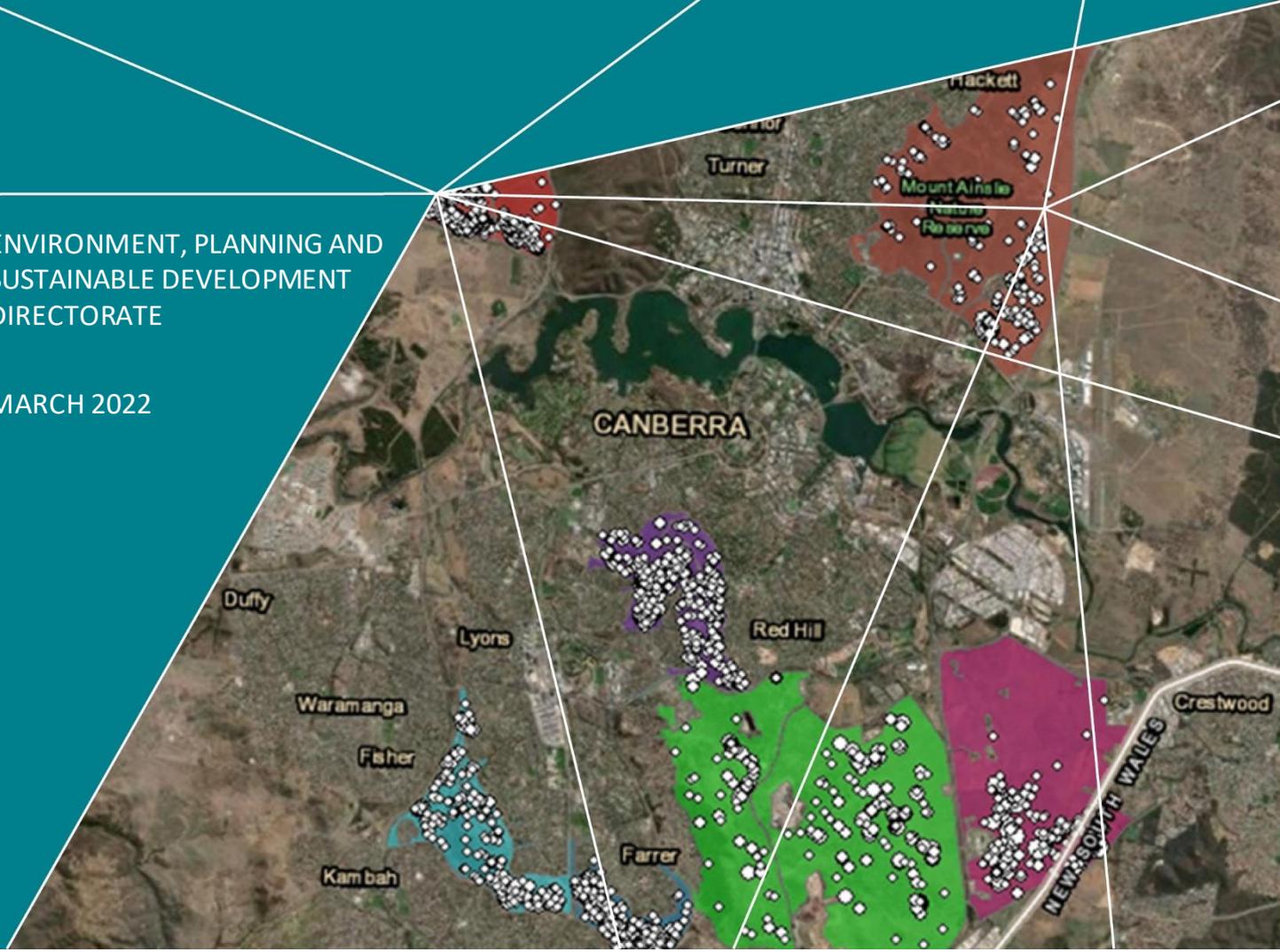


EASTERN GREY KANGAROO

CONSERVATION MANAGEMENT ADVICE 2022

ENVIRONMENT, PLANNING AND
SUSTAINABLE DEVELOPMENT
DIRECTORATE

MARCH 2022



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Front cover: Yellow-box Red-Gum Grassy Woodland with stunning display of native wildflowers. Photo credit Emma Cook.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	5
1. INTRODUCTION	8
2. SURVEY METHODS	10
KANGAROO MANAGEMENT UNITS	10
HERBAGE MASS SURVEYS	10
KANGAROO POPULATION SURVEYS.....	11
3. INFORMING MANAGEMENT ADVICE.....	13
ESTIMATING HERBAGE MASS PRODUCTIVITY.....	13
ESTIMATING KANGAROO POPULATION GROWTH.....	15
CALCULATING KANGAROO NUMBERS TO REMAIN.....	18
SELECTING A MANAGEMENT APPROACH	19
4. SUMMARY OF 2022 KANGAROO MANAGEMENT ADVICE	22
5. SITE SPECIFIC CONSIDERATIONS.....	23
AINSLIE MAJURA KMU.....	23
ARANDA PAINTER KMU.....	27
CRACE KMU	31
DUNLOP KMU.....	35
EAST JERRABOMBERRA KMU.....	39
FARRER RIDGE KMU	43
GOOGONG WEST KMU.....	47
GOOROOPYARROO KMU	51
GUNGADERRA KMU	55
KAMA EXTENDED KMU.....	59
MT TAYLOR KMU	63
MULANGGARI KMU	67

MULLIGANS FLAT KMU.....	71
RED HILL KMU.....	75
THE PINNACLE KMU.....	79
WEST JERRABOMBERRA KMU.....	83
6. RESERVE PRIORITISATION FRAMEWORK.....	87
7. REFERENCES.....	89

EXECUTIVE SUMMARY

Disturbance in the form of kangaroo grazing is an important part of maintaining functioning grassy ecosystems in the ACT. However, populations of Eastern Grey Kangaroos often reach unsustainable densities in the urban and peri-urban areas, due to a lack of natural predation and heavily fragmented habitat. As a result, excessive grazing pressure from kangaroos can deplete the grassy layer required to sustain grassy ecosystem function and biodiversity, including threatened species populations.

To prevent these impacts, kangaroos are managed in priority nature reserves within Canberra Nature Park to achieve a balance between grassy layer productivity (i.e. how quickly grass is growing) and grazing pressure (i.e. how quickly grass is consumed by kangaroos). Kangaroo management in this context involves both culling and the use of fertility control. The desired conservation outcome is native grass heights between 5 and 15 cm tall, within the 'grass height threshold', which has been demonstrated by local scientific studies to provide the greatest benefits to biodiversity (including several threatened species) and ecosystem processes.

