



DRAFT ACT NATIVE WOODLAND CONSERVATION STRATEGY

APRIL 2019



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Snow Gum woodland, Mt Bimberi (S. Taylor)

INTRODUCTION

i. Scope of the Strategy

The ACT Native Woodland Conservation Strategy (hereafter the Strategy) supersedes, and builds on the achievements of the 2004 ACT Lowland Woodland Conservation Strategy (hereafter the 2004 Woodland Strategy). It has a broader scope, including both lowland and subalpine native woodland communities across all tenures and land uses.

Woodland is a general term to describe ecosystems that contain widely spaced trees with crowns that do not overlap. The Strategy considers woodland in all conditions, including areas where the canopy and woody midstorey have been largely cleared (i.e. areas of secondary / derived grassland) and the Endangered Yellow Box – Blakely’s Red Gum Grassy Woodland community (hereafter Endangered YB-BRG Woodland).

ii. Objectives of the Strategy

The purpose of this Strategy is to guide the management and conservation of lowland and subalpine woodlands in the Australian Capital Territory (ACT) for the next 10 years. The Strategy is closely aligned with goals outlined in the ACT Nature Conservation Strategy (ACT Government, 2013a). It identifies how the ACT Government intends to manage threats, safeguard threatened species, enhance woodland structural complexity, undertake monitoring and research, and enhance resilience, ecosystem function and connectivity of woodlands. Collaboration between the ACT Government and non-government entities (including community groups, conservation organisations, rural landholders, Traditional Custodians and research institutions) is considered critical to ensure the successful management and protection of our woodlands into the future.

This Strategy is a reference document for ACT and Australian Government agencies, community groups, landholders, and other stakeholders with responsibilities and interest in the conservation, planning and management of lowland and subalpine woodlands.

This Strategy has four key goals, which are defined below and are outlined in Box 1. The development and execution of the Woodland Conservation Implementation Plan (CIP) (outlined in v), and the implementation of actions outlined in the action plans (Part B) will be critical to meeting the goals of this Strategy.

Protect. Commonwealth and ACT statutory requirements and ACT Government policies protect threatened species and other fauna and flora associated with woodlands within and outside formal reserves.

Maintain. Ongoing intervention is required to mitigate the impacts of a range of threats to woodland communities and associated flora and fauna. Management practices must adhere to best practice and be informed by an adaptive management system.

Improve. Management activities must, wherever appropriate, aim to enhance ecosystem function of woodlands by improving the condition and connectivity of woodlands. Enhancing ecosystem function improves a community’s resilience to existing and emerging threats, including climate change.

Collaborate. Successful protection and management of woodlands requires collaboration between the ACT Government, non-government entities and the broader community. This includes promoting and managing the sustainable use of woodland reserves.

Box 1. The objectives outlined in the Strategy aim to meet the ACT Government’s four key goals for woodland conservation

	Protect	Maintain	Improve	Collaborate
Relevant objectives	1.1 Retain and protect native woodlands 3.1 Address knowledge gaps in woodland conservation 3.2 Monitor woodland condition	1.2 Reduce threats to native woodland biodiversity 3.1 Address knowledge gaps in woodland conservation 3.2 Monitor woodland condition	1.2 Reduce threats to native woodland biodiversity 1.3 Enhance resilience, ecosystem function and habitat connectivity 3.1 Address knowledge gaps in woodland conservation 3.2 Monitor woodland condition	2.1 Promote community participation in woodland conservation 2.2 Support appropriate recreational use of woodlands 3.1 Address knowledge gaps in woodland conservation 3.2 Monitor woodland condition

iii. Structure of the Strategy

This document is divided into two main sections, Part A and Part B.

Part A outlines the primary objectives for woodland conservation in the ACT. These objectives are grouped under three overarching themes:

- Protect and manage woodland and component species
- Collaborate with the community
- Monitoring and research

Section 5.2 outlines the approximate level of investment required to achieve conservation objectives in both subalpine and lowland woodland. Part A also includes background information on woodlands in the ACT and the broader region, and an overview of a range of research and other projects that have informed this Strategy.

Part B summarises the relevant literature and details objectives specific to the Endangered YB-BRG Woodland and fauna and flora species that are dependent on woodlands in the ACT and are listed as threatened under the *Nature Conservation Act 2014*. This information is provided as a set of self-contained action plans.

iv. Action plans and conservation advice

The Conservator of Flora and Fauna is responsible for preparing draft action plans or conservation advice for each species or ecological community listed as threatened under the *Nature Conservation Act 2014*. Action plans and conservation advice are statutory documents and are prepared with expert input from the ACT Scientific Committee.

An action plan for the Endangered YB-BRG Woodland community and action plans for three plants and two birds are included in Part B of this document. These include:

- Canberra Spider Orchid (*Caladenia actensis*)
- Small Purple Pea (*Swainsona recta*)
- Superb Parrot (*Polytelis swainsonii*)
- Scarlet Robin (*Petroica boodang*)
- Tarengo Leek Orchid (*Prasophyllum petilum*).

Each action plan provides a detailed description of the community or species, its conservation status, ecology, key threats, and an outline of the major conservation objectives and intended management actions.

Conservation advice for the following woodland-dependant birds will be available on the [ACT Government's Environment website](#):

- Brown Treecreeper (*Climacteris picumnus victoriae*)
- Hooded Robin (*Melanodryas cucullata cucullata*)
- Painted Honeyeater (*Grantiella picta*)
- Regent Honeyeater (*Anthochaera phrygia*)
- Swift Parrot (*Lathamus discolor*)
- Varied Sittella (*Daphoenositta chrysoptera*)
- White-Winged Triller (*Lalage tricolor*).

Links between this Strategy and action plans

Action plans and conservation advice guide actions to benefit threatened species and the Endangered YB-BRG Woodland community. This Strategy provides overarching conservation goals and principles on which to base these actions. It also provides a framework for planning and prioritising actions across the range of woodland sites in the ACT.

Development and review of action plans and conservation advice

Since the 2004 Woodland Strategy, action plans for 12 threatened species dependant on woodlands have been reviewed and provided to the ACT Scientific Committee for assessment. The Committee assesses a plan with reference to the objectives and performance indicators in that action plan, and the progress that can reasonably have been expected within the review timeframe. Action plans for a number of species have been converted to conservation advice documents. Specific management actions, outside of those identified in this Strategy for the protection of woodland habitat (including the Endangered YB-BRG Woodland Action Plan), were considered unnecessary for the persistence of these species.

The ACT Government will continue to develop and implement action plans and conservation advice for threatened species and threatened ecological communities, and will regularly review progress towards achieving their conservation objectives.

v. Implementation

The ACT Government is responsible for coordinating and implementing the objectives outlined in this Strategy on ACT Government managed land, and for collaborating with various partners to meet objectives on other land tenures.

The development of the Woodland Conservation Implementation Plan (CIP) in 2019 is required to ensure the objectives outlined in this Strategy are effectively implemented. The development of the Woodland CIP will involve a review and synthesis of commitments and objectives outlined in this Strategy (including threatened species action plans) and other strategic documents that are relevant to the conservation of woodlands in the ACT. These include reserve management plans (e.g. (ACT Government, 2010b) * CNP Management Plan ref *)), documented offset commitments, the Woodland Conservation Effectiveness Monitoring Plan (CEMP) (in development), and several ACT management strategies (ACT Government, 2007a, 2009, 2012a, 2013a, 2014, 2016a, 2017b). The Woodland CIP will include specific actions to be carried out to meet the priority objectives outlined

in these documents. This will guide the development of operational plans for relevant business units within the ACT Government.

Local, regional and national cooperation

Protection and management of woodland in the ACT requires effective collaboration between the ACT Government and a range of stakeholders. This includes sharing knowledge, resources and skills with local, regional and national land managers, environmental authorities, and other knowledge holders (including research institutions, Aboriginal and other community members).

The ACT Government must work closely with rural landholders, and community groups who are active in woodland conservation, to undertake on-ground management and community education activities. There is also a critical need to work with Commonwealth agencies responsible for managing woodland sites in the ACT (i.e. Department of Defence and National Capital Authority). National and regional cooperation is central to considering a broader spatial perspective of woodland and woodland-associated species management. This is critical to ensure the persistence of species that are dependent on conservation measures outside of the ACT (e.g. Superb Parrot and Tarengo Leek Orchid) and to support woodlands to successfully adapt to climate change. Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (hereafter the EPBC Act), the ACT Government is responsible for ensuring the appropriate management of several woodland-associated 'matters of national environmental significance'. This includes the Endangered YB-BRG Woodland community and several flora and fauna species (see Table 3 and Section 4.6).

As outlined in the ACT Strategic Bushfire Management Plan (ACT Government, 2014), the ACT Government currently undertakes collaborative fire management planning with NSW agencies. Collaboration between the ACT Government and NSW (and ACT) rural landholders and government agencies has also been critical to the success of a number of woodland restoration projects (e.g. the ACT Woodland Restoration and Biodiversity Fund Project [see Section 4]), offset management planning (see TRC Tourism (2016)), research and translocations of woodland species (e.g. New Holland Mouse (*Pseudomys novaehollandiae*) into Mulligans Flat Woodland Sanctuary), and pest animal management. The management of subalpine woodlands is part of the Australian Alps Cooperative Management Program with Commonwealth, NSW and Victorian authorities. This program aims to establish best practice management to protect the natural and cultural values of the Australian Alps National Parks.

vi. Woodland communities in the ACT

This Strategy provides prescriptions for the ongoing protection and management of twelve woodland communities, including seven subalpine and five lowland systems that cover over 79 000 ha in the ACT (Figure 1 and 5.1).

Subalpine woodlands occur between 730 m and 1910 m above sea level and cover approximately 48 409 ha of the ACT. They occur in the high country in the west and southern parts of the ACT, primarily in Namadgi National Park and Tidbinbilla Nature Reserve. Eucalypt species dominate the canopy of subalpine woodlands and the understorey is dominated by native tussock grasses and a diversity of herbs and forbs. The most widespread subalpine woodland communities in the ACT are those dominated by Snow Gum / Candlebark (U27), Snow Gum / Mountain Gum / *Davesia mimosoides* (U28), and Mountain Gum / Snow Gum / Robertson's Peppermint (*Eucalyptus radiata*) (U22) (see 5.1).

Most subalpine woodland in the ACT is intact and in good condition. Areas subject to clearing for grazing have been confined primarily to the valley floors of the upper Gudgenby River, Tidbinbilla

and Uriarra Forest. There has been little clearing of subalpine woodlands dominated by Snow Gum (Carron, 1985; Landsberg, 2000). Subalpine communities have been subject to changes in ecological processes (e.g. fire frequency) and disturbance (e.g. seasonal grazing, invasive plants and pest animals) that influence species composition. For instance, weed species associated with early pastoralism are found in grassy areas of the upper Cotter Catchment. Inappropriate fire regimes are a significant threat to these communities (see Section 5.1).

Lowland woodlands in the ACT occur between 440 m and 1340 m above sea level and cover approximately 13 573 ha of the ACT (excluding secondary grasslands). They are broadly located in a north–south pattern along the hills and ridges that flank the urban and rural areas of the ACT. Eucalypt species dominate the canopy and the understorey is dominated by a range of shrubs, grasses, herbs and forbs. The most widespread lowland woodland communities in the ACT are those dominated by Blakely’s Red Gum / Yellow Box (u19) and Yellow Box / Apple Box (u178) (see 5.1).

Clearing for grazing and urban development has resulted in patches of lowland woodland of varying size and condition. While little is understood about the pre-European floristic composition of lowland woodlands, grazing has reduced the height, cover, biomass and diversity of the grassy stratum and dominant native grasses have, in many instances, been replaced by shorter, cool season, perennial native grasses or exotic grasses (Costin, 1954; McIntyre & Lavorel, 1994; Prober, 1996; Prober & Thiele, 1995; Stol & Prober, 2015).

Ongoing management is required to mitigate the impacts of a range of threats to subalpine and lowland woodlands (outlined in Section 1.2).



Snow Gum woodland, Mt Ginini (M. Jakobsons)

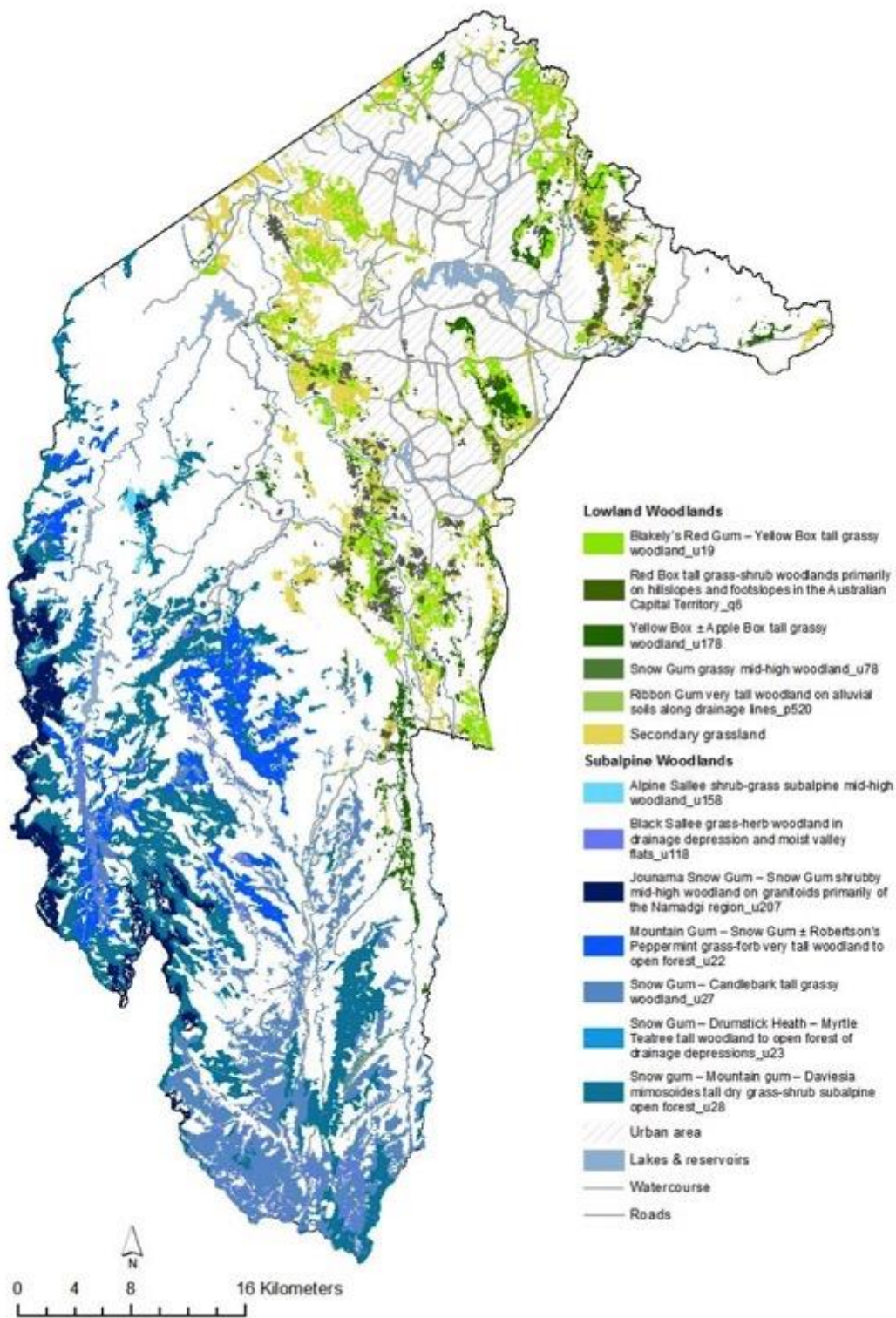
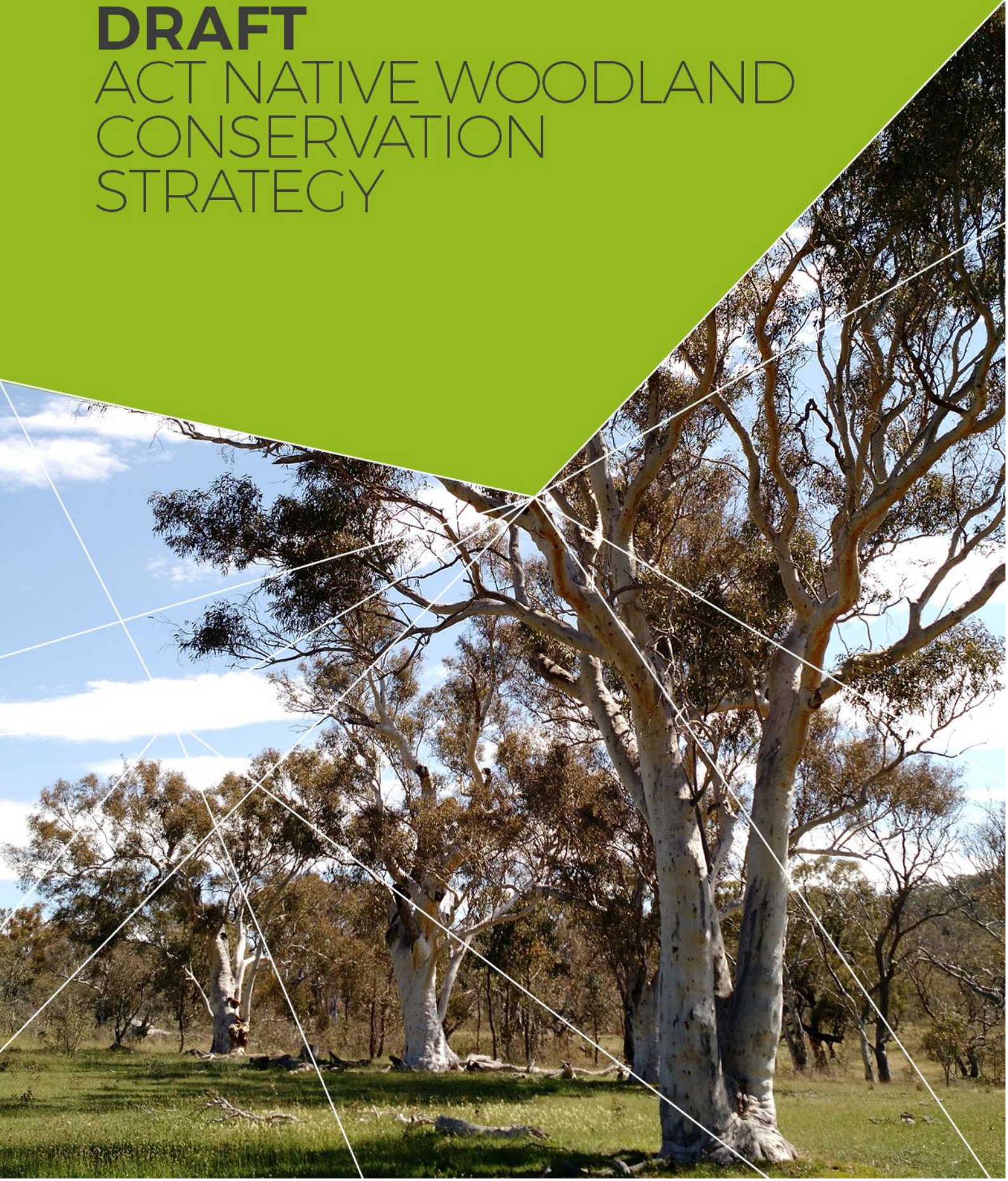


Figure 1. Distribution of woodland communities across the ACT

PART A

DRAFT

ACT NATIVE WOODLAND CONSERVATION STRATEGY



1. PROTECT AND MANAGE WOODLAND AND COMPONENT SPECIES

1.1 Retain and protect native woodlands

The ACT contains some of the most intact woodlands in Australia, including the Endangered YB-BRG Woodland. In terms of size, connectivity, diversity and habitat for threatened species, ACT's woodlands are exceptional. Large patches of subalpine woodland persist across the south and south west of the ACT. The mean size of these woodland areas are over 25 ha and are often contiguous with other associated subalpine and alpine vegetation communities. Over 80% of lowland woodland patches are less than 10 ha in size. Nineteen patches of lowland woodland greater than 100 ha persist in the landscape (see Figure 2). More than half of these sites are likely to meet the definition of Endangered YB-BRG Woodland; others are degraded but retain small areas that meet the definition.

Native woodland patches persist on lands under a range of land tenures and levels of protection (see Table 1, Table 2 and Figure 3). Approximately 70% of the extent of all woodland (including secondary grasslands) is protected within the ACT's formal reserve system. Approximately 85% of this area is in the subalpine region of the ACT. Since the declaration of Namadgi National Park in 1984 and Tidbinbilla Reserve in the early 1960s, the extent of subalpine woodland protected in the ACT has remained stable. Today, approximately 98% of subalpine woodland extent is protected in reserves (see Table 2).

In 2004, when the previous Lowland Woodland Strategy was developed, approximately 21% of lowland woodland (including secondary grasslands) was protected in reserves. Since then, an additional 1156 ha has been protected, including areas that contain Endangered YB-BRG Woodland. Today, approximately 29% of the total extent of lowland woodland is protected in reserves and 44% persists on rural lands (Table 1). The proportion of each lowland woodland community protected in reserves ranges from 23 - 100%. Lowland Snow Gum grassy woodland (u78), Red Box tall grass-shrub woodland (q6) and secondary grasslands have the lowest representation in the reserve system (23%, 20% and 26% of extent respectively).



Sticky Everlasting, Googong Dam (E. Cook)

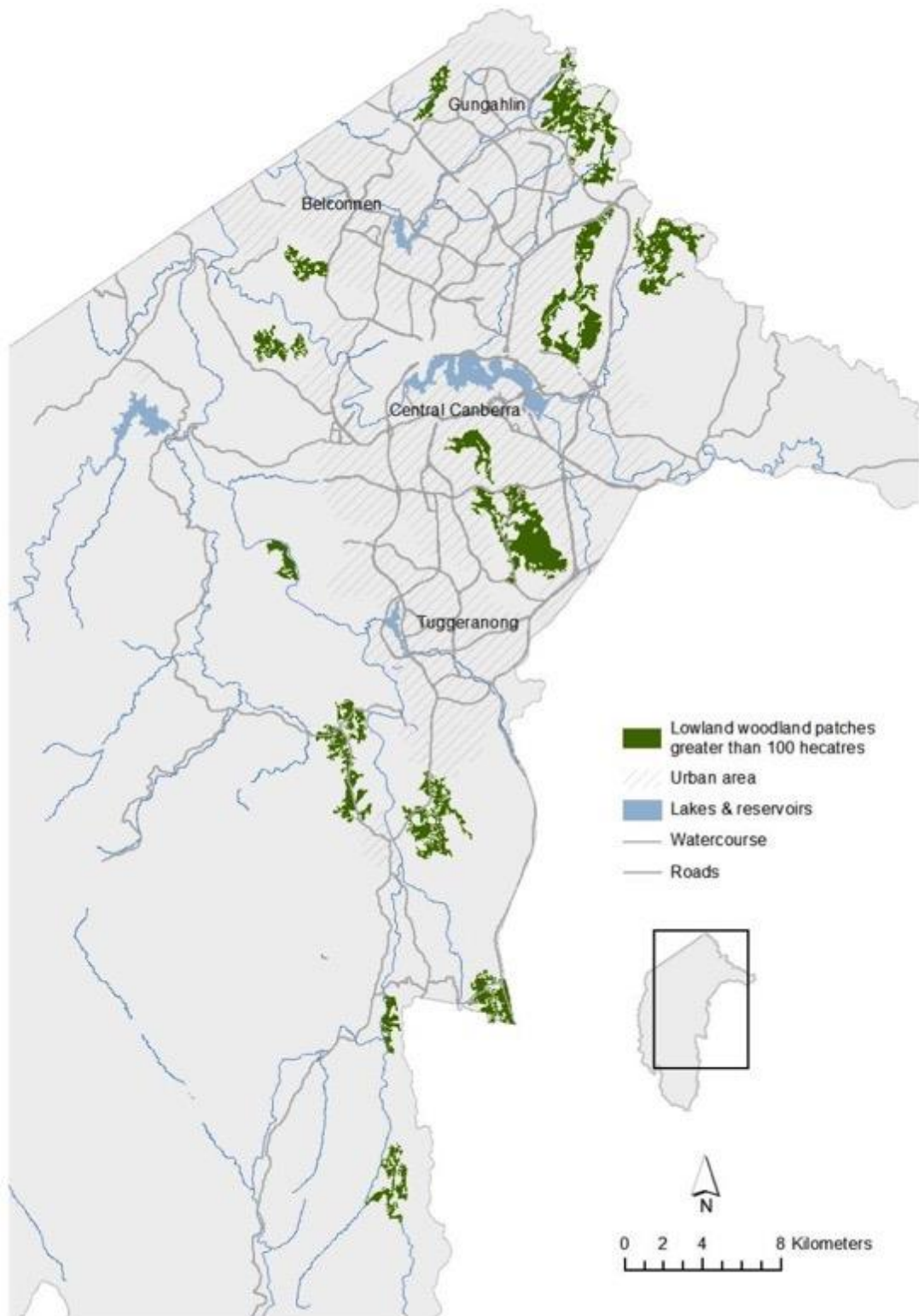


Figure 2. Distribution of lowland woodland patches larger than 100 ha in the ACT

Table 1. Lowland woodland communities across land tenures in the ACT

Woodland community*	Total extant hectares	Reserve⁽ⁱ⁾ (% of total)	Other conservation⁽ⁱ⁾ (% of total)	Rural lands⁽ⁱ⁾ (% of total)	National land (% of total)	Other⁽ⁱ⁾ (% of total)
Blakely's Red Gum – Yellow Box (± White Box) tall grassy woodland (u19)	7196	2138 (30)	829 (11)	3129 (43)	621 (9)	477 (7)
Yellow Box – Apple Box tall grassy woodland (u178)	4334	1289 (30)	251 (6)	2073 (47)	349 (8)	373 (9)
Red Box tall grass-shrub woodlands (q6)	1776	359 (20)	317 (18)	709 (40)	335 (19)	57 (3)
Ribbon Gum very tall woodland on alluvial soils along drainage lines (p520)	174	155 (89)	7 (4)	6 (3)	-	6 (4)
Snow Gum grassy mid-high woodland (u78)	90	21 (23)	3 (3)	61 (68)	-	5 (6)
TOTAL	13573	3963 (29)	1408 (10)	5978 (44)	1306 (10)	801 (7)
Secondary Grasslands	17868	4689 (26)	352 (2)	10813 (61)	1440 (8)	574 (3)

(i) Reserve: Nature Reserve, National Park. Other conservation: land managed to maintain the natural values of the area (including: urban open spaces, special purpose reserves, hills, ridges and buffers, and unleased areas managed as reserve). Rural lands: rural lease, unleased (grazing licence). Other: Forests, roads, unleased, SPR-Recreation and private leases. * A list of the full community name (as described by Armstrong et al. (2013)) is provided in 5.1.

