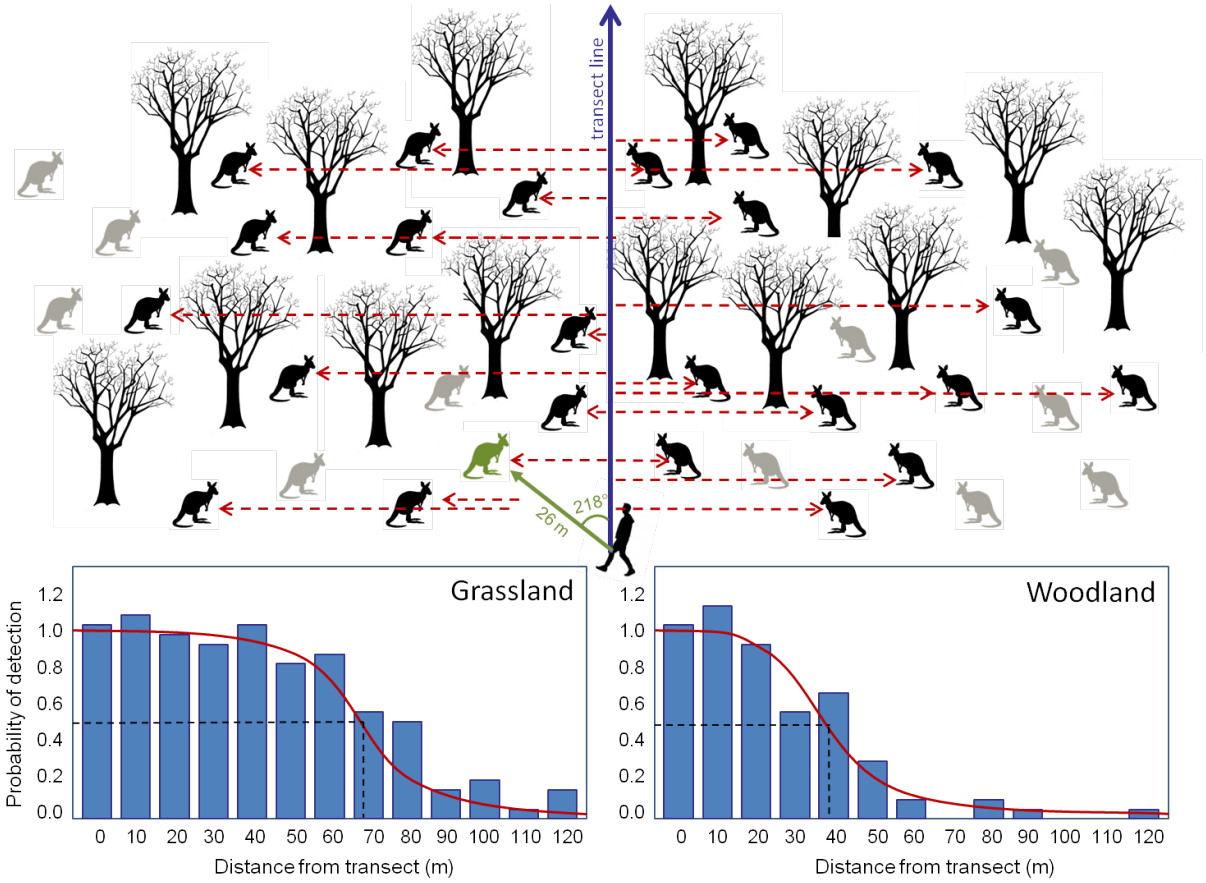

Figure 5. The perpendicular distance of kangaroo groups from a transect line are calculated based on the distance and bearing of kangaroos from the observer when they are first detected (as is shown for the green kangaroo). Note that single kangaroos represent groups in this diagram. The combined records for all observed (black) kangaroo groups allows a histogram to be developed indicating the likelihood of detecting kangaroos at increasing distance from the transect line. Assuming a random distribution of kangaroo groups across the landscape relative to the placement of transect lines, the area above the detection function (red line on histogram) is indicative of the number of kangaroos which are not being observed. The histograms show an example of the fitted detection function for grasslands (left) and woodlands (right), where vegetation density affects the likelihood of the observer seeing kangaroos at distance. Note that the 'effective strip width', i.e. the distance to which at least half of the kangaroos expect to be observed (black dashed line), is estimated to be approximately 70 m in grassland but only 40 m in woodland in this artificial example.

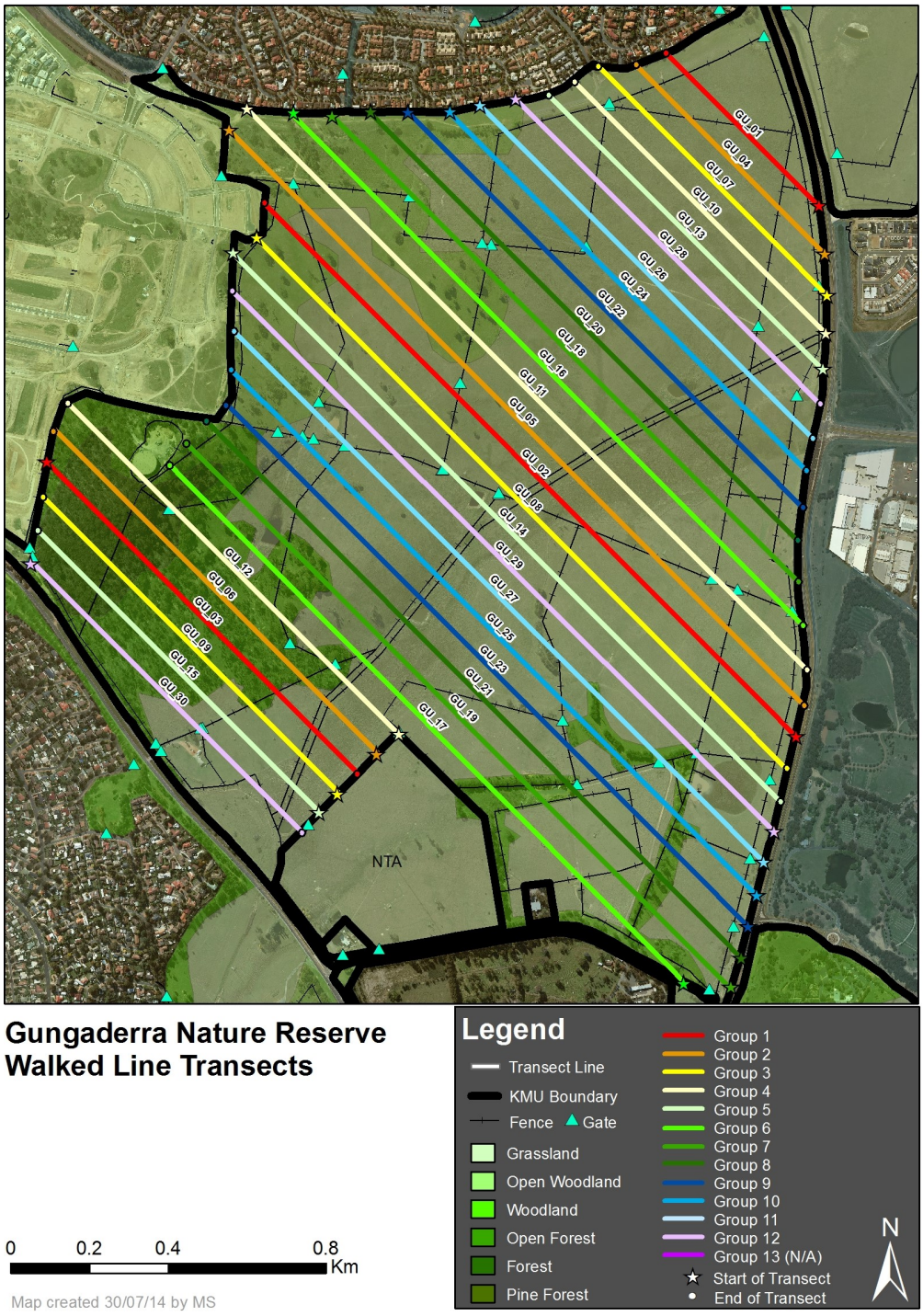

Figure 6. An example of transect layout for Gungaderra KMU. Colour coded transect groups are walked on different days to avoid kangaroos flushed off one transect being observed on another surveyed that day. Surveying extends beyond the boundary fences of the site to the feature considered to be a boundary to kangaroo movement, to ensure any 'edge effects' of the surrounding roads are factored into the density estimate.

STATISTICAL ANALYSIS

The effect of count method on estimated kangaroo density was assessed in R (R Core Team, 2013) using linear mixed modelling. The model assessed the effect of 'method' on the 'mean' and 'standard error' of counts at each site. The effect of 'site' on kangaroo density was corrected for by including site as a random term (equivalent to a nested ANOVA). As all methods were not assessed at all sites, additional analyses compared pair-wise (i.e. total *vs.* line transect, total *vs.* pellet and line transect *vs.* pellet) means and standard errors to include the maximum available data. A comparable linear mixed model assessed the effects of 'session' (morning or afternoon) and 'day' (day 1 or 2) on density estimated using total count methods. All results are presented as the mean ± standard error. Results are considered to be statistically significant where $p < 0.05$.

RESULTS

There was no effect of 'session' (i.e. morning or afternoon) on individual total counts within sites ($F = 0.83$, $p = 0.38$), nor did the number of kangaroos counted differ between days ($F = 0.56$, $p = 0.47$).

At the four sites where all three counting methods were assessed, there was no significant effect of count method on the mean estimated kangaroo density ($F = 0.13$, $p = 0.89$). The precision of the counts did differ between count methods however ($F = 11.95$, $p = 0.01$; Figure 7). No difference in estimated density was observed in pair-wise comparisons of total and line transect counts ($F = 0.03$, $p= 0.87$), total and pellet counts ($F = 3.36$, $p = 0.16$) or line transect and pellet counts ($F = 0.25$, $p = 0.65$). Precision was higher using total counts than both line transect ($F = 16.33$, $p = 0.03$) and pellet ($F = 13.51$, $p = 0.03$) counts, and line transect counts tended to be more precise than pellet counts although this result was not statistically significant ($F = 7.86$, $p = 0.07$). Importantly, neither sampling method consistently over- or under-estimated kangaroo density compared to total counts.

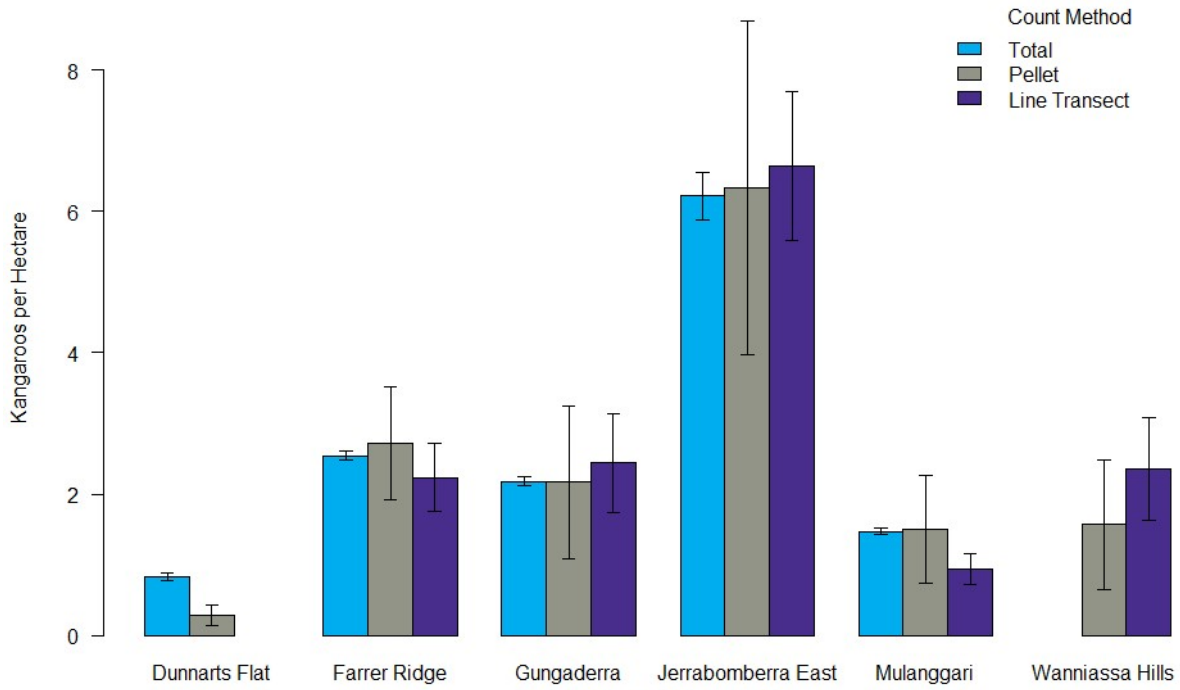

Figure 7. Kangaroo density estimates (mean ± SE) based on up to three methods across six sites. Estimates derived from pellet counts at Jerrabomberra East and Wanniassa Hills are based on plots within the Nature Reserve component of the KMU only.

DISCUSSION

This study has shown remarkable consistency between the various methods used to estimate kangaroo density within Canberra's peri-urban reserves. Given the variability between sites in terms of topography and vegetative cover, as well as in the density of kangaroos being counted, this result suggests that each of these methods can be confidently applied across the majority of Canberra's lowland reserves in order to assist with kangaroo research or effective kangaroo management.

Estimates of kangaroo density by total count methods (direct and sweep counts) showed high levels of consistency between the four component counts (both within and between days) and good precision overall. , supporting our preference to use these methods to estimate kangaroo populations where possible. Due to the strong community support for the kangaroo management program, leading to much of the person-power required for sweep counts being provided by volunteers

The greater error surrounding estimates arrived at using pellet counts in this research is of particular interest, despite the density estimates reached using this method being statistically comparable to the others assessed. As was identified by Parkes and Forsyth (2013), the calculation of error using this method does not take into consideration the error introduced by the use of a published defecation rate; and so would in fact be even greater than that reported here. In our prior local calculations of defecation rate (based on measurements of faecal pellet accumulation per kangaroo per day in sites with comparable herbage mass) we have recorded hugely variable

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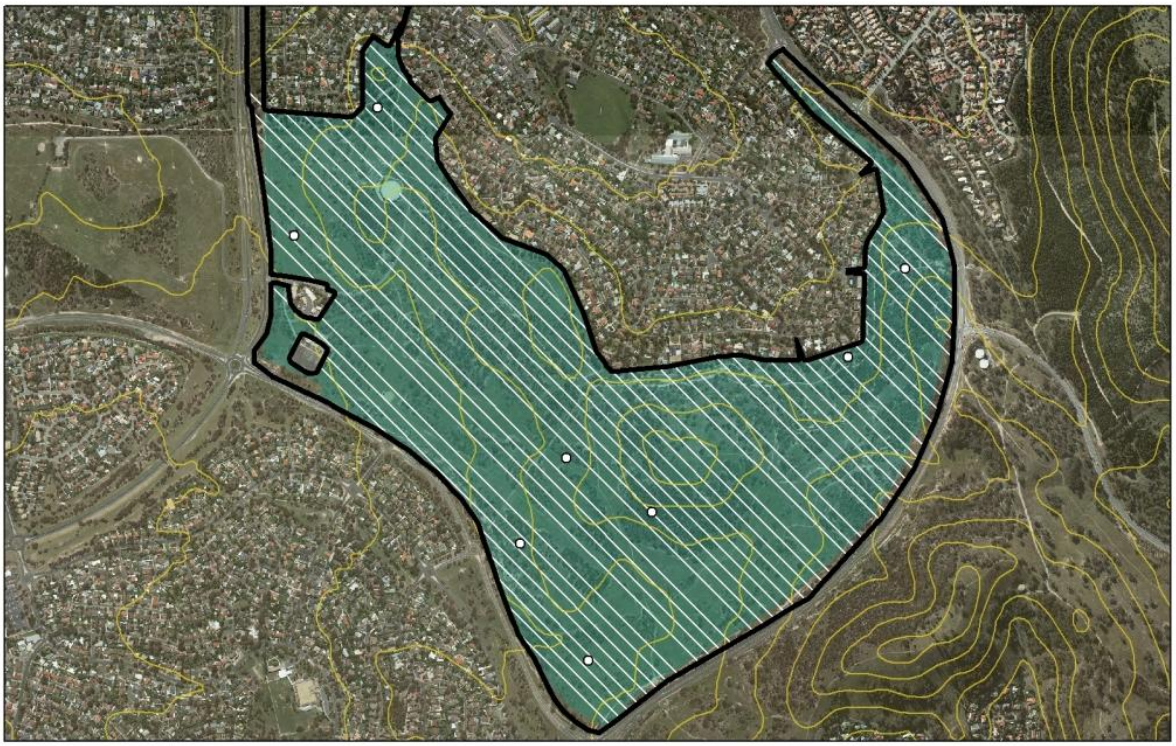
APPENDIX: MAPS OF COUNT AREAS

survey transect 20m contour line nature reserve KMU border pellet plot

Dunnarts Flat KMU

Mulanggari KMU



Farrer Ridge KMU

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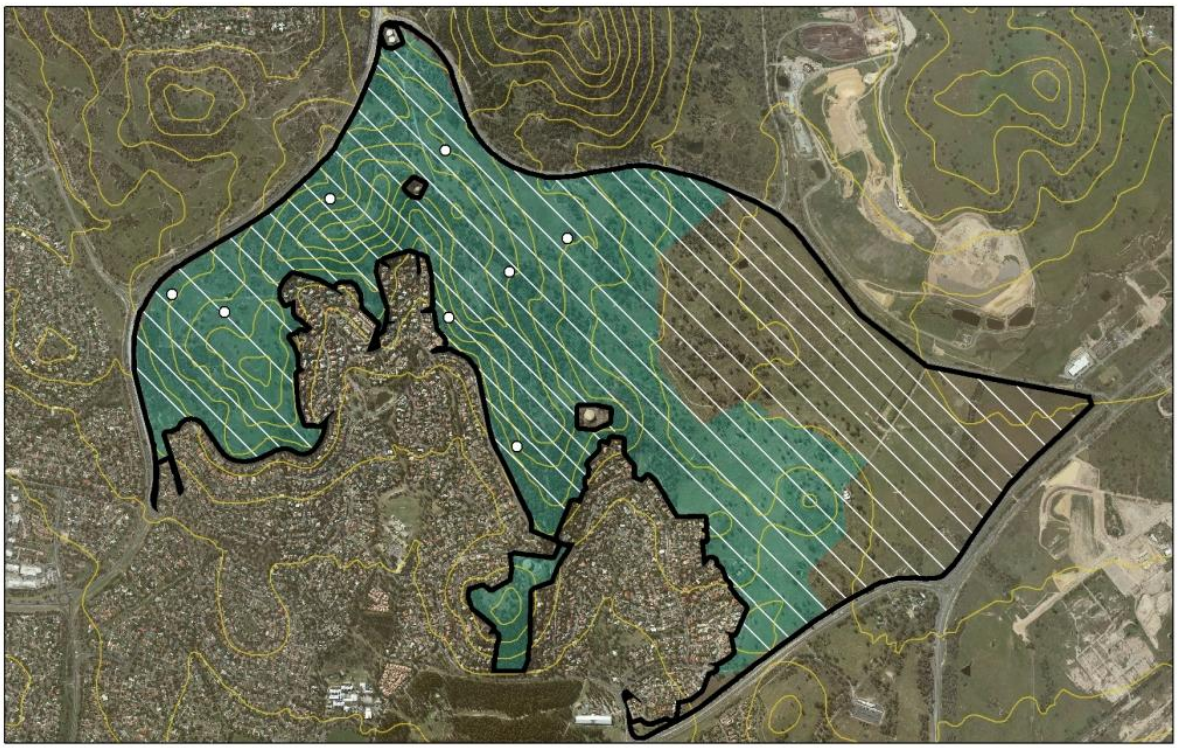

Wanniassa Hills KMU

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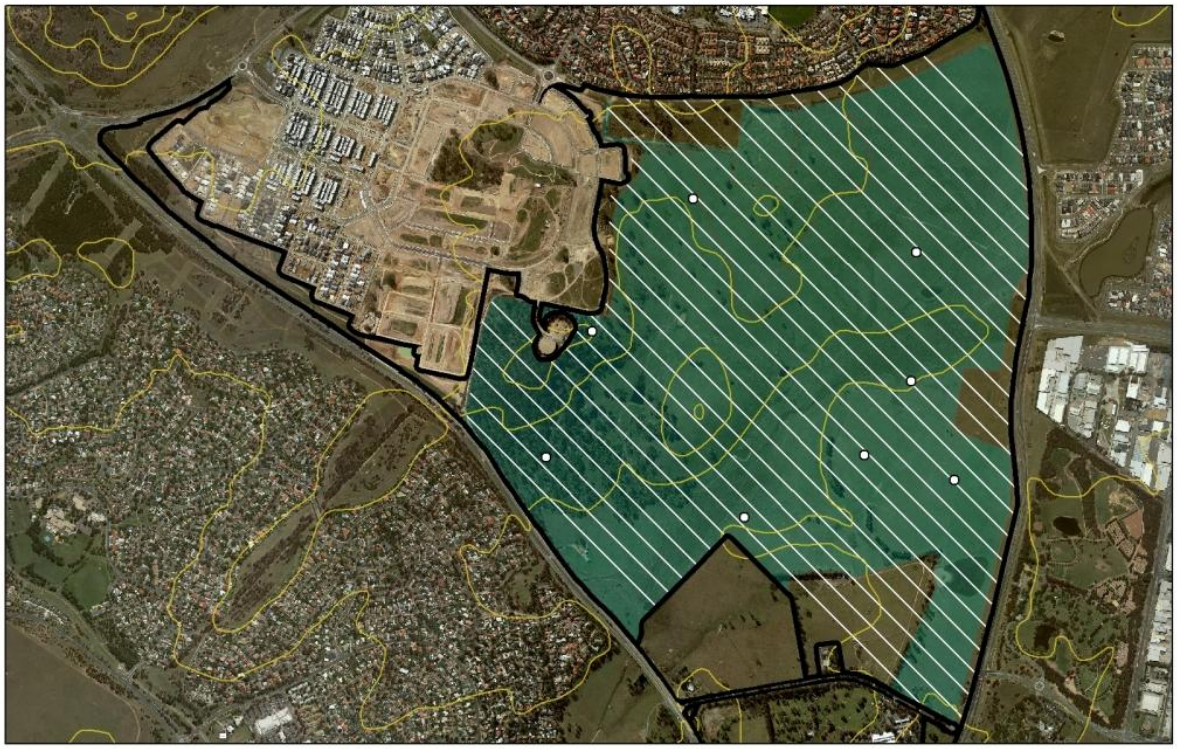

Gungaderra KMU

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Jerrabomberra East KMU

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ACT Government

Directorate name
Long name

Date 2016

Kangaroo management on a localised scale: an evaluation of effectiveness

Stephanie Pulsford and Melissa Snape

Research Report Series

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Conservation Research
Environment, Planning and Sustainable Development Directorate

June 2019

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Telephone: Access Canberra 13 22 81

Front cover: Revegetation efforts and barriers to herbivory put in place by the Friends of Mount Majura at Canberry Fair.

Contents

Summary

Highly abundant and widespread Eastern Grey Kangaroos (hereafter 'kangaroos') are associated with a range of environmental, social, and economic impacts within the ACT (ACT Government 2017). Kangaroo management within urban reserves is currently undertaken through the conservation culling program to minimise the environmental impacts of kangaroos on grassy ecosystems. Kangaroos are managed and monitored at the scale of the Kangaroo Management Unit (KMU), which comprise areas bordered by barriers that restrict kangaroo movement such as suburban edges, major roads or impenetrable fence lines.

Due to the limited operational capacity of the conservation culling program, it may not be feasible to reduce large kangaroo populations in some large sites to appropriate levels within the ideal timeframe. To address this issue, an adaptive management trial was undertaken in the Ainslie Majura KMU to assess the feasibility of managing kangaroo populations at a smaller, sub-KMU scale. The trial involved targeted culling within 'Canberry Fair' in 2016 and 2017. Regular monitoring of local kangaroo density within the culled area and a comparable un-culled area, 'Campbell Park', was undertaken to enable comparison of population responses to different management strategies. Kangaroo counts were also conducted at the full Ainslie Majura KMU scale to provide insight into broader population changes during the study period.

The density of kangaroos at Canberry Fair decreased immediately after both culls but increased again in subsequent surveys. Population responses indicated that home-ranges of remaining animals likely shifted to outside of the managed area in response to culling operations, but that immigration subsequently compensated for the effects of culling at the local scale over an annual timeframe. Despite removal of approximately 70% and 20% of the local Canberry Fair kangaroo population in 2016 and 2017 respectively, the kangaroo density was at 86% of the initial density by the end of the monitoring period. Fluctuating population densities in the un-culled Campbell Park area provided further evidence that populations were unstable at the sub-KMU scale.

The limited area cull resulted in only a marginal reduction of kangaroos within the target area at Canberry Fair, at a time when the density across the entire KMU was experiencing greater declines. These findings indicate that immigration and emigration significantly influence population dynamics at the small scale, and support the existing policy that effective management of kangaroo impacts requires identification of the functional kangaroo management unit, and subsequent density reductions at that scale.

1 Introduction

The Eastern Grey Kangaroo (*Macropus giganteus*) is an abundant and widespread species found throughout the woodlands and grasslands of the Australian Capital Territory (ACT). Eastern Grey Kangaroos (hereafter 'kangaroos') are a relatively gregarious species that form temporary and fluid groups known as "mobs" and have been demonstrated to occupy reasonably stable home ranges over the long term (Viggers and Hearn 2005; ACT Government unpublished).

While a significant element of the fauna of the region, kangaroos are currently managed to minimise their environmental impacts on grassy ecosystems (ACT Government 2017). Current management of kangaroos in the ACT is outlined in detail in the Eastern Grey Kangaroo: Controlled Native Species Management Plan (ACT Government 2017).

The monitoring and management of kangaroo populations in the ACT is conducted by defining occupied areas into Kangaroo Management Units (KMUs). KMUs often encompass lands of different tenure, including Nature Reserves or other Territory lands managed by the ACT Government, National Lands managed by the Commonwealth Government and/or leased Territory Lands managed privately by the lease holder (ACT Government 2017). In most cases, the boundaries of each KMU are defined by barriers that restrict kangaroo movement, such as the suburban edge, a major road, water body, or impenetrable fence line. The calculation of the target kangaroo density (number per hectare) to preserve biodiversity within a particular KMU is calculated according to the vegetation composition of the area managed for conservation. Management targets for culling are set based on the difference between the current population size and the target number.

The Ainslie Majura KMU is a large area (> 2000 ha) comprising a mix of critically endangered grassland and woodland lowland ecosystems, and steeper more densely forested terrain. It has a complex network of tracks and trails and is heavily utilised by the public for commuting and recreation. The area contains an array of land tenures, including two gazetted Nature Reserves (Mt Ainslie and Mt Majura), Environmental Offsets (West Majura grasslands), private leases (including sheep grazing properties, a vineyard and truffle farm), commercial pine forest, Commonwealth managed grasslands, privately run horse paddocks, and the grounds of the Australian War Memorial. In 2016, the kangaroo population was estimated to be approximately 4000 kangaroos higher than the target density recommended for grassy layer conservation (ACT Government 2016), cumulating in severe evidence of overgrazing and a high risk of erosion despite thousands of ACT Government staff and volunteer hours being committed to preserving the biodiversity of the reserved areas each year (The Conservation Council 2013). As the operational capacity for the conservation cull of kangaroos in the ACT is only around 3500-4000 annually for the whole of the Canberra Nature Park network, an adaptive management trial was undertaken in the Ainslie Majura KMU to assess the feasibility of an alternative approach to protect localised biodiversity values within this complex site.

This project aimed to address the overarching question: "*Can a local kangaroo population be effectively managed at the sub-KMU scale?* Based on kangaroo home range and movement data collected using GPS collared kangaroos from across Canberra Nature Park (ACT Government, unpublished, this project explored a new approach to attain effective conservation culling of kangaroos in areas such as Ainslie-Majura KMU, where the KMU scale management approach taken elsewhere may not be feasible. As kangaroos from unmanaged populations within Canberra Nature

Park have relatively small, stable home ranges (less than 1 km^2) and undertake very few excursions outside of this home range (ACT Government, unpublished; Figure 1), it was proposed that a targeted reduction in kangaroo density through culling may be effective in achieving a sustained, localised reduction in the kangaroo population with consequent benefits to biodiversity.

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2 Methods

Study Sites

To assess the relative changes in kangaroo population density in response to a localised culling program, two 'target' areas were identified within the Ainslie-Majura KMU. Each target area consisted of open grassy woodland, likely representing the preferred kangaroo habitat available within the broader KMU, surrounded by a buffer area (~1 km radius) which was considered likely to support individual kangaroos whose home range included some or all of the target area (Brunton et al. 2019).

The treatment area identified for localised culling in this study was 'Canberry Fair' in the north of the Ainslie-Majura KMU, which included a 98 ha target area surrounded by a 616 ha buffer consisting predominantly of denser forest, a privately managed horse paddock and a rural lease. Culling operations were undertaken across both of these areas in an effort to avoid the rapid recolonization of the target area by neighbouring (food limited) individuals which was otherwise anticipated (Figure 1).

An experimental control area (i.e. no culling in the target area) was also established at Campbell Park at the southern end of the broader KMU, which consisted of a 231 ha target area surrounded by an 883 ha buffer consisting of denser forest, rural lease, privately managed horse paddocks and Commonwealth managed land (Figure 2).

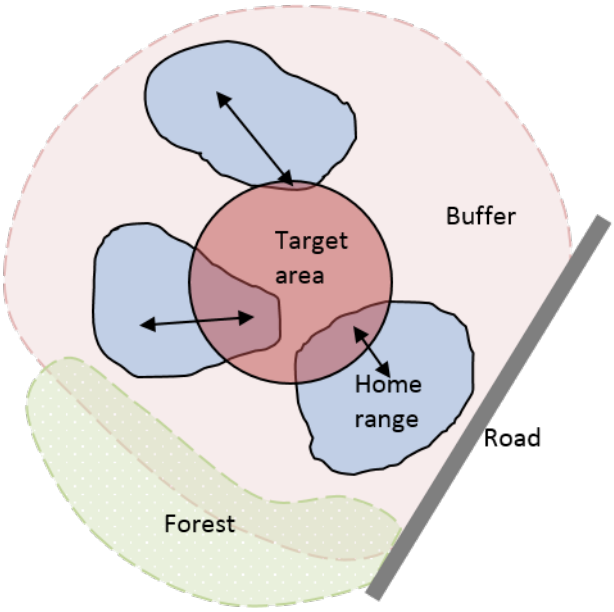

Figure 1. Achieving a sustained population reduction in the target area was considered more likely if culling was undertaken in both the target area and adjacent buffer area, to avoid kangaroos with home ranges overlapping both the target and buffer areas from shifting toward an increased use of the target area (hence lessening the effect of localised culling).

