threatened species with narrow requirements for grassy layer structure, or other factors. It is a crucial step in the cull calculations.

- Data from previous years monitoring and operations are available in each year's conservation advice, to show how the workplan and culling targets are arrived at.
- The annual workplan across all reserves is prioritised.

For other land managed for environmental outcomes

- The ACT Government staff may assist with the design, conduct and/or analysis of the kangaroo population monitoring, and grassland condition monitoring. They may provide advice on an appropriate cull target, based partly on the kangaroo population estimates, and grassland condition metrics if these are available. At some sites, the ACT Government assists with monitoring of threatened species.
- The extent of the assistance provided by the ACT Government depends partly on the conservation significance of the site (e.g., more help if threatened species present).

Below, the evidence used in these steps is reviewed.

3.2.2 Kangaroo Management Units

The delineation of Kangaroo Management Units – areas within which kangaroos are reasonably sedentary - almost certainly improves managers' abilities to track and manage populations of kangaroos.

A KMU is an area with one kangaroo population, because it has boundaries that constrain kangaroo movement, such as suburban edges or busy roads. Each KMU has at least one nature reserve, as well as other land used by kangaroos and managed by other landholders. Government staff or contractors are responsible for a proportion of the overall cull that is determined by the proportion of the KMU that is reserve (overall, about two-thirds of the KMUs are reserves). The other landholders are responsible for the balance of the cull. The KMU approach probably introduces some operational complexity, if substantial proportions of the cull for a KMU are the responsibility of a private landholder. Nevertheless, KMUs are an important innovation: by considering kangaroos populations within KMUs rather than solely in the reserves, the population density estimates, cull targets and associated monitoring are all more accurate and meaningful.

Commented [WC32]: Yes! Cull targets for rural lands are different to conservation lands and other landholders don't have to cull if they don't want to.

The delineation of KMUs has been informed by studies of kangaroo movement using radiotelemetry, and evidence of stability/instability in population size from repeated surveys (ACT government, unpublished data, Henderson *et al.* 2018; Smith 2018; Viggers and Hearn 2005). A trial to evaluate the efficacy of culling kangaroos at the sub-KMU scale showed that considering the population at the KMU scale was more likely to be effective (Pulsford and Snape 2019). The approach relies on assuming that kangaroos are reasonably sedentary within the KMU boundaries. This assumption is based on behavioural studies, including some done in the ACT, that show site fidelity by maternal-offspring groups and wider-ranging movements by males (reviewed in, Herbert *et al.* 2021). Given the fluid nature of kangaroo social organisation, and that they use home ranges but are not territorial, it is possible that individuals move short distances to exploit resources that become available (e.g. Wiggins *et al.* 2010), and that males move further seeking mates (Smith 2018). This seems to be borne out by genetic studies which show weak population genetic structuring or high levels of gene flow at regional scales (Brunton *et al.* 2022; Zenger *et al.* 2003). Nevertheless, as a planning instrument, KMUs almost certainly improve managers' abilities to track and manage populations of kangaroos.

3.2.3 Vegetation mapping

Two types of vegetation mapping are used to describe vegetation and thus inform kangaroo management. Satellite imagery was used to map vegetation across about a third of the ACT, including all urban and peri-urban bushland, into one of five classes, from open grassland to forest. The grass layer biomass, and thus kangaroo densities, vary inversely with canopy cover. This mapping can be used as a guide for determining coarse target kangaroo densities. Within the lowland grassy ecosystems of the KMUs, a more detailed mapping of the grass layer carried out in 2018-19 is improving estimates of herbage growth, offtake rates, and thus sustainable kangaroo densities in these mapped areas. The vegetation mapping helps decision-making and contributes to effectiveness.

Kangaroo densities vary across grasslands, woodlands, and forests, because the amount of grass biomass is inversely related to the canopy cover. Any measures of, or targets for, kangaroo density in the KMUs therefore need to consider the balance of vegetation types. The vegetation was mapped initially us~~ed~~ing satellite imagery (Wimpenny *et al.* 2015). This mapping classed bushland areas into one of five structural classes based on tree canopy cover (grassland: 0-2% tree canopy; open woodland: 2-20%; woodland: 20-50%; open forest: 50-80%; forest: >80%).

More recently, the KMUs have been more finely mapped into 'management polygons', according to their dominant perennial grass type (C4 kangaroo grass, C3 red-leg grass (native tussock), ~~and~~ exotic perennial with kangaroo grass and exotic perennial with native tussock) (ACT Government 2023a). This adaptation of the vegetation mapping ~~is used in the calculations for the kangaroo cull in each KMU, and it also~~ underpins stratification of the sampling for the grassy layer structure and condition monitoring which is used in the calculations for the kangaroo cull in each KMU.

Commented [SL33]: Is this right?

Commented [KM34R33]: I've modified to the four classes of our herbage mass monitoring units.

3.2.4 Kangaroo population monitoring

The kangaroo population monitoring is undertaken using direct counts, sweep counts, and distance sampling. The population estimation is carried out immediately before the culling season, so the data used to inform cull targets are current. Evidence that the population estimations are sound include 1) these methods are well-established in the scientific literature; 2) the distance sampling transects are spatially well-designed, carried out carefully, and are long enough to produce estimates with reasonable precision; 3) in trials the different methods have been shown to produce comparable population estimates; 4) for most KMUs, the annual count and cull data interleave in a coherent manner; and 5) in a sample of KMUs, the annual population estimates and population growth predictions are well-matched.

Kangaroo population size is estimated separately for each KMU. Population estimations are carried out between Dece~~Nove~~mber to ~~February~~March, not long before the culling season starts in March. This is a recent procedural adaptation; previously counts were carried out between April to June, just after culls, which meant that 10-12 months elapsed between the count and the next cull (Gordon *et al.* 2021).

Commented [WC35]: The culling program is usually undertaken later in the season - May/June/July

The approach for monitoring kangaroo populations was outlined initially in Appendix 1 of the 2010 and 2017 Plans. Monitoring methods used in Canberra Nature Park since 2009 have included:

- Direct Counts for small areas.
- Sweep Counts for larger areas.
    - For both direct and sweep counts, the area is counted at least twice, with those counts averaged. If the counts are very different (i.e. > 10% away from the average), then another count is done. The three counts are either averaged, or if one count differs substantially from the other two, it may be excluded.
- ~~o~~ Distance sampling along walked line transects, with ~44 km walked per reserve, aiming to achieve a coefficient of variation less than 15% at 'average' kangaroo densities for the ACT (ACT Government undated; Coulson *et al.* 2021). Transects are parallel, running NW-SE to avoid being blinded by morning sun, and transects surveyed on any one day are at least 600 m apart. The population density estimation is based on a detection function, which describes that detecting kangaroos far off the transect midline is harder than detecting kangaroos close to the transect midline. Bearings and distances of kangaroos off the transect line are determined using a rangefinder. Post survey, the data in the KMU are stratified by vegetation type (ACT Government undated).
- Faecal Pellet Counts (Coulson *et al.* 2021). Quadrats that have been previously cleared of pellets are surveyed after a period of time. Such counts are more accurate when the KMU is stratified by ecosystem type.

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These are all well-established survey methods for estimating kangaroo population size or density (reviewed in, Coulson *et al.* 2021). The ACT government has also compared the estimates produced by differing methods, and found them to be comparable, but concluded the pellet counts could be less reliable (ACT Government undated). As a result, pellet counts are no longer used, and distance sampling has increased. Robust population estimates using distance sampling requires that three assumptions be met: kangaroos on the transect line are not missed and have a detectability of 1 (which should be fine in grassy ecosystems with good visibility); kangaroos will move

Commented [WC36]: Also because they are very resource intensive and there can be issues if it rains between clearing and counting plots

away from the transect rather than along it (if this happens, the observer should usually notice it and avoid double counting); kangaroos do not move before they are detected and recorded by the observer (not usually a problem with habituated populations, and can be noticed if the detection function suggests that kangaroos have higher detectability away from the midline of the transect than on the midline).

In the 2023 conservation advice (ACT Government 2023a), the kangaroo population estimates for 16 KMUs are presented. Two were based on direct counts, two on sweep counts, and the remaining 12 on distance sampling. Of the latter, the coefficient of variation was less than 25% in 10 KMUs. The conservation advice also contains maps showing the transects walked in each KMU, and their scheduling (to avoid counting the same kangaroos on adjacent transects). The advice also presents the data (as available, from 2009) on each year's population density estimate, the cull achieved, and the projected population increase for the following year. In some KMUs, the projected population increase matches the following year's density estimate quite consistently (e.g., Crace, Gundagerra), in others there is less consistency (e.g., Dunlop). Presumably these inter-KMU differences are partly related to the potential for kangaroo movement into and out of the KMU. Nevertheless, the fact that the combination of each year's population estimates with the culls achieved are mostly internally coherent suggests the population estimation is working adequately.

Recommendation

3.4 Novel approaches for estimating density are being trialled elsewhere, such as drone-based visual or thermal imaging. Although there is no need to change density estimation methods, it's always worth keeping an eye on alternative approaches in case they are useful in certain circumstances.

Commented [WC37]: Yes, we have done a few trials here in the ACT. See page 22 in this report for a short summary: https://www.environment.act.gov.au/__data/assets/pdf_file/0004/1687792/biodiversity-research-and-monitoring-program-implementation-report-2017-19.pdf.
We have been chatting to the NSW Wildlife Drone Hub too who want to use ACT sites to test their new method for kangaroos

3.2.5 Kangaroo population growth predictions

The kangaroo population growth predictions are based on using empirical data to describe the relationship between one year's population density and the next. The population growth equations were developed with one set of empirical data, then validated with another set of empirical data. The population growth predictions do not incorporate the influences of inter year variation in food availability, nor mortality (caused by adverse winter weather and road collisions), but they nevertheless perform well, predicting within the 95% confidence band of the following year's density most of the time.

Each year's cull aims to remove kangaroos so that the population in the KMU in the middle of the coming year is the ideal size. This means the cull needs to account for the potential population increase through the year. Fecundity in female kangaroos is high each year (Herbert *et al.* 2021), but recruitment of juveniles is variable, with subadults (and older animals, Bergeron *et al.* 2023) dying when food is limiting, or weather is adverse (Juillard and Ramp 2022; Portas and Snape 2018). Thus, kangaroo growth rates are variable; growth rates of up to 40% per annum have been recorded in the ACT (see Table 1 in Gordon *et al.* 2021), although rates from 5-15% are more common.

As well as varying with food availability and weather, the population growth of kangaroos (r) is density dependent (i.e., decreasing as population density increases). The relationship between the current density and the growth rate has been estimated using empirical data from the Canberra Nature Park reserves, as:

$$r = 0.317 - 0.151 \times N_t \text{ (where } N_t \text{ is the starting density)}$$

The population growth (r) is used to predict the next year's population density using the logistic equation:

$$N_{t+1} = N_t \times e^r$$

The predictions for population density have been validated against empirical data (Hone 2022, cited in the 2023 conservation advice, and Hone and Snape 2024).

Kangaroo population growth will depend not only on the starting density, but also on the weather, the rate of road collisions (Herbert *et al.* 2021), as well as the grass type, standing biomass, and therefore ~~therefore~~ the amount of

green herbage available (Snape *et al.* 2018; Snape *et al.* 2021). For example, the kangaroo population at Farrer Ridge declined from 3.4 to 1.5 kangaroos/ha between 2015-19 without culling, and despite high female fecundity, because of drought conditions that reduced food availability (ACT unpublished data in Herbert *et al.* 2021).

A future iteration of the population growth predictions could possibly incorporate these complexities, especially the influence of food availability on population growth (e.g. Fletcher 2006a), given that food availability has a strong effect on subadults survival (Fletcher 2006b; Portas and Snape 2018) but the current approach is performing well under 'average' conditions, with predicted densities falling within the 95% confidence interval of nine out of 11 populations, and with the remaining two being one underestimate and one overestimate (Hone and Snape 2024).

Recommendation

3.5 The population growth predictions may be improved by considering the effect of predicted weather, grass type and standing biomass (especially in years of low rainfall when grass growth is low, and subadult mortality is expected), and the mortality from roads bordering the KMU, but in the meantime the current approach performs well.

3.2.6 Grass layer data

Grass layer composition and structure are measured in the mapped management polygons to track changes over time, and to inform the calculations of the kangaroo cull targets for each KMU. Dominant grass species, grass height, the percentage that is green, and the percentage cover, are combined for use in the calculations for the target kangaroo density. Finer-grained data on grass species, thatch depth, and ground cover metrics are being collected, but are not yet used in reporting.

The pasture growth and offtake relationships with kangaroo density have been considered for dominant grass types within each KMU separately since 2019. This refinement should substantially improve the ability of managers to maintain the grass layer in the optimum range.

To measure the grass layer structure and condition, sampling occurs in spring and summer (before the culling season) within the management polygons (areas dominated by one of four~~three~~ dominant perennial grass types (C4 kangaroo grass, C3 red-leg grass (native tussock), exotic perennial with themeda, and exotic perennial with native tussock). Each polygon has two permanent survey plots. A survey plot is an 11m radius circle.

- Ten 1m² quadrats are randomly placed within the 11.3m radius circle. Within the quadrats, the average grass height, dominant grass species, and the percentage of grass that is green (indicates palatability, productivity) is recorded. This information is used to inform the cull targets for the KMU (see Section 3.2.8).
- Within the circle, a step point survey (75 random steps) is carried out, and the vegetation at the toe-point is classed into one of 13 groups (native C4, native C3, native, native forb, cryptogram, rock, leaf litter, thatch, dead forb, bare ground, exotic forb, annual grass, exotic perennial grass). This information enables changes in composition to be detected over time (Snape *et al.* 2018).

Much of the data collected during the annual monitoring are not being used routinely in reporting, presumably because data exploration is still underway. The grass layer monitoring data are gathered form over 700 plots each year (ACT Government, pers. comm.). This is a very large dataset, and entails considerable human resources to collect. Completing any data exploration, with a view to rationalising the collection effort, could be substantially labour-saving. In addition, it would be worth considering whether a rapid assessment approach for key variables might be possible, so that the grass layer monitoring can be carried out more quickly, at least at a subset of sites.

Recommendations

3.6 Explore the value of all the data currently being collected during grass layer monitoring, and rationalise collection to winnow out data of limited value.

3.7 Consider the value of a rapid assessment approach to estimate key grass layer metrics, in order to save time and effort, and/or monitor a wider range of sites.

Commented [WC38]: Polygons that have too much thatch are marked on the maps in the advice reports

Commented [SL39]: Is this right?

Commented [KM40R39]: I've modified, as above.

Commented [SL41]: And cover? Is % cover recorded?

Commented [KM42R41]: % cover for the plot is recorded during the step point survey.
The % 'grass cover' (any type of grass) is what is used in the analysis. Rather than only taking the specific % cover of the type of grass that is dominant in the plot, all the steps that are grass (of any type) are summed to give the % cover which is then interpreted as the % cover of the dominant species for the purpose of calculations.
Whilst one may think it would be better to only apply the calcs to the %cover that is the dominant species, you'd then be ignoring potential feed from cover of other grasses.

Commented [WC43]: As we chatted about the other week, some of this monitoring data is used for purposes other than kangaroos. At some point we will look at the condition data in relation to effectiveness of kangaroo management

Commented [WC44]: Could do this on additional sites (eg rural lands?)

3.2.7 Other information that can be used to adjust the cull targets

Other information *used to adjust the cull targets include the predicted weather, mortality from roads, whether females have been contracepted, and other contextual information.*

The cull targets can be adjusted using:

- Information about the weather outlooks over the coming year. This can be used in a qualitative way to moderate expectations about herbage growth, and thus adjust the cull targets.
- Mortality from vehicle collisions on roads. Large numbers of kangaroos die from collisions each year. The toll is male-biased, and spatially dynamic (Dunne and Doran 2021). However, the narrative in the conservation advices suggests that managers use collision data to infer movement between KMUs, but they do not use the data to adjust the cull targets.
- The proportion of females treated with fertility vaccine (for KMUs where this option is in place).
- Whether other landholders in the KMU are likely to carry out culling on their land.

3.2.8 Conservation Culling Calculator

The Conservation Culling Calculator sets out the logic for calculating the number of kangaroos to be culled in an area, to reach kangaroo densities that are optimal for ecosystem health. The cull is the difference between the target number of kangaroos and the current population, making allowance for the population growth expected in the coming year, and allowing for target adjustment based on expert consideration of other factors. Initially, the size of the target population was guided by Fletcher's interactive population-pasture growth model outlined in the 2010 Plan. More recently, the target population size has been mostly determined using data directly from the grass layer monitoring in the management polygons, with Fletchers' model still used for areas other than the management polygons. This adaptation is a significant advance because it bases the cull targets directly on the structure of the grass layer, and allows kangaroo densities to vary. Ideally, it would be further improved by more formally incorporating the effects of the predicted weather over the coming year on grass growth.

The (A) **target number of kangaroos to remain** after culling is subtracted from (B) the **current population**, making allowance for (C) **population growth** in the interim to the next cull. The three components of this formula are explained in the following (A to C).

A. The target population size for the KMU.
    - This was initially based on the size of the KMU and the relative proportions of different grassy ecosystems with differing capacity to support kangaroos: 1 kangaroo per hectare in grasslands; 0.9 kangaroos/ha in grassy woodlands; 0.5 kangaroos/ha in woodlands; 0.1 kangaroos/ha in forest/open forest. The Ecosystem mapping is based on satellite image analysis (Wimpenny *et al.* 2015).
    - From 2019, the target population size for the lowland grassy ecosystem portions of the KMU has been based on estimating how many kangaroos can be supported in that KMU given the grass types and herbage mass available, to keep the herbage within the grass height targets. See 3.2.8.1 Target population size just below for how this is calculated.

B. The current population size of kangaroos. This is determined by on-ground surveys.

C. The estimated population growth rate for that KMU, which is based on the population growth model, with 'manual' adjustments made to account for weather predictions, grass availability, sources of mortality (including vehicle collisions), likely rate of immigration/emigration.

Expert ecological judgement is used to adjust the Calculator figures by considering site-specific management requirements (such as the presence of a threatened species with narrow herbage needs); or other management interventions (such as ecological burns, or managed livestock burning). In addition, the advent of female contraceptive treatment since 2022 in two KMUs ~~(increasing to three in 2023)~~ can cause the cull target to be

Commented [WC45]: The weather outlooks havent been used to adjust the actual cull numbers in recent years because they are not that reliable, but they are used in a less formal way of presenting expectations for coming years and for prioritising sites from an operational perspective (eg last year the ops team decided to go ahead with a lower priority, small cull so that we could stay on top of another site because 2024 was expected to be a big cull year because it was going to get dry again).

Commented [SL46]: Is this correct?

Commented [KM47R46]: Yes, I think so.

Commented [WC48R46]: yes

Commented [WC49]: As noted somewhere above, we haven't been combining the models, under the current method, areas outside the mapped polygons get a target density of zero kangaroos. Easy for us to combine though.

Commented [WC50]: The way this is described here is fine and correct, but just FYI, because according to the plan we HAVE to use the Conservation Culling Calculator, in the advice report we calculate the target density based on the Fletcher formula and state this is the long-term average, then we do the HM adjusted target density under the "expert ecological judgement" step

Commented [KM51]: Need to check with Claire, if this is so my comment above is incorrect.

Commented [WC52R51]: We don't adjust the population growth allowance for weather or grass, we do adjust it for sites that have experienced high growth rates in the past and don't seem to fit the model (eg fenced areas where mortality (from predators or cars) is low or more connected sites where there seems to be more immigration. In these cases we set the growth rate to rmax. And also starting last year I adjusted for fertility control

adjusted down. This flexibility, built into the Calculator, is critical for allowing the annual implementation to adapt as new evidence becomes available.

3.2.8.1 Target population size

For areas with the satellite-based vegetation mapping, the target densities (before adjustment using expert judgement) are estimated to vary proportionately with the canopy cover and thus grass biomass. Thus, target kangaroo density in grassland is 1/ha; in open woodlands it is 0.9/ha; in woodlands it is 0.5/ha; in open forest it is 0.1/ha.

For KMUs with management polygon mapping into dominant grass types (C3 kangaroo grass, C4 red-leg grass, exotic perennial), target kangaroo densities are calculated using the polygons' grass layer data. The information on target densities for multiple polygons (of given areas) within one KMU are combined to reach the target population size (and density) for the entire KMU.

Management polygon mapping may cover only part of a KMUs; in these cases the target densities from the original population-pasture interactive model are used elsewhere. In practice, these areas outside the management polygons will probably contain a relatively small proportion of the overall kangaroo population, as they will be the more wooded areas, with less grass available.

Managers can manipulate the change in grass layer biomass over the coming year (increasing or decreasing the biomass) by manipulating the number of kangaroos. However, the relationships between kangaroo density and biomass change are complicated because kangaroo offtake rates vary with grass type, the initial biomass, the annual growth rate, and even kangaroo density itself; annual grass growth also varies with grass type, and initial biomass (Snape *et al.* 2018; Snape *et al.* 2021). Target kangaroo densities are therefore calculated separately for each management polygon, based on data for the grass layer from that polygon, then combined across the KMU, as follows:

1. For every management polygon, calculate the Total Food Available in the year

Total Food Available = the difference between the current and the target Herbage Mass + Anticipated Annual Growth

where

- Herbage Mass is based on the Average grass height, the % Green herbage, the % Cover, and the Dominant grass species

and

- Anticipated Annual Growth (annual change in herbage mass) is based on the Average grass height & Dominant grass species for both spring and autumn growth (note that growth in autumn is mostly negative)

2. For every management polygon, calculate the anticipated annual per capita offtake (offtake is how much a kangaroo eats per hectare, and it varies with Dominant grass species, Herbage Mass and Season)

- Annual offtake: Spring offtake and Autumn offtake
  - Spring offtake~~:~~ is based on ~~D~~dominant species~~, and~~ Herbage Mass and Spring Growth
  - Autumn offtake~~:~~ is based on ~~D~~dominant species~~, and~~ Herbage Mass and Autumn Growth

3. For each management polygon, calculate the target kangaroo density:
   - Total Food Available / per capita offtake

The parameters for herbage growth and offtake used in these calculations are based on empirical data covering years of varying rainfall, and are considered 'average' values suitable for years with average weather. If conditions are very dry, or very wet, the anticipated herbage growth could vary substantially from the actual growth in the year following the cull, but there will not be another opportunity to adjust the kangaroo population size. For

Commented [WC53]: We also set some limits on how low or high we will let a population get. In recent years we have set the upper limit to 2.1EGK/ha (the ecological carrying capacity based on Jims work). This is so the population doesn't get too large in wet years for us to feasibly cull down again if it becomes dryer the next year. We set the lower limit to the number that will allow the population to grow to the average long term density (fletcher model) in 1-2 years. In some of our really overgrazed sites the grass growth models have recommended really low densities for some sites in some years that may put the population at risk from low genetic diversity and stochastic events.

Commented [KM54]: Claire made a comment about this above. In KMUs with management polygon mapping, the target density outside those polygons is currently set to '0'. However, we're considering changing the target density for non-polygon areas to reflect target densities based on canopy cover as you say here.

Commented [SL55]: Correct?

Commented [KM56R55]: Yep, sounds right.

Commented [WC57R55]: yep

Commented [SL58]: There's an awkwardness in this calc which uses 4 bits of input data vs the grass layer target which is just about grass height

Commented [KM59R58]: I think the awkwardness relates to trying to figure out roo food from height measurements, with a calculated herbage mass as an intermediate step. Not sure though.

example, if conditions turn out to be wetter than average, the post-cull population could be smaller than ideal and grass could exceed the height thresholds. If conditions are drier, the post-cull population could be too large, and grass could be lower than the height threshold, but follow up culls outside the culling season are not possible.

Alternative management options such as planned burns, slashing, using a managed livestock herd for a short period, could be used to reduce grass biomass (see Section 3.2.11 Complementary actions). To prevent damaging levels of grazing when grass heights are too low, physical exclusion from small areas using fencing and logs can be used, noting these are only effective at small scales (Manning *et al.* 2013; McDougall *et al.* 2016).

To be effective, these alternative measures would need to be used rapidly and flexibly; it was not clear to the Review whether the planning and triggers for this are in place.

Commented [SL60]: Can update this if there is info available.

Herbage growth in temperate grassy ecosystems is strongly affected by temperature and rainfall as well as by soil type (Cullen *et al.* 2008; Fletcher 2006a). Given the potential consequences to the grass layer when actual rainfall conditions deviate markedly from average, it would be ideal to incorporate weather predictions for the coming year. At present, the target population is adjusted 'manually' using judgement, and climate outlooks from the Bureau of Meteorology. Potentially this step could be formalised, after collecting data on herbage growth, for each of the dominant grass types, under conditions of varying rainfall and temperature. Alternatively, it may be possible to adapt existing models used to manage livestock stocking rates on different pasture grasses, for use in kangaroo management (see Alcock, D. in, Gordon and Snape 2019). Perhaps this step can be approximated in the meantime by incorporating the rainfall-temperature influences on herbage biomass from the Fletcher model.

Commented [WC61R60]: We need to 'reinvigorate' the Herbage Mass Working Group. The intention was that this group would oversee the planning for all types of herbage mass management. Things are still happening, but probably not in the most holistic and effective way (eg Brett has a risk tool which identifies areas to manage each year using different methods but I'm not sure how this is actually being fed into planning processes).
Agree that rapid and flexible are really important here. Fire planning is definitely not that. See additional comments in 3.2.11

Commented [SL62]: Talk to Mel Snape

Recommendation

3.8 Improve the current approach to estimating target kangaroo density by incorporating the effects of the coming year's weather into herbage response, either using data on how herbage growth of the main grass types is modified by variation in rainfall and temperature, or by using the rainfall-temperature-herbage growth relationships measured by Fletcher (2006).

3.2.9 Prioritisation of management actions

The annual conservation advice ranks KMUs for annual culls, based on a prioritisation framework that considers the extent of nationally endangered ecosystems, the presence of threatened species and their sensitivity to grazing levels, the strategic conservation importance of the site (e.g. its role in landscape connectivity), and the level of prior/ongoing investment at the site. Having a transparent mechanism for prioritising culls is very useful, because it lays out the values that the kangaroo management seeks to protect, and the factors that managers must consider when deciding where and how to allocate effort.

The framework is a guide rather than a hand-and-fast decision tool, which seems appropriate. Some KMUs with low scores do have culls in place (e.g., Aranda-Painter), and conversely, some reserves with high prioritisation scores have lacked culls (e.g., Mt Taylor). Conversations with ACT Government staff indicate these deviations are often about operational feasibility.

Commented [WC63]: Yes, we have been talking about updating this framework and possibly including operational feasibility in it, rather than it being considered at a later stage.

If the recommendation to develop a reintroduction program for grazing sensitive species is accepted (Section 3.5 Value-adding), then the framework could add consideration of the potential suitability of a KMU for translocating priority species, so that reserves that currently lack such species can be prioritised for grazing management, so their condition is optimised for future translocations.

Recommendation

3.9 Include the potential suitability of the reserve to receive a (future) translocation of a grazing sensitive threatened species as part of the prioritisation framework.

3.2.10 Culling operation

The culling operation is conducted by contracted professional shooters and trained ACT Government staff according to the 'National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-commercial Purposes' (NRMMC 2008), which was adopted in the ACT from March 2014. This Code deals with killing kangaroos (adults and young) for non-commercial purposes such as conservation management or compassionate euthanasia.

Further commentary on the conduct of culling, and recommendations, are provided at Section 4.2.2 Culling operation (on rural lands), and Section 6.1.1 Kangaroo welfare during culling.

3.2.11 Complementary actions for maintaining grassy ecosystem health

The 2017 Plan outlines actions to manipulate grazing in small areas, other than culling. Grazing can be excluded by temporary fencing, big logs, and even carcasses. Grass biomass can be quickly reduced by fire, slashing, or managed livestock. These are valuable options for fine tuning the biomass of the grass layer, but our knowledge of their impacts are variable.

The 2017 Plan, and the annual Conservation Advices consider managing kangaroo grazing as the principle way of influencing the grass layer structure. At times, complementary actions may be needed. This could happen if predictions about the next years kangaroo population growth turn out to be wrong (e.g., because the weather was unexpected, or road mortality deviated from average), or because a planned cull was not completed.

To exclude further grazing and retain grass biomass, options using temporary fencing, rocks, coarse woody debris or even carcasses to exclude grazing from small areas, and create micro niches for particular species (Barton *et al.* 2011; Barton *et al.* 2016; Goldin and Hutchinson 2013; Manning *et al.* 2013; McDougall *et al.* 2016; McIntyre *et al.* 2010). These are essentially variations of a mini safe haven concept (Smith *et al.* 2023). If grass biomass is higher than ideal, and kangaroos cannot, or will not graze it down, biomass can be removed using prescribed burns; slashing/mowing; or corralling livestock in an area so they graze the biomass down quickly (Mavromihalis *et al.* 2013; Morgan 2015; Smith *et al.* 2018).

These options of course need to be used carefully. First, they tend to interact with kangaroo grazing. For example, heavy grazing can reduce the ability of the grass layer to carry fire; and fire can be used to increase the palatability of grassy patches that kangaroos are avoiding, either because the patch is too thick and rank, or because it is dominated by a grass species that is only edible when young (Foster *et al.* 2020; Foster *et al.* 2014; Legge *et al.* 2019; Meers and Adams 2003). Second, the options have differing propensity to encourage weed spread; different advantages and disadvantages for native plants with contrasting life history and competitive traits; and pose different risks to the soil surface. For example, managed livestock grazing can trample habitat and compact the soil surface, and livestock will also selectively graze more palatable species. Repeated slashing will disadvantage taller species and increase the risk of introducing new weed species carried on the machinery. Finally, the history of the site is likely to affect the response to management intervention (Dorrough *et al.* 2006). For example, managed livestock grazing should probably not be used at sites with a limited grazing history, as these sites will retain palatable species that livestock have selectively removed from elsewhere (Dorrough *et al.* 2004; Morgan 2015).

Although it is clear from the annual Conservation Advices that these complementary actions are being used, the Reviewer is not aware of the spatial extent of these actions, or of their outcomes. Note that some actions, especially the use of managed livestock grazing, are perplexing to many members of the public, who query why kangaroos are killed, then heavy hooved cattle are brought in to the same reserve.

Recommendation

3.10 Continue using/trialling these complementary actions, ensuring that risks are appropriately considered each occasion, and that the actions are carried out so that knowledge is gained to optimise their ongoing use.

[see also recommendation 3.2]

Commented [SL64]: Can update this if there is information available for me to look at.

Commented [WC65R64]: Actions are that are undertaken for fuel management (grazing, slashing, burns, physical removal) are included in the annual Bushfire Operations Plan https://www.environment.act.gov.au/ACT-parks-conservation/bushfire-management/fire-management-policies-and-plans. The BOP also includes 'ecological' burns (done for ecological reasons rather than for fuel management to protect life and property). These plans are locked in well before the beginning of the year so there is no flexibility for adding new items to the plan during the year (can not do things though if conditions change or are not right).
Working towards a Ngunnawal led burning program might be a way to get more immediate and reactive burns done. There is some work happening in this space at the moment but its early days.
Rangers do have reserve plans that detail ecological grazing and other actions but I don't think these are collated into an overall plan at this stage. We check in with the rangers when we are formulating the cull advice to see what other management programs (eg pests, weeds, grazing, slashing) they have planned for the year so we can consider those if necessary. Grazing is usually done in the weedy bits that kangaroos wont touch.

3.3 Evaluate and Adapt

The Review considers the evaluate and adapt components of the adaptive management cycle together, because the Kangaroo Management Program has integrated these components very closely.

The 2017 Plan does not set out a reporting nor evaluation schedule. However, reporting and evaluation have occurred to a very high standard throughout the life of the Plan, and much of the information collected has been subject to peer-review via the publishing process of scientific journals. The 2017 Plan was informed by a very large amount of research and monitoring data. The implementation of the Plan has been accompanied by a thorough program of prioritised research and monitoring. The data generated during the life of the Plan have been soundly analysed, interpreted, and used to adapt management in a timely way. Evaluation of KMU boundaries, vegetation mapping, population estimates, predicted population growth, grass layer structure, road collision data, and weather forecasts have closely informed each year's conservation advice. These key information inputs to the annual conservation advice are backed by substantial field research and validation. An expert workshop held in 2018 helped to hone the priority research and monitoring directions.

3.3.1 Annual reports

The annual conservation advices (e.g., ACT Government 2023a) act as both a report of past activities and effectiveness, and a plan for the coming year. They present information on the kangaroo density estimates, the grass layer metrics (including a map to show where the grass height of the lowland grassy ecosystems is within, or outside, the safe operating zone), and the cull (targets and achieved) for each KMU where kangaroo culling has been carried out, or is being carried out, since 2009 (noting that in some years, a KMU may not have a cull). These annual advices also present KMU-specific information on any factors that are being used to moderate the cull targets, or interpret effectiveness to date. Finally, the advice also describes relevant management actions such as fencing, slashing, and planned burns.

3.3.2 The 2018 workshop

A kangaroo management research workshop was held in August 2018. The workshop convened internal, national and local researchers with expertise on large herbivores, grazing management, and grassy ecosystems. The purpose of the workshop was to review relevant kangaroo grazing research from the previous decade, including the grassy habitat condition needed to maintain or recover biodiversity; review kangaroo management policy to date, including the approach for estimating target kangaroo densities; discuss a new functional response model for the grass layer; propose grass layer targets that would support biodiversity; propose future research and monitoring priorities to validate that the management was improving ground layer vegetation structure in a way that should lead to improved biodiversity outcomes.

The workshop led to the updated vegetation mapping (into management polygons); an extensive program of grass layer monitoring; the new approach to calculating target kangaroo densities based on grass layer metrics; encouragement to use the options of burning, slashing, managed livestock grazing, fencing and log placement to augment the kangaroo culling; and a recommendation to evaluate effectiveness after five years.

3.3.3 Evaluating effectiveness

Outcome evaluation has shown that the culls are effective at maintaining kangaroo densities close to their targets, and maintaining the grass layer within a safe operating zone. This is important evidence for the performance of the program. However, the outcomes of the program for grazing sensitive species are not being monitored.

3.3.3.1 Are kangaroo populations closer to target densities?

The ACT Government have recently examined whether the culling program is bringing kangaroo densities closer to the targets for each KMU, by comparing the deviation from the target density for managed and unmanaged KMUs. This analysis shows that effectiveness has improved (i.e., deviations have decreased) at managed KMUs

since 2009, whilst the density deviation at unmanaged KMUs has increased over the same period (Fig. 3) (O'Loughlin 2024; O'Loughlin *et al.* 2023). Effectiveness was improved if culls had been carried out consistently over several years, and was poorer if the last cull occurred three or more years ago. Effectiveness improved also when KMUs had a greater proportion of grassland (easier operating environment), a greater proportion of reserve vs rural land (more control over total cull achieved), when the cull achieved was closer to what was planned, and when the kangaroo population was smaller.

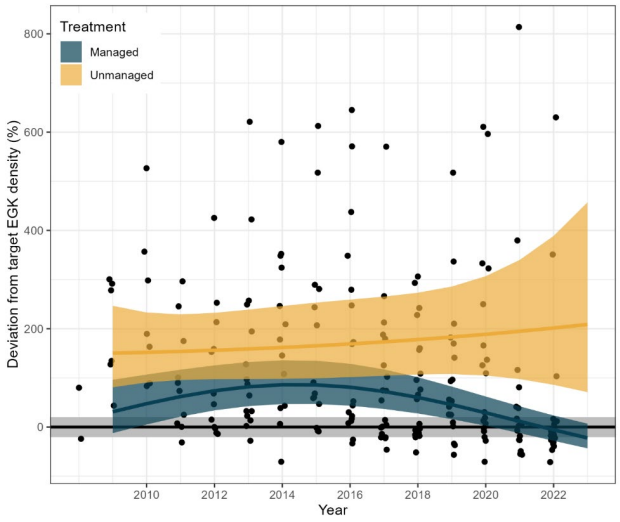


Fig. 3. The deviation from the target density, over time, for KMUs where populations are being managed using culling, and populations that are not being managed. The lines and bands show the predictions with 95% confidence intervals from a generalised linear mixed model, with year fitted with a linear and a quadratic term to improve model fit. From (O'Loughlin 2024; O'Loughlin *et al.* 2023).

3.3.3.2 Are grass layer structural targets being achieved?

The same analysis (O'Loughlin 2024; O'Loughlin *et al.* 2023) is also showing that when kangaroo densities are managed to be at target levels, then the grass height in the KMU is within the safe operating thresholds. In contrast, when kangaroo densities deviate from the target, then grass height can reach values outside the safe operating threshold, both too low in drought years (2018-19) and too high after wet years (2022) (Fig. 4).

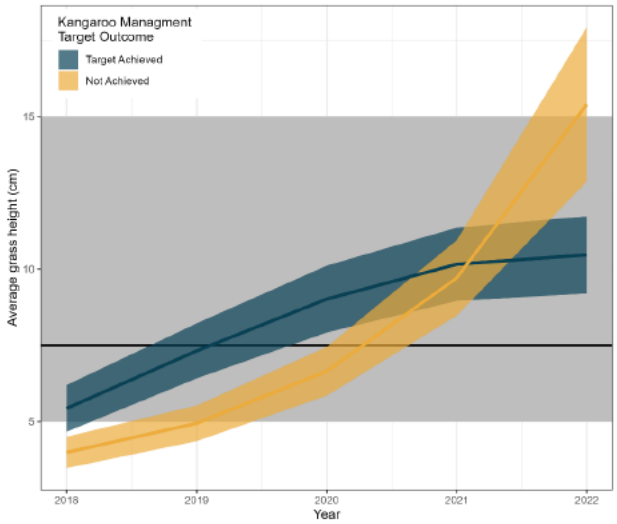


Fig. 4. The predicted grass height, over time, for KMUs where kangaroo population targets have been achieved, versus KMUs where these targets have not been achieved. The lines and bands show the predictions with 95% confidence intervals from a generalised linear mixed model, with year fitted with a linear and a quadratic term to improve model fit. The grey background shading shows the safe operating zone for grass height, and the black horizontal line is a target height of 7.5 cm. From (O'Loughlin 2024; O'Loughlin *et al.* 2023).

3.3.3.3 Are grazing sensitive species being maintained and recovering?

Grazing sensitive species are not being monitored as part of effectiveness evaluation. Instead, the program relies on using grass layer structure as a surrogate indicator, because of the targeted research that has shown the relationship between grass layer structure, soil condition, and the presence and/or abundance of particular species (e.g., Barton *et al.* 2011; Driscoll 2017; Howland *et al.* 2014; Howland *et al.* 2016a; Howland *et al.* 2016b; Manning *et al.* 2013; McIntyre *et al.* 2015; McIntyre *et al.* 2019; McIntyre and Tongway 2005; Neave and Tanton 1989; Snape *et al.* 2018).

Nevertheless, it would be ideal to demonstrate persistence or recovery of grazing sensitive species in reserves with sustained grassy layer management.

- Species that are mobile, such as birds, could respond to management by increasing in density, or by using reserves even in drought conditions, whereas in the past they may have been absent when the grass layer was too heavily grazed.
    - A well-designed monitoring program for birds could track for these signs of recovery, and the fieldwork could be carried out by volunteers with expertise, such as Canberra Ornithological Group. There may already be data on bird presence across reserves, that could form the basis for ongoing monitoring.
- For less mobile species, managing grazing should help them persist in reserves, as long as their recovery isn't suppressed by other factors, such as high nutrient levels in the soil, or abundant weeds. Monitoring to check that these populations remain present, and are not declining, would be worthwhile.
    - Table 1 (Section 3.5) shows that non-mobile threatened, grazing sensitive species occur in 0-13 reserves. Effective management should ensure this representation is maintained or increased. For an extreme example, the earless dragon is critically endangered and may persist now at only two sites in the ACT, each with very small populations (< 50 each). The cumulative effects of many

Commented [SL66]: Are there already data on birds across the reserves that would be useful?

Commented [WC67R66]: COG has an extensive woodland birds monitoring program. We could enquire about that?

Commented [WC68]: I think I mentioned when we met last that Brett has reptile tile grids in at least 5 culled reserves. GED are also extensively monitored in sites where they occur.

threats has led to this situation, but kangaroo grazing (both too much during drought, and too little in wetter years) has possibly contributed to the species' decline (CoA 2023).
    - From conversations with ACT Government staff, it seems that there may be data available on the grazing-sensitive species, collected for other reasons, that could be interrogated to examine whether these species are responding to kangaroo management and improvements in the grassy layer structure. These possibilities could be explored, with the aim of shaping future data collection so that changes in grazing sensitive species can be reported.
- However, less mobile species are unlikely to recolonise the isolated reserves if they have been extirpated. A translocation program could be designed to restore species to reserves with suitable habitat, and adequate threat management (see Section 3.5 Value-adding).

Recommendation

3.11 Reporting on the status of grazing sensitive species in reserves with kangaroo management would further validate the program and be a useful communication tool. Explore whether existing datasets, perhaps collected for other reasons, can be mined to produce such reports; whether partnerships with groups such as Canberra Ornithologists could lead to carefully designed surveys and analysis; and whether a program of translocations could be used to demonstrate management success (see Section 3.5 Value-adding).

3.3.4 Examples of data being used to adapt management

The reports (published and unpublished), conservation advices and published papers produced since 2017 contain many examples of management adaptations as a result of new information, illustrating a genuine commitment to adaptive management that seeks to continually improve outcomes.

The 2017 Plan incorporated the highly relevant research carried out on the links between grass structure and biodiversity, that had been carried out since 2010.

Refining the KMU boundaries:

- Radiotracking studies helped to understand kangaroo movement patterns, and the information was used to inform the position of KMU boundaries (ACT Government, unpublished data).
- Adjustments to KMU boundaries are made annually based on population stability of successive annual counts and information on road collisions from bordering roads (see annual Conservation Advices).
- Staff carried out a trial to see if kangaroo culls could be effective at the sub-KMU scale. The work showed that planning and implementing culls at the KMU scale was more likely to be effective (Pulsford and Snape 2019).

Refining the vegetation mapping:

- Initial mapping of canopy cover to use to adjust target kangaroo population size in KMUs.
- Mapping dominant grass species (aggregated into grass types for some purposes) across the lowland grassy ecosystems, to augment the existing mapping based on canopy cover (the vegetation mapping is described, and is visible in annual Conservation Advices).

Refining the kangaroo population estimates:

- Staff carried out an analysis to compare estimates produced using different methods (~~Wimpenny~~ ACT Government 2017).
- Reliance on distance sampling, a robust sampling method, has increased.
- Population estimates were moved from April-June, to Nov-Feb, so the cull calculations are based on more current data (Gordon *et al.* 2021).

Commented [WC69]: Not sure who wrote that draft, probably Mel, Ill check but can keep it general for now

Refining the kangaroo population growth model used in cull calculations:

- New model developed and validated using empirical data from the reserves (ACT Government 2023a; Hone and Snape 2024)

Refining monitoring and targets:

- Defining a safe operating zone, with upper and lower thresholds, for grassland biomass and height (Gordon and Snape 2019; Gordon *et al.* 2021; Snape *et al.* 2018; Snape *et al.* 2021).
- Developing a new monitoring program for grass layer structure and condition (Snape *et al.* 2018; Snape *et al.* 2021).
- Using these monitoring data and the new grass response models to inform the cull targets for KMUs, rather than solely relying on the interactive population-pasture model outputs (e.g., ACT Government 2023a).

Exploring alternative and complementary control options:

- Substantial research on fertility control for kangaroos, and the most effective and humane way to deliver the vaccine (Hampton *et al.* 2021; Wimpenny 2022; Wimpenny *et al.* 2021).
- Trails of the fertility vaccine in some reserves (ACT Government 2023a; Wimpenny 2022).

Exploring alternative and complementary grass layer management options:

- Trailing the use of managed livestock, fire, fencing and logs to manipulate grass biomass (see Section 3.2.11).

3.4 Communicate

The public engagement and reporting of the management program is remarkable: the volume of information available on the government website (including annual workplans and monitoring results), and the communication materials (e.g., factsheets, short videos), demonstrate a strong commitment to transparency.

The ACT government website on eastern grey kangaroo management for conservation is extensive. It explains the background to kangaroo management, with links to other web pages and supporting documents. Annual conservation advices present the latest data from kangaroo monitoring and the detailed thinking behind that year's cull targets. Reporting has occurred to a very high standard throughout the life of the Plan, and most of the information collected has been made publicly available via the ACT government website and scientific journal articles. The website also provides information to Canberra residents to increase awareness about how to reduce the risk of vehicle collisions, and kangaroo attacks (noting the latter is very rare).

Commented [WC70]: Note that we don't release these until after the cull is completed each year. We keep info released prior to the cull to the essential information for public safety and operational reasons

The ACT government appears to modify its communication in response to community feedback. For example, the Government modified its cull reporting protocol to include counts of independently mobile kangaroos (adults and subadults) and pouch young (e.g., ACT Government 2023a), in response to public concerns that pouch young and young-at-foot were being orphaned when their mothers were shot, and not accounted for. Independently mobile young-at-foot that are shot immediately after their mother were always counted, but this was not previously clear to the public. Including pouch young in the reporting was intended to reinforce that young-at-foot, if they occurred, would be shot and then counted as a culled kangaroo, noting that the culling season is designed to reduce the chance of this happening.

A series of surveys commissioned by the ACT Government, and carried out by Micromex Consulting, canvassed community attitudes to kangaroo management and impacts in the ACT. Five surveys carried out between 2008 and 2023 have consistently reported that over 75% of Canberrans support kangaroo culling under some circumstances. This support is likely due, in part, to the ACT Government's communication strategy.

The volume of material produced by the program may now be creating its own problem: for example, during the consultation for this Review, people often commented they were not aware of information even though it is actually available on the web. The webpages are extensive, with dozens of reports, and it's not always obvious where to go to find a particular piece of information.

There are specific crucial community communication misses, or misunderstandings, that need attention (some of these points were raised earlier, in Section 2.4 Planning links):

- Conveying that management has shifted focus to using the grass layer structure as the guide for setting kangaroo culling targets rather than aiming for a 'set kangaroo density'.

- This shift occurred after the release of the 2017 Plan, so there is a legacy misunderstanding in some parts of the community that the culls are aiming for a 'flat' target of 1 kangaroo per hectare. There is an opportunity now to illustrate the sophistication of the monitoring and target-setting, and what the kangaroo management is setting out to achieve.

- How kangaroo management fits into the bigger picture of Canberra Nature Park management; and how kangaroo management in Canberra Nature Park fits in to the bigger picture of kangaroo management in the ACT (considering kangaroos on rural land, and in the large reserves areas in the west and south of the territory; see section 7.1 Kangaroo culling in context).
  - During the consultation for this Review, some stakeholders queried why kangaroos were being managed in reserves when there were still rabbits, and weeds, present. As discussed in Section 2.4 Planning links, whereas the extent to which kangaroo grazing is a threat, and relative priority of kangaroo management, seems appropriately contextualised in other planning documents, such as the Canberra Nature Park Reserve Management Plan, (ACT Government 2021a), or the ACT Natural Resource Plan (ACT Government 2022), the reverse is less true: the 2017 Kangaroo Management Plan and the extensive website may inadvertently convey an impression that kangaroo management is the only or most important management lever in the reserves. In other words, addressing the sensitive issue of kangaroo management so thoroughly, with extensive documentation, has created a risk that the community perceives that kangaroos are being managed to the exclusion of all other reserve management.
  - Similarly, the kangaroo management in Canberra Nature Park should be understood in the context of kangaroo population status and management across the ACT, including in rural lands and in the large reserved areas of Namadgi and Tidbinbilla.
- How the urban expansion is factored into what happens with kangaroo management.
  - Some stakeholders expressed concern about the lack of regard to kangaroos during urban expansion. Concerns included that kangaroos were being culled to allow for expansion (a scenario that is briefly outlined in section 5.4.3 of the 2017 Plan); that kangaroos were being squeezed out into other areas where they could be shot (if on rural land) or might suffer because the diaspora caused unsustainable population density; that urban expansion paid no heed to ensuring connectivity among habitat fragments.
  - The strategy behind Canberra's urban expansion is outside the remit of this Review, but a revised kangaroo management plan could provide an overview of which parts of the expansion will impact kangaroos, how many kangaroos will be affected, what actions could be undertaken, and the implications (if any) for ACT's overall kangaroo population. Impacts could be on population size and/or on population connectivity.
- The use of intensive grazing by livestock in areas where kangaroo have been, or are being, culled.
  - Some stakeholders questioned why reserve managers would replace a native grazer with an introduced grazer that has hard hooves.
  - Communication about why livestock are used to graze down rank grass that is avoided by kangaroos, and how the risks from soil compaction, and weed introduction, have been evaluated, is needed.

Recommendations:

3.12 Ensure communication always conveys that the central issue is managing grass layer health, of which one component is kangaroo management. (That is, the management issue should never be framed as managing high densities of kangaroos in isolation).

3.13 Review the content and presentation of information on the government website, to communicate the sophistication of the monitoring and target-setting in the kangaroo management, and clarify what the program is setting out to achieve. The website should make it easy for the public to gain a snapshot of the key attributes of the conservation culling program. This may mean keeping the front end brief and accessible, with links to more detailed information. Include plain English summaries explaining the science behind some of the key monitoring steps (e.g., population density estimation, how cull targets are calculated, etc).

3.14 Despite the very high rate and standard of reporting, there is some lag in completing some of the in-house analyses to publication/communication standard. Some of the important material provided to the Review

had been in draft form for some time. Quarantining time for staff to complete the priority reports would be helpful.

3.15 Consider the potential of communicating about grassy ecosystem management (including kangaroo management) using a range of messengers other than government staff, such as through community groups (who are involved in reserve activities), and local vets and carers (who are involved in kangaroo welfare activities).

3.5 Value-adding - Translocations to improve ecosystem health

The conservation benefits of reserve management, including kangaroo grazing management, could be more clearly demonstrated, and accelerated, by designing and implementing a program to translocate grazing sensitive species into reserves with suitable habitat, and where all threats are adequately managed.

Such species may have disappeared from individual reserves because of livestock grazing and associated farming practices in the past, and these histories may have legacies (such as high nutrient loads in the soil), but in some reserves, current threats could be managed sufficiently to allow for more active restoration work such as reintroductions. However, unmanaged kangaroo grazing could reduce the likelihood of translocation success for many species. Translocations could therefore test and demonstrate the value of reserve management, including kangaroo management. The program could focus on less mobile plant and animal species that are unlikely to recolonise the remnant reserves unassisted (i.e., birds would not be a high priority). Although kangaroos are grass-eaters, forbs are affected when grazing levels are high (McIntyre *et al.* 2019; Morgan and Williams 2015). Plant translocations could occur via seeding as well as by moving seedlings or mature plants (Gibson-Roy and Delpratt 2015).

Note that not all reserves, even if they retain the right habitat characteristics, will be suitable recipient sites, if threats from weeds, invasive animals, added nutrients, and so on have not been adequately reduced (Prober and Thiele 2005). Translocations in Australia are subject to stringent regulatory and risk assessment filters, which consider, for example, the risks to the host population, the consequences of failure, and the adequacy of follow up management and monitoring (e.g. ACT Government 2017c; IUCN SSC 2013). Assisted colonisations, as well as reintroductions, should be in scope, and the changing climate should be considered both for host reserve selection and the provenance of source seed and individuals (McIntyre *et al.* 2019; Prober *et al.* 2015).

The advantages and opportunities of using translocations to fast-track restoration include:

- A translocation program will manifest the conservation outcomes of reserve management, including grazing management. Passive recovery potential for species with limited dispersal abilities is likely to be very modest (Price *et al.* 2021), so waiting for evidence that management, including kangaroo grazing management, is benefitting these species could be frustrating. Translocations are the only restoration option for species not mobile enough to recolonise reserves without assistance.
- Translocations can be a valuable opportunity to learn about what limits species recovery. For example, translocations could occur within an experimental design, with fenced and unfenced plots to examine the effect of kangaroo grazing and or rabbit grazing on translocation success (e.g., Bennett *et al.* 2020). For an excellent example of such an approach for grazing sensitive plants of grassy ecosystems, see (McIntyre *et al.* 2019).
- The program could make use of translocations that are happening anyway because of Canberra's urban expansion. Individuals of some grazing sensitive species are being moved already, usually into areas where populations of that species already exist (ACT Government, pers. comms). Instead, moving these animals into a reserve where they might (re)establish a new population would be a better conservation and welfare outcomes (Hangar and Nottidge 2009).
- These translocations would be inexpensive, costing substantially less than the Mulligans Flat-Goorooyarroo Project, as they would not need to exclude foxes and cats from a very large area.
- The program delivery could intentionally and constructively involve the Canberra Community, especially through environmental groups such as Friends of Grassland, and the ParkCare groups. These groups are

Commented [SL71]: This is my impression from talking to ACT gov staff, but im not confident about how this all happens. Are there any reports? Or guidelines?

Commented [WC72R71]: There have been some experimental translocations for SLL and PTWL (and at least some sourced animals from development sites) and others where animals are just moved 'over the fence', again this is specific threatened species only and I don't think it happens for all development sites. I'll ask the Conservators Team and get back to you.

capable, and consistent. For just one of many examples, the Friends of Mt Majura ParkCare group carried out work over several years to demonstrate the consequences of rabbit and kangaroo grazing to the grassy layer, and to map rabbit warrens to support management (documented in, Sharp *et al.* 2015).
    - Activities could include seeding and planting; ongoing weeding at translocation sites; maintenance of small grazing exclosure fencing; and monitoring of both plant and animal translocated populations.
    - ParkCare involvement in these activities is consistent with the intent of engaging the community through volunteer work expressed in the Native Grassland Strategy and Action Plans (ACT Government 2017a), and the ACT Wellbeing Framework (ACT Government 2020). It would also contribute to several recommendations in the recent Legislative Assembly Inquiry into environmental volunteerism (SCECCB 2022).
- The program could include a mix of threatened and non-threatened grazing sensitive species, including species that are culturally significant for the Ngunnawal Traditional ~~Owners~~Custodians, with their co-design and participation. For example,
    - Dharaban (yam daisy, *Microseris walteri*), which has a starchy root that is an important food source for Aboriginal people, has declined substantially because of the loss and degradation of grassy ecosystems, including grazing and routing up by high densities of sheep (Gott 2008). It remains now mainly in areas that are ungrazed, or only lightly grazed, by livestock or kangaroos (Rawlings *et al.* 2010).
    - Other culturally important food plants that have declined, and are grazing sensitive, include orchids, bulbine lilies (*Bulbine bulbosa*), vanilla lilies and chocolate lilies (*Arthropodium* spp.), milkmaids (*Burchardia umbellata*) and early nancies (*Wurmbea* species) (Gott 2008; McIntyre *et al.* 2019; Rawlings *et al.* 2010).
- Finally, some of the populations of threatened species in the reserves are presumably small, and at risk from stochastic events, as well as risks from inbreeding and loss of genetic diversity (Weeks *et al.* 2016; Willi *et al.* 2022). In the longer term, these isolated populations may need to be managed as a metapopulation, with translocations between reserves from time to time to maintain genetic health (genetic rescue), or to reintroduce a population that was unexpectedly lost (Hoffmann *et al.* 2021). Establishing a translocation program for Canberra Nature Parks to restore grazing sensitive species would build the in-house expertise to deal with these broader issues of genetic and metapopulation management.

Commented [SL73]: And Ngambri??

Commented [WC74R73]: ACT Gov recognises Ngunnawal as the traditional custodians of ACT land, but acknowledges other family groups and people that have connection to this land

The first step would be an initial analysis to identify which species could be translocated into which reserves. Although the reserves vary in habitat, land use history, and other factors, some translocations would be possible, especially given the current low representation of threatened species across reserves (Table 1). Following this analysis, it would be possible to set five and ten year targets for the program. Having a strategic longer-term plan so that the translocation program could be considered holistically, rather than translocation by translocation, would help to streamline the regulatory and administrative burden. Experimental translocations of some threatened species have been carried out already, and translocations to establish new populations (or to implement genetic rescue) are a priority action noted in the actions plans or conservation advices for many threatened grassy ecosystem species (Table 1).

