ACT Government

Loss of Mature Native Trees Key Threatening Process

Draft Action Plan

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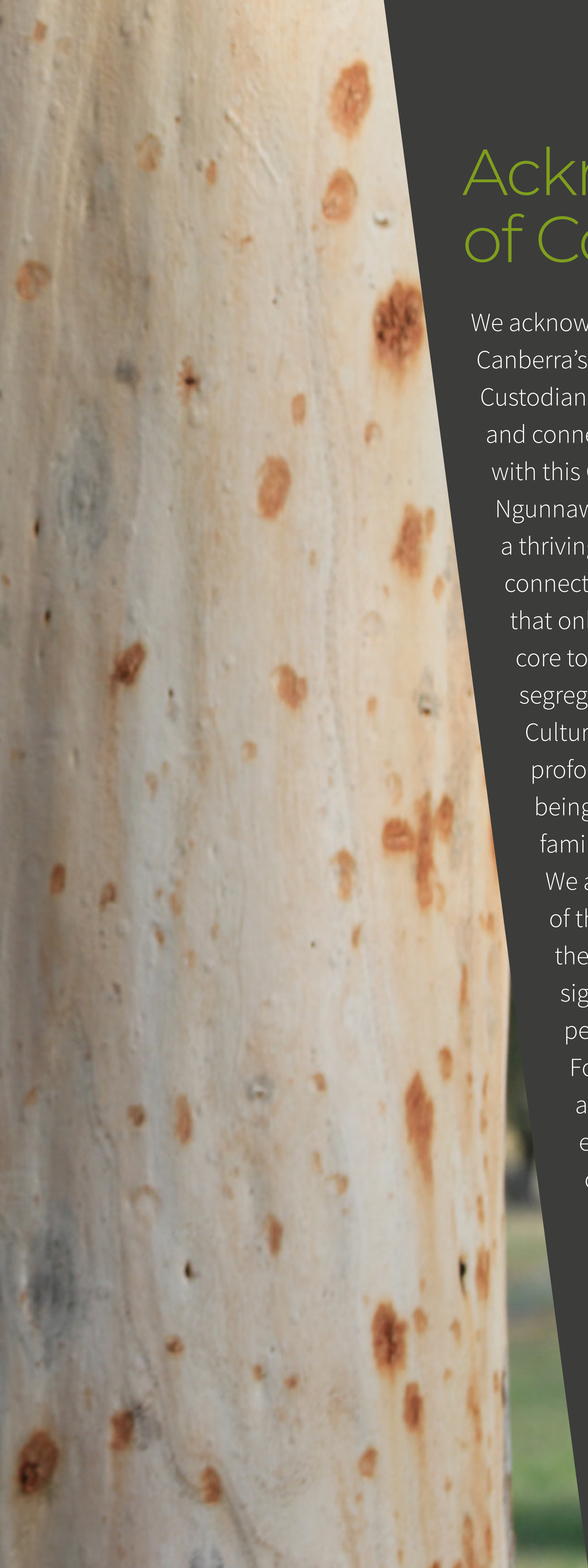


Acknowledgment of Country

We acknowledge the Ngunnawal people as Canberra's first inhabitants and Traditional Custodians. We recognise the special relationship and connection that Ngunnawal people have with this Country. Prior to the displacement of Ngunnawal people from their land, they were a thriving people whose life and culture was connected unequivocally to this land in a way that only they understand and know and is core to their physical and spiritual being. The segregation of the Ngunnawal people from Culture and Country has had long-lasting, profound, and ongoing health and well-being effects on their life, cultural practices, families, and continuation of their law/lore. We acknowledge the historic interruption of the Ngunnawal people of Canberra and their surrounding regions. We recognise the significant contribution the Ngunnawal people have played in caring for Country. For time immemorial they have maintained a tangible and intangible cultural, social, environmental, spiritual, and economic connection to these lands and waters.

Acronyms

CNP –
Canberra Nature Park

EPSDD –
Environment,
Planning and Sustainable
Development Directorate

KTP –
Key Threatening Process

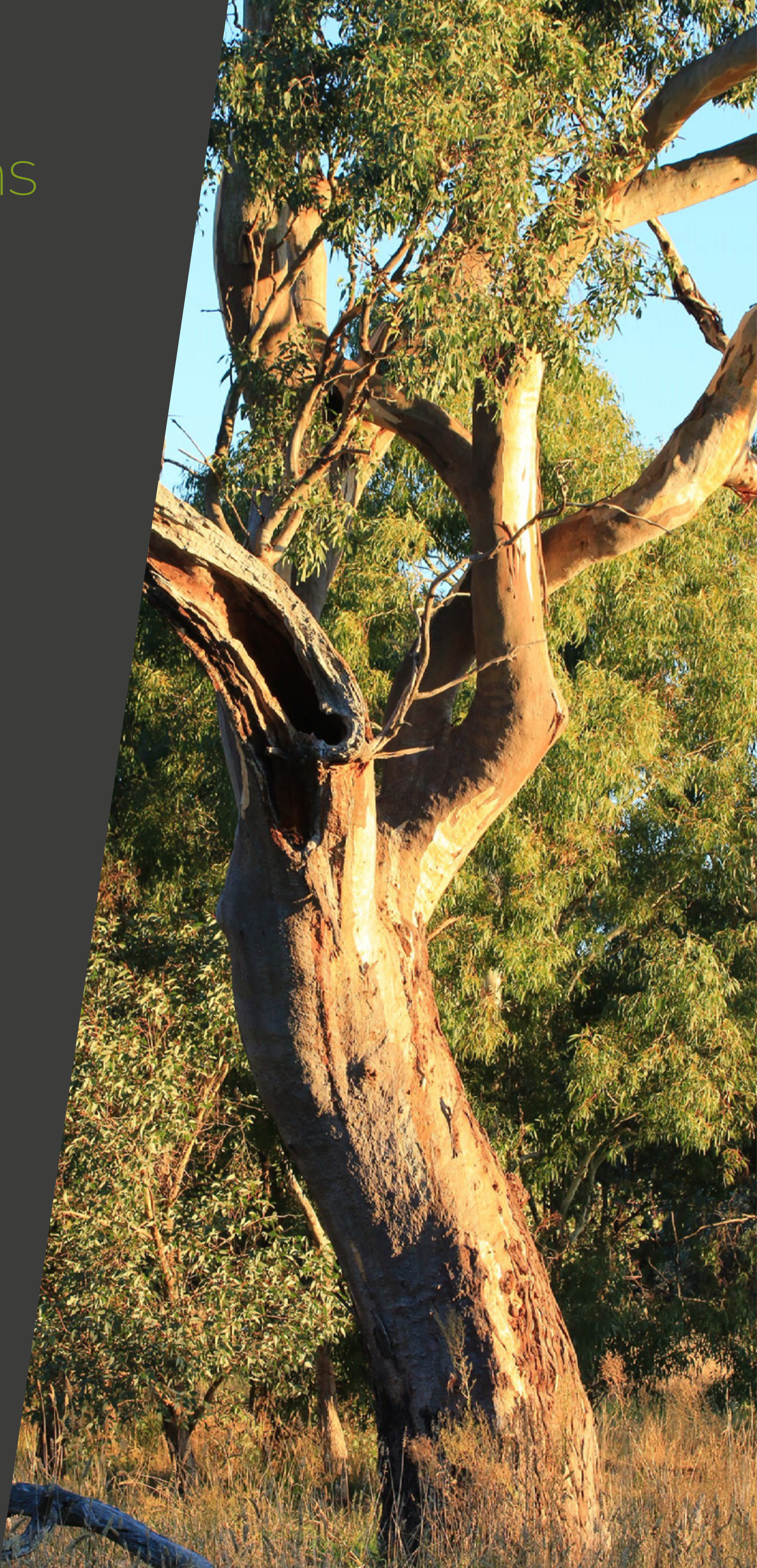
LMA –
Land Management Agreement

MNT –
Mature Native Tree

NC Act –
Nature Conservation Act 2014

TCCS –
Transport Canberra
andCity Services
Directorate

TP Act –
Tree Protection Act 2005



Preamble

The **loss of mature native trees (including hollow-bearing trees) and a lack of recruitment** was added to the List of Key Threatening Processes under section 87 of the Nature Conservation Act 2014 (NC Act) in September 2018 (Notifiable Instrument—Nature Conservation Key Threatening Processes List 2018 (No 1) NI2018-538). The associated Conservation Advice is Notifiable Instrument NI2018–536.

The process is eligible to be listed as a Key Threatening Process (KTP) as it meets the criterion of adversely affecting two or more threatened native species. The species that are adversely impacted are: Superb Parrot (*Polytelis swainsonii*), Brown Treecreeper (*Climacteris picumnus victoriae*), Glossy Black-cockatoo (*Calyptorhynchus lathami*) and Little Eagle (*Hieraaetus morphnoides*). All are listed as Vulnerable to extinction under the NC Act. These species are, however, only a small sub-set of those for which there are sufficient data to effectively demonstrate eligibility. There are many other threatened species (or ecological communities) affected by this KTP and actions to reduce the effect of this KTP on these species are also included in this plan.

Under s100(iii) of the NC Act, for each listed KTP an Action Plan must be prepared that sets out proposals to minimise any effect of the process that threatens a relevant species or relevant ecological community. In this context, 'relevant species' means listed migratory and threatened species and 'relevant ecological community' means listed threatened ecological community. The loss of mature native trees impacts numerous threatened native species in the ACT, as well as the threatened Yellow Box–Blakely's Red Gum Grassy Woodland ecological community (see Appendix A for the full list of impacted species and ecological communities).

Related listings State/ Commonwealth

Loss of Hollow-bearing Trees is listed as a Key Threatening Process in New South Wales under the Biodiversity Conservation Act 2016.

Loss of hollow-bearing trees from Victorian native forests is listed as a Potentially Threatening Process in Victoria under the Flora and Fauna Guarantee Act 1988.

Description

Identifying appropriate actions to address the **loss of mature native trees (including hollow-bearing trees) and a lack of recruitment** requires that the relevant components of the KTP be identified. While eligibility was established using the effect of the process on just four threatened species, it is not intended to be limited to those species. Broad definitions of what constitutes a Mature Native Tree (MNT) and the relevant species and ecological communities affected by the KTP are applied.

The Conservation Advice (Scientific Committee 2018) describes MNTs as:

> …large mature trees, including 'paddock trees'—large crowned trees on fertile soils and in small woodland patches where there is a lack of recruitment, as well as standing dead timber and trees showing dieback.

The species of mature tree is deliberately not specified, and the description includes isolated single trees and dead trees.

The Conservation Advice (Scientific Committee 2018) provides guidance about the sizes of mature trees:

> As a guide, tree size, indicated as diameter at breast height (DBH) for *Eucalyptus* species is considered at three sizes: small (20–50 cm DBH), medium (51–80 cm DBH), and large (≥80 cm DBH) (Le Roux et al. 2018). Mature Eucalyptus trees are considered to be those above 50 cm DBH. Mature trees of other species, such as She Oaks (*Allocasuarina*) and Cypress Pines (*Callitris*), are much smaller at maturity.

The guidance for eucalypt maturity in relation to tree size is based on lower elevation woodland species. Other eucalypt species, such as Snow Gum (*E. pauciflora*) or Alpine Ash (*E. delegatensis*), may not necessarily conform to these values. The scientific literature uses a variety of definitions of maturity, which tend to be context dependent. Noting that the full definition of the KTP includes 'a lack of recruitment', actions presented here were not developed under a strict definition of 'mature', but rather with acknowledgment of two key principles:

1. A large tree can only be replaced in the future by the recruitment of a tree that is not currently large.
2. Trees have habitat value at any size, but the abundance and diversity of those values increases with size (e.g. foraging substrates) and senescence (e.g. tree hollows).

Functions of Mature Native Trees in the ecosystem

The main species impacted by the KTP rely on MNTs in different ways. Glossy Black-cockatoos use MNTs for both nesting (hollows) and feeding, Brown Treecreepers and Superb Parrots use MNTs for nesting (hollows) and foraging, but also rely on scattered MNTs for movements between habitat patches. Little Eagles use MNTs for nesting.

MNTs fulfil a range of other functions in ecosystems, including:

- a source of natural recruitment
- a critical wildlife resource for nesting, roosting, feeding, moving and sheltering, including for ground-dwelling fauna when hollow-bearing trees collapse or shed limbs
- a source of food, refuge and nesting materials for fauna
- as 'islands' or 'stepping stones' across the landscape, facilitating dispersion and migration of a variety of species (which may aid species adaptation to future climate impacts)
- the last stronghold of the genetic diversity of some vegetation communities—many landscapes contain only scattered trees

- helping to limit fire fuel loads by constraining mid-storey vegetation (Wilson et al. 2018)
- a contributor to soil conservation and stability, water quality, air quality, nutrient cycling and carbon sequestration
- a contributor to pest management by providing shelter for insectivorous birds and bats
- a source of heritage landscape values (e.g. Aboriginal scar trees or trees within culturally important areas)
- a source of landscape and aesthetic value, including substantial contribution to the surrounding landscape (Tree Protection Act 2005 (TP Act)), Disallowable Instrument DI2018–50)
- other socio-economic benefits in modified landscapes, including provision of shade, mitigating against 'heat island effect', contributing to health, recreational and business opportunities, and enhancing property values.

The importance of mature native trees with cultural value

The functions and values of native mature trees include heritage landscape values (e.g. Aboriginal scarred trees or trees within culturally important areas). Both the Heritage Act and the Tree Protection Act include provisions to register and protect culturally significant trees, such as scarred trees. It is a requirement of the Heritage Act 2004 that all Aboriginal cultural sites identified within the ACT, including scarred trees are reported to the ACT Heritage Council. Organisations such as Greening Australia has worked with traditional custodians to identify and list Aboriginal scarred trees on the ACT Heritage Register. They reported that many of the eucalypt scarred trees are over 200 years of age (Greening Australia 2017).

Legislative and other provisions to protect mature native trees

Tree Protection Act 2005

The principal mechanism for protecting trees within the urban context in the ACT is the Tree Protection Act 2005 (TP Act). Trees covered by the TP Act are either Regulated Trees or Registered Trees. Any work which may cause damage to these trees, such as tree removal, major pruning or lopping and groundwork near a regulated or registered tree requires approval (the Urban Area section in the Threats in Habitat Context chapter provides more detail on regulated and registered trees). The provisions of the TP Act do not apply to trees on rural land unleased land, including roadsides, open space and reserves: the NC Act applies to those lands.

Nature Conservation Act 2014

Large mature native trees are protected under the provisions of the Nature Conservation Act 2014 on unleased land and leased land outside the built-up areas. It is an offence to damage a native tree on leased land outside the urban area. There are exceptions, including:

- trees planted by the leaseholder
- trees damaged by an occupier of the land with the intention of using it on the land for a purpose other than sale
- the landholder has development approval under the Planning and Development Act 2007.

It is also prohibited to damage or remove fallen native timber from leased land outside the built-up area.

