding the eye is a patch of warty yellowish bare skin which contrasts with the black head and neck. Bright yellow patches are conspicuous on the wings and edging the black tail.

The species once occurred from Adelaide in South Australia to Rockhampton in Queensland, on the coast to the inland slopes (Garnett and Crowley 2000), but is now probably extinct in South Australia and rarely occurs in Queensland. The number of Regent Honeyeaters has declined greatly since the 1940s and in 1997 the population was estimated at 1500 (Garnett and Crowley 2000). Poor breeding seasons in the NSW strongholds of the species have seen estimates of population size in NSW reduced to as low as 250 (NSW Scientific Committee 2011).

The Regent Honeyeater has never been common in the ACT. It was described by Mathews (1943) as 'occasional', but was reported regularly in small numbers from several locations during the 1960s (Wilson 1999). The number of sightings of the species in the ACT has declined rapidly since 2000, and in the last nine years there have only been five sightings, each of single birds (Canberra Ornithologists Group database). The last recorded breeding attempt was in 1998 but was unsuccessful (Bounds *et al.* 1999). Most records in the last decade have been from Box-Gum Woodland habitat at Campbell Park, North Watson and Mulligans Flat–Goorooyarroo. The birds have also been recorded from suburban locations feeding in nectar-rich plants including non-local natives and introduced species.

The Regent Honeyeater feeds mostly on nectar from the flowers of a few species of eucalypts. In the ACT the favoured indigenous feed species is Yellow Box (*Eucalyptus melliodora*). Another important nectar resource is the Needle-leaf Mistletoe (*Amyema cambagei*) which occurs in riparian areas as a parasite on the River She-oak. They also feed on lerps and a variety of insects and arthropods which become an essential part of the diet of nestlings and fledglings (Oliver 1998). Nesting occurs in spring through to early summer. The cup-shaped nest of bark or grass and spiderweb is built in the fork of a tree or clump of mistletoe.

The Regent Honeyeater has not been recorded in the Molonglo River Reserve. The closest records are from suburbs in Belconnen (Weetangera, Florey), Lake Ginninderra, Curtin and Black Mountain Peninsula (Canberra Ornithologists Group database), but most of these are from ten or more years ago.

When in flower the Box-Gum Woodland and Needle-leaf Mistletoe along the river provide suitable resources and it is possible that the species has occurred and not been observed, particularly in the more remote reaches of the Molonglo River.

THREATS TO REGENT HONEYEATER

Threats to the Regent Honeyeater include the loss of breeding and foraging habitat, and increasing competition for nectar-rich food sources from other honeyeaters and lorikeets.

Brown Treecreeper (*Climacterus picumnus victoriae*)

The Brown Treecreeper eastern subspecies (subsp. *victoriae*) is listed as Vulnerable in NSW and ACT, and Near Threatened in Victoria.

The Brown Treecreeper is 16–18 cm in length, and plain brown overall with dark-edged buff streaks on the underparts and black bars under the tail. A distinctive buff-orange wing patch is seen in flight.

The eastern subspecies of Brown Treecreeper (subsp. *victoriae*) occurs in woodlands and relatively dry forests of eastern Australia, from western Victoria to the Bunya Mountains in Queensland. It is found mostly on the slopes and plains inland of the Great Divide, with some populations in relatively dry coastal valleys. At its western edge it intergrades with the arid inland subspecies *picumnus*.

Subspecies *victoriae* has declined across its range with extinctions reported in several regions (e.g. Barrett *et al.* 1994; Keast 1995). In the ACT the Brown Treecreeper was previously described as 'common' (Mathews 1943), but it has declined, particularly as suburbs have encroached, and has become extinct at a number of locations such as Aranda–Black Mountain (Marchant 1973). The species was previously regularly recorded in COG woodland surveys of Mulligans Flat–Goorooyarroo but has disappeared from these reserves despite reintroduction efforts (Bennett *et al.* 2012). The only sites in the Woodland Bird Monitoring surveys where the Brown Treecreeper is regularly reported are those more distant from suburbs, including Naas Valley, Castle Hill, Kama, and less reliably, Newline Quarry (Canberra Ornithologists Group database).

The Brown Treecreeper forages on the bark of trunks and large branches of living and dead trees, and on the ground amongst fallen timber, bark and leaf litter, looking for invertebrates, particularly ants and beetles (Higgins *et al.* 2001). The Brown Treecreeper avoids foraging in areas of high grass cover, possibly because the invertebrate prey is less common or visible amongst the grass. Instead these birds prefer to forage in areas with bare ground or sparse native grasses or in areas that have been heavily grazed (Maron and Lill 2005).

Breeding occurs from late August through to early summer (Taylor and COG 1992). Nests of grass and bark, lined with feathers, are built in tree hollows usually 3–10 m off the ground.

Within the Molonglo River Reserve the Brown Treecreeper is found in Kama. It also occurs outside the Reserve in the Central Molonglo woodlands to the west of Kama extending through to the Murrumbidgee River (Davey 2013a; Canberra Ornithologists Group database), and has been very occasionally recorded from Piney Creek Farm on the south side of the Molonglo River next to Spring Valley Farm. Given the species' avoidance of urban areas, the Brown Treecreepers in the Molonglo River Reserve are effectively isolated from those on the eastern side of Canberra (Newline Quarry) and have only a tenuous link along the Murrumbidgee River corridor to the birds further south at Castle Hill.

THREATS TO BROWN TREECREEPER

Threats to the Brown Treecreeper include loss or degradation of key habitat features such as hollow-bearing trees, and suitable foraging habitat on the ground including fallen timber and areas of bare ground or sparse groundcover.

Glossy Black-Cockatoo (*Calyptorhynchus lathami lathami*)

The Glossy Black-Cockatoo is listed as Vulnerable in NSW, Queensland, Victoria and ACT.

The Glossy Black-Cockatoo is a small cockatoo (48 cm), predominantly black with a low rounded crest and bright scarlet panels in the tail. The female has large yellow patches on the head and neck, and the tail panel is orange-red with fine black bars.

The eastern subspecies *lathami* extends from south-eastern Queensland through NSW into Victoria, but has become extinct in Tasmania. It occurs in eucalypts in open forest and woodlands where there is an understorey of *Allocasuarina/Casuarina* species, from the coast to tablelands with separate populations on the NSW western slopes and an isolated population in the NSW Riverina (NSW Scientific Committee 2008).

The distribution of subspecies *lathami has* contracted around the edges since the 1970s, and within its range the density of birds is thought to have been more than halved (Garnett and Crowley 2000). The Riverina population is estimated to be as low as 40 birds (Garnett *et al.* 2011).

The Glossy Black-Cockatoo feeds almost exclusively on seeds of *Allocasuarina* species, and requires large hollows in living or dead eucalypts for nesting.

Within the ACT, seeds of the Drooping She-oak (*Allocasuarina verticillata*) are the primary food source for the species.

The Glossy Black-Cockatoo is rare within the ACT and most records come from areas where there are large stands of Drooping She-oak such as Mt-Majura–Mt Ainslie or Rob Roy (Bounds 2011). A single breeding record comes from Mt Majura (Lenz *et al.* 2004).

Within the Molonglo River Reserve there are no mapped stands of Drooping She-oak (Schweikle and Baines 2009), and only one record of the Glossy Black-Cockatoo in the Canberra Ornithologists Group database. In 2003 a single bird was recorded flying over the Lower Molonglo River, most likely passing between the closest stands of Drooping She-oak on Mt Stromlo and the Pinnacle.

THREATS TO GLOSSY BLACK-COCKATOO

The main threat to the Glossy Black-Cockatoo is loss, degradation or fragmentation of its feeding or breeding habitat.

Hooded Robin (*Melanodryas cucullata cucullata*)

The Hooded Robin south-eastern subspecies (subsp. *cucullata*) is listed as Vulnerable in NSW and ACT, Near Threatened in Victoria, and Rare in South Australia.

The Hooded Robin is one of the largest robins. The male is boldly marked with a black hood, back and tail, and a white breast and underparts, and white on the shoulder, wings and tail edges. The female is a soft grey with a white bar on brownish-grey wings.

The south-eastern subspecies (subsp. *cucullata*) occurs from Adelaide through to south-eastern Queensland. Although it is widespread from some coastal areas through to the dry inland it is sparsely distributed and declining throughout its range (Garnett and Crowley 2000). In the ACT the species was previously regarded as 'common' (Mathews 1943) but has declined and become extinct at a number of locations, particularly where suburbs have encroached. In the 1960s several breeding pairs were found on the lower slopes of Black Mountain, Mt Mugga and Mt Ainslie, but the species disappeared from Black Mountain and Mt Mugga in the 1970s and from Mt Ainslie in the early 1990s (Graham 1995; Marchant 1973). The Canberra Ornithologists Group woodland bird surveys regularly recorded two or three pairs in Mulligans Flat and Goorooyarroo Nature Reserves through the first decade of the surveys. The last breeding was reported in 2006 and no Hooded Robins have been sighted during the surveys since 2009 at Mulligans Flat and 2010 at Goorooyarroo.

In the ACT the Hooded Robin occupies dry woodlands particularly where interspersed with grasslands and patches of shrubs (Graham 1990). It requires trees, both mature and regenerating, for cover and nesting sites, areas of grassland or open ground for foraging, and perching points such as dead branches, logs or stumps from which to forage. Breeding occurs from August through to January (Taylor and COG 1992).

The cup nest is built from grass, bark and spiderweb, in a small fork 1–6 m above ground. Often at the lower heights it is hidden among dense regeneration or fallen timber.

THREATS TO HOODED ROBIN

The primary threat to the Hooded Robin appears to be loss and fragmentation of habitat or decline in habitat quality. Human disturbance may be an important factor in the decline of the species because it disappears from habitat as suburbs encroach without any other major change to the habitat.

Painted Honeyeater (*Grantiella picta*)

The Painted Honeyeater is listed as Vulnerable in NSW, Queensland, Victoria and ACT, and Rare in South Australia.

The Painted Honeyeater is a medium-size honeyeater (16 cm). The male has black upperparts, white underparts with black streaks on the flanks, bright yellow edges to wing and tail feathers, and a conspicuous pink bill. The female is slightly greyer on the back and has fewer streaks on the flanks (Pizzey and Knight 2012).

The Painted Honeyeater is nomadic and sparsely distributed from south-eastern Australia to north-western Queensland. Breeding records are largely from the southern parts of its range in spring–summer, after which it appears to migrate to semi-arid regions. It is reported to be declining across its range, particularly in the south-east (Garnett *et al.* 2011).

It occurs in forests and woodlands of eucalypt, acacia, paperbark and casuarina, the main requirement being the presence of mistletoes. Its primary food source is the berries of mistletoes, particularly *Amyema* species, but this species will also eat nectar and insects (Oliver *et al.* 1998). In the ACT region the Painted Honeyeater breeds between November and February, building a nest of bark, grass and spiderweb amongst foliage 3–20 m above the ground.

In the ACT the Painted Honeyeater was formerly reported regularly in summer from near Uriarra Crossing on the Murrumbidgee River (Wilson 1999) where River She-oak is a host to the Needle-leaf Mistletoe (*Amyema cambagei*). Other historical reports are from Mt Ainslie and occasionally from other woodland areas (Wilson 1999).

A major influx of Painted Honeyeaters to the ACT region occurred in 2002–03 (Bounds 2003; Lenz and Dabb 2003) when the birds were found attempting to breed in a number of Box-Gum Woodland sites.

Most recently a minor influx of Painted Honeyeaters occurred in November–December 2013. Two birds were first seen on 8 November at Stoney Creek Nature Reserve near Uriarra Crossing. Then possibly six birds were seen at this location on 10 November.

One of these pairs was seen gathering nest material, and a nest had been built and occupied by 15 November. The nest at Stoney Creek was last seen occupied on 4 December so it appears that the breeding attempt was abandoned. The last sighting of Painted Honeyeaters at this site was on 9 February 2014.

A male Painted Honeyeater was recorded in the Molonglo River Reserve on 11 December 2013 in *Casuarina cunninghamiana* south of the old sewage ponds. A single bird (presumably the same one) was seen here on three subsequent occasions in December, feeding in flowering mistletoe and on one occasion it was seen carrying a thin stick, possibly attempting to build a nest. This is the only record of the species for the Molonglo River Reserve.

Other records of the species in the region during the 2013 season came from near Gundaroo, at Gunning, and at Castle Hill (one bird) near Tharwa. The appearance of the species at Stoney Creek and in the Molonglo River Reserve in 2013 highlights the importance of the stands of mature *Casuarina cumminghamiana* and the associated mistletoe along the Murrumbidgee and Molonglo valleys.

THREATS TO PAINTED HONEYEATER

The main threats to the Painted Honeyeater appear to be the loss, degradation and/or fragmentation of its feeding or breeding habitat, through clearing of woodlands and open forests or the removal of large old trees with heavy mistletoe infestations, and overgrazing.

Varied Sittella (*Daphoenositta chrysoptera*)

The Varied Sittella is listed as Vulnerable in NSW and ACT.

The Varied Sittella is a small stubby bird (12 cm) with a sharp upturned bill. It is widely distributed across Australia in five or six distinctive geographic races. The south-eastern Australian race (*chrysoptera*) has a black-grey head, grey mantle and shoulders with dark streaks, a white rump and black tail with white tip. A bright orange band across the wings is most conspicuous in flight (Pizzey and Knight 2012).

The birds are highly sociable, with small groups foraging together in tree canopies, typically working downwards along the branches (particularly dead branches) and the trunk, probing and levering the bark with their upturned beaks, looking for invertebrates. The Varied Sittella breeds in spring–summer, building a deep cup nest of bark, lichen and spiderweb in the fork of two upright (often dead) branches.

The Varied Sittella is widespread across south-eastern Australia but the population is believed to have declined in the region over the past few decades (Barrett *et al.* 2007). In the ACT the species is found in eucalypt forests and woodlands of all but the highest or wettest areas. It favours rough-barked eucalypts for foraging in this region, particularly Red Stringybark (*Eucalyptus macrorhyncha*).

In the Molonglo River Reserve the Varied Sittella is recorded fairly regularly in Kama, with other occasional records from riparian areas along the Molonglo River (Canberra Ornithologists Group database).

THREATS TO VARIED SITTELLA

The main threats to the Varied Sittella are habitat degradation (including small-scale clearing, loss of paddock trees and connectivity, and firewood collection) and competition with Noisy Miners.

White-winged Triller (*Lalage tricolor*)

The White-winged Triller is listed as Vulnerable in ACT.

The White-winged Triller male is black on the upperparts and white on the underparts with a netted white pattern across the black wings. The female is a soft brown with a pale netted pattern on the darkish wings and a dark line through the eye.

The species occurs across Australia but is migratory in the southern half of its range. They arrive in the ACT region usually in October and leave by the end of February. The White-winged Triller can be found in the lowland woodlands and occasionally in the open grassy valleys and dry woodlands of the mountains (Taylor and COG 1992).

They feed primarily on insects, fruits and seeds, and will sometimes eat nectar. The White-winged Triller breeds from mid-spring when it arrives in the ACT region through to the end of summer when it departs. It builds a shallow saucer-shaped nest of grass and spiderweb on a horizontal branch or fork of a tree. Reporting rate for the White-winged Triller in the ACT region fluctuates from year to year depending on conditions across its range, but the overall reporting rate for the region has declined by more than 50% over the 20 years between the two national bird atlases (Barrett *et al.* 2007).

In the Molonglo River Reserve the Triller is found in Box-Gum Woodland in Kama and riparian River She-oak woodland along the river. There are no records from the woodlands in western Belconnen but few bird surveys have been carried out there. Breeding has been recorded in the River She-oak woodlands between Coppins Crossing and the old sewage ponds (Taws 2014).

THREATS TO WHITE-WINGED TRILLER

The White-winged Triller is threatened by loss, fragmentation and degradation of habitat, including the groundlayer in which it spends much of its time foraging.

Diamond Firetail (*Stagonopleura guttata*)

The Diamond Firetail is listed as Vulnerable in NSW and South Australia, and Near Threatened in Victoria.

The Diamond Firetail is a relatively large finch (10–12 cm). It has a grey head and back, white throat and underparts with broad black breast-band joining white-spotted black flanks. The bill and rump are bright red.

It occurs in south-eastern Australia from central Queensland through to Eyre Peninsula, South Australia, mostly west of the Divide with some occurrences in relatively dry coastal valleys (Pizzey and Knight 2012). The Diamond Firetail is found in open forests and woodlands of eucalypt, acacia, cypress pine and casuarina where there is a grassy understorey. It feeds mainly on grass seeds and other plant material, but also takes invertebrates (Read 1994).

The Diamond Firetail is reported to be declining within NSW (Barrett *et al.* 1994; Keast 1995; Reid 1999). The species is found in relatively undisturbed habitat and in the ACT it has declined in areas where suburbs have encroached (Taylor and COG 1992).

In the Molonglo River Reserve the Diamond Firetail is reported fairly regularly from Kama and along the river in grassland and River She-oak, particularly in the section between Coppins Crossing and the old sewage ponds, where it has also been recorded breeding (Taws 2014).

THREATS TO DIAMOND FIRETAIL

The species is threatened by loss and fragmentation of habitat, and degradation of the groundlayer, particularly grasses upon which it mainly feeds.

Flame Robin (*Petroica phoenicea*)

The Flame Robin is listed as Vulnerable in NSW and South Australia.

The Flame Robin is named for the vivid orange-red breast and underparts on the male, contrasting with the dark grey upperparts. The female is plain grey-brown. Both have a prominent white stripe in the wing and white edges to the tail.

The species is found in south-eastern Australia, from southern Queensland to south-eastern South Australia. It generally breeds in highland forests and woodlands, migrating to lowland during winter (Pizzey and Knight 2012). This pattern is quite pronounced within the ACT (Taylor and COG 1992) where it is common in subalpine vegetation between October and April and is mostly found in lowland grasslands and open woodlands during autumn–winter. It feeds on invertebrates on the ground amongst litter and fallen timber, foraging from low perches. The open cup nest of grass, bark, lichen and spiderweb is usually built low to the ground in a small niche in a tree fork, stump, log or upturned roots.

The Flame Robin reporting rate has declined in the south-east of NSW in the 20 years between the two national bird atlases (Barrett *et al*. 2007). In the Molonglo River Reserve the Flame Robin is reported mostly between April and October from Kama and grassland along the length of the Molonglo River.

THREATS TO FLAME ROBIN

The main threats to the Flame Robin are the loss, degradation and/or fragmentation of its feeding and breeding habitat, including the simplification of habitat by overgrazing, removal of standing trees and coarse woody debris, and dense regeneration following bushfire and other disturbances. Other threats include nest predation by exotic predators as well as artificially large populations of native predators (including Pied Currawongs).

Gang-gang Cockatoo (*Callocephalon fimbriatum*)

The Gang-gang Cockatoo is listed as Vulnerable in NSW.

The Gang-gang Cockatoo is a medium-size (35 cm) grey cockatoo. The male has a distinctive scarlet head and fine curled crest, the female is grey all over with orange edges to the feathers on the underparts. It occurs in south-eastern Australia from the coast to the inland slopes of western Victoria through to mid-northern NSW. The species breeds in tall forest and woodlands in the mountains and descends to drier lowland forests and woodlands for winter (Pizzey and Knight 2012).

The Gang-gang Cockatoo feeds mainly on seeds of both native and introduced trees and shrubs, and also fruits and insects and their larvae. It nests in hollows in large eucalypts usually close to water.

In the ACT the Gang-gang Cockatoo is most common throughout the mountain forests during spring-summer with a general movement to the lowlands for winter. The species can also be found in suburban areas throughout the year, and will feed on a range of introduced plants including hawthorn (*Cratageus monogyna*) and Chinese Pistachio (*Pistacia chinensis*).

The reporting rate for the Gang-gang Cockatoo in NSW has declined significantly in the 20 years between the two national bird atlases (Barrett and Silcocks 2002). However, the Gang-gang reporting rate within the ACT region has remained stable and there are indications that it also now breeds in lowland areas as well as the mountains (COG 2014).

The Gang-gang Cockatoo has been recorded infrequently within the Molonglo River Reserve (Canberra Ornithologists Group database). It prefers to feed in eucalypts with large seeds such as *E. macrorhyncha* and *E. pauciflora* so is most likely to be found in woodlands of these species, or in fruiting hawthorn bushes.

THREATS TO GANG-GANG COCKATOO

The main threat to the Gang-gang Cockatoo is the clearing and degradation (including by inappropriate fire regimes) of vegetation important to foraging, roosting and breeding. Climate change is also recognised as a significant threat that may alter the extent and nature of its preferred habitat (cool temperate vegetation). The species is also susceptible to Psittacine circoviral disease.

Scarlet Robin (*Petroica multicolor*)

The Scarlet Robin is listed as Vulnerable in NSW, Rare in South Australia.

The Scarlet Robin is named for the bright red breast on the male. The head, throat, back and wings are jet-black contrasting with a distinctive white spot above the beak and a white slash on wing. The female is dull grey-brown with a pale scarlet wash on the breast.

The Scarlet Robin occurs in south-eastern Australia from southern Queensland to south-eastern South Australia, and in south-west Western Australia. It is found in open forests and woodlands from the coast to the inland slopes. In the ACT it is widespread but generally avoids the wet mountain forests and urban habitats (Taylor and COG 1992). It is found in Box-Gum Woodland on relatively fertile soils but also in the drier scrubby forests of ridges and hilltops, particularly those with rough-barked eucalypts such as *E. macrorhyncha* and *E. goniocalyx* (Canberra Ornithologists Group database).

The Scarlet Robin forages from low perches, searching for invertebrates on the ground amongst logs and litter. It requires habitat with an understorey of shrubs, native grasses and forbs, litter and fallen timber (Higgins and Peter 2002). The cup nest of bark, grass, lichen and spiderweb is built in a fork or on a horizontal tree branch, usually up to 3 m above the ground but sometimes higher (Pizzey and Knight 2012).

The Scarlet Robin reporting rate has declined in NSW by more than 50% in the 20 years between the two national bird atlases (Barrett *et al*. 2007). In the ACT the Woodland Bird Monitoring project conducted by Canberra Ornithologists Group (COG) shows a significantly declining trend in occupancy for the Scarlet Robin over a ten-year period (Bounds *et al*. 2010). Factors at the site scale which were related to this decrease were a reduction in shrub cover and a decline in canopy tree health (Taws *et al*. 2012).

In the Molonglo River Reserve the Scarlet Robin is reported mostly between March and October from the woodlands in Kama, with occasional records from riparian woodlands and grasslands along the length of the Molonglo River.

THREATS TO SCARLET ROBIN

Threats to the Scarlet Robin include loss and fragmentation and degradation of habitat, particularly the loss of key understorey components such as shrubs, native groundcover, litter, fallen timber and standing dead trees. Other threats include predation by feral cats, by overabundant populations of Pied Currawongs, and by rats which nest and prey on fledglings. Habitat is also believed to become unsuitable if dense regeneration occurs following bushfires and other disturbances.

Speckled Warbler (*Chthonicola sagittata*)

The Speckled Warbler is listed as Vulnerable in NSW and Victoria.

The Speckled Warbler is a small bird (to 12 cm) with grey-brown upperparts, prominent white eyebrow and boldly streaked underparts. The male has a black line over the white eyebrow; the female has a chestnut line.

The Speckled Warbler occurs in south-eastern Australia, on the Divide and inland from southern Queensland through to western Victoria. It is found in dry woodlands of eucalypt, cypress or acacia, and requires good quality groundcover of native grasses and forbs, logs, rocks and litter, in which it forages for invertebrates. The domed nest is built of grass, bark and moss, and is hidden on the ground under a grass tussock or log, or low in a thick shrub (Pizzey and Knight 2012).

The Speckled Warbler has declined in parts of its range in NSW (Barrett *et al.* 1994; Keast 1995; Reid 1999). In the ACT the species is uncommon but can often be found at the same location year after year, in the woodlands and drier open forests of the lowlands and into the mountains. The reporting rate for the species in the ACT appears to be stable, and is even showing a weak increase in the COG Woodland Bird monitoring project (Bounds *et al.* 2010).

In the Molonglo River Reserve the Speckled Warbler has been recorded in the riparian woodland and grassland along the river, most frequently in the area between Coppins Crossing and the old sewage ponds, and at the lower end of the river, but also occasionally upstream from Coppins Crossing. The Speckled Warbler has rarely been reported from Kama (Canberra Ornithologists Group database).

THREATS TO SPECKLED WARBLER

The main threat to the Speckled Warbler is clearance or degradation of habitat, particularly the groundlayer. As a ground-nesting bird it is vulnerable to predation from introduced animals such as foxes, cats and dogs.

White-fronted Chat (*Epthianura albifrons*)

The White-fronted Chat is listed as Vulnerable in NSW.

The White-fronted Chat male has a white face and throat separated from the white belly by a broad black band which extends from the back of the head and shoulders. The wings and back are greyish-brown. The female is duller grey-brown. The White-fronted Chat occurs in southern Australia from NSW across to south-west Western Australia, in open damp habitats particularly wetlands containing saline areas adjacent to grassland or open woodlands (Higgins *et al*. 2001). It feeds on the ground on small invertebrates.

The White-fronted Chat reporting rate has declined in NSW by more than 30% in the 20 years between the two national bird atlases (Barrett *et al.* 2007). In the ACT they are rare and were thought to be nomadic (Taylor and COG 1992) with a fluctuating number of records coming from grassy wetland locations such as Uriarra Dam, West Belconnen ponds, Lake Ginninderra and Lake Tuggeranong. Since 2003 the White-fronted Chat has been reported regularly from Stromlo Forest Park (Canberra Ornithologists Group database).

The White-fronted Chat has been recorded occasionally in the Molonglo River Reserve, mostly in the area around Coppins Crossing downstream to the old sewage ponds.

THREATS TO WHITE-FRONTED CHAT

The major threats to the White-fronted Chat are reduction in habitat size and quality, elevated amounts of nest-predation, predation by feral cats and foxes, human disturbance (including urbanisation) and climate change.

2.5.2 Other woodland birds of interest recorded in the Reserve and offsets

Crested Shrike-tit (*Falcunculus frontatus*)

The Crested Shrike-tit is listed as Rare in South Australia.

The Crested Shrike-tit is a sturdy crested bird (15–19 cm). It has a striking black-and-white pattern on the head, a yellow breast and an olive-green back and a strong black bill. It forages noisily amongst foliage and bark for invertebrates. The powerful bill is used to prise open bark curls, or crush hard-shelled insects.

The eastern race of the Crested Shrike-tit is widespread across south-eastern Australia, mostly from Hervey Bay in Queensland through to Fleurieu Peninsula, South Australia (Birdata n.d.). It has been reported as declining across this distribution (Reid 1999) but not yet to the extent that warrants listing as a Threatened species.

In the ACT the species is sparsely distributed through the mountain ranges and is found even less commonly in the lower woodlands (Taylor and COG 1992). Pairs or family groups were recorded fairly reliably through the 1990s–2000s in areas such as Mulligans Flat–Goorooyarroo, Campbell Park, Newline Quarry and Castle Hill (Canberra Ornithologists Group database). However, the species has not been recorded at Mulligans Flat since 2007, Goorooyarroo since 2010, Newline Quarry since 2011, or Castle Hill since 2007, and only once at Campbell Park since 2004. In fact the most reliable lowland location now in which to find the Crested Shrike-tit in the ACT is Lake Ginninderra.

In the Molonglo River Reserve the Crested Shrike-tit has only been recorded at Kama, although not since 2007. It is most likely to be found in Box-Gum Woodland rather than the riparian woodland because River She-oaks do not have the peeling bark favoured by the species.

THREATS TO CRESTED SHRIKE-TIT

The primary threat to the Crested Shrike-tit appears to be loss and fragmentation of habitat or decline in habitat quality.

Double-barred Finch (*Taeniopygia bichenovii*)

The Double-barred Finch is attractively marked with a grey-brown head and back, black wings speckled white, and two thin black bands across the white chest.

It is distributed across eastern and northern Australia from the Victoria–NSW border north to Queensland and across the top of the continent to the southern Kimberley. It is found in woodlands, scrublands and areas of rank grass, particularly close to permanent water (Pizzey and Knight 2012). The bird feeds on grass seeds and takes invertebrates, particularly when breeding. The bulky dome-shaped nest is built from grass in cover of dense shrubs or tall grasses, or under eaves.

In the ACT the Double-barred Finch is uncommon but spread across the lowlands, particularly where there are patches of shrubs and long grass near water. The species is not often found in suburban gardens and may have declined in areas where suburbs have encroached (Taylor and COG 1992).

In the Molonglo River Reserve the Double-barred Finch has been reported regularly along the river corridor, particularly between Coppins Crossing and Kama. It has not been recorded from Kama but there is one record from the woodlands in western Belconnen (Canberra Ornithologists Group database).

Dusky Woodswallow (*Artamus cyanopterus*)

The Dusky Woodswallow is a neat dusky brown bird, with blue-grey wings edged in white, and a black tail with white tips. It occurs in eastern and southern Australia from mid-north Queensland right through to the south-west of Western Australia. It is a summer migrant in the south of its range, wintering in the north and inland (Pizzey and Knight 2012).

The Dusky Woodswallow is found in open habitats such as woodlands, scrublands and grasslands. It perches prominently on dead branches, fences, posts and wires to take insects on the wing or from the ground. The untidy stick nest is built low in the fork of a tree or stump (Pizzey and Knight 2012).

The Dusky Woodswallow is found across the ACT except at the highest altitudes. They are most common in open woodlands or the ecotone where treed vegetation meets grasslands (Taylor and COG 1992).

The species was regarded as declining in NSW (Reid 1999), and although numbers may fluctuate from year to year, within the ACT the species' reporting rate is stable (Bounds *et al.* 2010). The Dusky Woodswallow is regularly reported from the Molonglo River Reserve, including Kama and along the length of the river, particularly the stretch between Coppins Crossing and the old sewage ponds (Canberra Ornithologists Group database). Breeding has also been reported there and in Kama.

Jacky Winter (*Microeca fascinans*)

The Jacky Winter is listed as Rare in South Australia.

The Jacky Winter is a robin-size plain grey-brown bird with conspicuous white outer tail feathers. It feeds on insects caught on the wing or more frequently taken from the ground, and requires a groundlayer of native grasses and forbs, leaf litter and fallen timber, with dead branches and logs for perching points (Pizzey and Knight 2012).

The Jacky Winter is widespread across much of the treed areas of Australia but its occurrence in settled areas is patchy (Pizzey and Knight 2012). In the ACT it has been recorded only in larger relatively undisturbed woodland areas including Mulligans Flat, Campbell Park, Castle Hill and the grassy valleys of the Naas and Gudgenby Rivers, but it is not always reliably found in these areas (Taylor and COG 1992).

The Jacky Winter is regarded as declining in south-eastern Australia (Reid 1999). In the ACT it has been reported less from Mulligans Flat–Goorooyarroo and Uriarra homestead in the last 5–10 years than during the previous 20 years, although the number of records from Campbell Park is fairly stable (Canberra Ornithologists Group database).

The Jacky Winter has rarely been reported from the Molonglo Valley and there is only one definite record of the species in the Molonglo River Reserve, from Spring Valley Farm (Stagoll, unpublished data, 2008–09).

THREATS TO JACKY WINTER

The main threats to the Jacky Winter appear to be loss, fragmentation or degradation of habitat, and increased human disturbance.

Restless Flycatcher (*Myiagra inquieta*)

The Restless Flycatcher is declared Rare in South Australia.

The Restless Flycatcher is one of the larger flycatchers (up to 21 cm long). It has a glossy blue-black head and back with white throat and upper breast sometimes washed pale orange-buff (Pizzey and Knight 2012). It occurs around the northern, eastern and southern parts of Australia, avoiding the arid inland and western coastline. It is found in open forest, woodlands and farmlands. It forages from low perches taking insects in the air or plucking them from leaves as it hovers in the air.

In the ACT the Restless Flycatcher is more likely to be found in the southern valleys of the Naas, Gudgenby and the Murrumbidgee Rivers and it is uncommon in the woodlands closer to the suburbs (Taylor and COG 1992).

The species is regarded as declining in NSW (Reid 1999), and the reporting rate is declining in the ACT (Canberra Ornithologists Group database). In the Molonglo River Reserve the Restless Flycatcher has been recorded several times in Kama and once in the woodlands of western Belconnen.

Southern Whiteface (*Aphelocephala leucopsis*)

The Southern Whiteface is a small (12 cm) fairly plain bird, grey-brown above with a white mask from the face to the underparts, bordered on the top with a black line between the eyes. It occurs across the inland southern half of Australia, in grasslands, open woodlands and scrublands usually where there are dead trees and stumps. It feeds mostly on or near the ground on invertebrates and seeds, and builds an untidy nest of grass and bark within a tree hollow, stump or low shrub (Pizzey and Knight 2012).

Within NSW the Southern Whiteface is considered to be a declining woodland species (Reid 1999). It is uncommon within the ACT, found in lowland areas of grassland to open woodland where native understorey remains. It has disappeared from areas such as the Tuggeranong Valley where suburbs have encroached (Taylor and COG 1992).

The Southern Whiteface is reported fairly regularly from parts of the Molonglo River Reserve including Kama and the grassland slopes above the river from Misery Point downstream (Canberra Ornithologists Group database).

2.5.3 Threats to woodland birds

The main threats to woodland birds arise from loss or damage to their habitat. In general terms this includes:

- loss of mature trees;
- loss of canopy cover from fire, disease or insect attack;
- removal of standing dead trees, fallen timber or litter;
- predation or disturbance by pest species or uncontrolled domestic animals;
- competition from introduced or over-abundant native bird species such as Noisy Miners (*Manorina melanocephala*);
- weed invasion;
- excessive groundcover biomass;
- inappropriate fire regimes;
- overgrazing;
- lack of connectivity within and outside the Reserve;
- use of chemicals in control of weeds and pests;
- disturbance from human activity;
- human-induced climate change.

Woodland birds close to urban areas face additional threats:

- changes in vegetation composition and structure from invasion by escaped garden plants and other weeds, and increased nutrients from urban stormwater runoff;
- changes in predation and competition from native and non-native fauna, including over-abundant native species (Pied Currawongs, Rainbow Lorikeets, Brush-tailed Possums) or exotic species (Common Myna, Black Rats) or uncontrolled domestic animals;
- greater human presence;
- tall chain-mesh fences and buildings with large windows (Swift Parrot particularly);
- increased noise and air pollution.

Threats are further summarised below in s.2.8.

2.5.4 Raptors

Twelve species of raptor have been recorded hunting or breeding in the Molonglo Valley, but only three are considered here: Little Eagle (listed as Vulnerable in the NC ACT); and two species not listed in the ACT, namely Wedge-tailed Eagle, and White-bellied Sea-eagle which is also listed as a Migratory species under the EPBC Act.

The raptors are reliant on all habitats within the Molonglo River Reserve and the surrounding landscape, including threatened habitat and offsets, the river valley and the dryland matrix of modified habitats in between. This is partly because the area within the Molonglo River Reserve is not large enough to support territories of these species. It is also because the variety of vegetation types in the wider landscape provides additional habitat for the raptors' prey (mammals, birds and reptiles).

As nesting habitat, raptors particularly require large trees — either eucalypt or River She-oak (either living or dead) in either the non-riparian or the riparian zones — as structures that can support the bulky heavy nests of the Little Eagle, Wedge-tailed Eagle and potentially the White-bellied Sea-eagle.

Good quality habitat is necessary to support the range of fauna that the raptors rely upon. Many of the habitat features listed for the woodland birds will promote a diversity of fauna which will in turn support the raptors. In addition to the non-riparian habitats in the Reserve, the riparian area contains important foraging habitat for all three species of eagle (Olsen and Fuentes 2004). The Sea-Eagle hunts along the river for waterbirds, fish, reptiles and mammals. The Little Eagle includes the resource-rich riparian areas within its wider hunting territories.

Little Eagle (*Hieraaetus morphnoides*)

The Little Eagle is listed as Vulnerable in NSW and ACT.

The Little Eagle is a small stocky eagle with a wingspan of up to 130 cm, a slight dark crest on the head, and heavily feathered legs. The plumage can be of two distinct colour phases; the light phase is pale cream-buff underneath with dark back and wings; the dark phase is a darker brown all over (Pizzey and Knight 2012). Both phases have a distinct underwing pattern although it is more pronounced in the light phase.

The Little Eagle occurs across mainland Australia, although most breeding pairs are found in the south-east of the continent (Olsen and Fuentes 2004). It uses a range of habitat types except heavily forested areas. In the ACT, records of the Little Eagle are mostly from the lowlands away from built-up areas (Taylor and COG 1992).

The Little Eagle eats medium-size mammals, birds, reptiles and large insects. In the ACT region, prey is mostly rabbits and birds, primarily parrots (Olsen and Fuentes 2004). The Little Eagle builds a large stick nest generally in a tall tree within a remnant patch, or occasionally it will use an abandoned Wedge-tailed Eagle's nest (Olsen and Fuentes 2004).

The species has declined in NSW in the past few decades, particularly in the sheep–wheat belt (Barrett *et al.* 2007). The Little Eagle has undergone a severe decline in the ACT, from 13 breeding pairs in the 1980s to 11 pairs in the 1990s and only one or two breeding pairs in the most recent years (Olsen *et al.* 2012a,b; Olsen *et al.* 2013).

The Little Eagle hunts across the range of vegetation communities found in the Molonglo River Reserve, in a territory that could be expected to be as large as that of a Wedge-tailed Eagle (Olsen 2007), but it nests in areas outside the Reserve. Within the Reserve the species has been recorded along the length of the river from Scrivener Dam to the Murrumbidgee River but most of these records are of birds flying overhead. There have been occasional records from Kama and the western Belconnen woodlands (Canberra Ornithologists Group database). The most reliable breeding pair of Little Eagles in the ACT occupies a territory covering the lower Molonglo valley including the lower end of the river corridor. Several nesting sites of this pair are scattered through their territory, up to 5 km apart (Olsen 2007), but not within the Molonglo River Reserve.

THREATS TO LITTLE EAGLE

Primary threats to the Little Eagle include habitat loss, particularly due to urban expansion, human disturbance and, potentially, the chemicals used to control rabbits.

Wedge-tailed Eagle (*Aquila audax*)

The Wedge-tailed Eagle is the largest raptor in Australia with a wingspan of up to 280 cm. Older adults are mostly black; younger birds have paler golden brown feathers. The legs are heavily feathered and the diamond-shaped (wedge) tail is conspicuous in flight (Pizzey and Knight 2012).

The Wedge-tailed Eagle can be found across Australia in habitats ranging from heavily-forested mountains to almost treeless plains. In the ACT most records are from the grasslands and open woodlands, particularly those in the southern mountain valleys (Taylor and COG 1992).

Nests of the Wedge-tailed Eagle occur within the Reserve but the birds' home range can cover up to 32 km^2 (Marchant and Higgins 1993), over all vegetation types within the Molonglo River Reserve and extending well beyond the edges of the Reserve.

The Wedge-tailed Eagle eats mammals, birds, reptiles and carrion. In the ACT region rabbits were the principal prey item several decades ago, but now macropods and large birds are the primary prey. Carrion can make up a significant portion of their diet (Olsen and Fuentes 2004). The species builds a large stick nest high in a mature tree, often close to a waterbody.

The Wedge-tailed Eagle has declined in the ACT as suburbs have been developed in areas formerly used as hunting and breeding territories (Taylor and COG 1992). In the Molonglo River Reserve the Wedge-tailed Eagle is reported regularly along the length of the lower Molonglo River but more frequently from the downstream end. Three territories were identified covering the Molonglo River Reserve (Olsen 2007) but this has probably declined now to two with the recent abandonment of the territory closest to the new Molonglo suburbs (J. Olsen pers.comm. 2014).

THREATS TO WEDGE-TAILED EAGLE

The main threats to the Wedge-tailed Eagle are destruction of suitable habitat and human encroachment and disturbance, particularly around nest sites.

White-bellied Sea-eagle (*Haliaeetus leucogaster*)

The White-bellied Sea-eagle is listed as Endangered in South Australia and Vulnerable in Victoria.

The White-bellied Sea-eagle is a large raptor, only slightly smaller than the Wedge-tailed Eagle. The adults are white and grey, and immature birds are brownish. The species occurs from south-east Asia through to Australia where it is found right around the coast and inland along the larger rivers and water storages (Pizzey and Knight 2012).

The White-bellied Sea-eagle is an uncommon visitor to the ACT, found along the major rivers and lakes (Taylor and COG 1992). Breeding has not been confirmed for the species within the ACT but elsewhere in the region it builds a large stick nest placed high in eucalypts or casuarinas on the banks of large rivers or dams. It feeds on fish, birds, mammals, reptiles, crustaceans and carrion, and in the ACT it principally eats waterbirds (Olsen and Fuentes 2004).

In the Molonglo River Reserve there are records for the species along the length of the river below Scrivener Dam but most commonly at the confluence with the Murrumbidgee.

2.5.5 Threats to raptors

HUMAN DISTURBANCE

All eagles are sensitive to disturbance from humans, particularly near the nest. The amount and intensity of human activity within and around the Molonglo River Reserve can be expected to increase rapidly in the next few years. The Wedge-tailed Eagles' nest near Misery Point, close to the urban developments of Wright and Coombs, is thought to be no longer in use and it is believed that the breeding pair has left the territory (J. Olsen pers.comm.).

PEST CONTROL

For controlling rabbits to reduce their degradation of landscape, the Pindone poison used in peri-urban areas of the ACT is known to be particularly toxic to eagle species if ingested (Martin *et al.* 1994). This is a possible cause of the rapid decline of the Little Eagle in the ACT (Olsen 2007).

Reducing rabbit numbers may reduce food availability for these raptors, because the rabbit is a major prey species for the Little Eagle, and to a lesser extent the Wedge-tailed Eagle (Olsen *et al.* 2010). However, these raptors also eat other mammals and birds.

Threats are summarised below in s.2.8.

2.5.6 Migratory birds

Among migratory birds, these Guidelines consider in detail only the White-bellied Sea-eagle (under Raptors, above) and the Rainbow Bee-eater.

Several other migratory bird species listed in international agreements and in the EPBC Act have been recorded in or could occur in the Molonglo River Reserve. These include:

- Australian Reed-Warbler *Acrocephalus australis*, a species of wetlands, urban lakes and rural dams wherever there are beds of dense bulrushes or reeds. In the Molonglo River Reserve the species has been recorded at various locations along the river wherever slow-moving water has allowed dense reeds to establish. The species is common and widespread in Australia and is not considered specifically here.
- Latham's Snipe *Gallinago hardwickii*, a migratory wading bird arriving from Japan to spend the non-breeding season in south-east Australia. It requires wetland habitat with dense vegetation. It has not been recorded in the Molonglo River Reserve, but has been recorded infrequently at Warrina Inlet and Yarramundi Reach on Lake Burley Griffin. There is little suitable habitat for Latham's Snipe in the steep topography of the Molonglo River Reserve, but small areas of potential habitat could occur in drainage lines with wet grassland, such as in the lower reaches of Kama, or around the peninsula downstream of Coppins Crossing.
- White-throated Needletail *Hirundapus caudacutus*, an aerial species feeding on flying insects. It is an uncommon summer migrant and has been recorded occasionally over the Molonglo River Reserve. No specific guidelines are included for this aerial and transitory species other than the general guidelines for protection and enhancement of the Molonglo River Reserve.
- Rufous Fantail *Rhipidura rufifrons*, which migrates south from northern Australia and New Guinea to breed in the wet forests of southern Australia in spring–summer. In the Molonglo River Reserve it has only been recorded on two occasions on passage between the mountain forests and its northern wintering habitat.
- Satin Flycatcher *Myiagra cyanoleuca*, which follows a similar pattern to the Rufous Fantail but has not been recorded in the Molonglo River Reserve. General guidelines for protection and enhancement of the Molonglo River Reserve will provide migratory habitat for both these species and they are not considered further here.

Rainbow Bee-eater (*Merops ornatus*)

The Rainbow Bee-eater is a beautifully-coloured medium-size bird to 25 cm, with long slender beak and two long thin tail streamers. It has a golden-orange head and throat bisected by a prominent black line through the eye. The back and wings are blue-green, and underwings coppery-orange.

This species occurs across mainland Australia as well as in New Guinea and Indonesia. It is found in a variety of open habitats but avoids the cool wet forest areas and driest inland. It is most commonly seen near suitable breeding areas and a source of water. The birds feed chiefly on flying insects such as bees, wasps, dragonflies, butterflies and moths, catching them on the wing.

The population in the southern half of Australia migrates north for the winter; the northern populations are present year-round. The Rainbow Bee-eater is migratory to the ACT, and can be found along the major river valleys of the lowlands from October to February–March. In the Molonglo River Reserve it is reported in most years in the river valley downstream from Coppins Crossing, but less frequently upstream.

The nest is built at the end of a metre-long burrow, excavated directly into flat, gently sloping sandy or sandy-loam soils, or less commonly in vertical banks, not far from water. Nests may be solitary, or more typically colonial, and are built where groundcover is sparse and perching points such as dead branches or overhead wires occur near the nest, with good visibility of the surrounding area (Higgins 1999). Birds will return to the same nesting area each year but will build a new nest rather than re-use an old one.

In the Molonglo River valley the core breeding area for the Rainbow Bee-eater is the right (eastern) bank of the river for 1 km upstream of the old sewage ponds (Taws 2014), relatively near to a potential special purpose reserve identified as a possible recreation site in the (draft) Reserve Management Plan (ACT Government MP 2014).

This stretch of river bank contains suitable soils and perching points in many of the dead River She-oak, and a small area with sufficiently sparse groundcover for nesting, relatively free of dense weeds and introduced pasture grasses. Nesting burrows have also been found in roadside cuttings near Barrer Hill and Coppins Crossing (Taws 2014).

Breeding has been recorded at only a few other locations, mostly along major creeks and rivers such as the Naas and Murrumbidgee.

Although the population of Rainbow Bee-eater is considered to be secure in Australia, the species is included in these Guidelines for Molonglo River Reserve because of the presence of the breeding population and the limited breeding habitat available elsewhere in the ACT.

2.5.7 Threats to the Rainbow Bee-eater

DISTURBANCE OR TRAFFIC NEAR NESTS

Humans and feral or grazing animals are potential threats to the Rainbow Bee-eater in the Molonglo River Reserve, because they may disturb or damage the nests or nesting site or nesting areas. Cattle grazing in the nesting area might trample the nesting burrows where they are dug into flat or sloping ground.

The Rainbow Bee-eater gives alarm calls and may not enter the nest when a person is nearby (Comrie-Smith, in Higgins 1999). A high enough level of human disturbance could disrupt the birds to the point where the nest fails; for example, for nests in road cuttings, an increase in vehicle or pedestrian traffic along the roads could be threatening.

PREDATION

These nests are also vulnerable to predation by foxes which dig down through the sandy soils to reach the eggs or nestlings.

LOSS OF HABITAT

The nest site also might become unsuitable through encroachment of woody vegetation such as native shrubs (*Kunzea ericoides*) or woody weeds, or tall dense grasses particularly African Lovegrass or Phalaris. An increase in groundcover height and density around nesting areas is a potential threat.

2.5.8 Waterbirds

The four waterbirds outlined here are found across Australia apart from the arid inland, and are common residents of the urban lakes of the ACT. The Little Pied Cormorant is also found on farm dams and other small bodies of water within the ACT (Taylor and COG 1992).

The Great, Little Black and Little Pied Cormorants and the Darter feed underwater by diving and propelling themselves with their feet, catching fish, crustaceans, aquatic insects and frogs. The Darter specialises more in catching fish with its sharp pointed bill. The feathers of these birds are not waterproof and they must dry out their wings after fishing.