The kangaroo management context in 2022 is comparable to that experienced in 2021. Wetter than average conditions associated with a La Niña Southern Oscillation cycle have promoted strong growth in ground layer vegetation, which continues to recover from the extreme hot and dry conditions experienced through 2019 and into early 2020. Ground layer vegetation monitoring undertaken in spring and early summer (2021) showed 56% of monitoring polygons to be 'within' threshold levels for average grass height and 40% of monitoring polygons being 'above' threshold levels. Less than 4% of polygons were 'below' threshold levels for average native grass height. This compares to the 2021 kangaroo management advice, in which 16%, 63% and 21% of management polygons demonstrated below, within and above threshold average native grass heights respectively. The implications of the current set of monitoring findings are target 'sustainable' kangaroo densities (i.e. the number calculated to achieve the desired grass height) across many conservation areas which are higher this year, translating to moderate kangaroo management requirements in 2022.

One exception to the trend of reduced kangaroo management needs is the Ainslie Majura Kangaroo Management Unit (KMU), where kangaroo populations appear to have increased significantly from last year. This may be due to increased immigration from surrounding areas, or significant increases in populations due to kangaroo population increases on neighbouring rural properties. This trend, and above-anticipated increases in kangaroo population size in select other KMUs, should continue to be monitored carefully in future years to ensure management is effective in achieving conservation outcomes.

Large reductions in kangaroo density are also recommended for Red Hill KMU and Mt Taylor KMUs. At these areas, kangaroo densities are well above sustainable densities due to lack of previous kangaroo management at these sites.

The kangaroo management advice for 2022 includes the use of updated kangaroo population growth models for both annual population growth rates. These models are based on published studies of

vertebrate population dynamics and make use of long-term datasets generated by the annual monitoring programs undertaken to inform kangaroo management in the ACT.