Planning and Development Act 2007

The Planning and Development Act 2007 (PD Act) requires development approval be given if a proposal impacts on existing vegetation and regulated or registered trees. A development approval for a development in the merit or impact tracks needs cannot be inconsistent with the advice of the Conservator of Flora and Fauna in relation to registered trees. The PD Act also requires an impact assessment for any proposals that involve the clearing of more than 0.5 ha of native vegetation outside of areas designated as a future urban area and 5 ha inside designated future urban areas unless the Conservator of Flora and Fauna produces an environmental significance opinion that the clearing is not likely to have a significant adverse environmental impact. Impact assessment requirements also apply to any development proposals that will have significant adverse environmental impacts on threatened and protected species.

The Heritage Act 2004

The Heritage Act 2004 provides for registration of urban trees where an urban tree forms part of a place; and the council decides to register the place.

Rural lease conditions

Lease conditions for rural leases generally include the standard clause, “That the Lessee shall not cut down fell ringbark or otherwise injure of destroy (or suffer to permit the same) any live tree or tree-like plant on the land without the previous consent in writing of the Territory”. Leaseholders therefore generally require a licence under the NC Act and authorisation under the lease to remove living trees. Land Management Agreements signed by the Conservator of Flora and Fauna and the rural lessee may also include provisions.

Urban Forest Strategy

The Urban Forest Strategy was launched in 2021 with the vision for all Canberrans to enjoy the benefits of streets lined with healthy trees. An urban forest that is resilient and sustainable and contributes to the wellbeing of the community in a changing climate. There are a number of actions outlined in the Urban Forest Strategy that complement and support the Action Plan for the loss of Mature Trees. Notably, objective one of the urban forest strategy is to protect the urban forest by ensuring legislative frameworks that genuinely protect trees and ensures that when they are lost, they are replaced.

Objective four of the strategy is to take an ecological approach and support biodiversity, recognising that the urban forest supports biodiversity across urban areas.

Objectives

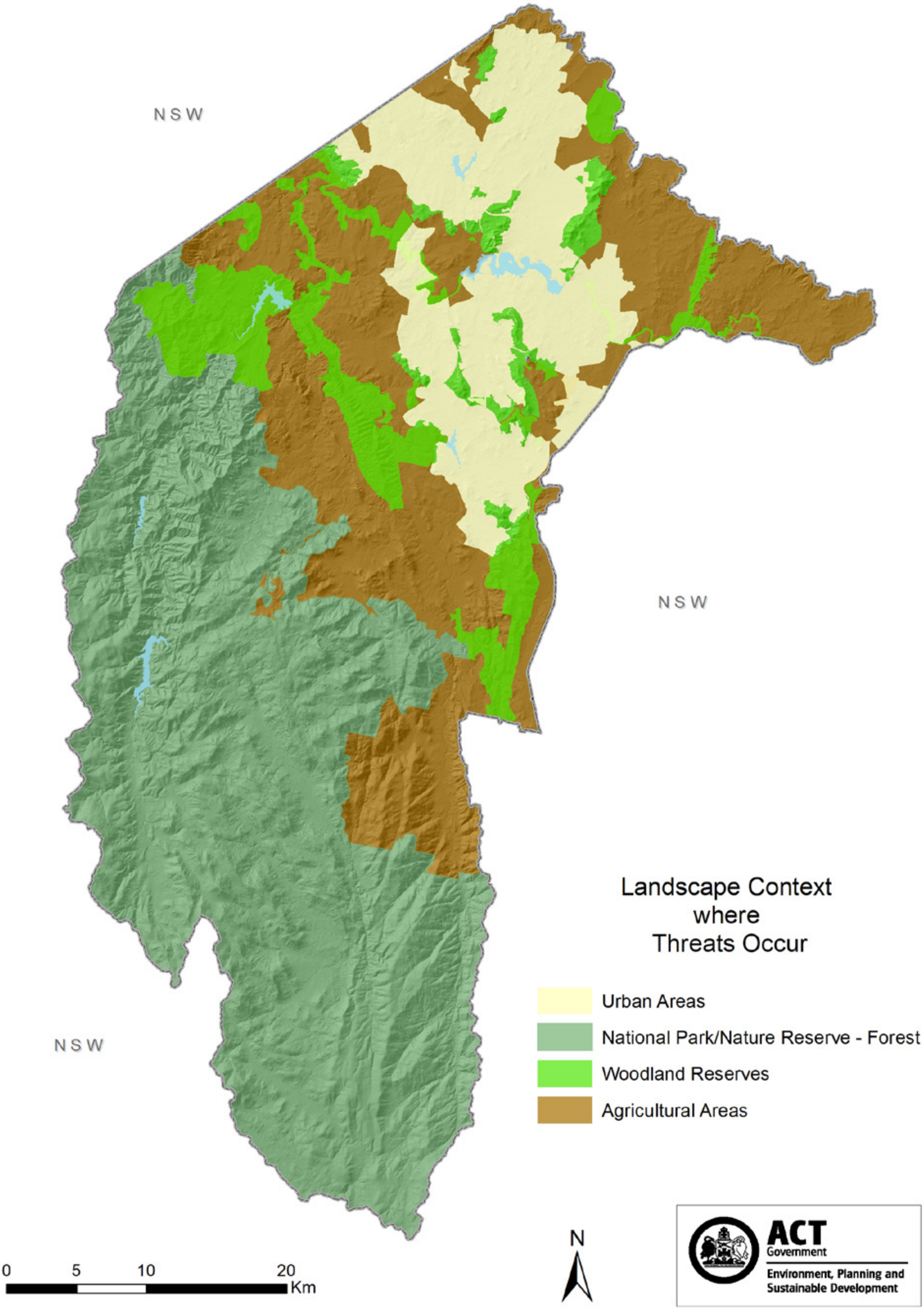
The overarching objective of this action plan is to maintain and improve the contribution of MNTs to biodiversity in the ACT.

It is important to note that while intuitively this action plan addresses the loss of MNTs as objects in space, its intent is to address a process. Thus, there is a temporal element to how existing and emerging threats to the persistence and recruitment of MNTs should be managed. MNTs are not static; they grow, decay, die and collapse over varying timeframes depending on the context in which they exist. To effectively ameliorate the KTP, it is not sufficient simply to protect existing MNTs, but rather it is necessary to allow for the long-term maturation and senescence of all suitable native trees across the landscape, and to foster the ecological processes leading to the essential replacement of MNTs.

Within that overarching objective, there are four principal objectives:

1. Protect existing mature native trees—recognising that large, mature trees are disproportionately valuable to ecosystems, and the considerable delay inherent in replacing a standing MNT.
2. Protect/enhance ecological context of existing mature native trees—recognising that the ecological function of MNTs may be enhanced when proximal to other biodiversity attributes, such as understorey vegetation, coarse woody debris and patches of high floral and/or faunal diversity; and substantially reduced when isolated in a highly modified urban environment without natural ground cover, shrubs and rocks, logs and other structural habitat elements.
3. Increase recruitment and survival of young native trees—recognising that failure to recruit is leading to regional decline in MNTs, and that rates of MNT loss are predicted to increase in the future.
4. Protect/enhance ecological context of young native trees—recognising that the value of these future MNTs will be greater if they exist within a biodiverse environment and that, just as trees can recruit into the future, so too can other biodiversity attributes.

Figure 1—Landscape context where threats to MNT occur



The trajectory for mature native trees

The loss of MNTs resulting from natural ageing and insufficient recruitment of new MNTs is an ongoing, and often gradual, process. For example, Yellow Box (*Eucalyptus melliodora*) may live to 500 years and take 60–80 years to reach full height (approx. 20 metres); thereafter the trunk thickens, taking considerably longer to approach maximum size (Banks 1997), and tree hollows may not form until a tree is 120–200 years old (Gibbons and Lindenmayer 2002). As such, this KTP currently operates in landscapes where an overall reduction in the density and habitat values of MNTs may not be evident for decades or more (Gibbons et al. 2008; Le Roux et al. 2014). Similarly, trees recruited now will take decades to become part of the MNT population and greater than a century to serve a functional role in terms of the provision of certain habitat elements (e.g. hollows).

This action plan must be robust to 'Shifting Baseline Syndrome' (Papworth et al. 2009), where long-term changes to a system are obscured by the passing of time, such that current condition is considered normal. Landscapes where this KTP applies have, in fact, been subject to extensive historic land clearing and their current state is depauperate of many ecological values that would have accompanied their original condition.

The position of trees in the landscape is another key variable. It is now well established that many early nature reserves were located in unproductive or economically less important parts of the landscape (Margules and Pressey 2000). In the ACT this is reflected in the protection of the hills and ridges as Designated Areas in the National Capital Plan. For example, bird biodiversity in unprotected woodlands in the ACT was higher than in nature reserves established before 1995 (Rayner et al. 2014). This effect has been reduced since more biodiversity-focussed legislation was introduced in 1995 (Rayner et al. 2014).

Nevertheless, extensive clearing for agriculture and urban development happened predominantly in flatter, more low-lying land of the ACT well before such legislation. Consequently, while the ACT does have a significant proportion of its land in reserves, there remains an imperative to protect existing trees and enhance recruitment in the urban and agricultural environments. Although there is seemingly effective recruitment in the Canberra Nature Park. (Le Roux et al. 2014) it doesn't necessarily compensate for the biodiversity value of the trees in these other areas.

In addition to the underlying process of natural attrition, other drivers of the KTP may act more quickly and at very broad spatial scales. Chief amongst these are land clearing and loss of connectivity, fire climate change and dieback. The relative impact and importance of these drivers varies with landscape context (see Figure 1), which is simplified for the purposes of this action plan as four combinations of land use and vegetation type, including:

1. **woodland in the urban area**
2. **woodland in agricultural/pastoral area**
3. **woodland in nature reserves**
4. **forests in national park/reserves.**

Land clearing applies only to the urban and agricultural context. Fire occurs in all environments but has been highlighted as a particular threat in forested areas. Climate change and dieback poses a threat across all contexts, but the mechanisms that govern change may differ. Below, drivers of the KTP are addressed for each landscape context separately, excluding climate change, drought, fire and dieback, which are spatially and structurally unconstrained and is addressed as cross-cutting drivers of the KTP.

LiDAR analysis of mature tree loss in the ACT from 2015 to 2020

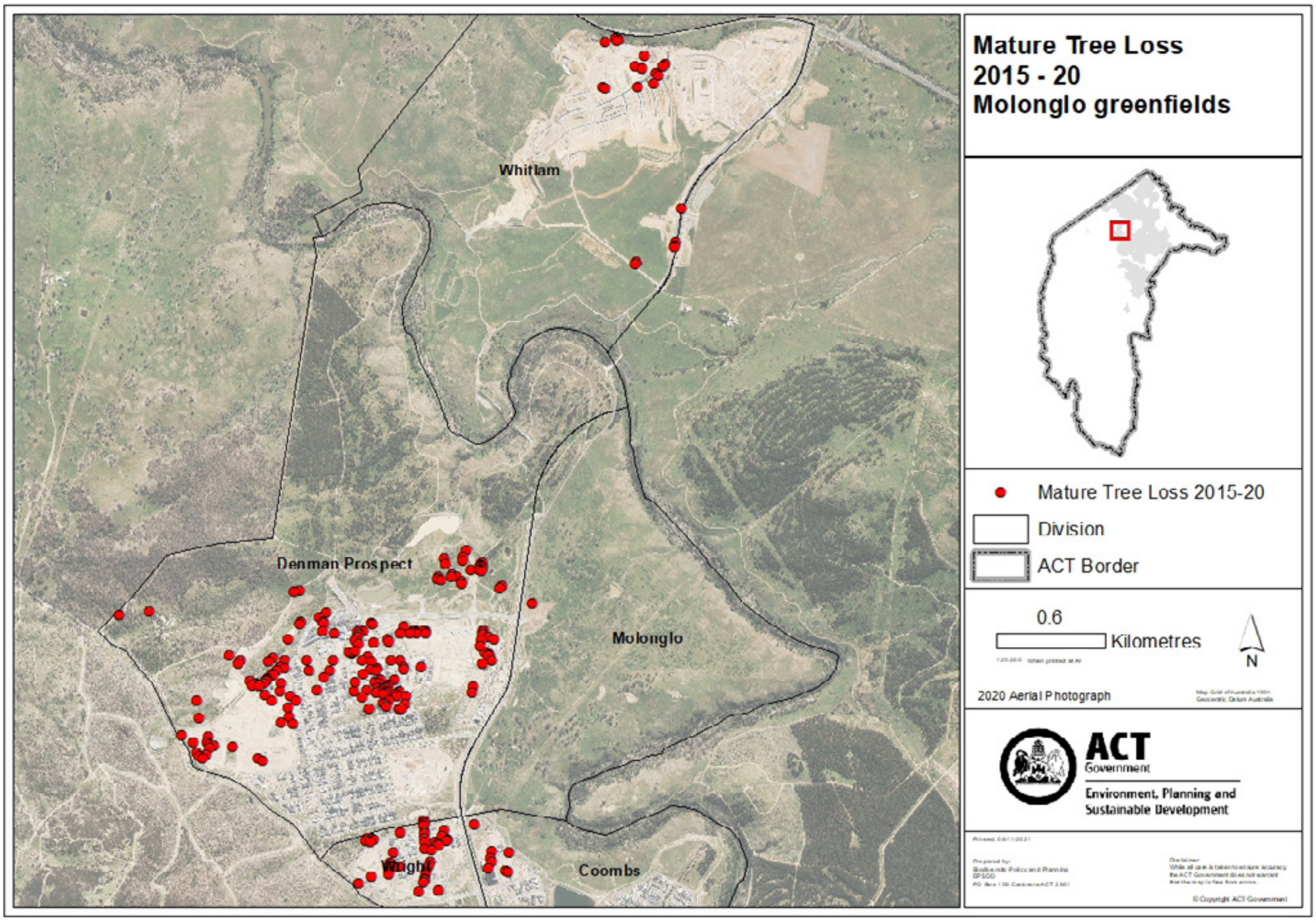
A research project was undertaken in conjunction with development of this action plan, to map the trajectory of mature tree loss over time for the ACT. Analysis occurred across three of the four landscape contexts, namely urban, rural and reserves. Mature tree loss for Namadgi and Tidbinbilla national parks were not analysed, due to the 2020 bushfire impact shortly before the 2020 LIDAR capture. The results of this study informs and complement actions in the action plan (Botha, 2021).

Total mature tree loss across urban Canberra (excluding nature reserves and exotic pine plantation) between 2015 and 2020 was 14,455 or 6.2% of the total mature trees, as at 2015.

Table 1—Mature tree loss by habitat context

Habitat context	Mature Trees 2015	Loss by 2020	Percentage Loss
Urban	231,366	14,455	6.2
Rural	446,027	4,846	1.1
Reserves	309,408	1,731	0.6

Figure 1—Mature tree loss in Molonglo Valley



Greenfield suburbs, including Coombs (22%), Denman Prospect (12.5%), Throsby (35%), Taylor (31%), Wright (42%) and Whitlam (23%) accounted for the largest percentage mature tree loss per suburb. An assessment of the number of individual mature trees lost indicated the urban district of Canberra Central lost more than 4,400 mature trees, while Belconnen district lost almost 3,500 mature trees. In terms of number of individual mature trees lost by suburb, Taylor, Yarralumla and Kambah each lost more than 600 mature trees, whilst Holt, Wanniassa, Kaleen, Acton, Pialligo and Bruce each lost more than 300 mature trees. Almost a thousand mature trees were lost across greenfield suburbs.