All four species build nests in tree branches overhanging deep water, where the branches or leaves do not block direct access to the water, but where the nests can be well screened by foliage from the riverbank. Prior to the development of the urban lakes in the ACT it is unlikely that any of the species would have bred here in significant numbers, and any breeding would have been confined to the riparian habitat along the Murrumbidgee and Molonglo Rivers (Davey and Fullagar 2008). Historically the three cormorant species were recorded only as 'occasional — rivers' (Mathews 1943) and the first observation in the area for the Australian Darter was not made until 1965 (Wilson 1999).

In the ACT the most common trees with branches overhanging the deep water of the urban lakes or major rivers are exotic species, primarily willow (*Salix* spp.) and poplars (*Populus* spp.), and most nests of cormorants and darters have been recorded in Crack Willow (*Salix fragilis*) (Davey and Fullagar 2008; Taws 2012). Recent breeding of these species in the ACT has been concentrated along the Molonglo River upstream of Lake Burley Griffin, and on the edge of Lake Burley Griffin near Sullivan's Creek (Davey and Fullagar 2008).

In the Molonglo River Reserve a small breeding colony of Little Pied Cormorants and Australian Darters occurs on the river 500 m downstream of Tuggeranong Parkway bridge (Taws 2011, 2014). Individual birds of all four species have been recorded along the full length of the river wherever there are deep still pools. However, the river depth and width, or the structure of the riparian vegetation, do not appear to be suitable for breeding, apart from the one known colony. The Little Black Cormorant and the Great Cormorant have not been found breeding in the Molonglo River Reserve (Canberra Ornithologists Group database).

Australian Darter (*Anhinga novaehollandiae*)

The Australian (or Australasian) Darter is slender, more so than cormorants; it has a long snake-like neck and sharp pointed bill. The male is dark with a red-brown neck, white streak on the cheek and white streaks across the wings. The female is paler grey on the neck and whitish underneath.

Great Cormorant (*Phalacrocorax carbo*)

The Great Cormorant is the largest of the cormorants, black all over with an orange throat pouch and facial skin, white cheek and white mark on the flank.

Little Black Cormorant (*Phalacrocorax sulcirostris*)

The Little Black Cormorant is a small black cormorant with a grey slender bill and approximately 20% smaller than the Great Cormorant.

Little Pied Cormorant (*Microcarbo melanoleucos*)

The Little Pied Cormorant is the smallest Australian cormorant. It is black on the crown, back of head, back, wings and tail, and white on the side of the head, throat and underparts.

2.5.9 Threats to waterbirds

LOSS OF HABITAT

General threats to the waterbirds include damage to riparian habitat quality, and poor water quality resulting from sediment and nutrient pollution from soil erosion and urban runoff.

The main specific threat to the Cormorants and Darters breeding in the Molonglo River Reserve is the loss of their nest trees through deliberate removal, senescence, or damage from storms or floods.

The exotic tree species in which Cormorants and Darters build their nests are subject to weed control programs by the ACT Government. Protection of nest trees and adjacent habitat is important to ensure continued breeding by these species until replacement native tree species can be established.

Removal of dense vegetation screening the nest from the river bank can also prevent nesting, even if the nest tree remains.

HUMAN DISTURBANCE

Human disturbance during the nesting period is also likely to pose a significant threat, with adults deserting their nests leaving them vulnerable to predation and exposure.

2.6 Other native fauna

A number of other threatened, protected and/or otherwise significant fauna species are noted as occurring or possibly occurring in the Molonglo River Reserve and offset areas. They include mammals, reptiles, invertebrates and fish.

Monitoring and baseline assessment techniques that may be useful for assessing habitats and for estimating populations of the species themselves are outlined in Chapter 4.

2.6.1 Mammals

In ACT as a whole, large areas of woodland in relatively good condition can support a greater number of threatened species (and other species) than more modified woodland areas (ACT Government 2004b). Mammals are often highly mobile, and use a variety of different parts of the landscape, and thus may be found in any particular area sporadically, including the Molonglo River Reserve and offset areas (NES patches).

The following observations have been recorded for the river valley in the Molonglo River Reserve.

- Spotted tail Quoll *Dasyurus maculatus* (Vulnerable under the EPBC Act): there has been one possible record in the river valley. The species is found across a variety of habitat types including forests, woodlands, rainforests and heathlands. There have been two recent records of the species from nearby suburbs, including Belconnen in 2010 and Oakey Hill Nature Reserve in 2013. In his 1992 survey Barrer noted that a Spotted-tail Quoll, which had been found in western Belconnen before his study, may have dispersed using the Molonglo River valley.
- Bush Rat *Rattus fuscipes*: Barrer (1992) concluded that the Bush Rat population in the river valley was locally significant, being likely to be the closest to urban Canberra. The remains of *R. fuscipes* were found in scats of a fox and dog in the river gorge.
- Grey headed Flying Fox *Pteropus poliocephalus*, which is listed as vulnerable in the EPBC Act, is likely to occur in the river valley trees of the Molonglo River Reserve, especially the flowering eucalypts near the water, and also in Kama and the offsets.

- Wallaroos and other macropods: the river valley of the Molonglo River Reserve is habitat as well as a movement corridor for larger vertebrates, and a corridor for short range and dispersal movements of the regionally uncommon Eastern Wallaroo which favours the rocky gorge-like environment (W. Osborne, pers.comm. 2014). Barrer (1992) recorded all the ACT macropods in 8.5 km of the river valley including the gorges, between the Murrumbidgee River and the downstream limit of NES patch P in the Spring Valley Farm offset area (downstream of Coppins Crossing).
- Native and introduced mammals: Barrer (1992) recorded 11 native and eight introduced mammals (excluding bats) in his survey of the Molonglo River valley, between the confluence with the Murrumbidgee River and the downstream limit of NES patch P (downstream of Coppins Crossing) including the steep gorges which protect a mosaic of habitats.
- Platypus: Barrer (1992) noted that the river provided habitat for the Platypus (which is also known from the stretch of river near the Lower Molonglo Water Quality Control Centre, near the Murrumbidgee River).

2.6.2 Reptiles and amphibians

The rocky habitat in the Molonglo River Reserve, with its cover of native grasses and shrubs is habitat for many species of reptiles. However, these valuable habitats for reptiles can be rapidly degraded by removal of rocks, by improvement of pasture (e.g. application of farm fertilisers) and by nutrients added to the soil (e.g. in sheep camps or from nutrient run off from altered hydrological regimes upslope).

Osborne and McKergow (1995) found 19 species of reptiles as well as Pink-tailed Worm-lizard, including:

- Nobbi Dragon *Diporiphora nobbi*, locally rare;
- Red-sided Skink *Carlia tetradactyla*;
- Spotted-backed Skink *Ctenotus orientalis*.

Among at least 20 species of reptiles Barrer (1992) also found:

- Stone Gecko *Diplodactylus vittatus*; and
- Marbled Gecko *Christinus marmoratus*.

Concerning Rosenberg's Monitor (very rare in the ACT and listed as Vulnerable in NSW), Barrer (1992) noted that a specimen found in western Belconnen may have come from the Lower Molonglo Gorge.

Waterbodies such as the dams in Kama and the offsets of the Arboretum woodland provide habitat for amphibians, as well as reptiles and invertebrates. Barrer (1992) recorded five species of frog, and considered other species possible or likely to also occur.

2.6.3 Terrestrial invertebrates

The Perunga Grasshopper *Perunga ochracea* (listed as vulnerable in the ACT Nature Conservation Act) has been recorded in the urban section of the Reserve (D. Wong pers.comm. 2009).

The Golden Sun Moth *Synemon plana* is not recorded as occurring in the Reserve or the offets, despite targeted surveys in the past ten years (Eco Logical Australia 2010a). The Golden Sun Moth is listed as critically endangered in the EPBC Act and Endangered in the NC Act. If present in the Molonglo River Reserve then it is likely to be limited to areas where grassland is dominated by short wallaby grasses. Current research is developing a translocation technique for Golden Sun Moth larvae, in the Arboretum woodland offset area (in NES patch N).

2.6.4 Fish and aquatic invertebrates

A range of exotic fish species inhabit the river.

Conservation-significant species of native fish have not been recorded since pre-2000 (Beitzel *et al*. 2009). In their report in 2006, Biosis Research identified that threatened fish and invertebrates which potentially could, or are known to, occur at the Murrumbidgee confluence include Macquarie Perch, Silver Perch and Murray Cod, as well as Murray Crayfish. Biosis Research noted these species might be supported if riparian vegetation and aquatic habitats could be improved such as by weed control, riparian protection, revegetation and reducing the impacts of Scrivener Dam.

Macquarie Perch (E NC, E EPBC, recorded before 1990), Silver Perch (E NC, likely to occur) and Murray Cod (E EPBC recorded before 2000) all need structural complexity in the river and woody debris in the river.

The fish assemblage of the Molonglo River was surveyed in 1977–81, 1992–93 (Lintermans 2002), 1994–97, 2003 and in 2009. The latter survey targeted Trout Cod, Macquarie Perch and Murray Cod, all of which are threatened under the EPBC Act (Beitzel *et al*. 2009). Lintermans recorded Murray River Crayfish in the lower Molonglo River in 1997 (Lintermans 1998) but there have been no other records (Mark Lintermans pers.comm.October 2014). Silver Perch have not been recorded in the lower Molonglo River since 2000, though they are stocked into Googong Dam and wash into Lake Burley Griffin; Trout Cod have not been recorded from the Molonglo River since 1984; Murray Cod are regularly angled from the Molonglo, but they have never shown up in fish surveys (which use techniques not particularly suited to this species) (Mark Lintermans pers. comm. October 2014).

2.7 Characteristics of habitats

Protection of all threatened and significant fauna, especially the Pink-tailed Worm-lizard and the Superb and Swift Parrots, will depend on management knowing characteristics that identify actual and potential habitat.

Monitoring methods for assessing habitats and for estimating populations of the species themselves are outlined in Chapter 4.

This section (s.2.7) describes habitat features that are important to threatened and significant fauna in the Guidelines area, including where the habitats are found (in general terms), and the resources they provide. The section notes fauna that have been recorded (in text above) as using each habitat feature, whether for living, feeding or nesting. Table 2.12 summarises species seen using or crossing the Guidelines area.

2.7.1 Habitat by vegetation-type

MNES and other vegetation communities

Box-Gum Woodland is one of the prime habitats used by all the woodland bird species under consideration. The important components are the mature trees and structural diversity in the grasses and forbs of the groundlayer. Large raptors use the strong mature branches for nest supports; the branch and foliage structures provide for smaller woodland birds' nests; parrots, including Superb Parrot, and cockatoos nest in large hollows in very old trees. Mature trees have complex bark which houses many invertebrates, and the trees may have mistletoe. Even modified Box-Gum Woodland can have these features.

Likewise, Natural Temperate Grassland, whether in good condition or modified to a mixed native/exotic grassland, is used for foraging by a number of the woodland birds, particularly if the grassland is close to areas of woodland. Where the grassland carries an open sward of native grass species that show it is relatively undisturbed, and there are suitable rocks and little ground litter, then these rocky grassy areas are likely to be habitat for Pink-tailed Worm-lizard, and foraging area for the Brown Treecreeper (a woodland bird). Birds such as Stubble Quail, Brown Quail, Australasian Pipit, Horsfield's Bushlark and Brown Songlark are grassland specialists, found only in this habitat; they are not discussed in these Guidelines.

All hollow-bearing eucalypts, whatever the vegetation community, should be given the highest priority for conservation.

Highly modified woodland, secondary grassland, other native woodlands and dry forests as well as former pine plantation near the Molonglo River Reserve form a mixture of overstorey and groundstorey that offers good habitat with landscape connectivity for many of the woodland birds. The Flame Robin, Dusky Woodswallow and Southern Whiteface in particular will forage out into grassy habitats. The finches — Diamond Firetail and Double-barred Finch — will forage in the grasslands if even a small amount of shelter from woody shrubs or clumps of Blackberry is available. Particular features in these areas are sometimes very important to the conservation of a bird species — possibly more so than Box-Gum Woodland.

When temperatures are low, open habitat warmed by the sun is favoured by small insectivorous birds for foraging, rather than shaded areas (Villén-Pérez 2013). Habitats that are more open than woodland are used by many of the woodland birds, such as Flame Robin, Scarlet Robin, Hooded Robin, Speckled Warbler, Double-barred Finch and Diamond Firetail, particularly in winter.

Black Cypress Pine Forest, Snow Gum Grassy Woodland, Apple Box – Broad-leaved Peppermint Shrubby Woodland, and Red Stringybark – Scribbly Gum Tall Dry Forest: these communities in the dryland matrix and offsets are all used by woodland birds that require denser tree cover or shrubbier habitats than Box-Gum Woodland provides. There are fewer survey data on birds in these vegetation communities than in Box-Gum Woodland (particularly in Kama), but most of the woodland bird species (apart from the particularly rare birds) have been recorded in them. Map 2.6 (s.2.3) shows the distribution of these vegetation communities along the Molonglo River Reserve.

Riparian areas

Stagoll *et al.* (2010) found more woodland bird species in the valley of the Molonglo River than in eucalypt woodlands in the surrounding rural lands. Their study reinforces the critical importance of the riparian zone to conservation of birds in the landscape (Fisher and Goldney 1997; Bennett *et al*. 2014).

In the riparian zone, the tree canopy is the habitat stratum most widely used by birds (Fisher and Goldney 1997). The dominant tree species along the Molonglo River, River She-oak (*Casuarina cunninghamiana*), is an important habitat that woodland birds use for foraging, roosting, perching and nesting. Needle-leaf Mistletoe (*Amyema cambagei*) is a very important parasite in River She-oak canopies. As in Box-Gum Woodland, mistletoe is an essential resource along the river valley. The flowers provide nectar for honeyeaters (Regent Honeyeater, Painted Honeyeater) and potentially for Swift Parrot — the fruit is a critical food for the Painted Honeyeater — and the dense structure of the leaves provides nesting habitat for small birds (Diamond Firetail).

Other important habitats in riparian areas are the tree branches overhanging deep water, where the branches or leaves do not block direct access to the water and waterbirds' nests can be well screened by foliage from the riverbank. Although these trees are mostly willows (*Salix* spp.) and poplars (*Populus* spp.), they are essential until other native species can be planted and mature to enough density to take their place.

2.7.2 Habitat types, resources and potential users

Mature healthy large trees

Mature (living) eucalypts in the Reserve or offsets, or River She-oak in the Reserve, may be several hundred years old. Mature trees of Black Cypress Pine are also important in the Reserve. The mature trees are large, have a strong branch structure, healthy foliage, plentiful flowers, nectar and fruit. Their bark is thick and fissured or peeling. The canopy includes some dead branches.

The main melliferous (honey-producing) eucalypt native to the ACT (and in the Reserve and offsets) is Yellow Box *E. melliodora*, which flowers primarily in spring–summer (Birtchnell and Gibson 2006).

The mature-tree habitat type is found in all woodland areas of the Reserve and offsets, and occasionally in grassland. Mature trees are in the river valley, both in the riparian zone and channel (River She-oak) and in the dryland matrix. Apple Box, Peppermint, Red Stringybark and Scribbly Gum are in the Reserve downstream of Kama with Snow Gum particularly in the urban section, in Molonglo River Reserve (Map 2.6). Mature trees outside the Reserve and offsets in adjacent parts of the ACT may also be habitat for threatened species that use the Reserve. Examples are melliferous eucalypts which flower in autumn–winter: *E. goniocalyx* and Red Box *E. polyanthemos* and the non-indigenous Mugga Ironbark *E. sideroxylon*, all of which offer food resources for the Swift Parrot.

Mature healthy large trees provide:

- nesting resources including hollows and a strong branched structures that can support heavy nests and birds;
- healthy foliage to screen smaller woodland birds nesting in the canopy; (depleted foliage limits cover, shelter and foraging opportunities);
- structure for birds that perch or nest in the branches or foliage of the canopy, such as White-winged Triller, Varied Sittella, Jacky Winter, Restless Flycatcher and Scarlet Robin;
- dead branches on living trees, which provide foraging sites for Varied Sittella, and perching points for various species;
- more flowers, and more nectar and fruit per flower than young trees, so foraging is more energy efficient for species such as Regent Honeyeater, Painted Honeyeater and Swift Parrot;
- insect prey (including lerps) for insectivorous birds and the Superb and Swift Parrot; and possibly mistletoe (see below);
- invertebrates under and in the thick fissured or peeling bark; these are particularly food for Crested Shrike-tit, Brown Treecreeper and Varied Sittella.

Species that potentially may use mature tree habitat in the Guidelines areas include:

- Little Eagle, Wedge-tailed Eagle, and potentially the White-bellied Sea-eagle, which build bulky heavy nests;
- woodland birds, including White-winged Triller, Varied Sittella, Jacky Winter, Restless Flycatcher and Scarlet Robin and potentially Regent Honeyeater;
- Superb Parrot, and other hollow-using species (see Hollows, below);
- species that use mistletoe, including Painted Honeyeater and Swift Parrot.

Mistletoe

Needle-leaf Mistletoe (*Amyema cambagei*) grows in the canopy of River She-oak and in the eucalypts of Box-Gum Woodland. In both locations mistletoe is an essential species. The flowers provide nectar for honeyeaters (Regent Honeyeater, Painted Honeyeater) and the Swift Parrot. The fruit is a critical food for the Painted Honeyeater, and the dense structure of the leaves provides nesting habitat for small birds (Diamond Firetail).

Mistletoe seed has a limited range. The Mistletoebird is the primary seed-dispersal vector for the Needle-leaf Mistletoe, which represents an important food source for a range of bird species (Barrer 1992). The Mistletoebird is capable of dispersing over relatively long distances between habitat patches, but because the mistletoe seed passes through the bird quickly, and because the birds do not undertake sustained flight, the dispersal range of the mistletoe is normally limited (ANBG 2011). Where fragmentation reduces tree cover beyond a certain threshold, the incidence of mistletoe has been shown to decline precipitously (MacRaild *et al*. 2010). Mistletoes are potentially a 'keystone' resource in woodlands and forests (Watson 2001).

Tree hollows

Hollows generally develop in trees or branches that are relatively old, at least 100–200 years, as a result of invertebrate attack, fungal infection, breakage of branches and/or fire (Lindenmayer *et al.* 1993, in Martin and Green 2004). The trees can be either living or dead.

Tree-hollows habitat may be found anywhere in the Guidelines area, and beyond.

Tree hollows provide:

- important shelter and nesting resources for Superb Parrot, Brown Treecreeper and Southern Whiteface;
- shelter for a large number of native animals, particularly birds and mammals (Gibbons and Lindenmayer 2002).

Standing and fallen dead timber

Standing dead and fallen timber and woody tree litter ranges from large pieces and logs to coarse woody fragments, bark and twigs. Woody litter helps retain rainfall-runoff; it protects the soil and enhances the development of an organic topsoil layer (Barton *et al.* 2009 in Sharp 2011). Logs and standing dead trees are often hollow-bearing or likely to bear hollows in the future.

This habitat type may be found anywhere in the Reserve and offsets where there is existing or former woodland, but not in Natural Temperate Grassland or Rocky Natural Grassland.

Standing dead trees and fallen logs and timber:

- contribute to the structural complexity of an area, adding to the overstorey, mid-storey or groundstorey according to the size of the wood;

and provide:

- foraging areas, perches, and feeding, breeding and sheltering places for a wide range of vertebrates and invertebrates, which provide food for a range of ground-feeding and other woodland birds and raptors;
- perching and vantage points for species such as Dusky Woodswallow, Jacky Winter, Hooded Robin, Scarlet Robin, Flame Robin and White-winged Triller, and the Rainbow Bee-eater (dead tree branches);
- shelter or nesting sites (in hollows or smaller niches).

Mammals shelter near fallen trees, logs and branches and often burrow into the soil beneath logs.

Mid-storey habitat

Mid-storey habitat is not typical of high-quality Box-Gum Woodland or Natural Temperate Grassland. The grassland benchmark is 0% mid-storey, and the woodland benchmark is 0–12.5% mid-storey, and Box-Gum Woodland by definition has less than 10% projective foliage cover in the mid-storey (ACT Government 2004b).

The other native woodlands and open forest communities in the Reserve and offsets may include shrubby mid-storey. The mid-storey component of River She-oak Forest, Black Cypress Pine Woodland, Snow Gum Grassy Woodland, Apple Box – Broad-leaved Peppermint Shrubby Woodland, and Red Stringybark – Scribbly Gum Tall Dry Forest, as well as Rocky Riparian Shrubland, can be as high as 55% when these vegetation communities are in good condition.

In natural stands, mid-storey structure can be provided by regenerating overstorey species, tall shrub or small tree species (*Allocasuarina verticillata*, *Exocarpos cupressiformis*, *Acacia dealbata*, *Acacia implexa*), low shrubs (*Acacia genistifolia*, *Cassinia* spp., *Indigofera adesmiifolia*), low-hanging tree branches, hanging mistletoe, fallen branches and trees, and woody weeds (including hawthorn, Briar Rose, Firethorn, Boxthorn and Blackberry). Since European settlement, grazing by stock and selective clearing of species has removed much of the mid-storey structure, and the shrub species have been unable to regenerate.

Mid-storey habitat provides:

- important breeding and foraging habitat for woodland birds such as Scarlet Robin, Hooded Robin, Speckled Warbler, Diamond Firetail, Double-barred Finch;
- habitat for raptors' prey species (including rabbits);
- habitat for fauna such as spiders and other invertebrates;
- food resources for Superb Parrots (*Acacia dealbata*, *A. rubida*).

Most of the woodland bird species use 'other' (not Box-Gum) woodlands of the Reserve's dryland matrix. In woodland sites monitored by COG over ten years, the presence of mid-storey shrubs was found to be the main predictor variable for presence of four of the woodland birds species analysed, including the Scarlet Robin (Taws *et al*. 2012).

Mosaic habitats

In the Guidelines area there is a mosaic of highly modified woodland, secondary grassland, good-quality grassland, other native woodlands and dry forests as well as former pine plantation, and the 'ecotonal' areas where these abut each other. The mosaic includes a range of habitat types, physical conditions and structural variation, supporting biodiversity.

Mosaic habitats and ecotonal areas:

- are more open than woodlands and are used by many of the woodland birds, such as Flame Robin, Scarlet Robin, Hooded Robin, Speckled Warbler, Double-barred Finch and Diamond Firetail, particularly in winter;
- offer open areas warmed by the sun, where small insectivorous birds selectively forage when temperatures are low, rather than in shaded areas (Villén-Pérez 2013);
- provide connectivity between habitats and across the landscape for many of the woodland birds; Superb Parrot for instance prefers to fly over wooded habitat rather than grassland;
- may provide habitat or particular features that are in some cases of greater importance to the conservation of a bird species than the threatened habitat areas;
- are important for the raptors, which have very large territories and are reliant on all habitats within the Molonglo River Reserve and the surrounding landscape, including the threatened habitat areas, the river valley and the matrix of modified habitats in between. The mosaic of vegetation types in the wider landscape offers additional habitat for the raptors' prey (mammals, birds and reptiles).

The Pink-tailed Worm-lizard also is associated with the mosaic habitats of low shrubland and small natural or artificial clearings in woodland, as well as with Natural Temperate Grassland and rocky grassland. Clearings may be in Box-Gum Woodland, or Yellow Box – Apple Box grassy woodland, or Red Stringybark – Scribbly Gum Tall Dry Forest, particularly where there is a relatively high cover of Kangaroo Grass and other plant species indicative of little disturbance.

Groundstorey, grassy areas

Grassland areas include derived Box-Gum Woodland as well as Natural Temperate Grassland and Rocky Natural Grassland in various conditions, and mixed native/exotic grasslands.

Habitat for the Pink-tailed Worm-lizard is found in Natural Temperate Grassland at Kama (type r7) and in the river valley (type r8), and cleared unimproved native pasture (i.e. secondary grassland), especially where there is a relatively high proportion of Kangaroo Grass and other species indicative of reduced disturbance. (See below, rocky areas.) Rocky grassland areas are important habitat for the lizard, as well as other reptile species and invertebrates.

Grassy areas are also habitat for woodland birds especially when close to woodland or trees that have low hanging branches (see also mosaic habitats above).

A diverse range of native grasses and forbs providing structural variety is important to ground-foraging birds (Antos *et al*. 2008; Barrett *et al*. 2008).

Good groundstorey habitat provides:

- foraging habitat for Superb Parrots;
- structural diversity, which supports a large range of invertebrates which in turn provides for a number of ground-feeding birds: Scarlet Robin, Flame Robin, Hooded Robin, Jacky Winter, Speckled Warbler, Restless Flycatcher, White-winged Triller, Brown Treecreeper, Dusky Woodswallow and Southern Whiteface;
- patches of bare ground and cryptogams (mosses, lichens) which are spaces for foraging by ground-feeding birds, especially Brown Treecreeper;
- foraging areas for the grass-seed-eating Diamond Firetail and Double-barred Finch which will feed in the grasslands if even a small amount of shelter from woody shrubs or clumps of Blackberry is available;
- features that suit the Rainbow Bee-eater, which needs sparse groundcover with good visibility of the surrounding area and the presence of perches near the nest (dead branches or overhead wires) for its breeding areas (Higgins 1999);
- habitat for grassland birds such as Stubble Quail, Brown Quail, Australasian Pipit, Horsfield's Bushlark and Brown Songlark. These species are grassland specialists and are only found in this habitat.

Gaps in the groundstorey cover are important to allow for regeneration of forbs, and optimal habitat for a range of fauna including the Pink-tailed Worm-lizard and ground-feeding birds. Most ground-foraging birds feed on invertebrates, which tend to be more diverse where there is a richer variety of plant species and substrates such as litter, woody debris, rocks, bare soil and cryptogams (Barton *et al.* 2009; Lindsay and Cunningham 2009).

When there is too much tall dense grass (biomass) the groundlayer habitat loses its structural diversity. A tall dense groundlayer can be a physical deterrent to many ground-foraging birds because it limits access to litter or bare ground or impedes movement through dense vegetation. In areas with a high cover of introduced grasses, birds need to use more energy-expensive manoeuvres to obtain food (Maron and Lill 2005). Some species, such as the Brown Treecreeper, avoid foraging in areas of high grass cover. Observations from within Kama indicate that the thickening of the grass layer and build up of biomass has restricted the Brown Treecreeper to foraging around logs and tree trunks (C. Davey pers.comm.). A tall dense groundlayer also reduces visibility at ground-level, limiting birds' ability to detect potential predators and deterring them from feeding on the ground (Antos *et al*. 2008).

It also deters species such as the Rainbow Bee-eater from building nests in the ground (Yuan *et al.* 2007). The Speckled Warbler nests on the ground and requires some tall grasses such as native tussock grasses or other structures (logs, ground shrubs) in which to hide its nest (Gardner 2002), but for foraging it needs an open and diverse native groundlayer.

Ground-surface litter, bare soil and sparse groundcover

Plant litter, dead plant material, seeds, spiderwebs, pieces of wood, twigs, bark, cryptogam cover (lichens, mosses, algae), fine and coarse litter, and small patches of bare soil or sparse groundcover, and stones and rocks, contribute to valuable habitat on the ground.

These habitat components provide:

- protection for the soil surface from erosion;
- nutrient recycling, through the decomposition of the litter by microorganisms;
- habitat for inverterbrates including spiders, small reptiles, amphibians (especially near water) and small mammals;
- nesting areas for some species;
- foraging areas where woodland birds and raptors, reptiles, invertebrates and mammals can find prey, fungi and plant food resources;
- access points to allow air and light and warmth into the groundstorey;
- visibility for ground-foraging birds while searching for food (see above).

For Pink-tailed Worm-lizard, good habitat has little or no plant litter on the ground amongst relatively short grassland groundstorey vegetation.

Rocky grassland and outcrops

Most sites where the Pink-tailed Worm-lizard is found have numerous scattered surface rocks that commonly are about 10–30 cm in diameter, well-weathered and partially embedded in the soil and grass. The sites are dominated by primary and secondary native grassland or pasture, no or very little tree cover and little or no leaf litter, and the vegetation is mainly native grasses, particularly Kangaroo Grass *Themeda triandra*, Barbed-wire Grass *Cymbopogon refractus* and Wattle Matrush *Lomandra filiformis*. Redleg Grass *Bothriochloa macra* predominates at more disturbed sites (Osborne *et al.* 1991; Osborne and McKergow 1993; Jones 1992, 1999; Wong *et al.* 2011). Pink-tailed Worm-lizard habitat is described in more detail above (s.2.4.1).

For other species, rocks contribute to the structural complexity of habitat and provide an ecological niche. Some species use complex outcrops with caves (e.g. Spotted-tailed Quoll). The riparian zone can also include rocky habitat.

Riparian zone and river channel

Habitat in and around waterbodies comprises the vegetation, plant material and wood on the banks and also in the water (submerged or sticking out ('emergent') and on islands).

River She-oak Forest and Rocky Riparian Shrubland, as well as Tableland Aquatic and Fringing Vegetation Complex are the recognised vegetation communities in the riparian zone. There is also a range of invasive woody weeds such as Willows, Poplars, Blackberry (and possibly Box Elder). The vegetation ranges from large old mature trees, through small native or invasive trees, to dense shrubs, reeds, rushes and grasses. Needle-leaf Mistletoe (*Amyema cambagei*) is an essential plant species in the canopy of River She-oak. Trees with branches overhanging the deep water of the urban lakes or major rivers are mainly the willows and poplars.

The waterbodies include dams in Kama and the Arboretum woodland, drainage lines, creeks and the Molonglo River itself. In-stream habitat features include not just the water but also its flow rates and depths (riffles, pools and the stream-edges are distinct habitats), and its sediment and organic matter. Large woody debris, submerged or emergent, is also an important component of habitat within waterbodies.

This range of habitats provides:

- foraging areas, shelter and nesting sites for many species that are associated with watercourses and wetland areas, including spiders and other invertebrates, amphibians, reptiles, waterbirds, fish and aquatic macroinvertebrates;
- hollows in trees (see above);
- dense foliage and shrubbery, including mistletoe (see above);
- mosaic habitats and biological diversity (see above);
- perches and fishing vantage points for waterbirds on emergent wood;
- foraging habitat for all three species of eagle (Olsen and Fuentes 2004);
- ecological corridors as a distinctive part of a wider habitat mosaic with special features such as access to water and often structurally complex vegetation;
- stable banks that support native riparian vegetation, providing shade, cover and nutrients for aquatic invertebrates and fish (Bauer and Ralph 1999);
- open areas with sandy soil near to water for use by the Rainbow Bee-eater for nesting sites.

Large woody debris such as fallen trees and logs, submerged or emergent, directly influences aquatic habitat through pool formation and effects on bank and substrate stability (Bauer and Ralph 1999).

Fallen trees and logs provide food substrates and cover for aquatic macroinvertebrates and fish. For example, Murray Cod are known to shelter beside and under submerged logs.

Drooping She-oak

The Glossy Black-Cockatoo (Vulnerable in the ACT) feeds almost exclusively on the seeds of Drooping She-oak (Allocasuarina verticillata). There are no stands of this species mapped in the Molonglo River Reserve (Schweikle and Baines 2009), and only one record of the Glossy Black-Cockatoo in the Molonglo River Reserve (Canberra Ornithologists Group database). The closest stands of Drooping She-oak occur on Mt Stromlo and the Pinnacle, so it can be presumed that the one record of the Cockatoo was of a bird passing through the Molonglo River Reserve. A stand of Drooping She-oak has been planted in the National Arboretum Canberra (which is near the Molonglo River Reserve and offsets). As this stand and the plantings on the Pinnacle mature and produce cones, the incidence of Glossy Black-Cockatoos in the Molonglo River Reserve could increase.

Drooping She-oak is a species that could be included in restoration plantings (see s.3.8), contributing mid-storey habitat (see above).

Table 2.12. Areas of the Molonglo River Reserve and offsets in which conservation-significant fauna have been recorded.

Area of the Reserve or offsets	Species recorded there	Woodland areas	Grassy areas	Activity noted
Kama	Restless Flycatcher			
	Southern Whiteface			
	Dusky Woodswallow			Breeding
	Crested Shrike-tit (2007)	Box-Gum Woodland		
	Speckled Warbler (rarely)			
	Scarlet Robin	Box-Gum Woodland		March–October
	Flame Robin			April–October
	Diamond Firetail			
	White-winged Triller	Box-Gum Woodland		
	Varied Sittella	Box-Gum Woodland		Breeding
	Brown Treecreeper	Box-Gum Woodland		Breeding
	Swift Parrot (1 record)			
	Little Eagle (occasional)			
	Pink-tailed Worm Lizard		Rocky	
Dryland adjacent to Kama	Superb Parrot	Scattered Box-Gum Woodland		
River valley near Coppins Crossing and sewage ponds	Dusky Woodswallow			Breeding
	Double-barred Finch			
	White-fronted Chat			
	Speckled Warbler	Riparian	Riparian	
	Diamond Firetail	Riparian	Riparian	Breeding
	White-winged Triller	Riparian		Breeding
	Painted Honeyeater (1 record)	Riparian		
	Southern Whiteface			Breeding
	Rainbow Bee-eater		Riparian	Breeding, October to February
	Pink-tailed Worm-lizard		Rocky	

Area of the Reserve or offsets	Species recorded there	Woodland areas	Grassy areas	Activity noted
River valley lower (and near Murrumbidgee River)	Speckled Warbler			
	Little Eagle	Riparian		Breeding
	Wedge-tailed Eagle			
	White-bellied Sea-eagle			
	Pink-tailed Worm-lizard	Rocky clearings	Rocky	
River valley (urban section) near Coombs, Tuggeranong Parkway, or Barrer Hill	Rainbow Bee-eater			Breeding (nr Barrer Hill)
	Wedge-tailed Eagle			Breeding (abandoned)
	Little Pied Cormorant			Breeding (nr Tug. Pkwy)
	Australian Darter			Breeding (nr Tug. Pkwy)
	Perunga Grasshopper (3 records)			
	Pink-tailed Worm Lizard	Rocky clearings	Rocky	
River valley in general	Spotted tail Quoll (possible)	Rocky		
	Pink-tailed Worm Lizard		Rocky	
	Southern Whiteface			
	Dusky Woodswallow			
	Double-barred Finch			
	Speckled Warbler	Riparian	Riparian	
	Scarlet Robin	Riparian	Riparian	
	Flame Robin		Riparian	
	Diamond Firetail	Riparian	Riparian	Breeding
	White-winged Triller	Riparian		Breeding
	Varied Sittella (occasional)	Riparian		
	Painted Honeyeater (1 record)	Riparian		
	Rainbow Bee-eater (see above)			
	Little Eagle	Riparian		
	Wedge-tailed Eagle			
	White-bellied Sea-eagle			
	Little Pied Cormorant			Feeding
	Great Cormorant			Feeding
	Australian Darter			Feeding
	Little Black Cormorant			Feeding
	Pink-tailed Worm Lizard	Rocky clearings		
Spring Valley Farm	Superb Parrot	Sparse Box-Gum Woodland		Breeding
	Jacky Winter (1 record)			
	Pink-tailed Worm Lizard	Rocky clearings	Rocky	

Area of the Reserve or offsets	Species recorded there	Woodland areas	Grassy areas	Activity noted
West Molonglo woodland (western Belconnen)	Restless Flycatcher			
	Double-barred Finch (1 record)			
	Little Eagle (occasional)			
Whole area and beyond	Wedge-tailed Eagle			
	Little Eagle			
	White-bellied Sea-eagle			
Whole area, unspecified	Southern Whiteface			
	Gang-gang Cockatoo (infrequent)			
No records in the Reserve or offsets or Molonglo River	Glossy Black-Cockatoo			
	Hooded Robin	Grassy woodland		
	Regent Honeyeater	Box-Gum Woodland & Riparian		
	Conservation significant fish sp.			
	Murray River Crayfish			

2.8 Threats

Threats and threatening processes, summarised here, are those factors that negatively affect the ecological values of the Molonglo River Reserve and offsets, in both non-riparian and riparian areas, and within the Reserve in threatened habitat and dryland matrix. They reduce the condition and survival of the MNES vegetation and fauna, and other threatened or significant flora and fauna species and their habitats including soil and water.

Threats and threatening processes include competition between desirable and pest species including weeds; nutrient pollution; active soil erosion and sedimentation; accumulation of excess biomass and fire fuel in grassy areas; some impacts of fire fuel management; wildfire; and aspects of urban life including structures and illegal or damaging human activities such as rubbish dumping, firewood or rock collection, arson and off-track vehicle access. Weeds (s.3.3), excess grassy biomass (s.3.4), pest animals (s.3.5), human impacts (s.3.6), and aspects of soil and water (s.3.7) are discussed in more detail in the management chapter.

The following Key Threatening Processes are listed under the EPBC Act, and Table 2.13 notes fauna species likely to be affected by them:

- competition and habitat degradation by European Rabbit *Oryctolagus cuniculus*, feral Pig *Sus scrofa*, feral Goat *Capra hircus*, deer and Sheep *Ovis aries*;
- invasion of habitat by introduced grasses and forbs, exotic vines and scramblers, exotic trees and shrubs;
- predation by and competition from Red Fox *Vulpes vulpes*, exotic rats, feral Cat *Felis catus* and feral Dog *Canis familiaris;*
- bush rock removal;
- competition from feral Honeybee *Apis mellifera;*
- loss of hollow-bearing trees, dead wood and dead trees.

Table 2.13. Key Threatening Processes and threatened and significant fauna species they affect in Molonglo River Reserve and offsets

Key threatening processes (KTP)	Species
Competition and habitat degradation by European Rabbit, feral Pig, feral Goat, deer and sheep.	Brown Tree-creeper, Hooded Robin, Varied Sittella, Diamond Firetail, Double-barred Finch, Flame Robin, Rainbow Bee-eater, Restless Flycatcher, Scarlet Robin, Speckled Warbler, Southern Whiteface, White-winged Triller, Spotted-tailed Quoll, Pink-tailed Worm-lizard.
Invasion of habitat by introduced grasses and forbs, exotic vines and scramblers, exotic trees and shrubs.	Pink-tailed Worm-lizard, Rainbow Bee-eater, Hooded Robin, Varied Sittella, Diamond Firetail, Double-barred Finch, Flame Robin, Restless Flycatcher, Scarlet Robin, Speckled Warbler, Southern Whiteface, White-winged Triller, Grey-headed Flying-fox, Macquarie Perch, Silver Perch, Murray Cod.
Predation by and competition from Red Fox, exotic rats, feral Cat and feral Dog.	Ground-dwelling or foraging species in particular, Hooded Robin, Varied Sittella, Diamond Firetail, Double-barred Finch, Flame Robin, Rainbow Bee-eater, Restless Flycatcher, Scarlet Robin, Speckled Warbler, Southern Whiteface, White-winged Triller, Superb Parrot Spotted-tailed Quoll, Pink-tailed Worm-lizard.
Bush rock removal.	Pink-tailed Worm-lizard, Spotted-tailed Quoll.
Competition from feral Honeybees.	Superb Parrot, Brown Tree-creeper, Southern Whiteface.
Loss of hollow-bearing trees, dead wood and dead trees	Superb Parrot, Brown Tree-creeper, Regent Honeyeater, Painted Honeyeater, White-winged Triller, Hooded Robin, Varied Sittella, Flame Robin, Rainbow Bee-eater, Restless Flycatcher, Scarlet Robin, Speckled Warbler, Southern Whiteface, White-winged Triller, Spotted-tailed Quoll.

Examples of many factors and processes that threaten species and habitats in the Guidelines area are listed below.

Clearing of dead or living trees or other native vegetation

- Factors leading to loss of trees, live or dead, such as felling, disease, insect attack, inappropriate fire.
- Factors that change the species composition of the overstorey, mid-storey and understorey vegetation.
- Factors affecting the condition, persistence and regeneration of that vegetation.

Changed and inappropriate fire regimes

- Too short or too long between burnings, or inappropriate fire intensities, affecting vegetation species' capacities to survive, regenerate and out-compete introduced species.
- Impacts on fauna habitat from inappropriate fire intensity or timing or location.

Competition, predation and habitat degradation by pest animals

- Impacts from pest animals and fauna species not naturally resident in grasslands and woodlands and the riparian zone (competition, predation, habitat damage through overgrazing, digging, and aggressive or non-aggressive behaviour). Species may include Noisy Miners, European Rabbit *Oryctolagus cuniculus*, Red Fox *Vulpes vulpes*, cats, dogs, feral Pig *Sus scrofa*, feral Goat *Capra hircus* and deer and species attracted to urban gardens, feral fish species such as Carp, and feral Honeybees (which occupy tree hollows and can kill birds nesting there).

Invasion of habitat by introduced pasture and weeds

- Competition from invasive plant species taking space from native plants, leading to loss of native plant habitat.
- Factors that facilitate invasion of the Reserve or offsets by pest plants, such as their use in urban gardens, or carriage of seed into the Reserve on vehicles, machinery, clothing, by fauna, etc., or dumping of garden waste in these areas.
- Herbicide damage to non-target species during weed control operations.
- Use of fertilisers, or their influx in runoff, favouring introduced plant species over native plant species.

Removal or destruction of habitat

- Removal or disturbance of rocks and stones on the ground, especially in Pink-tailed Worm-lizard habitat, for any reason (including clearing a path for management work and machinery; naturalists' interest in invertebrates and reptiles and amphibians; recreational activities including bike riding) (ACT Government TAMS 2010; Sharp 2011).
- Removal of wood lying on the ground, whether for firewood or clear passage during hazard reduction burns or any other reason (including cubby building) (ACT Government TAMS 2010; Sharp 2011).
- Removal of standing dead trees and hollow bearing trees.
- Smothering of forbs by unremoved slash after weed or biomass control.
- Activities including construction, clearing or other processes that disconnect connectivity and lead to habitat fragmentation and isolation, for both plants and animals.
- Factors that degrade the water quality in the river, including water temperature and dissolved oxygen concentrations, such as inappropriate flow regimes, contamination by sediment and nutrients and other pollutants, unnecessary release of cold bottom waters from Scrivener Dam (e.g. ENSR Australia 2008; ACT Government EA 2001; Eco Logical Australia 2009).
- Factors that degrade the river channel as habitat (its variable depths, rockiness, presence of riffles, sandiness, submerged and/or emergent woody debris, shape of banks, emergent vegetation at the edge, submerged aquatic vegetation, riparian tree communities).
- Factors that affect habitat characteristics of river flows (including choking by weeds such as willows; accelerated flow near culverts; etc.).
- Disturbance to the stability and shape of the river and riparian zone (riverbanks), such as for constructing roads, bridges, safe areas for people and recreational areas on the riverbank.
- Non-staged complete removal of riparian weeds and their roots which have been stabilising the riverbank and providing nesting habitat for some fauna species.
- Habitat fragmentation and isolation, such as by flood damage.
- Anything that upsets connectivity along the river and river valley and between the river and other large areas of natural vegetation.

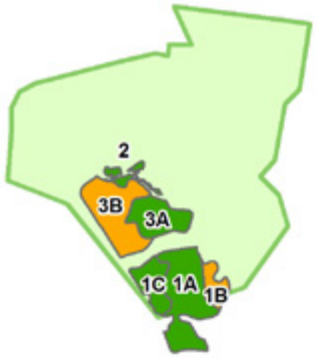
Nutrients, soil erosion, loss of landscape function

- Contamination of soil and waterbodies in the Reserve with phosphates, nitrates, other nutrients or with toxins (e.g. in runoff from upslope roadways, tracks, or urban areas).
- Factors that lead to soil erosion, such as burrowing or construction, or traffic (vehicle or foot), water movement or avoidable wind action.
- Natural climatic factors (possibly affected by climate change), such as storms and floods that topple trees and erode soil in riparian zone, dryland matrix and threatened habitat; and drought.
- Factors leading to bare soil such as overgrazing, trampling, removal of weeds without mulching the bared patch, or other processes that reduce plant biomass to below approximately 1.5–2 t/ha.
- Activities that degrade 'landscape function' including removal of cryptogams, soil crusts and ground litter diversity including leaves, twigs, and fallen branches and trees.

Indirect impacts from urban development

- Noise and human activity and traffic close to habitats, particularly over a long period such as during construction and ongoing residential use.
- Recreational impacts, such as walking or running off the tracks (by dogs and humans), cycling, horse-riding, that affect not only the soil and vegetation but also the fauna.
- Land-management and survey activities that disturb native fauna.
- Construction of tracks (for vehicle and foot) and establishment of buffer zones.
- Edge effects from fauna associated with urban living, such as Noisy Miners.
- Edge effects from garden plants spreading into nearby Reserve areas.

Threats and threatening processes — and the outcomes of managing them — should be assessed and regularly monitored as part of the ecological management program (see Chapter 4).