Table 2. Subalpine woodland communities across land tenures in the ACT

Woodland community*	Total extant hectares	Reserve⁽ⁱ⁾ (% of total)	Other conservation⁽ⁱ⁾ (% of total)	Rural lands⁽ⁱ⁾ (% of total)	National land (% of total)	Other⁽ⁱ⁾ (% of total)
Snow Gum – Mountain Gum – <i>Daviesia mimosoides</i> tall dry grass-shrub subalpine open forest (u28)	18235	18077 (99)	72 (<1)	83 (<1)	-	2 (<1)
Snow Gum – Candlebark tall grassy woodland in frost hollows and gullies (u27)	14442	13533 (94)	-	896 (6)	-	12 (<1)
Mountain Gum – Snow Gum ± Robertson's Peppermint grass-forb very tall woodland to open forest (u22)	8054	8042 (100)	6 (<1)	6 (<1)	-	-
Jounama Snow Gum – Snow Gum shrubby mid-high woodland on granitoids (u207)	4677	4677 (100)	-	-	-	-
Black Sallee grass-herb woodland in drainage depressions and moist valley flats (u118)	2623	2563 (98)	8 (<1)	51 (2)	-	-
Alpine Sallee shrub-grass subalpine mid-high woodland (u158)	378	378 (100)	-	-	-	-
Snow Gum – <i>Epacris breviflora</i> – <i>Leptospermum myrtifolium</i> tall woodland to open forest of drainage depressions (u23)	<1	<1 (100)	-	-	-	-
TOTAL	48409	47272 (98)	86 (<1)	1037 (2)	-	14 (<1)

(i) Reserve: Nature Reserve, National Park. Other conservation: land managed to maintain the natural values of the area (including: urban open spaces, special purpose reserves, hills, ridges and buffers, and unleased areas managed as reserve). Rural lands: rural lease, unleased (grazing licence). Other: Forests, roads, unleased, SPR-Recreation and private leases. * A list of the full community name (as described by Armstrong et al. (2013)) is provided in 5.1.

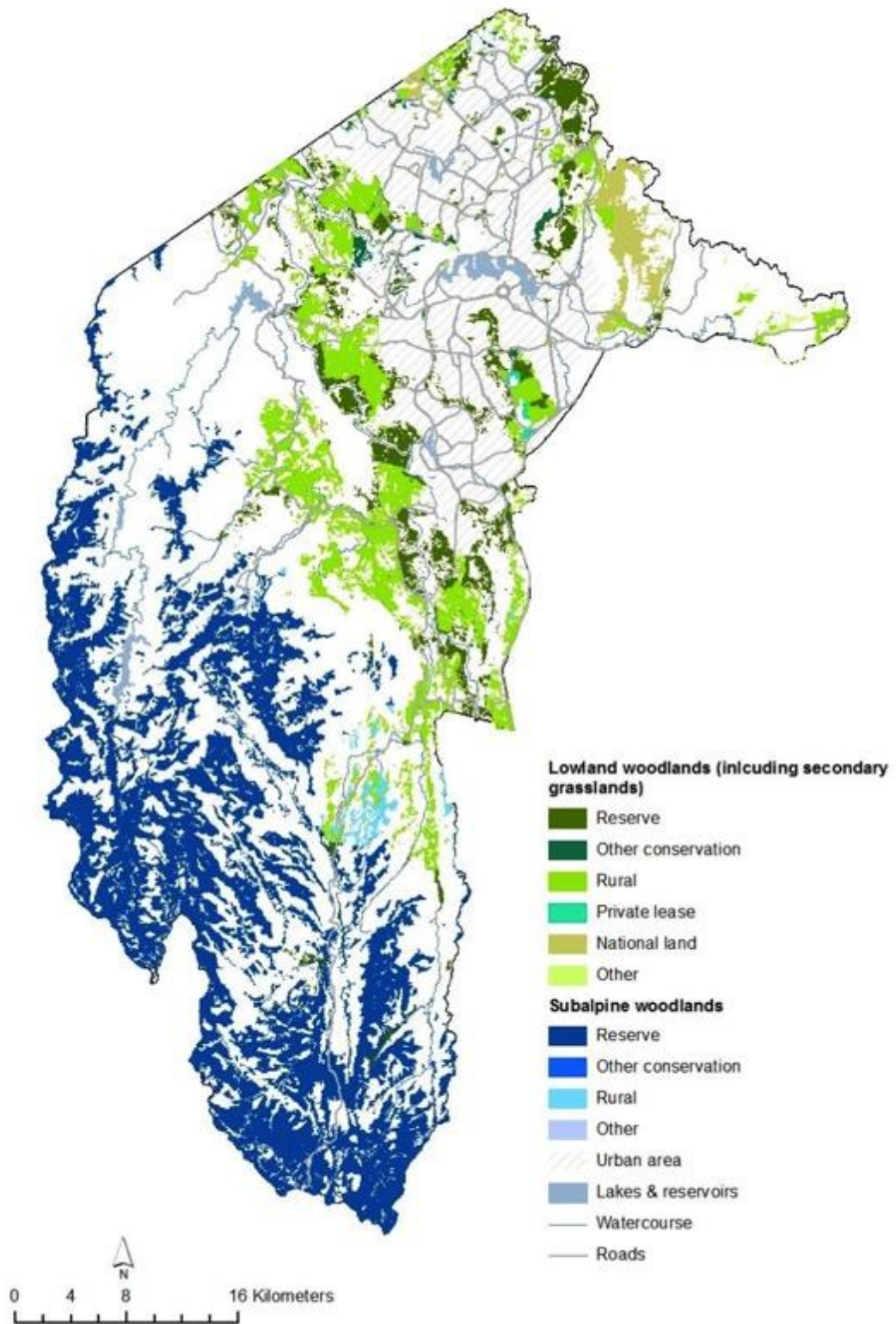


Figure 3. Distribution of lowland and subalpine woodland across tenures in the ACT

Formal protection of woodland, particularly the long-term conservation of remaining lowland woodland, facilitates functional connectivity, supports the maintenance of a diversity of slow-developing habitat features and supports the persistence of threatened woodland-dependent species. However, effective protection of woodlands against a range of threats (outlined below) requires an ecosystem management approach that prioritises actions based on need, regardless of tenure. This cross-tenure approach is critical to realising the conservation goals outlined in this Strategy.

The ACT Government supports the protection of woodlands by gazetting additional land as reserves under the *Nature Conservation Act 2014*. The protection of woodlands will also be supported by identifying priorities and partnerships with community and non-government agencies. A range of ACT Government policies that aim to protect and enhance the values of woodland outside of the reserve system will support these initiatives (e.g. various legislative frameworks [outlined in (iv)], land use licences and approvals, and Land Management Agreements). A Cultural Heritage Management System is currently being developed for the ACT Government that outlines the principles, policies and procedures to protect and monitor sites and objects of cultural significance from threatening processes within the reserve system.

CONSERVATION OBJECTIVES

Retain and protect native woodlands

- Ensure no net loss of the ecological and cultural values of woodlands in the ACT.
- Maintain or improve the proportion of each woodland community located within the ACT's formal reserve system (see Table 1, Table 2).
- Identify opportunities to improve representation of lowland Snow Gum woodland (u78) and Red Box tall grass-shrub woodland (q6) in the ACT's formal reserve system.
- All species of woodland flora and fauna should be represented by viable, wild populations that will enable the species to be conserved for perpetuity. The ACT Government will continue to support regional and national effort towards the conservation of these species
- Improve understanding of the distribution of Endangered YB-BRG Woodland community in the ACT and aim to protect all remaining areas from unintended impacts (see action plan, Part B).
- Prioritise the protection and ongoing management of woodland that contributes to threatened species conservation (as outlined in respective action plans and conservation advice, Part B).
- Identify opportunities to protect and enhance the values of woodlands outside the reserve system, guided by relevant policy and legislation and in collaboration with non-government agencies and community members (see Section 2.1).
- Manage the impact of residential and commercial development on woodlands in the ACT through the Environmental Offsets Policy and those strategies outlined in Section 1.2.

1.2 Reduce threats to native woodland biodiversity

Native woodlands and associated fauna across the ACT are subject to a range of impacts that threaten their condition, resilience and survival. Threatening processes include those that impact ecosystems at a regional scale (e.g. climate change) and those that are largely restricted to a single site (e.g. inappropriate grazing disturbance). These threats interact and where possible, should be

managed as part of a combined strategy to maintain and enhance the viability of woodlands in the ACT. The extent and severity of threatening processes may differ between lowland and subalpine woodlands.

Dieback

Dieback refers to the long-term decline in the health of trees, often leading to death. Symptoms of dieback include thinning of the canopy, regeneration of the crown from epicormic shoots, reduction in growth rate, increase in dead branches, and other symptoms of stress that may render the trees more susceptible to damage from insects and disease. The primary drivers of *Eucalyptus* dieback are usually fungal pathogens (Ciesla & Donaubauer, 1994; Jurskis & Turner, 2002; Scott et al., 2009) or high rates of defoliation by insects (Edwards et al., 1993; Gherlenda et al., 2016; Hall et al., 2015; Journet, 1981; Lowman & Heatwole, 1987; Ross & Brack, 2015; Steinbauer et al., 2015; Stone & Bacon, 1994; Wardell-Johnson et al., 2005).

A number of research projects link insect outbreaks to changes in weather and water stress (Clark, 1962; Clark & Dallwitz, 1974; White, 1969). Whether dieback is related to an increased susceptibility of trees to these drivers, and the potential reasons for this, is less well understood. Researchers have postulated that nutrient enrichment of woodland systems through pasture improvement has played a significant role in dieback on rural lands (Landsberg et al., 1990). Other suggested causes include fewer low intensity fires (Jurskis & Turner, 2002), higher rainfall and / or water logging (Gherlenda et al., 2016; Hall et al., 2015), climate change and plant stress due to changed soil conditions (Jurskis & Turner, 2002), and increased pest mobility associated with urbanisation (Hall et al., 2015).

Dieback is becoming an increasing threat to trees and associated flora and fauna in woodlands in the ACT and more broadly. For example, across the Monaro region of NSW, approximately 2000 km² of woodland is affected by dieback. The decline in condition, particularly of Ribbon Gum (*Eucalyptus viminalis*), is consistent across all land use types and has no relationship with fire regime or habitat complexity (Ross & Brack, 2015). Within the ACT, dieback has been described across all age classes and land tenures. It is most common in *Eucalyptus* trees across the lowlands (e.g. Blakely's Red Gum [*Eucalyptus blakelyi*] and Apple Box [*E. bridgesiana*]). However, it also has been noted in a number of species that occur in subalpine communities including Snow Gum (*E. pauciflora*), Ribbon Gum, and Candlebark (*E. rubida*). Blakely's Red Gum, a key component of the Endangered YB-BRG Woodland community, is particularly susceptible to dieback (Cowood et al., 2018).

In the ACT, affected trees show signs of foliar damage from insect herbivory, especially psyllids (*Cardiaspina albitextura* and *Lasiopsylla rotundipennis*) and the scarab beetle (*Anoplognathus* spp.). Dieback of Ribbon Gum and Apple Box noted in the southern regions of the ACT appears to be correlated with the presence of the native weevil (*Goniapterus* spp.). Preliminary analyses indicate fungal pathogens (*Phytophthora* spp.) are present in ACT woodlands, but further investigation is required to confirm their contribution to dieback in the ACT (ACT Government, 2017 unpublished data).

The cause (or interacting factors) leading to an increase in the abundance of psyllids or the scarab beetle that may cause dieback in the ACT is not known. Similarly, limited information is available to identify causative factors of eucalypt susceptibility to insect attacks (or other drivers) that cause dieback. However, recent modelling indicates that the change in condition (as a measure of dieback) of Blakely's Red Gum and lowland box gum grassy woodland (u178 and u19) between 2004 and 2017 was influenced by a range of habitat (e.g. soil characteristics and water table height), climate (e.g. seasonal precipitation) and cohort (e.g. tree canopy density) variables (Cowood et al., 2018). Specifically, declining condition of lowland box gum grassy woodland is associated with elevated

maximum temperatures during the warmest month of the year and high rainfall in the wettest month. Poor condition is also correlated with fewer fires since 1900 and with increasing distance between trees. The overall condition of trees on rural land is higher than on reserve land (Cowood et al., 2018). It is important to note that the health of trees in lowland woodland changes from year to year, and the relationship between condition and variables also changes.



Blakely's Red Gum, Isaac Ridge

CONSERVATION OBJECTIVES

Mitigate the impacts of dieback

- Continue to lead and support research and modelling to improve our understanding of the relationship between dieback and:
 - fire
 - the abundance and impact of insects and fungal pathogens
 - soil moisture and condition
 - vegetation density
 - land use.

This will require the collection of additional field data.

- Continue to map tree canopies using remote sensing methods and undertake associated modelling and analysis (as outlined in Cowood et al. (2018)) to track changes in the condition of trees in lowland woodland communities (e.g. Blakely's Red Gum, Yellow Box [*Eucalyptus melliodora*] and Apple Box) over time. Expand modelling and analysis to include subalpine woodland species (e.g. Snow Gum, Ribbon Gum and Candlebark).
- Lead and support research to improve our understanding of the susceptibility of individual *Eucalyptus* trees to dieback (including investigations into genetic variability and seed provenance trials [see Section 4]).
- Undertake and support restoration activities that enhance a system's resilience to climate change and other disturbances (see Section 1.3), and encourage regeneration and establishment of *Eucalyptus* trees.
- Management actions that aim to mitigate the impacts of dieback are informed by emerging ideas and research undertaken in the ACT and in *Eucalyptus* woodland communities across Australia.

Pest animals

Pest animals cause damage to native species associated with woodland ecosystems in the ACT. Pest species include the European Rabbit (*Oryctolagus cuniculus*), European Red Fox (*Vulpes vulpes*), feral cat (*Felis catus*), feral pig (*Sus scrofa*), feral horses (*Equus caballus*), Indian Myna (*Acridotheres tristis*), European Wasp (*Vespula Germanica*), Honey Bee (*Apis mellifera*) and several species of deer. Threats posed by pest animals do not occur in isolation; the impact of multiple pest species often interact with each other and with a range of other threatening processes that exert pressure on native biodiversity (e.g. fire, grazing and habitat fragmentation) (Molsher et al., 2017; Williams et al., 1995).

The Australian Government lists competition and land degradation caused by European Rabbits as a key threatening process (Commonwealth Government, 2011c). European Rabbits negatively impact ecosystems by disturbing the soil, preventing the regeneration of vegetation, ringbarking trees, promoting weed invasion and competing with native mammals for resources (Commonwealth Government, 2011c; Leigh et al., 1987; Williams et al., 1995; Wimbush & Forrester, 1988). Rabbits are widespread across a range of ecosystems and altitudinal gradients in the ACT. Leigh et al. (1987) found that rabbits in the subalpine woodlands in the ACT increase the risk of erosion and reduce the cover and diversity of forbs.

Deer can damage soils and reduce the abundance of native plants by rubbing against and damaging trees, trampling and eating saplings (Commonwealth Government, 2011b) and wallowing within and around the edges of waterbodies. Three species of deer have been recorded in woodlands and other ecosystems in the ACT. Fallow Deer (*Dama dama*) and Red Deer (*Cervus elaphus*) have scattered populations across a range of ecosystems in the ACT. Sambar Deer (*Rusa unicolor*) are an emerging threat in the ACT. Most sightings of Sambar Deer have been within Namadgi National Park. Monitoring by the ACT Government indicates they have had little impact on vegetation structure and composition to date (Mulvaney et al., 2017).

Predation by the European Red Fox and feral cat are both listed as key threatening processes by the Australian Government (Commonwealth Government, 2008, 2015b). Feral cats prey on a range of birds, reptiles and mammals and have been implicated in the widespread decline of native fauna across the country (Dickman, 1996). Predation by foxes is also believed to have contributed significantly to the decline of native animals in Australia (Commonwealth Government, 2011a). Both cats and foxes threaten the survival and persistence of woodland fauna in the ACT. Domestic cats in Canberra show a preference for mammals, but also kill a range of native birds, reptiles and amphibians (Barratt, 1997).

The Australian Government lists predation, habitat degradation, competition and disease transmission by feral pigs as a key threatening process (Commonwealth Government, 2017). Pigs can alter soil structure, nutrient cycles and water quality, and can alter plant species composition, including the distribution of weeds (Commonwealth Government, 2017). There are resident populations of pigs across the ACT. They are most likely to have an ongoing impact within subalpine ecosystems, including woodlands, which neighbour bogs, wetland areas and creeks.

Feral horses can cause soil compaction, erosion, damage to vegetation, introduction of weeds and damage to water bodies (Commonwealth Government, 2011d). While horses are abundant in Kosciusko National Park bordering the ACT, they are now largely absent from the ACT. Incursions into Namadgi National Park are monitored and controlled as required.

Box 2: Dingoes (*Canis lupus*), a controlled native species

Dingoes (*Canis lupus*) have functioned as a higher order predator in Australian ecosystems for approximately 4 000 years. They prey on a range of small, medium and large animals and may help suppress introduced species such as the European Red Fox, feral cat and European Rabbit (Corbett & Newsome, 1987; Letnic et al., 2013; Newsome et al., 2017). In the ACT, Dingoes show some hybridisation with domestic dogs and, due to their impact on sheep, are considered a pest by graziers (ACT Government, 2012a). They are currently controlled in areas adjoining rural properties to protect livestock, however in core areas of Namadgi National Park they are protected.

Indian Mynas are aggressive and may outcompete native animals for food and limited habitat features such as hollows. In the ACT they are most commonly found in urban areas, along the edges of woodland reserves, and within nature reserves with low densities of trees (Grarock et al., 2014b; Pell & Tidemann, 1997). Recent data analysis undertaken by the Canberra Ornithologists Group (COG) indicates that the number of Indian Mynas in the ACT is no longer increasing (Bounds et al., 2010). Community-led culling is likely to have played a role in reducing populations at a local level (Grarock et al., 2014a).

Aggressive exclusion of native birds from potential woodland and forest habitat by over-abundant Noisy Miners (*Manorina melanocephala*) is listed as a key threatening process by the Australian Government (Threatened Species Scientific Committee, 2013). Noisy Miners have been implicated in

the reduction of abundance and diversity of native birds within woodlands (Bennett et al., 2015; Dow, 1977; Grey et al., 1997; Taylor et al., 2008). The pressure exerted on native fauna is exacerbated by fragmentation and is most pronounced in the most productive areas (Bennett et al., 2015; Montague-Drake et al., 2011; Oldland et al., 2009; Taylor et al., 2008). Analysis of woodland bird data by COG indicates that the number of Noisy Miners in the ACT is increasing (Bounds et al., 2010; Canberra Ornithologist Group, 2018).

In addition to being a social nuisance, European Wasps may impact woodland and other ecosystems by preying on and competing with native invertebrates (Kenis et al., 2009). European Wasps are found throughout the ACT, including the most remote areas of Namadgi National Park. Competition from feral Honey Bees is listed as a key threatening process by the NSW Government (NSW Government, 2002). Honey Bees compete with native species for tree hollows and flora resources (NSW Government, 2002). Many woodland-associated birds (including the Superb Parrot) are dependent on tree hollows and may be affected by competition for hollows from European Wasps and Honey Bees. In addition, other hollow-dependent fauna, including Sugar Gliders (*Petaurus breviceps*), Brushtail Possums (*Trichosurus vulpecula*), Greater Gliders (*Petauroides volans*) and Yellow-bellied Gliders (*Petaurus australis*), may also be affected by European Wasps and Honey Bees.

CONSERVATION OBJECTIVES

Control pest animals

- Prevent costly, erratic pest animal control by ensuring long-term, regular funding for targeted pest management, according to the ACT Pest Animal Strategy 2012-2022 (ACT Government, 2012a).
- Reduce the impact of pest animals by prioritising management activities that detect and efficiently manage emerging pest species. Activities include:
 - responding promptly to emerging pest species and ensuring rigorous follow-up control
 - identifying additional strategies to expand community education regarding the threats and identification of pest animals
 - enhancing knowledge sharing between community members and land managers, including the ACT Government.
- Where eradication of a species is not feasible, prioritise management actions to protect significant cultural and ecological assets from further impacts.
- Facilitate and support cross-tenure management of pest animals.
- Consider the interactions between ecosystem processes, threatening processes and management activities during the development and implementation of control programs.
- Lead and support research to improve our understanding of the relationship between pest animal abundance/density and environmental impacts. Based on research findings, develop management actions that target actual, rather than perceived, impacts.
- For all control programs, develop and maintain a robust monitoring program to track changes in the abundance of pest animals and the impact they cause to woodland values.
- Develop management triggers for the control of pest animals that are informed by both the abundance of an animal and its environmental impact.

- Facilitate community education and participation in pest animal management to maintain community support for pest animal control and to improve efficiencies of control work through cross-tenure management.
- Lead and support research to identify and test innovative control methods and emerging technologies in the space of pest animal control to inform best-practice management.
- Maintain local, regional and national research collaborations (including the Centre for Invasive Species Solutions).

Fire

Fire is a critical component of a functioning woodland as it influences soil properties, vegetation structure and the regeneration of some plant species (Prober et al., 2008; Stol & Prober, 2015).

Fire regimes are characterised by the season, frequency and intensity of burning. Inappropriate fire regimes can negatively impact ecosystem processes, plant communities and fauna habitat (Driscoll et al., 2010). Fire season has the potential to change fire behaviour due to varied temperature and moisture conditions. Fire will also impact flora and fauna in different ways when occurring at different stages of a species life cycle.

Frequent fires can simplify woodland ecosystems by: limiting regeneration opportunities, eliminating fire-sensitive species, and damaging groundlayer and other habitat features (e.g. tree hollows in subalpine woodlands (Salmona et al., 2018)). Midstorey vegetation cover can also increase in woodlands that are burned too frequently (Dixon et al., 2018b; Foster et al., 2017) or too infrequently (Close et al., 2011; Wilson et al., 2018). If fire is too infrequent, plant species diversity in lowland systems may also decline (Penman et al., 2011).

Research suggests high intensity fires can damage belowground systems and simplify lowland woodland vegetation structure (Foster et al., 2017; Neary et al., 1999). The loss of young trees and seedlings to high intensity fire limits recruitment and creates a more homogenous stand age structure. The loss of mature trees can increase midstorey regeneration and fire fuel loads in lowland systems (Wilson et al., 2018), and decrease habitat availability and diversity in subalpine woodlands and forests (e.g. destroying tree hollows) (Salmona et al., 2018).

Tolerable fire intervals (TFIs) describe an inter-fire interval, between which plant species have optimum time to regenerate between fires. The minimum TFI defines the minimum interval between successive fires that allows species to either regenerate from seed or for resprouters to become fire tolerant, prior to the next fire. The maximum TFI defines the maximum fire-free interval before those species that require fire for regeneration, decline with age and die. Thus, prescribed TFIs define the optimum period within which fire should occur to maintain species diversity and minimize species loss.

In January 2003, wildfires burnt 70% (164 914 ha) of the ACT, including pine plantations, rural lands and extensive areas of woodland. The majority of subalpine woodland communities were burnt during these fires and are now below prescribed minimum TFIs (see 5.1). Consequently, extensive areas of subalpine woodland currently support young, regenerating vegetation. Conversely, significant areas of lowland woodland remained unburned during the 2003 wildfires and are currently above their prescribed maximum TFI (see 5.1).



Prescribed burning, Wanniasa Hill (M. Jakobsons)

Fuel reduction activities – including slashing, grazing and prescribed burning – are undertaken to mitigate the impacts of large-scale wildfire and to maintain and/or improve the health of woodlands (and other ecosystems) in the ACT. The ACT Government prepares annual Bushfire Operations Plans (BOPs) that guide the implementation of annual fuel management activities. These plans adopt current best practice management techniques and consider ecological knowledge to establish prescribed minimum and maximum TFIs of vegetation. Where the fire requirements of threatened species are known, annual BOPs also recommend fire management activities that aim to maintain or enhance conditions for these species (see action plans, Part B).

Box 3. Burning subalpine woodlands to reduce the risk of wildfire

There is limited, but growing knowledge available to inform fire management in subalpine woodlands. Recent research projects provide some insight into the dynamics of fuel loads and the response of fauna and flora to fire.

Fuel loads in subalpine woodland are lowest for the first few years directly after fire. However, as subalpine woodland (and other forest ecosystems) mature, they become less flammable than those burnt frequently (Zylstra, 2018). Fuel increases until between 6 and 12 years after fire and then, in the following decades begins to decline (Dixon et al., 2018b). In some areas of the ACT, long unburned (>96 years old) subalpine woodlands have fuel loads comparable with those areas burned recently in this ecosystem (Dixon et al., 2018b). Land managers should consider this information when planning fuel suppression efforts, as frequent burning is likely to lead to an increase in shrubby understorey and thus, flammability (Dixon et al., 2018b; Zylstra, 2013).