Table 1. A list of threatened or rare animal and plant species, and their representation in 3~~9~~ Canberra Nature Park Reserves, or reserve combinations for adjoining reserves. Six mobile bird species known from the reserves are excluded. The data on occurrence within reserves represent~~are taken from~~ ACT Wildlife Atlas and Canberra Nature Map records from within the last 10 years ~~(ACT Government 2023a)~~. The low occurrence rates across reserves will partly depend on habitat differences, but also on historical (and more recent) extirpations. Conservation status (national and ACT) are as of December 2023. The ACT action plans and Conservation Advices and national Conservation Advices and Recovery Plans were checked for whether translocations (for establishing new populations, or for genetic rescue) are noted as conservation actions for each species. Yes* indicates the plan/advice refers to encouraging expansion.

Threatened Species	National conservation status (EPBC Act)	ACT conservation status	Number of reserves with species presence (out of 39)	Number of reserves with kangaroo counts (out of 33)	Translocations noted as an action for new populations and/or genetic rescue		
					ACT Action Plan	ACT Conservation Advice	National Conservation
Fauna							
Canberra Raspy Cricket *Cooraboorama canberrae*	-	Rare	6	7	-	-	
Grassland Earless Dragon *Tympanocryptis lineata*)	CR	CR	1	2	Yes	Yes	
Golden Sun Moth *Synemon plana*	Vu	Vu	12	12	Yes	Yes	
Key's Matchstick Grasshopper *Keyacris scurra*	En	En	1	1	-	Yes*	
Perunga Grasshopper *Perunga ochracea*	-	En	7	10	Yes*	Yes*	
Pink-tailed Worm-lizard *Aprasia parapulchella*	Vu	Vu	6	13	Yes*	Yes*	
Striped Legless Lizard *Delma impar*	Vu	Vu	8	10	Yes	Yes*	
Flora							
Austral Toadflax *Thesium australe*	Vu	Vu	2	1 Mulligans Flat	-	No	
Button Wrinklewort *Rutidosis leptorhynchoides*	En	En	5	4	Yes	Yes	
Canberra spider orchid *Caladenia actensis*	CR	CR	3	3	Yes	Yes	
Ginnenderra Peppercress *Lepidium ginninderrense*	Vu	En	3	3	Yes	-	
Hoary Sunray *Leucochrysum albicans* var. *tricolor*	En	-	25	14	-	-	
Pale Pomaderris *Pomaderris pallida*	Vu	Vu	5	0?	-	No	
Small Purple Pea *Swainsona recta*	En	En	7	6	Yes	Yes	
Small snake-orchid* *Diuris subalpina*	-	Rare	1	0?	-	-	
Tarengo leek orchid *Prasophyllum petilum*	En	En	0	0	Yes	Yes	
Tuggeranong Lignum *Muehlenbeckia tuggeranong*	En	En	0	0 Murrumbidgee River corridor	Yes	Yes	

*Recommended taxonomic revision to *D. subalpina* yet to be recognised by the Council of Heads of Australasian Herbaria; still referred to sometimes as *D. pendunculata* from which it has been split.

Commented [KM76]: This is the number of KMUs in the prioritisation table in the cull advice, not necessarily CNP reserves as stated.

Commented [SL77]: These data are from the 2023 kangaroo conservation advice. It might be better to replace this column with a tally of presence across all CNP reserves??

Commented [WC78R77]: As discussed, we can update this for you

Commented [KM79R77]: I've added a new column for this. The recorded presences come from Canberra Nature Map records <10 years old.

Commented [KM75]: Aranda Bushland
Black Mountain
Bruce Ridge
Budjan Galindji
Callum Brae
Cooleman Ridge
Crace Grasslands
Dunlop Grasslands
Farrer Ridge
Goorooyaroo
Gossan Hill
Gungaderra Grasslands
Isaacs Ridge
Jarramlee - West Macgregor Grasslands
Jerrabomberra West Grasslands
Justice Robert Hope Park
Kinlyside
Kowen Escarpment
McQuoids Hill
Melrose
Molonglo Gorge
Mount Ainslie
Mount Majura
Mount Mugga Mugga
Mount Painter
Mount Pleasant
Mount Taylor
Mulanggari Grasslands
Mulligans Flat
Nadjung Mada
Oakey Hill
O'Connor Ridge
Percival Hill
Red Hill
Rob Roy
The Pinnacle
Tuggeranong Hill
Urambi Hills
Wanniassa Hills

Formatted Table

Commented [SL80]: Pale Pomaderris has been recorded in the ACT at Belconnen, Booth, Bullen Range, Calwell, Conder, Coree, Gigerline, Greenway, Kambah Pool, Kambah, Kowen Forest, Lower Molonglo, Mcquoids Hill, Namadgi National Park, Paddys River, Murrumbidgee River (Pine Island to Point Hut), Rendezvous Creek, Rob Roy Range, Stony Creek, Stromlo, Tennent, Theodore, Tuggeranong Hill, Tuggeranong, Uriarra Recreation (Canberra.naturemapr.org 2018).

Recommendation

3.16 Carry out a desktop analysis to identify which grazing sensitive species, including threatened species and species of cultural significance to the Ngunnawal Traditional Owners, could be included in a translocation program to restore grazing sensitive species to nature reserves with appropriate habitat, and where threats

(including excessive or insufficient kangaroo grazing) are adequately managed. Develop a strategic multi-species and multi-site translocation plan. To the extent possible, use plants and animals that are being moved out of the footprint of the urban expansion; implement the program to gain knowledge about species ecology and limits to recovery; to involve community environment groups in the program; and to administer it efficiently.

4 ECONOMIC IMPACTS

Summary assessment

It is challenging to assess whether kangaroo culling on rural lands is achieving the objective of maintaining the economic viability of properties. There are no data available on spatial and temporal changes in kangaroo density on rural land. The Review was not provided with any data on changes in livestock density, or pasture condition (if these data exist). However, records are kept of the numbers of kangaroos licenced to be shot per property, and the numbers that are reported as shot, and these numbers roughly track weather conditions (e.g., increasing after wet years shift to dry years). This suggests the rural cull is realistically responding to changes in kangaroo density. The rural cull calculator is logical, and designed to cover the needs of most properties. Property-level decisions about how many kangaroos are reasonable to cull are based on dialogue between ACT Government staff and the landholder, and their accumulated experience of that property.

The regulation and management of rural culls requires landholders to conduct operations to a standard that exceeds the national Code for non-commercial shooting of kangaroos.

Main recommendations

Kangaroo density on rural lands is highly variable, with some properties having no kangaroos, and others, especially some that border reserved areas, with very high densities. An ACT-wide spatial assessment could identify variation in kangaroo density across rural lands, and focal areas for collaborative kangaroo management. Focal areas would include 1) locations with grazing sensitive threatened species. In such cases, the ACT Government could ensure landholders are technically supported so that total grazing pressure, including kangaroo grazing, is managed appropriately at these locations. 2) Rural leases next to reserved land that routinely have very high kangaroo densities; this is likely to degrade the ecological health of the reserved land and the economic yields and sustainability of the rural lease. The Land Management Agreements may be the most appropriate mechanism for formalising the collaboration over kangaroo management at focal areas. Management could involve culling, strategic fencing, guardian dogs, etc. These suggestions are consistent with multiple actions in the 'Rural Landscapes' chapter of the ACT's Natural Resource Plan.

The results of the spatial assessment could be used to design and implement a monitoring program for changes in kangaroo density across rural lands in the ACT, ensuring that locations with grazing sensitive threatened species, and interfaces of rural and reserved land, are both included. The monitoring could be carried out periodically, for example every 4-5 years, possibly varying the frequency to coincide with major weather changes from wet to dry conditions and vice versa. The purpose of the program would be to generate information on kangaroo densities that can be used to inform livestock and kangaroo grazing management by rural landholders, and inform more specific objectives in the collaborative landholder-government planning that is formalised through the Land Management Agreements.

Commented [WC81]: The extent this happens is pretty minimal. Most landholders just apply for a number and we check if it's below the max allowed by the Rural Cull calculator. We do discuss numbers with landholders within KMUs and we do sometimes have to reduce cull numbers based on our KMU population estimates. Suggest referring to the Rural Culling Calculator here as the main decision making tool, rather than discussions between ACT Gov and landholders

4.1 Plan

Kangaroos are a drawcard for nature-based tourism. The main negative economic impact of high densities of kangaroos is on rural land, because kangaroos compete for grazing with stock (including horses), and damage fences. Collisions with kangaroos on roads also result in economic costs through vehicle damage and injury to people, but this issue is reviewed in the Social Impacts section.

In relation to land managed for agricultural outcomes, the objectives in the 2017 Plan are:

- *Rural land: Objective - Free-ranging kangaroo populations on rural lands are managed so that their densities do not seriously impact on the economic viability of rural properties.*
- *Government horse paddocks: Objective - Free-ranging kangaroo populations on government horse paddocks are managed so that their densities do not seriously impact on the viability of the paddock complexes.*

There are no specific performance criteria or outcomes articulated for this objective, perhaps to allow farmers some flexibility in deciding the acceptable level of kangaroo grazing for their situation. In addition, the Land Management Agreements, required for every rural lease, could provide for more specific objectives to be set. In

Commented [WC82]: yes

any case, in the absence of quantitative or qualitative data for total grazing pressure, kangaroo densities and pasture condition (see Sections 4.3 and 4.4), performance against the objective cannot be assessed.

The 2010 and 2017 Plans note that kangaroos bring positive economic benefits via nature-based tourism. However, on rural land, increasing densities of kangaroos negatively affect the viability of farming businesses by damaging fences, and grazing grass that could otherwise be eaten by livestock. Overgrazing by the combination of livestock, kangaroos and rabbits can lead to erosion, affecting longer-term economic viability. Kangaroo grazing has also affected the operation of government horse paddocks, leading to substantially fewer horses being maintained at paddocks where there are high numbers of kangaroos. During the consultation carried out during this review, farmers also mentioned that kangaroos contributed to the spread of weeds, including from roadsides to farms and then out to protected areas, with environmental and economic consequences.

There are economic costs from kangaroo-vehicle collisions, from damage to vehicles and medical costs to vehicle occupants (Cope and Herbert 2023), but the 2017 Plan states that reducing these impacts is not an objective of kangaroo management. Nevertheless, there is an objective relating to vehicle collisions, in section 6.4 of the 2017 Plan:

- The incidence of vehicle-kangaroo collisions in the ACT is reduced.

but the Plan states that actions to achieve this objective are the responsibility of road management. This Review considers the issue of road collision further in Section 5.2 Road collisions.

Recommendation
[See recommendation 2.2 about setting SMART objectives; See recommendation 4.4 for survey and monitoring to inform those objectives]

4.1 The revised Plan could identify where lease-level objectives in relation to kangaroo management are identified (e.g., in the Land Management Agreements). See recommendation 4.2.

4.1.1 Does the Plan make an evidence-based case for kangaroo management on rural lands?

The 2010 and 2017 Plans review the evidence for grazing competition between stock and kangaroos, and for kangaroo grazing in paddocks that are being spelled, or that have been sown with forage. There is no contention over the general effects of overgrazing, and that farmers must manage grazing from kangaroos, livestock, and introduced herbivores to match pasture productivity. Therefore, if kangaroo numbers increase (for a given amount of forage), livestock numbers need to be reduced.

There is discourse in the scientific literature about the extent and nature of dietary overlap between livestock and kangaroos, the relative amount of forage they consume and their contributions to overall grazing pressure, and the conditions under which competition is most pronounced (for example, see, Pahl 2020). However, there is no contention over the general effects of overgrazing, and that farmers must manage that grazing to match pasture productivity. If kangaroos (or rabbits or deer) are present, farmers must estimate how much of their forage budget will be consumed by these animals, and adjust livestock numbers accordingly. By culling kangaroos, farmers can make more of their forage budget available to livestock. There has been some interesting work to estimate the equivalence of grazing by a kangaroo to one sheep, with earlier work suggesting a standard kangaroo was equivalent to 0.4 or 0.7 of a standard sheep, but later work revising that number closer to 1 (reviewed in, Pahl 2020).

The 2017 Plan states that there are 150 rural leases in the ACT, covering 39,500 hectares or 17% of the Territory. Rural leases are required to develop Land Management Agreements, which set out the cooperative management of the lease for sustainable management that maintains the ecological and cultural value of the land. The Agreements are approved by the Conservator. A recent audit of the operation of Land Management Agreements for rural leases noted that as of March 2020 there were 180 Land Management Agreements for 27,000 ha of rural land, with leases varying in size from 2 to 500 hectares (ACT Auditor-General 2021). The government response to this audit states that there are 183 rural leases (held by 159 families), across 40,000 ha, of which 25,000 ha is

considered arable. The gross value of agricultural production in the ACT in 2019 was $34 million, mostly from livestock grazing (ACT Government 2021b).

4.1.1.1 Kangaroo density on rural lands in the ACT

There are very few data available on the density of kangaroos on ACT rural land (unless they are part of a KMU), and most estimates come from over 20 years ago. The average kangaroo density suggested by the estimates is 0.76 kangaroos/ha, but with low confidence.

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 (Table 2). Current data on kangaroo density from the commercial NSW commercial harvest zone that surrounds the ACT is also shown in Table 2. It seems likely that kangaroo densities in rural areas are highly variable, depending on the location of the farm. For example, during the consultation carried out during this Review, some farmers said they had very few kangaroos on their grazing lease, while other stated that very large numbers of kangaroos were a serious problem. The latter situation occurred for farms adjacent to bushland without active kangaroo management, presumably because this interface offers the ideal combination of cover and pasture (see also, Viggers and Hearn 2005). For rural lands that are part of KMUs, then the average kangaroo density estimated by monitoring across the KMUs between 2018-23 is the best estimate for those rural lands, but they cover a small area.

The 2010 Plan notes the lack of recent data on kangaroo density on rural lands, and states gaining density data is important. The situation has not changed since then, and the value of getting density information has only increased.

Table 2. Densities of kangaroos on rural land in the ACT, and from the NSW Southeast Tableland kangaroo harvest zone, which surrounds the ACT.

Year	Density (per ha)	Source
1986	1.67	Farm (Perry and Braysher 1986)
1995	0.50	Appendix 5; 2010 Plan
1996	0.59	Appendix 5; 2010 Plan
1996	0.48	Appendix 5; 2010 Plan
1997	0.39	Appendix 5; 2010 Plan
2015-23	0.37	Average density of kangaroos SE Tableland harvest zone NSW (NSW DPE 2023).
2018-23	1.35	Average density of kangaroos across all KMUs (some of which include small areas of rural lands) (value calculated during this Review). Note the area of rural land in the KMUs is small relative to the overall area of rural land, and it may not be representative.,
average	0.76	

Recommendation
[Consider an ACT-wide spatial assessment to identify variation in kangaroo density across rural lands, and focal areas for kangaroo management outside of the reserved areas. See recommendation 4.3.]

4.1.2 Does the plan have a conceptual model and evidence-based thresholds on rural lands?

Kangaroo grazing impacts and management are considered within the conceptual framework of Total Grazing Pressure from livestock, introduced species (rabbits, deer), as well as kangaroos. However, there is no guidance in the 2017 Plan on what that means in practice, perhaps because that is better handled in other planning instruments such as the Land Management Agreements. There are two scenarios where enhanced collaboration between rural landholders and the Government over grazing management is important, and more specific

kangaroo grazing impacts thresholds may need consideration within the Land Management Agreement system: one is at locations on rural lands with grazing sensitive native species, and the second is at the interface of reserved land and rural land. Where these interfaces are within a KMU, the conservation cull process triggers collaboration with the landholder, but there is no such trigger when the reserved land is not within a KMU.

The objectives of kangaroo management on rural lands and in the government horse paddocks are:

- Free-ranging kangaroo populations on rural lands are managed so that their densities do not seriously impact on the economic viability of rural properties.
- Free-ranging kangaroo populations on government horse paddocks are managed so that their densities do not seriously impact on the viability of the paddock complexes.

The 2017 Plan notes that "the concept of total grazing pressure" has been used as the conceptual framework for determining suitable kangaroo densities on ACT rural lands." However, there is no information on what that means in practice. The Rural Cull Calculator sets an upper limit on the number of kangaroos that can be killed, and then relies on the judgement of the lessees to manage kangaroos within that bound, and in accordance with the regulations set to protect kangaroo welfare (i.e., competency test, culling season). The Calculator encourages lessees who need to manage kangaroos to do so annually with modest culls, rather than intermittently with larger culls. Presumably most lessees will take a pragmatic cost-benefit approach toward the kangaroo density they aim to achieve, by stopping culling when the grazing benefits for livestock are less than the rising costs of continuing to kill kangaroos as their density declines.

On rural leases, kangaroo (and livestock) management may be especially important at sites with grazing sensitive species (including threatened species), or on farmland/bushland interfaces with very high kangaroo densities, where high total grazing pressure could damage pasture and soil. There is no information in either the 2017 Plan or the Rural Cull Calculator on how to identify such priority areas and then plan grazing management to protect farming viability or conservation values. The Land Management Agreements are potentially the most appropriate prism for identifying such priority areas and the relevant kangaroo management targets. For example, the Land Management Agreement for a rural lease that has a grazing-sensitive threatened species could identify the spatial location for the threatened species, and the specific grazing management (covering livestock, rabbits, and kangaroos) that will be used to maintain the grass layer appropriately at this location. This Review cannot assess whether this level of planning is occurring. However, a recent audit of Land Management Agreements found them lacking in the detail required to articulate such outcomes, and to monitor progress towards achieving outcomes (ACT Auditor-General 2021). The ACT Government has committed to improving the level of management detail in plans, and improving monitoring and compliance (ACT Government 2021b).

In another example, some rural leases are adjacent to reserves with high kangaroo densities. Where the rural land is part of a KMU, there are operational and monitoring mechanisms (kangaroo counts, grass layer monitoring, regular communication between government staff and landholders) in place to support a collaborative approach to kangaroo management across the KMU. In contrast, the consultation for the Review revealed that some rural leases are adjacent to reserves, and this interface has high kangaroo densities, with no kangaroo management taking place in the reserve portions; in these situations there are fewer mechanisms to support collaboration over kangaroo management, except for when the authorisation to cull is being sought. At that point, there can be discussion between government staff and the landholder about the numbers to be culled. In the 2017 Plan, this specific scenario is addressed in *section 6.1.1 'Kangaroo movement between government managed land and rural leases'*, and it opens the door for collaborative action between the landholder and the ACT Government. More involved collaboration between the lessee and the ACT Government could be articulated via the Land Management Agreement process, but the Review does not know whether this occurs or not. Extending the detailed planning and monitoring approach used in conservation culls in Canberra Nature Park to other reserved lands in the ACT is unrealistic, but planning support for rural landholders to ensure that management is as targeted and effective as possible, and maintains the values of the reserved land, is more achievable.

Commented [WC83]: We could improve this - we don't talk to all KMU landholders

Recommendation

4.2 Consider the options for enhancing government-landholder collaboration over kangaroo management planning on rural leases where kangaroo grazing, as a component of total grazing pressure, is a problem for threatened species; or where high kangaroo densities are occurring on the interface between rural lands and

reserves without regular kangaroo management, leading to high grazing pressure on rural land that damages short- and longer-term economic viability. Options may include ensuring that the specific issue, the management response, the required monitoring, and roles and responsibilities are detailed in revised Land Management Agreements.

4.2 Implement

Kangaroos on rural lands may be culled by landowners with authorisation from the Conservator. Authorisations are applied for, and granted, annually.

4.2.1 Rural Culling Calculator

The Rural culling Calculator sets a maximum number of kangaroos to be culled based on the area and shape of a property. Given the average densities on rural lands (see 4.1.1.1), the allowable cull appears generous, but kangaroo density is likely to vary substantially around this average.

The cull on rural lands seeks to reduce the economic costs of kangaroo grazing to farmers, and the managers of the government horse paddocks. Rather than setting a target density, the calculator sets a maximum that can be culled in a calendar year as:

2 per ha x immigration factor.

The immigration factor = 1+ (PA/5) where PA is the perimeter (km) to area (km^2) ratio. The immigration factor compensates for difficulties applying the calculator to small properties and long narrow properties. What this means in practice is that small properties may apply to cull a higher number of kangaroos, and properties that have a longer perimeter for the same area can apply to cull more kangaroos (Fig. 5).

Mixed sex culls on rural land are conducted between 1st March to 31st July. The rural cull calculator also allows for no more than 30% of the total cull for the calendar year to be a male-only cull, occurring from 1st August to 31st October.

The Rural Culling Calculator Determination states that the calculator aims to support the needs of property owners while preventing excessive culling; and that the formula is based on the experience of government ecologists over many years, and replaces earlier, more complex formulas that considered variation among properties in carrying capacity, the nature of neighbouring land, and the extent of previous culls.

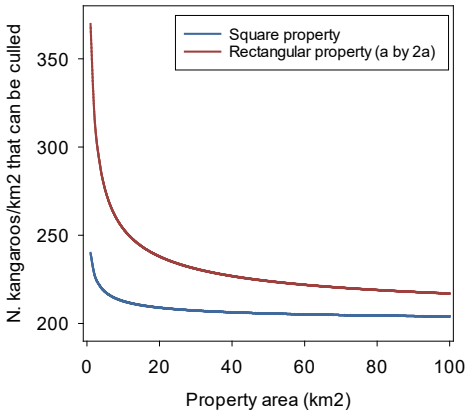


Fig. 5. The culling limit for hypothetical properties of increasing area, when they are shaped as a square, or a rectangle where the longer boundary is twice the length of the shorter boundary. Properties with more perimeter for the same area will always be able to request a higher cull, and small properties can request a higher cull.

4.2.2 Culling operation

Landholders must pass the Territory competency test every two years (including shooting accuracy and species Identification components), and mixed-sex culling must only occur within the March-July culling season, with a male-only cull allowed between August to October. Random audits occur to check compliance with the Code, and conditions of the authorisation.

Shooters must pass a competency test every two years, with tests shooting accuracy, knowledge of the National Code for non-commercial macropod shooting (NRMMC 2008), and macropod identification skills. If a shooter fails the test, they must wait two years before they can re-sit the test. Based on the consultation carried out for this Review, this long wait to re-sit the test can pose serious difficulties for farmers and professional shooters, if they need to defer culling on their lease, or defer their business activities, for two years. It would be better to allow shooters to re-sit the test more quickly, after one year. In addition, the tests could include tests of shooting using night-vision equipment, because most shooters are operating at night.

Rural landholders must apply annually to cull kangaroos on their lease(s). The application is reviewed by the ACT Government, following an internal SoP process. Compliance of landholders and shooters with the licence conditions, and the non-commercial Code, are checked in random audits (more detail in section 6.1.1 Kangaroo welfare during culling).

Rural landholders consulted as part of the Review were positive about the processes of obtaining authorisation to cull kangaroos, the use of the Rural Cull Calculator, and their interactions with ACT Government staff. Some suggested reducing the competency tests to once every five years, but others felt that every two years was appropriate. There was also commentary about the off-target licence conditions being too punitive, because misidentification could happen from time to time despite people's best efforts. Similarly, the male-only cull was challenging to undertake because the penalties for mistakenly shooting a female were severe. Landholders suggested that the tags applied to culled kangaroos should be biodegradable.

Recommendations:
[Suggested modifications to shooting/licencing protocols, captured in recommendation 6.1:

- Allow shooters who fail the competency test to re-sit the test the following year, instead of waiting two years.

- Include shooting tests using night-vision equipment.
- Consider whether the penalties for off-target kills, and female kills in the male-only culling season, can be modified to allow for mistakes.
- Make the ear tags biodegradable.]

4.3 Monitor

The ACT Government keeps records of the number of kangaroos that are licenced to be shot, and then the numbers that are reported as shot, on each property. The number of properties and kangaroos licenced/shot rose between 1997 and 2018-19, but have fallen since then. There are no current data on the density of kangaroos on rural land, and no data on pasture condition for most rural land (that this Review is aware of).

For rural leases within KMUs, there are data on kangaroo population density over time, and grassy layer structure from the reserve portions of these KMUs. This monitoring is carried out by the ACT Government and is reviewed in the section on Environmental Impacts.

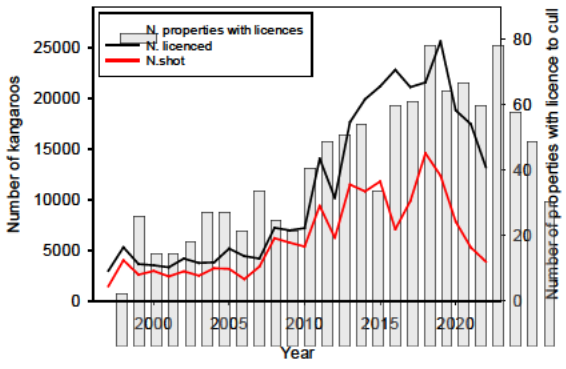
For rural leases outside the KMUs, there are no data on kangaroo density, or grass condition, over time.

Across all rural leases, records are kept of the number of kangaroos licenced to be shot on each property, and the number that are reported as shot by the landholders. The number of properties applying for authorisations, and the total number of kangaroos authorised to be culled, increased from 1997 to 2017, but has declined since 2019, perhaps because the break of the drought (2017-19) lessened the need to kill kangaroos to preserve feed for livestock (Fig. 6a). The number of kangaroos reported as shot shows a similar increase to 2018-19, then decrease. The number killed is always less that the number authorised, with the discrepancy more marked in the last seven or so years when authorisations are higher (Fig. 6b).

Commented [WC84]: I think there were also operational reasons for some landholders not culling, eg the ground was too wet to drive on and rainy nights not good for shooting

The increase in the number of authorised properties (and thus the number of kangaroo kills licenced) from 1997 to 2019 may be due to:

- Enhanced compliance with regulations over time, due to positive engagement by ACT Government staff with rural landholders.
- Increasing kangaroo populations after the end of the Millennial Drought from 2010 to 2016, followed by high kangaroo numbers relative to food availability in the 2017-19 drought. Non-commercial licences and culling figures also increased in NSW and Qld over the period 2013-17 (Wilson and Edwards 2019).



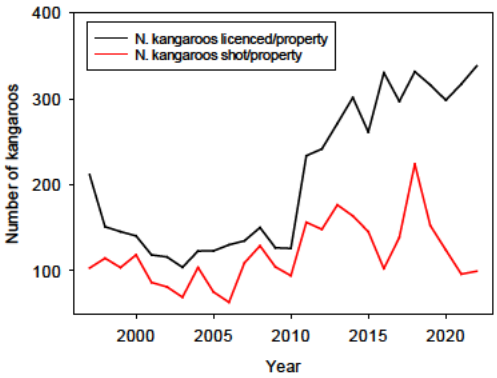


Fig. 6. (a) shows the number of properties authorised to cull kangaroos (bars and right-hand axis) over time, the total number of kangaroos authorised to be culled (black line), and the total number reported as shot (red line). The lower panel (b) shows the number of kangaroos authorised (black line) and reported as shot (red line), per property. Data for these graphs were supplied by the ACT Government.

Recommendation
[Design and implement a monitoring program to describe spatial and temporal variation in kangaroo density and pasture condition across rural lands in the ACT. See recommendation 4.3.]

4.4 Evaluate and Adapt

Given the paucity of data on kangaroo densities on rural land, it is difficult to evaluate the impacts of the rural cull on kangaroo populations, and the Review is not aware of any data on pasture condition from the rural leases (although it may exist).

If we take the average density for kangaroos on rural land shown in Table 2 (0.76/ha) and apply it to the total area of rural lands in the ACT (39,500 ha), this suggests a total population of 30,000 kangaroos. The average number reported as killed each year between 2017 to 2022 was 9100, or about 30% of the total population. For a back-of-the-envelope alternative approach to estimating the total kangaroo population on ACT rural lands, this Review uses the work of Hone (2007), who suggests that if we assume a high population growth rate of 40%, then about 30% of the kangaroos would need to be culled each year to maintain a stable population size. If we assume the kangaroo population on rural lands is stable and has a growth rate of 40%, and the annual cull (of 9100) is 30% of the total population, then the total population is 30,300, which is very similar to the population size based on using the density estimates. However, if the population growth rate of kangaroos is lower, then the kangaroo density on rural lands must be larger than 0.76/ha, to sustain the reported levels of culling.

The Review is not aware of data on total grazing pressure or pasture condition on rural lands, although it may exist.

Recommendation

4.3 Consider an ACT-wide spatial assessment to identify variation in kangaroo density across rural lands, and focal areas for collaborative kangaroo management on rural lands; including:

3. Locations with grazing sensitive threatened species. In such cases, ensure landholders are supported with information on how best to monitor and manage total grazing pressure, including kangaroos, at these sites. Detail could be included in the Land Management Agreement for the lease.
4. Rural leases next to reserved land that routinely have very high kangaroo densities; this is likely to degrade the ecological health of the reserved land and the economic yields and sustainability of the rural lease. The Land Management Agreement may again be the most appropriate mechanism for cooperating over

kangaroo management at these locations. Management could involve culling, strategic fencing, guardian dogs, etc.

These suggestions are consistent with multiple actions in the 'Rural Landscapes' chapter of the ACT's Natural Resource Plan (ACT Government 2022), especially in the themes of Native vegetation and biodiversity; Soil and groundcover management; Agricultural policy and practice; Land management and tenure policy; for example:

- Review LMA to ensure they are fit for purpose to conserve key ecological values and align with initiatives for farm diversification and sustainable land use.
- Implement effective monitoring and enforcement of LMA to ensure the sustainable management of rural lands.
- Investigate opportunities for supporting the protection of important environmental assets on rural lands through land stewardship programs.
- Develop integrated rural lands and agricultural policy that ties together all aspects of sustainable land management—natural, cultural and social values.

The results of the spatial assessment could be used to design and implement a monitoring program for changes in kangaroo density across rural lands in the ACT, ensuring that locations with grazing sensitive threatened species, and interfaces of rural and reserved land, are both included. The monitoring could be carried out periodically, for example every 4-5 years, possibly varying the frequency to coincide with major weather changes from wet to dry conditions and vice versa. The purpose of the program would be to generate current information on kangaroo densities that can be used to inform livestock and kangaroo grazing management by rural landholders, and inform more specific objectives in the collaborative landholder-government planning that is formalised through the Land Management Agreements.

4.5 Communicate

The ACT Government interacts with landholders directly, and does not share specific details of the rural culling program with the broader public, for privacy reasons.

The ACT Government interact with landholders via the management of competency tests, and the issuance of licences to cull kangaroos. For rural lands within KMUs, there is also case-by-case communication to support the kangaroo management outcomes sought across the KMU. From the consultation carried out as part of this Review, this communication seems to operate well (albeit the consultation was based on a small sample of landholders). For rural lands outside the KMUs, there is a level of frustration for some landholders that neighbour reserved land with unmanaged kangaroos, and deal with very high kangaroo densities.

5 SOCIAL IMPACTS

Summary assessment

The 2017 Plan focuses on kangaroo-vehicle collisions as the main social impact of high density kangaroo populations living in the urban and peri-urban reserves. The Plan has an objective to reduce the incidence of such collisions. This objective has not been met: the absolute number, and the per capita rate of collisions, are increasing. This probably reflects the expansion of the urban footprint, causing more people to use roads that intersect areas where kangaroos are living. The Review was unable to assess what mitigation measures had been put in place, and how effective they were.

Main recommendations

The available data clearly show where the collision hotspots are. The ACT Government could consider mitigation strategies that could be put in place immediately (e.g., reducing speed limits), whilst considering longer-term solutions such as underpasses at these locations. Research to improve data collection on collisions, and to determine the most cost-effective options for mitigation in different circumstances, would be very helpful.

The revised Plan should incorporate the perspectives and input of the Ngunnawal Traditional Owners more explicitly.

Commented [SL85]: To be completed

5.1 Plan

The 2010 and 2017 Plans describe the diversity of social impacts of kangaroos, but objectives, outcomes and actions related to these impacts are more loosely organised than those relating to environmental and economic impacts.

The values associated with kangaroos are diverse. Kangaroos are an iconic Australian marsupial, and many Canberran residents experience pleasure and joy from having these native animals in urban bushlands. Farmers may regard them as a pest, and car drivers may view them as a hazard. People (drivers, passengers and other witnesses, wildlife rangers, wildlife carers) involved in vehicle collisions with kangaroos can experience emotional trauma from these events. Watching kangaroos starve during drought is traumatic, and the issue of kangaroo population management itself is traumatic for some people (Robinson and Grace 2022). When kangaroo densities increase, the more negative social effects (car collisions, conflict with farming objectives, mass starvation) intensify.

The 2010 and 2017 Plans describe the diversity of social impacts of kangaroos, but objectives or outcomes related to these impacts are not clearly organised. There is an objective relating to vehicle collisions (section 6.4 of the 2017 Plan), but the Plan states that culling is not carried out to reduce road collisions and the actions to achieve this objective are the responsibility of road management:

- Vehicle-kangaroo collision objective: The incidence of vehicle-kangaroo collisions in the ACT is reduced.

The section of the 2017 Plan that describes the four key policy areas contains another relevant objective under the Human Welfare policy:

- Human Welfare Objective - Kangaroo management and community education minimise negative encounters between people and kangaroos in the ACT.

And another objective nested in the Kangarooo Welfare Policy:

- Kangaroo Welfare Objective - Kangaroo management in the ACT is undertaken in a way that accords with ACT legislation, codes of practice and current Australian standards for animal welfare.

Thus, the 2017 Plan lacks some clarity over which social impacts from high density kangaroos are in scope in the implementation of the 2017 Plan, how these impacts will be reduced (and who is responsible for the actions), and how the outcomes will be measured.

In this section on Social Impacts, the Review considers some key impact pathways (Road collisions; Kangaroo attacks on people; Carcass utilisation; Perspectives of Traditional Owners; Trauma to people caused by kangaroo

management). For Road collisions, which is the pathway with the most fully developed adaptive management approach in the 2017 Plan, the Review summarises the Planning, Implementation, Monitoring, Evaluation, Adaptation and Communication activities. For the other pathways, the Review assesses relevant material presented in the 2017 Plan and any other documents produced since then, and discusses some additional issues.

The final section proposes that considering social impacts through a lens of Overall Welfare could bring these disparate pathways, along with some other components of the 2017 Plan, together into a single coherent framework.

5.1 There is potential in a revised Plan to develop more clarity over the 'social impacts' relevant to the implementation of the kangaroo management Plan; how these impacts will be reduced, or balanced; who is responsible for the actions; and how the outcomes will be measured. Social impacts could be better viewed through a 'One Welfare lens', applied equally for impacts to people, as well as to kangaroos and other animals.

5.2 Road collisions

5.2.1 Plan and Implement

The main social impacts from high kangaroo densities noted in the 2017 Plan stems from the consequences of collisions between vehicles and kangaroos. These collisions can injure or kill the kangaroo, damage the vehicle, and traumatise, injure (or kill) people in the car. Rangers, wildlife carers, and vets are called out to euthanase injured animals, and to move carcasses, which can be unpleasant or traumatic experiences. The 2017 Plan has an objective relating to vehicle-kangaroo collisions:

- *The incidence of vehicle-kangaroo collisions in the ACT is reduced*

The 2017 Plan states clearly that kangaroos are not culled to reduce the frequency of road collisions; and that achieving the objective of reduced collisions is the responsibility of Canberra Transport. However, the Environment, Planning and Sustainable Development Directorate has supported some research, funded by the ACT Road Safety Fund, to identify the spatial location of collision hotspots, and the landscape and other factors that tend to encourage such hotspots (Cope and Herbert 2023; Dunne and Doran 2021).

Mitigation options for reducing the collision rates are reviewed in (ACT Government 2010; ACT Government 2017b; Cope and Herbert 2023). The Plan outlines policies designed to reduce collision frequency, including:

- Modifying attributes of the road (e.g., fencing, underpasses).
- Studies to improve understanding of the factors contributing to collision risk, and the effectiveness of alternative mitigation measures.
- Modifying driver behaviour with awareness programs.

The Review was unable to assess what mitigation measures had been put in place, and how effective they were.

Commented [KM86]: Expand to make sense with text outside of brackets.

Commented [WC87]: It might be worth getting some information from Roads about the number of fences/underpasses included in new road constructions (or % of new roads that include these features)? I can chat to them if you like?

5.2.2 Monitor

Data on the frequency of kangaroo-vehicle collisions from public survey and ranger callouts indicate that both the absolute number of collisions, and the frequency per capita, continues to increase. Around 7400 kangaroos are now killed annually on Canberra roads, possibly more. A similar number of kangaroos are injured during collisions, with their fate unknown. Collisions increase during dry years, and during the winter months. Collisions are more likely on roads with higher speed limits, and on roads next to KMUs with high kangaroo densities and short grass (a situation that encourages kangaroos to come to road verges to feed). Road intersections, and the ends of roadside barrier fences, can also be collision hotspots.

Over a third of Canberran residents have been in a vehicle that has struck a kangaroo. Collisions result in injury to the vehicle occupants about 5% of the time (¬740 collisions a year), and an insurance claim about 60% of the time. Estimates of the annual cost of kangaroo-vehicle collisions range from $2.5 to 8 million.

5.2.2.1 Kangaroos affected

The ACT Government contracted Micromex Research to conduct surveys to understand how Canberra residents felt about kangaroos and their management five times between 2008 and 2023. Some of the survey questions relate to kangaroo-vehicle collisions, and provide a useful data source on the frequency and outcomes of such collisions. The reports are available on the ACT Government website. Key statistics across the reports are:

- Kangaroo-vehicle collisions are common: in the most recent survey (2022) 36% of Canberran residents stated that they have been in a vehicle that has hit a kangaroo.
- Collision resulted in the death or serious injury to the kangaroo about half of the time.
- Of the 50% of collisions where the kangaroo moves away from the road, the proportion that slowly die from injuries is unknown.
- The number of collisions is increasing, from 6% of respondents (who have driven a car that hit a kangaroo in the previous three years) in 2011 to 14% in 2022 (Table 3). Presumably this is because of the increasing human population and Canberra's urban expansion, which increases the area of overlap between people and kangaroos.
- An 'authority' is notified about the collision about a third of the time.

Accounting for the changing population size of Canberra, the collision rates translate to an increasing number of collisions ~~from~~ 12,300 to 14,800 per year between 2019 and 2022 (Table 3). Given about half the collisions result in the death of the kangaroo, this suggests that between 6100 and 7400 kangaroos are killed on the roads per year (Table 3). These numbers are underestimates, because a) some respondents were involved in more than one collision, and b) the figures do not account for kangaroos that hop away from the collision site and die later from their injuries.

Commented [KM88]: I think this could benefit from more discussion since it's similar to the longer term trend from micromex surveys (above). Does the above presumption about urban expansion extend to explaining this trend also, or might something else be going on? If it's more research that's needed (as you mention below), perhaps highlight this trend as an example?

Commented [WC89R88]: I think these numbers are based on the Micromex results, is this right?

Table 3. Estimates of the number of kangaroos killed in the ACT, based on public surveys carried out by Micromex for the ACT Government (blue columns) and on ACT Government ranger call out data (green columns).

Micromex: The % drivers involved in a collision with a kangaroo at least once in the past 3 years are taken from the survey reports. These values are used to calculate the number of collisions per year, adjusting for the increase in Canberra population size over time; the % of adults that have drivers licence (93%; from the 2022 Micromex report); and the population that are under 18 (~20%). The number of killed kangaroos is approximately 50% of the collisions, according to survey respondents across all the reports.
Ranger callouts: The first column is the call out data shown in Cope and Herbert (2023); the second column is the callout data summarised from a download from the ACT Government ranger call out data carried out in December 2023 by the Review.

Commented [WC90]: We have previously calculated this for 2011 and 2015 using the number of licenced drivers in the ACT (so probably similar to your calc?), the 2011 value comes out pretty close but 2015 is much lower than our calc. Did you include the number of collisions each person had in the 3 year period? Our 2015 value came out at almost 14000.

Year	Drivers involved in a kangaroo collision in the previous 3 years	Number of collisions per year	Number of kangaroos killed (50% of collisions)	Number of ranger callouts to a kangaroo collision (Hope and Herbert)	Number of ranger callouts to a kangaroo collision (ACT gov data downloaded and filtered)
2011	6%	5473	2736		
2015	8%	7751	3876		
2016				2531	2775
2017				2271	2522
2018				3652	4044
2019	12%	12278	6139	3003	3446
2020					1731
2021					1221
2022	14%	14800	7400		1679
2023					181

Commented [SL91]: Maybe the data are not up to date? Given the webpage says to July 2022??

In some collisions, ACT Government rangers are called to deal with the injured animal or carcass. Information on these callouts is available in an ACT government database (ACT Government 2023b). From December 2015, a smartphone application using Collector for ESRI ArcGIS has helped to improve the accuracy and timeliness of data collected (Dunne and Doran 2021). The database can be downloaded, but may only be accurate to mid 2022.

Commented [WC92]: I think it's good up to the end of 2022 and is updated every 6 or 12 months - Will N would be able to confirm that

Holly Cope and Catherine Herbert (University of Sydney) recently undertook an analysis of ranger callout data (2016-22), as well as other data sources, to identify the locations of wildlife collision hotspots, and examine what landscape features and other factors led to hotspot occurrence. They focussed on 2016-19, to avoid COVID-related artefacts. They also assessed the merits of different data sources (e.g., insurance claims, crash statistics) for understanding wildlife collisions and for estimating the costs of these collisions, and they carried out a brief review of mitigation strategies to reduce collision rates. They kindly supplied their draft, unpublished report for this Review (Cope and Herbert 2023). Their report finds that:

- Between 2016 and 2019, rangers were called out to the sites of kangaroo-vehicle collisions 11,457 times, to euthanise a struck animal, or to remove a carcass.
    - This equates to average of 2864 road-killed kangaroos per year, or almost 8 per day.
- More collisions involve male kangaroos than females (about two-thirds are male).
- Collision frequency increases in the winter (because food is scarcer so kangaroos are drawn to road verges, and because the traffic overlaps with kangaroo activity more).
- Collision frequency increases in drier weather. For example collisions peaked in 2018 in the ACT, and also in the six NSW Local Government Areas surrounding the ACT (across multiple data sources); the authors suggest that kangaroos were coming to road verges because conditions were very dry during 2017-19. The year 2018 had a record number of warm days, was the warmest year on record (for mean maximum temperature), and with below average rainfall. Other studies have similarly found that kangaroo-vehicle collisions increase in dry conditions, including one in Victoria showing thar road kills were higher during the 1981-83 drought than before or after (Coulson 1989); and another in NSW that showed kangaroo road kills during drought were substantially higher (Lee *et al.* 2004).

The locations of these collision sites are spatially uneven (Fig. 7). When collisions exceeded 65 per km of road (during 2016-19), the authors called those sites 'hotspots'. Characteristics of hotspots included:

- Major roads with speed limits of ≥ 80 km/h.
- For all hotspots: adjacent to a KMU with high kangaroo densities (on average, over 200% larger than the target density for the KMU), low grass height (< 8 cm grass height). Kangaroos were likely coming to road verges for food.
- Road intersections; the worst location was the intersection of Sulwood Dr and Athllon Dr, bounded by Farrer Ridge and Mt Taylor reserves.
- The authors noted that the ends of kangaroo exclusion fencing along roads could also be problem areas.

Commented [KM93]: The worst hotspot is in a location where a culled KMU (Farrer Ridge) is next to an unculled one (Mt Taylor). Would be interesting to know if and how collision rate changed since culling began at FR.

A comparison of the information available from the Micromex surveys and the ranger callout data is provided in Table 3. The road killed kangaroo estimates based on the Micromex survey data are about twice those from the ranger call outs. This is consistent with the survey result that respondents only notified an authority about the collision around one third of the time (i.e., collisions are under-reported). Given rangers are called out to only some collision incidents, the Micromex survey results on collision rates may be closer to the mark. For every kangaroo killed outright in a collision, there is another kangaroo that is struck but hopes away, injured, with its fate unknown.

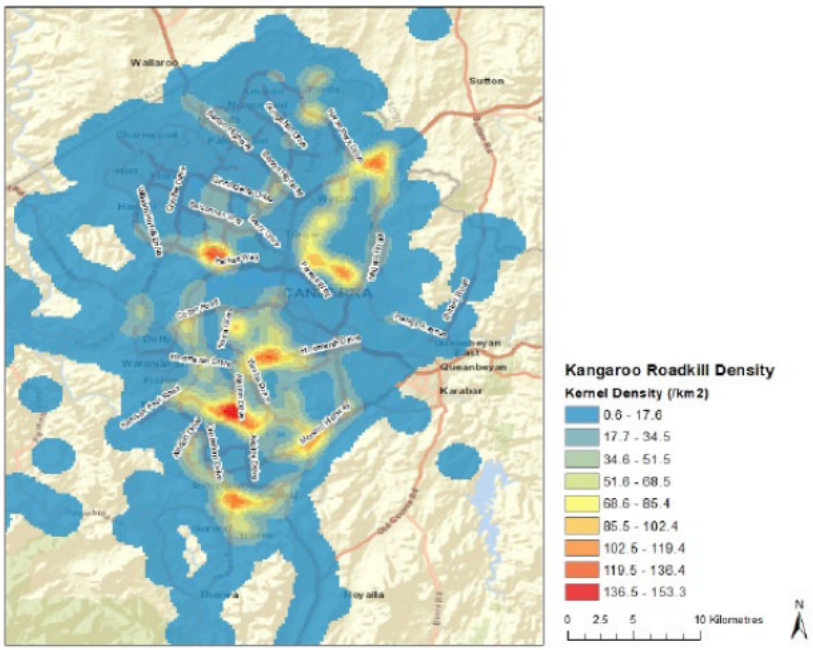


Fig. 7. Density of reports of kangaroo injuries or mortalities requiring attendance by the ACT Parks and Conservation Service rangers between 2016 and 2019. Figure courtesy of Holly Hope and Catherine Herbert.

Commented [SL94]: Check it is ok to use

The broad patterns of increasing collision frequency, and the locations of some spatial hotspots, were also identified in the 2010 Plan.

5.2.2.2 People affected

- Many Canberrans are experiencing the trauma of hitting a kangaroo with their car: 36% of Canberran residents stated in the Micromex surveys that they have been in a vehicle that has hit a kangaroo at least once.
- The collisions caused injury to vehicle occupants about 5% of the time (varies between 2 and 11% across surveys) or ~740 collisions in 2022. Injuries may have affected one or more people. Note that other studies report higher injury rates, of around 30%; human fatalities from kangaroo collisions happen but are not common (reviewed in Herbert *et al.* 2021).
- The collisions result in an insurance claim ~60% of the time.
- Estimates for these annual costs of kangaroo collisions range from $2.5 million (Cope and Herbert 2023) to $8 million (Dunne 2017, cited in, Wilson and Edwards 2019).

5.2.3 Evaluate, Adapt, and Communicate

From the information summarised in the Planning and Monitoring sections just above, it seems that the absolute number, and the per capita frequency, of collisions are increasing, but that there is scope to reduce collision frequency with strategic actions. The 2017 Plan mentions some mitigation actions that have been, or were to be undertaken, including long stretches of barrier fencing along roads, and driver awareness programs. However, the Review is unable to assess the extent to which evidence on collision patterns has been used to evaluate the success of these interventions, and adapt collision mitigation measures, as these actions are the responsibility of another arm of the ACT Government.

Commented [SL95]: Claire: do you want me to look into this?

Commented [WC96R95]: I think it would be worth including a little bit of detail on what mitigation measures have been installed on roads to demonstrate that something is being done (but monitoring of effectiveness is not!)

Of relevance to this Review, is the finding that collision hotspots are all next to KMUs with high kangaroo densities and low grass biomass. Thus, although culling in reserves is not carried out to reduce collision risk, these reduced risks could be considered a co-benefit of culling, as the welfare outcomes from culling are better than the welfare outcomes from road collision to both kangaroos and people (Hampton *et al.* 2019). The presence of collision hotspots next to KMUs could be considered in the workplan prioritisation framework, as a co-benefit of kangaroo management (see section 3.2.9).

Recommendations

5.2 Many people and kangaroos are adversely affected by collisions on Canberra roads, and it appears that the objective of reducing the incidence of vehicle-kangaroo collisions is not being met.

Many people and kangaroos are adversely affected by collisions on Canberra roads. Overall welfare outcomes for people and kangaroos would be enhanced if the frequency of kangaroo-vehicle collisions was reduced. Research to improve data collection on collisions, and to determine the most cost-effective options for mitigation in different circumstances, would be very helpful. In the meantime, the available data clearly show where the hotspots for collisions are, and the EPSD Directorate could consider this information when prioritising KMUs for kangaroo population management, and work with the Transport Canberra to prioritise mitigation strategies that could be put in place immediately (e.g., reducing speed limits) and in the longer-term (e.g., underpasses) at these locations.

5.3 Kangaroo attacks

Kangaroo attacks are rare, and the ACT Government includes advice to residents about how to avoid these events.

The 2017 Plan notes that are no data on negative kangaroo-people interactions, but the events mostly occur when dogs harass kangaroos and the dog owner intervenes in the confrontation.

The management action is to inform the public about the risks of moving too close to large kangaroos, and to encourage dog owners to keep their dogs restrained. This information is visible on the ACT Government's eastern grey kangaroo website, including via a downloadable factsheet.

This review is unable to assess whether this response has been effective at reducing the incidence of conflict between people and kangaroos. If the occurrence of such events is low, then discerning change is challenging.

Commented [SL97]: Check with....Claire?

Commented [WC98R97]: Yeah, hard to say anything on this. Reported incidents are very rare, only one in the last few years that I recall. I could check with PCS to see if they have a register of incidents so that the number recorded could be included if you like? but I think it's fine to leave as is.

5.4 Traditional Owner perspective on kangaroo management

Xxxx to be completed after attending yarning meeting 20 Jan

5.3

5.5 Trauma to people concerned about kangaroo management

Most Canberrans support kangaroo management for welfare, environmental, and economic reasons. About 10% of Canberran residents do not and another 10% are unsure; a subset of these may experience trauma that kangaroo management occurs at all. Considering the views of all stakeholders through an ethical framework may help develop a shared understanding of the issues, and reduce conflict.

Most Canberrans support the current kangaroo management. The ACT government commissioned a series of surveys by Micromex Consulting to gauge community attitudes to kangaroo management and impacts in the ACT. These five surveys carried out between 2008 and 2023 have consistently shown:

- Over 75% of the public support culling kangaroos under certain circumstances whereas around 10% do not support culling under any circumstances (the balance of respondents, about 10%, are unsure).
- Most respondents (> 60%) consider that kangaroos are killed humanely.
- Respondents consider that justifications for culling are to prevent mass starvation of kangaroos during drought, to maintain the ecological health of reserves, to look after the economic viability of farms, to commercially harvest meat and skins (noting that this does not occur in the ACT), and to reduce collision rates with cars (in roughly that order). It is notable that kangaroo welfare is the most supported justification for culling.

The broad support for the governments kangaroo management program is likely influenced by the lived experience of Canberra residents, who have seen the effects of heavy grazing in the urban reserves, seen the large numbers of starving kangaroos during drought, and experienced the trauma of hitting kangaroos that are concentrating on road verges to seek food.

Nevertheless, the surveys equally show that around 10% of Canberrans do not support the kangaroo management, with another 10% unsure. For some of these people, the very issue of kangaroo management may be deeply traumatic (Robinson and Grace 2022).

The act of killing a native animal may be confronting to people for several reasons. For example, people may object to killing any sentient animal (an animal rights perspective); they may value charismatic species like kangaroos more highly that the smaller, more obscure plants and animals that live in the grass layer; they may object to killing a native animal as a means to fix a deeper human-caused problem (such as the loss, fragmentation and degradation of grassy ecosystems); they may worry about the pain or suffering experienced by culled kangaroos (a welfare perspective). These variations on animal rights-centric and welfare-centric views raise moral and ethical dilemmas that validly challenge a conservation-centric perspective (which is the prevailing compass of the 2017 Plan). Situations of conflict among conservation, welfare, and animal rights perspectives are increasing in frequency, as human alteration of natural systems increasingly results in situations, such as the ACT's kangaroo management, where managers face decisions about whether to kill native animals or not. In addition, there is substantial discourse about how humans can integrate the interests of non-human animals into governance, including conservation governance (Schapper *et al.* 2022). Section 7 describes a framework for guiding decisions about animal control for conservation outcomes that supports different perspectives to be considered.

5.4 Consider the international principles for ethical wildlife control (or something similar) when revising the management plan; ensure the perspectives of all stakeholders are fairly and transparently considered.

5.6 Carcass utilisation

Most carcasses from culls on conservation and rural land in the ACT are disposed of in burial pits or left to rot in situ. A very small number of carcasses have been used in conservation programs (to feed native carnivores at wildlife holding facilities, or to make poison baits for foxes and dogs) or given to local Indigenous people. Farmers can use culled kangaroos for their own domestic purposes, but the fraction so-used is also very small. This 'wastage' is a concern to some members of the public, and inconsistent with ACT's Waste Management Strategy and Climate Change Strategy. A recent commissioned report considered the options for alternative uses of culled carcasses. The report suggests upscaling the current use of kangaroo meat in conservation programs, using commercial processing facilities in NSW to prepare meat and skins for consumption by the ACT Indigenous community, and sending offcuts and offal to frass processers to produce fertiliser that could be used by community groups involved in ecological restoration activities. Carcasses from conservation culls would be gifted to these uses, but rural landholders may choose to recoup some costs from these pathways.

Carcass utilisation is discussed here, under social impacts, but noting there are economic implications: On rural lands landholders may recoup some money from selling carcasses that could help to offset the cost of culling. On conservation land, the costs of carcass disposal (over $6 each not accounting for costs of collection and transport,

AWS 2020) may be partly covered, or the costs of culling could increase if the processing of the carcasses exceeds those savings.

About 18,500 kangaroos are killed each year in the ACT by conservation culling (~2000), rural culling (~9100) and road kills (~7400) (see Section 5.7 for details). The carcasses are either left in situ or buried in pits.

Carcasses left to rot in situ create micro-niches that favour some plants (including exotic species) and animals, and contribute to nutrient cycling and soil health (Barton *et al.* 2019; Barton *et al.* 2016). They may also attract scavengers. Large rotting carcasses may not have been a very common feature when people and dingoes were hunting them, and dingoes were eating carrion. Regardless, leaving thousands of culled kangaroos, shot over the culling season, on the ground surface is not possible, especially on public land, which is why many carcasses are disposed of in pit burials.

A report prepared in late 2020 (AWS 2020) discussed the issues associated with pit burial, and alternative options for carcass utilisation. The report states that 'wasting culled animals does not meet community expectations when there are other methods available'. The objection to waste may be especially felt by Traditional Owners. Pit burial takes up landfill space, causes higher methane emissions, and is considered 'wasteful' by many in the community. The report states that reducing the organic material going to landfill, and instead finding other uses for this material, is aligned with the ACT's Waste Management Strategy and the ACT Climate Change Strategy.

Current carcass fate:

- On rural land, rural landholders can use carcasses of kangaroos they shoot, for example as meat (for human and animal consumption). Given the number shot, most carcasses are not used. Many are left in situ, but some landholders are concerned about attracting canids, or are worried about having the carcasses visible to the public. Some landholders bury their carcasses or pay their shooters to remove the carcasses from their land.
- On public land, most carcasses from culled kangaroos are buried. A small number are used by Traditional Owners (~~meat,~~ skin); a small number are provided local wildlife facilities to feed carnivores; a small number are processed into meat baits for ACT conservation programs for fox and dog control.
- Road-killed kangaroos are either left in situ, or moved (by rangers) to waste facilities for burial.

Commented [WC99]: There is rules around not leaving carcasses close to boundaries where the public could see them that apply to some rural properties. Sal and Sweaney will know the specifics of this

Commented [WC100]: Just skins so far

The AWS report confirmed the conclusion of an earlier study in 2011 that setting up a commercial kangaroo meat industry in the ACT was not economical, because the numbers culled were too low, and the culling was seasonal. (The report notes that ACT Traditional Owners have expressed interest in a local processing facility.). However, the AWS report concludes that exporting kangaroo carcasses to existing NSW processing facilities is feasible. The AWS report also recommends expanding some existing carcass use options. The overall proposal is:

- Rural landholders could be given the option of selling carcasses to interstate processors (for human or pet food) under a Wildlife Trade Operation (approved under the Commonwealth EPBC Act). The payment for this meat could help offset the costs of culling, and might elevate the value of kangaroos to the farming sector, and enhance the management of total grazing pressure (see also, Wilson and Edwards 2019).