Map 2.1: Protected Areas
Box-Gum Woodland and Natural Temperate Grassland

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Projection: Transvers Mercator
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False Northing: 4,510,193.4939
Central Meridian: 149.0093
Scale Factor: 1.0001
Latitude of Original: 0.0000
Units: Metre
Date: 16/05/2013

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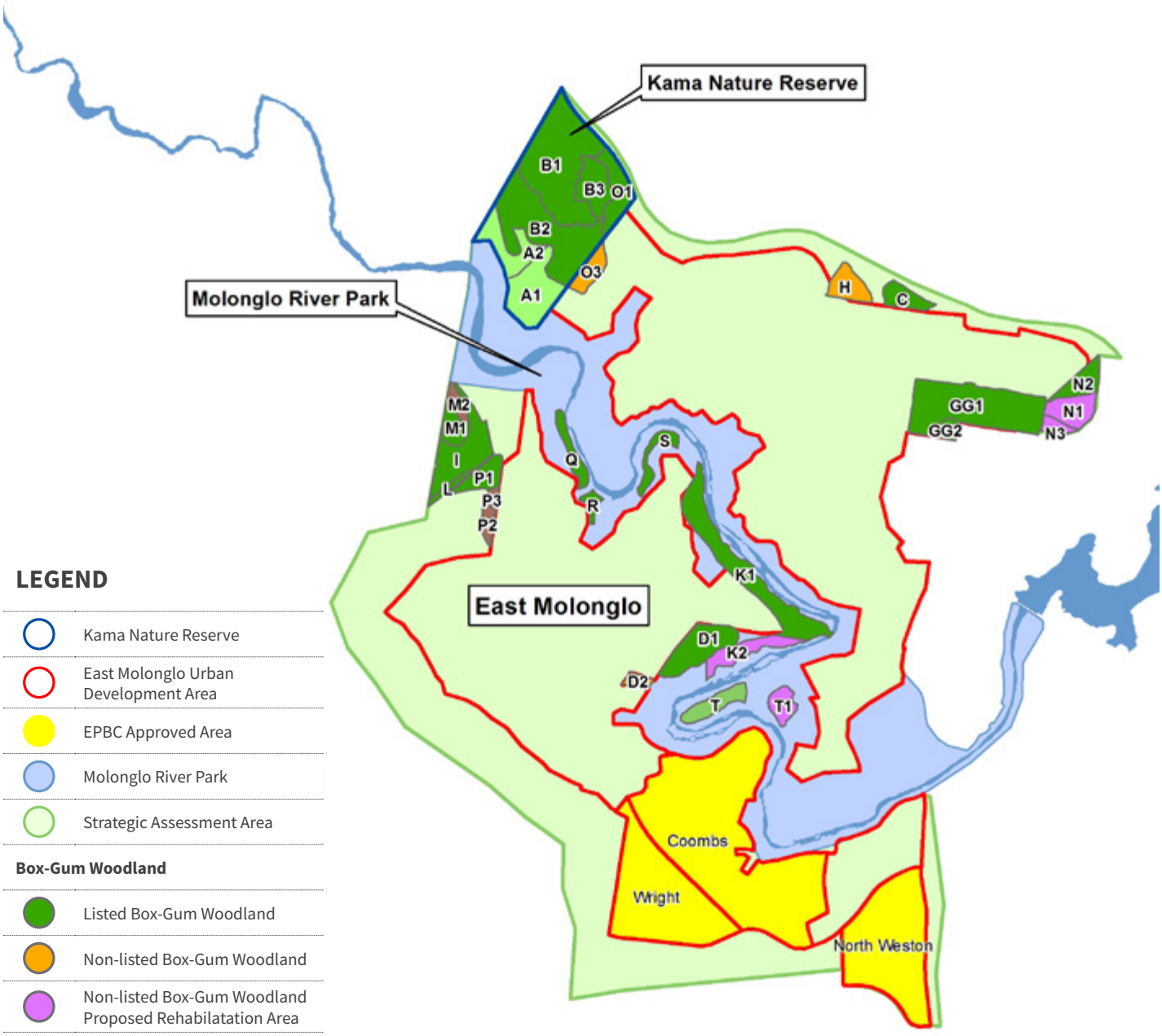


LEGEND

- Kama Nature Reserve
- East Molonglo Urban Development Area
- EPBC Approved Area
- Molonglo River Park
- Strategic Assessment Area

Box-Gum Woodland

- Listed Box-Gum Woodland
- Non-listed Box-Gum Woodland
- Non-listed Box-Gum Woodland Proposed Rehabilatation Area
- Natural Temperate Grassland (A1, A2)
- Other Vegetation

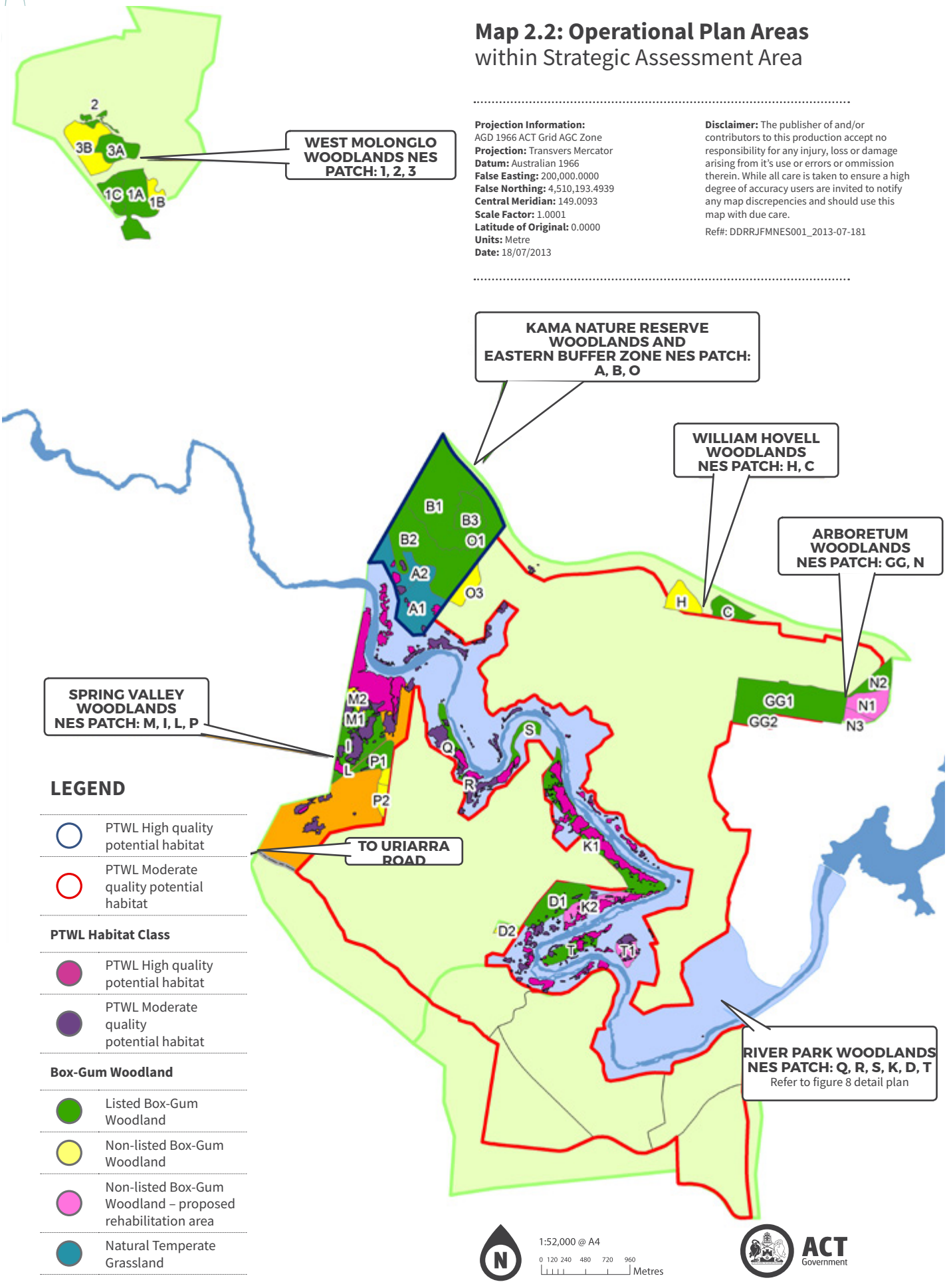
N

1:52,000 @ A4

0 250 500 1,000 Metres

ACT Government
Territory and Municipal Services

Map 2.2: Operational Plan Areas
within Strategic Assessment Area



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Date: 18/07/2013

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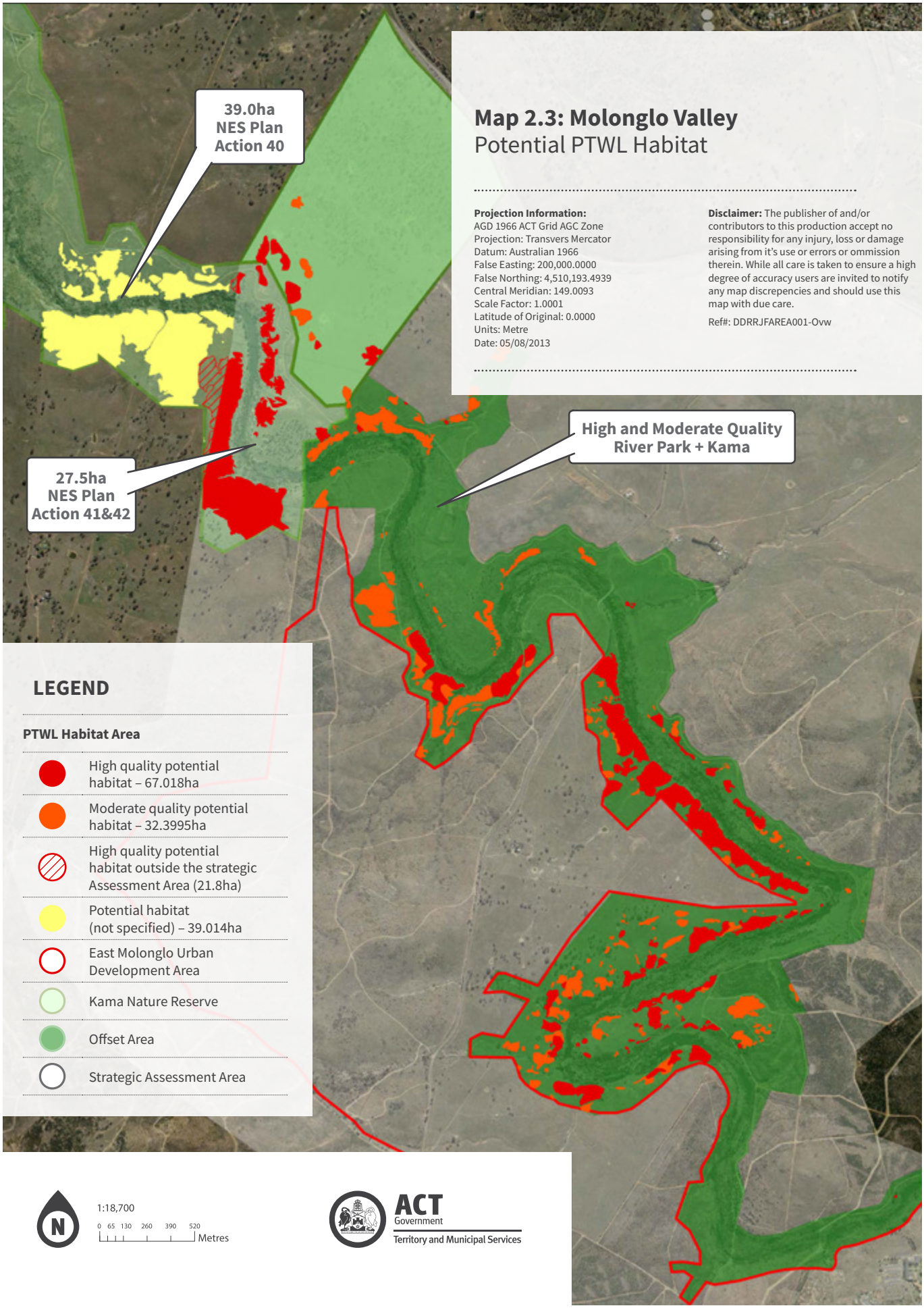
Ref#: DDRRJFMNES001_2013-07-181



Map 2.3: Molonglo Valley
Potential PTWL Habitat

Projection Information:
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Projection: Transvers Mercator
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False Northing: 4,510,193.4939
Central Meridian: 149.0093
Scale Factor: 1.0001
Latitude of Original: 0.0000
Units: Metre
Date: 05/08/2013

Ref#: DDRRJFAREA001-Ovw

LEGEND

PTWL Habitat Area

- High quality potential habitat – 67.018ha
- Moderate quality potential habitat – 32.3995ha
- High quality potential habitat outside the strategic Assessment Area (21.8ha)
- Potential habitat (not specified) – 39.014ha
- East Molonglo Urban Development Area
- Kama Nature Reserve
- Offset Area
- Strategic Assessment Area

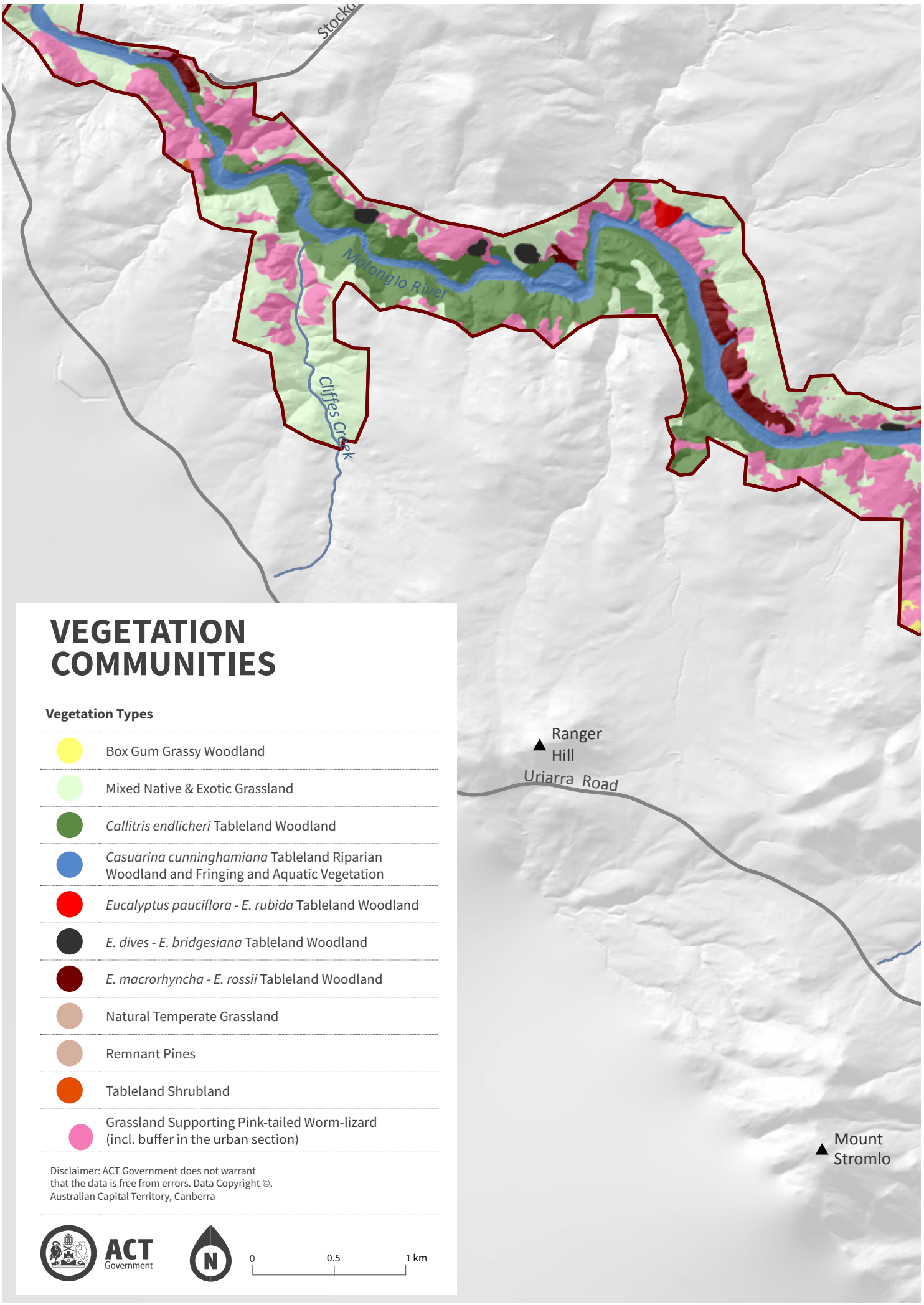
N

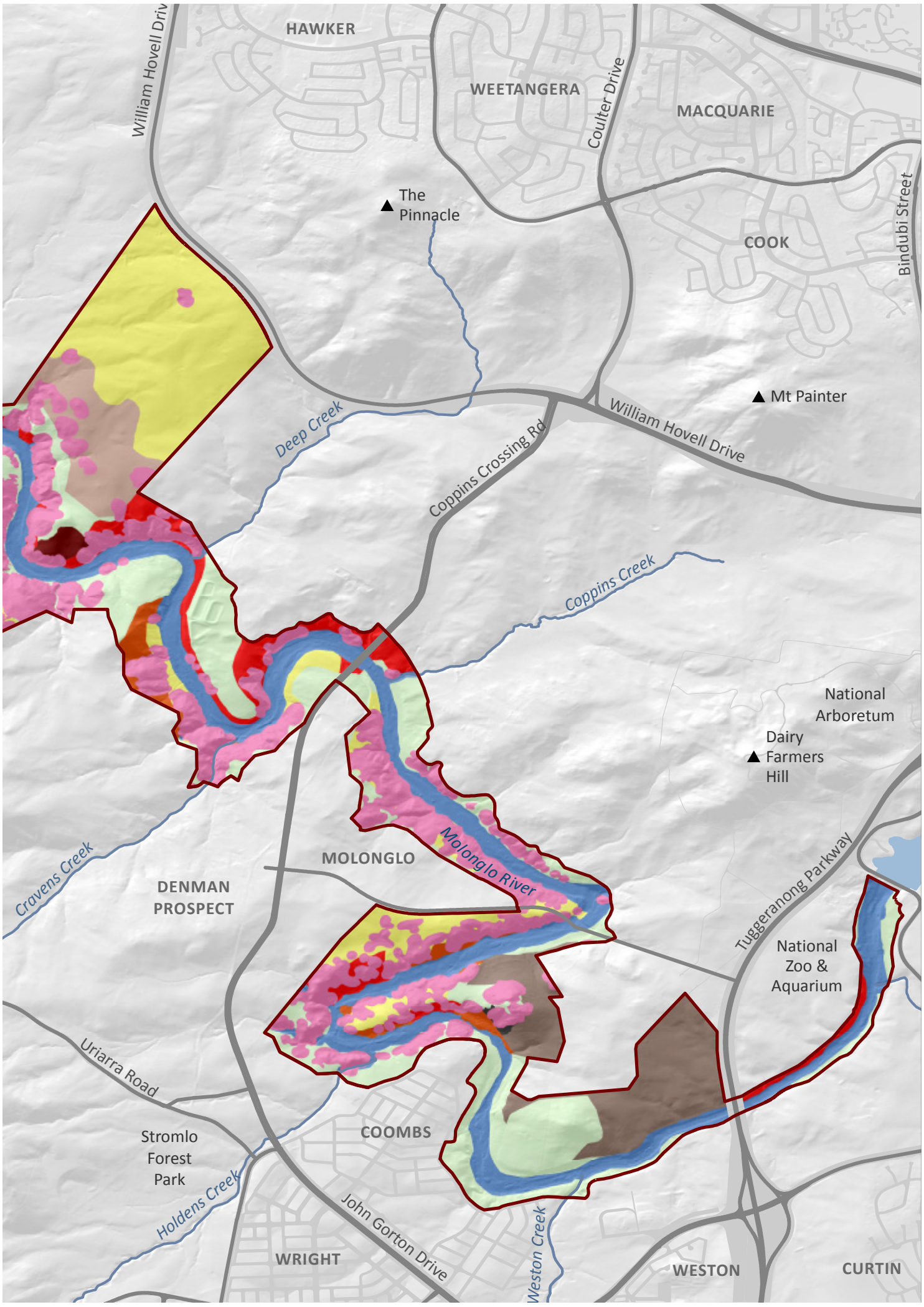
1:18,700

0 65 130 260 390 520 Metres

ACT Government
Territory and Municipal Services

Map 2.3 Vegetation of the Molonglo River Reserve




HAWKER
WEETANGERA
MACQUARIE
COOK
William Hovell Driv
Coulter Drive
Bindubi Street
The Pinnacle
Mt Painter
William Hovell Drive
Deep Creek
Coppins Crossing Rd
Coppins Creek
National Arboretum
Dairy Farmers Hill
Molonglo River
MOLONGLO
Cravens Creek
DENMAN PROSPECT
Tuggeranong Parkway
National Zoo & Aquarium
Uriarra Road
Stromlo Forest Park
COOMBS
Holdens Creek
John Gorton Drive
Weston Creek
WRIGHT
WESTON
CURTIN

ACT Parks and Conservation Service Ranger, at Molonglo River Reserve

3. MANAGEMENT

This chapter discusses environmental management applicable in the Guidelines area. Initially the chapter outlines the requirements of management as set out in the NES Plan and Adaptive Management Strategy.

For quick reference there is a summary checklist of management objectives and conservation targets for the MNES in s.1.4, at the end of Chapter 1. For management recommendations, see s.1.5.

3.1 General principles, objectives, strategies and plans

3.1.1 Principles

The overarching management principle is 'adaptive management' of the MNES values within the area covered by the NES Plan (ACTPLA 2011) and the same principle is to be applied in the rest of the Molonglo River Reserve, as specified by the Reserve Management Plan (ACT Government MP 2014 s.11.2, p. 91):

> An adaptive management approach to the areas covered by the NES Plan is already in place. This is an important foundation but it represents only about 18% of the area of the Reserve (Chapter 5). Many Reserve objectives fall fully or partially outside this area, and a system for monitoring their progress and developing and applying new knowledge to their achievement is required. The Reserve Management Plan proposes that complementary adaptive management strategies be developed for the two other major classifications of the ecosystems of the Reserve: the dryland matrix and the river and riparian areas

Adaptive management refers to systematic monitoring and evaluation of environmental outcomes after management actions, taking context (such as season and other factors) into account. Managers use the results of the evaluation to decide whether to maintain or adapt management practices so as to improve their ecological outcomes.

The Reserve Management Plan (ACT Government MP 2014) also notes five general principles of management to support threatened species and communities:

- protect habitat from further loss,
- manage threats,
- improve habitat condition,
- extend the areas through rehabilitation and revegetation (particularly important where former land use has led to fragmentation and degradation); and
- enhance connectivity.

3.1.2 Objectives

Five objectives for ecological management are set out in the Draft Reserve Management Plan (ACT Government MP 2014):

> **Objective D:** The population size of threatened species increases and the extent of listed dryland threatened communities is at least maintained and their condition improved.
>
> **Objective E:** Maintain the diversity of all other native species and improve the ecological condition of the dryland matrix.
>
> **Objective F:** Raise the ecological condition in the river and riparian zone from fair/moderate to good and achieve sustainable populations of native fish in the river.
>
> **Objective G:** Manage vegetation to achieve fire protection for people and property and effective protection of threatened habitat and other ecological conservation values.
>
> **Objective H:** Improve connectivity within and outwards from the Reserve.

3.1.3 Directives to management in Strategies and Plans

The Adaptive Management Strategy (AMS; ACT Government TAMS 2013) for the Molonglo Valley provides for:

- establishing the current ecological condition and value of MNES within the Molonglo strategic assessment area;
- identifying performance targets and objectives;
- monitoring and evaluation of management actions;
- revising actions as required; and
- ensuring that the NES Plan's objectives for MNES continue to be met.

It also identifies the key threats to MNES conservation as well as uncertainties in relation to management and the achievement of performance targets and objectives. The Adaptive Management Strategy establishes measures to deal with these threats and uncertainties, as follows (AMS p.11, sec 1.5) (see also Figure 3.1):

Adaptive management promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood.

In terms of process, adaptive management works through the identification of clear objectives, identifying areas of uncertainty and alternative hypotheses, testing assumptions, monitoring to provide feedback about the system and actions, learning from the system as actions are taken to manage it, and incorporating what is learned into future actions (see Diagram 1).

In summary adaptive management:

- allows resource managers to maintain flexibility in their decisions, knowing that uncertainties exist;
- provides managers the latitude to change direction;
- improves understanding of ecological systems to achieve management objectives; and
- ensures actions are taken to improve progress towards desired outcomes.

Figure 3.1. 'Diagram 1: Adaptive Management Process (taken from the NES Plan page 36)'. From ACT Government TAMS 2013 p.11.

The NES Plan (ACTPLA 2011) gives focused directives as follows (summarised):

- Management will be based on an adaptive management process.
- Management will be focused on the ecological condition of MNES values. Baseline monitoring will be conducted to determine the starting point for ecological condition.
- MNES values will be protected as part of the development within the Molonglo Valley.
- Objectives, conservation targets and measurable performance indicators for each management area will be set. These will include management, performance and condition milestones to be achieved over time, within an adaptive management framework.
- Conservation strategies, processes and timeframes will be defined to achieve targets and implement the plans, including allocation of responsibilities and identification of resources.
- Mechanisms will be established to monitor, evaluate, and annually report on progress to achieve objectives for management, including how management actions will be adjusted to account for new information. This new information will include new, peer reviewed scientific literature. Annual reports will be made publicly available.
- Kama will be managed as part of the Molonglo River Reserve, focusing on protecting its Natural Temperate Grassland as well as its Box-Gum Woodland, Pink-tailed Worm-lizards and threatened parrots.
- Additional offset areas will be managed for the maintenance and enhancement of the Box-Gum Woodland and its habitats within them, namely patch GG (to be part of the National Arboretum Canberra), patches C, H and N, and patches I, L, M and P. (If more than 30% of patches I, L, M and P no longer meets the EPBC Act listing criteria for Box-Gum Woodland over two consecutive years, then another offset site is to be established and managed as a nature reserve.)
- Management will aim to restore areas of Box-Gum Woodland: (a) within the Reserve, in Patch GG; (b) in an indirect offset off-site, at Patch T on Barrer Hill.
- Management will avoid direct or indirect impacts to Natural Temperate Grassland including patches that may be identified outside Kama.
- Appropriate condition monitoring will track the ecological condition of Box–Gum Woodland, Natural Temperate Grassland, the Pink-tailed Worm-lizard habitat and Swift Parrot and Superb Parrot habitat against management objectives.

And

- Research projects will improve knowledge relating to the conservation of the Pink-tailed Worm-lizard and Box-Gum Woodland.

Planning and management within the river valley should be consistent with relevant national Recovery Plans and Action Plans for threatened species and communities listed under ACT and Commonwealth legislation (e.g. see s.5.1.1).

Site-specific operational plans

Operational plans, produced for each part of the Molonglo River Reserve and offsets, include management actions designed to achieve the management objectives above. The operational plans should also allow for detailed monitoring, evaluation and reporting of the outcomes of management, collecting the following information:

- native species richness and diversity, and habitat features;
- distribution and abundance of significant and threatened species;
- distribution and abundance of invasive weeds;
- pest animal distribution and damage (particularly rabbits);
- locations of disturbed areas, including actively eroding gullies or sites of potential sheet erosion;
- sites to be used as ‘reference’ for comparing changes after management is applied or because of human activity;
- attributes in buffer zones;
- issues likely to have an impact on ecological values in each patch/units within patches;
- requirements for various management actions, such as weed control, revegetation and restoration of habitat.

3.2 Management of MNES: overview

The overall goal is to maintain and improve the condition of of the MNES vegetation communities and fauna species in all relevant habitats of the Molonglo River Reserve and offsets, and the diversity and conservation of threatened and significant flora and fauna species within the whole Guidelines area including the riparian zone. Particular management aims include the following.

To maintain or improve:

- Superb Parrot and Swift Parrot distribution and abundance (especially in woodlands);
- Pink-tailed Worm-lizard populations and their habitat (in rocky grassland areas);
- native plant species richness and diversity;
- habitat diversity, including key habitat features, tree hollows, fallen timber, rocks and wetland areas, and structural diversity in the vegetation as appropriate, in the ground-, mid- and upper-storey;
- threatened woodland bird diversity and population abundance;
- connectivity between patches; and
- ecological functions and processes.

To reduce or prevent increase in:

- the cover, abundance and incursion of weeds and pest animals species; and
- active soil erosion and soil compaction, disturbance and nutrient levels.

To ensure that:

- human activities do not reduce the ecological values of threatened habitat or pose new threats to MNES and other threatened and significant species;
- water run-off into the river valley is of high quality; and
- stormwater and silt run-off does not inundate or smother flora and fauna habitats, especially that of Pink-tailed Worm-lizard.

3.2.1 Box-Gum Woodland and Natural Temperate Grassland

Management of Box-Gum Woodland and Natural Temperate Grassland, and the methods used to maintain and enhance the ecological values, are likely to vary between the NES patches because their previous land uses have differed and their condition differs. Management requirements identified for Box-Gum Woodland will also apply to the other eucalypt woodlands in the Reserve's dryland matrix and in NES patches beyond the Reserve.

All the management information below relates to the MNES vegetation communities, except where it is specific to fauna rather than to their habitat.

3.2.2 Superb Parrot and Swift Parrot

Objectives

- Maintain and improve specific habitat features of value to Superb Parrot and Swift Parrot, including breeding habitat for the Superb Parrot and foraging habitat for both species.
- Increase the breeding population of the Superb Parrot in woodlands of the Molonglo River Reserve and offsets.
- Increase the extent and quality of Box-Gum Woodland foraging habitat for the Swift Parrot.

For management of the MNES parrot species, the objectives are similar to those for Box-Gum Woodland and other woodlands and vegetation communities which provide the species' food sources (seeds of grasses and forbs, fruits, nectar, pollen, lerps and occasionally insects; see s.2.4.2, s.2.4.3).

Threats to be managed include weed invasion, excess groundstorey biomass, inappropriate fire and loss of mature woodlands; and human activities in relation to nesting habitat for Superb Parrots and feeding habitat for Swift Parrots; and competition for nest hollows from feral Honeybees or other fauna. These topics, as well as restoration of broadscale habitat connectivity, are addressed below.

3.2.3 Pink-tailed Worm-lizard

Objectives

- Manage threats to the Pink-tailed Worm-lizard and its habitat.
- Conserve in perpetuity representative, viable populations of the Pink-tailed Worm-lizard in appropriate habitats throughout the Molonglo River Reserve and offsets.
- Consider mapped habitat in the design of in-Reserve infrastructure and in management planning so as to have a minimal impact on the potential habitat.
- Prevent further fragmentation of populations and habitat.
- Maintain and enhance potential connectivity between the major areas of habitat.
- Build community support for habitat conservation.

Some protection measures are required under the EPBC Act referral decision for the Coombs development. For example, the decision requires that moderate and high quality Pink-tailed Worm-lizard habitat be fenced to minimise unregulated public access, rock collection, access by domestic animals and unregulated stock grazing (Australian Government Department of the Environment, Water, Heritage and the Arts 2009). The Molonglo Riparian Strategy (Eco Logical Australia 2011b) indicates potential locations for fencing in the Coombs area. Downstream of Kama, the NES Plan provides for the continued implementation of the Reserve Management Plan for the river valley, formerly called Lower Molonglo River Corridor Nature Reserve and now part of the Molonglo River Reserve, to protect high- and moderate-quality Pink-tailed Worm-lizard habitat.

Day to day management of the Pink-tailed Worm-lizard in the Molonglo River Reserve focuses mainly on protecting known and potential habitat from threats (habitat is described in s.2.4.1).

The ACT and Commonwealth Governments recommend buffer zones 20 m wide around the outside of all habitat areas in the Molonglo River Reserve (ACT Government 2011a), extending outwards from the edge of the actual habitat. Well-managed buffer zones can be very effective at protecting against the threats of rapid influx of weeds, pollutants or sediments and the potential for trampling and other disturbances such as inappropriate fire, fire management and recreation.

Within these 20 m buffers to lizard habitat, and particularly within habitat areas themselves, there should be no:

- ditches, roads, trails or similar facilities, but if essential they should be of elevated mesh, or gravel, and constructed so as to not increase water run-off or other disturbance that would impact on the function of the buffer zone; frequently-used walking trails passing close to habitat areas should be edged by low fencing to restrict off-trail walking at these locations;
- non-essential entry or movement of heavy vehicles and machinery, to avoid disturbance to rocks and soil, although slashing, burning and herbicide spraying may be required within them to reduce biomass, fire fuel loads and weeds; any machinery should be thoroughly cleaned before entry to avoid bringing in weed seed;
- erosion from the buffers, nor run-on of stormwater or sediment or nutrients which could promote weed invasion of the buffer;
- plantings of trees or shrubs taller than 2 m because they could in later years shade the adjacent habitat;
- restoration by adding additional rocks unless it can be done in a way that allows for the primary function of the buffer zone to continue;
- dumping of piles of rock which could bring in weeds and provide cover for pest animals;
- overlap between the buffer zones and the Inner and Outer Asset Protection Zones (APZ) used for management activities in fire prevention and control, because APZ activities are not compatible with conservation of Pink-tailed Worm-lizard habitat[5];
- indirect impacts from urban activities (e.g. dumping rubbish, removing rocks, etc.) even where the edge of the urban areas is close to lizard habitat;
- horse riding;
- mountain bike riding (off tracks);
- unleashed dogs, because they are known to catch and kill reptiles and ground-nesting birds.

Management of potential impacts on Pink-tailed Worm-lizards from weeds, excess biomass, fire, predation and human activities, as well as techniques of habitat restoration, is discussed below in the relevant sections.

5 For places where APZs overlap lizard buffers a sympathetic fuel management technique is being developed to avoid impacts to the lizard (R. Milner pers. comm. August 2014).

3.3 Weeds management

3.3.1 Impacts of weeds and aims of management

Weeds (invasive or pest plants) are a threat because they compete with, suppress and replace native vegetation, and take over and alter native habitat so it may no longer be suitable for native flora and fauna. Weeds are arguably the most important threatening process in relation to MNES and other conservation matters within the Guidelines area.

The weed problem strongly affects other management issues, particularly protection and restoration of ecological values and protection against fire. Weeds significantly hinder both ecological recovery and recreational use, and are likely to be a major threat in the Guidelines area into the foreseeable future. The extent and persistence of weeds has implications for long-term planning and budgeting, monitoring and surveillance, and ongoing management access.

Seedbanks of weed species will occur in soils throughout the Guidelines area (except possibly in the best-quality areas of MNES vegetation communities and Pink-tailed Worm-lizard habitat) and will supply new plants for years ahead. Weeds are also likely to continually invade from surrounding areas and the suburbs. Sites where soil phosphorus exceeds 5 mg/kg tend to become dominated by introduced annual species and weeds such as Barley Grass, Sorrel, Wild Sage and Capeweed (Dorrough *et al*. 2008) which use the soil nutrients to produce large amounts of biomass in spring (depending on rainfall). When they die and break down during summer and autumn they release the nutrients back into the soil (Prober *et al*. 2009). Elevated soil nutrient levels are a legacy of past land-management activities such as fertiliser input and/or grazing in the Molonglo River Reserve and the offsets, and they will continue to contribute to the threat posed by introduced plants and weeds. (See s.3.8.2 for management to reduce soil nutrients.)

Weed management programs aim to bring the weed problem under control by reducing infestations to an ecologically benign maintenance level. Management should focus on minimising or eliminating major weed infestations already present in the Guidelines area, as well as minimising the risks of new problems that may arise if weed propagules are imported in contaminated materials, or on machinery or clothing or fur. All weed programs should include follow-up management, such as secondary treatment or mulching or replacement plantings, to avoid leaving ground bare and vulnerable to new invasion after existing weeds have been killed.

3.3.2 Weed management legislation and codes

Weed management is guided by the ACT Weeds Strategy 2009–2019 (ACT Government DECCEW 2009), the annual Environmental Weeds Operations Plans (eWOP), and the ACT Government Invasive Weed Management Guidelines (ACT Government PCS 2011a) which advise on treatment of environmental weeds generally. Successful weed management will need a coordinated approach involving both government and the community. Prevention and early intervention are the most cost-effective approaches that can be deployed against weeds (ACT Government DECCEW 2009).

3.3.3 Weed species important in the Guidelines area

Table 3.1 shows important weed species currently known or expected in the Guidelines area. They include non-native species and native species not indigenous to the ACT which have become naturalised (e.g. Cootamundra Wattle *Acacia baileyana*) or have been introduced, deliberately or inadvertently. Species that are 'Declared Pest Plants' are very invasive, and are required, under legislation, to be suppressed, contained or controlled. Serrated Tussock, African Lovegrass, St John's Wort, Blackberry and Crack Willow have a very high weed danger rating (bold and asterisked in Table 3.1) in the ACT Environmental Weeds Operations Plans (eWOP; e.g. ACT Government 2012b), meaning that they are capable of dominating disturbed and undisturbed areas with very high rates of spread, and can form monocultures. Weed priorities are also guided by the Weeds of National Significance guidelines (Thorp and Lynch 2000) and the list of species declared under the Pest Plants and Animals Act 2005 (as indicated in Table 3.1).

Table 3.1. Status and control targets of priority weeds known or likely to be in the Molonglo River Reserve and offsets, and included in the 2012–13 ACT Environmental Weed Control Operations Plan (eWOP), and/or mentioned in the Act, and/or listed as Weeds of National Significance (WoNS), and/or declared in the Pest Plants and Animals (Pest Plants) Declaration 2008.

Common name, Species name, recorded in Molonglo River Reserve and offsets	Risk as in 2012–13 eWOP	Potential risk to Pink-tailed Worm-lizard habitat	Effect on (or as) fauna habitat, other than Pink-tailed Worm-lizard		Abundance. Priority for control. Feasibility of coordinated control
	eWOP (*priority sp.), Declared, in Act &/or a WoNS		Desirable	Undesirable	
Blackberry, *Rubus fruticosus* sp. aggregate	Very high risk. Must be contained. eWOP*, WoNS	Very high	Nesting habitat and cover for small woodland birds	Cover for pest species (rabbits)	Common, widespread. Contain spread. Negligible–medium feasibility.
Crack Willow, *Salix fragilis*	Very high risk. Must be suppressed. Propagation & supply prohibited. eWOP*, WoNS	N/a	Nesting habitat for waterbirds on the Molonglo River	Affect habitat for native fish and native riparian vegetation communities and species	Destroy infestations. Medium–high feasibility.
African Lovegrass, *Eragrostis curvula*	Very high risk. Must be contained. eWOP*, Act	Very high		May form grass thickets. Prevents ground-foraging by birds.	Common, localised. Manage weed. Protect priority sites. Negligible–medium feasibility.
Chilean Needlegrass, *Nassella neesiana*	Very high risk. Must be contained. Propagation & supply prohibited. eWOP, WoNS	Very high			Uncommon, localised. Manage weed. Protect priority sites. Negligible–medium feasibility.
Serrated Tussock, *Nassella trichotoma*	Very high risk. Must be contained. Propagation & supply prohibited. eWOP*, WoNS	Very high			Common, widespread. Manage weed. Protect priority sites. Negligible–medium feasibility.
African Boxthorn, *Lycium ferocissimum*	High risk. Must be suppressed. Propagation & supply prohibited. eWOP, WoNS		Woodland bird habitat and food for native species such as Gang-gang Cockatoo		Destroy infestations. Medium–high feasibility.
St Johns Wort, *Hypericum perforatum*	High risk. Must be contained. eWOP*, Act	High			Common, widespread. Protect priority sites. Negligible–medium feasibility.
Fireweed, *Senecio madagascariensis*	Notifiable. Propagation & supply prohibited. WoNS.	Very high			Must be suppressed
Tree of Heaven, *Ailanthus altissima*	High risk. Propagation & supply prohibited. eWOP, Act				Destroy infestations. Medium–high feasibility.

Common name, Species name, recorded in Molonglo River Reserve and offsets	Risk as in 2012–13 eWOP	Potential risk to Pink-tailed Worm-lizard habitat	Effect on (or as) fauna habitat, other than Pink-tailed Worm-lizard		Abundance. Priority for control. Feasibility of coordinated control
	eWOP (*priority sp.), Declared, in Act &/or a WoNS		Desirable	Undesirable	
Firethorn, *Pyracantha* spp.	High risk. Propagation & supply prohibited. eWOP, Act		Nesting habitat and cover for small woodland birds; foraging habitat for, e.g., Gang-gang Cockatoo, currawong		Contain spread. Medium–high feasibility.
Hawthorn, *Crataegus monogyna*	High risk. Must be contained. Propagation & supply prohibited. eWOP, Act		Nesting habitat and cover for small woodland birds; foraging habitat for, e.g., Gang-gang Cockatoo		Contain spread. Medium–high feasibility.
Black Alder, *Alnus glutinosa*	High risk. Propagation & supply prohibited. eWOP, Act				Contain spread. Medium–high feasibility.
Cootamundra Wattle, *Acacia baileyana*	High risk. Propagation & supply prohibited. eWOP, Act				Protect priority sites. Negligible–medium feasibility.
Saffron Thistle, *Carthamus lanatus*	High risk. Must be contained. eWOP	Medium			Common, widespread, patches. Manage sites. Negligible–medium feasibility.
Cotoneaster, *Cotoneaster glaucophyllus*	Medium risk. Propagation & supply prohibited. eWOP, Act				Protect priority sites. Medium–high feasibility.
Briar Rose, *Rosa rubiginosa*	Medium risk. Must be suppressed. Propagation & supply prohibited. eWOP, Act	High	Woodland bird habitat		Uncommon, widespread. Protect priority sites.
Periwinkle, *Vinca major*	Medium risk. Propagation & supply prohibited. eWOP, Act				Protect priority sites. Medium–high feasibility.
Paterson's Curse, *Echium plantagineum*	Medium risk. Must be contained. eWOP, Act	Medium			Common. Manage sites. Negligible–medium feasibility.
Capeweed, *Arctotheca calendula*	Low risk. eWOP	Low			Uncommon. Limited action. Negligible–medium feasibility.

Common name, Species name, recorded in Molonglo River Reserve and offsets	Risk as in 2012–13 eWOP eWOP (*priority sp.), Declared, in Act &/or a WoNS	Potential risk to Pink-tailed Worm-lizard habitat	Effect on (or as) fauna habitat, other than Pink-tailed Worm-lizard Desirable	 Undesirable	Abundance. Priority for control. Feasibility of coordinated control
Horehound, *Marrubium vulgare*	Medium risk. eWOP	Low			Uncommon, localised. Monitor. Medium–high feasibility.
Great Mullein, *Verbascum Thapsus*	Medium risk. eWOP	Medium			Common, widespread. Protect priority sites. Medium–high feasibility.
Scotch Thistle, *Onopordum acanthium*	Low risk. Must be contained. eWOP, Act				Contain spread. Very high feasibility.
Box Elder, *Acer negundo*	Propagation & supply prohibited. Act				
Privets, *Ligustrum* spp.	Propagation & supply prohibited. Act				
Monterey/Radiata Pine (*Pinus radiata*)	Must be contained. Act	Potential			
Poplars, *Populus* spp.	Propagation & supply prohibited. Act				
Viper's Bugloss, *Echium vulgare*	Must be contained. Act				
Pampas Grass, *Cortaderia* sp.	Propagation & supply prohibited. Act				
Phalaris, *Phalaris aquatica*	(not a recognised weed elsewhere)	Environmental weed in habitat areas.			Common, localised. Protect priority sites.

Surveys have noted the following information about weeds in particular parts of the Molonglo River Reserve and offsets.

- Fireweed *Senecio madagascariensis*, a Weed of National Significance, was found in 2014 in the urban development area near Misery Point. It is notifiable and must be suppressed (ACT Government 2014a).
- Monterey Pine *Pinus radiata* exists in plantations below Scrivener Dam near Barrer Hill. It also regenerates from seed in areas such as Spring Valley Farm NES patch P where the former Bluetts Pine plantation was burnt in the 2003 bushfire. Trees of this species are killed by fire.
- The riparian zone, moist and fertile, has been invaded by weed species, except where the River She-oak community is dominant. African Lovegrass *Eragrostis curvula*, Blackberry *Rubus fruticosus* aggregate, Wild Oats *Avena fatua* and St John's Wort *Hypericum perforatum* are common and widespread throughout the Molonglo River Reserve and the offsets (ngh environmental 2012).
- In the Molonglo River valley the core breeding area for the Rainbow Bee-eater is the eastern bank of the river for 1 km upstream of the old sewage ponds (Taws 2014). Much of the otherwise suitable habitat is covered in dense weed growth of African Lovegrass, St John's Wort and introduced pasture grasses, leaving only a small area with sufficiently sparse groundcover for nesting.
- Several kilometres of riparian vegetation downstream of Scrivener Dam, including west of the Tuggeranong Parkway overpass and near and at Coppins Crossing, has become dominated by exotic species. These are mainly willows, *Salix fragilis*, *S. nigra*, *S. babylonica* and some shrub willows, with Poplars *Populus nigra*, *P. alba*, and *Corylus avellana*, hawthorn *Cratageus monogyna* and Firethorn *Pyracantha* sp. and Box Elder *Acer negundo* (e.g. Peden *et al*. 2011). The channel has been seen choked by willow roots and debris, and Blackberries have formed thickets along the river. Exotic species such as *Veronica anagalis aquatica*, *Nasturtium officinale*, *Ranunculus repens*, *Plantago major*, and *Taraxacum officinale* are common.
- In the gorge zone of the river valley, Peden *et al*. (2011) found the flood terrace was weedy, with *Hirschfeldia incana*, African Lovegrass *Eragrostis curvula* and Serrated Tussock *Nassella trichotoma*. Occasional willows and Box Elder *Acer negundo* were establishing in the area of the gorge: mainly *S. fragilis* with some *S. babylonica*. Downstream of the gorge, willows and other weeds alternated with the River She-oak Forest.
- At the Murrumbidgee confluence delta, the understorey included woody weeds (Peden *et al*. 2011).

3.3.4 Management of woody weeds

Woody weeds are more common in woodland areas including Box-Gum Woodland than they are in grassland areas. They compete with native groundstorey vegetation and interfere with native habitat. However, they can have ecological value for some native fauna. Birds eat the fruit and distribute the seed of woody weeds, helping these species to spread quickly.

As well as being a source of food for large birds (such as Pied Currawong and Gang-gang Cockatoo) dense woody weeds can have habitat value for small woodland birds because they provide nesting habitat where native mid-storey shrubs are absent (see s.2.7) and cover from predators. Riparian woody weeds, such as Crack Willow, are also used as nesting habitat on the Molonglo River by Little Pied Cormorant and Australian Darter (see s.2.5.8). Woody weeds occupying ground that would otherwise be bare may be restricting invasion by more serious weeds, and preventing erosion on slopes or in drainage lines.

The following dense and spiky woody weeds give small birds protective habitat (Stagoll *et al*. 2010) where native mid-storey structure or shrubs are absent, such as in Box-Gum Woodland and disturbed other woodland, though Blackberry also protects pest animals such as rabbits:

- Hawthorn *Crataegus monogyna*;
- Briar Rose *Rosa rubiginosa*;
- *Pyracantha* sp.;
- Boxthorn *Lycium ferocissimum*; and
- Blackberry *Rubus anglocandicans*, *Rubus fruticosus* agg.

In arranging a program of weed control, management should consider the ecosystem role weeds may be playing at each site, and whether native plants should be installed to take over that role before the weeds are removed or contained.

Control methods

Control methods used on woody weeds by operators such as ACT Government staff, contractors and qualified members of community groups include (ACT Government PCS 2011a):

- foliage spraying using registered herbicides;
- cut–paint (daubing cut stems with herbicide);
- frill–inject (herbicide into the base of the trunk); and
- basal bark spraying.

Timing is important for maximum effect. If timed too late, seeds already in the seed head or berry may not be affected by herbicide applications, and may also be spread inadvertently on clothing and machinery.

Beneath and close to eucalypts, herbicides should only be used for spot-treating woody weeds or for daubing onto cut weed trunks, to avoid contaminating the soil and affecting the eucalypt canopy. Eucalypts are known to die after weed-spraying within their driplines.

Spraying should not be used when there is risk of temperature inversions and unsuitable wind strengths. Extreme care should be taken when using herbicide near waterways or waterbodies because of the risk of contaminating the water and damaging riparian vegetation.

Grubbing out and removal is a practical method for individual small woody weeds in situations where herbicide application is not advisable. Young plants can easily be pulled out by hand. Native grass seed or seedy hay should be spread on the resulting bare patch immediately, or the patch should be mulched with native plant-litter to reduce further infestation by weed seeds. It is important to plan for follow-up weed control.

An alternative to removing woody weeds immediately is to kill them (by frilling, spraying or cutting) and leave them in situ to retain the mid-storey structure they provide. Where weeds have useful roles, control programs should aim to replace them some time beforehand with native species, planted in dense clusters so their foliage has adequate density while retaining the open grassy nature of woodlands and complying with fire management requirements. Suitable replacement shrubs include *Acacia or Bursaria* species. Native shrub species provide food and sheltering resources for a greater variety of native fauna, thus supporting biodiversity.

These practices, well-managed, can retain and improve habitat values over time as the native replacement species become established; they have been in use by ACT Government teams in areas beside the Molonglo River (see s.3.3.6, Management of weeds in the riparian zone).

Grazing management and revegetation can also be used as longer-term practices to restrict woody weeds, in conjunction with management of groundstorey plant species and restoration activities (see below).

3.3.5 Management of groundstorey weeds

Herbaceous weeds and weed grasses can restrict habitat quality and feeding opportunities for the threatened and significant ground-foraging birds in the Guidelines area. However, **Superb Parrots** and other threatened woodland species have been seen feeding on the seed of introduced grasses and forbs in Box-Gum Woodland when native groundstorey species are not available (see s.2.4.2). Grassy weeds and Phalaris in rocky grassland are also threats to **Pink-tailed Worm-lizard** (Table 3.1).

Typical herbaceous weeds include the highly invasive species African Lovegrass, Chilean Needlegrass, Serrated Tussock and St John's Wort as well as many other species of annual and perennial grasses and forbs and sub-shrubs. Introduced species can comprise 25–50% of the species present in grasslands, and their cover can exceed 50% in spring but would usually decline to 35% or less in those same sites in summer when the annual weeds die (Sharp 1997). Even in grassland considered only partially to moderately modified, weeds and introduced species may still make up more than 20% of the herbaceous cover (ACT Government 2005). In grassland in Molonglo River Reserve, African Lovegrass, St John's Wort and thistles are present, as well as Briar Rose. Human activity there is likely to bring in other environmental weed species.

Soils in south-eastern Australia are naturally low in fertility (McIntyre 2011), and where there is good native plant diversity and groundcover soil phosphorus concentrations are likely to be <20 mg/kg (Dorrough *et al*. 2008). However, in sites that have been heavily grazed and have high soil nutrient concentrations, or after soil disturbance or following removal of patches of other weeds, annual weeds are particularly prevalent (Dorrough *et al.* 2008). Annual grasses generally indicate that an area has high concentrations of soil nitrate (Prober *et al*. 2009).