There is evidence that long unburned woodland is disproportionately more important for reptile richness and abundance (Dixon et al., 2018a) and mammal richness (K. Dixon 2018, pers. communication) than recently burned sites. Less than 8% of subalpine woodland and forest in Namadgi National Park remains long unburned (>96 years old) (Dixon et al., 2018b) and many areas of subalpine woodland in the ACT have burnt within the last 20 years (ACT Government data, unpublished). The ACT Government aims to continue to protect patches of long unburned subalpine woodland (ACT Government, 2014) .

Using fire to conserve woodland-associated biodiversity in the ACT is challenging. The specific responses of most fauna and flora to different fire regimes are unknown (see Box 3). Where lowland woodlands are in close proximity to urban areas, ACT land managers must strike the right balance

between reducing fuel loads to protect human life and property, and undertaking ecological burning to maintain and enhance biodiversity. Trade-offs are also required in subalpine areas where prescribed burning of corridors is required to slow the spread of unplanned fires. Furthermore, there is a risk that prescribed burning can result in adverse ecological impacts, such as the collapse and loss of mature, hollow-bearing trees (see discussion in Bluff (2016)). Furthermore, invasive plant species can become established following disturbance from fire (e.g. Cootamundra Wattle [*Acacia baileyana*] and a range of exotic annuals) (Stol & Prober, 2015). Future challenges for fire management in a changing climate are discussed below.

CONSERVATION OBJECTIVES

Fire management

- Undertake strategic prescribed burning and other fuel reduction activities within woodlands to protect human life and property, maintain species diversity and minimise species' losses according to the ACT Strategic Bushfire Management Plan (ACT Government, 2014).
- Use the best available ecological knowledge to evaluate and make decisions regarding balancing asset protection and woodland biodiversity conservation.
- As part of planning for prescribed burning, take appropriate measures to mitigate potential negative ecological impacts.
- Lead and support research to improve our understanding of the responses of fauna and flora to different fire regimes in the ACT.
- Facilitate and support cross-tenure fire management planning and activities (including with rural landholders and NSW land managers).
- Where it is consistent with objectives to reduce the risk to human life and property, increase the diversity of subalpine woodland post fire age classes. Priority activities include:
 - protecting areas of long unburned subalpine woodlands from fire for the foreseeable future
 - identifying areas of subalpine woodland to transition to older post-fire age classes.
- Develop weed management strategies for fire management when there is a likelihood of invasive species responding positively to burning (e.g. English Broom [*Cytisus scoparius*], African Lovegrass [*Eragrostis curvula*], Cootamundra Wattle, Oxeye Daisy [*Leucanthemum vulgare*] and Nodding Thistle [*Carduus nutans*]).
- Facilitate community education initiatives to improve understanding of the complexities of fire management in the ACT and the use of fire to manage woodland biodiversity.
- Undertake robust monitoring and evaluation to assess the ecological (and human life and property protection) outcomes of planned fire management activities (See Section 3) and unplanned fire events.
- In accordance with ACT Government (2015a), protect cultural sites during fire management activities and work in collaboration with Traditional Custodians and the broader Aboriginal community to plan, implement and monitor cultural burns in woodlands.

Urbanisation

Extensive areas of lowland woodland have been cleared across southeast Australia and many now exist as fragmented patches within a landscape of urban and rural development (see Section 4). The development and expansion of new suburbs will be the primary cause of future losses of woodland habitat in the ACT. Future suburbs to accommodate the growth of Canberra in the Molonglo Valley and Gungahlin have been subject to rigorous ACT and Commonwealth statutory environmental assessment processes and approvals to avoid, mitigate or offset the impacts of development on woodland habitats.

The ACT Planning Strategy 2018 outlines a strategic approach to investigate the potential for new residential areas to the west of the city to meet future housing need. A key action is to undertake environmental, infrastructure and planning studies for the western edge of the city (to identify suitable areas for a range of uses) (ACT Government, 2018a). Natural habitat and conservation areas are considered in the urban planning and design processes to promote habitat connectivity and support landscape resilience. Offset areas are also identified and established to offset any unavoidable impacts on the natural environment (ACT Government, 2018a). The western edge investigation area contains patches of Endangered YB-BRG Woodland, and habitat for threatened birds and the vulnerable Pink-tailed Worm-lizard. Woodland patches in this area also have local and regional habitat connectivity value.

While there is significant ecological value in retaining small woodland patches (Eldridge & Wong, 2005; Fischer & Lindenmayer, 2002), scattered and isolated remnant trees (Fischer et al., 2010; Le Roux et al., 2018; Manning et al., 2006; Stagoll et al., 2010), and urban green space (Ikin et al., 2013a; Stagoll et al., 2012), urban areas contain limited habitat structure that support woodland biodiversity (Le Roux et al., 2014b). Habitat features such as hollows, logs and litter are significantly reduced in urban greenspace compared with rural lands and nature reserves in the ACT (Le Roux et al., 2014b). The regeneration of trees in the urban context is also limited, and lower than in nature reserves (Le Roux et al., 2014a; Le Roux et al., 2014b).

While the canopy cover of mature trees has declined in urban areas since 2004, it has increased across rural lands and nature reserves (J. Botha 2018, pers. communication). Modelling suggests that while reserves will continue to provide a stable source of hollows, under existing management practices, the availability of hollow-bearing trees in the urban environment is likely to decline over time (Le Roux et al., 2014a). The loss of mature native trees (including hollow bearing trees) and a lack of recruitment is listed as a key threatening process under the *Nature Conservation Act 2014*. The importance of mature and hollow-bearing trees is discussed in Section 1.3 (and in ACT Government (2018g)).

Urban development also leads to further fragmentation of woodland, resulting in the loss of structural connectivity that supports landscape permeability for movement of species (see Section 1.3). The state of the landscape-scale urban-woodland matrix has significant impacts on the habitat features and species located in lowland woodland across the ACT. Disturbances to lowland woodlands is greatest proximal to urban areas. These may include:

- increased visitor access resulting in higher rates of removal of rocks and timber for firewood, trampling and other impacts from unmanaged access and activities, and damage to sites of Aboriginal and / or heritage value
- dumping of garden waste, rubble and other rubbish
- changes in nutrient inputs and soil properties

- spread of garden weeds and invasive plants (e.g. Cotoneaster [*Cotoneaster spp.*], Hawthorn [*Crataegus monogyna*] and Firethorn [*Pyracantha spp.*])
- invasion by aggressive or exotic birds that are prevalent in urban areas
- noise and light pollution
- interactions with native wildlife, including bird feeding (which may change the behaviour and composition of native birds and spread avian disease (Goddard et al., 2017; Jones & Reynolds, 2008)) and predation by domestic cats and dogs
- the need, in some cases, to undertake frequent fuel management activities within asset protection zones to reduce the risk of wildfire to human life and property.

Urban development and low levels of vegetation across the agricultural landscape are likely to influence the composition of birds found within adjacent woodland patches (Ikin et al., 2014a; Ikin et al., 2014b). A number of woodland bird species, some which are declining in the region, avoid habitat that is in close proximity to the urban edge (e.g. Scarlet Robin and Striated Thornbill [*Acanthiza lineata*]). Other species are also impacted by the rate of urban encroachment (e.g. Brown Treecreeper) (Rayner et al., 2015a).

With the development of new suburbs and the growth of Canberra's population, pressure from recreational access is likely to increase. Potential visitor impacts are outlined in Section 2.2.

CONSERVATION OBJECTIVES

Mitigate the impact of urbanisation

- Mitigate impacts of existing urban development on adjacent woodland habitat, by:
 - protecting, maintaining and improving habitat features across the urban landscape
 - supporting community-led stewardship of woodlands by facilitating education initiatives and fostering relationships with relevant organisations (including Bush on the Boundary community groups) to improve understanding of the value of woodland and threats to its survival (see Section 2)
 - ongoing maintenance of access tracks, and visitor interpretation and other educational signage
 - maintaining vigilance in detecting and eradicating newly emerged invasive plants.
- Mitigate impacts of future urban development on woodland areas by:
 - assessing the woodland values in and surrounding identified potential future development areas to inform planning and conservation outcomes
 - supporting the identification, establishment and ongoing management of offset areas according to the ACT Environmental Offsets Policy or Commonwealth approved offset requirements (and associated documents), where relevant
 - incorporating consideration of natural habitat and conservation areas into urban planning and design processes to promote habitat connectivity and support the establishment of biodiversity refuges
 - ensuring buffer zones (including inner asset protection zones for bushfire management) are incorporated into the planned urban development area
 - ensuring consideration is given to the impacts of urban development on neighbouring woodland and associated biodiversity during the planning and development process

- ensuring new residential areas developed in the vicinity of a woodland area with high conservation value, or threatened woodland fauna habitat, are declared cat containment areas.

Overgrazing

- Eastern Grey Kangaroo

The Eastern Grey Kangaroo (hereafter kangaroo) is an iconic species often encountered by residents in the ACT. It is the dominant herbivore in grasslands and grassy woodlands, including the plains around Canberra and the foothills and lower elevation valleys of the western and southern ranges. Kangaroos play a central role in these ecosystems, modifying their habitat through selective grazing and browsing.

The abundance of kangaroos in subalpine areas (including Namadgi National Park and Tidbinbilla Nature Reserve) are regulated primarily by food supply and predation pressures (ACT Government, 2010a). These populations will remain unmanaged unless undesirable impacts are identified or specific ecological (or other) objectives require management intervention (ACT Government, 2017c).

While grassy ecosystems in the ACT evolved under the influence of grazing macropods, densities of kangaroos in lowland areas have increased considerably since the 1960s (ACT Government, 2010a). Today, kangaroos exert high grazing pressure across a number of lowland reserves in the ACT (ACT Government, 2017c; McIntyre et al., 2010). High grazing pressure from kangaroos can reduce plant species richness (Driscoll, 2017), simplify grass structure, increase the proportion of short vegetation, and reduce regeneration and herbage mass (Howland et al., 2014; McIntyre et al., 2015; Neave & Tanton, 1989; Stapleton et al., 2017; Vivian & Godfree, 2014). Sustained high grazing pressure from kangaroos also negatively impacts a range of fauna associated with grasslands and grassy woodlands in the ACT. For example, the abundance and diversity of beetles and reptile species at a site is impacted by kangaroo grazing pressure (Barton et al., 2011; Howland et al., 2014; Manning et al., 2013). Kangaroo grazing also influences the presence of a number of bird species reliant on grassy layers for foraging and / or nesting (Howland et al., 2016).

Kangaroos show a preference for new vegetation growth (Meers & Adams, 2003; Snape et al., 2018) and without intervention their populations in lowland woodlands are limited largely by the seasonal abundance of food. Maintaining a stable population of kangaroos, which is not limited by its food supply and exerts only a moderate level of grazing pressure, is important for the maintenance of plant species richness (Driscoll, 2017) and for the conservation of fauna that depend on a complex structure of understorey vegetation.



Kangaroos grazing, Mulligans Flat Woodland Sanctuary (M. Jakobsons)

- Livestock

Similar to overgrazing by kangaroos, grazing by livestock can simplify understorey vegetation structure, age and size (including eliminating grazing-sensitive species and reducing native plant species richness), and negatively impact woodland-associated fauna assemblages (Barton et al., 2016; Dorrough et al., 2012; Dorrough et al., 2011; Lindsay & Cunningham, 2009; Morgan, 2015). Grazing by livestock can also negatively impact woodland vegetation by reducing the regeneration and recruitment potential of eucalypts (Sato et al., 2016) and changing the chemistry and condition of soils (Close et al., 2008; Yates et al., 2000).

Soil compaction from livestock inhibits a plants ability to grow roots and thus to access adequate water and nutrients (Yates & Hobbs, 1997). Disturbance to the soil and increases in some soil nutrients can also facilitate the establishment of invasive plants (Close et al., 2008; Pettit et al., 1995). Furthermore, grazing pressure can prevent the movement and establishment of native, palatable species into an area. This is a significant issue to consider, as some species will need to move to new locations to persist within a changing climate (Morgan, 2015).

The impacts of grazing by livestock are dependent on the frequency, duration, intensity and timing of grazing (Barton et al., 2016; Kay et al., 2017; McIvor et al., 2011; Stol & Prober, 2015), site-level factors (e.g. fertilisation history, exotic plant competition, microsite conditions) and the climate (Dorrough et al., 2011; Prober & Wiehl, 2011).

CONSERVATION OBJECTIVES

Mitigate the impact of overgrazing

- Manage kangaroo densities according to the Controlled Native Species Management Plan for Eastern Grey Kangaroos (ACT Government, 2017c), the Kangaroo Management Plan (ACT Government, 2010a), and other subsidiary documents.
- Continue the trial of dart-delivered GonaCon on kangaroos in Canberra Nature Park (CNP) and continue to assess the long-term effectiveness of dart-delivered GonaCon on fecundity. Ensure future culling programs are informed by the outcomes of this program.
- Undertake activities, including restoration and herbage mass management techniques, to maintain, wherever possible:
 - a heterogeneous mosaic of grazing intensity by native herbivores
 - at least some pasture that is at a level palatable to kangaroos and other native herbivores.
- Continue long-term monitoring of the interaction between vegetation and principal herbivores in grasslands and grassy woodlands to inform ongoing management.
- Consider actions to enhance woody debris (including fine woody components) to reduce kangaroo browsing pressure in woodland areas where naturally occurring debris is deficient (see: Stapleton et al. (2017)).
- Work with rural landholders to support the maintenance and enhancement of woodland values, including protection from overgrazing (as outlined in Section 2.1).
- Reduce the impact of overgrazing from non-native herbivores according to ACT Government (2012a).

Invasive plants

The spread and infestation of invasive plants are threatening processes that can impact the ecological and cultural values of woodlands across the ACT. Exotic plants can change the structure and function of woodlands (e.g. by altering fire regimes) and can cause a decline in native species (e.g. Yates and Hobbs (1997) and Faithfull (2012)). Furthermore, when large stands of exotic plants establish as thickets or extensive grassy monocultures, they act to further fragment the landscape (Godfree et al., 2017).

Invasion of subalpine and lowland grassy systems by invasive plants is often driven by resource availability and is commonly associated with disturbance (Faithfull, 2012; Johnston & Pickering, 2001; Leigh et al., 1987; McIntyre & Lavorel, 1994). Invasive species found in subalpine woodlands are primarily associated with anthropogenic disturbance such as roadsides, paths and infrastructure. In the ACT, invasive plants are more abundant, diverse and widespread in lowland woodlands than subalpine woodlands (S. Taylor 2018, pers. communication). Lowland woodlands have been subject to a range of historical disturbances (Landsberg, 2000) and the high edge-to-area ratio of many patches increases their susceptibility to plant invasion (Saunders et al., 1991). Some exotic plants, including *Pinus sp.* (wildlings from former and existing pine plantations) and blackberry (*Rubus fruticosus*), are currently being managed in both lowland and subalpine woodland patches.

Annual grasses, forbs and shrubs are the most common weeds in lowland and subalpine woodlands (see Table 3). Several of these species are identified as Weeds of National Significance (WONS) (see the [Commonwealth Government Environment website](#)). Exotic grasses currently pose the biggest

threat to woodlands in the ACT. A number of species, including African Lovegrass and Chilean Needle Grass (*Nassella neesiana*), have become so abundant and widespread that eradication is not feasible. Some woodland areas have become so highly degraded and dominated by invasive species that they act as novel ecosystems. Indeed, some species of woody weeds (e.g. blackberry) in woodlands of poor condition provide valuable habitat for native animals, particularly birds (Stagoll et al., 2010).

There are a number of invasive plants that are not yet established in the ACT, but have the potential to cause significant damage to woodlands. For example, Coolatai grass (*Hyparrhenia hirta*), which can significantly impact the diversity of woodland ground cover (McArdle et al., 2004), was recently discovered in the ACT (and swiftly treated). People, vehicles, animals and machinery pose a significant biosecurity threat to woodland (particularly subalpine woodland) values through the potential introduction of invasive plants (and pathogens). Many invasive plants have a long lag time before they establish at a site. Thus prevention, and early detection and treatment, is essential to effectively and efficiently manage the impacts of plant invasions (Hobbs & Humphries, 1995). The ACT Government is on high alert to detect and eradicate a number of emerging species outlined in Table 4.

Table 3. Invasive species prioritised for control in woodlands in the ACT (WONS are bolded)

Common name	Scientific name	Woodland association
African lovegrass	<i>Eragrostis curvula</i>	Lowland and Subalpine
Blackberry	<i>Rubus fruticosus</i>	Lowland and Subalpine
Chilean needle grass	<i>Nassella neesiana</i>	Lowland
Cootamundra wattle	<i>Acacia baileyana</i>	Lowland
English broom	<i>Cytisus scoparius</i>	Subalpine
Nodding thistle	<i>Carduus nutans</i> subsp. <i>nutans</i>	Subalpine
Pine	<i>Pinus radiata</i> / <i>Pinus sylvestris</i>	Lowland and Subalpine
Serrated tussock	<i>Nassella trichotoma</i>	Lowland and Subalpine
St John's wort	<i>hypericum perforatum</i>	Lowland and Subalpine
Sweet briar	<i>Rosa rubiginosa</i>	Subalpine
Sweet vernal grass	<i>Anthoxanthum odoratum</i>	Subalpine
Garden escape woody weeds	(various)	Lowland

Table 4. Emerging invasive species in woodlands in the ACT (WONS are bolded)

Common name	Scientific name	Woodland association
Bridal creeper	<i>Asparagus asparagoides</i>	Lowland
Chilean needle grass	<i>Nassella neesiana</i>	Subalpine
Coolatai grass	<i>Hyparrhenia hirta</i>	Lowland and Subalpine
Fireweed	<i>Senecio madagascariensis</i>	Lowland
Mexican feather grass	<i>Nassella tenuissima</i>	Lowland and Subalpine
Mouse-ear hawkweed	<i>Hieracium pilosella</i>	Subalpine
Orange hawkweed	<i>Hieracium aurantiacum</i>	Subalpine
Ox-eye daisy	<i>Leucanthemum vulgare</i>	Subalpine
Spanish heath	<i>Erica lusitanica</i>	Lowland
Whiskey grass	<i>Andropogon virginicus</i>	Lowland



Spraying African Lovegrass, Mt Taylor Nature Reserve

CONSERVATION OBJECTIVES

Mitigate the impact of invasive plants

- Manage established invasive species according to the ACT Weeds Strategy 2009 -2019 (ACT Government, 2009) and annual Invasive Plants Operations Plans.
- Prevent costly, erratic invasive plant control by ensuring long term, regular funding for targeted management.
- Reduce the likelihood of new plant invasions by prioritising management activities that prevent the introduction of invasive species, and rapidly detect and efficiently eradicate emerging species. Activities include:
 - responding promptly to outbreaks of emerging species and ensuring rigorous follow up control
 - continue to engage the community in reporting weed sightings and infestations through Canberra Nature Map and the Collector Application
 - identify additional strategies to:
 - enhance community education regarding the threat and identification of invasive species, using a variety of media platforms
 - expand community education regarding the biosecurity risk people and vehicles pose to woodland values, and appropriate hygiene measures to reduce the likelihood of species being unintentionally introduced
 - enhance knowledge sharing between community members and land managers, including the ACT Government.
- Where eradication of a species is not feasible, prioritise management actions to protect significant cultural and ecological assets from further invasion.
- When required, undertake staged removal of woody weeds and plan and implement revegetation (e.g. with fast growing native shrubs) to maintain critical habitat for fauna in the absence of complex habitat structure.
- Facilitate and support cross-tenure management of invasive plants where relevant.
- As part of control programs, monitor the changes in abundance of invasive plants and their impacts on woodlands.
- Continue to use and promote digital technologies to assist in the systematic recording of invasive species distribution and control activities and use this information to monitor changes in the area and density of infestations.
- Keep up to date with new control methods and emerging technologies to inform best practice invasive plant species management.

Climate change

Over the past 60 years Australia has experienced a shift in rainfall patterns, a warming climate, and rising sea levels (Timbal et al., 2015). With continued emissions of greenhouse gas, changes to the climate are likely to continue. Future projections for the ACT and the broader region (i.e. the 'Murray Basin Cluster', identified in Timbal et al. (2015)) include: warmer temperatures (including an increase in the average mean temperature and the number of extremely hot days), a reduction in snowfall and fewer frost days, an increase in the occurrence and duration of extreme drought, an increase in

the number of severe fire danger days, and a reduction in cool-season rain (and high variability of warm-season rainfall) (Timbal et al., 2015). These changes will alter the structure and floristic composition of woodlands in the ACT and likely compromise their function and resilience. While changes to lowland and subalpine woodlands are inevitable, understanding these changes will help us develop realistic and achievable goals, and prioritise and implement strategies to maintain biodiversity.

Overall plant productivity and the persistence of some species across the landscape will be limited by changes in the availability of soil moisture (Prober et al., 2014b; Timbal et al., 2015). Warming temperatures are likely to impact the life history strategies of some species (Timbal et al., 2015), including a number of threatened lowland woodland species (see Wilson et al. (2016)). The future climatic suitability of the local area for some species may also change. For instance, climate refugia modelling undertaken by the ACT Government predicts the persistence of Snow Gum at lower elevations is at risk, however, there will continue to be suitable climate conditions at high elevations (Mackenzie et al., 2018). Modelling also suggests there will continue to be climatically suitable habitat for a number of other common subalpine woodland canopy and midstorey species (including Mountain Gum (*Eucalyptus dalrympleana*), Candlebark, Black Sallee (*E.stellulata*) and *Daviesia mimosoides*) in the near (2020-2039) and far (2060 -2079) future (Mackenzie et al., 2018).

The climate suitability of areas across the ACT in the near or far future is predicted to remain stable for many common lowland woodland canopy species in the ACT, including Blakely's Red Gum, Yellow Box, Apple Box and Ribbon Gum (Mackenzie et al., 2018). The climate suitability for many common midstorey and understorey species in lowland woodland is also likely to be maintained in the near future. The local climate is predicted to become increasingly unsuitable for some species associated with woodlands. For instance, the persistence of *Themeda triandra* is likely to be confined to small refuges in the ACT (Mackenzie et al., 2018).

Increasing temperatures and changes to concentrations of atmospheric CO₂ are likely to impact both lowland and subalpine woodland plant species in different ways, and thus alter the composition of woodland communities (Hovenden & Williams, 2010; Jarrad et al., 2009; Prober et al., 2012a). Increased CO₂ leading to increased growth rates and improved water use efficiency of woody plants may also result in denser midstorey and canopies (Hovenden & Williams, 2010; Prober et al., 2012a). However, some woodland species (including the Snow Gum), may experience increased susceptibility to damage from frosts when grown at higher atmospheric CO₂ concentrations (Lutze et al., 1998).



Mulligans Flat Woodland Sanctuary (M. Jekabsons)

Research suggests warming and drying conditions are likely to change the availability of soil nutrients in subalpine systems (White-Monsant et al., 2015). Furthermore, the effects of climate change will interact with, and potentially exacerbate the impacts of other threatening processes, such as fire, fragmentation and invasive plants (and animals). The increased growth of woody vegetation in grassy woodlands could result in changes to fuel loads and the response of woodland communities to different fire intervals and intensity. Lack of habitat connectivity across the landscape is likely to impede the successful migration and adaptation of native species to changed environmental conditions. In particular, poor dispersers (e.g. native perennial herbs) and those species that lack long-lived seed banks will have limited capacity to recover after extreme climatic events and to otherwise distribute to climatically suitable areas (Prober et al., 2012a). These species may require assistance to colonize new areas (see McIntyre (2011)). As habitat becomes unsuitable for native species and disturbance events increase, the encroachment and establishment of invasive plant species are likely to increase and further compromise the resilience of woodland vegetation under new conditions (Prober et al., 2012a).

Changes in local temperatures are likely to impact the physiology and development of a number of fauna species (Hughes & Westoby, 1994). As woodland vegetation structure, function and resources change, the suitability of current habitat for some woodland-associated fauna species will also decline. For instance, the availability and nutritional content of food for herbivores (i.e. leaf nitrogen concentrations and secondary metabolites) is likely to be lower with higher atmospheric CO₂ concentrations (Hovenden & Williams, 2010). A lack of connectivity across the landscape will impede the migration of fauna species to habitat with suitable nesting, food and shelter. Fauna species most at risk include those with a long time to maturity, poor mobility, narrow ranges, specific host relationships, isolated and specialised species, and those with large home ranges (Hughes & Westoby, 1994).

CONSERVATION OBJECTIVES

Mitigate the impact of climate change

- Improve understanding of:
 - the predicted impacts of climate change on woodland-associated fauna and flora
 - future climate refugia for woodland communities and potential colonisation sites for associated biodiversity
 - which species are likely to require assistance to migrate to suitable areas and how translocations could be used to assure the survival of populations of species
 - changes in the invasion potential of high-risk invasive plants
 - changes to woodland soil condition with drying conditions.
- Identify management priorities and protect sites identified as significant refugia (and potential colonisation sites) for woodland species.
- As outlined in Section 1.3, woodland restoration activities will consider future climate impacts and will aim to enhance a system's ability to adapt to changing conditions.
- Collaborate with local, regional, state and federal stakeholders to undertake research, management activities, and facilitate community awareness raising and knowledge sharing between all parties.
- Monitor the long-term response of species (that are characteristic of woodland communities) to climate change. Use monitoring data to inform the selection of thresholds above or below which management actions should be triggered.

1.3 Enhance resilience, ecosystem function and habitat connectivity

Stol and Prober (2015) describe high quality box-gum grassy woodland as having effective ecological processes, a diverse ground-layer with patches of shrubs, a range of tree sizes (with an open canopy), and hollows, fallen timber, and vegetation structure that provides habitat for fauna. Across eastern Australia, few lowland grassy woodlands are of high quality; they are frequently in poor to moderate ecological condition.

To enhance the resilience, function and overall condition of woodland across the ACT, restoration works must aim to maintain (or improve) a range of habitat features. Maintaining heterogeneous understorey structure and intermediate herbage mass are critical components of the restoration of our lowland woodland systems. Habitat connectivity is also a critical consideration in ensuring the long-term resilience and function of woodland and associated biodiversity.