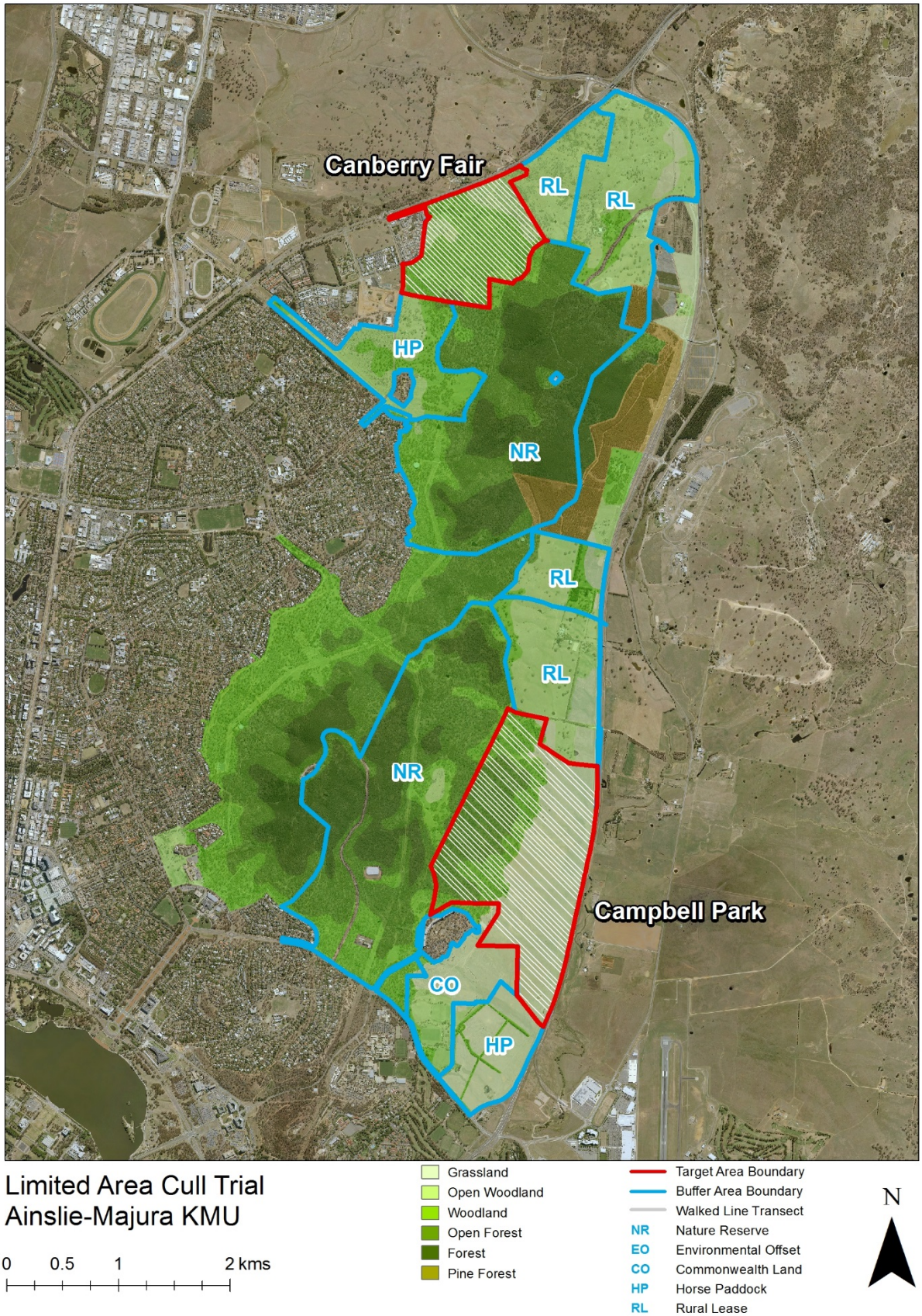

Figure 2. Map showing the Canberry Fair (culled) and Campbell Park (un-culled) target areas and their associated buffer areas within the greater Ainslie-Majura Kangaroo Management Unit.

Kangaroo Culls

Kangaroo culls were undertaken within the Canberry Fair area during late autumn and winter, with 800 and 237 animals being removed from the site in 2016 and 2017 respectively. The culling in 2016 targeted animals from across the Canberry Fair target and buffer areas whilst in 2017 the vast majority of animals were removed from the target area alone. No kangaroo culling occurred within the target area of Campbell Park, however a total of 92 (in 2016) and 300 (in 2017) animals were removed from Campbell Park buffer area.

The total number of kangaroos to remove from each area was calculated in accordance with the Eastern Grey Kangaroo: Controlled Native Species Management Plan (CNSMP), and associated calculator instruments. Culling operations were undertaken by accredited shooters in accordance with the CNSMP and the National Code of Practice for the Humane Shooting of Kangaroos for Non-Commercial Purposes.

Population assessments

Kangaroo density was assessed three times annually within both the Canberry Fair and Campbell Park target areas using the walked line transect method (WLT) (Buckland et al. 2001; Buckland et al. 2015). Specifically, counts were undertaken in May, September and December 2016, in March, July and December 2017, and in March 2018. An annual assessment of kangaroo density at the broader KMU level was also undertaken annually in autumn. For each survey, predetermined transects were walked by an observer who recorded the distance and bearing to each group of kangaroos observed, as well as the number of individuals within each group. The total transect distance for each component was 26.2 km for Canberry Fair, 47.5 km for Campbell Park, and 43.3 km for Ainslie Majura KMU.

Table 1. Timing of kangaroo density surveys and anticipated population responses based on population demographics typical for seasonally breeding kangaroos in the ACT (ACT Government 2017).

Survey Timing	Expected Population Change
Winter	Stable, unless populations reduced through culling
Spring	Decrease in food limited populations due to increased juvenile mortality in late winter[1]
Summer	Increase due to pouch young emergence in late spring
Autumn	Stable, low recruitment or mortality expected

[1] (see Portas and Snape 2018)

Statistical analysis

Data from walked line transect surveys were collated in Microsoft Excel before individual kangaroo group locations were stratified against vegetation and land tenure layers in ArcMap 10.5.1 (ESRI 2017). Population density and abundance was then estimated using distance sampling in the

program Distance (Thomas et al. 2010) or the Distance package of R (Miller 2017), using the radial distance and angle to each individual kangaroo group (i.e. observations were taken as clusters). Density estimates were analysed separately to give individual counts for each site and survey period. In all analyses, site was used as the stratum layer, transect was used as the sample layer, and the observation layer included the distance, angle, cluster size and covariate data. Both Conventional Distance Sampling (CDS) and Multiple Covariate Distance Sampling (MCDS) models were performed, with the best model for each dataset determined using Akaike's Information Criterion (AIC). Detection functions explored included the key functions of half normal, hazard and uniform, with adjustments of cosine, hermite polynomial and simple polynomial where appropriate. Covariates analysed were: vegetation class ('woodland', 'open woodland', 'grassland', 'forest', 'open forest' or 'pine forest'), vegetation types ('open' or 'woody), and/or land tenure ('conservation' or 'grazing'). Truncation and binning were used as appropriate to fit the distance functions.

The number of kangaroo deaths through vehicle collisions was calculated from the records of collected by ACT Parks and Conservation wildlife officers who are called out in the event of wildlife vehicle collisions in the ACT. For the 12 months prior to the kangaroo counts in Ainslie Majura in 2017 and 2018, all records for kangaroo vehicle collisions that occurred within a 400m buffer of the Ainslie Majura KMU were tallied. A 400m buffer was used as this captured the majority of kangaroo records that likely originated from within the KMU.

3 Results

The changes in population density within each component area of the broader Ainslie-Majura KMU, and the KMU as a whole, are shown in Figure 3, with reference to the timing of the culls at Canberry Fair and within the buffer areas of Campbell Park.

At Canberry Fair, the pre-cull density of kangaroos in May 2016 was 1.6 animals per hectare. By the subsequent survey in September 2016, this density had reduced by 43% to 0.9 animals per hectare, despite 1.12 animals per hectare having being culled from the area in the interim. By December 2016, after the period of expected pouch young emergence, the population had increased by 55% to 1.4 animals per hectare and by March 2017 an additional 23% population increase brought the kangaroo density within the target area of Canberry Fair back to 1.72 animals per hectare, or 106% of the pre-cull density (Figure 3a). In the second year, a smaller cull of a 0.33 animals per hectare (~19%) resulted in a 30% reduction in the population density to 1.21 animals per hectare by July 2017. Subsequently, increases of only 11% (to 1.34 animals per hectare) and 3% were observed to December 2017 and March 2018 respectively, leaving the population at 1.38 animals per hectare, or 80% of the 2017 pre-cull density. This final survey in autumn 2018 saw the population to be 86% of its initial density after the two years and two culls.

At Campbell Park, significant fluctuations in the population density were observed which were inconsistent in both scale and timing with anticipated natural processes of recruitment (late spring/early summer) and mortality (late winter/early spring; Figure 3a). With an initial density of 5.4 animals per hectare in May 2016, and a small amount of culling taking place in the buffer area during autumn and early winter of the same year, population density in this area was observed to increase

by 9% to September 2016, but decline by 24% over summer and autumn (during the period of anticipated peak recruitment). Similar trends were observed in 2017 with a 26% increase in population density between March and July (corresponding with a larger cull within the adjacent buffer) followed by a 13% decline to December 2017 and 9% increase to March 2018.

The population as a whole in the Ainslie Majura KMU declined across the three annual counts between autumn 2016 to autumn 2018 (Figure 4b). Between the autumn of 2016 and 2017, the population had declined by 23% after approximately 15% of the population had been culled and a further 9.9% (n=447) had been killed as a result of vehicle collisions (ACT Government 2017, unpublished data). A further reduction of 21% was observed between autumn 2017 and autumn 2018, with 11% of animals having been removed through culling and 8.9% of the population (n=316) having been killed on nearby roads over a similar timeframe (ACT Government 2018, unpublished data).

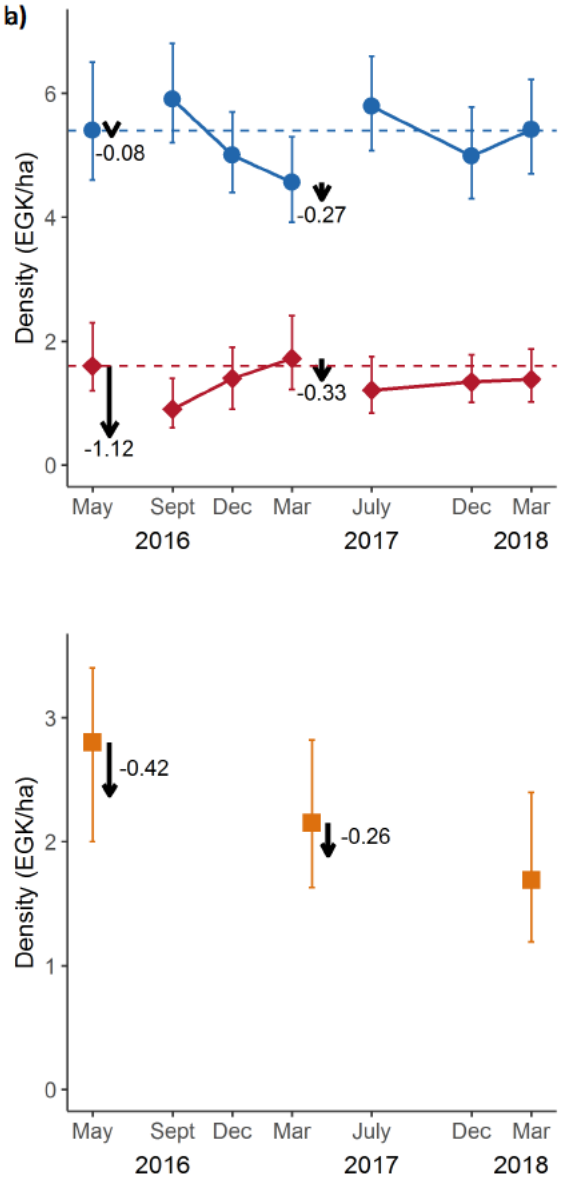

Figure 3. The change in density of kangaroos in the target areas at Canberry Fair (red diamonds) and Campbell Park (blue circles) (a), and across the entire Ainslie Majura KMU between autumn 2016 and autumn 2018 (b). Dashed lines indicate initial kangaroo density at each site. The arrows indicate the timing and size (density) of the culls within the respective areas

(see text for details).

4 Discussion

Over two years, the limited area cull trial at Canberry Fair was associated with a modest reduction in kangaroo density within the target area relative to the initial levels. However, significant changes in population density at Canberry Fair throughout this time could not be solely attributed to the cull and subsequent population growth through recruitment, especially given that the population decline in the Canberry Fair target area (14% decline) was far less than that observed more broadly at the KMU scale (40% decline) over the same time period.

In 2016, the cull which removed 1.12 animals per hectare from Canberry Fair and its buffer area failed to achieve the anticipated reduction in population density at the September count (2 months post cull) of that year. Although the proportion of animals removed from the target area versus the buffer was unknown for this cull, the sharp increases in population density between subsequent surveys of the target area in December 2016 and March 2018 were likely too great to be explained by recruitment alone. This strongly indicates that animals remaining in the adjacent areas had shifted their home ranges into the Canberry Fair target area after the first cull. Conversely, the density of kangaroos in Canberry Fair was lower than expected 1 month after the second cull (i.e. in July 2017), which may indicate that some remaining individuals were temporarily displaced from the target area as a result of culling operations.

In both 2016 and 2017, the population density in the Campbell Park target area increased during late autumn and winter (9% between May – September in 2016; and 26% between March – July 2017) a period usually associated with steady or declining populations due to a peak in resource-dependent natural mortality (i.e. starvation or increased vehicle strike due; (Dunne 2017; Brunton et al. 2019)). This unseasonal increase in kangaroo density may again have resulted from culling in the adjacent Campbell Park buffer area, temporarily displacing animals into the adjoining “safe” area of the Campbell Park target area where no culling was being undertaken. Conversely, the period usually associated with increases in population density due to natural recruitment (late spring to summer) was associated with population decreases in the Campbell Park target area across both years (-15% in 2016 and -13% in 2017). These declines may either be indicative of significant natural mortality due to starvation (Portas and Snape 2018) or increased vehicle strike (Dunne 2017) in late winter and early spring; or represent a return of migrant kangaroos back into adjacent areas in response to a decrease in the perceived threat outside of the mixed sex culling season of March – July (ACT Government 2010).

The overall density of kangaroos across the entire Ainslie Majura KMU reduced substantially between autumn 2016 and autumn 2018, during which time the two limited area culls took place. It is clear that these declines were driven by more than culling alone, as the reduction in numbers within Ainslie Majura was far greater than the number of kangaroos removed. The main causes of population decline in peri-urban populations of kangaroos in Canberra (other than culling) are considered to be starvation in food limited populations, (Portas and Snape 2018), vehicle-strike (Dunne 2017), and predation by native or introduced predators (Banks et al. 2000; ACT Government

2010). Whilst the relative contribution of each of these factors is likely to be site specific, high reports of vehicle strikes on suburban roads surrounding this KMU coupled with serious deficiencies in ground layer vegetation provide grounds (ACT Government, unpublished data) for significant alternative causes of mortality at this site. Moreover, decreases in population density at Ainslie Majura above those accounted for by culling are consistent with those observed at other food limited sites across the ACT, especially during 2016-2017 when population reductions of between 10% and 35% were observed across two of three comparable sites (ACT Government, unpublished data).

5 Conclusion and management implications

Evidence of effective (and sustained) kangaroo management at the local (i.e. sub-KMU) scale was not demonstrated in this study. Changes in kangaroo density observed within both the Canberry Fair and Campbell Park target areas did not match predicted responses from culling and recruitment alone, indicating that immigration and emigration, possibly in response to disturbance caused by management activities, have a strong impact on population density at the sub-KMU scale.

These findings support the ongoing management of kangaroos at the whole of KMU scale, as the most effective means of reducing population density and associated grazing impacts in areas of high conservation significance.

6 References

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ACT Government. (2016) *Calculation of the number of kangaroos to cull - Internal report.* Canberra: Environment, Planning and Sustainable Development Directorate.

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Banks PB, Newsome AE & Dickman CR. (2000) Predation by red foxes limits recruitment in populations of eastern grey kangaroos. *Austral Ecology*, *25* (3), 283-91.

Brunton EA, Srivastava SK & Burnett S. (2019) Spatial ecology of an urban eastern grey kangaroo (Macropus giganteus) population: local decline driven by kangaroo–vehicle collisions. *Wildlife Research*, *45* (8), 685-95.

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Buckland ST, Rexstad EA, Marques TA & Oedekoven CS. (2015) *Distance sampling: methods and applications*: Springer.

Dunne B. (2017) *Spatio-temporal analysis of kangaroo-vehicle collisions in Canberra, Australia.* Master of Environment (Advanced), The Australian National University, 81

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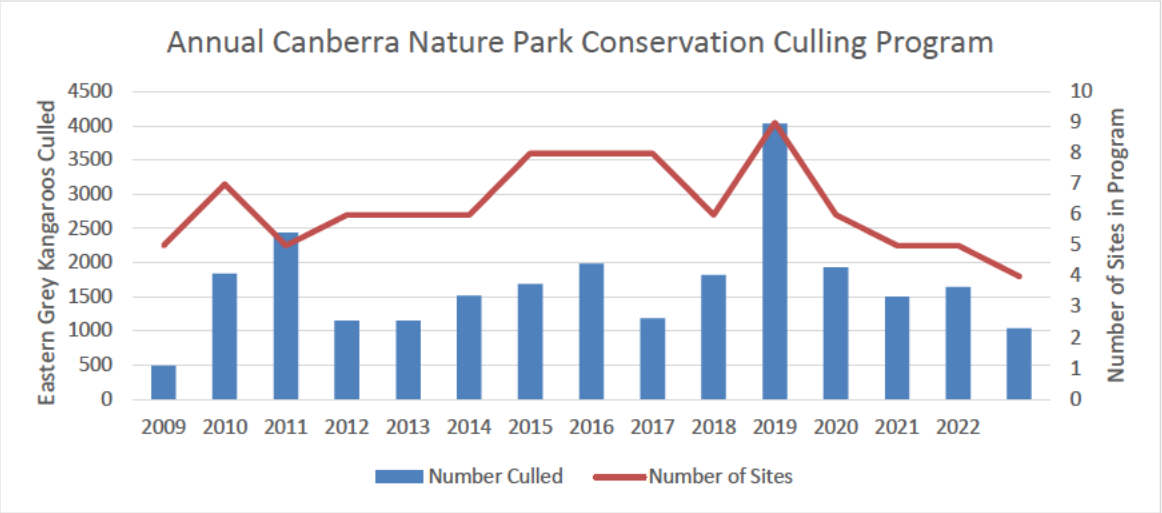
The Conservation Council. (2013) History of Mt Majura, Fact sheet 8 2013. In, http://majura.org/wp-content/uploads/2009/04/History-of-Mt-Majura.pdf.

Thomas L, Buckland ST, Rexstad EA, Laake JL, Strindberg S, Hedley SL, Bishop JRB, Marques TA & Burnham KP. (2010) Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology*, *47* (1), 5-14.

Viggers K & Hearn J. (2005) The kangaroo conundrum: home range studies and implications for land management. *Journal of Applied Ecology*, *42* (1), 99-107.

Year	Total Cull	No. Sites
2009	494	5
2010	1839	7
2011	2439	5
2012	1154	6
2013	1149	6
2014	1521	6
2015	1689	8
2016	1989	8
2017	1186	8
2018	1822	6
2019	4035	9
2020	1931	6
2021	1505	5
2022	1645	5
2023	1041	4
Total	25439	



Summary of information

- The conservation culling program aims to protect the critically endangered grassy ecosystems within Canberra Nature Park from the threat of overgrazing by kangaroos.
- The program began in 2009, and has continued annually for 14 years
- The numbers of kangaroos to remove from individual management units is determined based on the Conservation Culling Calculator which sits under the Eastern Grey Kangaroo: Controlled Native Species Management Plan (ACT Government, 2017)
- Since 2019, herbage mass monitoring and more sophisticated modelling has allowed these calculator outputs to be adjusted to account for the current condition of ground layer vegetation.
- The herbage mass monitoring is also used to assess the effectiveness of kangaroo management in achieving biodiversty benefits
- Managing kangaroos at any given site usually involves larger initial reductions in kangaroo population density over 1-3 years, followed by smaller annual 'maintanence' programs to maintain an equilibrium between kangaroo grazing pressure and grassy habitat
- The capacity of the program has increased over time, enabling new sites within Canberra Nature Park to be added to the program based on prioritisation of conservation values and consideration of operational constraints
- The wetter than average conditions in the last 3 years has resulted in good vegetation recovery at sites where kangaroos have been regularly managed. This has meant that reduced or no culling has been required at some sites since 2020.

- Note - the data provided for the 2019 report included cull numbers for Googong Foreshores in some years, Googong has now been excluded from all years so the data reflects sites only within Canberra Nature Park and within the ACT.
- Note - number of 'sites' has been provided to keep data consistent with what was provided for 2019 however some sites have been combined in some years. It might be better to provide number of 'reserves' instead, please let me know if you would like that information instead.

From: [redacted]
Sent: Tue, 19 Dec 2023 18:25:44 +1100
To: Wimpenny, Claire
Subject: RE: docs

OH – PS – do you have a file with each years' population estimates (and #sites) as well?

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Tuesday, December 19, 2023 6:14 PM
To: [redacted]
Cc: Keighley, Miles <Miles.Keighley@act.gov.au>
Subject: docs

OFFICIAL

Hi Sarah,
Here are some of the docs you are looking for.
I can't find anything about looking at the replication of sweep and direct counts but it was definitely done in response to the 2014 review recommendations. I'll ask Mel when she's back. Actually, is there anything you would like to chat to Mel about? She has been away for the last couple of months but will be back in Jan.
I have most of the rural cull records, just missing a couple of years, so I will send that in the next few days. Also, did you want the number of PY killed in the conservation cull? The attached file just has adults but I can add PY to it without too much trouble.

Miles – I found a digital copy of the Morgan and Pegler paper so could you please just have a look for this one at DOB:

- Fletcher D 2006b. What process limits the high-density populations of eastern grey kangaroos at Gudgenby and other local sites? in *Caring for Namadgi: Science and People*, ed. National Parks Association of the ACT (National Parks Association of the ACT, Canberra.):pp. 61–77.

Regards,

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
Phone +61 2 6205 8252 | Email claire.wimpenny@act.gov.au

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Conservation Research Website | EPSDD Environment Science Platform | View our story map collection here!

I acknowledge the Ngunnawal people as traditional custodians of the ACT and recognise any other people or families with connection to the lands of the ACT and region. I acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

From: Wimpenny, Claire
Sent: Tue, 19 Dec 2023 20:41:09 +0000
To: [redacted]; Howland, Brett
Subject: RE: figure
Attachments: Brett Howland Grassland figure.png

OFFICIAL

Hi Sarah,
Is this version better? I copied it from the powerpoint presentation.

Regards,

Claire Wimpenny

Senior Ecologist
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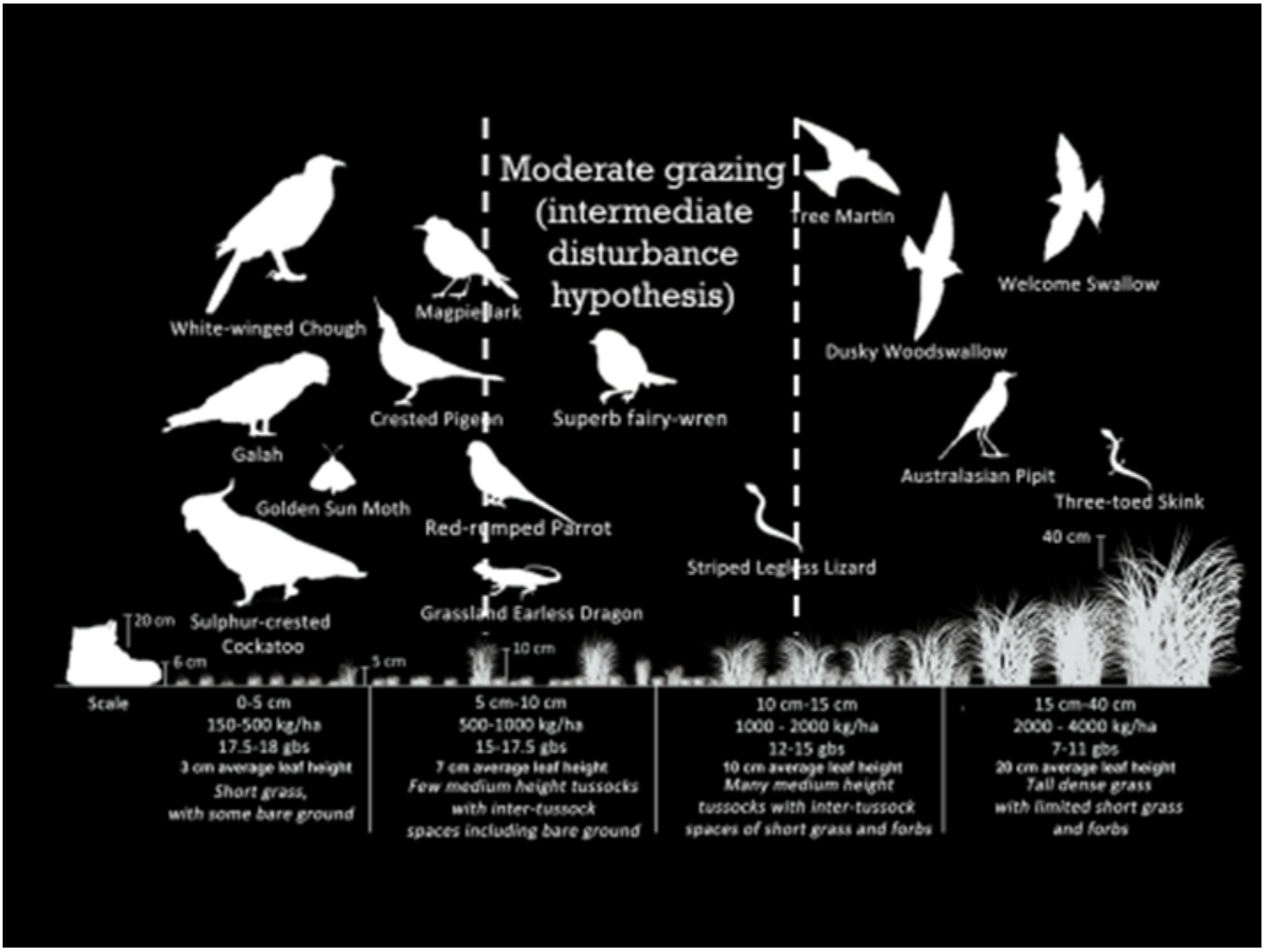
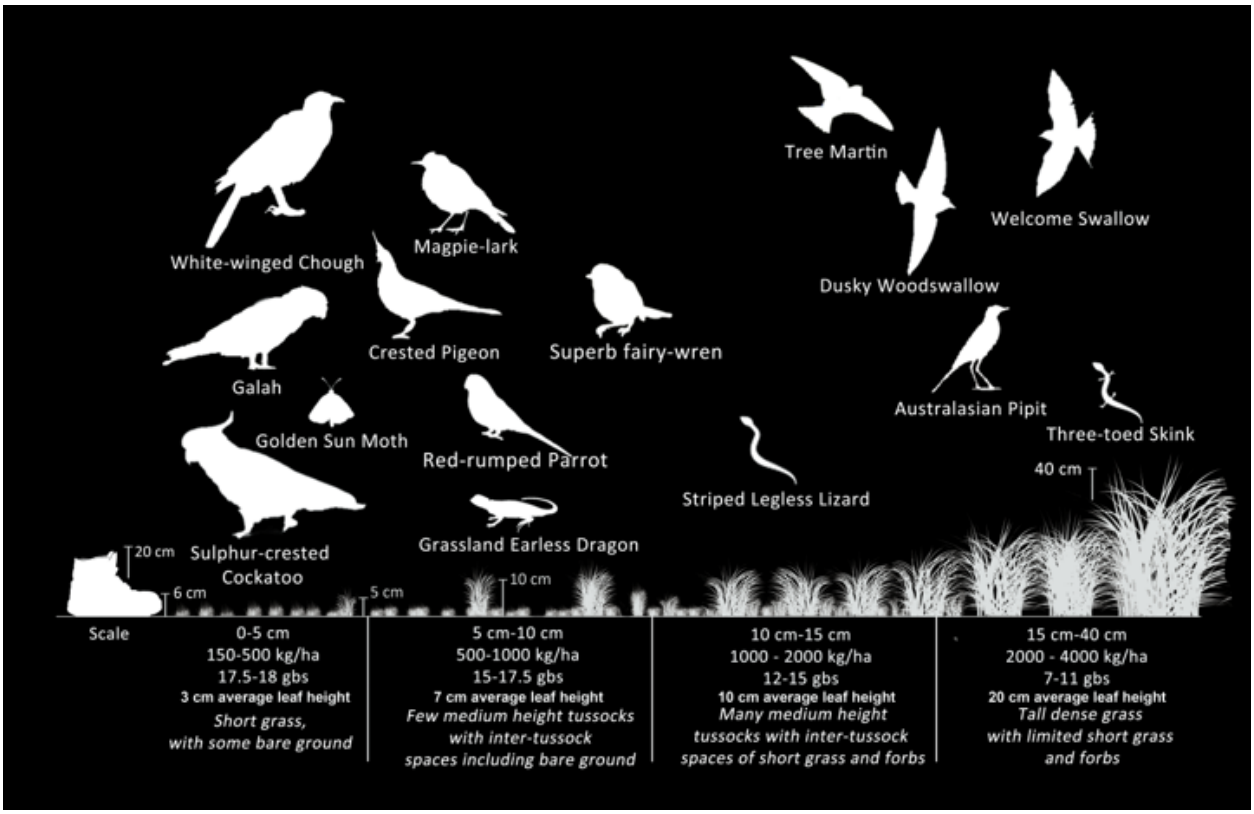
---

From: [redacted]>
Sent: Wednesday, 20 December 2023 6:51 AM
To: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>; Howland, Brett <Brett.Howland@act.gov.au>
Subject: figure

Hi Claire, Brett
Do you have this figure or a similar one at a better resolution? It is fig 8 in the 2018 workshop report, and I think its in one of your papers Brett. I will probably stick it in the report, it is very helpful for getting the point over. Its ok if you cant easily get it, I can recreate it.
S


Moderate grazing (intermediate disturbance hypothesis)
White-winged Chough
Magpie-lark
Tree Martin
Welcome Swallow
Dusky Woodswallow
Crested Pigeon
Superb fairy-wren
Galah
Australasian Pipit
Three-toed Skink
Golden Sun Moth
Red-rumped Parrot
Striped Legless Lizard
Grassland Earless Dragon
Sulphur-crested Cockatoo
20 cm
6 cm
5 cm
10 cm
40 cm
Scale
0-5 cm
150-500 kg/ha
17.5-18 gbs
3 cm average leaf height
Short grass, with some bare ground
5 cm-10 cm
500-1000 kg/ha
15-17.5 gbs
7 cm average leaf height
Few medium height tussocks with inter-tussock spaces including bare ground
10 cm-15 cm
1000 - 2000 kg/ha
12-15 gbs
10 cm average leaf height
Many medium height tussocks with inter-tussock spaces of short grass and forbs
15 cm-40 cm
2000 - 4000 kg/ha
7-11 gbs
20 cm average leaf height
Tall dense grass with limited short grass and forbs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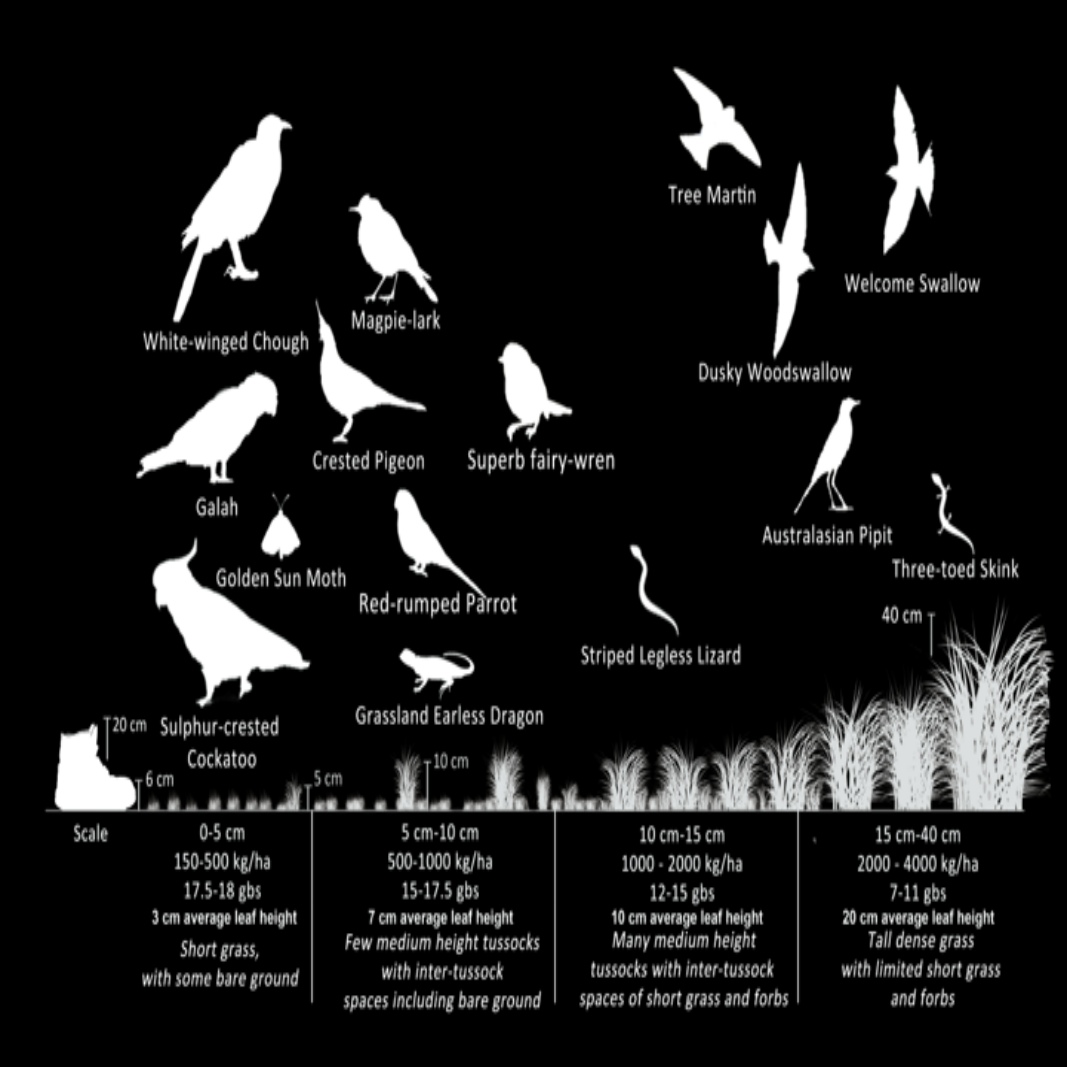
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Tall dense grass with limited short grass and forbs

From: [redacted]
Sent: Wed, 20 Dec 2023 13:29:24 +1100
To: Howland, Brett; Wimpenny, Claire
Subject: RE: figure

That would be handy Brett, bec I'll invert the colour and edit out any text I dont need. I can do that in photoshop if I start with a high res version.