High nutrient levels, particularly available nitrate, impede the successful establishment of plantings and suppress natural regeneration (Dorrough *et al.* 2008; Prober *et al.* 2009; McIntyre 2011). It is likely that within Box-Gum Woodland patches that have a high weed content, nitrate levels in particular may need to be reduced before restoration of native plants can be successfully achieved. Methods of most effectively reducing nutrient levels should be trialled, so as to enhance natural regeneration and improve revegetation success in such sites as Barrer Hill which is targeted for restoration (see also s.3.8.2).

Increases in soil fertility and subsequent weed establishment can be reduced by preventing unnecessary access by livestock, horse-riding, pets and pest animals, and by avoiding soil cultivation and clearing of vegetation (ACT Government EA 2001; Eco Logical Australia 2011a).

As with woody weed control, when groundstorey weeds are removed there needs to be active replacement with native groundstorey species, if native species are unlikely to regenerate naturally. Otherwise the plants that establish in bare ground are more likely to be weeds than native plants because weeds are strong competitors for growth resources and their seeds are likely to predominate in the soil seedbank.

There is a fire risk involved in infestations of annual grassy weeds such as Wild Oats, though they also have impacts through altering the structure and composition of the native groundstorey. When these weeds hay off in late spring or summer they form a significant bank of fuel. African Lovegrass also is very inflammable. From the point of view of fire risk, management should devise a strategic weed control program to contain the spread of inflammable invasive plants such as African Lovegrass and Wild Oats and replace them with low fire-hazard native and indigenous species.

Control methods

Weed grasses and other herbaceous species are most commonly controlled by spraying with herbicide, either broadscale or focused, which may also involve using residual herbicides that can kill the soil seedbank.

Well-timed and well-managed slashing, burning or grazing can reduce seed-set, impede weed invasion and reduce soil nutrients over time. See s.3.4, Managing plant biomass, below.

Preferred methods of weed control will depend on the presence of particular native species, including threatened species. The weed species and extent of infestation within and beyond the site, as well as the position of the site in the landscape, also affect the choice of control method. In the long term, competition from native grasses also helps control weed grasses and forbs.

Frequently, for widespread weeds, a better outcome can be achieved by adopting a regional integrated approach with liaison between ACT Government staff and other ACT region land managers (ACT Government DECCEW 2009).

Many herbaceous weeds such as African Lovegrass, Chilean Needlegrass and Serrated Tussock are readily transported, by wind, overground waterflow, streamflow, vehicles, animals and humans. Management to reduce the incursion and spread of readily transported weeds may involve:

- coordinated action,
- hygiene controls,
- visitor management,
- surveillance,
- staff training,
- community education,
- rapid response following reports of new weeds, and
- monitoring and rapid response after disturbances such as earthworks (and construction), fire, drought or floods.

3.3.6 Management of weeds in the riparian zone

The weed problem is most acute in the riparian zone in areas of existing or former River She-oak Forest. Almost all the priority weed species (see Table 3.1) occur within this community and elsewhere in the moist and fertile riparian zone which provides a refuge and a reservoir for weeds. Streamflow also is an effective dispersal mechanism for weed seeds (and native seeds). According to the eWOP the priority weeds in the riparian zone include:

- Crack Willow,
- Serrated Tussock,
- African Lovegrass,
- Blackberry.

Control work in the River She-oak Forest over recent years has focused on Willow and Blackberry control (Bowman and Keyzer 2010). In a few sections along the Molonglo River where woody weeds are widespread and very common TAMS staff are removing them in strips and replanting the strips with native species before removing woody weeds in adjacent strips (R. Milner pers. comm. 2014).

The exotic vegetation that screens willows currently in use by nesting waterbirds should not be removed[6]. Development of new nesting trees for cormorants and darters will take many decades and there is no indication that the local native riparian trees are as suitable in structure. The exotic plants providing screening could be removed gradually, but only after replacement native species have been planted and grown enough to provide sufficient screening. Where willows have already been removed in a control program, appropriate native riparian species have been planted.

Control methods

Bowman and Keyzer (2010) and Eco Logical Australia (2011b) list strategies for vegetation management and weed control in the river valley. Methods include:

- spraying
- frilling, and
- mechanical removal at the upstream end of the urban section.

6 The aim is to maintain the breeding population of the birds in this location.

3.3.7 Management of weeds in relation to the MNES fauna

Pink-tailed Worm-lizard

Weed infestation will compromise the conservation value of grassy Pink-tailed Worm-lizard habitat. The weeds that threaten lizard habitat and the lizard are those species that can become dominant and out-compete the native grasses and forbs associated with good habitat.

- African Lovegrass is arguably the main threat because of its rapid spread and tendency to form dense tussocks. When combined with other individuals, these tussocks form very dense (and often tall) localised thickets that can eventually completely dominate the landscape.
- Chilean Needlegrass *Nassella neesiana*, which is easily and commonly spread by mowers and other vehicles, would be of particular concern for Pink-tailed Worm-lizard habitat in rocky grassland.
- Serrated Tussock is another threat that would modify Pink-tailed Worm-lizard habitat.
- Shrubs and trees (even if deliberately planted) that shade Pink-tailed Worm-lizard habitat in rocky grassland areas are also effectively 'weeds' and a threat (see Table 3.1); for example, wilding trees (particularly Monterey/Radiata Pine) and the native shrub *Kunzea ericoides*.
- Annual and perennial exotic pasture grasses and herbaceous plants, including Phalaris and Wild Oats, are also threats.

To manage the interaction of such weeds and lizard habitat will require extreme vigilance and complete eradication of the weeds, including in the proposed 20 m buffer zones surrounding habitat areas. Appropriate techniques will be required to control the invasion of weeds and pasture species within habitat areas and buffers, and reduce their biomass (see also s.3.2.3). The impact of herbicide use on Pink-tailed Worm-lizard habitat should be known before application.

Superb Parrot and Swift Parrot

As noted above, Superb Parrot adapts its feeding to the resources available. However, weeds lower the condition of Box-Gum Woodland and other woodlands, and weed control as above should benefit these parrots by protecting woodland ecological values and habitat structure. The Superb Parrot breeding season should be avoided when weed control work needs to be done within 100 m of known nesting habitat.

3.4 Managing plant biomass and fuel loads

Plant biomass is the aboveground plant material that accumulates through new growth of herbaceous species, particularly grasses, and woody species, combined with the very slow decomposition of dead leaves, stalks, twigs, branches and other plant parts.

Large amounts of plant biomass affect ecological values in the groundstorey as well as being potential fuel for a bushfire. Too little plant biomass at a site can also be ecologically detrimental, giving ground-living fauna insufficient cover against predators, and the soil surface and plant roots little protection against trampling and erosion.

Among native plant species producing large amounts of biomass is the tall perennial Kangaroo Grass *Themeda triandra*, which grows in summer and hays-off in autumn. Kangaroo Grass is one of the native grasses characteristic of all **Box-Gum Woodland** sites and other parts of the Reserve including **Natural Temperate Grassland** and **Pink-tailed Worm-lizard habitat**. Unless subjected to some form of biomass reduction, Kangaroo Grass swards can become dense, and their height, litter accumulation and lateral tillering can exclude other plant species (Stuwe and Parsons 1977; Kirkpatrick 1986; McDougall 1989 in Lunt 1990). Unrestricted growth can cause Kangaroo Grass itself to decline (Eddy 2002). In some areas, Kangaroo Grass will begin to die after eight years if there is no disturbance, and sooner in wetter areas (Bush and Faithfull 1997).

Weed grasses and forbs also can produce a vigorous tall thick growth of biomass in spring, summer and/or autumn, depending on timing of rainfall events. African Lovegrass, Wild Oats and other herbaceous weed species, especially annuals, are particular examples, and they occur throughout the Reserve and offsets. In areas of **Box-Gum Woodland**, for a few years after disturbance (e.g. by fire), particularly where grazing has ceased, acacias and regenerating eucalypt saplings can form mid-storey thickets, accumulating large amounts of plant biomass.

Amounts of biomass to expect in any given season depend on a range of factors, including rainfall and temperature and the dominant species in the groundlayer. Where relatively short grasses such as wallaby grasses (*Rytidosperma* spp.) predominate, and beneath trees, the quantity of biomass may remain relatively low and little or none of it may need to be removed, but the opposite situation applies where Kangaroo Grass is the dominant groundstorey species.

In drought or cool seasons, plant growth will be severely limited and the vegetation may be particularly susceptible to defoliation. With adequate rain, introduced annual grasses and weed grasses typically produce large amounts of biomass in spring which dies off in summer — or sooner if there is a hot spell in spring.

3.4.1 Biomass impacts on ecological values and MNES, and aims of management

Large amounts of dense biomass of native and introduced tall dense grasses and forbs are a threat to ecological values in **Box-Gum Woodland** and derived grassland, in **Natural Temperate Grassland**, in **Pink-tailed Worm-lizard** habitat, and throughout the Reserve and offsets.

- Plant biomass exceeding approximately 4 t dry matter/ha is a severe fire hazard.
- Dense groundstorey plant biomass inhibits the establishment and growth of a diverse groundstorey layer of native forbs (Antos *et al.* 2008; Barrett *et al.* 2008) including native legumes, and is therefore a threat to the condition of the **MNES vegetation communities**.
- Excess plant biomass unbalances the natural mixtures of native groundstorey species in the threatened habitat and the dryland matrix of the Reserve and in the MNES habitats of the offsets.
- Seedling recruitment of many native plant species is less likely when dense plant biomass fills up inter-tussock spaces (Lunt 1995).
- Dense plant biomass restricts the diversity of groundcover of plant litter (Antos *et al.* 2008), which in turn lessens the variety of invertebrates available for ground-foraging birds (Barton *et al*. 2009; Lindsay and Cunningham 2009).
- Excess plant biomass is a threat to the **Pink-tailed Worm-lizard** in its habitat. Dense tall clumps or swards of plant material smother the rocks and open spaces, preventing direct sunlight from warming the rocks and ground, and making the habitat less suitable for the ants on which the lizards depend. Dense plant material can also depress the diversity of forbs, subshrubs and graminoids typical of high or moderate quality habitat. Most commonly the biomass consists mainly of weeds such as African Lovegrass.
- Excess biomass restricts diversity, access, visibility and air-movement in grassy areas that **Superb Parrots** might use for foraging. **Swift Parrots** are unlikely to be affected by excess biomass, except if its control poses risks to trees in which the parrots feed.
- A tall dense groundlayer limits the diversity and value of feeding and nesting habitats for birds — Scarlet Robin, Flame Robin, Hooded Robin, Diamond Firetail, Double-barred Finch, Rainbow Bee-eater, Restless Flycatcher, Speckled Warbler, Southern Whiteface, White-fronted Chat and White-winged Triller — that use the groundlayer (see habitats, s.2.7). It reduces their access to food at ground level, impedes their movement and blocks their ability to see potential predators.
- Observations from within Kama indicate that the thickening of the grass layer and build up of biomass has restricted the Brown Treecreeper to foraging around logs and tree trunks (C.Davey pers. comm.).

Aims of management

Management of herbaceous biomass (mostly of grasses) is considered to be particularly important in the Guidelines area.

The ultimate aims are both to maintain the fire fuel load at an acceptable level, and to restore a mixture of vegetation species associated with good condition in threatened habitat and dryland matrix, specifically so that:

- fire fuel management and biomass manipulation result in an increase in native species diversity, structure and habitat, when measured against baseline condition;
- bushfire operations are managed in ways that retain ecological values;
- fire management does not result in damage to habitat for threatened species or fire-sensitive species.

Biomass manipulation needs to be guided by clearly articulated management goals relevant to each management area (Lunt *et al*. 2010) and target species (Dorrough *et al*. 2004).

ECOLOGICALLY

For ecological reasons it is important to avoid removing too much biomass. Biomass management aims for a structurally patchy cover of vegetation, which makes for heterogeneity of habitat. To achieve that, opportunities for natural regeneration (by seed production and seed set of native and weed species) need to be enhanced via biomass-control methods and timing (see s.3.4.2).

A mix of tall, intermediate and short tussocks and presence of small creeping or tufted grasses and forbs is the ideal structure for retention of flora and fauna diversity (McIntyre 2005). For example, birds such as the Brown Treecreeper prefer to forage in areas with bare ground or sparse native grasses or in areas that have been heavily grazed (Maron and Lill 2005). Many native species rely on regular, relatively frequent defoliation of the dominant grasses to provide inter-tussock spaces for seedling recruitment (Lunt 1995).

Particular management targets include these:

- in patches with high and moderate native vegetation diversity, including **Natural Temperate Grassland**, native groundcover should exceed 70%; there should be no more than 20% bare ground (McIntyre *et al*. 2000);
- the vegetation structure and habitat should be kept heterogeneous, with areas of short and tall tussocks (ACT Government 2004b; McIntyre and Tongway 2005);
- in patches with low native vegetation diversity, native groundcover should exceed 50%, and there should be no more than 20% bare ground (McIntyre *et al*. 2000).

In any NES patch, based on current knowledge, it is likely that optimal groundstorey structure, function and species composition will be maintained when the plant biomass is 2–4 t/ha (and no less than 1.5 t/ha), measured in autumn (CSIRO Ecosystem Services 2012).

In removing excess plant biomass, management must take care to:

- protect live native trees from damage, and dead standing trees from removal;
- create gaps in the groundstorey vegetation, but minimal bare ground, to enable natural regeneration of native vegetation while managing weed invasion;
- create a mosaic of habitat resources for the threatened fauna species and their feed sources or prey;
- protect sensitive vegetation from trampling, overgrazing, fire damage and weed competition;
- maintain buffer zones to protect sensitive areas such as Kama (protection from future urban areas to the east), and the banks of waterbodies and the river, to prevent physical damage and contaminants in runoff.

Allowing too much biomass to be removed too often, including by overgrazing by kangaroos, can cause long-term damage, sometimes irreversible, to native vegetation, habitat and ecological function.

Excessive biomass reduction can reduce structural diversity whether in woody ecosystems or in herbaceous systems.

Frequent defoliation can kill desirable groundstorey plants, leaving open space and bare soil that weeds can invade, preventing natural regeneration and leading to soil erosion and loss of soil biota.

FOR FIRE PREVENTION

Near the developing suburbs, management must aim to maintain the quantities of inflammable vegetation at levels that are not a threat to human life and property protection (ACT Government 2014b). In such areas, the fuel load/biomass must be managed so as to retain outcomes defined for biodiversity conservation (see s.3.6.4).

Biomass removal should be guided by clearly identified goals related to fire fuel management as well as goals specific to the NES requirements (ACTPLA 2011), land use and issues in each site as identified in the initial baseline condition assessment. The ACT Government has prepared Ecological Guidelines for Fuel and Fire Management Operations, covering prescribed burning, slashing, chemical application and grazing (and also physical removal of rocks, soil and vegetation, and access management) (ACT Government ESDD 2012b). Those guidelines identify likely impacts on areas containing threatened communities and species. Any activities outside these recommendations may result in a loss of condition within management areas.

Special management may be needed in Spring Valley Farm which is a known breeding site for **Superb Parrot** (in NES patch M). Eco Logical Australia (2011a) identified that the management and maintenance of ecological values within Spring Valley Farm are particularly challenging given that the area is at high risk of wildfire. The NES Plan specifies there must be fuel-hazard management in NES patches I, L, M and P, with the protection of **Box-Gum Woodland** as a critical consideration, and annual condition monitoring. Early recognition of the management requirements in this offset area will counter the need to find an alternative offset area (see ACTPLA 2011), and reduce the threat of loss of diversity.

3.4.2 Factors affecting the control program

In biomass management it is very important to base the control program on the amounts of biomass present and particularly on the life cycles of the target plant species, rather than relying on a seasonal schedule without the backup of field observation (Dorrough *et al.* 2004). The existing intensity of grazing by resident kangaroos must be considered when determining whether to remove additional biomass using other methods.

Whichever control methods are used, the optimal rate (intensity), timing and frequency at which each is applied will depend on:

- the type of vegetation or foliage;
- dominant species and target species (threatened species and weeds);
- seasonal conditions;
- the site's initial condition, location and current land use;
- fauna habitats present;
- the threats that the operations might impose on native fauna in the area, such as birds and particularly the **Superb Parrot**;
- other factors (such as kangaroos or rabbits) that may be removing biomass.

However, the optimal regimes for manipulating biomass for ecological outcomes are largely unknown.

Regular monitoring of the condition of the MNES should reveal outcomes of any additional biomass and fuel management programs. The results of the monitoring can be used to develop more prescriptive goals for future complementary action. Ideally, the impacts of slashing, grazing by livestock, grazing by kangaroos and burning should be trialled as well as monitored.

Herbicide, grazing, slashing or burning

Apart from use of herbicide for managing weed biomass (s.3.3), there are three other main methods of managing biomass which allow for natural regeneration of native species:

- burning (see s.3.4.5),
- slashing (see s.3.4.4), and
- grazing (by livestock or native fauna including kangaroos, or pest animals; see s.3.4.3).

Management needs to balance the threats and benefits of each method, as shown in Table 3.2. In general, to retain species diversity ecological burns can be better than livestock-grazing. However, burning can also give a range of undesirable species (native and exotic) an opportunity to regenerate, thereby potentially adding to biomass management issues in the long term. Burning may also temporarily reduce 'landscape function' elements such as plant litter and wood on the ground, which are also important components of groundstorey habitat. Whichever method is used for biomass control, management should aim to maintain heterogeneity of habitats while also reducing the hazard of wildfires.

Several methods and timeframes may be needed within a site to achieve the required outcomes. For example, it may be determined that ecological burning is the major technique to be applied in a site, but some parts of the site may be better treated in other ways, such as by herbicide application to kill weed grasses such as African Lovegrass or Wild Oats.

A fifth approach to biomass manipulation is through restoration activities (s.3.8); for example, bringing in rock (perhaps to extend Pink-tailed Worm-lizard habitat) or logs or reinstating native groundstorey plants (such as wallaby grass species) that produce less biomass and potential fuel than many exotic grasses.

With each method, the intensity, frequency, timing and past history will affect the ecological outcomes and the effectiveness of reducing biomass and fuel load.

Table 3.2. Comparison and summary of outcomes from defoliation by two types of grazing, or slashing or burning.

Impact on targets	Burning	Livestock grazing	Kangaroo grazing	Slashing
Impact on biomass	Removal of vegetation cover and woody and plant litter can result in exposed soil.	Selective removal of grasses and forbs depending on palatability; no significant exposure of soil unless over-grazed. Compaction from hoofs.	Selective removal of grasses in particular, depending on palatability. Fewer compaction effects except along tracks and in camps.	All erect material removed, trash usually left on site, including seed, unless baled. Mulch can suppress regeneration.
Impact on native species	Impact depends on season of burn (e.g. fire during spring may prevent or reduce seed maturation but may result in cool burns that minimise loss of target species). *Fauna*: Hot burns can have a high impact due to direct mortality and effects on habitat resources. Patchy and 'cool' burns can increase habitat diversity and increase short-term foraging opportunities. Fires can reduce availability of large logs and hollow-bearing trees but may also create new hollows.	A diversity of short and longer pasture can enhance native fauna diversity. Risk of trampling or compaction of habitat or species (particularly Pink-tailed Worm-lizard). Often impacting natural regeneration, many herbaceous and shrub species die out over time. Usually results in loss of tall erect herbaceous species and dominance by short perennial grasses.	A diversity of short and longer pasture can enhance native fauna diversity. Heavy grazing pressure can result in damage to native plants and loss of cover for small fauna.	If undertaken too frequently can minimise seed maturation of native species limiting natural regeneration. Frequently taller species are disadvantaged and can die out from slashed sites. Trash can result in death of plants underneath and replacement by introduced species. Mechanical slashing can cause direct mortality of fauna and can have long-term negative effects on habitat structure.
Impact on native species (cont)	Moderate intensity burns are required to facilitate regeneration in plant species that are reliant on fire to break dormancy (e.g. obligate seeders and some legumes).			Soil compaction is also possible from the mowers and soil disturbance in wet conditions.
Impact on introduced species	Potentially high impact, particularly after hot burns where introduced species can invade while soil exposed. African Lovegrass is highly advantaged by burning.	Stock can bring in seeds in coats or dung. High grazing pressure results in dominance by annual introduced species. Soil disturbance can result in invasion by introduced species. Conversely, grazing animals can assist to keep woody weeds under control (under a strategic grazing regime). Use of fertiliser favours introduced species, especially annual grasses.	Can spread seed in dung and sticky seeds on coats.	Very difficult to control the spread of weed seeds by mowers and other machinery.
Ability to control biomass removal	Maximum bare ground exposure until plants regrow; response is usually quick.	Can control how much is removed by moving stock.	Difficult to control kangaroo grazing pressure.	Cutting height should be no lower than 100 mm to minimise loss of reproductive parts of native plants.

Impact on targets	Burning	Livestock grazing	Kangaroo grazing	Slashing
Timing and frequency for conservation outcomes	Only undertaken at intervals that would not prevent natural regeneration of slowest species to respond.	Can control timing and frequency of domestic stock to maximise native regeneration (but see impact on species above).	Can only control kangaroo grazing pressure by culling. Use of kangaroo proof fencing not practical but may be required in extreme situations.	Can control frequency of slashing. Should be undertaken several times a year to reduce biomass effectively for fire fuel reduction. Nesting periods need to be considered for fauna such as Superb Parrot, and small birds that nest or forage in long grass.
Impact if too frequent	Risk of higher fire intensity especially on steep slopes. May result in erosion if plants are continuously defoliated.	High impact to flora and fauna habitat from loss of vegetation, soil compaction and erosion. Stock camps affect trees, have high weed content, high soil nutrient levels, and are compacted.	Loss of groundcover from grazing and communal sheltering.	May result in erosion if plants are continuously defoliated. Usually invaded by annual or perennial introduced species if bare ground exposed.
Impact on wetlands	Wetlands may be subject to contaminated run-off until vegetation recovers.	High impact from stock watering, wallowing or camping on or near water.	Minimal impact.	Minimal impact.
Impact on steep slopes	Impacted by exposure of soil until vegetation recovers.	May have a high impact — tracks, disturbing soil, dislodging rocks.	Low impact. Kangaroo tracks generally do not cause significant erosion unless population levels are very high.	Cannot slash with tracked (tyred) machinery on steep slopes.
Recommendations	Use where possible as the most natural form of defoliation, and by applying cool burns, but not more frequently or at seasons other than recommended in guidelines (ACT Government TAMS 2008; ACT Government 2009a,b; ACT Government ESDD 2012b).	Inappropriate to use within the river valley, especially in steeper areas with restricted access. Only use in sites that have a grazing history. Plant diversity is unlikely to increase under a grazing regime, but grazing can be used to retain other ecological values such as habitat (Lunt *et al*. 2007).	Take into account the grazing pressure of kangaroos when planning for biomass control. May need to consider culling if density and impacts are high.	Only use on tracks for visibility; need to assume that weeds will invade and need to be treated. Unlikely to result in an increase in ecological values unless implemented with other strategies.

3.4.3 Grazing to manage biomass for conservation and fire mitigation

Impacts of grazing on ecological values

Grazing can control the build-up of grassy biomass and fuel, and it can also achieve ecological outcomes (Lunt *et al.* 2007) when:

- it reduces the biomass of potentially dominant, grazing-sensitive native or introduced plants (e.g. Kangaroo Grass, Wild Oats) at the site;
- it prevents encroachment by undesirable, grazing-sensitive potential dominants (e.g. Phalaris);
- it opens up niches (gaps) in dense groundstorey vegetation, suitable for rare or significant species (particularly native forbs);
- it maintains habitat structure for threatened or significant fauna (e.g. short grass structure for Golden Sun Moth habitat);
- it enhances the diversity of species across the landscape.

Overgrazing by any herbivores in woodland or grassland takes away plant material and foliage repeatedly over a period, preventing leaves growing back, and potentially killing the above-ground parts and the roots and exposing the soil. This can lead to:

- a decline in the diversity of native forb species;
- the replacement of tall warm-season grass species with shorter cool-season grasses;

- increasing dominance by introduced annual species; and
- soil compaction and disturbance (Eddy 2002; Dorrough *et al*. 2004; ACT Government 2005; Lunt *et al*. 2007).

Kangaroos can exert a significant impact on native vegetation structure and composition. Green grass makes up 99% of kangaroos' diet. When feed is in short supply, such as during drought (ACT Government TAMS 2010; Sharp 2011), kangaroos will eat grasses faster than they are growing, and almost all other available herbage as well (ACT Government TAMS 2010). Other herbivores such as sheep, cattle, goats, horses and rabbits eat forbs as well as grass at any time.

Overgrazing by kangaroos can be difficult to manage. The amount of biomass they are removing should be considered before introducing livestock grazing to the same site, so that the need to cull kangaroos or put up expensive fences to restrict their access is minimised.

Intensity (grazing pressure), timing and frequency of livestock grazing need to be carefully managed (Table 3.3). Before introducing livestock to a site its grazing history also needs to be considered. Even when grazing is controlled and at planned frequency, it can be ecologically damaging where:

- a site has rarely been grazed in the past by livestock;
- it contains rare, grazing-sensitive species;
- it contains species that require specific mechanisms such as fire to regenerate; or
- it contains unpalatable/undesirable species that are potentially dominant.

Livestock should not be grazed on sites that have never previously had livestock grazing (Lunt *et al*. 2007), and each site should be considered on the basis of its history and current condition (CSIRO Ecosystem Services 2012).

In the Guidelines area, several offset areas of Box-Gum Woodland are, or were formerly, leased or grazed: NES patches C, H (William Hovell woodland), N, GG (Aboretum woodland), I, L, M, P (Spring Valley Farm) and E, F and G (now 1, 2, and 3) (West Molonglo/western Belconnen). Ecological outcomes here will be optimised by developing and implementing a strategic grazing program, depending on the ecological targets to be achieved. For example, if tree regeneration is a target, it is likely that grazing frequency and/or patterns will need to be modified.

Table 3.3. Livestock grazing as a tool for biodiversity conservation in temperate grassy ecosystems.

Vegetation type (understorey)	Characteristics (Sharp 2006)	Grazing (Dorrough 2010; CSIRO Ecosystem Services 2012)	Timing (CSIRO Ecosystem Services 2012)
High Conservation Value grassland or grassy woodland (Partially Modified, ACT Government 2005)	Very diverse range of native species including grazing-sensitive species.	Short duration pulse grazing. Avoid grazing when native forbs and grasses are establishing, growing and seeding.	Mid-February to end May
High Diversity Native Pasture (Partially Modified, ACT Government 2004b, 2005)	Diverse range of native species, most grazing-sensitive species no longer present.		
Moderate Diversity Native Pasture (Moderately Modified, ACT Government 2004b, 2005)	Lower diversity of grazing-tolerant species, but including some forbs; some exotic annuals. Likely to have been fertilised in past.	Pulse graze or rest to maintain high perennial (native) pasture cover and restrict annual exotic growth and seeding in autumn. Pulse graze or burn in spring to reduce exotic annuals.	Mid-August to end October or burn 1–3 years to reduce exotic annuals. Late February to end May only if native biomass high and to restrict annual exotic growth and seeding.
Low Diversity Native Pasture (Highly Modified, ACT Government 2004b, 2005)	Grazing-tolerant native plants, mostly grasses; significant proportion of exotic annual species present.	Rest in autumn and winter to build up perennial native grasses, groundcover and seed reserves which will suppress exotic annual species.	Mid-August to end October or burn annually to reduce exotic annuals.
Fertilised Native Pasture (Substantially Modified, ACT Government 2004b, 2005)	Some phosphorus and grazing-tolerant native grasses, mostly annual exotics.		

Timing and frequency of livestock grazing

The timing and frequency of livestock grazing affect whether it will achieve biodiversity conservation while controlling biomass and fuel load.

Areas should not be grazed when there is little biomass or feed (e.g. as a result of fire or other biomass removal, or during drought conditions). These conditions stress both the pasture or grassland and the livestock.

Grazing should generally be applied rotationally: high intensity grazing can be used for short periods followed by long rests, to build-up desirable species and enable native species to germinate and establish.

When grazing is withdrawn or the grazing regime is modified, there can be significant increases in plant diversity and natural regeneration, including of native trees, particularly where nutrient levels are moderately low. That is evidence that the seeds of many native species remain in the seedbank at grazed sites though they are unable to grow and set seed. Nutrients such as nitrogen and phosphorus also gradually decline over time, which may also result in a gradual increase in native species over time.

Intensity and stocking rate

When grazing for biodiversity conservation in grassy ecosystems (CSIRO Ecosystem Services 2012):

- manage the grazing pressure so that only herbaceous vegetation is eaten, and there is no browsing or ringbarking of trees and shrubs;
- use grazing in conjunction with other management methods, such as weed removal, fire or slashing;
- maintain biomass at more than 1.5 t/ha, and groundcover between 70% and 100% with no addition of fertiliser.

To protect ecological values, management should avoid heavy prolonged grazing by livestock, kangaroos or pest animals. The risks of using high intensity grazing (large numbers of animals) are:

- physical damage to native vegetation (groundstorey and shrubs);
- damage to ground-dwelling fauna habitat and nests, by removing the animals' protective cover and by physical trampling;
- too thorough removal of seeding grasses and forbs which may be feeding habitat for Superb Parrot and other woodland birds;
- exposure and disturbance of soil where plants have died from overgrazing, and along tracks, and at camps.

When there is a high density of animals, trampling by livestock and kangaroos and digging by rabbits loosen groundstorey plant roots and the soil, causing erosion and compaction. They also add nutrients to the soil at their camps. The overall results can be significant loss of '**landscape function**' (Sharp 2011) and threat **to ground-dwelling fauna**.

In **woodland**, tree recruitment is better under infrequent or rotational (or crash) grazing by livestock than under prolonged medium to high intensity grazing (Dorrough 2010; Kirkpatrick 2010).

In **grassy landscapes**, low levels of continuous grazing (4 DSE/ha; approx. 1 steer/2–3 ha), or more intense grazing with rest periods, give native species opportunities to flower and set seed (Dorrough *et al.* 2008). The aim is to achieve a mixture of tall and short grasses, offering a range of habitats and niches in which grazing-sensitive plants can survive (Dorrough *et al.* 2004; McIntyre 2005). Management should take into account the total number of herbivores including livestock, and their relative feed requirements, aiming to maintain an average groundlayer biomass at no less than 1.5 t/ha.

In the **riparian zone**, there should be no livestock grazing. Observed or potential grazing pressure should be managed by fencing.

For **significant bird species**, cattle grazing during the breeding season may trample ground-built nests of species such as Speckled Warbler or damage the sandy banks occupied by nests of Rainbow Bee-eater; the larger the number of animals, especially cattle, the greater the risk.

Grazing in relation to MNES

In **Box-Gum Woodland**, high-input livestock grazing (prolonged medium to high intensity grazing and/or use of fertilisers) will not maintain ecological values (Dorrough *et al.* 2008; Dorrough 2010).

For **Pink-tailed Worm-lizard**, carefully controlled livestock grazing can be used at times to manage excessive groundcover in high-quality and moderate-quality habitat and buffer zones. However, overgrazing, whether by kangaroos or livestock or pest herbivores, and especially during drought, damages vegetation, particularly *Themeda* grassland. There is a risk of loss of groundcover and consequent erosion. If bare soils are upslope of lizard habitat areas, heavy rain can carry sediment across the buffer and onto the habitat. Cattle grazing upslope can also cause erosion and disturbance by dislodging stones or small rocks and by their tracks.

In **Natural Temperate Grassland** and grassy ecosystems, kangaroos grazing also threaten native ground fauna — birds and reptiles. Heavy grazing pressure from kangaroos was the apparent reason for ground-nesting birds being unable to persist in the area studied by Neave and Tanton (1989, in ACT Government TAMS 2010). Heavy grazing by kangaroos in native grassy ecosystem vegetation at the Majura Training Area in the drought in the 2000s was associated with a sharp fall in the population of the endangered Grassland Earless Dragon *(Tympanocryptis pinguicolla*), whereas in nearby less grazed areas the Grassland Earless Dragon population remained higher (ACT Government TAMS 2010).

3.4.4 Slashing to manage biomass for conservation and fire mitigation

Impact of slashing on ecological values

Slashing (or mowing) can control biomass and reduce fire fuel loads in areas of extensive herbaceous vegetation. It is a useful method for improving lines of sight and ease of access, and is applied in some areas to defoliate native grasslands for conservation outcomes (ACT Government 2005). A program of slashing helps maintain an open structure in native grassland, allowing forbs to regenerate in the gaps (ACT Government 2005). See Table 3.2.

Slashing can also be detrimental. Timing, frequency and operational aspects of slashing are critical. It is very important to know the ecology of the site to be slashed to avoid negative impacts to plant species composition and damage to native ground-dwelling fauna. Slashing can result in:

- weed seeds being spread across the site or brought in from other sites;
- windrows of slashed biomass being left on the ground, which will
  (a) smother plants and cryptogams, and
  (b) rot, releasing nutrients to the soil, and
  (c) form a microenvironment where annual weeds will readily germinate;
- soil compaction and/or rutting, especially when the ground is wet or damp, which will also damage cryptogams (lichens, moss, algae) (Eddy 2002; ACT Government 2005);
- damage to habitat structure for fauna such as birds and reptiles;
- injury or death to ground-dwelling fauna that cannot escape.

Intensity and frequency

Slashing can be used strategically, to reduce or prevent seed production by weed species.

Verrier and Kirkpatrick (2005) found that frequent long-term mowing (with the removal of slash) resulted in a higher cover of rare and threatened species, greater native plant cover and lower exotic grass cover than long-term sheep grazing.

Mowing low to the ground and/or too frequently prevents flowering. There should not be regular mowing before native plants produce and disperse viable seed.

Frequent slashing/mowing depletes root reserves, and may also physically damage ground flora including cryptogams.

Timing

Slashing that is well-timed and with knowledge of the plant ecology of the site, including the proportions of annual and native grasses, should promote the natural regeneration of native plants, and reduce seed set by introduced species.

In 2009 the Natural Temperate Grassland at Yarramundi Reach was mown (and slash removed) to reduce the very dense biomass of (mainly) native grasses. The result was a significant and immediate growth response by Kangaroo Grass and increase in seed production in the following summer (Sharp and Pittock 2011). However, there was also significant germination by Wild Oats and other introduced species.

For native fauna, timing is important in relation to both feeding habitat and nesting habitat.

Other operational aspects

Slashed material should be removed. (Slashed grasses may be valuable for regeneration work if rich in native grass seeds; see s.3.8.2.) If made into hay, slashed material could be sold or supplied to livestock.

It is important for mowers to be thoroughly cleaned after each site to prevent them carrying weed seeds between sites.

Slashing in relation to MNES fauna and other fauna and habitats

Slashing can reduce the seed supply for ground-feeding fauna including **Superb Parrot**.

Other ground-foraging species will be affected if the slashed vegetation is critical habitat for shelter and food (Sharp and Rehwinkel 1998; Eddy 2002; ACT Government 2005).

Ground-dwelling fauna or their nests may be physically damaged by slashing.

Slashing or mowing in high- and moderate-quality habitat for **Pink-tailed Worm-lizard** risks disturbing rocks and introducing highly invasive weeds. As a rule only hand-slashing should occur within Pink-tailed Worm-lizard habitat. Machinery can be used for slashing within the buffer zones around high- and moderate-quality habitat, to reduce biomass and fire fuel loads and weeds; any machinery should be thoroughly cleaned before entry to avoid bringing in weed seed.

Slashing to control biomass and fuel loads on facilities such as firebreaks, fire access suppression trails, utilities such as powerlines, drainage ditches and other places, can present threats from soil erosion and smothering effects on any nearby Pink-tailed Worm-lizard habitat. To prevent conflict between lizard habitat and biomass reduction operations, there must be clear knowledge of the extent of Pink-tailed Worm-lizard habitat in the Molonglo River Reserve, and these facilities shoud be located well away such habitat.

3.4.5 Planned burning to manage biomass for conservation and fire mitigation

Impact of planned burns on ecological values

Planned burns can be used to manage grassy biomass and fuel loads and open the groundstorey vegetation for the benefit of fauna and native forbs in woodland and grassland.

Inappropriate fire practices, however, can kill vegetation and fauna and remove habitats, including standing dead trees and hollow bearing trees which are important breeding habitat for Superb Parrot. Even when controlled, fire is likely to consume dead wood on the ground and groundlayer litter (important for fauna such as reptiles, invertebrates and ground-foraging or ground-dwelling birds).

Natural Temperate Grassland and Box-Gum Woodland vegetation communities are adapted to fire and in some cases depend on some form of regular groundlayer defoliation to maintain their health. Biomass reduction by prescribed ecologically-timed burning can be beneficial in managing these ecosystems (Eddy 2002; ACT Government ESDD 2012b).

It may also promote regeneration of obligate seeders — that is, those species that respond either to heat or smoke to release seed (e.g. some *Acacias*).

Fire, as such, is not regarded as a specific threat to any of the protected and threatened fauna species known in the Molonglo River Reserve and offsets, including Pink-tailed Worm-lizard. However, all species would suffer under an 'inappropriate' fire regime; that is, regular hot fires which would lead to reduced microhabitat availability (by causing simplification of habitat) or frequent fires.

Under the NES Plan, fire management in the Molonglo River Reserve (urban section) and offsets is aimed at the protection both of built assets and of MNES values. It requires asset protection zones and hazard reduction techniques which will reduce the fuel load to standards defined in the ACT Strategic Bushfire Management Plan and also protect MNES values through the use of sympathetic management techniques. The buffer to the east of Kama (Kama East, s.2.2.3) needs to be used as an Asset Protection Zone for bushfire management for adjacent suburbs, to reduce impacts on the Reserve. It should be managed in such a way that the ecological values of Kama are not compromised by fire fuel management actions.

However (see s.3.6.4), if there is conflict between bushfire risk reduction and management of other values in asset protection zones within the Molonglo River Reserve and offset areas (excluding Kama), bushfire risk reduction takes precedence unless suitable alternatives can be achieved (ACT Government 2014c) or the ACT Government's commitments to maintain and enhance the ecological condition of NES patches is not reached (ACTPLA 2011).

Strategic management of fire in threatened habitat and the dryland matrix must aim to ensure:

- fuel levels that will minimise wildfire events and impacts;
- protection of ecological values through ecological burning;
- readiness for fire suppression activities in the event of wildfire.

Fuel hazard should be assessed and monitored annually.

Applying planned burns for conservation outcomes

The ACT Government has prepared Fuel and Fire Suppression Guidelines for ACT Declared Threatened Species and Endangered Ecological Communities (ACT Government TAMS 2008; ACT Government ESDD 2012b). All deliberate burning in the Reserve's and offsets' grassland and woodland must aim to achieve ecological outcomes and be incompliance with the fuel and fire suppression guidelines (ACT Government TAMS 2008).

Those guidelines cover the following communities and species that occur or may occur in the Molonglo River Reserve and offsets:

- Natural Temperate Grassland,
- Yellow Box – Red Gum Grassy (Box-Gum) Woodland,
- Pink-tailed Worm-lizard,
- Superb Parrot,
- Swift Parrot,
- Snow Gum Grassy Woodland,
- Hooded Robin,
- Brown Treecreeper,
- Painted Honeyeater,
- Regent Honeyeater,
- Varied Sittella, and
- White-winged Triller.

Fire defoliates vegetation, generates heat and smoke, causes changes in nutrient status, and can trigger regeneration events. It can pose significant threats to ecological values, particularly to **Superb** and **Swift Parrots**, if not managed appropriately, and can negatively affect other fauna habitats including that of **Pink-tailed Worm-lizard**. On the other hand, burns have been shown to reduce tree and shrub dieback in Tasmania (Kirkpatrick 2010).

Fire modifies the structure of habitats, and removes or provides food sources and shelter. It can damage or remove desirable perennial native vegetation cover, cryptogam cover (lichens, mosses, algae), fallen woody branches and logs, dead trees and stumps (Stagoll *et al.* 2010) and fine and coarse litter. These all enhance woodland bird habitats and soil and ecosystem function and help protect soils from erosion, and fire management should aim to protect them, or minimise the damage, especially where threatened bird populations occur.

A balance is needed. Intensity, frequency, fire history and timing are important factors in managing fire to control biomass. Vegetation communities and species and habitats have limits of tolerance in relation to the frequency and intensity of fire and the season in which the fire is applied. Each factor must be considered in prescribing a fire management regime so that it avoids unacceptable impacts to ecological values.

Ecological fire thresholds have been identified for ACT vegetation communities that are present in the Molonglo River Reserve and offsets (Table 3.4; ACT Government ESDD 2012b). They indicate maximum and minimum fire intervals and give guidance on fire frequency and intensity, based on the time after fire required for plant species to regenerate and become fire tolerant prior to the next fire (ACT Government ESDD 2012b).

These thresholds have been used as supporting information in the development of the Strategic Bushfire Management Plan for the ACT.

Vegetation alongside the river and riparian zone of the Molonglo River Reserve downstream of Kama has the potential to carry a wildfire approaching from the north-west into suburban Canberra (ABPP 2010a,b). Biomass and fuel loads may be relatively small in rocky areas and narrow river sections with little floodplain development, and these areas may inhibit the spread of wildfire within the riparian zone (ABPP 2010a,b). However, African Lovegrass has invaded gaps in the distribution of the riparian River She-oak Forest community. Regeneration work is currently in progress to re-establish the River She-oak community and once established the community itself should reduce the biomass and fuel load of the Lovegrass (R. Milner, pers.comm. 2014).

Intensity

There is a general lack of scientifically verified and tested data on using fire in relation to managing threatened plant species. Therefore, as a precautionary principle, it is recommended to undertake only patchy and low intensity burns (ACT Government ESDD 2012b) when using fire to control excess biomass.

The fire must be hot enough to trigger plant reproductive processes (such as breaking the dormancy of seed stored in soil, or melting the resin encasing seed capsules on adult plants), yet not so hot as to cause damage to overstorey species, sensitive gully communities, soil-borne seed and habitat features such as tree hollows.

Pink-tailed Worm-lizards are still very common at sites entirely burnt in very hot wildfire in 2003 — perhaps protected by their subterranean behaviour. However, hot grass fires have killed some individuals (W. Osborne pers.obs.), so fires are likely to have some impact. When the soil and litter layer are cold and moist (probably late autumn or winter), or during very dry periods when the soil beneath rocks is dry, or on hot days such as during summer, fire is less likely to affect the lizards because they will be deep in the ant nests.

Frequency

For vegetation, Table 3.4 summarises the estimated desirable fire frequencies of the MNES vegetation and other vegetation communities in all areas of the Molonglo River Reserve and offsets, including the riparian zone.

In **Kangaroo Grass**-dominated dry tussock grassland the recommended frequency of burning is 4–10 years. This estimate of the maximum interval is based on some evidence but few data (ACT Government ESDD 2012b).

Similarly, the optimal fire frequency for **Box-Gum Woodland** in the ACT has not been defined, and there are varying recommendations in the literature for 'woodlands'. For instance, Kirkpatrick (2010) recommends burning no more often than 10–20 years for woodlands. For Western Plains Woodland in Victoria the Victorian Department of Sustainability and Environment (website viewed June 2012) recommends low severity burns every 4–12 years, but leaving an interval of >30 years after a severe fire. These Guidelines recommend that monitoring and trials be established in Natural Temperate Grassland and Box-Gum Woodland patches that will be subjected to operational burns, to measure the impacts of frequency and intensity on particular species and on 'landscape function'.
The information should help guide the frequency and intensity of burns that will maintain ecological values.

Some plant species (e.g. Black Cypress Pine; Fabaceae such as *Daviesia* species) depend on fire to trigger regeneration events, and need to be burnt to prevent or minimise their loss from the ecosystem. Conversely, if fire kills adult plants, and recurs before seedlings have had time to mature and set seed (that is, it is too frequent), those species may be lost or reduced. The Fuel and Fire Suppression Guidelines for ACT Declared Threatened Species and Endangered Ecological Communities (ACT Government TAMS 2008) recognise the fire-sensitivity of the **Black Cypress Pine Woodland** community. The ACT Government Ecological Guidelines for Specified Conservation Actions (ACT Government 2011a) indicate that: 'Black Cypress Pine is fire sensitive and, as far as possible, should not be burnt'. The previous Strategic Bushfire Management Plan for the ACT (ACT Government 2009a,b)[7] also noted that fire sensitive vegetation communities (e.g. *Callitris* woodland) may be adversely impacted by prescribed burning. Respecting those fire guidelines, the Black Cypress Pine woodland community in the Molonglo River Reserve should be protected from regular prescribed fuel hazard reduction burns until it is assessed as having fully recovered from being severely burnt in 2003.

The River She-oak Forest in the riparian zone is also a fire-sensitive community that is still recovering from the 2003 wildfire. Its recovery and conservation will depend partly on future fire frequency and intensity (as well as on the control of weeds and rabbits).

River She-oak is a fire-sensitive species and the majority of mature River She-oak trees are killed in high intensity fires (ACT Government 2007). River She-oaks will resprout after lower intensity fires. River She-oak Forest suffered significant loss of mature trees in the high intensity 2003 bushfire but continues to persist, with reduced vigour, throughout its range in the ACT. In the Murrumbidgee River corridor, recovery from the 2003 fire has been largely restricted to resprouting and seedling regrowth in high soil moisture zones including riverbanks and instream emergent habitat. Most trees situated on the floodplain away from the river have died and the limited numbers of seedlings in these areas face vigorous weed competition (Johnston et al. 2009; ACT Government 2007). The community is well represented in riparian reserves in the ACT but is poorly reserved in the southern tablelands of NSW (ACT Government EA 2001). In view of the fire sensitivity of this River She-oak community and the impacts of the 2003 wildfire, fuel hazard reduction using regular prescribed burning is not recommended in the riparian zone.

River She-oak bark is 'tight' with a relatively low hazard rating, and the understorey of the River She-oak community typically contains limited biomass to carry fires (ACT Government 2007). Although fine ground fuel is generated by the shedding of spent leaves (cladodes) forming a discontinuous mulch mat beneath the canopy, it will periodically be washed away in high river flows (though possibly replaced by an alternative fuel load of flood debris).

High frequency burning may promote establishment of highly flammable shrub species and lead to an increase in density of woody vegetation: for example, Drooping Sheoak *Allocasuarina verticillata*, Black Wattle *Acacia mearnsii*, Silver Wattle *A. dealbata* and Australian Blackthorn *Bursaria spinosa*.

Frequent burning potentially will have severe impacts on **fauna habitat** and **landscape function** by repeatedly removing coarse woody litter, logs and other debris. These help capture rainfall-runoff, protect the soil surface and contribute to organic topsoil (Barton *et al.* 2009 in Sharp 2011), and are important habitat for invertebrates, amphibians, reptiles, birds and small mammals.

Little is known about the impact of frequent fires on **Pink-tailed Worm-lizards** and their habitat. Until more is known, habitat areas for the lizards should be burnt only every 7–10 years. Individual fires are unlikely to affect Pink-tailed Worm-lizards provided that they are able to escape down their burrows, and provided there is adequate time for the habitat to recover from the fire event.

7 The 2009 plan is now superseded by ACT Strategic Bushfire Management Plan 2014–19 (ACT Government 2014b).

Table 3.4. Ecological fire thresholds for vegetation communities in the Molonglo River Reserve and offsets (from ACT Government ESDD 2012b).