Maintain and improve woodland condition

The most important consideration in seeking to enhance the function of woodland ecosystems is to maintain the extent, integrity and habitat features of existing woodland in the ACT. Where woodland areas are in an altered, but relatively good condition, removing the source of degradation, and thus facilitating natural regeneration, can be effective (Standards Reference Group, 2017). In low quality sites, activities to assist natural regeneration (e.g. planting, pest animal control, and introducing habitat features) may be required. Principles guiding the maintenance and improvement of woodland condition in the ACT are derived primarily from research undertaken in lowland woodlands of the region. Little research has been undertaken to inform this work in subalpine woodlands.

Natural regeneration is often cheaper than planting, and typically results in the establishment of healthy plants, well-adapted to site-specific conditions (Rawlings et al., 2010; Spooner et al., 2002). Research indicates that vegetation within restoration sites are genetically poorer than remnant trees and thus may not be able to adapt to environmental change as well as sites with natural regeneration (Broadhurst, 2013). Remnant vegetation also provides important habitat for fauna that plantings may not provide for many years (Lindenmayer et al., 2016).

Large, mature trees enhance critical ecosystem functions (e.g. carbon storage and water production) (Keith et al., 2017), and also encourage movement of fauna, which facilitates pollination and seed dispersal of woodland vegetation (Doerr et al., 2014a). They provide breeding, roosting and foraging habitat that smaller trees or artificial structures may not provide (Ikin et al., 2013b; Le Roux et al., 2016b; Le Roux et al., 2015, 2018) and are a critical source of leaf litter (McElhinny et al., 2010), seed for recruitment (Vesk et al., 2008), and fallen debris (Killey et al., 2010).

Coarse woody debris takes a long time to accumulate and significantly influences the function of woodland ecosystems (Manning et al., 2007). Coarse woody debris may help protect understorey plants from moisture loss, and play a role in enhancing plant growth and cover in woodlands (Goldin & Brookhouse, 2015). It may also improve soil nutrition (Goldin & Hutchinson, 2013) and facilitate natural regeneration by reducing browsing pressure in grassy systems (Stapleton et al., 2017). Research also indicates coarse woody debris plays a role in enhancing overall soil microbial diversity (Hamonts et al., 2017), maintaining beetle diversity (Barton et al., 2009) and increasing reptile abundance (Manning et al., 2013). Research from the Mulligans Flat-Goorooyarroo Woodland Experiment has been instrumental in guiding the scale and placement of coarse woody debris to enhance the function of woodland ecosystems across the ACT. Maintaining other key habitat features such as mistletoe (see: Ikin et al. (2014b); Watson (2002)) and a variable ground cover (Snape et al., 2018) is also critical to maintain woodland ecosystem function.



Mulligans Flat Woodland Sanctuary (M. Jekabsons)

Plantings and other assisted natural regeneration activities are important for the restoration of woodland sites with compromised ecosystem function. For instance, undertaking plantings is necessary for the restoration of lowland woodland sites with poor natural regeneration (due, at least in part, to past grazing and associated soil enrichment) (Dorrrough et al., 2012; Dorrrough et al., 2011; Spooner et al., 2002; Windsor, 2000). In some instances, revegetation may also enhance the resistance of some systems to invasion by exotic plants (Prober & Lunt, 2009). Successful revegetation of some woodland areas support fauna assemblages otherwise absent from a system (Ikin et al., 2014b) and can support higher fauna species diversity when plants of different ages are established (Lindenmayer et al., 2016). Enhancing the diversity of flora at some woodland sites is likely to require the addition of seed, as well as the management of biomass and competition (Johnson et al., 2018).

High-density regeneration or plantings can reduce the growth rate of woodland trees; this delays the creation of large boughs, tree hollows and fallen timber (Killey et al., 2010; Vesk et al., 2008). Recent modelling also suggests that management actions must be tailored to specific areas, for example different systems may require planting and / or thinning of vegetation (as well as efforts to enhance germination and recruitment) to create optimal stand densities (see Gibbons et al. (2010)).

The management of site level threats such as grazing pressure (Manning et al., 2013; Stapleton et al., 2017), inappropriate fire regimes and exotic plant invasion (Yates & Hobbs, 1997), is critical to facilitate natural regeneration and / or ensure the success of restoration activities. In some cases this requires an improved understanding of the impacts of these threats to biodiversity and the mechanisms that enhance a system's resilience to them. Processes operating at the landscape scale that threaten the success of restoration activities, such as weather and natural events (Hagger et al., 2018), dieback, vegetation clearing and climate change, must also be considered.

The functioning of soil microbial communities is responsive to the quality and quantity of organic matter input by plants (Hamonts et al., 2017), and thus disturbance that threatens woodland plant communities is likely to have a major negative impact on soil microbial communities. Soil communities, including fungi and bacteria, are a critical ecosystem resource; they are an essential component of plant nutrient uptake systems and food webs of many animals (Tommerup & Bougher, 2000). A number of woodland plants, including the threatened Tarengo Leek Orchid and Canberra Spider Orchid, are reliant on associations with mycorrhizal fungi for successful reproduction and the provision of adequate nutrients (see Part B). Given the direct link between soil communities and above ground plant communities (Hamonts et al., 2017), restoration of woodland is likely to be improved by an enhanced understanding of belowground community and trophic relationships (Kardol & Wardle, 2010).

Changing climatic conditions pose challenges for the success and sustainability of restoration efforts. Species that are unable to adapt or evolve to new environmental conditions as fast as the climate changes will rely on dispersal to more suitable areas to persist in the future. Hence, maintaining and increasing connectivity of woodlands at a local and regional scale will support species to persist, and is critical to ensure the long-term resilience of woodland. Sites with a poor ground layer condition, including nutrient depleted topsoil, exhibit characteristics that are likely to exacerbate the impacts of a drying climate (Prober et al., 2014a). Restoration efforts to improve ground layer and vegetation-soil water feedback, including water infiltration and retention, will enhance the resilience of these systems to increased moisture stress (Prober et al., 2014b). Sourcing non-local seed may enhance the potential for revegetation areas to adapt to a changing climate by incorporating a broader gene pool that may be adapted to different climatic conditions (e.g. genotypes sourced from drier areas) (Prober et al., 2012b; Prober et al., 2015). The ACT Government is undertaking an investigation into biodiversity refugia and, in collaboration with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), a seed provenance trial (see Section 4); these projects will inform restoration projects under predicted climate change.

CONSERVATION OBJECTIVES

Maintain and improve habitat features and habitat heterogeneity

- Enforce policy and undertake management action to retain large, mature trees and other critical woodland habitat features (e.g. mistletoe) across all tenures.
- Undertake plantings and introduce habitat elements to restore soil health, increase woodland extent, enhance functional woodland connectivity and enhance habitat for target fauna species.

- The prioritisation and planning of restoration projects should:
 - define site and landscape-scale goals
 - evaluate the appropriateness and cost-effectiveness of assisted natural regeneration to meet objectives otherwise addressed through revegetation and other active regeneration activities
 - be informed by the best available knowledge of the local system and the most appropriate management techniques
 - consider the best available science regarding the future implications of climate change
 - consider the likely impacts of past land use practices on the success of intervention
 - create opportunities to partner with community groups, including Traditional Custodians, local landholders and research organisations (see Section 3)
 - consider how landscape-scale restoration is best achieved across multiple tenures (e.g. control measures coordinated with adjoining tenures)
 - consider opportunities to enhance connectivity through improved habitat quality (see below)
 - consider the habitat and resource requirements of threatened species.
- Work closely with rural landholders and other local land managers to plan and undertake restoration activities to maintain and improve habitat features and contribute to landscape-scale restoration, as outlined in Section 2.1.
- Ensure long term funding for ongoing management and / or monitoring of restoration sites.
- Continue to undertake and support research that informs restoration activities (see Section 3.1 and 4.8).
- If there is conflict between habitat management for two or more threatened species, consideration must be given to abundance, habitat specialisation, functional traits, mobility, adaptability and the ACT and National conservation status of the species. The nature of ongoing threats, and how important the site is to the conservation of the species must also be considered.
- Seek to improve our understanding of aboveground-belowground linkages to inform effective restoration techniques. This includes:
 - knowledge of species-specific symbiotic relationships
 - management actions that are advantageous to soil communities and soil community structure
 - potential for re-establishing mutualistic species relationships through direct introduction of soil organisms.

Implement ecologically appropriate biomass management

Native grasses and forbs play an essential role in maintaining the structure and function of grassy systems, and provide important resources for a range of fauna species associated with woodland. Principles guiding the implementation of ecologically appropriate biomass management in woodland in the ACT are derived primarily from research in the lowland woodlands of the region.

The natural processes that influence herbage mass levels are usually disrupted in modified vegetation communities and, as a result, herbage mass levels can become too high, too low, or too homogeneous to support a diverse flora and / or fauna community (ACT Government, 2017a). In open lowland woodlands that have not been subject to disturbance such as grazing, fire or slashing,

tussock grasses grow large and can create a dense floor canopy and increase overall biomass. The spaces between grass tussocks are important for the establishment of native forbs (Morgan, 1998); thus with increasing biomass, plant diversity often declines. As time since disturbance increases, dead leaf matter also accumulates and can smother native grasses; this may facilitate exotic species establishing in the system (Morgan, 2015). Furthermore, if grasses are left to grow long, they are no longer a preferred food resource for native herbivores such as kangaroos (Snape et al., 2018), which changes the dynamic between biomass and natural control agents in the system.

Natural grazing pressures generally create intermediate herbage mass and heterogeneous understorey structure (e.g. average grass height, grass height variability and the proportion of bare ground). However, many lowland woodland patches in the ACT are highly modified and fragmented and are subject to high levels of grazing by kangaroos (and non-native herbivores such as rabbits). This leads to lower biomass and increased homogeneity of understorey structure (see discussion above). A change in plant species composition through invasion by non-native plants can also substantially change the herbage mass and structure of grassy systems (ACT Government, 2017a).

The need for active biomass management at a lowland woodland site depends on a range of site-specific factors (e.g. species composition, productivity, time since last disturbance and grazing pressure) and climatic conditions. There are a number of tools available to manage biomass in woodlands including fire management, manipulation of grazing regimes (including stock and kangaroo), mowing and slashing. Each technique has a different effect on plant biomass and biodiversity. The history of disturbance and past management practices at a site is likely to influence the response of woodland communities to different biomass management techniques applied today (Stol & Prober, 2015) and thus it is an important consideration when implementing a disturbance regime. Additional considerations as part of planning the implementation of biomass management are outlined below.



Mulligans Flat Woodland Sanctuary (M. Jekabsons)

Fire management is a traditional tool for biomass reduction, specifically in lowland woodlands. Burning removes biomass of dominant grasses (providing space for the establishment of less competitive species) and promotes flowering of some species (Morgan, 2015). The influence fire has on species diversity is, at least in part, determined by the fire history of a site (Stol & Prober, 2015). Other considerations for implementing fire as a tool for biomass reduction include the: frequency and intensity of burning (and the likely impacts on the life-cycle of understorey species), season and weather conditions, topography, presence and sensitivity of rare and threatened species, risk of weed establishment and erosion following burning, and the proximity to urban or other built assets.

Grazing removes biomass of palatable understorey species. In lowland woodlands research indicates that where heavy grazing by kangaroos leads to low biomass, a reduction in the density of kangaroos will recover biomass (McIntyre et al., 2015). Other restoration activities, including the addition of coarse woody debris, will also support the recovery of biomass (McIntyre et al., 2015).

The impact stock grazing has on plant species diversity is, at least in part, determined by the grazing history of a site. While there is some evidence that pulse grazing can reduce the abundance of exotic annual grasses (Cole et al., 2016), there is no consensus on its use to enhance biodiversity or its effectiveness in reducing fire severity in some woodland systems (Williamson et al., 2014). However, stock grazing may effectively manage biomass (without negatively impacting plant species diversity) at lowland woodland sites with a history of grazing, and where grazing intolerant species have already been excluded (leaving palatable grazing-tolerant species) (McIntyre et al., 2015; Morgan, 2015). In lowland woodland sites containing abundant exotic annuals, strategic grazing may be useful to deplete the cover of exotic annuals and promote native perennials (Lunt, 2005).

Other considerations for introducing stock grazing as a tool for biomass management include: frequency, duration and timing of grazing, recent rainfall, stocking rates, quarantine procedures (to reduce the introduction of exotic plants), presence of rare and threatened species, palatability of desirable and undesirable understorey species, and the need and ability to control stock movements at a site (see discussion in Stol and Prober (2015), Morgan (2015) and Lunt (2005)).

When burning or grazing are not viable options to manage biomass, **slashing and mowing** can be considered to remove some of the bulk of grasses in lowland woodlands. This can be a particularly useful tool to manage herbage mass for non-conservation purposes in urban reserves. Different species respond differently to slashing and many are sensitive to regular slashing (Morgan, 2015). Other considerations for using slashing and mowing to manage biomass in woodlands include: timing (i.e. avoiding active growing, flowering and seeding season), frequency, removal of clippings, the risk of introducing exotic plants, height of slashing, the presence of rare and threatened species, and the size of the area where management intervention is required (see discussion in Stol and Prober (2015) and Morgan (2015)).

CONSERVATION OBJECTIVES

Manage biomass

- In the absence of knowledge regarding species-specific understorey habitat requirements, aim to maintain intermediate levels of herbage mass and a heterogeneous (or 'patchy') grassland structure at the reserve and / or landscape scale.
- Evaluate the risk and appropriateness of implementing different biomass techniques (fire, grazing or slashing / mowing) at a site, and compare with the risk of inaction.

- Develop ACT Government guidelines for the management of biomass within lowland woodlands. Consistent with the Grassland Biomass Management Guidelines; this will include a process for making decisions at a site, which considers:
 - understory thresholds and requirements for species associated with, or dependant on understory habitat
 - the historic land use and management at a site
 - the maintenance and / or enhancement of habitat for threatened species and the Endangered YB-BRG Woodland
 - the prescriptions and priorities of existing conservation management plans for the area.
- Manage kangaroo densities (according to the guidelines outlined above) at sites where heavy kangaroo grazing is resulting in a substantial decline in biomass and structural heterogeneity.
- Undertake and support research and ongoing monitoring to evaluate the ecological, social and economic outcomes of controlled grazing by native herbivores and livestock.
- If there is conflict between biomass management for two or more threatened species, consideration must be given to abundance, habitat specialisation, functional traits, mobility, adaptability and the ACT and National conservation status of the species. The nature of ongoing threats, and how important the site is to the conservation of the species must also be considered.

Livestock grazing for conservation purposes should only be used to manage biomass on ACT Government managed land where the following criteria are met:

- native herbivore populations are unable to maintain the desired herbage mass and structure
- other biomass management techniques are deemed too hazardous or otherwise not appropriate
- the site is outside of a reserve / is not of high quality within a reserve
- the site has a history of grazing and palatable, grazing tolerant species account for a large proportion of the understory biomass
- stock movement can be controlled and fertilisers or exotic pastures are not required to maintain animal health
- the site has not been identified as potential habitat for an understory threatened species (that is sensitive to grazing pressure) or as climatic refugia for any significant woodland-associated species.

Enhance habitat connectivity

Fragmentation of woodland can have complex effects on remnant vegetation (including a reduction in plant diversity) (Ramalho et al., 2014) and can reduce structural connectivity that facilitates the dispersal of plants and animals across the landscape. This reduces population gene flow, which increases inbreeding and reduces genetic variability; this can ultimately reduce the viability of plant and animal populations (Amos et al., 2014; Doerr et al., 2014a). Importantly, small, isolated populations with low genetic variability will be less able to adapt to new conditions under a changing climate.

Improving habitat connectivity improves population viability by allowing small populations to interact and function as larger, more resilient populations. Connecting woodland patches through the development and maintenance of woodland corridors or isolated 'stepping stone' trees

facilitates dispersal of fauna to locations with more favourable climatic conditions and critical habitat resources, and assists pollen dispersal (Doerr et al., 2014a). However, a species' ability to effectively disperse and persist in the landscape is also influenced by factors such as its dispersal mode and efficiency (Amos et al., 2014), habitat condition (Schutz & Driscoll, 2008) and overall habitat loss across the landscape (Mortelliti et al., 2010). Efforts to improve landscape connectivity for particular species could be ineffective if these factors are not considered in restoration initiatives.

CONSERVATION OBJECTIVES

Enhance habitat connectivity

- Projects aiming to maintain or enhance connectivity should:
 - prioritise the protection and effective management of woodland patches
 - identify target species, and consider their requirements for functional connectivity
 - consider habitat connectivity at both a local and landscape scale (within reserves and outside of reserves)
 - consider links between woodland patches and between woodland and other ecosystems across the landscape (e.g. grassland, forest, riparian communities)
 - link large patches of habitat as a first priority
 - be informed by the best available local and regional connectivity models. Assess the value and regional context of habitat patches (see Barrett and Love (2012) and Love et al. (2015)).
- Maintain isolated trees on and off reserve as 'stepping stone' connectivity, especially when revegetation is not feasible.
- Ensure the key east – west and north – south wildlife corridors across the ACT are maintained and where required, restored.
- Work with rural landholders and other land managers to improve connectivity of woodland habitat at a landscape scale.

2. COLLABORATE WITH THE COMMUNITY

Meaningful collaboration between the ACT Government and various stakeholders including rural landholders, community members and groups, Traditional Custodians and research institutions will enhance our ability to mitigate current threats to native woodlands in the ACT (see Objective 2). Sharing resources, information and skills between all interest groups will provide the best opportunity to protect and manage woodlands into the future.

Collaboration with the community should be based on the premise that no single agency or group holds all the information to successfully manage woodlands. Knowledge held by interest groups and the broader ACT community can and should contribute to the conservation of woodlands in the ACT as we have a mutual obligation to look after our environment.

2.1 Promote community participation in woodland conservation

Collaborate with rural landholders

Lowland woodland or grassland once covered much of the area now designated as rural land. Today, more than 40% of lowland woodland remains on rural land across the ACT.

Recent research illustrates the importance of maintaining a diversity of woodland habitat features as part of the rural landscape. Management activities including revegetation, fencing remnant and regrowth vegetation, reducing grazing pressure, retaining old trees and controlling invasive species, are effective in improving woodland habitat for biodiversity within agricultural areas (Briggs et al., 2008; Ikin et al., 2015; Kay et al., 2013; Lindenmayer et al., 2016; Spooner et al., 2002; Tulloch et al., 2016). Maintaining even small patches of remnant woodland vegetation such as scattered trees, can benefit a range of taxa including invertebrates (Le Roux et al., 2018; Ng et al., 2018), reptiles and frogs (Pulsford et al., 2018; Pulsford et al., 2017), woodland birds (Fischer & Lindenmayer, 2002; Le Roux et al., 2018; Rayner et al., 2014) and bats (Le Roux et al., 2018; Reid & Landsberg, 2000). Maintaining scattered trees can also improve soil conditions (Barnes et al., 2009; Barnes et al., 2011) and may benefit production in a range of other ways, including providing shelter and shade for livestock (Reid & Landsberg, 2000).

To contribute to a whole of landscape approach to woodland conservation, the ACT Government aims to support rural landholders to undertake conservation and sustainable agricultural practices on their properties. Land Management Agreements, required under the *Planning and Development Act 2007*, are administered by the ACT Government and aim to establish a cooperative management regime that supports the objectives of both the lessee and the ACT Government. They provide a tool that the ACT Government can use to work together with landholders to manage woodland vegetation to preserve its conservation value, retain or enhance the condition of remnant woodland and preserve populations of threatened species.



Rural property

In 2018, the ACT Government received funding from the Australian Government to implement a five year collaborative project that aims to enhance and connect woodland habitat. A key aspect of the project is the facilitation of a range of activities (including restoration, threat management, education and improved land management practices) with rural landholders, community groups and other community members. Ongoing opportunities for landholders to manage or improve the condition of their land, as well as its production and conservation value, exist through programs such as the ACT Environment Grants (ACT Government funded), ACT Rural Grants program (supported under the National Landcare Program), and other grant schemes administered by the ACT

Government. These on-ground incentives are supported by community groups (such as Friends of Grasslands [FOG] and Greening Australia) and catchment groups.

CONSERVATION OBJECTIVES

Collaborate with rural landholders

- Work closely with rural landholders and their representative body, the Rural Landholders Association (RLA), to identify additional strategies to collaborate on projects and support landholders to protect and / or enhance woodland values on rural land. Priority activities include:
 - maintaining remnant vegetation where possible, in particular, the maintenance of regeneration, large old trees and scattered trees
 - maintaining a diversity of habitat features across the rural landscape, including woody debris, vegetation cover, leaf litter and rocks
 - planting and maintaining stands of native woodland species
 - targeting the protection and enhancement of lowland snow gum woodland (u78), red box tall grass-shrub woodland (q6) and the Endangered YB-BRG Woodland
 - controlling invasive plants
 - restoration projects that contribute to improved landscape-scale connectivity (see Objective 3)
 - monitoring results of management activities to inform future management.
- To effectively work with rural landholders, consideration must be given to:
 - the diversity of priorities rural landholders have regarding the management of their properties, including the need to manage for production and profitability
 - mechanisms to maintain open communication and effective relationships, including ensuring appropriate levels of on-ground staff to support initiatives
 - prioritising work on properties that have high biodiversity value and / or significant potential to mitigate landscape scale threats.

Support community participation and raise community awareness

There are many community groups (and conservation organisations) interested and active in woodland conservation in the ACT, including:

- Molongolo, Ginninderra and Southern ACT Catchment Groups
- Parkcare and Landcare Groups
- FOG
- COG
- Kosciuszko to Coast
- Grassy Woodland Stakeholder Group
- Greening Australia
- Conservation Council
- Bush on the Boundary
- Capital Woodland and Wetlands Conservation Trust.

These groups are instrumental in advocating for native woodland conservation, undertaking management, monitoring and restoration projects, and raising public awareness of the values and threats to woodlands in the ACT (see Box 4). The knowledge held by the members of these groups and the work they undertake is critical to the ongoing conservation of woodlands in the ACT (see

Section 4.7 for an outline of projects undertaken since the previous Strategy). Seeking to work collaboratively with community groups will improve community ownership of woodland protection and enhance the value of projects.

Community members who participate in on-ground activities with others who are knowledgeable and passionate about woodland conservation develop emotional connections to woodlands and may develop feelings of stewardship over areas. While the benefits to woodland conservation from work undertaken by community members are significant, participants are also likely to experience physical, mental and social health benefits, including developing positive relationships with like-minded people (Townsend, 2006).

Around 3% of ACT residents are currently engaged in volunteering within the reserve system and an additional 13-20% have expressed interest in becoming a volunteer (MARS, 2017). There is significant opportunity to raise the awareness of woodland values and conservation by engaging with community members, particularly young people and residents at the urban-reserve interface, who are not actively involved in its protection. Education initiatives with this broader community group may lead to an increased perceived value of woodlands and participation in conservation activities or other behavioural changes that reduce the ongoing threats to woodlands (e.g. improved vigilance in managing domestic plants and animals).



Parkcare activity, Mt Taylor

CONSERVATION OBJECTIVES

Support community participation and raise community awareness

- Collaborate with community groups to deliver woodland conservation activities (e.g. restoration activities) to address the priorities outlined in this Strategy.
- Support community groups to undertake on-ground and other projects through the provision of grants, advice and access to research and other knowledge.

- Provide opportunities for community members to engage in volunteer activities through the ParkCare program. Providing training and access to other ACT Government resources will ensure the sustainability of ParkCare activities into the future.
- Facilitate, and collaborate with external groups to deliver community education programs that engage the broader community. Priority topics include:
 - the value of lowland and subalpine woodlands, including the conservation significance of box-gum woodlands in the ACT and the threats to these values
 - the implications of climate change on woodland biodiversity
 - opportunities for community members to support the conservation of woodland biodiversity through management of residential risks and participation in volunteer opportunities
 - the management priorities and challenges of effective woodland conservation in the ACT (e.g. balancing multiple priorities such as fire risk, biodiversity and community amenity within lowland woodland reserves)
 - promoting the use of grassy woodland species in residential plantings
 - disseminating the outcomes of relevant research and the outcomes and achievements of community activities.
- Facilitate information and knowledge sharing between ACT Government staff, research institutions and community groups to encourage best practice management of woodlands through, for example:
 - workshops and seminars
 - on-ground activities
 - training opportunities
 - online resources (e.g. ACTMAPi and ACT Government – Environment website)
 - presentations
 - production of educational resources and user-friendly publications.
- Develop and maintain appropriate interpretative signage and other educational materials in reserves and other open spaces.

Box 4. Collaborative management of Stirling Park

In 2009, FOG entered a contractual agreement with the National Capital Authority to undertake collaborative management of Stirling Park woodland (and nearby Yarramundi Reach and Scrivener’s Hut). Stirling Park is 52 ha of woodland reserved by the Commonwealth Government and managed by the National Capital Authority. It includes Endangered YB-BRG Woodland and a large population of the endangered Button Wrinklewort (*Rutidosis leptorhynchoides*). It is also of cultural significance to Traditional Custodians as it forms part of a ceremonial pathway and contains a number of recorded Aboriginal places.

A Conservation Management Plan was developed in 2009 (Sharp, 2009) and was reviewed and updated in 2016 (Sharp, 2016). Together with a number of stakeholder groups (including traditional knowledge holders, Greening Australia, Yarralumla Residents Association and Molonglo Catchment Group), FOG has improved the condition of Stirling Park through on-ground management work including revegetation, fire management, and control and mapping of invasive plants. Collaborative management across Stirling Park and a neighbouring woodland property (managed by the ACT Government) has enhanced the local connectivity of woodland habitat in the area. FOG continues to

play an advocacy role to ensure the protection of the site and to encourage its dedication to nature conservation.