- Carcasses from the conservation cull could be collected for dressing (or dressed at the point of cull), then:
  - Offal and offcuts would be supplied to local frass producers, who use insects to produce high nutrient soil conditioner. [The product could be distributed to community groups for use in plant restoration programs].
  - Smaller carcasses would be given to local wildlife facilities for carnivore food, and exported to NSW wildlife facilities for the same purpose.
  - Some smaller carcasses would be used locally to produce meat baits for conservation programs.
  - Larger carcasses would be exported to NSW facilities that process kangaroo meat for human consumption. Meat and skins would be delivered back to the ACT Indigenous community for food and traditional use (several pathways are described).

There would be no payment for carcasses from kangaroos killed in the conservation cull, to avoid any potential confusion about the objectives of that culling. The most recent public survey on attitudes and opinions about

kangaroos in the ACT (Micromex 2023) suggests that although most (>55%) support kangaroo culling for commercial meat and skins, they do not support this purpose for culling in reserved lands (20%).

Although the report did not discuss welfare, there would be substantial overall welfare benefits from adopting part or all of this proposal, because livestock would not be killed to feed animals kept in captivity, or to feed people, and so on. Kangaroos sent to a NSW processor would need to be shot according the commercial Code rather than the non-commercial Code. The commercial Code has higher standards, but the ACT requirements for shooting already meet these standards.

The AWS report outlines ten further steps required to explore these options for carcass use. They include a deeper exploration of the regulatory steps involved. The proposal also needs to be costed fully (this is not in the ten next steps).

Recommendations

5.5 Continue exploring alternatives for carcass utilisation instead of the current practice of pit burial and leaving in situ, by undertaking the next steps outlined in the Australian Wildlife Services report, and fully costing their proposed model. Involve the community in this discussion, by 1) including targeted questions about kangaroo carcass utilisation in the next public survey on kangaroo management; and 2) ensuring Traditional Owners can participate fully in the discussion and decisions.

5.7 Overall Welfare as an 'impact area' in the kangaroo management planning framework

Attention to kangaroo welfare is prominent in the 2017 Plan, and references to welfare crops up frequently, in different contexts, throughout the document. Welfare outcomes for other animals, and for people, are raised (less often) in the context of specific issues, and sometimes labelled differently. For example, the impacts of kangaroo-vehicle collisions are nested under social and economic impacts. An alternative approach, that recognises recent amendments to the ACT Welfare Act, the development of the ACT Wellbeing Framework, and the One Welfare concept, would be to replace 'Social Impacts in the Plan with 'Overall Welfare Impacts', providing a single coherent framework for considering all welfare outcomes from decisions to act (or not to act), to kangaroos, other animals, and to people.

Kangaroo welfare is referred to in the Purpose of the 2017 Plan "*The purpose of the controlled native species management plan is to set out the approach to be adopted in maintaining wild populations of Eastern Grey Kangaroos in the ACT while managing their environmental, economic and social impacts and ensuring their welfare".*

Overall welfare is also referenced in the Plan's Principles (section 4.2): "*Kangaroo welfare is a primary consideration in all kangaroo management and all kangaroos are to be treated humanely*." And "*Human welfare and the conservation of other grassy ecosystem species are key considerations in all kangaroo management*."

Policies regarding welfare then occur at different structural levels of the Plan. For example, Greenfield Development Sites and Other Land have area-specific policies that kangaroos are to be managed to achieve the best welfare outcomes. For example, on Greenfield Development Sites, kangaroos may face unacceptable risks of vehicle collisions, dog attacks, and starvation because of the development. (Sections 5.4.3 and 5.4.4 in the 2017 Plan). But the 2017 Plan also makes animal welfare one of four key policy areas that cut across the entire Plan. This higher level kangaroo welfare policy has an explicit objective: that kangaroo management should adhere to legislation, codes of practice, and Australian standards (section 4.3.1 of the 2017 Plan).

In this review, detailed comments on the substance of the kangaroo welfare policy as expressed in the 2017 Plan are given at 6.1 Kangaroo Welfare. Here, the review makes the case for replacing **Social Impacts** in the 2017 Plan

with **Overall Welfare Impacts** as an explicit impact area that guides kangaroo management with the aim of optimising net welfare outcomes across all sentient animals, including humans. By doing this the new Plan would:

- Signal clearly that Overall Welfare is a central issue in kangaroo management.
- Recognise feedback from some stakeholders during the consultation carried out as part of this Review, who wished to see welfare addressed more coherently.
- Provide a clearer framework for a raft of welfare-related issues that crop up in the 2017 Plan, but are currently dealt with in a piecemeal and sometimes incomplete fashion.
- Extend welfare considerations to encompass the welfare of all animals, and people, and allow contrasting perspectives about which welfare to privilege, to be considered with the same framework.
- Be more consistent with an Indigenous, holistic approach to Country
- Respond to the intent of the 2019 updates to the Animal Welfare Act 1992 (see below).
- Be aligned with the ACT Wellbeing Framework (see below).
- Be aligned with the international One Welfare movement (see below).

All the practices and adaptations to enhance welfare outcomes that have been incorporated into the existing kangaroo management program would be covered by this approach (e.g., a culling season to avoid shooting females with large pouch young and small young-at-foot; stringent requirements for licensed shooters; prioritising culling to occur only in reserves where this will have conservation benefit; small reductions in kangaroo population size each year, rather than less frequent but very large culls, resulting in fewer kangaroos being killed overall; etc. See section 6.1 Kangaroo welfare for more detail).

Additional issues that would be covered more coherently under this proposed approach include:

- Reducing the suffering of individuals from other species, when heavy kangaroo grazing in grassy ecosystems causes the loss of their resources and increases exposure to risk (e.g., from weather or from predators). Reducing kangaroo population sizes to avoid adverse welfare outcomes for other species may result in a net welfare gain (see section 3.1.1.2).
- Reducing the extent of suffering of individual kangaroos in high density populations that experience starvation and higher disease burdens when the food resources diminish from overgrazing or drought (see section 6.1.3.3)
- Reducing the adverse human and kangaroo welfare outcomes associated with kangaroo-vehicle collisions that are more frequent when kangaroo densities are high (see section 6.1.3.4)
- Fairly considering the negative welfare impacts to members of the public that are traumatised by kangaroo management (see section 5.5).

The **Animal Welfare Act 1992** was updated in 2019. This update included a "*new set of objects to ensure that animals are recognised as sentient beings (meaning they can subjectively feel and perceive the world around them), have intrinsic value and deserve to be shown compassion and have an acceptable quality of life, and to reflect the community's expectations around animal welfare and the proper treatment of all animals*"[1].

The new Objects [4A(1)] are:

a. animals are sentient beings that are able to subjectively feel and perceive the world around them; and
b. animals have intrinsic value and deserve to be treated with compassion and have a quality of life that reflects their intrinsic value; and
c. people have a duty to care for the physical and mental welfare of animals.

In amending the Act to recognise 'sentience' the 'Explanatory Statement' stated:

- *….animal welfare encompasses all aspects of animal health and wellbeing, and all people have a responsibility to take reasonable measures to protect the welfare of animals in all human-animal interactions*.
- *Animal welfare in a modern context describes how an animal is coping both mentally and physically and recognises that animals are sentient beings that have the capacity to feel and perceive things. Achieving*

[1] Explanatory Statement for the Animal Welfare Legislation Amendment Bill 2019

good animal welfare relies on recognising the five freedoms of animals … and encompass at a high level the freedom from hunger and thirst, freedom from discomfort, freedom from pain, injury or disease, freedom to express natural behaviour, and freedom from fear and distress. It also relies on recognising that animals deserve having a life worth living, in terms of both physical and mental wellbeing.

This update to the Welfare Act should be reflected in appropriate revisions to the Kangaroo Management Plan, and an effective way to achieve that would be to recognise welfare as a high-level impact area, on a par with environmental and economic impact areas.

The ACT Wellbeing Framework categorises areas (domains) that have been identified as consistently contributing to the overall quality of life for Canberrans (ACT Government 2020). 'Wellbeing Impact Assessments' are embedded into ACT Government Budget and Cabinet processes. The management Plan for the Canberra Nature Park states that the Park contributes to all 12 domains, or areas affecting our quality of life, as described in the ACT Wellbeing Framework. Kangaroo management in the ACT is integral to the management of Canberra Nature Park, and therefore all 12 domains are arguably relevant; the most pertinent domains for the three main impact areas relevant to kangaroo management are summarised in Table 4.

Including Overall Welfare as an impact area in the revised kangaroo management plan would align with the ACT Wellbeing Framework.

Finally, thinking about optimising Overall Welfare would be consistent with the international 'One Welfare' movement: "'*One Welfare projects are intended to address the interconnections between animal welfare, human wellbeing and the environment*." One Welfare encourages a broad, multidisciplinary approach that can connect science, ethics, economics, conservation, and other values (Kennedy *et al.* 2022; Pinillos *et al.* 2016).

Table 4. The relationship between the most pertinent domains and indicators in the ACT Wellbeing Framework, and how they map onto the impacts areas central to kangaroo management.

Domain in the Wellbeing Framework, and *aspiration for the domain (in italics, paraphrased from the Framework)*	**Indicators**	**Kangaroo Management Impact Area**
Environment and Climate *Canberra's natural environment sustains all life and is climate-resistant; this supports long-term economic sustainability*	• Healthy and resilient natural environment • Connection to Nature • Climate resilient environment and community	Environment Economy Welfare (all animals including humans)
Economy *Strong farming and tourism business (both rely on environmental sustainability)*	• Economic performance • Business conditions (of farming sector, nature-based tourism sector)	Environment Economy Welfare (all animals including humans)
Health *Canberrans have good physical and mental health … including through access to health-promoting environments [such as natural environments]*	• Overall health • Mental health • Healthy lifestyle	Welfare (Human)
Social connection *Canberrans are connected and supported within our community*	• Sense of social connection • Levels of volunteering	Welfare (Human, possibly other animals) Environment (Through the activities of volunteer groups such as Park Care)
Safety *Canberrans are and feel safe and secure*	• Road safety	Welfare (for people and kangaroos on roads) Environment (kangaroo population size)
Identity and belonging *Connection to Canberra, Valuing Indigenous history and culture*	• Sense of belonging and inclusion • Connection to Canberra	Environment Welfare (People)

Commented [KM101]: Resilient?

	• Valuing Indigenous culture	
Governance and institutions ***Canberrans participate and are heard; Government is transparent***	• Trust in government • Feeling that voice and perspective matter	Environment Economy (from effective government) Welfare (People)

Recommendation

6.1 ~~5.6~~ Replace 'Social Impacts'; in the Plan with 'Overall Welfare Impacts'. Make Overall Welfare a high-level impact area, on a par with Environmental and Economic Impacts, so that the welfare consequences of management actions (or inaction) for kangaroos, people, and other animals, can be explicitly and consistently considered within the same framework. This change would recognise recent amendments to the ACT Welfare Act, the development of the ACT Wellbeing Framework, and the One Welfare concept.

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6 Have the policies contributed towards achieving the management objectives?

The Review was asked to consider the policies contained in the EGK CNSMP and where possible evaluate the degree to which the policies have achieved the management objectives stated in the plan in the last five years (2017-2022).

This task has been partially accomplished in the sections above; where this is the case, the section(s) above will be referred to.

The 2017 Plan groups a collection of policies, some with their own objectives, into four categories (Kangaroo Welfare, Interactions between human and kangaroos; Managing kangaroo densities; Managing captive populations). The Review deals with each category in turn.

6.1 Kangaroo welfare

The 2017 Plan's policy on kangaroo welfare (section 4.3.1) has an explicit objective:

- *Kangaroo management in the ACT is undertaken in a way that accords with ACT legislation, codes of practice and current Australian standards for animal welfare.*

To support this objective there are a collection of policies relevant to the operation of the management program (e.g., shooter testing, culling season urban wildlife program, legislation and Codes of Practice); a policy for wildlife care of kangaroos; and a policy for translocation.

6.1.1 Kangaroo Welfare during culling

Culling is carried out to comply with a National Code of Practice for humane shooting of kangaroos and wallabies for non-commercial purposes. However, the ACT has additional regulation and practice designed to enhance welfare outcomes considerably. In particular, shooters must regularly pass a competency test (of shooting accuracy, familiarity with the Code, and macropod identification); audits of operations are undertaken on both the conservation and rural culls; a culling season reduces the risk that large, mobile pouch young and small young at foot will be orphaned, the conservation cull occurs only in reserves where conservation benefits are expected; and the overall number of kangaroos to be culled is reduced by culling regularly with small culls.

Humane killing of pouch young remains a sensitive issue for some people. This Review found that the protocols for humanely killing pouch young of different stages that is outlined in the Commercial Code (rather than the non-commercial Code) was clear, useful, and supported by the available evidence. There may be potential for research to develop alternative methods.

The ACT Government's requirements and practice surrounding kangaroo management are dispersed across regulation and various internal guidelines and processes; there may be value in gathering some of these into a single SOP~~op~~ style document, for transparency and to drive positive change more broadly.

The Plan makes it clear that killing kangaroos without being authorized to do so under the Plan, without a license or by an exception under Nature Conservation Act, is illegal.

The Plan establishes that kangaroo management must be carried out in accordance with legislation in the Animal Welfare Act 1992, and ministerially approved codes of practice.

The Plan defines animal welfare as "the health, safety and welfare of animals in general, or one or more animals in particular". [The Review notes that the **Animal Welfare Act 1992** has been updated since the 2017 Plan was released and this should be reflected in the revised Kangaroo Management Plan.]

For kangaroo culling, the relevant code of practice is the 'National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-commercial Purposes' (NRMMC 2008), which was adopted in the ACT from March 2014. This Code deals with killing kangaroos (adults and young) for non-commercial purposes such as conservation management or compassionate euthanasia. This National Code was reviewed by a working group that includes representatives from states/territories, animal welfare organisations, and the kangaroo industry, and there was a public comment process.

There is also a National Code of Practice for humane shooting of kangaroos and wallabies for commercial purposes (AgriFutures 2020). This Code is more recent, was informed by a broad pre-consultation process (Sharp and McLeod 2020), and has several useful advances compared with the older, non-commercial Code. For example, it includes more detailed standard operating procedures for shooting kangaroos and humanely killing joeys. Although commercial shooting does not occur in the ACT, much of the requirements for non-commercial culling comply with these more current standards.

The ACT requires shooters to exceed the specifications in the non-commercial Code (although the Code encourages states/territories to "promote measures to ensure competency"), in several ways:

- Having stringent tests for non-commercial shooters, requiring them to pass a shooting accuracy test, a test on the Code, and a macropod identification test every two years. These are considerable improvements over the situation in other states (Wilson and Edwards 2019). If a shooter fails the test, they must wait two years before they can re-sit the test. Based on the consultation carried out for this Review, this lengthy wait to re-sit the test can be problematic for professional shooters as they are unable to work for two years.

- Auditing compliance and performance. Auditing processes are in place to assess compliance with the code during rural and conservation culling.

    - Rural: Pre-COVID, random audits were carried out on about 10% of people holding a licence to shoot kangaroos. During the audit, shooters were assessed for compliance with the non-commercial Code; for the percentage of kill-shots to the kangaroos' heads; for correct checking of pouches and humane killing of pouch young; and for tagging of killed animals. The landholders (if not the shooter) were checked to ensure compliance with conditions. If audits revealed a breach, the case was passed to the Licensing and Compliance team for further action. These processes are described in internal SoP documents. Post-COVID, the ACT Government team are currently assessing whether and how to vary the audit process to make it as efficient and effective as possible.

    - Conservation: Independent veterinary welfare assessments of the ACT Government conservation culling have been conducted in 2013, 2015, 2017, and 2023. These assessments considered compliance with the Code, welfare outcomes for shooting of adults and independent juveniles, and welfare outcomes of humane killing of pouch young (as per the Code). The independent audits are important for maintaining public confidence in the program.

      In the most recent assessment (Atkinson and Hampton 2023), of 144 shot kangaroos, 97% died instantly from a single head shot, 3 animals required two shots (with 28-49 seconds between shots) and two kangaroos escaped after being shot. An additional two animals were missed altogether. There were 56 pouch young associated with the adult females; of these two-thirds were unfurred. Of the 18 furred young, one escaped before it could be euthanased. Apart from the escapee, the pouch young were killed promptly using a concussive blow to the head. These statistics are similar to the results of the earlier assessments (all are available on the Government website).

      The proportion of kangaroos that insensible immediately upon the first shot is similar to another study of welfare outcomes for four large macropod species which reported a wounding rate of 0.4% for 279 kangaroos killed during a commercial harvest (McLeod and Sharp 2014); and higher than in some other wildlife shooting and abattoir slaughter of livestock (Hampton and Forsyth 2016; Smith and Ryeng 2022). A review of all killing methods for large macropods concluded that an accurate shot to the head is least likely to cause suffering to individual kangaroos (Descovich *et al.* 2015).

Commented [WC102]: An ACT Gov vet has also audited (formally and informally) the program in previous years. Sal/Sweaney might have details about frequency of this.

An earlier assessment of the ACT Government conservation culling (Hampton and Forsyth 2016) measured the duration of stress in sentient young (i.e. the time between being extracted from the pouch and killed), reporting this as 4 seconds. The 2015 assessment also considered the stress imposed on kangaroos standing near to the shot individuals: of 124 kangaroos that were positioned near to shot individuals, only 73% moved away from the shot animal, and only for a short period (median time of 5 seconds).

The welfare outcomes from conservation culling in the ACT study are likely due to the competence of the shooters, avoiding the use of spotlights (using thermal scopes and night vision instead), using suppressors on the guns, and the habituated nature of the kangaroos which allows for close shooting distances; these features may not be present in all large macropod shooting programs.

In addition to the external audits, it could be worthwhile to increase the involvement of the government vets in the conservation culling program. The vet on the team should have experience of culling operations and be willing to be part of the team and aim to assist the operation. During planning, they can keep the shooting team abreast of any developments in kangaroo welfare and veterinary science. In the field, a staff vet could help check for pouch young, collect data on demographics of the culled animals, and sample the condition of animals; these data may help inform predictions for population growth over the coming year (Wilson and Coulson 2021). Vets have knowledge that could be valuable at unexpected times during the operation, and they are expert and trusted conduits of information on animal welfare and health for the public.

Commented [WC103]: As noted above, Gov vet did audit program in some years and is on the steering committee, but agree, this involvement could be increased

The ACT has additional regulation and practice to improve kangaroo welfare as a resulting of non-commercial shooting:

- The ACT imposes culling seasons. Mixed sex culls can occur only between 1st March and 31st July each year when 8-12 month old young-at-foot are unlikely to be present. Young of this age are old enough to be outside the pouch and evade a follow-up shot if their mother is killed. The assumption is that the orphaned animal is still too young to survive without their mother (Sharp and McLeod 2016). McLeod and Sharp (2014) showed that such young potentially do survive after their mother is shot, but experience some mental distress, and the authors concluded that such young at foot should be euthanased to reduce suffering. The culling season is effective at reducing the risk of orphaning because kangaroo breeding in the ACT is strongly seasonal, with pouch emergence timed to coincide with the flush of green grass of spring (Fletcher 2007; Lucas *et al.* 2021). Studies of the age profile of young encountered during culls carried out over multiple years and sites in the ACT show that 8-12 month old juveniles are least likely to be seen between April and June, and most likely to be seen between September and December (Fletcher 2007; Lucas *et al.* 2021). In addition to the mixed-sex cull, on rural land (i.e., not on conservation lands), farmers may also kill males from 1st August to 31st October, but there are constraints placed on the number of males that can be killed (<30% of the number shot in the mixed season~~total cull for that year~~).

- In addition to these formal requirements, in the conservation culling program the contracted shooters and ACT Government staff use additional measures to improve welfare outcomes for the kangaroos and the efficiency of the program. For example, shooting is carried out at night, using night-vision and thermal imaging (instead of spotlights), and suppressors on the guns. The procedures covering all aspects of the conservation culling operation are outlined across various documents (e.g., tender documents and contracts), and it could be useful to gather them together in one set of Standard Operating Procedures to communicate how carefully the culling is organised, and to share with professional shooters working on rural lands, and managers in other jurisdictions.

- The ACT favours small, regular (annual) culls, rather than less regular, very large culls. The culling operations aim to bring the population size in reserves down closer to the target densities, then carry out smaller maintenance culls each year instead of less frequent but larger culls. This results in an overall welfare benefit because fewer animals are killed (section 4.3.3 in the 2017 Plan) when populations are not released to grow exponentially between culls.

- Culling is prioritised across the reserves and is most likely to occur in reserves with greater anticipated conservation benefit to other species. Conversely, culling is less likely when conservation benefits are considered to be less (ACT Government 2023a). This program design feature also reduces the total number of kangaroos that need to be killed.

6.1.1.1 Euthanasia of pouch young

During consultation for this review, some stakeholders voiced concerns over the methods outlined in the non-commercial Code for killing pouch young. The recommended methods are a concussive blow to the head or stunning and decapitation for unfurred young; and a concussive blow to the head for furred young (NRMMC 2008). The specific concern regarding decapitation is that if pouch young develop sentience before fur develops, then decapitation may cause suffering because the brain remains active for a short period after the head is severed. The specific concern about concussive blows is whether it is successful at killing the pouch young all the time. In addition, both decapitation and a concussive blow to the head have a connotation of violence that can be upsetting for some people.

The recommended methods for humanely killing pouch young in the more recently updated Code for commercial shooting of macropods (Australia 2020) are cervical dislocation or decapitation for pouch young under 5 cm long; decapitation for unfurred pouch young larger than 5 cm long; and a concussive blow to the head for partially furred or fully furred pouch young. The commercial Code contains more detailed information on the developmental stages of joeys, and how that affects whether methods are humane or not; and more detailed instructions on how to use each method properly. The Code also states that if the shooter is uncertain about the age and therefore sentience of a pouch young, then they should assume the young is sentient, and use a concussive blow.

Are unfurred young sentient?

Research has shown that brain activity *begins* developing from around the time the eyes begin to open and fur begins to develop in large kangaroos (Diesch *et al.* 2010; Diesch *et al.* 2008; McLeod and Sharp 2014). Thus, cervical dislocation and decapitation for very small pouch young should not cause distress, and these methods – which can be undertaken without removing the young from the pouch or off the teat – do appear to be the most humane way of killing these animals.

Is a concussive blow to the head for partially furred/furred pouch young a humane killing method?

A recent investigation of killing methods for pouch young of all ages concluded that a concussive blow (or 'blunt trauma') to the head was the most effective method and least likely to cause suffering (McLeod and Sharp 2014). An alternative method, using a captive-bolt device, was trialled but found to cause poorer welfare outcomes because too many animals were not properly stunned with a single shot when using the device (McLeod and Sharp 2014). Another review of all methods of killing large macropods (of all ages) also concluded that blunt trauma for young kangaroos was acceptable if properly delivered (Descovich *et al.* 2015). The Australian and American Veterinary Associations both state that blunt trauma, when done correctly by experienced operators, results in rapid death and is therefore an acceptable method of euthanasia (ANVMA 2020).

The issue of how to humanely kill pouch young was also raised as a concern in some submissions to the recent NSW Parliamentary Inquiry into the '*Health and wellbeing of kangaroos and other macropods in NSW*' (NSW Legislative Council 2021). However, other submissions noted that research-based veterinary advice considered this method as the most humane. The Portfolio Committee acknowledged that the killing of joeys (by blunt trauma to the head) was "shocking to many people" (Committee Comment 5.47) but made no recommendations for review of the euthanasia method.

It therefore seems that a concussive blow to the head/blunt trauma is the most humane way to kill joeys, because it is rapid, effective, and consistent. However, it is very unpalatable to some of the public. The 2020 commercial Code notes that using captive bolts may provide an alternative option for humanely killing pouch young the future, but that the effectiveness and consistency of this techniques are yet to be demonstrated. The 2020 Code

also has more specific instructions about how to deliver the concussive blow to pouch young that are much more useful than the material available in the non-commercial Code. Given the public sensitivity to the killing of pouch young, the ACT Government could encourage and support research to explore whether captive bolts, or some other approach, could potentially replace a concussive blow to the head.

6.1.1.2 Other issues raised during consultation

Euthanasia or humane killing?

Some stakeholders questioned the use of the term 'euthansia' for killing pouch young, and felt that 'humane killing' was more accurate. Euthanasia refers to killing to end incurable suffering and is carried out in the best interest of the killed individual. A pouch young (without care) whose mother has been shot is almost certain to die from exposure, starvation, or predation; it may experience emotional distress and fear after the loss of its mother. Thus, killing an orphaned joey could be viewed as an act of mercy, consistent with the meaning of euthanasia. Alternatively, the killing of the mother and the dependent pouch young should be regarded as the same, single event, in which case we should apply the same term of 'humane killing' to both mother and pouch young. The research, livestock, and animal rescue/care sectors have been narrowing their use of the term euthanasia, retaining it for only the subset of humane killing scenarios that genuinely involve the relief of suffering because there is no other option. Both the commercial and non-commercial Codes for shooting kangaroos use the term euthanasia for killing pouch young, but the ACT could review its use of the term, and decide to use more specific language in its own documentation.

Including pouch young in culling targets and reports

During consultation, some stakeholders suggested that pouch young numbers should be included both in the cull targets, and the cull reports. The 2017 Plan states that cull reports will include the number of adults, subadults and young-at-foot that are independently mobile. The Plan states that pouch young will not be counted and reported (section 4.3.2). However, this situation changed from 2014, when management reports (e.g. ACT Government 2023a) began reporting pouch young as well as independently mobile individuals, in response to public feedback. Including pouch young in cull targets does not seem feasible, given managers cannot predict, and shooters cannot know whether adult females are carrying pouch young or not, until they check the pouch after shooting the female. Note that

Commented [WC104]: Agreed. This was raised by a few members of the public a couple of years ago. There was some thought that we could include a prediction of PY in the cull targets, but this obviously would never be correct (which could have PR implications around killing more PY than predicted), so we have decided it's better to just keep reporting PY killed

Commented [KM105]: Delete?

Recommendations

6.4 The Code for non-commercial shooting of kangaroos is 16 years old. The ACT Government should work with counterparts in the other jurisdictions to update the Code, and bring it at least to the standard of the current Code for commercial shooting of kangaroos (dated 2020). The 2020 Code for commercial kangaroo shooting has some useful new material (such as more detailed and updated standard operating procedures appended to the Code) that could be incorporated into a new non-commercial Code. In addition, the pre-consultation approach used in the development of the commercial Code – where stakeholder views were gathered to inform the revision – could also be considered for the non-commercial Code.

6.5 In the interim, the ACT Government could consider gathering all the information that guides the current conduct of the conservation culling operation into a single, non-statutory 'standard operating procedures' style of document, that can be used to communicate the very high standards and careful operation of the conservation culling program to other shooters working on rural lands, and even to the public. To inform these SoPs and further enhance public trust, consider seeking input and endorsement from the **ACT's Animal Welfare Advisory Committee**, a body with broad community representation from the animal welfare, farming, veterinary, research, conservation, companion animal, recreational/sporting and environmental legislation sectors.

6.6 Consider making the government vet(s) an integral member of the culling operations, helping to plan the year's program, to gather additional information on kangaroo demographics and health, and helping to communicate to the public that animal welfare is a primary consideration during the culling.

6.7 Explore the potential for further research to improve the effectiveness and consistency of captive bolts as an alternative method for humanely killing pouch young of certain ages. If potential exists, then support that research.

6.8 Shooter competency:

- Allow shooters who fail the competency test to re-sit the test the following year, instead of waiting two years.
- Include shooting tests using night-vision equipment.
- Consider whether the penalties for off-target kills, and female kills in the male-only culling season, can be modified to allow for unintended mistakes.

6.9 Make the ear tags biodegradable.

6.10 Consider how to design and manage field audits during rural culls to optimise welfare benefits, make audits a constructive opportunity for two-way exchange, and reduce administrative burdens on farmers and government staff.

6.11 The Animal Welfare Act has been updated since the 2017 Plan was released and this should be reflected in the revised Kangaroo Management Plan.

6.12 In the revised Plan, and other (new) documents relating to kangaroo management in the ACT, consider replacing the term 'euthanasia' with 'humane killing' for pouch young that are killed because their mothers have been shot during the conservation culling.

6.1.2 Kangaroo welfare in wildlife caring and translocations

The 2017 Plan does not support translocations, or the release of hand-reared kangaroos, because of poor welfare outcomes for kangaroos, and some risks to humans (from hand-reared kangaroos). Research since 2017 on the outcomes of large macropod translocations corroborates this position.

The Plan outlines the welfare arguments against hand-rearing and releasing kangaroos in the ACT (welfare concerns for the individual kangaroo, risk that hand-reared males could later injure people when they are mature, risk to resident kangaroos). There is a licence to export 35 kangaroos that come into care in the ACT, into NSW, each year. The Plan notes that there is no justification for hand-rearing and release on conservation grounds as the eastern grey kangaroo is an abundant species.

The Plan does not support alternative actions to culling that have poor welfare outcomes for individual kangaroos, including translocation of kangaroos. Kangaroos to be moved must be captured and sedated, transported, then released to a novel site, steps that each present risks of distress, injury, and death from various mechanisms. Research carried out since the 2017 Plan was published corroborates this assessment (e.g. Cowan *et al.* 2020; Thompson *et al.* 2022).

In addition, translocations can also not be carried out on the scale required to keep kangaroo populations at lower levels, they are resource-intensive, and there are no/few suitable release sites. Since eastern grey kangaroos are not threatened, there is no conservation justification for translocations.

Recommendation

6.2 A revised Plan should continue not supporting hand-rearing and translocations of kangaroos.

6.1.3 Kangaroo welfare considerations only partially, or not, considered by the 2017 Plan

The 2017 Plan focussed mainly on kangaroo welfare during culling. In the revised Plan, if the recommendation of adding 'Overall Welfare' as an impact area is adopted, then the kangaroo welfare considerations of other actions can also be explicitly considered. These include fertility treatment, fencing, inaction when high density kangaroo populations starve during drought conditions, and kangaroo-vehicle collisions.

6.1.3.1 Fertility treatment

The Plan has supported research into fertility control methods that avoid poor welfare outcomes. For example, the Plan does not support fertility control treatments that involve immobilising kangaroos, because this is stressful

Commented [KM106]: Given that we immobilise to deliver GonaCon at our current fert. control sites, perhaps a revised plan would consider the balance between wellfare considerations and the information gained by monitoring kangaroos that have ear-tags fitted (that have been immobilised). It is also possible to avoid these roos during any maintenance culling.

Commented [WC107R106]: Is it possible to re-jig this sentence so it is more about promoting research/support for remotely deliverable options? As Miles says above, we are currently immobilising kangaroos for this program. We are still working towards the ultimate goal of dart delivery that is suitable for large, free-ranging populations, but we aren't there yet. Agree that the new plan should address the welfare impacts of fertility control in more detail, plus the operational requirements (like Miles mentions above) and the trade off between the higher welfare impacts of fertility control but potentially lower number of animals being subjected to a management action in the long term compared to shooting.

and involves risk of injury and death. The Plan has supported research to develop, and assess the welfare outcomes, of dart-delivered immune-contraceptive techniques which do not require an animal to be immobilised.

Although fertility treatment can reduce the number of kangaroos that are killed, it may not be considered ethical from an animal rights perspective.

Commented [KM108]: This could be expanded but I also like having this slim, like it currently is.
Possible expansion could include:
- actual interference with animal during treatment
Additional animal welfare considerations:
- absence of positive welfare states associated with having offspring
- extra perhaps unwanted attention from males given to untreated females

6.1.3.2 Welfare outcome from exclusion fencing and barrier fencing

Large fenced exclosures may affect kangaroo movement. Kangaroos could get caught in large or small exclusion fences. Alternatively, the use of fencing to protect grazing sensitive areas can reduce the need to kill kangaroos by excluding them, or by allowing fertility treatment to be used on the small enclosed kangaroo population. Barrier fences along roads can reduce the number of collisions with vehicles. Road barrier fences can restrict kangaroo movements. If poorly designed, they can act as funnels, directing kangaroos to sections of roads and creating a collision hotspot (Cope and Herbert 2023).

6.1.3.3 Poor welfare outcomes when high density populations face food shortage

Herbivore populations that lack top-down predation pressure are often characterised by marked population fluctuations. Episodes of greater food availability (for example, after good rain) causes numbers to increase but the population eventually overshoots their food supply, especially if conditions change (for example, to a dry spell). The population crash that follows has poor welfare outcomes for individual kangaroos, affecting young and old animals most strongly (Bergeron *et al.* 2023; Wilson and Edwards 2019).

Eastern grey kangaroos are reported to experience mass die-offs, when low food, increased disease burdens, and low overnight temperatures combine to increase mortality rates, especially in sub-adults (Coulson 2007; Fletcher 2006b; Portas and Snape 2018; Wilson and Coulson 2021) but also in adults (Brandimarti *et al.* 2021; Hunter and Hunter 2019). Subadults in higher density populations in the ACT have been shown to have lower bone marrow fat and blood metrics (such as haematocrit, red cell count, albumin, etc), making them more vulnerable to die off events from starvation, hastened by disease, or predation, during winter and early spring when food shortages are most likely (Fletcher 2006b; Portas and Snape 2018).

Culling could improve overall welfare outcomes if it reduces suffering across individual kangaroos exposed to starvation (Hampton *et al.* 2019). Note that Fletcher (2007) suggests that mass starvation is a natural process, and should not be a reason to cull. That statement makes sense in large protected areas like Namadgi NP. However, in the managed kangaroo populations of Canberra Nature Park, where welfare outcomes from management actions is a critical factor in decision-making, then it makes sense to consider welfare more comprehensively, across all management decisions to act, or not act.

Wilson and Coulson (2021) suggest that early intervention to cull animals when populations begin to increase would improve welfare outcomes for individual kangaroos, and/or reduce the number of kangaroos that need to be killed in a later intervention, because intervening later would mean killing more kangaroos. They describe the relationships between the direction of population change (increasing or decreasing) with female reproductive rate (higher when population is increasing) and adult sex ratio (even when population is increasing; female biased when population is decreasing because of differential male mortality), and suggest these markers could be used to help gauge the likely population trajectory in the near future.

6.1.3.4 Poor welfare outcomes from high rates of vehicle collisions during dry conditions

Collisions between vehicles and kangaroos increase when conditions are dry, because kangaroos move to the road verges to access the forage there. The effect is accentuated when the kangaroo densities neighbouring the road are high (Cope and Herbert 2023; Herbert *et al.* 2021). In the ACT, at least 7400 kangaroos are killed annually by collisions with vehicles, and thousands more are injured (some of which may also die). (see Sections 5.2 and 5.7)

Commented [WC109]: And probably crossing to search for food elsewhere

6.2 Interactions between humans and kangaroos

The 2017 Plan's policy on managing interactions between humans and kangaroos has an explicit objective:

- *Kangaroo management and community education minimise negative encounters between people and kangaroos in the ACT.*

This review is unable to assess whether this response has been effective at reducing the incidence of conflict between people and kangaroos. If the occurrence of such events is low, then discerning change is challenging.

Commented [SL110]: Check with....Claire?

The Plan states the incidents between kangaroos and people are few, and mainly arise when unrestrained dogs harass kangaroos. The ACT government has established an 'urban wildlife program' to support welfare of kangaroos, by euthanasing injured animals, and sharing information about kangaroos and their welfare, and people's responsibilities with respect to welfare, including by controlling their pet dogs.

6.3 Managing kangaroo densities

This group of policies outline the Plan's position on the menu of approaches for controlling kangaroo populations. It establishes that professional shooting is the most humane way to kill independently mobile kangaroos, and that the ACT would work to advance the use of fertility control as a viable population control method for specific circumstances. This last commitment has resulted in field deployment of contraception.

The 2017 Plan's policy on managing kangaroo densities (section 4.3.3) has two objectives:

- Kangaroo densities in the ACT are managed according to the management objectives for the land on which the populations occur.
- Methods of managing kangaroo densities in the ACT are based on the best available scientific knowledge, animal welfare and cost effectiveness.

6.3.1 Methods of culling

This section of the Plan contains information on options for killing kangaroos, and considers that shooting is the most humane option. However, capture darts followed by hand-delivered lethal injections may be used in areas where shooting is not possible. Orally ingested poison is not to be used. The point is made that regular, smaller culls result in fewer kangaroos being killed than irregular, much larger culls (this point is noted also in the section 6.1 Kangaroo Welfare).

6.3.2 Fertility control

The Plan summarises the available approaches for fertility control at that time, and commits to continuing to support and conduct research on fertility control, as has happened since the late 1990s. As noted in section 3.1.3.4 Fertility control target, this research has been very successful, and has resulted in the inclusion of contraception as a population management tool in three reserves, with expansion to additional reserves being planned.

6.3.3 Environmental modification

This collection of policies addresses the options for managing kangaroo densities with broad-scale ecological manipulations of the environment, such as increasing tree cover, reducing water sources, encouraging top-down population regulation from dingoes, and exclusion by fencing. Most of these options are not viable or useful in the reserves of Canberra Nature Park, except in exceptional circumstances such as the large fenced area of Mulligan's Flat-Goorooyarroo, or using long lengths of fencing to edge a road.

However, at smaller scales, modification could be effective. Using piles of coarse woody material, or small fenced plots, or even carcasses, to exclude kangaroo grazing from small areas, can have marked effect on species richness at those sites (Barton *et al.* 2011; Barton *et al.* 2016; Manning *et al.* 2013; McIntyre *et al.* 2019; Smith *et al.* 2023).

Allowing the grass in some small patches to become so thick that kangaroos avoid eating it is another example of small-scale manipulation. The use of environmental modification at small scales is discussed in this Review at Section 3.2.11.

6.4 Managing captive populations

This policy deals with the issues of enclosed populations of kangaroos in a logical way and makes the responsibilities of managers of such areas clear.

This policy does not have an explicit objective. The policy deals with situations where kangaroos are enclosed by a fence. When emigration is impossible, and some sources of mortality (such as road collisions) are eliminated populations can grow very quickly, and kangaroo welfare could be poor (Herbert *et al.* 2021; Mawson *et al.* 2016). In areas greater than 100 ha, that population is to be managed as a wild population, but in smaller areas the kangaroos must be managed as a captive population. In these cases, the landholder must seek a licence to keep and prepare a management plan, and must control breeding mainly by controlling breeding rather than culling. The management should aim to maintain the ecological (including soil) and cultural values of the site. Site owners/managers can apply to remove all kangaroos from small, fenced areas.

The requirement to use fertility control rather than culling makes sense when the population ~~i~~Is small and~~,~~ females are not emigrating into the area. In addition, there are likely to be human safety concerns about using guns in small areas, potentially surrounded by suburbs. The Review spoke to three site managers of large, fenced areas (>100 ha); the kangaroos in these areas were all managed as wild populations, with varying levels of management advice/support (for example, for kangaroo counts, or monitoring threatened species) from the ACT Government.

7. Is kangaroo culling justified?

The Review assessed the ACT Kangaroo Management program against a set of seven international consensus principles for ethical wildlife control, finding the program mostly adheres to the principles. Using the framework is a reminder that other threats to the ecological integrity of grassy ecosystems (fire regimes, invasive species) should be managed to the extent possible; that kangaroo management must be justified (on environmental, economic, and welfare grounds); that management must have clear and achievable outcome-focussed objectives; that overall welfare is considered; that the diversity of human values is considered; that management is well-planned; and that kangaroos are not labelled in a way that scape-goats them for a situation not of their making.

As described in section 5.5 Trauma to people, killing native animals for conservation purposes poses a valid moral and ethical challenge, and highlights that people value animals and nature in diverse ways. Broadly, a person's values may align with conservation-centric, animal rights-centric, welfare-centric perspectives, or some combination of these. As the natural world is reduced and degraded, the potential for discord between conservation, welfare, and animal rights perspectives is increasing in frequency; at the same time, the morality of considering non-human animal interests in decisions, including conservation decisions, continues to be discussed (Schapper *et al.* 2022).

Dubois et al. (2017) propose a framework, with seven principles, to support decisions about controlling native species (for a variety of reasons) that is rational, evidence-based, and ethical because it considers and weighs the needs, benefits, and costs from various perspectives. The authors suggest this framework could lessen controversy over wildlife control, although it will not remove controversy if stakeholders want decisions to be made solely on one set of rights, such as the right of a farmer to guard their livelihood against any animals, or the rights of animals to live without intervention from people.

Another approach to embed killing animals for conservation into a moral framework was explored recently in Woinarski (2018), who developed a set of principles to guide decision-making by adapting a rubric designed to identify a 'just war'. The principles outlined in Woinarski are slightly more detailed, and pertain to a narrower set of circumstances, than those proposed by Dubois et al., but the two frameworks substantially overlap. The seven principles of Dubois et al. (2017), with some additional detail drawn from Woinarski (2018), are listed in Table 5, against a column that evaluates how the ACT Kangaroo Management Plan ~~stacks up~~rates against these principles.

Table 5. An assessment of the ACT Kangaroo Management program against international consensus principles for ethical wildlife control, based on (Dubois *et al.* 2017, Woinarski, 2018 #6561). The table asks: Is the conservation culling of eastern grey kangaroos predicated on a net benefit to environment, other animals, people, livelihoods, and overall welfare? Text in red font suggests areas for further consideration, that are mostly reiterated in other parts of this Review.

Principle	ACT Kangaroo Management – performance against the principle
1. Modify human practices: Address the ultimate factors responsible for the ecological imbalance to the extent possible.	• The ultimate factors of the imbalance - of urban and agricultural expansion, causing habitat loss, fragmentation, removal of dingos, dispossession of Indigenous people, invasive species, nutrient loading, proliferation of water points, and changed fire regimes - are mostly impossible or impractical to wind back. The revised Plan could make it clearer that kangaroo management is one part of integrated management in the reserves, and other threats are being managed as effectively as possible.
2. Justification for control: Is there compelling evidence that eastern grey kangaroos have a significant detrimental impact on the environment, other animals, people, livelihoods, and overall welfare.	• Given the current distribution of habitat fragments, and their ecological condition, high or low levels of kangaroo grazing can now contribute to further ecological degradation, and further decline and extinction risk in other native species. Preventing such extinctions has a justifiable ethical basis, because species have intrinsic values and rights to exist; because future human generations have the right to experience the diversity of the natural world in the way previous generations have; and because further erosion of nature diminishes Country for Indigenous Australians.

Principle	ACT Kangaroo Management – performance against the principle
	• High densities of kangaroos adversely affect economic viability of farms and increase risks of road collisions (which causes injury, trauma, and costs). • Welfare outcomes for high density kangaroo populations can be poor for the kangaroos (starving, vehicle collisions), other animals (habitat quality and reduced survival), and people (from vehicle collisions, and from seeing starving animals).
3. Clear and achievable outcome-based objectives: Are there net conservation, economic, welfare benefits, which are clearly expressed, monitored, with information used to adapt management?	• Kangaroo management for conservation outcomes has clear and achievable objectives for grass layer condition and thus the viability of several threatened species; the outcomes (for the grass layer) are monitored; implementation is adapted based on evidence. Adding monitoring of the response of grazing-sensitive species would further improve the performance of the management program against this principle. Periodic monitoring of kangaroo density in reserves other than Canberra Nature Park would provide the broader context in which the kangaroo management sits. • Economic outcomes for farmers are assumed based on past research, but not directly monitored or used to adapt management. Adding strategic monitoring of grass layer condition and kangaroo density at priority locations on rural land would improve the performance of the management program against this principle. • Welfare outcomes (for people, kangaroos, other animals) have not been holistically articulated, monitored, or evaluated, although most of the building blocks are in place. Adding Overall Welfare as a high level impact area with clear objectives and desired outcomes would improve performance of the program against this principle.
4. Overall welfare: Control should be humane, and cause the least harm to the least number of animals. Options other than killing should be assessed.	• Culling operations are caried out to minimise pain and suffering to kangaroos. The ACT Government is exceeding national standards, and is committed to continuous improvement. • Culling reduces harm by preventing mass starvation of kangaroos (when food is short); by retaining habitat for grass-dependent animals that are affected by heavy grazing; and by reducing the number of people and kangaroos involved in kangaroo-vehicle collisions. • Welfare outcomes of non-culling options have been assessed and mostly considered worse (e.g. translocations of large macropods have poor outcomes). Contraception may be useful in limited situations, and exclusion (using fences, or logs) may be possible in small areas. • Culling, and fertility control, ~~they~~ may cause emotional suffering to some people, because they have an animal-rights perspective; they worry about pain and suffering during a cull; they form attachments to particular kangaroo individuals that are culled. • Adding Overall Welfare as a high level impact area with clear objectives and desired outcomes would allow management decisions to act (or not to act) to be weighed up more consistently and comprehensively, and thus help the management program's performance against this principle.
5. Social acceptability: The management plan should consider the range of community values	• The management plans present a comprehensive range of conservation, economic, and social issues and perspectives. • It was open for public comment, and its performance is subject to regular review. • The annual operation of the plan is transparent, with monitoring results and culling targets available on the government website. • Facilitating broad community engagement with the process for revising the Plan will help the management program's performance against this principle.
6. Systematic planning No ad hoc culling	• A comprehensive management plan is in place, supported by law and policy, and by a thorough research program with extensive collaboration to the research sector.
7. Decision-making by specifics rather than labels: Focus management on the specific issue, rather than negatively labelling kangaroos	• The management focus on maintaining the grass layer at a certain height is appropriate (compared to reducing the density of 'overabundant' kangaroos, which is less appropriate).

Principle	ACT Kangaroo Management – performance against the principle
	• Terms that categorise kangaroos negatively could lead to poorer welfare or ethical outcomes. For example, best to avoid terms such as 'pest' (in the context of farms). The 2017 Plan mostly achieves this.

Recommendations

7.1 Consider the international principles for ethical wildlife control when revising the management plan; ensure the perspectives of all stakeholders are fairly and transparently considered.

7.1 Kangaroo conservation culling in the context of other mortality, and overall population size

Of the direct anthropogenic causes of kangaroo mortality, culling on rural lands affects the largest number of kangaroos (~9100 per year), followed by road kills (~7400 per year), then conservation culls (2000 per year). Therefore, of mortality caused directly by humans (conservation cull, rural cull, road kills), the conservation cull represents 11%. The Review did not estimate the number of kangaroos displaced (and thus probably killed) by urban expansion.

There are about 6 million eastern grey kangaroos in NSW west of the Divide. The Review estimates that there are about 99,000 eastern grey kangaroos in the ACT, of which most are in the large protected areas in the west and south of the ACT (48%) and on rural lands (31%). Canberra Nature Park contains about 16% of the population, and the remaining 6% is on Commonwealth land. Conservation culling therefore affects 2% of the ACT kangaroo population, road kills around Canberra affect 7%, and rural culls affect 9% (stressing these figures are very approximate).

Given the ethical complexities of killing kangaroos for environmental benefits (previous section), it may be useful to compare the extent of mortality caused directly by human action covered in this plan: culling for conservation, culling for economic benefits, and accidental mortality from collisions with vehicles on roads.

Culling for conservation:

- Since 2018, the kangaroo populations in 15 to 16 KMUs have been estimated each year, returning an average density (given the area sampled, usually around 8300 ha, but varies between years) of 1.35 kangaroos per ha.
- Annually, culling has occurred at reserves within 4 to 8 KMUs, with 1041 to 4035 independently mobile kangaroos killed each year (**mean = 1997**), and an additional 362 to 1603 (mean = 769) pouch young killed each year.
- The culls remove about 18% of the independently mobile kangaroos in the reserves within the 15-16 KMUs.

Commented [WC111]: We have additional counts for populations that aren't currently considered in the cull program that we could provide if you like?

Culling for farm economic benefit:

- The number of kangaroos reported as shot on rural lands has varied from 3878 to 14,569 (**mean 9077**) between 2015 and 2022.

Death by vehicle collision:

- The average number of road killed kangaroos across three public surveys is 5800, but the current figure is closer to **7400** (the result from the 2022 survey) as Canberra has been expanding rapidly since the first survey in the series occurred (2015). This does not include kangaroos that left the collision site and died later from injuries.

These figures indicate that most kangaroos are killed on rural lands, followed by road collision, then conservation culls. However, another way of looking at this is to consider the proportion killed in terms of their relevant population sizes, because these kangaroos are living in different areas (albeit with some overlap). Table 6 shows

the numbers killed, their relevant overall population size and therefore the proportion. Considering the figures in this way, it still seems that the greatest proportion of kangaroos are killed on rural lands, then roads, then on reserves in Canberra Nature Park.

Table 6. The number of independently mobile kangaroos killed in conservation culls, rural culls, and by vehicle collisions; and the proportion this represents out of the relevant total population. (Details in Appendix 1).

Mortality source	Average N. kangaroos killed (years)	Population total with rationale, and assessment of uncertainty		Kangaroo mortality as % of population
cull	1997 (2018-2023)	11,250	Population in reserves with culls over last 5 years (8310 ha), with average density 1.35/ha. High certainty because it is based on annual kangaroo count and cull data, and the areas of reserves and KMUs are measured.	18%
rural	9077 (2015-2023)	30,200	Population on rural lands (39,500 ha), with density 0.76/ha. Low certainty, because data on density are few and old; it's possible that not all culling is reported.	30%
road	5805 (2015, 2019, 2023)	23,300	Population in all KMUs (17,300 ha), with average density 1.35/ha. Low certainty; data on number of collisions is extrapolated from surveys of 600 people; overall kangaroo population used here is based on an estimate for summed KMU areas, but collisions also occur outside of KMUs.	25%

To put these numbers in a broader context, the Review carried out some back-of-envelope calculations, summarised in Table 7. The total population of eastern grey kangaroos in the commercial harvest zones (i.e., west of the Divide) is close to 6 million, but this number fluctuates with weather conditions (NSW DPE 2023). The harvest zone that surrounds the ACT contains about 1.4 million eastern grey kangaroos. Using density data from empirical studies in different parts of the ACT, the Review estimates – very approximately – that there are 128,000 eastern grey kangaroos in the ACT, with most of these (46%) on rural lands and in the large, contiguous protected areas (37%). About 12% of the ACT population is in Canberra Nature Park, and another 5% is on Commonwealth land.

Thus, conservation culling therefore affects 1.6% of the ACT kangaroo population, road kills around Canberra affect 5.8%, and rural culls affect 7.1% (stressing these figures are very approximate).

Table 7. The number of kangaroos, and their density, in different land tenure/uses, a confidence rating for the estimate, and the source for the estimates. Note that in some cases these estimates are very approximate, especially those for rural lands, and protected areas in the ACT that are not Canberra Nature Park.

Statistic **NSW**	Population size	Density	Confidence rating	Source
Population size of EG kangaroos in NSW commercial harvest zones (everywhere west of the Divide; 688,004 km²)	5,880,000	0.86/ha	high	(NSW DPE 2023) (Lunney *et al.* 2018) Quota is 14-15%, and actual harvest is <3% of population
Population size of EG kangaroos in NSW Southeast Tableland commercial harvest zone	1,428,800	0.35/ha	high	(NSW DPE 2023) (Lunney *et al.* 2018) Quota is 15%, and actual harvest is <1% of population

(surrounds ACT), 40,705 km²				
ACT	Population size % of total ACT population			
Population size of EG kangaroos in the ACT (2358 km²)	128,000 *100%*	0.54/ha	low	Based on adding estimated populations of rural land; Canberra Nature Park; other Protected Areas (split into grassy ecosystems and forests with different density estimates); Commonwealth land.
Population size of EG kangaroos in all Canberra Nature Park (114 km²)	15,400 *12%*	1.35/ha	high	average density of years 2018-2023 multiplied by CNP area 11,400 ha). CNP land is ~66% of KMU areas.
Population size of EG kangaroos on rural lands (395 km²)	59,300 *46%*	0.76 to 1.5/ha	low	Lower bound from old empirical data (ACT Government 2010; NSW DPE 2023; Perry and Braysher 1986); upper bound from considering size of rural cull and roo population growth rates.
Population size of EG kangaroos in other ACT Protected Areas (1270 km²)	47,500 *37%*	0.3 to 3.4/ha	low	• 30 km² grassy areas with 3.4 roos/ha, (ACT Government 2010; Banks *et al.* 2000; Fletcher 2006b) • 1243 km² forests with 0.3 roos/ha, being 10% of the figure above
Population size of EG kangaroos on Commonwealth land (96 km²)	5760 *5%*	0.6/ha	low	Assuming half is bushland with densities similar to CNP

Commented [SL112]: 30 km 2 is a guess

Commented [WC113R112]: We can check this on our mapping

Commented [WC114]: This is probably a bit high, maybe 0.1 or 0.2??

Commented [SL115]: Another guess

Commented [WC116R115]: We can check area of comm land too

Commented [WC117R115]: There are also other urban space areas that contain kangaroos (eg golf courses, Weston Park) often at high densities - might be worth including a density for these areas as well? We have counts for various sites in this category that could help.

Recommendation

7.2 These estimates for kangaroo population sizes across the ACT are very uncertain, because of the paucity of data on kangaroo densities from rural lands and the large protected areas that are not Canberra Nature Park (e.g., Namadgi NP). Obtaining density estimates from these areas, periodically, would help to understand the broader context in which kangaroo management is operating. Recommendation 4.3 was for an assessment of spatial variation in kangaroo density on rural lands, followed by an ongoing monitoring program carried out around every 5 years or another ecologically sensible interval. Here, the recommendation is to integrate this with periodic surveys on the large reserved areas in the west and south of the ACT. This information will help contextualise the intensive management in Canberra Nature Park, and provide an overall status assessment of one of the ACT's iconic species.

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From: Burkevics, Bren
Sent: Tue, 6 Feb 2024 20:31:05 +0000
To: Wimpenny, Claire
Cc: Cooney, Rosie; Alegria, Stephen; ConservatorFloraFauna; Glennon, Chris
Subject: FW: EGK plan Independent review - DRAFT REPORT
Attachments: Kangaroo Review_20240205.docx, FINAL DRAFT Kangaroo Review_20240205.obr

OFFICIAL

Hi Claire

Many thanks for sending this through and for briefing the Minister yesterday. I will send the report to MO for their early awareness pending formal briefings to come.

I will also come back to you with comments. I note that the report is very, very detailed!

I have included Stephen, and Chris in this reply as well.

Bren Burkevics | Executive Group Manager
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From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Tuesday, February 6, 2024 12:14 PM
To: Burkevics, Bren <Bren.Burkevics@act.gov.au>
Cc: ConservatorFloraFauna <ConservatorFloraFauna@act.gov.au>
Subject: EGK plan Independent review - DRAFT REPORT

OFFICIAL

Hi Bren,
Professor Legge has just sent through her draft report, see attached (word doc attached in case the Objective link doesn't work).
Would you or someone from your team like to review it? I am hoping to get comments on the draft by next Friday 16th February with the aim of having the report finalised by the end of February.

I'm happy for this version to be shared with Minister Vassarotti's office too if you like.

Regards,

Claire Wimpenny

Senior Ecologist
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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: Gannon, Claire
Sent: Tue, 13 Feb 2024 22:25:42 +0000
To: Wimpenny, Claire
Subject: RE: EGK Plan Independent review - DRAFT FOR COMMENT

OFFICIAL

Hi Claire,

Thank you for the opportunity to provide comment on the draft review. Both Greg and myself have had a look and note the following:

The EGK Plan Review contains 39 recommendations on how EGK management can be improved. The Summary of the report makes three main recommendations for improving the management of environmental impacts. One of these is:

- The Review recommends developing a strategic translocation program for grazing sensitive plant and animal species (including threatened species, and culturally significant species) into reserves with suitable habitat, where threats are adequately managed. Such a program would accelerate ecosystem restoration and demonstrate the value of managing the threats to these fragments, including grazing management. It could offer enhanced conservation outcomes for plants and animals already being translocated out of the expanding urban footprint; opportunities to gain knowledge about species ecology and what limits their recovery; and opportunities to leverage and extend the participation of community environmental groups, and Traditional Custodians, in reserve restoration. This program should be embedded in a strategic, ACT-wide program to protect, reconnect, and restore ecological integrity across grassy ecosystems on multiple tenures (see cross-plan recommendations).