Community	Fire thresholds (min–max fire interval in years)	Fire threshold guidelines
Forests		
River She-oak Dry Riparian Forest (River She-oak Forest)	25–100	A decline in biodiversity is likely if: 1) 2 or more consecutive fires occur with inter-fire intervals of <25 years, and 2) no high intensity fires occur within 50–100 years.
Black Cypress Pine – Brittle Gum Tall Dry Woodland (Black Cypress Pine Woodland)	No planned burning	No planned burning until recovery post 2003 fires is fully assessed and established.
Red Stringybark – Scribbly Gum – Redanther Wallaby Grass Tall Grass-Shrub Dry Sclerophyll Forest (Red Stringybark – Scribbly Gum Forest)	10–50	A decline in biodiversity is likely if: 1) 3 or more consecutive fires occur with inter-fire intervals of <10 years, and 2) no moderate to high intensity fires occur within 50–100 years.
Woodlands		
Blakely's Red Gum – Yellow Box Grassy Tall Grassy Woodland (Yellow Box – Blakely's Red Gum Grassy Woodland or Box-Gum Woodland)	10–40 (possibly longer)	A decline in biodiversity is likely if: 1) 3 or more consecutive fires occur with inter-fire intervals of <10 years, and 2) no moderate to high intensity fires occur within 40–50 years.
Snow Gum – Candlebark Tall Grassy Woodland (Snow Gum Woodland)	12–50	A decline in biodiversity is likely if: 1) 3 or more consecutive fires occur with inter-fire intervals of <12 years, and 2) no moderate to high intensity fires occur within 50–100 years.
Apple Box – Broad-leaved Peppermint Tall Shrub-Grass Woodland (Apple Box – Broad-leaved Peppermint Shrubby Grassland	Unknown	
Shrublands		
River Bottlebrush – Burgan Rocky Riparian Shrubland (Riparian Shrubland)	10–30	A decline in biodiversity is likely if: 1) 3 or more consecutive fires occur with inter-fire intervals of <10 years, and 2) no high intensity fires occur within 30–40 years.
Grasslands		
Kangaroo Grass – Wallaby Grass – Snow-grass Moist Tussock Grassland (Kangaroo Grass Moist Tussock Grassland)	4–10	There are currently insufficient data to estimate the maximum interval but some evidence indicates it would be approximately 10 years.
Kangaroo Grass – Purple Wiregrass Dry Tussock Grassland (Rocky Natural Grassland)	4–10	
River Tussock – Kangaroo Grass – Rush Tussock Grassland (River Tussock Wet Tussock Grassland)	Unknown, probably 4–10 years	
Riparian communities		
Tableland Aquatic and Fringing Aquatic Vegetation Complex	No planned burning	

Timing

Burning will always favour some species more than others, and timing also affects the risk of further fires. Understorey structure will be affected by fire, and the effects will differ with season and between locations and vegetation communities (e.g. Baird 1977 in Tanton 1994; Christensen *et al*. 1981; VDCE 1993). Both season and frequency of controlled and ecological burns should be varied over time, to achieve the desired outcomes.

In late winter or spring, burning may disrupt flora and fauna reproductive processes.

Spring burns can reduce seed production by introduced annuals and weeds, and reduce soil nutrient levels, but it can also disrupt flowering and seeding of native species (Prober *et al.* 2005). Spring burns should not be undertaken so regularly that native vegetation species are unable to regenerate. There is also a risk that material burnt in late spring will smoulder and re-ignite during summer.

Spring fire is most likely to harm **Pink-tailed Worm-lizards**, when they tend to be near the underside of rocks but are not warm enough to be able to move rapidly back into their burrows. However, there is little information available about the effects of fire season, and how fires in lizard habitat may be affected by seasonal litter loads, ground moisture content, air temperature, etc. Impacts of fire on Pink-tailed Worm-lizard will be evaluated by monitoring the impacts of controlled fire in threatened habitat in Molonglo River Reserve.

Burning in summer carries greater risk of excessive intensity, and intrusion into fire-sensitive gully and riparian communities.

Fauna are likely to be directly affected by burning during key breeding and dispersal periods. It is important that prescribed burning avoids the breeding season when brooding birds, nestlings and fledglings would be particularly susceptible to direct mortality from fire. Table 3.5 summarises information (see s.2.4, s.2.5) on threatened and significant birds in the Molonglo River Reserve and offsets that build nests near the ground, showing that spring–summer is a critical time for breeding.

Fire at any time will affect fauna habitat. For the first few months after fire, there may be less shelter and cover (foliage, logs) and food (fruits, seeds, nectar, invertebrates). These impacts can be significant, especially reducing the abundance and species richness of small bird populations (Turner 1987). Limiting the ground area and grouping of areas covered by each burn could minimise direct fauna impacts and post-burn grazing pressure on vegetation.

On the other hand, fire benefits bird species that are independent of dense shrubbery or groundcover, such as relatively large insectivores or scavengers. Immediately after a fire the reduced vegetation cover makes it easier for these species to see prey (Taylor 1985). Eventually (several years post-fire) regrowth vegetation can support a greater number and more species of birds (Turner 1992).

Table 3.5. Summary of threatened and significant bird breeding times and placements near or on the ground.

Bird species	Breeding season	Likely nest location	Areas found; see Table 2.12	Threat
Superb Parrot	October–December	Hollows; Gum trees	Spring Valley Farm (breeding); near Kama (breeding)	
Brown Treecreeper	August–summer	3–10 m off the ground	Kama	
Painted Honeyeater	November–February	3–20 m off the ground	River valley	
Varied Sittella	Spring–summer	In a vertical fork	Kama	
White-winged Triller	Mid-spring–end of summer	Horizontal branch or fork or old Magpie-lark nest	River valley (breeding) Kama	
Flame Robin	August–January	1–20 m above ground	Kama	
Hooded Robin	August–January	1–6 m above ground	–	Human disturbance
Scarlet Robin	July–January	1–3 m above ground	Kama	
Speckled Warbler	August–January	On the ground	River valley; Kama (rarely)	Trampling by grazing cattle
Double-barred Finch	July–December	Tall grass; dense shrubs	River valley	
Dusky Woodswallow	August–January	Low fork or stump	River valley; Kama (breeding in both)	
Southern Whiteface	June–December	Hollow, stump or low shrub	Kama	
Rainbow Bee-eater	October–December	Flat or sloping sandy banks	Coppins Crossing, near 'Sludge Pits', Barrer Hill	Trampling by grazing cattle. Fox predators.

3.5 Managing pest ANIMALS

Impacts of pest animals on ecological values

Pest animals in the Molonglo River Reserve and offsets include introduced herbivores such as European Rabbit, hares, deer and goats, and introduced predators such as the Red Fox, feral dogs, feral pigs and feral cats (Environment ACT 1998, 2001a in ACT Government 2007), and some native predatory birds that benefit from the urban environment. Fallow Deer *Dama dama* are widely distributed throughout the lower elevation riparian areas (D. Fletcher, pers.comm. in ACT Government 2007).

Some of these pest species threaten native vegetation and its value as habitat for fauna by grazing, uprooting, undermining or occupying it. Several other pest animals species prey on native fauna, or interfere with their ecology by scaring them off or out-competing them for food resources and nesting habitat.

Table 3.6 summarises threats posed by pest animals in the Guidelines area.

3.5.2 Aims of pest animals control and management

The objective of managing pest animals in the Guidelines area is to control their impacts on MNES and other ecological values. The target is to control pest animals populations, keeping them at very low levels compared to overall activity and abundance documented in baseline assessment, and to prevent new incursions.

As fauna habitat and connectivity progressively improve in the Molonglo River Reserve and offsets, populations of native birds, reptile and mammals can be expected to increase. Reduced rabbit numbers may result in increased pressure on native wildlife from native and introduced predators. There are potentially complicated predator–prey and predator–competitor relationships involving cats, foxes, rabbits and native fauna. Pest animals will need to be monitored in conjunction with habitat improvement (see Table 4.9 for survey techniques), and the data collected will help in prioritising management in relation to population fluctuations.

Table 3.6. Outline summary of threats posed to ecological values by pest animals.

Pest species	Victim	Threats and impacts
Rabbits and hares	Native vegetation	Graze groundstorey vegetation, and trees and shrubs, killing them. A particular threat to River She-oak and Black Cypress Pine seedlings.
	Native fauna	Feeding and digging helps destroy ground habitats for fauna Not the best food for raptors, especially when killed by poison.
	Soil	Expose soil surface and dig: erosion, loss of soil, loss of ground habitats for native flora and fauna.
	Overall or other	Prime cause of degradation. They kill perennial native trees and shrubs which are valuable fauna habitat (Williams 2011), making possible invasion by weedy annuals and other weeds.
Pig	Native vegetation	Rooting damages native vegetation and its value as habitat.
	Native fauna	Destroy nests and eat eggs and chicks of ground-dwelling birds such as Speckled Warbler and Rainbow Bee-eater.
	Soil	Rooting causes erosion and soil loss and disturbs ground habitats for native flora and fauna.
Fox	Native fauna	• Possible predator of Pink-tailed Worm-lizards that come to the surface. Several have been found lying dead on rocks after predation (Barrer 1992), and 20–62% of live individuals seen have lost tails, apparently to predators. • Natural predator and significant risk to birds, especially those that feed or nest on the ground or in low vegetation, including: Brown Treecreeper, Scarlet Robin, Hooded Robin, Diamond Firetail, Double-barred Finch and Speckled Warbler, and Rainbow Bee-eater. • Foxes are known to dig out Rainbow Bee-eater nests and eat the entire brood, accounting for up to 80% of nest losses due to predation (Higgins 1999).
	Soil	Digging can cause erosion, loss of soil, loss of ground habitats for native flora and fauna.
	Overall or other	Typically occurs in high densities within woodland–urban interfaces (Dickman 1987).
Cat	Native fauna	• Possible predator of Pink-tailed Worm-lizards that come to the surface. Several lizards have been found lying dead on rocks after predation (Barrer 1992), and 20–62% of live individual lizards have been seen to have lost tails, apparently to predators. • Significant natural predator of native birds (Dickman 1996; Barratt 1997; Saunders et al. 2010). • Cats nearby cause birds to stop feeding and attending to breeding and instead react, show vigilance and take flight (Holderness-Roddam 2011). • Prey on mammals, frogs, and lizards.
	Overall or other	House cats are likely to enter all areas of Molonglo River Reserve and offsets, once urban development proceeds. Containment may reduce predation.
Dog	Native fauna	• A significant threat to native wildlife, which they injure or kill (Holderness-Roddam 2011). • Natural predators of birds. With their acute sense of smell, dogs are particularly effective at finding ground-dwelling birds and nests (Van't Woudt 1990). • Dogs, even on-leash, near nests and feeding areas cause birds to adopt anti-predator behaviour, including vigilance and early flight, which reduces feeding time and attention to breeding activities, and uses up energy, even if the dog does not attack (Holderness-Roddam 2011). Bird abundance and species richness in bushland can fall by ~40% (Banks and Bryant 2007). Ground-dwelling birds are particularly affected (e.g. such as Brown Treecreeper, Speckled Warbler, Scarlet Robin, Hooded Robin, Diamond Firetail, Restless Flycatcher, White-winged Triller and Rainbow Bee-eater). They do not seem to become habituated to disturbance. Raptors are also scared off by dogs in their vicinity.
Euopean Honeybee	Native fauna	Occupy tree hollows (an important habitat resource) preventing their use by Superb Parrots, many threatened and other birds, and other wildlife.
	Overall or other	Competition from feral Honeybees is listed as a Key Threatening Process by the NSW Government.

Pest species	Victim	Threats and impacts
Indian or Common Myna	Native fauna	Widely believed to aggressively displace hollow-nesting native birds and outcompete them for food (Grarock *et al*. 2012) especially in urban parks and suburban gardens (Davis *et al*. 2013), but little evidence.
	Overall or other	Listed in the top 100 of the world's worst invaders (Lowe *et al*. 2000).
Noisy Miner	Native fauna	Aggressively drives other bird species, particularly insectivores and nectarivores, from its territory. Has a negative impact on populations of small woodland birds (Maron *et al*. 2013).
	Overall or other	Listed as a Key Threatening Process (Australian Government Department of the Environment, Water, Heritage and the Arts n.d.).
Currawong	Native fauna	Considerable impact on cup-nesting native bird species such as robins (Debus 2006). In urban areas, Currawongs may be more of a threat to common introduced bird species than small native birds, though blamed for the latters' decline (Major *et al*. 1996; Bayly and Blumstein 2001).
	Overall or other	Woodland sites near established suburbs have a higher occupancy by Pied Currawongs than more distant sites (Taws *et al*. 2012). As the new suburbs develop, woodland birds in sites previously distant from suburbs may face increased predation pressure from an increased Currawong population.
Starling	Native fauna	Compete with native fauna for resources.
	Overall or other	May become more common as residential development spreads and establishes.
European Wasp	Native fauna	Competes with native fauna for resources.
	Overall or other	May become more common as residential development spreads and establishes.
Fallow Deer; Goats	Native vegetation	Possible grazing threat to seedlings of River She-oak and Black Cypress Pine. Threaten flora habitat through browsing and grazing damage to vegetation.
	Native fauna	Threaten fauna habitat through browsing and grazing damage to vegetation. May compete with native fauna for resources.
	Overall or other	Deer are widely distributed throughout the lower elevation riparian areas (D. Fletcher, pers.comm. in ACT Government 2007).

ACT Vertebrate Pest Management Operations Plans emphasise the importance of coordinated management via an inter-agency Pest Animal Management Group (complementing similar arrangements for weed control). Based on monitoring results, and in line with the ACT Pest Management Strategy 2012–2022 (ACT Government ESDD 2012a), pest animal management programs in the Reserve and offsets should strategically target actual (rather than perceived) pest problems. The potential need to control iconic native species such as kangaroos has a social dimension which adds complexity to the pest management task.

3.5.3 Pest management legislation and codes

The ACT Pest Animal Management Strategy (ACT Government ESDD 2012a) provides a series of principles (summarised here) for managing pest animals across the ACT:

- individuals and groups have significant interest in the pest animals, and it is important to understand their attitudes and concerns;
- the most cost-effective management is based on prevention and early intervention;
- management programs need to strategically target actual (rather than perceived) pest problems;
- management programs need to be accurately monitored and evaluated;
- government agencies, industry, land and water managers and the community need to be coordinated in their responses;
- pest animal damage should be managed using a risk-based, whole-of-system approach.

Management practices available to control vertebrate pests in the ACT are summarised in the ACT Vertebrate Pest Management Strategy (ACT Government EA 2002). Pest animal management in Molonglo River Reserve and offsets must also be consistent with the ACT Pest Plants and Animals Act 2005, and the ACT Kangaroo Management Plan (ACT Government TAMS 2010). Control methods must comply with relevant animal welfare legislation (the Animal Welfare Act 1992), and codes of practice, including the National Code of Practice for the Humane Control of Invasive Animals, and Codes of Practice for individual pest species.

National Model Codes of Practice for Humane Control have been developed for foxes, cats and rabbits and goats (Sharp and Saunders 2004a,b,c,d). The Model Codes review control methods in terms of acceptability with regard to humaneness, efficacy, cost-effectiveness and target specificity.

3.5.4 Rabbits

Rabbits damage bird habitat in woodland and grassland by undermining the survival of native trees and shrubs and facilitating the spread of annual weeds (Williams 2011). Rabbit control should benefit native bird species. On the other hand, a reduction in rabbit numbers may result in increased pressures on native wildlife from native and introduced predators, because rabbits are a major prey item for foxes and feral cats.

Rabbits are also prey for the Little Eagle and to a lesser extent the Wedge-tailed Eagle (Olsen *et al.* 2010). These raptors also eat other mammals and birds. In fact, rabbit is reportedly nutritionally inferior to other foods for raptors, such as birds, macropods and hares (Olsen *et al.* 2013) so reducing rabbit numbers may not necessarily reduce food availability for the Little Eagle.

In the riparian zone, River She-oak and Black Cypress Pine seedlings are susceptible to rabbit predation which may be inhibiting regeneration of these vegetation communities. However, the moist and fertile conditions in River She-oak Forest habitat are likely to be attractive to all herbivores, particularly where there is native Weeping Grass *Microlaena stipoides* groundcover.

Exclusion plots can be established, maintained and monitored to determine the impact of rabbits and other herbivores on local vegetation (Williams 2011).

Control methods

For rabbit control, planning is important, as is continued funding.

Primary control by warren-ripping and fumigation can be followed by regular maintenance control by fumigation (Williams 2011). Although poisoning is a primary control method used elsewhere, the poison 'Pindone' is not recommended for the Guidelines area.

- Pindone poison used to control rabbits in peri-urban areas of the ACT is known to be particularly toxic to eagle species if ingested (Martin *et al.* 1994). Given the dramatic decline in the Little Eagle population in the ACT (Olsen and Fuentes 2005) and its declaration as a Vulnerable species, the use of Pindone to control rabbits is of particular concern (Olsen and Osgood 2006).
- Pindone is not to be used within the Reserve or offset areas without prior consultation with the ACT Government section for Conservation Planning and Research, because of the high diversity and abundance of raptor species within the vicinity of the Molonglo River (including a breeding pair of Little Eagles).
- The possible role of Pindone in the decline of the Little Eagle needs to be investigated further (Olsen *et al.* 2012).

For fumigation,

- Phostoxin tablets were found to be more effective than 'Rid-a-rabbit' in South Australian rangelands (Moseby *et al.* 2005), and are conditionally acceptable in the Molonglo River Reserve and offsets.
- It is unacceptable to use pressure fumigation of warrens with chloropicrin.

After successful treatment, sustained follow-up control is essential, because rabbits rapidly recolonise treated areas.

As another control method, Williams (2011) recommends considering pest animal exclosures to promote the recovery or restoration of suppressed plant and animal species, drawing on the Mulligans Flat–Goorooyarroo Woodlands Experiment research.

3.5.5 Foxes and cats

Foxes are likely to benefit from the Molonglo development because typically they occur in high densities within woodland–urban interfaces (Dickman 1987). House cats based within the urban development are also likely to explore all habitat types in the Molonglo River Reserve and offsets.

Both foxes and feral cats prey on native birds, lizards, frogs and small mammals (see Table 3.6; Saunders *et al.* 2010; Dickman 1996). Roaming house cats are predators where new residential suburbs abut relatively natural areas, and their presence severely disturbs feeding and breeding activity by small birds (Barratt 1997; Holderness-Roddam 2011). Foxes are known to dig out Rainbow Bee-eater nests and eat the entire brood, accounting for up to 80% of nest losses due to predation (Higgins 1999).

Control of foxes and feral cats is likely to have most benefit for the ground-frequenting species or those that feed or nest in low vegetation (see Table 3.5). These bird species include:

- Brown Treecreeper,
- Scarlet Robin,
- Hooded Robin,
- Diamond Firetail,
- Double-barred Finch,
- Speckled Warbler, and
- Rainbow Bee-eater.

Fox and cat predation on **Pink-tailed Worm-lizard** is unmeasured. The lizards are most vulnerable to predation when they are dispersing over the ground surface between rocks and rock outcrops. However, the lizard's cryptic and burrow-living behaviour should render impacts of predators minimal. A study of the diet of foxes and cats using a scat analysis would be valuable for determining predation impacts on the species .

Control methods

For foxes and feral cats, some older control methods are no longer available. The Model Code for foxes declares strychnine baiting and steel-jawed traps inhumane and unacceptable. The Model Code of Practice for the Humane Control of Feral Cats (Sharp and Saunders 2004b) also declares steel-jawed traps unacceptable for cat control.

For fox control, standard operating procedures are currently available for the following methods:

- ground baiting of foxes with 1080,
- aerial baiting of foxes with 1080,
- ground shooting of foxes,
- fumigation of fox dens with carbon monoxide,
- trapping of foxes using padded-jaw traps,
- trapping of foxes using cage traps.

Poisoning of foxes in the urban section and perhaps other offsets will be limited by very high use of the area for walking dogs, or working dogs, which might accidentally eat the baits. As the urban population increases in Molonglo the number of domestic animals will increase.

House-cat containment controls will be declared for all suburbs in the Molonglo Valley. Residents within these areas must keep their cats confined to their premises 24 hours a day. Compliance with these requirements will reduce the impact of domestic and stray cats on native birds. However, compliance will need to be adequately enforced, and there will be some individuals that escape from containment.

3.5.6 Dogs

Dogs, with their acute sense of smell, are natural predators of birds (Van't Woudt 1990). In some situations dogs have been found to be responsible for the injury or death of more native wildlife than cats (Holderness-Roddam 2011).

Dogs near nests and feeding areas, even on a leash during walks, severely disturb feeding and breeding activity by small birds (Holderness-Roddam 2011). The presence of dogs will also scare off raptors which can perceive a dog from a long way off. However, dog-walking is a popular recreation and important for the welfare of dogs and owners in urban environments. Walks will tend to include recreational areas, parks and natural areas as well as suburban streets (see http://www.canberradogwalks.com.au/).

Control methods

Owners' control of their domestic dogs needs to be enforced, to prevent stray dogs causing disturbance and injury or death to native birds.

Dog-walking, off-leash and on-leash, should be excluded from areas important for bird breeding and bird conservation. This includes the riparian corridor from the confluence of Deep Creek upstream for 1200 m. In this area the Rainbow Bee-eater, White-winged Triller, Diamond Firetail, Double-barred Finch and Southern Whiteface have been recorded breeding (Taws 2014). Near waterbird breeding areas in trees overhanging the river in the urban section, dogs should only be walked on-leash. (Table 3.5 summarises woodland bird species known to build nests near the ground; birds are discussed at length in s.2.5.)

3.5.7 Pigs

Pigs destroy nests and eat eggs and chicks of ground-dwelling birds such as Speckled Warbler and Rainbow Bee-eater. Pigs' presence and numbers can be estimated by methods in Table 4.9.

Control methods

Methods in use for controlling feral pigs include baiting, trapping, and shooting.

3.5.8 Feral Honeybees

Feral Honeybees (*Apis mellifera*) take over tree hollows and exclude other wildlife. Tree hollows can be a critical resource for threatened species such as the Superb Parrot and others. If Honeybees are observed to be inhabiting a hollow the colony needs to be removed. Competition from feral Honeybees has been listed as a Key Threatening Process by the NSW Government.

Control methods

Feral Honeybees need to be removed as a colony, when detected in a hollow.

3.5.9 Common Myna

The Common or Indian Myna is a problem species in urban parks and suburban gardens rather than adjacent nature reserves (Davis *et al.* 2013). Despite little evidence (Grarock *et al*. 2012) the myna is believed to take over nesting hollows, evicting birds and small mammals, and preying on nestlings (CIMAG n.d.).

This species tends to invade areas where trees are sparse, and as tree density in urban areas or nature reserves increases the abundance of Common Mynas decreases (Grarock *et al.* 2014). However, the new suburbs in the Molonglo Valley development have relatively small block sizes and are likely to have relatively few trees, making them more suitable for Common Mynas. Nearby areas of the Molonglo River Reserve, such as the partly-cleared woodlands, also have sparse trees and may therefore also be invaded by Common Mynas as the suburbs expand.

Control methods

Revegetation to increase tree density and provide mid-storey structure is recommended as the best way of reducing the impact of the Common Myna (Grarock *et al*. 2014).

Trapping and humane killing is organised by community groups within the ACT (http://www.indianmynaaction.org.au/).

3.5.10 Noisy Miner

The Noisy Miner is a native communally-dwelling honeyeater, common in Box-Gum Woodland in the ACT (Bounds *et al.* 2010). It is highly territorial and will aggressively drive other bird species, particularly insectivores and nectarivores including **Swift Parrots**, from its territory. The negative impact of the Noisy Miner on populations of small woodland birds has been well-documented (Maron *et al.* 2013), and it is now listed as a Key Threatening Process (Australian Government Department of the Environment and Energy n.d.).

The Noisy Miner has undergone a significant increase in occupancy over the last ten years in woodland sites monitored by COG (Bounds *et al.* 2010). The best habitat predictor in these sites for an increase in Noisy Miner occupancy was a decrease in the cover of mid-storey shrubs (Taws *et al*. 2012). The species has also increased dramatically in abundance since 2004 in urban sites monitored in the Garden Bird Survey (COG 2014).

Control methods

Revegetation with mid-storey shrubs is recommended as a means of reducing Noisy Miner occupancy (Montague-Drake *et al*. 2011). In the Molonglo River Reserve and offsets *Acacia dealbata* is common and particularly suitable for this purpose (Hastings and Beattie 2006; Howes and Maron 2009; Lindenmayer *et al*. 2010).

In some areas, fire management requirements or other constraints may prevent the restoration of a mid-storey. For example, other species may need an open mid-storey, or the high density of shrubs needed to deter Noisy Miners may not be possible.

Removal of Noisy Miners by culling or trapping has been shown to have immediate and long-lasting benefits to small woodland birds (Grey *et al.* 1997, 1998; Debus 2008), including a number of threatened species (Scientific Advisory Committee – Flora and Fauna Guarantee 2001). This method is calculated as being many times more cost-effective than revegetation (Clarke and Grey 2010).

The positive effects of removing Noisy Miners are likely to be most enduring when accompanied by revegetation to deter this species from recolonising.

3.5.11 Pied Currawong

The Pied Currawong is a large native omnivorous bird found in a wide range of habitats in the ACT. Until the 1960s it mainly bred in montane forests in spring–summer and moved to lowland woodlands for autumn and winter (Wilson 1999). Since the 1960s, with the rapid growth of urban Canberra, the Pied Currawong has become a year-round resident within the suburbs and is now the fourth most commonly reported bird in the annual Garden Bird Survey (COG 2014). The increase in the Pied Currawong population in Canberra and other parts of eastern Australia has been attributed partly to the greater availability of food year-round in urban environments (Bass 1989).

Pied Currawongs feed in introduced berry-producing bushes such as *Pyracantha* spp., Privet *Ligustrum* spp. and Hawthorn *Cratageus* spp. During the breeding season their diet changes to include more insects and avian prey for their nestlings (Wood 1998).

Away from urban areas Pied Currawong predation has been found to have considerable impacts on cup-nesting species such as robins (Debus 2006). In urban areas, predation by Pied Currawongs has been implicated in the decline of small native birds (Major *et al*. 1996), though there has been more impact on common introduced species than on common and rare native species (Bayly and Blumstein 2001).

In the new suburbs of the Molonglo Valley the habitat may not be as ideal for the Pied Currawong as in older Canberra suburbs. There will probably be relatively few large trees on the relatively small blocks, and there should be relatively few introduced berry-producing shrubs because of greater community awareness of their environmental impact and the fact that many of these shrubs are now Declared Pest Plants (ACT Government DECCEW 2009). Nevertheless, the Pied Currawong could be expected to increase in the new residential areas as trees are planted and gardens develop in areas that have been largely treeless.

Woodland areas near the older suburbs of Canberra have larger populations of Pied Currawongs than more distant sites (Taws *et al.* 2012). Similarly, as the new suburbs develop, birds in nearby woodland areas may face increased predation pressure from an increased Currawong population.

Control methods

In the long term, for managing Currawong numbers and predation it will be most effective to:

- improve the habitat for small birds, so as to provide optimum nesting and foraging habitat; and
- decrease habitat suitability for the Currawong.

This will involve:

- increasing the mid-storey structure in woodlands;
- increasing the extent of native groundcover;
- retaining or increasing woody debris; and
- reducing the prevalence of introduced berry-producing shrubs.

However, interactions between predation of small birds and habitat or resource availability, for both the prey and the predator species, make it difficult to separate the effects of predation from other causes of declines in small native birds such as habitat change.

3.5.12 Pest animals in relation to the MNES

Swift Parrots come into competition with aggressive large honeyeaters, including Noisy Miners, which drive other birds away from sources of nectar they find (Taws and Saunders 2005).

Superb Parrots must compete with other fauna for use of nesting hollows. Feral Honeybees and the Common Starling (Taws 2001) may be among competitors.

As noted above, foxes and cats, and possibly dogs, may take **Pink-tailed Worm-lizards** if they are on the ground surface. Some dead lizards have been found, and several have been noted to have lost tails. However, the scale of possible predation is not known.

Box-Gum Woodland and **Natural Temperate Grassland** can be affected by uncontrolled grazing by pest herbivores such as goat, deer and rabbit. Rabbits can also undermine mid- and upperstorey vegetation in woodland with their burrows, and cause soil erosion in exposed sites.

3.6 Management of human impacts and benefits

Ecological management is likely to have positive effects on the people of the Molonglo Valley through improving species richness of birds and plants and perhaps fish and therefore adding value for recreational bird-watching and fishing. The aesthetics of woodland and grassland are also likely to benefit from ecological management. On the other hand, people may view controls imposed for ecological reasons as having a negative impact on their lives: for example, via restrictions on access to some areas; burning practices; and requirements for domestic animal control.

Management will inevitably need to find a balance between protecting ecological values and encouraging human interaction with the natural environment. As outlined below, people may unknowingly disturb fauna and interfere with feeding or breeding habitats. On the other hand, people can contribute greatly to weeds management, species monitoring and restoration work, and boost ecological management as a whole by respecting and 'taking ownership' of the area's ecological values.

3.6.1 Management possibilities

To help build support from the suburban population of Molonglo, management could adopt the objective of involving the local community in the management and care of as much as possible of the ecology of the area, via Parkcare, Landcare, Waterwatch and Frogwatch opportunities and bird surveys. As the Reserve Management Plan (ACT Government MP 2014) points out, all the values being managed in the Molonglo River Reserve are ultimately human values.

Development planning and the protection of ecological values in the Reserve and the offsets must be closely coordinated. Management activities applied with the intention of protecting ecological values in these areas need to be selected to suit the values, threats and locations.

There are a number of ways in which positive management can stimulate human interactions with the environment of the Guidelines area.

(i) Educate the people of Molonglo Valley:

- use community education and rural communication initiatives to ensure the general public who use these areas understand the ecological values and their importance;
- involve the community in the management, stewardship and monitoring of the grassland and woodland areas, by establishing and resourcing Parkcare groups;
- establish educational programs for school children and adults;
- educate the community so they help limit recreational impact and do not create informal tracks, off-track mountain bike courses, or bike jumps;
- educate people using areas close to threatened habitat about the negative effects of noise on threatened fauna;
- educate businesses and people about the risks of spreading weeds such as African Lovegrass on clothing and animal fur, on vehicles, and in surface runoff from weed-infested areas;
- educate businesses and residents about environmental weeds and other plant species that threaten ecological values.

The three listed 'sleeper weed' species below (only recently identified as invasive) are among plants that should not be used in Molonglo suburban development.

— Chinese Pistachio, which is invasive into natural areas; documented throughout Canberra Nature Park. It should not be planted within the Molonglo development.

— *Miscanthus sinensis* (all varieties) Chinese Fairy Grass; this species has been recommended for listing as Prohibited in the ACT.

— *Leptospermum laevigatum* (Coastal Tea-tree); this species is not to be planted within the Molonglo development. It spreads to even the hardest poorest sites, and naturalises.

(ii) Protect the ecological values from inadvertent impacts by the community:

- ensure visitation and recreational uses do not compromise conservation values, especially when suburbs are developed close by the areas of threatened habitat and the NES patches;
- ensure high impact recreational activities occur outside the Reserve;
- protect sensitive habitat within the Reserve from low-impact recreation such as walking and dog-walking;
- enforce responsible pet ownership, including cat containment, to minimise predation.

(iii) Prevent damage by people, inadvertent or deliberate:

- ensure there are no illegal or damaging human activities such as rubbish dumping, firewood or rock collection, arson and vehicle access in any parts of the threatened habitat and riparian zone, and if possible also not in the dryland matrix or offsets;
- use fencing, signage, use-restrictions and environmentally sensitive design of facilities and tracks to help protect ecological values. Adequate fencing will control many of the threats to the MNES and other vegetation communities (ACT Government EA 2001).
- position, design and maintain tracks so they do not result in loss of native diversity, erosion, and increased weed invasion;
- maintain buffer zones around **Pink-tailed Worm-lizard** habitat and other threatened habitat and NES patches wherever possible. Buffer zones distance a patch from the noise and human activity typical of urban areas; they help in fire management, reduce the influx of weeds and pest animals, and provide off-Reserve areas for activities that may compromise ecological values.

3.6.2 Potential human impacts on MNES and birds

People who are too near to birds at sensitive places and times, such as during the breeding season, may disturb them. **Superb Parrot**, raptors or the Rainbow Bee-eater are among bird species that can be affected. People may put up large glass constructions or tall mesh fences without realising they could be a hazard to **Swift Parrot**. People may damage habitats and vegetation diversity and structure, deliberately or unknowingly, for **Pink-tailed Worm-lizard** and in **Box-Gum Woodland** and **Natural Temperate Grassland**.

Superb and Swift Parrots

To achieve the objective of maintaining or improving the distribution and abundance of the Superb Parrot in the Guidelines area, people should not go near their nesting habitat. Currently the birds nest near Kama and in the Spring Valley Farm offset area. If disturbed during the breeding season, the parrots are likely to abandon these areas.

It is possible that suitable education will persuade people of the risks and deter them from visiting these areas at sensitive times.

Although the Swift Parrot is a rare visitor, threats could arise if these parrots were to adopt particular flowering eucalypts or trees bearing mistletoe in the Guidelines area, and if those trees were to be felled. Controls on felling of trees need to be consistent, to avoid any such feeding habitat being removed.

Swift Parrots will also be at risk if structures such as chain link fences or large glass surfaces are in close proximity to trees typically used by the parrots for feeding. Swift Parrots are known to have dashed themselves to death by colliding with such structures.

Birds in general

Disturbance by humans is well-known to have an impact on bird activities, including breeding success and foraging activities (Beale and Monaghan 2004). Even low-disturbance activities such as recreational walking can have an impact (Banks and Bryant 2007). When birds detect humans within a certain distance they usually increase the time they spend in vigilance rather than feeding, or they flee the area (Fernandez-Juricic 2001). The level of disturbance is proportional to both the number of people and their nearness (Beale and Monaghan 2004).

Larger bird species can be disturbed by humans relatively far away, possibly because they can see relatively farther than smaller birds. Ground-dwelling species are also less tolerant of human disturbance but this may be improved by increasing habitat structure near walking areas, such as shrub cover into which birds can seek shelter when disturbed (Fernandez-Juricic 2001).

Sites which are of particular sensitivity to disturbance by humans include nesting sites of all bird species, sites frequented by large birds (specifically the raptors), and feeding areas favoured by ground-foraging species. Human activities for management purposes should be planned and timed to avoid causing disturbance at sensitive sites.

Several parts of the valley near the river itself are of particular significance to woodland birds, the Rainbow Bee-eater and raptors and nesting waterbirds. The righthand side of the river, from the old sewage ponds upstream for 1 km, is particularly rich in woodland bird species and provides the main nesting site for the Rainbow Bee-eater.

Pink-tailed Worm-lizard

It can be difficult to protect lizard habitat that is subject to high levels of human recreational use (for example sites near popular picnic areas, fishing locations and along popular walking trails). The damage from activities that impact on the habitat of the Pink-tailed Worm-lizard is likely to accumulate over time unless there is an effective response by staff responsible for management.

Generally, disturbance related to recreational activities is quite localised and can include, for example, the illicit turning over, or removal, of stones (for example rolling stones down a hillside, constructing stone cubby houses, looking for lizards), and the direct trampling of vegetation (such as occurs with excess trampling and off-trail cycling). Trampling can be particularly pronounced near lookouts, picnic areas and other vantage points. Preventing such disturbance requires careful planning with respect to access points, car parks, foot paths and bicycle paths (including the need to control unplanned trails). It will also require ongoing input from field management staff and a program of community education.

- Direct trampling of habitat by pedestrians is likely to be quite minor because in most situations people will prefer not to walk through the rocky areas. These impacts are likely to be further reduced if walking paths are sensibly located away from the habitat areas. Frequently-used walking trails near habitat areas can be separated from them by a low guiding fencing (for example a low stone wall or pole barrier).
- Horse riding and mountain bike riding (off tracks) should not be allowed in habitat areas or in the 20 m buffer zones.
- Dog-walking is unlikely to impact on the habitat of Pink-tailed Worm-lizard or on individuals because of their cryptic behaviour, but dogs should always be on-leash to control their hunting instincts.

A considerable area of planned urban edge (mostly near the Molonglo River in East and Central Molonglo) will be located upslope of extensive areas of Pink-tailed Worm-lizard habitat. The presence of wide asset protection zones and 20 m buffer zones around high- and moderate-quality habitat should protect lizard habitat downslope, though some indirect impacts from urban runoff and human activities (e.g. dumping rubbish, removing rocks, etc.) can be expected .

Education and vigilance will also be needed into the future to protect the urban–threatened habitat boundaries.

3.6.3 Potential interference with other ecological values

Structures

Construction and related activities can disturb the stability and shape of the river and riparian zone (riverbanks); this might happen during construction of roads, bridges, safe areas for people and recreational areas on the riverbank. However, Construction Environmental Management Plans (CEMPs) are required to avoid direct or indirect impacts from construction within the development area and the river corridor.

The NES Plan requires infrastructure in the urban section to be designed to minimise impacts to Box-Gum Woodland. Under the NES Plan, a Concept Plan is required for the urban section which indicates management zones, public access routes and areas to be managed for recreation development and conservation.

As above, structures that may risk the lives of Swift Parrots, should they happen to visit the suburban areas, should not be erected. Equally, nectar-rich trees likely to be visited by Swift Parrots should not be planted near types of structures known to be of risk to these parrots (see s.2.4.3).

Damage to habitats including soil and vegetation

Removal of dead or living material or stones or bush-rock from woodland or grassland, especially in threatened habitat areas, is a threat or key threatening process to the ecological values of these communities under the EPBC Act (Table 2.13). They are threats regardless of the reason for them — which might be recreation, management work, art or study (ACT Government TAMS 2010; Sharp 2011).

Fertilisers should never be used in any of the native vegetation and fauna habitats in the Guidelines area. Care is needed with toxins such as herbicides and pesticides, and with moving soil or garden waste or other materials near native vegetation and habitats, including the river and riparian zone.

Loss of soil should be avoided where possible. Tracks, especially informal tracks, are particularly likely to become eroded unless managed or armoured in some way.

3.6.4 Potential impacts of bushfire hazard management

The need to reduce the bushfire risk to the ACT may be in conflict with ecological management in some Asset Protection Zones (APZs) in the Guidelines area. Where fire management conflicts with the maintainance and enhancement of ecological condition within Kama - no fire management, except for ecological purposes, will be permitted and a buffer will be established to the east of the reserve to ensure that fire management that may be damaging to environmental values is undertaken outside the reserve (ACTPLA 2011). Elsewhere in the Guidelines area, bushfire risk reduction requirements prevail unless suitable alternatives can be achieved (ACT Government 2014c) or the ACT Government's commitments to maintain and enhance the ecological condition of NES patches is not reached (ACTPLA 2011) Non-compliance with a MNES conservation outcome or action may require corrective action at the discretion of the Commonwealth Government. For example, in the case of non-compliance with a conservation outcome, the ACT Government must submit a remedial plan for addressing non-compliance for approval by the commonwealth Government (ACTPLA 2011).

APZs are being 'established along the urban interface of Molonglo River Reserve (urban section), to reduce the potential direct impact of a fire in these areas by minimising potential fuel availability' (Hassall 2012). In these zones, the amount of vegetation (the fuel load) is managed so as to reduce the impact of a bushfire on adjacent assets, which are usually buildings or other constructions (NSW RFS n.d.; Building Code n.d.).

Standards for APZs, including widths of these zones, are given in the ACT Bushfire Management Standards, and locations and sizes of APZs are subject to approval by the ACT Emergency Services Agency (ACT Government 2014b).

Suppressing and reducing impacts of bushfires

Threatened flora and fauna species, threatened and fire-sensitive communities and cultural heritage sites are all present in the Reserve, in close proximity to existing or proposed urban development. The protection of these values must be taken into account in the development of bushfire hazard reduction strategies in the Reserve and offsets. As noted above (s.3.4.5), guidelines exist for fuel and fire management operations in areas containing threatened communities and species (ACT Government ESDD 2012b).

In areas where the OAPZ occurs within areas supporting the MNES (that is, parts of the Molonglo River Reserve and Box-Gum Woodland in Spring Valley Farm) fire fuel management may require trees and shrubs to be removed. Whether this significantly compromises ecological values will need to be monitored and changes to management applied if the NES Plan requirements are to be met.

In the riparian zone River She-oak Forest community, it may be necessary to widen naturally occurring gaps in the canopy (for example, in Strategic Fire-fighting Advantage Zones) to prevent flame contact, reduce radiant heat and minimise the potential for wind-driven embers to spread the fire between patches of the trees. Patch discontinuities could be supported by access arrangements, water supplies and other resources to assist the containment of the fire at these points. Gaps between patches should exceed the length of the flame zone, but downwind patches should remain within the ember zone in severe fire weather. The flame zone in bushfires typically ranges up to 20 m (NSW RFS 2006), although the distance increases with slope. Extensive ember attack can occur beyond 100 m ahead of a bushfire (NSW RFS 2006) so patches of vegetation separated by narrower gaps will be at risk from radiant heat and embers.

The previous Strategic Bushfire Management Plan for the ACT (ACT Government 2009a,b) identified a series of core principles which apply to management for fire protection purposes. Principles of particular relevance to the management of MNES values in the Molonglo River Reserve include (summarised):

- rapid detection and response;
- science-based risk management;
- strategic use of planned fires for fuel reduction (most effective for fires under moderate fire conditions);
- need for clear objectives and an adaptive approach to environmental management, including the identification of desirable fire regimes to maintain the ecological integrity of ecosystems;
- that adverse biodiversity impacts may occur if planned fire regimes do not adequately reflect natural processes. In some cases, planned fire regimes may differ from the natural regimes, and may cause changes to natural ecosystems.

Management

The Strategic Bushfire Management Plan for the ACT (ACT Government 2014b) identifies strategies and actions to suppress and reduce the impacts of bushfires.

In the main, biomass control methods that achieve ecological outcomes in the Guidelines area (see s.3.4 above) are also suitable for reducing the grassy fuel load for fire fuel management. However, in some instances, biomass management for ecological purpose may be in conflict with fire fuel hazard reduction. Three instances are identified in the NES Plan (ACTPLA 2011).

- Kama is required to be managed for ecological outcomes, and only fire mitigation actions that will not compromise ecological values may be applied there. Fuel management will not be required in Kama, where it might have an impact on the site's ecological values. Recognising the potential bushfire risk to the urban area north of the Molonglo River and William Hovell Drive, however, the NES Plan requires establishment of a buffer zone on the eastern side of Kama, which is to be managed in such a way that it removes any need for fuel management within Kama. The buffer zone (Kama East, s.2.2.3) includes NES patches O2, O3 and O4, which have already been surveyed (Eco Logical Australia 2013).
- There is potential for fire mitigation actions to have negative impacts on MNES in the Spring Valley Farm offset, as recognised in the NES Plan. If the condition of the MNES is reduced through fire mitigation, then the NES Plan requires further offset areas to be established.
- The NES Plan requires buffer zones 20 m wide to be established around all high and moderate-quality areas of Pink-tailed Worm-lizard habitat. They are designed to ensure habitat is not compromised through bushfire mitigation management.

3.7 Soil and water management

Soil and water in the Reserve and offsets provide habitat and ecosystem services in the form of structural support and water resources for the threatened and significant vegetation and fauna.

Soil function for native vegetation and fauna is threatened by factors that add soil nutrients or other contamination or cause erosion, including pest animals, human activities and climatic factors (such as drought and wind). Soil function is also threatened by loss of elements of 'landscape function' from the soil surface, such as by application of frequent or intense fire events (see s.3.4.5).

Water quality and river condition are threatened by factors such as upstream management and weeds and nutrients, which change the river's physical and ecological characteristics. Other threats are those that degrade the river channel and bed.

These can include excessive sediment inflows resulting from erosion and from construction activity near or in the riparian zone, and factors that destabilise the banks of the waterbody, such as complete removal of riparian weeds and their roots over a short period of time.

3.7.1 Objectives — Soil and water protection

Management for protecting the ecological values conferred by soil and water should aim to:

- maintain and enhance soil ecological function and processes;
- prevent active erosion, stabilise existing active erosion;
- prevent soil being transported onto sensitive areas, especially habitats of Pink-tailed Worm-lizard and groundstorey flora and other ground-dwelling fauna;
- avoid soil compaction or disturbance, or an increase in soil nutrients;
- maintain landscape function at or better than baseline condition;
- ensure water entering the riparian zone, such as rainfall-runoff, is not contaminated; and
- maintain water quality at or better than baseline condition.

3.7.2 Runoff, soil disturbance

Urban development has negative effects on soils and ground-based habitats. Soils may become compacted, lose their organic matter content, and be turned over and mixed. Volcanic soils in the Molonglo River Reserve and offsets are highly erodible, with dispersing clay subsoils, and there is active gully erosion within the area. In any part of the Reserve and offsets, soil that has been disturbed or loosened and that has lost its plant cover is liable to be eroded and transported elsewhere by wind or water movement.

In urban areas, rainfall that previously entered the ground is shed by the urban impervious surfaces such as roofs, pavements and roads. There is an increase in rainfall-runoff, which can readily carry sediment and other contaminants downslope. Where the Reserve is downslope of impervious parts of the new suburbs in which construction and other activities have loosened the soil, eroded soil is likely to be carried into threatened habitat, dryland matrix or the riparian zone by runoff, and degrade the habitats of threatened flora and fauna.

On steep slopes in the dryland matrix, the soil is held in place by the roots of native vegetation including trees such as the Black Cypress Pine Woodland community.

If the Cypress trees and groundcover are killed or damaged so their roots no longer hold the soil, these slopes will be at high risk of erosion, with consequent sediment contamination downslope.

In the riparian zone, the River She-oak Forest community and riparian habitats are inherently sensitive to soil and water issues. These areas are particularly vulnerable to erosion as well as impacts from sedimentation and poor water quality. Soil and water issues occurring in upstream parts of the Molonglo River catchment as a whole eventually affect the condition of downstream riparian communities.

Management of erosion and sedimentation

Erosion management requires coordinated action throughout the Molonglo River catchment, giving attention to the effects of wind and rain and water flow on bare ground, including tracks and roadsides, riverbanks and drains, firebreaks, patches of soil where the groundcover has died or been removed, and construction sites. Soil is also protected against erosion by wind and runoff if it has a cover of tree and plant litter including branches, and by stones and rocks — which are also important elements of flora and fauna habitats. In slowing air and water movement across the ground, these elements also promote water infiltration and confer good 'landscape function' (Tongway and Hindley 2004).

Typical management against erosion and sedimentation can involve:

- erosion control techniques, such as diversion banks, surface matting and mulching, cover-cropping, deliberate maintenance of landscape function via plantings, twigs, leaf litter, branches, etc.;
- drainage controls, such as hardened channelling, outlet protection and energy dissipation, check dams, infiltration zones;
- sedimentation controls, such as sediment fences and traps, buffer zones and filter strips, and detention basins.

In vegetated areas of the Molonglo River Reserve and offsets (including swales in urban areas and gullies in grassy areas) maintenance of groundcover and the health of the vegetation community will be essential to protect the soils from erosion and subsequent impacts on downstream water values. For areas that are not vegetated (such as trails, roadsides, construction sites) existing best practice construction and maintenance standards should be applied, especially upslope of Pink-tailed Worm-lizard habitat.

For retaining soil and streambank stability, the major objective of ecological management is to maintain plant cover and reduce threats to vegetation. Vegetation and its roots protect soil and streambank stability, helping prevent erosion and therefore also protecting water quality and ecological processes, and contributing to weed control. Loss of vegetation is likely in situations where heavy rain or strong flows can wash roots out of the soil on slopes, in drains and on streambanks. As well, vegetation can be smothered by sediment deposits, and killed by trampling or untimely mowing or overgrazing or inadequate access to growth factors such as water, light and air.

Riparian vegetation buffers are generally recommended to protect streambanks from damage and streams from contaminants including eroded sediments in runoff. Buffer widths can be up to several hundred metres, depending on land use and stream order, to protect instream and terrestrial biodiversity and to be self-regenerating (Price *et al*. 2004; Hansen *et al.* 2010). NSW DIPNR (2004) suggests a minimum width of 40 m plus a 10 m wide vegetated buffer. For both resource protection and biological conservation, McIntyre *et al.* (2000) advise a riparian buffer width of 50–100 m. For the protection of water quality, the Wentworth Group (2003) recommends a minimum of 50–100 m for rivers and wetlands, from the top of the channel bank, and 20–50 m for creeks and 10–20 m for smaller streams.