Figure 2—Proportional urban mature tree loss

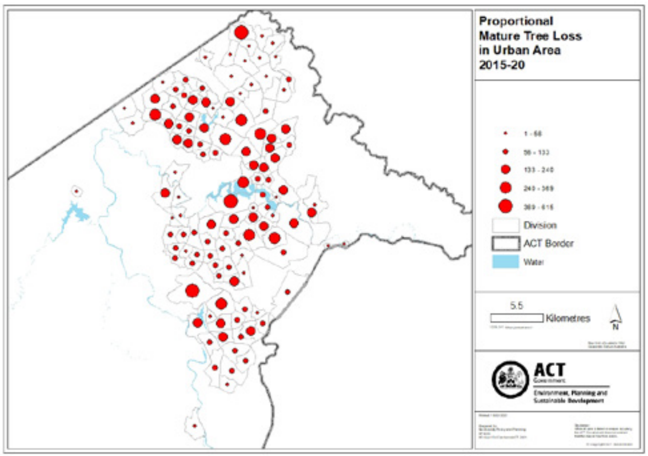
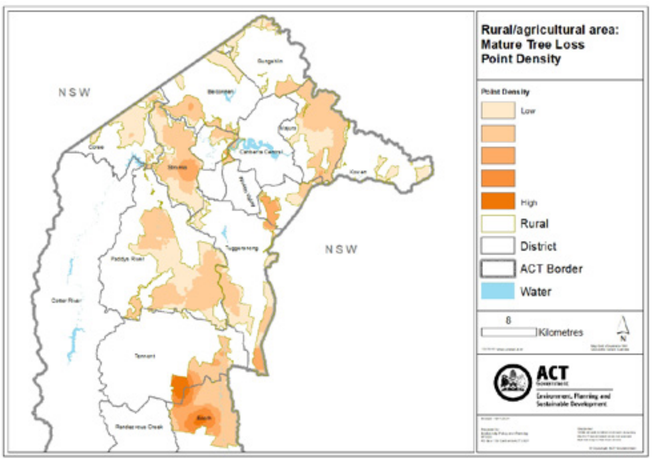
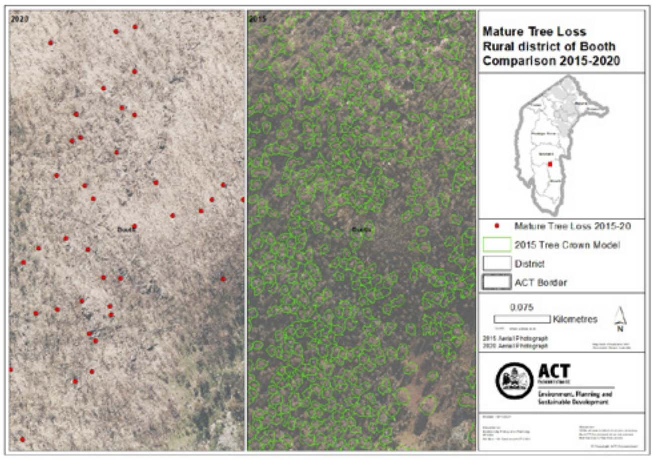


Figure 3—Density of tree loss in the rural areas



Total mature tree loss across the rural districts (excluding nature reserves, national parks, the national arboretum and exotic pine plantation) was 4,846, or 1.1% of the total mature trees, as at 2015. The southern rural districts of Booth (1,091), Tennent (904) and Paddy's River (556) experienced the highest number of individual mature tree loss from 2015-2020. These relatively high figures in the southern rural districts, indicated in the tree loss density map, can be attributed to the impact of the 2020 bushfires in the region. An example of bushfire impact on tree loss in the Tennent district can be seen in the figure below.

Figure 4—Mature tree loss in the Tennent district due to bushfire



Total mature tree loss across nature reserves (excluding national parks) between 2015 and 2020 was 1,728, or 0.6% of the total mature trees, as at 2015.

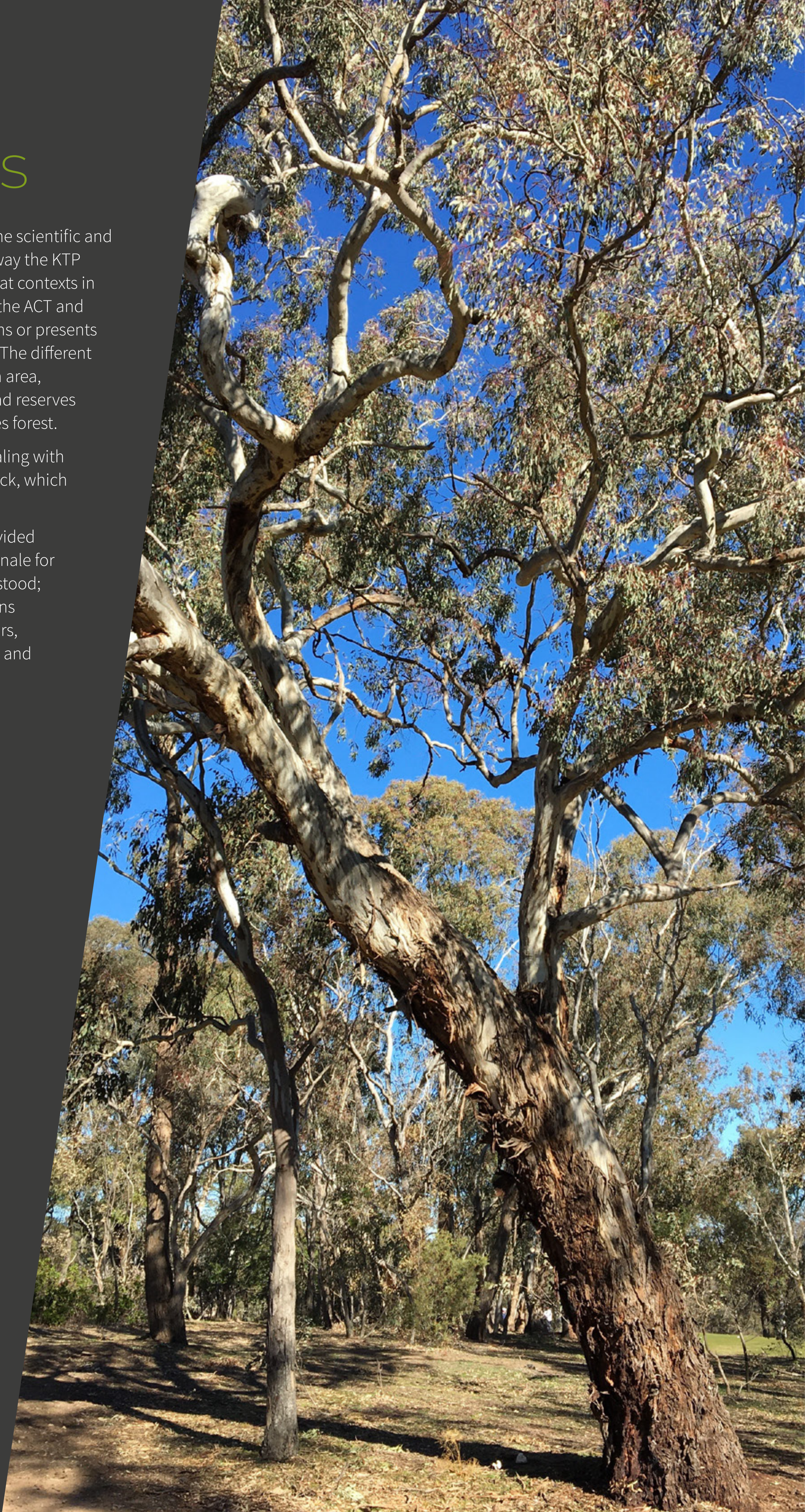
The result of this analysis for the ACT urban area will be made available as an interactive online map (dashboard), and the data product will be released on the ACT Government's Open Data Geospatial Catalogue in 2022.

Threats

The text below provides the scientific and operational basis for the way the KTP operates in different habitat contexts in which MNTs occur within the ACT and how that context constrains or presents opportunities for actions. The different habitat contexts are urban area, agricultural area, woodland reserves and National Park/reserves forest.

There is also a section dealing with climate change and dieback, which occur across all habitat.

Indicative actions are provided below the text so the rationale for each action can be understood; for specific detail on actions and performance indicators, please refer to the Actions and Indicators section.



Urban area

Many trees are removed in the creation and maintenance of the urban area. Those that remain may be isolated individuals in yards, street verges, or groups in urban greenspace such as parklands, around sporting fields or remnant patches. In this context, MNTs are on a trajectory of long-term decline (Le Roux et al. 2014). Threats specific to this area that contribute to the KTP are:

- clearing of ground cover to facilitate human activity (e.g. mowing and removal of woody debris)
- development in proximity to trees which may damage their trunks or roots
- the pruning or removal of trees, particularly with a human safety focus.

For example, current management of trees on public land by Transport Canberra and City Services (TCCS) prescribes the removal of dead, diseased, cracked, hollow or otherwise unsound wood (ACT Government 2019c). These components may be precisely the parts of the tree utilised, or which eventually develop into suitable habitat for utilisation, by wildlife species for breeding, roosting and shelter. Similarly, ageing trees in parks and streets are subject to strategic tree replacement programs that result in the disproportionate removal of MNTs (with and without defect). The need for maintaining mature trees needs to be considered in future iterations of Canberra's Living Infrastructure Plan, which currently states that "Native species planted from the 1960s are simultaneously reaching the end of their lives" (ACT Government 2019b). Such trees are less than 60 years old.

The Urban Forest Strategy sets a number of actions to support mature trees in the urban environment through assessing ageing native trees for retention as habitat in preference to being removed. It also aims to identify opportunities to protect young seedlings growing from mature remnant trees on unleased public land where it is appropriate.

Protecting urban trees under the Tree Protection Act

The principal mechanism for protecting trees within the urban context in the ACT is the Tree Protection Act 2005 (TP Act). This Action Plan was developed concurrently and cooperatively with the 2021/22 TP Act Review, for consistency and to ensure the Plan and the results of the TP Act review are complimentary. Some of the actions in this Action Plan were developed in concert with the TP Act review, specifically actions 2, 6, 7 and 8. Any legislative changes to the TP Act as a result of the review, may be incorporated in the Action Plan before finalisation, if relevant and depending on timing.

The TP Act identifies 'regulated trees' and 'registered trees' and places restrictions on damaging, modifying or removing them. The Act does not make a distinction between native and non-native tree species, although it does make an exception for pest plants under the Pest Plants and Animals Act 2005.

A 'regulated tree' is one on leased land only (i.e. excludes urban open space, road verges and parklands) that has:

a. a height of 12 metres or more or

b. a trunk circumference of 1.5 metres or more, at 1 metre above natural ground level or

c. two or more trunks and the total circumference of all trunks is 1.5 metres or more, at 1 metre above natural ground level or

d. a canopy width of 12 metres or more.

'Registered Trees' are trees of particular importance to the community that receive specific protection on either leased land or public land. While the TP Act offers some protection to MNTs, it provides no measure to ensure or encourage recruitment of trees into the population. Stagoll et al. (2012) demonstrated that trees with a trunk circumference of 1.25 metres (smaller than the current threshold for protection) have a strong positive effect on bird diversity and suggested that the criteria for defining a regulated tree should be evidence-based and regularly reviewed in light of new data.

Under the Tree Protection (Criteria for Registration and Cancellation of Registration) Determination 2018 (DI2018–50), the Conservator may include a tree on the register under section 52 of the TP Act if it is located on built-up urban area and it can be demonstrated that it significantly contributes to one or more of the following values:

(1) Natural or cultural heritage value

(2) Landscape and aesthetic value

(3) Scientific value

The criteria for approval to damage a regulated tree, including local native species and remnant eucalypts, are provided in Disallowable instrument DI2006—60.

In making an approval decision, the Conservator of Flora and Fauna may consider: the importance of the tree in the surrounding landscape; and, if the tree species is listed on a schedule of local ecologically beneficial species (attached to the disallowable instrument), whether the tree has ecological importance to the local environment. However, the instrument does not give guidance regarding how to assess those values. Appropriate guidance could be informed by the substantial body of research that has been conducted since the approval of that instrument (described and cited herein, and ongoing).

> The criteria for how to assess the ecological importance of a regulated tree in the landscape, and how this is used in assessing applications to damage regulated trees, will be reviewed and revised regularly in response to new research findings (**Actions 2a, 2b**).

> Research will also be continued into the ecology of key fauna species and their habitat use in the urban context and used in subsequent review and revision of this action plan (**Action 8a**).

> One of the aims of this research should be to aim to evaluate landscape connectivity and how best to improve or restore it for key taxonomic groups (**Action 8c**).

For the TP Act to be effective requires awareness and compliance by landholders. There are no data currently available on either of these variables. It can reasonably be assumed that awareness is high, at least amongst those seeking professional assistance in tree removal, as such services act in accordance with the TP Act. Nevertheless, in a city of over 400,000 people with high population growth and turnover and with over 700,000 urban trees, the risk of self-regulation among members of the public is high.

> A public campaign should be undertaken to raise awareness of the values that MNTs provide to humans and wildlife (**Action 6**).

> Tree protection outcomes should be monitored and reported on regularly and transparently (**Action 7a**).

Tree removal undertaken in compliance with the TP Act may be a contributor to the KTP. Under the previous Tree Protection (Interim Scheme) Act 2001 (with similar regulations to the current Act), Gilbert and Brack (2007) reported an approval rate of removal requests of 88% over three years (2001–04). However, there are no comparable data under the current TP Act.

> Data should be collected and reported regularly to quantify the rate of regulated tree loss **(Action7b),** including trees removed under planning approvals.

Additional trees may also be lost where planning approvals based on design may overrule a decision not to allow removal of a tree. No data is recorded for tree removals due to planning approvals. These planning decisions cannot, however, overrule decisions on Registered Trees.

At present there are approximately 150 MNTs registered as individuals, six spatial clusters of MNTs together, and one group of mixed native and exotic trees. This is considerably less than 1% of all the native trees in the urban context. Given that trees on public land are not regulated trees under the TP Act, the remainder are managed at the discretion of TCCS in line with the Urban Forest Strategy. The ACT Urban Forest Strategy (the Strategy) was released on 30 March 2021 and will guide the growth of the urban forest to maintain a resilient, diverse and sustainable tree canopy. One of the Strategy's main objectives is to conserve and protect mature and remnant native trees on public land. Le Roux et al. (2014) identified a need to maximise the standing life of existing trees (to at least 400 years) and increase recruitment to reverse the trend of long-term decline of MNTs. This would be helped by increasing the number of registered MNTs and by developing an explicit policy for the remaining (non-registered) trees.

Criteria for the addition of a tree to the ACT Tree Register are specified in Disallowable Instrument DI2018—50 Tree Protection (Criteria for Registration and Cancellation of Registration) Determination 2018, and include trees that have:

1. natural or cultural heritage value
2. landscape and aesthetic value and/or
3. scientific value.