The Review Summary Table provides further detailed recommendations relating to this main recommendation:

3.5 – Recommends the translocation of grazing sensitive species from areas of high grazing pressure

3.7 - Recommends reporting on the status of grazing sensitive species in reserve where kangaroos are managed.

3.12 – Recommends analysing which grazing sensitive species could be included in a translocation program and the development of a strategic multi-species, multi-site translocation plan

There is no evidence that broadscale translocation of grazing sensitive species is a viable or cost-effective means of conserving those species. I don't believe the Conservator should support the main recommendation or detailed recommendations 3.5 and part of 3.12. Reporting on the status of grazing sensitive species and analysing conservation objectives and actions for at risk species (3.7 and part of 3.12) can be supported. These recommendations would provide improved knowledge on the effectiveness of kangaroo management.

Recommendation 4.2 suggests considering the options for enhancing government-landholder collaboration over kangaroo management planning on rural leases. This recommendation provides a

better solution than 3.5 and 3.12, for managing grazing sensitive species outside of reserves where kangaroo management already occurs.

I'm happy to set up a Teams meeting if you would like to discuss any of the above.

Kind regards,

Claire Gannon
A/g Conservator Liaison I Office of the Conservator of Flora and Fauna
Phone: +61 2 6207 8357 **I** Email: claire.gannon@act.gov.au

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Monday, February 12, 2024 2:31 PM
To: Watts, Michaela <Michaela.Watts@act.gov.au>; Alegria, Stephen <Stephen.Alegria@act.gov.au>; Ralph, Michelle <Michelle.Ralph@act.gov.au>; Bauer, Jo-Anne <Jo-Anne.Bauer@act.gov.au>; Roach, Adam <Adam.Roach@act.gov.au>; Gannon, Claire <Claire.Gannon@act.gov.au>; Daines, Nicholas <Nicholas.Daines@act.gov.au>
Subject: FW: EGK Plan Independent review - DRAFT FOR COMMENT

OFFICIAL

Hi all,
As discussed at the MMSC meeting on Friday, here is the draft independent review of the Eastern Grey Kangaroo Controlled Native Species Management Plan. If you would like to comment on the draft could you please do so by this Friday 16th February. It would be great if you could add comments to the Objective version but I have also attached a word version in case you can't access our area on Objective.

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

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From: Wimpenny, Claire
Sent: Tuesday, February 6, 2024 12:04 PM
To: McIntosh, Sally <Sally.McIntosh@act.gov.au>; Sweaney, Mark <Mark.Sweaney@act.gov.au>; Arguelles, Rheyda <Rheyda.Arguelles@act.gov.au>; Cooney, Rosie <Rosie.Cooney@act.gov.au>; Keighley, Miles <Miles.Keighley@act.gov.au>; Glennon, Chris <Chris.Glennon@act.gov.au>; Driver, Kyeelee <Kyeelee.Driver@act.gov.au>
Subject: EGK Plan Independent review - DRAFT FOR COMMENT

OFFICIAL

Hi all,
Sarah has just sent through her draft review report for comment, see attached.
Could you all please review the document and provide any comments/edits in track changes? I am hoping to get **comments by next Friday 16th Feb** at the latest if possible, with the aim of having the report finalised by the end of February. Let me know if this timing doesn't work for you (noting the report is about 100 pages long).

Kyeelee – Sarah has asked if you could please review Sections 5.6 and 6.1. These are the sections that include the information you discussed with her. Feel free to comment on the rest of it if you like, but completely understand if you don't have time.

I will also send a copy to the Conservator's team to see if they want to comment and to send on to Minister Vassarotti's office.

Let me know if you think the draft should go to anyone else at this stage. I was planning to check in with the Steering Committee at the meeting on Friday to see if anyone else in that group wants to look at it.

Regards,

Claire Wimpenny

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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: Gannon, Claire
Sent: Mon, 19 Feb 2024 01:00:06 +0000
To: Wimpenny, Claire
Subject: RE: EGK Plan Independent review - DRAFT FOR COMMENT

OFFICIAL

Hi Claire,

I am happy to address the concerns in the Conservator's response to the final report.

We don't require any extra clarification or detail. Our concerns are around the feasibility and cost of translocation and including this as a recommendation.

Let me know if you would like to discuss.

Kind regards,

Claire Gannon
A/g Conservator Liaison I Office of the Conservator of Flora and Fauna
Phone: +61 2 6207 8357 **I** Email: claire.gannon@act.gov.au

From: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Sent: Friday, February 16, 2024 5:02 PM
To: Gannon, Claire <Claire.Gannon@act.gov.au>
Subject: RE: EGK Plan Independent review - DRAFT FOR COMMENT

OFFICIAL

Hi Claire,
Thanks for your feedback, a couple of others have raised similar points about that recommendation. Are you comfortable with the current wording of the recommendation in the report and happy for us to address your concerns in the Conservator's response to the final report? Or would you like to request that the reviewer clarifies anything or provides extra detail around this recommendation?

Regards,

Claire Wimpenny

Senior Ecologist
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480 Northbourne Avenue, Dickson ACT 2602| GPO Box 158 Canberra ACT 2601 | www.environment.act.gov.au

From: Gannon, Claire <Claire.Gannon@act.gov.au>
Sent: Wednesday, February 14, 2024 9:26 AM
To: Wimpenny, Claire <Claire.Wimpenny@act.gov.au>
Subject: RE: EGK Plan Independent review - DRAFT FOR COMMENT

OFFICIAL

Hi Claire,

Thank you for the opportunity to provide comment on the draft review. Both Greg and myself have had a look and note the following:

The EGK Plan Review contains 39 recommendations on how EGK management can be improved. The Summary of the report makes three main recommendations for improving the management of environmental impacts. One of these is:

- The Review recommends developing a strategic translocation program for grazing sensitive plant and animal species (including threatened species, and culturally significant species) into reserves with suitable habitat, where threats are adequately managed. Such a program would accelerate ecosystem restoration and demonstrate the value of managing the threats to these fragments, including grazing management. It could offer enhanced conservation outcomes for plants and animals already being translocated out of the expanding urban footprint; opportunities to gain knowledge about species ecology and what limits their recovery; and opportunities to leverage and extend the participation of community environmental groups, and Traditional Custodians, in reserve restoration. This program should be embedded in a strategic, ACT-wide program to protect, reconnect, and restore ecological integrity across grassy ecosystems on multiple tenures (see cross-plan recommendations).

The Review Summary Table provides further detailed recommendations relating to this main recommendation:

3.5 – Recommends the translocation of grazing sensitive species from areas of high grazing pressure

3.7 - Recommends reporting on the status of grazing sensitive species in reserve where kangaroos are managed.

3.12 – Recommends analysing which grazing sensitive species could be included in a translocation program and the development of a strategic multi-species, multi-site translocation plan

There is no evidence that broadscale translocation of grazing sensitive species is a viable or cost-effective means of conserving those species. I don't believe the Conservator should support the main recommendation or detailed recommendations 3.5 and part of 3.12. Reporting on the status of grazing sensitive species and analysing conservation objectives and actions for at risk species (3.7 and part of 3.12) can be supported. These recommendations would provide improved knowledge on the effectiveness of kangaroo management.

Recommendation 4.2 suggests considering the options for enhancing government-landholder collaboration over kangaroo management planning on rural leases. This recommendation provides a better solution than 3.5 and 3.12, for managing grazing sensitive species outside of reserves where kangaroo management already occurs.

I'm happy to set up a Teams meeting if you would like to discuss any of the above.

Kind regards,

Claire Gannon
A/g Conservator Liaison I Office of the Conservator of Flora and Fauna
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From: Wimpenny, Claire
Sent: Wed, 21 Feb 2024 22:57:23 +0000
To: [redacted]
Subject: FINAL DRAFT Kangaroo Review_20240205 EPSDD comments (A45504829)
Attachments: FINAL DRAFT Kangaroo Review_20240205 EPSDD comments.docx

OFFICIAL

Hi Sarah,
Hope your week is going well.

Attached are comments from various people on your draft report. I have had lots of positive feedback on it.

The draft report was shared with everyone on the Macropod Management Steering Committee but I didn't get comments back from everyone.
Rosie accidentally commented on the earlier draft version, so I have copied her comments across to this version (most were still relevant) and for reference, Hannah Evans is from the Comms Team.

As I was doing my final read through, I thought it would be worth getting Nick Daines from PCS and Brett Howland to have a look at the sections about how other herbage mass removal tools are implemented and reported and also the translocation section. I will pass on any additional comments they have as soon as I can.

Did you manage to chat to Pawel?

Cheers

Claire

Independent Review of the ACT's Eastern Grey Kangaroo: Controlled Native Species Management Plan

DRAFT 6 Feb 2024

Photos on cover:

Top: Eastern grey kangaroos on a closely grazed grassy area (Credit: Steve Bittinger)
Lower: Female eastern grey kangaroo and joey in a grassy area with thicker, and more variable grass layer structure (Credit: Spelio on Flickr)

Cite as:

Legge, S (2024) Independent statutory review of the ACT's eastern grey kangaroo controlled native species management plan 2017. Report to the Act Government.

Acknowledgements

Many people generously gave their time, and shared their knowledge and experience, to help inform this Review. I'd like to thank the staff of the Environment, Planning and Sustainable Development Directorate, who were endlessly patient and helpful, directing me to material, answering questions, and putting me in contact with stakeholders. They do an amazing job.

I acknowledge the Ngunnawal People and their long and ongoing custodianship of Country, and other Indigenous families in the ACT, and I pay respect to their past and current elders. Thank you for sharing what you had to say about kangaroos.

I received excellent expert input from advisory committees (ACT Natural Resource Management Advisory Committee, ACT Animal Welfare Advisory Committee, ACT Scientific ~~Threatened Species~~ Committee); conservation groups (ACT Conservation Council, Woodlands and Wetlands Trust, Ginninderry Conservation Trust, Friends of Grasslands, Parkcare groups); animal rights, wildlife care, and animal welfare groups (RSPCA, ACT Wildlife, Animal Protectors Alliance, Animal Liberation ACT, Save Canberra's Kangaroos, Animal Defenders Office); and from the Rural Landholders Association.

Finally, many individuals kindly gave their time and expertise, including many landholders, professional shooters, veterinarians, and ecologists, as well as the people representing organisations (listed above). The people who interacted with this review process have a diverse spectrum of values, but a common thread is that they care, and have thought deeply, about kangaroo management, animal welfare, and the ethics of conservation, and I'd like to thank them for sharing that thinking with me, it has been a privilege.

Summary

Background

Eastern grey kangaroos (*Macropus giganteus*) are an iconic resident species of the ACT. Their numbers have recovered since the 1960s, before which farming practices held them at very low densities. The ACT landscapes have changed substantially since colonisation: lowland grassy ecosystems have been cleared and modified for urban development and agricultural use, and what remains is highly fragmented. The remaining fragments, often sitting adjacent to rural land with pasture and additional water sources, can provide ideal habitat for kangaroos, especially in the absence of dingoes. Grassy ecosystems also include critically endangered ecological communities and many threatened species, but the ecological integrity of the remnants is fragile.

Grassy ecosystems face pressures from exotic plant and animal species, extra nutrients, and changed disturbance processes (from fire, digging, and grazing). Kangaroo grazing is a vital disturbance in healthy grassy ecosystems, but too much, or too little grazing, changes the grass structure and leads to declines in other grass-dependent species. In the lowland grassy ecosystem fragments around Canberra, kangaroo populations can increase beyond the capacity of the grass layer to regrow, especially during drought, and they have limited options for moving away. This leads to overgrazing, increased risk of local population extinctions in grass-dependent species, and high rates of starvation among the kangaroos. It also leads to higher rates of collisions with vehicles, as kangaroos move more widely and come to road verges seeking greener grass.

The 2017 ACT Eastern Grey Kangaroo Controlled Native Species Management Plan (the 2017 Plan) states that the ACT Government manages kangaroos as one part of a broader strategy to maintain healthy grassy ecosystems for all their constituent species. Kangaroo management, as outlined in the 2017 Plan, also seeks to reduce economic impacts of kangaroo grazing on livestock production and farming sustainability, and to minimise the economic and social impacts from vehicle collisions, and from kangaroo control itself. Direct kangaroo population control is carried out mainly by culling, but some small populations are managed with fertility control treatments. On conservation land, culling to protect the ecological health of lowland grassy ecosystems occurs within some of the Canberra Nature Park reserves (in up 18 of the 39 reserves, covering ~8300 ha), the Molonglo River Reserve (~1300 ha), and on some Commonwealth land (~4500 ha). Kangaroo populations in other ACT protected areas such as Namadgi National Park and Tidbinbilla Nature Reserve ~~exist~~ (~120,000 ha) exist without culling interventions. Other actions to influence kangaroo grazing at small scales, such as planned burns and exclusion techniques (fencing, logs), are increasing in frequency. Kangaroo culling is also carried out by landholders on rural lands (~39,500 ha), to reduce impacts on the economic viability of livestock production.

Commented [EH1]: Have we never culled in these areas? I thought we had at Tid...

Commented [WC2R1]: Tidbinbilla has been culled but not since 1997

Commented [WC3]: Rosie - worth highlighting not ACT Gov doing this?

The objective of this Review is to "*Review the effectiveness of the current management plan and associated legislative instruments for reducing the adverse environmental, economic and social impacts of Eastern Grey Kangaroos (EGK) in the ACT.*"

Review Findings

The 2017 Plan is a very comprehensive and complex document, with many associated documents, some of which are also large and complex. The Review is therefore extensive; it makes 39 recommendations for adjusting aspects of planning or practice, that could be captured in a new Plan. The Review Summary Table contains rows for the main subheadings in the Review. Under each subheading, there is a summary of the Review's assessment of that topic, and any recommendations against that topic. The recommendations range from more substantial to less so; the more substantial recommendations are summarised here.

The 2017 Plan is structured around the management of environmental, economic and social impacts of kangaroos; the Review follows this structure, but also makes some higher-level, cross-plan recommendations:

Environmental Impacts

Summary assessment

The kangaroo management program in the lowland grassy ecosystems of Canberra Nature Park is an outstanding example of adaptive management. The program is informed by a large body of research, some of it instigated or encouraged by the ACT Government, covering kangaroo ecology in temperate grassy ecosystems, grassy ecosystem ecology, the ecology and conservation of grassy ecosystem species, grazing impacts (on plants and animals), and fertility control for kangaroos. The program monitors kangaroo density and grass layer condition, and uses these data in conjunction with the Conservation Cull Calculator to derive annual cull targets. These elements are well conceptualised and linked, and are being constantly refined. Monitoring data show that the grass layer structure is being maintained within thresholds, as kangaroo densities are managed closer to their targets. ACT Government staff have collaborated widely with the research community to achieve these outcomes. The data gathered during the program have been peer-reviewed by the scientific community and shared with the Canberra public.

The operation and management of the conservation culling program is effective and has put kangaroo welfare at the heart of activities: the ACT conservation culling program far-exceeds the requirements of the national Code for non-commercial kangaroo shooting, and the contracted shooters and ACT Government staff involved in culling strive to improve standards continually.

Main recommendations

Currently, there is limited monitoring of grazing sensitive species because grass layer structure is being used as the surrogate for these species, backed by past, focal research. Ideally, the consequence of improvements to the grass layer on grazing sensitive species would be checked, at least periodically. There may be opportunities to mine data collected in other programs, or adapt the data collection in other existing programs, to demonstrate changes in grazing sensitive species associated with kangaroo grazing management. However, if grazing sensitive species have been lost from reserves, many are unlikely to recolonise unassisted.

The Review recommends developing a strategic translocation program for grazing sensitive plant and animal species (including threatened species, and culturally significant species) into reserves with suitable habitat, where threats are adequately managed. Such a program would accelerate ecosystem restoration and demonstrate the value of managing the threats to these fragments, including grazing management. It could offer enhanced conservation outcomes for plants and animals already being translocated out of the expanding urban footprint; opportunities to gain knowledge about species ecology and what limits their recovery; and opportunities to leverage and extend the participation of community environmental groups, and Traditional Custodians, in reserve restoration. This program should be embedded in a strategic, ACT-wide program to protect, reconnect, and restore ecological integrity across grassy ecosystems on multiple tenures (see cross-plan recommendations).

Commented [WC4]: The Conservators Team commented that there is no evidence that broadscale translocation of grazing sensitive species is a viable or cost-effective means of conserving those species. I asked if they wanted any clarification or extra detail added to the text, but they didn't, so this is one we can work through internally when we prepare a response to your final report. But do note Rosie's comments below about noting that substantial additional resourcing would be required for this (and other) recommendations.

Commented [WC5R4]: (and Rosie, Miles and I think this rec is a good idea)

The Review makes some recommendations to further enhance the regulation and organisation of culling operations so that the community can continue to have confidence that welfare outcomes for kangaroos are being optimised. This includes working with jurisdictional counterparts to update the non-commercial Code for shooting kangaroos, and consolidating details of current practice into a Standard Operating Procedures style of document, with input from key advisory groups.

Economic Impacts

Summary assessment

It is challenging to assess whether kangaroo culling on rural lands is achieving the objective of maintaining the economic viability of properties. There are no data available on spatial and temporal changes in kangaroo density on rural land. The Review was not provided with any data on changes in livestock density, or pasture condition (if these data exist). However, records are kept of the numbers of kangaroos licenced to be shot per property, and the numbers that are reported as shot, and these numbers roughly track weather conditions (e.g., increasing after wet years shift to dry years). This suggests the rural cull is realistically responding to changes in kangaroo grazing pressure. Property-level decisions about how many kangaroos are reasonable to cull are based on the Rural Cull Calculator, which is logical, and designed to cover the needs of most properties.

The regulation and management of rural culls requires landholders to conduct operations to a standard that exceeds the national Code for non-commercial shooting of kangaroos.

Main recommendations

Kangaroo density on rural lands is highly variable, with some properties having no kangaroos, and others, especially some that border reserved areas, with very high densities. An ACT-wide spatial assessment could identify variation in kangaroo density across rural lands, and focal areas for collaborative kangaroo management. Focal areas would include 1) locations with grazing sensitive threatened species. In such cases, the ACT Government could ensure landholders are technically supported so that total grazing pressure, including kangaroo grazing, is managed appropriately at these locations. 2) Rural leases next to reserved land that routinely have very high kangaroo densities; this is likely to degrade the ecological health of the reserved land and the economic yields and sustainability of the rural lease. The Land Management Agreements are one possible mechanism for formalising the collaboration over kangaroo management at focal areas, but there may be more suitable alternatives. Management could involve culling, strategic fencing, guardian dogs, etc, and there are likely to be opportunities for landholders to seek funding through grant systems (e.g., Regional Landcare Partnerships Program), or stewardship payments (e.g., Nature Repair Market). These suggestions are consistent with multiple actions in the 'Rural Landscapes' chapter of the ACT's Natural Resource Plan (ACT Government 2022).

The results of the spatial assessment could also be used to design and implement a monitoring program for changes in kangaroo density across rural lands in the ACT, ensuring that locations with grazing sensitive threatened species, and interfaces of rural and reserved land, are both included. The monitoring could be carried out periodically, for example every 4-5 years, possibly varying the frequency to coincide with major weather changes from wet to dry conditions and vice versa. The purpose of the program would be to generate information on kangaroo densities that can be used to inform livestock and kangaroo grazing management by rural landholders, and inform more specific objectives in the collaborative landholder-government planning. Ideally monitoring on rural lands would be embedded in an ACT-wide program (see cross-plan recommendations).

Commented [WC6]: Rosie - While these are very sensible recs, worth noting they would require additional substantial dedicated resourcing. Given the pressures on many ACT threatened spp populations, we'd need to work out whether this would be the intervention that's going to deliver the biggest payoff for threatened spp.

Commented [WC7]: Rosie added a comment here: "might just want to reword this sentence to make clear the "very high densities" applies to the rural lands, not reserves", but I think you are referring to the reserved land aren't you?

Social Impacts

Summary assessment

The 2017 Plan focuses on kangaroo-vehicle collisions as the main social impact of high density kangaroo populations living in the urban and peri-urban bushland fragments. The Plan has an objective to reduce the incidence of such collisions. This objective has not been met: the absolute number, and the per capita rate of collisions, may be increasing. The urban expansion may be causing more people to use roads that intersect areas where kangaroos are living, and mitigation measures are not effective enough. Collision rates increase during dry conditions, when kangaroos range more widely in search of food.

Commented [EH8]: Have TCCS been given an opportunity to review this content?

Commented [WC9R8]: Sarah was planning to chat to Pawel from ACT Roads about this

Main recommendations

The available data clearly show where the collision hotspots are. The ACT Government could consider mitigation strategies that could be put in place immediately (e.g., reducing speed limits in hotspots, especially when kangaroos are most likely to be active on the road verge), whilst trialling longer-term solutions to reduce collision risk whilst enhancing habitat connectivity with vegetated overpasses and underpasses. Research to improve data collection on collisions, and to evaluate the most cost-effective options in an adaptive management framework, would be useful.

Cross-plan recommendations

Indigenous engagement

The 2010 and 2017 Plans do not consider Indigenous perspectives on the ecological and cultural significance of kangaroos, nor how Indigenous people wish to be involved in kangaroos management. With the Plan revision, there is an opportunity to engage with Ngunnawal Traditional Custodians and other Indigenous families, so that kangaroo management moves towards a model of co-design and co-implementation, and the place of kangaroos in Indigenous and Australian culture can be respectfully recognised.

The next Plan should be configured so that its performance can be more easily assessed

The revised Plan should set SMART objectives, with performance criteria, for each of three impacts areas: environmental, economic, and overall welfare (see below). There should be a reporting schedule, based on the annual conservation advices that are already being produced.

Introduce 'Overall Welfare' as an impact area

Attention to kangaroo welfare is prominent in the 2017 Plan, and references to welfare crops up frequently, in different contexts, throughout the document. Welfare outcomes for other animals, and for people, are raised more idiosyncratically, and sometimes considered through a different lens.

An alternative approach, that recognises recent amendments to the ACT Welfare Act, the development of the ACT Wellbeing Framework, and the One Welfare concept, would be to replace 'Social Impacts' with 'Overall Welfare Impacts', aiming to impose the least harm, to the least number of animals (including people). Adopting this change would signal clearly that Overall Welfare is a central issue in kangaroo management, and it would be more consistent with an Indigenous, holistic approach to Country. It would extend welfare considerations to encompass the welfare of all animals, and people, and allow contrasting perspectives about whose welfare to privilege, to be considered with the same framework, including:

- The welfare of kangaroos during culling.
- The suffering of individual kangaroos in high density populations that experience starvation and higher disease burdens when the food resources diminish from overgrazing or drought.
- The suffering of individuals from other species, when heavy kangaroo grazing in grassy ecosystems causes the loss of their resources and increases exposure to risk (e.g., from weather or from predators).
- The adverse human and kangaroo welfare outcomes from kangaroo-vehicle collisions that are more frequent when kangaroo densities are high.
- The emotional suffering of people who are traumatised by kangaroo management, or by the lack of it (if this leads to ecological degradation, or threatens economic viability of farms).

Commented [WC10]: Rosie - and fertility control?

Embed ACT kangaroo management into strategic, cross-tenure environmental management

The 2017 Plan covers kangaroo management across many land tenures and uses, but especially the lowland grassy ecosystems of Canberra Nature Park and some Commonwealth land. This focus can encourage a misleading impression that kangaroos are being managed in these reserves instead of managing other threats such as rabbits and weeds. The focus also makes it hard to understand how kangaroo management in the Canberra Nature Park Reserves sits within the broader context of the status and management of kangaroos ACT-wide, including on the non-reserved land peppered through the urban areas, the rural lands, the large protected areas of Namadgi-Tidbinbilla-Cotter, and in areas earmarked for urban expansion.

To some extent, these relationships (between kangaroo management and other management actions in Canberra Nature Park reserves; between kangaroo management within and outside of Canberra Nature Park), could be clarified by better describing the links to other planning processes and documents. However, it would also be helpful to set the kangaroo management in a broader context by more explicitly considering:

- How kangaroos are distributed (and connected, or fragmented) across the ACT: on reserved and non-reserved land in and around Canberra, on rural land, in existing urban areas and land earmarked for future urban expansion.
- Where and how human causes of direct mortality (culling, road kills, habitat loss from urban expansion) affect the population of ACT kangaroos.
- Based on intersecting the information above with other data (for example, on the locations of grazing sensitive threatened species, and culturally significant species; and where such species could be reintroduced/translocated), identify where kangaroo management is a priority for rural, conservation or cultural outcomes, where enhancing habitat connectivity to allow kangaroo movement is a priority; and conversely where preventing kangaroo movement may be a priority.

The Review estimates that there are – very approximately - 142,000 eastern grey kangaroos in the ACT, of which most are in Namadgi-Tidbinbilla-Cotter (46%) and on rural lands and government horse paddocks (22%). Canberra

Nature Park contains about 12% of the population, 15% are on other non-reserved lands managed for conservation, 4% is on Commonwealth land, and 1% in plantations. Culling on rural lands affects an average of 9100 per year (~6% of the ACT kangaroo population), road kills affect around 4200 per year (~3%), and conservation culls in Canberra Nature Park affect an average of 2000 per year (less than 2%). The Review did not estimate the number of kangaroos displaced (and thus probably killed) by urban expansion. However, the estimates for kangaroo population sizes across the ACT are very uncertain because of the paucity of data on kangaroo densities from rural lands and Namadgi-Tidbinbilla-Cotter (containing the bulk of the kangaroo population).

Therefore, the Review recommends an ACT-wide assessment of spatial variation in kangaroo density, including on rural lands and in Namadgi-Tidbinbilla-Cotter. The information can be used to inform strategic management (such as native species translocations, locations for collaborative management between government and landholders), and to design on ongoing periodic monitoring program. It will help contextualise the intensive management (of a small proportion of the overall kangaroo population) in Canberra Nature Park, and provide periodic, overall status assessments of one of the ACT's iconic species. Now that the monitoring and operations of the kangaroo management in lowland grassy ecosystems are well-established, embedding the program into a more expansive, strategic vision is the next step.

Is kangaroo culling for conservation justified?

The Review assessed the ACT eastern grey kangaroo management program against a set of seven international consensus principles for ethical wildlife control for conservation outcomes, finding the program mostly adheres to the principles. Using the framework is a reminder that threats to the ecological integrity of grassy ecosystems (fragmentation, fire regimes, invasive species) should be managed to the extent possible before kangaroo culling is considered; that kangaroo management must be justified (on environmental, economic, and welfare grounds); that management must have clear and achievable outcome-focussed objectives; that overall welfare is considered; that the diversity of human values is considered; that management is well-planned; and that kangaroos are not labelled in a way that scape-goats them for a situation not of their making.

Review Summary Table

The ACT EGK CNSM Plan is a very comprehensive and complex document, with many associated documents, some of which are also large and complex. The Review makes 39 recommendations for adjusting aspects of planning or practice in a new Plan. The Review Summary Table below contains rows for the main subheadings in the Review. Against each subheading, there is a summary of the Review's assessment of that topic, and where relevant, the recommendations against that topic. Recommendations are labelled by Section Number.Sequence. The more substantive recommendations (referred to in the Executive Summary) are shown in yellow-shaded boxes.

Review section	Summary text from that section of the Review	Rec #	Recommendation
1	**Introduction** *This section provides a brief background to the ecological, legislative and policy context to the issue.*	1.1	The commentary and recommendations in this Review aim to contribute to a goal of continuous improvement. Overall though, the planning, implementation, monitoring and reporting for kangaroo management in the ACT is extremely impressive, and an outstanding exemplar for adaptive management.
2	**The 2017 Plan - Overview**		
2.1	*The* **Plan's purpose and goals** *are set out clearly in both the 2010 and 2017 Plans (Section 2.2 of the latter). They strike a balance between affirming that kangaroos are ecologically and socially valued, and that kangaroo populations may need to be managed in some circumstances, to maintain the ecological health of grassy ecosystems and the persistence of grass-dependent species, and to reduce economic and social impacts. The Plan's Principles are useful to setting the tone of the document and program.*	2.1	Add another principle, about a commitment to open, transparent reporting and communication with the public.
2.2	*The* **Plan's objective** *is to detail how kangaroos will be managed on land of varying tenure and use. Given the complexity of developing a plan for a range of tenure and land uses, that also addresses related issues of welfare and social impacts, this non-specific objective makes sense. However, it means the more specific objectives for kangaroo management in relation to conservation, economic or social impacts are scattered throughout the Plan, and mixed with objectives relating to various policies. The hierarchy of objectives, and their inter-relationships, can be hard to follow; the objectives lack performance criteria and are not SMART (Specific Measurable Achievable Relevant and Timebound). These two features makes it challenging to evaluate the performance of the Plan against stated objectives.*	2.2	Consider including a clearer set of SMART objectives, and relevant performance criteria, for the Plan. These objectives could potentially be set for each of the 'impact areas' (i.e., environment, economic, and overall welfare (instead of social, see Section 5.7 below).
2.3	*There has been substantial reporting since 2017, however the 2017 Plan does not establish a* **reporting schedule** *for the kangaroo management.*	2.3	Outline the reporting requirements, which should include an evaluation of the progress made against the SMART objectives, and a summary of the activities carried out under the Plan. These reports could be brief and produced annually or biannually, building on the existing annual conservation advices, with more extensive evaluations carried out every 5 years.

Commented [EH11]: Although this table would be useful internally - for a public facing document I would recommend simplifying by removing the summary text (could keep the reference to where relevant text is though)

Commented [WC12R11]: I think leave the summary text in for now, we can simplify the table for public release if required

Commented [EH13]: The table is a bit inconsistent with repeated recommendations. If the above recommendation is taken on then I don't imagine there will be a need for repeats. If not, would recommend either repeating each time OR using the "see x.y"

Commented [WC14]: Rosie - And respect for Ngunnawal values, in line with the relevant Rec?

Review section	Summary text from that section of the Review	Rec #	Recommendation
			Alternatively, kangaroo management reports could align with existing reporting in the Conservation Effectiveness Monitoring Program.
2.4	*The 2017 Plan focusses on one issue (kangaroo management) across many land tenures, but especially in lowland grassy ecosystems of Canberra Nature Park reserves, as well as unleased and some national land. This can encourage an impression that controlling kangaroos is the main management tool in these areas, rather than managing other threats such as rabbits and weeds. Similarly, how the kangaroo management in the Canberra Nature Park Reserves sits within the broader context of the status and management of kangaroos ACT-wide, including on rural land, in the large protected areas such as Namadgi, and areas given over to urban expansion, could be better explained.*	2.4	Make it clearer that kangaroo management for conservation should be understood as one part of a broader conservation management program on reserved land; this could be helped by cross-referencing to the Canberra Nature Park Reserve Management Plan. Explain how the kangaroo management in the urban and peri-urban areas of Canberra fits into the larger context of kangaroo management in the ACT, including on rural lands, large reserved areas (e.g., Namadgi, Tidbinbilla), and in areas slated for urban expansion.
2.5	*The 2010 and 2017 Plans are comprehensive documents that have been followed by a substantial and impressive body of research, monitoring, and management adaptation, particularly for managing kangaroo grazing for conservation in lowland grassy ecosystems. The evolution of the planning, implementation and monitoring that has occurred since 2017, although mostly documented and available on the government website, has possibly become confusing to some stakeholders. A revised management plan for eastern grey kangaroos provides an opportunity to integrate and consolidate the information that is now spread across planning documents and many technical reports (published and unpublished), to help with accessibility.*	2.5	The documentation of the planning, implementation, and monitoring for kangaroo management is unusually rich and also dispersed after some years of activity; the next version of the plan should consolidate and integrate this information, and consider alternative ways of presenting the plan to support accessibility. For example, a shorter Plan with an accompanying, more comprehensive, Background Document may be helpful.
	The 2010 and 2017 Plans do not include Indigenous perspectives about kangaroo management. This should be (and is being) addressed in the revised Plan.	2.6	The revised Plan should outline the pathways by which the perspectives of Traditional Custodians and other Indigenous People can be integrated into the framing, design, implementation, monitoring and reporting/evaluation of kangaroo management.

Review section	Summary text from that section of the Review	Rec #	Recommendation
3	**Environmental Impacts**		
3.1	**Plan** *Kangaroo management planning focusses on the lowland grassy ecosystems which are distributed as remnant fragments around Canberra. These areas include critically endangered ecological communities and many threatened species. Here, heavy grazing by kangaroos could affect ecological integrity and cause local extinctions that would accelerate degradation. The ultimate cause of the situation is not kangaroo grazing; it is habitat loss, fragmentation, and degradation in all its forms. However, if these issues cannot be adequately reversed, then managing kangaroo populations may be one of the few viable options for maintaining ecosystem health and retaining grazing-sensitive species. The 2017 Plan has the following objective for lowland grassy ecosystems on public and unleased land, managed by either the Territory or the Commonwealth:* • *Kangaroo populations are maintained in lowland native grassy ecosystems at densities that conserve the natural integrity of the grassland ecological community and result in the maintenance of habitat for all grassland plant and animal species.* *The objective is not SMART, and there are no performance criteria or outcomes articulated for this objective, but the Plan is particularly focussed on maintaining the integrity of two nationally threatened ecological communities, and almost 20 threatened plant and animal species that occur in lowland grassy ecosystems.*		*See recommendation 2.2 regarding SMART objectives.* *See recommendation 7.2 regarding monitoring kangaroos in reserves other than Canberra Nature Park.*
3.1.1	***Evidence base case for management**: The 2017 and the 2010 Plans, and subsidiary documents, comprehensively review the evidence that eastern grey kangaroos can reach densities high enough to cause adverse effects on the integrity of grassy ecosystems.* • *The Plans present credible empirical and inferential evidence that kangaroo densities in the ACT are high relative to other temperate areas. Whether these densities are higher than pre-European densities is less certain. Regardless, the more salient issue is whether unmanaged populations of kangaroos could negatively affect the health of grassy ecosystems.* • *There is substantial evidence from many years of research, including targeted research on lowland grassy ecosystems in the ACT, to show that*		

Commented [WC15]: Rosie - Surely also loss of dingo predation and of hunting by Tos, and increased water availability?

Review section	Summary text from that section of the Review	Rec #	Recommendation
	when kangaroo grazing outstrips vegetative productivity (which is most likely in dry years), the grassy layer is grazed to very low levels, increasing the risk that remnant patches will experience soil degradation, erosion, and increasing the risk that populations of some species (including threatened species) could be extirpated. Given these risks of an ongoing ratchet of decline, the commitment in the 2017 Plan to manage kangaroo population size and thus avoid further deterioration is supported by the evidence available. It is of course critical that kangaroo grazing and its management is considered in the context of other processes that remove grass – principally fire and grazing by rabbits – and that management across these processes is integrated.		
3.1.2	***Conceptual model**: Kangaroo management has been underpinned by a conceptual model since the 2010 Plan. Research since then has added to this model. Some of this research was captured in the 2017 Plan but there have been significant updates since then, which will need to be captured and consolidated in the revised Plan.*		
3.1.3	***Evidence-based thresholds/targets**: A careful reading of the 2017 Plan makes it clear that the ultimate focus is the ecological health of grassy ecosystems, that this is tightly coupled to the grass layer, and that kangaroo management is one means of influencing the grass layer. Yet the subtleties of this message seem to be easily lost. For example, the original yardstick of aiming for about 1 kangaroo per hectare in grassy ecosystems of conservation land was always intended to be starting point for identifying the target density in a reserve, but it has led to misunderstanding in some stakeholders, because they think the density is applied to all areas, in all conditions.* *Since 2019, management has been adapted, and now the explicit aim is **to maintain the grassy layer within a "safe operating environment" of herbage mass, with lower and upper thresholds**. Thus, excessive herbage biomass (from not enough grazing) is considered within the same planning and decision framework as low herbage (from overgrazing). Excessive herbage means culls can be skipped, or ecological burns, slashing, or managed grazing by livestock animals can be used to remove rank grass instead. These actions can increase palatability for kangaroos, helping to make kangaroo management more effective for maintaining grassland health. To support the use of these thresholds, grassland types with different growth patterns have been mapped*	3.1	The revised Plan (and edits to the Conservation Culling Calculator) should consider how to be very clear that grass layer structure and health is the critical attribute that affects many other species, that kangaroo density and culling targets are based on grass layer monitoring data, and thus the target kangaroo densities can vary between reserves and years depending on the condition of the reserve ~~and the weather expected over the coming year~~.
		3.2	The existing Plans tend to focus on the consequences of heavy kangaroo grazing, particularly during dry conditions. This focus is sensible if the main concern is recognising and preventing over-grazing. However, now that kangaroo populations have been reduced at many sites, the revised Plan could also explicitly consider the risks of light kangaroo grazing, leading to a thicker grassy layer, especially if this is sustained over years. This risk may vary between sites. If risks are material, and kangaroos either can't remove the herbage (because their density is low) or wont (because it is unpalatable) then this could trigger other management options (e.g., fire, managed livestock, mowing), but they should be implemented carefully and outcomes monitored. [see also recommendation 3.6]

Review section	Summary text from that section of the Review	Rec #	Recommendation
	across the lowland grassy ecosystems of the KMUs, and herbage biomass is monitored across these mapped grassland types. The current reliance on herbage thresholds to determine the target kangaroo density and thus the kangaroo cull is a substantial improvement to the planning approach, it has occurred as part of management adaptation, and it REPLACES the previous use of kangaroo densities, which had been used (until 2018) as a proxy for grassland structure, and tends to be highlighted in the 2017 Plan and the Conservation Culling Calculator. *There are **no targets for grazing sensitive species** in the current Plan. Instead, the focus has been on managing the grass layer to optimise habitat for these species, based on the results of focal research into grazing sensitive species. This is a potential weakness of the management program.* ***Fertility control** is an option for reducing the population growth rate of small populations with limited immigration. It is a useful addition to the menu of control options. To be effective, a high enough proportion of females need to be sterilised so that recruitment from non-treated, fertile females balances mortality. The initial target proportion, based on a population growth model constructed from empirical data from ACT kangaroos, is approximately 70%, and seems reasonable as a starting point.*	3.3	Given the importance of heterogeneity in grass structure at small to larger scales, explore the scope for including heterogeneity metrics and targets in the grassland condition monitoring and reporting, based on the existing data being collected.
3.2 **3.2.1**	**Implement and Monitor** ***Annual work cycle**: Annual workplans for reserves in the Canberra Nature Park are set out in annual 'Conservation Advices'. The workplan is iteratively and tightly based on extensive monitoring data and other contextual information.*		
3.2.2	*The delineation of **Kangaroo Management Units** – areas within which kangaroos are reasonably sedentary - almost certainly improves managers' abilities to track and manage populations of kangaroos.*		
3.2.3	*Two types of **vegetation mapping** are used to describe vegetation and thus inform kangaroo management. Satellite imagery was used to map vegetation across about a third of the ACT, including all urban and peri-urban bushland, into one of five classes, from open grassland to forest. The grass layer biomass, and thus kangaroo densities, vary inversely with canopy cover. This mapping can be used as a guide for determining coarse target kangaroo densities. Within the lowland grassy ecosystems of the KMUs, a more detailed mapping of the grass layer carried out in 2018-19 is improving estimates of herbage growth, offtake rates, and thus sustainable kangaroo densities in these mapped areas. The vegetation mapping helps decision-making and contributes to effectiveness.*		

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3.2.4	*The **kangaroo population monitoring** is undertaken using direct counts, sweep counts, and distance sampling. The population estimation is carried out immediately before the culling season, so the data used to inform cull targets are current. Evidence that the population estimations are sound include 1) these methods are well-established in the scientific literature; 2) the distance sampling transects are spatially well-designed, carried out carefully, and are long enough to produce estimates with reasonable precision; 3) in trials the different methods have been shown to produce comparable population estimates; 4) for most KMUs, the annual count and cull data interleave in a coherent manner; and 5) in a sample of KMUs, the annual population estimates and population growth predictions are well-matched.*		
3.2.5	*The **kangaroo population growth** predictions are based on using empirical data to describe the relationship between one year's population density and the next. The population growth equations were developed with one set of empirical data, then validated with another set of empirical data. The population growth predictions do not incorporate the influences of inter year variation in food availability, nor mortality (caused by adverse winter weather and road collisions), but they nevertheless perform well, predicting within the 95% confidence band of the following year's density most of the time.*		
3.2.6	***Grass layer composition and structure** are measured in the mapped management polygons to track changes over time, and to inform the calculations of the kangaroo cull targets for each KMU. Dominant grass species, grass height, the percentage that is green, and the percentage cover, are combined for use in the calculations for the target kangaroo density. Finer-grained data on grass species and ground cover metrics are being collected, but are not yet used in reporting.*	3.4	Consider the value of a rapid assessment approach to estimate key grass layer metrics, in order to monitor a wider range of sites.
3.2.7	***Other information** used to adjust the cull targets include the predicted weather, mortality from roads, whether females have been contracepted, and other contextual information.*		
3.2.8	*The **Conservation Culling Calculator** sets out the logic for calculating the number of kangaroos to be culled in an area, to reach kangaroo densities that are optimal for ecosystem health. The cull is the difference between the target number of kangaroos and the current population, making allowance for the population growth expected in the coming year, and allowing for target adjustment based on expert consideration of other factors. Initially, the size of the target population was guided by Fletcher's interactive population-pasture growth model outlined in the 2010 Plan. More recently, the **target population size** has been mostly determined using data directly from the grass layer monitoring in the management polygons. This adaptation is a significant*		

Commented [WC16]: These aren't actually used to adjust the cull target, they are included in report for context. Weather outlooks are sometimes used in the operational decision making - eg whether or not low priority sites get done might depend on if it is likely to be wet or dry over the coming year.

Review section	Summary text from that section of the Review	Rec #	Recommendation
	advance because it bases the cull targets directly on the structure of the grass layer, and allows kangaroo densities to vary. Ideally, it would be further improved by more formally incorporating the effects of the predicted weather over the coming year on grass growth.		
3.2.9	*The annual conservation advice ranks KMUs for annual culls, based on **a prioritisation framework** that considers the extent of nationally endangered ecosystems, the presence of threatened species and their sensitivity to grazing levels, the strategic conservation importance of the site (e.g. its role in landscape connectivity), and the level of prior/ongoing investment at the site. Having a transparent mechanism for prioritising culls is very useful, because it lays out the values that the kangaroo management seeks to protect, and the factors that managers must consider when deciding where and how to allocate effort.*	3.5	Include the potential suitability of the reserve to receive a (future) translocation of a grazing sensitive threatened species as part of the prioritisation framework.
3.2.10	*The **culling operation** is conducted by contracted professional shooters and trained ACT Government staff according to the 'National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-commercial Purposes'.*		See recommendation 6.1
3.2.11	***Complementary management actions**: The 2017 Plan outlines actions to manipulate grazing in small areas, other than culling. Grazing can be excluded by temporary fencing, big logs, and even carcasses. Grass biomass can be quickly reduced by fire, slashing, or managed livestock. These are valuable options for fine tuning the biomass of the grass layer, but our knowledge of their impacts are variable*	3.6	Continue using/trialling these complementary actions, ensuring that risks are appropriately considered on each occasion, and that the actions are carried out so that knowledge is gained to optimise their ongoing use. Include more information about why, when, and how these actions are used in reserves, on the public-facing website. Explore the potential for Ngunnawal to play a leading role in more responsive fire management that complements the kangaroo control. [see also recommendation 3.2]
3.3	**Evaluate and Adapt** *The 2017 Plan does not set out a reporting nor evaluation schedule. However, reporting and evaluation have occurred to a very high standard throughout the life of the Plan, and much of the information collected has been subject to peer-review via the publishing process of scientific journals. The 2017 Plan was informed by a very large amount of research and monitoring data. The implementation of the Plan has been accompanied by a thorough program of prioritised research and monitoring. The data generated during the life of the Plan have been soundly analysed, interpreted, and used to adapt management in a timely way. Evaluation of KMU boundaries, vegetation mapping, population estimates, predicted population growth, grass layer structure, road collision data, and weather forecasts have closely informed each year's*		

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	conservation advice. These key information inputs to the annual conservation advice are backed by substantial field research and validation. An expert workshop held in 2018 helped to hone the priority research and monitoring directions.		
3.3.3	***Evaluating effectiveness:*** *Outcome evaluation has shown that the culls are effective at maintaining kangaroo densities close to their targets, and maintaining the grass layer within a safe operating zone. This is important evidence for the performance of the program. However, the outcomes of the program for grazing sensitive species are not being monitored.*	3.7	Reporting on the status of grazing sensitive species in reserves with kangaroo management would further validate the program and be a useful communication tool. Explore whether existing datasets, perhaps collected for other reasons, can be mined to produce such reports; whether partnerships with groups such as Canberra Ornithologists could lead to carefully designed surveys and analysis; and whether a program of translocations could be used to demonstrate management success (see Section 3.5 Value-adding).
3.3.4	*The reports (published and unpublished), Conservation Advices and published papers produced since 2017 contain many examples of management adaptations as a result of new information, illustrating a genuine commitment to adaptive management that seeks to continually improve outcomes.*		
3.4	**Communicate** *The public engagement and reporting of the management program is remarkable: the volume of information available on the government website (including annual workplans and monitoring results), and the communication materials (e.g., factsheets, short videos), demonstrate a strong commitment to transparency.*	3.8	Ensure communication always conveys that the central issue is managing grass layer health, of which one component is kangaroo management. (That is, the management issue should never be framed as managing high densities of kangaroos in isolation).
		3.9	Review the content and presentation of information on the government website, to communicate the sophistication of the monitoring and target-setting in the kangaroo management, and clarify what the program is setting out to achieve. The website should make it easy for the public to gain a snapshot of the key attributes of the conservation culling program. This may mean keeping the front end brief and accessible, with links to more detailed information. Include plain English summaries explaining the science behind some of the key monitoring steps (e.g., population density estimation, how cull targets are calculated, etc).
		3.10	Despite the very high rate and standard of reporting, there is some lag in completing some of the in-house analyses to publication/communication standard. Some of the important material provided to the Review had been in draft form for some time. Quarantining time for staff to complete the priority reports would be helpful.

Commented [WC17]: Rosie - All these things are great - but would again require substantial additional resources to implement

Commented [WC18]: Rosie - and maintaining habitat for threatened species?

Commented [EH19]: If possible, it might be worth fleshing out this "lag" - e.g., does ACT Gov need more FTE/resources?

Commented [WC20]: Rosie - Back to the resourcing issue.....! (i.e. completing what is already necessary under the program is already a stretch for available resourcing)

Review section	Summary text from that section of the Review	Rec #	Recommendation
		3.11	Consider the potential of communicating about grassy ecosystem management (including kangaroo management) using a range of messengers other than government staff, such as through community groups (who are involved in reserve activities), and local vets and carers (who are involved in kangaroo welfare activities).
3.5	**Value-adding – Translocations** *The conservation benefits of reserve management, including kangaroo grazing management, could be more clearly demonstrated, and accelerated, by designing and implementing a program to translocate grazing sensitive species into reserves with suitable habitat, and where all threats are adequately managed.*	3.12	Carry out an analysis to identify which grazing sensitive species, including threatened species and species of cultural significance to the Ngunnawal Traditional Custodians, could be included in a translocation program to restore grazing sensitive species to nature reserves with appropriate habitat, and where threats (including excessive or insufficient kangaroo grazing) are adequately managed. Develop a strategic multi-species and multi-site translocation plan, ideally considering non-reserved as well as reserved land. To the extent possible, use plants and animals that are being moved out of the footprint of the urban expansion; implement the program to gain knowledge about species ecology and limits to recovery; to involve community environment groups in the program; and to administer it efficiently.
4	**Economic Impacts**		
4.1	**Plan** *Kangaroos are a drawcard for nature-based tourism. The main negative economic impact of high densities of kangaroos is on rural land, because kangaroos compete for grazing with stock (including horses), and damage fences. Collisions with kangaroos on roads also result in economic costs through vehicle damage and injury to people, but this issue is reviewed in the Social Impacts section.* *In relation to land managed for agricultural outcomes, the objectives in the 2017 Plan are:* • *Rural land: Objective - Free-ranging kangaroo populations on rural lands are managed so that their densities do not seriously impact on the economic viability of rural properties.* • *Government horse paddocks: Objective - Free-ranging kangaroo populations on government horse paddocks are managed so that their densities do not seriously impact on the viability of the paddock complexes.* *There are no specific performance criteria or outcomes articulated for these objectives, to allow landholders some flexibility in deciding the acceptable level*	4.1	See recommendation 2.2 about setting SMART objectives See recommendation 4.4 for survey and monitoring to inform those objectives. The revised Plan could identify where any relevant lease-level objectives in relation to kangaroo management should be identified (e.g., in the Land Management Agreements). See recommendation 4.2.

Review section	Summary text from that section of the Review	Rec #	Recommendation
	of kangaroo grazing for their situation. In addition, the Land Management Agreements, required for every rural lease, could provide for more specific objectives to be set. In any case, in the absence of quantitative or qualitative data for total grazing pressure, kangaroo densities and pasture condition (see Sections 4.3 and 4.4), performance against the objective cannot be assessed.		
4.1.1	***The evidence-based case for kangaroo management on rural lands*** *The 2010 and 2017 Plans review the evidence for grazing competition between stock and kangaroos, and for kangaroo grazing in paddocks that are being spelled, or that have been sown with forage. There is no contention over the general effects of overgrazing, and that farmers must manage grazing from kangaroos, livestock, and introduced herbivores to match pasture productivity. Therefore, if kangaroo numbers increase (for a given amount of forage), livestock numbers need to be reduced.*		
4.1.1.1	***Kangaroo density on rural lands:*** *There are very few data available on the density of kangaroos on ACT rural land (unless they are part of a KMU), and most estimates come from over 20 years ago. The average kangaroo density suggested by the estimates is 0.76 kangaroos/ha, but with low confidence.*		Consider an ACT-wide spatial assessment to identify variation in kangaroo density across rural lands, and focal areas for kangaroo management outside of the reserved areas. See recommendation 4.3.
4.1.2	***Conceptual model and evidence-based thresholds for kangaroo management on rural lands*** *Kangaroo grazing impacts and management are considered within the conceptual framework of Total Grazing Pressure from livestock, introduced species (rabbits, deer), as well as kangaroos. However, there is no guidance in the 2017 Plan on what that means in practice, perhaps because that is better handled in other planning instruments such as the Land Management Agreements. There are two scenarios where enhanced collaboration between rural landholders and the Government over grazing management is important, and more specific kangaroo grazing impact thresholds may need consideration: one is at locations on rural lands with grazing sensitive native species, and the second is at the interface of reserved land and rural land. Where these interfaces are within a KMU, the conservation cull process triggers collaboration with the landholder, but there is no such trigger when the reserved land is not within a KMU.*	4.2	Consider the options for enhancing government-landholder collaboration over kangaroo management planning on rural leases where kangaroo grazing, as a component of total grazing pressure, is a problem for threatened species; or where high kangaroo densities are occurring on the interface between rural lands and reserves without regular kangaroo management, leading to high grazing pressure on rural land that damages short- and longer-term economic viability, and high grazing pressure on conservation land that damages ecological health. Options may include ensuring that the specific issue, the management response, the required monitoring, and roles and responsibilities are detailed in revised Land Management Agreements (or some other mechanism).
4.2	**Implement** *Kangaroos on rural lands may be culled by landowners with authorisation from the Conservator. Authorisations are applied for, and granted, annually.*		

Review section	Summary text from that section of the Review	Rec #	Recommendation
4.2.1	*The Rural culling Calculator sets a maximum number of kangaroos to be culled based on the area and shape of a property. Given the average densities on rural lands (see 4.1.1.1), the allowable cull appears generous, but kangaroo density is likely to vary substantially around this average.*		
4.2.2	***Culling operation**: Landholders must pass the Territory competency test every two years (including shooting accuracy and species Identification components), and mixed-sex culling must only occur within the March-July culling season, with a male-only cull allowed between August to October. Random audits occur to check compliance with the Code, and conditions of the authorisation.*		Suggested modifications to shooting/licencing protocols, are captured in recommendation 6.1.
4.3	**Monitor** *The ACT Government keeps records of the number of kangaroos that are authorised to be shot, and then the numbers that are reported as shot, on each property. The number of properties and kangaroos authorised/shot rose between 1997 and 2018-19, but have fallen since then. There are no current data on the density of kangaroos on rural land, and no data on pasture condition for most rural land (that this Review is aware of).*		Design and implement a monitoring program to describe spatial and temporal variation in kangaroo density across rural lands in the ACT (see recommendation 4.3).
4.4	**Evaluate and Adapt** *Given the paucity of data on kangaroo densities on rural land, it is difficult to evaluate the impacts of the rural cull on kangaroo populations, and the Review is not aware of any data on pasture condition from the rural leases (although it may exist).*	4.3	Consider an ACT-wide spatial assessment to identify variation in kangaroo density across rural lands, and identify focal areas for collaborative kangaroo management on rural lands; including: • Locations with grazing sensitive threatened species. • Rural leases next to reserved land that routinely have very high kangaroo densities. The assessment could also be used to design an ongoing monitoring program for changes in kangaroo density on rural lands, that would inform kangaroo management broadly, but including in the focal areas noted above. See also recommendations 4.2, 7.2
4.5	**Communicate** *The ACT Government interacts with landholders directly, and does not share details of the rural culling program with the broader public, for privacy reasons.*		
5	**Social Impacts**		
5.1	**Plan**	5.1	There is potential in a revised Plan to develop more clarity over the 'social impacts' relevant to the implementation of the kangaroo management Plan; how these impacts will be reduced, or balanced; who is responsible for the

Review section	Summary text from that section of the Review	Rec #	Recommendation
	The 2010 and 2017 Plans describe the diversity of social impacts of kangaroos, but objectives, outcomes and actions related to these impacts are more loosely organised than those relating to environmental and economic impacts.		actions; and how the outcomes will be measured. Social impacts could be better viewed through a 'One Welfare lens', applied equally for impacts to people, as well as to kangaroos and other animals.
5.2 5.2.1	**Road collisions** *The main social impacts from high kangaroo densities noted in the 2017 Plan stems from the consequences of collisions between vehicles and kangaroos. These collisions can injure or kill the kangaroo, damage the vehicle, and traumatise, injure (or kill) people in the car. Rangers, wildlife carers, and vets are called out to euthanase injured animals, and to move carcasses, which can be unpleasant or traumatic experiences. The 2017 Plan has an objective relating to vehicle-kangaroo collisions:* • *The incidence of vehicle-kangaroo collisions in the ACT is reduced* *The 2017 Plan states clearly that kangaroos are not culled to reduce the frequency of road collisions; and that achieving the objective of reduced collisions is the responsibility of Canberra Transport. However, the Environment, Planning and Sustainable Development Directorate has supported some research, funded by the ACT Road Safety Fund, to identify the spatial location of collision hotspots, and the landscape and other factors that tend to encourage such hotspots.*	5.2	Many people and kangaroos are adversely affected by collisions on Canberra roads, and the objective of reducing the incidence of vehicle-kangaroo collisions is not being met. Overall welfare outcomes for people and kangaroos would be enhanced if the frequency of kangaroo-vehicle collisions was reduced. Research to improve data collection on collisions, and to determine cost-effective mitigation options would be very helpful. Such options should allow kangaroos to move across habitat patches that are now fragmented by roads wherever possible, and be trialled and monitored in an adaptive management framework. In the meantime, the available data clearly show where the hotspots for collisions are, and the EPSD Directorate could work with the Transport Canberra and City Services Directorate to prioritise mitigation strategies that could be put in place immediately (e.g., reducing speed limits, especially at times when kangaroos are more active) whilst longer term solutions are developed. Community input to developing a short and long term strategic plan to enhance reserve connectivity whilst reducing collision risk for kangaroos, would help with its efficacy and socialisation.
5.2.2	*Data on the frequency of kangaroo-vehicle collisions from public survey and ranger callouts indicate that both the absolute number of collisions, and the frequency per capita, continues to increase. Between 2600 (based on ranger callouts to collisions) and 5800 (based on public survey results) kangaroos have been killed annually on Canberra roads since 2015. A similar number of kangaroos are injured during collisions, with their fate unknown. Collisions increase during dry years, and during the winter months. Collisions are more likely on roads with higher speed limits, and on roads next to KMUs with high kangaroo densities and short grass (a situation that encourages kangaroos to come to road verges to feed). Road intersections, and the ends of roadside barrier fences, can also be collision hotspots.* *Based on public survey results, over a third of Canberran residents have been in a vehicle that has struck a kangaroo, at some point in the past. Collisions result in injury to the vehicle occupants about 5% of the time (~740 collisions a*		

Commented [EH21]: For TCCS awareness

Review section	Summary text from that section of the Review	Rec #	Recommendation
	year), and an insurance claim about 60% of the time. Estimates of the annual cost of kangaroo-vehicle collisions range from $2.5 to 8 million.		
5.3	**Kangaroo attacks** *are rare, and the ACT Government includes advice to residents about how to avoid these events.*		
5.4	**Trauma to people concerned about kangaroo management** *Most Canberrans support kangaroo management for welfare, environmental, and economic reasons. About 10% of Canberran residents do not; a subset of these may experience trauma that kangaroo management occurs at all. Considering the views of all stakeholders through an ethical framework may help develop a shared understanding of the issues, and reduce conflict.*	5.4	Consider the international principles for ethical wildlife control (or something similar) when revising the management plan; ensure the perspectives of all stakeholders are fairly and transparently considered.
5.5	**Carcass utilisation** *Most carcasses from culls on conservation and rural land in the ACT are disposed of in burial pits or left to rot in situ. A very small number of carcasses have been used in conservation programs (to feed native carnivores at wildlife holding facilities, or to make poison baits for foxes and dogs). Skins have also been given to local Indigenous people. Farmers can use culled kangaroos for their own domestic purposes, but the fraction so-used is very small. This 'wastage' is a concern to some, including Traditional Custodians, farmers, and some conservation groups, and inconsistent with ACT's Waste Management Strategy and Climate Change Strategy. A recent commissioned report considered the options for alternative uses of culled carcasses. The report suggests upscaling the current use of kangaroo meat in conservation programs, using commercial processing facilities in NSW to prepare meat and skins for consumption by people in the ACT Indigenous community, sending small carcasses to be used by certain wildlife facilities, and sending offcuts and offal to frass processers to produce fertiliser that could be used by community groups involved in ecological restoration activities. Carcasses from conservation culls would be gifted to these uses, but rural landholders may choose to recoup some costs from these pathways.*	5.5	Continue exploring alternatives for carcass utilisation instead of the current practice of pit burial and leaving in situ, by undertaking the next steps outlined in the Australian Wildlife Services report, and fully costing their proposed model. Involve the community in this discussion, by 1) including targeted questions about kangaroo carcass utilisation in the next public survey on kangaroo management; and 2) ensuring Traditional Custodians can participate fully in the discussion and decisions.
5.6	**Overall Welfare as an impact area in the kangaroo management planning framework** *Attention to kangaroo welfare is prominent in the 2017 Plan, and references to welfare crops up frequently, in different contexts, throughout the document. Welfare outcomes for other animals, and for people, are raised (less often) in the context of specific issues, and sometimes labelled differently. For example, the impacts of kangaroo-vehicle collisions are nested under social and economic impacts. An alternative approach, that recognises recent amendments to the ACT Welfare Act, the development of the ACT Wellbeing Framework, and the One Welfare concept, would be to replace 'Social Impacts'*	5.6	Replace 'Social Impacts'; in the Plan with 'Overall Welfare Impacts', making Overall Welfare a high-level impact area, on a par with Environmental and Economic Impacts. This means that the welfare consequences of management actions (or inaction) for kangaroos, people, and other animals, can be explicitly and consistently considered within the same framework. This change would recognise recent amendments to the ACT Welfare Act, the development of the ACT Wellbeing Framework, and the One Welfare concept.