Water management in the urban development

Managing Urban Stormwater: Soils and Construction (the 'Blue Book') (Landcom 2004) contains a set of principles to guide soil and water management during construction, focusing on site planning, and appropriate erosion control and sediment control measures, as follows.

- Assess the soil and water implications of a project at the planning stage.
- Plan for erosion and sediment control during the project's design and before any earthworks begin, including assessment of site constraints.
- Minimise the area of soil disturbed and exposed to erosion.
- Conserve topsoil for later site rehabilitation or regeneration (in a stabilised stockpile).
- Control water flow from the top of and through the project area by diverting up-slope 'clean' water away from disturbed areas and ensuring concentrated flows are below erosive levels and sediment is retained from disturbed areas.
- Rehabilitate disturbed lands quickly.
- Maintain erosion and control measures appropriately.

In both new and established urban areas, water sensitive urban design (WSUD) is a well-known approach for reducing the flow rate, erosive power and water quality effects of stormwater. The ACT Government has recently reviewed WSUD in the ACT, releasing the Water Sensitive Urban Design Review Report in August 2014, with up-to-date recommendations (ACT Government EP 2014).

A four-part publication called Water Sensitive Urban Design Strategy (Landcom 2009) deals with interactions between urban development and the water cycle. It targets water conservation, pollution and flow management, and is aimed at:

- reducing potable water demand through use of water efficient appliances and rainwater, and grey water reuse;
- minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or release to receiving waters;
- treating urban stormwater to meet water quality objectives for reuse and/or discharge to receiving waters;
- using stormwater in the urban landscape to maximise the visual and recreational amenity of developments.

ACT water policy supports the incorporation of WSUD principles into urban development in the ACT. The policy also has the objectives of protecting the water quality in ACT rivers and optimising environmental flows through implementation of the ACT Environmental Flow Guidelines (ACT Government 2006). WSUD principles are reflected in the WaterWays: Water Sensitive Urban Design General Code in the Territory Plan (ACTPLA 2007).

Other comprehensive references guiding the protection of soils and water during construction and development include: Managing Urban Stormwater, Soils and Construction (NSW DECC 2008); Think Water, Act Water (ACT Government 2004a); and Water Sensitive Urban Design Strategy (Landcom 2009). The effective implementation of these guidelines, both within and around the Molonglo River Reserve, should be considered for the protection of soil and water values and dependent flora, fauna and ecosystems.

3.7.3 Soil and water management for Pink-tailed Worm-lizard

Pink-tailed Worm-lizard habitat areas are generally in dry non-riparian rocky treeless areas on the slopes of the river valley. They are typically in well-drained parts of the landscape, and often downslope from urban development.

Any movement of water, nutrients, other contaminants, and sediments into Pink-tailed Worm-lizard habitat may wet and contaminate the habitat to the detriment of native grassland species.

The rocks and vegetation may be smothered by sediment. Management procedures are needed so that any such inflow and contamination can be prevented, both during development and construction and into the future.

Poorly managed trails and roads are likely to be local sources of runoff, sediment and contaminants from erosion along the edges and during construction. Other likely local sources of sediment are facilities including firebreaks, fire access suppression trails, utilities such as powerlines, drainage ditches and areas where grass can be slashed. Without management and preventative action, stormwater will take these materials into undisturbed habitat downslope of the road or track, where they will accumulate.

Preventing damage to habitat

Drains and spill off areas from trails and roads must be built in such a way as to protect nearby lizard habitat.

Facilities that are likely sources of sediment need to be located well away from Pink-tailed Worm-lizard habitat.

Preventing any disturbance to habitat areas should be given a high priority during the implementation phase of the new developments.

Boundaries between the urban areas and threatened habitat will need continued vigilance and education, based on clear knowledge of the extent of Pink-tailed Worm-lizard habitat (see s.4.2.6 for habitat assessment technique).

Buffer zones, 20 m wide, are needed around the outside edge of all high- and moderate-quality Pink-tailed Worm-lizard habitat areas, as recommended by the ACT and Commonwealth Governments. The buffers should be designed to intercept any runoff and eroded soil before it reaches the threatened habitat (ACT Government 2011a). As far as is practicable, all constructed features such as ditches, roads and trails should be located outside the 20 metre buffer zones.

3.7.4 Water quality issues

Sediment, such as from soil erosion, can be carried by stormwater runoff into the Molonglo River, where it contaminates the river's water quality. Sediment affects the river's ecological condition and value as aquatic habitat, as well as human uses of the river for amenity.

Other water quality issues include unnatural water temperatures and dissolved oxygen concentrations, other contaminants and pollutants such as nutrients, biological wastes and chemicals, and unnatural concentrations of aquatic algae. All of these occur at times in the Molonglo River downstream of Scrivener Dam.

Factors affecting the water quality of the river include: the limited flow releases from Scrivener Dam; urban runoff high in fine sediments and nutrients from Yarralumla Creek; potential sediment, nutrient and animal waste runoff from rural land; potential residual effects of heavy metal pollution from mining at Captains Flat; and discharge from the former Weston Creek sewage treatment plant and high quality treated effluent from the Lower Molonglo Water Quality Control Centre (LMWQCC) (ENSR Australia 2008; ACT Government EA 2001; Eco Logical Australia 2009).

Scrivener Dam also affects water quality through release of: cold bottom water; water with high concentrations of blue-green algal cells and faecal contamination; water with low dissolved oxygen; and water with high concentrations of suspended solids and bacteria (e.g. ACT Government EA 2001; ENSR Australia 2008).

Recreational swimming in the Molonglo River is currently not allowed because of poor water quality and the variable water level following rainfall or release from the dam (Eco Logical Australia 2011b).

Currently, regular water testing is carried out at Coppins Crossing by the Wirinjani Waterwatch Group, and at the LMWQCC by ACTEW (ACT Government EA 2001; Eco Logical Australia 2011b). A water quality and biological (AUSRIVAS) sampling site in the ACT Water Quality Monitoring Program is located on the Yarralumla Creek tributary of the Molonglo River, at Cotter Road bridge (ACT Government ESDD 2011). Findings of monitoring for water quality, streamflow and biological condition undertaken by the ACT Government are published annually on the government website in ACT Water Reports.

Management of water quality

Water quality standards in the ACT are identified in Schedule 4 of the Environment Protection Regulation 2005, which provides standards for various water uses identified in the Territory Plan (including swimming and aquatic habitats). The standards cover total phosphorus, turbidity, suspended solids, chlorophyll, faecal coliforms, dissolved oxygen, acidity and total dissolved solids.

Secondary ambient environmental standards are also provided, including sediment loads for specific river sections, temperature change, biochemical oxygen demand and sediment contaminants.

Water quality is generally managed by catchment-wide actions and considerations. Flow is a major factor affecting river water quality, and so is sedimentation resulting from erosion upslope of the river, as discussed above.

3.7.5 Flow regime issues

Scrivener Dam has significantly altered the flow regime in the river, which has consequences for channel geomorphology and the life cycles of aquatic fauna. With the dam reducing the height and frequency of flood flows, river terraces formed during the natural flow regime have become relict features (ACT Government 2007).

The altered flow regime may also be exacerbating weed problems in the riparian zone, allowing invasive plants to establish on exposed riverbanks and sand bars, for example (Bowman and Keyzer 2010).

Management

The river flow regime (that is, the seasons, rates, depths/volumes, etc., of flow), water-quality, erosion and sedimentation issues should be addressed and managed as part of long-term restoration and rehabilitation in the Molonglo River Reserve. The protection of soil and water resources should also be reflected in development planning, design and control, construction mitigation measures and management practices. Implementation of environmental flows is considered a minimum response for the recovery and health of riparian and aquatic communities in the lower Molonglo River (Peden *et al.* 2011).

The Water Resources Act 2007 requires that water needed to maintain river systems and associated ecosystems is identified and reserved for that purpose (ACT Government ESDD 2011). The ACT Environmental Flow Guidelines (ACT Government 2006, 2011b) guide flow management in modified river ecosystems in the ACT. Environmental flows are designed to mimic essential features of the natural flow regime in rivers where flow has been modified such as by damming or abstraction, to support their aquatic ecosystems (ACT Government 2011b). The guidelines include environmental flow prescriptions for the Molonglo River downstream of Scrivener Dam and drawdown limits for Lake Burley Griffin. The guidelines are a disallowable instrument under the Water Resources Act 2007.

The ACT Environmental Flow Guidelines (ACT Government 2006, 2011b) include prescriptions for the following components of flow:

- base flow,
- small floods (riffle maintenance flows),
- larger floods (pool or channel maintenance flows),
- special purpose flows,
- impoundment drawdown level.

Base flow is primarily produced by groundwater, and is the minimal volume of water that the stream needs to support the fish, plants, insects, and protect water quality (ACT Government 2011b). Small and large floods move sediment deposits, scour pools and riffles and maintain channel form. Special purpose flows are intended for a particular ecological need, such as stimulating fish breeding in the spring. No special purpose flows are currently specified in the Environmental Flow Guidelines.

The objectives, indicators and flow guidelines relevant to Modified Ecosystems (such as the lower Molonglo River) are listed in Tables 3.7, 3.8. Current and proposed new guidelines indicate that the flow (measured via river level at gauging stations) should always be greater than the 80th percentile. Percentiles are calculated from daily flow data collected over at least 10 years in the river upstream of any effects from dams, weirs or abstractions — that is, at least 10 years of natural flow data. The 80th percentile is 'the volume that flows 80% of the time'; in other words, during the year only 73 days have a lower river level. The relatively high flow rates and water levels required for channel maintenance are to flush or scour out sediment deposits and maintain the channel's form. Equally, limits on groundwater abstraction are designed to maintain the flow of groundwater into the river and therefore the minimum flows in the channel of normally perennial streams such as the Molonglo River.

Following the referral of the control of Commonwealth water resources in the ACT (including Lake Burley Griffin) to the ACT Government, the National Capital Authority (NCA) and the ACT Government are to formulate plans to meet environmental flow obligations in the Molonglo River below the dam (ACT Government 2011b). Currently, Scrivener Dam releases can only be made through a valve at the base of the dam, or by lowering the dam gates. Improved water quality and environmental flows may be possible through modifications to Scrivener Dam, including the installation of a multi-level off-take.

Table 3.7. ACT Environmental Flow Guidelines (2006) — Objectives and indicators for modified ecosystems.

Objective	Indicator
To maintain healthy aquatic ecosystems in terms of biota	Macroinvertebrate assemblages are maintained at AUSRIVAS band A level. Assessed using protocols as per the ACT AUSRIVAS sampling and processing manual (http://ausrivas.canberra.edu/au/ausrivas) Non-dominance (<20% cover) of filamentous algae in riffles for 95% of the time. Assessed using standardised collection and processing methods as per Norris *et al*. 2004.
To prevent degradation of riverine habitat through sediment deposition	Sediment deposition is limited to <20% of total depth of pools measured at base flow using techniques per Ecowise Environmental (2005) methods.
To prevent degradation of macrophytes in urban lakes and ponds	Extent of emergent macrophyte beds are maintained at current levels or enhanced.

Table 3.8. ACT Environmental Flow Guidelines (2006) — Summary of environmental flow requirements for modified ecosystems.

Objective	Indicator
Base flow	Maintain 80th percentile monthly flow in all months. Abstractions may not exceed flow rate.
Channel Maintenance Flows	Protect 90% of the volume in events above the 80th percentile from abstraction
Groundwater Abstraction Limits	Groundwater abstraction is limited to 10% of the long term recharge

Fish movement also is related to flows. The Concept Plan for the Molonglo River Park (Hassell 2011, 2012) proposes vehicle and pedestrian river crossings at regular intervals, which will include culverts similar to the existing Southwells Crossing near Coombs, or bridges. The Ecological Guidelines for Specified Conservation Actions (ACT Government 2011a) states that new instream structures should be designed to comply with guidelines in 'Fish passage requirements for waterway crossings' (Fairfull and Witheridge 2003), allowing free fish passage, including during low flows except where the structure prevents upstream colonisation by introduced species such as trout.

This means that crossings should allow the river to flow as naturally as possible under them, through structures that do not modify flow rates, water levels and light levels very much, so that native fish can pass through easily. Trout are introduced species which prey on smaller native fiish. Bridge design should also consider the potential for the bridge structure to cause localised flooding and trap debris, and the potential impacts of flooding on the bridge and approaches.

3.8 Restoration and connectivity

3.8.1 Overview

'Restoration' entails returning areas of land to a known past state or to an approximation of the natural condition so as to improve habitats, by repairing degradation, removing introduced species, and reinstating habitat elements. Building 'connectivity' entails linking patches of habitat, usually via corridors or islands of new vegetation that native species can use to cross areas of land that do not otherwise provide for their requirements. For some species the links may not be vegetation but other habitat features instead, such as rocks brought in to connect patches of Pink-tailed Worm-lizard habitat.

In the Molonglo River Reserve, restoration work will be applicable in some areas of threatened (MNES) habitat, and it is almost certain to be necessary in parts of the offsets and the riparian zone. The objective is to improve the viability of these areas as habitats for the MNES and other threatened species. Restoration should be tailored towards the requirements of particular species or vegetation associations to be of particular benefit. Connectivity work will aim to install habitat links throughout the areas, and expand the sizes of patches partly through adding to areas of Box-Gum Woodland.

At broad scale, the aim is to increase and enhance connectivity between habitats of the Guidelines area and habitats existing at nearby sites, such as the Murrumbidgee River corridor, Canberra Nature Park and the National Arboretum Canberra.

For the Box-Gum Woodland patches, restoration of natural tree and understorey cover, and increasing patch size and connectivity through revegetation of particular structural elements, will add resilience and reduce weed pressures in the longer term. Any management that improves this vegetation community will also improve its value as habitat for Superb and Swift Parrots as well as other woodland birds.

Natural Temperate Grassland in Kama is unlikely to need extensive revegetation or restoration of habitat. However, some restoration may be beneficial for enhancing plant species diversity or existing habitat, or replacing infestations of weeds.

Objectives

- Manage for natural regeneration of native trees, shrubs and herbaceous species to provide a variety of habitats and on-going replacement of species.
- Where weeds have been cleared, revegetate with suitable indigenous native species if natural regeneration is not sufficient to prevent exposure of bare soil.
- Establish and achieve targets for appropriate revegetation and improved general fauna habitat of each area of threatened habitat and each NES patch of Box-Gum Woodland, to complement natural regeneration.
- Establish and achieve targets to increase connectivity between separated areas of habitat for threatened species and between NES patches, where possible and relevant.
- Revegetate with appropriate native vegetation around dams and other wetlands to improve bank stability, water quality and habitat values.
- Introduce habitat features that are missing from the areas being managed.
- Facilitate ecological recovery by increasing native species diversity and structural diversity, reducing threats to native species and communities, and improving resilience (Munro and Michael 2012).
- Include restoration work in the monitoring program to assess its achievements and adapt the work as necessary.

3.8.2 Some types of restoration

Reducing nutrient levels in soils

Native plants are unlikely to flourish, and are likely to have strong competition from weeds, in places where the soil has relatively high concentrations of available nitrates and phosphates (Prober *et al*. 2005, 2009; McIntyre 2011). These sites are likely to be identifiable by the significant proportion of non-native plants, especially annual grasses and herbaceous species, in the vegetation. By contrast, woodlands and grasslands dominated by native grasses, particularly Kangaroo Grass, have consistently small concentrations of available soil nitrate (Prober *et al.* 2009). If competition from exotic annuals can be reduced, as much as a 10-fold increase in Kangaroo Grass establishment from sown seed may be possible (Prober *et al*. 2005).

For successful restoration of vegetation the nitrate needs to be re-allocated within the ecosystem (Prober *et al*. 2009), by establishing perennial native plants (grasses and forbs) to sequester it.

Although additions of sugar appeared a promising treatment to lock up soil nutrients (Prober *et al*. 2005), recent trials at the Pinnacle (in southern Belconnen) comparing sugar and grazing, slashing and burning have so far been inconclusive (Driscoll 2014).

Reducing soil nutrients can benefit both the Superb and the Swift Parrot by improving the native vegetation in their habitat, and it can particularly benefit the Pink-tailed Worm-lizard habitat by reducing weed infestations in rocky grassland.

MANAGEMENT

- Mow/slash non-native biomass in spring before seed set, and remove it; or
- Burn or graze the non-native plant material in spring.

Providing opportunities for natural regeneration

Natural regeneration is always preferable to planting, because the species are adapted to the local environment and the local genetic material is conserved (McIntyre 2002). A burst of regeneration often follows removal or reduction in grazing pressure, and recovery from drought also often triggers regeneration of trees and other species (Kirkpatrick 2010), resulting in thickets of young trees.

At sites where natural regeneration is already occurring it may be enhanced by small changes to management. It is important that the desirable regenerating species are able to flower and set seed and that viable seed can disperse. In some cases particular conditions may be needed for seed to germinate, such as fire or smoke, and lowered soil nutrient concentrations.

MANAGEMENT

- Provide conditions in which seeds can mature.
- Provide a suitable seedbed for the germination (McIntyre 2002), particularly where competition from introduced species is high.
- Protect regenerating native species, seed and plantings from grazing by stock, kangaroos and rabbits.
- In general keep fire away from the plants until after they reach maturity (set seed) (but see below).

Revegetating areas

Species used for revegetation should generally be sourced from local populations. Over-collecting from one or several closely spaced specimens may lead to a limitation of genetic diversity, but introducing completely new genetic material is also an issue (Carr *et al.* 2010). For use in projects, there may be opportunities to collect seed or plant material from parts of the Molonglo Valley before those areas are destroyed during development.

According to the restoration plan prepared for Barrer Hill (SMEC 2013, p. 56),

> seed should always be sourced from a large, healthy population even if this means sourcing seed from a larger population that is further away but from a similar environment. Seed collectors must consider the health of the source population, and its ability to provide genetically diverse seed, as well as its geographical location.
>
> When selecting seed for the restoration project it will be important to match the environmental conditions of where the seed was sourced from to where it is going. Matching soil type (texture and geology), slope position, aspect, altitude and rainfall gives the best chance of survival. Environmental similarities between sites are a much better predictor of provenance than geographic distance but collecting from within tens of kilometres rather than hundreds of kilometres should be factored as part of the 'matching' process.
>
> Risks from using poor quality seed, collected from small populations with low genetic diversity include:
>
> - Compromised genetic integrity of a species;
> - Reduced ability to thrive in local conditions;
> - Reduced seed set, which is especially critical for species that cannot self-pollinate;
> - Reduced growth, vigor or production of less fit progeny. Occasionally, different provenances of the same species cannot interbreed, so mixing them will reduce restoration success;
> - Limited evolutionary potential to help plants adapt to environmental change.

For native grasses, especially Kangaroo Grass, viable seed can be collected in hay gathered during slashing for biomass reduction. The hay is laid down on the site to be revegetated, as soon as possible after collection; then the seeds dry in-situ and on release from the stems they corkscrew into the soil (McDougall 1989).

Herbaceous species, especially forbs and inter-tussock grasses have declined over much of their range and are candidates for revegetation (McIntyre 2011), but they are unlikely to establish where soil nutrient concentrations are high. See above for reducing nutrient status.

Maintaining and enhancing existing habitat

Where a Box-Gum Woodland site has some large habitat elements in good condition, then improving microhabitat quality may be an effective restoration approach (e.g. Garden *et al*. 2006). Regenerating native vegetation can benefit from microhabitats created by elements such as branches, logs and rocks which modify the microclimate around them.

They give shade, shelter and affect air and soil temperature and soil moisture, for instance, which can help the survival and growth of new seedlings and plantings, including protecting them from grazers.

In Natural Temperate Grassland it can be inappropriate to introduce logs and branches, unless for particular purposes such as erosion control (e.g. use of branches across a slope can slow overland water flow). However, importing cleaned rocks into grassy areas is an important element of Pink-tailed Worm-lizard habitat restoration (see s.3.8.4).

MANAGEMENT

- If wood and rocks are being brought into an area as part of the restoration, ensure they are clear of soil contaminated with weed seeds and possibly soil-borne fungal spores, such as by storing them suitably for a period of time. This also applies to Pink-tailed Worm-lizard habitat restoration by addition of rocks from off-site.
- For fauna, in sites where hollow-bearing trees are rare, install artificial microhabitat such as nest boxes. This may indirectly or directly benefit Superb Parrots, which nest in tree hollows.

Reintroducing important species

In woodland patches it may be feasible to reintroduce uncommon or threatened native flora if:

- appropriate habitat is present that has received no or minimal fertiliser; and
- the sites are appropriately managed and protected against disturbance.

Reintroduction may also be beneficial in low condition Natural Temperate Grassland to enhance plant species diversity or existing habitat, or replace plant cover after clearing infestations of weeds.

McIntyre (2011) recommends that assisted colonisation is feasible for species that have persisted over their geographical range but have declined because of previous land use. These would be species that are endemic to Box-Gum Woodland or Natural Temperate Grassland and that occur in low abundance in the ACT.

Success in such reintroduction requires significant planning and involvement of experts. Species translocation by transplanting local native and threatened species is a skilled job. The plants need to be dug up without damage and replanted successfully, possibly after a period of caring for them ex-situ. Plant species that can be moved from areas destined for urban development, and rare and threatened plant species, may be candidates for translocation. The following species could be considered for translocation into the Guidelines area from other areas of the ACT:

- Tuggeranong Lignum (*Muehlenbeckia Tuggeranong*) from the population near Pine Island on the Murrumbidgee River and several isolated plants further downstream. Cuttings of these plants are growing within the Australian National Botanic Gardens. Similar habitat exists downstream of Coppins Crossing.
- Button Wrinklewort (*Rutidosis leptorrhynchoides*) could be sourced from the several populations at Crace Nature Reserve, Red Hill Nature Reserve and Stirling Park. Open woodland would be appropriate habitat.
- Small Purple Pea (*Swainsona recta*) could be sourced from populations at Aranda and Mt Taylor, and possibly the railway easement in southern ACT.

To achieve success it is important to establish viable populations of the species (i.e. self-regenerating populations).

McIntyre (2011) suggests that in some cases it may be advantageous to source genotypes from beyond the local gene pool (see also 'Revegetate areas', above). While techniques to establish trees and shrubs are relatively well known, techniques to achieve medium to large scale restoration (more than tens of square metres in area) of herbaceous species should be trialled to determine which techniques will achieve the best outcomes (high native cover and/or diversity of species) in the most cost-effective manner. Trials will be required, also, to determine which of these species may be propagated in sufficient numbers to re-introduce them into selected habitat, habitat preference and disturbance regimes that are required to maintain them (McIntyre 2011). Greening Australia is propagating large numbers of herbaceous species endemic to woodlands and grasslands and is currently undertaking trial plantings of these species.

Increasing patch size

Where a landscape has been extensively cleared or disturbed and the remaining habitat is in small fragments in poor condition, the most effective habitat management approach may be to increase the amount of habitat by increasing the size of patches through protection (e.g. fencing off), natural regneration and restoration (e.g. planting), and thus increasing connectivity between fragments (Garden *et al*. 2006).

Patch size of native vegetation containing trees is particularly important for birds (McIntyre 2002). Revegetation of only 3–5 ha has been found occupied by moderately-sensitive woodland species such as Speckled Warbler, Scarlet Robin and Diamond Firetail (Taws 2000), although other research recommendations indicate that 10 ha is the minimum useful size (McIntyre 2002). Mid-storey structure and species diversity may be the difference between this revegetation and larger remnants, particularly those with a long history of grazing.

Other research suggests that remnant patches at least 100 ha in size are required by highly sensitive woodland birds, and that to maximise bird species diversity, woodland remnants should be greater than 150 ha (LWA 2005).

Many studies have shown that patches of about 10 ha or more are able to contain a significantly higher number of bird species (e.g. Loyn 1987; Freudenberger 1999) and mammal species (Bennett 1990), although threatened species including the Brown Treecreeper and Hooded Robin have declined or disappeared from remnants as large as 300 ha (Freudenberger 1999; Garnett and Crowley 2000 in ACT Government 2004b). The larger the area the more likely it is to have heterogeneous landforms, soil types and habitat (and thus native species) (ACT Government 2004b; Watson 2010). Therefore a principle should be to retain and enhance the links between woodland patches and other native vegetation.

In the Reserve and offsets, most Box-Gum Woodland patches that are smaller than 10 ha are linked to other woodland patches, except NES patches C and H, which are both less than 10 ha and are separated by an area of mostly untried land (Map 1.2, s.1.1).

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Revegetation and restoration of other habitat features between NES patches C and H, as well as within these patches, will enhance the habitat values of this area and decrease the sizes of the gaps between habitats north and south of Willam Hovell Drive and in other offset patches.

Reducing edge effects

The larger the patch the more resilient it is to edge effects. Edges of remnants are particularly susceptible to external impacts, including invasion by weed species and feral or pest animals, and movement of nutrients, in or out (McIntyre 2002). The Noisy Miner is characteristically associated with edge habitats such as roadsides and the edges of woodlands (Dow 1977; Loyn 1987).

Ideally patches should also have a low edge-to-area ratio — that is, they should be square or circular. Therefore, revegetation within or adjacent to the edges of a remnant can be very effective, particularly if it not only increases the area of remnant but also acts as a buffer to the remnant itself, reducing edge effects by reducing the edge-to-area ratio, and possibly changing the shape of the remnant to one more ideal.

If species used in revegetating edges are capable of withstanding high intensity management, or are species that can reduce fire intensity, the inside of the patch may be spared high intensity management regimes (e.g. for fire fuel management).

No species that are invasive or that would in any way damage MNES ecological values should be planted adjacent to NES patches. For example, if non-indigenous deciduous trees were planted the fallen leaves would smother native groundstorey vegetation.

A planting list needs to be agreed, identifying species most suitable for planting in buffers adjacent to habitats and woodlands of the Guidelines area, and only those species should be used (Greening Australia, unpublished).

Linking existing patches of habitat

Habitats can be linked via linear corridors (such as rivers), 'stepping stone' patches, and permeable landscapes[8] (Bennett and Mulongloy 2006). Habitat corridors have been shown to provide valuable connectivity for fauna in fragmented landscapes (Beier and Noss 1998). According to Biosis Research (2006):

> The purpose of wildlife corridors should be to (a) provide resource opportunities to native species as well as viable movement corridors, (b) to alleviate the loss of habitat as a result of urban expansion, and (c) to provide functional habitat linkages that assist regional conservation aims.

Many fauna, even those capable of dispersing and migrating great distances, rely on some form of vegetation connectivity across the landscape for movement. For example, migrating honeyeaters prefer to make short distance flights between cover rather than crossing extensive open areas (ACT Government 2007). As noted in s.2.4.2, the **Superb Parrot** requires wooded movement corridors between breeding and foraging habitat. It appears to avoid areas of open ground (Webster 1988), flying over woodland or scattered trees instead.

Freudenberger (1999) recommends that linear woodland plantings should be at least 25 m wide with a range of tree and shrub species. Lambeck (1999) recommends a minimum width of 50 m for corridors to provide habitat for woodland birds and reduce edge effects.

Patches of habitat or cover should be spaced so that woodland bird species can fly between them. Freudenberger (1999) found that many fragmentation sensitive woodland birds require structurally diverse vegetation patches within 500–1000 m of other remnants. Isolated patches of woodland or forest smaller than 10 ha — even single mature trees in a cleared landscape — can function as movement corridors or 'stepping stones' between larger remnants.

8 Landscape permeability is a term describing the ease with which fauna can and will move between resources and patches of habitat in a landscape; it depends both on physical structure and fauna ability. Fauna in a permeable landscape can move around readily; landscapes they cross reluctancly are called semi-permeable; and landscapes that fauna will not cross are called impermeable (Schaefer-Joel 2012).

Remnants within 500 m of large areas of native vegetation are more likely to support wildlife such as small mammals, arboreal marsupials and birds than isolated patches (RIRDC 2000).

However, habitat and cover connectivity requirements vary between species: while some woodland birds need large patches within 1 km of each other (Freudenberger 1999), others are most likely to use 'stepping stones' if there is less than 100 m between patches of habitat 10 ha or larger which are no more than 1.1 km apart (Doerr *et al*. 2013). Poor dispersers such as the threatened Golden Sun Moth can become isolated if habitat gaps exceed 200 m. Mistletoe seed, generator of a very important food source for the Swift Parrot and Superb Parrot and other bird species in the Guidelines area (Watson 2001), has a very short range because of its rapid passage through its carrier the Mistletoebird, which does not make sustained flights (ANBG 2011).

3.8.3 Restoring habitat elements for birds

For many woodland birds, mid-storey structure is a critical habitat element that should be incorporated into revegetation. Mid-storey habitat can be created in clusters with open patches in between so that it provides both dense cover for shelter and open areas for foraging, rather than an even spread of sparser cover. Common mid-storey species in the Molonglo Valley which create habitat for birds include small trees such as *Acacia implexa* and *Exocarpos cupressiformis* and the shrubs *Acacia dealbata*, *A. rubida*, *A. genistifolia*, *Cassinia quinquefaria*, *C. longifolia*, *Bursaria spinosa* subsp. *lasiophylla* and *Dodonaea viscosa* subsp*. angustissima.* The bipinnate acacia species, in this case *A. dealbata*, provide particularly useful foraging habitat for small woodland birds and reduce the suitability of the habitat for Noisy Miners.

Revegetation activities need to comply with the Strategic Bushfire Management Plan (ACT Government 2014b) which may limit the density of plantings and distance between tree canopies and shrubs. Planting of shrubs can comply with these guidelines and still create habitat and connectivity for woodland birds. The configuration may not allow large patches of habitat to be created but smaller patches can still provide connectivity for woodland birds.

Diversity of native grasses and forbs is a key habitat element for woodland birds, but restoration of native groundcover in areas of introduced pasture grasses and other weeds is challenging. It involves control of biomass, reduction in nutrients and depletion of soil seedstores (Lunt *et al*. 2010). Any of these actions requires significant intervention and long-term commitment.

Revegetation initiatives could be trialled in sections of the Molonglo River Reserve, such as at Barrer Hill.

Even if native grasses are dominant in an area there may still be little diversity of native forb species. Forbs may have been lost through past grazing practices and now be unable to recolonise. These areas could be supplemented with some of the relatively robust forbs such as *Chrysocephalum apiculatum*, *C. semipappossum*, *Leucochrysum albicans*, *Lomandra* spp. and *Xerochrysum viscosum* to increase forb diversity.

3.8.4 Restoring Pink-tailed Worm-lizard habitat

Researchers in the ACT Government and at the Australian National University are (as of 2014) trialling techniques including weed control, burning, tubestock planting and rock placement for restoring lizard habitat. Successful techniques will later be applied at landscape scale across a number of areas within the Molonglo River Reserve, aiming to improve habitat connectivity while also controlling fuel loads (excess biomass; see s.3.4) especially within fire management zones.

It is now apparent that clearing of timbered landscape near the Molonglo River has helped expand the distribution and abundance of the lizards by adding habitat. Removal of the forest cover in rocky areas (for example the low hills on Spring Valley Farm and some slopes within parts of the Molonglo River valley) has increased areas of rocky habitat beyond those originally smaller rocky openings which did not support tree cover. It is likely that the local population of the species increased and colonised new sites, particularly if these were previously unsuited due to dense tree cover. However, these processes would have been counteracted by pasture improvement and the application of fertilisers. Furthermore, natural regeneration of shrubby understorey and overstorey species in areas originally cleared is likely to now put pressure on exisiting populations and consideration should be given to controlling these species (e.g. *Kunzea ericoides*).

There may be some barriers to the Pink-tailed Worm-lizard expanding its distribution. These include the Coppins Crossing Road (this low-level crossing provides a complete barrier) and locations where highly disturbed areas of former pine plantations occur to the edge of the riparian zone. The river itself is likely to isolate populations on either side from each other (this is strongly supported by genetic data that are being prepared for publication by T. Knopp at the Institute for Applied Ecology, University of Canberra).

Until studies confirm techniques for successfully restoring Pink-tailed Worm-lizard habitat, the following approach should be practicable. It is based on knowledge of the species' habitat (e.g. Jones 1992, 1999; Wong *et al.* 2011), and observations of the lizard in landscapes semi-restored following the 2003 Canberra fires.

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- Before restoration at any site, there should be a botanical survey to determine the plant species already present. A site already dominated by native grasses and forbs will simply require placement of rocks. A site completely lacking native ground flora would not be suitable for rehabilitation unless it could have a full ecological restoration, including lowering the soil nutrient status and establishing groundcover dominated by native grasses such as Kangaroo Grass *Themeda triandra* and including plant species characteristic of nearby high-quality habitat. Plant species introduced to the site would need to be of local provenance.
- Rock type, shape and depth buried: Silurian volcanic rock that has weathered into small chunky blocks should be ideal for use in rehabilitation, being the main type of rock in the lower Molonglo River valley. Aim for a range of shapes and sizes throughout the rehabilitation area. Small rocks should be 15 cm x 15 cm to 30 cm x 30 cm. Some larger rocks can be placed as well to add habitat diversity. All should be more than ~5 cm thick, so that they do not heat up too quickly (for example on sunny days or during a fire), which would not suit ants and the lizards. Place rocks directly on the soil or vegetation surface or shallowly embed them (to about 5 cm depth) to facilitate their colonisation by ants which will then construct burrows. Four to six rocks per square metre should be adequate.
- Disturbance should be kept to a minimum. Any exposed soil remaining at the end of the rehabilitation process is likely to encourage invasion by weeds. Depressions created for placement of rocks should be shallow and ideally the same size and shape as the rocks, so little or no soil is exposed once the rocks have been placed. Soil removed from the depressions should be taken away from the site.
- Rock picking and ground reshaping should **not** occur within Pink-tailed Worm-lizard habitat or the 20 m buffer zones.

3.8.5 Connectivity

The potential for dispersal between different populations is an important consideration in the conservation of species. Connectivity helps ensure that populations and ecosystems are viable and able to adapt to change (Mackey *et al.* 2010), and is an essential ingredient of good conservation practice (Lindenmayer and Burgman 2005). As with restoration, connectivity enhancement should be tailored towards the requirements of particular species or species groups. For example, connectivity can be enhanced for small fauna by adding groundstorey or herbaceous species or other habitat elements (see below) or, for birds, by improving tree structure.

Connectivity helps prevent the processes that affect very small populations, such as reduced gene flow, inbreeding, genetic drift and the loss of small populations due to unpredictable events (e.g. fires) that can occur with increasing fragmentation (Hilty *et al.* 2006). Larger interconnected populations often comprise metapopulations — that is, clusters of interconnected local populations that have some migration between them and that, over time, may increase and decrease in size depending on environmental conditions (Hanski and Gilpin 1991). When small parts of the overall population are lost, connectivity gives the opportunity for recruitment from other parts of the population (whether vegetation or fauna), so the population can re-establish itself when conditions again become favourable. It is thought that such processes are essential to the long-term survival of many species in the landscape (Hilty *et al.* 2006).

Manning *et al.* (2010) have identified key connectivity principles and issues in the ACT, including (summarised):

- linking existing ACT nature reserves to each other and to those in NSW;
- avoiding further fragmentation of woodland habitat;
- recognising that all parts of a given landscape may play a role in conservation and connectivity (irrespective of that land use, tenure or formal designation);
- considering connectivity in project planning;
- undertaking habitat recovery actions in key locations, with targeted monitoring;
- considering human-assisted translocation of animals to ensure genetic mixing, where remediation of isolated habitats cannot reasonably be implemented or natural movement of fauna is not expected (e.g. specialist flora and fauna of native grasslands);
- assessing the connectivity impacts to in-stream environments, particularly where roads cross or impact on creeks or wet areas, including impacts to ecological processes such as sediment processes and nutrient movement.

In the Molonglo Valley, the Reserve and offsets will, ideally, become a series of habitat patches useful as 'stepping-stones' linking to other existing ecological assets in ACT. The Canberra Spatial Plan indicates the following potential wildlife corridors:

- the lower Molonglo River downstream of Coppins Crossing, linked through Kama to the nature reserves in the Belconnen Hills (the Pinnacle, Mount Painter, Aranda Bushland), and Black Mountain (Manning *et al.* 2010);
- the river valley connection to the extensive Murrumbidgee River corridor and west to the Brindabella Ranges. Significant north–south migrants (such as **Swift Parrot**, White-winged Triller) and altitudinal migrants (such as the Flame Robin) could use the Molonglo River valley on an annual basis;
- links between the modified landscapes of the National Arboretum Canberra and Stromlo Forest Park through the Misery Point area in the Molonglo River Reserveand associated watercourse reserves. This corridor potentially links the Murrumbidgee River in the west with Black Mountain Reserve to the east of the reserve;
- connections to Canberra's central urban parklands around Lake Burley Griffin as well as important links to surrounding rural areas for bird species.

Within the Guidelines area, there are opportunities to improve connectivity along the Molonglo River valley, between riparian and dryland woodland communities, between grassy and grassy woodland patches and between Pink-tailed Worm-lizard habitat areas, as well as within the Molonglo River Reserve and the new suburbs.

However, fire can run easily through well-connected patches of habitat based on vegetation and woodlands. Therefore, it is important to integrate restoration planning and fire management planning for all parts of the Molonglo River Reserve and offsets and their vegetation communities.

Elements for use in restoring habitats to build connectivity

Important elements of habitats have been outlined above (s.2.7), relevant to MNES and other threatened and significant species in the Guidelines area. The following are some components that can be used to improve connectivity between habitats.

- Native vegetation can be added, contributing nesting sites, foraging areas and shelter, whether around watercourses, drainage lines, artificial ponds or dams, wetland areas and the river itself, or as understorey vegetation, or sub-canopy species, including groundlayer vegetation in drier sites. Habitat values of dams and ponds are enhanced by adding fringing native vegetation and indigenous wetland species, which also trap silt and other material before the water reaches the Molonglo River.
- Fencing can be used to protect sensitive areas from trampling and grazing by livestock or other herbivores, including existing and new wetlands and stream banks, and new plantings.
- Plants that can be added include sub-shrubs (less than 0.5 m tall), shrubs, or trees. Bird species are more diverse where the habitat is complex and diverse; for example, with a tussock grass/shrub understorey (Barrett and Davidson 1999 in Martin and Green 2004). Fauna such as spiders and other invertebrates also use this habitat for shelter, foraging and nesting.
- The tree canopy of River She-oak is a critical habitat element for birds in the riparian area. Many of the mature trees along the Molonglo were killed by bushfires in 2003. Natural regeneration is occurring in some areas where the canopy was destroyed but additional planting of tubestock in the gaps would assist the recovery of the canopy. Trees should not be planted in known breeding areas of the Rainbow Bee-eater, however, because it requires open grassy sites in which to dig nesting burrows.
- Ground litter can be added, to protect the soil surface from erosion and fill other functions. Decomposition of the litter by micro-organisms recycles nutrients, provides habitat for a range of invertebrates, and therefore in turn provides feed resources and habitat for a range of vertebrates. Vertebrates, including reptiles, amphibians and small mammals, forage for invertebrates, fungi and plant matter and take refuge and build nesting sites amongst litter.
- Nest boxes can be installed where there are no tree hollows. Nest box design is complex. Nest boxes are useful if designed to meet the specific needs of a particular species (Lindenmayer *et al.* 2003), with entrances that exclude feral Honeybees or Common Mynas for example. Nest boxes have been used successfully to provide artificial roost sites for Sugar Gliders in Box-Gum Woodland remnants on Narrabundah Hill near Duffy (D. Smillie, University of Canberra pers.comm.).
- Piles of logs, rocks, tin sheets or tiles can provide habitat for reptiles and some species of small native mammals (Lindenmayer *et al.* 2003). Placement of suitable rock in situations unlikely to become weed infested can improve habitat conditions for reptiles.
- Branches can slow water flow off steep slopes, minimise erosion (Sharp 2011; Tongway and Ludwig 2011), and accommodate a range of species, including plants that gain protection from grazing; a wide range of vertebrates and invertebrates use fallen dead timber for foraging, perching, feeding, breeding and sheltering.

- Topsoil can be brought in, but only if it has separately become available from an area of high quality, relatively weed-free, native herbaceous vegetation (a suitable 'donor' site; Tozer *et al.* 2012). In addition to plant propagules, topsoil contains invertebrates, soil microbes and other soil biota typical of an ecosystem (Tozer *et al*. 2012). It can bring in a high diversity of species, many of which may not be easily propagated. A trial of bringing in topsoil was relatively successful, particularly when it did not need stockpiling before use (Tozer *et al.* 2012).

3.8.6 Steps in a restoration program

1. Determine what is to be restored at each site and the outcome(s) to be achieved

Recognise that an ideal 'natural' state is unlikely to be achieved and may not be the best option. Decide on particular aims, such as to increase the cover of shrubs beyond the defined cover (10%) for the Box-Gum Woodland ecological community so as to enhance woodland bird habitat, especially where such habitat may be reduced elsewhere through fire fuel management. Restoration activities can achieve multiple outcomes, including recreation, landscape and conservation outcomes. Adverse outcomes also need to be recognised and planned for, by integrating restoration planning into the overall management plan for the areas, including fire management planning.

2. State desired outcomes as quantitative goals

Quantitative goals make it possible to measure and monitor progress towards them and to identify when and if the aims and desired outcomes are reached. Examples of quantitative aims and associated desired outcomes are presented in Table 3.9. Each of these aims requires a different set of restoration activities.

Table 3.9. Examples of aims and associated desired outcomes for restoration activities.

Aims (Bennett *et al.* 2000)	Example of target condition
To stabilise eroding soils	Gully is no longer actively eroding. More than five plant species have established over 80% of the site.
To protect a wetland, drainage line or river	Cattle no longer accessing the wetland. Vegetation is re-established over 80% of the bank.
To provide habitat for particular threatened species	Logs and litter have accumulated and surveys indicate that Hooded Robins are utilising the habitat.
To increase species diversity in depleted vegetation types	Species diversity of plants has increased to 80% of the benchmark and subsequently there is an increase of birds recorded in annual surveys.
To establish a diverse habitat	Logs, rocks and branches have been reinstated and there is an increase of 20% diversity of species using that habitat.
To enlarge areas of existing natural vegetation or fill gaps in existing vegetation	The entire site has increased to 10 ha. Trees, shrubs, grasses and other herbaceous species have been successfully established to achieve a native groundcover of 80%, shrub cover (when mature) of 20% and anticipated tree projective foliage cover of 10% (after 20 years).

3. Plan the restoration work around the requirements of particular ecological entities

Site-specific programs can be planned with the aims of restoring habitat for individual vegetation units or fauna species.

4. Plan to protect what is already there

Use existing vegetation and habitat, and encourage natural regeneration (Bennett *et al.* 2000; McIntyre 2002). Plan to add to habitats rather than removing existing elements and leaving nothing (Bennett *et al.* 2000). As noted above (s.3.3), for ecological values even weeds are better than bare soils, and they should be valued for their soil-protection benefits until native species have grown to take their place.

5. Make detailed site assessment and recommendations

Use a baseline assessment to identify existing species on site and relevant threats and threatening processes. Then decide on actual species and materials (seed, wood, etc.) and resources such as labour required for the project; find local or regional sources; find out how to manage and apply them. Use GIS map layers (as follows) to support restoration planning.

- High quality and current aerial photography.
- Slope.
- Pre-European distribution of vegetation communities.
- Current distribution of vegetation community stands, isolated overstorey dominants and community indicator species.
- Community condition classes, distinguishing stands with native and non-native groundcover.
- Survey and monitoring vegetation units, and locations of survey sites, monitoring sites and reference sites.
- Current distributions and densities of major weed species.
- Locations of rare, declining and threatened flora and fauna records.
- Existing and proposed management zonings and developments (including roads, tracks, visitor facilities, irrigated parkland, utilities, fencing).
- Asset Protection Zones (Inner and Outer), Strategic Fire-fighting Advantage Zones and other fire protection requirements.

6. Activate on-ground restoration works

Stage on-ground work, based on planning, season, resources and the weather.

7. Assess the end-product of the work, monitor and evaluate subsequent habitat improvement

Establish benchmark data and monitor the progress of each site regularly using scientifically credited performance measurements.

3.8.7 Restoration trials relevant to the Molonglo River Reserve and offsets

Restoration and enhanced habitat can be achieved in various ways, and work is under way in several innovative projects (below). Trials of different methods in different habitats (including nutrient enriched sites) are recommended. They can specifically measure survival, cost effectiveness, reproductive success of established species, and the capacity of plantings to control weed invasion.

Ideally, new restoration work in the Molonglo River Reserve and offsets can be coordinated with existing nearby restoration projects (especially the ACT Woodlands Restoration Project below). Coordination helps to ensure the projects have consistent aims (such as connectivity) while also using existing resources efficiently to achieve restoration aims and objectives.

1. Revegetation by direct seeding has been in use for some years for establishing farm shelter belts, especially by Greening Australia. Advantages of direct seeding over planting tubestock include the reduced price, the more natural distribution of species across the landscape and higher plant density. A great deal of seed is required. Difficulties in controlling the density of plants can be overcome by spot sowing.
2. Restoring herb-rich grassy ecosystems by direct seeding. The Grassy Groundcover Research Project is designed to achieve large scale restoration of rich grassland plant diversity and is being undertaken by Greening Australia, Victoria. The project direct seeds multiple species together into sites, to restore the diversity of native plants, as well as cover (Freudenberger and Gibson-Roy 2012). This approach is reliant on high quantities of seed of multiple species being available and is not yet feasible to achieve without significant input.
3. Build onto existing vegetation. The ACT Woodlands Restoration Project is being implemented by the ACT Government. The aim of the project is to, within a whole of landscape focus, achieve connectivity between existing remnants, and improve habitat diversity and structural complexity. It is a collaborative project with contributions from community groups, research organisations and Ngunnawal people, and cooperation with neighbouring land managers. A priority is to retain large scattered trees and enhance opportunities for regeneration of these trees across the landscape. Plantings are guided by a plan developed by Greening Australia. Restoration work in the Molonglo River Reserve and offsets will complement this project, and should be planned in cooperation with the project team.
4. The long-term experiment in the Mulligans Flat–Goorooyarroo Nature Reserves is being undertaken collaboratively by the Australian National University and the ACT Government to research effects of management regimes and their interactions (Manning *et al.* 2011). One of the treatments being researched is the effects of adding coarse woody debris. Preliminary results indicate that coarse woody litter addition has provided important niches for a range of plants and animals.
5. At the Canberra International Airport Greening Australia is investigating the various processes which affect grassland quality and methods to improve condition of the grassland (Fifield 2014).

4. CONDITION ASSESSMENT & MONITORING

Low impact population monitoring research for Pink-tail Worm-lizard

4.1 Baseline assessment and monitoring: general

The first step in ecological and adaptive management and restoration is to identify and map the key ecological values and assets within the management area via a full '**baseline assessment**'.

The baseline assessment assesses the existence and biological condition of the important ecological values already identified in the target areas (i.e. the condition of the vegetation and various habitats, and evidence of fauna, both invasive and native), and also the threats and threatening processes existing and predictable.

Biological condition relates to the state or ecological 'health' an area is in at a particular time. It is usually measured in terms of the status of particular populations of species, the diversity of species and habitat, and the functional condition of the landscape and its ability to retain rainfall, support vegetation (which requires stable and uncompacted soils that can cycle nutrients) and provide suitable habitat.

Condition is generally recognised through indicators such as species richness, vegetation composition and abundance, extent, spatial arrangement and structural characteristics, and functional attributes including soil properties, surface characteristics and disturbance regimes (various authors, in Gibbons *et al.* 2008).

The ability to detect and compare change in condition depends on the establishment of benchmarks. A benchmark is a quantitative measure that provides a standard against which to compare measurements collected later during monitoring. The baseline assessment defines 'site benchmarks' (the actual starting condition) in relation to 'attribute benchmarks' (the near natural, or target, condition). It is the starting point, before management planning and before monitoring program design.