Each criterion has more specific subcriteria, of which two subcriteria are relevant to this KTP:

- (2)(c) The tree is an exceptional example of a locally native species that reached maturity prior to urban development in its immediate vicinity.
- (3)(e) The tree is a significant habitat element for a threatened native species.

The studies of Stagoll et al. (2012) and Le Roux et al. (2018) demonstrate that large trees (> 100 centimetres DBH sensu Stagoll et al. 2012) in the urban context are both 'exceptional' in relation to criterion (2)(c) and significant habitat elements in relation to (3)(e), supporting substantially greater biodiversity than smaller trees. In urban areas of the ACT, approximately one quarter of all bird species were only recorded in large trees, including all raptors and the superb parrot (Le Roux et al. 2018). Using the equations provided in Le Roux et al. (2014), which modelled the trajectory of hollow-bearing trees in urban greenspace, a Yellow Box tree of 80 centimetres DBH would be approximately 100 years old, unlikely to have hollows and only 1/500 seedlings would live to that age. A tree of 100 centimetres DBH would be over 150 years old, expected to have hollows, and only 1/10,000 seedlings would live to that age. In terms of the probability of reaching that size, an existing 100 centimetres DBH tree could be considered to be 'worth' more than 20 trees with 80 centimetres DBH.

> The instrument for the criteria for registration of trees should be revised to expand and clarify criteria under s 1(3) of the DI, incorporating ecological criteria developed under Action 1 (**Action 3**).

> Modern techniques such as remote sensing and LiDAR should then be used to identify candidate large trees across the urban ACT and nominate them for registration (**Action 4d**).

Protecting mature native trees under the Urban Forest Strategy

The urban forest of the future will provide habitat and resources for wildlife, with a number of objectives in the Urban Forest Strategy supporting the protection and care of MNT in the urban environment. Canberra's urban forest and network of nature reserves and green spaces provide important areas of habitat for the conservation of biodiversity.

The Urban Forest Strategy recognises the challenges facing our urban forest (including MNT) and the requirement for legislative frameworks that protect the right trees for our future urban forest. It also recognises that protecting our trees extends beyond legislative frameworks, through regular assessments and pro-active management. Protecting the urban forest and our MNT is not just the responsibility of the ACT Government. It is important that we partner with communities to grow and maintain the urban forest and protect MNT.

Other actions to protect mature native trees in the urban environment

A large street tree in Canberra may be greater than 350 years old (Banks 1997). While new trees can be planted to replace them, Le Roux et al. (2018) showed that multiple small trees cannot provide the same biodiversity value for birds as a single large tree in an urban context. Each of the new trees would also likely take multiple decades or more before they were large enough to even begin to make that contribution. Ensuring human safety is an unequivocal priority in the urban environment, but the removal of perceived dangerous tree structures can exacerbate and accelerate the loss of MNTs.

> Policy and guidance will be developed to ensure an appropriate balance between eliminating all public risk through early or excessive tree removal, and more considered removal of tree material where a likely risk is manifest (**Actions 1a-c**).

Even dead trees retain significant habitat value in the urban context, particularly those with hollows (Pecenko 2016, Hannan et al. 2019). TCCS has a policy of retaining dead 'habitat trees' in some limited circumstances (https://www.tccs.act.gov.au/city-living/trees/frequently_asked_questions_about_urban_trees). More than 100 such trees have been retained within the urban area during the past 20 years, but this is only a fraction of the overall number of trees removed (Pecenko 2016).

> This policy will be retained and expanded (**Action 9a**).

Where living urban trees require removal, in some cases the trunk and larger branch architecture have been moved and reinstated elsewhere to create habitat structure, although these are typically moved out of the urban environment and into reserves (Hannan et al. 2019). The vertical resurrection of relocated trees demonstrates a novel method for adaptively reusing intact felled trees to restore degraded landscapes and bring forward some of the keystone functions that mature trees provide in areas experiencing accelerated declines in MNTs or that have completely lost MNTs.

> Opportunities for extending the resurrection of felled MNTs to retain biodiversity under a variety of contexts will be tested and implemented wherever possible (e.g. enriching waterways and retention ponds, installations in urban open space as focal points for wildlife and community engagement) (**Action 1d, 9b, 9c**)

However, as any resurrected trees are not alive, they cannot fully offset the loss of equivalent MNTs. Protection of living, established trees is fundamental to halting the decline of MNTs.

The biodiversity value of a MNT is dependent on its context. It is maximised in natural woodland or forest, and substantially reduced when isolated in a highly modified urban environment without natural ground cover, shrubs, rocks, logs and other structural habitat elements (Le Roux et al. 2014b). Within the urban environment, it is common to find trees surrounded by uniform, mown grass. This reduces their biodiversity value (and potentially their aesthetic and social value), exposes them to wind and other stressors, and provides easy access by pedestrians who are then exposed to the potential public safety hazard of falling branches. There are opportunities to improve biodiversity value and reduce public exposure to a safety hazard while reducing expenditure on the maintenance of grasses and tree condition.

For example, planting of understorey shrubs and clumping grasses add biodiversity value to trees in urban open space and also maintain or improve visual amenity, deter pedestrian access and allow branches to fall safely and remain in situ (**Action 13**) (Le Roux et al. 2014b, Ikin et al. 2015, Fenner School of Environment and Society 2018).

Additionally, biodiversity benefits from MNTs in urban environments also translate to improved biodiversity values in adjacent habitats, such as nature parks (Ikin et al. 2013). Such landscaping approaches will be constrained by other regulations including line of sight, clearance from services, clearance from the back of kerb (to allow someone to safely step off the road if required), clearance from footpaths for cyclists etc. An important experimental trial of this approach began in Canberra in late 2019, run by the Fenner School of Environment and Society at the Australian National University.

An isolated urban tree may still have significant biodiversity value in some circumstances. For example, scattered trees support significantly more birds and bird species than trees in reserves, attributed to higher marginal value due to the lack of available alternatives (Le Roux et al. 2018). Isolated urban trees can also function as stepping stones to connect other, larger or important habitat patches, including for threatened species (e.g. Superb Parrots, Rayner et al. 2016, 2017).

Policy and criteria should be developed to identify when isolated urban MNTs deliver specific values to support the recovery of threatened species and these trees should be targeted for retention (**Action 5**).

Recruitment of new native trees is limited in the urban environment and needs to be increased to maintain numbers of MNTs, and avert biodiversity loss, into the future (Ikin et al. 2012, Le Roux et al. 2014). Action 4.1.4 of the Urban Forest Strategy seeks to address this through the Identification of opportunities to protect young seedlings growing from mature remnant trees on unleased public land where it is appropriate. Climate appropriate species which offer improved amenity in both summer (shade) and winter (solar gain) would need to be given consideration, subject to a broader urban forest management strategy.

When MNTs are removed they should, wherever possible, be replaced by the planting of the same species, ensuring sufficient maintenance that the re-planted trees survive. This action is subject to consideration of climate-appropriate species that offer improved amenity in both summer (shade) and winter (solar gain) and subject to a broader urban forest management strategy. However, simple 1:1 replacement is not enough and additional planting (up to 20:1) is required to prevent long-term reduction in MNTs (**Action 11, 12a**).

Additional programs are also required to increase planting of native tree seedlings independent of the removal of MNTs to ensure that overall replacement rates are sufficient to prevent decline in the long term (**Action 12b**).

The ACT Government has developed guidelines for plantings for urban design projects (Municipal Infrastructure Standards 25 (MIS 25)).

A simple measure to aid in long-term conservation of MNTs would be to update MIS 25 to encourage the use of native trees wherever practicable, or identify particularly desirable trees species, with some background information about biodiversity biodiversity values and climate resilience, and how to maximise them (**Action 12c**).

Additionally, to maintain or increase the number of MNTs with hollows, the use of artificial means of increasing hollow availability should be evaluated and criteria developed to identify the circumstances under which they should be employed (**Action 10**).

It is important to clearly identify where MNTs are, or are not, acceptable within the urban matrix. MNT species of particular ecological value in the urban ACT environment, such as Yellow Box (*E. melliodora*) and Blakely's Red Gum (*E. blakelyi*), are large trees that may not be suitable in new developments with limited space. Trees on narrow verges may prove problematic for, and be perceived to be dangerous by, residents who then agitate for the trees' removal. In contrast, trees in urban open space, particularly when removed from thoroughfares and centres of activity, can be protected by landscaping.

Proactive measures should be undertaken to identify and designate those places likely to provide security for MNTs in the long term. These can be marked on the ground by signage, fencing and/or landscaping, but should ideally also be recognised in planning approvals as areas set aside for native vegetation (**Action 11, 13**).

Where new urban development is taking place, the retention of MNTs with sufficient space around them to ensure public safety and ongoing regeneration should be incorporated in the design. In selecting such sites, consideration should also be given to providing connectivity through the development area to nearby reserves or other adjacent patches woodland vegetation (**Action 11**. See also **Action 22**).

The development of formal policy and training in tree risk assessment is also required to effectively circumscribe the conditions under which MNT removals will be approved (**Action 1a-d**).

The key models of Le Roux et al. (2014, 2018) were unable to include trees on urban leasehold land. New technologies such as LiDAR may enable this limitation to be overcome.

The use of new technologies like LiDAR will be investigated and, if feasible, used to estimate the current standing population of MNT (and regenerating smaller trees) (**Action 4a**).

These data will then be used to refine the model to evaluate the trend in MNT into the future and spatially across the urban ACT (**Action 4b**).

Development of such models will allow the overall efficacy of this plan to be evaluated regularly, and adapted accordingly (**Action 4c**).

There is an extensive body of research on tree risk assessment that may guide development of such policy (e.g. Ellison 2005, Koeser et al. 2016, Koeser and Smiley 2017). Importantly, it has been demonstrated that assessors with formal training and industry credentials assigned lower risk ratings and were less likely to prescribe more active mitigation measures like tree removal (Koeser and Smiley 2017). Several staff in the TCCS Urban Treescape Unit have completed studies in Certificate 5 Diploma of Arboriculture.

Although not directly affected by this action plan, it is relevant to note that the National Capital Authority (NCA) manages approximately 20,000 trees in the national capital estate (Cooper 2011) (approximately 3% of which are managed by ACT Government). These are largely in the parliamentary triangle and designated areas including Lake Burley Griffin and foreshores. The NCA has developed a new tree management policy, but it is focused on heritage and planning (e.g. sympathy with the original design for Canberra) and have limited scope to facilitate the planting of native tree species in substantial numbers. Of particular relevance are the NCA-managed areas containing natural woodland, including Stirling Park in Yarralumla, State Circle Woodland and O'Malley Woodland. These are managed under an ecological management plan (Sharp 2016), with objectives and actions complementary to those espoused here. In particular, there is a focus on retaining MNTs, including those with hollows, and on facilitating natural regeneration. Where plantings are necessary, local species and provenance are prescribed (Sharp 2016).

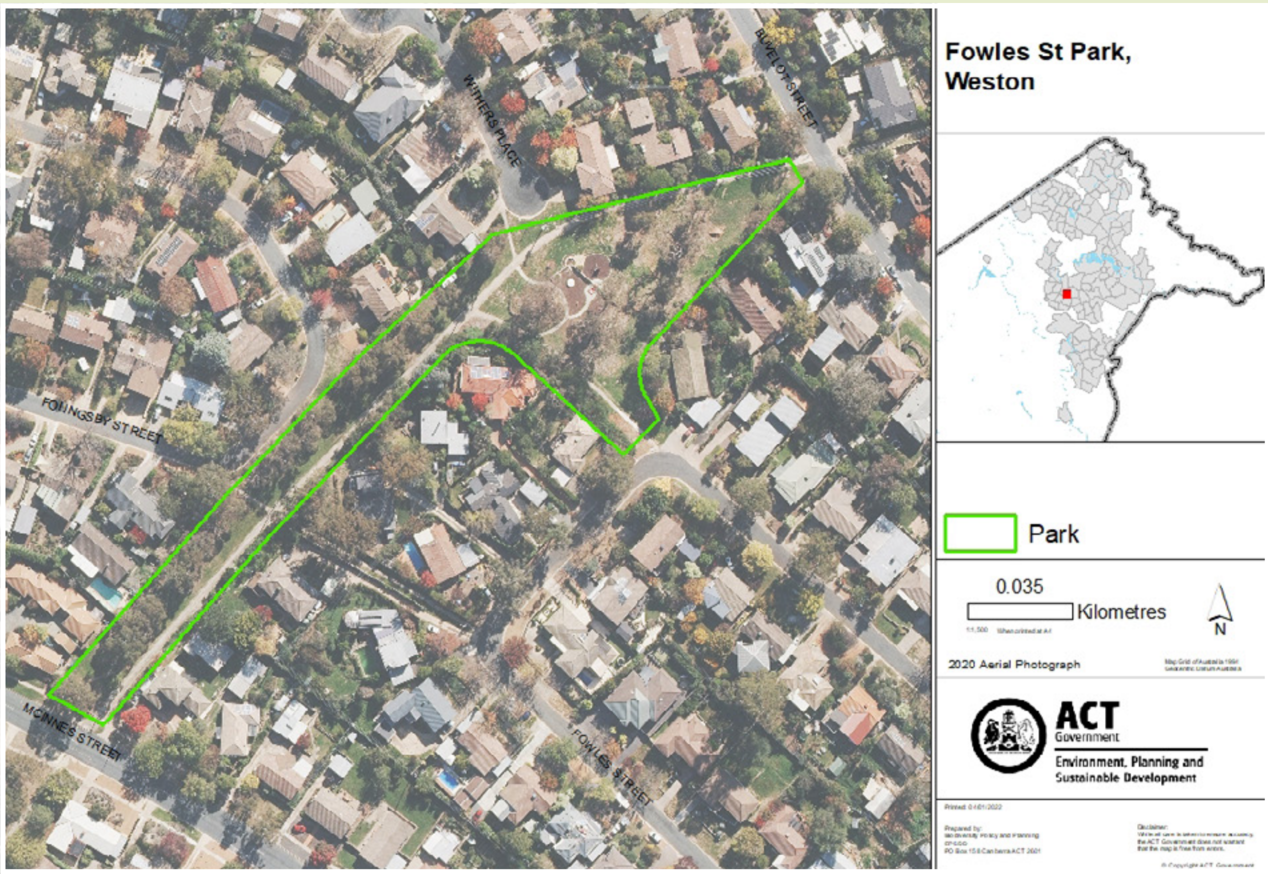
Importantly, the work of Le Roux et al. (2014) demonstrates that no individual measure (increasing standing life, increasing regeneration, artificial hollows) will be sufficient by itself to reverse the decline of MNT. To prevent decline in the urban context requires effective implementation of the range of activities listed in Actions and Indicators.