Commented [EH22]: This sounds like we're not currently considering ethics - could it be prefaced with something like "To support the subset of Canberrans that experience trauma in relation to kangaroo management..."?

Commented [EH23]: Can we explain why they are "left to rot"? E.g., is it an ecological or resourcing decision?

Review section	Summary text from that section of the Review	Rec #	Recommendation
	in the Plan with 'Overall Welfare Impacts', providing a single coherent framework for considering all welfare outcomes from decisions to act (or not to act), to kangaroos, other animals, and to people.		
6	**Have the policies contributed towards achieving the management objectives?**		
6.1	**Kangaroo welfare** *The 2017 Plan's policy on kangaroo welfare (section 4.3.1) has an explicit objective:* • *Kangaroo management in the ACT is undertaken in a way that accords with ACT legislation, codes of practice and current Australian standards for animal welfare.* *To support this objective there are a collection of policies relevant to the operation of the management program (e.g., shooter testing, culling season urban wildlife program, legislation and Codes of Practice); a policy for wildlife care of kangaroos; and a policy for translocation.*		
6.1.1	**Kangaroo welfare during culling** *Culling is carried out to comply with a National Code of Practice for humane shooting of kangaroos and wallabies for non-commercial purposes. However, the ACT has additional regulation and practice designed to enhance welfare outcomes considerably. In particular, shooters must regularly pass a competency test (of shooting accuracy, familiarity with the Code, and macropod identification); audits of operations are undertaken on both the conservation and rural culls; a culling season reduces the risk that that large pouch young and small young at foot will be orphaned, the conservation cull occurs only in reserves where conservation benefits are expected; and the overall number of kangaroos to be culled is reduced by culling regularly with small culls.* *Humane killing of pouch young remains a sensitive issue for some people. This Review found that the protocols for humanely killing pouch young of different stages that is outlined in the Commercial Code (rather than the Non-commercial Code) was clear, useful, and supported by the available evidence. There may be potential for research to develop alternative methods.* *The ACT Government's requirements and practice surrounding kangaroo management are dispersed across regulation and various internal guidelines and processes; there may be value in gathering some of these into a single Standard Operating Procedures document, for transparency and to drive positive change more broadly.*	6.1	The Code for non-commercial shooting of kangaroos is 16 years old. The ACT Government should work with counterparts in the other jurisdictions to update the Code, and bring it closer to the standard of the current Code for commercial shooting of kangaroos (dated 2020). The 2020 Code for commercial kangaroo shooting has some useful new material (such as more detailed and updated standard operating procedures appended to the Code) that could be incorporated into a new non-commercial Code. In addition, the pre-consultation approach used in the development of the commercial Code – where stakeholder views were gathered to inform the revision – could also be considered for the non-commercial Code.
		6.2	In the interim, the ACT Government could consider gathering all the information that guides the current conduct of the conservation culling operation into a single, non-statutory 'standard operating procedures' style of document, that can be used to communicate the very high standards and careful operation of the conservation culling program to all shooters working in the ACT, to shooters working in other jurisdictions, and to the public. To inform these SOPs, consider seeking review from the **ACT's Animal Welfare Advisory Committee**, a body with broad community representation from the animal welfare, farming, veterinary, research, conservation, companion animal, recreational/sporting and environmental legislation sectors.
		6.3	Consider increasing the involvement of government vet(s), making them integral member(s) of the culling operations, helping to plan the year's program, to gather additional information on kangaroo demographics and

Review section	Summary text from that section of the Review	Rec #	Recommendation
			health, and helping to communicate to the public that animal welfare is a primary consideration during the culling.
		6.4	Explore the potential for further research to improve the effectiveness and consistency of portable non-penetrating captive bolts as an alternative method for humanely killing pouch young of certain ages. If potential exists, then support that research. Similarly, remain aware of further research into the development of sentience in pouch young, and implications for adjusting methods for humanely killing unfurred joeys.
		6.5	Shooter competency: • Consider providing shooter competency tests annually instead of every two years. Allow shooters that fail, to re-sit the test the following year; and drop the frequency of retesting to one in 3-5 years, so the overall workload of administering the tests is not increased, yet shooters are able to take the test again sooner. • Include the use of night-vision equipment in shooter tests. • The current penalties for killing females currently deter landholders from using the male-only culling season; consider modifying penalties to encourage male only culls to occur, whilst maintaining strong discouragement for shooting females out of the mixed-cull season.
		6.6	Make the ear tags biodegradable.
		6.7	Consider how to design and manage field audits during rural culls to optimise welfare benefits, make audits a constructive opportunity for two-way exchange, and reduce administrative burdens on farmers and government staff.
		6.8	The Animal Welfare Act has been updated since the 2017 Plan was released and this should be reflected in the revised Kangaroo Management Plan.
		6.9	In the revised Plan, and other (new) documents relating to kangaroo management in the ACT, consider replacing the term 'euthanasia' with 'humane killing' for pouch young that are killed because their mothers have been shot during the conservation culling. This is in line with the terminology used in the National Animal Welfare Standards and Guidelines.
6.1.2	**Kangaroo welfare in wildlife caring and translocations** *The 2017 Plan does not support translocations, or the release of hand-reared kangaroos, because of poor welfare outcomes for kangaroos, and some risks to humans (from hand-reared kangaroos). Research since 2017 on the outcomes of large macropod translocations corroborates this position.*		

Commented [SM24]: The vet should participate but not in the planning of the program

Commented [SM25]: The ACT cull is very small this would be a large amount of work that should align with the national code - the commercial code was updated recently and includes other methods for pouch young

Commented [WC26R25]: Agree it would take a bit to do this ourselves but I think it would more likely be we support/encourage another research institute to do it, which could be very little work for us (someone might already be doing it!)

Review section	Summary text from that section of the Review	Rec #	Recommendation
6.1.3	**Other kangaroo welfare considerations** *The 2017 Plan focussed mainly on kangaroo welfare during culling. In the revised Plan, if the recommendation of adding 'Overall Welfare' as an impact area is adopted, then the kangaroo welfare considerations of other actions can also be explicitly considered. These include fertility treatment, fencing, inaction when high density kangaroo populations starve during drought conditions, and kangaroo-vehicle collisions.*		
6.2	**Interactions between humans and kangaroos** *The 2017 Plan's policy on managing interactions between humans and kangaroos has an explicit objective:* • *Kangaroo management and community education minimise negative encounters between people and kangaroos in the ACT.* *This review is unable to assess whether this response has been effective at reducing the incidence of conflict between people and kangaroos. If the occurrence of such events is low, then discerning change is challenging.*		
6.3	**Managing kangaroo densities** *This group of policies outline the Plan's position on the menu of approaches for controlling kangaroo populations. It establishes that professional shooting is the most humane way to kill independently mobile kangaroos, and that the ACT would work to advance the use of fertility control as a viable population management method for specific circumstances. This last commitment has resulted in field deployment of contraception.*		
6.4	**Managing captive populations** *This policy deals with the issues of enclosed populations of kangaroos in a logical way and makes the responsibilities of managers of such areas clear.*		
7	**Is kangaroo culling justified?**		
	The Review assessed the ACT Kangaroo Management program against a set of seven international consensus principles for ethical wildlife control in conservation programs, finding the program mostly adheres to the principles. Using the framework is a reminder that other threats to the ecological integrity of grassy ecosystems (fire regimes, invasive species, fragmentation) should be managed to the extent possible; that kangaroo management must be justified (on environmental grounds); that management must have clear and achievable outcome-focussed objectives; that overall welfare (least harm to least animals) is considered; that the diversity of human values is considered; that management is well-planned; and that kangaroos are not labelled in a way that scape-goats them for a situation not of their making.	7.1	Consider the international principles for ethical wildlife control (or something similar) when revising the management plan; ensure the perspectives of all stakeholders are fairly and transparently considered.

Commented [EH27]: As above

Commented [EH28R27]: Also, should this be "see 5.4"?

Review section	Summary text from that section of the Review	Rec #	Recommendation
7.1	**Kangaroo culling in the context of other mortality sources, and the overall population size** *Of the direct anthropogenic causes of kangaroo mortality, culling on rural lands affects the largest number of kangaroos (~9100 per year), followed by road kills (midpoint 4200, range 2600 - 5800 per year), then conservation culls (~2000 per year). Therefore, of mortality caused directly by humans (conservation cull, rural cull, road kills), the conservation cull represents 13%. The Review did not estimate the number of kangaroos displaced (and thus probably killed) by urban expansion.* *There are about 6 million eastern grey kangaroos in NSW west of the Divide. The Review estimates that there are about 142,000 eastern grey kangaroos in the ACT, of which most are in the large protected areas in the west and south of the ACT (46%) and on rural lands and government horse paddocks (22%). Canberra Nature Park contains about 12% of the population, and 4% is on Commonwealth land and in plantations (1%). Conservation culling therefore kills less than 2% of the ACT kangaroo population every year, road kills around Canberra affect around 3%, and rural culls affect 6% (stressing these figures are very approximate).*	7.2	These estimates for kangaroo population sizes across the ACT are uncertain, because of the paucity of data on kangaroo densities from rural lands and the large protected areas that are not Canberra Nature Park (i.e., Namadgi NP, Tidbinbilla NR). Obtaining density estimates from these areas, periodically, would help to understand the broader context in which kangaroo management is operating. Recommendation 4.3 was for an assessment of spatial variation in kangaroo density on rural lands, followed by an ongoing monitoring program carried out around every 5 years or another ecologically sensible interval. Here, the recommendation is to integrate this with periodic surveys on the large, reserved areas in the west and south of the ACT. This information will help contextualise the intensive management in Canberra Nature Park, and provide an overall status assessment of one of the ACT's iconic species.

1. Introduction

This section provides a brief background to the ecological, legislative and policy context to the issue.

Eastern grey kangaroos (*Macropus giganteus*) are an iconic resident species of the ACT. Eastern grey kangaroo populations have re-established in and around Canberra over the past decades, after being locally extirpated by previous farming practices. However, the ACT landscapes have radically changed since colonisation. Grasslands and open woodlands have been heavily cleared for urban development, pastures for agriculture have expanded and been altered by the introduction of exotic pasture grasses and the addition of nutrients (fertilisers), water sources have proliferated, a suite of digging mammals are extinct, and dingoes are now absent from much of the ACT. The grassy ecosystems that remain are highly threatened and distributed as small fragments. Their legacy of past degradation and current threats means that ongoing management in these fragments is essential for preventing further decline (McIntyre *et al.* 2004; Prober and Thiele 2005; Sharp *et al.* 2015). The habitat loss, fragmentation, and degradation have likely affected the population dynamics of kangaroos in the modified landscapes, by removing top-down population control by predators, whilst increasing the extent of high quality food and habitat, and preventing movement and dispersal.

Kangaroos are an important component of healthy grassland, woodland and forest ecosystems. By introducing disturbance to the grassy layer, their grazing limits competitively dominant grass species, creating space between tussocks that are niches for other species (Price *et al.* 2019; Prober *et al.* 2013). However, high levels of grazing in remnant grassy ecosystems, especially in dry conditions, can change the structure of the grass layer to the extent that other native species of plant and their dependent fauna, including some threatened species, are very disadvantaged (Morgan 2021). Kangaroos in high-density populations are vulnerable to starvation if their overgrazing reduces food resources, which can easily occur when plant growth is limited for reasons such as drought (Portas and Snape 2018; Sharp *et al.* 2015). These scenarios have poor welfare outcomes for individual kangaroos, for grass-dependent fauna with inadequate food and shelter, and for people witnessing the starvation and degradation. Kangaroo populations in and around suburban and metropolitan areas are vulnerable to being hit by vehicles if they are forced to cross roads to reach other patches of habitat; such vehicle collisions again cause pain and suffering to individual kangaroos, as well as the human occupants of the vehicles (Cope and Herbert 2023; Dunne and Doran 2021).

The ACT Government manages kangaroos as one part of a broader strategy to maintain healthy grassy ecosystems for all their constituent species. Kangaroo management also seeks to reduce economic impacts of kangaroo grazing on livestock production and farming sustainability, and to minimise the economic and social impacts from vehicle collision, and from kangaroo control itself. Direct kangaroo population control is carried out mainly by culling, but some small populations are managed with fertility control treatments. On conservation land, culling to protect the ecological health of lowland grassy ecosystems occurs only within some Canberra Nature Park reserves (in up to 18 of the 39 reserves, covering ~8300 ha) (ACT Government 2021a), and on Commonwealth land (~4500 ha). Other actions to influence kangaroo grazing at small scales, such as planned burns and exclusion techniques (fencing, logs), are increasing in frequency. Kangaroo populations in other ACT protected areas such as Namadgi National Park and Tidbinbilla Nature Reserve (127,300 ha) exist without culling interventions. Kangaroo culling is also carried out on rural lands (39,500 ha), to reduce impacts on the economic viability of livestock production.

Commented [EH29]: Note my question in the summary background

1.1 Policy and legislative context

The potential impacts of high densities of kangaroos in the ACT was investigated by the ACT Kangaroo Advisory Committee in the mid 1990s, who recommended that a management plan for kangaroos be put in place. In 2010, kangaroo management in the ACT was set out in detail in the 'ACT Kangaroo Management Plan' (ACT Government 2010). This Plan focussed on eastern grey kangaroos, but also covered the common wallaroo (*Osphranter robustus*), red-necked wallaby (*Notamacropus rufogriseus*) and swamp wallaby (*Wallabia bicolor*).

A revision to the Nature Conservation Act in 2014 provided for the declaration of controlled native species that has a detrimental environmental, social, or economic impact. Once a species is so-declared, the Conservator for Flora and Fauna may prepare a 'controlled native species management plan', in order to detail the appropriate management of the species on the land specified in the plan. The eastern grey kangaroo is a declared controlled

native species in the ACT. The 'Eastern Grey Kangaroo Controlled Native Species Management Plan' was released in 2017 under the Nature Conservation Act 2014 (ACT Government 2017b).

The focus of the Eastern Grey Kangaroo Controlled Native Species Management Plan (ACT Government 2017b) is managing kangaroo grazing pressure on native lowland grassy ecosystems to support the conservation of plants and small animals that depend on the ground-layer vegetation. The Plan must be implemented by the Conservator or land custodian on public land and unleased land (Territory or Commonwealth), and it may be implemented on rural lands by leaseholders (including government horse paddocks). Any culling requires authorisation by the Conservator, and must have regard to the culling calculator instruments:

- for nature reserves and adjacent land — the Nature Conservation (Eastern Grey Kangaroo) Conservation Culling Calculator
- for rural lands and horse paddocks — the Nature Conservation (Eastern Grey Kangaroo) Rural Culling Calculator.

These calculators guide the number of kangaroos to cull in any year for the different land types. They are both notifiable instruments that have been in force since 2017. Minor updates were made to the Conservation Culling Calculator in 2018. The Nature Conservation Act also provides for the monitoring of the effectiveness of controlled native species management plans with a review at least once every five years; this provision is the prompt for this Review.

1.1.1 Relationship between the 2010 and 2017 kangaroo management plans

The ACT Kangaroo Management Plan (ACT Government 2010) is considered the source document for the background and justification leading to policy statements about kangaroo management (all species) in the ACT. For macropod species other than eastern grey kangaroos and for all kangaroos at Googong Foreshores, the 2010 Plan continues to be the key ACT policy document for kangaroo management.

The Eastern Grey Kangaroo Controlled Native Species Management Plan (ACT Government 2017b) contained several updates to the 2010 Plan, including:

- Recognition that the ACT had adopted the National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-commercial Purposes (NRMMC 2008).
- Recognition that the Conservator or land custodian are required under the Nature Conservation Act to implement the plan and can authorise others to undertake certain management activities that previously required a licence under the Nature Conservation Act.
- Revisions to the section on managing captive populations to include definitions of the different types of enclosed kangaroo populations in the ACT and which of these are subject to the captive management policies.
- Recognition of the decision of the ACT Civil and Administrative Tribunal in 2011 to approve the licence to Wildcare Queanbeyan to export 35 dependent animals from the ACT *[Wildcare Queanbeyan NSW Inc & Conservator of Flora and Fauna (Administrative Review) [2011] ACAT 68]*
- Addition of policies relating to fencing, management of kangaroos at greenfield development sites and on agisted and unleased land.
- An overview of the research conducted since 2010 that was relevant to eastern grey kangaroos.
- Detail on how eastern grey kangaroos control programs were to be conducted, as per the legislative requirements for a plan of a controlled native species.

1.1.2 Previous review history

Coulson (2010) carried out an independent review of the 2010 ACT Kangaroo Management Plan, assessing the comprehensiveness, policies, scientific robustness, presentation of statistical material, and giving an overall assessment. Coulson concluded the Plan was unique, and a model for similar plans elsewhere in Australia.

The kangaroo population count methods and the rationale for the target densities for kangaroos were reviewed in 2013 (Parkes and Forsyth 2013). This review endorsed the ACT Government's methods. The review, and the ACT Government's response, are available from the ACT Government Environment website.

Other overviews of the ACT Government's kangaroo management program are also available on the government website.

1.2 Purpose of this Review

The brief provided to the Reviewer was:

Objective
Review the effectiveness of the current management plan and associated legislative instruments for reducing the adverse environmental, economic and social impacts of Eastern Grey Kangaroos (EGK) in the ACT.

Scope
The review will assess the effectiveness of the EGK CNSMP and associated legislative instruments for maintaining wild populations of Eastern Grey Kangaroos in the ACT while managing their environmental, economic and social impacts. The following documents will be reviewed:

- Nature Conservation (Eastern Grey Kangaroo) Controlled Native Species Management Plan 2017
- Nature Conservation (Eastern Grey Kangaroo) Conservation Culling Calculator Determination 2018
- Nature Conservation (Eastern Grey Kangaroo) Rural Culling Calculator Determination 2017

The review will consider the policies contained in the EGK CNSMP and where possible evaluate the degree to which the policies have achieved the management objectives stated in the plan in the last five years (2017-2022).

In particular, the review will focus on evaluating the management of kangaroo grazing pressure on native grassy ecosystems. This will include evaluating the current kangaroo population survey methods and processes for calculating culling targets, as well as the appropriateness of those targets for achieving ecosystem outcomes. This part of the review will be informed by an ACT Government research report assessing the program's achievement of its targets for kangaroo population density and grass structure, as well as other relevant reports and data.

In undertaking the review, the consultant is expected to:

- Review available data and reports from across the years in relation to kangaroo management in the ACT, including the conservation culling program.
- Contact units/offices within EPSDD and other Directorates to obtain information relevant to the review.
- Conduct targeted interviews with key EPSDD ~~EHW internal~~ staff ~~(in the Office of Nature Conservation, Resilient Landscapes branch, and the Parks and Conservation Service)~~ and external stakeholders (including ACT Conservation Council, rural land holders and managers of National Land) to gain insights and understanding on current kangaroo management activities and to obtain feedback to inform recommendations.

Based on the review findings, recommend improvements to future ACT Government policies and programs that will support ongoing best-practice kangaroo management.

1.3 Material considered in this Review

The 2017 Eastern Grey Kangaroo Management Plan (ACT Government 2017b) (hereafter, the 2017 Plan) builds on information presented in the 2010 Kangaroo Management Plan (ACT Government 2010) (hereafter, the 2010 Plan), and the documents need to be considered together. The implementation of the 2017 Plan is supported by the two Culling Calculators (one for conservation, and one for rural land). In addition, there are dozens of published and unpublished technical reports, conservation advices (which present the annual workplans with some monitoring data), and papers in the peer-reviewed literature, that document how ACT government staff have refined and improved kangaroo management since 2017. A kangaroo management research workshop convened by the ACT government in 2018 resulted in some important changes to planning, implementation and

monitoring for the program (Gordon and Snape 2019). All these post-Plan documents are considered in this Review because they have substantially modified how the Plan is implemented.

The Review assessed the evidence used to justify and design the management program, and the evidence produced during the management program, by referring to the findings in many other published studies, including many produced after 2017. The Review was also informed by input and discussions with many stakeholders, including:

- Advisory Committees:
  - ACT Natural Resource Management Committee
  - ACT Animal Welfare Advisory Committee
  - ACT Scientific ~~Threatened Species~~ Committee
- Conservation groups, including volunteer groups:
  - ACT Conservation Council
  - Woodlands and Wetlands Trust
  - Ginninderry Conservation Trust
  - Friends of Grasslands
  - Parkcare groups (Mt Taylor, Aranda, Mt Ainslie, Mt Majura)
- Animal rights, wildlife care, and animal welfare groups
  - RSPCA
  - ACT Wildlife
  - Animal Protectors Alliance
  - Animal Liberation ACT
  - Save Canberra's Kangaroos
  - Animal Defenders Office
- Mangers of national land (Sch 2.2(a)(x))
- Rural Landholders Association
- Individual rural landholders (Letters/emails were sent to all rural landholders, inviting them to contact the Reviewer if they wanted to discuss aspects of the Kangaroo Management Plan. The Reviewer met with respondents individually, mostly on their properties, but also via online meetings.)
- Professional shooters (met individually, online)
- Researchers (met individually, online and via email)
- Veterinarians (met individually)
- The Reviewer attended a yarning circle with Ngunnawal Traditional Custodians

Commented [WC30]: FYI, Rosie noted this as the reason for using Custodian rather than Owners - "As there has been no formal binding determination of ownership as yet in the ACT"

The Reviewer also met with many ACT Government staff across several EPSDD business units ~~in the Office of Nature Conservation~~.

1.4 Structure of the Review

The first section of this review ('The 2017 Plan - Overview') considers the 2017 Plan's overall Purpose, Goals, and Objectives.

The next three sections focus on the three 'impact areas' of high density kangaroos, outlined in the 2017 and 2010 Plans:

- Environmental Impacts
- Economic Impacts
- Social Impacts

The first two sections, and part of the third section, are structured into subsections on Planning, Implementing, Monitoring, Evaluating, Adapting, and Communicating. In each subsection, the Review examines the evidence underpinning, or being generated, by activities in that subsection. These subsections mimic the typical cyclical process of adaptive management. Adaptive management is considered the gold standard approach when knowledge is imperfect. The key component is that management is systematically improved by using monitoring

and evaluation to measure outcomes, learn, and adapt (Dixon *et al.* 2019; Legge *et al.* 2018; Lindenmayer and Likens 2010; Westgate *et al.* 2013). The Review is structured this way because the 2017 Plan establishes the ACT Government's commitment to "evidence-based management" (section 4.2.1 of the 2017 Plan).

Note that the bulk of the Plan, and therefore the bulk of this Review, focuses on the management of environmental impacts in lowland grassy ecosystems. However, the Review also makes some substantial recommendations relating to the economic and social impact areas.

After considering the three impact areas, in Section 6 the Review considers how the four key policy areas of the 2017 Plan (Kangaroo welfare; Interactions between humans and kangaroos; Managing kangaroo densities; Managing captive populations) have contributed to the plan's delivery (as required by the review brief).

In section 7, the Review considers whether kangaroo management for a conservation outcome is justified, by first evaluating the program against an international framework for ethical wildlife control; and second, by contextualising the magnitude of the conservation against other mortalities caused directly by humans, and against estimates of the population sizes of kangaroos in the ACT and NSW.

Within the subsections, summaries of the key findings are given in blue italic font at the start of subsections (where relevant). Recommendations are shown in red font at the end of subsections. Hyperlinks to other subsections in the Review aim to help readers navigate across the text.

1.2. The commentary and recommendations in this Review aim to contribute to a goal of continuous improvement. Overall though, the planning, implementation, monitoring and reporting for kangaroo management in the ACT is, extremely impressive, and an outstanding exemplar for adaptive management.

Commented [EH31]: Should this be 1.1, instead of 1.2?

2. The 2017 Plan – overview

The 2017 Eastern Grey Kangaroo Controlled Native Species Management Plan is a comprehensive and authoritative document. It leans on, and extends, information presented in the 2010 Kangaroo Management Plan which is also a comprehensive and thorough document, covering all four species of large macropod in the ACT. Both Plans encompass a variety of land tenures and uses, multiple kangaroo-related issues, and they fold in a suite of related, subsidiary policy positions and issues. The implementation of the 2017 Plan is supported by the Culling Calculators (one for conservation, and one for rural land). The Culling Calculators are separate, notifiable instruments. Their purpose is to make the workflow for arriving at cull targets transparent, and to enable updates to be made to that workflow as needed, rather than waiting for the next iterations of the Plan itself.

Since 2017, a substantial body of research, monitoring and management adaptation has occurred, and can be mostly tracked through a suite of reports (published and unpublished), and articles in the peer-reviewed literature. This is especially true for the part of the Plan that focuses on environmental impacts of heavy kangaroo grazing in lowland grassy ecosystems.

2.1 Does the Plan have a clear purpose and goals?

*The **Plan's purpose and goals** are set out clearly in both the 2010 and 2017 Plans (Section 2.2 of the latter). They strike a balance between affirming that kangaroos are ecologically and socially valued, and that kangaroo populations may need to be managed in some circumstances, to maintain the ecological health of grassy ecosystems and the persistence of grass-dependent species, and to reduce economic and social impacts. The Plan's Principles are useful to setting the tone of the document and program.*

***Purpose**: "The purpose of the controlled native species management plan is to set out the approach to be adopted in maintaining wild populations of Eastern Grey Kangaroos in the ACT while managing their environmental, economic and social impacts and ensuring their welfare. Particular consideration is given to managing kangaroo grazing pressure on native grassy ecosystems in the context of grazing pressure from all herbivores and additional factors influencing ground layer vegetation."*

Goals: *"The primary goals of kangaroo management in the ACT are to:*

- *maintain populations of kangaroos as a significant part of the fauna of the 'bush capital' and a component of the grassy ecosystems of the Territory.*
- *manage and minimise the* ***environmental, economic and social impacts*** *of those kangaroo populations on other biota, grassy ecosystems and primary production."*

The purpose and goals are supported by a set of principles (in section 4.2) that are crucial for conveying how kangaroo management must be approached, including that such management:

- Values the role of kangaroos in the ecosystem.
- Is based on the best science available.
- Aligns with legislative requirements to conserve native grassy ecosystems and their constituent species.
- Considers the economic impacts of kangaroos to farmers, and road users.
- Considers kangaroo welfare, and the welfare of humans and other species in grassy ecosystems.
- May include managing kangaroo impacts, including by culling; such management must be based on ongoing science, regulation, monitoring, and codes of practice.

These principles are valuable, and a variation of them should be retained in an updated Plan. The Principles lack any reference to open communication and transparency with the public. The ACT Government has been very transparent about kangaroo management (see Section 4.5 Communicate), so adding this principle would better reflect this practice.

Recommendation

2.1 Add another principle, about a commitment to open, transparent reporting and communication with the public.

2.2 Does the plan have clear objectives and performance criteria?

The ***Plan's objective*** *is to detail how kangaroos will be managed on land of varying tenure and use. Given the complexity of developing a plan for a range of tenure and land uses, that also addresses related issues of welfare and social impacts, this non-specific objective makes sense. However, it means the more specific objectives for kangaroo management in relation to conservation, economic or social impacts are scattered throughout the Plan, and mixed with objectives relating to various policies. The hierarchy of objectives, and their inter-relationships, can be hard to follow; the objectives lack performance criteria and are not SMART (Specific Measurable Achievable Relevant and Timebound). These two features makes it challenging to evaluate the performance of the Plan against stated objectives.*

The 2017 Plan covers kangaroo management across land of different tenure and use. The objectives of kangaroo management differ across those tenure and uses, and therefore the Plan objective is:

"*…to detail the appropriate management of the species on the land specified in the plan*" [section 2.3].

Some of the policies that are embedded within the 2017 Plan have specific objectives. These include three of the four key policy areas (see Section 6: Policies) on:

- Kangaroo Welfare:
  - Objective – Kangaroo management in the ACT is undertaken in a way that accords with ACT legislation, codes of practice and current Australian standards for animal welfare.
- Human Welfare:
  - Objective – Kangaroo management and community education minimise negative encounters between people and kangaroos in the ACT.
- Managing Kangaroo Densities:
  - Objective – Methods of managing kangaroo densities in the ACT are based on the best available scientific knowledge, animal welfare and cost effectiveness.
  - Objective – Kangaroo densities in the ACT are managed according to the management objectives for the land on which the populations occur.

The objectives under the policy area to manage kangaroo densities are then further parsed to area-specific objectives related to land use:

1. In areas managed for environmental outcomes, these are:
   - Grassy ecosystems in the western and southern ACT:
     - Objective - Kangaroo populations are maintained in Namadgi National Park, the Tidbinbilla precinct and the Lower Cotter Catchment. These will be: (a) unmanaged populations unless undesirable impacts or specific ecological or other objectives require management intervention; and (b) managed in accordance with the objectives and policies in the management plan for each area.
   - Lowland native grasslands:
     - Objective - Kangaroo populations are maintained in lowland native grassy ecosystems at densities that conserve the natural integrity of the grassland ecological community and result in the maintenance of habitat for all grassland plant and animal species.
   - National land:
     - Objective - Kangaroo populations are maintained in National Land areas that contain lowland native grassy ecosystems at densities that conserve the natural integrity of the grassland ecological community and result in the maintenance of habitat for other grassland plant and animal species.

2. In areas managed for agricultural outcomes, these are:
   - Rural:
     - Objective - Free-ranging kangaroo populations on rural lands are managed so that their densities do not seriously impact on the economic viability of rural properties.
   - Government horse paddocks:
     - Objective - Free-ranging kangaroo populations on government horse paddocks are managed so that their densities do not seriously impact on the viability of the paddock complexes.

There is also an objective relating to vehicle collisions, in section 6.4:
   - Objective - The incidence of vehicle-kangaroo collisions in the ACT is reduced.

but the Plan states that actions to achieve this objective are the responsibility of road management.

The complexity of these hierarchical objectives, where the Kangaroo Management Plan objective is set at a high and general level (to manage kangaroos appropriately according to the land specified), and then land-specific objectives and policy-specific objectives are nested lower down, is driven by the complexity of tenures and uses of land for which the Plan applies. Setting the objective at this high level also allows for adaptation; for example, research carried out since the 2017 Plan has led to an evolution of management targets being set in annual conservation advices for Canberra Nature Park reserves (e.g., from aiming for a kangaroo density of 1/ha in grasslands, and lower densities in woodlands and forests; to aiming to manage kangaroo grazing so that grass height lies within 5-15 cm).

However, the suite of objectives are scattered throughout the document, relate to a mix of topic areas and levels, and they are not SMART (Specific, Measurable, Achievable, Relevant, and Time-Bound). During the consultation for this Review, some stakeholders commented that they were 'unsure what the Plan was meant to achieve'. This confusion may partly arise because although the Purpose and Goals of the Plan are clear, the Objectives are harder to discern, and relate to lower and variable levels of the Plan structure.

Recommendation

2.2 Consider including a clearer set of SMART objectives, and relevant performance criteria, for the Plan. These objectives could potentially be set for each of the 'impact areas' (i.e., environment, economic, and overall welfare (instead of social, see Section 5.7 below)).

2.3 Does the Plan describe the reporting schedule?

*There has been substantial reporting since 2017, however the 2017 Plan does not establish a **reporting schedule** for the kangaroo management.*

The ACT Government has been committed to timely and transparent reporting, as shown by the wealth of material on the kangaroo management website. In particular, the annual conservation advices present data on kangaroo population sizes, the culling targets, monitoring information on grassland condition and other factors that influence the cull targets, and the prioritisation of the annual workplan.

However, the 2017 Plan does not establish the reporting requirements for the kangaroo management, and it should. The existing annual conservation advices could easily be turned into annual reports, by adding a section that evaluates performance against SMART Objectives for each impact area (environmental, economic, overall welfare), and a section that summarises the research, monitoring, and any other salient activities that have been undertaken that year. If annual reporting is too onerous, then reporting every two years could be acceptable.

Recommendation

2.3 Outline the reporting requirements, which should include an evaluation of the progress made against the SMART objectives, and a summary of the activities carried out under the Plan. These reports could be brief and produced annually or biannually, building on the existing annual conservation advices, with more extensive evaluations carried out every 5 years. Alternatively, kangaroo management reports could align with existing reporting in the Conservation Effectiveness Monitoring Program.

Commented [WC32]: Rosie - yes I think that's very sensible and feasible

2.4 Does the Plan outline the links to other relevant planning documents?

The 2017 Plan focusses on one issue (kangaroo management) across many land tenures, but especially in lowland grassy ecosystems of Canberra Nature Park reserves, as well as unleased and some national land. This can encourage an impression that controlling kangaroos is the main management tool in these areas, rather than managing other threats such as rabbits and weeds. Similarly, how the kangaroo management in the Canberra Nature Park Reserves sits within the broader context of the status and management of kangaroos ACT-wide, including on rural land, in the large, protected areas such as Namadgi, and areas given over to urban expansion, could be better explained.

During consultation for this Review, some stakeholders expressed that they did not understand what the long-term purpose of the kangaroo management was, or how it was integrated with other aspects of reserve management such as rabbit control or weed control. In fact, these issues are dealt with comprehensively and clearly in the ACT Government conservation action plans for threatened species and ecological communities, and also the Canberra Nature Park Reserve Management Plan (ACT Government 2021a). However, although the 2017 Plan cross-references to action plans, it does not refer to the management plan for Canberra Nature Park (ACT Government 2021a). The revised Plan could consider ways of making it clearer that kangaroo management is just one aspect of a more holistic approach to managing reserves.

The revised Kangaroo Management Plan could also better explain how kangaroo management within Canberra Nature Park and other peri-urban land managed for conservation fits in to the bigger picture of kangaroo management in the ACT, including kangaroos on rural land, and in the large reserved areas in the west and south of the territory (see Section 7.1 Kangaroo culling in context). The revised Plan should refer to all other relevant planning documents, such as the ACT's NRM Investment Plan (ACT Government 2022), produced after the 2017 Kangaroo Management Plan; the planning documents for Namadgi and Tidbinbilla (currently being revised); and the system of Land Management Agreements for rural leaseholders. All such planning documents should also reference the Kangaroo Management Plan (as the Canberra Nature Park Reserve Management Plan does).

Commented [WC33]: Rosie - agreed, Nature Conservation Strategy too

Related to this point, during the Review's consultation, some stakeholders expressed concern about the lack of regard to kangaroos, and biodiversity more broadly, during urban expansion. Concerns included that kangaroos were being culled to allow for expansion. Culling has not been undertaken for this purpose, but plan includes a

policy to encourage kangaroo management for welfare and conservation reasons during urban development (section 5.4.3 of the 2017 Plan). Stakeholders also raised concerns that urban development meant that kangaroos were being squeezed out into other areas where they could be shot (if on rural land) or might suffer because the diaspora caused unsustainable population density; and that urban expansion paid no heed to ensuring connectivity among habitat fragments. A revised kangaroo management plan could provide an overview of which parts of the expansion will impact kangaroos, how many kangaroos will be affected, what actions could be undertaken, and the implications (if any) for ACT's overall kangaroo population, and connectivity between the urban kangaroo populations. These issues are discussed again at 3.4.

Commented [EH34]: Suggest flagging this with Planning staff/ exec

Recommendations

2.4 Make it clearer that kangaroo management for conservation should be understood as one part of a broader conservation management program on reserved land; this could be helped by cross-referencing to the Canberra Nature Park Reserve Management Plan.

Explain how the kangaroo management in the urban and peri-urban areas of Canberra fits into the larger context of kangaroo management in the ACT, including on rural lands, large reserved areas (e.g., Namadgi, Tidbinbilla), and in areas slated for urban expansion.

2.5 Other general comments

The 2010 and 2017 Plans are comprehensive documents that have been followed by a substantial and impressive body of research, monitoring, and management adaptation, particularly for managing kangaroo grazing for conservation in lowland grassy ecosystems. The evolution of the planning, implementation and monitoring that has occurred since 2017, although mostly documented and available on the government website, has possibly become confusing to some stakeholders. A revised management plan for eastern grey kangaroos provides an opportunity to integrate and consolidate the information that is now spread across planning documents and many technical reports (published and unpublished), to help with accessibility.

The 2017 Plan does not include Indigenous People's perspectives about kangaroo management. This should be (and is being) addressed in the revised Plan.

Given the substantial volume of information underlying kangaroo management in the ACT, one presentation option would be to create a shorter, concise plan that focuses on the purpose, goals, objectives, performance criteria, and that steps (more briefly) through the implementation, monitoring and reporting requirements, and then assemble the evidence base for the plan and its delivery into a background document.

The 2010 and 2017 Plans do not consider Indigenous perspectives on the ecological and cultural significance of kangaroos, nor how kangaroos should be managed in a contemporary context with Indigenous participation. With the Plan revision, there is an opportunity to engage with Ngunnawal Traditional Custodians and other Indigenous families, so that kangaroo management moves towards a model of co-design and co-implementation, and the place of kangaroos in Indigenous and Australian culture can be respectfully recognised. The ACT Government has begun this engagement process.

Recommendations

2.5 The documentation of the planning, implementation, and monitoring for kangaroo management on conservation land is unusually rich and also dispersed after some years of activity; the next version of the plan should consolidate and integrate this information, and consider alternative ways of presenting the plan to support accessibility. For example, a shorter Plan with an accompanying, comprehensive Background Document may be helpful.

2.6 The revised Plan should outline the pathways by which the perspectives of Traditional Custodians can be integrated into the framing, design, implementation, monitoring and reporting/evaluation of kangaroo management.

3. ENVIRONMENTAL IMPACTS

Summary assessment

The kangaroo management program in the lowland grassy ecosystems of Canberra Nature Park is an outstanding example of adaptive management. The program is informed by a large body of research, some of it instigated or encouraged by the ACT Government, covering kangaroo ecology in temperate grassy ecosystems, grassy ecosystem ecology, the ecology and conservation of grassy ecosystem species, grazing impacts (on plants and animals), and fertility control for kangaroos. The program monitors kangaroo density and grass layer condition, and uses these data in conjunction with the Conservation Cull Calculator to derive annual cull targets. These elements are well conceptualised and linked, and are being constantly refined. Monitoring data show that the grass layer structure is being maintained within thresholds, as kangaroo densities are managed closer to their targets. ACT Government staff have collaborated widely with the research community to achieve these outcomes. The data gathered during the program have been peer-reviewed by the scientific community and shared with the Canberra public.

The operation and management of the conservation culling program is effective and has put kangaroo welfare at the heart of activities: the ACT conservation culling program far-exceeds the requirements of the national Code for non-commercial kangaroo shooting, and the contracted shooters and ACT Government staff involved in culling strive to improve standards continually.

Main recommendations

Currently, there is limited monitoring of grazing sensitive species because grass layer structure is being used as the surrogate for these species, backed by past, focal research. Ideally, the consequence of improvements to the grass layer on grazing sensitive species would be checked, at least periodically. There may be opportunities to mine data collected in other programs, or adapt the data collection in other existing programs, to demonstrate changes in grazing sensitive species associated with kangaroo grazing management. However, if grazing sensitive species have been lost from reserves, many are unlikely to recolonise unassisted.

The Review recommends developing a strategic translocation program for grazing sensitive plant and animal species (including threatened species, and culturally significant species) into reserves with suitable habitat, where threats are adequately managed. Such a program would accelerate ecosystem restoration and demonstrate the value of managing the threats to these fragments, including grazing management. It could offer enhanced conservation outcomes for plants and animals already being translocated out of the expanding urban footprint; opportunities to gain knowledge about species ecology and what limits their recovery; and opportunities to leverage and extend the participation of community environmental groups, and Traditional Custodians, in reserve restoration. This program should be embedded in a strategic, ACT-wide program to protect, reconnect, and restore ecological integrity across grassy ecosystems on multiple tenures (see cross-plan recommendations).

The Review makes some recommendations to further enhance the regulation and organisation of culling operations so that the community can continue to have confidence that welfare outcomes for kangaroos are being optimised. This includes working with jurisdictional counterparts to update the non-commercial Code for shooting kangaroos, and consolidating details of current practice into a Standard Operating Procedures style of document, with input from key advisory groups.

Commented [WC35]: Rosie - If possible, would be good to recognise that this reflects practical resource constraints. We have talked for years about doing this but it would currently come at the expense of higher-priority threatened species interventions.

3.1 Plan

Kangaroo management planning focusses on the lowland grassy ecosystems which are distributed as remnant fragments around Canberra. These areas include critically endangered ecological communities and many threatened species. Here, heavy grazing by kangaroos could affect ecological integrity and cause local extinctions that would accelerate degradation. The ultimate cause of the situation is not kangaroo grazing; it is habitat loss, fragmentation, and degradation in all its forms. However, if these issues cannot be adequately reversed, then managing kangaroo populations may be one of the few viable options for maintaining ecosystem health and retaining grazing-sensitive species. The 2017 Plan has the following objective for lowland grassy ecosystems on public and unleased land, managed by either the Territory or the Commonwealth:

4. *Kangaroo populations are maintained in lowland native grassy ecosystems at densities that conserve the natural integrity of the grassland ecological community and result in the maintenance of habitat for all grassland plant and animal species.*

The objective is not SMART, and there are no performance criteria or outcomes articulated for this objective, but the Plan is particularly focussed on maintaining the integrity of two nationally threatened ecological communities, and almost 20 threatened plant and animal species that occur in lowland grassy ecosystems.

The two nationally threatened ecological communities are both critically endangered, with important occurrences in the ACT, and both list overgrazing (and undergrazing) by kangaroos as a potential problem.

- White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland (DCCEEW 2023b)
- Natural Temperate Grassland of the South Eastern Highlands (DCCEEW 2023a)

These threatened ecological communities, and other grassy ecosystem remnants, provide habitat for many grazing sensitive species and at last 18 threatened species of plants and animals (Tables 5, 6, section 3.8 in the 2017 Plan).

Specifically, the Plan aims to forestall situations where kangaroo density is high relative to grass growth, and heavy grazing impacts become evident in the grass layer structure, to the detriment of grass-dependent species. This is most likely during extended dry periods. The Plan also considers the adverse environmental consequences for grassy ecosystems when eastern grey kangaroo densities are too low, because kangaroos are large-bodied grazers and important agents of disturbance within grassy ecosystems. However, the focus for management intervention to date has been preventing high intensity grazing, rather than avoiding low intensity grazing. The consequences of episodes of extreme grazing are accentuated in the lowland grassy ecosystems because they are now distributed as small, unconnected fragments. With this configuration, local extinction risks for small populations of threatened and declining species are high, and once extirpated, recolonisation of these fragmented patches is unlikely or impossible for many species. This configuration of remnant grassy ecosystems also has implications for the population dynamics of kangaroos, now living at high densities (from changes to predation, food, water and shelter) but with curtailed dispersal options.

In the higher elevation grasslands of Namadgi National Park and Tidbinbilla Nature Reserve, the default kangaroo management approach is not to intervene; however, intervention is possible if circumstances change. The reasons stated for the difference are that while there is a suite of grazing sensitive species that are at risk from heavy kangaroo grazing in the lowland grassy ecosystems, ~~but~~ this is not the case in the higher elevation grasslands (one grazing sensitive threatened plant, *Gentiana baeuerlenii*, has not been seen in the ACT since 1998). In addition, the Namadgi and Tidbinbilla grasslands are embedded in large, contiguous areas of habitat, whereas the lowland grassy ecosystems of Canberra Nature Park are distributed as small, unconnected fragments. This difference has implications for the population dynamics of kangaroos, and the local extinction risks for small populations of threatened and declining species. Nevertheless, the lack of current data on kangaroo densities across protected areas other than Canberra Nature Park is not ideal. It means there are no data on the largest portion of the ACT's kangaroo population, and it means the status and cull of kangaroos in Canberra Nature Park and other urban reserves cannot be put into context; this is discussed further in Section 7.1, leaving the remainder of section 3 to focus on kangaroo management in lowland grassy ecosystems.

3.1.1 Does the Plan make an evidence-based case for eastern grey kangaroo management?

The 2017 and the 2010 Plans, and subsidiary documents, comprehensively review the evidence that eastern grey kangaroos can reach densities high enough to cause adverse effects on the integrity of lowland grassy ecosystems.

Kangaroos may reach high densities because of the loss of population regulation by predators, and because land transformation has increased food and water availability. Importantly, lowland grassy ecosystems are now distributed as remnant patches, subject to many historical and ongoing pressures related to fragmentation and degradation, species loss, and the effects of introduced species. Kangaroos living at high densities in small urban reserves with a history of degradation may - because of that history and the contemporary context – now

contribute to ongoing deterioration and species loss in those ecosystems (Croft and Witte 2021; Prowse *et al.* 2019). When native species are lost from these remnants, recolonisation is unlikely or impossible. Thus, without management, ongoing deterioration in ecological health and function seems inevitable.

The ultimate cause of the situation is not kangaroo grazing; it is habitat loss, fragmentation, and degradation in all its forms. However, if these issues cannot be reversed, then managing kangaroo populations may be one of the few viable options for maintaining ecosystem health and retaining (and restoring) other grazing-sensitive species.

3.1.1.1 Are kangaroos at high density in the ACT?

The 2010 and 2017 Plans present credible empirical and inferential evidence that kangaroo densities in the ACT are high relative to other temperate areas. Whether these densities are higher than pre-European densities is less certain. Regardless, the more salient issue is whether unmanaged populations of kangaroos could negatively affect the health of grassy ecosystems.

The Plans outline our knowledge of changes in kangaroo distribution and density over time. In brief, kangaroo densities before European colonisation are unknown. Following colonisation, the persecution of dingos and dispossession of Aboriginal people reduced the previous hunting pressure on kangaroos (Croft and Witte 2021; Morris and Letnic 2017). In parts of the ACT where dingoes persist, they appear to limit the population size of kangaroos (Fletcher 2006b). Introduced European foxes (*Vulpes vulpes*) may have partly substituted this role by preying on young kangaroos (Banks *et al.* 2000; Stobo-Wilson *et al.* 2021), and collisions with vehicles on roads now kill large numbers of kangaroos (Croft and Witte 2021; Dunne and Doran 2021). Land use changes including tree clearing, the creation of pasture (and improved pasture) for livestock grazing, and the proliferation of watering points, may have allowed eastern grey kangaroos to expand along the inland edge of their distribution, and may have enhanced resource availability and habitat quality for kangaroos in the temperate regions, including the ACT. The combination of reduced predation and increased resource availability could explain the higher kangaroo densities anecdotally reported during this period, but only temporarily, as kangaroos were systematically persecuted (including via state-organised bounties) by colonists through the late 1800s and into the 1900s, because they competed with sheep for pasture, and damaged fences (Fletcher 2006a; Shumack 1977). Kangaroos were also killed to feed farm dogs.

The 2010 Plan notes that changes to farming practices and communities meant that kangaroo persecution eased from the 1950s, and kangaroo populations increased in reserves from the 1960s to the 1990s. For example, eastern grey kangaroos were observed in only two Canberra Nature Park reserves in 1975, but were present in all 37 reserves by 2021 (Gordon *et al.* 2021). Reliable estimates of kangaroo densities in the ACT became available from the early 1980s, starting with an estimate by Graeme Caughley of 2 kangaroos per hectare in Tidbinbilla Nature Reserve. Estimates in the 1990s and 2000s returned densities of 1.9 to 5.1 kangaroos per hectare in the ACT. Some more recent estimates reach higher values (e.g. 6.6/ha and 7.0/ha, Herbert *et al.* 2021; Snape *et al.* 2021). The 2010 Plan notes that these densities are amongst the highest recorded in Australia. Examples of sites with comparable densities includes grasslands at Wilsons Prom, Victoria (e.g. Plaisir *et al.* 2022). The 2010 Plan also notes that the density estimates for kangaroos on rural lands over the same period (1990s to 2000s), where culling was occurring, were much lower (0.4 to 0.6 kangaroos per hectare). Note that the expansion of urban areas in the ACT may lead, at least temporarily, to higher kangaroo densities if animals are displaced from development footprints into adjacent bushland and rural areas.

3.1.1.2 Can unmanaged populations of kangaroos adversely affect lowland grassy ecosystems?

There is substantial evidence from many years of research, including targeted research on lowland grassy ecosystems in the ACT, to show that when kangaroo grazing outstrips vegetative productivity (which is most likely in dry years), the grassy layer is grazed to very low levels, increasing the risk that remnant patches will experience soil degradation, erosion, and increasing the risk that populations of some species (including threatened species) could be extirpated. Given these risks of an ongoing ratchet of decline, the commitment in the 2017 Plan to manage kangaroo population size and thus avoid further deterioration is supported by the evidence available. It is of course critical that kangaroo grazing and its management is considered in the context of other processes that remove grass – principally fire and grazing by rabbits – and that management across these processes is integrated.

Grazing is a natural disturbance factor in grassy ecosystems worldwide (Gordon *et al.* 2023; McIntyre *et al.* 2004). Grazing prevents a uniformly thick grassy layer from developing, maintaining spaces between perennial tussocks for annual grasses and forbs, and creating a heterogenous structure with niches for diverse fauna (Gordon *et al.* 2004; Price *et al.* 2019; Prober *et al.* 2013). As well as influencing grass layer structure and floristics by grazing, large herbivores also affect plant productivity and composition indirectly via nutrient cycling, and by changing the occurrence of other disturbance processes such as fire (Bowman and Legge 2016; Fuhlendorf *et al.* 2009; Pringle *et al.* 2023). However, although some large herbivore grazing is a critical component of healthy grassy ecosystems, marked increases or decreases in grazing intensity may be associated with negative effects on other species and profound ecosystem changes (Ceballos *et al.* 2010; Foster *et al.* 2014; Ripple *et al.* 2014).

The 2010 and 2017 Plans recognise the critical role of kangaroo grazing as a natural disturbance factor in temperate, lowland grassy ecosystems of southeastern Australia. However, the Plans note that changes in kangaroo population dynamics (arising from changes to top down and bottom up population regulation), the history of degradation to grassy ecosystems and their exposure to ongoing threats, means that kangaroo populations in the remnant fragments of these ecosystems may need active management to avoid further deterioration of ecological integrity. The loss of habitat connectivity means that even a short spell of heavy grazing kangaroos could cause populations of native species to be permanently extirpated from these grassy ecosystem remnants.

The 2010 Plan documented the peer-reviewed evidence, to that point, for high grazing impacts of kangaroos. This evidence base was updated in the 2017 Plan with new research findings, especially from eight studies (see Table 4 in section 3.8 of the 2017 Plan) carried out on the impacts of variation in kangaroo grazing intensity on birds, reptiles, invertebrates and plants. These studies occurred in the ACT and were designed to inform local kangaroo management.

More recent research on temperate grassy ecosystems, published after 2017, support the general patterns described in the 2010 and 2017 Plans (e.g., Driscoll 2017; Morgan 2021; Prowse *et al.* 2019; Travers and Berdugo 2020). A recent review of the effects of overabundant kangaroos in southeastern Australia (Morgan 2021) concluded that a high level of kangaroo grazing tends to have adverse effects on plant regeneration, flowering and seeding, and even on the recruitment of woody shrubs and trees. Effects on species diversity are more variable and context-dependent; for example, when kangaroos are selectively foraging on the dominant grass species, then grazing reduces its competitive advantage and plant diversity may increase. Conversely, if kangaroos are avoiding a dominant grass species because it is unpalatable, then plant diversity will diminish. High kangaroo densities are also shown in this review to affect ecological processes such as fire, water and nutrient cycling, soil health, and habitat structure for fauna. These post-2017 research findings should be incorporated into an updated version of the Management Plan.

Collectively, the large body of work over the past 30 years shows that in temperate grassy ecosystems:

- Rainfall and temperature patterns strongly influence grass biomass productivity (e.g. Fletcher 2006a; McIntyre *et al.* 2015; Snape *et al.* 2021).
- Higher levels of biomass contribute to soil health (nutrient cycling, infiltration); conversely heavily grazed areas have less soil stability, and less water and nutrient infiltration (McIntyre and Tongway 2005).
- As kangaroo population size increases, grass layer biomass reduces, and structure is increasingly affected. The area covered by large tussocks is progressively reduced and replaced by a short sward of small tufted or creeping grasses and forbs (e.g. Fletcher 2006a; Howland *et al.* 2014; McIntyre 2005; McIntyre *et al.* 2015; Neave and Tanton 1989; Snape *et al.* 2021).
- Different plant species respond differently to variation in grazing pressure, with some doing best in heavily grazed areas, some preferring light grazing, some preferring no grazing, and others being generalists (Dorrough *et al.* 2004; McIntyre *et al.* 2015; McIntyre *et al.* 2003; McIntyre *et al.* 2019; Snape *et al.* 2021). Forbs may also respond to grazing by flowering and seeding less (McIntyre *et al.* 2019).
- Maintaining structural heterogeneity at a variety of scales is therefore a pragmatic way to maintain plant species richness. Maintaining some areas of taller grassy structure may be the most difficult grassland condition to achieve when grazing (from all herbivores) is ubiquitous in the landscape. This leads to recommendations such as ensuring that no more than 30% of a patch of temperate grassy ecosystem should be short (McIntyre 2005).