Attribute benchmarks generally describe the condition of the thing to be measured (e.g. vegetation type) in a relatively natural state. Attribute benchmarks have been developed for vegetation communities in the ACT for lowland grassy vegetation communities, based on criteria established in NSW (Gibbons *et al*. 2008).

Site benchmarks are site-specific, describing the condition of the thing to be measured (e.g. vegetation type, soil surface characteristics) at a particular location prior to an intervention such as development or restoration. Site benchmarks are determined based on data collected at the baseline assessment (before beginning any management or development activities).

The baseline assessment is a descriptive, qualitative and one-off field survey used to describe each target ecological entity and its condition (site benchmarks). It is an opportunity to:

- make an inventory of species, species abundance and distribution, and habitats;
- identify their biological condition in relation to attribute benchmarks;
- identify their diversity and the likelihood they can be used by threatened species, especially features critical to such species' survival;
- map important ecological values as well as threats or management issues;
- fine-tune the mapping of vegetation unit boundaries if required, particularly in relation to groundcover quality;
- note issues that may require management actions (e.g. fencing, revegetation, erosion control) to support conservation, and raise questions to be answered by the program;
- identify what should be monitored to meet the desired outcomes, in each section of the Molonglo River Reserve and offsets;
- consider the placement of monitoring sites (Sharp 2012).

After evaluating the findings of the baseline assessment, in relation to target condition (or 'attribute benchmarks'), a practical management program as well as a practical monitoring program can be designed.

Monitoring consists of measurements and observations repeated at intervals over a period of time. Evaluation of the results provides information on trends (or constancy), which is fundamental to the adaptive management process and achievement of its objectives and conservation targets (ACTPLA 2011; ACT Government TAMS 2013). Monitoring as specified under the NES Plan in relation to adaptive management in Molonglo River Reserve and offsets is described in s.4.2.

4.1.1 Designing a monitoring program

The program of monitoring and assessment must acknowledge and understand the ultimate objectives of the management and restoration program. The following steps are involved in designing the program.

- Define a conceptual model, and suitable indicators, of effects that management and restoration is to achieve in relation to each monitoring target.
- Define how change will be identified for each indicator, in relation to climatic variation and other confounding factors, via (Lindenmayer and Likens 2010; Sharp and Gould 2014):

  - use of peer-reviewed, scientifically sound methodology;
  - application of standardised methodology across a range of sites;
  - replication within patches to take into account internal variation;
  - use of continuous (quantitative) data to allow for detailed statistical analysis;
  - use of measures that can be consistently applied and repeated readily when collecting data;
  - repetition over an adequate length of time for changes in measures to be statistically valid;
  - inclusion of control sites where specific management is not applied (this could be through replication of sites with different management activities applied) to assist in interpreting cause and effect.
- Decide how the results of analyses of change will be handled, discussed and explained, in relation to the conceptual model. An objective assessment of management performance in meeting benchmarks and targets is required, in terms of effectiveness, efficiency, and timeliness.
- Decide on monitoring methods and schedules, data cleaning and storage methods.
- Plan how to present measurements and results of analysis. Indicator measurements from monitoring need to be presented clearly alongside the community benchmarks and management targets. Where possible the information should also be presented graphically.
- Arrange for scientifically rigorous and standardised statistical analysis of monitoring results.
- Plan for public reporting of the regular reviews of monitoring results, in a range of formats.
- Stratification. Stratify the survey area into relatively homogeneous units to make sure that the assessment captures the full range of environmental variation. Most commonly used vegetation units (or zones) are based on vegetation structure and composition, which also reflect condition (Gibbons *et al*. 2008; Sharp and Gould 2014). Assessment and monitoring sites are set within each vegetation unit. The initial stratification is based on available information, including previous surveys and mapping and aerial photography. Stratification should be related to desired outcomes of management or particular areas.

BACI or BA monitoring

The ideal monitoring program is based on the Before–After, Control–Impact (BACI) model. In the context of Molonglo River Reserve and offsets a monitoring program will be testing for change after urban development or implementation of management actions (Smith 2002).

For BACI monitoring there needs to be a 'control' — that is, a site outside the area, which is not subject to the same management regimes (Smith 2002). For Molonglo there are data from existing monitoring programs in nearby sites, and these can act as a control. The existing data also provide a rigorous baseline dataset. Therefore, for Molonglo, BACI monitoring will make it easier to identify which trends in the data are likely to result from changes caused by management.

Where a BACI design is not feasible, a Before–After (BA) monitoring program (with no 'control' site) makes it possible to compare data from the site before and after treatment. BA monitoring is most rigorous when it includes multiple sites in a management area (Smith 2002).

Defined monitoring points

Monitoring is a series of quantitative repeated and repeatable surveys at defined points in the landscape. Monitoring personnel measure a range of environmental indicators at these points repeatedly over time (usually years), aiming to detect changes by comparing the monitoring data against the site benchmarks and attribute benchmarks.

Quantitative data

For monitoring data to be useful in a long-term program, the measurements need to be quantitative. Qualitative measurements are generally not comparable over time because of surveyor subjectivity and lack of numerical data for statistical tests. Qualitative information also generally lacks the sensitivity necessary to detect environmentally significant change (Bauer and Ralph 1999).

A disadvantage of quantitative and semi-quantitative surveys is that they take more time in the field and the monitoring personnel need to be trained to ensure standard methods are being applied. However, the data obtained from fewer quantitative surveys will be more useful than data from a greater number of qualitative surveys (Bauer and Ralph 1999).

Personnel

It is important that personnel are adequately trained to ensure they collect the data consistently and accurately, and record them correctly. Monitoring of vegetation and fauna needs to be done by ecologists with general field survey experience and/or expertise in survey and monitoring of particular species. Volunteers may be able to help in monitoring particular components.

A skilled biometrician should analyse the data and help in statistical interpretation. At the very least a biometrician should advise on how the data should be analysed.

The baseline studies required under the NES Plan (condition assessment and monitoring and population studies) should be done by field scientists who have experience in collecting appropriate detailed data. If resources are available, less experienced community volunteers could work on other monitoring studies.

Timing and frequency of monitoring

In making measurements and interpreting the data to identify effects of management, it is important to recognise the dynamic nature of vegetation communities, especially herbaceous vegetation. There can be substantial differences in species diversity between seasons: many forbs die back to rootstock after flowering; many native grasses die back to straw after seeding; and many introduced species are annuals and therefore also die after seeding. The abundance and seed production of any species can vary significantly between seasons, depending on conditions. The timing of rainfall during autumn and winter, and temperatures after winter, can all significantly affect the numbers of plants that emerge. Therefore monitoring should be done at the same time(s) of the year each year, and take climatic variation into account when comparing results between years.

Reference or 'control' sites

For vegetation monitoring, reference sites should be established near the monitoring area and in similar habitat, to provide a local comparison. A suitable reference site would be in very good condition in its plant diversity, composition, structure and fauna habitats, and would be located as close as possible to, but outside of, the appropriate part of the Molonglo River Reserve or offset areas.

Management targets

In addition to attribute benchmarks, monitoring results need to be assessed against defined management targets. Management targets may, for example, be set for the incidence and cover of particular invasive weeds (such as willows, African Lovegrass or St John's Wort), streambank stability, water quality, native species cover, and other non-community attributes.

Meta-data and data management

It is important to record in detail all management activities which may affect the monitoring indicators, such as weed control, revegetation and fuel hazard reduction. This information should include what was done (with mapping as required), how it was done (techniques, materials), when it was done and who did it. Impacts such as pollution events and illegal access, and natural events including wildfire and floods, can also affect vegetation and need to be recorded in similar detail. Climate data also need to be recorded, because climatic variables affect growth and development of plant species, biomass and herbivore off-take.

An example of very effective information gathering is shown by the ACT and Southern Tablelands Weed Spotter website (ALA 2014) and smartphone app. It uses the Atlas of Living Australia website to keep track of the occurrence and control of weeds.

Recording expenditure and staff time is also useful for the later evaluation of economic performance and value for money (Sharp and Gould 2014).

Monitoring data should be collected and stored in a manner that makes analysis and presentation easy, flexible and accessible to a wide range of users. Data should be collated each year, and stored at one location (with copies at additional locations to guard against loss or destruction of data). Indicator measurements from monitoring need to be presented clearly alongside the community benchmarks and management targets. Where possible the information should also be presented graphically. Monitoring data should be freely available to members of the public, interest groups and educational institutions for alternative or additional analyses.

Detecting changes in relation to context and management

To detect changes, the monitoring data (measurements) are compared to the attribute and site benchmarks, and to comparable data collected from reference sites, and to management targets. 'Before' and 'control site' data also help in gauging management progress and effectiveness. Categorical data show changes, but for statistically sound evidence continuous data must be used.

Monitoring data should be analysed comprehensively every five years (although it is likely that many changes will take longer to become apparent). Interim reviews focusing on specific issues (such as weed control and revegetation success) should be made more frequently.

There should be statistically rigorous and standardised analysis of monitoring results, clearly documenting all assumptions. The regular reviews of monitoring results should be presented in a public report, available in a range of formats.

Review of monitoring results, management policies and practices

The results of analyses need discussion and explanation. There should be objective assessment of management performance in meeting benchmarks and targets, in terms of effectiveness, efficiency, and timeliness.

To close the adaptive management loop, management actions are assessed for their effectiveness in causing change in condition relative to the attribute benchmarks and time-framed management targets. Management policies, actions and targets are adjusted as required, and the cycle begins again.

4.2 Monitoring for adaptive management in the Guidelines area

Under the NES Plan (ACTPLA 2011), a monitoring program in the Molonglo River Reserve and offsets should aim specifically to:

1. measure change in condition of the vegetation against benchmark condition in endangered ecological communities;
2. observe and measure changes in vegetation and habitat resulting from management applied to achieve specified results;
3. trial the best ways to manage areas to achieve performance targets;
4. observe and measure changes in populations of fauna species and their habitat condition against the application of management actions;
5. use these data to review outcomes of the management applied and change the management if required to ensure the desired outcomes are achieved.

The NES Plan specifies the monitoring requirements quoted below for the five MNES in the Guidelines area: Box-Gum Woodland, Natural Temperate Grassland, Pink-tailed Worm-lizard, Superb Parrot and Swift Parrot.

> 'The monitoring regime will take into account and track the ecological condition of Box-Gum Woodland, Natural Temperate Grassland and the Pink-tailed Worm-lizard habitat against the objectives for management' (p. 38).
>
> 'Ecological condition for Box-Gum Woodland and Natural Temperate Grassland will be measured using a peer reviewed, repeatable and scientifically robust methodology for examining and comparing the condition of woodland, derived grassland patches and grassland patches over time' (pp. 20, 27).
>
> 'Ecological condition of Pink-tailed Worm-lizard habitat will be measured using the criteria described in Osborne and Wong 2010' (p. 29).
>
> 'Construction Environmental Management Plans will include appropriate monitoring and reporting' (p. 34).
>
> 'Mechanisms will be established to monitor, evaluate, and annually report on progress to achieve objectives for management, including how management actions will be adjusted to account for new information' (p. 37).
>
> 'Establish benchmark data and monitor rehabilitation success using scientifically credited performance measurements already adopted by regional leaders in rehabilitation assurance' (p. 39).

Table 4.1 identifies attributes that need to be assessed and/or monitored to fulfil obligations under the NES Plan, and also other potential monitoring or assessment that will help detect whether diversity generally is being maintained. In some cases, these other attributes (e.g. control of weeds) will help in determining why changes are occurring to the MNES.

Prior to the implementation of monitoring, however, to meet NES Plan directives the methods to be applied in each of the offset areas must be peer reviewed for their effectiveness in meeting NES requirements.

Table 4.1. Attributes to assess and monitor MNES and other ecological matters in Molonglo River Reserve and offsets.

Attributes	Baseline condition assessment	Monitoring
Vegetation condition		
Cover and diversity of native and introduced herbaceous plants	NES	NES
Relative cover of shrubs and trees against the benchmark of Box-Gum Woodland and Natural Temperate Grassland in the ACT	NES	NES
Groundlayer cover	NES	NES
Degree of natural plant regeneration occurring and range of age cohorts present	NES	NES
Presence of habitat specific to the requirements of selected species	NES	
Condition and diversity of terrestrial and waterbody habitat		NES

Attributes	Baseline condition assessment	Monitoring
Flora monitoring		
Abundance of reproductive populations of selected flora (native and exotic)		Other
Successful revegetation		NES
Fauna monitoring		
Superb Parrot population abundance and habitat utilisation		NES
Woodland bird monitoring	Other	
Frogwatch		Other
Physical attribute monitoring		
Erosion and soil condition		Other
RARC Rapid Assessment of Riparian Condition (Jansen *et al*. 2005) (if urban impacts on the Molonglo River warrant monitoring)		Other
Biomass to guide implementation of biomass control		Other

4.2.1 Objectives of baseline assessment, monitoring and evaluation in the Guidelines area

Baseline assessment

- Identify the diversity of plant species present in each conservation area.
- Identify the diversity of habitat present and likelihood of utilisation by threatened species.
- Identify the ecological condition of each conservation area against benchmarks for that vegetation type (NSW DECCW 2011).
- Identify issues that require management intervention (e.g. rabbit disturbance, dumping, erosion) in each remnant and patch to guide the development and implementation of operational plans).
- Use the information from the assessment to
  - identify a strategic conservation goal and desired outcomes for the conservation area.
  - assist in the identification of actions required to manage the conservation areas for conservation (e.g. fencing or revegetation requirements) for development of operational plans.
  - identify what should be monitored to meet the desired outcomes.
- Identify the population abundance and distribution of Superb Parrot, Swift Parrot and Pink-tailed Worm-lizard in the conservation areas.
- Identify the abundance and condition of the specific habitat features that are critical to these MNES fauna species' survival.

Monitoring

- Measure changes in the condition of habitat and species diversity and dynamics in selected sites within the conservation areas against benchmarks for that vegetation community.
- Advise the operational plans, by identifying issues that may need addressing in the short-term.
- Measure changes in the condition of habitat for the MNES fauna species, and the species' population dynamics.

Evaluation of monitoring data

- Analyse the data from the monitoring in order to identify changes against the desired outcomes of the management applied.
- Determine whether management needs to be modified or changes to land use applied in the conservation areas.
- Advise on requirements to modify management practices and land use to achieve conservation objectives for the MNES fauna species.

4.2.2 Recommended process for monitoring for adaptive management

The following process is recommended for applying the adaptive management outlined in the Adaptive Management Strategy (ACT Government TAMS 2013).

1. For vegetation, develop a procedures manual for baseline condition assessment and monitoring methods which will be peer reviewed.
2. Undertake baseline condition assessment of vegetation in all management areas to provide a benchmark of the condition of the site, and to assist in identifying issues and developing operational plans to meet conservation objectives.
3. Identify conservation targets for each management area.
4. Identify monitoring requirements to measure whether conservation and management objectives and targets are being met in each management area. Monitoring should be based on methods appropriate for collecting data to answer specific questions.

5. Establish an adequate number of replicate plots, including control plots, so the vegetation data collected can be statistically analysed to identify causes of any changes measured.
6. Monitor annually at times appropriate for each species and community and for the elements being monitored.
7. Review the management applied in the previous year in relation to the results of the monitoring.
8. Annually assess issues present in the management areas and implement changes to management if required.
9. Review the results after three years.
10. Every five years analyse the data and review the management applied, and review the monitoring program.
11. Review the results in terms of best practice management (adaptive management): e.g. fire frequency, establishment of revegetation. The review should be prepared by an expert ecologist, and peer reviewed by an independent third party.

4.2.3 Overview of methods for use in Molonglo River Reserve and offsets

Monitoring methods for vegetation in the Guidelines area have been developed (Sharp and Milner 2014), based on the outcomes of the baseline assessment, the identified management actions to be applied, and likely impacts (e.g. intensity of visitation, encroachment of urban areas, fragmentation of patches and implementation of bushfire mitigation operations). The methods (e.g. Table 4.2) and the final design are derived from standardised published methods and have been reviewed by expert groups, according to requirements in the NES Plan, to ensure the most effective methods to measure changes over time are applied in the most effective locations. See s.4.2.5–s.4.2.8 for methods for monitoring fauna.

The indicators recommended to be used in Molonglo (Sharp and Milner 2014) meet the following criteria.

- They are currently in use at other sites in the ACT and elsewhere.
- They have been scientifically reviewed and are robust and repeatable and provide useful data.
- Methods to measure the indicators are fully explained, recording sheets are available, and spreadsheets have been designed so that as data are entered simple summaries and statistical results are automatically produced.
- They cover the range of issues that need to be measured.

It may be relevant to add to the monitoring program over time, if, for example, an area is burnt and lends itself to monitoring recovery for particular species; new species are discovered that may require monitoring; or management actions identify particular issues that may require monitoring. It is not recommended, however, to cease monitoring the core attributes or to change the methods used, because that will negate the value of the data already collected.

Restoration programs, and invasion by weeds, will need to be monitored using methods in the monitoring procedures manual (Sharp and Milner 2014), to check on the effectiveness of:

a) techniques used in establishing vegetation and/or habitat features;

b) survival of the species revegetated (or success of plantings);

c) utilisation of the restored area by native fauna and flora.

For both fauna and vegetation, specific questions arise from data gathered in a baseline assessment. Typical questions may test policy and resource management decisions (Lindenmayer and Likens 2010). Table 4.3 shows examples relevant to the Molonglo River Reserve and offsets.

Table 4.2. Methods for assessment of baseline condition and monitoring to be applied within the Molonglo River Reserve and offsets.

Level	Condition to be assessed	Proposed methods to be used for baseline condition assessment	Proposed timing or methods to be used to monitor condition
Landscape	Vegetation clearing and enhancement; development of tracks; erosion.	Interpretation of aerial photography using ADS40 imagery and comparison with previous images.	Repeat every five years.
Patch or management area	Description of vegetation associations, condition and health of the overall management area.	Mapping of the management areas. Description of the management areas, including overall survey of vegetation units within the areas (presence of plants, habitat features and identification of management issues; based on Sharp and Gould 2014).	Review issues present (annually).
	Identify actions required to strengthen the resilience of the MNES values at the remnant level (e.g. linking patches; planting requirements).	Develop a list of recommended management actions.	Review actions required (annually).
Representative plots within each patch or management area	Quantitative condition assessment based on plant diversity and abundance, presence of significant plant species, habitat condition and diversity.	Baseline condition assessment methods in Sharp and Milner 2014. Biomass (ACT Government unpublished). Riparian condition (Jansen *et al*. 2005).	Monitor vegetation and habitat condition against benchmarks identified in baseline assessment as management changes are implemented. Monitor revegetation projects. Monitor impacts of fire fuel management in patches within the Outer Asset Protection Zones in regard to maintenance of condition.
	Quantitative assessment of population abundance and distribution of selected species.	Initial assessment of populations of threatened species: Woodland bird survey (e.g. Bounds *et al*. 2010; Taws 2012, 2013; Taws *et al*. 2012) Pink-tailed Worm-lizard (Osborne and Wong 2010, 2012) Superb Parrot (e.g. Davey 2011, 2013b).	Species requiring monitoring to measure change related to implementation of management actions and other impacts (species to be determined after baseline assessment). Frogwatch (Mantle 2008).
	Quantitative assessment of landscape function: soil surface condition; drainage; e.g. as a result of bushfire operations, changes to management and habitat modification.	Landscape function analysis (Tongway and Hindley 2004; Tongway and Ludwig 2011). Drainage line stability (Tongway and Ludwig 2011).	Landscape function analysis and drainage line stability. Biomass (ACT Government, unpublished). Waterwatch (http://www.act.waterwatch.org.au).

Table 4.3. Possible questions for monitoring the ecological values.

Questions	Sub-questions	Methods	Products
Habitat			
What is the change in condition of the vegetation?	What change has occurred compared to the baseline condition in each patch? What change has occurred against ACT benchmark sites? Can the change be attributed to particular methods of management, e.g. ecological burns?	Condition assessment of attributes, including species richness and diversity, groundcover, habitat features.	Quantitative data from replicate sites to assess change.
What are the microhabitat characteristics in management areas?	What habitat damage can be attributed to the presence of pest animals?	Condition assessment to quantify microhabitat characteristics per site.	Maps of microhabitat characteristics to identify high quality heterogeneous habitat, to inform a broad management approach (habitat vs species).
What are the temporal patterns of various microhabitat characteristics?	Do aspects of development (human recreation, roads, housing, etc.) have an effect on the habitat quality of a given area (based on microhabitat heterogeneity)? How do management activities (e.g. weed removal) affect the habitat quality of a given area?	Condition assessment to quantify each microhabitat characteristic per site. Habitat quality changes may be correlated to other changes e.g. human use.	Maps of microhabitat characteristics to show expansion/contraction. Locations of areas that require habitat management. A picture of how habitat quality changes over time.
Do habitat quality results reflect diversity and abundance of species assemblages?	Is there a correlation between habitat quality, as perceived by humans, and biodiversity?	Statistical analysis of species suite datasets.	Information for evaluating effectiveness of survey and management.
Species suites			
What are the distribution, composition and/or abundance of species assemblages? How are the distribution, composition and/or abundance of species assemblages changing over time?		Area search Habitat search Long-term artificial shelter Nocturnal survey: spotlight.	Analyses providing evidence of changes in abundance and distribution.
Are there identifiable 'hotspots' that are used consistently by feeding, roosting or travelling congregations of migratory species (and are the hotspots consistent over time)?		Area search bird surveys. Statistical analysis of datasets.	Areas identified for special management.
What are the distribution and abundance of exotic and pest species (birds, mammals, bees)?		Range of techniques specific to the species in question. Trends may be correlated to other changes, e.g. management activities.	Locations of areas that require habitat management.
Species-	**Target species**		
Are Superb Parrots using hollow-bearing trees at this site for breeding?	Superb Parrot	Population counts; habitat tree evaluations.	Datasets for analysis. Locations of areas that may require habitat- or special management.

Questions	Sub-questions	Methods	Products
Is the reporting rate for ... in ... (e.g. Kama) changing over time? (e.g. is there a trend?).	Superb Parrot, Swift Parrot, Pink-tailed Worm-lizard, Rainbow Bee-eater	Trends may be correlated to other changes, e.g. management activities.	A picture of how habitat quality for the species has changed over time.
Has Pink-tailed Worm-lizard habitat been disturbed?	Pink-tailed Worm-lizard	Correlate changes to, e.g., visitation and population fluctuation in a range of habitat areas in and away from developed areas.	A picture of how habitat quality for the species has changed over time.

4.2.4 Wider objectives

Monitoring will ideally aim to achieve a wider set of purposes than those set out in the NES Plan. These wider objectives may include measuring the:

- effectiveness of weed control, undertaken in accordance with the ACT Weeds Strategy (ACT Government DECCEW 2009);
- effectiveness of pest control, undertaken in accordance with ACT Pest Animal Management Strategy (ACT Government ESDD 2012a);
- impacts on species listed as threatened under ACT legislation, and other Special Protection Status species, for example the Little Eagle, Rainbow Bee-eater and Pale Pomaderris;
- occurrence of particular species groups, including bats, reptiles or mammals;
- changes in the condition of habitat and species diversity and population dynamics against benchmarks for that habitat or vegetation community;
- and identifying issues that may need addressing in the short-term via the operational plans.

4.2.5 Methods for monitoring fauna

Pink-tailed Worm-lizard and Superb Parrot and Swift Parrot are to be monitored as indicated in the NES Plan (ACTPLA 2011). Each species requires the application of particular methods.

Other threatened woodland birds and populations of threatened or significant flora groups may require monitoring, especially those that are particularly sensitive to human occupation. Other species may be surveyed if opportunities or issues arise. Ideally, community volunteers will take part using standard programs for entities such as frogs (Frogwatch), water quality (Waterwatch), vegetation condition (Vegwatch; Sharp and Gould 2014), birds (surveys by Canberra Ornitholigists Group (COG)) and platypuses (Platypuswatch).

Flora and fauna population dynamics are unlikely to be sufficiently elastic for changes to be detected in the short-term. Some species exhibit time lags in their responses to habitat changes (Garden *et al*. 2006). Other species are long-lived and population effects may not show up over long periods (masking effects of changes such as urban development or conservation initiatives). Additionally, species monitoring can be costly and it may be difficult to monitor species populations. Monitoring may have an impact on the habitat on which the species depends. This includes repeated lifting of rocks to monitor Pink-tailed Worm-lizard populations, an issue that is discussed further below.

Determining which species is the appropriate one to monitor should be based on the questions being asked (Lindenmayer and Likens 2010; Table 4.3). For example, for monitoring to meet the obligations of the NES Plan, suitable questions could include:

- Are Superb Parrot/Pink-tailed Worm-Lizard breeding in known habitat?
- Is the reporting rate for Superb Parrot/Pink-tailed Worm-Lizard in ... (e.g. Kama) changing over time? Is there a trend?

Species suites rather than individual species may be monitored, for example, the diversity and abundance of woodland birds. Suitable questions may include:

- Does the abundance of ground-foraging birds increase over time in restored woodland at Barrer Hill?

Where species monitoring is undertaken it must be made clear that results reflect effects upon that species only and do not provide a surrogate measure for other species (Lindenmayer and Likens 2010). In such circumstances, basing management decisions around a single species or small group of species may actually negatively affect others.

Existing and ongoing fauna and fauna habitat surveys

Native fauna surveys should use standard survey methods, which are available from various sources and can be applied in many situations in the Molonglo areas. Where possible native fauna monitoring should tie-in with existing survey programs, such as:

- the Canberra Ornithologists Group Woodland Bird Monitoring Project, which uses a 0.8 ha 10 minute area search method (Bounds *et al*. 2010; Taws *et al*. 2012). It is readily repeatable, gives an accurate coordinate for the centre of the site, already has algorithms developed for analysing data, and can be compared to the existing Woodland bird surveys. The project has been running since 1996. Data collected are robust and have been used to analyse trends in species richness and relative abundance, among other things. Nine sites are located within Kama, and there may be an opportunity to incorporate additional sites within the river valley into this program.
- general reptile surveys, using the 30-minute habitat search method recommended by NSW Office of Environment & Heritage (NSW DEC 2004).
- nocturnal native mammal surveys, using spotlighting methods recommended in Survey Guidelines for Australia's Threatened Mammals (Australian Government Department of the Environment 2011).
- Molongo River water quality monitoring by the Molonglo Catchment Group (a sub-group of Upper Murrumbidgee Waterwatch) who measure parameters such as water temperature, turbidity and dissolved oxygen. There is a monitoring site at Coppins Crossing in the valley.
- Frogwatch surveys which provide information about amphibian diversity and abundance.

Fish surveys have specific licensing requirements and are too technical for community groups (S. Skinner, Molonglo Waterwatch Co-ordinator pers.comm. 14 June 2012). For example, dip netting is not recommended for species such as Macquarie Perch because they are difficult to catch; instead electro-fishing is used (Australian Government Department of the Environment n.d.-e). The most recent survey in the Molonglo River below Lake Burley Griffin was in 2009 (L. Evans, Senior Aquatic Ecologist, ACT Government pers.comm. 14 June 2012) by the ACT Government (Conservation Planning and Research). The results of this survey would provide a suitable baseline for fish species assemblage and abundance. A repeat survey using the same methodology may be appropriate again in five or more years following habitat management along the riparian zone; it is thought that more regular surveys would not yield useful data (L. Evans, Senior Aquatic Ecologist, ACT Government pers.comm. 14 June 2012).

Linking with existing monitoring projects in and adjacent to the Molonglo area should provide 'control' or 'before' sites, enabling BACI or BA monitoring. Other benefits of linking with existing monitoring include:

- access to existing long-term data;
- a comparable and standard dataset (assuming use of the same methodology for collecting data);
- longevity of monitoring, because resourcing commitments will be shared across multiple organisations, including community organisations;
- involvement of the public in environmental monitoring, where appropriate;
- efficiency of monitoring.

If baseline assessment and monitoring of fauna in the Molonglo River Reserve and offsets uses the same methods, at the recommended seasons (Table 4.4), it should be possible to gain significant insight into the outcomes of management across a range of vegetation types and condition states.

Table 4.4. Recommended seasons for assessment and monitoring.

Assessment	Date, season
Baseline condition assessment	November to January
Habitat monitoring	Annually in spring; some measures may be repeated in autumn
Woodland birds monitoring	Four times a year (in each season), at the same time as the COG woodland birds program monitoring
Bird blitz	Twice a year, autumn and spring, at the same time as the COG bird blitz
Targeted Superb Parrot monitoring and survey	September to January annually
Targeted Pink-tailed Worm-lizard abundance monitoring Other reptiles monitoring	Regular
Targeted Pink-tailed Worm-lizard habitat monitoring	Annually in spring
Frog monitoring co-ordinated with the regional program	October–November annually during the Frogwatch census

Species habitat monitoring

Habitat monitoring can be used instead of, or to enhance, individual species monitoring. Specific parameters for fauna habitat can be incorporated into standardised vegetation condition assessments. The criteria will arise from the questions at the core of the monitoring program and surveys as discussed below.

The fauna habitat assessment parameters suggested in Table 4.5 are based on a number of existing guidelines and survey method reviews (Bauer and Ralph 1999; NSW DEC 2004; Garden *et al*. 2006; Mitchell and Balogh 2007a,b,c,d,e).

Table 4.5. Qualitative, quantitative and semi-quantitative habitat parameters for measurement to answer proposed monitoring questions.

Parameter	Type	Provides information about ...	
Terrestrial habitat		**Habitat quality**	**Threatening processes**
Number of hollows, hollow-bearing trees (hbt) and standing dead trees per transect/quadrat (e.g. 4 hollows, 2 hbt, 1 standing dead tree)	Quantitative	✓	
Number of hollows with bees	Quantitative		✓
Extent of fallen timber and logs (metres)	Semi-quantitative	✓	
An index of structural complexity (low, moderate, high)	Qualitative	✓	
Type and extent of rock (% of ground surface)	Semi-quantitative	✓	
Evidence of surface rock disturbance (% of total rock)	Semi-quantitative	✓	✓
Presence of important key flora feed species (e.g. mistletoe, *Casuarina*) (%)	Semi-quantitative	✓	
Evidence of pest animals species:			
– Patches of bare ground (%)	Semi-quantitative		✓
– Tracks, scats and signs including diggings and evidence of vegetation browsing (at what height)	Qualitative		✓
– Identification of species from track, scat or sign			
– Indication of extent (e.g. number or area of digs per transect/quadrat)			
–Number of warrens / burrows / dens per transect or quadrat	Quantitative		✓
Number of bird nests by type (e.g. scrape, mound, burrow, cup, saucer, platform, pendant, sphere) excluding hollows	Semi-quantitative	✓	
Aquatic habitat			
Channel morphology (type)	Qualitative	✓	
Substrate type	Qualitative	✓	
Pool:riffle ratio	Quantitative	✓	
Pool frequency (number of pools/100 m)	Quantitative	✓	
Mean residual depth of pools (cm)	Semi-quantitative	✓	
Extent of large woody debris (LWD) (e.g. frequency LWD/100 m)	Semi-quantitative	✓	
Extent of aquatic vegetation	Qualitative	✓	✓
Evidence of actively eroding banks (% that are stable)	Semi-quantitative		✓
Percentage fines and sands (%)	Semi-quantitative or Quantitative		✓
Percent overhanging vegetation (proportion of shaded to non-shaded)	Semi-quantitative	✓	
Water quality parameters including turbidity, temperature, flow velocity and dissolved oxygen content	Quantitative	✓	✓

Habitat monitoring can be boosted by monitoring species *suites* rather than individual species: for example, monitoring the diversity and abundance of woodland birds (this would include small ground-hunting birds, honeyeaters) or raptors.

Monitoring needs to include time as a dimension. Long-term monitoring is the most informative, particularly as some species exhibit time lags in their responses to habitat changes (Garden *et al*. 2006). For habitat surveys to be useful in a long-term monitoring program, the parameters measured need to be as quantitative as possible.

Surveys need to adequately consider the presence of microhabitat attributes that are important for fauna, including (see also Table 4.5):

- litter,
- woody debris,
- rocky outcrops, and
- tree hollows.

Standard vegetation surveys do not usually adequately consider those microhabitat features.

4.2.6 Pink-tailed Worm-lizard habitat assessment and monitoring

There are no ACT monitoring programs currently in place for the Pink-tailed Worm-lizard. Field procedures for habitat evaluation have been developed (Wong and Osborne 2010), and baseline assessment of lizard habitat has guided planning and management decision making at sites in the ACT (Osborne and Wong 2010, 2012).

Mapping lizard habitat is relatively simple. It involves describing landform, geology, vegetation (dominant plant species) and habitat condition, via:

(i) low-level (high resolution) remote-sensed imagery capable of allowing for the mapping of rocky terrain, coupled with GIS data to delineate likely habitat;

(ii) mapping, completed on the ground by examining all areas of potential habitat and mapping these with the assistance of a GPS, directly onto aerial photographs;

(iii) evaluation of the habitat condition and the actual boundary of each patch by checking the extent of rock areas, searching for plant indicator species and assessing the extent of disturbance.

Osborne and Wong used habitat mapping, followed by direct searching for lizards, to reassess populations of Pink-tailed Worm-lizard in the Mt Taylor Reserve in the ACT in 2012. The survey repeated one carried out 20 years earlier (1993) by Osborne and McKergow (Osborne and Wong 2012). If continued at regular intervals, such comparisons could constitute monitoring.

In the successful re-survey at Mt Taylor, Osborne and Wong first mapped habitat quality over the entire reserve. Then 44 survey sites were authoritatively chosen based on aspect and tree cover and ranked habitat condition. These sites were surveyed by hand-searching beneath a minimum of 500 stones per site (as recommended by probability of detection modelling; from Jones 1999). Comparison of the records from the two surveys indicated that there has been little change in the distribution and abundance of the species (Osborne and Wong 2012).

The (draft) National Recovery Plan for the Pink-tailed Worm-lizard (Brown 2009) suggests that searching beneath rocks is not an appropriate method for monitoring. The plan recommends that the technique should only be used once at a site, unless the disturbance that this causes can be mitigated.

Unfortunately, there is no validated alternative to the technique of searching beneath rocks as an approach to monitoring the species. Hand-searching disturbs the habitat (by loosening rocks and disturbing both the ants and any lizards found). In the past some specimens have been caught in reptile pitfall traps (Rauhala 1993), but the difficulty of establishing pitfall traps with drift fences in rocky terrain effectively precludes this approach. Moreover the technique is very labour intensive, requires many weeks of on-going daily checking of traps, and results in extensive disturbance to the habitat — a level of difficulty unlikely to lend itself to a long-term program of monitoring. It is therefore important that a less invasive procedure is developed.

A trial of artificial cover objects is recommended in the draft national recovery plan (Brown 2009) as an approach to monitoring the species. It is very likely that artificial substrates (i.e. alternative substrates such as bricks, concrete blocks or roof tiles placed on the ground to mimic natural rocks) could be used as an alternative to the turning of rocks. These alternative cover objects could be designed to replicate the average dimensions of rock preferred by the species (see Wong *et al.* 2011). The advantage of the artificial substrates is that they can be placed flat on the ground and should be easier to turn over and put back in place, and should cause less disturbance.

The ACT Government will establish a program of long-term monitoring to measure the response of the Pink-tailed Worm-lizard and their habitat at selected sites that are close to the suburbs that are being constructed near the Molonglo River Reserve. Control sites will also be monitored at remote sites. Before being fully implemented, the monitoring program will include an assessment of a suitable low impact technique such as the one outlined above. Monitoring will include estimates of lizard abundance as well as measurement of key habitat variables (Table 4.6).

Table 4.6. Habitat variables to be measured annually at selected sites during a long-term monitoring program for Pink-tailed Worm-lizard.

Variable	Measurement
Disturbance to rocks	Number of dislodged rocks
Relative abundance of small ants	Presence/absence of active ant nests under 50 stones or artificial cover objects
Dominant grasses	Percentage cover
Shrubs greater than 1 m tall	Percentage cover
Tree canopy directly over site	Percentage cover
Bare ground	Percentage cover
Key indicator plants (see Table 4.7)	Checklist presence only
Weeds	Percentage cover of species that contribute to greater than 20% of the vegetation cover on the site

Measurement of cover for each variable can be made using transect intercept methods similar to those used in monitoring vegetation (Sharp and Gould 2014). Details will be developed in a full plan for monitoring.

The monitoring program for the Pink-tailed Worm-lizard and its habitat will operate within a broader adaptive management framework. Monitoring will be conducted at sites that occur within the Molonglo River Reserve near areas that are being developed as new suburbs and in control sites well away from urban areas (further downstream in the river valley). Monitoring will involve treatments (proximity to residential areas) and replication (at least five sites per treatment). If the monitoring results indicate a decline in lizard numbers that is greater than experienced at control sites then the monitoring program should be capable of identifying plausible reasons for that decline. A decline might be caused by factors such as increased occurrence of weeds, increased shading from adjacent tree growth of construction of facilities, and/or disturbance to rocks.

When management has been applied to reduce the level of these threats there should be further monitoring to evaluate their success.

Table 4.7. A checklist of groundlayer plants indicative of relatively little disturbance to an area.

Grasses/graminoids	Forbs	Forbs continued	Low or procumbent shrubs
Aristida ramosa	*Ajuga australis*	*Hydrocotyle laxiflora*	*Acrotriche serrulata*
Cymbopogon refractus	*Asperula conferta*	*Isoetopsis graminifolia*	*Astroloma humifusum*
Poa sieberiana	*Asplenium flabellifolium*	*Leptorhynchos squamatus*	*Brachyloma daphnoides*
Sorghum leiocladum	*Astroloma humifusum*	*Luzula* sp.	*Cryptandra amara*
Themeda triandra	*Bulbine bulbosa*	*Opercularia hispida*	*Dillwynia retorta*
Dianella revoluta	*Cheilanthes distans*	*Plantago varia*	*Dillwynia sericea*
Dianella sp.	*Cheilanthes sieberi*	*Polygala japonica*	*Hibbertia riparia*
Lomandra bracteata	*Chrysocephalum apiculatum*	*Poranthera microphylla*	*Hovea heterophylla*
Lomandra filiformis	*Desmodium varians*	*Stackhousia monogyna*	*Leucopogon* sp
Lomandra longifolia	*Epilobium billardierianum*	*Stellaria pungens*	*Lissanthe strigosa*
Lomandra multiflora	*Eryngium ovinum*	*Stypandra glauca*	*Melichrus urceolatus*
Lomandra sp.	*Galium gaudichaudii*	*Tricoryne elatior*	*Mirbelia oxylobioides*
Luzula sp.	*Glycine clandestina*	*Triptilodiscus pygmaeus*	*Monotoca scoparia*
	Glycine tabacina	*Velleia paradoxa*	*Pultenaea procumbens*
	Gonocarpus tetragynus	*Viola betonicifolia*	*Phyllanthus hirtellus*
	Goodenia hederacea	*Wurmbea dioica*	*Pimelea curviflora*
	Coronidium scorpioides syn. *Helichrysum scorpioides*		

Table 4.8. Schedule for bird monitoring surveys: species and months, highlighting MNES parrots.

Bird group	J	F	M	A	M	J	J	A	S	O	N	D
Superb Parrot										X	X	X
Swift Parrot					X			X				
Woodland (Kama)			X			X			X			X
Raptor							X	X	X	X	X	X
Rainbow Bee-eater											X	X
Waterbirds	X										X	

4.2.7 Monitoring birds in Molonglo River Reserve and offsets

As discussed above, methods for use in baseline assessment and monitoring of bird fauna in the Molonglo River Reserve and offsets should follow practices and timing established by the Canberra Ornithologists Group (COG; s.4.2.5, Table 4.4, Table 4.8).

Superb Parrot

Baseline assessment of the breeding activity of the Superb Parrot within the Molonglo River valley occurred in 2012 and 2013 (Davey 2013a; Eco Logical Australia 2014). These surveys covered key Box-Gum Woodland habitat within the Molonglo River Reserve and offset areas as well as an area of rural leasehold land known as Central Molonglo adjacent to Kama.

Within the offset areas, Spring Valley Farm was identified as important breeding habitat, particularly the NES patch known as M1 (see s.2.2.3 and Map 1.2). Central Molonglo was identified as the core breeding area. Superb Parrots were observed within the adjacent Box-Gum Woodland of Kama, but not breeding there. The surveys identified a number of trees definitely used for breeding and others which were potential nest trees. Superb Parrots are known to return to the same nest hollow in subsequent years (Manning *et al*. 2004).

A full survey of breeding activity of the Superb Parrot would be resource intensive. The birds are secretive near the nest and it can take many hours of observation to confirm one nest.

In monitoring for the Superb Parrot, one objective should be to observe threats to the nest trees and hollows. Threats could include fire, firewood removal, and competition for the hollows from other fauna, both native and non-native. For example, any observations of feral Honeybees should be noted.

Monitoring should concentrate on the known breeding areas in Spring Valley and Central Molonglo (Davey 2013a; Eco Logical Australia 2014). Surveys carried out annually using the same methods as are used for the monitoring Superb Parrot breeding activity in Throsby (Davey 2013b) would confirm the species' ongoing use of the Molonglo areas and assess the level of competition for nesting hollows. The Throsby surveys follow established transects through the breeding area, four times during the season. They record Superb Parrot breeding activity as well as that of competitor species including Galah, Corella species, Crimson Rosella, Eastern Rosella, Red-rumped Parrot and Common Myna. Although Davey (2013b) did not consider the Common Starling to be a competitor with the Superb Parrot for hollows, observations of aggression between these two species (Taws 2001) suggest that it should be included.

Swift Parrot

The Swift Parrot is nomadic, and its occurrence in this region is reliant on the presence of suitable food sources, which vary from year to year. Records of the species are usually a result of chance observations or incidental to other surveys, such as the COG woodland bird survey. Effective survey and monitoring of a species with such an unpredictable occurrence is difficult.

There are ongoing annual surveys for the Swift Parrot in its winter habitat. Volunteers monitor occurrence of the parrot over two survey weekends in May and August, coordinated by Birdlife Australia (http://birdlife.org.au/projects/woodland-birds-for-biodiversity).

In the Molonglo River Reserve, the most effective monitoring for the species, from a national perspective, would be to survey the Box-Gum Woodland threatened habitat, during these same two periods. Even if no Swift Parrots were seen, the volunteers could monitor all other bird species observed at the time, providing useful information for management in the Guidelines area as a whole.

Woodland birds

The Canberra Ornithologists Group (COG) Woodland Bird Monitoring program (Bounds *et al*. 2010) encompasses 14 locations in lowland woodlands in the ACT including Kama, and there are up to nine survey sites in each location. Surveys are conducted quarterly and provide high-quality consistent long-term monitoring data for woodland birds.

If resources and personnel were available it would be valuable for the COG program to include more monitoring locations in the Molonglo River Reserve and offsets, such as Spring Valley Farm (offsets I, L, M, P), Barrer Hill (offset T1 in Molonglo River Reserve) and West Molonglo (in western Belconnen). Bird data from other Box-Gum Woodland areas of the Molonglo River Reserve and offsets are relatively sparse and opportunistic. They are useful for documenting bird distributions and some breeding records, but they are not useful as baseline assessment data, for assessing long-term changes.

Some other bird species, including rare species and raptors, are not adequately monitored by the point-count method of these COG surveys.

Raptors

For raptors, monitoring surveys should look for active nests. This method is more reliable than standard bird observation data for determining the status of raptor species. For example, numbers of observations of the threatened Little Eagle have remained fairly stable over a period when the number of active nests has declined dramatically (Debus *et al*. 2013).

Surveys of active nests of several raptor species in the ACT over a number of years (Olsen *et al.* 2012a,b) have yielded valuable data that are not necessarily reflected in general reporting rates for the species. This annual assessment needs to continue through the wider Molonglo River Reserve and offsets, and in other parts of the ACT.

Eagles generally breed from July to December in the ACT. The Little Eagle lays eggs in late August–early September and fledges young in December. The White-bellied Sea-eagle breeding season runs from August to December, and the Wedge-tailed Eagle begins egg-laying in July–August and continues to November–December (Olsen and Fuentes 2004).

Radio-tracking studies of Little Eagles are urgently needed, to determine home-range size and habitat use. The Little Eagle territory in the Molonglo River Reserve is, in some years, the only successful breeding territory in the ACT (Olsen *et al*. 2012a,b). This pair uses nest sites that can be up to 5 km away from the nest sites of previous years, and the birds appear to travel long distances to find food (Olsen *et al.* 2013).

With the rapid urban development planned for the Molonglo Valley it is critical that the habitat needs of this pair are investigated before the Little Eagle is lost as a breeding species in the ACT.

Rainbow Bee-eater

Baseline assessment of the Rainbow Bee-eater breeding population in 2013 (Taws 2014) identified a small but successful breeding colony on the righthand side of the Molonglo River 1 km upstream of the old sewage ponds (Sludge pits, ACT Government MP 2014), between Deep Creek and Coppins Crossing. Other nest sites were found in road cuttings near Coppins Crossing and Barrer Hill. All these areas are experiencing increasing levels of disturbance from construction activities, weed control works and human activity.

Rainbow Bee-eaters return each year to the same nesting area (Boland 2004). It will be important to monitor the nesting sites to determine whether the species is able to continue breeding successfully despite the encroaching disturbance.

Waterbirds

In the Molonglo River Reserve, the only breeding site for Darter and Cormorant species is 500 metres downstream of Tuggeranong Parkway. The birds can be found along the river both upstream and downstream of here, fishing in the deeper reaches and pools, and drying their wings on suitable perches.

The breeding site should be monitored on a biennial basis to determine whether the birds continue to nest there. Monitoring may need to be more frequent if there is a major disturbance such as flood or fire, or if there is a change to the vegetation around the site such as planting of native species and removal of some of the introduced species. Breeding generally occurs between October and May with numbers, breeding success and duration depending on local conditions (Canberra Ornithologists Group database). A breeding survey may need to be undertaken in more than one month during this period to cover the variable breeding season.

4.2.8 Monitoring pest animals

Regular surveys (such as by methods in Table 4.9) are important for quantifying the diversity, abundance and extent of pest animals and their effects, and detecting the effectiveness of habitat management and pest control programs. Choice of survey methods will depend on the resources available and whether these surveys can be linked to other ongoing monitoring programs (ACT Vertebrate Pest Management Operations Plans e.g. ACT Government PCS 2011b).

Table 4.9. Direct and indirect survey techniques for measuring the abundance and distribution of pest animal species in aquatic and terrestrial habitats.

Survey technique	Resource input	Efficacy	Target species					
			Fox / Dog	Pig	Deer	Rabbit	Bees	Fish
Baiting	High	High	✓					
Remote cameras	Moderate	Moderate	✓	✓	✓			
Sand plots (tracks)	Moderate	Low	✓					
Sight counts (diurnal)	Low	Moderate				✓	✓	
Sighting reports	Low	Low	✓	✓	✓	✓		
Spotlighting (nocturnal)	Low	Low	✓	✓	✓	✓		
Track, scat and sign searches	Moderate	Moderate	✓	✓	✓	✓		
Trapping	High	Moderate	✓	✓		✓		
Warren/burrow/den/hollow counts	Low	Moderate – High	✓			✓	✓	
Angler catch reports	Low	Low						✓
Electro-fishing	High	Moderate						✓
Changes in vegetation cover	High	Low		✓	✓	✓		
Mapping habitat damage	High	Moderate		✓	✓	✓		
Monitoring abundance of prey/ competition species	High	Moderate	✓			✓		
Seedling loss	Low	Moderate				✓		

Sources: deer — Locke 2007; dog, fox, pig, rabbit — Mitchell and Balogh 2007a,b,c,e.

Peregrine Falcon
Falco peregrinus macropus

5. LEGISLATION, ZONING AND PREVIOUS SURVEYS OF MOLONGLO RIVER RESERVE AND OFFSETS

5.1 Legislation

5.1.1 Government plans and policies apart from the NES Plan

The Territory Plan has policies relevant to the River valley, in particular Part B13: River Corridors Land Use Policies, which provides for the protection and enhancement of riparian vegetation and implementation of environmental flows. The Canberra Spatial Plan states that major river corridors that create the main links for wildlife movement and connect into natural areas south and west of the Murrumbidgee River will be protected as wildlife corridors.