Or else if you have the source file in an editable format, that would be the most perfect thing.

From: Howland, Brett <Brett.Howland@act.gov.au>
Sent: Wednesday, December 20, 2023 9:17 AM
To: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>; [redacted]
Subject: RE: figure

OFFICIAL

I have a high resolution version if needed.

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Wednesday, December 20, 2023 7:41 AM
To: [redacted] Howland, Brett <Brett.Howland@act.gov.au>
Subject: RE: figure

OFFICIAL

Hi Sarah,
Is this version better? I copied it from the powerpoint presentation.

Regards,

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
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480 Northbourne Avenue, Dickson ACT 2602| GPO Box 158 Canberra ACT 2601 | www.environment.act.gov.au

From: [redacted]
Sent: Wednesday, 20 December 2023 6:51 AM
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Subject: figure

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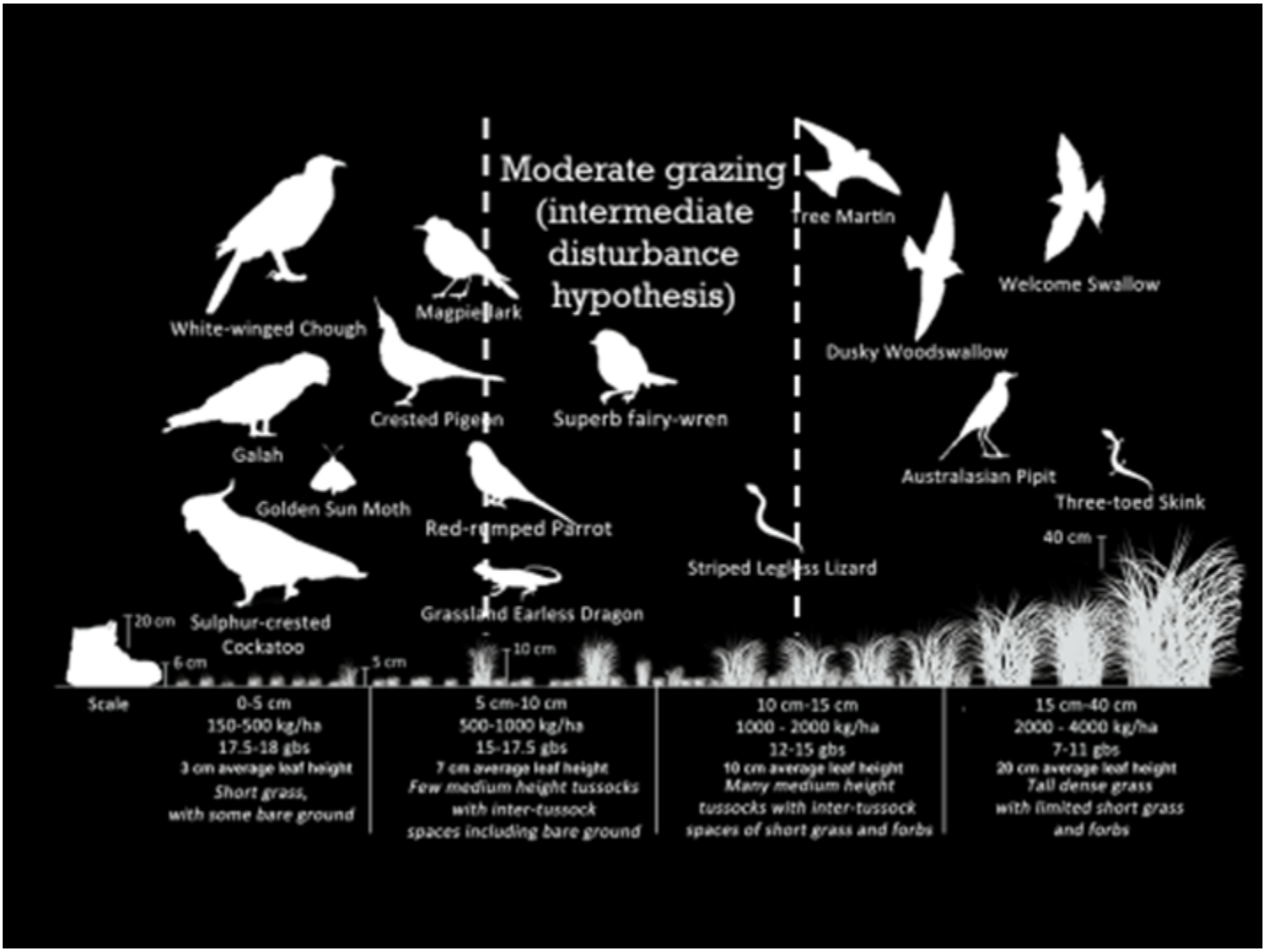

From: Sarah Legge
Sent: Thu, 21 Dec 2023 10:30:02 +1100
To: Keighley, Miles
Cc: Wimpenny, Claire
Subject: Re: docs

Don't worry about it, I can ask Don himself. thanks for looking.

Sent from my iPhone

> On 21 Dec 2023, at 10:28 am, Keighley, Miles <Miles.Keighley@act.gov.au> wrote:
>
> Hi Sarah,
> I'm afraid we don't have a copy of this at DOB or at Mitchell Depot:
>
> - Fletcher D 2006b. What process limits the high-density populations of eastern grey kangaroos at Gudgenby and other local sites? in *Caring for Namadgi: Science and People*, ed. National Parks Association of the ACT (National Parks Association of the ACT, Canberra.):pp. 61–77.
>
> If you would like I could ask Mim Jambrecina, head ranger at Namadgi?
> Cheers,
> Miles.
>
> ---
>
> **From:** [redacted]>
> **Sent:** Tuesday, December 19, 2023 6:25 PM
> **To:** Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
> **Cc:** Keighley, Miles <Miles.Keighley@act.gov.au>
> **Subject:** RE: docs
>
>
>
> **Caution:** This email originated from outside of the ACT Government. Do not click links or open attachments unless you recognise the sender and know the content is safe. Learn why this is important

Brilliant, thanks Claire.
Yes, better give me the info on PY, just so no one can say we are ignoring them.

And yes, I would love to meet and talk to Mel, but let's pick that up in Jan.

S

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Tuesday, December 19, 2023 6:14 PM
To: [redacted]
Cc: Keighley, Miles <Miles.Keighley@act.gov.au>
Subject: docs

OFFICIAL

Hi Sarah,
Here are some of the docs you are looking for.
I can't find anything about looking at the replication of sweep and direct counts but it was definitely done in response to the 2014 review recommendations. I'll ask Mel when she's back. Actually, is there anything you would like to chat to Mel about? She has been away for the last couple of months but will be back in Jan.
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Miles – I found a digital copy of the Morgan and Pegler paper so could you please just have a look for this one at DOB:

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Regards,

Claire Wimpenny

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Conservation Research Website | EPSDD Environment Science Platform | View our story map collection here!

I acknowledge the Ngunnawal people as traditional custodians of the ACT and recognise any other people or families with connection to the lands of the ACT and region. I acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

From: Wimpenny, Claire
Sent: Thu, 21 Dec 2023 11:02:47 +0000
To: [redacted]
Subject: Cath Herbert kangaroo vehicle collision report
Attachments: Stage 3 Report. Final Report and Draft Grant Application_FINAL.pdf

Hi Sarah,
Catherine Herbert said she is happy for me to share the kangaroo-vehicle collision report I mentioned the other day with you, see attached. I haven't read it yet. She's also happy for you to contact her if you like but she wont be back at work until the 15th Jan - [redacted]

I have a list of various other things to send you today/tomorrow.

Regards,

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
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From: [redacted]
Sent: Fri, 22 Dec 2023 08:31:57 +1100
To: McIntosh, Sally; Wimpenny, Claire
Subject: RE: carcass utilisation report

Got it, thanks Sally.
What an interesting report!
And same to you – have a good break, and catch you in the new year.
S

From: McIntosh, Sally <Sally.McIntosh@act.gov.au>
Sent: Thursday, December 21, 2023 1:50 PM
To: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>; [redacted]
Subject: RE: carcass utilisation report

OFFICIAL

Hi Sarah,

Please find attached the carcass utilisation report as requested by Claire.

Hope you manage a relaxing and enjoyable break over the Christmas period!

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Wednesday, December 20, 2023 2:28 PM
To: McIntosh, Sally <Sally.McIntosh@act.gov.au>
Subject: carcass utilisation report

OFFICIAL

Hi Sal,
Could you please send Sarah Legge [redacted] a copy of the carcass utilisation report? (assuming it's ok to share with her?) I couldn't find the final in the depths of Objective.
Hope your chat with her goes well today!

Regards,

Claire Wimpenny

Senior Ecologist

Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
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From: Wimpenny, Claire
Sent: Fri, 22 Dec 2023 05:38:28 +0000
To: [redacted]
Subject: Animal Welfare Advisory Committee meetings
Attachments: AWAC Meetings December 2023 - EGK plan review.docx

OFFICIAL

Hi Sarah,

I thought it might be worth me sharing my quick notes from the AWAC meeting on the 1st December and the meeting with the AWAC kangaroo sub-committee on 20th December, see attached.

Key questions from the group have been about: the need to engage a kangaroo welfare expert, treatment of PY, how numbers to cull are calculated, alternatives to shooting, fertility control.

The Chair expressed strongly that she would like the committees input to be incorporated into your draft before it is submitted to ACT Gov. A possible complicating factor in this is that after you meet with the sub-committee, she would like to submit a written position statement that has been endorsed by the whole committee. I'm not sure what sort of timing would be required for this, but I suggested they discuss the need for this when you meet.

Regards,

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
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Animal Welfare Advisory Committee Meeting – 1st December 2023

Notes on discussion about EGK CNSMP review:

Overall:

[redacted] (Chair) - The Committee are interested in participating in the external review process and will form a sub-committee to work on the issue. Would like to meet with CW initially to discuss current policies/program details that aren't in the 2017 plan so that can inform their input to SL.

Main individual comments/questions:

[redacted] ([redacted] – Stated the 2017 plan is old. Suggested meeting with CW prior to meeting with SL

[redacted]) – Suggested that a macropod welfare expert needed to be consulted. Asked if ACT Gov research would be peer reviewed.

[redacted]) – Does not agree with wording in current plan around the development of PY neurological system and onset of pain perception – said it needed to be reviewed, but might just be a matter of inappropriate wording. Asked if there were any new alternative methods to shooting (eg poisons, fertility control – I gave a quick update on current GonaCon work). Asked about methods for euthanasing PY and that this wasn't specified in the plan (I advised her it was addressed in the COP).

[redacted] – asked why the ACT Government blamed only kangaroos for negative impacts on threatened species when there are many other threats, including urban development. I explained that ACT Government doesn't just blame kangaroos, agree that there are many threats, kangaroo management is just one part of a suite of management tools that are used in reserves, these reserves are fragmented and impacted by many threats which is why it is so important to manage them carefully (not sure I did a very good job on this answer!)

Powerpoint slides provided to Secretariat.

Sub-committee meeting with CW arranged for 20th December.

Animal Welfare Advisory Committee Kangaroo Sub-committee Meeting – 20th December 2023

Members:

[redacted]

[redacted]

Prior to meeting:

[redacted] indicated the sub-committee would like to focus on the welfare aspects of the plan in this meeting, she also forwarded some questions from [redacted] who was unable to attend the meeting:

"My questions are mainly around:

1. *Ensuring updated science is used to inform the strategies around use of alternatives to shooting (eg reproductive control, humane drugs)*
2. *Reviewing the current methods for destroying pouch young (currently blunt trauma). There needs to be input from an expert in stunning and euthanasia methods to see if there are better ways this could be done (eg captive bolt, injectable euthanasia??). Eg [redacted] or [redacted] are vets who are both very knowledgeable about humane killing techniques. Or may be able to suggest someone*
3. *There are claims in the document about what age the neonatal joey becomes conscious, which don't look correct to me – I think this needs review (suggest Craig Johnston veterinary neurophysiologist at Massey Uni): Prof Craig Johnson - Professor of Veterinary Neurophysiology - Massey University. Or he may be able to suggest someone"*

I responded saying these questions were best directed to Sarah so they could be considered in the review (if they weren't already) but that I could address these topics at the meeting in terms of what we do now and why. I also provided them with a link to *McLeod and Sharp, 2014 Improving the humaneness of commercial kangaroo harvesting* for information relevant to questions 2 and 3.

At the meeting:

The beginning of the discussion focussed on the scope and timing of the review (recap of previous meeting) and I advised I would put [redacted] in contact with Sarah so that a meeting could be organised for early January. I mentioned that we were likely to have a draft report mid January but AWAC feedback could be included after that if required. The sub-committee were of the strong view that they would like their feedback incorporated before the draft is provided to ACT Gov. Genevieve also mentioned that they would like to provide a written position statement after the meeting with Sarah and that this would need to be endorsed by the wider AWAC committee (not just the sub-committee). This may impact timelines. I mentioned that other groups were contributing to the review verbally only but she could discuss options with Sarah.
They did express some concern that the review was being held at this time of year when people are busy/away.
[redacted] raised that it would be good for Sarah to talk to groups like Save Canberra's Kangaroos. I gave a rundown on which groups have been consulted and that the focus of this part of the review was engaging with key local groups. Broader public consultation would be undertaken when the new draft report is released. They were supportive of this approach.

Other topics that were discussed:

- [redacted] questions were mentioned and it was noted that I had provided the link to the McLeod & Sharp report – no one else had any addition questions related these topics.
- I provided some background information about the COP and the other animal welfare measures the ACT has (shooter testing, culling season, vet audits), also talked about terminology of counts and culls are of "independently mobile animals" – includes YAF, sub-adults and adults but excludes PY).
- [redacted] asked whether "euthanasia" was the agreed term used for pouch young in culling activities (because that's what I was saying), I said yes, that's what was in the Code. [redacted] I referred to it being defined as a "good death" and in animals often referring to the method of killing, rather than the reason for killing. [redacted] I agreed that terminology was important and that we should use correct, "honest/true" words. Some options discussed were kill or cull. After the meeting I sent some further information confirming the use of the word in the COP and the definition I had referred to in the meeting. I said I was comfortable with the use of the term in this context but understood this would not be everyone's definition and it might be something to raise with Sarah.
- [redacted] had 3 main points:
    - Reviewing how PY were killed
    - Given the 95% instantaneous death rate in the latest vet report - was there appetite in government to improve this? I said we were always striving for the highest possible animal welfare standards and would continue to do what we could to maintain and improve these but culling operations are challenging. Vet audits have all shown high compliance with the Code.
    - How numbers to cull are calculated – I ran through the calculation of the number to cull, including count methods briefly, but the meeting had already run overtime so there wasn't really time to do this topic justice.
- Someone (I think [redacted] asked about the current fertility control program – I provided a quick update on what we have done since 2022.

I provided the group with my powerpoint slides after the meeting (including some we didn't get time to talk about).

From: [redacted]
Sent: Fri, 22 Dec 2023 17:34:22 +1100
To: Wimpenny, Claire
Subject: RE: bits and pieces

Out of Scope

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Friday, December 22, 2023 5:31 PM
To: [redacted]
Subject: RE: bits and pieces

OFFICIAL

According to our leave spreadsheet, [redacted] His mobile number is [redacted] if it's easier to catch him on the phone rather than email.

It will definitely be tomorrow for those numbers now Out of Scope [redacted]

Your plan for AWAC sounds perfect.

Thanks so much for all your work on this so far, and for putting up with the ever-increasing stakeholder list! It's so valuable to have a fresh perspective on the issue and your insights/suggestions so far have been great. I'm really glad you agreed to take on the job!

Regards,

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
Phone +61 2 6205 8252 | Email claire.wimpenny@act.gov.au
480 Northbourne Avenue, Dickson ACT 2602| GPO Box 158 Canberra ACT 2601 | www.environment.act.gov.au

From: [redacted]>
Sent: Friday, 22 December 2023 5:14 PM
To: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Subject: RE: bits and pieces

Hi Claire
Thanks for all that.

One last question: when is [redacted]? I have a couple of things to ask him, and I wasn't able to catch him today.

Those cull/roadkill figs would be lovely, IF EASY!

Rest, you earn it that's for sure.
S

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Friday, December 22, 2023 5:11 PM
To: [redacted]
Cc: Keighley, Miles <Miles.Keighley@act.gov.au>
Subject: bits and pieces

OFFICIAL

Hi Sarah,
A few bits and pieces before [redacted]

RSVPs for meeting with PCS - Tues 9th January 3pm:

Stephen Alegria	Executive Group Manager - Parks and Conservation Service	Accepted
Michaela Watts	Senior Director - Parks and Partnerships	Accepted
Nick Daines	Director Urban Reserves	No response yet [redacted]
Peter Cotsell	Director - NNP, TNR, MRC	No response yet

Veg data outside CNP

I spoke to Brett Howland briefly about vegetation monitoring on rural lands and in Namadgi NP. There are veg plots in some valleys in Namadgi that include grass height/cover data that would be useful from a kangaroo perspective and there are plans to potentially add some more plots in Gudgenby valley soon. Brett also mentioned that a PhD student who is starting work on Dingoes in Namadgi soon is planning to do vegetation surveys, so there's potential to get useful data from that too. Similarly, there is veg data collected on some rural lands as part of Land Management Agreement assessments. So, some relevant data out there that could be built on if required.

Due dates

As discussed, we are happy to extend the due dates for both the draft and the final report as required, let me know what works for you. So sometime around mid-Jan for the draft works for us if that works for you and gives you enough time to wrap up the last of the stakeholder chats? We can discuss pushing it out further if required. We will prioritise your draft as soon as it comes in so we can get comments back to you ASAP (and I am still willing to read it over my holidays if you need me to!).

Count, cull, roadkill numbers

I will send what I have later today or tomorrow.

I think that's it for now. Miles will be back at work on the 2nd so he can be your primary contact while Please don't hesitate to ring me on my mobile if you need to though (I promise I don't mind!).

Hope you have a lovely Christmas break!

Regards,

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
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Conservation Research Website | EPSDD Environment Science Platform | View our story map collection here!

I acknowledge the Ngunnawal people as traditional custodians of the ACT and recognise any other people or families with connection to the lands of the ACT and region. I acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

From: Wimpenny, Claire
Sent: Sat, 23 Dec 2023 07:41:42 +0000
To: [redacted]
Subject: cull and count numbers
Attachments: Rural and Conservation Cull numbers for Sarah.xlsx

OFFICIAL

Hi Sarah,
Here are the cull numbers you were after.

In the conservation cull tab I have included:

- The number of sites counted - these are the sites counted and considered in culling advice, we may have counted additional sites that aren't included here for other reasons
- The total number of EGKs counted at the above sites
- The number of sites culled
- The Operational Cull Target – every year the ecological advice is considered against operational considerations to come up with a feasible program, so the operational target is usually lower than our recommendations (and less sites)
- The total number shot - 'independently mobile' is used here to cover adults, subadults and YAFs
- The number of PY killed

Miles (or me when I'm back!) will be able to help you with site-specific details if needed.

Regards,

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
Phone +61 2 6205 8252 | Email claire.wimpenny@act.gov.au
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Conservation cull in CNP reserves

Year	No. of Sites Counted	Total Counted EGK	No. Sites Culled	Operational Target	Total Independently mobile EGK Culled	Total PY Culled	
2009	5	902	5	539	494	not recorded	I'm pretty sure additional sites were counted this year but couldn't easily find details, will check and update later
2010	7	3043	7	1890	1839	not recorded	
2011	5	4625	5	3427	2439	not recorded	
2012	11	5,333	6	1,880	1,154	not recorded	
2013	12	6,206	6	1,244	1,149	not recorded	
2014	13	10,118	6	1,606	1,521	560	
2015	11	6,236	8	1,962	1,689	701	
2016	14	13,952	8	1,991	1,989	800	
2017	12	14,540	8	1,197	1,186	502	
2018	15	16,341	6	1,822	1,822	793	need to check the cull figures for this year, found a discrepancy between records
2019	15	14,680	9	4,076	4,035	1603	
2020	16	11,320	6	1,958	1,931	631	
2021	16	11,397	5	1,568	1,505	619	
2022	15	15,456	5	1,650	1645	608	
2023	15	12,609	4	1042	1041	362	

Rural EGK cull

Year	Number of properties authorised to cull kangaroos	Number of kangaroos authorised to be shot	Number of kangaroos reported shot
2015	81	21166	11783
2016	69	22795	7069
2017	71	21090	9855
2018	65	21555	14569
2019	81	25609	12359
2020	63	18798	7820
2021	55	17444	5284
2022	39	13193	3878

Notes:

2015 numbers in EGK CNSMP 2017 appear to be incorrect or incomplete, numbers here are taken from original cull spreadsheet.

Number authorised and shot includes mixed sex and male only seasons.

Numbers reported shot in some years is indicative only because some properties did not provide reports (recent

From: Wimpenny, Claire
Sent: Sat, 23 Dec 2023 07:47:10 +0000
To: [redacted]
Subject: Project Plan for GonaCon program
Attachments: Integrating GonaCon into the EGK management program - PROJECT PLAN.docx

OFFICIAL

Hi Sarah,
Just thought it might be worth sending you the project plan for the GonaCon program in case it's of use/interest. I'm very behind with formal reporting on this project (never enough time!) but this will give an overview of what we are planning to do over the next few years.

Cheers
Claire
Claire Wimpenny has sent you a copy of "Integrating GonaCon into the EGK management program - PROJECT PLAN" (A30414820) v4.0 from Objective.

ACT Government
Environment, Planning and Sustainable Development

Project Plan

Integrating the use of GonaCon Immunocontraceptive Vaccine into the Eastern Grey Kangaroo Management Program

Conservation Research and Evaluation, Resilient Landscapes, Parks and Conservation Service; Environment, Heritage and Water Division

PaGA reference: A4-Grn1.2

Start: 1/1/2022

Version History

Version	Revision Date	Approval Date	Author	Key Differences
1.0	06/04/2022	07/04/22	Claire Wimpenny	Final plan incorporating comments by R Cooney

Document Location

File Name:	Integrating GonaCon into the EGK management program
Objective Link:	https://objective.act.gov.au/#/documents/A30414820
Objective File No.:	<Insert number>

Project Details

Project Manager	
Claire Wimpenny	Senior Ecologist
claire.wimpenny@act.gov.au	6205 8252

Lead Business Unit	
Conservation Research and Evaluation branch, Environment Division	
Senior Director:	Rosie Cooney
Executive Branch Manager:	
Executive Group Manager:	Ian Walker

Parliamentary and Governing Agreement Information	
401 – A4-Grn1.2	Expand GonaCon dart delivery rollout to enable a more humane approach to kangaroo population management ($1.4M over four years)

Program Logic	
Program Logic link:	https://objective.act.gov.au/#/documents/A30451121

Project Document Storage	
Objective Folder(s):	https://objective.act.gov.au/#/documents/fA11266926

Approvals

Prepared by		
Claire Wimpenny		
Claire Wimpenny	Senior Ecologist, Conservation Research, EHW	6/4/22

Approved by		
Rosie Cooney (see approval email)		
Rosie Cooney	Senior Director, Conservation Research, EHW	7/4/22

Approved by		
Daniel Iglesias (see approval email)		
Daniel Iglesias	Executive Branch Manager, Parks and Conservation Service, EHW	7/4/22

Contents

1. Project Definition

1.1 Introduction

ACT Government undertakes an annual Eastern Grey Kangaroo conservation culling program in priority areas of Canberra Nature Park (CNP) to manage the negative impacts of excessive kangaroo grazing on critically endangered grassy ecosystems. Whilst the capacity and cost-effectiveness of the conservation culling program has increased significantly over its 12-year history, it is still delivered in only a subset of impacted reserves due to logistical and operational constraints associated with culling in the peri-urban environment.

The inclusion of an effective fertility control method in the kangaroo management program would reduce population growth rates and decrease the amount of future culling required at sites where it is used. This is projected to reduce the number of individual animals impacted by management activities within selected sites, as well as decrease the long-term site-specific costs of macropod management over a 20-year horizon. The reduction in management costs will allow for expansion of kangaroo management into new areas, thus increasing the biodiversity benefit of the program. The use of fertility control for managing kangaroos is supported by the ACT community, with 80% of residents surveyed in 2019 believing it was important to apply fertility control to kangaroos in Canberra.

ACT Government and CSIRO research into fertility control methods for kangaroos has shown that GonaCon Immunocontraceptive Vaccine provides long lasting infertility in treated females following administration of a single dose and can be administered via an injection given by hand, or remotely via a dart. Recent research results show GonaCon is effective in reducing population growth within small, discrete populations. Based on these results, priority nature reserves that are currently managed by culling have been identified, in which GonaCon is likely to effectively reduce population growth.

The ACT Government 2020 Parliamentary and Governing Agreement (PaGA) (Appendix 4 Priority 1.2: *Expand GonaCon dart delivery rollout to enable a more humane approach to kangaroo population management [$1.4M over four years]*) identified as a high priority the rollout of GonaCon contraceptive vaccine into the conservation culling program. A budget bid was prepared to enable integration of this tool into standard operational practice from 2022 onwards and initiative funding has been granted for 2022/23 to 2024/25 (Budget Initiative E01 – Innovations in macropod management). To enable GonaCon to be included in the 2022 kangaroo management season, existing EH&W funding will be used to commence GonaCon treatments at one site in April 2022.

Further information about the ACT Government and CSIRO trials of GonaCon can be found in: Wimpenny C and Hinds LA (2018). Fertility control of Eastern Grey Kangaroos in the ACT - Assessing efficacy of a dart-delivered immunocontraceptive vaccine. Environment, Planning and Sustainable Development Directorate, ACT Government, Canberra.
https://www.environment.act.gov.au/__data/assets/pdf_file/0003/1195077/Technical-Report-Fertility-Control-of-Eastern-Grey-Kangaroos-in-the-ACT-Assessing-Efficacy-of-a-Dart-Delivered-Immunocontraceptive-Vaccine-March-2018.pdf

Further information about fertility control for macropods can be found in: Wimpenny C, Hinds L.A, Herbert C.A, Wilson M & Coulson G (2012) Fertility Control for managing macropods – Current approaches and future prospects. Ecological Management & Restoration 22(S1), 147 – 156.
https://onlinelibrary.wiley.com/doi/10.1111/emr.12461

1.2 Project Objectives

To integrate the use of GonaCon Immunocontraceptive Vaccine into the ACT Kangaroo Management Program with the aim of reducing kangaroo population growth rates and decreasing the need for culling at sites where it is used.