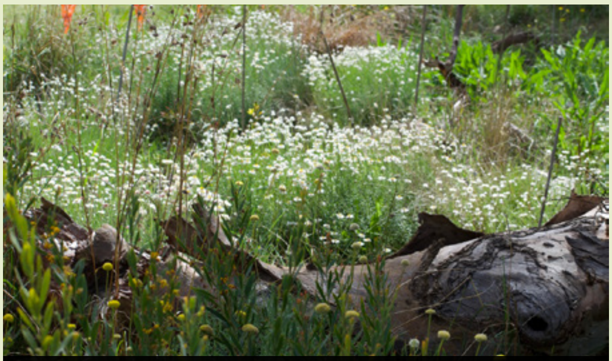
It will be important to monitor the overall effect of the combined activities, tracking the trend in MNT over time using updated models and data collected under this action plan (**Action 4c**).

CASE STUDY:

How ecologically-sensitive landscaping can improve mature native tree health in the urban area – Fowles Street Park, Weston

Fowles St. Woodland in Weston is an urban restoration project by ACT Urban Woodland Rescue. Here, low-cost evidence-based methods have replaced the exotic weed understorey of five declining 200-300 year old hollow bearing red gum and yellow box trees with native biodiversity producing impressive results. This restoration significantly increases the economic, social and ecological values mature/hollow bearing trees deliver for climate change. The benefits they provide increase with their age, a biodiverse native understorey, improved soil hydrologic processes, minimal disruption, fallen timber and positive community perceptions of their value.





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Method

The project applied low cost methods to return ecological function, tree health, address negative community perceptions about tree risk and appearance.

Methods include:

- manual weed removal or shallow scrape
- native tussock boundary around the trees providing a visual cue trees are cared for and a pedestrian and mowing barrier.
- beautifying fallen timber and ageing trees with flowering vegetation
- slowing water, reversing soil compaction, adding carbon, restoring hydrological processes and providing insect habitat by preventing mowing, adding native grasses, flowering herbs/forbs/mid-storey acacias, timber, mulch and sugar
- Information signs at park entrance
- community group presentations
- responses to enquiries.

Maintenance

During establishment hand weeding or spot spraying. Annual/bi annual light maintenance including manual removal of biomatter, slashing or episodic patch burning in autumn.

Barriers to tree protection

- Negative perceptions from the community and others that a tree with dead branches/sparse canopy/hollows is a danger and/or eyesore requiring tree removal.
- Lack of understanding of the essential ecological, economic and social services mature/hollow bearing trees provide.
- Perceptions that heavy mowing is aesthetically pleasing.

Outcomes

- Native tussock boundary reduces perceptions of risk favouring tree retention
- Restoring native biodiversity
  - creates positive perceptions of the value of even a declining tree and fallen timber
  - improves the health and resilience of mature and hollow bearing trees and the essential services they provide
  - reduces the costs of mowing and removes the need for tree removal/pruning.

Agricultural areas

Historically, there was substantial loss of MNTs in the ACT due to European settlement and the development of pastoralism, with widespread clearing of vegetation to allow grass growth for sheep and cattle (Threatened Species Scientific Committee 2006). Currently, 44% of ACT woodlands are in rural lands (ACT Government, 2019a). As a broadscale threat in the ACT, clearing is much diminished now, but clearing of remnant vegetation and individual scattered trees may still occur through pastoralism, conversion to cropping and land use intensification. Other threats to MNTs persist in the form of dieback, drought and climate change (addressed below).

Gibbons et al. (2008) modelled the population of MNTs in south-east Australia, determining that, under management conditions at that time, extinction of MNTs could be expected in approximately 200 years, and perhaps as little as 120 years. They noted the structural diversity of stands was so simplified (i.e. mostly mature trees, very few young trees) that no amount of management intervention could avert declines in the numbers of mature trees before new trees could grow to replace them. Nevertheless, earlier intervention can minimise the magnitude of the resource bottleneck to come. The trajectory is sensitive to recruitment and particularly to mortality of MNTs. Options to prevent mortality pertain strongly to restricting land clearing, which should be implemented wherever possible.

As noted previously, recently recruited trees will take over a century to begin to produce hollows, so protection of the existing stock of MNTs is critical to minimise the bottleneck.

The costs of improving tree recruitment in agricultural landscapes can be significant—a native tree and shrub planting guide produced by the Upper Snowy Landcare Network advocates planting plots of at least ¼ hectare to gain biodiversity benefits, and planting approximately 1,000 seedlings per hectare. They estimate the cost (at 2017 prices) of ripping and treating the soil, buying, planting and installing tree guards around seedlings at $6,200–$13,300. While fencing of the plot to exclude stock was recommended, it was not included in the estimated cost. However, Gibbons et al. (2008) show that recruitment 'events' need not be frequent to achieve conservation gains. They demonstrate that MNTs could be perpetuated in agricultural landscapes if recruitment (two or more new trees for each existing MNT) occurs every 30–90 years, reducing the cost of broad-scale applications.

Financial and/or logistical assistance should be provided to landholders willing to allocate land to regeneration, including both trees and understorey species (**Action 18, 19**). This should be complemented by advice on location of sites to maximise connectivity gains where applicable.

Importantly, Sato et al. (2016) demonstrate that, while regeneration was occurring, it was occurring at only 45% of remnant vegetation sites on average, compared to expected rates of 95–100% of sites showing revegetation under natural conditions. Indeed, other authors (Fischer et al. 2009) have referred to a 'tree regeneration crisis'. In pastoral land, lower levels of regeneration are associated with continuous grazing, but not with intermittent grazing (Sato et al. 2016), suggesting that regeneration could be facilitated by adopting an approach of rotational grazing. An approach similar to rotational grazing, known as holistic management, has been advocated as one means to address the lack of regeneration (Fischer et al. 2009). This approach is characterised by subdividing a farm into a larger number of smaller blocks and allowing cattle or sheep to graze intensely for short periods followed by a longer term of rest (Fischer et al. 2009). The approach allows greater adaptability in management and can significantly increase the probability of natural tree regeneration (Fischer et al. 2009. Sherren et al. 2012). Landholders have also observed other advantages of implementing holistic management such as reduced fertiliser use, better water infiltration and more diverse and resilient pasture grasses (Sherren et al. 2012). Related research identified rotational grazing and planting and protecting seedlings as the most favoured management measures, with short term financial or material support as the favoured policy instruments to encourage their implementation (Schirmer et al. 2012).

Landholders will be encouraged to adopt rotational grazing or holistic management principles via grant funding and expert advice (**Action 17a**).

In some localities, non-urban areas provide a reserve of land for future urban uses (e.g. Ginninderry). Where this is the case, the concerns identified above under the Urban Woodland context apply. In some cases, a loss of MNTs is unavoidable and this has been, and should continue to be, addressed via offsets (see below under Woodland Nature Reserves). Nevertheless, a principle of offsets policy is that impacts should first be avoided or mitigated before offsets are established.

In this case, planning will refer to actions identified above for the Urban Woodland context to ensure MNTs, or patches of MNTs, retain their habitat and connectivity values to the fullest extent possible (**Action 15**)

Protection and regeneration of native trees in riparian zones can be of particular value (ACT Government 2018). Tree species characteristic of the riparian zone may be quite different from surrounding vegetation and thus contribute to increased biodiversity. Riparian vegetation prevents erosion and sedimentation and acts as a buffer strip by filtering sediment and pasture effluent. Riparian trees provide shade, reducing stream temperatures and are a source of in-steam large wood debris which is important habitat for key fish species. Importantly, there are also significant benefits accruing to landholders in undertaking works to protect and restore the riparian zone. These may include:

- reduced fertiliser cost because nutrients in urine and faeces are not lost to the water
- reduced risk of bogging and injury of stock in the water
- increased ease of mustering
- increased amenity
- increased land value (Evidentiary 2016).

Landholders will be encouraged to employ measures such as fencing and revegetation to protect and restore the riparian zone via grant funding and expert advice (**Action 17b**).

Management for conservation of MNTs can be further enhanced via government facilitating the efforts of landholders moving to more environment-friendly farming techniques or to undertake restoration activities. This might be via providing technical expertise or support, or direct funding of activities for grant programs. In recent years the ACT Rural Grants Fund has provided support for agronomist advice and installation of farm fencing for more strategic grazing. Future iterations can be modified to increase opportunities for regeneration of native trees (as described above) while continuing to achieve commercial outcomes. Other funding sources in recent years have supported landholders to manage their woodland and paddock trees through fencing, revegetation, Whole of Paddock Rehabilitation (stock removal) and weed control.

Future funding schemes will include the retention or reinstatement of understorey and ground cover species along with MNTs, particularly where groups of MNTs occur, or there is high connectivity value (**Action 16)**.

Protecting mature native trees on rural land with Land Management Agreements

In the ACT, rural land is held under a lease that may only be granted if the lessee has entered into a Land Management Agreement (LMA) with the Territory. The agreement must be in a form approved by the Minister and signed by the Conservator of Flora and Fauna and the lessee. An LMA is subject to compliance and enforcement action as outlined in sections 339 and 361 and schedule 2 of the Planning and Development Act 2007. LMAs 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. However, a review by the ACT Commissioner for Sustainability and the Environment (Cooper, 2009) found that monitoring and enforcement of LMAs was lacking. While there was a commitment to "focus on implementing a strong culture and formal process of compliance, monitoring and enforcement of LMAs" (ACT Legislative Assembly 2010), there are limited data available on how effective LMAs are, particularly in the protection of MNTs specifically.

Current LMAs provide some protection for MNTs, with most including the following terms:

- to prevent the removal of standing timber from mapped Endangered Ecological Communities
- that hollow-bearing trees be left in place
- encouraging efforts to ensure regeneration and that some young tree stock survives to replace older trees.

It is notable that they do not necessarily provide protection for trees that are not part of an Endangered Ecological Community. They typically are not intended to regenerate past timber clearing but to manage remnant vegetation to maximise its benefits. These measures should continue in subsequent iterations, with adjustment as appropriate in response to on-site monitoring data and new research insights.

An audit will be conducted to establish a baseline measure of the effect of LMAs on MNT conservation, along with a regular monitoring and reporting framework to provide for adaptive management (**Action 14a**).

Where possible, negotiations on new LMAs will discuss potential to regenerate cleared areas, with assistance provided as described above (**Actions 14b**).

Priority will be given to maintaining the goodwill inherent in working cooperatively with landholders, but consideration will be given to identifying the (rare) circumstances under which compliance and enforcement actions are appropriate. In development of LMAs, landholders will also be provided with information on appropriate fire regimes based on the results of research by the ACT Government's Conservation Research group (**Action 14c**).

Woodland reserves

The ACT has extensive woodland (and secondary grassland; that is, grasslands where trees have been removed) protected in a variety of reserves managed at least partly for nature conservation. This includes 33 reserves collectively known as Canberra Nature Park (CNP) plus the Lower Cotter Catchment, the Murrumbidgee River Corridor and the Lower Molonglo River Corridor. Additional reserves have been created as development offsets (e.g. Isaacs Ridge, Molonglo Valley, Ginninderry Conservation Corridor). Although the specific focus of each reserve varies, the conservation of natural vegetation, including regeneration and revegetation, is included as a specific management objective in their respective management plans. For example, the 2020 draft management plan t for Canberra Nature Park includes a commitment to "… Plan and implement (assisted) rehabilitation of ecological communities, priority plant species and animal habitat. Prioritise restoration/regeneration activities that: increase habitat size, condition and connection, reduce perimeter-to-area ratio of habitat patches, assist species movement within and across reserves that contain bottlenecks or break points in connectivity.."

This management approach has been effective in CNP for the purposes of MNT conservation. Large, old trees are not subject to premature removal or major pruning (despite large pedestrian numbers, Fenner

School of Environment and Society 2018) and thus have standing lives much longer than in urban environments. Importantly, because it has largely maintained its natural attributes, it also has effective natural regeneration of trees. Consequently, the modelling work of Le Roux et al. (2014), based on the age structure of trees across the CNP, concluded that MNTs should persist at similar densities to the present over the longer term (200–300 years).

It should be noted that this modelling applies specifically to the CNP and may not necessarily apply to the other reserves (Lower Cotter, Murrumbidgee, offset areas). For example, in the case of the Cotter, much of the area was pine plantation and was severely burned in the 2003 fires. Nevertheless, in many of the reserves, particularly those created as offsets, there is active work to increase the extent and quality of woodland. For example, the primary aim of the 2018 Lower Cotter Catchment Reserve Management Plan is to actively promote regeneration of the Lower Cotter Catchment to a fully functioning natural ecosystem (following the loss of substantial pine plantations to the 2003 fires) and protect it from activities that may have adverse impacts on water quality.

Additional gains are made via the ACT Environment Grants and other Commonwealth or private philanthropic funding sources. In recent years, a number of supported projects have aimed to regenerate native vegetation, increase habitat connectivity or control weeds or introduced herbivores. Approximately $200,000 has been awarded annually as part of ACT Environment Grants over the past several years. Given that this funding typically involves volunteer workers and increases community awareness and feelings of stewardship, it represents good value for money and should be continued.

The ACT Government will evaluate the potential to facilitate its expert staff to assist volunteer groups in preparing applications for Commonwealth or other funding (**Action 21**).

An excellent example of the value of community and NGO involvement is the regeneration of the Lower Cotter Catchment by Greening Australia and volunteers where, following the 2003 fires, over 500 hectares has been planted with 306,343 seedlings from 62 species of native trees, shrubs and grasses and nearly 30,000 pine seedlings removed (Greening Australia 2015).

Perhaps the most significant potential threat to MNTs in woodland reserves is inappropriate fire. The modelling results described above suggest that the management regime applied in reserves by the ACT Parks and Conservation Service has been appropriate to ensure the continuation of regeneration. One note of caution is that dead standing trees may be particularly susceptible to loss even in quite low intensity fires.

This loss can be reduced by clearing flammable material away from the base of such trees for up to 30-50 cm prior to prescribed burning (**Action 20**).

Nevertheless, trees have been lost on occasion even when this method has been employed and efforts to refine its use and to identify complementary methods to prevent the loss of standing dead trees should continue.

The ACT has extensive areas of land reserved, relative to its size. For example, 29% of the total extent of lowland woodlands is protected in reserves, having increased from 21% in 2004 (ACT Government 2019a). Reserved areas will likely continue to expand due to the offsets policy.

> In doing so, care will be taken to ensure that connectivity of new reserves with existing reserves (both within the ACT and beyond) is maximised (**Action 22**).

To date this has been informed by the modelling of Barrett and Love (2012) and this plan encourages such consideration to continue. However, the data on which the models were based are heavily skewed towards birds and mammals (Doerr et al. 2010). Thus the model would benefit from revision where new data becomes available, particularly for other taxa such as reptiles.

Substantial effort and resources have gone into on-ground efforts to improve woodland condition in the ACT since the 2004 Lowland Woodland Conservation Strategy. These are provided in some detail in the 2019 ACT Native Woodland Conservation Strategy. They include the planting of many thousands of seedlings, activities to strategically restore or improve connectivity and the control of invasive weeds and feral animals. The 2019 ACT Native Woodland Conservation Strategy builds on that foundation and complement many of the actions identified in this action plan (and vice versa).

National park/nature reserve – forest

Namadgi National Park and Tidbinbilla Nature Reserve are positioned along the wetter, high altitude western portion of the ACT. There are a range of vegetation types across both Namadgi and Tidbinbilla, and Tidbinbilla in particular has occurrences of woodland types found in adjacent rural lands and in Canberra Nature Park. However, this action plan focusses on the qualitatively different taller, wetter forests not found elsewhere in the ACT.