Stirling Park (M. Jekabsons)

Enhance and promote citizen science

Monitoring and research activities undertaken by community members and organised groups make a significant contribution to our knowledge of woodlands; the breadth of data gathered by these groups is unattainable by research institutions and the ACT Government alone. Groups such as COG have long term monitoring projects that contribute large amounts of data to our shared understanding of woodland biodiversity (see Box 6). Resources developed by community groups (such as the Vegwatch Manual) provide guidance to community members to undertake monitoring using a consistent methodology.

New technologies enable community groups to collect data with accuracy and precision. Parkcare and other groups use GIS mapping tools to record and report on management issues such as invasive plants and pest animals. Canberra Nature Map, and the corresponding NatureMapr Application, allows community members to report the location of plants, fungi, animals, insects and fish species that they observe across the Canberra region. NatureMapr is very popular and public submissions have vastly improved the understanding of the distribution of threatened and uncommon species (including the identification of new populations of rare plants), allowed early intervention against high risk early invader environmental weeds (following records of new weed outbreaks) and has contributed to an increased public awareness of the flora and fauna of the ACT region.

As with other community-led on-ground environmental projects, citizen science projects do not simply achieve environmental outcomes. As the participants and breadth of citizen science activities continue to expand, there is also significant opportunity for these projects to contribute to the broader community understanding of the threats to and values of woodlands across the ACT. Citizen science projects can also benefit the community through educational outcomes, increased awareness of environmental issues and changes in behaviour of community members (Roetman et al., 2014).

CONSERVATION OBJECTIVES

Enhance and promote citizen science

- Explore opportunities for citizen science initiatives to meet conservation objectives outlined in this Strategy. Provide support to relevant community groups to plan projects and implement them.
- Encourage the systematic collection and effective use of data collected through citizen science projects by:
 - supporting the management and use of digital information tools (e.g. ACTMapi and Canberra Nature Map / NatureMapr Application)
 - ensuring data collected is subject to appropriate quality control (e.g. through expert screening of data and developing and disseminating data collection protocols)
 - supporting community groups to access grants, professional and technical advice, training and equipment.

Enhance the participation of Aboriginal people

While Traditional Custodians no longer rely on traditional resources found throughout the landscape for survival, retaining a connection to traditional lands remains important in defining and maintaining cultural identity. This includes accessing the landscape for cultural and social purposes (e.g. ceremonies, gatherings, fishing, cooking, healing, resource collection and knowledge transfer) and protecting significant places and features of the landscape from threatening processes (see Box 5).

Traditional Custodians of the Canberra region view all Aboriginal places and objects as an important part of their history and want to ensure their appropriate maintenance and protection. The ACT Parks and Conservation Service, including Aboriginal staff, work to improve participation of Traditional Custodians in identifying the traditional uses and values of the land, and to plan for, and manage the cultural landscape according to contemporary Aboriginal aspirations. Included in the BOPs are guidelines and principles for facilitating Aboriginal cultural burning practices. These guidelines were developed by the Murumbung Yurung Murra Rangers in conjunction with RAOs and Traditional Custodians. The primary purpose of facilitating cultural burns is cultural renewal, however they may also complement ecological and / or hazard reduction objectives or the protection of culturally significant sites. Work is currently being undertaken to develop policy to support Traditional Custodians to access their Country and make use of traditional resources.

Box 5. Impacts on Aboriginal cultural sites within woodlands

Cultural sites include sites that have physical remains or are significant to Aboriginal people due to their connection with traditional stories. Sites, regardless of whether physical remains exist, are afforded the same level of protection and priority for management.

A range of land management issues and natural processes threaten the integrity of cultural sites throughout the ACT region. For example, weeds can cause the decline of native plant species, including traditional food resources, provide fuel for fire and reduce access to important places. Significant sites and objects are threatened by inappropriate fire regimes and disturbance caused by nearby development or management activities. Rock art sites are also threatened by natural processes such as intrusion by native vegetation, growth of lichen / moss, nesting invertebrates such as termites and wasps, and erosion from wind and water runoff. Community groups (including the Mullangang Traditional Aboriginal Landcare Group) and the ACT Government are working to maintain and restore these sites and the surrounding areas.



Aboriginal rock shelter, Namadgi National Park

CONSERVATION OBJECTIVES

Enhance participation of Aboriginal people

- Work in collaboration with Aboriginal community members to manage and monitor woodlands and fill knowledge gaps regarding their long term conservation. Initiatives may include:
 - employment of Aboriginal rangers and other natural resource management officers
 - planning, implementing and monitoring of cultural burns
 - planning and / or implementing the maintenance of cultural sites in accordance with the Cultural Heritage Management System (in development) and the *Heritage Act 2004*.
- Support Traditional Custodians to access and use the landscape in accordance with Aboriginal Access to Country Cultural Guidelines (in development). Wherever possible, and with the permission and support of Traditional Custodians, collaborative activities should:
 - provide opportunities for two way knowledge sharing between Aboriginal and non-Aboriginal people
 - facilitate the rediscovery of cultural knowledge, including Indigenous Ecological Knowledge (IEK)
 - facilitate the adoption of IEK in the management of woodlands.
- Implement and / or collaborate with RAOs and other community groups to deliver activities that:
 - improve broad community understanding of the cultural significance and traditional responsibilities for caring for lowland and upland woodlands. Strategies include formalising Aboriginal place names and reserve interpretation that features language and cultural knowledge
 - facilitate Traditional Custodians to access woodlands and reconnecting with Country
 - support Aboriginal people to gain employment and training relevant to the conservation of woodland and other ecosystems in the ACT

- identify and map cultural values of woodlands and develop appropriate management actions
- facilitate two way knowledge sharing between natural resource managers and researchers, and Aboriginal people
- identify opportunities to assist Aboriginal people to rediscover and adopt IEK in woodland conservation.

2.2. Support sustainable recreational use of woodlands

Woodland reserves offer Canberra residents and tourists a range of recreation opportunities, including walking, running, bird and wildflower appreciation, orienteering, rogaining, cycling and mountain biking, dog walking, horse riding and geocaching. The proximity of CNP to residential areas facilitates regular access by community members and thus encourages many Canberra residents to maintain a healthy lifestyle.

The number of visitors to woodland areas within CNP is steadily increasing. Areas containing subalpine woodland, including Namadgi National Park and Tidbinbilla Nature Reserve, also have a steady flow of visitors, although at lower rates than lowland woodland within CNP (MARS, 2017). Community members who regularly access woodland areas for recreation are likely to feel a sense of ownership over areas. As different users are likely to value different aspects of the reserves they access, engaging with a wide section of interest groups through reserve visitation provides a great opportunity to broaden support for woodland conservation.

Visitation to reserves can negatively impact woodlands but should, wherever possible, be compatible with the natural and cultural values of woodlands. Factors such as the number and frequency of visitors, type of activity, visitor behaviour and specific site characteristics will influence how the values of woodlands are impacted and the management approach required to mitigate impacts. Potential impacts include:

- vegetation clearing and soil changes through maintaining access tracks and the creation of unofficial tracks
- introduction of non-native plant species
- removal or damage to sites, vegetation or other habitat
- illegal collection of plants, animals, timber and rocks
- rubbish dumping and deliberate damage
- changes in fauna species composition.

CONSERVATION OBJECTIVES

Support sustainable recreational use of woodlands

- Undertake effective monitoring of visitor impacts to inform a proactive and adaptive approach to visitor management.
- Undertake effective visitor management, as outlined in individual Reserve Management Plans, to minimise detrimental impacts on the natural and cultural values of woodlands.
- Effectively communicate with visitors to:
 - promote responsible and respectful use of woodland reserves
 - promote an understanding of woodland systems and their values, threats and required management
 - advise visitors of community safety concerns such as wildfires and native animals

- interpret Aboriginal values and cultural sensitivities of areas to encourage respectful behaviour within woodland reserves.
- Promote the appropriate use of woodland reserves and, where practical, reduce physical barriers to community access.

3. MONITORING AND RESEARCH

The ACT Government is committed to the ongoing collection of data and information to contribute to our understanding of woodland ecosystems. The ACT Government supports a research and monitoring process where relevant information is collected, interpreted, disseminated and applied operationally, with monitoring and evaluation in place.

A range of projects aimed at addressing knowledge gaps and monitoring woodland condition since the 2004 Lowland Woodland Strategy are [published online](#) (ACT Government, 2018h) and are outlined in Section 4.7. These projects, as well as evidence from other literature relevant to lowland and / or subalpine woodland conservation and management, guide the strategies and objectives outlined in this Strategy.

3.1 Monitor woodland condition

Monitoring the condition of ecosystems and the flora and fauna associated with them is critical to recognise change, including gradual change that happens steadily over time (Lindenmayer et al., 2015). Observing and quantifying changes to ecosystems is required to better understand the processes driving these changes and to identify the appropriate management action to address the negative impacts on ecosystems. In this way, monitoring underpins an adaptive management approach to support the protection and conservation of woodlands across the ACT.

The ACT Government undertakes regular monitoring of many of its threatened flora and fauna species. These programs are outlined in the respective action plans and conservation advice for threatened species and the Endangered YB-BRG Woodland (Part B). Other monitoring programs are established to measure changes in environmental values within a range of ecosystems across the ACT reserve system and offset areas (see SMEC (2016)). Ecological consultants, research institutions and various community groups also undertake monitoring of woodland condition and collect relevant information that can inform management decision making (see Box 7).

The ACT Government recently developed the CEMP as a way to systematically and comprehensively monitor the condition of ecosystems across the ACT reserve system. The CEMP identifies a range of indicators, including ecological values and stressors (imposed by threatening processes), to measure ecosystem condition. Information gathered from monitoring projects and qualitative sources, from both government and non-government agencies, is used to assess an ecosystem's conditions and the effectiveness of relevant management programs. The ACT Government is currently developing a CEMP for ACT woodlands that will, in addition to providing a framework to monitor changes in woodland condition over time and assess the efficacy of management actions, identify knowledge gaps and prioritise future research projects to inform woodland conservation.

Collect baseline information

To undertake effective monitoring and management of woodlands requires a detailed understanding of the distribution and characteristics of woodland communities and associated species. Baseline information facilitates the adaptive management of woodlands by enabling managers to monitor changes to woodland ecosystems arising from threatening processes and to track the impact of management interventions.

Data has been collected and documented that describes the distribution and characteristics of woodlands in the ACT, including a range of surveys undertaken by the ACT Government prior to the publication of the 2004 Lowland Woodland Strategy. Recent survey and mapping projects outlined in Section 4.7 contribute to this knowledge. However, baseline knowledge gaps exist, providing an opportunity for projects to support informed decision making into the future.

Box 6. Canberra Ornithologists Group undertakes critical monitoring of woodland birds

The COG has been surveying bird abundance at a number of locations in lowland woodland since 1995. Surveys commenced in Mulligans Flat (then a grazing leasehold) and monitoring locations had been added progressively since. The Woodland Bird Monitoring Project now includes 145 sites at 15 locations across lowland reserve and leasehold areas. Sites include areas of Endangered YB-BRG Woodland, and other woodland areas in a range of conditions, including secondary grasslands. Surveys are undertaken seasonally, four times a year.

An analysis of long term trends in occupancy of woodland-associated birds, including a number of species in decline, was undertaken recently (Bounds et al., 2010). An analysis to better understand the relationship between habitat change and bird occupancy has also been undertaken (Taws et al., 2011). Species records have been used by the ACT Government to inform management decisions (e.g. fire and reserve visitor management). Importantly, data also informs priority actions for threatened bird species in the ACT.

The Woodland Bird Monitoring Project is ongoing and will continue to be a valuable dataset that informs the work of researchers, community groups, and Government and private agencies.



Woodland condition monitoring

CONSERVATION OBJECTIVES

Monitor woodland condition

- Employ the Woodland CEMP (in development) to guide monitoring priorities. Monitor changes in ecological condition, including the impacts of threats and the effectiveness of management actions within reserves across the ACT.

- Continue to plan and implement monitoring programs to address ecological and management-related questions within woodlands across the ACT by:
 - establishing monitoring programs with well-defined objectives, sound experimental design and effective data management and assessment standards
 - seeking collaboration with ecological consultants, researchers and community groups with an interest in undertaking monitoring programs within and outside of Territory-owned land
 - designing and implementing targeted monitoring programs designed to measure the impact of management actions such as pest animal and invasive species control and restoration works
 - designing and implementing targeted, long-term, cross-tenure monitoring to detect environmental drivers of change (e.g. climate change and agents of dieback) and their impacts on woodland condition at an appropriate scale.
- In line with action plans and conservation advice (Part B), monitor threatened, declining and rare species, and the Endangered YB-BRG Woodland community to:
 - detect short-term changes in distribution or abundance that may require management intervention
 - determine long-term trend and status in the ACT and broader region
 - identify changes in species composition in threatened ecological communities
 - evaluate whether management activities are producing desired results.
- In planning monitoring programs, ensure long-term investment and sustained funding and resourcing beyond short-term cycles.
- Collaborate with community groups to collect and use monitoring data systematically and effectively by providing, for example:
 - professional and technical advice
 - training
 - screening of data
 - data collection protocols
 - support to access grants and equipment.
- Priority projects to improve baseline information include:
 - on-ground assessment of the condition of large patches of lowland woodland and those that make a significant contribution to the integrity of the Endangered YB-BRG Woodland across the ACT
 - improve knowledge of fauna distribution and abundance in subalpine and lowland woodland and associated ecosystems, particularly in relation to habitat preferences and response to disturbance
 - develop methods to improve mapping of secondary grasslands and to monitor changes to its extent, and improve knowledge of the ecological values of this community
 - condition mapping of lowland Snow Gum woodland to monitor the change in extent and condition of the community in response to climate change and land use practices.

3.2 Address knowledge gaps in woodland conservation

The ACT Government undertakes a range of activities aimed at addressing knowledge gaps and research questions. Wherever possible, collaboration with research institutions, community groups and cross-border agencies provides further opportunity to improve our understanding the flora and fauna associated with woodlands and the ecological processes operating within these ecosystems. A key aim of these projects is to inform the management of woodlands in the ACT and broader region. They also provide information that can be integrated with traditional ecological knowledge and employed by Traditional Custodians when working on Country. A number of current and recently completed research projects are outlined in Section 4.7.

Research priorities to improve our understanding and management of threatened species and the Endangered YB-BRG Woodland are outlined in action plans and conservation advice (Part B). Knowledge gaps that the ACT Government seek to address with dedicated research are listed below.

Threats

- Effects of climate change on lowland and upland woodlands and the best management techniques to improve the resilience of biodiversity to a changing climate (including climatic refugia locations for woodland communities).
- Relationships between pest animal and invasive plant abundance and impacts on woodland values.
- Impacts of fragmentation, and management actions aimed at increasing connectivity, on woodland dependant species.
- Response of fauna to aspects of fire regimes in subalpine and lowland woodlands.
- Drivers of dieback and management actions to effectively mitigate its impact.
- Potential impacts on woodland biodiversity located at or near the urban fringe, and trials of innovative solutions.

Woodland biodiversity

- Ecology and diversity of invertebrates associated with woodlands in the region.
- Biology of woodland understory plant species (such as rare orchids and forbs).

Ecosystem processes

- Impact of dense regeneration on biodiversity in woodland reserves.
- Habitat restoration techniques for areas in poor or declining condition (due to invasive plants and pest animal impacts).
- Ecological and conservation outcomes of controlled grazing by livestock.
- Links between woodland vegetation condition and soil microbial communities.
- Effect of disturbance and management on subalpine woodland.

A critical outcome for research undertaken or supported by the ACT Government is maintaining strong links with end users of the knowledge generated. Wherever relevant, end users such as ACT Government land managers, private land holders and community groups, should inform the priorities of the research and be involved in various stages of a research project. Correspondingly, the dissemination of research findings back to end users is critical to support land managers to make informed decisions regarding the management of woodland across all tenures. The Mulligans Flat – Goorooyarroo Experiment is an excellent example of multiple stakeholders working together to

undertake research that is improving our understanding of woodlands, and is directly informing management activities for woodland restoration across the ACT (see Box 7).

Box 7. Mulligans Flat – Gorooyarroo Woodland Experiment

The Mulligans Flat – Gorooyarroo Woodland Experiment commenced in 2004 and is a collaboration between The Australian National University, the ACT Government and James Cook University. The site, which includes both Mulligans Flat and Gorooyarroo Woodland Nature Reserves, incorporates approximately 1145 ha of Yellow Box – Blakey’s Red Gum grassy woodland. It is the largest and most intact example of its type in the ACT. The predator proof fence, which was constructed around Mulligans Flat in 2009, will soon be expanded to include the Gorooyarroo Woodland.

The project aims to undertake long term research to understand ways of restoring the structure and function of temperate woodlands for biodiversity (Manning et al., 2011). Current research includes monitoring the ecological impact and restoration value of techniques in biomass management (including manipulation of fire), grazing impacts, addition of coarse woody debris, feral species exclusion, species introductions within a predator proof sanctuary, and other woodland restoration techniques. Recent highlights include the successful breeding of reintroduced Eastern Bettongs (*Bettongia gaimardi*) (Portas et al. 2016), New Holland Mouse, Eastern Quoll (*Dasyurus viverrinus*) and Bush Stone-curlew (*Burhinus grallarius*).

Research findings are building a strong evidence base that is informing restoration and management activities undertaken within woodlands across the region. Importantly, the benefits of retaining and adding coarse woody debris to woodlands (Barton et al., 2011; Manning et al., 2013) has resulted in on ground changes to restoration works and management in the region.



Mulligans Flat Woodland Sanctuary (M. Jakobsons)

CONSERVATION OBJECTIVES

Deliver research outcomes

- Implement and support research projects to address knowledge gaps and answer ecological questions (priorities outlined above) to inform the adaptive management of woodlands.
- Continue to support the Mulligans Flat – Goorooyarroo Woodland experiment as a key research and learning site for woodland restoration and management throughout the ACT.
- Identify opportunities to partner with Traditional Custodians to develop research projects that can inform land management, resource use and other activities undertaken by Traditional Custodians in woodlands.
- In line with action plans and conservation advice (Part B), undertake and support research into the ecology and conservation requirements of threatened species and communities including:
 - habitat requirements and key resources, including distribution of key habitats
 - effects of habitat modification, land use practices and key threats
 - movement patterns, particularly in relation to the availability of key resources and habitat connectivity
 - breeding success, survival and recruitment rates of breeding populations.
- In planning and implementing research projects, maintain open dialogue between ACT Government policy, research and land management staff and when appropriate seek collaboration with non-government organisations to:
 - identify and prioritise knowledge gaps for future research
 - inform research questions and project design
 - implement and review projects and share skills and knowledge
 - ensure project outcomes are appropriate, accessible and can contribute effectively to the adaptive management of woodlands
- Communicate research results to land managers, including non-government organisations through:
 - research and technical reports published on ACT Government website and in scientific journals
 - social media platforms (e.g. ACT Environment, Planning and Sustainable Development and ACT Parks and Conservation Service Facebook pages)
 - workshops and seminars
 - presentations and meetings
 - the production of educational resources.

4. BACKGROUND INFORMATION

4.1 What is a woodland?

Woodland is a general term to describe ecosystems that contain widely spaced trees with crowns that do not overlap and with less than 30% projected foliage cover. Woodland communities vary structurally from low open woodland (trees up to 10 m high with up to 10% projective foliage cover) to tall woodland (trees up to 35 m high with between 10-30% projective foliage cover) (Specht, 1970; Yates & Hobbs, 2000). The understorey of woodlands vary considerably in form, but include a combination of low trees, shrubs, grasses, herbs and graminoids (Yates & Hobbs, 2000). Ground

layer vegetation constitutes most of the plant diversity in a woodland. High quality grassy woodlands have an especially diverse range of native ground-layer species (including orchids, lilies, wildflowers, sub-shrubs and grasses) (Stol & Prober, 2015).

The structure of a woodland is determined, at least in part, by influences operating at a local level (e.g. disturbance and regeneration). This can result in a structure that is more characteristic of other associated ecosystems. For example, patches of woodland dominated by Snow Gum in the ACT have dense regeneration following the 2003 wildfires and resemble forests. Furthermore, former woodland habitat that has been subject to widespread clearing of canopy trees and woody mid-storey vegetation, but maintains a relatively intact, diverse understorey of native grasses and forbs, is termed a 'derived' or 'secondary' grassland and, where appropriate, is managed as a woodland community according to this Strategy.

Woodlands in the region

Lowland and subalpine woodland in the ACT occur within the South Eastern Highlands (SEH) Bioregion and Australian Alps Bioregion respectively (Environment Australia, 2000; Thackway & Cresswell, 1995).

The SEH Bioregion covers approximately 80% of the ACT and includes the ranges and plateaus of the Great Dividing Range within southern NSW and eastern Victoria. It is characterised by sclerophyll forests, woodland, grassland and cool rainforests (Environment Australia, 2000). Located at a higher altitude and surrounded by the SHE Bioregion, the Australian Alps Bioregion has a restricted extent within NSW, Victoria and southwest ACT. It is characterised by treeless communities, *Eucalyptus* woodlands and alpine ash forests (Environment Australia, 2000).



Snow Gum woodland, Namadgi National Park

4.2 A brief history of woodland in the ACT and surrounding region

Traditional Custodians

For over 25 000 years, the life of Aboriginal people was directly connected with the ecosystems that sustained them and the health of the people was dependent on the health of the Country. The lowland and foothill areas of the ACT provided reliable resources for Traditional Custodians at particular times of the year, including food (e.g. Yam Daisy [*Microseris lanceolata*]) and materials for tools and weapons (e.g. Blakely's Red Gum). Subalpine woodlands and associated ecosystems also provided some seasonal (e.g. Bogong Moth [*Agrotis infusa*]) and reliable (e.g. *Lomandra longifolia*)

resources, which allowed Aboriginal people to exploit the subalpine areas (Bowdler, 1981; Coyne, 2000). Of particular nutritional and cultural significance was the Bogong Moth, which breeds on the plains and moves to the mountains to aestivate during summer. While Traditional Custodians no longer rely on traditional resources to survive, retaining a connection to traditional lands remains important in defining and maintaining cultural identity.

The use of woodlands by Traditional Custodians has shaped the structure and function of woodlands and other ecosystems. For instance, lowland woodlands have evolved with relatively frequent burning as fire was a tool used by Traditional Custodians to stimulate green pick for marsupial grazers and to promote the growth of favoured plant resources (Stol & Prober, 2015). While Traditional Custodians used fire quite extensively in the foothills and lower tablelands, there is no evidence or known reason that fire was used to manipulate the landscape across the higher altitudes (Coyne, 2000). Thus fires, primarily ignited by lightning strikes, were likely to be less frequent in upland woodlands. While details about the historic severity, extent and frequency of traditional burning in the region is unknown, the discovery and occupation of the local area by European settlers resulted in significant modification to traditional burning regimes.

Early European exploration and settlement

The Canberra district and broader region was first visited by European explorers in the 1810s and early 1820s. Early explorers reported prime grazing country, including expanses of grassland and open woodland with a variety of grasses and herbs. By the mid-1820s the region was colonised by those keen to secure land for grazing.

The earliest landholdings within what is present-day ACT were clustered around rivers and creeks and initial stocking was possible without the need to undertake extensive tree felling (Costin, 1954; Moore, 1970). The ensuing expansion and intensification of pastoralism in the region led to large scale clearing (and ringbarking) of trees, converting what were continuous tracts of lowland woodland to fragments of various sizes. The introduction of pasture species and selective grazing (often at high densities) also significantly modified the ground cover vegetation of these areas. Fire became a tool which was used or suppressed to improve and maintain pasture value (Costin, 1954). Summertime grazing in the subalpine and alpine tracts of grasslands and grassy woodlands commenced in the 1830s. Woodlands and forests in the valley areas were cleared for both grazing and small-scale farming.

Minor infrastructure, including homes, roads and drainage, was established in association with the pastoral industry. Native trees were used as a major source material for fencing, buildings and fuel (Carron, 1985).

Fortunately, the establishment of the ACT in 1911 and associated leasehold tenure and planning policies discouraged the adoption of intense pasture improvement techniques commonly adopted in the region from the 1950s onwards (e.g. increased mechanisation, use of sown pastures and fertilisers) (Stol & Prober, 2015). The termination of grazing leases in the highlands during this time also limited the long-term impacts of grazing within subalpine systems.

Historical distribution

Prior to European settlement temperate woodlands were widespread; their distribution was driven primarily by responses to environmental conditions (e.g. climate, topography, hydrology and soil type), disturbance (e.g. storms and fire) and biotic interactions (e.g. with native grazers) (Yates & Hobbs, 2000). In the south east, woodlands were the dominant vegetation type inland of the Great

Dividing Range, from southern Queensland through NSW, Victoria and into South Australia (Yates & Hobbs, 2000). While woodlands remain geographically widespread, the current distribution of temperate lowland woodland reflects the preferential clearing of the most fertile areas in plains, lower slopes and stream valleys. Today, many woodlands persist as degraded, often small, remnants amongst forests and grasslands.

Approximately 96% of the Yellow Box - Apple Box Grassy Woodlands vegetation class has been lost from its former distribution across the South-East Highlands bioregion in NSW. Other modelling estimates that more than 90% of lowland woodland (dominated by Yellow Box, Blakely's Red Gum, White Box [*Eucalyptus albens*] and / or Apple Box) has been cleared in the Tumut region in NSW (bordering the ACT and Victoria) (Landsberg, 2000). Other areas in NSW have approximately 1 – 7% of the pre 1750 extent of White Box–Yellow Box–Blakely's Red Gum Woodland community remaining (Austin et al., 2000; Gibbons & Boak, 2002).

Modelling undertaken by Gellie (2005) predicts the Southern Tablelands Yellow Box-Apple Box Grassy Woodlands vegetation class (which comprises four widespread lowland woodland communities in the ACT) covered an area of approximately 47 000 ha in the ACT prior to 1750 (see Figure 4). Comparison of this historic distribution with mapping of extant vegetation across the ACT illustrates approximately 11 568 ha or 25% of this vegetation class exists across its former distribution (note, this excludes derived grasslands and woodland that exists outside of the pre-1750 distribution modelled by Gellie (2005)). Comparatively, there has been little clearing of upland woodland in the ACT and broader region. It is estimated that 99% of the historic distribution of woodlands dominated by Snow Gum in the ACT exists today (Landsberg, 2000).