1.3 Project Outcomes and Indicators

Outcome	Indicator(s)	Data Source(s)	Collection Method(s)
Female kangaroos treated with GonaCon become infertile.	• Consistent with previous trials, a high percentage (>80%) of treated females fail to reproduce each year following treatment with GonaCon for at least 5 years.	• 6 monthly observations of tagged treated individuals	• Field surveys
Kangaroo populations treated with GonaCon have lower rates of annual growth	• Annual population growth 2 years after the commencement of GonaCon treatments is significantly less than pre-treatment values • Annual population growth at sites where GonaCon is used is significantly less 2 years after commencement of GonaCon treatments compared to population growth at similar untreated sites • Long-term modelled population growth rates are significantly less when GonaCon is used compared to when only culling or no management is implemented	• Annual kangaroo population estimates • Fecundity data collected from treated and untreated sites during this project • Population dynamics modelling	• Field surveys • Population modelling

Kangaroo populations treated with GonaCon require less culling from the second year after initial GonaCon treatment onwards.	• Number of kangaroos recommended for culling at sites treated with GonaCon, from 2 years after treatment onwards, is less than pre-treatment cull numbers • Number of kangaroos recommended for culling at sites treated with GonaCon, from 2 years after treatment onwards, is less than numbers to cull at similar untreated sites • Long-term modelled numbers to cull are significantly less when GonaCon is used compared to when only culling or no management is implemented	• Annual kangaroo culling advice • Population dynamics modelling	• Review of existing and future management advice prepared by Conservation Research and Evaluation • Population modelling
The long-term cost of managing kangaroos is reduced at sites where GonaCon is used	• Long-term modelled costs of kangaroo management are significantly less when GonaCon is used compared to when only culling is used	• Annual Kangaroo Management Program costs • Budget tracking for this project • Population dynamics modelling	• Obtain costs of culling from Resilient Landscapes Team • Collect data on costs of GonaCon deployment • Modelling
The total number of animals impacted by management is less when GonaCon is included in the management program compared to when only culling is used.	• Long-term modelled number of animals impacted by management are significantly less when GonaCon is used compared to when only culling is used	• Kangaroo Management Program records • GonaCon treatment records for this project • Population dynamics modelling	• Obtain cull numbers from Resilient Landscapes Team • Collect data on number of females treated with GonaCon • Population modelling

ACT Government land managers and decision makers have sufficient knowledge around the feasibility and costs associated with delivery of GonaCon to free-ranging kangaroos within Canberra Nature Park to inform future kangaroo management.	• Costs and feasibility of program known, collated, reported and shared	• Collation of data from objectives listed above	• Collation of data from objectives listed above
The scientific community, land managers and the general public have access to research findings about the effectiveness of GonaCon in reducing kangaroo population growth rates.	• The communications plan is implemented as intended • Information about program is disseminated internally within ACT Government, on the website, in general media and in peer reviewed scientific journals	• Review of communications plan • Number of reports and publications	• Communications Team to provide review of communications plan • Track number and timing of reports against reporting milestones listed in project plan • Track number of open access publications

1.4 Scope

Activities in Scope	Activities Out of Scope
Deployment of GonaCon to female Eastern Grey Kangaroos at suitable CNP reserves.	Eastern Grey Kangaroo culling in CNP reserves – will likely be required at sites where GonaCon use is planned but will be funded and resourced from the general kangaroo management budget. Research on the efficacy of GonaCon in Red-necked Wallabies and Swamp Wallabies. Deployment of GonaCon at sites outside CNP.
Annual population level fecundity assessments at sites treated with GonaCon and untreated comparison sites. 6-monthly observations of tagged treated female kangaroos to assess breeding status.	Annual Eastern Grey Kangaroo population estimates – will be used in the determination of numbers to treat with GonaCon and the evaluation of its effectiveness but will be funded and resourced from the general kangaroo management program budget. Annual Herbage mass monitoring – will be used to determine target kangaroo densities at sites where GonaCon is used but will be funded and resourced from the general kangaroo

	management program budget. Ongoing monitoring of existing GonaCon research sites established in 2015/16.
Evaluation of the effectiveness and cost efficiency of including GonaCon in the kangaroo management program.	Evaluation of the biodiversity benefits of kangaroo management in CNP.

1.5 Assumptions

- Kangaroo management continues to be supported as a high priority program within EHW.
- This project will form part of the broader ACT Government Eastern Grey Kangaroo management program, which will be undertaken annually.
- Adequate budget and resources (including 1 FTE at SPOC level and 0.5 FTE PO2 to coordinate the program) will be available to undertake this work and will continue after the current 3-year funding to allow follow-up administration of GonaCon at treatment sites as required into the future.
- Four staff from within the Environment, Heritage and Water Division (2 with dart gun experience) will be available for all fieldwork components of this project.
- All key staff required for the delivery of this program remain available in the long-term to contribute to this project.
- The research collaboration with CSIRO will continue while there is a research component to the rollout of GonaCon. Funding will be provided to CSIRO under a contract arrangement to cover the contribution of Dr Lyn Hinds to the project.
- AVPMA and AQIS will continue to renew the required permits for the research use (until the product is registered), and import, of GonaCon from USA.
- Sufficient GonaCon will be available and shipped under appropriate conditions as required.
- Other field equipment and veterinary medications will be available when required.
- The effectiveness of GonaCon is consistent with previous studies.
- Kangaroo populations remain stable within kangaroo management units, with little immigration or emigration which would reduce the effectiveness of fertility control as a management approach.

1.6 Constraints

- No specific funding was allocated to this project in 2021. Existing staff were pulled off other projects to advance this work in preparation for further funding anticipated in 2022. Internal EHW funding was identified to cover this work from Jan-Jun 2022. Budget initiative funding has been granted for 3 years from July 2022. However, no secure funding has been secured in the long term.
- GonaCon is not yet registered for use in Australia, so a restricted use permit is required from the APVMA to use it for research purposes. A permit is currently in place to cover this work (issued to CSIRO with ACT Government project staff are listed on the permit – this is the only permit for GonaCon use in Australia), but this permit needs to be regularly renewed. The current permit is valid until 31st October 2024.
- GonaCon is unlikely to be a feasible option for all sites. Consideration needs to be given to the sites where GonaCon is deployed.
- Darting of kangaroos can only be undertaken in suitable weather (no/low wind, moderate temperatures).
- Darting can only be undertaken by trained and licenced staff.
- Kangaroos can only be safely darted out to a maximum distance of approximately 35m.
- GonaCon has a 6-month shelf life and is manufactured in the USA, so orders and shipments need to be timed appropriately in relation to the timing of deployment.
- All use of veterinary drugs must be supervised by the ACT Government Veterinarian.

- Eastern Grey Kangaroos breed seasonally in the ACT region, and GonaCon is best applied within the period of March – July when females have small-medium pouch young and there is sufficient time for treated individuals to mount an antibody response before the next breeding attempt.
- Weather conditions, such as extreme heat or rainfall, can hamper access to reserves and hence have the potential to impact on operational delivery of this program.
- Covid-19 related restrictions on operational capacity within projects may also interfere with delivery.

1.7 Dependencies

- This project is dependent on ongoing funding being secured. A new budget bid will be submitted in 2024 to cover the project after the current funding period is over.
- Approval from the University of Canberra Animal Ethics Committee is required for all work involving animals in this project. Approval was granted in December 2021 and will be renewed every three years.
- A Nature Conservation Act licence is required for the capture of kangaroos by anaesthetic darting (defined as 'take' under the Act) and to cover all field staff not designated as Conservation Officers under the Act.
- Population dynamics modelling for Eastern Grey Kangaroos will be used to determine the appropriate number of female kangaroos to treat at each site. In 2022, modelling by Jim Hone (University of Canberra) will be used. A population dynamics model that allows for comparison of fertility control and culling is currently under development by Steve McLeod (NSW DPI) and may be used in future years.
- Eastern Grey Kangaroo population estimates and herbage mass assessments are used to determine annual target densities for sites considered for inclusion in the ACT Government kangaroo management program. These target densities will feed into the population dynamics model to inform the number of females to be treated at each site.
- Sites selected for GonaCon deployment are likely to also need culling to bring the population down to the target density. This must be done shortly after or before GonaCon is administered. If the intention is to permanently mark treated kangaroos (e.g., with ear tags) it is highly preferrable to undertake culling after GonaCon deployment. Darting after culling is expected to be more challenging because fewer animals are present for darting and they are likely to be more wary and harder to approach.
- Following the initial GonaCon treatment at a site, annual monitoring of the population level fecundity (number of young produced) will be undertaken. Assessments will also be made at untreated sites for comparison. These will be used alongside the population estimates and model to evaluate the effectiveness of GonaCon at the population level and inform the number of follow-up GonaCon treatments required at the site in future years.

1.8 Links to other project(s)

Project Reference	Project Name	Group	Branch
	Evaluating the efficacy of dart delivered GonaCon in female Eastern Grey Kangaroos	Environment Heritage and Water	Conservation Research and Evaluation
	Eastern Grey Kangaroo population estimates	Environment Heritage and Water	Conservation Research and Evaluation
	Herbage Mass	Environment Heritage	Conservation Research

	monitoring	and Water	and Evaluation / Offsets Team
	Population dynamics model for Eastern Grey Kangaroos	Environment Heritage and Water NSW DPI	Conservation Research and Evaluation/ NSW DPI
	ACT Kangaroo Management Program	Environment Heritage and Water	Resilient Landscapes/Parks and Conservation Service

2. Strategic Alignment

2.1 Organisational strategy

Alignment (select all that are applicable)		Choose item or enter text as applicable
Strategic Objective	☒	SO2 - Enhance Canberrans quality of life by conserving and experienceing nature and culture
Wellbeing Domain 1	☒	Environment and Climate
Wellbeing Domain 2	☒	Health
PaGA Initiative (Appendices 1 & 2)	☒	**401 –** A4-Grn1.2: Expand GonaCon dart delivery rollout to enable a more humane approach to kangaroo population management ($1.4M over four years)
Strategy and/or Action Plan	☒	ACT Native Woodlands Conservation Strategy (2019); ACT Native Grassland Conservation Strategy (2017)
Legislation/Statutory Obligations	☒	Eastern Grey Kangaroo: Controlled Native Species Management Plan (2017) Nature Conservation Act (2014)

2.2 Wellbeing Domain

Wellbeing Impact Assessment Link:	https://objective.act.gov.au/#/documents/A30592192

3. Project Organisation

3.1 Project Team

Name and Organisation	Project Role	Project Responsibilities
Claire Wimpenny Conservation Research and Evaluation	Project Manager	Project planning and coordination, ethics applications and reports, training field staff, communications, project reporting.

Lyn Hinds CSIRO Health and Biosecurity	Research Partner, Project Team Member	Providing expert input to project, managing all permits associated with the use and supply of GonaCon, sourcing GonaCon, administering GonaCon, project reporting
Mel Snape Conservation Research and Evaluation	Project Team Member	Providing scientific advice to project, managing Conservation Research and Evaluation's Overabundant Fauna team and projects, preparing advice for ACT Kangaroo Management Program
Mark Sweaney Biosecurity and Rural Services	Project Team Member	Providing operational advice and coordination for project, coordination of the broader ACT Kangaroo Management Program
Sally McIntosh Biosecurity and Rural Services	Project Team Member	Providing operational advice and coordination for project, coordination of the broader ACT Kangaroo Management Program
Miles Keighley Conservation Research and Evaluation	Project Team Member	Support for Project Manager, organizing darting and other field equipment, data management, participating in fieldwork.
Kyeelee Driver	Project Veterinarian	Providing supervision of use of veterinary drugs and oversight of animal welfare aspects of the project
Field staff Environment, Heritage and Water	Field Team (2 darters, 2 drivers, 1 processing assistant as required)	Deployment of GonaCon to female kangaroos at selected sites, either by darting with anaesthetics and injecting GonaCon by hand or by dart delivery

3.2 Governance

Role	Name
Steering Committee	Macropod Management Steering Committee
Project Sponsors	Rosie Cooney (Conservation Research and Evaluation), Daniel Iglesias (PCS), Chris Glennon (Resilient Landscapes)
Project Team - Manager	Claire Wimpenny
Project Team	Lyn Hinds
Project Team	Mel Snape
Project Team	Mark Sweaney
Project Team	Sally McIntosh
Project Team	Miles Keighley
Project Team - Veterinarian	Kyeelee Driver

4. Methodology and Schedule Management

4.1 Methodology

Licences, Permits and Approvals

The following licences, permits and approvals are required for this project:

- Animal Ethics Approval - GonaCon can currently only be used in Australia for research purposes, therefore this project requires approval by the University of Canberra's Animal Ethics Committee. The current project approval is valid until the 31st of January 2025. All staff who will be darting &/or handling animals are required to be individually authorised by the UC committee and added to the project as investigators. Individual authorisations require renewal every 3 years.
- Australian Pesticides and Veterinary Medicines Authority (APVMA) *Permit to allow the possession and supply for research use of an unregistered Agvet chemical product*) – GonaCon is currently unregistered in Australia and can only be used under a research permit. The use of GonaCon in this project will be covered by an APVMA permit issued to CSIRO Health and Biosecurity with relevant CSIRO and ACT Government staff listed on the permit as authorised to use the product. This permit will be maintained and renewed as required by Dr Lyn Hinds. The current permit is valid until 31st October 2024.
- Biosecurity Australia (AQIS) Import Permit – A permit is required to import GonaCon from the USA. This permit will be maintained and renewed as required by Dr Lyn Hinds.
- Nature Conservation Act Licence – Licences are issued for actions that would otherwise be an offence under the Nature Conservation Act 2014. It is an offence to 'Take' (which includes harvest, catch, capture and trap) an animal under the Nature Conservation Act, therefore a licence is required when capture darting kangaroos with anaesthetics for the purpose of administering GonaCon. A licence is also required to cover all activities undertaken by staff that are not designated Conservation Officers under the Act. A licence application will be submitted in prior to the commencement of work at each site, once final numbers to be treated are known. A licence is not required for remote dart delivery of GonaCon. However, field staff that are not Conservation Officers may need to apply for a licence to undertake this work.
- Dart gun possession and use – EH&W holds a permit to possess gas powered dart guns for animal welfare and research purposes. All ACT Government staff who operate dart guns are required to hold a Category A Licence under the EWH Composite Entity Firearms Licence. All darting staff will be required to undertake a training course delivered by an external training provider. The 2022 field team undertook training with Ron Tolling from Firearm Safety & Training Council Ltd in March 2022.
- Supply and use of veterinary medicine – The supply and use of all veterinary medicines in this project will be supervised by ACT Government Veterinarian, Kyeelee Driver.

Site Selection

Research to date indicates that fertility control is unlikely to be a suitable management tool for all sites and all populations. It is best suited to relatively small, discrete populations that experience minimal immigration and emigration. When selecting priority sites in the ACT where the use of GonaCon may be appropriate, the following characteristics have been considered:

- Population size – Due to the high resource requirements involved in deploying GonaCon (and all currently available contraceptive options for kangaroos), fertility control will be most efficiently used in sites with relatively small population sizes where it is achievable to administer GonaCon to a sufficient proportion of females to have an impact on population growth.

- Approachability - GonaCon is administered by injecting it by hand into the thigh muscle of the kangaroo after it has been darted with anaesthetics or by remote injection using a dart. It is suited to populations where kangaroos can be easily approached within the maximum safe darting distance (~35m).
- Immigration/emigration - A sufficient proportion of infertile females must be maintained in the population for the long-term in order to keep reduce population growth, so fertility control is going to be most effective where movement of animals in and out of the population is low (e.g., discrete sites that are surrounded by suburbs or high-speed roads) or not possible (e.g., fenced sites).
- Previous management - The aim of fertility control is to reduce population growth by preventing animals from reproducing. It is not effective at reducing density in the short term. Fertility control is best used in combination with culling, so preference will be given to sites that are currently part of the culling program and have been successfully managed to the desired target density.

In addition to these considerations, it is preferable to initially use GonaCon in areas where the ACT Government is responsible for kangaroo management across the entire Kangaroo Management Unit. This will ensure the kangaroo management objectives are consistent across the whole KMU and across years and that management is undertaken each year as required. Once more is known about the resourcing implications and effectiveness of using GonaCon in the kangaroo management program, it may be feasible to include KMUs with multiple landholders, following consultation and agreement with all relevant parties.

Sites that are considered annually for inclusion in the ACT Government conservation culling program were evaluated against these characteristics and a priority list of sites suitable for fertility control was established (Table 1). This site prioritisation will be used to select sites for GonaCon deployment in 2022. The list will be reviewed annually and updated as required.

Table 1. Site prioritisation for GonaCon deployment 2022

Site	Population size[1]	Darting Approachability[2]	Immigration[3]	Previous management[4]	Other landholders in KMU[5]	Overall score	Priority for GonaCon deployment
Farrer Ridge KMU	3	2	2	3	2	12	Priority 1
Mulangarri KMU	3	2	2	3	2	12	Priority 1
Mulligans Flat KMU	2	2	3	3	2	12	Priority 1
The Pinnacle KMU	3	2	2	3	1	11	Priority 2
Crace KMU	3	1	2	3	2	11	Priority 2
Goorooyarroo Sanctuary KMU	1	2	3	3	2	11	Priority 2
Gungaderra KMU	2	2	2	3	2	11	Priority 2
Aranda Painter KMU	3	2	2	2	1	10	Priority 3
Ainslie Majura KMU	1	2	2	3	1	9	Currently unsuitable - large population size
Red Hill KMU	3	2	2	1	1	9	Currently unsuitable - no previous management at site
Googong West KMU	1	2	1	3	2	9	Connected landscape, FC unlikely to work
Kinlyside KMU	2	2	1	2	1	8	Connected landscape, FC unlikely to work
Mt Taylor KMU	2	2	2	1	1	8	Currently unsuitable - no previous management at site
West Jerrabomberra Valley KMU	1	1	2	3	1	8	Currently unsuitable - large population size
Dunlop KMU	3	1	1	1	2	8	Connected landscape, FC unlikely to work
Kama Extended KMU	1	2	1	2	1	7	Currently unsuitable - large population size
East Jerrabomberra Valley KMU	1	1	1	2	1	6	Currently unsuitable - large population size

[1] Long term target density: 1 = >400 EGK; 2 = 200-400 EGK; 3 = <200 EGK

[2] Approachability of kangaroos: 1 = hard; 2 = moderate; 3 = easy

[3] Predicted immigration: 1 = connected site, high immigration; 2 = discrete population, low immigration; 3 = fenced population, no immigration

[4] Previous management: 1 = no previous management; 2 = previous management but target density not yet achieved/maintained, or management not consistently undertaken; 3 = previous management to target density

[5] Other landholders in KMU: 1 = Yes; 2 = No

Final selection of the sites where GonaCon will be used each year will be based on the annual kangaroo management recommendations, available budget, and a more detailed operational feasibility assessment. Once GonaCon is deployed at a site, the expectation is that ongoing follow-up GonaCon treatments will be required in future years to maintain a sufficient proportion of treated females in the population, so priority will be given to deploying GonaCon at existing treatment sites before any new sites are added to the program.

Determining the number of females to treat

For fertility control to be effective at the population scale, a high enough proportion of females must be rendered infertile to have an impact on population growth. In some situations, the use of fertility control may result in compensatory effects in the population, such as increased survival of the fewer young that are produced, or increased survival of adults. The level of fertility control applied to a population needs to be high enough to overcome these effects.

Once a sufficient proportion of females is rendered infertile, this level needs to be maintained in the population in the long-term. To achieve this, follow-up GonaCon treatments will be required in future years for young females that commence breeding, new animals that have moved to the site and previously treated individuals that have resumed breeding. In recent trials of GonaCon, small numbers of females have resumed breeding from 3 years after treatment, however, some individuals have been rendered infertile for over 10 years. In the current ACT Government and CSIRO trials, approximately 80% of females treated with GonaCon remain infertile after 5 years.

The current trials are also evaluating the effect of treating over 90% of adult females with GonaCon in two small kangaroo populations in Canberra. In the initial treatment year, as many adult female kangaroos were treated as possible. In each year since then, the populations were assessed and any females with pouch young are administered GonaCon (these may be young females breeding for the first time, new animals that have moved into the site or previously treated individuals who have resumed breeding). The approach of only treating females with a visible young means that each female produces at least one young before it is rendered infertile. This provides a low level of births to offset natural mortality and is intended to help maintain a stable population size. Results to date indicate that this approach is providing effective population control, but the populations have decreased in some years.

The kangaroo management program in ACT nature reserves aims to maintain kangaroos at a desired kangaroo density to maximise biodiversity outcomes, and this target density changes in response to the condition of the ground layer vegetation. Managing to these densities with fertility control will require a careful balance of treating enough individuals to reduce population growth while maintaining an adequate level of breeding to compensate for natural mortality and provide some flexibility to respond to changing target densities. Culling will still be required in sites where GonaCon is used. Initially, this will be to reduce populations down to the desired target density before, or shortly after, GonaCon is applied. Once population control is achieved with GonaCon, a low level of culling may still be required in some years to return the population to the target density.

Recommendations for the number of female kangaroos to treat with GonaCon will be informed by annual population estimates, site specific target densities that take into consideration the current ground layer vegetation condition, and population modelling. These recommendations will be described in the annual *Eastern Grey Kangaroo Conservation Management Advice* reports.

The 2022 fertility control recommendations will be informed by kangaroo population modelling by Professor Jim Hone (University of Canberra) which estimates the proportion of infertile females required to maintain a kangaroo population at a given target density. A second kangaroo population model is currently being developed in collaboration with Dr Steve McLeod from NSW Department of Primary Industries. This model will allow different levels and combinations of culling and fertility control to be evaluated in order to determine the most cost-effective approach for meeting the

management goal for each site. This model may be used to develop management recommendations in future years.

The general approach to using GonaCon at each site is expected to be:

Year 1 –Treat a high proportion of adult females (determined by population modelling, expected to be 70 -80%) with GonaCon and permanently mark them with ear tags (in March/April or July/August) and cull the population to the target density if required. Most females will have a young in the pouch which will be unaffected by GonaCon and will emerge from the pouch in Spring. Therefore, population level fecundity will not be affected in Year 1 and the population will grow at a rate unaffected by GonaCon administration from Year 1 to Year 2.

Year 2 – Treat additional breeding females with GonaCon to maintain the desired proportion of treated individuals in the population (as determined by population modelling) and cull the population to the target density if required (avoiding the ear-tagged females that were treated with GonaCon in Year 1). If immigration is low, the number of females requiring treatment is expected to be lower than in Year 1. Population level fecundity and population growth are expected to be reduced this year because the females treated in Year 1 will not reproduce.

Year 3 onwards – Treat breeding females with GonaCon to maintain the desired proportion of treated individuals in the population. If immigration is low and GonaCon is effective, only small numbers of treatments are expected to be required each year. Low levels of culling may be required in some years to maintain the population at the desired target density.

Methods for administering GonaCon

GonaCon can be administered in two ways:

1. Injecting it by hand following capture of the kangaroo by darting with anaesthetics (capture-hand inject method), or
2. Delivering it remotely using a combined injection/marker dart that simultaneously spays a temporary marker paint on the animal's fur (dart delivery method).

Dart delivery has the advantage of eliminating the need for anaesthetics and reducing the resourcing requirements associated with the care of anaesthetised kangaroos. However, the combined injection/marker darts used for administering GonaCon remotely are heavier than the standard anaesthesia darts and under current protocols the maximum darting distance for the injection/marker darts is less than for standard anaesthesia darts. Given the high number of females that are likely to need treatment in the first year at any site, it is expected that the greater darting distance possible with the capture-hand inject method will prove more efficient than dart delivery. In addition, a normal level of culling is expected to be required in the year following the first GonaCon treatments, so having the treated animals permanently marked with ear tags so they can be avoided by shooters will be advantageous. Further, having the ability to monitor permanently tagged individuals in the population will provide insight into level of immigration/emigration at these sites and evaluate how this influences ongoing management requirements. For these reasons, GonaCon will be administered by capture-hand inject method in the first year of treatment and dart delivery will likely be used in future years when smaller numbers of animals need to be treated and the need for permanent marking is reduced because future culling is expected to be minimal.

Initial field deployment of GonaCon

In the first year of deployment at a site, GonaCon will be administered by the capture-hand inject method.

Field Team:

Field deployment of GonaCon will be carried out by a team of 6 people:

- *Darting Teams x 2* - each consisting of a trained dart gun operator and a driver.
- *Processing Team* - consisting of a GonaCon administrator (Lyn Hinds) and an assistant to help with processing kangaroos.

Additional darting teams could be established if resourcing is available.

Kangaroo capture and treatment:

Capture darting will be undertaken by trained and experienced dart-gun shooters. An anaesthetic dart will be fired into the muscles of the hindquarters using a CO2 powered dart rifle (Pneu-Dart X-Caliber). 1ml Pneu-Dart type P darts with 3/4-inch needles with dissolving gel collars will be used. The darts will contain 180mg of Zoletil (6mg/kg of Zoletil mixed up for a nominal kangaroo weight of 30kg). These darts have been chosen to minimise weight and have short needles to reduce the potential consequences of hitting a non-target area such as the body cavity.

The velocity the dart is fired at, and thus the impact force the dart strikes the animal, is minimised to reduce the risk of impairing the mobility of the animal. To achieve this, the dart guns have been calibrated to determine the appropriate gas settings that minimise the velocity of the dart (measured using a chronograph set up close to a foam target) and still maintain an acceptable level of precision. Prior to darting, the distance to the target animal will be measured using a laser rangefinder and the gas pressure will be set accordingly.

Darting will be from a vehicle (4WD or ATV) or on foot and will be initially attempted during daylight hours. Night or dusk/dawn darting may be attempted if insufficient numbers of kangaroos are able to be approached within darting distance during the day.

If free-range darting proves difficult, feeding stations will be established to draw kangaroos to particular areas to be darted. Carrot, apple, lucerne and kangaroo pellets will be provided in feeding bins, with a small amount scattered around the bins to draw the kangaroos in. Feeders will only be open at times when darting will be undertaken (e.g., 6am until 9am &/or 3pm until dark) and will be closed/removed at all other times.

Breeding females (with visible pouch young) will be targeted when darting. If any males are accidentally darted, they will not be treated. These males will be marked with a temporary paint so they can be avoided in subsequent darting and taken to the recovery area (see below).

The anaesthetised kangaroos will be fitted with Lycra blindfolds to protect their eyes and will be transported in the back of the darting vehicle to a central processing location. The kangaroos will be placed on a tarpaulin and insulating mat with a rolled hessian sack under their shoulders to promote drainage of fluid from their mouths and to maintain their airways.

Whilst anaesthetised, female kangaroos will be fitted with a coloured/numbered ear tag in each ear. Two sizes of ear tag (Allflex 'small' and 'mini' cattle tags) in six colours will be used which allows for 144 unique colour/size combinations. If more than 144 individuals are treated at a site, a single colour will be chosen to tag all additional animals, but these tags will still be uniquely numbered. Ear tags are attached close enough to the head to reduce the risk of the tags being torn out but not so close as to result in rubbing on ear cartilage. Before the insertion of the ear tag, a 5mm diameter ear biopsy is taken using a sterilised hole punch. This serves two purposes. Firstly, the ear biopsies are preserved for future DNA research, and secondly, it provides a cleanly cut hole for the ear-tag to be inserted through. Although Allflex tags are designed to be inserted directly through the skin, we have found that pre-punching the hole achieves a better result.

Female kangaroos will be injected with 1ml GonaCon (1000µg) into the rump muscle on the opposite side to the capture dart site. Body measurements (head length, arm length, leg length, pes length) and body weight will be recorded. Pouch condition and the sex and body measurements of any pouch young will be recorded. Pouch young will be retained. There is no population management benefit of removing pouch young from females treated with GonaCon, because it is likely that any

removed young would be replaced before the treated individual mounts a sufficient antibody response and becomes infertile.

Following processing and treatment, the kangaroos will be moved to a quiet, shady recovery area. In low temperatures the kangaroos will be provided with hot water bottles and covered with hessian sacks to keep them warm during processing and recovery.

Annual follow-up treatments

Follow-up treatments with GonaCon will be required in subsequent years to maintain the desired proportion of infertile females in the population. The number of females requiring treatment in these subsequent years is expected to be much lower than in the first year, so GonaCon will likely be administered remotely using a dart. A dart containing GonaCon will be fired into the muscles of the hindquarters using a CO2 powered dart rifle (Pneu-Dart X-Caliber). Two types of darts will be used to administer GonaCon:

1. Custom Injection-Marker Dart

   This type of dart was designed specifically for administering GonaCon to kangaroos by dart manufacturers, Pneu-Dart, and is smaller and lighter than the standard injection-marker darts that are available. The darts have 3/4-inch needles with dissolving gel collars and will contain 1ml (1000µg) of GonaCon and 0.7ml of marking paint which is sprayed on the fur as the GonaCon is injected to allow treated individuals to be identified. Testing on targets and carcasses determined that these darts can achieve an impact force that we deem acceptable for EGKs (approximately 12 Joules) for darting distances up to 25m, and they have been successfully used on live animals at various sites in the ACT.

   Within a treatment period, individuals that have already been treated will be identified by the temporary marker paint which is expected to last on the fur for a few weeks. This is likely to be the maximum time required to treat the required number of new breeding females at a site each year.

   The approach of only vaccinating females with visible pouch young each year removes the need for the marker paint to last for multiple years. Given the high efficacy of GonaCon and the fact that vaccinations will be carried out well before the breeding season each year (ensuring adequate antibody levels have been reached before treated individuals attempt to breed again), if a female has a pouch young it is highly likely it has not been treated in a previous year, or it has resumed breeding following a period of infertility and requires treatment again.

2. Standard Injection Darts

   For situations where a marking paint is not required (e.g., when dart vaccinating kangaroos that are tagged, or at sites with only a small number of breeding animals that can be identified without the use of a marking paint) a standard 1ml Pneu-Dart type P dart with 3/4-inch needle with dissolving gel collar will be used. These darts are the same as are used for injecting anaesthetics and can be safely used at darting distances up to 35 - 40m.

For dart vaccination with either dart type, the kangaroos will be approached in a vehicle (4WD or ATV) or on foot and will be darted from a distance within the safe range for the dart type being used. Once darted, the kangaroos will be observed until the dart drops out and can be collected. The dart needles are fitted with a dissolving gel collar which allows the dart to be held in long enough to inject the GonaCon and then after a few minutes is melted by the animal's body heat causing the dart to drop out.

We do expect that a small proportion of dart vaccination attempts will fail. For example, the dart may appear to hit the animal, but the vaccine may not inject correctly, and the animal could remain fertile. There is a chance that these individuals may be darted again the following year, however, the only negative impact of this is likely to be the minor, temporary pain associated with darting. In some species, more than one dose of GonaCon is required to achieve long lasting infertility, so in the

rare chance that a kangaroo receives more than the 1ml dose, there is not expected to be any negative side effects.

Field Team:

Annual follow-up GonaCon treatments will be carried out by a team of 2-3 people:

- *Trained dart gun operator*
- *Driver*
- *GonaCon handler* – approved person to handle GonaCon and fill darts (Lyn Hinds), could also fill the role of driver to reduce resourcing requirements.

Additional dart teams could be established if resourcing is available.

Monitoring

The following monitoring activities will be undertaken as part of this project:

Observations of tagged individuals

Observations of tagged individuals at each site will be undertaken in February/March and September/October (during the fecundity assessments, see below) each year to determine how many remain at each site and their breeding status. Nearby sites will also be checked for tagged individuals in case some emigration has occurred. Tagged kangaroos will be approached in a vehicle or on foot close enough to, with the use of binoculars and spotting scopes, observe the ear tags and accurately assess the size of any young in the pouch.