Further, since the 2021 advice, funding for the operational delivery of kangaroo fertility control vaccines has been secured. This program will take advantage of over two decades of ACT Government supported research and development surrounding non-lethal management tools. Administration of GonaCon immunocontraceptive vaccine for fertility control will be implemented as an integrated part of the kangaroo management program for the first time beginning in April of this year, with the aim of reducing the dependency on lethal kangaroo management into the future.

Finally, a number of new scientific publications detailing the basis for kangaroo management in the ACT have been published over the last year and are now available for free public access.

EASTERN GREY KANGAROO CONSERVATION MANAGEMENT ADVICE 2022

SITE	Adjusted TARGET Kangaroo Population Size	CURRENT Kangaroo Population Size	Recommended NUMBER TO CULL in 2022	Recommended NUMBER TO CONTRACEPT in 2022
Ainslie Majura KMU	644	1898	1311	-
Aranda Painter KMU	221	323	123	-
Crace KMU	298	130	0	-
Dunlop KMU	241	278	NA	-
East Jerrabomberra Valley KMU	840	788	NA	-
Farrer Ridge KMU	219	143	0	53
Googong West KMU	1521	1398	245	-
Goorooyarroo Sanctuary KMU	1001	923	159	-
Gungaharra KMU	482	258	0	-
Kama Extended KMU	409	397	85	-
Mt Taylor KMU	164	919	775	-
Mulangari KMU	316	197	0	56
Mulligans Flat KMU	252	348	160	82
Red Hill KMU	121	1300	1194	-
The Pinnacle KMU	181	157	0	-
West Jerrabomberra Valley KMU	1528	1293	131	-
TOTAL			4183	191

Table 1. Summary of the adjusted target population size for each KMU (i.e. number of kangaroos to remain) the current population size (within the conservation estate component of the full KMU); and the recommended number to cull within each KMU in 2022, allowing for population growth over the 12 month period ahead. The number of female kangaroos recommended to be treated with the contraceptive vaccine 'GonaCon' has also been provided for 2022, based on the identification of priority sites. Management of the remainder of the kangaroo population, within the KMU but outside of the conservation estate, is undertaken separately in accordance with the *Nature Conservation (Eastern Grey Kangaroo) Rural Culling Calculator Determination* (ACT Government 2017c) and is not summarised here.

1. INTRODUCTION

Grassy ecosystems are under threat worldwide (Eddy 2002; Prober & Thiele 2005). In south-eastern Australia, natural temperate grasslands and yellow-box red-gum grassy woodlands are two examples of such communities now listed as critically endangered following a significant contraction in their former distribution. Where remnant patches of these communities persist, the cessation of indigenous burning practices, altered herbivore dynamics, supplementation of soil nutrients (through the addition of fertilisers) and encroaching urbanisation represent some of the major shifts away from natural disturbance practices. These changes have significantly altered the diversity and composition of grassy ecosystems, primarily through the introduction of invasive species, the loss of grazing-sensitive species, and the loss or decline of species that rely on regular biomass removal or fire (Williams et al. 2006; Moxham et al. 2016). Inappropriate disturbance regimes associated with this shift away from traditional indigenous land management is now considered one of the greatest threats to the ongoing function and resilience of these native grassy ecosystems (Eddy 2002; Dorrrough et al. 2007; Williams & Morgan 2015).

As a result of their adaptation to frequent disturbance from grazing and fire, the application of appropriate levels of disturbance is considered critical in maintaining native plant and animal diversity within native grassy ecosystems (Lunt et al. 2012; Howland et al. 2014; Howland et al. 2016b; Keen 2021). In a peri-urban ecosystem, this often involves managing the impacts of habitat fragmentation and urban edge effects on these underlying natural processes, as well as the implications of issues such as an absence of natural herbivore predation (e.g. by dingoes). To ensure the correct balance is achieved to protect ecological functionality of lowland grassy ecosystems, and to enable their restoration and ongoing conservation, active adaptive management including the application of appropriate and context-specific grassy layer disturbance interventions is recognised as a key land management objective.