Yam Daisy

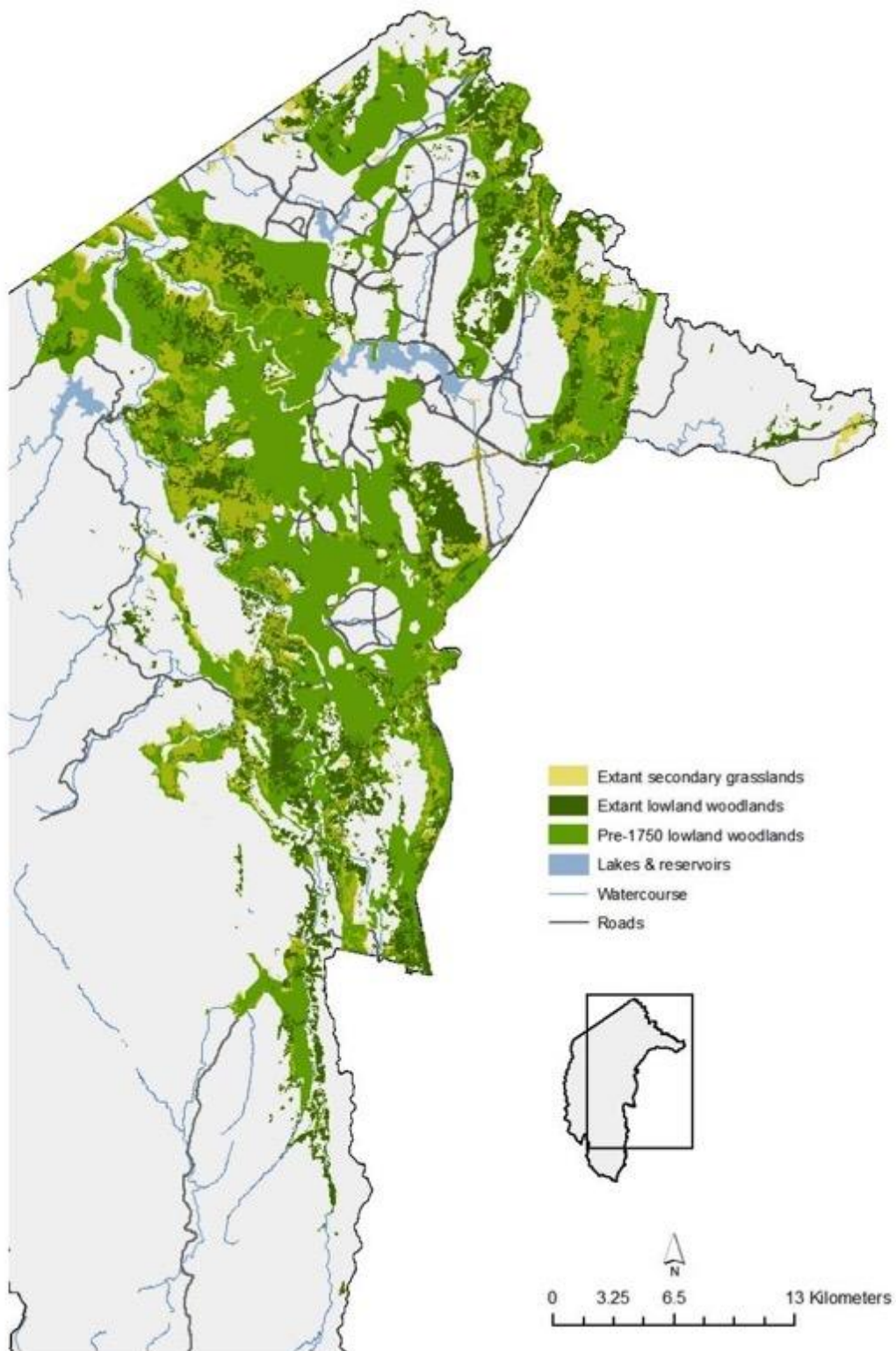


Figure 4. Historic (pre 1750)* and current (2018) distribution of lowland woodlands** in the ACT
 * Modelled by (Gellie, 2005) ** Southern Tablelands Yellow Box-Apple Box Grassy Woodlands vegetation class (incorporating u178, u19, q6 and u78)

4.3 Threatened and uncommon woodland species in the ACT

Threatened Species

Native woodlands in the ACT provide critical habitat for a range of threatened flora and fauna species. This includes three plant species and nine bird species that are listed as threatened under the *Nature Conservation Act 2014* and several species listed as threatened in other jurisdictions (Table 5 and Table 7). An additional eleven threatened species are associated with both woodlands and other ecosystems (such as grasslands or forests). These species are listed in Table 6.

The ACT Government is working to align the method for assessing and listing threatened species with those categories and criteria adopted under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This will ensure the consistent use of threat categories with the Australian Government, and thus contribute to the development of a single operational list of nationally threatened species (see Commonwealth Government (2015a)).

The Mulligans Flat Woodland Sanctuary also provides critical habitat for several species that have been reintroduced to the ACT. This includes established populations of: New Holland Mouse, Eastern Bettong, Eastern Quoll and Bush Stone Curlew.



Hoary Sunray, Mt Majura (E. Cook)

Table 5. Woodland-dependant threatened fauna and flora species found in the ACT. V = vulnerable, E = endangered, CE = critically endangered

Common name	Species	ACT	NSW/ VIC*	C'wth	Subalpine / Tableland
Brown Treecreeper	<i>Climacteris picumnus</i>	V	-	-	Tableland
Hooded Robin	<i>Melanodryas cucullata</i>	V	-	-	Tableland
Painted Honeyeater	<i>Grantiella picta</i>	V	V (VIC, NSW)	V	Tableland
Regent Honeyeater	<i>Anthochaera phrygia</i>	V	CE (VIC, NSW)	CE	Tableland
Scarlet Robin	<i>Petroica boodang</i>	V	V (NSW)	-	Tableland
Superb Parrot	<i>Polytelis swainsonii</i>	V	V (NSW) E (VIC)	V	Tableland
Swift Parrot	<i>Lathamus discolor</i>	V	E (NSW, VIC)	CE	Tableland
Varied Sittella	<i>Daphoenositta chrysoptera</i>	V	V (NSW)	-	Tableland
White-Winged Triller	<i>Lalage sueurii</i>	V	-	-	Tableland
Canberra Spider Orchid	<i>Arachnorchis actensis</i>	E	-	CE	Tableland
Small Purple Pea	<i>Swainsona recta</i>	E	E (VIC, NSW)	E	Tableland
Tarengo Leek Orchid	<i>Prasophyllum petilum</i>	E	E (NSW)	E	Tableland

*As listed under the Victoria Threatened Species Advisory List and / or under the Victorian *Flora and Fauna Guarantee Act 1988*

Table 6. Woodland-associated threatened fauna and flora species found in the ACT. V = vulnerable, E = endangered, CE = critically endangered

Common name	Species	ACT	NSW/ VIC*	C'wth	Subalpine / Tableland
Pink Tailed Worm Lizard	<i>Aprasia parapulchella</i>	V	E (VIC)	V	Tableland
Spotted-tailed Quoll	<i>Dasyurus maculatus</i>	V	V (NSW), E (VIC)	E	Tableland
Little Eagle	<i>Hieraetus morphnoides</i>	V	V (NSW)	-	Tableland
Pink-tailed Worm- lizard	<i>Aprasia parapulchella</i>	V	V (NSW, E (VIC)	V	Tableland
Glossy Black Cockatoo	<i>Calyptorhynchus lathami</i>	V	V (NSW, VIC)	-	Tableland
Perunga Grasshopper	<i>Perunga ochracea</i>	V	-	-	Tableland
Golden Sun Moth	<i>Synemon plana</i>	E	E (NSW), CE (VIC)	CE	Tableland
Striped Legless Lizard	<i>Delma impar</i>	V	V (NSW), E (VIC)	V	Tableland
Northern Corroboree Frog	<i>Pseudophryne pengilleyi</i>	E	CE (NSW)	CE	Subalpine
Smoky mouse	<i>Pseudomys fumeus</i>	E	CE (NSW), E (VIC)	E	Subalpine
Button Wrinklewort	<i>Rutidosis leptorrhynchoides</i>	E	E (NSW)	E	Tableland

*As listed under the Victoria Threatened Species Advisory List and / or under the Victorian *Flora and Fauna Guarantee Act 1988*

Table 7. ACT woodland flora and fauna species threatened outside of the ACT V = vulnerable, E = endangered, CE = critically endangered

Common name	Species	ACT	NSW/ VIC*	C'wth	Subalpine / Tableland
Barking Owl	<i>Ninox connivens</i>	-	V (NSW), E (VIC)	-	Tableland
Black Falcon	<i>Falco subniger</i>	-	V (NSW, VIC)	-	Tableland
Broad-toothed Rat	<i>Mastacomys fuscus</i>	-	V (NSW), E (VIC)	V	Subalpine
Diamond Firetail	<i>Stagonopleura guttata</i>	-	V (NSW), NT (VIC)	-	Tableland
Dusky Woodswallow	<i>Artamus cyanopterus</i>	-	V (NSW)	-	Tableland
Flame Robin	<i>Petroica phoenicea</i>	-	V (NSW)	-	Tableland / Subalpine
Gang Gang Cockatoo	<i>Callocephalon fimbriatum</i>	-	V (NSW)	-	Subalpine / Tableland
Greater Glider	<i>Petauroides volans</i>	-	V (VIC)	V	Subalpine
Speckled Warbler	<i>Chthonicola sagittata</i>	-	V (NSW, VIC)	-	Tableland
Austral Toadflax	<i>Thesium australe</i>	-	V (VIC, NSW)	V	Tableland
Black Gum	<i>Eucalyptus aggregata</i>	-	V (NSW), E (VIC)	V	Tableland
Blue-tongued Greenhood	<i>Pterostylis oreophila</i>	-	CE (NSW), E (VIC)	CE	Subalpine
Hoary Sunray	<i>Leucochrysum albicans var. tricolor</i>	-	E (VIC)	E	Tableland
Kydra Dampiera	<i>Dampiera fusca</i>	-	E (NSW, VIC)	-	Subalpine
Mountain Spider Orchid	<i>Caladenia montana</i>	-	V (NSW)	-	Subalpine
Pale Pomaderris	<i>Pomaderris pallida</i>	-	V (NSW)	V	Tableland
Summer Leek Orchid	<i>Prasophyllum canaliculatum</i>	-	CE (NSW)	-	Subalpine

*As listed under the Victoria Threatened Species Advisory List and / or under the Victorian *Flora and Fauna Guarantee Act 1988*

Rare and data deficient species

Woodlands in the ACT provide critical habitat for a number of flora and fauna species that, although not listed as threatened species under ACT or Commonwealth legislation, are of conservation concern (see Table 8, Table 9). These species may be susceptible to local extinction because of their small overall population size and / or restricted distribution within the ACT. Several species (considered to be rare in the ACT) are listed as 'Data Deficient'; more information (e.g. distribution and abundance) is required to determine the conservation status of these species.

Table 8. Rare fauna and flora species found in woodlands in the ACT

Common name	Species	Subalpine / Tableland
Alpine Darner Dragonfly	<i>Austroaeschna flavomaculata</i>	Subalpine

Common name	Species	Subalpine / Tableland
Alpine Redspot Dragonfly	<i>Austropetalia tonyana</i>	Subalpine
Bronze Ant-blue Butterfly	<i>Acrodipsas brisbanensis</i>	Subalpine
Golden Ant-Blue Butterfly	<i>Acrodipsas aurata</i>	Tableland
Harriss's Peacock Spider	<i>Maratus harrissi</i>	Subalpine
Key's Matchstick Grasshopper	<i>Keyacris Scura</i>	Tableland
Montane Grass-Skipper	<i>Anisynta monticola</i>	Subalpine
Moonlight Jewel	<i>Hypochrysops delicia</i>	Tableland
Rosernbergs Monitor	<i>Varanus rosenbergi</i>	Tableland
Silky Hairstreak	<i>Pseudalmenus chlorinda</i>	Subalpine
Small Alpine Xenica	<i>Oreixenica latialis</i>	Subalpine
Small Ant-blue Butterfly	<i>Acrodipsas mymecophila</i>	tableland
Springtail – undescribed	<i>Australotomurus sp.</i>	Tableland
-	<i>Tomocerus militum</i>	Tableland
Alpine Starbush	<i>Asterolasia trymalioides</i>	Subalpine
Argyle Apple	<i>Eucalyptus cinerea</i> subsp. <i>triplex</i>	Subalpine
Austral Pillwort	<i>Pilularia novae-hollandiae</i>	Subalpine
Big Bird Orchid	<i>Simpliglottis turfosa</i>	Subalpine
<i>Billy buttons</i>	<i>Craspedia aurantia</i>	Subalpine
Brindabella Leek Orchid	<i>Prasophyllum montanum</i>	Subalpine
Brindabella Potato Orchid	<i>Gastrodia entomogama</i>	Subalpine
Coprosma	<i>Coprosma nivalis</i>	Subalpine
Cunningham's Gentian	<i>Chionogentias cunninghamii</i>	Subalpine
Daisybush	<i>Olearia rhizomatica</i>	Subalpine
Dwarf Buttercup	<i>Ranunculus millanii</i>	Subalpine
Erect Midge Orchid	<i>Corunastylis arrecta</i>	Subalpine
Hairy Pomaderris	<i>Pomaderris phyllicifolia</i> subsp. <i>ericoides</i>	Subalpine
Kangaroo Fern	<i>Microsorium pustulatum</i> subsp. <i>pustulatum</i>	Subalpine
Kydra Dampiera	<i>Dampiera fusca</i>	Subalpine
Late Forest Gentian	<i>Chionogentias sylvicola</i>	Subalpine
Moonwort	<i>Botrychium lunaria</i>	Subalpine
Mountain Greenhood	<i>Pterostylis alpina</i>	Subalpine
Mountain Willowherb	<i>Epilobium sarmentaceum</i>	Subalpine
Parantennaria	<i>Parantennaria uniceps</i>	Subalpine
Scaly Everlastingbush	<i>Ozothamnus cupressoides</i>	Subalpine
Shining Westringia	<i>Westringia lucida</i>	Subalpine
Silver Caraway	<i>Oreomyrrhis argentea</i>	Subalpine
Simple-leaved Dwarf Boronia	<i>Boronia nana</i> var. <i>hyssopifolia</i>	Subalpine

Common name	Species	Subalpine / Tableland
Small Royal Grevillea	<i>Grevillea diminuta</i>	Subalpine
Small Snake Orchid	<i>Diuris subalpina</i>	Subalpine
Smooth Nardoo	<i>Marsilea mutica</i>	Subalpine
Spinning Gum	<i>Eucalyptus perriniana</i>	Subalpine
Subalpine Leek Orchid	<i>Prasophyllum sphacelatum</i>	Subalpine
Swamp Everlastingbush	<i>Ozothamnus rosmarinifolius</i>	Subalpine
Sweet Forget-me-not	<i>Myosotis exarrhena</i>	Subalpine
Thyme Mitrewort	<i>Mitrasacme serpyllifolia</i>	Subalpine
Tingaringi Gum	<i>Eucalyptus glaucescens</i>	Subalpine
Tiny Willowherb	<i>Epilobium curtisiae</i>	Subalpine
-	<i>Logania granitica</i>	Subalpine

Table 9. Data deficient species found in woodlands in the ACT

Common name	Species	Subalpine / Tableland
Alpine Clubsedge	<i>Isolepis crassiuscula</i>	Subalpine
Alpine Native Cherry	<i>Exocarpos nanus</i>	Subalpine
Alpine Wattle	<i>Acacia alpina</i>	Subalpine
Grey Billy Buttons	<i>Craspedia canens</i>	Subalpine
Kosciuszko Rose	<i>Pimelea ligustrina</i> subsp. <i>ciliata</i>	Subalpine
Matted Water Milfoil	<i>Myriophyllum pedunculatum</i> subsp. <i>pedunculatum</i>	Subalpine
Mountain correa	<i>Correa lawrenceana</i> var. <i>lawrenceana</i>	Subalpine
Mountain Dandelion	<i>Taraxacum aristum</i>	Subalpine
Mountain Hooksedge	<i>Uncinia flaccida</i>	Subalpine
Mountain Needlebush	<i>Hakea lissosperma</i>	Subalpine
Mountain Plum Pine	<i>Podocarpus lawrencei</i>	Subalpine
Mountain Triggerplant	<i>Stylidium montanum</i>	Subalpine
Sickle Orchid	<i>Pterostylis falcata</i>	Subalpine
Snow Daisy	<i>Celmisia pugioniformis</i>	Subalpine
Tall Riceflower	<i>Pimelea ligustrina</i> subsp. <i>ligustrina</i>	Subalpine
Thyme Speedwell	<i>Veronica serpyllifolia</i>	Subalpine
Velvet Wheatgrass	<i>Australopyrum velutinum</i>	Subalpine
Yellow-leaved Sedge	<i>Carex rara</i> subsp. <i>capillacea</i>	Subalpine
-	<i>Deyeuxia crassiuscula</i>	Subalpine
-	<i>Geranium obtusisepalum</i>	Subalpine
-	<i>Juncus alexandri</i>	Subalpine
-	<i>Simpliglottis</i> sp. aff. <i>valida</i>	Subalpine

4.4 Traditional and contemporary Aboriginal values

Ngunnawal people participated in trade with neighbouring language groups such as Wiradjuri, Walgalu, Yuin, Ngarigo, Gundungurra and Ngambri. Ceremonies, corroborees and the collection of seasonal foods such as Bogong Moths brought large gatherings of Aboriginal people from the greater region to Ngunnawal Country. These gatherings facilitated the exchange of knowledge between groups and maintained connectivity between them.

The stories and corresponding traditional rights and responsibilities to manage certain places are complex and are handed down primarily through family lines. The stories associated with the Dreaming not only determine custodianship of Country, they also impart important knowledge related to the environment and its management. This includes information about the relationships between all living organisms (including the interactions between humans and the environment), information about seasonal changes, the ecology and use of many organisms, and the effect of fire and other disturbances on the landscape.

For Aboriginal people being 'on Country' provides an opportunity to maintain connections with the spirits of the land and to uphold traditional responsibilities to care for the Country. This includes maintaining cultural sites and their associated stories that link places to people. There are 580 recorded Aboriginal sites in woodlands across the ACT. Sites that are associated with Dreaming stories include notable landforms such as hills, mountains, ridgelines and water places. For example, Mt Ainslie and Mt Majura, which comprise several woodland communities, are important men's and women's sites.

Numerous archaeological sites are located within woodlands in the ACT; they provide evidence of Ngunnawal people and other language groups occupying and undertaking ceremonial activities in the ACT region for thousands of years. Sites within lowland woodland include scarred trees, and artefact (knapping or camp), burial, corroboree and rock art sites. While there are fewer known sites located in subalpine woodlands, very significant stone arrangement sites, which mark important ceremonial locations, are found at the top of a number of hills and mountains amongst woodland dominated by Snow Gum. Known Bogong Moth aestivation sites on exposed rock shelters and caves are also associated with several subalpine woodland communities.

Sites within the ACT reserve system continue to be uncovered opportunistically by visitors and land managers. Disturbance events that expose the landscape (e.g. the 2003 wildfires) have facilitated the discovery of many sites. The Cultural Heritage Management System (in development) will identify a number of priorities that will guide future survey effort and provide advice on the ongoing management and conservation of Aboriginal heritage values.

4.5 Woodland management plans

Management plans set prescriptions for the effective management of woodland sites. Management plans in place for native woodland areas in the ACT are outlined in Table 10. Incorporating flexibility into plans to account for underlying uncertainty is a key component of an adaptive management approach.

The Woodland located in ACT Government Horse Holding Paddocks is managed according to a Business Plan and Service Agreement agreed to by Territory Agistment and the ACT Government. Through the provision of advice and educational materials, collaborative management opportunities and grants, Land Management Agreements, and through enforcement of the *Nature Conservation Act 2014*, the ACT Conservator of Flora and Fauna will continue to encourage rural lessees to manage native woodland on their lands to maintain and improve their condition as outlined in this

Strategy. A number of travelling stock reserves contain woodland and are actively managed without strategic management plans in place (i.e. Hall, Hume, Kowen, Paddy’s River, Tharwa, Uriarra Rd, Melrose and Williamsdale). The Suburban Land Agency also recently acquired land parcels in the Molonglo – Murrumbidgee area that contain large areas of lowland woodland. No conservation management plans are in place to protect the ecological values of this area.

Table 10: Management Plans for areas that include woodland in the ACT

	Name	Management plan
Nature Reserve	Namadgi National Park	(ACT Government, 2010b)
	Tidbinbilla Nature Reserve	(ACT Government, 2012b)
	Canberra Nature Park	To be finalised
	Lower Cotter Catchment Reserve	(ACT Government, 2018e)
Offset	Molongolo Valley	(ACT Government, 2013c)
	Kinlyside	(ACT Government, 2015c, 2015d)
	Horsepark North	
	Jacka	
	Taylor	
	Throsby	(ACT Government, 2015b, 2015d)
	Kenny Broadacre	
	Isaacs Ridge	(ACT Government, 2017d)
	Justice Robert Hope Park	(ACT Government, 2018d)
	The Pinnacle	(ACT Government, 2016c)
	Bonner	(ACT Government, 2016b)
	Williamsdale	(Eco Logical Australia, 2010)
	Ginninderry Development / Conservation Corridor	(TRC Tourism, 2018) (SMEC, 2018)
ACT Government Land (other)	Gunghalin Region	(ACT Government, 2007b)
	Hughes Garran Woodland	(Fearnside et al., 2012)
	Hall Cemetery	(ACT Government, 2013b)
National Capital Authority Conservation Areas	Stirling Park, Yarralumla, State Circle Woodland and O’Malley Diplomatic Estate	(Sharp, 2016)
	Majura Federal Police Training Facility	(Commonwealth Government, 2012)
Australian Government Department of Defence Land	Majura Training Area	(Commonwealth Government, 2016a)
Icon Water pipeline corridor	Murrumbidgee to Googong water transfer	(Icon Water, 2017)

4.6 Relevant policy and legislation

Management of threatened species and ecological communities is guided by international and national agreements, policy and legislation. Several legislative instruments in the ACT also recognise, and provide for the protection of the ecological and cultural values of woodlands.

International and national context

The United Nations Convention on Biological Diversity is an international legal instrument for the conservation and sustainable use of biological diversity. Australia ratified the Convention in 1993 and, in line with the Convention, prepared the first national biodiversity strategy in 1996

- (ANZECC, 1996). This document has since been reviewed and replaced by Australia's Strategy for Nature 2018 – 2030 (Commonwealth Government, 2018) and the Strategy for Australia's National Reserve System 2009–2030 (Commonwealth Government, 2009).
- The International Union for Conservation of Nature (IUCN) establishes criteria for assessing the conservation status of a species. The ACT Scientific Committee (a statutory committee under the *Nature Conservation Act 2014*) is guided by the IUCN criteria when assessing the conservation status of species in the ACT.
- The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* includes criteria for environmental impact assessments and provides for the protection of 'matters of national environmental significance'. The Endangered YB-BRG Woodland is part of the EPBC-listed White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland. Several woodland-dependant species listed as threatened in the ACT are also listed as matters of national environmental significance under the EPBC Act. An ACT Environmental Offsets Policy is required by the Commonwealth Government under the EPBC Act.
- In accordance with the ACT *Planning and Land Management Act 1988*, the National Capital Plan seeks to ensure Canberra and the ACT are planned and developed in accordance with their national significance. This includes conserving and enhancing the landscape features that give the national capital its character and that contribute to the integration of natural and urban environments (Commonwealth Government, 2016b).

ACT legislation

- The *Nature Conservation Act 2014* provides for the protection and management of native plants and animals in the ACT. This includes the identification and management of threatened species and ecological communities and authority of the ACT reserve network. The *Nature Conservation Act 2014* prescribes the statutory functions of a number of government staff, including the Conservator of Flora and Fauna, Conservation Officers, and Parks and Conservation Service roles. It also includes provisions for offences against native species.
- The *Planning and Development Act 2007* has provisions for sustainable development. Development proposals that may significantly impact a threatened species or ecological community require an environmental impact assessment under this Act.

This Act includes requirements for environmental offsets in the ACT. The ACT Environmental Offsets Policy outlines a consistent way in which environmental compensation must be made to offset the impact of development or other activities that have a significant adverse impact on natural (and other protected) assets. Land Management Agreements between rural landholders and the ACT Government are required under this Act.

The *Planning and Development Act 2007* requires a Territory Plan to ensure, in a manner not inconsistent with the National Capital Plan, the planning and development of the ACT provide the people of the ACT with an attractive, safe and efficient environment in which to live, work and have their recreation. The Territory Plan is the key statutory planning document in the ACT. The Act also requires a planning strategy for the ACT that sets out long term planning policy and goals to promote the orderly and sustainable development of the ACT, consistent with the social, environmental and economic aspirations of the people of the ACT. The ACT Planning Strategy is the key strategic document for managing growth and change in the Territory.