- The structural changes in the grass layer that occur with grazing also affect fauna species, with reductions in species richness and/or abundance reported for beetles, reptiles, and some groups of birds when the grass layer is heavily grazed, noting the grazing effect may interact with other factors (e.g. Barton *et al.* 2011; Howland *et al.* 2014; Howland *et al.* 2016a; Howland *et al.* 2016b; Manning *et al.* 2013; Neave and Tanton 1989).
- Although the effects of extreme grazing on fauna are mostly negative, it is important to note that a minority of species benefit, such as galahs (*Eolophus roseicapilla*) and white-winged choughs (*Corcorax melanorhamphos*) (Howland *et al.* 2016b).
- Some fauna species show strong preferences for a grass layer with intermediate structure, for example:
    - Striped legless lizards (*Delma impar*) prefer grass structures associated with intermediate levels of kangaroo grazing, providing a mix of shelter from predators and the sun, and food (Howland *et al.* 2016a; Scroggie *et al.* 2019).
    - Earless dragons (*Tympanocryptis lineata*) are disadvantaged by thicker grass layer structures that remove open spaces for basking and foraging. However, the dragons also experience increased mortality if extreme grazing (especially during drought) exposes them to increased surface temperatures and probably reduced invertebrate prey (CoA 2023; Dimond *et al.* 2012).
- Maintaining patches of thicker grass (at the scale of animals' home ranges) could help animals evade predators (Leahy *et al.* 2016; McGregor *et al.* 2015). Thick grass patches can also modify microclimates for other plant and animal species, reducing frost and desiccation risks (McIntyre *et al.* 2019).
- Thus, for fauna, having heterogenous grass structure is also a pragmatic way to support species richness.
- Animal species with grass structure preferences that occur at only a small number of sites may need sustained grassland management to maintain their persistence over the long term, including through cycles of wet and dry years, when grass layer growth will otherwise fluctuate markedly.

The 2017 Plan includes two tables (Table 5, 6 in section 3.8) of nine threatened animal species and nine threatened plant species, with comments on their sensitivity to kangaroo grazing. In all animal species, heavy kangaroo grazing has been shown, or is inferred, to be a threat. In four animal species, light kangaroo grazing is specifically noted as a habitat enhancer. There has been less research on the effects of variation in grazing intensity on threatened plants. Based on knowledge of each species' ecology, and some studies of livestock grazing, it seems that some threatened plant species are known to be sensitive to livestock grazing, or to the spread of weeds that can be facilitated by heavy grazing. However, light grazing may be beneficial for some species.

3.1.1.3 Complexities in interpreting research on kangaroo grazing impacts, and in expectations for improving ecological condition

Whereas most studies have shown that gradients of kangaroo grazing pressure or experimental reductions in grazing pressure are related to changes in grass structure and biomass, and in species richness and abundance of plants and animals, some studies have not found this relationship, or reported mixed results, when kangaroo (or livestock) grazing is reduced. This may be partly due to inadequacies and vagaries of the sampling design, especially in correlative studies (e.g., Vivian and Godfree 2014). Sign of species recovery can be obscured by variation among sites in productivity and ecology, canopy cover and dominant grass species (Snape *et al.* 2018), and the legacy of past threats including some that are persistent, such as increased nutrients or invasive species, which can act to filter the species assemblages (Lunt *et al.* 2007; Lunt and Spooner 2005; Price *et al.* 2021; Prober *et al.* 2013; Spooner and Briggs 2008). There may be lag effects in species responses if the more grazing sensitive species have been winnowed out by historic grazing, making a positive response to reductions in grazing pressure difficult to observe (Dorrough *et al.* 2012; Travers *et al.* 2018). Recovery may take many years, especially if seedbanks are lacking (Morgan and Williams 2015) or have been exhausted (Price *et al.* 2021); or species are relying on structural ecosystem components that are slow to re-form, such as woody vegetation and coarse woody debris (Manning *et al.* 2013), or additional interventions to manage fire and invasive species are needed (Spooner and Briggs 2008). Finally, the relationship between kangaroo density and grass structural attributes and species responses may be masked under some climatic conditions and in some vegetation types, becoming apparent mainly in dry years when pasture growth (to offset grazing) is lower, and when kangaroos are forced to be less selective grazers (Dimond *et al.* 2012; Vivian and Godfree 2014).

The complexities of inter-site variation in productivity, ecology, landscape context, and their history of degradation (including which native species have been filtered out) can make it hard to show positive biodiversity outcomes from management actions, including the prevention of heavy grazing. However, the challenge of improving the ecological condition of grassy ecosystem fragments overlaps but differs from the challenge of preventing further degradation. These two issues are easily conflated.

Managing kangaroo grazing and other threats may prevent further deterioration, but if species have already been winnowed out of remnants, then restoring these species will probably require a more active approach of translocations, because dispersal into remnants will be slow or impossible otherwise. This is discussed further in Section 3.5 Value-adding to the program.

The existing Plans tend to focus on the consequences of heavy kangaroo grazing, particularly during dry conditions. This focus is sensible if the main concern is recognising and preventing over-grazing. However, now that kangaroo populations have been reduced at many sites, the revised Plan could also explicitly consider the risks of light kangaroo grazing, leading to a thicker grassy layer, especially if this is sustained over years, because research in the ACT shows clearly that kangaroos avoid eating green pick from very thick grassy areas (Snape *et al.* 2018). This risk may vary from site to site, depending on whether there are grass species there that are likely to become competitively dominant in the absence of grazing (e.g. Driscoll 2017), and which grazing sensitive species are there. For example, it is possible that under-grazing has contributed to declines of earless dragons in recent years (CoA 2023). Given that increasing kangaroo numbers takes time, and kangaroos may avoid thick grass if more palatable herbage is available, it may be necessary to consider other management options for rapidly reducing herbage biomass, such as using fire, or managed livestock, or mowing/slashing. The outcomes from using these tools are somewhat uncertain (see Section 3.2.11 Complementary management), so their use and outcomes should be carefully designed and monitored.

3.1.2 Does the plan have a conceptual model?

Kangaroo management has been underpinned by a conceptual model since the 2010 Plan. Research since then has added to this model. Some of this research was captured in the 2017 Plan but there have been significant updates since then, which will need to be captured and consolidated in the revised Plan.

The rationale for managing kangaroo population size is that high kangaroo density, especially during dry years, can lead to heavy grazing that outstrips herbage growth. In these conditions, herbage will be progressively reduced, grass structure is homogenised, and the extent of bare ground increases. Water and nutrient infiltration is adversely affected, soil erosion becomes increasingly likely, kangaroos begin to starve, some plant and animal species are disadvantaged, potentially to the point of local extirpation. Conversely, very light kangaroo grazing can lead to a very thick grassy layer that is favoured by some species but unsuitable for others (and may be avoided by kangaroos, locking it in that state until drought forces kangaroos to eat it). Thus, aiming for intermediate levels of grazing, and having some heterogeneity in grass structure at scales smaller than the size of a reserve, should provide a range of structural conditions to suit the greatest range of species.

Management decisions were based on a conceptual model with two interacting components: one component that describes the relationships between the grass biomass, grass growth, kangaroo offtake, and kangaroo density; and a second that describes the relationships between grassland structure and its suitability for a range of species. Of the first component, an interactive model of kangaroos and grass biomass was described in the 2010 Plan (Section 5.2, especially Figs 5.1, 5.2), and referred to in the 2017 Plan. This was later augmented by work that describes grass growth and kangaroo offtake depending on a range of variables (Gordon and Snape 2019). All models are discussed further in the next sections on thresholds/targets.

3.1.3 Does the plan have evidence-based thresholds/targets for key metrics?

A careful reading of the 2017 Plan makes it clear that the ultimate focus is the ecological health of grassy ecosystems, that this is tightly coupled to the grass layer, and that kangaroo management is one means of influencing the grass layer. Yet the subtleties of this message seem to be easily lost. For example, the original yardstick of aiming for about 1 kangaroo per hectare in grassy ecosystems of conservation land was always

intended to be starting point for identifying the target density in a reserve, but it has led to misunderstanding in some stakeholders, because they think the density is applied to all areas, in all conditions.

Since 2019, management has been adapted, and now the explicit aim is to maintain the grassy layer within a "safe operating environment" of herbage mass, with lower and upper thresholds. Thus, excessive herbage biomass (from not enough grazing) is considered within the same planning and decision framework as low herbage (from overgrazing). Excessive herbage means culls can be skipped, or ecological burns, slashing, or managed grazing by livestock animals can be used to remove rank grass instead. These actions can increase palatability for kangaroos, helping to make kangaroo management more effective for maintaining grassland health. To support the use of these thresholds, grassland types with different growth patterns have been mapped across the lowland grassy ecosystems of the KMUs, and herbage biomass is monitored across these mapped grassland types. The current reliance on herbage thresholds to determine the target kangaroo density and thus the kangaroo cull is a substantial improvement to the planning approach, it has occurred as part of management adaptation, and it REPLACES the previous use of kangaroo densities, which had been used (until 2018) as a proxy for grassland structure, and tends to be highlighted in the 2017 Plan and the Conservation Culling Calculator.

The most effective adaptive management programs include trigger points, or thresholds, for guiding management interventions. Given the conceptual model underpinning kangaroo management, potential thresholds/targets could be set for

- Kangaroo density
- Grassland structure/condition
- The presence/abundance of species sensitive to changes in grassland structure.

The 2017 Plan and the Conservation Culling Calculator highlight the use of targets for kangaroo density (as a means for optimising grassland structure) for determining how many kangaroos should be culled. Following a workshop convened by the ACT Government in 2018, the management focus shifted to using grassland structure more directly to determine the kangaroo cull. To support this shift, additional research sharpened predictions for biomass growth in individual reserves: empirical data on grass growth and kangaroo offtake for different grass types was collected; the distributions of these grass types across the Kangaroo Management Unit areas were mapped (see Section 3.2.2 Vegetation mapping), and annual condition monitoring has been established in the mapped polygons (see Section 3.2.6 Grass layer data).

This focus shift - from using kangaroo density to using grassland structure to determine the cull is a significant advance in how the management of the grassy ecosystems is approached, but it is not captured in the 2017 Plan. The revised Plan will need to consolidate and clarify the thinking that has occurred over the past six years, which is currently scattered across multiple documents, including some that are not published. This is not a criticism – the situation reflects the real commitment of the ACT Government team to adaptive management, where new information is being used to drive improvements in management. But the revision to the Plan offers an opportunity to bring all the work together in a refreshed document.

Below, the Review considers the evidence underpinning the thresholds/targets used for kangaroo density, grassland structure/condition, and grazing sensitive species.

3.1.3.1 Kangaroo density targets

The 2017 Plan establishes approximate target kangaroo densities for grassy ecosystems, based on an interactive population-pasture model for eastern grey kangaroos developed by Fletcher (2006a). Fletcher took an existing, well-established model that was developed by Caughley (1987), and adapted it for eastern grey kangaroos in temperate grassy ecosystems, using empirical data collected in the ACT during experiments designed for the purpose (Fig. 1). The model describes the interactions between:

- Pasture growth rate, which varies with
    - weather (increasing with rainfall, especially at higher temperatures)
    - herbage biomass

- Kangaroo food consumption (offtake), which varies with pasture availability
- Kangaroo population growth, which also varies with pasture availability

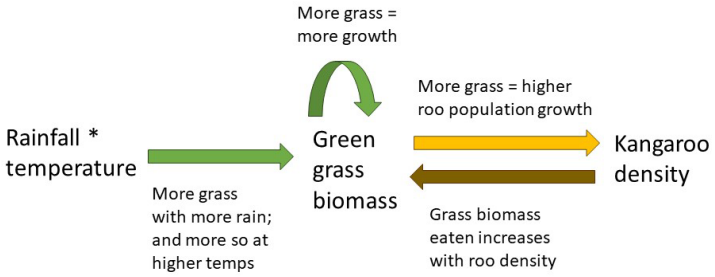

Fig. 1. The interactive kangaroo population-pasture model developed by Fletcher (2006a).

To help inform kangaroo management, Fletcher ran models to estimate herbage mass over time under different scenarios of kangaroo density. A key result of the model is that if densities are high (i.e., >2 kangaroos/hectare), then density needs to be reduced to about 1 kangaroo/ha before the grass layer increases in biomass enough to support grazing-sensitive fauna species (see Figure 7 in Gordon et al. 2021). Independently, research carried out between the 2010 and 2017 Plans on some grazing sensitive species concluded that kangaroo densities somewhere between 0.4 and 1.2 per hectare should provide the right grassy structure for these species (see Table 4 in Section 3.8.3 of the 2017 Plan). The combination of the Fletcher model and the focal work on species led to a rule-of-thumb target density for grasslands of about 1 kangaroo per hectare, under normal conditions. As the canopy cover increases, the target kangaroo density declines commensurately because tree cover reduces the biomass of the grass layer. Target kangaroo densities are thus adjusted as follows:

- 1 kangaroo per hectare in grasslands (0-2% canopy)
- 0.9 kangaroos/ha in open woodlands (2-20% canopy)
- 0.5 kangaroos/ha in woodlands (20-50% canopy)
- 0.1 kangaroos/ha in forest/open forest (50 to >80% canopy).

Of course, these densities are ballpark figures – the optimal density at any place and time will depend on a combination of the weather, the grass species present, and many other factors. These issues are noted in the 2017 Plan and built into the last step of the Calculator (which allows for expert judgement to modify cull figures). However, the intent to use the target density of 1 kangaroo/hectare as only the starting point for estimating the cull, has been lost in some of the public discourse about kangaroo management.

3.1.3.2 Grass layer targets

The impacts of high-density kangaroo populations on other species in grassy ecosystems arises from what kangaroo grazing does to the grass layer, how that affects the resources (food, space and shelter) available to other species, and increases risks of damage to soil health and stability. The 2017 Plan and Conservation Culling Calculator focus attention on using kangaroo density as a proxy for grazing impacts on the grass layer. However, focussing on the condition of the grass layer itself is a more salient measure.

The Kangaroo Management Research Workshop in 2018 (Gordon and Snape 2019) brought together work on the grass structure preferences across a range of species, and recommended that herbage mass, or average grass height as a proxy for herbage mass, be kept in a 'safe operating zone' of 5-15 cm. The safe operating zone thresholds were based on studies of plants, birds, reptiles, and invertebrates (Fig. 2) (e.g. Barton *et al.* 2011; Driscoll 2017; Howland *et al.* 2014; Howland *et al.* 2016a; Howland *et al.* 2016b; Manning *et al.* 2013; McIntyre *et al.* 2015; McIntyre *et al.* 2019; Neave and Tanton 1989; Snape *et al.* 2018). They were also informed by pasture management studies, that recommend not allowing pasture biomass in these ecosystems to fall beneath the point

at which soil health is compromised and erosion ensues (McIntyre 2005). These thresholds (rather than kangaroo density) have been used to determine target kangaroo densities and thus kangaroo culls since 2019.

One of the benefits from this adjusted perspective is that it allows managers to consider excessive herbage biomass within the same planning framework as low herbage because of overgrazing. Excessive herbage means the cull can be relaxed (if higher densities will reduce that biomass), or that another management action is in scope (e.g., ecological burns, slashing, or managed grazing by livestock animals to remove rank pasture). These other management actions can also improve palatability of thickly grassed areas for kangaroos, which may contribute to improving grassland health whilst allowing for higher numbers of kangaroos in the future.

Research underpinning the grass layer targets

Herbage growth, which determines the level of grazing that can occur whilst maintaining the herbage within the safe operating zone, is affected by many abiotic and biotic factors (ACT Government 2023a). To improve the application of the safe operating thresholds to guide kangaroo management, new research was undertaken to:

- Determine the herbage growth rates and kangaroo offtake rates, across different grass types with varying kangaroo densities. This work was carried out during 2014-19 (Snape *et al.* 2018; Snape *et al.* 2021).
    - For each grass type, data were collected from 30 pairs of grazed/ungrazed plots, in remnant grassy ecosystems of at least 100 ha, and with kangaroo densities ranging from 0.4 to 6.6 kangaroos/ha. The sampled years include wet and dry years, so the models are considered 'average'.
    - Overall, offtake rate increases as grass growth increases; increases initially then decreases with the standing grass biomass (because less green pick is produced in thick grass, and the green pick is harder for kangaroos to access); and increases slightly with kangaroo density. However, there are important differences between pastures dominated by different grasses, relating to differences in their palatability, grazing tolerance, and life histories. For example, as kangaroo density increases, progressively more of kangaroo grass (*Themeda triandra*) and red-leg grass (*Bothriochloa macra*) (both native and palatable) are eaten, to the point where these grasses are almost absent at high kangaroo densities. In contrast, kangaroo density has little effect on the feed available in plots dominated by exotic wild oats (*Avena* spp.).
- To use this information in kangaroo management, the vegetation mapping was updated in 2018-19 (see section 3.2.3: Vegetation mapping) The lowland grassy ecosystem portions of each Kangaroo Management Unit were mapped into polygons, where each polygon is categorised as one of four broad classifications ~~(that group 11 dominant grass species)~~ (ACT Government 2023a). The four polygon types are native tussock, native Themeda, exotic perennial with native tussock, exotic perennial with Themeda (ACT Government 2019a).

How the information on herbage growth for different grass types is combined with the updated vegetation mapping to guide target kangaroo densities for each Kangaroo Management Unit (and thus the cull) is reviewed at 3.2.9 Target Population Size.

Considerations for future refinement of targets

Research has suggested that the heterogeneity of grass structure (not just the average biomass), at a variety of scales is important for maintaining grassy ecosystem health. For example, small patches of heavily grazed areas may have some positive effects on plant diversity at some scales (Snape *et al.* 2018; Vivian and Godfree 2014). At the other extreme, patches of thick, rank grass can provide refuge to small native animals from predators (Leahy *et al.* 2016; McGregor *et al.* 2015), and a more favourable microclimate during hot or dry conditions. Heterogenous grass heights at the scale of an individual animal's home range may be beneficial (Brown *et al.* 2011; Howland *et al.* 2016a) and can increase the species diversity, richness or abundance of plants and reptiles (Smith *et al.* 2018; Snape *et al.* 2018). The importance of heterogeneity in grassy ecosystems with large herbivores is a recuring pattern in the global as well as the Australian literature (e.g., Fischer *et al.* 2004; Fuhlendorf *et al.* 2009).

The ACT Government's Herbage Mass Guidelines (ACT Government 2019a), currently in draft form, highlights the importance of heterogeneity in the structure of the grass layter. It states that large, homogeneous areas of very

short, or very thick grass, should be avoided, and includes an aim to achieve "a mosaic of patches of grass with intermediate height and density interspersed with patches of shorter sparser grass and patches of longer denser grass". The 2018 workshop report implies that grass structural heterogeneity at small scales is to be achieved by aiming for average grass heights of 5-15 cm. There may be value in considering heterogeneity at medium and larger scales, such as the Kangaroo Management Unit, so patches of marsupial lawns and patches of thick grass are acceptable, if their spatial extent stays within thresholds (e.g., <30% for marsupial lawns, McIntyre 2005). The ACT Native Grassland Conservation Strategy and Action Plans also notes this type of heterogeneity as a target to aim for (ACT Government 2017a). The data that are already being collected during the grass layer monitoring (such as variability in the amount of bare ground, or of grass height, across sampling quadrats Snape *et al.* 2018) should be sufficient to set thresholds for meaningful heterogeneity metrics. As well as metrics relating to grass structure, heterogeneity targets could include more durable structural elements such as logs, shrubs, and rocks, which can affect plant and animal richness on very small scales (Barton *et al.* 2011; Manning *et al.* 2013; McDougall *et al.* 2016).

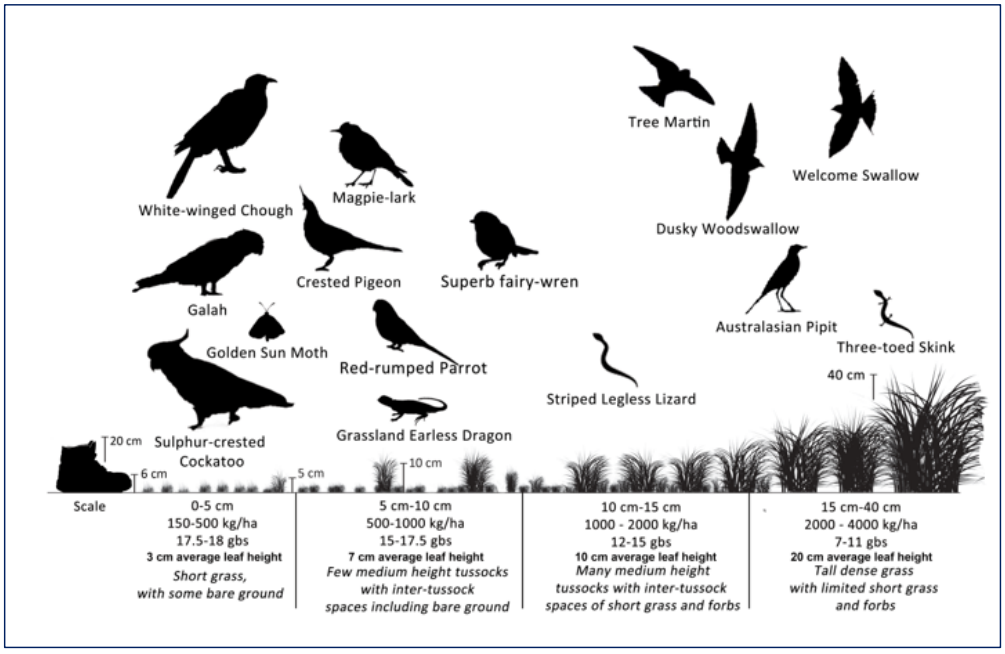

Fig. 2. Some species have preferences for specific grass structures, including some threatened species. Aiming for an intermediate structure, on average, with spatial heterogeneity in that structure, should provide suitable habitat for a wide range of species. (Figure by Brett Howland).

3.1.3.3 Grazing sensitive species targets

There are no targets for grazing sensitive species in the current Plan. Instead, the focus has been on managing the grass layer to optimise habitat for these species, based on the results of focal research into grazing sensitive species. This is a potential weakness of the management program.

Currently, there are no targets for grazing-sensitive species across the reserves. However, focal research has demonstrated the link between grass layer structure and species richness, and the presence of some grazing-sensitive species (e.g., Barton *et al.* 2011; Driscoll 2017; Howland *et al.* 2014; Howland *et al.* 2016a; Howland *et al.*

2016b; Manning *et al.* 2013; McIntyre *et al.* 2015; McIntyre *et al.* 2019; Neave and Tanton 1989; Snape *et al.* 2018). In addition, maintaining the grass layer thick enough to support water and nutrient infiltration and prevent erosion will maintain longer term ecosystem health for all species (McIntyre and Tongway 2005). Using grass layer structure as a proxy for habitat quality for fauna is therefore a reasonable approach.

Nevertheless, it would be ideal to include targets for the maintenance and recovery of grazing sensitive species in reserves with sustained grassy layer management. Managing grazing should benefit grazing sensitive species that are still present in the remnants, as long as their recovery isn't suppressed by other factors, such as high nutrient levels in the soil, or abundant weeds. At the very least, the program could have a target to retain grazing sensitive species in reserves where they currently exist.

Species that are mobile, such as birds, could respond to management by increasing in density, or by using reserves even in drought conditions, whereas in the past they may have been absent when the grass layer was too heavily grazed. However, less mobile species are unlikely to recolonise the isolated reserves if they have been extirpated. This, together with the land use history, may explain why a review of a subset of grassy ecosystem restoration projects found that passively waiting for species to recolonise and recover tends to have muted outcomes (Price *et al.* 2021).

Grazing sensitive plant and animal species have certainly been lost from some Canberra Nature Park reserves, because of the long history of degradation. One way to accelerate the grazing management outcomes and demonstrate the improved ecological health of the reserves would be to design a program to reintroduce grazing sensitive plants and animals into reserves where they occurred, or are suspected to have occurred, in the past (see Section 3.5 Value-adding). These could be a mix of threatened and non-threatened species, including culturally significant species for the Ngunnawal and other Indigenous people. Once an initial analysis was undertaken to identify which species could be translocated into which reserves, it would be possible to set five and ten year targets for the program. These translocations would be considerably less expensive than the Mulligans Flat-Goorooyarroo Project, as they do not seek to exclude foxes and cats from a very large reintroduction area. They also offer the opportunity for substantial involvement from the Canberra Community, especially through the ParkCare groups. The urban expansion means that individuals of some grazing sensitive species are sometimes being moved already, usually just beside the developed area, or into areas where populations of that species already exist, which is unlikely to result in a net conservation benefit for that species. Instead, moving these animals into a reserve where they might establish a new population, would be a better conservation outcome.

Commented [WC36]: Rosie - This has been happening for pink tailed worm lizard I believe (Richie Milner's work)

3.1.3.4 Fertility control target

Fertility control is an option for reducing the population growth rate of small populations with limited immigration. It is a useful addition to the menu of control options. To be effective, a high enough proportion of females need to sterilised so that recruitment from non-treated, fertile females balances mortality. The initial target proportion, based on a population growth model constructed from empirical data from ACT kangaroos, is approximately 70%, and seems reasonable as a starting point.

The ACT government has carried out and supported substantial research into developing a contraceptive approach for controlling kangaroo population growth, that can be delivered humanely, cost-effectively, and that lasts for a reasonable length of time. GonaCon is an immune-contraceptive fertility vaccine that causes infertility for several years, without affecting young that are already present (Wimpenny *et al.* 2021). The vaccine is administered by capturing, sedating and injecting the animal in the thigh (and ear tagging it for later identification). The vaccine can be injected remotely using a dart (Hampton *et al.* 2021), which would be preferable as it would reduce the chances of injury and death to the animal.

Fertility control is likely to be of greatest value in smaller populations where immigration and emigration are limited, and it could be a useful tool for situations where shooting kangaroos poses unacceptable safety concerns to people. It should also be cost-effective, as it removes the need for an annual shooting cull (Wimpenny 2022). Note that although it may prevent population growth, culling may still be required to bring the population down to target levels before the fertility control can be used effectively.

The initial target for fertility control, in populations where this is being used, is to treat around 70% of all females. This target is based on a model by Hone (see Figure 6 in ACT Government 2023a) which considers a population at growth equilibrium (2.1 kangaroos/ha); a maximum theoretical growth rate of r = 0.55; and a fecundity rate of 0.7 young per female per year. This seems a sensible starting point, and can be refined, if needed, in the future.

GonaCon has been used since 2022 at two KMUs (Mulligans Flat and Farrer Ridge), and a third KMU (Mulanggari) is being added in 2024. The 2023 conservation advice reports that the required treatment level ~~(70%)~~ had still not been achieved at either Mulligans Flat nor Farrer Ridge, but activity during 2023 brought the proportion of treated females up to target levels at both sites. GonaCon use may be extended to an additional five KMUs (Wimpenny 2022).

Commented [EH37]: Exciting! We may want to note this in the media release so that min gets the op to announce program expansion.

Recommendations

3.1 The revised Plan (and edits to the Conservation Culling Calculator) should consider how to be very clear that grass layer structure and health is the critical attribute that affects many other species, that kangaroo density and culling targets are based on grass layer monitoring data, and thus the target kangaroo densities can vary between reserves and years depending on the condition of the reserve and the weather expected over the coming year.

3.2 The existing Plans tend to focus on the consequences of heavy kangaroo grazing, particularly during dry conditions. This focus is sensible if the main concern is recognising and preventing over-grazing. However, now that kangaroo populations have been reduced at many sites, the revised Plan could also explicitly consider the risks of light kangaroo grazing, leading to a thicker grassy layer, especially if this is sustained over years. This risk may vary between sites. If risks are material, and kangaroos either can't remove the herbage (because their density is low) or wont (because it is unpalatable) then this could trigger other management options (e.g., fire, managed livestock, mowing), but they should be implemented carefully and outcomes monitored. [see also recommendation 3.10]

3.3 Given the importance of heterogeneity in grass structure at small to larger scales, explore the scope for including heterogeneity metrics and targets in the grassland condition monitoring and reporting, based on the existing data being collected.

3.2 Implement and Monitor

The review considers the Implementation and Monitoring stages of the kangaroo management together because they are inseparable in the annual cycle of planning, implementation, and monitoring, particularly for the component of the Plan that focuses on managing environmental impacts from kangaroo grazing.

3.2.1 Summary of the annual work cycle

Annual workplans for reserves in the Canberra Nature Park are set out in annual 'Conservation Advices'. The workplan is iteratively and tightly based on extensive monitoring data and other contextual information, so the Review considers these steps together.

- The objectives for kangaroo management are set for spatially defined operational areas called **Kangaroo Management Units** (KMUs).
- Kangaroo management in each KMU may include direct actions (culling, fertility control (since 2022)), and/or complementary actions than manipulate grassland attributes directly and thus the kangaroo population indirectly (ecological burns, slashing, managed livestock grazing, physical exclusion).
- The management actions are informed by data including:
    - Kangaroo population monitoring
    - Predicted kangaroo population growth over the next year
    - Grassland monitoring and predicted herbage biomass gain
- If a cull is planned, the number to be culled is determined, using the information listed above, in a formal process set out in the Conservation Cull Calculator, and based on current kangaroo population size and predicted growth; the amount of herbage available given the target herbage biomass; plus other

contextual factors. These factors include considering the presence of threatened species with narrow requirements for grassy layer structure, or other factors.
- Data from previous years monitoring and operations are available in each year's conservation advice, to show how the workplan and culling targets are arrived at.
- The annual workplan across all reserves is prioritised.

For other land managed for environmental outcomes
- The ACT Government staff may assist with the design, conduct and/or analysis of the kangaroo population monitoring, and grassland condition monitoring. They may provide advice on an appropriate cull target, based partly on the kangaroo population estimates, and grassland condition metrics if these are available. At some sites, the ACT Government assists with monitoring of threatened species.
- The extent of the assistance provided by the ACT Government depends partly on the conservation significance of the site (e.g., more help if threatened species present).

Below, the evidence used in these steps is reviewed.

3.2.2 Kangaroo Management Units

The delineation of Kangaroo Management Units – areas within which kangaroos are reasonably sedentary - almost certainly improves managers' abilities to track and manage populations of kangaroos.

A KMU is an area with one kangaroo population, because it has boundaries that constrain kangaroo movement, such as suburban edges or busy roads. Each KMU has at least one nature reserve, as well as other land used by kangaroos and managed by other landholders. Government staff or contractors are responsible for a proportion of the overall cull that is determined by the proportion of the KMU that is reserve (overall, about two-thirds of the KMUs are reserves). The other landholders are responsible for the balance of the cull. The KMU approach probably introduces some operational complexity, if substantial proportions of the cull for a KMU are the responsibility of a private landholder. Nevertheless, KMUs are an important innovation: by considering kangaroos populations within KMUs rather than solely in the reserves, the population density estimates, cull targets and associated monitoring are all more accurate and meaningful.

The delineation of KMUs has been informed by studies of kangaroo movement using radiotelemetry, and evidence of stability/instability in population size from repeated surveys (ACT government, unpublished data, Henderson *et al.* 2018; Smith 2018; Viggers and Hearn 2005). A trial to evaluate the efficacy of culling kangaroos at the sub-KMU scale showed that considering the population at the KMU scale was more likely to be effective (Pulsford and Snape 2019). The approach relies on assuming that kangaroos are reasonably sedentary within the KMU boundaries. This assumption is based on behavioural studies, including some done in the ACT, that show site fidelity by maternal-offspring groups and wider-ranging movements by males (reviewed in, Herbert *et al.* 2021). Given the fluid nature of kangaroo social organisation, and that they use home ranges but are not territorial, it is possible that individuals move short distances to exploit resources that become available (e.g. Wiggins *et al.* 2010), and that males move further seeking mates (Smith 2018). This seems to be borne out by genetic studies which show weak population genetic structuring or high levels of gene flow at regional scales (Brunton *et al.* 2022; Zenger *et al.* 2003). Nevertheless, as a planning instrument, KMUs almost certainly improve managers' abilities to track and manage populations of kangaroos.

3.2.3 Vegetation mapping

Two types of vegetation mapping are used to describe vegetation and thus inform kangaroo management. Satellite imagery was used to map vegetation across about a third of the ACT, including all urban and peri-urban bushland, into one of five classes, from open grassland to forest. The grass layer biomass, and thus kangaroo densities, vary inversely with canopy cover. This mapping can be used as a guide for determining coarse target kangaroo densities. Within the lowland grassy ecosystems of the KMUs, a more detailed mapping of the grass layer carried out in 2018-19 is improving estimates of herbage growth, offtake rates, and thus sustainable kangaroo densities in these mapped areas. The vegetation mapping helps decision-making and contributes to effectiveness.

Kangaroo densities vary across grasslands, woodlands, and forests, because the amount of grass biomass is inversely related to the canopy cover. Any measures of, or targets for, kangaroo density in the KMUs therefore need to consider the balance of vegetation types. The vegetation was mapped initially usinged satellite imagery (Wimpenny *et al.* 2015). This mapping classed bushland areas into one of five structural classes based on tree canopy cover (grassland: 0-2% tree canopy; open woodland: 2-20%; woodland: 20-50%; open forest: 50-80%; forest: >80%).

More recently, the KMUs have been more finely mapped into 'management polygons', according to their dominant perennial grass type (Themeda, native tussock, exotic perennial with Themeda, exotic perennial with native tussock) (ACT Government 2023a). This adaptation of the vegetation mapping underpins stratification of the sampling for the grassy layer structure and condition monitoring which is used in the calculations for the kangaroo cull in each KMU.

3.2.4 Kangaroo population monitoring

Commented [EH38]: Is there scope to further or more clearly dispute other methods the community try to use?

The kangaroo population monitoring is undertaken using direct counts, sweep counts, and distance sampling. The population estimation is carried out immediately before the culling season, so the data used to inform cull targets are current. Evidence that the population estimations are sound include 1) these methods are well-established in the scientific literature; 2) the distance sampling transects are spatially well-designed, carried out carefully, and are long enough to produce estimates with reasonable precision; 3) in trials the different methods have been shown to produce comparable population estimates; 4) for most KMUs, the annual count and cull data interleave in a coherent manner; and 5) in a sample of KMUs, the annual population estimates and population growth predictions are well-matched.

Kangaroo population size is estimated separately for each KMU. Population estimations are carried out between December to March, not long before the culling ~~season~~ program (usually May to July). This is a recent procedural adaptation; previously counts were carried out between April to June, just after culls, which meant that 10-12 months elapsed between the count and the next cull (Gordon *et al.* 2021).

The approach for monitoring kangaroo populations was outlined initially in Appendix 1 of the 2010 and 2017 Plans. Monitoring methods used in Canberra Nature Park since 2009 have included:

- Direct Counts for small areas with open vegetation.
- Sweep Counts for larger areas with mostly open vegetation.
    - For both direct and sweep counts, the area is counted at least twice, with those counts averaged. If the counts are very different (i.e., > 10% away from the average), then another count is done. The three counts are either averaged, or if one count differs substantially from the other two, it may be excluded.
- Distance sampling along walked line transects, with ~44 km walked per reserve, aiming to achieve a coefficient of variation less than 15% at 'average' kangaroo densities for the ACT (ACT Government undated; Coulson *et al.* 2021). Transects are parallel, running NW-SE to avoid being blinded by morning sun, and transects surveyed on any one day are at least 600 m apart. The population density estimation is based on a detection function, which describes that detecting kangaroos far off the transect midline is harder than detecting kangaroos close to the transect midline. Bearings and distances of kangaroos off the transect line are determined using a rangefinder. Post survey, the data in the KMU are stratified by vegetation type (ACT Government undated).
- Faecal Pellet Counts (Coulson *et al.* 2021). Quadrats that have been previously cleared of pellets are surveyed after a period of time. Such counts are more accurate when the KMU is stratified by ecosystem type.

These are all well-established survey methods for estimating kangaroo population size or density (reviewed in, Coulson *et al.* 2021). The ACT government has also compared the estimates produced by differing methods, and found them to be comparable, but concluded the pellet counts were less useful because they were resource-intensive, and potentially disrupted if rain falls between the clearing and counting steps (ACT Government undated). As a result, pellet counts are no longer used, and distance sampling has increased. Robust population estimates using distance sampling requires that three assumptions be met: kangaroos on the transect line are not missed and have a detectability of 1 (which should be fine in grassy ecosystems with good visibility); kangaroos

will move away from the transect rather than along it (if this happens, the observer should usually notice it and avoid double counting); kangaroos do not move before they are detected and recorded by the observer (not usually a problem with habituated populations, and can be noticed if the detection function suggests that kangaroos have higher detectability away from the midline of the transect than on the midline).

In the 2023 conservation advice (ACT Government 2023a), the kangaroo population estimates for 16 KMUs are presented. Two were based on direct counts, two on sweep counts, and the remaining 12 on distance sampling. Of the latter, the coefficient of variation was less than 25% in 10 KMUs. The conservation advice also contains maps showing the transects walked in each KMU, and their scheduling (to avoid counting the same kangaroos on adjacent transects). The advice also presents the data (as available, from 2009) on each year's population density estimate, the cull achieved, and the projected population increase for the following year. In some KMUs, the projected population increase matches the following year's density estimate quite consistently (e.g., Crace, Gundagerra), in others there is less consistency (e.g., Dunlop). Presumably these inter-KMU differences are partly related to the potential for kangaroo movement into and out of the KMU. Nevertheless, the fact that the combination of each year's population estimates with the culls achieved are mostly internally coherent suggests the population estimation is working adequately.

ACT Government staff have carried out trials of, and are continuing to explore, the use of drone-based surveys as an alternative survey technique (ACT Conservator of Flora and Fauna 2020). Although there seems no need to change density estimation methods, it's always worth keeping an eye on alternative approaches in case they are useful in certain circumstances.

3.2.5 Kangaroo population growth predictions

The kangaroo population growth predictions are based on using empirical data to describe the relationship between one year's population density and the next. The population growth equations were developed with one set of empirical data, then validated with another set of empirical data. The population growth predictions do not incorporate the influences of inter year variation in food availability, nor mortality (caused by adverse winter weather and road collisions), but they nevertheless perform well, predicting within the 95% confidence band of the following year's density most of the time.

Each year's cull aims to remove kangaroos so that the population in the KMU in the middle of the coming year is the ideal size. This means the cull needs to account for the potential population increase through the year. Fecundity in female kangaroos is high each year (Herbert *et al.* 2021), but recruitment of juveniles is variable, with subadults (and older animals, Bergeron *et al.* 2023) dying when food is limiting, or weather is adverse (Juillard and Ramp 2022; Portas and Snape 2018). Thus, kangaroo growth rates are variable; growth rates of up to 40% per annum have been recorded in the ACT (see Table 1 in Gordon *et al.* 2021), although rates from 5-15% are more common.

As well as varying with food availability and weather, the population growth of kangaroos (r) is density dependent (i.e., decreasing as population density increases). The relationship between the current density and the growth rate has been estimated using empirical data from the Canberra Nature Park reserves, as:

$$r = 0.317 - 0.151 \times N_t \text{ (where } N_t \text{ is the starting density)}$$

The population growth (r) is used to predict the next year's population density using the logistic equation:

$$N_{t+1} = N_t \times e^r$$

The predictions for population density have been validated against empirical data (Hone 2022, cited in the 2023 conservation advice, and Hone and Snape 2024).

Kangaroo population growth will depend not only on the starting density, but also on the weather, the rate of road collisions (Herbert *et al.* 2021), as well as the grass type, standing biomass, and therefore the amount of green herbage available (Snape *et al.* 2018; Snape *et al.* 2021). For example, the kangaroo population at Farrer Ridge

declined from 3.4 to 1.5 kangaroos/ha between 2015-19 without culling, and despite high female fecundity, because of drought conditions that reduced food availability (ACT unpublished data in Herbert *et al.* 2021).

A future iteration of the population growth predictions could possibly incorporate these complexities, especially the influence of food availability on population growth (e.g. Fletcher 2006a), given that food availability has a strong effect on subadults survival (Fletcher 2006b; Portas and Snape 2018) but the current approach is performing well under 'average' conditions, with predicted densities falling within the 95% confidence interval of nine out of 11 populations, and with the remaining two being one underestimate and one overestimate (Hone and Snape 2024).

3.2.6 Grass layer data

Grass layer composition and structure are measured in the mapped management polygons to track changes over time, and to inform the calculations of the kangaroo cull targets for each KMU. Dominant grass species, grass height, the percentage that is green, and the percentage cover, are combined for use in the calculations for the target kangaroo density. Finer-grained data on grass species and ground cover metrics are being collected, but are not yet used in reporting.

The pasture growth and offtake relationships with kangaroo density have been considered for dominant grass types within each KMU separately since 2019. This refinement should substantially improve the ability of managers to maintain the grass layer in the optimum range.

To measure the grass layer structure and condition, sampling occurs in spring and summer (before the culling season) within the management polygons. Each polygon has two permanent survey plots. A survey plot is an 11m radius circle.

- Ten 1m² quadrats are randomly placed within the 11m radius circle. Within the quadrats, the average grass height, dominant grass species, and the percentage of grass that is green (indicates palatability, productivity) is recorded. This information is used to inform the cull targets for the KMU (see Section 3.2.8).
- Within the circle, a step point survey (75 random steps) is carried out, and the vegetation at the toe-point is classed into one of 13 groups (native C4, native C3, native, native forb, cryptogram, rock, leaf litter, thatch, dead forb, bare ground, exotic forb, annual grass, exotic perennial grass). The percentage grass cover is estimated from these data. This information enables changes in composition to be detected over time (Snape *et al.* 2018).

The grass layer monitoring data are gathered from over 700 plots each year (ACT Government, pers. comm.), entailing considerable human resources to collect. Much of the data collected during this monitoring are used for other purposes, and not used routinely in reporting for the kangaroo management. It could be worth considering whether a rapid assessment approach for key variables might be possible, so that the grass layer monitoring for kangaroo management purposes can be carried out more quickly, at additional sites (e.g., in Namadgi NP, or on rural lands). ACT Government staff mentioned they had started working on a web-based tool to support landholders to establish cull targets, that incorporated a rapid assessment of pasture biomass as one of the input steps.

Commented [WC39]: Did this come from Brett or Rural Services team? I've not heard about it. We have updated the rural cull application form so it now tells the landholder what there maximum cull number is but that is purely based on the Rural Cull Calculator

Recommendations

3.4 Consider the value of a rapid assessment approach to estimate key grass layer condition, in order to monitor a wider range of sites.

3.2.7 Other information that can be used to adjust the cull targets

Other information *used to adjust the cull targets include the predicted weather, whether females have been contracepted, and other contextual information.*

The cull targets can be adjusted using:

- Information about the weather outlooks over the coming year. This can be used in a qualitative way to moderate expectations about herbage growth, and thus adjust the cull targets.
- The proportion of females treated with fertility vaccine (for KMUs where this option is in place).
- Whether other landholders in the KMU are likely to carry out culling on their land.
- Large numbers of kangaroos die from collisions each year. The toll is male-biased, and spatially dynamic (Dunne and Doran 2021). However, although collision data is used to infer movement pathways between KMUs, it is not used to adjust cull targets.

3.2.8 Conservation Culling Calculator

The Conservation Culling Calculator sets out the logic for calculating the number of kangaroos to be culled in an area, to reach kangaroo densities that are optimal for ecosystem health. The cull is the difference between the target number of kangaroos and the current population, making allowance for the population growth expected in the coming year, and allowing for target adjustment based on expert consideration of other factors. Initially, the size of the target population was guided by Fletcher's interactive population-pasture growth model outlined in the 2010 Plan. More recently, the target population size in reserves has been mostly determined using data directly from the grass layer monitoring in the management polygons. This adaptation is a significant advance because it bases the cull targets directly on the structure of the grass layer, and allows kangaroo densities to vary. Ideally, it would be further improved by more formally incorporating the effects of the predicted weather over the coming year on grass growth.

The (A) **target number of kangaroos to remain** after culling is subtracted from (B) the **current population**, making allowance for (C) **population growth** in the interim to the next cull. The three components of this formula are explained in the following (A to C).

A. The target population size for the KMU.
    - This was initially based on the size of the KMU and the relative proportions of different grassy ecosystems with differing capacity to support kangaroos: 1 kangaroo per hectare in grasslands; 0.9 kangaroos/ha in grassy woodlands; 0.5 kangaroos/ha in woodlands; 0.1 kangaroos/ha in forest/open forest. The Ecosystem mapping is based on satellite image analysis (Wimpenny *et al.* 2015). The approach can still be used for areas that lack management polygon mapping.
    - From 2019, the target population size for ~~the lowland grassy ecosystem portions of~~ the KMU has been based on estimating how many kangaroos can be supported in that KMU given the grass types and herbage mass available, to keep the herbage within the grass height targets. See 3.2.8.1 Target population size just below for how this is calculated.

B. The current population size of kangaroos. This is determined by on-ground surveys.

C. The estimated population growth rate for that KMU, which is based on the population growth model, sometimes adjusted for sites that have high rates of immigration, or ~~are~~ fences (reducing mortality), or for populations with contracepted females.

Expert ecological judgement is used to adjust the Calculator figures by considering site-specific management requirements (such as the presence of a threatened species with narrow herbage needs); or other management interventions (such as ecological burns, or managed livestock grazing). In addition, the advent of female contraceptive treatment since 2022 in two KMUs (increasing to three in 2024) can cause the cull target to be adjusted down. Density targets derived from the herbage biomass models in wet years are also adjusted down if they would exceed the ecological carrying capacity based on the population growth models (of 2.1 kangaroos/ha), and impose high risk if conditions turned suddenly from wet to dry. Similarly, target densities may be adjusted upwards if they would be lower than the number that will allow the population to grow to the average long-term density (from the Fletcher model) within two years, ~~or~~ which would increase the risk of stochastic and genetic risks. This flexibility, built into the Calculator, is critical for allowing the annual implementation to adapt as new evidence becomes available.

3.2.8.1 Target population size

For areas with the satellite-based vegetation mapping, the target densities (before adjustment using expert judgement) are estimated to vary proportionately with the canopy cover and thus grass biomass. Thus, target kangaroo density in grassland is 1/ha; in open woodlands it is 0.9/ha; in woodlands it is 0.5/ha; in open forest it is 0.1/ha.

For KMUs with management polygon mapping, target kangaroo densities are calculated using the polygons' grass layer data. The information on target densities for multiple polygons (of given areas) within one KMU are combined to reach the target population size (and density) for the entire KMU.

Management polygon mapping may cover only part of a KMUs. The areas outside the management polygons contain a relatively small proportion of the overall kangaroo population, as they will be the more wooded areas, with less grass available. The densities in these areas are currently set as zero, which could lead to slight underestimation of the kangaroo population, but will be changed to the target densities from the original population-pasture interactive model.

Commented [WC40]: Miles and I chatted to Mel about this. Her research showed very little/no offtake in the low palatability grasses that dominate the woodland/forest areas. After having a closer look at some of the maps, we decided that rather than using the original model for the unmapped areas, it was probably better to review the management polygon mapping and add new polygons into some of the sites (eg Red Hill and Mt Taylor) because there seems to be areas of grassy woodland that were missed (they might not have been grassy when the mapping was done during drought!). We will aim to do that in time for next year. This year we will likely use the existing herbage mass data and other veg mapping data to adjust the targets to account for the additional grassy areas.

Managers can manipulate the change in grass layer biomass over the coming year (increasing or decreasing the biomass) by manipulating the number of kangaroos. However, the relationships between kangaroo density and biomass change are complicated because kangaroo offtake rates vary with grass type, the initial biomass, the annual growth rate, and even kangaroo density itself; annual grass growth also varies with grass type, and initial biomass (Snape *et al.* 2018; Snape *et al.* 2021). Target kangaroo densities are therefore calculated separately for each management polygon, based on data for the grass layer from that polygon, then combined across the KMU, as follows:

1. For every management polygon, calculate the Total Food Available in the year

Total Food Available = the difference between the current and the target Herbage Mass + Anticipated Annual Growth

where

- Herbage Mass is based on the Average grass height, the % Green herbage, the % Cover, and the Dominant grass species

and

- Anticipated Annual Growth (annual change in herbage mass) is based on the Average grass height & Dominant grass species for both spring and autumn growth (note that growth in autumn is mostly negative)

2. For every management polygon, calculate the anticipated annual per capita offtake (offtake is how much a kangaroo eats per hectare, and it varies with Dominant grass species, Herbage Mass and Season)

- Annual offtake: Spring offtake and Autumn offtake
    - Spring offtake is based on Dominant species, Herbage Mass and Spring Growth
    - Autumn offtake is based on Dominant species, Herbage Mass and Autumn Growth

3. For each management polygon, calculate the target kangaroo density:
    - Total Food Available / per capita offtake

The parameters for herbage growth and offtake used in these calculations are based on empirical data covering years of varying rainfall, and are considered 'average' values suitable for years with average weather. If conditions are very dry, or very wet, the anticipated herbage growth could vary substantially from the actual growth in the year following the cull, but there will not be another opportunity to adjust the kangaroo population size. For example, if conditions turn out to be wetter than average, the post-cull population could be smaller than ideal and grass could exceed the height thresholds. If conditions are drier, the post-cull population could be too large, and grass could be lower than the height threshold, but follow up culls outside the culling season are not possible.

Alternative management options such as planned burns, slashing, and using a managed livestock herd for a short period, could be used to reduce grass biomass (see Section 3.2.11 Complementary actions). To prevent damaging levels of grazing when grass heights are too low, physical exclusion from small areas using fencing and logs can be used, noting these are only effective at small scales (Manning *et al.* 2013; McDougall *et al.* 2016).

To be effective, these alternative measures would need to be used rapidly and flexibly. There is a 'Herbage Mass Working Group' that potentially could oversee such decisions, and the Herbage Mass Management Guidelines outline the use of these tools, and include some decision trees for triggering their use (ACT Government 2019a). It was not clear to the Review how consistently and responsively these guidelines were being used, nor whether outcomes were being monitored.

Commented [WC41]: Rosie - I think the threat prioritisation tool (the tool Claire highlights here) is worth mentioning - it is an evidence-based tool rangers can use to work out what intervention is most appropriate at that particular spot. It is being used already in some cases, and it will be rolled out more broadly once a current process of automation of workflows is done.

I might get Brett to check this section and get back to you...

Herbage growth in temperate grassy ecosystems is strongly affected by temperature and rainfall as well as by soil type (Cullen *et al.* 2008; Fletcher 2006a). Given the potential consequences to the grass layer when actual rainfall conditions deviate markedly from average, it would be ideal to incorporate weather predictions for the coming year. Potentially this step could be informed with data on herbage growth, for each of the dominant grass types, under conditions of varying rainfall and temperature. This step could also be approximated by incorporating the rainfall-temperature influences on herbage biomass from the Fletcher model. Alternatively, it may be possible to adapt existing models used to manage livestock stocking rates on different pasture grasses, for use in kangaroo management (see Alcock, D. in, Gordon and Snape 2019). The barrier for achieving this is that weather predictions over the coming year are not reliable enough, but if that situation changes, then incorporating the effects of the coming year's weather into herbage response would be very useful.

3.2.9 Prioritisation of management actions

The annual conservation advice ranks KMUs for annual culls, based on a prioritisation framework that considers the extent of nationally endangered ecosystems, the presence of threatened species and their sensitivity to grazing levels, the strategic conservation importance of the site (e.g. its role in landscape connectivity), and the level of prior/ongoing investment at the site. Having a transparent mechanism for prioritising culls is very useful, because it lays out the values that the kangaroo management seeks to protect, and the factors that managers must consider when deciding where and how to allocate effort.

The framework is a guide rather than a hand-and-fast decision tool, which seems appropriate. Some KMUs with low scores do have culls in place (e.g., Aranda-Painter), and conversely, some reserves with high prioritisation scores have lacked culls (e.g., Mt Taylor). Conversations with ACT Government staff indicate these deviations are often about operational feasibility.

If the recommendation to develop a reintroduction program for grazing sensitive species is accepted (Section 3.5 Value-adding), then the framework could add consideration of the potential suitability of a KMU for translocating priority species, so that reserves that currently lack such species can be prioritised for grazing management, so their condition is optimised for future translocations.

Recommendation

3.5 Include the potential suitability of the reserve to receive a (future) translocation of a grazing sensitive threatened species as part of the prioritisation framework.

3.2.10 Culling operation

The culling operation is conducted by contracted professional shooters and trained ACT Government staff according to the 'National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-commercial Purposes' (NRMMC 2008), which was adopted in the ACT from March 2014. This Code deals with killing kangaroos (adults and young) for purposes such as conservation management or compassionate euthanasia.

Further commentary on the conduct of culling, and recommendations, are provided at Section 4.2.2 Culling operation (on rural lands), and Section 6.1.1 Kangaroo welfare during culling.

3.2.11 Complementary actions for maintaining grassy ecosystem health

The 2017 Plan outlines actions to manipulate grazing in small areas, other than culling. Grazing can be excluded by temporary fencing, big logs, and even carcasses. Grass biomass can be quickly reduced by fire, slashing, or managed livestock. These are valuable options for fine tuning the biomass of the grass layer, but our knowledge of their impacts are variable.

The 2017 Plan, the annual conservation advices, and the Herbage Mass Guidelines (ACT Government 2019a) consider managing kangaroo grazing as the principle and preferred way of influencing the grass layer structure. However, at times, complementary actions may be needed. This could happen if predictions about the next years kangaroo population growth turn out to be wrong (e.g., because the weather was unexpected), or because a planned cull was not completed, or because patches of grass are thick or unpalatable and kangaroos are ~~not~~ therefore avoiding grazing there.

If grass biomass is higher than ideal, and kangaroos cannot, or will not graze it down because it is unpalatable, biomass can be removed using prescribed burns; slashing/mowing; or corralling livestock in an area so they graze the biomass down quickly (Mavromihalis *et al.* 2013; Morgan 2015; Smith *et al.* 2018). To exclude further grazing and retain grass biomass, options include the use of temporary fencing, rocks, coarse woody debris or even carcasses to exclude grazing from small areas, and create micro niches for particular species (Barton *et al.* 2011; Barton *et al.* 2016; Goldin and Hutchinson 2013; Manning *et al.* 2013; McDougall *et al.* 2016; McIntyre *et al.* 2010). These are essentially variations of a mini safe haven concept (Smith *et al.* 2023).

These options of course need to be used carefully. First, they tend to interact with kangaroo grazing. For example, heavy grazing can reduce the ability of the grass layer to carry fire; and fire can be used to increase the palatability of grassy patches that kangaroos are avoiding, either because the patch is too thick and rank, or because it is dominated by a grass species that is only edible when young (Foster *et al.* 2020; Foster *et al.* 2014; Legge *et al.* 2019; Meers and Adams 2003). Second, the options have differing propensity to encourage weed spread; different advantages and disadvantages for native plants with contrasting life history and competitive traits; and pose different risks to the soil surface. For example, managed livestock grazing can trample habitat and compact the soil surface, and livestock will also selectively graze more palatable species. Repeated slashing will disadvantage taller species and increase the risk of introducing new weed species carried on the machinery. Finally, the history of the site is likely to affect the response to management intervention (Dorrough *et al.* 2006). For example, managed livestock grazing should probably not be used at sites with a limited grazing history, as these sites may retain palatable species that livestock have selectively removed from elsewhere (Dorrough *et al.* 2004; Morgan 2015).

Decision trees to select when to intervene with a complementary grass management action, which intervention to use, and information about how different species respond to each intervention, are described in the draft Herbage Mass Management Guidelines (ACT Government 2019a). The most appropriate fuel management approach(es) for threatened species are also outlined in the ecological guidelines for fire operations (ACT Government 2019b). Note that some actions, especially the use of managed livestock grazing, are perplexing to many members of the public, who query why kangaroos are killed, then heavy hooved cattle are brought into the same reserve to graze the thick grass. This situation may occur (for example) in areas of thick grass dominated by unpalatable introduced species, or in areas near to suburbs where grass biomass must be quickly reduced for fire hazard reduction, but clearly the way that these complementary tools are being used needs to be better communicated to the public.