Annual population level fecundity assessments

Population level fecundity will be assessed annually in September-October at all treated sites and a selection of untreated sites where only culling has been undertaken by recording the proportion of adult females with pouch young. Due to the seasonal breeding of kangaroos in this region, at this time of year most females have a large pouch young that is easily observed from a distance. Groups of kangaroos will be approached in a vehicle or on foot only close enough to, with the use of binoculars and spotting scopes, accurately classify each individual as adult male, adult female with pouch young, adult female without pouch young or subadult. Three assessments at each site will be undertaken. This information will be used to assess the efficacy of GonaCon and inform the number of follow-up treatments that will be required in the following year.

Annual population estimates (funded by existing kangaroo management program budget)

Annual population estimates will be undertaken annually in December-July at all sites where kangaroo management (including GonaCon) is being considered. Results from population estimates at GonaCon treated sites will be used to measure annual population growth rates to assess the efficacy of GonaCon at the population level.

Herbage mass assessments (funded by existing kangaroo management program budget)

Herbage mass assessments will be undertaken annually in October-December at all sites where kangaroo management (including GonaCon) is being considered to measure the response of grassy habitat to kangaroo management as part of an integrated land management approach.

Opportunistic collections of tissues from dead kangaroos

If any tagged kangaroos are found dead (e.g., as a result of motor vehicle collisions), where possible, information will be gathered on the general condition of the animal, pouch condition and presence of young, the pathology of the GonaCon injection site, and the status of the reproductive tract (active or inactive based on gross morphology). Staff and visitors to reserves where GonaCon is used will be provided with information about reporting dead tagged kangaroos.

Evaluation and review

This project will evaluate the cost effectiveness of incorporating GonaCon into the kangaroo population management program. This evaluation will bring together data collected during the monitoring activities detailed above, population modelling, budget figures and information about the efficiency of field operations.

Progress reports will be prepared annually following the completion of field operations. The outcomes of the GonaCon program and other kangaroo management interventions, both generally and at a site level, will be included in the annual *Eastern Grey Kangaroo Conservation Management Advice* reports.

An interim project report will be prepared in late 2024 to present results from the initial 3-year budget initiative and inform the subsequent budget bid. A full project report evaluating the effectiveness and cost efficiency of including GonaCon in the kangaroo management program will be prepared after 5 years (due June 2027). Given the relevance of this information to macropod management nationally, this will include the open-access publication of results of this program in a peer reviewed scientific journal.

4.2 Milestones

No.	Milestone	Estimated Completion
1.	Permits for use and import of GonaCon renewed	31 October 2021 (then renewed as required until GonaCon is registered in Australia)
2.	Project application submitted to University of Canberra Animal Ethics Committee	31 November 2021 (approval granted 31/1/2022 – renewal required every 3 years)
3.	Budget Bid submitted	31 December 2021
4.	GonaCon ordered for April 2022 field delivery	31 December 2021 (then annually as required)
5.	Field staff identified	4 March 2022
6.	Ear tags, veterinary drugs and other equipment ordered for April 2022 field delivery	10 March 2022 (then annually as required)
7.	Darting staff trained	15/16 March 2022
8.	GonaCon recommendations finalised – sites and numbers to treat	25 March 2022 (then annually)
9.	Brief to Executive Group Manager and Minister submitted	30 March 2022 (then annually)
10.	Communications Package completed	30 March 2022 (then reviewed annually)
11.	Licence to 'take' under the Nature Conservation Act is issued to cover capture of kangaroos by darting with anaesthetics	8 April 2022 (then annually as required)

12.	Field delivery of GonaCon completed	11 April- 28 April and 9 May – 20 May 2022 approx. (then annually as required)
13.	Field delivery report completed	17 June 2022 (then annually)
14.	GonaCon ordered for July field delivery (if required)	13 May 2022 (then annually as required)
15.	Field delivery of GonaCon completed (if required)	July 2022 – August 2022 (then annually as required)
16.	Field delivery report completed (if required)	September 2022 (then annually as required)
17.	Fecundity assessments and observations of tagged individuals undertaken	19 September 2022 – 30 September 2022 (then annually)
18.	Population estimates undertaken (funded by general KMP budget)	December 2022 – March 2023 (then annually)
19.	Animal ethics annual report submitted	31 January 2023 (then annually)
20.	Breeding observations of treated individuals undertaken	February 2023 (then every ~6 months)
21.	Interim report completed (review of results to date to inform next budget bid)	30 November 2024
22.	Full project report completed (Evaluation of the effectiveness and cost efficiency of including GonaCon in the kangaroo management program)	30 June 2027

4.3 Work breakdown structure

The Work Breakdown Structure (WBS) for this project is recorded at **Annexure A**.

5. Project Budget

5.1 Budget

A summary of the financial resources available to the project is as follows ($m):

Budget summary ($1.283, Ex GST)

Funding Source	Previous Years (Actuals)	#Current Year 2021-22	#Budget Year 2022-23	#Forward Year 1 2023-24	#Forward Year 2 2024-25	Total
CAPITAL – Bid #	0	0	0	0	0	0
RECURRENT TOTAL– Bid #	**0**	**0.129**	**0.422**	**0.427**	**0.434**	**1.283**
Senior Ecologist	*0*	*0.55*	*0.168*	*0.171*	*0.173*	*1.062*
Ecologist	*0*	*0*	*0.070*	*0.071*	*0.072*	*0.213*
CSIRO contract	*0*	*0.015*	*0.045*	*0.045*	*0.045*	*0.150*
Vehicle	*0*	*0*	*0.012*	*0.012*	*0.013*	*0.037*
Equipment	*0*	*0.015*	*0.030*	*0.031*	*0.032*	*0.108*
Field Staff Overtime	*0*	*0.044*	*0.089*	*0.090*	*0.092*	*0.315*
Monitoring (casual staff)	*0*	*0*	*0.008*	*0.008*	*0.008*	*0.024*
FTE	0	0.3	1.5	1.5	1.5	4.8

Current Year Forecast ($0.129, Ex GST)

Funding source - Internal EHW (CR) budget

Note table below does not include costs for FTE

2021-22	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Capital													
Recurrent (excluding FTE)									**0.007**	**0.029**	**0.038**		**0.074**
CSIRO contract											*0.015*		*0.015*
Vehicle													
Equipment									*0.007*	*0.007*	*0.001*		*0.015*
Field staff overtime										*0.022*	*0.022*		*0.044*
Monitoring (casual staff)													
FTE									1	1	1	1	0.3

Budget Year Forecast ($0.422, Ex GST)

Funding source –Budget Initiative E01 – Innovations in macropod management.

Note table below does not include costs for FTE

2022-23	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Capital	0	0	0	0	0	0	0	0	0	0	0	0	0
Recurrent (excluding FTE)	**0.05**	**0.03**	**0.009**	**0.001**	**0.001**	**0.001**	**0.021**	**0.002**	**0.008**	**0.031**	**0.024**	**0.006**	0.184
CSIRO contract	*0.020*						*0.020*					*0.005*	*0.045*
Vehicle	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.012*
Equipment	*0.007*	*0.007*	*0.001*						*0.007*	*0.007*	*0.001*		*0.030*
Field staff overtime	*0.022*	*0.022*								*0.023*	*0.022*		*0.089*
Monitoring (casual staff)			*0.007*					*0.001*					*0.008*
FTE	2	2	2	1	1	1	1	1	2	2	2	1	1.5

Forward Year 1 Forecast ($0.427, Ex GST)

Funding source – Budget Initiative E01 – Innovations in macropod management.

Note table below does not include costs for FTE

2023-24	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Capital	0	0	0	0	0	0	0	0	0	0	0	0	0
Recurrent (excluding FTE)	**0.05**	**0.031**	**0.010**	**0.001**	**0.001**	**0.001**	**0.021**	**0.002**	**0.008**	**0.031**	**0.024**	**0.006**	**0.186**
CSIRO contract	*0.020*						*0.020*					*0.005*	*0.045*
Vehicle	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.012*
Equipment	*0.007*	*0.007*	*0.002*						*0.007*	*0.007*	*0.001*		*0.031*
Field staff overtime	*0.022*	*0.023*								*0.023*	*0.022*		*0.090*
Monitoring (casual staff)			*0.007*					*0.001*					*0.008*
FTE	2	2	2	1	1	1	1	1	2	2	2	1	1.5

Forward Year 2 Forecast ($0.434, Ex GST)

Funding source – Budget Initiative E01 – Innovations in macropod management.

Note table below does not include costs for FTE

2024-25	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total

Capital	0	0	0	0	0	0	0	0	0	0	0	0	0
Recurrent (excluding FTE)	**0.051**	**0.031**	**0.010**	**0.001**	**0.001**	**0.001**	**0.021**	**0.002**	**0.008**	**0.031**	**0.026**	**0.007**	**0.19**
CSIRO contract	*0.020*						*0.020*					*0.005*	*0.045*
Vehicle	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.002*	*0.013*
Equipment	*0.007*	*0.007*	*0.002*						*0.007*	*0.007*	*0.002*		*0.032*
Field staff overtime	*0.023*	*0.023*								*0.023*	*0.023*		*0.092*
Monitoring (casual staff)			*0.007*					*0.001*					*0.008*
FTE	2	2	2	1	1	1	1	1	2	2	2	1	1.5

5.2 FTE Breakdown

Note this table includes new positions funded by the budget initiative plus existing positions within EH&W. It does not include time for staff that will contribute less than 2 weeks to the project (e.g., other CR SPOC, CR Senior Director, RL Senior Director, PCS Executive Branch Manager, EH&W Executive Group Manager).

Role/name	Current Year 2021-22	Budget Year 2022-23	Forward Year 1 2023-24	Forward Year 2 2024-25
SPOC (Conservation Research)	0.5	1	1	1
Field Staff	0.1 x4	0.2 x4	0.2 x4	0.2 x4
CSIRO contractor	0.3	0.3	0.3	0.3
PO2 (Conservation Research)	0.1	0.5	0.5	0.5
SPOC (Resilient Landscapes)	0.05	0.05	0.05	0.05
TO4 (Resilient Landscapes)	0.05	0.05	0.05	0.05
Total	1.4	2.7	2.7	2.7
Total ACT Government only	1.1	2.4	2.4	2.4

6. Stakeholder Engagement

6.1 Internal Stakeholders and Collaborators

Supporting/Collaborating Group

Group or Agency	Branch	Nature of Relationship
EPSDD	Conservation Research	Project Leader
EPSDD	Resilient Landscapes	Project Collaborator
EPSDD	Parks and Conservation Service	Project Collaborator, Land Manager

Support Services

Branch and Business Area	Engagement Required
Finance Information and Assets	
Finance	☒
Procurement	☐
Digital Solutions	☐
People and Capability	
Workplace Relations	☐
Safety and Wellbeing	☐
Capability and Performance	☐
Inclusion & Engagement	☐
Governance Compliance and Legal	
Legal	☐
Records Management	☐
Governance and Risk	☐
Performance, Assurance and Reporting	☐
Government Services	☐
Communications and Engagement	
Communications	☒
Media	☒
Graphic Design	☐
Web Services	☒

6.2 External Stakeholders

Stakeholder	Nature of Relationship
CSIRO Health and Biosecurity	GonaCon research collaborator, involved in project delivery and ongoing research under contract arrangement.
University of Canberra Animal Ethics Committee	Required to approve the use of animals for scientific purposes in this project.
Local environmental community groups (e.g., Friends of Grasslands, Conservation Council, local ParkCare groups, Woodlands and Wetlands Trust)	Have interest and involvement in the conservation and management of grassland and woodland ecosystems that are impacted by high kangaroo densities.
Animal welfare groups (e.g., RSPCA)	Have interest in advocating for humane wildlife management practices, expected to be generally supportive of fertility control.
Animal rights groups	Have interest in wildlife management techniques and the use of animals for research. Support for fertility control is expected to be mixed, some will see it as a preferable option to lethal methods, some oppose fertility control because it removes the animals' right to reproduce and oppose all management techniques and use of animals in research.
General public	Are generally interested in environmental issues and iconic species. Are expected to be supportive of fertility control – 80% of residents surveyed in 2019 thought it was important to apply fertility control to kangaroos in Canberra.
Land managers of sites with high kangaroo densities (ACT and nationally)	Likely to have interest in the effectiveness of managing kangaroo populations with GonaCon and future prospects for its use on their land.
Research partners and affiliates	Will have an interest in the effectiveness of managing kangaroo populations with GonaCon and the management of native grassy ecosystems in general. May provide opportunities for additional research not currently included in the scope of this project (e.g., looking at behavioural effects of GonaCon or levels of immigration/emigration from treated sites).

6.3 Stakeholder Communications Plan

Stakeholder Communications Plan:	https://objective.act.gov.au/#/documents/A33295505

7. Project Reports

Type of Communication	Communication Schedule	Communication Mechanism	Initiator	Recipient(s)
EMB Internal Report	Every six weeks	EMB paper	Project Manager	EMB

External Report	Twice yearly	SharePoint Report	Project Manager	EMB Cabinet Public (annually)
Input to Kangaroo Management Program advice report	Annual	Internal ACT Government Report (made public on ACT Government website after completion of annual program)	Conservation Research	Resilient Landscapes, Parks and Conservation Service
Animal Ethics Annual Report	Annual	University of Canberra Animal Ethics Committee Annual Report	Project Manager	UC Animal Ethics Committee
Planning Progress Report provided at MMSC meetings and Operations Team meetings	Monthly/fortnightly in lead-up to program	MMSC meeting, MM Operations Team meeting	Project Manager	MMSC MM Operations Team
Ministerial Briefs	Twice yearly – before and after field operations	Brief	Conservation Research/ Resilient Landscapes	Executive Group Manager/EPSDD Executive/ Ministers
Project Team meetings	As required in lead up to program	Team meeting	Project Manager	Project Team
Operations Status Report	Every day whilst field operations are underway	Team meeting	Project Manager	Field Team
Field delivery report	Annual, following completion of field operations	Short report/PowerPoint presentation	Project Manager	Project Team MMSC Executive Group Manager
Project Report	5 years after commencement of project (due June 2027)	ACT Government Technical Report/ Scientific publication/short summary	Project Manager	EMB Cabinet Internal and external stakeholders Public

Project Reports:	https://objective.act.gov.au/#/documents/fA11352148

8. Project Risk Register

Project Risk Register:	https://objective.act.gov.au/#/documents/A33382562

Annexure A: Work Breakdown Structure

Phase (Level 1)	Activity (Level 2)	Task (Level 3)
Project Planning	Secure necessary licences, permits and approvals	• Animal ethics approval – submit project application and individual staff authorization applications
		• GonaCon permits – ensure APVMA and import permits are current and renew as necessary
		• Nature Conservation Act Licence – submit application for Nature Conservation Licence
		• Dart gun use – ensure EH&W dart gun permits are current and renew as necessary, ensure all darting staff have current firearms licences
		• Use of veterinary drugs – engage ACT Government Veterinarian to provide oversight of drug use
	WHS	• Complete project Risk Assessment and seek approval
		• Review and update existing specific GonaCon and darting SOPs and Risk Assessments
		• Create new veterinary drug supply and use records and have approved by ACT Government Veterinarian
		• Update field information folder to contain all current safety information and permits
		• Develop Incident Action Plan
	Budget	• Plan project budget
		• Submit budget bid
	CSIRO research contract	• Provide written confirmation to CSIRO about additional funding to cover April - June 2022 work (an additional payment to current contract)
		• Amend current contract to cover next 3 years of work

	Sites and numbers	• Prepare recommendations for GonaCon deployment (sites and numbers to treat)
		• Finalise sites with Kangaroo Ops Team
		• Undertake sites visit to determine appropriate staging area and assess site specific conditions
	Briefings	• Organise meeting/s with Executive Group Manager and MMSC to seek endorsement for program
		• Draft briefs and submit
		• Prepare QTB and talking points as required
Communications	Communications Plan	• Engage Communications Team to assist with Communications Plan
		• Consider communication approach and draft Communications Plan
		• Identify spokesperson
		• Prepare media release when required
		• Seek approval for Communications Plan
	Stakeholder engagement	• Brief Access Canberra
		• Identify and notify key stakeholders
Project Delivery	Staff	• Identify suitable field staff
		• Have darting staff undertake dart gun training
		• Field staff apply for individual animal ethics approval
		• Brief staff about project and safety considerations
	Administration	• Finalise staff sign-on sheets
		• Finalise process for overtime submission and recording
		• Finalise staff rosters
	Equipment orders	• Order GonaCon

		• Order darts and gas
		• Order ear tags
		• Check field gear and order new equipment as required
	Equipment preparation	• Make up ear tag packs
		• Update digital and hard copy maps
		• Prepare data sheets
		• Prepare darts (add reflective sticker)
		• Sort and organize darting and general field equipment
		• Make up darting ops kits
		• Identify vehicles for use in project
	Field work	• Administer GonaCon to female kangaroos in accordance with recommendations
Project review and evaluation	Data management	• Establish data management protocols
		• Identify staff with responsibility for data entry and management
	Monitoring	• Prepare monitoring schedule
		• Identify and train monitoring staff
		• Undertake monitoring in accordance with schedule
	Data analysis	• Collate data and analyse as required
	Reporting	• Undertake literature review
		• Prepare draft reports according to Project Reports schedule in Section 7
		• Seek input on drafts from project team
		• Finalise reports and disseminate as required
		• Liaise with Communications Team about potential media opportunities following key reporting milestones

From: EPSDD, Dhawura Ngunnawal
Sent: Wed, 3 Jan 2024 21:58:25 +0000
To: Sarah Legge
Subject: FW: PLACEHOLDER Buru Management Yarning Circle

Hi Sarah,
This is to keep you in the loop about our plans for a Buru (kangaroo) management yarning circle coming up soon.
Cheers,
Miles

-----Original Appointment-----
From: EPSDD, Dhawura Ngunnawal <EPSDDdnc@act.gov.au>
Sent: Monday, November 20, 2023 3:10 PM
To: EPSDD, Dhawura Ngunnawal; Wimpenny, Claire; Keighley, Miles; Mudford, Mary; [redacted]
Cc: Gavin, Canada; McIntosh, Sally; Sweaney, Mark; Bell, Bradley; BellGarner, Braithan; Arguelles, Rheyda
Subject: PLACEHOLDER Buru Management Yarning Circle
When: Saturday, 20 January 2024 10:00 AM-11:00 AM (UTC+10:00) Canberra, Melbourne, Sydney.
Where: TBC

Yuma all

This is just a placeholder for the Buru management Yarning Circle that will be held next year, details will be distributed closer to the date.

Kind regards,

Canada Gavin (She/Her)
Coordinator, Traditional Custodian Engagement
Conservator Support and Partnerships | Environment Division
Environment, Planning & Sustainable Development Directorate
480 Northbourne Avenue, Dickson ACT 2602 | Post: GPO Box 158 Canberra ACT 2601
Email: canada.gavin@act.gov.au

I acknowledge the Ngunnawal People as the Traditional Custodians of this land – and pay my respects to Elders past, present and future, and acknowledge their continuing culture and connection to Country and community and the contribution they and the broader ACT Aboriginal and Torres Strait Islander community make to the ACT and region.

From: EPSDD, Dhawura Ngunnawal
Sent: Wed, 3 Jan 2024 22:05:27 +0000
To: Sarah Legge
Subject: FW: Buru Management Yarning Circle

I sent you the placeholder invite before, here's the actual invite that just came out this morning.

-----Original Appointment-----
From: Gavin, Canada <EPSDDdnc@act.gov.au> **On Behalf Of** EPSDD, Dhawura Ngunnawal
Sent: Wednesday, January 3, 2024 7:41 AM
To: EPSDD, Dhawura Ngunnawal; Wimpenny, Claire; Keighley, Miles; Mudford, Mary; [redacted]
Cc: Gavin, Canada; McIntosh, Sally; Sweaney, Mark; Bell, Bradley; BellGarner, Braithan; Arguelles, Rheyda
Subject: Buru Management Yarning Circle
When: Saturday, 20 January 2024 10:00 AM-3:00 PM (UTC+10:00) Canberra, Melbourne, Sydney.
Where: Tidbinbilla Nature Reserve (Paddys River Road, Paddys River Australian Capital Territory 2620, Australia)

Yuma all

You are invited to attend a consultation session on the ACT Kangaroo Management Plan.

In accordance with the *Nature Conservation Act 2014*, the Conservator of Flora and Fauna is required to review Controlled Native Species Management Plans every 5 years. The current Eastern Grey Kangaroo: Controlled Native Species Management Plan is available here: https://www.legislation.act.gov.au/di/2017-37.
Currently an independent review of the plan is being conducted and in addition to this review, the team would also like to consult with the Ngunnawal community to seek their views on kangaroo management in the ACT and invite input to the new plan before a draft is released for general public consultation.

A consultation session will be held for the Ngunnawal community on the 20th of January 2024.

Details

Date: Saturday January 20th
Time: 10am -3pm
Location: Ribbon Gum Theatre Tidbinbilla
RSVP: Please email EPSDDTCE@act.gov.au with your full name, email address and any dietary or accessibility requirements by Monday 15th January 2024.

Children are welcome to attend however only participants over the age of 16 will be remunerated. Travel and accommodation costs will be at the participants expense.

Kind regards,

Canada Gavin (She/Her)
Coordinator, Traditional Custodian Engagement
Conservator Support and Partnerships | Environment Division
Environment, Planning & Sustainable Development Directorate
480 Northbourne Avenue, Dickson ACT 2602 | Post: GPO Box 158 Canberra ACT 2601
Email: canada.gavin@act.gov.au

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From: EPSDD, Dhawura Ngunnawal
Sent: Sun, 7 Jan 2024 23:28:55 +0000
To: OLoughlin, Luke
Subject: FW: Buru Management Yarning Circle

-----Original Appointment-----
From: Gavin, Canada <EPSDDdnc@act.gov.au> **On Behalf Of** EPSDD, Dhawura Ngunnawal
Sent: Wednesday, January 3, 2024 7:41 AM
To: EPSDD, Dhawura Ngunnawal; EPSDD, Dhawura Ngunnawal; Wimpenny, Claire; Keighley, Miles; Mudford, Mary; [redacted]
Cc: Gavin, Canada; McIntosh, Sally; Sweaney, Mark; Bell, Bradley; BellGarner, Braithan; Arguelles, Rheyda; Sarah Legge; Braithan Bell-Garner; Bradley Bell; Courtney Garner; [redacted]
Subject: Buru Management Yarning Circle
When: Saturday, 20 January 2024 10:00 AM-3:00 PM (UTC+10:00) Canberra, Melbourne, Sydney.
Where: Tidbinbilla Nature Reserve (Paddys River Road, Paddys River Australian Capital Territory 2620, Australia)

Yuma all

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Kind regards,

Canada Gavin (She/Her)
Coordinator, Traditional Custodian Engagement
Conservator Support and Partnerships | Environment Division
Environment, Planning & Sustainable Development Directorate
480 Northbourne Avenue, Dickson ACT 2602 | Post: GPO Box 158 Canberra ACT 2601
Email: canada.gavin@act.gov.au

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From: Keighley, Miles
Sent: Mon, 8 Jan 2024 06:04:48 +0000
To: [redacted]
Subject: RE: Herbage mass analysis steps

Thanks Sarah,
Yep let's book in a time for a chat whenever suits on Friday 19th. [redacted]
Cheers,
Miles

From: [redacted]
Sent: Monday, January 8, 2024 4:54 PM
To: Keighley, Miles <Miles.Keighley@act.gov.au>
Subject: RE: Herbage mass analysis steps

Thanks Miles, yes, we're on the same page!! It doesn't matter that the method isn't written up in detail, its all part of the evolving nature of the program.

Im going to book flights to come to Canberra for that meeting on the 20th. I'm planning to come a day earlier, and offer to meet the animal rights groups again. Maybe it wont be too early to book in some time with you and Claire (on the 19th) to go over any comments you might have by that stage?

S

From: Keighley, Miles <Miles.Keighley@act.gov.au>
Sent: Monday, January 8, 2024 9:53 AM
To: [redacted]
Subject: RE: Herbage mass analysis steps

Hi Sarah,

I had a chat with Mel about this on Friday, which prompted her to check what one of the other papers which she published in that EMR edition – basically the history and future of the KMP in the ACT. https://onlinelibrary.wiley.com/doi/pdf/10.1111/emr.12443. I'm sure you've come across this paper already, but we were thinking you might be able to use that to reference the method used now, in saying that the ACT Gov adopted all of the recommendations described for 'future management approach' in that paper. That includes a six step process to shift toward a grassy sward focused

kangaroo management approach. There are aspirational comments in this paper that accurately describe the overall approach. E.g:

- '...modelling of anticipated pasture growth rates at the management polygon scale, would provide an improved basis for managing the impacts of kangaroo grazing as part of an integrated approach to protecting conservation values.'
- 'Monitoring will include on ground and quadrat-based assessments of grass height and cover, as well as other information relevant to informing management decisions including dominant grass type, percentage of bare ground, and depth and cover of grass thatch. This approach will enable land managers to meet conservation aims at multiple scales, including within the broader KMU at which kangaroo management occurs.'

However, there's not a heap of detail about the calculation steps in that publication.

I'm sure you've thought of this already, but we should probably update the legislative instrument calculator for non-commercial culling with some communication of the new analysis steps.

Cheers,
Miles

From: [redacted]
Sent: Friday, December 22, 2023 8:32 AM
To: Keighley, Miles <Miles.Keighley@act.gov.au>
Subject: RE: Herbage mass analysis steps

Hi Miles
No its ok. I will just talk about this in terms of the constant adaptation that you all do. Its just a normal lag between practice and documentation.
S

From: Keighley, Miles <Miles.Keighley@act.gov.au>
Sent: Thursday, December 21, 2023 8:13 AM
To: [redacted]
Subject: RE: Herbage mass analysis steps

There is the R script that runs the analysis. Not sure if that's citeable though?

From: [redacted]
Sent: Wednesday, December 20, 2023 12:57 PM

To: Keighley, Miles <Miles.Keighley@act.gov.au>
Subject: RE: Herbage mass analysis steps

You don't often get email from [redacted] Learn why this is important

Caution: This email originated from outside of the ACT Government. Do not click links or open attachments unless you recognise the sender and know the content is safe. Learn why this is important

No worries, thanks Miles.
S

From: Keighley, Miles <Miles.Keighley@act.gov.au>
Sent: Wednesday, December 20, 2023 11:35 AM
To: [redacted]
Subject: RE: Herbage mass analysis steps

Hi Sarah,
I'm afraid I don't think it is! I've just had training from Mel in the form of email correspondence on how to do it.

From: [redacted]
Sent: Wednesday, December 20, 2023 6:24 AM
To: Keighley, Miles <Miles.Keighley@act.gov.au>
Subject: RE: Herbage mass analysis steps

You don't often get email from [redacted]. Learn why this is important

Caution: This email originated from outside of the ACT Government. Do not click links or open attachments unless you recognise the sender and know the content is safe. Learn why this is important

Miles
A thought - This isn't written down anywhere in a methods doc or anything else I can cite?
S

From: Keighley, Miles <Miles.Keighley@act.gov.au>
Sent: Tuesday, December 19, 2023 4:39 PM
To: Sarah Legge <[redacted]>
Subject: Herbage mass analysis steps

Hi Sarah,
I've listed the steps for the herbage mass analysis here. Sorry it's not in a friendlier format. Let me know

if there's anything you'd like explained in more detail.
Cheers,
Miles.

Calculate Herbage Mass *(Plot level data)*
Average grass height + % Green + % Cover + Dominant Species ID -> Herbage mass for each plot

Calculate growth *(Plot level data)*
Average grass height + Dominant Species ID -> Spring and Autumn growth -> Annual change in HM (Spring + Autumn, note that growth in autumn is mostly negative).

Calculate anticipated annual per capita offtake per plot
Dominant species + spring growth + plot level HM -> Spring offtake
Dominant species + autumn growth + plot level HM -> Autumn offtake
Spring offtake + Autumn offtake = Annual offtake

Calculate target HM
Average grass height + % Green + % Cover + Dominant Species ID -> target HM

Calculate HM change (to get to target)
Current HM – Target HM

Calculate Plot total food
HM Change + Annual Growth -> Total food

Plot Kangaroo target density
Total Food / per capita offtake -> Kangaroo target density

Miles Keighley (he/him)

Ecologist
Office of Nature Conservation | Environment, Health and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
Phone +61 2 6205 8252 | Email miles.keighley@act.gov.au
480 Northbourne Avenue, Dickson ACT 2602| GPO Box 158 Canberra ACT 2601 | www.environment.act.gov.au

Conservation Research Website | EPSDD Environment Science Platform | View our story map collection here!

I acknowledge the Ngunnawal people as traditional custodians of the ACT and recognise any other people or families with connection to the lands of the ACT and region. I acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

Out of Scope

From: [redacted]
Sent: Tuesday, January 9, 2024 1:46 PM
To: Alegria, Stephen <Stephen.Alegria@act.gov.au>; Watts, Michaela <Michaela.Watts@act.gov.au>; Daines, Nicholas <Nicholas.Daines@act.gov.au>; Cotsell, Peter <Peter.Cotsell@act.gov.au>
Subject: RE: Eastern Grey Kangaroo Controlled Native Species Management Plan review - meet with Sarah Legge

Hello there
Given many are re-surfacing after the Christmas break, I thought I should send a confirmation that I'll be online this avo (at 3). I am keen to hear your thoughts about the kangaroo management – what works well, what works less well, and any other input you'd like to share. I also have few questions that Id like to put to you.

Talk soon!
Sarah

-----Original Appointment-----
From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Thursday, December 21, 2023 9:20 AM
To: [redacted] Alegria, Stephen; Watts, Michaela; Daines, Nicholas; Cotsell, Peter
Subject: Eastern Grey Kangaroo Controlled Native Species Management Plan review - meet with Sarah Legge

When: Tuesday, 9 January 2024 3:00 PM-4:00 PM (UTC+10:00) Canberra, Melbourne, Sydney.
Where: Microsoft Teams Meeting

Hi all,
As most of you will know, the Conservator is currently undertaking a review of the Eastern Grey Kangaroo Controlled Native Species Management Plan and Prof Sarah Legge has been engaged to undertake an independent review of the plan.
Sarah would like to meet with you to discuss the plan from a PCS perspective to inform her review.

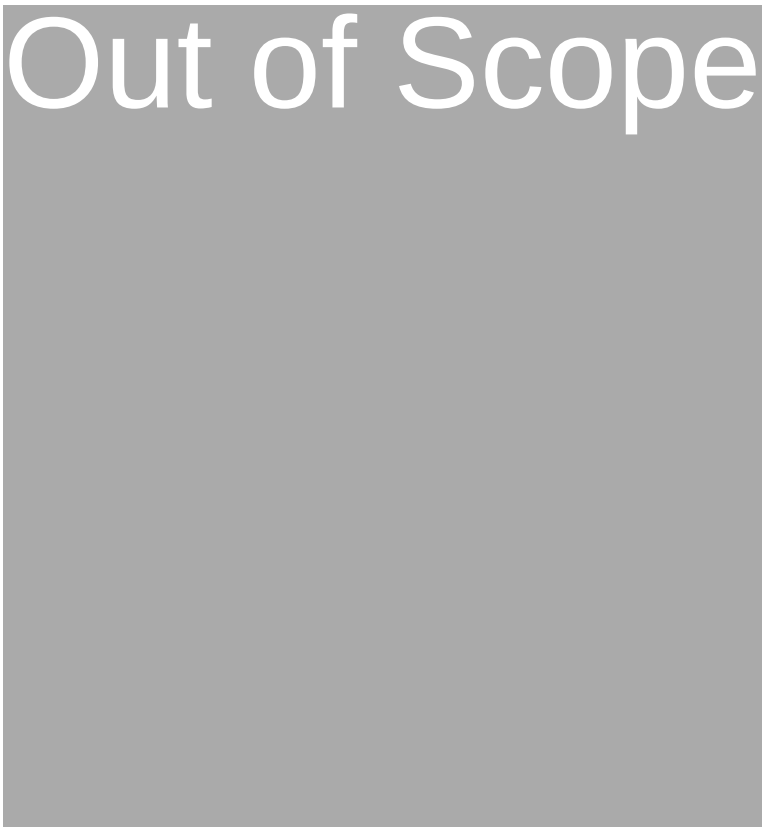
Cheers
Claire

(note I won't attend the meeting – I'm just the organiser!)