- The *Tree Protection Act 2005* protects trees in urban areas of the ACT that have exceptional natural or cultural value. This legislation protects trees that are not otherwise protected under the *Nature Conservation Act 2014*.
- The *Pest Plants and Animals Act 2005* identifies pest plants and animals in the ACT. It prescribes approaches to manage pest species, including the development of pest plant and animal management plans.
- The *Emergencies Act 2004* requires the development of a Strategic Bushfire Management Plan which guides the management of fire in the ACT.
- The *Human Rights Act 2004* acknowledges that Aboriginal and Torres Strait Islander people hold distinct cultural rights and must not be denied the right to maintain, protect and develop their culture. The Act recognises their material and economic relationship with the land, waters and other resources.
- The *Heritage Act 2004* establishes a system for the recognition and conservation of places and objects of natural, historic and Aboriginal cultural significance through, for example, the development of Conservation Management Plans. All Aboriginal places, such as trees culturally modified by Traditional Custodians, are afforded protection by the *Heritage Act 2004*, and a number of woodland areas that provide habitat for threatened species are also registered on the ACT Heritage Register. Representative Aboriginal Organisations (RAOs) are also declared under the *Heritage Act 2004*, and these groups have a statutory role in the assessment and management of Aboriginal heritage in the ACT.
- The *Domestic Animals Act 2000* includes provisions for declaring cat containment areas.

4.7 Progress since the 2004 Lowland Woodland Conservation Strategy

The 2004 Woodland Strategy identified three primary conservation objectives. These objectives, and progress made towards meeting them, is briefly summarised below. Note, these objectives are not commitments under the 2019 Woodland Conservation Strategy.

- *Conserve in perpetuity all types of lowland woodland communities in the ACT, as viable and well-represented ecological systems.*

With the addition of several new reserves and extensions to existing reserves, over 1100 ha of woodland (including secondary grasslands) have been added to the reserve network. This includes approximately 600 ha of lowland box gum woodland that contain some Endangered YB-BRG Woodland community. Other woodland areas are now managed as environmental offset areas or have been re-zoned to other tenures managed by the ACT Government for conservation.

- *Conserve in perpetuity, viable, wild populations of all lowland woodland flora and fauna species in the ACT and support regional and national efforts towards conservation of these species (including declared threatened species).*

Research and monitoring undertaken by the ACT Government, community groups and research institutions has improved our understanding of the distribution and habitat requirements of threatened woodland plants and birds, and the processes threatening their survival. Particularly noteworthy is the Mulligans Flat – Gurooyaroo Woodlands Experiment, which has enhanced our knowledge of a range of management techniques including biomass management, pest animal control, native fauna reintroductions and habitat restoration techniques. The ACT Government continues to trial Eastern Grey Kangaroo (*Macropus giganteus*) fertility techniques while undertaking an active control program to maintain sustainable wild populations.

Monitoring undertaken by the ACT Government indicates that current management is ensuring the persistence and viability of a number of woodland dependant species, including the sole population of the threatened Tarengo Leek Orchid at Hall Cemetery.

- *Manage and rehabilitate lowland woodlands across all tenures with appropriate regeneration, restoration and reinstatement practices.*

There has been significant investment by the Australian Government, ACT Government and non-government organisations to implement management and restoration activities, and to undertake research projects to improve our understanding of restoration techniques. Relevant initiatives of the ACT Government are listed below; details of major projects are provided in Section 4.8.

- ACT Woodland Restoration Project (Greater Gurooyaroo region) and Biodiversity Fund Projects (2011 - 2017).
- Investment and support provided to National and ACT Landcare Program
- One Million Trees Project (2008 - 2018).
- Management and restoration activities undertaken at conservation offset areas (including Barrer Hill, Molonglo Valley, Throsby, Isaac and Watson).
- Research illustrating the benefits of adding coarse woody debris to woodland and the subsequent addition of over 4000 tonnes of coarse woody debris to woodland in the ACT.



Mulligans Flat Woodland Sanctuary (M. Jekabsons)

4.8 Woodland conservation and research activities in the ACT since 2004

Many conservation activities that aim to protect, manage and restore woodlands have been undertaken since the 2004 Lowland Woodland Strategy was released. Community groups, research institutions and the ACT Government have also sought to better understand woodland ecosystems through research, mapping and monitoring of woodland sites and woodland biodiversity (including threatened species). An outline of these activities is provided below.

Restoration and conservation activities

Since the 2004 Strategy, a number of projects that aimed to enhance and restore woodland have been undertaken throughout the ACT. Major projects included:

- The ACT Woodland Restoration Project and Biodiversity Fund Project, which aimed to enhance woodland connectivity and condition using a whole of landscape approach, engage the community in woodland restoration, introduce missing habitat elements and undertake invasive species control. The projects were funded by the Commonwealth and ACT Governments and delivered by Greening Australia Capital Region and the ACT Government, in collaboration with rural landholders and other community and volunteer groups. The projects were implemented across all land tenures in the ACT; major achievements included:
 - engagement of 18 rural landowners, and 43 schools / community groups
 - over 900 ha of revegetation, including 28 548 tube stocks planted and 101 km of direct seeding
 - enhancement and protection of 844 ha of remnant woodland (including the distribution of 4 415 tonnes of coarse woody debris)
 - invasive species control over an area of 4 494 ha
 - feral animal control over an area of 9 555 ha
 - establishment of 10 monitoring sites to review different treatment types and techniques.
- Preparation of a woodland restoration plan for Barrer Hill and Misery Point (together encompassing approximately 50 ha in the Molonglo Valley) (SMEC, 2014). Restoration activities included: revegetation, addition of rock and coarse woody debris, scraping topsoil at a site dominated by exotic species and reseeding with native flora, direct seeding, interpretative signage and the planned addition of vertical habitat structure.
- Planting box-gum woodland trees and understorey species (approximately 2000 plants) at 15 plots within and adjacent to the National Arboretum to improve connectivity between Black Mountain and the Molonglo River corridor. One hundred logs have also been added throughout the plots.
- Trialling forb enhancement techniques in Kama Nature Reserve. The project has illustrated that native forb enhancement via direct seeding is a viable technique where there is appropriate soil fertility and when biomass is reduced (Johnson et al., 2018)
- Large-scale restoration program (including soil erosion works and replanting) within the Lower Cotter Catchment (LCC) following extensive loss of vegetation during the wildfires in 2003. Restoration activities will be maintained to support natural regeneration of forest and woodland communities.
- Collaboration between the Australian National Botanic Gardens (ANBG) and the ACT Government to collect and store the seed of a number of understorey species, including several rare and threatened species. Seed of the Canberra Spider Orchid and Tarengo Leek Orchid are

banked at the ANBG and a translocation plan is currently being developed for the Canberra Spider Orchid (see action plans, Part B).

- One Million Trees Project: as outlined in the ACT Government's Climate Change Strategy 2007 – 2011 (ACT Government, 2007a), the ACT Government, with funding support from the Commonwealth Government, aimed to plant one million trees between 2007 and 2017. Plantings occurred in the LCC, the Murrumbidgee River Corridor (MRC) and within urban areas. The LCC and MRC plantings were undertaken strategically to increase the connectivity of woodland patches across multiple tenures (including rural lands), increase riparian and woodland habitat for fauna, stabilise soils and provide future carbon sequestration.
- To address the loss of habitat values associated with mature trees (including carved hollows and artificial bark), the addition of vertical structures enriched with fauna habitat is being trialled and monitored in the Molonglo Valley.
- Activities towards restoring woodland areas as part of environmental offset requirements have been undertaken at Isaacs Ridge, Gungahlin Strategic Assessment Areas and Justice Robert Hope Park (for woodland locations see: ACT Government (2017d), ACT Government (2015c) and ACT Government (2018b) respectively). Activities include, but are not limited to, weed and pest animal monitoring and control, monitoring threatened species and the Endangered YB-BRG Woodland, the addition of coarse woody debris, kangaroo monitoring and control, and revegetation.
- The declaration of the Scarlet Robin as Vulnerable in May 2015, under the *Nature Conservation Act 1980* (and later, the *Nature Conservation Act 2014*). An associated action plan was developed and is included in Part B of this Strategy.

Eastern Grey Kangaroo management

Since 2009 the ACT Government has actively monitored and managed Eastern Grey Kangaroos in the ACT. The control program aims to maintain wild populations of kangaroos while managing their environmental, economic and social impacts. Culling for conservation purposes is undertaken across sixteen reserves (and some adjacent properties), many of which contain areas of the Endangered YB-BRG Grassy Woodland community or natural temperate grassland communities.

The program is managed in accordance with the Controlled Native Species Management Plan for Eastern Grey Kangaroos (ACT Government, 2017c), and the ACT Kangaroo Management Plan (ACT Government, 2010a). Culling numbers are determined according to the Nature Conservation (Eastern Grey Kangaroo) Conservation Culling Calculator (ACT Government, 2018f). Where possible, conservation culling is also managed cooperatively with land managers of surrounding properties, including the Commonwealth Government and rural landholders (as outlined in ACT Government (2017c) and ACT Government (2017e)).

Kangaroo culling on rural properties is permitted to mitigate the economic impacts of kangaroo grazing. It may also contribute to managing long-term sustainable densities of kangaroos and meeting the conservation objectives outlined in the Controlled Native Species Management Plan for Eastern Grey Kangaroos (see: ACT Government (2017c)).

Mulligans Flat – Gorooyarroo Woodland Experiment

The Mulligans Flat – Gorooyarroo Woodland Experiment commenced in 2004 and is a collaboration between The Australian National University, the ACT Government, James Cook University and the CSIRO. The site incorporates approximately 1145 ha of Yellow Box – Blakey's Red Gum Grassy Woodland. It is the largest and most intact example of its type in the ACT.

The project aims to undertake long term research to understand ways of restoring the structure and function of temperate woodlands for biodiversity (Manning et al., 2011). Current research includes monitoring the ecological impact and restoration value of techniques in biomass management (including manipulation of fire), grazing impacts, coarse woody debris, feral species exclusion, species introductions within a predator proof sanctuary, and other woodland restoration techniques (including fauna reintroductions). Research findings are building a strong evidence base that is informing restoration and management activities undertaken within woodlands across the region (see: www.mfgowoodlandexperiment.org.au).

Community conservation work

Through education, advocacy and on-ground initiatives, community groups play a key role in the protection and conservation of native woodlands in the ACT. Below are a number of major projects and initiatives implemented by community groups since 2004.

- Educational forums and workshops (e.g. Friends of Grassland's 2004 'Grass half full or grass half empty? Valuing native grassy landscapes' forum).
- Contributions to, and maintenance of, Canberra Nature Map, which provides a comprehensive, accessible and educational map of fauna and flora across the ACT.
- On-ground management and engagement activities undertaken by ParkCare groups (including: weed treatment, grazing and erosion control, tree and shrub planting and interpretive walks for the public).
- On-ground management and restoration projects facilitated by Landcare ACT and the Molonglo, Ginninderra and Southern ACT Catchment Groups.
- Production of community education resources, including newsletters (e.g. Canberra Bird Notes and the Gang-Gang newsletter published by COG and resources to assist community members to undertake regular and consistent woodland management activities).
- The Canberra Indian Myna Action Group was formed in 2006 to reduce the impact of Indian Mynas in and around Canberra.
- The Southern Tablelands Ecosystems Park (STEP), established within the National Arboretum, represents the major forest and woodland communities in the region, including the Endangered YB-BRG Grassy Woodland community.
- The 'Caring for Ngunnawal Pathways' project, developed by the Molonglo Catchment Group (in partnership with Buru Ngunnawal Aboriginal Corporation, Thunderstone Aboriginal Cultural and Land Management Services, Friends of Grasslands, Save Stirling Park, Yarralumla Residents Association and the ACT Government) engages Ngunnawal people in the restoration of a culturally and ecologically important site at Yarralumla called *Bullan Mura*.
- The expansion of COG's long-term monitoring program of woodland birds to include 145 sites at 15 locations across reserve and leasehold areas. The long term data set was analysed by COG in 2010 (see Bounds et al. (2010) and an analysis of the relationship between habitat change and bird occupancy was undertaken in 2011 (Taws et al., 2011).
- The establishment of the Grassy Woodlands Stakeholder Group: a consultative committee comprised of representatives from several community groups engaged in conservation and land management within the ACT. The group meets to discuss a range of issues and exchange ideas and information with the ACT Government regarding the conservation of lowland woodlands. This includes providing input into the development of this Strategy.

- A recommendation to list the “Loss of Native Hollow-bearing Trees” as a threatening process was submitted by several community groups in 2017. The *loss of mature native trees (including hollow bearing trees) and a lack of recruitment* has since been listed as a key threatening process under the *Nature Conservation Act 2014*.
- Vegwatch, a monitoring program run by the Molonglo Catchment Group since 2012, adopts consistent techniques outlined in Sharp and Gould (2014) to monitor the effects of change such as weed control, burns and other management activities. Currently six woodland sites are monitored as part of this program.
- Publication of *Woodland Flora, a Field Guide for the Southern Tablelands (NSW and ACT)*, which covers 444 Southern Tableland species across the broader ACT region (Sharp et al., 2015).

Baseline information

Survey and mapping projects since the 2004 Strategy have improved our understanding of the distribution of a range of vegetation types across the ACT. Major projects are listed below.

- Classification of 41 vegetation communities in the ACT according to the classification system developed by Armstrong et al. (2013).
- A comprehensive map of vegetation in the ACT was completed in 2018 using aerial photography. Structural attributes of the vegetation (e.g. tree height, crown cover and shrub cover) were added using data derived from Light Imaging Ranging and Detection. Mapped vegetation communities include those described by Armstrong et al. (2013), one previously undescribed woodland community (see Baines et al. (2013)), and 20 modified vegetation types. The mapping was completed between 1:3 000 and 1:10 000 scale. It is available to the public on ACTMapi and is being used to inform management activities and modelling of ecological processes.
- Weed infestation and control work within reserves mapped using the Collector Application. Weed mapping undertaken by community members using the Weed Spotter website and associated application has also contributed to the knowledge of the distribution of weeds.
- Surveys undertaken as part of Environmental Offset requirements have improved distribution maps of a range of woodland biodiversity values, including threatened species. These surveys aim to track the extent and condition of communities, and the occurrence / abundance of threatened species through time.
- Description and mapping of soil landscapes across the ACT by the NSW Office of Environment and Heritage. Fifty five soil landscapes were described (see Cook et al. (2016)) and a digital map was produced for use by land managers, planners and researchers.

Research, modelling and monitoring

Research projects undertaken in the ACT and surrounding region have improved our understanding of the function and value of woodlands and their primary threats in the ACT. Key research projects are listed below.

- **Disturbance, biomass management and woodland restoration**
 - Several local research projects investigating the impact of high intensity grazing by native herbivores on:

- vegetation structure and species diversity and abundance (Driscoll, 2017; Manning et al., 2013; McIntyre et al., 2015; McIntyre et al., 2010; Snape et al., 2018; Vivian & Godfree, 2014)
- birds (Howland et al., 2016)
- invertebrates (Barton et al., 2011)
- reptiles (Howland et al., 2014).
- Research illustrating the importance of coarse woody debris in reducing the impacts of browsing pressure on vegetation in woodlands in the ACT (Stapleton et al., 2017).
- Research trials to develop an effective and efficient method for fertility control of Eastern Grey Kangaroos (ACT Government, 2018c).
- Trials of disturbance and restoration regimes to inform management of grasslands (and grassy woodlands), including improving habitat for threatened species. Management techniques include fire, grazing, slashing, rock placement and complementary weed and pest animal control.
- Research in Namadgi and other National Parks within the Australian Alps investigating fuel hazard and flammability in subalpine woodland and forests (Dixon et al., 2018b; Zylstra, 2018).
- Research investigating the interaction between dieback severity of Blakely's Red Gum and time since fire, landscape position and stand structure (i.e. regeneration density) in the ACT.
- As part of a PhD thesis, Darren Le Roux investigated the future availability of large old trees around Canberra (Le Roux et al., 2014a) and policy options to retain habitat structures in urban areas (Le Roux et al., 2014b), the impact on bird diversity of replacing single large trees with several small trees (Le Roux et al., 2015), factors influencing use of artificial nest boxes (Le Roux et al., 2016a) and the failure of nest boxes to attract native hollow nesting birds to small- and medium-sized trees (Le Roux et al., 2016b).
- **Threatened species**
 - Monitoring and on-ground activities undertaken by the ACT Government to better understand and conserve threatened woodland vegetation species, as detailed in respective action plans (Part B). These include:
 - monitoring of Small Purple Pea and Tarengo Leek Orchid populations since 2001 and 1991, respectively. Long-term data will allow for the effective analysis of population trends and identification of relationships with management activities and other impacts (including climate change).
 - Monitoring threats to Canberra Spider Orchid populations and implementing management interventions when required.
 - Research into a failed reintroduction of the Brown Treecreeper and implications for woodland restoration (Bennett et al., 2012a; Bennett et al., 2012b, 2013a; Bennett et al., 2013b).
- **Woodland birds**
 - Analysis of long term monitoring data and population trends for woodland birds, including the seven species listed as threatened in the ACT (Barrett et al., 2007; Rayner, 2014).

- Research investigating the response of woodland birds to various habitat features (Stagoll et al., 2010), the urban interface (Ikin et al., 2014a; Ikin et al., 2013a; Ikin et al., 2013b) and large trees in urban areas (Stagoll et al., 2012).
- Intensive nest monitoring of Superb Parrots in Canberra to assess the number of pairs displaying breeding behaviour within the Gungahlin and Molonglo Strategic Assessment Areas and to monitor competitive interactions with other hollow nesting species (Rayner et al., 2015b, 2016). This research contributes to our understanding of site fidelity, breeding success, and the habitat and breeding requirements of the Superb Parrot.
- **Climate change**
 - Modelling by the ACT Government to identify climate refugia for vegetation across the ACT (Mackenzie et al., 2018). The model-predicted future distribution of vegetation is informing current management activities undertaken by the ACT Government (e.g. such as fire management and restoration activities).
 - A spatial multi-criteria analysis, which aims to improve understanding of the factors associated with dieback across the ACT, was recently completed for the ACT Government (Cowood et al., 2018).
 - Research and modelling into the likely impacts of climate change on structure, processes and biodiversity of temperate grasslands and grassy woodland communities across southeast Australia (Prober et al., 2012a).
 - Research illustrating the importance of several factors for successful ecological restoration in a changing climate (Prober et al., 2014a; Prober et al., 2014b).
 - Analysis of genetic variability in Yellow Box remnant and restoration sites (including sites in northern ACT and north of the ACT border) (Broadhurst, 2013). Broadhurst's (2013) paper discusses the relationship between the genetic variability of vegetation at these sites and the likelihood they will successfully adapt to the impacts of climate change.
 - The genetic diversity of two Yellow Box seed production areas were evaluated to determine if the harvestable seed contains sufficient genetic diversity to supply effective future restoration projects (Broadhurst et al., 2015).
 - Development of a trial by CSIRO (for the ACT Government) to test the suitability of seeds of Blakely's Red Gum, sourced from local populations and the broader region, to ACT's present and predicted future climate conditions. Information from the provenance trial will inform potential management activities to mitigate the impact of climate change and dieback on Blakely's Red Gum. This may include the selection and breeding of dieback resistant individuals, assisted migration and genetic enrichment of natural populations
- **Habitat connectivity**
 - Landscape modelling, undertaken by Manning et al. (2010), to identify priority places to improve habitat connectivity across the ACT. The analysis mapped the location of habitat links across the region, identified key considerations and issues for land planning and management and proposed a range of remedial and future actions. Habitat connectivity models and guidelines to ensure adequate connectivity for species (including woodland specialists) within the ACT were further developed by Barrett and Love (2012) and later by Doerr et al. (2014b). Mapping products and recommendations produced from these projects have been used in town planning and have guided revegetation projects.

- Love et al. (2015) identified areas across the South East Local Land Services region (including the ACT) where maintaining or improving connectivity of native vegetation will best support woodland dependant (and other) species most sensitive to landscape fragmentation.
- **Monitoring**
 - The development of the CEMP in 2017 as a framework for monitoring the condition of ecosystems across the ACT network. The program gathers information from various monitoring programs and qualitative sources across government and non-government groups to make assessments of reserve condition and to evaluate the effectiveness of management actions in achieving conservation outcomes. The CEMP ensures information is available to support adaptive, evidence-based decision making into the future. A monitoring plan for native woodlands is currently under development.
 - The impact of Sambar Deer on vegetation structure and composition in montane forests and woodlands in the Cotter Catchment is being monitored by the ACT Government. Surveys commenced in 2014-2015 and data collected will inform future management decisions (see Mulvaney et al. (2017)).
 - The ACT Government is monitoring the effects of thinning (according to benchmark densities outlined in Gibbons et al. (2010)) on the structural diversity and growth rates of woody species within a lowland woodland site at Isaacs Ridge offset area.
 - The ACT Government has undertaken long-term monitoring of lowland grasslands and woodlands since 2009. This includes measuring species richness and structural characteristics. As part of the 5 year collaborative woodland enhancement and connectivity program, additional monitoring sites are being developed to identify management priorities and track changes in habitat condition.
 - The ACT Government is undertaking research to better understand the response of subalpine woodland ecosystems to fire. Vegetation structural dynamics and patterns of fauna diversity are being recorded at monitoring plots throughout Namadgi National Park that have experienced different fire regimes. Ecological insights from this research informs fire management activities undertaken by the ACT Government.
 - Monitoring is undertaken at all offset sites, which together include over 650 ha of box-gum woodland, to understand if management objectives are being achieved and if changes to management are required. This includes monitoring the ecological condition of box-gum woodland and monitoring the population status of threatened species.
 - The ACT Government undertakes annual monitoring of feral pig populations in Namadgi National Park to estimate local populations to inform control activities
 - Biannual surveys to monitor rabbit populations across a number of grassland and woodland sites within Canberra Nature Park. Monitoring tracks long term trends in rabbit abundance and informs rabbit control activities.

5. APPENDICES

5.1. Lowland and subalpine woodland communities in the ACT

Name	Structure	Condition and threats	Location	Conservation significance
u22. Mountain Gum – Snow Gum ± Robertson’s Peppermint grass-forb very tall woodland to open forest of the Australian Alps and South Eastern Highlands bioregions	Tall dense canopy (grading to open forest) dominated by <i>Eucalyptus dalrympleana</i> and <i>Eucalyptus pauciflora</i> subsp. <i>pauciflora</i> . Midstorey variable (may be absent) with dense grass and herbaceous ground cover, usually dominated by <i>Poa sieberiana</i> .	<ul style="list-style-type: none"> • Most of this community is below its prescribed minimum tolerable fire interval • Extensive areas burnt in 2003, resulting in a dense cover of vegetation in the 1-3 m height class • Well represented in the ACT reserve system 	<ul style="list-style-type: none"> • 865 – 1588 m asl • Widespread on ridges and slopes of the Gudgenby, Corin, Bendora, Paddy’s River and Cotter catchments 	
u23. Snow Gum – Drumstick Heath – <i>Leptospermum myrtifolium</i> tall woodland to open forest of drainage depressions primarily of the South Eastern Highlands bioregion	Mid-high dense canopy (grading to open forest) dominated by <i>E. pauciflora</i> subsp. <i>pauciflora</i> , <i>E. dalrympleana</i> and <i>Eucalyptus stellulata</i> . Well-developed shrub layer (including <i>Epacris breviflora</i> , <i>Leptospermum myrtifolium</i> and <i>Hakea macrocarpa</i>) and diverse ground cover.	<ul style="list-style-type: none"> • Most of the community is below its prescribed minimum tolerable fire interval • Primary current threats include invasive plants • Well represented in the ACT reserve system 	<ul style="list-style-type: none"> • 931-1707 m asl • Very patchy distribution on lower slopes and sheltered areas, including the Paddy’s River, Bendora, and Gudgenby catchments 	
u27. Snow Gum – Candlebark tall grassy woodland in frost hollows and gullies of the South Eastern Highlands bioregion	Tall canopy dominated by <i>E. pauciflora</i> subsp. <i>pauciflora</i> often with <i>Eucalyptus rubida</i> , and occasionally with <i>Eucalyptus dives</i> , <i>Eucalyptus bridgesiana</i> or <i>Eucalyptus viminalis</i> . Dense grass and herbaceous ground cover.	<ul style="list-style-type: none"> • Most of the community is below its prescribed minimum tolerable fire interval • Approximately 70% of extent was burnt in 2003, resulting in a dense cover of vegetation in the 1-3 m height class • Well represented in the ACT reserve system 	<ul style="list-style-type: none"> • 890-1558 m asl • Mid to lower slopes and valley floors on ranges and frost hollow depressions, including Gudgenby, Naas and Corin catchments 	This community is part of an Endangered Ecological Community (<i>Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes bioregions</i>) listed under the NSW Threatened Species Conservation Act 1995
u28. Snow Gum – Mountain Gum – <i>Daviesia mimosoides</i> tall dry grass-shrub subalpine open forest of the Australian Alps and South Eastern Highlands bioregions	Tall canopy (grading to open forest) dominated by <i>E. pauciflora</i> subsp. <i>pauciflora</i> and <i>E. dalrympleana</i> . Shrubby, diverse midstorey (often dominated by <i>D. mimosoides</i> and <i>Oxylobium ellipticum</i>). Diverse groundcover dominated by <i>P. sieberiana</i> .	<ul style="list-style-type: none"> • Approximately 90% of this community is below its prescribed minimum tolerable fire interval • Extensive areas burnt in 2003, resulting in a lower canopy height than less disturbed systems • Well represented in the ACT reserve system 	<ul style="list-style-type: none"> • 978-1582 m asl • Widely distributed on ridges, summits and slopes, including the Corin, Gudgenby, Bendora, Lower Cotter, Naas and Paddy’s River catchments 	