Alongside the use of ecological burns, grazing by native herbivores and particularly that of kangaroos is recognised as the preferred disturbance mechanism for maintaining grassy ecosystem health and function in the ACT conservation estate (ACT Government 2017a, 2019). The Eastern Grey Kangaroo (*Macropus giganteus*) is the dominant native mammalian herbivore in most grassy ecosystems of the south-eastern bioregion, although the Red-necked Wallaby (*Macropus rufogriseus*) and Common Wombat (*Vombatus ursinus*) also play a role in some locations. Recorded in densities up to almost 700 animals per square kilometre in grasslands of the Jerrabomberra Valley (Gordon et al. 2021), the Eastern Grey Kangaroo is well recognised as an ecosystem engineer in grassy ecosystems of the ACT due to its role in influencing grassy habitat structure and productivity through direct grazing (Howland et al. 2014; Howland et al. 2016a; Howland et al. 2016b; Snape et al. 2021) and nutrient cycling (Morris & Letnic 2017). Non-uniform impacts of kangaroo grazing, for example in response to the perceived risk of predation (Banks 2001), support the role of sustainable native herbivore grazing as a mechanism for promoting beneficial habitat heterogeneity at both the patch and landscape scales (Gordon et al. 2004).

Regardless of whether populations are regulated by natural predation or other means, maintaining a balance between native herbivore grazing pressure and rates of grass productivity (or growth) is recognised as key to ensuring ongoing health and resilience of grassy ecosystems (Morris & Letnic

2017; Gordon et al. 2021). Multiple scientific studies have investigated the two-way relationships between kangaroo populations and grassland structure within the Australian Capital Territory (Fletcher 2006; Howland et al. 2014; Portas & Snape 2018; Snape et al. 2021), as well as the relationships between grassy layer structure and the biodiversity of other native species including beetles (Barton et al. 2011), birds (Neave & Tanton 1989; Howland et al. 2016b), plants (McIntyre et al. 2015; Driscoll 2017; Snape et al. 2018) and reptiles (Manning et al. 2013; Howland et al. 2014; Howland et al. 2016a; Snape et al. 2018). Grass heights of around 5 – 15 cm have consistently been associated with providing the maximum biodiversity benefits for both native plant and animal species (Howland et al. 2016a; Snape et al. 2018; Gordon et al. 2021; Sato et al. *in prep*), and hence this is set as the preferred management target for grassy ecosystems within the ACT.

Despite these clear management targets for grass height, setting specific kangaroo population target densities to achieve this outcome is a complex undertaking. The relationship between kangaroo population size, associated grazing pressure and the outcomes in terms of grass structure has been shown to vary according to the composition, current condition, and the productivity (or growth rate) of the grassy layer (Snape et al. 2021). As such, assessments of grassy layer composition and condition are recognised as an important component of managing native herbivore impacts in these systems (Gordon et al. 2021; Snape et al. 2021), despite grass productivity (which is based on future climatic conditions) being largely impossible to predict at operationally relevant temporal scales. Where ‘average’ climatic conditions are assumed, as is the approach adopted for kangaroo management within the ACT, abundant grass growth resulting from above average rainfall will trigger the integrated use of alternative management tools such as ecological burns or physical removal, to restore grass palatability to local kangaroo populations and encourage targeted grazing in priority landscapes (McIntyre et al. 2015). Conversely, where hotter and drier than average climatic conditions prevail, exclusion devices such as non-vegetative habitat structures (logs, rocks) or temporary fencing may be required to protect the grassy layer as associated conservation values on a fine scale (Manning et al. 2013; McDougall et al. 2016).

Eastern Grey Kangaroos were declared a controlled native species under the *Nature Conservation Act* (2014) in 2017 in recognition of the importance of maintaining sustainable kangaroo population densities as part of the conservation of our critically endangered lowland grassy ecosystems. Since this time, kangaroo populations and their associated impacts have been carefully managed across the ACT in accordance with the *Eastern Grey Kangaroo: Controlled Native Species Management Plan* (ACT Government 2017b) and associated instruments. Kangaroo populations were managed previously in accordance with the ACT Kangaroo Management Plan (ACT Government 2010).