Although it is apparent from the annual conservation advices that these complementary actions are being used, it seems difficult to access documentation on the spatial extent of these actions, or of their outcomes. Reserves have operational plans for burns, slashing, pest management, and so on, and staff discuss the mix of actions in each reserve when the kangaroo management for each year is being planned. Fuel management (via grazing, slashing, burning) to protect life and property, or for ecological purposes, is outlined in the annual Bushfire Operations Plan. However, Bushfire Operations Plans are developed well before the beginning of each year and there is no flexibility for adding sections of reserves to the fire plan during the year, should grass layer conditions

not match expectations. Thus, it is unclear (to the Review) how these complementary actions are triggered in a timely way.

There may be some potential for supporting Ngunnawal to lead more reactive ecological burns to restore the health of Country in areas where grass is thick.

Commented [WC42]: Rosie - Discussions on Ngunnawal burning have progressed rapidly in recent months and four Ngunnawal-led burns are now planned for late summer/autumn

Recommendation

3.6 Continue using/trialling these complementary actions, ensuring that risks are appropriately considered, and that the actions are carried out so that knowledge is gained to optimise their ongoing use. Include more information about why, when, and how these actions are used in reserves, on the public-facing website. Explore the potential for Ngunnawal to play a leading role in more responsive fire management that complements the kangaroo control.

[see also recommendation 3.2]

3.3 Evaluate and Adapt

The Review considers the evaluate and adapt components of the adaptive management cycle together, because the Kangaroo Management Program has integrated these components very closely.

The 2017 Plan does not set out a reporting nor evaluation schedule. However, reporting and evaluation have occurred to a very high standard throughout the life of the Plan, and much of the information collected has been subject to peer-review via the publishing process of scientific journals. The 2017 Plan was informed by a very large amount of research and monitoring data. The implementation of the Plan has been accompanied by a thorough program of prioritised research and monitoring. The data generated during the life of the Plan have been soundly analysed, interpreted, and used to adapt management in a timely way. Evaluation of KMU boundaries, vegetation mapping, population estimates, predicted population growth, grass layer structure, road collision data, and weather forecasts have closely informed each year's conservation advice. These key information inputs to the annual conservation advice are backed by substantial field research and validation. An expert workshop held in 2018 helped to hone the priority research and monitoring directions.

3.3.1 Annual reports

The annual conservation advices (e.g., ACT Government 2023a) act as both a report of past activities and effectiveness, and a plan for the coming year. They present information on the kangaroo density estimates, the grass layer metrics (including a map to show where the grass height of the lowland grassy ecosystems is within, or outside, the safe operating zone), and the cull (targets and achieved) for each KMU where kangaroo culling has been carried out, or is being carried out, since 2009 (noting that in some years, a KMU may not have a cull). These annual advices also present KMU-specific information on any factors that are being used to moderate the cull targets, or interpret effectiveness to date. Finally, the advice also describes complementary management actions such as fencing, slashing, and planned burns.

3.3.2 The 2018 workshop

A kangaroo management research workshop was held in August 2018. The workshop convened internal, national and local researchers with expertise on large herbivores, grazing management, and grassy ecosystems. The purpose of the workshop was to review relevant kangaroo grazing research from the previous decade, including the grassy habitat condition needed to maintain or recover biodiversity; review kangaroo management policy to date, including the approach for estimating target kangaroo densities; discuss a new functional response model for the grass layer; propose grass layer targets that would support biodiversity; propose future research and monitoring priorities to validate that the management was improving ground layer vegetation structure in a way that should lead to improved biodiversity outcomes.

The workshop led to the updated vegetation mapping (into management polygons); an extensive program of grass layer monitoring; the new approach to calculating target kangaroo densities based on grass layer metrics;

encouragement to use the options of burning, slashing, managed livestock grazing, fencing and log placement to complement the kangaroo culling; and a recommendation to evaluate effectiveness after five years.

3.3.3 Evaluating effectiveness

Outcome evaluation has shown that the culls are effective at maintaining kangaroo densities close to their targets, and maintaining the grass layer within a safe operating zone. This is important evidence for the performance of the program. However, the outcomes of the program for grazing sensitive species are not being monitored.

3.3.3.1 Are kangaroo populations closer to target densities?

The ACT Government has recently examined whether the culling program is bringing kangaroo densities closer to the targets for each KMU, by comparing the deviation from the target density for managed and unmanaged KMUs. This analysis shows that effectiveness has improved (i.e., deviations have decreased) at managed KMUs since 2009, whilst the density deviation at unmanaged KMUs has increased over the same period (Fig. 3) (O'Loughlin 2024; O'Loughlin *et al.* 2023). Effectiveness was improved if culls had been carried out consistently over several years, and was poorer if the last cull occurred three or more years ago. Effectiveness improved also when KMUs had a greater proportion of grassland (easier operating environment), a greater proportion of reserve vs rural land (more control over total cull achieved), when the cull achieved was closer to what was planned, and when the kangaroo population was smaller.

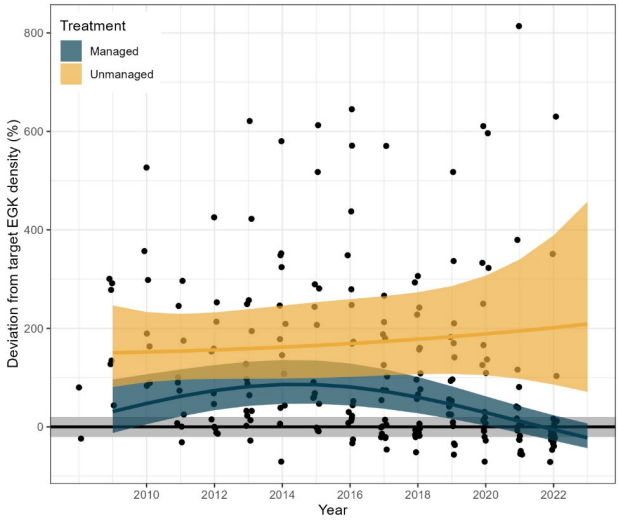

Fig. 3. The deviation from the target density, over time, for KMUs where populations are being managed using culling, and populations that are not being managed. The lines and bands show the predictions with 95% confidence intervals from a generalised linear mixed model, with year fitted with a linear and a quadratic term to improve model fit. (O'Loughlin 2024; O'Loughlin *et al.* 2023).

3.3.3.2 Are grass layer structural targets being achieved?

The same analysis (O'Loughlin 2024; O'Loughlin *et al.* 2023) also shows that when kangaroo densities are managed to be at target levels, then the grass height in the KMU is within the safe operating thresholds. In contrast, when kangaroo densities deviate from the target, then grass height can reach values outside the safe operating threshold, both too low in drought years (2018-19) and too high after wet years (2022) (Fig. 4).

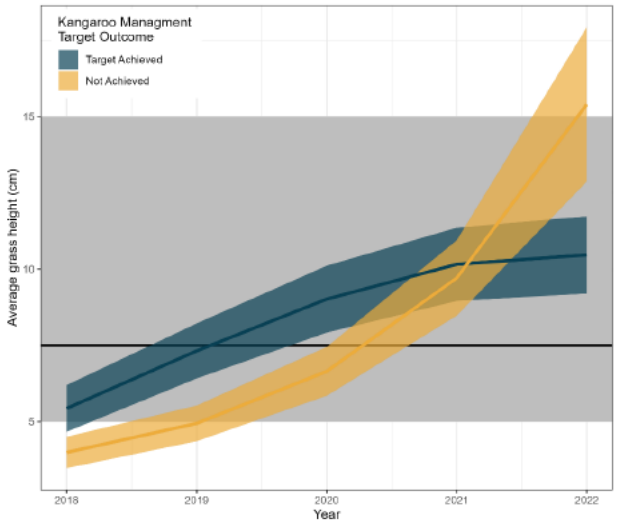

Fig. 4. The predicted grass height, over time, for KMUs where kangaroo population targets have been achieved, versus KMUs where these targets have not been achieved. The lines and bands show the predictions with 95% confidence intervals from a generalised linear mixed model, with year fitted with a linear and a quadratic term to improve model fit. The grey background shading shows the safe operating zone for grass height, and the black horizontal line is a target height of 7.5 cm. From (O'Loughlin 2024; O'Loughlin *et al.* 2023).

3.3.3.3 Are grazing sensitive species being maintained and recovering?

Grazing sensitive species are not being monitored as part of effectiveness evaluation. Instead, the program relies on using grass layer structure as a surrogate indicator, because of the targeted research that has shown the relationship between grass layer structure, soil condition, and the presence and/or abundance of particular species (e.g., Barton *et al.* 2011; Driscoll 2017; Howland *et al.* 2014; Howland *et al.* 2016a; Howland *et al.* 2016b; Manning *et al.* 2013; McIntyre *et al.* 2015; McIntyre *et al.* 2019; McIntyre and Tongway 2005; Neave and Tanton 1989; Snape *et al.* 2018).

Nevertheless, it would be ideal to demonstrate persistence or recovery of grazing sensitive species in reserves with sustained grassy layer management.

- Species that are mobile, such as birds, could respond to management by increasing in density, or by using reserves even in drought conditions, whereas in the past they may have been absent when the grass layer was too heavily grazed.
    - A well-designed monitoring program for birds could track for these signs of recovery, and the fieldwork could be carried out by volunteers with expertise, such as Canberra Ornithological Group. There may already be data on bird presence across reserves, that could form the basis for ongoing monitoring.
- For less mobile species, managing grazing should help them persist in reserves, as long as their recovery isn't suppressed by other factors, such as high nutrient levels in the soil, or abundant weeds. Monitoring to check that these populations remain present, and are not declining, would be worthwhile.
    - Table 1 (Section 3.5) shows that non-mobile threatened, grazing sensitive species occur in 0 to 13 reserves. Effective management should ensure this representation is maintained or increased. For an extreme example, the earless dragon is critically endangered and may persist now at only two

Commented [WC43]: Rosie - These data (COG supplemented with offsets/ONC monitoring) have all been freshly analysed by the Adaptive Mgt Support team, to be included in the upcoming Woodlands Ecosystem Assessment. Luke would know whether it would be possible to use them in this way.

sites (not reserved land) in the ACT, each with very small populations (< 50 each). The cumulative effects of many threats has led to this situation, but kangaroo grazing (both too much during drought, and too little in wetter years) has possibly contributed, with other factors, to the species' decline (CoA 2023).
    - From conversations with ACT Government staff, it seems that there may be data available on the grazing-sensitive species, collected for other reasons, that could be interrogated to examine whether these species are responding to kangaroo management and improvements in the grassy layer structure. These possibilities could be explored, with the aim of shaping future data collection so that changes in grazing sensitive species can be reported.
- However, less mobile species are unlikely to recolonise the isolated reserves if they have been extirpated. A translocation program could be designed to restore species to reserves with suitable habitat, and adequate threat management (see Section 3.5 Value-adding).

Recommendation

3.7 Reporting on the status of grazing sensitive species in reserves with kangaroo management would further validate the program and be a useful communication tool. Explore whether existing datasets, perhaps collected for other reasons, can be mined to produce such reports; whether partnerships with groups such as Canberra Ornithologists could lead to carefully designed surveys and analysis; and whether a program of translocations could be used to demonstrate management success (see Section 3.5 Value-adding).

3.3.4 Examples of data being used to adapt management

The reports (published and unpublished), conservation advices and published papers produced since 2017 contain many examples of management adaptations as a result of new information, illustrating a genuine commitment to adaptive management that seeks to continually improve outcomes.

The 2017 Plan incorporated the highly relevant research carried out on the links between grass structure and biodiversity, that had been carried out since 2010.

Refining the KMU boundaries:

- Radiotracking studies helped to understand kangaroo movement patterns, and the information was used to inform the position of KMU boundaries (ACT Government, unpublished data).
- Adjustments to KMU boundaries are made annually based on population stability of successive annual counts and information on road collisions from bordering roads (see annual conservation advices).
- Staff carried out a trial to see if kangaroo culls could be effective at the sub-KMU scale. The work showed that planning and implementing culls at the KMU scale was more likely to be effective (Pulsford and Snape 2019).

Refining the vegetation mapping:

- Initial mapping of canopy cover to use to adjust target kangaroo population size in KMUs.
- Mapping dominant grass types across the lowland grassy ecosystems, to augment the existing mapping based on canopy cover (the vegetation mapping is described, and is visible in annual conservation advices).

Refining the kangaroo population estimates:

- Staff carried out an analysis to compare estimates produced using different methods (ACT Government 2017c).
- Reliance on distance sampling, a robust sampling method, has increased.
- Population estimates were moved from April-June, to ~~Nov-Feb~~Dec - Mar, so the cull calculations are based on more current data (Gordon *et al.* 2021).

Refining the kangaroo population growth model used in cull calculations:

- New model developed and validated using empirical data from the reserves (ACT Government 2023a; Hone and Snape 2024).

Refining monitoring and targets:

- Defining a safe operating zone, with upper and lower thresholds, for grassland biomass and height (Gordon and Snape 2019; Gordon *et al.* 2021; Snape *et al.* 2018; Snape *et al.* 2021).
- Developing a new monitoring program for grass layer structure and condition (Snape *et al.* 2018; Snape *et al.* 2021).
- Using these monitoring data and the new grass response models to inform the cull targets for KMUs, rather than solely relying on the interactive population-pasture model outputs (e.g., ACT Government 2023a).

Exploring alternative and complementary control options:

- Substantial research on fertility control for kangaroos, and the most effective and humane way to deliver the vaccine (Hampton *et al.* 2021; Wimpenny 2022; Wimpenny *et al.* 2021).
- Trails of the fertility vaccine in some reserves (ACT Government 2023a; Wimpenny 2022).

Exploring alternative and complementary grass layer management options:

- Trailing the use of managed livestock, fire, fencing and logs to manipulate grass biomass (see Section 3.2.11).

3.4 Communicate

The public engagement and reporting of the management program is remarkable: the volume of information available on the government website (including annual workplans and monitoring results), and the communication materials (e.g., factsheets, short videos), demonstrate a strong commitment to transparency.

The ACT government website on eastern grey kangaroo management for conservation is extensive. It explains the background to kangaroo management, with links to other web pages and supporting documents. Annual conservation advices present the latest data from kangaroo monitoring and the detailed thinking behind that year's cull targets. Reporting has occurred to a very high standard throughout the life of the Plan, and most of the information collected has been made publicly available via the ACT government website and scientific journal articles. The website also provides information to Canberra residents to increase awareness about how to reduce the risk of vehicle collisions, and kangaroo attacks (noting the latter is very rare).

The ACT government appears to modify its communication in response to community feedback. For example, the Government modified its cull reporting protocol to include counts of independently mobile kangaroos (adults and subadults) and pouch young (e.g., ACT Government 2023a), in response to public concerns that pouch young and small young-at-foot were being orphaned when their mothers were shot, and not accounted for. Large, independently mobile young-at-foot that are shot immediately after their mother were always counted, but this was not previously clear to the public. Including pouch young in the reporting was intended to reinforce that large young-at-foot, if they occurred, would be shot and then counted as a culled kangaroo.

A series of surveys commissioned by the ACT Government, and carried out by Micromex Consulting, canvassed community attitudes to kangaroo management and impacts in the ACT. Five surveys carried out between 2008 and 2023 have consistently reported that over 75% of Canberrans support kangaroo culling under some circumstances. This support is likely due, in part, to the ACT Government's communication strategy.

The volume of material produced by the program may now be creating its own problem: for example, during the consultation for this Review, people often commented they were not aware of information even though it is available on the web. The webpages are extensive, with dozens of reports, and it's not always obvious where to go to find a particular piece of information.

There are specific crucial community communication misses, or misunderstandings, that need attention (some of these points were raised earlier, in Section 2.4 Planning links):

- Conveying that management has shifted focus to using the grass layer structure as the guide for setting kangaroo culling targets rather than aiming for a 'set kangaroo density'.

- This shift occurred after the release of the 2017 Plan, so there is an understandable legacy perception in some parts of the community that the culls are aiming for a target of 1 kangaroo per hectare (e.g., Seymour 2023). There is an opportunity now to illustrate the sophistication of the monitoring and target-setting, and what the kangaroo management is setting out to achieve.

- How kangaroo management fits into the bigger picture of Canberra Nature Park management; and how kangaroo management in Canberra Nature Park fits in to the bigger picture of kangaroo management in the ACT (considering kangaroos on land slated for urban expansion, on rural land, and in the large reserves areas in the west and south of the territory; see section 7.1 Kangaroo culling in context).
  - During the consultation for this Review, some stakeholders queried why kangaroos were being managed in reserves when there were still rabbits, and weeds, present. As discussed in Section 2.4 Planning links, whereas the extent to which kangaroo grazing is a threat, and relative priority of kangaroo management, seems appropriately contextualised in other planning documents, such as the Canberra Nature Park Reserve Management Plan, (ACT Government 2021a), or the ACT Natural Resource Plan (ACT Government 2022), the reverse is less true: the 2017 Kangaroo Management Plan and the comprehensive website may inadvertently convey an impression that kangaroo management is the only or most important management lever in the reserves. In other words, addressing the sensitive issue of kangaroo management so thoroughly, with extensive documentation, has created a risk that the community perceives that kangaroos are being managed to the exclusion of all other reserve management.
  - Similarly, the kangaroo management in Canberra Nature Park should be understood in the context of kangaroo population status and management across the ACT, including in rural lands and in the large reserved areas of Namadgi and Tidbinbilla.
- How the urban expansion is factored into what happens with kangaroo management.
  - Some stakeholders expressed concern about the lack of regard to kangaroos during urban expansion. Concerns included that kangaroos were being culled to allow for expansion; that kangaroos were being squeezed out into other areas where they could be shot (if on rural land) or might suffer because the diaspora caused unsustainable population density; that urban expansion paid no heed to ensuring connectivity among habitat fragments.
  - The strategy behind Canberra's urban expansion is outside the remit of this Review, but a revised kangaroo management plan could provide an overview of which parts of the expansion will impact kangaroos, how many kangaroos will be affected, what actions could be undertaken, and the implications (if any) for ACT's overall kangaroo population. Impacts could be on population size and/or on population connectivity.
- The use of intensive grazing by livestock in areas where kangaroo have been, or are being, culled.
  - Some stakeholders questioned why reserve managers would replace a native grazer with an introduced grazer that has hard hooves.
  - Communication about why livestock are used to graze down unpalatable introduced grass that is avoided by kangaroos, and how the risks from soil compaction, and weed introduction, have been evaluated, is needed.

Commented [EH44]: Flagging with planning/ exec

Recommendations:

3.8 Ensure communication always conveys that the central issue is managing grass layer health, of which one component is kangaroo management. (That is, the management issue should never be framed as managing high densities of kangaroos in isolation).

3.9 Review the content and presentation of information on the government website, to communicate the sophistication of the monitoring and target-setting in the kangaroo management, and clarify what the program is setting out to achieve. The website should make it easy for the public to gain a snapshot of the key attributes of the conservation culling program. This may mean keeping the front end brief and accessible, with links to more detailed information. Include plain English summaries explaining the science behind some of the key monitoring steps (e.g., population density estimation, how cull targets are calculated, etc).

3.10 Despite the very high rate and standard of reporting, there is some lag in completing some of the in-house analyses to publication/communication standard. Some of the important material provided to the Review

had been in draft form for some time. Quarantining time for staff to complete the priority reports would be helpful.

3.11 Consider the potential of communicating about grassy ecosystem management (including kangaroo management) using a range of messengers other than government staff, such as through community groups (who are involved in reserve activities), and local vets and carers (who are involved in kangaroo welfare activities).

3.5 Value-adding - Translocations to improve ecosystem health

Commented [EH45]: I worry that this section sets an expectation that is not easily funded/resourced/achieved - could there be some stronger wording upfront acknowledging the barriers to successful translocations?

The conservation benefits of reserve management, including kangaroo grazing management, could be more clearly demonstrated, and accelerated, by designing and implementing a program to translocate grazing sensitive species into reserves with suitable habitat, and where all threats are adequately managed.

Such species may have disappeared from individual reserves because of livestock grazing and associated farming practices in the past, and these histories may have legacies (such as high nutrient loads in the soil) that are difficult to overcome. In other reserves, current threats could be managed sufficiently to allow for more active restoration work including reintroductions. However, unmanaged kangaroo grazing could reduce the likelihood of translocation success for many species. Translocations could therefore test and demonstrate the value of reserve management, including kangaroo management.

The program could focus on less mobile plant and animal species that are unlikely to recolonise the remnant reserves unassisted (i.e., birds would not be a high priority). Plant translocations could occur via seeding as well as by moving seedlings or mature plants (Gibson-Roy and Delpratt 2015). Although kangaroos are grass-eaters, forbs are affected when grazing levels are high (McIntyre *et al.* 2019; Morgan and Williams 2015). Assisted colonisations, as well as reintroductions, should be in scope, and the changing climate should be considered both for host reserve selection and the provenance of source seed and individuals (McIntyre *et al.* 2019; Prober *et al.* 2015). Note that not all reserves, even if they retain the right habitat characteristics, will be suitable recipient sites, if threats from weeds, invasive animals, added nutrients, and so on have not been adequately reduced (Prober and Thiele 2005).

Such a program could be nested within an ACT-wide design that considered translocations to non-reserved sites as well as reserved sites. The need to consider biodiversity (including kangaroo) management in a more tenure-blind way was raised by several stakeholder groups consulted during the review, including the Friends of Grasslands and the Conservation Council.

Translocations in Australia are subject to stringent regulatory and risk assessment filters, which consider, for example, the risks to the host population, the consequences of failure, and the adequacy of follow up management and monitoring (e.g. ACT Government 2017d; IUCN SSC 2013).

The advantages and opportunities of using translocations to fast-track restoration include:

- A translocation program will manifest the conservation outcomes of reserve management, including grazing management. Passive recovery potential for species with limited dispersal abilities is likely to be very modest (Price *et al.* 2021), so waiting for evidence that management, including kangaroo grazing management, is benefitting these species could be frustrating. Translocations are the only restoration option for species not mobile enough to recolonise reserves without assistance.
- Translocations can be a valuable opportunity to learn about what limits species recovery. For example, translocations could occur within an experimental design, with fenced and unfenced plots to examine the effect of kangaroo grazing and or rabbit grazing on translocation success (e.g., Bennett *et al.* 2020). For an excellent example of such an approach for grazing sensitive plants of grassy ecosystems, see (McIntyre *et al.* 2019).
- The program could make use of translocations that are happening anyway because of Canberra's urban expansion. Individuals of some grazing sensitive species have been moved already, in a small number of experimental trials, or to remove them from a development footprint, usually into areas where

populations of that species already exist (ACT Government, pers. comms). Instead, moving these animals into a reserve where they might (re)establish a new population would be a better conservation and welfare outcomes (Hangar and Nottidge 2009).

- These translocations would be inexpensive, costing substantially less than the Mulligans Flat-Goorooyarroo Project, as they would not need to exclude foxes and cats from a very large area.
- The program delivery could intentionally and constructively involve the Canberra Community, especially through environmental groups such as Friends of Grasslands, and the ParkCare groups. These groups are capable, and consistent. For just one of many examples, the Friends of Mt Majura ParkCare group carried out work over several years to demonstrate the consequences of rabbit and kangaroo grazing to the grassy layer, and to map rabbit warrens to support management (documented in, Sharp *et al.* 2015).
    - Activities could include seeding and planting; ongoing weeding at translocation sites; maintenance of small grazing exclosure fencing; and monitoring of both plant and animal translocated populations.
    - ParkCare involvement in these activities is consistent with the intent of engaging the community through volunteer work expressed in the Native Grassland Strategy and Action Plans (ACT Government 2017a), and the ACT Wellbeing Framework (ACT Government 2020). It would also contribute to several recommendations in the recent Legislative Assembly Inquiry into environmental volunteerism (SCECCB 2022).
- The program could include a mix of threatened and non-threatened grazing sensitive species, including species that are culturally significant for the Ngunnawal Traditional Custodians and other Indigenous People, with their co-design and participation. For example,
    - Dharaban (yam daisy, *Microseris walteri*), which has a starchy root that is an important food source for Aboriginal people, has declined substantially because of the loss and degradation of grassy ecosystems, including grazing and routing up by high densities of sheep (Gott 2008). It remains now mainly in areas that are ungrazed, or only lightly grazed, by livestock or kangaroos (Rawlings *et al.* 2010).
    - Other culturally important food plants that have declined, and are grazing sensitive, include orchids, bulbine lilies (*Bulbine bulbosa*), vanilla lilies and chocolate lilies (*Arthropodium* spp.), milkmaids (*Burchardia umbellata*) and early nancies (*Wurmbea* species) (Gott 2008; McIntyre *et al.* 2019; Rawlings *et al.* 2010).
- Finally, some of the populations of threatened species in the reserves are presumably small, and at risk from stochastic events, as well as risks from inbreeding and loss of genetic diversity (Weeks *et al.* 2016; Willi *et al.* 2022). In the longer term, these isolated populations may need to be managed as a metapopulation, with translocations between reserves from time to time to maintain genetic health (genetic rescue), or to reintroduce a population that was unexpectedly lost (Hoffmann *et al.* 2021). Establishing a translocation program for Canberra Nature Park reserves to restore grazing sensitive species would build the in-house expertise to deal with these broader issues of genetic and metapopulation management.

Commented [WC46]: Rosie made the following comment against your comment about including Ngambri as well (I don't think you need to change anything, just FYI) - Noting this is a difficult and contested space. The above is formally the Interim Protocol, while the ACT Gov continues investigations into traditional custodianship, which is also claimed for parts of the ACT by Ngambri and Ngarigo.

The first step would be an analysis to identify which species could be translocated into which reserves. Although the reserves vary in habitat, land use history, and other factors, some translocations would be possible, especially given the current low representation of threatened species across reserves (Table 1). Following this analysis, it would be possible to set five and ten year targets for the program. Having a strategic longer-term plan so that the translocation program could be considered holistically, rather than translocation by translocation, would help to streamline the regulatory and administrative burden, especially if the program was nested into a larger, ACT-wide strategy. Experimental translocations of some threatened species have been carried out already, and translocations to establish new populations (or to implement genetic rescue) are a priority action noted in the actions plans or conservation advices for many threatened grassy ecosystem species (Table 1).

Table 1. A list of threatened or rare animal and plant species, and their representation in 33 Canberra Nature Park Reserves, or reserve combinations for adjoining reserves. Six mobile bird species known from the reserves are excluded. The data on occurrence within reserves represent ACT Wildlife Atlas and Canberra Nature Map records from within the last 10 years. The low occurrence rates across reserves will partly depend on habitat differences, but also reflect local extirpations. Conservation status (national and ACT) are as of December 2023. The ACT action

plans and Conservation Advices and national Conservation Advices and Recovery Plans were checked for whether translocations (for establishing new populations, or for genetic rescue) are noted as conservation actions for each species. Yes* indicates the plan/advice refers to encouraging expansion.

Threatened Species	National conservation status (EPBC Act)	ACT conservation status	Number of reserves with species present (out of 39)	Translocations noted as an action for new populations and/or genetic rescue		
				ACT Action Plan	ACT Conservation Advice	National Conservation Advice or Recovery Plan
Fauna						
Canberra Raspy Cricket *Cooraboorama canberrae*	-	Rare	6	-	-	-
Grassland Earless Dragon *Tympanocryptis lineata*)	CR	CR	1	Yes	Yes	Yes
Golden Sun Moth *Synemon plana*	Vu	Vu	12	Yes	Yes	Yes
Key's Matchstick Grasshopper *Keyacris scurra*	En	En	1	-	Yes*	Yes
Perunga Grasshopper *Perunga ochracea*	-	En	7	Yes*	Yes*	-
Pink-tailed Worm-lizard *Aprasia parapulchella*	Vu	Vu	6	Yes*	Yes*	No
Striped Legless Lizard *Delma impar*	Vu	Vu	8	Yes	Yes*	Yes - examine feasibility
Flora						
Austral Toadflax *Thesium australe*	Vu	Vu	2	-	No	Yes
Button Wrinklewort *Rutidosis leptorhynchoides*	En	En	5	Yes	Yes	-
Canberra spider orchid *Caladenia actensis*	CR	CR	3	Yes	Yes	-
Ginninderra Peppercress *Lepidium ginninderrense*	Vu	En	3	Yes	-	Yes
Hoary Sunray *Leucochrysum albicans* var. *tricolor*	En	-	25	-	-	Yes
Pale Pomaderris *Pomaderris pallida*	Vu	Vu	5	-	No	Yes
Small Purple Pea *Swainsona recta*	En	En	7	Yes	Yes	Yes
Small snake-orchid* *Diuris subalpina*	-	Rare	1	-	-	-
Tarengo leek orchid *Prasophyllum petilum*	En	En	0	Yes	Yes	Yes
Tuggeranong Lignum *Muehlenbeckia tuggeranong*	En	En	0	Yes	Yes	Yes

*Recommended taxonomic revision to *D. subalpina* yet to be recognised by the Council of Heads of Australasian Herbaria; still referred to sometimes as *D. pendunculata* from which it has been split.

Recommendation

3.12 Carry out an analysis to identify which grazing sensitive species, including threatened species and species of cultural significance to the Ngunnawal Traditional Custodians, could be included in a translocation program to restore grazing sensitive species to nature reserves with appropriate habitat, and where

threats (including excessive or insufficient kangaroo grazing) are adequately managed. Develop a strategic multi-species and multi-site translocation plan, ideally considering non-reserved as well as reserved land. To the extent possible, use plants and animals that are being moved out of the footprint of the urban expansion; implement the program to gain knowledge about species ecology and limits to recovery; to involve community environment groups in the program; and to administer it efficiently.

4. ECONOMIC IMPACTS

Summary assessment

It is challenging to assess whether kangaroo culling on rural lands is achieving the objective of maintaining the economic viability of properties. There are no data available on spatial and temporal changes in kangaroo density on rural land. The Review was not provided with any data on changes in livestock density, or pasture condition (if these data exist). However, records are kept of the numbers of kangaroos licenced to be shot per property, and the numbers that are reported as shot, and these numbers roughly track weather conditions (e.g., increasing after wet years shift to dry years). This suggests the rural cull is realistically responding to changes in kangaroo grazing pressure. Property-level decisions about how many kangaroos are reasonable to cull are based on the Rural Cull Calculator, which is logical, and designed to cover the needs of most properties.

The regulation and management of rural culls requires landholders to conduct operations to a standard that exceeds the national Code for non-commercial shooting of kangaroos.

Main recommendations

Kangaroo density on rural lands is highly variable, with some properties having no kangaroos, and others, especially some that border reserved areas, with very high densities. An ACT-wide spatial assessment could identify variation in kangaroo density across rural lands, and focal areas for collaborative kangaroo management. Focal areas would include 1) locations with grazing sensitive threatened species. In such cases, the ACT Government could ensure landholders are technically supported so that total grazing pressure, including kangaroo grazing, is managed appropriately at these locations. 2) Rural leases next to reserved land that routinely have very high kangaroo densities; this is likely to degrade the ecological health of the reserved land and the economic yields and sustainability of the rural lease. The Land Management Agreements are one possible mechanism for formalising the collaboration over kangaroo management at focal areas, but there may be more suitable alternatives. Management could involve culling, strategic fencing, guardian dogs, etc, and there are likely to be opportunities for landholders to seek funding through grant systems (e.g., Regional Landcare Partnerships Program), or stewardship payments (e.g. Nature Repair Market). These suggestions are consistent with multiple actions in the 'Rural Landscapes' chapter of the ACT's Natural Resource Plan (ACT Government 2022).

The results of the spatial assessment could also be used to design and implement a monitoring program for changes in kangaroo density across rural lands in the ACT, ensuring that locations with grazing sensitive threatened species, and interfaces of rural and reserved land, are both included. The monitoring could be carried out periodically, for example every 4-5 years, possibly varying the frequency to coincide with major weather changes from wet to dry conditions and vice versa. The purpose of the program would be to generate information on kangaroo densities that can be used to inform livestock and kangaroo grazing management by rural landholders, and inform more specific objectives in the collaborative landholder-government planning. Ideally monitoring on rural lands would be embedded in an ACT-wide program (see cross-plan recommendations).

4.1 Plan

Kangaroos are a drawcard for nature-based tourism. The main negative economic impact of high densities of kangaroos is on rural land, because kangaroos compete for grazing with stock (including horses), and damage fences. Collisions with kangaroos on roads also result in economic costs through vehicle damage and injury to people, but this issue is reviewed in the Social Impacts section.

In relation to land managed for agricultural outcomes, the objectives in the 2017 Plan are:

- *Rural land:*
  - *Objective - Free-ranging kangaroo populations on rural lands are managed so that their densities do not seriously impact on the economic viability of rural properties.*
- *Government horse paddocks:*
  - *Objective - Free-ranging kangaroo populations on government horse paddocks are managed so that their densities do not seriously impact on the viability of the paddock complexes.*

There are no specific performance criteria or outcomes articulated for these objectives, to allow landholders some flexibility in deciding the acceptable level of kangaroo grazing for their situation. In addition, the Land Management Agreements, required for every rural lease, could provide for more specific objectives to be set. In any case, in the absence of quantitative or qualitative data for total grazing pressure, kangaroo densities and pasture condition (see Sections 4.3 and 4.4), performance against the objective cannot be assessed.

The 2010 and 2017 Plans note that kangaroos bring positive economic benefits via nature-based tourism. However, on rural land, increasing densities of kangaroos negatively affect the viability of farming businesses by damaging fences, and grazing grass that could otherwise be eaten by livestock. Overgrazing by the combination of livestock, kangaroos and rabbits can lead to erosion, affecting longer-term economic viability. Kangaroo grazing has also affected the operation of government horse paddocks, leading to substantially fewer horses being maintained at paddocks where there are high numbers of kangaroos. During the consultation carried out during this review, farmers also mentioned that kangaroos contributed to the spread of weeds, including from roadsides to farms and then out to protected areas, with environmental and economic consequences.

There are economic costs from kangaroo-vehicle collisions, from damage to vehicles and medical costs to vehicle occupants (Cope and Herbert 2023; Dunne and Doran 2021), but the 2017 Plan states that reducing these impacts is not an objective of kangaroo management. Nevertheless, there is an objective relating to vehicle collisions, in section 6.4 of the 2017 Plan:

- The incidence of vehicle-kangaroo collisions in the ACT is reduced.

but the Plan states that actions to achieve this objective are the responsibility of road management. This Review considers the issue of road collision further in Section 5.2 Road collisions.

Recommendation
[See recommendation 2.2 about setting SMART objectives; See recommendation 4.4 for survey and monitoring to inform those objectives]

4.1 The revised Plan could identify where any relevant lease-level objectives in relation to kangaroo management should be identified. See recommendation 4.2.

4.1.1 Does the Plan make an evidence-based case for kangaroo management on rural lands?

The 2010 and 2017 Plans review the evidence for grazing competition between stock and kangaroos, and for kangaroo grazing in paddocks that are being spelled, or that have been sown with forage. There is no contention over the general effects of overgrazing, and that farmers must manage grazing from kangaroos, livestock, and introduced herbivores to match pasture productivity. Therefore, if kangaroo numbers increase (for a given amount of forage), livestock numbers need to be reduced.

There is some debate in the scientific literature about the extent and nature of dietary overlap between livestock and kangaroos, the relative amount of forage they consume and their contributions to overall grazing pressure, and the conditions under which competition is most pronounced (for example, see, Pahl 2020). However, there is no contention over the general effects of overgrazing, and that farmers must manage that grazing to match pasture productivity. If kangaroos (or rabbits or deer) are present, farmers must estimate how much of their forage budget will be consumed by these animals, and adjust livestock numbers accordingly. By culling kangaroos, farmers can make more of their forage budget available to livestock. There has been some interesting work to estimate the equivalence of grazing by a kangaroo to one sheep, with earlier work suggesting a standard kangaroo was equivalent to 0.4 or 0.7 of a standard sheep, but later work revising that number closer to 1 (reviewed in, Pahl 2020).

The 2017 Plan states that there are 150 rural leases in the ACT, covering 39,500 hectares or 17% of the Territory. Rural leases are required to develop Land Management Agreements, which set out the cooperative management of the lease for sustainable management that maintains the ecological and cultural values of the land. The Agreements are approved by the Conservator. A recent audit of the operation of Land Management Agreements for rural leases noted that as of March 2020 there were 180 Land Management Agreements for 27,000 ha of rural

land, with leases varying in size from 2 to 500 hectares (ACT Auditor-General 2021). The government response to this audit states that there are 183 rural leases (held by 159 families), across 40,000 ha, of which 25,000 ha is considered arable. The gross value of agricultural production in the ACT in 2019 was $34 million, mostly from livestock grazing (ACT Government 2021b).

4.1.1.1 Kangaroo density on rural lands in the ACT

There are very few data available on the density of kangaroos on ACT rural land (unless they are part of a KMU), and most estimates come from over 20 years ago. The average kangaroo density suggested by the estimates is 0.76 kangaroos/ha, but with low confidence.

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 (Table 2). Current data on kangaroo density from the commercial NSW commercial harvest zone that surrounds the ACT is also shown in Table 2. It seems likely that kangaroo densities in rural areas are highly variable, depending on the location of the farm. For example, during the consultation carried out during this Review, some farmers said they had very few kangaroos on their grazing lease, while others stated that very large numbers of kangaroos were a serious problem. The latter situation occurred for farms adjacent to bushland without active kangaroo management, presumably because this interface offers the ideal combination of cover and pasture (see also, Viggers and Hearn 2005). For rural lands that are part of KMUs, then the average kangaroo density estimated by monitoring across the KMUs between 2018-23 is the best estimate for those rural lands, but they cover a small area.

The 2010 Plan notes the lack of recent data on kangaroo density on rural lands, and states gaining density data is important. The situation has not changed since then, and the value of getting density information has only increased.

Table 2. Densities of kangaroos on rural land in the ACT, and from the NSW Southeast Tableland kangaroo harvest zone, which surrounds the ACT.

Year	Density (per ha)	Source
1986	1.67	Farm (Perry and Braysher 1986)
1995	0.50	Appendix 5; 2010 Plan
1996	0.59	Appendix 5; 2010 Plan
1996	0.48	Appendix 5; 2010 Plan
1997	0.39	Appendix 5; 2010 Plan
2015-23	0.37	Average density of kangaroos SE Tableland harvest zone NSW (NSW DPE 2023).
2018-23	1.35	Average density of kangaroos across all KMUs (some of which include small areas of rural lands) (value calculated during this Review). Note the area of rural land in the KMUs is small relative to the overall area of rural land, and it may not be representative.,
average	0.76	

Recommendation
[Consider an ACT-wide spatial assessment to identify variation in kangaroo density across rural lands, and focal areas for kangaroo management outside of the reserved areas. See recommendation 4.3.]

4.1.2 Does the plan have a conceptual model and evidence-based thresholds on rural lands?

Kangaroo grazing impacts and management are considered within the conceptual framework of Total Grazing Pressure from livestock, introduced species (rabbits, deer), as well as kangaroos. However, there is no guidance in the 2017 Plan on what that means in practice, perhaps because that is better handled in other planning

instruments such as the Land Management Agreements. There are two scenarios where enhanced collaboration between rural landholders and the Government over grazing management is important, and more specific kangaroo grazing impact thresholds may need consideration: one is at locations on rural lands with grazing sensitive native species, and the second is at the interface of reserved land and rural land. Where these interfaces are within a KMU, the conservation cull process triggers collaboration with the landholder, but there is no such trigger when the reserved land is not within a KMU.

The 2017 Plan notes that "the concept of total grazing pressure" has been used as the conceptual framework for determining suitable kangaroo densities on ACT rural lands." However, there is no information on what that means in practice. The Rural Cull Calculator sets an upper limit on the number of kangaroos that can be killed, and then relies on the judgement of the lessees to manage kangaroos within that bound, and in accordance with the regulations set to protect kangaroo welfare (i.e., competency test, culling season). The Calculator encourages lessees who need to manage kangaroos to do so annually with modest culls, rather than intermittently with larger culls. Presumably most lessees will take a pragmatic cost-benefit approach toward the kangaroo density they aim to achieve, by stopping culling when the grazing benefits for livestock are less than the rising costs of continuing to kill kangaroos as their density declines.

On rural leases, kangaroo (and livestock) management may be especially important at sites with grazing sensitive species (including threatened species), or on farmland/bushland interfaces with very high kangaroo densities, where high total grazing pressure could damage pasture and soil. There is no information in either the 2017 Plan or the Rural Cull Calculator on how to identify such priority areas and then plan grazing management to protect farming viability and conservation values. The Land Management Agreements are one potential prism for identifying such priority areas and the relevant kangaroo management targets. For example, the Land Management Agreement for a rural lease that has a grazing-sensitive threatened species could identify the spatial location for the threatened species, and the specific grazing management (covering livestock, rabbits, and kangaroos) that will be used to maintain the grass layer appropriately at this location. This Review cannot assess whether this level of planning is occurring. However, a recent audit of Land Management Agreements found them lacking in the detail required to articulate such outcomes, and to monitor progress towards achieving outcomes (ACT Auditor-General 2021). The ACT Government has committed to improving the level of management detail in plans, and improving monitoring and compliance (ACT Government 2021b).

In another example, some rural leases are adjacent to reserves with high kangaroo densities. Where the rural land is part of a KMU, there are operational and monitoring mechanisms (kangaroo counts, grass layer monitoring, regular communication between government staff and landholders) in place to support a collaborative approach to kangaroo management across the KMU. In contrast, the consultation for the Review revealed that some rural leases are adjacent to reserves, and this interface has high kangaroo densities, with no kangaroo management taking place in the reserve portions; in these situations there are fewer mechanisms to support collaboration over kangaroo management, except for when the authorisation to cull is being sought. At that point, there can be discussion between government staff and the landholder about the numbers to be culled. In the 2017 Plan, this specific scenario is addressed in *section 6.1.1 'Kangaroo movement between government managed land and rural leases'*, and it opens the door for collaborative action between the landholder and the ACT Government. More involved collaboration between the lessee and the ACT Government could be articulated via the Land Management Agreement process, but the Review does not know whether this occurs or not. Extending the very detailed planning and monitoring approach used in conservation culls in Canberra Nature Park to other reserved lands in the ACT is unrealistic, but planning support for rural landholders to ensure that management is as targeted and effective as possible, and maintains the values of the reserved land, is achievable.

Recommendation

4.2 Consider the options for enhancing government-landholder collaboration over kangaroo management planning on rural leases where kangaroo grazing, as a component of total grazing pressure, is a problem for threatened species; or where high kangaroo densities are occurring on the interface between rural lands and reserves without regular kangaroo management, leading to high grazing pressure on rural land that damages short- and longer-term economic viability, and high grazing pressure on conservation land that damages ecological health. Options may include ensuring that the specific issue, the management response, the

required monitoring, and roles and responsibilities are detailed in revised Land Management Agreements, or some other mechanism.

4.2 Implement

Kangaroos on rural lands may be culled by landowners with authorisation from the Conservator. Authorisations are applied for, and granted, annually.

4.2.1 Rural Culling Calculator

The Rural culling Calculator sets a maximum number of kangaroos to be culled based on the area and shape of a property. Given the average densities on rural lands (see 4.1.1.1), the allowable cull appears generous, but kangaroo density is likely to vary substantially around this average.

The cull on rural lands seeks to reduce the economic costs of kangaroo grazing to farmers, and the managers of the government horse paddocks. Rather than setting a target density, the calculator sets a maximum that can be culled in a calendar year as:

2 per ha x immigration factor.

The immigration factor = 1+ (PA/5) where PA is the perimeter (km) to area (km^2) ratio. The immigration factor compensates for difficulties applying the calculator to small properties and long narrow properties. What this means in practice is that small properties may apply to cull a higher number of kangaroos, and properties that have a longer perimeter for the same area can apply to cull more kangaroos (Fig. 5).

Mixed sex culls on rural land are conducted between 1st March to 31st July. The rural cull calculator also allows for no more than 30% of the total cull for the calendar year to be a male-only cull, occurring from 1st August to 31st October.

The Rural Culling Calculator Determination states that the calculator aims to support the needs of property owners while preventing excessive culling; and that the formula is based on the experience of government ecologists over many years, and replaces earlier, more complex formulas that considered variation among properties in carrying capacity, the nature of neighbouring land, and the extent of previous culls.

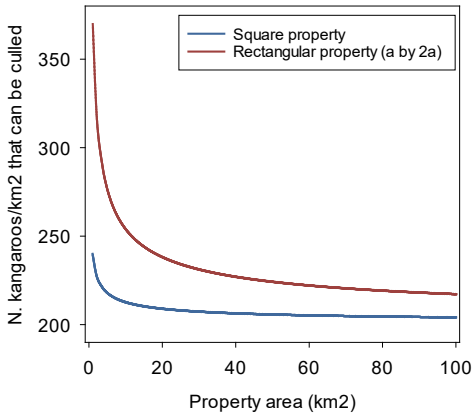

Fig. 5. The culling limit for hypothetical properties of increasing area, when they are shaped as a square, or a rectangle where the longer boundary is twice the length of the shorter boundary. Properties with more perimeter for the same area will always be able to request a higher cull, and small properties can request a higher cull.

4.2.2 Culling operation

Landholders must pass the Territory competency test every two years (including shooting accuracy and species Identification components), and mixed-sex culling must only occur within the March-July culling season, with a male-only cull allowed between August to October. Random audits occur to check compliance with the Code, and conditions of the authorisation.

Shooters must pass a competency test every two years, with tests shooting accuracy, knowledge of the National Code for non-commercial macropod shooting (NRMMC 2008), and macropod identification skills. If a shooter fails the test, they must wait two years before they can re-sit the test. Based on the consultation carried out for this Review, this long wait to re-sit the test can pose serious difficulties for farmers and professional shooters, if they need to defer culling on their lease, or defer their business activities, for two years. It would be better to allow shooters to re-sit the test more quickly, after one year. In addition, the tests could include tests of shooting using night-vision equipment, because most shooters are operating at night.

Rural landholders must apply annually to cull kangaroos on their lease(s). The application is reviewed by the ACT Government, following an internal process. Compliance of landholders and shooters with the licence conditions, and the non-commercial Code, are checked in random audits (more detail in section 6.1.1 Kangaroo welfare during culling).

Rural landholders consulted as part of the Review were positive about the processes of obtaining authorisation to cull kangaroos, the use of the Rural Cull Calculator, and their interactions with ACT Government staff. Some suggested reducing the competency tests to once every five years, but others felt that every two years was appropriate. There was also commentary about the off-target licence conditions being too punitive, because misidentification could happen from time to time despite people's best efforts. Similarly, the male-only cull was challenging to undertake because the penalties for mistakenly shooting a female were severe. Landholders suggested that the tags applied to culled kangaroos should be biodegradable.

Recommendations:
[Suggested modifications to shooting/licencing protocols, are captured in recommendation 6.1]

4.3 Monitor

The ACT Government keeps records of the number of kangaroos that are authorised to be shot, and then the numbers that are reported as shot, on each property. The number of properties and kangaroos authorised/shot rose between 1997 and 2018-19, but have fallen since then. There are no current data on the density of kangaroos on rural land, and no data on pasture condition for most rural land (that this Review is aware of).

For rural leases within KMUs, there are data on kangaroo population density over time, and grassy layer structure from the reserve portions of these KMUs. This monitoring is carried out by the ACT Government and is reviewed in the section on Environmental Impacts.

For rural leases outside the KMUs, there are no data on kangaroo density, or grass condition, over time.

Across all rural leases, records are kept of the number of kangaroos authorised to be shot on each property, and the number that are reported as shot by the landholders. The number of properties applying for authorisations, and the total number of kangaroos authorised to be culled, increased from 1997 to 2017, but has declined since 2019, perhaps because the break of the drought (2017-19) lessened the need to kill kangaroos to preserve feed for livestock, and because the wet conditions made for poor shooting conditions (Fig. 6a). The number of

kangaroos reported as shot shows a similar increase to 2018-19, then decrease. The number killed is always less that the number authorised, with the discrepancy more marked in the last seven or so years when authorisations are higher (Fig. 6b).

The increase in the number of authorised properties (and thus the number of kangaroo kills authorised) from 1997 to 2019 may be due to:

- Enhanced compliance with regulations over time, due to positive engagement by ACT Government staff with rural landholders.
- Increasing kangaroo populations after the end of the Millennial Drought from 2010 to 2016, followed by high kangaroo numbers relative to food availability in the 2017-19 drought. Non-commercial licences and culling figures also increased in NSW and Qld over the period 2013-17 (Wilson and Edwards 2019).

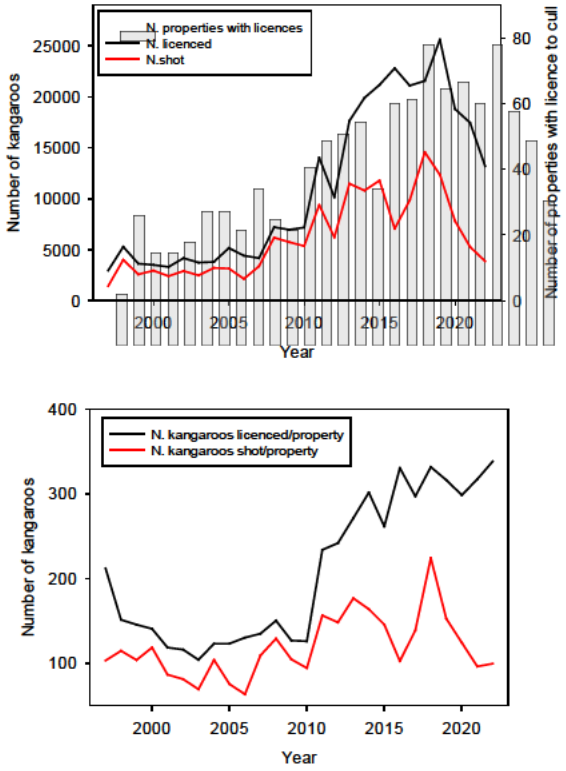

Fig. 6. (a) shows the number of properties authorised to cull kangaroos (bars and right-hand axis) over time, the total number of kangaroos authorised to be culled (black line), and the total number reported as shot (red line). The lower panel (b) shows the number of kangaroos authorised (black line) and reported as shot (red line), per property. Data for these graphs were supplied by the ACT Government.

Recommendation

[Design and implement a monitoring program to describe spatial and temporal variation in kangaroo density and pasture condition across rural lands in the ACT. See recommendation 4.3.]

4.4 Evaluate and Adapt

Given the paucity of data on kangaroo densities on rural land, it is difficult to evaluate the impacts of the rural cull on kangaroo populations, and the Review is not aware of any data on pasture condition from the rural leases (although it may exist).

The Review is not aware of data on total grazing pressure or pasture condition on rural lands, although it may exist.

If we take the average density for kangaroos on rural land shown in Table 2 (0.76/ha) and apply it to the total area of rural lands in the ACT (39,500 ha), this suggests a total population of 30,000 kangaroos. The average number reported as killed each year between 2017 to 2022 was 9100, or about 30% of the total population. For a back-of-the-envelope alternative approach to estimating the total kangaroo population on ACT rural lands, this Review uses the work of Hone (2007), who suggests that if we assume a high population growth rate of 40%, then about 30% of the kangaroos would need to be culled each year to maintain a stable population size. If we assume the kangaroo population on rural lands is stable and has a growth rate of 40%, and the annual cull (of 9100) is 30% of the total population, then the total population is 30,300, which is very similar to the population size based on using the density estimates. However, if the population growth rate of kangaroos is lower, then the kangaroo density on rural lands must be higher than 0.76/ha, to sustain the reported levels of culling.

Obtaining current density estimates, and understanding how this density varies spatially across the rural lands, would help strategic management. For example, this information could help prioritise locations for collaborative management between the government and landholders, including:

- Locations with grazing sensitive threatened species. In such cases, landholders could be supported with information on how best to monitor and manage total grazing pressure, including kangaroos, at these sites.
- Rural leases next to reserved land that routinely have very high kangaroo densities; this is likely to degrade the ecological health of the reserved land and the economic yields and sustainability of the rural lease.

The Land Management Agreement may be an appropriate mechanism for cooperating over kangaroo management at these locations. Management could involve culling, strategic fencing, guardian dogs, etc, and there are likely to be opportunities for landholders to seek funding through grant systems (e.g., Regional Landcare Partnerships Program). Such stewardship work may also be supported in the near future through the Commonwealth's Nature Repair Market, and similar initiatives.

The results of the spatial assessment could also be used to design and implement a monitoring program for changes in kangaroo density across rural lands in the ACT, ensuring that locations with grazing sensitive threatened species, and interfaces of rural and reserved land, are both included. The monitoring could be carried out periodically, for example every 4-5 years, possibly varying the frequency to coincide with major weather changes from wet to dry conditions and vice versa. The purpose of the program would be to generate current information on kangaroo densities that can be used to inform livestock and kangaroo grazing management by rural landholders, and inform more specific objectives in the collaborative landholder-government planning.

These suggestions are consistent with multiple actions in the 'Rural Landscapes' chapter of the ACT's Natural Resource Plan (ACT Government 2022), especially in the themes of Native vegetation and biodiversity; Soil and groundcover management; Agricultural policy and practice; Land management and tenure policy; for example:

- Review LMA to ensure they are fit for purpose to conserve key ecological values and align with initiatives for farm diversification and sustainable land use.
- Implement effective monitoring and enforcement of LMA to ensure the sustainable management of rural lands.
- Investigate opportunities for supporting the protection of important environmental assets on rural lands through land stewardship programs.
- Develop integrated rural lands and agricultural policy that ties together all aspects of sustainable land management—natural, cultural and social values.

Recommendation

4.3 Consider an ACT-wide spatial assessment to identify variation in kangaroo density across rural lands, and identify focal areas for collaborative kangaroo management on rural lands; including:

- Locations with grazing sensitive threatened species.
- Rural leases next to reserved land that routinely have very high kangaroo densities.

The assessment could also be used to design an ongoing monitoring program for changes in kangaroo density on rural lands, that would inform kangaroo management broadly, but including in the focal areas noted above.

4.5 Communicate

The ACT Government interacts with landholders directly and does not share specific details of the rural culling program with the broader public, for privacy reasons.

The ACT Government interact with landholders via the management of competency tests, and the issuance of authorisations to cull kangaroos. For rural lands within KMUs, there is also case-by-case communication to support the kangaroo management outcomes sought across the KMU. From the consultation carried out as part of this Review, this communication seems to operate well (albeit the consultation was based on a small sample of landholders). For rural lands outside the KMUs, there is a level of frustration for some landholders that neighbour reserved land with unmanaged kangaroos, and deal with very high kangaroo densities.

5. SOCIAL IMPACTS

Summary assessment
The 2017 Plan focuses on kangaroo-vehicle collisions as the main social impact of high density kangaroo populations living in the urban and peri-urban bushland fragments. The Plan has an objective to reduce the incidence of such collisions. This objective has not been met: the absolute number, and the per capita rate of collisions, may be increasing. The urban expansion may be causing more people to use roads that intersect areas where kangaroos are living, and mitigation measures are not effective enough. Collision rates increase during dry conditions, when kangaroos range more widely in search of food.

Main recommendations
The available data clearly show where the collision hotspots are. The ACT Government could consider mitigation strategies that could be put in place immediately (e.g., reducing speed limits in hotspots, especially when kangaroos are most likely to be active on the road verge), whilst trialling longer-term solutions to reduce collision risk whilst enhancing habitat connectivity with vegetated overpasses and underpasses. Research to improve data collection on collisions, and to evaluate the most cost-effective options in an adaptive management framework, would be useful.

5.1 Plan

The 2010 and 2017 Plans describe the diversity of social impacts of kangaroos, but objectives, outcomes and actions related to these impacts are more loosely organised than those relating to environmental and economic impacts.

The values associated with kangaroos are diverse. Kangaroos are an iconic Australian marsupial, and many Canberran residents and visitors experience pleasure and joy from having these native animals in urban bushland. Farmers may regard them as a pest, and car drivers may view them as a hazard. People (drivers, passengers and other witnesses, wildlife rangers, wildlife carers) involved in vehicle collisions with kangaroos can experience emotional trauma from these events. Watching kangaroos starve during drought is traumatic, and the issue of kangaroo population management itself is traumatic for some people (Robinson and Grace 2022; Seymour 2023). When kangaroo densities increase, the more negative social effects (car collisions, conflict with farming objectives, mass starvation) intensify.