These forests have largely been able to maintain natural processes of regeneration and have not been subject to extensive clearing or other losses due to human activity. Thus, natural regeneration has generally not been impeded. Exceptions to this include areas of Tidbinbilla that are regenerating from previous grazing or pine plantations. In those areas that have been subject to grazing, colonisation by native *Kunzea* is preventing the re-establishment of trees. Previous pine plantations are now in varying stages of natural regeneration involving mainly native tree species, some pine wildings and weeds (Territory and Municipal Services Directorate 2012).

The principal threat to the persistence of MNTs in these forested areas is inappropriate fire regimes, including its interaction with climate change. The devastating 2003 wildfires burnt 70% (164,914 hectares) of the ACT including 90% of Namadgi National Park and Tidbinbilla Nature Reserve (Carey et al. 2003).

The 2020 Orroral Valley fire burnt 80% of Namadgi National Park (82,700 hectares) and 22% of Tidbinbilla Nature Reserve (1444 hectares) and 3350 hectares of rural lands. There is a growing body of work that suggests the frequency and severity of fires is increasing in response to climate change, and that this will have severe consequences for temperate Australian forests. The Forest Fire Danger Index in south-east Australia increased from the 1970s to 2010s (Clarke et al 2013) and wildfire extent, frequency and severity are all expected to increase in south-east Australia's temperate forests in the coming decades (Bradstock 2010; Clarke et al. 2011; King et al. 2013). The 2019–20 bushfire season provided evidence of these forecasts.

Fire severity and intensity determine the extent of damage from a particular fire and influence how many MNTs die or collapse. The frequency of fire across a landscape also influences the persistence and value of MNTs. Salmona et al. (2018) illustrated the negative relationship between frequent fires and tree hollows. Tree hollows are a key habitat value of MNTs, particularly for birds and arboreal mammals. More generally, when fires are too frequent, they may exhaust or exceed the capacity of eucalypts to recover.

Eucalypt species tend to fall into two broad categories according to their response to fire: the tree may die but regenerate from seed, or the tree may survive and regrow via resprouting from epicormic buds or lignotubers (Fairman et al. 2016).

Species that recover from seeds require that fire intervals be greater than the time it takes for seed to germinate, grow and produce the next generation of seed. In Namadgi National Park, Alpine Ash (*Eucalyptus*

delegatensis) is such a species (Fairman et al. 2016, Salmona et al. 2018). If a subsequent fire occurs before the new generation of trees has reached maturity (approximately 20 years) and set sufficient seed, there will be little regeneration and a fundamental shift in the vegetation community may occur, towards short-lived fire-prone species such as *Acacia* (Lindenmayer et al. 2011, Bowman et al. 2014, Fairman et al. 2016). Bowman et al. (2014) recorded that a single fire in Alpine Ash forest killed most adult trees and elicited mass regeneration, and that a second fire a few years later killed 97% of regenerating trees.

Resprouting species are often considered to be fire tolerant. However, if fires occur in quick succession they may deplete the trees' ability to recover post-fire (Fairman et al. 2016). Fairman et al. (2017) studied this in Snow Gum (*E. pauciflora*) and found that, at least two years after the most recent fire, sites burned multiple times had higher proportions of fire-killed stems and lower densities of basal resprouts. More clumps (whole multi-stemmed trees) were killed after three fires, leading to increased patchiness. This mortality was not offset by seed germination. In addition, the understorey layer tended more toward grasses in sites burned multiple times. Furthermore, the potential for re-establishment of eucalypts over large areas, by either reseeders or resprouters, is limited by the poor dispersal of the seeds, which tend to be of the order of only tens of metres (Fairman et al. 2016). This phenomena is now being studied in the sub-alpine woodlands of Namadgi by the EPSDD Conservation Research and Evaluation team.

The above phenomena are exacerbated by positive feedback effects in the years immediately following the fire. Regrowth vegetation is dense, well aerated and the tree crowns are close to the source of the flames. Thus, fire in regenerating forest can be both more severe (Lindenmayer et al. 2011, Bowman et al. 2014) and up to eight times more likely (Zylstra 2018). Zylstra (2018) also noted that where a resprouting species is sub-dominant to a reseeding species, increased fire frequency may lead to a shift toward a more open forest dominated by the resprouting species.

As evidence, Zylstra (2018) cited surveys of the NSW Alps forests that in the 1930s were almost entirely dominated by Alpine Ash but now approximately a third of the forests are no longer dominated by Alpine Ash. Such open forests are more flammable, and thus more likely to burn again. This has the potential to increase fire contagion and fundamentally change the landscape.

Options to address these effects in the face of climate change currently appear limited. Prescribed burning may be an option (Bowman et al. 2014), but it appears to be ineffective under Very High or Catastrophic fire weather conditions (Price and Bradstock, 2012). Additionally, prescribed burning reduces the availability of hollow-bearing trees (Salmona et al. 2018) and thus may negatively affect a range of hollow dependent fauna. However, Salmona et al. (2018) noted that prescribed burns tend to be lower intensity and thus may have differing effects than wildfire (although their study had too few prescribed burn sites to allow statistical testing of those differences).

> Prescribed burns is a valuable area for future research (**Action 23**).

It has also been suggested that aerial sowing of seeds might be used to re-establish Alpine Ash (or other reseeder species as applicable) where recurrent fire has killed regenerating seedlings/saplings (Bowman et al. 2014). Aerial sowing has been shown to be effective in establishing seedlings in the short term (measured nine months after sowing) (Bassett et al. 2015) but if fire frequencies remain high it will be difficult to collect and maintain sufficient seed stocks (Bowman et al. 2014, Bassett et al. 2015, Fairman et al. 2016).

> The potential value of aerial sowing and other responses to successive fires at short intervals will be evaluated and, if shown to be necessary, the collection and storage of seeds will be commissioned (**Action 25**).

Some cause for optimism can be found in the identification of 'precocious' individuals, which produce viable seeds within only six years after germination (Doherty et al. 2017). This may allow for Alpine Ash to persist where the above discussion might have suggested extirpation. Nonetheless, it does not suggest forests of the same nature would continue. As research into the adaptability of various tree species to climate change and increasing fire frequency continues, we may see further refinement of approaches to active adaptation of forests, such as distributing seeds to higher elevations, selection for specific genetic traits and targeted fire management (e.g. Keenan and Nitschke 2016, Doherty et al. 2016).

Management of fire in the ACT (including Namadgi and Tidbinbilla) is governed by an ACT Strategic Bushfire Management Plan 2019–24 (ACT Government 2019d). Underneath sits the Regional Fire Management Plan and then a series of Bushfire Operational Plans. The issues raised above are not addressed explicitly in as much detail in those documents, but do note a need to be compatible with ecological requirements and, importantly, a clear commitment to adaptive management.

> Given the complexity of these systems, our developing understanding of both fire dynamics and ecology, and the expected influence of climate change (particularly increasing number of days of extreme fire weather), continued research and monitoring will be a key part of refining fire management approaches in the future (**Action 24**).

Beyond fire, relatively few additional threats to forested areas of the ACT have received much attention. One emerging threat may be the increasing population of deer. Deer are increasingly being encountered in the ACT, and Sambar deer are found throughout Namadgi (Mulvaney et al. 2017). Deer may have a range of negative effects on vegetation communities and, as browsers (feeding on leaves of shrubs and trees), they have the potential to affect regeneration of tree species (Davis et al. 2016). The limited data available to date do not record browsing on eucalypts, but do report Acacia species found in Namadgi (Forsyth and Davis 2011, Mulvaney et al. 2017). Additional effects may be exerted by rubbing of antlers and thrashing of saplings (Davis et al. 2016). At present there are too few data available to determine whether this is likely to be a significant problem for long term numbers of MNTs in the ACT. The extensive review by Davis et al. (2016) noted the paucity of data on the ecological effects of deer in Australia and made six research recommendations, two of which are pertinent in the context here: (i) identifying long-term changes in plant communities caused by deer and; (ii) quantifying changes in distribution and abundance of deer. The study by Mulvaney et al (2017) reports the commencement of intended long-term study of those two key issues and thus its continuation is encouraged by this plan.

Climate change, fire, drought and dieback

Climate change is widely recognised as a major threat to biodiversity across south-east Australia. Climate projections indicate that the ACT will see a higher frequency of extremes of heat, rainfall, bushfire weather, meteorological drought and thunderstorm energy, while extreme heat events are projected to occur at least every 5 years across most of southeast Australia, by the late 21st century (Herold et al. 2021).

The average Forest Fire Danger Index will increase slightly, as will the number of days when we experience severe fire weather. The reduced rainfall and higher temperatures are also expected to lead to more frequent and intense droughts.

Frequent high intensity fire can reduce and homogenise biodiversity, favouring species that thrive under frequent burning at the cost of those that are more fire sensitive (ACT Government 2019d). Management of fire in the ACT is governed by the ACT Strategic Bushfire Management Plan (SBMP). Bushfire operational plans, sitting under the SBMP identify and protect sites with high biodiversity value from bushfire risks. The SBMP also states that the ACT Government will review, monitor and research its past, current and future strategies for fire management to identify gaps and implement changes and better practices.

One of the key actions identified in the SBMP is to undertake research and monitoring to target biodiversity conservation and understanding of appropriate fire regimes.

Actions 23 and 24 discussed under the National park/ Forest habitat context above, are also applicable across all habitat contexts in light of ongoing climate change.

Conduct further research on whether prescribed burns have quantitatively different effects on hollow bearing trees than wildfire (**Action 23**).

Given the complexity of these systems, our developing understanding of both fire dynamics and ecology, and the expected influence of climate change (particularly increasing number of days of extreme fire weather), continued research and monitoring will be a key part of refining fire management approaches in the future (**Action 24**).

Recent research has indicated that rising temperatures and altered rainfall patterns due to climate change can cause large-scale tree dieback (Hoffmann et al. 2019). This has implications for tree longevity and sustaining the amount of mature native trees across the landscape. Survival to maturation will be increasingly difficult under climate change-induced drought and altered rainfall regimes.

Climate change has increased the likelihood and severity of extreme weather events, such as storms which damage urban trees (Kendal & McDonnell 2014). Urban tree failures can cause severe property damage and electric outages, as was seen in Canberra in early January 2022, and even human injuries or fatalities.

Simultaneously, damage by severe windstorms or lightning which result in natural branch shedding can contribute to the formation of hollows in mature Australian native trees, playing an essential part in biodiversity conservation, as discussed earlier.

Urban foresters must therefore weigh the pros and cons of storm impact on native trees in urban areas and manage these risks accordingly. While trees can become hazards during high-wind events, proper preparations, such as pruning high-risk trees can make trees more wind-resistant and storm recovery more effective (Janowiak et al. 2021).

The ACT Government has undertaken several exercises to evaluate the risks posed by climate change and potential responses. In the context of MNTs, a recent exercise of modelling climate refugia is informative. MacKenzie et al. (2018) used species distribution models, combined with data from the NSW and ACT Regional Climate Modelling (NARCliM) project to estimate plant species distributions in 2030 and 2070. The climate suitability of areas across the ACT is predicted to remain stable for Blakely's Red Gum (*Eucalyptus blakelyi*).

However, Cowood et al. (2018) suggest that the influence of dieback on community condition is greater in the north and east of the ACT. Other species, such as Brittle Gum (*E. mannifera*), may be climate stressed in their current distribution, but expand their range towards the south and west. Alpine Ash (*E. delegatensis*) and Brown Barrel (*E. fastigata*), both characteristic of higher elevation moist forests in the south west of the ACT, are expected to have much reduced ranges within the ACT. Further, species that are currently uncommon or do not occur in the ACT (e.g. Silvertop Ash *E.sieberi*, River Red Gum *E. camaldulensis*) may expand their ranges into the Territory.

Ongoing monitoring will be required to ensure that changes in species distributions are detected and understood promptly (**Action 28**).

Given this complexity of responses there is a need to continue to refine the research, including how climate change interacts with other threats (e.g. dieback dieback or fire) and as new data and insights become available begin to use these to form policy responses (**Action 28**).

A range of potential policy responses is available including active translocation beyond the existing range (to areas predicted to have suitable climate in the future), ensuring connectivity between patches to increase the likelihood of re-colonisation following major disturbances and greater resilience of the population overall. In that context, a key question to address will be the choice of seed provenance. As MNTs may last hundreds of years, revegetation and translocation need to consider the full extent of potential climate change over the long term, far beyond even the typical 'long range' scenarios to 2070. There is a growing body of literature to address such questions (e.g. Prober et al. 2015, Breed et al. 2013) and this should be used in developing appropriate policy.

Any such translocations or revegetation will be carefully designed and monitored to provide ongoing data to inform adaptive responses in policy and practice (**Action 29, 30**).

It is important to note that any advantage conferred by a non-local provenance may only become apparent after an extended period. For example, Prober et al. (2016) cite the example of Alpine Cider Gum (*Eucalyptus gunnii-archeri*) in Tasmania where local temperatures have increased and rainfall decreased. Survival of the local provenance decreased substantially relative to the non-local provenance, but this did not become evident until 25 years after planting (Prober et al. 2016).

As with climate change, eucalypt dieback is a complex and widespread phenomenon for which a clear policy response has not been identified. Dieback affects several species of eucalypt in the ACT but currently is most severely affecting Blakely's Red Gum. Dieback of Red Gum is particularly severe in the north of the ACT although severity is temporally and spatially variable (Cowood et al. 2018). Causes of dieback in the ACT are not well understood. 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 Red Gum correlates with some environmental variables but the strength of these relationships is generally weak (Cowood et al. 2018).

Given the scale and unpredictability of dieback incidence, there is an urgent need to study the regulatory factors (biotic and abiotic) of dieback (**Action 27**), as outlined in Cowood et al. (2018).

Cowood et al. (2018) also recommend the collection and propagation of seeds of local provenance from identified individual trees that have shown consistent inter-annual resistance to dieback. This action is included in the Actions and Indicators section, and expanded to consider non-local provenances that may contribute further variation in susceptibility and opportunities for enhancing species resilience to climate change (Bush 2017). A trial of this nature for Blakely's Red Gum started in late 2019 over four sites within the ACT, combining both provenance and family trials, where the specific tree from which the seed came is identified.

ACT Parks and Conservation Service planted 7000 Red Gum seedlings in collaboration with National Landcare Program, CSIRO, Greening Australia and Molonglo Conservation Group. At two sites the trees have been significantly affected by grasshoppers, (approx. 40% of total number planted). Many are unlikely to survive, however there is some possibility of resprouting. Additionally, there is a current project within the ACT Government investigating the potential for remedial actions to deal with current outbreaks.

More recently, extensive dieback of subalpine snow gums (*Eucalyptus debeuzevillei* and *E. niphophila*) has been identified as a major cause for concern in the Brindabellas and Koscuiszko National Park (Brookhouse personal communication). The dieback is caused by the larvae of a long horned beetle (*Phoracantha*, species not yet identified) and appears to be associated with ongoing drought. Drought stressed individuals of other eucalypt species show much greater susceptibility to attack by long horned beetles (Caldeira et al. 2002, Seaton et al. 2015).