2. SURVEY METHODS

KANGAROO MANAGEMENT UNITS

A kangaroo management unit (KMU) is defined as a parcel of land which comprises one or more nature reserves and any adjoining areas of habitat which are potentially used by a single, shared kangaroo population. In the urban matrix, KMUs are usually separated from other areas of potential kangaroo habitat by a barrier to kangaroo movement such as a significant water body, main road, kangaroo-proof fence, or suburb boundary. Boundaries to kangaroo movements have been identified based on the results of local kangaroo movement studies, which utilised GPS collars or repeated population surveys to determine home-ranges and movement behaviour of kangaroos in the urban space (ACT Government, unpublished data; Viggers & Hearn 2005; Pulsford & Snape 2019).

Following the outcomes of an expert workshop on kangaroo management for conservation in 2018 (Gordon et al. 2021), objectives for kangaroo management to achieve biodiversity conservation outcomes are set explicitly at the scale of the KMU. This includes setting management targets around both grass height (nominally 5 – 15 cm to indicate broad suitability of grassy layer habitat) and kangaroo population size (set based on vegetation structure adjusted according to current condition). Accordingly, surveys of both ground layer vegetation (herbage mass) and kangaroo populations are also undertaken at the KMU scale to inform additional modelling and the basis for the kangaroo management advice presented throughout this report.

HERBAGE MASS SURVEYS

Herbage mass surveys are undertaken annually within each KMU to collect data on the current composition and condition of the grassy layer. This data is used to inform and evaluate annual kangaroo management advice. To capture the variability in grass condition across the landscape, the conservation area of each KMU is divided up into survey polygons classified according to their dominant perennial grass type (native C3, native C4, or exotic perennial grass). Each survey polygon contains two permanent survey plots which are positioned to be representative of the heterogeneity at the polygon scale. Each of the two survey plots within the survey polygon is a circle with an 11 m radius from a central point. Herbage mass surveys within each plot involve both a step point and a quadrat-based survey approach.

The step point survey involves the surveyor taking 100 random steps within the survey plot. At each step, the dominant vegetation type at point of the observer's shoe is recorded (native C4, native C3 native, native forb, cryptogram, rock, leaf litter, thatch, dead forb, bare ground, exotic forb, annual grass, or exotic perennial grass). This information provides current compositional data for the survey plot, and also enables changes in composition to be detected over time. For the quadrat-based survey, a 1m² quadrat is randomly positioned within the plot area to enable an average grass height and the percentage of grass which is green (an indicator of both palatability and productivity) to be assessed. The dominant grass species present within each quadrat is also recorded. This process is repeated to achieve ten quadrat surveys per plot. Quadrat data provides data on the amount of grass currently available within each survey polygon, and an indication of its current palatability and

productivity, enabling kangaroo population targets to be set and evaluated over time according to the method described by Snape *et al* (2021).

For both survey types, data is collected in an ESRI ArcGIS Collector app and is analysed in R. Outcomes for the herbage mass surveys undertaken to inform the 2022 kangaroo management advice are shown for each KMU later in this report.

KANGAROO POPULATION SURVEYS

Assessing current kangaroo population size is an important part of informing kangaroo management decisions within individual KMUs. A number of methods are available to assess kangaroo densities on a small scale (Coulson *et al.* 2021) which are selected based on site specific factors such as topography, vegetation type, the boundary of the survey area and KMU size. Common survey techniques adopted for this purpose in Canberra Nature Park reserves include direct and sweep count techniques (where the number of kangaroos in a landscape is counted directly by a coordinated team of surveyors) and walked line transect 'Distance' counts, where kangaroo density is estimated based on sampling kangaroo numbers from along fixed transect lines. Density estimates derived from the surveyed density of faecal pellets are no longer routinely used for informing kangaroo management decisions in the ACT. Further information on each of these methods is provided by Coulson *et al.* (2021), including reference to their application in the ACT.

All kangaroo surveys undertaken to inform kangaroo management advice provided in this report consider only 'independently mobile' kangaroos. No attempt is made to count young in the pouch due to their difficulty to detect at young ages, and highly variable recruitment rate into the adult population. Annual kangaroo population estimates are undertaken under the approved of an animal ethics committee.

A summary of the results of kangaroo population surveys undertaken to inform the 2022 kangaroo management advice are shown in Table 2. For many sites, as was true in 2021, surveyor capacity to clearly observe kangaroos during population surveys was limited due to areas of very high vegetation (including grass seed stems) in 2022. As such, it is possible that kangaroo densities estimated this year may represent underestimates compared to the true density. Alternative survey techniques effective in overcoming this issue are yet to be identified.