From: Keighley, Miles
Sent: Thu, 18 Jan 2024 05:51:24 +0000
To: Sarah Legge; Arguelles, Rheyda
Cc: Wimpenny, Claire
Bcc: 480NBA 00.032 (Capacity 12, Webex Board)
Subject: Kangaroo Management Plan Review Consultation

Inviting Rheyda along, she will likely be able to help with the drinks and access at the start.

Hi Sarah,
I've made this room booking for the lobby level of 480 Northbourne Avenue for the meeting with animal rights people. Claire and I will discuss who we can ask to attend at the start to address access/tea requirements (at least I've been told how to sort tea/coffee ☺).
Cheers,
Miles



From: Keighley, Miles
Sent: Wed, 10 Jan 2024 11:09:39 +0000
To: [redacted]
Cc: Wimpenny, Claire
Subject: RE:

Hi Sarah,
[redacted] I'm heading out to Namadgi to help with some Veg fieldwork tomorrow. I'll have a look at this on Friday if that's OK?
Cheers,
Miles.

From: [redacted]
Sent: Wednesday, January 10, 2024 8:31 AM
To: Keighley, Miles <Miles.Keighley@act.gov.au>
Cc: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Subject:

Hi Miles, Claire

Can I run some back-of-envelope calculations past you? Don't get too bogged down in detail, it's ballpark stuff. I am most keen on you checking the text in red below.

I was interested in contextualising the cull in CNP against

1. the other main sourced of direct mortality from people – the rural cull and road-kills
2. the overall pop of EGK in the ACT

1. Summarised in the 'Roo mortality summary' tab of the attached excel spreadsheet.
Note: for the conservation cull figures, I used data from the annual conservation advices rather than the summary you sent Claire, because I needed to work out the areas in which the counts took place each year, and think about the overlap of areas between years (which I did in the tab called 'CNP areas and culls from CAs'). I noticed that the numbers of culled roos in the CA are different from in the excel summary you sent (which is in the tab 'conservation culls') – I think its because you sent me count numbers for the KMU, and the Cons Advice presents numbers for the reserves….does that sound right?

2. Pls see the 'ACT pop calcs' tab

- CNP: I could work out density in CNP from reserve areas and count info.
- Rural: There are very few data available on the density of kangaroos on ACT rural land (unless they are part of a KMU), and the estimates come from over 20 years ago. But I collated them, and I threw in an estimate for rural lands that are part of KMUs (ie same as CMP density),

although they cover a small area. I also threw in the current data on kangaroo density from the commercial NSW commercial harvest zone that surrounds the ACT.
    - The average of all these figures (0.76/ha) means the rural pop size = 30,000, and means the cull (9100 pa) takes out about 30%. I also worked it out from another direction, and used one of Jim Hone's rubrics: "Using a population growth figure of 40%, then you need to cull 30% of the pop to stay stable"… So if the cull is 9100, then the total pop is 30300. Very neat! But given some farmers don't report kills, and the pop may be growing at < 40% then the average density could be higher (but spatially variable).
- Namadgi: I guessed there are 3000 ha of grassy areas (??), and used a few old estimates for them; and I made the forested areas 10% of that (using the canopy/grass tradeoff)
- I assumed no roos in plantations (bec no grass, I know they might shelter there)
- I assumed half the Commonwealth area was covered in buildings, and half was like CNP.

I have tallied these pops sizes up and compared them to NSW (west of divide) in the third tab 'relative pop sizes'.

How does that chain of thinking seem to you?

S

From: Keighley, Miles
Sent: Fri, 12 Jan 2024 01:19:20 +0000
Cc: Wimpenny, Claire; Sarah Legge
Bcc: 480NBA 01.102 (Capacity 6, Webex Board)
Subject: Kangaroo plan review

Room change 12/1/24

_____

Hi Sarah and Claire,

Setting aside time to give early feedback on the Plan. Not sure yet how much time we'll need so we can adjust the length of this meeting as necessary once we've had a look.

From: Keighley, Miles
Sent: Fri, 12 Jan 2024 01:21:22 +0000
To: Wimpenny, Claire; Sarah Legge
Bcc: 480NBA 01.102 (Capacity 6, Webex Board)
Subject: Kangaroo plan review

Room change, attendees shifted to 'required' 12/1/24

_____

Hi Sarah and Claire,

Setting aside time to give early feedback on the Plan. Not sure yet how much time we'll need so we can adjust the length of this meeting as necessary once we've had a look.

From: Nguyen, William
Sent: Mon, 15 Jan 2024 03:00:49 +0000
To: Wimpenny, Claire; [redacted]
Subject: RE: Eastern Grey Kangaroo vehicle collision numbers for 2016 to 2023

Hi Claire,

Yep the way to narrow down car crashes is exactly how you describe it in counting the locations on roads.

We do mark down the sex and if there is pouch young but due to sensitivities we don't give out pouch young information.

The way the data is collected is in these Issue and Action options.

Macropod Action	Total
⊟DEAD	
⊞CAPTURED & RELEASED	
⊞EUTHANASED	
⊞NO ACTION REQUIRED	
⊞ATTENDED BUT NO ACTION REQUIRED	
⊞ANIMAL DEAD ON ARRIVAL	
⊞ATTENDED BUT NOT LOCATED	
⊞CARCASS REMOVED	
⊟INFORMATION REQUIRED	
⊞CARCASS REMOVED	
⊞ATTENDED BUT NOT LOCATED	
⊟INJURED/SICK	
⊞CAPTURED & RELEASED	
⊞TELEPHONE ADVICE	
⊞TAKEN TO CARER_VET_RSPCA	
⊞CARCASS REMOVED	
⊞NO ACTION REQUIRED	
⊞ATTENDED BUT NO ACTION REQUIRED	
⊞ANIMAL DEAD ON ARRIVAL	
⊞ATTENDED BUT NOT LOCATED	
⊞EUTHANASED	
⊟OTHER	
⊞TELEPHONE ADVICE	
⊞NO ACTION REQUIRED	
⊞ATTENDED BUT NOT LOCATED	
⊞ATTENDED BUT NO ACTION REQUIRED	
⊟TRAPPED	
⊞ATTENDED BUT NOT LOCATED	
⊞NO ACTION REQUIRED	
⊞ATTENDED BUT NO ACTION REQUIRED	
⊞CAPTURED & RELEASED	
⊟(blank)	
⊞ATTENDED BUT NOT LOCATED	

William Nguyen
Project Ranger | Canberra Nature Park South | ACT Parks & Conservation
Athllon Depot - Cnr Athllon Dr & Sulwood Dr, FARRER ACT 2607
M: [redacted] | P: 02 6207 3355 | E: William.Nguyen@act.gov.au

ACT Government

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Monday, 15 January 2024 1:19 PM
To: Nguyen, William <William.Nguyen@act.gov.au>; [redacted]
Subject: RE: Eastern Grey Kangaroo vehicle collision numbers for 2016 to 2023

OFFICIAL

Thanks Will,
My mistake, I thought the data did include if it was a road collision or something else.
Cope and Herbert (University of Sydney) did use our data. It was a few years ago now and the request for it probably came to you via Mel. I suspect Sarah is correct and they filtered out some of the data points. Possibly based on location (to exclude points not on roads?) and there is mention in the report of some EGKs being recorded as male but having pouch young which I think they deleted.

Regards,

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
Phone +61 2 6205 8252 | Email claire.wimpenny@act.gov.au
480 Northbourne Avenue, Dickson ACT 2602| GPO Box 158 Canberra ACT 2601 | www.environment.act.gov.au

From: Nguyen, William <William.Nguyen@act.gov.au>
Sent: Monday, 15 January 2024 12:20 PM
To: [redacted] Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Subject: RE: Eastern Grey Kangaroo vehicle collision numbers for 2016 to 2023

Hi Sarah,

Give me till the end of this week at the latest and I'll clean up some data for you to the end of 2023 and will be able to start giving you complete figures then.

I'm not familiar with the Cope and Herbert report but if they used our data perhaps they filtered to specifically EGK, I usually report by Macropods as a whole as requested by the rangers.

We don't actually specify if it was a car crash or not but rangers have always said that pretty much 99% of the data we collect are car crashes so you can pretty much assume it's a car crash with a the odd outlier.

I hope that gives you a bit of clarity but let me know if I missed anything.

Cheers!

William Nguyen
Project Ranger | Canberra Nature Park South | ACT Parks & Conservation
Athllon Depot - Cnr Athllon Dr & Sulwood Dr, FARRER ACT 2607
M: [redacted] | P: 02 6207 3355 | E: William.Nguyen@act.gov.au

From: [redacted]
Sent: Tuesday, 9 January 2024 10:47 AM
To: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>; Nguyen, William <William.Nguyen@act.gov.au>
Subject: RE: Eastern Grey Kangaroo vehicle collision numbers for 2016 to 2023

Hi Will
Cc Claire

Hope you had a nice holiday break!

I had a go at getting this data summary myself, by downloading the wildlife callout data, filtering for EGK, then tabulating the callouts by year. I noticed a couple of things:

- The numbers for 2022 and especially 2023 are low – is this because these later data are not yet available in the downloadable spreadsheet?
- Also, Claire shared the Cope and Herbert report with me, and their numbers for callouts are a bit smaller than in my tabulation (their report only states the EGK-specific data for 2016-19). Perhaps they did some extra filtering/data cleanups that sharpened the numbers – for example from Claire's email, I take it that not all callouts are for a vehicle collision?

Any insights appreciated.
Thanks
Sarah

Year	My tabulation	Cope and Herbert
2016	2775	2531
2017	2522	2271
2018	4044	3652
2019	3446	3003
2020	1731	

2021	1221	
2022	1679	
2023	181	

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Saturday, December 23, 2023 6:31 PM
To: Nguyen, William <William.Nguyen@act.gov.au>
Cc: [redacted]
Subject: Eastern Grey Kangaroo vehicle collision numbers for 2016 to 2023

OFFICIAL

Hi Will,
Assuming you won't see this until January, I hope you had a lovely Christmas/New Year break!

At some time in early January would you please be able to provide a summary table from the Wildlife Callout Database to Sarah Legge who is currently undertaking an independent review of the Eastern Grey Kangaroo Controlled Native Species Management Plan?

She is after the annual number of Eastern Grey Kangaroo records related to motor vehicle collisions only. Is that possible? I assume there is field that distinguishes vehicle collisions from other reasons for ranger attendance?

I have cc'd Sarah into this email because I will be away at the beginning of January so if you could send the table directly to her, that would be great.

Thanks!

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
Phone +61 2 6205 8252 | Email claire.wimpenny@act.gov.au
480 Northbourne Avenue, Dickson ACT 2602| GPO Box 158 Canberra ACT 2601 | www.environment.act.gov.au

Conservation Research Website | EPSDD Environment Science Platform | View our story map collection here!

I acknowledge the Ngunnawal people as traditional custodians of the ACT and recognise any other people or families with connection to the lands of the ACT and region. I acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

From: Keighley, Miles
Sent: Mon, 15 Jan 2024 21:59:29 +0000
To: Sarah Legge
Cc: Wimpenny, Claire
Bcc: 480NBA 00.028 (Capacity 4, Video Conf)
Subject: Kangaroo counting methods

From: Keighley, Miles
Sent: Mon, 15 Jan 2024 22:55:00 +0000
To: Sarah Legge
Cc: Wimpenny, Claire
Subject: RE: Roo plan review chat

Thanks Sarah,
Claire got in first and booked you and Mel meeting slot at this time so I cancelled my one 😊
Let's see what Mel reckons and perhaps Claire can modify her meeting invite accordingly, if necessary.

From: Sarah Legge <[redacted]>
Sent: Tuesday, January 16, 2024 9:45 AM
To: Keighley, Miles <Miles.Keighley@act.gov.au>; Snape, Melissa <Melissa.Snape@act.gov.au>
Subject: RE: Roo plan review chat

Hi Miles, Mel

At this stage im free between 9 and 3 on Friday, so whatever works for you is fine with me.

S

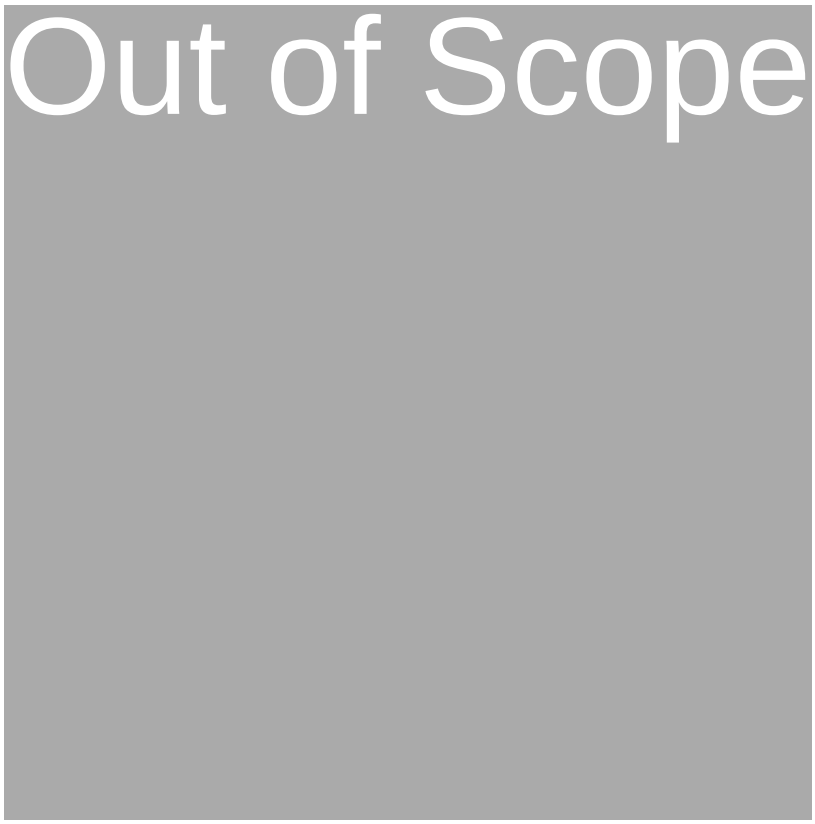
-----Original Appointment-----
From: Keighley, Miles <Miles.Keighley@act.gov.au>
Sent: Tuesday, January 16, 2024 9:42 AM
To: Sarah Legge; Snape, Melissa
Subject: Canceled: Roo plan review chat
When: Friday, 19 January 2024 9:30 AM-10:30 AM (UTC+10:00) Canberra, Melbourne, Sydney.
Where: 480NBA 01.102 (Capacity 6, Webex Board)
Importance: High

Hi Mel,

Sarah's flying down to Canberra this week and keen to catch up with you as part of the review process. She suggested this time before she has a chat with Claire and I.

Sarah, in case Mel's not available for this time perhaps we could push our chat with Claire back an hour and grab some lunch as part of it. I'm still keen to keep our chat slot of two hours in case there's a heap to discuss based on our first read of your review but there is also a chance we may not need that long.

I've included a teams link for flexibility, but there's also a room booked if you're both in Dickson.



From: Sarah Legge
Sent: Tue, 16 Jan 2024 07:16:45 +0000
To: Snape, Melissa; Keighley, Miles
Subject: RE: Roo plan review chat

Great, looking forward to it Mel.
Sarah

From: Snape, Melissa <Melissa.Snape@act.gov.au>
Sent: Tuesday, January 16, 2024 11:22 AM
To: Sarah Legge <[redacted]>; Keighley, Miles <Miles.Keighley@act.gov.au>
Subject: RE: Roo plan review chat

Hi Sarah, hi Miles

9:30 on Friday suits me fine. I'll have to dust some cobwebs off my kangaroo management brain 😉

See you then!

Mel

From: Sarah Legge <[redacted]
Sent: Tuesday, January 16, 2024 9:45 AM
To: Keighley, Miles <Miles.Keighley@act.gov.au>; Snape, Melissa <Melissa.Snape@act.gov.au>
Subject: RE: Roo plan review chat

Hi Miles, Mel

At this stage im free between 9 and 3 on Friday, so whatever works for you is fine with me.

S

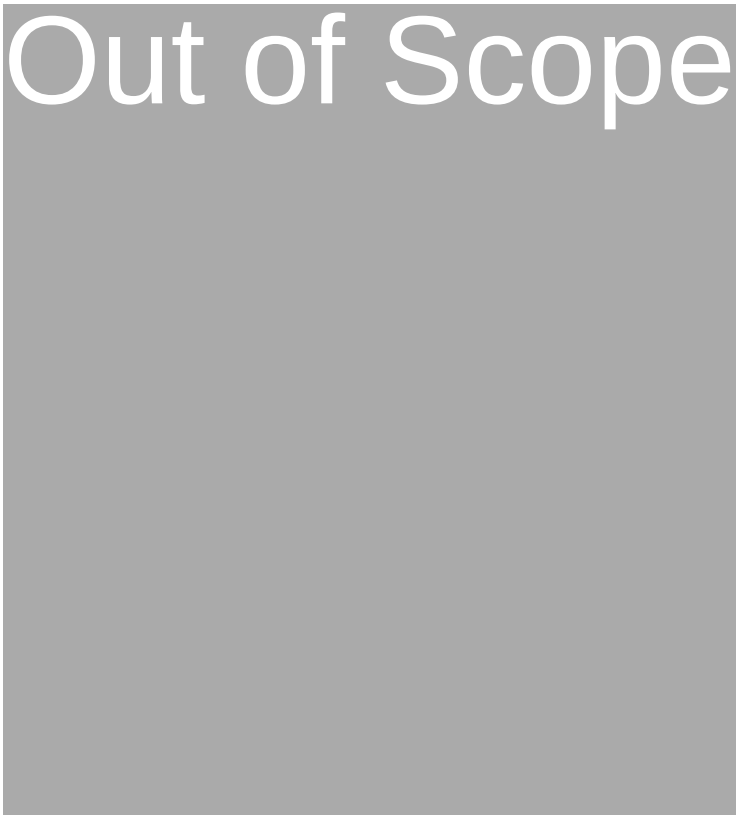
-----Original Appointment-----
From: Keighley, Miles <Miles.Keighley@act.gov.au>
Sent: Tuesday, January 16, 2024 9:42 AM
To: Sarah Legge; Snape, Melissa
Subject: Canceled: Roo plan review chat
When: Friday, 19 January 2024 9:30 AM-10:30 AM (UTC+10:00) Canberra, Melbourne, Sydney.
Where: 480NBA 01.102 (Capacity 6, Webex Board)
Importance: High

Hi Mel,

Sarah's flying down to Canberra this week and keen to catch up with you as part of the review process. She suggested this time before she has a chat with Claire and I.

Sarah, in case Mel's not available for this time perhaps we could push our chat with Claire back an hour and grab some lunch as part of it. I'm still keen to keep our chat slot of two hours in case there's a heap to discuss based on our first read of your review but there is also a chance we may not need that long.

I've included a teams link for flexibility, but there's also a room booked if you're both in Dickson.



From: Wimpenny, Claire
Sent: Fri, 19 Jan 2024 07:16:43 +0000
To: [redacted]
Subject: FW: Additional material for Sarah
Attachments: Decision support tool - Ver 4 Oct 21.docx, Herbage Mass Management Guidelines - Draft 24 April 2020.docx

OFFICIAL

Hi Sarah,
Here are the Draft Herbage Mass Guidelines and the draft paper that Mel spoke to you about this morning. Based on a really quick skim through, looks like there are some details that have not yet been updated to reflect methods. Let me know if you would like to clarify anything.

Both of these are prime candidates for your recommendation about us having time to complete reports! 😊

Regards,

Claire Wimpenny

Senior Ecologist
Office of Nature Conservation | Environment, Heritage and Water Division | Environment, Planning and Sustainable Development Directorate (EPSDD) | ACT Government
Phone +61 2 6205 8252 | Email claire.wimpenny@act.gov.au
480 Northbourne Avenue, Dickson ACT 2602| GPO Box 158 Canberra ACT 2601 | www.environment.act.gov.au

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From: Snape, Melissa <Melissa.Snape@act.gov.au>
Sent: Friday, 19 January 2024 12:13 PM
To: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>; Keighley, Miles <Miles.Keighley@act.gov.au>
Subject: Additional material for Sarah

Hi guys

In chatting to Sarah this morning we decided that the (perpetually in draft) herbage mass guidelines and half baked paper (with references) might be a useful thing for her to access (and probably recommend get finished and made public…… sorry!)

Each are attached, but thought I'd send to you first to pass on if it makes sense (which I presume it will!)

Thanks 😊
Mel

Dr **Melissa Snape**

Senior Ecologist – Urban Ecology
Office of Nature Conservation | Environment, Planning and Sustainable Development Directorate
w +61 2 6205 0001 *m* +61
Location: Naas Neighbourhood, Level 2 | 480 Northborne Avenue | Dickson ACT 2602
Mail to: Conservation Research | PO Box 1908 | Canberra ACT 2601 | Australia

I acknowledge the Ngunnawal people as traditional custodians of the ACT and recognise any other people or families with connection to the lands of the ACT and region. I acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

Managing ground layer vegetation in lowland grassy ecosystems of the south-eastern highlands, Australia: A case study and decision support tool

Keywords: natural temperate grassland, box-gum grassy woodland, vegetation, fire, grazing, slashing, grass height, kangaroos, decision tree, management

Abstract

On a global scale, grassy ecosystems are under threat due to the intensification of agriculture, urban development, and altered management regimes. Having evolved with regular disturbance in the form of grazing and fire, the conservation and restoration of grassy ecosystems in Australia depends on informed management and, in many instances, a reintroduction of disturbance regimes typical of pre-European settlement.

This paper presents an evidence-based framework for the adaptive management of grassy ecosystems in south eastern Australia, with a focus on the reintroduction of key disturbance mechanisms (grazing, physical removal and fire). Referencing a case study from the Australian Capital Territory, we describe the process of setting clear management thresholds for grassy layer metrics (grass height and grass thatch), which combined with on ground monitoring and the decision support tool presented enable an adaptive and evidence-based approach to informing management interventions. An approach to guiding the timing of management interventions to be consistent with the life history traits of species of interest is also provided as a part of this framework.

By drawing together learnings from previous studies and on ground practical experience, this paper aims to provide land managers with a guide for on-ground management with the objective of conserving and enhancing biodiversity and ecosystem health and resilience. Application of this tool will enable the reintroduction of appropriate disturbance mechanisms at appropriate times to encourage persistence of these endangered communities into the future.

Introduction

Grassy ecosystems are the most degraded ecosystems globally. Once covering 40% of the worlds terrestrial surface, grasslands occur where either abiotic (climate, soil profile, fire) or biotic (grazing by large herbivores) processes prevent establishment of trees. Less than 10% of these ecosystems are now considered intact, having been directly lost through urban expansion or agricultural cultivation, or degraded through the invasion of exotic plant and animal species, altered soil structure and nutrient profiles, changed fire regimes, the replacement of native grazers with domestic stock, and the impacts of climate change.

In ecosystems where grasses naturally make up most of the vegetative biomass, appropriate management of the grassy layer is key to maintaining ecological function and conserving native biodiversity. Historically, biodiverse grassy ecosystems were maintained by the combined influences of disturbance events such as fire and grazing by native herbivores, which varied over space and time, and which were mediated by the underlying effects of environmental context such as topographic position, soil type, hydrology, and climate. At a finer scale, the impacts of these disturbance processes were further influenced by the physical, chemical, or biological conditions introduced by habitat features such as logs or surface rocks, as well as the learned behaviours of native grazing animals.

In south-eastern Australia, contemporary land use patterns have altered natural disturbance regimes and underlying environmental context for native grassy ecosystems in many areas. For example, where agricultural enterprises have been introduced, significant changes to landscape hydrology,

soil chemistry and structure, and the composition and structure of plants have occurred as a result of soil disturbance, compaction and/or treatment with fertilisers, the deliberate and non-deliberate introduction of non-native plants and animals, and changes in both the timing and frequency of fire relative to historical context. Elsewhere, urban development has devoured open grassy ecosystems, concentrated the impacts of people on habitat structure (e.g. via the removal of surface rock), and resulted in the functional isolation of remnant patches within the landscape. Where the underlying landscape context does remain conducive to the preservation of native grassy systems, ecological recovery, or even the arrest of further decline, has not necessarily occurred due in part to an absence of historical disturbance regies which mimic those with which these ecosystems have evolved.

In light of the context within which many of the native grassy ecosystems of south-eastern Australia now persist, active and evidence-based adaptive management of habitat remnants has become paramount to their conservation. With a significant body of research being available to inform our collective understanding of the ecology of these systems, including anticipated responses to common management interventions, an evidence based adaptive management approach is considered well within the grasp of on-ground practitioners. In this paper, we aim to synthesise available knowledge to inform a practical guide for evidence-based and context-specific management interventions for grassy ecosystem conservation. Following an adaptive 'plan', 'do', 'review' management framework, we step through the processes of setting explicit and measurable conservation objectives, the collection of informative field data, the selection and deployment of appropriate management tools, approaches to prioritising on-ground actions, and a framework for reviewing management effectiveness. This approach is presented alongside a contemporary case study documenting the application of this method to grassy ecosystem conservation in the Australian Capital Territory.

Defining management objectives and thresholds

Defining a clear management objective is the important first step of any adaptive management program. In the context of grassy ecosystem conservation, creating a patchy mosaic of native grasses and forbs with different grass heights, thatch depths and inter-tussock spaces has been shown in numerous contexts to support greater biodiversity and species richness in grassy ecosystems (Wong and Morgan 2007, Lunt et al 2012, Howland et al 2014, Morgan 2015, Howland et al 2014 and Howland et al 2016b), particularly when observed in association with intact non-grass habitat elements such as rocks and logs (Barton et al 2011, Manning et al 2013, McDougall et al 2016). As such, such an outcome represents a sound objective for conservation land managers to work towards when applying and managing appropriate disturbance regimes within a grassy ecosystem setting. To support delivery against this objective, the identification of measurable target 'thresholds' for key grass structural metrics will enable land managers to work towards a set of specific outcomes when managing disturbance in grassy landscapes, and also enable the effective evaluation of management success.

Whilst quantified management thresholds for grassy ecosystem conservation may be scarce within the literature, and recommendations such as achieving 'high grass complexity' or 'low grazing pressure' generally provide little in the way of practical advice for on-ground management of disturbance regimes, studies reporting on 'raw' metrics (such as grass height, or litter depth) do provide a basis from which measurable management thresholds can be derived. In grasslands, for example, native plant species richness has been shown to be highest where average grass heights are below 5 cm (Snape et al 2018). Improved floristic diversity associated with direct seeding of

native forbs has also been associated with live tussock cover percentages of between 10 – 50%, and litter depths of less than 0.5 cm (Johnson et al 2018). Reptile abundance in grasslands has been shown to increase up to average native grass heights of ~10 – 12 cm (the maximum observed by Snape et al. 2018), whilst reptile species diversity improved as the percentage of bare ground increased to the maximum observed of 10 – 20%. Under short grass conditions (< 5cm), the diversity of reptile and native plant species was shown to increase where a greater proportion of habitat being within close proximity (< 2m) to surface rock (Snape et al. 2018), demonstrating the important interaction between grassy habitat structure and non-grass habitat features.

Similar quantified metrics may be derived from studies in grassy woodland ecosystems. For example, positive outcomes for reptile and plant species diversity have been observed in association with shorter grass conditions (< 5cm), except where logs or shrubs were scarce in which case higher average grass heights were associated with improved diversity of native plants (Snape et al. 2018). Proximity to logs was also highly beneficial to native floristic and reptile diversity respectively where average grass heights in grassy woodlands exceeded 5 cm.

Combined, the research above highlights a number of key metrics which are relevant to guiding the informed management of grassy ecosystem structure as it relates to achieving conservation objectives. From these, context specific and measurable management 'thresholds' can be derived as a basis for triggering the application of relevant disturbance mechanisms (e.g. the introduction of fire in grasslands where grass heights exceed a threshold associated with optimal plant diversity), and for evaluating management outcomes (Box 1). Where specific management thresholds relevant to the environmental context are absent in the literature, interim targets informed by expert opinion should be adopted and trialled according to an adaptive management approach.

Defining and attributing management units

Once management objectives and thresholds have been defined, being clear in the spatial extent to which these targets apply is a useful next step in undertaking adaptive management. Defining and attributing spatially explicit management units should delineate between areas which require differing forms of management intervention, for example due to spatial variability in grass species composition, the spatial extent of conservation values to be protected, or the on-ground feasibility of different management interventions. A substantial body of research exists which describes the variable responses of grassy ecosystem species and communities to commonly applied management tools, such as grazing, fire, mechanical removal, or the installation of grazing exclusion fences, rocks or logs.

The impacts of grazing by the native eastern grey kangaroo, for example, have been shown to vary substantially according to grass height and species composition (Snape et al. *in press*). Supplementary grazing by introduced herbivores such as sheep and cattle can hence be beneficial in reducing average grass heights and opening up inter-tussock spaces (Dorrough et al 2004, Kirkpatric et al 2005), particularly in highly productive areas dominated by exotic grass species or areas which are devoid of or avoided by native grazers (Snape et al *in press*). Fire responses also vary according to community composition, with C4 perennial grasses such as *Themeda* having been shown to increase under more frequent fire regimes where as C3 perennial grasses such as *Poa* are fire sensitive and will decrease with regular fire regimes (Prober et al 2007). In terms of more recently adopted disturbance mechanisms, mechanical removal of grass (via mowing) has been shown to increase native perennial grass cover and decrease exotic perennial grass cover in both C3 and C4 dominated grasslands, with cut areas demonstrating higher species diversity overall (Smith *et al* 2018). Cutting grass was also associated with a decrease in abundance of exotic species wild oats (

Avena fatua) and Chilean needle grass (*Nassella neesiana*; Smith *et al* 2018), hence this tool may be preferred where these species pose a threat to ecosystem condition.

[Add section on fencing, rocks and logs – are there any grass community type specific responses?]

Recognising the variable effects of disturbance processes across different grass community types is a critical first step in defining individual management units which have meaningful application to on-ground interventions. Overlaying these management units with spatially explicit management objectives (e.g. protection of habitat for a particular threatened species), management thresholds (e.g. 5 – 12 cm average grass height) or operational constraints (e.g. inability to apply fire due to proximity to urban development) will also be relevant to informing the spatial delineation of management units in this context (Box 2).