The 2010 and 2017 Plans describe the diversity of social impacts of kangaroos, but objectives or outcomes related to these impacts are not clearly organised. There is an objective relating to vehicle collisions (section 6.4 of the 2017 Plan), but the Plan states that culling is not carried out to reduce road collisions and the actions to achieve this objective are the responsibility of road management:

- Vehicle-kangaroo collision objective: The incidence of vehicle-kangaroo collisions in the ACT is reduced.

The section of the 2017 Plan that describes the four key policy areas contains another relevant objective under the Human Welfare policy:

- Human Welfare Objective - Kangaroo management and community education minimise negative encounters between people and kangaroos in the ACT.

And another objective nested in the Kangarooo Welfare Policy:

- Kangaroo Welfare Objective - Kangaroo management in the ACT is undertaken in a way that accords with ACT legislation, codes of practice and current Australian standards for animal welfare.

Thus, the 2017 Plan lacks some clarity over which social impacts from high density kangaroos are in scope in the implementation of the 2017 Plan, how these impacts will be reduced (and who is responsible for the actions), and how the outcomes will be measured.

In this section on Social Impacts, the Review considers some key impact pathways (Road collisions; Kangaroo attacks on people; Carcass utilisation; Trauma to people caused by kangaroo management). For Road collisions,

which is the pathway with the most fully developed adaptive management approach in the 2017 Plan, the Review summarises the Planning, Implementation, Monitoring, Evaluation, Adaptation and Communication activities. For the other pathways, the Review assesses relevant material presented in the 2017 Plan and any other documents produced since then, and discusses some additional issues.

The final section proposes that considering social impacts through a lens of Overall Welfare could bring these disparate pathways, along with some other components of the 2017 Plan, together into a single coherent framework.

5.3 There is potential in a revised Plan to develop more clarity over the 'social impacts' relevant to the implementation of the kangaroo management Plan; how these impacts will be reduced, or balanced; who is responsible for the actions; and how the outcomes will be measured. Social impacts could be better viewed through a 'One Welfare lens', applied equally for impacts to people, as well as to kangaroos and other animals.

5.2 Road collisions

5.2.1 Plan and Implement

The main social impacts from high kangaroo densities noted in the 2017 Plan stems from the consequences of collisions between vehicles and kangaroos. These collisions can injure or kill the kangaroo, damage the vehicle, and traumatise, injure (or kill) people in the car. Rangers, wildlife carers, and vets are called out to euthanase injured animals, and to move carcasses, which can be unpleasant or traumatic experiences. The 2017 Plan has an objective relating to vehicle-kangaroo collisions:

- *The incidence of vehicle-kangaroo collisions in the ACT is reduced.*

The 2017 Plan states clearly that kangaroos are not culled to reduce the frequency of road collisions; and that achieving the objective of reduced collisions is the responsibility of Canberra Transport. However, the Environment, Planning and Sustainable Development Directorate has supported some research, funded by the ACT Road Safety Fund, to identify the spatial location of collision hotspots, and the landscape and other factors that tend to be associated with hotspots.

Mitigation options for reducing the collision rates are reviewed in the 2010 and 2017 Plans, and a more recent report (Cope and Herbert 2023). The Plan outlines policies designed to reduce collision frequency, including:

- Modifying attributes of the road (e.g., fencing, underpasses).
- Studies to improve understanding of the factors contributing to collision risk, and the effectiveness of alternative mitigation measures.
- Modifying driver behaviour with awareness programs.

The Review was unable to assess what mitigation measures had been put in place, and how effective they were.

Commented [SL47]: It might be worth getting some information from Roads about the number of fences/underpasses included in new road constructions (or % of new roads that include these features)?

Commented [EH48]: Was the data/info not available? Or did we not ask? If we didn't ask, this should be rephrased to say it was outside scope or something so that we're not throwing TCCS under the bus

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5.2.2 Monitor

Data on the frequency of kangaroo-vehicle collisions from public survey and ranger callouts indicate that both the absolute number of collisions, and the frequency per capita, may be increasing. A collation of two different datasets suggests that between 2600 (based on ranger callouts to collisions) and 5800 (based on public survey results) kangaroos have been killed annually on Canberra roads since 2015. A similar number of kangaroos are injured during collisions, with their fate unknown. An analysis of the spatio-temporal patterns of collisions shows that they increase during dry years, and during the winter months. Collisions are more likely on roads with higher speed limits, and on roads next to KMUs with high kangaroo densities and short grass (a situation that encourages kangaroos to come to road verges to feed). Road intersections, and the ends of roadside barrier fences, can also be collision hotspots.

Based on public survey results, about a third of Canberran residents have been in a vehicle (as a driver or passenger) that has struck a kangaroo, at some point in the past. Collisions result in injury to the vehicle occupants about 5% of the time (¬740 collisions in 2022), and an insurance claim about 60% of the time. Estimates of the annual cost of kangaroo-vehicle collisions range from $2.5 to 8 million.

5.2.2.1 Kangaroos affected

The ACT Government contracted Micromex Research to conduct surveys to understand how Canberra residents felt about kangaroos and their management five times between 2008 and 2023. Some of the survey questions relate to kangaroo-vehicle collisions, and provide a data source on the frequency and outcomes of such collisions ACT-wide (i.e., covering a larger road network than those surrounding the Canberra Nature Park reserves). The reports are available on the ACT Government website. Key statistics across the reports are:

- Kangaroo-vehicle collisions are common: in the most recent survey (2022) 36% of Canberran residents stated that they have been in a vehicle (as a driver or a passenger) that has hit a kangaroo in the ACT, at some point in the past.
- Collision resulted in the death or serious injury to the kangaroo about half of the time.
- Of the 50% of collisions where the kangaroo moves away from the road, the proportion that slowly die from injuries is unknown.
- The per capita rate of collisions may be increasing, from 6% of respondents (who have driven a car that hit a kangaroo in the previous three years) in 2011 to 14% in 2022 (Table 3). Presumably this is because of the increasing human population and Canberra's urban expansion, which increases the area of overlap between people and kangaroos.
- An 'authority' is notified about the collision about a third of the time.

The survey data can be used to estimate the approximate number of kangaroo-vehicle collisions each year. Accounting for the growing population size of Canberra, the collision rates translate to an increasing number of collisions over time, to 12,300 and 14,800 per year between 2019 and 2022 (Table 3). Given about half the collisions result in the death or serious injury of the kangaroo, the data suggest that since 2015, an average of 5805 kangaroos were killed or seriously injured on the roads each year (Table 3). This number may be an underestimate, because a) some respondents were involved in more than one collision, and b) the figures do not account for kangaroos that hop away from the collision site and die later from their injuries. The number may be an overestimate if some seriously injured kangaroos survive, or if survey respondents recall collisions that occurred outside the three-year period, or outside the ACT.

In some collisions, ACT Government rangers are called to euthanase the injured animal or remove the carcass. Information on these callouts is available in an ACT government database (ACT Government 2023b). From December 2015, a smartphone application using Collector for ESRI ArcGIS has helped to improve the accuracy and timeliness of data collected (Dunne and Doran 2021). The database was downloaded, and the figures for collisions with eastern grey kangaroos are shown in Table 3. The average number of collisions that kill a kangaroo are 2589 per year, or 7 kangaroos per day. These figures include some low annual figures during the COVID lockdown period. They also likely underestimate kangaroo mortality from vehicle collisions because not all collisions are reported, and because some kangaroos move off the road after the collision and later die.

The kangaroo collision estimates based on the Micromex survey data are about twice those from the ranger call outs (Table 3). This difference is expected because respondents also reported that they notified an authority about the collision only around one third of the time. In addition, as noted above, if respondents are being asked to recall incidents over a three year period, it is possible the date and location of collisions that they have experienced are incorrectly recalled, and the collision figures are inflated.

Table 3. Estimates of the number of kangaroos killed in the ACT, based on public surveys carried out by Micromex for the ACT Government (blue columns) and on ACT Government ranger call out data (green columns).

Micromex: The % drivers involved in a collision with a kangaroo at least once in the past 3 years are taken from the survey reports. These values are used to calculate the number of collisions per year, adjusting for the increase in

Canberra population size over time; the % of adults that have drivers licence (93%; from the 2022 Micromex report); and the population that are under 18 (~20%). The number of kangaroos killed or seriously injured is approximately 50% of the collisions, according to survey respondents across all the reports. For every kangaroo killed or seriously injured in a collision, there is another kangaroo that is struck but hops away, injured, with its fate unknown.

Ranger callouts: downloaded (Jan 2024) from the ACT Government ranger callout data. Rangers are called out to remove carcasses or euthanase an injured kangaroo.

Year	Drivers involved in a kangaroo collision in the previous 3 years	Number of collisions per year	Number of kangaroos killed or seriously injured (50% of collisions)	Number of ranger callouts to kangaroo collisions (ACT gov data)
2011	6%	5473	2736	
2015	8%	7751	3876	
2016				2775
2017				2522
2018				4044
2019	12%	12278	6139	3446
2020				1731
2021				1220
2022	14%	14800	7400	1679
2023				3297
			Av. Since 2015 = 5805	Av. since 2015 = 2589

Holly Cope and Catherine Herbert (University of Sydney) recently undertook an analysis of ranger callout data as well as other data sources, to identify the locations of wildlife collision hotspots, and examine what landscape features and other factors led to hotspot occurrence. They focussed on 2016-19, to avoid COVID-related artefacts. They also assessed the merits of different data sources (e.g., insurance claims, crash statistics) for understanding wildlife collisions and for estimating the costs of these collisions, and they carried out a brief review of mitigation strategies to reduce collision rates. They kindly supplied their draft, unpublished report for this Review (Cope and Herbert 2023). Their report finds that:

- More collisions involve male kangaroos than females (about two-thirds are male).
- Collision frequency increases in the winter (because food is scarce so kangaroos are drawn to road verges, and because the peak traffic overlaps with kangaroo activity more).
- Collision frequency increases in drier weather. For example, collisions peaked in 2018 in the ACT, and also in the six NSW Local Government Areas surrounding the ACT (across multiple data sources). The year 2018 had a record number of warm days, was the warmest year on record (for mean maximum temperature), and with below average rainfall. Other studies have similarly found that kangaroo-vehicle collisions increase in dry conditions, including one in Victoria showing that road kills were higher during the 1981-83 drought than before or after (Coulson 1989); and another in NSW that showed kangaroo road kills during drought were substantially higher (Lee *et al.* 2004). Cope and Herbert (2023) suggest that kangaroos were coming to road verges because conditions were very dry during 2017-19.

The locations of these collision sites are spatially uneven (Fig. 7). When collisions exceeded 65 per km of road (during 2016-19), the authors called those sites 'hotspots'. Characteristics of hotspots included:

- Major roads with speed limits of ≥ 80 km/h.
- For all hotspots: adjacent to a KMU with high kangaroo densities (on average, over 200% larger than the target density for the KMU), low grass height (< 8 cm grass height). Kangaroos were likely coming to road verges for food.
- Road intersections; the worst location was the intersection of Sulwood Dr and Athllon Dr, bounded by Farrer Ridge and Mt Taylor reserves.
- The authors noted that the ends of kangaroo exclusion fencing along roads could also be problem areas.

Commented [SL50]: Claire: We have previously calculated this for 2011 and 2015 using the number of licenced drivers in the ACT (so probably similar to your calc?), the 2011 value comes out pretty close but 2015 is much lower than our calc. Did you include the number of collisions each person had in the 3 year period? Our 2015 value came out at almost 14000.

Sarah: I guess its bec we estimate the size of the driving pop using different routes. Both could be a bit wrong in different ways.

Commented [WC51R50]: Yeah, we used the total number of collisions, rather than the number of drivers that were involved in at least one collision (so in 2015, 8% = 46 people but 76 accidents in total - someone said they hit 8 in 3 years!)

Commented [SL52]: Miles: The worst hotspot is in a location where a culled KMU (Farrer Ridge) is next to an unculled one (Mt Taylor). Would be interesting to know if and how collision rate changed since culling began at FR. Sarah: Sure would!

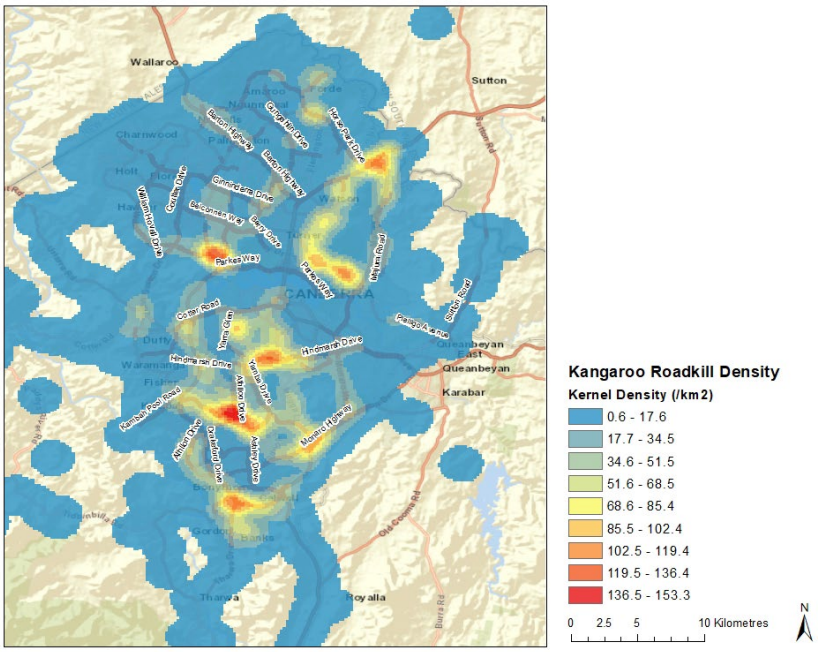

Fig. 7. Density of reports of kangaroo injuries or mortalities requiring attendance by the ACT Parks and Conservation Service rangers between 2016 and 2019. Figure courtesy of Holly Cope and Catherine Herbert.

The broad patterns of increasing collision frequency, and the locations of some spatial hotspots, were also identified in the 2010 Plan.

5.2.2.2 People affected

- Many Canberrans are experiencing the trauma of hitting a kangaroo with their car: about a third of Canberran residents stated in the Micromex surveys that they have been in a vehicle (as a driver or passenger) that has hit a kangaroo in the ACT at least once.
- The collisions caused injury to vehicle occupants about 5% of the time (varies between 2 and 11% across surveys) or ~740 collisions in 2022. Injuries may have affected one or more people. Note that other studies report higher injury rates, of around 30%; human fatalities from kangaroo collisions happen but are not common (reviewed in Herbert *et al.* 2021).
- The collisions result in an insurance claim ~60% of the time.
- Estimates for these annual costs of kangaroo collisions range from $2.5 million (Cope and Herbert 2023) to $8 million (Dunne 2017, cited in, Wilson and Edwards 2019).

5.2.3 Evaluate, Adapt, and Communicate

From the information summarised in the Planning and Monitoring sections just above, it seems that the objective of reducing the incidence of kangaroo-vehicle collisions in the ACT is not being met. Instead, the per capita frequency of collisions may be increasing. However, there is scope to reduce collision frequency with strategic actions. There are precedents for integrating a range of mitigation measures from other urban and peri-urban environments (e.g., Brisbane City Council). The 2017 Plan mentions some mitigation actions that have been, or

were to be undertaken, including long stretches of barrier fencing along roads, and driver awareness programs. However, the Review is unable to assess the extent to which evidence on collision patterns has been used to evaluate the success of these interventions, and adapt collision mitigation measures, as monitoring has not occurred.

ACT-based animal welfare groups also keep records about the locations of kangaroo-vehicle collisions, and have considered options for allowing kangaroos to cross busy roads to travel between reserves. These groups could provide community input to a strategic program that aims to reduce the collision rate.

Of relevance to this Review, is the finding that collision hotspots are all next to KMUs with high kangaroo densities and low grass biomass. Thus, although culling in reserves is not carried out to reduce collision risk, the overall welfare outcomes from culling (where some kangaroos are shot humanely and fewer kangaroos and people are involved in collisions) may be better than the welfare outcomes from not culling (where more kangaroos and people are involved in road collisions) (Hampton *et al.* 2019).

Recommendations

5.4 Many people and kangaroos are adversely affected by collisions on Canberra roads, and the objective of reducing the incidence of vehicle-kangaroo collisions is not being met.

Overall welfare outcomes for people and kangaroos would be enhanced if the frequency of kangaroo-vehicle collisions was reduced. Research to improve data collection on collisions, and to determine cost-effective mitigation options would be very helpful (e.g., strategic fencing, virtual fencing, vegetated overpasses, underpasses). Such options should allow kangaroos to move across habitat patches that are now fragmented by roads wherever possible, and be trialled and monitored in an adaptive management framework. In the meantime, the available data clearly show where the hotspots for collisions are, and the EPSD Directorate could work with the Transport Canberra to prioritise mitigation strategies that could be put in place immediately (e.g., reducing speed limits at collision hotspots with signs, speed bumps and speed cameras, especially at times when kangaroos are more active) whilst longer term solutions are developed. Community input to developing a short and long term strategic plan to enhance reserve connectivity whilst reducing collision risk for kangaroos, would help with its efficacy and socialisation.

5.3 Kangaroo attacks

Kangaroo attacks are rare, and the ACT Government includes advice to residents about how to avoid these events.

The 2017 Plan notes that are no data on negative kangaroo-people interactions, but the events mostly occur when dogs harass kangaroos and the dog owner intervenes in the confrontation.

The management action is to inform the public about the risks of moving too close to large kangaroos, and to encourage dog owners to keep their dogs restrained. This information is visible on the ACT Government's eastern grey kangaroo website, including via a downloadable factsheet.

This review is unable to assess whether this response has been effective at reducing the incidence of conflict between people and kangaroos. If the occurrence of such events is low, then discerning change is challenging.

5.4 Trauma to people concerned about kangaroo management

Most Canberrans support kangaroo management for welfare, environmental, and economic reasons. About 10% of Canberran residents do not and another 10% are unsure; a subset of these may experience trauma that kangaroo management occurs at all. Considering the views of all stakeholders through an ethical framework may help develop a shared understanding of the issues, and reduce conflict.

Most Canberrans support the current kangaroo management. The ACT government commissioned a series of surveys by Micromex Consulting to gauge community attitudes to kangaroo management and impacts in the ACT. These five surveys carried out between 2008 and 2023 have consistently shown:

- Over 75% of the public support culling kangaroos under certain circumstances whereas around 10% do not support culling under any circumstances (the balance of respondents, about 10%, are unsure).
- Most respondents (> 60%) consider that kangaroos are killed humanely.
- Respondents consider that justifications for culling are to prevent mass starvation of kangaroos during drought, to maintain the ecological health of reserves, to look after the economic viability of farms, to commercially harvest meat and skins (noting that this does not occur in the ACT), and to reduce collision rates with cars (in roughly that order). It is notable that kangaroo welfare is the most supported justification for culling.

The broad support for the governments kangaroo management program is likely influenced by the lived experience of Canberra residents, who have seen the effects of heavy grazing in the urban reserves, seen the large numbers of starving kangaroos during drought, and experienced the trauma of hitting kangaroos that are concentrating on road verges to seek food.

Nevertheless, the surveys equally show that around 10% of Canberrans do not support the kangaroo management, with another 10% unsure. For some people, the very issue of kangaroo management may be deeply traumatic (Robinson and Grace 2022; Seymour 2023).

The act of killing a native animal may be confronting to people for several reasons. For example, people may object to killing any sentient animal (an animal rights perspective); they may value charismatic species like kangaroos more highly that the smaller, more obscure plants and animals that live in the grass layer; they may object to killing a native animal as a means to fix a deeper human-caused problem (such as the loss, fragmentation and degradation of grassy ecosystems); they may worry about the pain or suffering experienced by culled kangaroos (a welfare perspective). These variations on animal rights-centric and welfare-centric views raise moral and ethical dilemmas that validly challenge a conservation-centric perspective (which is the prevailing compass of the 2017 Plan). Situations of conflict among conservation, welfare, and animal rights perspectives are increasing in frequency, as human alteration of natural systems increasingly results in situations, such as the ACT's kangaroo management, where managers face decisions about whether to kill native animals for conservation ~~objectoves~~objectives. In addition, there is substantial discourse about how humans can integrate the interests of non-human animals into governance, including conservation governance (Schapper *et al.* 2022). Section 7 describes a framework for guiding decisions about animal control for conservation outcomes, although even this framework is conservation-centric, and assumes that the conservation of species is highly valued by all.

5.4 Consider the international principles for ethical wildlife control (or something similar) when revising the management plan; ensure the perspectives of all stakeholders are fairly and transparently considered.

5.5 Carcass utilisation

Most carcasses from culls on conservation and rural land in the ACT are disposed of in burial pits or left to rot in situ. A very small number of carcasses have been used in conservation programs (to feed native carnivores at wildlife holding facilities, or to make poison baits for foxes and dogs). Skins have also been given to local Indigenous people. Farmers can use culled kangaroos for their own domestic purposes, but the fraction so-used is very small. This 'wastage' is a concern to some, including Traditional Custodians, farmers, and some conservation groups, and inconsistent with ACT's Waste Management Strategy and Climate Change Strategy. A recent commissioned report considered the options for alternative uses of culled carcasses. The report suggests upscaling the current use of kangaroo meat in conservation programs, using commercial processing facilities in NSW to prepare meat and skins for consumption by people in the ACT Indigenous community, sending small carcasses to be used by certain wildlife facilities, and sending offcuts and offal to frass processers to produce fertiliser that could be used by community groups involved in ecological restoration activities. Carcasses from conservation culls would be gifted to these uses, but rural landholders may choose to recoup some costs from these pathways.

Carcass utilisation is discussed here, under social impacts, but noting there are economic implications: On rural lands landholders may recoup some money from selling carcasses that could help to offset the cost of culling. On conservation land, the costs of carcass disposal (over $6 each not accounting for costs of collection and transport, AWS 2020) may be partly covered, or the costs of culling could increase if the processing of the carcasses exceeds those savings.

About 15,000 kangaroos are killed each year in the ACT by conservation culling (~2000), rural culling (~9100) and road kills (2600-5800) (see Section 5.7 for details). The carcasses are either left in situ or buried in pits.

Carcasses left to rot in situ create micro-niches that favour some plants (including exotic species) and animals, and contribute to nutrient cycling and soil health (Barton *et al.* 2019; Barton *et al.* 2016). They may also attract scavengers. Large rotting carcasses may not have been a very common feature when people and dingoes were hunting them, and dingoes were also eating carrion. Regardless, leaving thousands of culled kangaroos, shot over the culling season, on the ground surface is not possible, especially on public land, which is why many carcasses are disposed of in pit burials.

A report prepared in late 2020 (AWS 2020) discussed the issues associated with pit burial, and alternative options for carcass utilisation. The report states that 'wasting culled animals does not meet community expectations when there are other methods available'. The objection to waste may be especially felt by Traditional Custodians. Pit burial takes up landfill space, causes higher methane emissions. The report states that reducing the organic material going to landfill, and instead finding other uses for this material, is aligned with the ACT's Waste Management Strategy and the ACT Climate Change Strategy.

Current carcass fate:

- On rural land, rural landholders can use carcasses of kangaroos they shoot, for example as meat (for human and animal consumption). Given the number shot, most carcasses are not used. Many are left in situ, but some landholders are concerned about attracting canids, Carcasses cannot be left where they are visible to the public. Some landholders bury their carcasses or pay their shooters to remove the carcasses from their land.
- On public land, most carcasses from culled kangaroos are buried. The skins from a small number have been given to Traditional Custodians; some have been provided to local wildlife facilities to feed native carnivores; a small number are processed into meat baits for ACT conservation programs for fox and dog control.
- Road-killed kangaroos are either left in situ, or moved (by rangers) to waste facilities for burial.

The AWS report agreed with the conclusion of an earlier study in 2011 that setting up a commercial kangaroo meat industry in the ACT was not economical, because the numbers culled were too low, and the culling was seasonal. (However, the report notes that ACT Traditional Custodians have expressed interest in a local processing facility.). In contrast, the AWS report concludes that exporting kangaroo carcasses to existing NSW processing facilities is feasible. The AWS report also recommends expanding some existing carcass use options. The overall proposal is:

- Rural landholders could be given the option of selling carcasses to interstate processors (for human or pet food) under a Wildlife Trade Operation (approved under the Commonwealth EPBC Act). The payment for this meat could help offset the costs of culling, and might elevate the value of kangaroos to the farming sector, and enhance the management of total grazing pressure (see also, Wilson and Edwards 2019).
- Carcasses from the conservation cull could be collected for dressing (or dressed at the point of cull), then:
    - Offal and offcuts would be supplied to local frass producers, who use insects to produce high nutrient soil conditioner. [The product could be distributed to community groups for use in plant restoration programs].
    - Smaller carcasses would be given to local wildlife facilities for native carnivore food, and exported to NSW wildlife facilities for the same purpose.
    - Some smaller carcasses could be used locally to produce meat baits for conservation programs.
    - Larger carcasses would be exported to NSW facilities that process kangaroo meat for human consumption. Meat and skins would be delivered back to the ACT Indigenous community for food and traditional use (several pathways are described).

There would be no payment for carcasses from kangaroos killed in the conservation cull, to avoid any potential confusion about the objectives of that culling. The most recent public survey on attitudes and opinions about kangaroos in the ACT (Micromex 2023) suggests that although most (>55%) support kangaroo culling for commercial meat and skins, they do not support this purpose for culling in reserved lands (20%).

Although the report did not discuss welfare, there would be overall welfare benefits from adopting part or all of this proposal, because livestock would not be killed to feed animals kept in captivity, or to feed people, and so on. Kangaroos sent to a NSW processor would need to be shot according the commercial Code rather than the non-commercial Code. The commercial Code has higher standards, but the ACT requirements for shooting already meet these standards.

The AWS report outlines ten further steps required to explore these options for carcass use. They include a deeper exploration of the regulatory steps involved. The proposal also needs to be costed fully (this is not in the ten next steps).

Recommendations

5.5 Continue exploring alternatives for carcass utilisation instead of the current practice of pit burial and leaving in situ, by undertaking the next steps outlined in the Australian Wildlife Services report, and fully costing their proposed model. A risk analysis should also be conducted. Involve the community in this discussion, by 1) including targeted questions about kangaroo carcass utilisation in the next public survey on kangaroo management; and 2) ensuring Traditional Custodians can participate fully in the discussion and decisions.

5.6 Overall Welfare as an 'impact area' in the kangaroo management planning framework

Attention to kangaroo welfare is prominent in the 2017 Plan, and references to welfare crops up frequently, in different contexts, throughout the document. Welfare outcomes for other animals, and for people, are raised (less often) in the context of specific issues, and sometimes labelled differently. For example, the impacts of kangaroo-vehicle collisions are nested under social and economic impacts. An alternative approach, that recognises recent amendments to the ACT Animal Welfare Act, the development of the ACT Wellbeing Framework, and the One Welfare concept, would be to replace 'Social Impacts in the Plan with 'Overall Welfare Impacts', providing a single coherent framework for considering all welfare outcomes from decisions to act (or not to act), to kangaroos, other animals, ~~and~~ to people, and to the environment.

Kangaroo welfare is referred to in the Purpose of the 2017 Plan "*The purpose of the controlled native species management plan is to set out the approach to be adopted in maintaining wild populations of Eastern Grey Kangaroos in the ACT while managing their environmental, economic and social impacts and ensuring their welfare*".

Overall welfare is also referenced in the Plan's Principles (section 4.2): "*Kangaroo welfare is a primary consideration in all kangaroo management and all kangaroos are to be treated humanely*." And "*Human welfare and the conservation of other grassy ecosystem species are key considerations in all kangaroo management*."

Policies regarding welfare then occur at different structural levels of the Plan. For example, Greenfield Development Sites and Other Land have area-specific policies that kangaroos are to be managed to achieve the best welfare outcomes. On Greenfield Development Sites, kangaroos may face unacceptable risks of vehicle collisions, dog attacks, and starvation because of the development (sections 5.4.3 and 5.4.4 in the 2017 Plan). But the 2017 Plan also makes animal welfare one of four key policy areas that cut across the entire Plan. This higher level kangaroo welfare policy has an explicit objective: that kangaroo management should adhere to legislation, codes of practice, and Australian standards (section 4.3.1 of the 2017 Plan).

Commented [DK53]: Sarah, I made comments/ provided thoughts as I read. So my apologies if my feedback is addressed further in, or elsewhere in, the document.

Commented [DK54]: Does this need to be defined/explained as it is likely to be a new concept for many and may cause confusion? For example - the RSPCA definition is *'One Welfare' is the concept that animal welfare depends on and influences human welfare and environmental sustainability* . Another brief 'explanation' is ' One Welfare' promotes the link between animal welfare, human wellbeing and the physical and social environment (Four Paws)

Commented [DK55]: My understanding of 'One Welfare' is that it encompasses animal welfare, human welfare and environmental welfare. So does this sentence need to include the environment? Which also feeds into a number of the Wellbeing domains.

In this review, detailed comments on the substance of the kangaroo welfare policy as expressed in the 2017 Plan are given at 6.1 Kangaroo Welfare. Here, the review makes the case for replacing **Social Impacts** in the 2017 Plan with **Overall Welfare Impacts** as an explicit impact area that guides kangaroo management with the aim of optimising net welfare outcomes across all sentient animals, including humans. By doing this the new Plan would:

- Signal clearly that Overall Welfare is a central issue in kangaroo management.
- Recognise feedback from some stakeholders during the consultation carried out as part of this Review, who wished to see welfare addressed more coherently.
- Provide a clearer framework for a raft of welfare-related issues that crop up in the 2017 Plan, but are currently dealt with in a piecemeal and sometimes incomplete fashion.
- Extend welfare considerations to encompass the welfare of all animals, and people, and allow contrasting perspectives about which welfare to privilege, to be considered with the same framework.
- Be more consistent with an Indigenous, holistic approach to Country.
- Respond to the intent of the 2019 updates to the Animal Welfare Act 1992 (see below).
- Be aligned with the ACT Wellbeing Framework (see below).
- Be aligned with the international One Welfare movement (see below).

Commented [DK56]: For consideration - Should this be 'Overall' or 'One' welfare impacts? Or is Overall Welfare have nuanced differences to 'One Welfare' concept? My thoughts would be to consider using a recognised term - One Welfare (if that is what you mean) rather than coining an additional term 'Overall Welfare'

Commented [DK57]: Not sure what this sentence is saying. Should 'with' be 'within'?

All the practices and adaptations to enhance welfare outcomes that have been incorporated into the existing kangaroo management program would be covered by this approach (e.g., a culling season to avoid shooting females with large pouch young or small young-at-foot; stringent requirements for licensed shooters; prioritising culling to occur only in reserves where this will have conservation benefit; small reductions in kangaroo population size each year, rather than less frequent but very large culls, resulting in fewer kangaroos being killed overall; etc. See section 6.1 Kangaroo welfare for more detail).

Additional issues that would be covered more coherently under this proposed approach include:

- Reducing the suffering of individuals from other species, when heavy kangaroo grazing in grassy ecosystems causes the loss of their resources and increases exposure to risk (e.g., from weather or from predators). Reducing kangaroo population sizes to avoid adverse welfare outcomes for other species may result in a net welfare gain (see section 3.1.1.2).
- Reducing the extent of suffering of individual kangaroos in high density populations that experience starvation and higher disease burdens when the food resources diminish from overgrazing or drought (see section 6.1.3.3)
- Reducing the adverse human and kangaroo welfare outcomes associated with kangaroo-vehicle collisions that are more frequent when kangaroo densities are high (see section 6.1.3.4)
- Fairly considering the negative welfare impacts to members of the public that are traumatised by kangaroo management (see section 5.5).

The **Animal Welfare Act 1992** was updated in 2019. This update included a "*new set of objects to ensure that animals are recognised as sentient beings (meaning they can subjectively feel and perceive the world around them), have intrinsic value and deserve to be shown compassion and have an acceptable quality of life, and to reflect the community's expectations around animal welfare and the proper treatment of all animals*"[1].

The new Objects [4A(1)] are:

a. animals are sentient beings that are able to subjectively feel and perceive the world around them; and
b. animals have intrinsic value and deserve to be treated with compassion and have a quality of life that reflects their intrinsic value; and
c. people have a duty to care for the physical and mental welfare of animals.

In amending the Act to recognise 'sentience' the 'Explanatory Statement' stated:

- *....animal welfare encompasses all aspects of animal health and wellbeing, and all people have a responsibility to take reasonable measures to protect the welfare of animals in all human-animal interactions.*

[1] Explanatory Statement for the Animal Welfare Legislation Amendment Bill 2019

- *Animal welfare in a modern context describes how an animal is coping both mentally and physically and recognises that animals are sentient beings that have the capacity to feel and perceive things. Achieving good animal welfare relies on recognising the five freedoms of animals … and encompass at a high level the freedom from hunger and thirst, freedom from discomfort, freedom from pain, injury or disease, freedom to express natural behaviour, and freedom from fear and distress. It also relies on recognising that animals deserve having a life worth living, in terms of both physical and mental wellbeing.*

This update to the Welfare Act should be reflected in appropriate revisions to the Kangaroo Management Plan, and an effective way to achieve that would be to recognise welfare as a high-level impact area, on a par with environmental and economic impact areas.

The ACT Wellbeing Framework categorises areas (domains) that have been identified as consistently contributing to the overall quality of life for Canberrans (ACT Government 2020). 'Wellbeing Impact Assessments' are embedded into ACT Government Budget and Cabinet processes. The management Plan for the Canberra Nature Park states that the Park contributes to all 12 domains, or areas affecting our quality of life, as described in the ACT Wellbeing Framework. Kangaroo management in the ACT is integral to the management of Canberra Nature Park, and therefore all 12 domains are arguably relevant; the most pertinent domains for the three main impact areas relevant to kangaroo management are summarised in Table 4. Including Overall Welfare as an impact area in the revised kangaroo management plan would align with the ACT Wellbeing Framework.

Finally, thinking about optimising Overall Welfare would be consistent with the international 'One Welfare' movement: "'*One Welfare projects are intended to address the interconnections between animal welfare, human wellbeing and the environment*." One Welfare encourages a broad, multidisciplinary approach that can connect science, ethics, economics, conservation, and other values (Kennedy *et al.* 2022; Pinillos *et al.* 2016).

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Commented [DK58]: You have provided a definition of 'One Welfare ' here. 😊

Table 4. The relationship between the most pertinent domains and indicators in the ACT Wellbeing Framework, and how they map onto the impact areas central to kangaroo management.

Domain in the Wellbeing Framework, and *aspiration for the domain (in italics, paraphrased from the Framework)*	**Indicators**	**Kangaroo Management Impact Area**
Environment and Climate *Canberra's natural environment sustains all life and is climate-resilient; this supports long-term economic sustainability*	• Healthy and resilient natural environment • Connection to Nature • Climate resilient environment and community	Environment Economy Welfare (all animals including humans)
Economy *Strong farming and tourism business (both rely on environmental sustainability)*	• Economic performance • Business conditions (of farming sector, nature-based tourism sector)	Environment Economy Welfare (all animals including humans)
Health *Canberrans have good physical and mental health … including through access to health-promoting environments [such as natural environments]*	• Overall health • Mental health • Healthy lifestyle	Welfare (Human)
Social connection *Canberrans are connected and supported within our community*	• Sense of social connection • Levels of volunteering	Welfare (Human, possibly other animals) Environment (Through the activities of volunteer groups such as Park Care)
Safety *Canberrans are and feel safe and secure*	• Road safety	Welfare (for people and kangaroos on roads) Environment (kangaroo population size)
Identity and belonging *Connection to Canberra, Valuing Indigenous history and culture*	• Sense of belonging and inclusion • Connection to Canberra	Environment Welfare (People)

	• Valuing Indigenous culture	
Governance and institutions *Canberrans participate and are heard; Government is transparent*	• Trust in government • Feeling that voice and perspective matter	Environment Economy (from effective government) Welfare (People)

Recommendation

5.6 Replace 'Social Impacts'; in the Plan with 'Overall Welfare Impacts', making Overall Welfare a high-level impact area, on a par with Environmental and Economic Impacts. This would mean that the welfare consequences of management actions (or inaction) for kangaroos, people, and other animals, can be explicitly and consistently considered within the same framework. This change would recognise recent amendments to the ACT Welfare Act, the development of the ACT Wellbeing Framework, and the One Welfare concept.

6. Have the policies contributed towards achieving the management objectives?

The Review was asked to consider the policies contained in the EGK CNSMP and where possible evaluate the degree to which the policies have achieved the management objectives stated in the plan in the last five years (2017-2022).

This task has been partially accomplished in the sections above; where this is the case, the section(s) above will be referred to.

The 2017 Plan groups a collection of policies, some with their own objectives, into four categories (Kangaroo Welfare, Interactions between human and kangaroos; Managing kangaroo densities; Managing captive populations). The Review deals with each category in turn.

6.1 Kangaroo welfare

The 2017 Plan's policy on kangaroo welfare (section 4.3.1) has an explicit objective:

- *Kangaroo management in the ACT is undertaken in a way that accords with ACT legislation, codes of practice and current Australian standards for animal welfare.*

To support this objective there are a collection of policies relevant to the operation of the management program (e.g., shooter testing, culling season, urban wildlife program, legislation and Codes of Practice); a policy for wildlife care of kangaroos; and a policy for translocation.

6.1.1 Kangaroo Welfare during culling

Culling is carried out to comply with a National Code of Practice for humane shooting of kangaroos and wallabies for non-commercial purposes. However, the ACT has additional regulation and practice designed to enhance welfare outcomes considerably. In particular, shooters must regularly pass a competency test (of shooting accuracy, familiarity with the Code, and macropod identification); audits of operations are undertaken on both the conservation and rural culls; a culling season reduces the risk that large pouch young and small young at foot will be orphaned, the conservation cull occurs only in reserves where conservation benefits are expected; and the overall number of kangaroos to be culled is reduced by culling regularly with small culls.

Humane killing of pouch young remains a sensitive issue for some people. This Review found that the protocols for humanely killing pouch young of different stages that is outlined in the Commercial Code (rather than the Non-commercial Code) was clear, useful, and supported by the available evidence. There may be potential for research to develop alternative methods.

The ACT Government's requirements and practice surrounding kangaroo management are dispersed across regulation and various internal guidelines and processes; there may be value in gathering some of these into a single Standard Operating Procedures document, for transparency and to drive positive change more broadly.

The Plan makes it clear that killing kangaroos without being authorized to do so under the Plan, without a license or by an exception under the Nature Conservation Act, is illegal.

The Plan establishes that kangaroo management must be carried out in accordance with legislation in the Animal Welfare Act 1992, and ministerially approved codes of practice.

The Plan defines animal welfare as "the health, safety and welfare of animals in general, or one or more animals in particular". [The Review notes that the **Animal Welfare Act 1992** has been updated since the 2017 Plan was released and this should be reflected in the revised Kangaroo Management Plan.]

For kangaroo culling, the relevant code of practice is the 'National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-commercial Purposes' (NRMMC 2008), which was adopted as an approved Code of Practice (not mandatory) in the ACT from March 2014. This Code deals with killing kangaroos (adults and young) for non-commercial purposes such as conservation management or compassionate euthanasia. This National Code was reviewed by a working group that includes representatives from states/territories, animal welfare organisations, and the kangaroo industry, and there was a public comment process.

Commented [DK59]: This CoP is an 'approved CoP (s22)' not a 'Mandatory CoP (s23)'

There is also a National Code of Practice for humane shooting of kangaroos and wallabies for commercial purposes (AgriFutures 2020). This Code is more recent, was informed by a broad pre-consultation process (Sharp and McLeod 2020), and has several useful advances compared with the older, non-commercial Code. For example, it includes more detailed standard operating procedures for shooting kangaroos and humanely killing joeys. Although commercial shooting does not occur in the ACT, much of the requirements for non-commercial culling in the ACT comply with these more current standards.

The ACT requires shooters to exceed the specifications in the non-commercial Code (although the Code encourages states/territories to "promote measures to ensure competency"), in several ways:

- Having stringent tests for non-commercial shooters, requiring them to pass a shooting accuracy test, a test on the Code, and a macropod identification test every two years. These are considerable improvements over the situation in other states (Wilson and Edwards 2019). If a shooter fails the test, they must wait two years before they can re-sit the test. Based on the consultation carried out for this Review, this lengthy wait to re-sit the test can be problematic for professional shooters as they are unable to work for two years.

- Auditing compliance and performance. Auditing processes are in place to assess compliance with the code during rural and conservation culling.

    - Rural: Pre-COVID, random audits were carried out on about 10% of people holding a licence to shoot kangaroos. During the audit, shooters were assessed for compliance with the non-commercial Code; for the percentage of kill-shots to the kangaroos' heads; for correct checking of pouches and humane killing of pouch young; and for tagging of killed animals. The landholders (if not the shooter) were checked to ensure compliance with conditions. If audits revealed a breach, the case was passed to the Licensing and Compliance team for further action. These processes are described in internal documents. Post-COVID, the ACT Government team are currently assessing whether and how to vary the audit process to make it as efficient and effective as possible.

    - Conservation: Independent veterinary welfare assessments of the ACT Government conservation culling have been conducted in 2013, 2015, 2017, and 2023. These assessments considered compliance with the Code, welfare outcomes for shooting of adults and independent juveniles, and welfare outcomes of humane killing of pouch young (as per the Code). The independent audits are important for maintaining public confidence in the program. An ACT Government vet also assessed the culling program in earlier years.

      In the most recent assessment (Atkinson and Hampton 2023), of 144 shot kangaroos, 97% died instantly from a single head shot, 3 animals required two shots (with 28-49 seconds between shots) and two kangaroos escaped after being shot. An additional two animals were missed altogether. There were 56 pouch young associated with the adult females; of these two-thirds were unfurred. Of the 18 furred young, one escaped before it could be ~~euthanased~~euthanised. Apart from the escapee, the pouch young were killed promptly using a concussive blow to the head. These statistics are similar to the results of the earlier assessments (all are available on the Government website).

      The proportion of kangaroos that insensible immediately upon the first shot is similar to another study of welfare outcomes for four large macropod species which reported a wounding rate of 0.4% for 279 kangaroos killed during a commercial harvest (McLeod and Sharp 2014); and higher than in some other wildlife shooting and abattoir slaughter of livestock (Hampton and Forsyth 2016; Smith

and Ryeng 2022). A review of all killing methods for large macropods concluded that an accurate shot to the head is least likely to cause suffering to individual kangaroos (Descovich *et al.* 2015).

An earlier assessment of the ACT Government conservation culling (Hampton and Forsyth 2016) measured the duration of stress in sentient young (i.e. the time between being extracted from the pouch and killed), reporting this as 4 seconds. The 2015 assessment also considered the stress imposed on kangaroos standing near to the shot individuals: of 124 kangaroos that were positioned near to shot individuals, only 73% moved away from the shot animal, and only for a short period (median time of 5 seconds).

The welfare outcomes from conservation culling in the ACT study are likely due to the high competence of the shooters, avoiding the use of spotlights (using thermal scopes and night vision instead), using suppressors on the guns, and the habituated nature of the kangaroos which allows for close shooting distances; these features may not be present in all large macropod shooting programs.

In addition to the external audits, it could be worthwhile to reinvigorate the involvement of the government vets in the conservation culling program. The vet(s) should have experience of culling operations and be willing to be part of the team and aim to assist the operation. During planning, they can keep the shooting team abreast of any developments in kangaroo welfare and veterinary science. In the field, a staff vet could help check for pouch young, collect data on demographics of the culled animals, and sample the condition of animals; these data may help inform predictions for population growth over the coming year (Wilson and Coulson 2021). Vets have knowledge that could be valuable at unexpected times during the operation, and they are expert and trusted conduits of information on animal welfare and health for the public.

The ACT has additional regulation and practice to improve kangaroo welfare as a resulting of non-commercial shooting:

- The ACT imposes culling seasons. Mixed sex culls can occur only between 1st March and 31st July each year when 8-12 month old young-at-foot are unlikely to be present. Young of this age are old enough to be outside the pouch and evade a follow-up shot if their mother is killed. The assumption is that the orphaned animal is still too young to survive without their mother (Sharp and McLeod 2016). The culling season is effective at reducing the risk of orphaning young of this age because kangaroo breeding in the ACT is strongly seasonal, with pouch emergence timed to coincide with the flush of green grass of spring (Fletcher 2007; Lucas *et al.* 2021). Studies of the age profile of young encountered during culls carried out over multiple years and sites in the ACT show that 8-12 month old juveniles are least likely to be seen between April and June, and most likely to be seen between September and December (Fletcher 2007; Lucas *et al.* 2021). In addition to the mixed-sex cull, on rural land (i.e., not on conservation lands), farmers may also kill males from 1st August to 31st October, but there are constraints placed on the number of males that can be killed (<30% of the number shot in the mixed season).

- In addition to these formal requirements, in the conservation culling program the contracted shooters and ACT Government staff use additional measures to improve welfare outcomes for the kangaroos and the efficiency of the program. For example, shooting is carried out at night, using night-vision and thermal imaging (instead of spotlights), and suppressors on the guns. The procedures covering all aspects of the conservation culling operation are outlined across various documents (e.g., tender documents and contracts), and it could be useful to gather them together in one set of Standard Operating Procedures to communicate how carefully the culling is organised, and to share with professional shooters working on rural lands, and managers in other jurisdictions.

- The ACT favours small, regular (annual) culls, rather than less regular, very large culls. The culling operations aim to bring the population size in reserves down closer to the target densities, then carry out smaller maintenance culls each year instead of less frequent but larger culls. This results in an overall welfare benefit because fewer animals are killed (section 4.3.3 in the 2017 Plan) when populations are not released to grow exponentially between culls.

- Culling is prioritised across the reserves and is most likely to occur in reserves with greater anticipated conservation benefit to other species. Conversely, culling is less likely when conservation benefits are considered to be less (ACT Government 2023a). This program design feature also reduces the total number of kangaroos that need to be killed.

6.1.1.1 Euthanasia of pouch young

During consultation for this review, some stakeholders voiced concerns over the methods outlined in the non-commercial Code for killing pouch young. The recommended methods are a concussive blow to the head or stunning and decapitation for unfurred young; and a concussive blow to the head for furred young (NRMMC 2008). The specific concern regarding decapitation is that if pouch young develop sentience before fur develops, then decapitation may cause suffering because the brain remains active for a short period after the head is severed. The specific concern about concussive blows is whether it is successful at killing the pouch young all the time. In addition, both decapitation and a concussive blow to the head have a connotation of violence that can be upsetting for some people.

The recommended methods for humanely killing pouch young in the more recently updated Code for commercial shooting of macropods (Australia 2020) are cervical dislocation or decapitation for pouch young under 5 cm long; decapitation for unfurred pouch young larger than 5 cm long; and a concussive blow to the head for partially furred or fully furred pouch young. The commercial Code contains more detailed information on the developmental stages of joeys, and how that affects whether methods are humane or not; and more detailed instructions on how to use each method properly. The Code also states that if the shooter is uncertain about the age and therefore sentience of a pouch young, then they should assume the young is sentient, and use a concussive blow.

Are unfurred young sentient?

Research has shown that brain activity *begins* developing from around the time the eyes begin to open and fur begins to develop in large kangaroos (Diesch *et al.* 2010; Diesch *et al.* 2008; McLeod and Sharp 2014). Thus, cervical dislocation and decapitation for very small pouch young should not cause distress, and these methods – which can be undertaken without removing the young from the pouch or off the teat – do appear to be the most humane way of killing these animals.

Is a concussive blow to the head for partially furred/furred pouch young a humane killing method?

A recent investigation of killing methods for pouch young of all ages concluded that a concussive blow (or 'blunt trauma') to the head was the most effective method and least likely to cause suffering (McLeod and Sharp 2014). An alternative method, using a captive-bolt device, was trialled but found to cause poorer welfare outcomes because too many animals were not properly stunned with a single shot when using the device (McLeod and Sharp 2014). Another review of all methods of killing large macropods (of all ages) also concluded that blunt trauma for young kangaroos was acceptable if properly delivered (Descovich *et al.* 2015). The Australian and American Veterinary Associations both state that blunt trauma, when done correctly by experienced operators, results in rapid death and is therefore an acceptable method of euthanasia (ANVMA 2020).

The issue of how to humanely kill pouch young was also raised as a concern in some submissions to the recent NSW Parliamentary Inquiry into the '*Health and wellbeing of kangaroos and other macropods in NSW*' (NSW Legislative Council 2021). However, other submissions noted that research-based veterinary advice considered this method as the most humane. The Portfolio Committee acknowledged that the killing of joeys (by blunt trauma to the head) was "shocking to many people" (Committee Comment 5.47) but made no recommendations for review of the method.

It therefore seems that a concussive blow to the head/blunt trauma is the most humane way to kill joeys, because it is rapid, effective, and consistent. However, it is very unpalatable to some of the public. The 2020 commercial Code notes that using captive bolts may provide an alternative option for humanely killing pouch young in the future, but that the effectiveness and consistency of this technique is yet to be demonstrated. The 2020 Code also

has more specific instructions about how to deliver the concussive blow to pouch young that are much more useful than the material available in the non-commercial Code. Given the public sensitivity to the killing of pouch young, the ACT Government could encourage and support research to explore whether captive bolts, or some other approach, could potentially replace a concussive blow to the head.

6.1.1.2 Other issues raised during consultation

Euthanasia or humane killing?

Some stakeholders questioned the use of the term '~~euthansia~~euthanasia' for killing pouch young, and felt that 'humane killing' was more accurate. Euthanasia refers to killing to end incurable suffering and is carried out in the best interest of the killed individual. A pouch young (without care) whose mother has been shot is almost certain to die from exposure, starvation, or predation; it may experience emotional distress and fear after the loss of its mother. Thus, killing an orphaned joey could be viewed as an act of mercy, consistent with the meaning of euthanasia. Alternatively, the killing of the mother and the dependent pouch young should be regarded as the same, single event, in which case we should apply the same term of 'humane killing' to both mother and pouch young. The research, livestock, and animal rescue/care sectors have been narrowing their use of the term euthanasia, retaining it for only the subset of humane killing scenarios that genuinely involve the relief of suffering because there is no other option. Both the commercial and non-commercial Codes for shooting kangaroos use the term euthanasia for killing pouch young, but the ACT could review its use of the term, and decide to use more specific language in its own documentation.

Including pouch young in culling targets and reports

During consultation, some stakeholders suggested that pouch young numbers should be included both in the cull targets, and the cull reports. The Plan states that pouch young ~~will~~are not ~~be~~ counted or shot~~and reported~~ (section 4.3.1 (h)~~2~~). In the early years of the program, the number of pouch young killed was not reported, h~~H~~owever, this situation changed from 2014, when management reports (e.g. ~~ACT Government 2023a~~) began reporting pouch young, in response to public feedback. Including pouch young in cull targets does not seem feasible, given managers cannot predict, and shooters cannot know whether adult females are carrying pouch young or not, until they check the pouch after shooting the female.

The 2017 Plan states that cull reports will include the number of adults, subadults and young-at-foot that are independently mobile. There has been some concern that independently mobile young at foot could be orphaned when females are shot *[Animal Liberation ACT & Conservator of Flora and Fauna (Administrative Review) [2014] ACAT 35, No. 48]*. In practice this may be rare, since large young-at-foot should be shot and counted as a culled kangaroo. If it does occur, research suggests that the young kangaroo may survive, but experience emotional distress (McLeod and Sharp 2014).

Commented [EH60]: Unsure why we would target pouch young?

Commented [WC61R60]: They are suggesting that at the start of the culling season we announce how many pouch young are likely to be killed, along with the number of independently mobile kangaroos.

Commented [WC62]: PY numbers are in Table 8 of the 2017 plan and more recent years are on the webpage

Commented [WC63]: These were really small YAFs too, during our culling season most YAFs would be older than this and less reliant on milk, but could still experience emotional distress

Recommendations

6.3 The Code for non-commercial shooting of kangaroos is 16 years old. The ACT Government should work with counterparts in the other jurisdictions to update the Code, and bring it closer to the standard of the current Code for commercial shooting of kangaroos (dated 2020). The 2020 Code for commercial kangaroo shooting has some useful new material (such as more detailed and updated standard operating procedures appended to the Code) that could be incorporated into a new non-commercial Code. In addition, the pre-consultation approach used in the development of the commercial Code – where stakeholder views were gathered to inform the revision – could also be considered for the non-commercial Code.

6.4 In the interim, the ACT Government could consider gathering all the information that guides the current conduct of the conservation culling operation into a single, non-statutory 'standard operating procedures' style of document, that can be used to communicate the very high standards and careful operation of the conservation culling program to all shooters working in the ACT, to shooters working in other jurisdictions, and to the public. To inform these SOPs, consider seeking review from the **ACT's Animal Welfare Advisory Committee**, a body with broad community representation from the animal welfare, farming, veterinary, research, conservation, companion animal, recreational/sporting and environmental legislation sectors.

6.5 Consider increasing the involvement of government vet(s), making them integral member(s) of the culling operations, helping to plan the year's program, to gather additional information on kangaroo demographics and health, and helping to communicate to the public that animal welfare is a primary consideration during the culling.

6.6 Explore the potential for further research to improve the effectiveness and consistency of portable non-penetrating captive bolts as an alternative method for humanely killing pouch young of certain ages. If potential exists, then support that research. Similarly, remain aware of further research into the development of sentience in pouch young, and implications for adjusting methods for humanely killing unfurred joeys.

6.7 Shooter competency:

- Consider providing shooter competency tests annually instead of every two years. Allow shooters that fail, to re-sit the test the following year; and drop the frequency of retesting to one in 3-5 years, so the overall workload of administering the tests is not increased, yet shooters are able to take the test again sooner.
- Include the use of night-vision equipment in shooter tests.
- The current penalties for killing females currently deter landholders from using the male-only culling season; consider modifying penalties to encourage male only culls to occur, whilst maintaining strong discouragement for shooting females out of the mixed-cull season.

6.8 Make the ear tags biodegradable.

6.9 Consider how to design and manage field audits during rural culls to optimise welfare benefits, make audits a constructive opportunity for two-way exchange, and reduce administrative burdens on farmers and government staff.

6.10 The Animal Welfare Act has been updated to recognize animal sentience since the 2017 Plan was released and this should be reflected in the revised Kangaroo Management Plan.

6.11 In the revised Plan, and other (new) documents relating to kangaroo management in the ACT, consider replacing the term 'euthanasia' with 'humane killing' for pouch young that are killed because their mothers have been shot during the conservation culling. This is in line with the terminology used in the National Animal Welfare Standards and Guidelines.

6.1.2 Kangaroo welfare in wildlife caring and translocations

The 2017 Plan does not support translocations, or the release of hand-reared kangaroos, because of poor welfare outcomes for kangaroos, and some risks to humans (from hand-reared kangaroos). Research since 2017 on the outcomes of large macropod translocations corroborates this position.

The Plan outlines the welfare arguments against hand-rearing and releasing kangaroos in the ACT (welfare concerns for the individual kangaroo, risk that hand-reared males could later injure people when they are mature, risk to resident kangaroos). There is a licence to export 35 kangaroos that come into care in the ACT, into NSW, each year. The Plan notes that there is no justification for hand-rearing and release on conservation grounds as the eastern grey kangaroo is an abundant species.

The Plan does not support alternative actions to culling that have poor welfare outcomes for individual kangaroos, including translocation of kangaroos. Kangaroos to be moved must be captured and sedated, transported, then released to a novel site, steps that each present risks of distress, injury, and death from various mechanisms. Research carried out since the 2017 Plan was published corroborates this assessment (e.g. Cowan *et al.* 2020; Thompson *et al.* 2022).

In addition, translocations can ~~also~~ not be carried out on the scale required to keep kangaroo populations at lower levels, they are resource-intensive, and there are no/few suitable release sites. Since eastern grey kangaroos are not threatened, there is no conservation justification for translocations.

6.1.3 Kangaroo welfare considerations only partially, or not, considered by the 2017 Plan