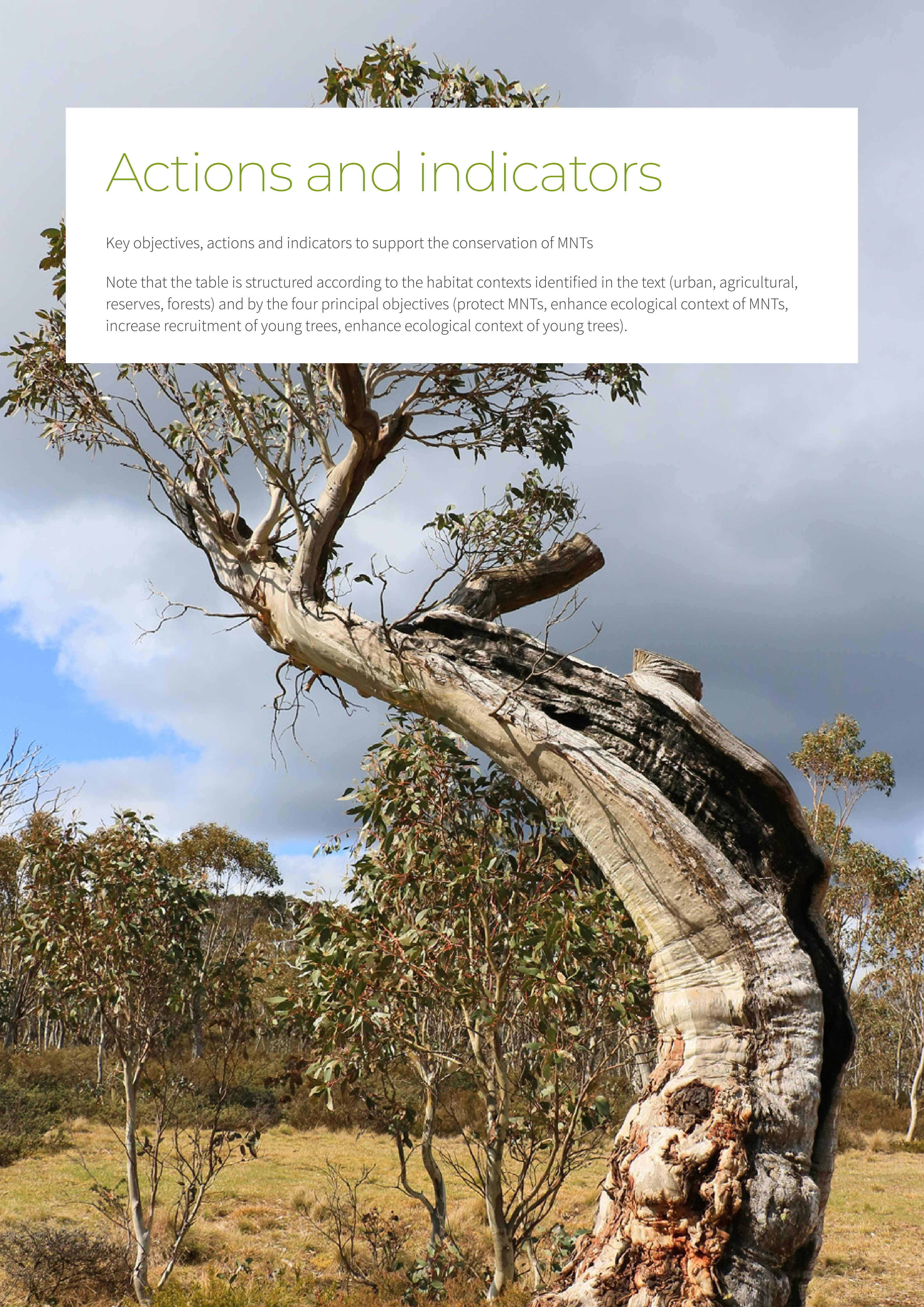
There is an urgent need to evaluate the extent of the problem and to research the causative factors with a few to identifying actions to address the threat (**Action 27b**).

To date, dieback of subalpine eucalypts has received little research or management attention.

Actions and indicators

Key objectives, actions and indicators to support the conservation of MNTs

Note that the table is structured according to the habitat contexts identified in the text (urban, agricultural, reserves, forests) and by the four principal objectives (protect MNTs, enhance ecological context of MNTs, increase recruitment of young trees, enhance ecological context of young trees).



ACTION AND NUMBER	INDICATOR
CONTEXT: URBAN	
OBJECTIVE : PROTECT EXISTING MNTS	
ACTION 1	
For ACT Government employees and contractors, develop formal policy regarding: a. constraining circumstances under which to lop or fell non-registered native trees in urban public spaces to extend standing life of trees, particularly through to hollow development and beyond b. guidance for the evaluation of the ecological value of native trees in urban context e.g. connectivity value, food tree, nest tree, isolated or in group c. combining the above in a risk assessment format with appropriate formal training of assessors d. guidance to ensure the most ecologically valuable use of felled timber (e.g. re-site as standing tree, use as coarse woody debris) e. investigating alternative engineering solutions prior to removing MNTs for infrastructure reasons.	Native tree retention policy written and adopted by appropriate directorate of ACT Government. → The policy should include guidelines for quantitative evaluation of ecological values of trees to reduce subjectivity of assessments. → The policy should follow the principles of Offset Policy: > Avoid tree lopping or removal. > Mitigate (e.g. barriers to access below tree to limit pedestrian access and thus reduce required modification to tree). > Offset—plant (and maintain and protect) sufficient seedlings to replace the tree in the longer term. > Where trees are felled, a supplementary decision support tool is available to identify the most ecologically valuable re-use of that timber. See Actions 1.3.1, 4.1.2, 4.1.3, 4.1.4 and 4.3.2 of the Urban Forest Strategy.
ACTION 2	
a. Review and revise the criteria that define a regulated tree under the Tree protection Act to include dead native trees with a DBH >60cm. b. Regular review and revision of regulated tree criteria under the Tree Protection Act to recognise new ecological data (e.g. threshold DBH value). This may include protection of dead standing trees that offer habitat value.	TCCS to amend the criteria that define a regulated tree be extended to include dead native trees with a DBH >60cm. Reviews of tree criteria under the TP Act have been undertaken regularly (every five years). Link to Action 8 of Canberra's Living Infrastructure Plan: Cooling the City which indicates a review of the TP Act to commence in 2020. See Actions 1.1.1 and 1.2.1 of the Urban Forest Strategy.
ACTION 3	
Incorporate quantitative criteria to identify 'exceptional' trees for registration under the Tree Protection Act based on current research. Ecological criteria developed under Action 1 can be used to assist.	Disallowable Instrument DI2018—50 Tree Protection (Criteria for Registration and Cancellation of Registration) Determination 2018 revised to expand and clarify criteria under s 1(3) of the DI, incorporating ecological criteria developed under Action 1. Trees that are identified as meeting the quantitative criteria are rapidly added to the Tree Register and the number of registered trees has significantly increased. See Action 1.1.1 of the Urban Forest Strategy.

ACTION AND NUMBER	INDICATOR
CONTEXT: URBAN	
OBJECTIVE : PROTECT EXISTING MNTS	
ACTION 4	
a. Use appropriate technologies (e.g. LiDAR) and ground-truthing to identify and estimate the current standing population of MNT in the urban environment and estimate rate of loss over future years. b. Use the data to model the trajectory of the MNT population in urban leasehold land. c. Use the above to evaluate the overall effect of this action plan in the urban context and revise accordingly. d. LiDAR/remote-sensed data used by EPSDD to identify tranches of trees to nominate for registration under the Tree Protection Act. These would need to be evaluated against the qualitative criteria of the Act.	Model of trajectory of MNT population in urban context developed, including trees on leasehold land. → Model used to develop Key Performance Indicators for tree managers, with regular review to ensure the trajectory is prevented from going negative. Mature trees identified through use of LiDAR/remote sensing for nomination for registration under the Tree Protection Act.
ACTION 5	
Develop policy for identifying and evaluating isolated public urban trees of high ecological priority for retention and protection. See Actions 1 and 3.	Ecologically significant urban trees are nominated to the Tree Register and steps taken to protect those trees (e.g. via landscaping, fencing or other barriers). See Action 1.2.3 of the Urban Forest Strategy.
ACTION 6	
Develop educational materials to increase awareness of the habitat value of MNTs in urban open space and leasehold. Communicate principles of the Tree Protection Act and ACT Tree Register (and outcomes of their review) to the community. Conduct surveys to evaluate effectiveness.	Awareness campaigns conducted and effectiveness evaluated. See Actions 6.1.1, 6.1.2, 6.3.1 and 6.3.3 of the Urban Forest Strategy
ACTION 7	
a. Increase monitoring and compliance efforts for breaches of Tree Protection Act by leaseholders. b. Collate and report data on the rates of approved removals of regulated native trees. c. Collate and report data on the rates of tree removals under planning approvals. d. Increased monitoring and compliance efforts for tree damaging activities on public land.	Investigate the creation of a dedicated compliance position within the TCCS Tree Protection Unit. Regular (annual) reporting on rates of approvals and non-compliance. See Action 1.2.3 of the Urban Forest Strategy.
ACTION 8	
a. Support research into the ecology of key fauna species and their habitat use in the urban context (e.g. Superb Parrots). b. Identify species at risk from MNT loss in urban woodland and develop research/management priorities. c. Develop models to evaluate landscape connectivity for taxonomic groups other than birds (as data become available). See Barrett and Love 2012.	Research continuing, analysis and reports updated and used in adaptive management. See Action 6.1.2 of the Urban Forest Strategy.

ACTION AND NUMBER	INDICATOR
CONTEXT: URBAN	
OBJECTIVE : PROTECT/ENHANCE ECOLOGICAL CONTEXT OF MNTS	
ACTION 9	
On Parks and Conservation Service-managed and other appropriate urban open space areas, not including verges (nature strips): a. continue and expand policy of retaining dead trees in situ as 'habitat' trees b. continue and expand policy of resurrection of trunks and branches of larger trees removed from urban locations. Erection of artificial structures for nesting/roosting should also be considered, as appropriate c. continue research and monitoring to better understand how to maximise the value of habitat and resurrected trees.	Increasing number of habitat trees retained, preferably in-situ. See also Action 5. Condition and biodiversity value monitored and reported on regularly. See Action 4.1.2 of the Urban Forest Strategy.
ACTION 10	
In selected areas, encourage artificial creation of hollows in standing dead trees to accelerate development of habitat quality variables. Such hollows should be carved into the existing structure where possible (e.g. using chainsaws) or additional hollows added by attachment of natural or artificial hollows to the existing structure. Nest boxes typically should not be used as they do not have appropriate thermal properties and degrade quickly. Monitoring (e.g. via automatic cameras) should be conducted to collect data to determine usage to inform adaptive management.	Condition and biodiversity value monitored and reported on regularly. Data used to refine policy on when/where to apply. This could be incorporated in the policy developed under Action 5.
OBJECTIVE : INCREASE RECRUITMENT OF MNTS	
ACTION 11	
a. Encourage greenfield estate development or infill development approvals to identify locations likely to support MNT in the long term within the urban matrix (e.g. open spaces with little foot traffic). These should ideally have existing mature trees, but some valuable locations may require additional (or initial) planting. See also Action 2. b. Encourage developers/TCCS to install complementary landscaping to minimise public risk and enhance habitat value where feasible: → including plantings to ensure regeneration/replacement of trees in the longer term → including both existing and proposed development areas. See also Action 13.	MNT locations are identified, and appropriate landscaping installed. Regular reporting on locations/condition. Estate development and urban infill approvals should identify future MNT designated areas or explain why they are lacking.

ACTION AND NUMBER	INDICATOR
CONTEXT: URBAN	
OBJECTIVE : INCREASE RECRUITMENT OF MNTS	
ACTION 12	
Plant more native trees in urban open space, urban reserves and greenfield development: a. Develop policy to ensure replacement planting when an MNT is removed. The policy should require ongoing maintenance and replacement of each planting until it is well established and/or planting of sufficient trees (up to 1:20 for each tree removed) to allow for some mortality. b. Seek to identify additional areas where native trees can be planted without the requirement for zoning and/or barriers. c. Include advice in planning guidance documents (e.g. MIS 25, ACT Smart Canberra Plant Selector) to encourage further plantings of local native tree species. Advice should include recommendations about appropriatecontext. Including climate-resilience for individual species. d. Link this action to Canberra's Living Infrastructure Plan: Cooling the City (2019) which aims to increase the canopy coverage in the urban environment to 30% by 2045. Since the release of the Living Infrastructure Plan, tree canopy cover has been estimated at 22.5%. Advice may also be informed by Actions 3 and 4 above. This action is subject to consideration of climate-appropriate species in high density built-up areas that offer improved amenity in both summer (shade) and winter (solar gain) and subject to a broader urban forest management strategy.	Advice included in appropriate documents (such as, but not limited to, MIS 25 and ACT Smart Canberra Plant Selector). Advice related to Canberra's Living Infrastructure Plan: Cooling the City incorporates recommendation to include native trees, particularly species such as Blakely's Red Gum and Yellow Box, which are local to the region and provide biodiversity values such as hollows.
OBJECTIVE: PROTECT/ENHANCE ECOLOGICAL CONTEXT OF IMMATURE NTS	
ACTION 13	
Include landscaping to protect small trees, add coarse woody debris and understorey species to community plantings in selected areas to improve public safety and biodiversity values. → Seek to do this in conjunction with, for example, plantings aimed at improving stormwater quality or around public open spaces. → Bushfire fuel reduction around small trees should be cognisant of the EPSDD Ecological Guidelines for Fire, Fuel, and Access Management Operations. → During extended dry periods, improve growing conditions of immature native trees through watering and other landscaping treatments suited for highly urban areas– this could include porous paving and/or soft landscape solutions in high-density/paved areas. Note that a project to assess the utility of this approach commenced in 2019, conducted by the Fenner School of Environment and Society. The results of this project should be used to inform the development of formal policy in this area.	Increased landscaping are used in selected areas to protect small trees, add coarse woody debris and understorey species to community plantings. During dry conditions, watering and landscaping used on immature native trees in the urban environment.

ACTION AND NUMBER	INDICATOR
CONTEXT: AGRICULTURAL	
OBJECTIVE: PROTECT EXISTING MNTS	
ACTION 14	
a. Conduct an audit of the efficacy of Land Management Agreements (LMAS), including specific reference to MNTs. Establish a regular monitoring and reporting framework to provide for adaptive management. Revise LMAs accordingly.	Land Management Agreements have been audited and revised to incorporate specific measures for MNT conservation. Monitoring and reporting framework has been established.
b. Negotiations on new or revised LMAs to discuss potential for regeneration of previously cleared woodland, with assistance as per Actions 16–19 below.	Bushfire operational plans specify TFI and report on consistency with it.
c. Provide information to landholders on appropriate fire regimes (including Tolerable Fire Interval, which should be periodically reviewed in light of new research) to landholders. Encourage the use of protection buffers around standing dead hollow bearing trees (i.e. clear fuels within 30–50 centimetres of base).	
ACTION 15	
Where broadacre sites are to be cleared for conversion to urban development, the actions cited above for the urban environment should be considered proactively. Planning should identify key locations with a view to ensuring that the context (location, connectedness, surrounding vegetation) is maintained to maximise the retention of MNT and their biodiversity values.	New estate development plans explicitly address MNT retention and recruitment and demonstrate effective protection consistent with, for example, Action 12 above. → Policy approach should follow the principles of the Offset Policy: > Avoid tree removal. > Mitigate (e.g. change decision to reduce tree removal, use landscaping or barriers to limit to access below tree canopy to limit pedestrian access and thus reduce safety concerns). > Offset. Plant (and protect) sufficient seedlings to replace the tree(s) in the longer term and maintain and enhance broader landscape connectivity.