Monitoring grassy layer condition

Monitoring grassy ecosystems is crucial for understanding their current condition, as well as to evaluate the effectiveness of management interventions in achieving target outcomes. If undertaken consistently over the long-term, ecosystem monitoring can also demonstrate trajectories of change, and provide insight into the effectiveness of management interventions under the broader influences of processes such as soil health, hydrology, and climate. As with any monitoring program, efficiencies can be gained by applying a stratified approach to data collection in grassy ecosystems. In practice, this involves identifying areas which are likely to introduce variability into monitoring data which are unrelated to management intervention (e.g. where an area is dominated by very tall vs. very short species of grass), and ensuring a monitoring design which accounts for this 'background noise' in the data. By accounting for such natural variability, any meaningful effect of a management intervention can be better identified without the need for very large and expensive levels of survey effort.

In the process presented here, the prior identification of management units classified according to variables associated with the anticipated responses to management intervention (described in the previous section) will enable a streamlined approach where at least some of the anticipated variability in either starting condition or responses to management intervention will already be accounted for. As such, within each management unit or classification type, fewer monitoring points will likely be required to portray an accurate representation of ecosystem health for that area. Capturing data around the type and timing of the management intervention which occurred (including its spatial extent) is necessary in addition to the monitoring of key habitat metrics if management effectiveness is to be effectively evaluated in this context (Box 3). In addition, care should be taken to ensure consistent measurement approaches across space and time, particularly for metrics which can be subjective and easily approached differently by different surveyors (Box 4) and which vary substantially as a result of seasonal change (Box 5).

Selecting and deploying a management tool

With land management objectives and thresholds set, management units spatially delineated and the current state of the ground layer determined via a robust monitoring approach, the next step in the adaptive management approach is to identify which management intervention to apply (and when to apply it) in areas where the current disturbance patterns are inconsistent with achieving management objectives.

There are broadly two classes of management tools available which relate to achieving appropriate disturbance regimes in the grassy layer. These are interventions which reduce overall grass biomass

and open up vegetative structure (e.g. grazing, fire, mechanical removal), and those which prevent excessive disturbance at various scales (e.g. grazing exclusion fencing, surface rocks, and woody debris). Each intervention type will have variable impacts according to the ecology of the environment to which it is applied, and the timing of its deployment. A significant body of literature is available to support decision making around many of the tools commonly used to achieve appropriate disturbance regimes. The collation of this scientific knowledge provides an opportunity to develop context-specific decision support tools to guide grassy ecosystem management across south-eastern Australia (Boxes 6-10).

Native herbivore grazing

In conservation settings, grazing by native herbivores, particularly kangaroos, is often seen as the preferred disturbance mechanism for maintaining grassy ecosystem health and function (ACT Government 2017b). The eastern grey kangaroo (*Macropus giganeteus*) is the dominant native mammalian herbivore in most grassy ecosystems of the south-eastern bioregion, although the red-necked wallaby (*Macropus rufogriseus*) and common wombat (*Vombatus ursinus*) also play a role in disturbance of the grassy layer some locations. The eastern grey kangaroo is well recognised as an ecosystem engineer due to its role in influencing grassy habitat structure (Howland *et al* 2014, Howland *et al* 2016a) and nutrient cycling (Morris and Letnic 2017). The impacts of grazing by kangaroos are rarely uniform across the landscape, varying according to dominant grass species, initial herbage mass and concurrent grass productivity (Snape *et al* 2021). Animals also demonstrate non-random spatial positioning, likely in response to reducing predation risk, showing a preference for open grazing areas closer to wooded habitat (Banks 2001). These combined behavioural and ecological drivers of native grazer impacts support the role of native herbivores as a mechanism for promoting habitat heterogeneity at both the patch and landscape scales (Gordon *et al* 2004).

Maintaining a balance between native herbivore density and grass availability is key to ensuring ongoing health and resilience of grassy ecosystems, regardless of whether populations are regulated by natural predation or other means (Morris and Letnic 2017, Gordon *et al* 2021). The relationship between kangaroo grazing impacts and current and projected ecosystem condition have important implications for identifying sustainable kangaroo densities for a given area (Gordon *et al* 2021, Snape *et al* 2021). Where favourable climatic influences or a dominance of highly productive exotic pasture grasses promote abundant grass growth and excessive herbage mass, alternative management tools such as ecological burns, mechanical removal or livestock grazing may be required to restore grass palatability to local kangaroo populations and encourage targeted grazing in above-threshold landscapes (McIntyre *et al* 2015; Snape *et al* 2021). Whilst the impacts of native herbivore grazing can also be difficult to manage spatially due to the ineffectiveness of traditional infrastructure (e.g. fences) used for introduced livestock, highly mobile native grazers such as kangaroos do appear to be responsive to the availability of fresh green pick and hence may be an effective means of maintaining short, productive grasslands after the introduction of fire in the landscape (M Snape, pers comms).

Fire

Ecological burns are generally small, patchy, low intensity burns that lead to a rapid reduction in herbage mass and may promote native plant seed regeneration (Hodgkinson 1995, Morgan 2015). The presence of fire in an ecosystem can also affect biodiversity by creating fertile spaces on the soil that allow plant species to establish that would otherwise be shaded out or out competed (Lunt *et al* 2012). Fire can also influence the distribution grass species by changing conditions to promote different functional traits (e.g. winter growing C3, summer growing C4, or annual species). For

example, C4 perennial grasses such as *Themeda* have been shown to increase under more frequent fire regimes where as C3 perennial grasses such as *Poa* are fire sensitive and will decrease with regular fire intervals (Prober et al 2007). Ecological burn frequency of 5 years is recommended to promote C4 species such as Themeda (Morgan and Lunt 1999, Prober *et al* 2007, Prober *et al* 2009).

In addition to the timing of fire frequency, the seasonal timing of fire can also have an important influence on the outcomes of this intervention method. Autumn burns (after native grass and forb seed has set) are the most effective for regenerating native grasslands (Morgan 2001) as this timing allows native plants to set seed and establish, giving them the competitive advantage over exotic species such as African Love Grass (*Eragrostis curvula*) which die down over winter (Firn *et al* 2010). Spring burns can be useful in reducing grass biomass and seed set of exotic annual grasses such as wild oats (*Avena* spp.), bromes (*Bromus* spp.), quaking grasses (*Briza* spp.), rye grasses (*Lolium* spp.), barley grasses (*Hordeum* spp.) and fescue species (*Vulpia* spp.) (Prober *et al* 2004 and Prober *et al* 2005). However, burns at this time also risk impacting native grasses while flowering and setting seed. [Insert reference] suggests a maximum of 70% of a site is burned at any one time to allow fire sensitive species to persist on site.

Mechanical removal

Mechanical removal of grass biomass, generally in the form of slashing or mowing, is an effective method to quickly reduce grass height, increase inter tussock space and allow light penetration. It has been effectively used to increase the percentage of native rather than exotic perennial grass cover and to increase plant species richness in both C3 and C4 dominated grasslands (Smith et al 2018). Exotic grass species, including wild oats (*Avena fatua*) and Chilean needle grass (*Nassella neesiana*) were also shown to decrease in number on cut areas (Smith *et al* 2018), supporting a role of mechanical grass removal in reducing the prevalence of invasive plant species when timed to remove flower heads before the onset of seed production (Lommen *et al* 2018).

When operationalising mechanical removal, consideration should be given to the height to which grasses are cut, the risk of invasive species incursion, the appropriate use of equipment, and the appropriate timing of management interventions to avoid negative outcomes. Native grasses cut shorter than 10 cm have shown increased risk of mortality, especially in drought conditions (Hodgkinson 1995). Mechanical removal operations also present an increased risk of soil compaction (particularly for wet soils), weed incursion (often due to poor equipment hygiene), and elevated thatch (resulting from retention of cut material in the environment). Hence these risks should be mitigated wherever possible. To maximise positive outcomes for native dominated grasslands, mechanical removal should be undertaken outside of the flowering season and once seeds have fallen, preferably in winter (Chan 1980). Operations should also be undertaken to achieve a patchy mosaic of grass structures at the appropriate scale for the values being managed.

Livestock grazing

Sheep and cattle grazing can be effectively used in grasslands to reduce excessive herbage mass, decrease competition between tussock forming grasses (Hodgkinson 1995) and increase inter tussock space (Dorrough et al 2004, Kirkpatrick et al 2005). Livestock may be especially useful in grazing areas which have become unpalatable to kangaroos due to excessive grass biomass (McIntyre? Snape?), or where the mechanical trampling effect of hooved stock can speed up the decomposition of excessive grass thatch (REF).

The use of introduced livestock in managing conservation areas is not without risk however. Many native grass species are not tolerant of continuous grazing and hence stock impacts must be monitored and animals removed before reducing grass height below a threshold of ~10 cm (Hodgkinson 1995) to maintain structural heterogeneity. Livestock, particularly sheep, may also selectively impact on grazing sensitive herbs and other native species (REF), whilst cattle can cause pugging and issues around soil compaction (REF). Given the legacy impacts of stock on native grassy ecosystems in south-eastern Australia, the introduction of stock grazing to areas not previously managed in this way is generally not recommended unless no other disturbance mechanisms are in place (REF – I made this up, might not even be right). Like all disturbance interventions, the timing of action is an important consideration and should align with the life history traits of the species being conserved. In general, stock should be removed when native plants are flowering and setting seed (Lunt 2005), usually throughout spring and summer, but timing will vary according to the specific species of concern.

Exclusion fencing

Exclusion fencing is a means of preventing excessive grass biomass removal by both native and introduced herbivores. The type of fencing employed will differ depending on the species being excluded. Studies have demonstrated the use of exclusion fences designed to prevent access by native macropods to increase grass biomass within grassy ecosystems in south-eastern Australia, resulting in subsequent increases in the abundance and diversity of frog, beetle and reptile species (Mulligans). Exclusion fences have also demonstrated successful protection of ground layer vegetation against introduced herbivores such as the European rabbit (REF). Fence lines themselves have also been demonstrated to provide some protective habitat for small animals where they result in a reduced impact of herbivores on a fine scale.

In general, the installation of fences may be avoided in the conservation estate due to the impacts of the fence along its footprint and the disruptive impacts they can have on connectivity and movement for a variety of fauna species. Fences may also provide additional perching locations for predatory birds, which may increase the risk of predation on threatened species. In some circumstances, such as during periods of prolonged drought or where a significant shift from a highly degraded state may be desirable on a small scale, temporary fencing may be able to be installed to enable recovery and stabilisation of important habitat areas without notable lasting impacts on the landscape or wildlife populations. This has been shown to be effective in various locations, including within the ACT (Brett Howland, pers. comms). Ensuring fencing is removed once the grassy layer objectives are achieved, or ensuring some alternative (non-herbivore) disturbance is introduced within fenced areas, will be important to avoid areas becoming degraded due to a lack of disturbance over time.

Addition of rocks or woody debris

Surface rock and woody debris are important components of healthy and intact grassy ecosystems, providing fine scale habitat heterogeneity by means of capturing water, nutrients and seeds in surface run-off and through the provision of microclimatic niches for a range of plant and animal species. In this way, surface rock and woody debris are able to bring about heterogeneity in the grassy layer both by physically preventing close grazing access by some native and introduced herbivores, but also through providing improved growing conditions (additional moisture, nutrient or altered thermal niche) for individual plants in the immediate vicinity.

Some examples of successful use of surface rock.

The addition of woody debris into grassy ecosystems of south-eastern Australia has been associated with an increase in the abundance and diversity of reptiles, birds, frogs etc (Mulligans and Brett's work?). The slow decomposition of woody debris remaining in place, coupled with the additional microbial activity associated with such habitat features has also demonstrated a positive influence on soil chemical and biological properties.

For both rocks and woody debris, the additional disturbance associated with their installation brings about risks of soil compaction and the introduction of invasive plant species where heavy machinery is used. The increase in soil nutrient levels immediately surrounding these fine scale habitat features may also result in a competitive advantage for non-native plant species, whilst the direct effects of providing additional habitat structures in the landscape may increase the refugia harbour for introduced animals, such as European rabbits. In general, the application of these techniques in the landscape should be sympathetic to the conservation values being protected in the management unit, with careful consideration around hygiene (as it relates to the introduction of invasive plant species) and the potential flow on effects associated with bringing additional hard habitat structures into the environment (e.g. accessibility for future mowing programs).

Prioritising management intervention

Evaluating effectiveness

[Yet to do]

Conclusions

This decision support tool aims to support land managers in their on-ground management of lowland grassy ecosystems of south-eastern Australia. The approaches recommended here utilise a range of management tools, to promote biodiversity, maintain ecosystem function and resilience, and protect habitat for threatened grassland flora and fauna.

We advise introducing strategic disturbance regimes into ~~grasslands and grassy woodlands~~grasy ecosystems to promote biodiversity. Reintroducing appropriate disturbance regimes to ~~grassy~~ these ecosystems is necessary for the conservation of these important habitats and associated species. This paper sets out the considerations and management tools available for the conservation of grassy ecosystems in south eastern Australia. It lays out methods to assess grassy layer condition, outlines management tools available and presents decision trees and species timing tables to help land managers choose the best course of action for managing grassy ecosystems. By presenting these tools and case studies of how we manage grassy ecosystems in the ACT, we hope this furthers action bring informed appropriate disturbance to manage grassy ecosystems across temperate Australia.

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ACT Government

DRAFT HERBAGE MASS MANAGEMENT GUIDELINES

FOR LOWLAND GRASSY ECOSYSTEMS OF THE ACT

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Front cover (clockwise from top left): Livestock grazing is employed to protect life, property and the environment in strategic bushfire asset protection zones within the ACT; grazing by native herbivores (here Eastern Grey Kangaroos) is the preferred disturbance mechanism in Canberra's nature reserves; ecological burning is an important part of managing grassy landscapes.

CONTENTS

OVERVIEW

This document aims to provide a consistent and transparent basis for the management of the ground layer vegetation in the ACTs lowland grassy ecosystems. It encompasses a review of the available scientific literature, as well as interim results from grassy ecosystem management and restoration studies being undertaken with various business units of the ACT Government Environment Division.

In accordance with recommendations stemming from the Grassland Conservation Effectiveness Monitoring Program (CEMP), the Canberra Nature Park Plan of Management, and an expert workshop on managing kangaroo grazing impacts, these guidelines will establish a protocol for evidence-based grassy ecosystem management as part of an ongoing adaptive management framework.

There will be four main steps to this process:

1. Establish spatially explicit Herbage Mass Polygons across the extent of lowland grassy ecosystems within the ACTs conservation estate, classified according to areas of consistent grassland community and delineated at an appropriate management scale.

2. Establish an appropriate 'Safe Operating Environment' (SOE) for each classification of Herbage Mass Polygon, identifying the target grassy layer structure to support biodiversity.

3. Establish a Herbage Mass Decision Framework to underpin polygon scale management advice (both tools and timing), where the grassy layer structure is found to be outside of the stated SOE.

4. Establish a monitoring protocol to provide input into the Herbage Mass Decision Framework, and to evaluate the effectiveness of management actions within individual Herbage Mass Polygons over time.

These guidelines will be available publically to all land managers to assist in a coordinated and consistent approach to grassy ecosystem management (see 'Pathway to Adoption' section below for further information). It will be reviewed regularly to enable adoption of new techniques and strategies as they are developed based on learnings from the adaptive management process. Note that whilst this document provides a framework for evidence-based management recommendations, based on advice compiled by the Herbage Mass Working Group, it does not address in detail the operational constraints and considerations around how these recommendations may be implemented in the field.

PATHWAY TO ADOPTION

The success of these herbage mass management guidelines will depend on a clear pathway to adoption, with the various roles and responsibilities of business units stated up front (but recognising the capacity for change over time). The current proposed process in regard to collection of herbage mass data, development of management recommendations, prioritisation in regard to operational capacity and resourcing, and management implementation is outlined below (Figure 1). Opportunities to increase the role of district land managers in data collection and recommendation development will likely be sought in future iterations of this process.

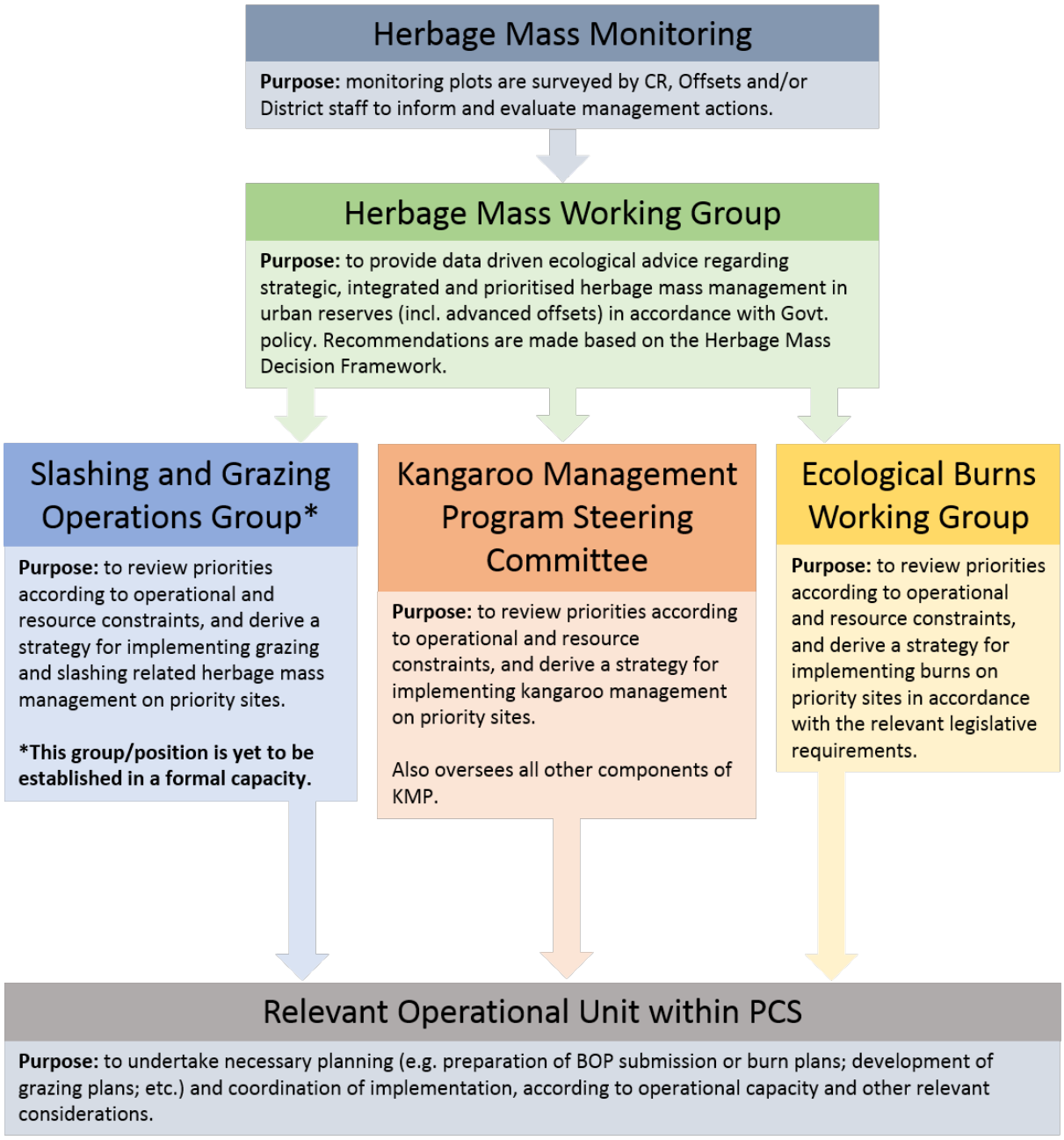


Figure 1. Proposed pathway to adoption for herbage mass management guidelines.

INTRODUCTION TO HERBAGE MASS MANAGEMENT IN GRASSY ECOSYSTEMS

Recognising the variable nature of an 'ideal' grassy layer structure, depending on the vegetation community being considered, is a key component of grassy ecosystem management. The role of climate in determining grass productivity (i.e. grass growth rate) is also key when considering the need to balance the relative rates of herbage mass accumulation and removal. Key concepts for the management of herbage mass accumulation are explained below. The following recommendations provide general guidance for the management of herbage mass in lowland grassy ecosystems, with consideration of the effects of grass composition, climatic variability, stochastic events and other management objectives.

The key management objective for grassy ecosystems is to promote grassy ecosystem function, including provision of threatened species habitat, through the maintenance of a heterogeneous grassy layer. Management should be undertaken according to an adaptive management approach. In general, management will aim to:

- Maintain a variable (or 'patchy') grass structure at the reserve or landscape scale to provide suitable habitat for a range of grass dependent species, including threatened species. A variable grass structure has a mosaic of patches of grass with intermediate height and density interspersed with patches of shorter sparser grass and patches of longer denser grass.
- Avoid removing most of the herbage mass to create a very short, homogeneous grass sward (bulk of grass tussocks < 5cm, herbage mass < 600 kg/ha, bare ground >25%) across a significant proportion (e.g. > 10%) of the site.
- Avoid the formation of dense grass patches across significant areas (>10% of site) that are dominated by tall and dense grass tussocks (bulk of grass tussocks mostly long > 20cm, herbage mass > 3000 kg DM/ha, <5% bare ground), with very little or no inter-tussock spaces and potentially a large build-up of thatch (>1.5 cm deep).

Grassy ecosystems which contain multiple vegetation communities, differences in soil and topography (slope, valley, ridge), and/or which have a mix of dominant grasses at the landscape scale, will naturally provide some level of structural heterogeneity (Figure 2).

Figure 2. The 'ecotone' between two adjacent areas of grassland dominated by different species demonstrates how variable grassy layer structure can be, based on vegetation community and other factors. The patchy colouration in the background of this image demonstrates landscape scale heterogeneity, or 'patchiness', resulting from a mix of different vegetation communities within a site. Photo credit: M. Snape.

MANAGEMENT TOOLS

There are five main methods available to manage herbage mass in grasslands and grassy woodlands. The regime for using each management method will vary in frequency, timing, intensity and scale and differ depending on the grass community and past management of the site.

- Grazing by native herbivores is the preferred tool for herbage mass management in all grassy ecosystems. The dominant native herbivore in ACT grasslands is the Eastern Grey Kangaroo, *Macropus giganteus*. Monitoring of kangaroo populations and current grassy layer condition is necessary to manage grazing intensity (and thus kangaroo density) across each management unit.

- Ecological burns are small, patchy, low intensity burns that lead to a reduction in herbage mass and promote regeneration. The suitability of ecological burns to a given situation will depend on the grass community and available herbage mass.

- Slashing or mowing leads to a reduction in standing herbage mass and can promote tillage in grasses. Slashing can be undertaken with machines or by hand. In high herbage mass areas, removal of slashed material may be necessary to avoid excessive thatch retention.

- Grazing by stock can be used to reduce excessive herbage mass which has become unpalatable to kangaroos, or to reduce growth potential of undesirable species within the grassy layer (e.g. exotic annual or perennial grasses). The suitability and timing of grazing by sheep or cattle will depend on the grass community.

- Installation of physical barriers to protect against grazing, such as rocks, woody debris, or fences, can also be used to enable restoration of heavily grazed sites and provide alternative habitat niches for vulnerable species during periods of low herbage mass (e.g. drought). These are generally deployed to achieve variability at the sub-hectare scale.

CONSIDERATION OF CLIMATE

The rate of herbage mass removal by any method (grazing, slashing, fire) should reflect the current and/or predicted productivity of grass within the management area in order to maintain inter-tussock spaces and support higher biodiversity (Wong & Morgan 2007). Productivity varies spatially and temporarily based on grass species (ACT grassland associations outlined in Section 8.9 Grassland Strategy), soil fertility, topography and climatic factors ADDIN EN.CITE (Morgan, 2015, Lunt & Morgan, 2002, Schultz et al., 2011). The rate of herbage mass removal should be adjusted to *exceed* the rate of growth where a reduction in herbage mass is required, to be *below* the rate of growth where an increase in herbage mass is required, or *match* the rate of growth where the grassy layer is considered to already exhibit an appropriate structure.

Grass structural measurements, local site knowledge, and ongoing development of predictive models for native dominated grassy ecosystems will be important tools in adjusting management regimes to reflect predicted climate and landscape condition. For example, at sites with high moisture and nutrient availability, such as many highly productive kangaroo grass (*Themeda triandra*) dominated grasslands, grass growth is relatively fast and will require more frequent herbage mass removal (e.g. grassland associations r3 - if dominated by *Themeda*). Whilst in lower productivity sites, grass growth is more likely to be limited by lower resource availability and poorer growing conditions, requiring less herbage mass removal. The latter is likely to be the case in grasslands dominated by *Rytidosperma* spp. and *Austrostipa* spp. (e.g. grassland associations r3 - if dominated by *Rytidosperma*, r5, r6), and grasslands at higher elevations (e.g. grassland associations a14, a30, r1 and r2) or on poorer quality soils (e.g. grassland association r8).

MANAGEMENT OF NATIVE HERBIVORES

The Eastern Grey Kangaroo: Controlled Native Species Management Plan (ACT Government, 2017) identifies a kangaroo density of approximately 0.5 – 1.6 kangaroos per hectare (~0.5 dry sheep equivalent) to be appropriate to avoid herbage mass declining below a critical habitat threshold during drought conditions. Higher kangaroo densities may be ecologically sustainable in years of average to high rainfall however, and recently development in kangaroo management models now provide more targeted recommendations for kangaroo management based on site-specific herbage mass condition (Snape et al. 2018). Consideration of kangaroo population dynamics, other land management processes, and operational constraints will also influence kangaroo management programs.

MANAGEMENT HISTORY

Past management practices at a site can influence the outcome of different herbage mass management techniques. For example, implementation of fire in long-unburned grassland may have different outcomes to fire used in regularly-burned grassland, due to changes in the dominant grass species over time (). Fire is generally regarded as important in maintaining species richness in kangaroo grass dominated grasslands but may lead to species loss in spear grass/wallaby grass communities which have less capacity to survive frequent burning. Where past management practises have been stable for many years (> 10 years), new practices should be adopted as part of an adaptive management framework to guide herbage mass management methods into the future.

MANAGEMENT OF THREATENED SPECIES HABITAT

The management of threatened plants should be given equal priority to the management of threatened animals in lowland grassy ecosystems. If there is conflict between habitat management for two or more threatened species, the priority for management should be determined on the basis of the threatened species listing category (critically endangered, then endangered, then vulnerable), how abundant and/or restricted in distribution the remaining populations are, how important the site is to the conservation of the species, and the nature of any ongoing threats.

DEFINITION OF TERMS

Grassy layer structure can be measured and reported in a variety of ways leading to seemingly conflicting ecological advice. The definitions below describe the various measurements used throughout this document, with the aim of providing a consistent approach to monitoring and management in the field.

Herbage mass

Herbage mass refers to both the living and dead components of grass material, excluding seed stalks, which are attached to the tussock. Herbage mass excludes any unattached, dead grass (see 'Thatch' below). Herbage mass is generally reported in kilograms of dry matter per hectare (kg DM/ha).

Average grass height

The average leaf height of grass in centimetres (cm within a survey quadrat. Using this method, the sa leaf mass should be above and below the average areas of the survey quadrat covered in litter are ex estimates of grass height.

Maximum tussock height

Maximum grass height refers to the tallest grass le stems) within a quadrat. An analogy to this measu the height of the highest emergent tree in a forest forest. This measure is used to describe SLL habita 'Gungahlin Strategic Assessment' and the 'SLL Hab Plan', but is considered a less useful measure than for gaining a general understanding of habitat stru

Thatch

Thatch describes the detached, dead component of the grassy layer. Typically, this is comprised of dead grass leaves and stems, but can also include fallen forbs. Exotic forbs such as St John's Wort can contribute a large component to thatch depth. Thatch is often a smaller component in native swards (< 5% of total herbage mass), but can make up a substantial component of exotic and annual grass communities (~30%) due to the rapid growth (e.g. Phalaris), and short life cycle (e.g. Wild Oats) of these communities. For the purpose of this document, the depth (in centimetres) and percent cover of thatch are the metrics of interest for guiding management.

Dry Sheep Equivalent (DSE)

A measure commonly used in agriculture to compare the food requirements of livestock. DSE is used as a method of standardised grazing unit and is equivalent to the feed required for a two-year-old, 50 kg Merino wether to maintain weight. The Eastern Grey Kangaroo is considered to have a DSE of somewhere between 0.15 and 0.7 DSE depending on herbage condition and animal size, but an average of approximately 0.42 DSE is often used. Values for other livestock can be found here.

HERBAGE MASS POLYGONS

To enable identification of management units in the field, herbage mass polygons (HMPs) have been developed to provide a spatial basis for planning and recording management actions, enabling a convenient means of tracking, monitoring and reporting on management effort over the long term.

The initial identification of individual management polygons within a reserve used in these guidelines has considered multiple factors. Firstly, HMPs aimed to delineate boundaries between areas which differ in the management regime deemed most suitable. For example, areas dominated by *Themeda sp.* which would likely benefit from frequent (4-10 yearly) application of fire, were separated from areas dominated by *Austrostipa bigeniculata* which may suffer species decline under the same regime. Similarly, areas of predominately native grasses were separated from areas where restoration of a predominantly exotic perennial grass community would be the conservation objective. The positioning of HMPs in the field also considered the underlying topographic position and soil type.

Operational constraints were the second major consideration in determining HMPs, given the commitment to routine monitoring of polygon condition over time and the scale at which various management activities can be implemented. Based on plans for twice yearly polygon monitoring across Canberra Nature Park (and Environmental Offsets), the number of polygons within each reserve was kept to the minimum necessary to balance an appropriate level of precision in grassy layer condition, with resource availability for monitoring and management (e.g. ecological burns are unlikely implementable at scales greater than ~20ha).

Figure 3 outlines the process used to apportion areas of the landscape into one of four HMP classifications (which in turn feeds into the decision making framework). This process recognised the likely historical extent of *Themeda* spp. dominated communities across the lowland grassy ecosystems of the ACT, except in areas where *Austrostipa bigeniculata* remains the dominant grass type (G Baines, pers. comm). It is worth noting that this initial effort to delineate management polygons is likely to be further refined over time.

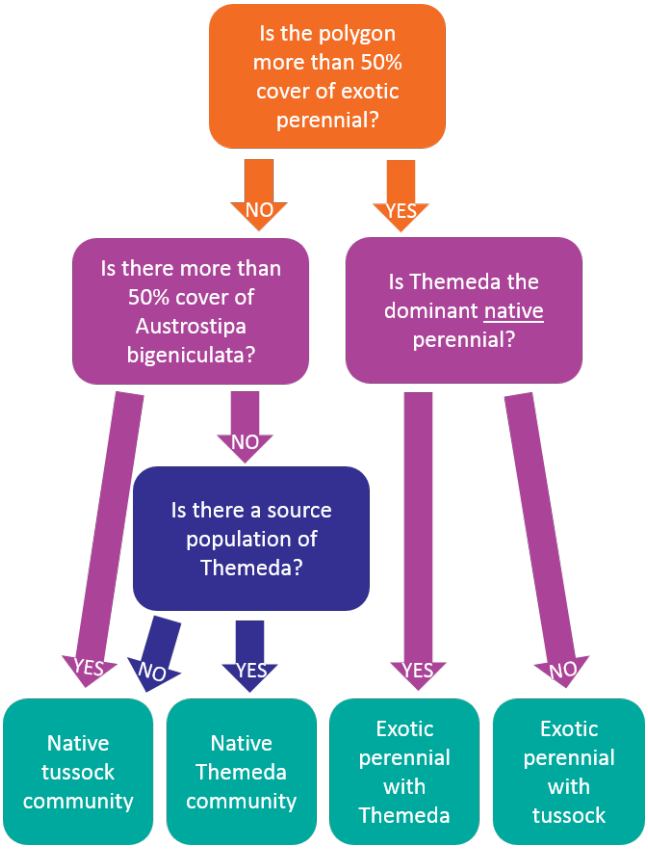


Figure 3. Decision tree used to support apportioning of grassy lowland ecosystems into one of four herbage mass management polygon classifications.