Name	Structure	Condition and threats	Location	Conservation significance
u118. Black Sallee grass-herb woodland in drainage depressions and moist valley flats in the South Eastern Highlands and Australian Alps bioregions	Tall canopy dominated by <i>E. stellulata</i> and occasional <i>E. rubida</i> and/or <i>E. pauciflora</i> subsp. <i>pauciflora</i> . Moderate shrub layer (often including <i>Hakea microcarpa</i> and <i>Leptospermum</i> spp.) and dense groundlayer with a diversity of forbs and low shrubs between grass tussocks.	<ul style="list-style-type: none"> Approximately 70% of this community is below its prescribed minimum tolerable fire interval Well represented in the ACT reserve system 	<ul style="list-style-type: none"> 972-1400 m asl Narrow bands on the footslopes of drainage depressions and valleys in the Naas, Gudgenby, Corin and Paddy's River catchments 	This community is part of an Endangered Ecological Community (<i>Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes bioregions</i>) listed under the NSW Threatened Species Conservation Act 1995
u158. Alpine Sallee shrub-grass subalpine mid-high woodland of the Australian Alps bioregion	Low to tall canopy dominated by <i>E. pauciflora</i> subsp. <i>niphophila</i> , <i>E. pauciflora</i> subsp. <i>debeuzevillei</i> and <i>Eucalyptus glaucescens</i> . Shrubs, grasses and forbs create a diverse groundlayer, often including <i>Hovea montana</i> , <i>Acrothamnus hookeri</i> , <i>Acrothamnus montanus</i> , <i>Poa phillipsiana</i> and <i>Stellaria pungens</i> .	<ul style="list-style-type: none"> Much of this community is below the prescribed minimum tolerable fire interval Majority of extent burnt in 2003, resulting in a very dense shrub layer Entire distribution protected within ACT reserve system 	<ul style="list-style-type: none"> 1005-1553 m asl Very patchy distribution on exposed and rocky summits and ridges, primarily along the Tidbinbilla Range in the Lower Cotter, Bendora and Paddy's River catchments. Isolated patches occur in the Gudgenby catchment 	
u207. Jounama Snow Gum – Snow Gum shrubby mid-high woodland on granitoids primarily of the Namadgi region	Low to tall canopy dominated by <i>E. pauciflora</i> subsp. <i>debeuzevillei</i> and <i>E. pauciflora</i> subsp. <i>pauciflora</i> . Diverse, shrubby midstorey including <i>Tasmannia xerophila</i> , <i>Podolobium alpestre</i> , <i>Daviesia ulicifolia</i> , <i>Oxylobium ellipticum</i> and <i>Hovea montana</i> . Groundlayer includes a diverse suite of grass and herb species.	<ul style="list-style-type: none"> Majority of extent burnt in 2003 and is likely to be well below its prescribed minimum tolerable fire interval Entire distribution protected within ACT reserve system 	<ul style="list-style-type: none"> 1297-1910 m asl Primarily located on the highest ridges of the Brindabella Range, including the Corin and Bendora Catchments 	
q6. Red box tall grass-shrub woodlands	Tall canopy dominated by <i>E. polyanthemus</i> with occasional <i>E. blakelyi</i> , <i>E. melliodora</i> , <i>E. bridgesiana</i> and <i>E. nortonii</i> . Midstorey ranges from diverse to sparse (including species such as <i>Bursaria spinosa</i> , <i>Kunzea ericoides</i> and <i>A. dealbata</i>). Groundlayer varies from moderate to sparse.	<ul style="list-style-type: none"> Approximately 50% of the community is above its prescribed maximum tolerable fire interval Historic grazing has resulted in a simplified mid and ground cover and inhibited recruitment of canopy species Many old trees have been removed for use as firewood Some areas have been converted to derived grasslands Current threats include invasive plants 	<ul style="list-style-type: none"> Largely confined to the ACT Fragmented distribution across hills, ridges and mid-slopes, primarily within the Kambah, Tharwa, Woolshed, Fyshwick and Kowen catchments 	

Name	Structure	Condition and threats	Location	Conservation significance
<p>u19. Blakely's Red Gum – Yellow Box ± White Box tall grassy woodland of the Upper South Western Slopes and western South Eastern Highlands bioregions</p>	<p>Tall canopy dominated by <i>E. blakelyi</i> and/or <i>E. melliodora</i>. Sparse or absent shrub layer often comprised of regenerating Eucalypts, <i>Acacia</i> species or <i>B. spinosa</i>. Groundlayer includes a range of grass and forb species. Undisturbed sites have a greater diversity of forbs; degraded areas are dominated by less palatable, robust species.</p>	<ul style="list-style-type: none"> • Approximately 40% of the community is above its prescribed maximum tolerable fire interval • Historic grazing has resulted in a simplified mid and ground cover and inhibited recruitment of canopy species • Few areas remain in good, intact condition and some areas have been converted to derived grasslands • Extensive areas suffer from dieback and have sparse to very sparse canopy cover • Current threats include dieback, grazing (native and non-native), urbanisation and invasive plants 	<ul style="list-style-type: none"> • Widespread across gently sloping country in most catchments north of Mt Tennent and north-east of the Murrumbidgee River 	<p>This community is part of the:</p> <ul style="list-style-type: none"> ○ <i>Yellow Box/Red Gum Grassy Woodland</i> listed as endangered under the Nature Conservation Act (ACT) 1980 ○ <i>White Box Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland</i> listed as Critically Endangered under the EPBC Act 1999. ○ <i>White Box Yellow Box Blakely's Red Gum Woodland</i> listed under the NSW TSC Act 1995.
<p>u178. Yellow Box – Apple Box tall grassy woodland of the South Eastern Highlands</p>	<p>Tall canopy dominated by <i>E. melliodora</i> and/or <i>E. bridgesiana</i>, occasionally with <i>E. blakelyi</i> or <i>E. rubida</i> along creeklines and in moist depressions. Sparse (or absent) shrub layer primarily comprised of <i>Acacia</i> spp., <i>B. spinosa</i> and <i>K. ericoides</i>. Dense groundlayer of grasses and forbs.</p>	<ul style="list-style-type: none"> • Approximately 40% of the community is above its prescribed maximum tolerable fire interval • Historic grazing has resulted in a simplified mid and ground cover and inhibited recruitment of canopy species • Few areas remain in good, intact condition • Extensive areas suffer from dieback and have sparse to very sparse canopy cover • Current primary threats include dieback, grazing (native and non-native), urbanisation and invasive plants 	<ul style="list-style-type: none"> • A significant proportion of extent is within the ACT • Widespread across variable topography, from valley floors to ridges, including the Naas Kowen and Uriarra and Coppins catchments 	<p>This community is part of the:</p> <ul style="list-style-type: none"> ○ <i>Yellow Box/Red Gum Grassy Woodland</i> listed as endangered under the Nature Conservation Act (ACT) 1980 ○ <i>White Box Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland</i> listed as Critically Endangered under the EPBC Act 1999. ○ <i>White Box Yellow Box Blakely's Red Gum Woodland</i> listed under the NSW TSC Act 1995.
<p>p520. Ribbon Gum very tall woodland on alluvial soils along drainage lines of the eastern South Eastern Highlands bioregion</p>	<p>Very tall canopy dominated by <i>E. viminalis</i> and occasionally <i>E. bridgesiana</i>, <i>E. rubida</i> or <i>E. pauciflora</i>. Sparse to moderate shrub layer (often comprised of <i>A. dealbata</i>, <i>A. melanoxylon</i> or <i>K. ericoides</i>) and grassy groundlayer. Areas that have suffered severe disturbance have little to no native ground cover</p>	<ul style="list-style-type: none"> • Most of this community is below its prescribed maximum tolerable fire interval • Historic grazing has resulted in a simplified mid and ground cover, altered hydrology and inhibited recruitment of canopy species • Most areas are in low to moderate condition • Current primary threats include invasive plants and dieback • Well represented in the ACT reserve system 	<ul style="list-style-type: none"> • Fragmented distribution along alluvial flats adjacent to larger drainage lines, primarily in the Naas, Gudgenby and Tharwa catchments 	<ul style="list-style-type: none"> • This community is part of an Endangered Ecological Community (<i>Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes bioregions</i>) listed under the NSW Threatened Species Conservation Act 1995

Name	Structure	Condition and threats	Location	Conservation significance
<p>u78. Snow Gum Grassy mid-high woodland of the South Eastern Highlands bioregion</p>	<p>Low to tall canopy dominated by <i>E pauciflora</i> subsp. <i>pauciflora</i> occasionally with <i>E. bridgesiana</i> and / or <i>E. rubida</i>. Sparse to moderate shrub layer (including <i>K. ericoides</i>, <i>B. spinosa</i> and <i>A. delabata</i>) and dense groundlayer including a variety of grasses and forbs. Heavily grazed remnants are dominated by less-palatable species such.</p>	<ul style="list-style-type: none"> • Over 70% of the community is the same fire age class • Historic grazing has resulted in a simplified mid and ground cover, altered hydrology and inhibited recruitment of canopy species • Current primary threats include invasive plants and grazing 	<ul style="list-style-type: none"> • Rare • Over 60% of this community is within rural lands • Fragmented distribution across areas where cold air accumulates overnight (varied topography). • Largest remnants are located in the Paddy's River catchment in the Tidbinbilla Valley, Mt Ainslie-Majura and Aranda bushland 	<ul style="list-style-type: none"> • This community is part of an Endangered Ecological Community (<i>Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes bioregions</i>) listed under the NSW Threatened Species Conservation Act 1995

5.2. Management investment required* to achieve conservation objectives (identified in this strategy) in lowland woodlands (including secondary grasslands) and subalpine woodlands

■ = Significant, ■ = High, ■ = Medium – Low, □ = Not currently applicable.

*Ranking considers extent and severity of threat / issue and resources required to implement associated actions (not identified in the Strategy)

Conservation objectives	S.alpine L.land	
RETAIN AND PROTECT NATIVE WOODLANDS	■	■
Ensure no net loss of the ecological and cultural values of woodlands in the ACT.	■	■
Maintain or improve the proportion of each woodland community located within the ACT’s formal reserve system	■	■
Identify opportunities to improve representation of lowland Snow Gum woodland (u78) and Red Box tall grass-shrub woodland (q6) in the ACT’s formal reserve system.	□	■
All species of woodland flora and fauna should be represented by viable, wild populations that will enable the species to be conserved for perpetuity (cont. pg. 14).	■	■
Improve understanding of the distribution of Endangered YB-BRG Woodland community in the ACT and aim to protect all remaining areas from unintended impacts (see action plan, Part B).	□	■
Prioritise the protection and ongoing management of woodland that contributes to threatened species conservation (as outlined in respective action plans and conservation advice, Part B).	■	■
Identify opportunities to protect and enhance the values of woodlands outside the reserve system (cont. pg. 14).	□	■
Manage the impact of residential and commercial development on woodlands in the ACT through the Environmental Offsets Policy and those strategies outlined in Section 1.2.	□	■
Mitigate the impacts of dieback	■	■
Continue to lead and support research and modelling to improve our understanding of the relationship between: dieback and fire, the abundance and impact of insects and fungal pathogens, soil moisture and condition, vegetation density, and land use.	■	■
Continue to map tree canopies using remote sensing methods and undertake associated modelling and analysis to track changes in the condition of trees in lowland woodland communities over time. Expand modelling and analysis to include subalpine woodland species.	■	■
Lead and support research to improve our understanding of the susceptibility of individual <i>Eucalyptus</i> trees to dieback (including investigations into genetic variability and seed provenance trials).	■	■
Undertake and support restoration activities that enhance a system’s resilience to climate change and other disturbances, and encourage regeneration and establishment of <i>Eucalyptus</i> trees.	■	■
Management actions that aim to mitigate the impacts of dieback are informed by emerging ideas and research undertaken in the ACT and in <i>Eucalyptus</i> woodland communities across Australia.	■	■
Control pest animals	■	■
Prevent costly, erratic pest animal control by ensuring long-term, regular funding for targeted pest management, according to the ACT Pest Animal Strategy 2012-2022(ACT Government, 2012a)(ACT Government, 2012a)(ACT Government, 2012a).	■	■

Conservation objectives	S.alpine L.land	
Reduce the impact of pest animals by prioritising management activities that detect and efficiently manage emerging pest species (cont. pg. 19).		
Where eradication of a species is not feasible, prioritise management actions to protect significant cultural and ecological assets from further impacts.		
Facilitate and support cross-tenure management of pest animals.		
Consider the interactions between ecosystem processes, threatening processes and management activities during the development and implementation of control programs.		
Lead and support research to improve our understanding of the relationship between pest animal abundance/density and environmental impacts. Based on research findings, develop management actions that target actual, rather than perceived, impacts.		
For all control programs, develop and maintain a robust monitoring program to track changes in the abundance of pest animals and the impacts they cause to woodland values.		
Develop management triggers for the control of pest animals that are informed by both the abundance of an animal and its environmental impact.		
Facilitate community education and participation in pest animal management to maintain community support for pest animal control and to improve efficiencies of control work through cross-tenure management.		
Lead and support research to identify and test innovative control methods and emerging technologies in the space of pest animal control to inform best-practice management.		
Maintain local, regional and national research collaborations (including the Centre for Invasive Species Solutions).		
Fire management		
Undertake strategic prescribed burning and other fuel reduction activities within woodlands to protect human life and property, maintain species diversity and minimise species' losses according to the ACT Strategic Bushfire Management Plan (ACT Government, 2014).		
Use the best available ecological knowledge to evaluate and make decisions regarding balancing asset protection and woodland biodiversity conservation.		
As part of planning for prescribed burning, take appropriate measures to mitigate potential negative ecological impacts.		
Lead and support research to improve our understanding of the responses of fauna and flora to different fire regimes in the ACT.		
Facilitate and support cross-tenure fire management planning and activities (including with rural landholders and NSW land managers).		
Where it is consistent with objectives to reduce the risk to human life and property, increase the diversity of subalpine woodland post fire age classes. Priority activities include: protecting areas of long unburned subalpine woodlands from fire for the foreseeable future and identifying areas of subalpine woodland to transition to older post-fire age classes.		
Develop weed management strategies for fire management when there is a likelihood of invasive species responding positively to burning (e.g. English Broom [<i>Cytisus scoparius</i>], African Lovegrass [<i>Eragrostis curvula</i>], Cootamundra Wattle, and Oxeye Daisy [<i>Leucanthemum vulgare</i>] and Nodding Thistle [<i>Carduus nutans</i>]).		
Facilitate community education initiatives to improve understanding of the complexities of fire management in the ACT and the use of fire to manage woodland biodiversity.		
Undertake robust monitoring and evaluation to assess the ecological (and human life and property protection) outcomes of planned fire management activities and unplanned fire events.		
In accordance with ACT Government (2015a), protect cultural sites during fire management activities and work in collaboration with Traditional Custodians and the broader Aboriginal community to plan, implement and monitor cultural burns in woodlands.		

Conservation objectives	S.alpine L.land	
Mitigate the impact of urbanisation		
Mitigate impacts of existing urban development on adjacent woodland habitat (cont. pg. 24)		
Mitigate impacts of future urban development on woodland areas by (cont. pg. 24)		
Mitigate the impact of overgrazing		
Manage kangaroo densities according to the Controlled Native Species Management Plan for Eastern Grey Kangaroos (ACT Government, 2017c) (ACT Government, 2017c) (ACT Government, 2017c), the Kangaroo Management Plan, and other subsidiary documents.		
Continue the trial of dart-delivered GonaCon on kangaroos in Canberra Nature Park and continue to assess the long-term effectiveness of dart-delivered GonaCon on fecundity. Ensure future culling programs are informed by the outcomes of this program.		
Undertake management activities, including restoration and herbage mass techniques, to maintain, wherever possible a heterogeneous mosaic of grazing intensity by native herbivores and at least some pasture that is at a level palatable to kangaroos and other native herbivores.		
Continue long-term monitoring of the interaction between vegetation and principal herbivores in grasslands and grassy woodlands to inform ongoing management.		
Consider actions to enhance woody debris (including fine woody components) to reduce kangaroo browsing pressure in woodland areas where naturally occurring debris is deficient		
Work with rural landholders to support the maintenance and enhancement of woodland values, including protection from overgrazing		
Reduce the impact of overgrazing from non-native herbivores according to ACT Government (2012a).		
Mitigate the impact of invasive plants		
Manage established invasive species according to the ACT Weeds Strategy 2009 -2019 (ACT Government, 2009) and annual Invasive Plants Operations Plans.		
Prevent costly, erratic invasive plant control by ensuring long term, regular funding for targeted management.		
Reduce the likelihood of new plant invasions by prioritising management activities that detect and efficiently eradicate emerging species (cont. pg. 29)		
Where eradication of a species is not feasible, prioritise management actions to protect significant cultural and ecological assets from further invasion.		
When required, undertake staged removal of woody weeds and plan and implement revegetation (e.g. with fast growing native shrubs) to maintain critical habitat for fauna in the absence of complex habitat structure.		
Facilitate and support cross-tenure management of invasive plants where relevant.		
As part of control programs, monitor the changes in abundance of invasive plants and their impacts on woodlands.		
Continue to use and promote digital technologies to assist in the systematic recording of invasive species distribution and control activities and use this information to monitor changes in the area and density of infestations.		

Conservation objectives	S.alpine L.land	
Keep up to date with new control methods and emerging technologies to inform best practice invasive plant species management.		
Mitigate the impact of climate change		
Improve understanding of: the predicted impacts of climate change on woodland-associated fauna and flora, future climate refugia for woodland communities and potential colonisation sites for associated biodiversity (cont. pg. 31)		
Identify management priorities and protect sites identified as significant refugia (and potential colonisation sites) for woodland species.		
As outlined in Section 1.3, woodland restoration activities will consider future climate impacts and will aim to enhance a system's ability to adapt to changing conditions.		
Collaborate with local, regional, state and federal stakeholders to undertake research, management activities, and facilitate community awareness raising and knowledge sharing between all parties.		
Monitor the long-term response of species (that are characteristic of woodland communities) to climate change. Use monitoring data to inform the selection of thresholds above or below which management actions should be triggered.		
Maintain and improve habitat features and habitat heterogeneity		
Enforce policy and undertake management action to retain large, mature trees and other critical woodland habitat features (e.g. mistletoe) across all tenures.		
Undertake plantings and introduce habitat elements to restore soil health, increase woodland extent, enhance functional woodland connectivity and enhance habitat for target fauna species.		
The prioritisation and planning of restoration projects should: define site and landscape-scale goals, evaluate the appropriateness and cost-effectiveness of assisted natural regeneration to meet objectives otherwise addressed through revegetation and other active regeneration activities, be informed by the best available knowledge (cont.		
Work closely with rural landholders and other local land managers to plan and undertake restoration activities to maintain and improve habitat features and contribute to landscape-scale restoration, as outlined in Section 2.1.		
Ensure long term funding for ongoing management and / or monitoring of restoration sites.		
Continue to undertake and support research that informs restoration activities (see Section 3.1 and 4.8).		
If there is conflict between habitat management for two or more threatened species, consideration must be given to abundance, habitat specialisation, functional traits, mobility, adaptability and the ACT and National conservation status of the species (cont. pg. 34).		
Seek to improve our understanding of aboveground-belowground linkages to inform effective restoration techniques. This includes: knowledge of species-specific symbiotic relationships, management actions that are advantageous to soil communities and soil community structure (cont. pg. 34)		
Manage biomass		
In the absence of knowledge regarding species-specific understorey habitat requirements, aim to maintain intermediate levels of herbage mass and a heterogeneous (or 'patchy') grassland structure at the reserve and / or landscape scale.		
Evaluate the risk and appropriateness of implementing different biomass techniques (fire, grazing or slashing / mowing) at a site, and compare with the risk of inaction.		
Develop ACT Government guidelines for the management of biomass within lowland woodlands (cont. pg. 37)		

Conservation objectives	S.alpine L.land	
Manage kangaroo densities (according to the guidelines outlined above) at sites where heavy kangaroo grazing is resulting in a substantial decline in biomass and structural heterogeneity.		
Undertake and support research and ongoing monitoring to evaluate the ecological, social and economic outcomes of controlled grazing by native herbivores and livestock.		
If there is conflict between biomass management for two or more threatened species, consideration must be given to abundance, habitat specialisation, functional traits, mobility, adaptability and the ACT and National conservation status of the species (cont. pg. 37.)		
Livestock grazing for conservation purposes should only be used as a short-term tool to manage biomass on ACT Government managed land (cont. pg. 37).		
Enhance habitat connectivity		
Projects aiming to maintain or enhance connectivity should: prioritise the protection and effective management of woodland patches, identify target species, and consider their requirements for functional connectivity, consider habitat connectivity at both a local and landscape scale (cont. pg. 38)		
Maintain isolated trees on and off reserve as 'stepping stone' connectivity, especially when revegetation is not feasible.		
Ensure the key east – west and north – south wildlife corridors across the ACT are maintained and where required, restored.		
Work with rural landholders and other land managers to improve connectivity of woodland habitat at a landscape scale.		
Collaborate with rural landholders		
Work closely with rural landholders and their representative body, the Rural Landholders Association (RLA), to identify additional strategies to collaborate on projects and support landholders to protect and / or enhance woodland values on rural land.		
To effectively work with rural landholders, consideration must be given to the diversity of priorities rural landholders have regarding the management of their properties, including the need to manage for production and profitability, mechanisms to maintain open communication and effective relationships (cont. pg. 40).		
Support community participation and raise community awareness		
Collaborate with community groups to deliver woodland conservation activities (e.g. restoration activities) to address the priorities outlined in this Strategy.		
Support community groups to undertake on-ground and other projects through the provision of grants, advice and access to research and other knowledge.		
Provide opportunities for community members to engage in volunteer activities through the ParkCare program. Providing training and access to other ACT Government resources will ensure the sustainability of ParkCare activities into the future.		
Facilitate, and collaborate with external groups to deliver community education programs that engage the broader community (cont. pg. 42).		
Facilitate information and knowledge sharing between ACT Government staff, research organisations and community groups to encourage best practice management of woodlands (cont. pg. 42).		
Develop and maintain appropriate interpretative signage and other educational materials in reserves and other open spaces.		
Enhance and promote citizen science		

Conservation objectives	S.alpine L.land	
Explore opportunities for citizen science initiatives to meet conservation objectives outlined in this Strategy. Provide support to relevant community groups to plan projects and implement them.		
Encourage the systematic collection and effective use of data collected through citizen science projects by: supporting the management and use of digital information tools, ensuring data collected is subject to appropriate quality control, and supporting community groups to access grants, professional and technical advice, training and		
Enhance participation of Aboriginal people		
Work in collaboration with Aboriginal community members to manage and monitor woodlands and fill knowledge gaps regarding their long term conservation. Initiatives may include: employment of Aboriginal rangers and other natural resource management officers, and planning, implementing and monitoring of cultural burns (cont. pg. 45).		
Support Traditional Custodians to access and use the landscape in accordance with Aboriginal Access to Country Cultural Guidelines (in development) (cont. pg. 45)		
Implement and / or collaborate with RAOs and other community groups to deliver activities (cont. pg. 45).		
Support sustainable recreational use of woodlands		
Undertake effective monitoring of visitor impacts to inform a proactive and adaptive approach to visitor management.		
Undertake effective visitor management, as outlined in individual Reserve Management Plans, to minimise detrimental impacts on the natural and cultural values of woodlands.		
Effectively communicate with visitors to promote responsible and respectful use of woodland reserves, promote an understanding of woodland systems and their values, threats and required management, and advise visitors of community safety concerns such as wildfires and native animals (cont. pg. 46)		
Promote the sustainable use of woodland reserves and, where practical, reduce physical barriers to community access.		
Monitor woodland condition		
Employ the Woodland CEMP (in development) to guide monitoring priorities. Monitor changes in ecological condition, including the impacts of threats and the effectiveness of management actions in achieving conservation goals across the ACT.		
Continue to plan and implement monitoring programs to address ecological and management-related questions within woodlands across the ACT by: establishing monitoring programs with well-defined objectives, sound experimental design and effective data management and assessment standards, and seeking collaboration (cont.		
In line with action plans and conservation advice, monitor threatened, declining and rare species and the Endangered YB-BRG Woodland community to: detect short-term changes in distribution or abundance that may require management intervention, and determine long-term trend and status in the ACT and broader region (cont.		
In planning monitoring programs, ensure long-term investment and sustained funding and resourcing beyond short-term cycles.		
Collaborate with community groups to collect and use monitoring data systematically and effectively by providing, for example: professional and technical advice, training, screening of data, data collection protocols, and support to access grants and equipment.		
Priority projects to improve baseline information include: on-ground assessment of the condition of large patches of lowland woodland and those that make a significant contribution to the integrity of the Endangered YB-BRG Woodland across the ACT, improve knowledge of fauna distribution and abundance in subalpine and lowland		
Deliver research outcomes		
Implement and support research projects to address knowledge gaps and answer ecological questions (priorities outlined above) to inform the management of woodlands.		

Conservation objectives	S.alpine L.land	
Continue to support the Mulligans Flat – Gorooyarroo Woodland experiment as a key research and learning site for woodland restoration and management throughout the ACT.		
Identify opportunities to partner with Traditional Custodians to develop research projects that can inform land management, resource use and other activities undertaken by Traditional Custodians in woodlands.		
In line with action plans and conservation advice, undertake and support research into the ecology and conservation requirements of threatened species and communities including: habitat requirements and key resources, including distribution of key habitats, effects of habitat modification, land use practices, and key threats		
In planning and implementing research projects, maintain open dialogue between ACT Government policy, research and land management staff and when appropriate seek collaboration with non-government organisations to: identify and prioritise knowledge gaps for future research, inform research questions and project design (cont. pg.		
Communicate research results to land managers, including non-government organisations through: research and technical reports published on ACT Government website and in scientific journals, social media platforms, workshops and seminars, presentations and meetings, and the production of educational		



Canberra Spider Orchid, Mt Majura (E. Cook)

5.3 List of acronyms

ACT	Australian Capital Territory
ANBG	Australian National Botanical Gardens
ANZECC	Australian and New Zealand Environment and Conservation Council
BOP	Bushfire Operations Plans
CEMP	Conservation Effectiveness Monitoring Program
CIP	Conservation Implementation Plan
COG	Canberra Ornithologists Group
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EPBC	Environment Protection and Biodiversity Conservation
IUCN	International Union for Conservation of Nature
LCC	Lower Cotter Catchment
MARS	Market Attitude and Research Services
MRC	Murrumbidgee River Corridor
NSW	New South Wales
RAO	Representative Aboriginal Organisations
TFI	Tolerable Fire Interval
TRC	Tourism Recreation Conservation Consultants
WONS	Weeds of National Significance
YB-BRG	Yellow Box – Blakely’s Red Gum

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