ACTION AND NUMBER	INDICATOR
CONTEXT: AGRICULTURAL	
OBJECTIVE: PROTECT/ENHANCE ECOLOGICAL CONTEXT OF MNTS	
ACTION 16	
Encourage/facilitate, via grant funding and provision of expert support, the retention of understorey and ground cover species along with MNTs, particularly where groups of MNTs occur, or there is high connectivity value.	Regular reviews of LMA demonstrate retention or increase of understorey and ground cover vegetation.
OBJECTIVE: INCREASE RECRUITMENT OF MNTS	
ACTION 17	
a. Encourage/facilitate via grant funding and provision of expert support, adoption of rotational grazing or holistic management principles by rural landholders. b. Encourage/facilitate via grant funding and provision of expert support the fencing and revegetation trees in the riparian zone.	(Where funding is available) grants are awarded to projects demonstrating capacity to improve recruitment of native trees (including, where appropriate, the riparian zone).
ACTION 18	
Encourage/facilitate via grant funding and provision of expert support active plantings of native tree species, particularly where they would enhance connectivity.	Grants awarded demonstrate potential to improve habitat connectivity of woodland. Link to Action 7.3 of ACT Climate Change Strategy 2019–25: → Identify suitable sites in the ACT for 'carbon sinks' and develop a plan for planting trees or using soil carbon in these areas to sequester carbon with consideration of biodiversity outcomes and competing land uses.
OBJECTIVE: PROTECT/ENHANCE ECOLOGICAL CONTEXT OF IMMATURE NTS	
ACTION 19	
As above for MNTs, encourage landholders to retain understorey and ground cover species along with MNTs, particularly where groups of MNTs occur, or there is high connectivity value.	Regular reviews of LMA demonstrate retention or increase of understorey and ground cover vegetation.

ACTION AND NUMBER	INDICATOR
CONTEXT: WOODLAND RESERVES	
OBJECTIVE: PROTECT EXISTING MNTS	
ACTION 20	
In consultation with land custodians, evaluate appropriate clearing of flammable material from around the base of dead standing trees before prescribed burns to minimise loss of these susceptible trees. A minimum diameter for trees protected in this manner should be stipulated, in consultation with operational staff and academic experts and land custodians. Any tree with a hollow should be protected irrespective of size.	Post-burn audits demonstrate no/minimal loss of dead standing trees. Practices reviewed/revised as necessary after such audits.
OBJECTIVE: PROTECT/ENHANCE ECOLOGICAL CONTEXT OF MNTS	
ACTION 21	
Continue or expand the ACT Environment Grants program to increase planting of native trees. Consider offering ACT Government expert assistance to volunteer groups in preparing applications for Commonwealth or other funding.	(Where funding available) grants awarded to projects demonstrating capacity to improve recruitment and/or ecological context of native trees.
ACTION 22	
Ensure additional reserves, such as offsets, and revegetation activities are planned to maximise connectivity where possible, guided by the Barrett and Love (2012) model.	New declared reserves demonstrate potential to improve habitat connectivity of woodland.

ACTION AND NUMBER	INDICATOR
CONTEXT: NATIONAL PARK/RESERVE – FOREST	
OBJECTIVE: PROTECT EXISTING MNTS	
ACTION 23	
Conduct further research on whether prescribed burns have quantitatively different effects on hollow bearing trees than wildfire.	Research conducted/reported. Fire planning modified as appropriate.
ACTION 24	
Continue research on the effect of fire on these systems, including incorporation of new insights from climate change research. Incorporate into fire management planning, including re-estimation of TFI where required.	Research conducted/reported. Fire planning modified as appropriate.
OBJECTIVE: INCREASE RECRUITMENT OF MNTS	
ACTION 25	
Evaluate utility of aerial sowing or other potential interventions to regenerate Alpine Ash forest in case of successive fires.	Evaluation conducted. Commence accumulation of appropriate seeds or other resources if recommended.
ACTION 26	
Continue research to: a. quantify changes in distribution and abundance of deer b. identify long-term changes in plant communities caused by deer.	Research continuing, aims/design adjusted if required. Trigger points for control actions should be identified once sufficient data have been accumulated and adaptive management principles applied.

ACTION AND NUMBER	INDICATOR
CONTEXT: CROSSCUTTING THREATS – CLIMATIC CHANGE AND VARIABILITY AND DIEBACK	
OBJECTIVE: PROTECT EXISTING MNTS	
ACTION 27	
Continue field monitoring and analysis of dieback and associated variables to better understand the causes and appropriate responses, particularly in Blakely's Red Gum. a. Ongoing—Review/revise priorities/focus as each stage of data analysis completed. b. Extend consideration to other priority tree species (esp. subalpine *Eucalyptus debeuzevillei* and *and E. pauciflora).* c. Extend field monitoring to increase knowledge of invertebrate populations that interact with these tree species.	Research conducted and analysed as appropriate. Used to inform improvements to relevant policy. → In 2019 an ACT Government officer was appointed to investigate potential remedial actions for dieback (e.g. manipulation of soil nutrients). The results of this work should be implemented as appropriate.

ACTION AND NUMBER	INDICATOR
ACTION 28	
Build on past research conducted in the ACT and elsewhere to better understand the implications of climate change on plant health and community structure. Research could also consider individual tree level response, including how climate change influences susceptibility to other threats that may be manageable locally. → Ongoing, as insights/opportunities arise. → Actions 23 and 24 above regarding research into prescribed burning and fire management planning in the context of climate change can also be applied here.	Research conducted and analysed as appropriate. Used to inform improvements to relevant policy (e.g. translocations, prioritising of climate refuge areas or strategic bushfire management plans).
OBJECTIVE: INCREASE RECRUITMENT OF MNTS	
ACTION 29	
Develop and implement policy regarding active translocation/ assisted colonisation of species consistent with expected distributional change under projected climate change. → Include provision for ongoing monitoring with appropriate scientific/statistical design to ensure maximum information is gathered to inform adaptive responses in policy and practice. → Revise and review every five years.	Translocation policy written and adopted by appropriate directorate(s) of ACT Government. → Areas of climate stress and climate refugia identified for key tree species in ACT. → Appropriate provenance for seeds for revegetation identified (see Action #30) Translocation policy reviewed after five years. Policy advice used to advise landholders and land managers undertaking revegetation projects.
ACTION 30	
Develop policy regarding the choice of seed provenance for revegetation and translocation under projected climate change. Where possible, incorporate with complementary research about intra- and inter- provenance variability in susceptibility to dieback. → Include provision for ongoing monitoring with appropriate scientific/statistical design to ensure maximum information is gathered to inform adaptive responses in policy and practice. → Revise and review every five years.	Seed provenance policy written and adopted by appropriate directorate of ACT Government. → Provenance trials conducted (or expanded) for key tree species. > In 2019 a provenance trial for Blakely's Red Gum commenced. ACT Parks and Conservation Service planted 7000 Red Gum seedlings in collaboration with National Landcare Program, CSIRO, Greening Australia and Molonglo Conservation Group. → Seed sources consistent with policy identified and sufficient seed secured/stored. Seed provenance policy reviewed after five years. Policy advice used to advise landholders and land managers undertaking revegetation projects.

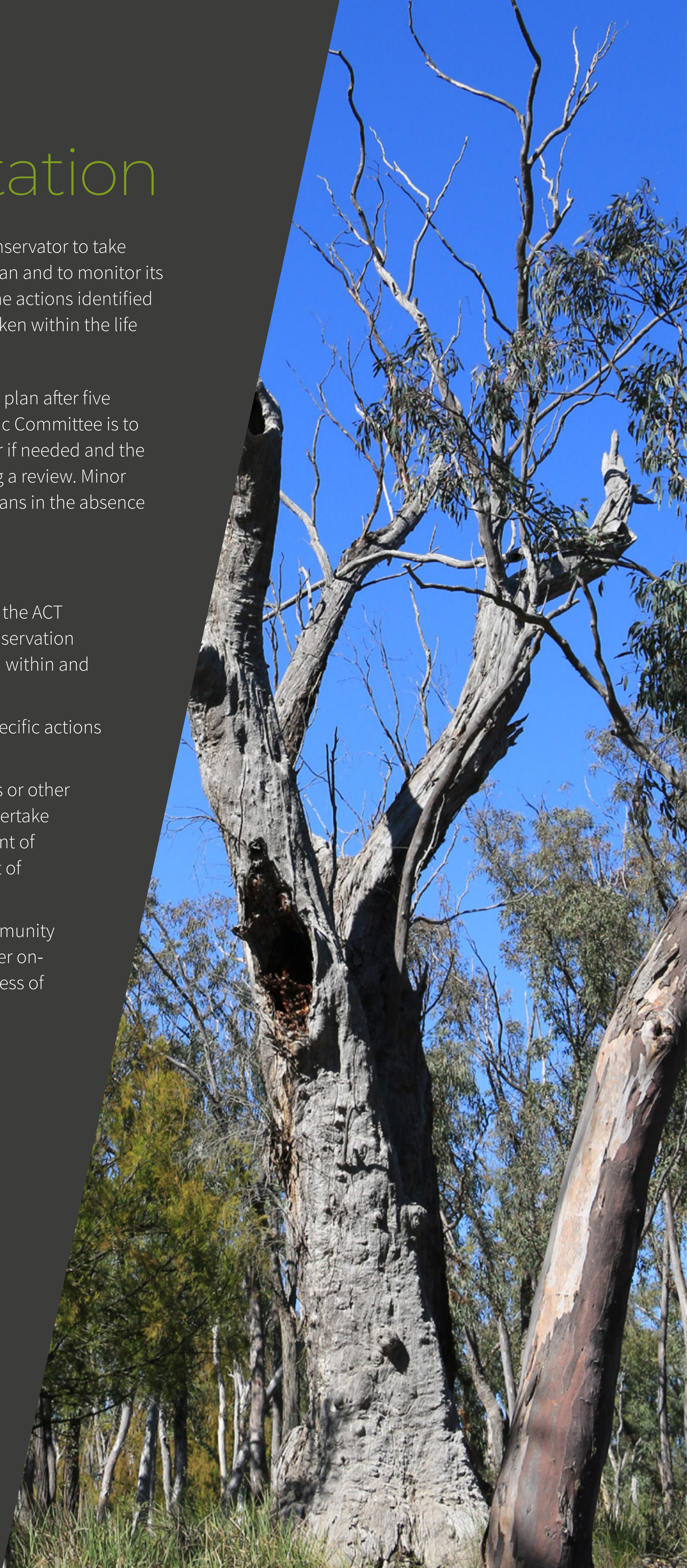
Implementation

Provisions within the NC Act require the Conservator to take reasonable steps to implement an action plan and to monitor its effectiveness. Unless otherwise specified, the actions identified within this plan are proposed to be undertaken within the life of the plan.

A progress report is required on each action plan after five years and mandatory review by the Scientific Committee is to occur at ten years. Reviews can occur earlier if needed and the Minister may extend the time for conducting a review. Minor amendments can also be made to action plans in the absence of a full review.

Implementation of this plan will require:

- land planning and management areas of the ACT Government to take into account the conservation requirements of mature native trees both within and outside the reserve system
- adequate resourcing to undertake the specific actions identified
- collaboration with the CSIRO, universities or other research institutions to facilitate and undertake research necessary to inform management of mature native trees, including the impact of climate change
- engagement and collaboration with community groups to assist with monitoring and other on-ground actions, and to help raise awareness of conservation issues for these species
- engagement and collaboration with rural landholders.



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Appendix A

Relevant species and ecological communities* affected by the loss of Mature Native Trees (including hollow-bearing trees) and lack of recruitment.

* 'Relevant species' means listed migratory and threatened species and 'relevant ecology community' means listed threatened ecological community.

COMMON NAME	SCIENTIFIC NAME	ACT STATUS	NATIONAL STATUS (EPBC ACT)[1]	DIRECTLY USES MATURE NATIVE TREES
Small Purple Pea	*Swainsona recta*	Endangered	Endangered	N
Tarengo Leek Orchid	*Prasophyllum petilum*	Endangered		N
Black Gum	*Eucalyptus aggregata*	Vulnerable	Vulnerable	Y
Brindabella Midge Orchid	*Corunastylis ectopa*	Critically Endangered	Critically Endangered	N
Regent Honeyeater	*Anthochaera phrygia*	Critically Endangered	Critically Endangered	Y
Swift Parrot	*Lathamus discolor*	Critically Endangered	Critically Endangered	Y
Brown Treecreeper	*Climacteris picumnus victoriae*	Vulnerable		Y
Glossy Black-cockatoo	*Calyptorhynchus lathami lathami*	Vulnerable		Y
Hooded Robin	*Melanodryas cucullata cucullata*	Vulnerable		Y
Little Eagle	*Hieraaetus morphnoides*	Vulnerable		Y
Painted Honeyeater	*Grantiella picta*	Vulnerable	Vulnerable	Y
Scarlet Robin	*Petroica boodang*	Vulnerable		Y
Superb Parrot	*Polytelis swainsonii*	Vulnerable	Vulnerable	Y
Varied Sittella	*Daphoenositta chrysoptera*	Vulnerable		Y
White-winged Triller	*Lalage tricolor*	Vulnerable		Y
Black-faced Monarch	*Monarcha melanopsis*	Regular migratory[2]	Migratory	Y
Rufous Fantail	*Rhipidura rufifrons*	Regular migratory	Migratory	Y
Satin Flycatcher	*Myiagra cyanoleuca*	Regular migratory	Migratory	Y
Smoky Mouse	*Pseudomys fumeus*	Endangered	Endangered	N
Greater Glider	*Petauroides volans*	Vulnerable	Vulnerable	Y
Grey-headed Flying Fox	*Pteropus poliocephalus*	Vulnerable	Vulnerable	Y
Koala	*Phascolarctos cinereus*	Vulnerable	Vulnerable	Y
Spotted-tailed Quoll	*Dasyurus maculatus maculatus*	Vulnerable	Endangered	N
Eastern Bettong	*Bettongia gaimardi*	Regionally Conservation Dependent		N
Yellow Box/Red Gum Grassy Woodland	An ecological community	Endangered	Critically Endangered	Y

1 Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

2 Regular migratory species are the subset of EPBC listed migratory species occurring regularly in the ACT. This is operationalised by the Action Plan for Migratory Species which defines regular migratory as being recorded in more than 10% of years. Only those regular migratory species that use forest and woodland are included here.