GRASSY LAYER MONITORING PROTOCOL

The monitoring protocol adopted to gather information on the current structure and condition of the grassy layer was adapted from that being undertaken by the Environmental Offsets team to track grassland condition against Commonwealth targets, and that used throughout the Grasslands Restoration Project (B Howland, *pers. comm.)*.

The monitoring protocol involves the collection of key structural attribute data from five 1m^2 quadrats at each of two monitoring plots per polygon (i.e. giving total of 10 quadrats per polygon; Figure 4). Summary data on the grassy layer condition for each polygon is based on the average and coefficient of variation of these 10 measurements.

At each quadrat, the following data are recorded:

- Dominant plant species; dominant, secondary and tertiary type, or two co -dominant and one secondary type as appropriate; identified to species or genus for grass, or as 'forb', 'sedge', or 'woody' for non-grass vegetation.
- Average grass height (cm); four measurements per quadrat
- Percent cover of grass; a visual estimate of the area of projected grass cover
- Percent cover of forbs, moss/lichens and sedges; as for grass, recorded individually
- Percent cover of bare ground; a visual estimate of the area of exposed soil
- Percent cover of embedded rock (i.e. not gravel)
- Percent cover of thatch and litter; recorded individually
- Depth (cm) of thatch and litter; recorded individually

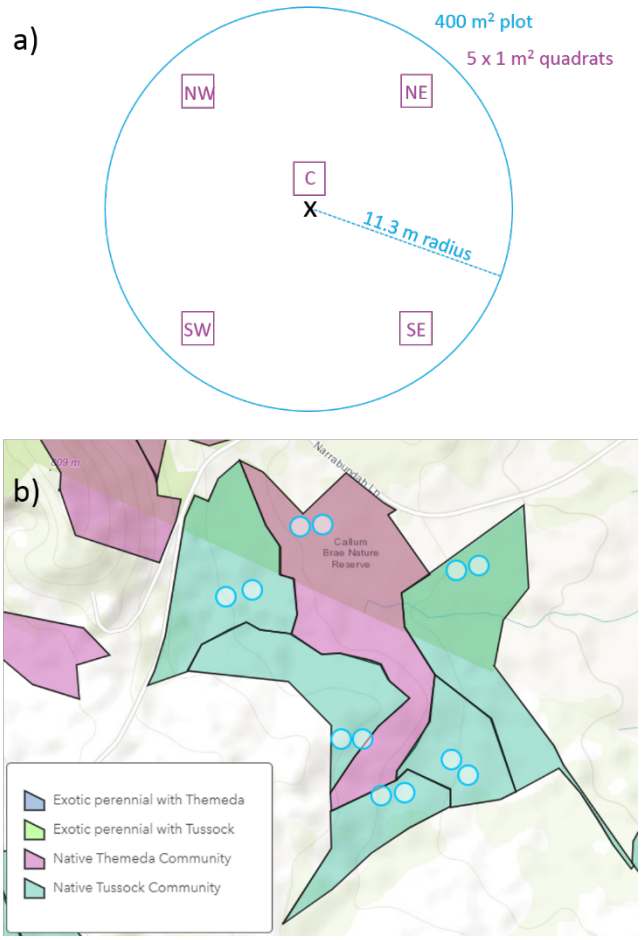


Figure 4 (above right). Plots contain five quadrats (a), with two plots being surveyed per polygon (b). Plots are positioned ~100m to be representative of the heterogeneity at the polygon scale, except for where existing survey plots from the Grassland Restoration Project or Offset Monitoring Program are used.

HERBAGE MASS DECISION TOOLS

Grassy ecosystems are dynamic and exist within a range of conditions depending on climate, soil, topography, land use history and current disturbance processes. Measurements of grass structural attributes in have informed research to determine tolerable thresholds for each grass community type; and for threatened species therein (REFERENCES). This research subsequently informed the development of the 'Safe Operating Environment' (SOE) for each herbage mass management polygon classification, as well as for individual threatened species and communities.

When herbage mass monitoring demonstrates grass structure within the SOE, current approaches to herbage mass management are likely to be appropriate and should be maintained. If measurements fall within the low or high alert zones however, additional management interventions should be considered in the context of recent and anticipated climatic conditions and other planned land management actions.

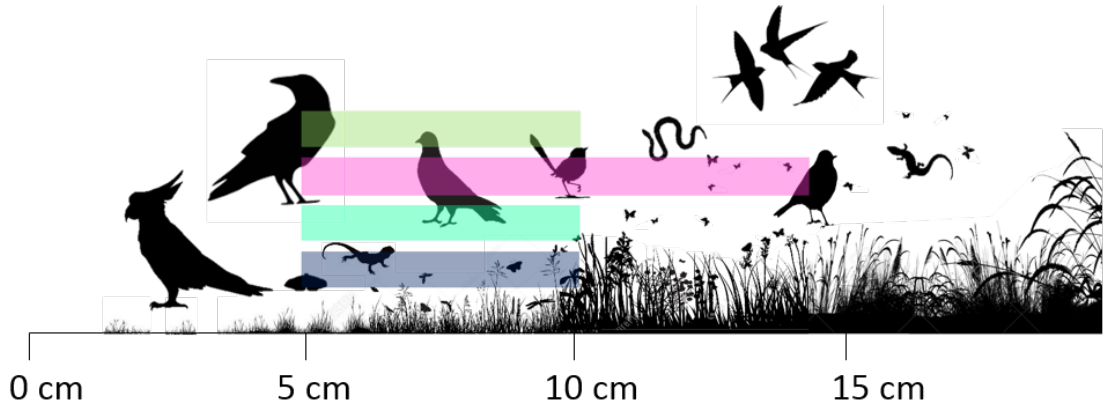
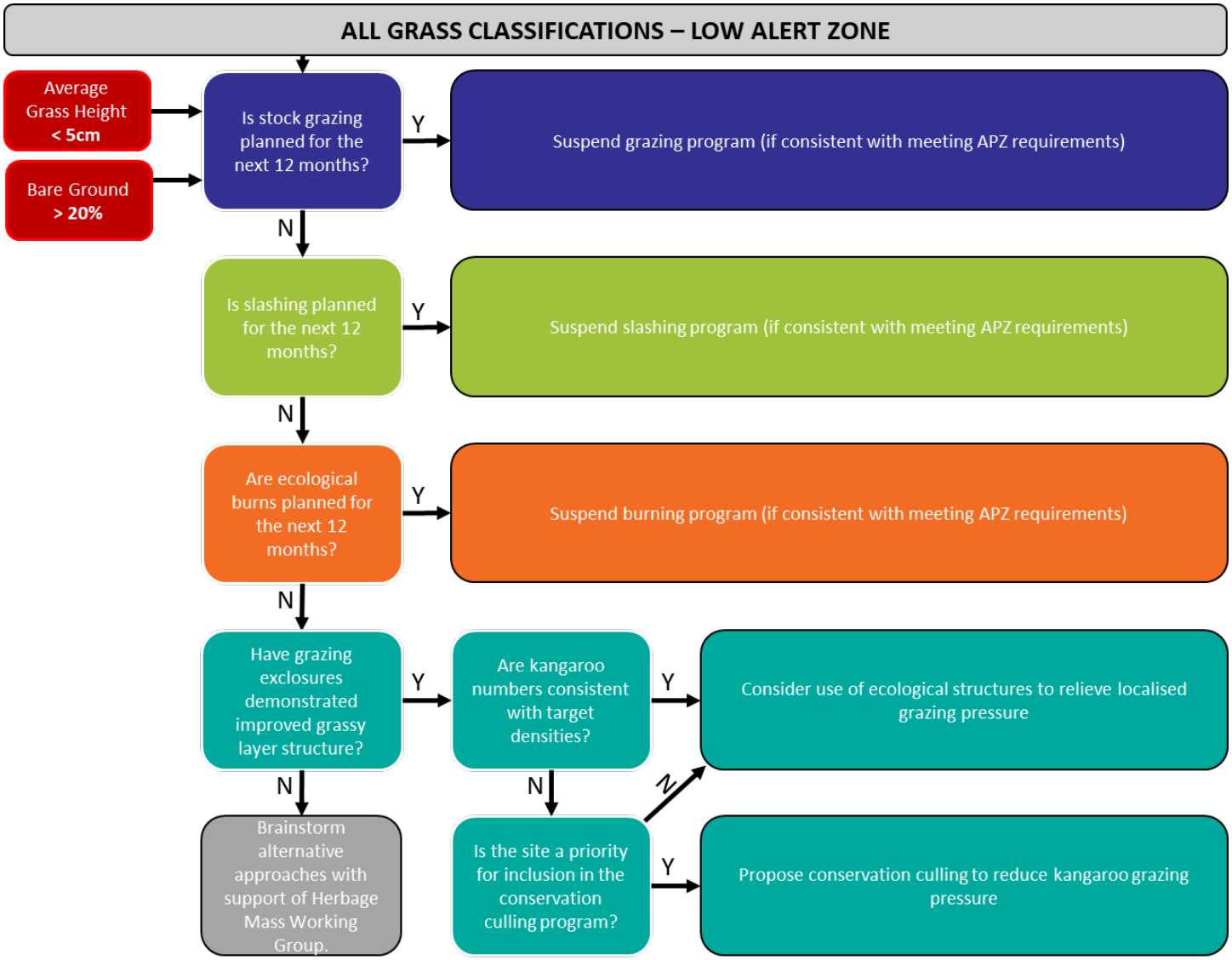
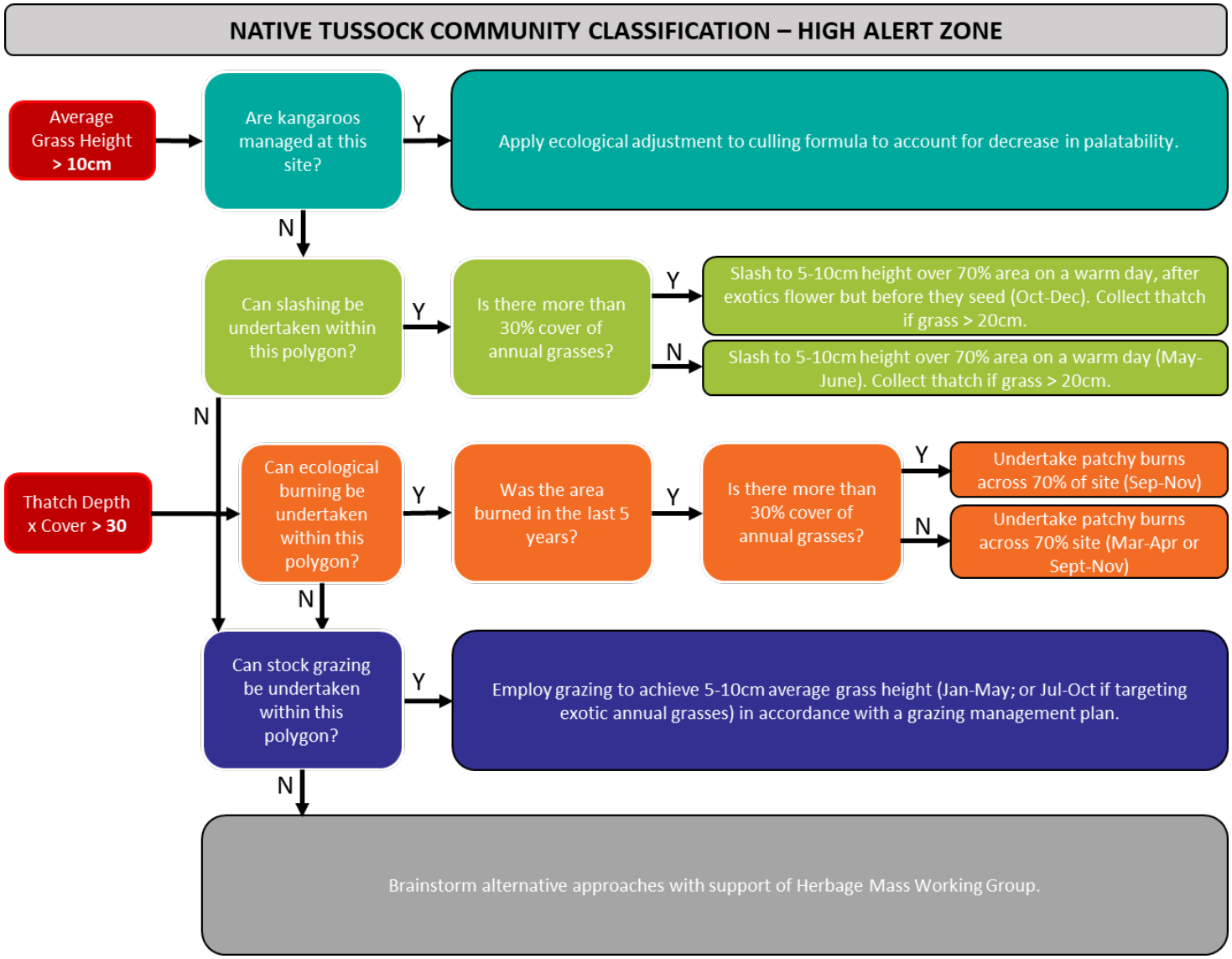
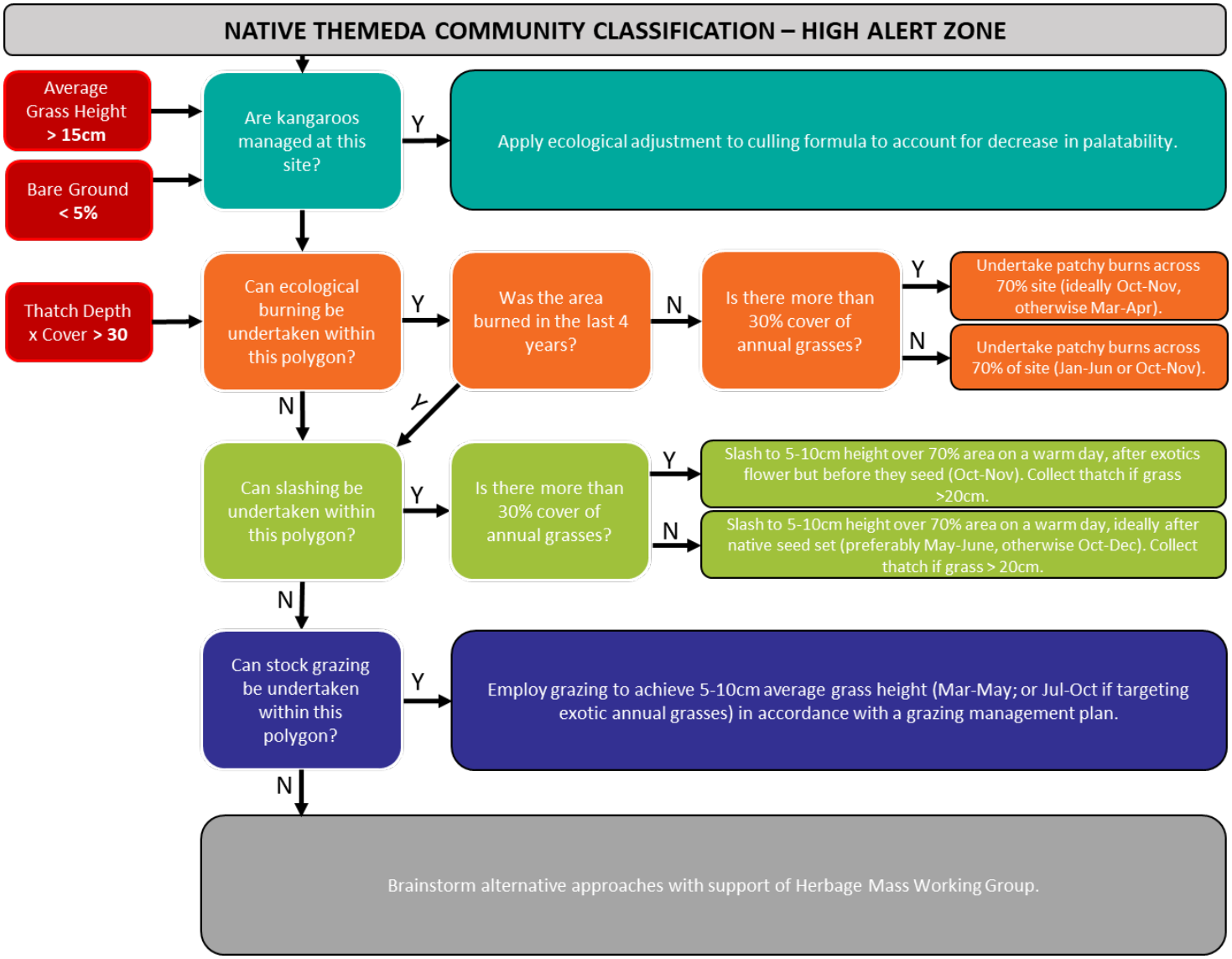


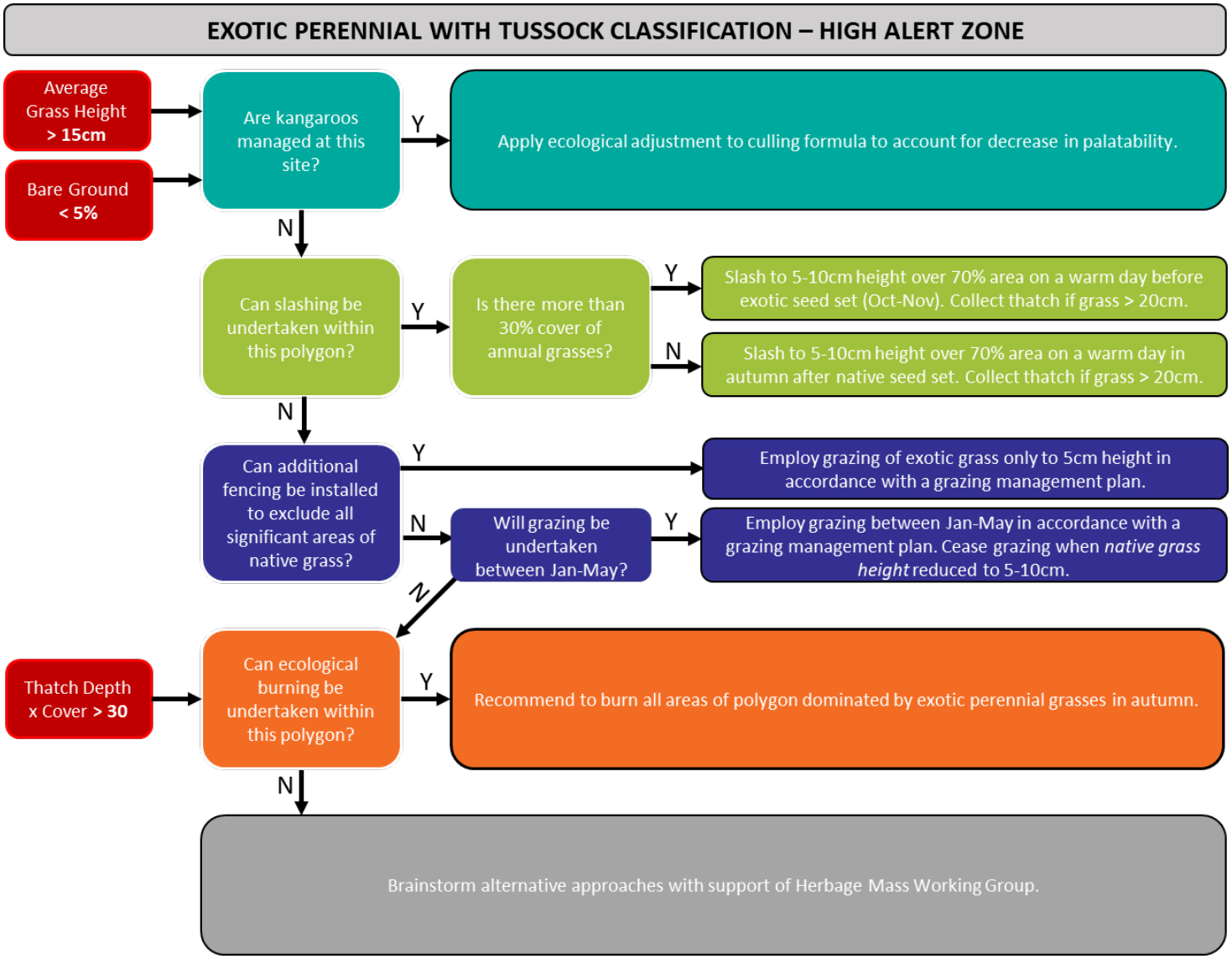
Figure 5. Diagram demonstrating the habitat preferences of varying grassy ecosystem flora and fauna, as well as the structural 'Safe Operating Environments' for polygons classified as Native Tussock Community , Native Themeda Community , Exotic Perennial with Tussock Community , and Exotic Perennial with Themeda Community . **Need references.**

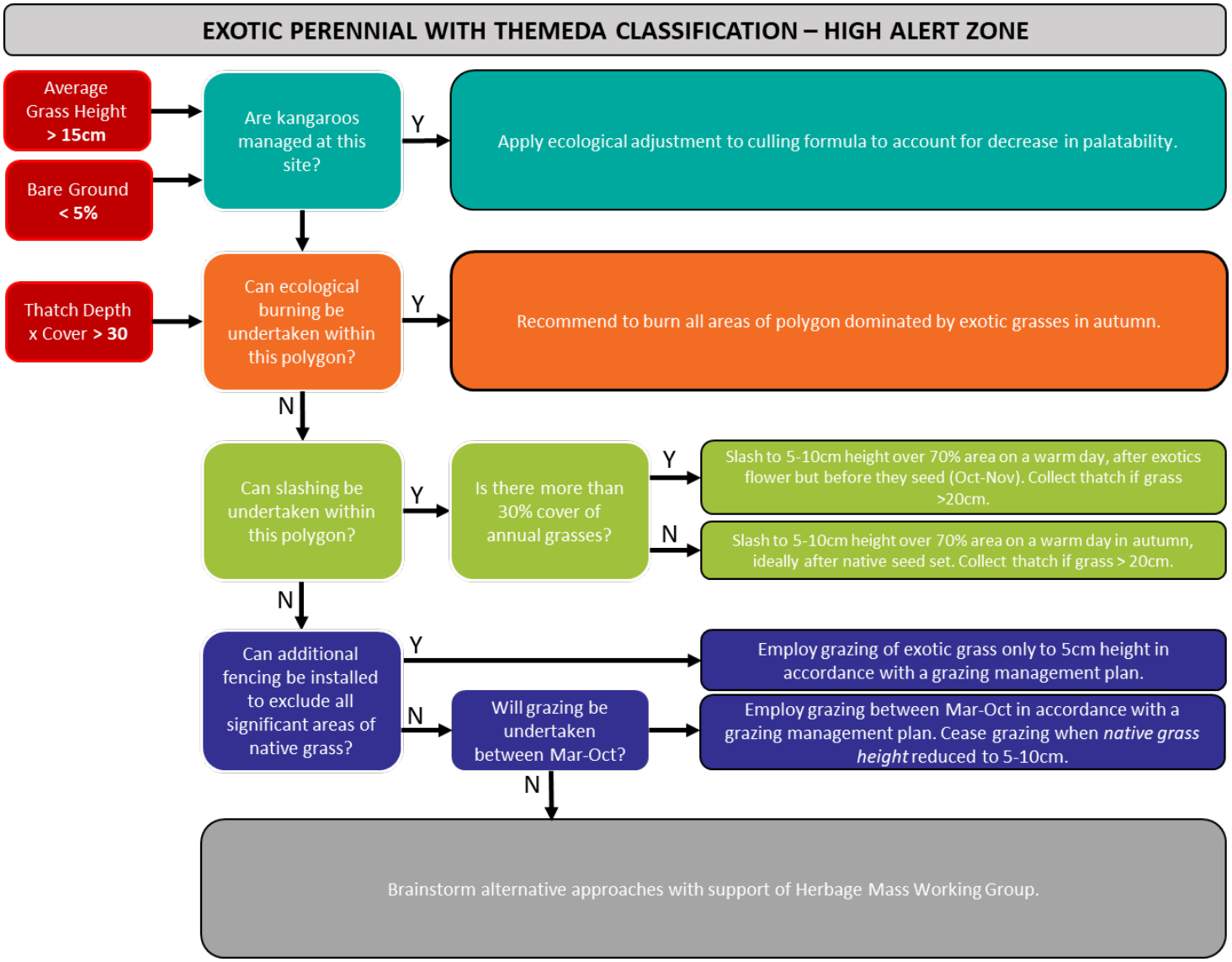
The Herbage Mass Decision Framework examines different management scenarios depending on the alert zone (above or below the SOE), grass community and management objective to assist with informing management recommendations. They are intended for use as a decision support tool, enabling both ecological and operational considerations to be factored into consistent and transparent decision making for grassy layer management. These decision tools should be paired with the management timing table below to guide the selection of management tools and the timing of implementation for any given herbage mass scenario.


ALL GRASS CLASSIFICATIONS – LOW ALERT ZONE
Average Grass Height < 5cm
Bare Ground > 20%
Is stock grazing planned for the next 12 months?
Y
Suspend grazing program (if consistent with meeting APZ requirements)
N
Is slashing planned for the next 12 months?
Y
Suspend slashing program (if consistent with meeting APZ requirements)
N
Are ecological burns planned for the next 12 months?
Y
Suspend burning program (if consistent with meeting APZ requirements)
N
Have grazing exclosures demonstrated improved grassy layer structure?
Y
Are kangaroo numbers consistent with target densities?
Y
Consider use of ecological structures to relieve localised grazing pressure
N
N
Brainstorm alternative approaches with support of Herbage Mass Working Group.
Is the site a priority for inclusion in the conservation culling program?
N
Y
Propose conservation culling to reduce kangaroo grazing pressure


NATIVE TUSSOCK COMMUNITY CLASSIFICATION – HIGH ALERT ZONE
Average Grass Height > 10cm
Are kangaroos managed at this site?
Y
Apply ecological adjustment to culling formula to account for decrease in palatability.
N
Can slashing be undertaken within this polygon?
Y
Is there more than 30% cover of annual grasses?
Y
Slash to 5-10cm height over 70% area on a warm day, after exotics flower but before they seed (Oct-Dec). Collect thatch if grass > 20cm.
N
Slash to 5-10cm height over 70% area on a warm day (May-June). Collect thatch if grass > 20cm.
N
Thatch Depth x Cover > 30
Can ecological burning be undertaken within this polygon?
Y
Was the area burned in the last 5 years?
Y
Is there more than 30% cover of annual grasses?
Y
Undertake patchy burns across 70% of site (Sep-Nov)
N
Undertake patchy burns across 70% site (Mar-Apr or Sept-Nov)
N
Can stock grazing be undertaken within this polygon?
Y
Employ grazing to achieve 5-10cm average grass height (Jan-May; or Jul-Oct if targeting exotic annual grasses) in accordance with a grazing management plan.
N
Brainstorm alternative approaches with support of Herbage Mass Working Group.


NATIVE THEMEDA COMMUNITY CLASSIFICATION – HIGH ALERT ZONE
Average Grass Height > 15cm
Bare Ground < 5%
Are kangaroos managed at this site?
Y
Apply ecological adjustment to culling formula to account for decrease in palatability.
Thatch Depth x Cover > 30
Can ecological burning be undertaken within this polygon?
Y
Was the area burned in the last 4 years?
N
Is there more than 30% cover of annual grasses?
Y
Undertake patchy burns across 70% site (ideally Oct-Nov, otherwise Mar-Apr).
N
Undertake patchy burns across 70% of site (Jan-Jun or Oct-Nov).
N
Y
Can slashing be undertaken within this polygon?
Y
Is there more than 30% cover of annual grasses?
Y
Slash to 5-10cm height over 70% area on a warm day, after exotics flower but before they seed (Oct-Nov). Collect thatch if grass >20cm.
N
Slash to 5-10cm height over 70% area on a warm day, ideally after native seed set (preferably May-June, otherwise Oct-Dec). Collect thatch if grass > 20cm.
N
Can stock grazing be undertaken within this polygon?
Y
Employ grazing to achieve 5-10cm average grass height (Mar-May; or Jul-Oct if targeting exotic annual grasses) in accordance with a grazing management plan.
N
Brainstorm alternative approaches with support of Herbage Mass Working Group.


EXOTIC PERENNIAL WITH TUSSOCK CLASSIFICATION – HIGH ALERT ZONE
Average Grass Height > 15cm
Bare Ground < 5%
Are kangaroos managed at this site?
Y
Apply ecological adjustment to culling formula to account for decrease in palatability.
N
Can slashing be undertaken within this polygon?
Y
Is there more than 30% cover of annual grasses?
Y
Slash to 5-10cm height over 70% area on a warm day before exotic seed set (Oct-Nov). Collect thatch if grass > 20cm.
N
Slash to 5-10cm height over 70% area on a warm day in autumn after native seed set. Collect thatch if grass > 20cm.
N
Can additional fencing be installed to exclude all significant areas of native grass?
Y
Employ grazing of exotic grass only to 5cm height in accordance with a grazing management plan.
N
Will grazing be undertaken between Jan-May?
Y
Employ grazing between Jan-May in accordance with a grazing management plan. Cease grazing when native grass height reduced to 5-10cm.
N
Thatch Depth x Cover > 30
Can ecological burning be undertaken within this polygon?
Y
Recommend to burn all areas of polygon dominated by exotic perennial grasses in autumn.
N
Brainstorm alternative approaches with support of Herbage Mass Working Group.


EXOTIC PERENNIAL WITH THEMEDA CLASSIFICATION – HIGH ALERT ZONE
Average Grass Height > 15cm
Bare Ground < 5%
Are kangaroos managed at this site?
Y
Apply ecological adjustment to culling formula to account for decrease in palatability.
Thatch Depth x Cover > 30
Can ecological burning be undertaken within this polygon?
Y
Recommend to burn all areas of polygon dominated by exotic grasses in autumn.
N
Can slashing be undertaken within this polygon?
Y
Is there more than 30% cover of annual grasses?
Y
Slash to 5-10cm height over 70% area on a warm day, after exotics flower but before they seed (Oct-Nov). Collect thatch if grass >20cm.
N
Slash to 5-10cm height over 70% area on a warm day in autumn, ideally after native seed set. Collect thatch if grass > 20cm.
N
Can additional fencing be installed to exclude all significant areas of native grass?
Y
Employ grazing of exotic grass only to 5cm height in accordance with a grazing management plan.
N
Will grazing be undertaken between Mar-Oct?
Employ grazing between Mar-Oct in accordance with a grazing management plan. Cease grazing when native grass height reduced to 5-10cm.
N
Brainstorm alternative approaches with support of Herbage Mass Working Group.