The ACT Natural Resource Management Plan 2004–2014 includes the objective of conserving and rehabilitating native riparian vegetation adjacent to plantations, public and rural lands with a priority focus on threatened species habitat and fire-affected land.

The Ribbons of Life: ACT Aquatic Species and Riparian Zone Conservation Strategy Action Plan No. 29 (ACT Government 2007) has the goals of conserving aquatic and riparian native vegetation communities and, where degraded, rehabilitation to support the range of flora and fauna typical of the ACT.

The Lower Molonglo River Corridor Nature Reserve Plan of Management provides for the conservation and protection of dryland, riparian and aquatic ecosystems and habitats in the Reserve.

Draft Concept Plan for the Molonglo River Park

The draft and final Concept Plans for the Molonglo River Park (Hassell 2011, 2012) accommodate features and developments which would potentially affect vegetation communities in the Molonglo River Park directly, as in these examples (from Hassell 2011).

- A 50 metre wide Inner Asset Protection Zone and 100 metre wide Outer Asset Protection Zone adjacent to the Coombs development.
- Strategic fire protection zones at Misery Point and an area downstream of Coppins Crossing, characterised by good vehicle access and reduced fuel levels.
- A major recreation node and Visitor Centre at Coppins Crossing.
- 'Pool Park' and 'Riverside Park' near Coppins Crossing, and several local parks.
- A network of walking tracks ('Minor paths, 1.2–1.8 metres wide, unsealed/boardwalks') and management roads.
- Canoe access points at Coppins Corner and Riverside Park.
- Low level vehicle and pedestrian river crossings at regular intervals, which include culverts similar to the existing Southwells Crossing or bridges, and informal stepping stone crossings.

Other existing ACT and Commonwealth Government plans and policies

A number of existing ACT Government and Commonwealth Government plans and policies relate to the Molonglo River Reserve and offsets. In common, these plans aim to conserve aquatic, riparian and terrestrial native flora, fauna and ecological communities and their connectivity. This includes goals to both maintain and rehabilitate native ecosystems. Key actions in the plans and policies include monitoring, management and implementation planning and the preparation of best practice management plans. Many of the plans also aim to provide for appropriate low-impact recreational, tourism and scientific opportunities and allow for effective fire protection.

White Box – Yellow Box – Blakely's Red Gum Grassy Woodlands and Derived Native Grasslands. SPRAT profile (Australian Government Department of the Environment n.d.-a) contains the listing advice, conservation advice and policy statement for the critically endangered ecological community. The advice includes a flowchart describing the lowest condition at which patches are included in the listed ecological community.

ACT Government 2004b. Woodlands for Wildlife. ACT Lowland Woodland Conservation Strategy. Action Plan No. 27. This is a statutory document that directs maximum effort be put into the protection, management and restoration of Box-Gum Woodland and other woodlands in the ACT. It provides information on management and threats, and presents a strategy for conservation.

ACT Government EA 1999. Canberra Nature Park Management Plan (currently under review) provides objectives that are also relevant for managing Kama and the land beside the Molonglo River downstream of Kama:

- Conserve and improve native plant and animal communities and maintain biodiversity and ecological processes.
- Conserve features of cultural, geological, geomorphological and landscape significance.
- Protect Canberra Nature Park (CNP) and adjacent areas from the damaging effects of fire, erosion, pollution, pest plants and animals or other disturbances.
- Ensure appropriate practices by other agencies carrying out works in or adjacent to Canberra Nature Park.

- Provide and promote a range of opportunities for raising awareness, appreciation and understanding of natural and cultural heritage values through research, education, community participation and interpretation.
- Provide and promote appropriate recreation and tourism opportunities that are consistent with the management objectives.
- Preserve sites and biodiversity elements of scientific significance.

ACT Government EA 2005. National Recovery Plan for Natural Temperate Grassland of the Southern Tablelands (NSW and ACT): an endangered ecological community. This is the National Recovery Plan for Natural Temperate Grassland of the Southern Tablelands (NSW and ACT).

ACT Government 2005. A Vision Splendid of the Grassy Plains Extended. ACT Lowland Native Grassland Conservation Strategy. Action Plan No. 28. This is a strategy to direct maximum effort into the protection, management and restoration of Natural Temperate Grassland and other grasslands in the ACT and encompasses all threatened species that occur within lowland grasslands in the ACT.

5.1.2 The NES Plan (excerpts)

The Molonglo Valley Plan for the Protection of Matters of National Significance (the NES Plan) identifies the commitments and undertakings of the ACT Government in regards to protection of MNES. Key commitments and undertakings defined in the NES Plan in relation to Box-Gum Woodland and Natural Temperate Grassland include the following.

Management and offsetting

- Recognition of Kama Nature Reserve as an offset site and on-going management of the areas to focus on its MNES values and the establishment of a buffer outside the Kama Nature Reserve on its eastern side to protect the ecological values of the Reserve.
- Establishment and management of Patch GG as an offset site by incorporating the areas into the National Arboretum.
- Management of Box-Gum Woodland patches C, H and N to maintain and enhance their ecological values.
- Management of Box-Gum Woodland in patches I, L, M and P to maintain their ecological values.
- Implementation of a number of research projects to improve the knowledge relating to conservation of Box-Gum Woodland.

Bushfire management framework

- Within the strategic assessment area fire management will be aimed at the protection of both built assets and MNES values. This will be achieved through the identification of appropriate asset protection zones and the application of hazard reduction techniques that will both ensure the standards for fuel loads in the Strategic Bushfire Management Plan are met; and protect MNES values through the use of sympathetic management techniques.

Conservation outcomes and actions to achieve these outcomes

a) **Impacts to Box-Gum Woodland will be limited to a maximum of 110 ha and a range of measures will be implemented to minimise this area of impact.**
   - Ensure that the combined impacts on Box-Gum Woodland from development within East Molonglo and construction of infrastructure within the river corridor do not exceed 110 ha.
   - Amend the East Molonglo river corridor boundary with a view to reducing the impacts to Box-Gum Woodland. This process will ensure that connectivity within the Corridor is maintained.
   - Design the infrastructure that will occur in the Molonglo River Reserve to minimise impacts to Box-Gum Woodland.
   - Develop, implement and independently monitor Construction Environmental Management Plans (CEMPs) to ensure that unforseen direct or indirect impacts from construction activities within the development area and the Corridor are avoided.

b) **Three offset sites will be established within the strategic assessment area (Kama Nature Reserve, Molonglo River Park and Patch GG) that will provide for the long term protection of 234 ha of Box-Gum Woodland. The three offset sites will be adaptively managed to maintain and enhance the ecological condition of the Box-Gum Woodland that occurs there.**
   - Develop and implement a management plan for Kama Nature Reserve; Molonglo River Park; and Patch GG to provide for the maintenance and enhancement of the ecological condition of Box-Gum Woodland.
   - Establish a buffer outside the Kama Nature Reserve between the Reserve and the proposed development area, and allow for appropriate uses consistent with nature conservation uses of the Reserve. The buffer will be developed to ensure that fire management is undertaken outside the Kama Nature Reserve and will provide protection against urban edge effects.

c) **Adaptively manage 28 ha of Box-Gum Woodland within the strategic assessment area to maintain and enhance its ecological condition (patches C, H and N).**

- Develop and implement a management plan for patches C, H and N to provide for the maintenance and enhancement of the ecological condition of Box-Gum Woodland within these areas.

d) **Adaptively manage 45.4 ha of Box-Gum Woodland within the strategic assessment area to maintain its ecological condition (patches I, L, M and P).**

- Develop management plans for patches I, L, M and P to provide for the maintenance of the ecological condition of Box-Gum Woodland within these areas.
- Undertake fuel hazard management in patches I, L, M and P with the management and protection of Box-Gum Woodland as a critical consideration (within the constraints of ensuring the safety of the urban population).
- Annually monitor the condition of the Box-Gum Woodland patches I, L, M and P on the western boundary of East Molonglo to ensure that fuel hazard management is not negatively impacting on the Box-Gum Woodland values.
- An offset site will be established if more than 30% of patches I, L, M and P no longer meet the EPBC Act listing criteria for Box-Gum Woodland over two consecutive years, and managed as a nature reserve.

e) **Maintenance and enhancement of the Box-Gum Woodland that occurs within the West Molonglo component of the strategic assessment area.**

- Manage the Box-Gum Woodland that occurs in West Molonglo in accordance with the terms of a Land Management Agreement, which will ensure that the ecological functioning and integrity of Box-Gum Woodland on the lease is retained and improved; the extent and character of the Box-Gum Woodland is preserved; and there is an Action Plan which details the activities, timeframes and performance measures put into place to ensure that conservation outcomes are met.
- West Molonglo is zoned Broadacre and is not part of the ACT Government's current land release program. In the event West Molonglo is developed in the future for broadacre uses or residential development then, subject to confirmatory ecological assessment of Box-Gum Woodland, the area of EPBC Act Box-Gum Woodland that occurs there will be set aside as a nature reserve.

f) **Improving and applying the knowledge about the management of Box-Gum Woodland.**

- Establish and manage an off-site restoration project, as an indirect offset, for Box-Gum Woodland.

And for Natural Temperate Grassland:

- No direct or indirect impacts to Natural Temperate Grassland.
- Protection of the Natural Temperate Grassland within the Kama Nature Reserve.
- Adaptive management of the Natural Temperate Grassland that occurs within the Kama Nature Reserve to maintain and enhance its ecological condition.

Monitoring ecological condition

- Ecological condition for Box-Gum Woodland will be measured using a peer reviewed, repeatable and scientifically robust methodology for examining and comparing the condition of woodland and derived grassland patches over time.
- Ecological condition for Natural Temperate Grassland will be measured using a peer reviewed, repeatable and scientifically robust methodology for examining and comparing the condition of Natural Temperate Grassland patches over time.

5.1.3 Molonglo River Reserve and offsets: zoning and jurisdiction

Table 5.1. Molonglo River Reserve and offsets: zoning and jurisdiction.

Area	Territory Plan Land Use Zone	Land Use Zone -Objectives	Territory Plan Classification	Classification Objectives *(Planning and Development Act 2007)*	Land Type	Land Management	Land Management Responsibility	NES Plan Commitments
Molonglo River Park **Including BGW Patches Q, R, S, T, partial D, & K**	NUZ4 River Corridor	• Conserve the ecological and cultural values of the ACT's major river corridors. • Protect stream flow, water quality and floodplains from adverse impacts. • Ensure that the type and intensity of development is sustainable. • Provide opportunities for a range of ecologically sensitive water and land based recreational activities. • Ensure compatibility between land uses, water uses and the general character of the rivers. • Provide opportunities for appropriate environmental education and scientific research activities. • Prevent development that would significantly increase fire hazard.	Special Purpose Reserve	Management Objectives for Public Land 1. To provide for public and community use of the area for recreation and education	Public Land	Statutory Reserve Management Plan under-preparation for 2014	ACT Government Environment, Planning and Sustainable Development Directorate	Three offset sites will be established within the strategic assessment area (Kama Nature Reserve, Molonglo River Park, Patch GG) that will provide for the long term protection of 234 ha of Box-Gum Woodland. The three offsite sites will be adaptively managed to maintain and enhance the ecological condition of the Box-Gum Woodland that occurs there.

Area	Territory Plan Land Use Zone	Land Use Zone -Objectives	Territory Plan Classification	Classification Objectives *(Planning and Development Act 2007)*	Land Type	Land Management	Land Management Responsibility	NES Plan Commitments
Lower Molonglo Nature Reserve	NUZ4 River Corridor	As above	Nature Reserve	Management Objectives for Public Land 1. To conserve the natural environment 2. To provide for public use of the area for recreation, education and research	Public Land	Statutory Plan of Management 2001 To be incorporated into Statutory Reserve Management Plan under-preparation for 2014	ACT Government Environment, Planning and Sustainable Development Directorate	**Action 40.** Continued implementation of the Plan of Management for the Lower Molonglo Nature Reserve to provide for the maintenance of the ecological condition of the high- and moderate-quality Pink-tailed Worm-lizard habitat that occurs there (approximately 28.1 ha).
Kama Nature Reserve (now 'Kama') **(including NTG patch A, BGW patch B &O)**	NUZ3 Hills Ridges and Buffer	• Conserve the environmental integrity of the hill system as a visual backdrop and a unified landscape setting for Canberra. • Provide opportunities for appropriate recreational uses. • Conserve the significant cultural and natural heritage resources and a diversity of natural habitats and wildlife corridors. • Provide predominantly open buffer spaces for the visual separation of towns and to provide residents with easy access to hills, ridges and buffer areas and associated recreation facilities. • Provide opportunities for appropriate environmental education and scientific research activities.	Nature Reserve	Management Objectives for Public Land 1. To conserve the natural environment 2. To provide for public use of the area for recreation, education and research	Public Land	Plan of Management Canberra Nature Park in 1999	ACT Government Environment, Planning and Sustainable Development Directorate	**Action 11**. Recognition of Kama Nature Reserve as an offset site and ongoing management of the area with a focus on its MNES values. This process will include the development and implementation of management plan for the Kama Nature Reserve that will provide for adaptive management and condition improvement of the Reserve. This management plan will then inform a statutory Reserve Management Plan for Kama Nature Reserve. **Action 34**. Implement the management plan for the Kama Nature Reserve to provide for the maintenance and enhancement of the ecological condition of Box-Gum Woodland within the Reserve.

Area	Territory Plan Land Use Zone	Land Use Zone -Objectives	Territory Plan Classification	Classification Objectives *(Planning and Development Act 2007)*	Land Type	Land Management	Land Management Responsibility	NES Plan Commitments
BGW Patch P	NUZ3 Hills Ridges and Buffer	As above	Special Purpose Reserve		Public Land	Statutory Reserve Management Plan under-preparation for 2014	ACT Government Environment, Planning and Sustainable Development Directorate	**Action 15**. Management of Box-Gum Woodland patches I, L, M and P to maintain their ecological values. **Action 25**. Adaptively manage 45.4 ha of Box-Gum Woodland within the strategic assessment area to maintain its ecological condition. This will be made up of patches I, L, M, and P. Develop management plans for Box-Gum Woodland patches I, L, M, and P to provide for the maintenance of the ecological condition of Box-Gum Woodland within these areas.
BGW Patch C & H **William Hovell Drive**					Rural Lease	Land Management Agreement		**Action 14**. Management of Box-Gum Woodland patches C, H and N to maintain and enhance their ecological values. **Action 42**. Develop management plans for Box-Gum Woodland patches C, H, and N to provide for the maintenance and enhancement of the ecological condition of Box-Gum Woodland within these areas. **Action 43**. Implement management plans for Box-Gum Woodland patches C, H, and N to provide for the maintenance and enhancement of the ecological condition of Box-Gum Woodland within these areas.

Area	Territory Plan Land Use Zone	Land Use Zone -Objectives	Territory Plan Classification	Classification Objectives *(Planning and Development Act 2007)*	Land Type	Land Management	Land Management Responsibility	NES Plan Commitments
BGW patch GG & N **(Adjacent to Arboretum)**					Rural Lease	Land Management Agreement	Lease holder	**Action 13**. Establishment and management of Patch GG as an offset site by incorporating the area into the National Arboretum which is directly to the east. **Action 39**. Establish Patch GG as an offset site by incorporating the area into the National Arboretum. **Action 40**. Develop a management plan for Patch GG to provide for the maintenance and enhancement of the ecological condition of Box-Gum Woodland (approximately 44 ha).
BGW Patch I, M & L	NUZ3 Hills Ridges and Buffer				Rural Lease	Land Management Agreement	Lease holder	**Action 15**. Management of Box-Gum Woodland patches I, L, M and P to maintain their ecological values. **Action 25**. Adaptively manage 45.4 ha of Box-Gum Woodland within the strategic assessment area to maintain its ecological condition. This will be made up of patches I, L, M, and P. Develop management plans for Box-Gum Woodland patches I, L, M, and P to provide for the maintenance of the ecological condition of Box-Gum Woodland within these areas.
BGW Patches E,F& G (West Molonglo)					Rural Lease	Land Management Agreement	Lease holder	**Action 26**. Maintenance and enhancement of the Box-Gum Woodland that occurs within the West Molonglo component of the strategic assessment area.

5.2 Ecological studies in the area up to 2014

Reports on the Guidelines area during 1992–2013

There were 16 reports, during 1992–2013, about ecology and vegetation of the Molonglo River Reserve and offsets (summarised below; details of references cited are to be found in those reports). There were also nine studies and reports specific to birds, 2004–14 (citations only below).

1. Barrer P. (1992). A study of flora and fauna in the lower reaches of the Lower Molonglo River Corridor, ACT.

This report presents the findings of surveys undertaken for vascular flora and many vertebrate fauna (excluding bats and fish) along a section of approximately 8.5 kilometres of the Molonglo River corridor, extending from above the confluence with the Murrumbidgee River to the downstream limit of Bluett's Pine Plantation (below Coppins Crossing).

FINDINGS

Eleven open forest and woodland associations, seven riverine shrubland associations, five native grassland associations, eight wetland associations and one regionally significant fernland (*Pellaea falcata*) community were recognised (these associations are defined at a more detailed level than the vegetation communities). The Black Cypress Pine Woodland was identified to be a rare *Callitris endlicheri - Eucalyptus macrorhyncha* association of regional and possibly national significance because of their extent. Barrer mapped the River She-oak Woodland community more or less continuously through the Gorges section of the nature reserve. The steep gorges protected a mosaic of habitats and several significant flora species. River She-oak Woodland extended upstream to Misery Point, above which it was largely or entirely replaced by willows.

The native flora was unusually diverse, with 225 species recorded, including two, probably three, nationally significant species, including *Discaria pubescens* and *Pomaderris pallida*. Sixty-seven species were deemed by Barrer to be regionally rare or uncommon plant species in the study area. Seventeen species were formally listed as regionally significant (ACT Planning Authority 1992). A further 43 species were deemed to be regionally uncommon.

Eleven native and eight introduced mammals (excluding bats) were recorded, including all of the ACT macropods. The area provided habitat for the regionally uncommon Eastern Wallaroo and Platypus.

Barrer concluded that the Bush Rat population was locally significant, being likely to be the closest to urban Canberra.

More than ninety-four bird species were recorded in the study area. The area provided regionally significant habitat for raptors, and Peregrine Falcon, Wedge-tailed Eagle, Brown Goshawk, Brown Falcon, Australian Kestrel and possibly Little Eagle were observed to be breeding. The Whistling Kite was breeding nearby and included the river valley within its territory. The regionally rare Red-capped Robin was observed throughout the year, and Barrer concluded that it was probably breeding in sites along the left bank. The area provided important woodland habitat for several species Barrer deemed to be regionally rare, including the Southern Whiteface (which was often fairly common) and Diamond Firetail, together with the Spotted Warbler and Double-barred Finch. Barrer observed at least 12 other birds he considered to be rare or regionally uncommon in the study area.

The study area supported a diverse reptile fauna of at least 20 species. Almost the entire left bank and parts of the right bank provided Pink-tailed Worm-lizard habitat. Four regionally significant reptiles were also recorded in the area[9]: the skink (*Ctenotus uber orientalis*), Nobbi Dragon (*Amphibolurus nobbi*), Stone Gecko (*Diplodactylus vittatus*) and Marbled Gecko (*Phyllodactylus marmoratus*). Barrer concluded that several other regionally uncommon reptiles were possibly or likely to occur in the area. Five species of frog were recorded, and other species were possible or likely.

Barrer concluded that the river corridor served local and regional roles as a movement corridor for birds, although only small numbers of migrating honeyeaters pass through. Its significance in the short range seasonal movements of a number of small passerines had yet to be determined, but appeared to be high. The river zone also had some significance for the movement of the larger vertebrates, including the short range and dispersal movements of Eastern Wallaroo. Barrer observed that a Tiger Quoll and a Rosenberg's Monitor, both found in West Belconnen prior to his study, might have dispersed using the river valley.

Barrer identified existing and past impacts on the study area to include: the partial or complete clearing; grazing by sheep or cattle; small areas of pasture improvement; generally minor weed and exotic plant problems; significant numbers of feral predators; an increased frequency of highly destructive bushfires along the downstream section of the right bank; a low level of recreational activity; various urban infrastructural developments; and urban and rural influences upstream that influence water quality and quantity.

9 Some of these scientific names have since changed; e.g. see s.2.6.2.

The report identifies management objectives and strategies, including boundary adjustments.

RELEVANT MAPPING

The report provides a detailed map showing locations of significant flora species, vegetation communities, known bird breeding sites, and significant reptile records.

2. Barrer P. (1992). A study of flora and fauna in the lower reaches of the Lower Molonglo River Corridor, ACT. Unpublished report prepared for ACT Heritage Council, Canberra.

In his study of the vegetation of the Lower Molonglo River Corridor Nature Reserve Barrer recognised several grassland associations, which may be natural. These included one in rocky substrate that was dominated by species including Purple Wire-grass and Kangaroo Grass, and another association dominated by Kangaroo Grass. He identified other grassland associations that were likely to be derived from various woodland or forest vegetation communities.

3. Biosis Research (2006). Final Molonglo Valley Ecological Impact Review. Prepared for ACTPLA.

This study reviewed potential ecological impacts and provided management and mitigation recommendations in relation to urban development and dam construction in the Molonglo River corridor, based on available information. Threatened fauna records were mapped. The study area extends from the Tuggeranong Parkway to the Murrumbidgee River.

FINDINGS

Major communities/habitats were identified, with associated significant flora (riparian vegetation types are not described – the report refers to Barrer 1992). Box-Gum Woodland (partially modified, moderately modified and secondary grassland), and Natural Temperate Grassland mapping based on Environment ACT data are provided. The report identified that there may be impact on the Natural Temperate Grassland within Kama, and to exclude development from this area. The report notes the potential for and local distribution of the threatened *Swainsona recta* and *Pomaderris pallida* (and ROTAP *Discaria pubescens*) in woodland. The report concluded that the development is unlikely to significantly affect threatened species. The report recommended targeted surveys for various orchids (e.g. *Diuris pedunculata*), *Swainsona recta, Leucochrysum albicans var tricolor,* and *Thesium australe*. It recommended targeted surveys at the concept planning stage for Perunga, Lewis's Laxabilla and Keys Matchstick Grasshoppers and the Golden Sun Moth.

Recommendations were that restoration works in the river corridor should be commenced in advance of development. the report pointed to the importance of the river corridor for bird habitat connectivity. It identified that threatened fish have potential or were known to occur at the Murrumbidgee confluence, including Murray Crayfish, Macquarie Perch, Silver Perch and Murray Cod. The report identified that there is a significant opportunity to improve riparian vegetation and aquatic habitats, including by weed control, riparian protection, revegetation and reducing the impacts of Scrivener Dam.

RELEVANT MAPPING

Pink-tailed Worm-lizard habitat, raptor territories and wildlife corridors within the River valley are mapped. Vegetation community mapping excludes the River valley.

SURVEY DATA

The report is based on available information; no survey data are provided.

4. Osborne W. (2008). Environmental planning principles for the protection of the Pink-tailed Worm-lizard *Aprasia parapulchella* in the Lower Molonglo Valley, ACT. Prepared for ACTPLA.

In relation to the Molonglo and North Weston area, the report identifies threats likely to result from urban development, and principles and measures to conserve local populations. It considers case studies involving the conservation and management of the species in other urban environments. Practical measures to protect habitat during and after development are identified.

HABITAT MAPPING

Provided from previous work.

5. Eco Logical Australia (2008). Molonglo river riparian zone vegetation and habitat survey and mapping project. Prepared for ACTPLA.

This study involves baseline vegetation and habitat surveys assessing the approximate extent and condition of vegetation of the Molonglo riparian zone between Scrivener Dam and the confluence with the Murrumbidgee River. Vegetation community mapping is provided based on air photos, previous mapping (including Barrer 1992), and field validation. Habitat types, significant trees, vegetation structure and condition information are also reported. The report does not record or map any Box-Gum Woodland in the corridor, but does map 'secondary grassland'. The report maps threatened species habitat within the river corridor. Potential threatened species habitat is mapped as present throughout the corridor.

Field surveys were used to validate the vegetation community mapping and assess condition. Random meanders were used to survey mapped polygons to gather information, using standard data sheets provided by TAMS, which were adapted from Land and Water Australia's Rapid Assessment of Riparian Condition (Jansen *et al.* 2005). The data sheets cover flora species, vegetation structure and composition, presence of exceptional trees, habitat features and other attributes. The condition assessment involved four condition categories based on the proportion of native species in the vegetation strata, evidence of regeneration, damage to regeneration and total weeds.

FINDINGS

The River She-oak Dry Riparian Forest (River She-oak Forest) community in the River valley consisted mainly of River She-oak growing in cracks in exposed bedrock, between boulders and on alluvial deposits next to the river. Mid-storey and understorey layers were restricted to stands more than one tree wide. A thin layer of leaf litter and fallen wood was present in sections where the overstorey was more developed. Dead standing trees and shrubs from the 2003 fires were present among living trees. Most of this community of River She-oak Woodland in the River valley was considered to be in low and moderate condition: low and very low in the River Park area and moderate in the gorge section of the nature reserve. The section near the confluence with the Murrumbidgee was in very low condition. A small section in the gorge and a small patch closer to Scrivener Dam were in high condition.

Tableland Wetland Fringing Riparian Aquatic Vegetation was in patches along the banks of the river, mostly near Scrivener Dam. It was not observed elsewhere, possibly due to high water levels. Condition was not assessed. Black Cypress Pine – Brittle Gum Tall Dry Woodland (Black Cypress Pine Woodland) was on the dry, rocky steep slopes in the lower reaches, on both sides of the river, but more commonly on the left bank. The community was mostly in moderate condition, with two small sections (right and left bank) assessed as high condition. Snow-Gum Grassy Woodland occurred in the upstream sections from Scrivener Dam to the beginning of the gorge, on both sides of the river, but more commonly on the right bank. The community was in low condition between Scrivener Dam and just past Coppins Crossing, and moderate condition in areas further past Coppins Crossing.

Areal estimates were calculated for each community, although it is noted that the mapped River She-oak Woodland includes areas which are currently dominated by weeds. Secondary grassland was not attributed to vegetation types.

The study also has limitations because not all of the polygons were assessed on the ground, the simplified data sheets did not incorporate information on vegetation cover or species rarity, and did not account for naturally treeless communities.

RELEVANT MAPPING

The report includes GIS maps showing vegetation communities, vegetation condition with areas of good, moderate and low condition, and locations of Exceptional Trees.

SURVEY DATA

The report does not include survey data.

6. Eco Logical Australia (2009). Molonglo Valley Ecological Report — EPBC listed flora, ecological communities and Golden Sun Moth mapping in the Molonglo Valley. Report to ACTPLA.

This report provides information for the Strategic Assessment by surveying and mapping the following MNES: Box-Gum Woodland, Natural Temperate Grassland, threatened flora and the Golden Sun Moth. The study area includes the river corridor between the Tuggeranong Parkway and the Lower Molonglo Nature Reserve. Endangered Ecological Communities (EECs) and potential threatened fauna habitat were mapped. The study included surveys along transects and plots of Box-Gum Woodland patches, during severe drought conditions in 2008.

FINDINGS

The Box-Gum Woodland CEEC was mapped (3 condition classes); areas from each class occur within the River valley. No Natural Temperate Grassland was recorded in river corridor. Six traverses and one quadrat were located within the river valley. A targeted flora survey was undertaken in the river corridor (both sides of the river) from the Tuggeranong Parkway to 500 m west of the (then) proposed dam west of Coppins Crossing, with no MNES species recorded. Targeted species included *Rutidosis leptorrhynchoides, Swainsona recta, Thesium australe, Pomaderris pallida* and *Leucochrysum albicans* var. *tricolor.* The report concluded that the Golden Sun Moth does not occur in the river corridor. Tree hollow abundance was also mapped. The Superb Parrot was observed on each visit to the Kama Nature Reserve, but not in the river corridor.

RELEVANT MAPPING

Mapping of Box-Gum Woodland CEEC presence and condition and relative tree hollow abundance mapping is provided. Mapping was based on data provided by Conservation Planning and Research section (ACT Government).

SURVEY DATA

Quadrat and traverse results data are provided. Precise locations of survey sites are not provided. Two 20 m x 20 m quadrats were completed across the Natural Temperate Grassland site in Kama. Threatened flora were also subject to survey, but none were found.

7. Osborne W. and Wong D. (2010). Extent of potential Pink-tailed Worm-lizard (Aprasia parapulchella) habitat in the Stage 2 Investigation Area — East Molonglo. Prepared for ACTPLA.

This report presents the results of GIS mapping and ground-truthing of habitat condition of all rocky areas that provide potential *Aprasia habitat* in the entire East Molonglo Stage 2 area and an area to the west and north (including land adjacent to Kama Woodlands). Detailed habitat mapping is provided, including potential movement corridors and restoration areas.

8. Wong D. and Osborne W. (2010). Confirmatory surveys for Pink-tailed Worm-lizards (Aprasia parapulchella) and additional mapping of habitat along the Molonglo River corridor between Coppins Crossing and Tuggeranong Parkway, ACT. Prepared for ACTPLA.

This report presents the results of field surveys in all previously mapped potential habitat in the Molonglo River valley between Coppins Crossing and the Tuggeranong Parkway. Relevant conservation issues are discussed, including the impact of the proposed roads. Habitat areas and movement corridors are identified. Detailed habitat maps and records are provided.

9. Eco Logical Australia (2010a). Draft strategic assessment report of the Molonglo Valley Plan for the Protection of Matters of National Environmental Significance. Prepared for ACTPLA.

This study assessed the potential impacts of the Molonglo Valley Plan in relation to Matters of National Environmental Significance (MNES), particularly threatened species and communities, as part of the EPBC Act (Part 10) approval process. The assessment area runs from the Tuggeranong Parkway to Coppins Crossing. It mapped Box-Gum Woodland patches and Natural Temperate Grassland in development areas. The report provides recommendations for preparation of a Management Plan, managing impacts, monitoring and establishing a buffer.

10. Eco Logical Australia (2010b). Molonglo Development Stage 2 vegetation assessment. Prepared for ACTPLA.

This report identified gaps in the surveys from all available mapping for the study area. The study reported on surveys undertaken in these areas to identify presence of threatened ecological communities and their condition.

11. Eco Logical Australia (2011a). Molonglo and North Weston EPBC Act strategic assessment supplementary report. Prepared for ACTPLA.

The report includes an analysis of the conservation outcomes for MNES, updated from previous reports (see above). The surveys indicated a variable condition of existing Box-Gum Woodland areas. Four classes were used to detail floristic diversity in each patch of the listed Box-Gum Woodland. The report identifies that the development and implementation of a management regime to provide long term positive outcomes for the ecological community within the framework of an adaptive management strategy is key to delivering successful offset outcomes for Box-Gum Woodland and Natural Temperate Grassland. The report identifies potential direct impacts from development, including weed invasion and inappropriate fire management, provides an overview of the variation and condition of significant Box-Gum Woodland patches in the East Molonglo area, and recommends adaptive management and offsetting and conservation outcomes. This report, together with Eco Logical Australia (2010) above informed the NES Plan.

12. Eco Logical Australia (2011b). Molonglo Riparian Strategy, Coombs and North Weston. Prepared for LDA.

This is a strategy for the rehabilitation and management of the Molonglo River Corridor Conservation Areas between the Tuggeranong Parkway and Misery Point, adjacent to Coombs and North Weston. It is intended to provide the framework for a River Park Concept Plan and plan of management. The strategy identifies and maps proposed vegetation communities based on original vegetation patterns. It evaluates the potential for threatened species, before and after rehabilitation. It identifies major weed species, broad weed control management objectives and strategy, and bush regeneration zones.

13. ngh environmental (2011). Vegetation Survey Molonglo River Park (Coombs) Interface.

This short survey report describes, maps and assesses the condition and significance of vegetation within the Molonglo River Park, on the south-western side of the river, adjacent to the Coombs development.

Using aerial photography, homogeneous vegetation units were identified and mapped according to community, apparent condition and topographic context. Field surveys were used to confirm and refine vegetation boundaries. A combination of representative quadrat and random meander surveys were undertaken in each vegetation unit recording floristics, structural data, condition, physical values and significant fauna habitat features.

FINDINGS

Vegetation units within the survey area were identified and mapped according to community, condition and topographic context. Vegetation composition and structure, significant species and major weeds were recorded in each map unit, using random meanders. Grassy vegetation condition was rated according to a four-point scale, focusing on floristic diversity.

The report identified that the river channel sideslopes carried native grassland likely to be derived from Box-Gum Woodland, with some areas dominated by Kangaroo Grass. Grassland condition in most areas ranged between poor and moderate. A high quality patch was present in the north of the site. The valley floor was largely dominated by exotic vegetation. River She-oaks have been replaced by willows over most of the riparian zone. River She-oaks were present as sparse, isolated mature trees and saplings along the river and in tributary drainage lines in the northern half of the Interface area, and as a woodland formation in the braided channel to the north of the area, near Misery Point.

There was a small patch of wet grassland dominated by the native River Tussock (*Poa labillardierei*) on valley floor alluvium at the south-eastern end.

A number of nationally and regionally significant plant species were listed in the Coombs Interface area, including the ROTAP species Australian Anchor Plant (*Discaria pubescens*).

The report recommended that vegetation management should aim to selectively target key weeds while retaining and promoting foundation native species such as native grasses, woodland trees and River She-oak.

RELEVANT MAPPING

Vegetation communities, condition classes, significant flora locations and major weed concentrations were mapped. The report includes a GIS map showing vegetation community and condition class boundaries, significant species locations, major isolated weed occurrences and survey sites.

SURVEY DATA

The report includes data for each survey site.

14. Peden et al. (2011). Survey of vegetation and habitat in key riparian zones in tributaries of the Murrumbidgee River in the ACT: Cotter, Molonglo, Gudgenby, Naas and Paddys Rivers.

This study defined and mapped riparian vegetation communities and their condition along major tributaries of the Murrumbidgee River in the ACT, including the Molonglo River. The study involved vegetation community mapping derived from remote sensing, which was field tested at point locations. Condition scores were derived from attributes that could be interpreted remotely. Vegetation composition and condition are described sequentially, moving downstream through the river valley.

FINDINGS

The report found that there are significant and extensive areas of River She-oak Woodland in the river valley. Close to the Deep Creek confluence, the River She-oak Woodland contains mature, well established River She-oaks on the sandy floodplain and in the tributary gullies. The stand is in excellent condition with plenty of mature and regenerating plants, some with mistletoe (Peden *et al.* 2011). There is extensive River She-oak Woodland at the Murrumbidgee River confluence, with associated understorey species on a broad delta opposite Woodstock Reserve, with some woody weeds (Peden *et al.* 2011).

Scrivener Dam to Coppins Crossing

The report stated that water quality in the Molonglo River is poor, due to high sediment and nutrient loads, cold and low oxygen bottom releases from Scrivener Dam and heavy metal pollution from upstream mining activities (NCPA 1995). Yarralumla and Weston Creeks are also likely to contribute heightened nutrient levels and turbidity. Clearing, grazing and rabbits have resulted in extensive erosion and the replacement of the natural 'chain of ponds' sequence with an incised, permanently flowing stream (Eyles 1977).

For some kilometres below Scrivener Dam, the riparian vegetation was found to be dominated by exotic species, mainly *Salix* species (*S. fragilis*, *S. nigra*, *S. babylonica* and some shrub willows), with *Populus nigra*, *P. albicans*, *Corylus avellana*, *Cratageus monogyna* and *Pyracantha* sp. Blackberries form a thicket along the entire stretch of river and the channel is choked by willow roots and debris. Some native shrubs such as *Acacia rubida*, *A. mearnsii*, *A. dealbata*, *A. parramattensis* and *A. baileyana* (sic) remain, with a weedy groundlayer of *Bromus* sp., *Holcus lanatus* and *Avena* sp. and some remnant native grasses (*Themeda triandra*, *Rytidosperma* spp. syn *Austrodanthonia* spp.).

There is a high cover and abundance of native semi-aquatic fringing vegetation in the backed-up water created by the willows and low flows caused by the Dam, including *Typha domingensis, Schoenoplectus validus* and *Lythrum salicaria*. The native *Hydrocotyle tripartita*, *Ranunculus amphitrichus* and *Acaena agnipila* grow abundantly on the raised moist rocky areas above the low base flow level. Exotic species such as *Veronica anagalis-aquatica*, *Nasturtium officinale*, *Ranunculus repens*, *Plantago major*, and *Taraxacum officinale* are common throughout the reach. West of the Tuggeranong Parkway overpass, the stream channel and banks continue to be dominated by willows which completely choke the river in parts. The aquatic fringing species still have a high native component and include *Schoenoplectus* sp., *Bolboschoenus* sp., *Cyperus* sp., *Persicaria* sp., and algal species (*Spirogyra* spp.) typical of the Tableland Aquatic and Fringing Vegetation Complex. Some *Melaleuca paludicola* syn. *Callistemon sieberi* and *Acacia mearnsii* remain in the understorey in an otherwise weed infested riparian zone. African Lovegrass and many other groundlayer weeds grow down the valley slopes to the river.

Along the floodplain below Misery Hill the riparian vegetation returns to more native condition with the beginning of River She-oak Woodland and a marked decrease in the number of willows. The River She-oak trees have been affected by fire but are regenerating well, with many seedlings observed along the river bank. The river opens up into a large, clear pool with Tableland Aquatic and Fringing Vegetation Complex (*Phragmites australis*, *Persicaria* sp., *Bolboschoenus* sp., *Schoenoplectus* sp., *Juncus* sp.) on the north-east bank and a relatively bare bank to the south-west.

Where the river enters a broad bedrock floodplain, stunted River She-oaks occur among the midstream boulders. Many fallen willows and broken branches litter the river bed, showing a history of flood events and subsequent recovery. The invasive African Lovegrass has established on the sand bars. The adjacent hillslope is mostly cleared grazing land with patchy Red Stringybark – Scribbly Gum Forest and an understorey of *Themeda triandra*, *Austrostipa* sp., *Bursaria spinosa* and *Kunzea ericoides*. As the river nears Coppins Crossing the River She-oak Woodland is again invaded by willows and other weeds.

Coppins Crossing to the Murrumbidgee River

With the exception of the short reach immediately downstream of Coppins Crossing, the stretch between Coppins Crossing and the Murrumbidgee confluence is in moderate to high condition throughout. This section of the river was surveyed in more detail by Barrer (1992); see above.

At Coppins Crossing River She-oak Woodland is still present but in poor condition following the 2003 bushfire. Prior to the fire this community formed a dense cover in places. The riparian zone is dominated by woody weeds, including willows, blackberries and an assortment of exotic tree species. The margins of the river have patches of Tableland Aquatic and Fringing Vegetation Complex in good condition, containing *Persicaria lapathifolia*, *Juncus usitatus* and *Cyperus eragrostis*. As the river spreads out among the boulders in the flat-bottomed but quite narrow valley floor, the terraces and river-line have *C. cunninghamiana* with *A. mearnsii* and occasional patches of *Salix nigra*, *S. fragilis*, *Populus nigra* and *Acer negundo*. The instream vegetation includes extensive patches of *Myriophyllum verrucosum* and emergent *Phragmites australis*, *Persicaria lapathifolia*, *Juncus usitatus* and *Cyperus eragrostis*.

The adjacent valley slope near the crossing and continuing further downstream contains mostly grassland with remnants of Box-Gum Woodland with clumps of *Eucalyptus bridgesiana* and the occasional scattered *E. melliodora*, *E. mannifera, E. polyanthemos* and *E. blakelyi*. The grassland is rich in native species, with prominent patches of *Themeda triandra* and *Bothriochloa macra*.

Close to the Deep Creek confluence, the river contains sand bars and the riparian vegetation is 3–15 m wide. This area contains mature, well established River She-oaks on the floodplain near the mouth of Deep Creek and in the tributary gullies. The floodplain also includes some *Typha* beds. There has been some Blackberry control work in this area with variable success. There are also a few Box Elder (*A. negundo*), which is a woody weed in the Canberra area. Deep Creek, running under the aqueduct, is a base flow creek with *Crassula helmsii*, *Nasturtium officinale*, *Juncus articulatus* and similar plants in the riparian zone. The stream channel is braided in parts of the floodplain and wetlands have formed in some subsidiary channels.

The right-bank adjacent hillslope is treeless, with native pasture (*T. triandra*, *Rytidosperma* spp.) on very shallow soils. On the left bank, where steep slopes and rocky spurs occur, there is a patchy Burgan shrubland containing *K. ericoides* and *B. spinosa* as well as *Pinus radiata* wildings. As the gullies and valley slopes become progressively rockier, *Callitris endlicheri* occurs. There are walls of columnar basalt with a light native shrubland and open grassland above.

Just upstream of the gorge there is a stand of River She-oak Woodland in excellent condition with plenty of mature and regenerating plants. On a midstream island there are several ages of River She-oak represented, some with mistletoe. Willows are also establishing in the area, mainly *S. fragilis* with some *S. babylonica*.

The adjacent hillslope and some of river bed are fire affected, especially to the east. On the right side, there is a stand of *E. pauciflora* with about three mature and dead standing trees and one regenerating mature tree, and a coppice of perhaps 25 young trees.

At the upstream entrance to the gorge, there is a 2–3 ha patch of *C. endlicheri* on the left side commencing a stand of Black Cypress Pine Woodland across the top of the gorge and continuing into the gorge. No *C. endlicheri* were observed on the more gently sloping right side.

In the upper gorge where the stream channel is a 40–50 m wide bedrock floodplain, the river may cease to flow in drought periods and between releases from Scrivener Dam. Occasional sandbars containing *Myriophyllum verrucosum* cross the floodplain marking the ends of pools in dry periods. Dead, young River She-oaks were observed in the river bed. At the foot of the slope on the left side, there is a River Bottlebrush – Burgan Rocky Riparian Shrubland containing *A. mearnsii, K. ericoides* and occasional *M. paludicola* with marginal beds of stranded *Schoenoplectus validus*. The right bank is lined with River She-oak Woodland with an understorey of *Acacia mearnsii* and *Kunzea ericoides*. The flood terrace is weedy and includes *Hirschfeldia incana*, *Eragrostis curvula* (African Lovegrass) and *Nassella trichotoma* (Serrated Tussock). An occasional River She-oak occurs in the back floodrunner above which is a bare hillslope. Throughout this area River She-oak grows into the gullies. Occasional Willows and Box Elder (*Acer negundo*) occur in the gorge.

Above the gorge there are a few patches of fire-affected *E. macrorhyncha*, remnants of Red Stringybark – Scribbly Gum Forest, which are very heavily fire affected. The Black Cypress Pine Woodland was destroyed by the 2003 bushfire on shallow soils but has survived on the deeper soils persisting at the bases of gullies. As the slope in the gorge declines, *E. blakelyi* returns and there is a second patch of *E. pauciflora* consisting of perhaps 10 trees. Towards the end of the grazing land the hillslope on the right side contains a well wooded patch of *E. dives*, which is recovering from the fire.

Further downstream the river forms a series of large pools. The fringing emergent vegetation includes some *Schoenoplectus validus* and *Persicaria lapathifolia*. The River Bottlebrush – Burgan Rocky Riparian Shrubland (Riparian Shrubland) of *Acacia mearnsii* and *Bursaria spinosa*, as well as willows and other weeds, alternates with the River She-oak Forest.

Approaching the Murrumbidgee River, the Molonglo opens out into a floodplain with more gentle sloping sides, a short distance above the Lower Molonglo Water Quality Control Centre. The river flows across a broad delta to enter the Murrumbidgee opposite Woodstock Reserve and below the treatment plant. The riparian vegetation community is River She-oak Forest with associated understorey species. Occasional patches of willows, Box Elder and some poplars can still be found. In the deeper soils of the delta region, the floor of the valley supports an extensive River She-oak Forest with many herbaceous weeds. Around the YMCA there are some plantings of poplars. On the left hillside the Black Cypress Pine Woodland is gradually replaced by open grassland with scattered exotic trees. On the right there is a remnant of Blakely's Red Gum – Yellow Box Grassy Woodland (Box-Gum Woodland), represented by a few *E. blakelyi.*

At the confluence with the Murrumbidgee there is an opportunity to restore a section of significant River She-oak Forest. The existing access through Camp Sturt would allow the use of such a restored area for educational programs without further disturbance. This would involve considerable rehabilitation and weed control.

RELEVANT MAPPING

The report appendices include sets of maps of riverine vegetation communities, vegetation dominance change and management recommendations.

SURVEY DATA

The report does not include data from survey sites.

15. ACT Government unpublished data. Surveys undertaken by Conservation, Planning and Research, in the Environment and Sustainable Development Directorate.

Data from surveys undertaken by ACT Government are held by [the] Conservation, Planning and Research [Section] (CPR) in databases. Data include surveys and polygon maps of the Natural Temperate Grassland in Kama and the Box-Gum Woodland in the parts of the Molonglo River Reserve between Coppins Crossing and the Murrumbidgee River corridor. The polygon maps prepared by CPR have provided the basis for all other mapping and survey location sites undertaken in subsequent studies.

16. Eco Logical Australia (2013). Molonglo Valley vegetation survey baseline condition assessment. Report prepared for Territory and Municipal Services Directorate.

These surveys were undertaken in December 2012 to January 2013 in the Natural Temperate Grassland in Kama Nature Reserve, as well as in patches of Box-Gum Woodland. The study was undertaken as the first step in implementing these guidelines — to undertake a baseline condition assessment to assist with the development of operational plans and a subsequent monitoring program. Further separate analysis of the data from this report found that much of the derived grassland (Box-Gum Woodland) identified along the slopes above the Molonglo River were more likely to be natural grassland, of the type 'Rocky Natural Grassland' (Sharp *et al*. 2013).

5.2.2 Birds previous studies (no summaries available)

Superb Parrot

Davey, C. (2013). Distribution, abundance and breeding status of the Superb Parrot (*Polytelis swainsonii*) during the 2011–12 breeding season, central and lower Molonglo Valley, ACT. Canberra Bird Notes 38(2), 134–154.

Eco Logical Australia (2014). Molonglo NES Plan Superb Parrot Survey — Baseline Survey 2013. Unpublished report prepared for Territory and Municipal Services, ACT Government.

Raptors

Olsen J. and Fuentes E. (2004). Preliminary report on the effect of the development of the Molonglo Valley on the community of Birds of Prey. Applied Ecology Research Group, University of Canberra.

Woodland birds

Bounds J., Taws N. and Cunningham R. (2010). A statistical analysis of trends in occupancy rates of woodland birds in the ACT, December 1998 to December 2008: The ten-year data analysis. Canberra Bird Notes 35, 158–191.

Stagoll K., Manning A.D., Knight E., Fischer J. and Lindenmayer D.B. (2010). Using bird–habitat relationships to inform urban planning. Landscape and Urban Planning 98, 13–25.

Taws N., Bounds J., Rowell A. and Cunningham R. (2012). An analysis of bird occupancy and habitat changes at six woodland locations: 2003 and 2010. Canberra Bird Notes 37(2), 100–129; and <http://canberrabirds.org.au> under 'conserving birds'.

Rainbow Bee-eater

Taws N. (2013). Report on Lower Molonglo River Bird Surveys: Potential Rainbow Bee-eater nesting habitat. Report for ACT Territory and Municipal Services Directorate, Canberra.

Taws N. (2014). Rainbow Bee-eater Breeding Surveys, Spring 2013. Report for ACT Territory and Municipal Services Directorate, Canberra.

Waterbirds

Taws N. (2011). Nesting waterbird surveys of the Molonglo River; Oaks Estate and Below Scrivener Dam. Spring 2011. Report for ACT Territory and Municipal Services Directorate, Canberra.

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Yellow-box flowers
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