EASTERN GREY KANGAROO CONSERVATION MANAGEMENT ADVICE 2022

Table 2. Kangaroo population survey results used to inform conservation culling advice for 2022.

Count methods include 'WLT', walked line transect count; 'Sweep', sweep count; 'Direct', direct count. The calculated 95% confidence interval and coefficient of variation (CV) are shown for WLT counts whilst the range (minimum and maximum count) and number of repeat counts is shown in brackets for sweep and direct counts.

Site	Count Year	Count Type	Population Density	Number of Kangaroos	95% Confidence Interval (or Range)	CV (or Number of Counts)
Ainslie Majura KMU	2022	WLT	1.32	2770	1951 - 3932	17.6%
Aranda Painter KMU	2022	WLT	1.29	492	341 - 710	18.0%
Crace KMU	2022	Direct	0.72	130	125 - 134	(2)
Dunlop	2022	Sweep	2.4	279	265 - 292	(2)
East Jerrabomberra Valley KMU	2022	WLT	1.97	2723	1801 - 4118	21.2%
Farrer Ridge KMU	2022	WLT	0.71	144	95 - 219	21.4%
Googong West KMU	2022	WLT	0.8	1405	752 - 2627	32.0%
Goorooyarroo Sanctuary KMU	2022	WLT	1.16	920	636 - 1331	19.0%
Gungaharra KMU	2022	Sweep	0.71	258	240 - 275	(2)
Kama Extended KMU	2022	WLT	0.98	1506	771 - 2941	34.7%
Mt Taylor KMU	2022	WLT	2.75	1047	719 - 1525	19.0%
Mulangarri KMU	2022	Direct	1.25	197	162 - 232	(3)
Mulligans Flat KMU	2022	WLT	0.72	349	274 - 443	12.0%
Red Hill KMU	2022	WLT	4.29	1748	1326 - 2304	14.0%
The Pinnacle KMU	2022	WLT	1.02	371	254 - 544	18.8%
West Jerrabomberra Valley KMU	2022	WLT	1.28	2524	1573 - 4051	24.1%

3. INFORMING MANAGEMENT ADVICE

ESTIMATING HERBAGE MASS PRODUCTIVITY

Herbage mass productivity, more simply referred to as grass growth, is an important element of estimating the sustainable level of grazing by native herbivores in native grassy ecosystems as it is the major driving factor influencing the structure of grassy habitat in lowland ecosystems. Temperature, rainfall and the relative timing of these two climatic variables have demonstrated a strong influence in herbage mass growth models, in both dry (Caughley 1987; Owen-Smith 2002; Bayliss & Choquenot 2003) and temperate (Clark et al. 2000; Fletcher 2006; Cullen et al. 2008) environments. The rate of pasture growth is additionally influenced by soil characteristics (Cullen et al. 2008), which in itself can be dependent on a range of ecological and anthropogenic processes; and by the composition, cover and condition of existing pasture (Brougham 1956).

To facilitate the practical estimation of herbage mass growth rates within KMUs in the absence of detailed climatic and environmental information (e.g. soil chemistry and future weather patterns), a simple model of herbage mass productivity has been developed based on field measurements collected across Canberra Nature Park between 2014 and 2019. These data were subsequently used to construct models of herbage mass productivity for eleven different dominant grass species found within the ACT as per the methods described by Snape et al (2021). Models were optimised for each different species, but considered current grass height, the percentage of grass cover, the percentage of grass that was green, and season (spring or autumn) as variables in a generalised additive mixed modelling approach. As the survey period included a mix of both historically wet and dry years, the results of these models were taken to indicate an 'average' herbage mass productivity rate for each species based on variables readily measured in the field.

In addition to this modelling approach, three monthly climate outlooks published by the Bureau of Meteorology are also considered as part of informing kangaroo management advice for the year ahead. The current reports, published 28th April 2022 for the June to August outlook indicate a very high likelihood (80%) of wetter than average conditions for the ACT throughout winter, associated with a very likely chance of above average minimum temperatures (80%; Figure 1). Taken together, these climate outlooks indicate a continuation of favourable herbage mass productivity conditions at least in the three months ahead.

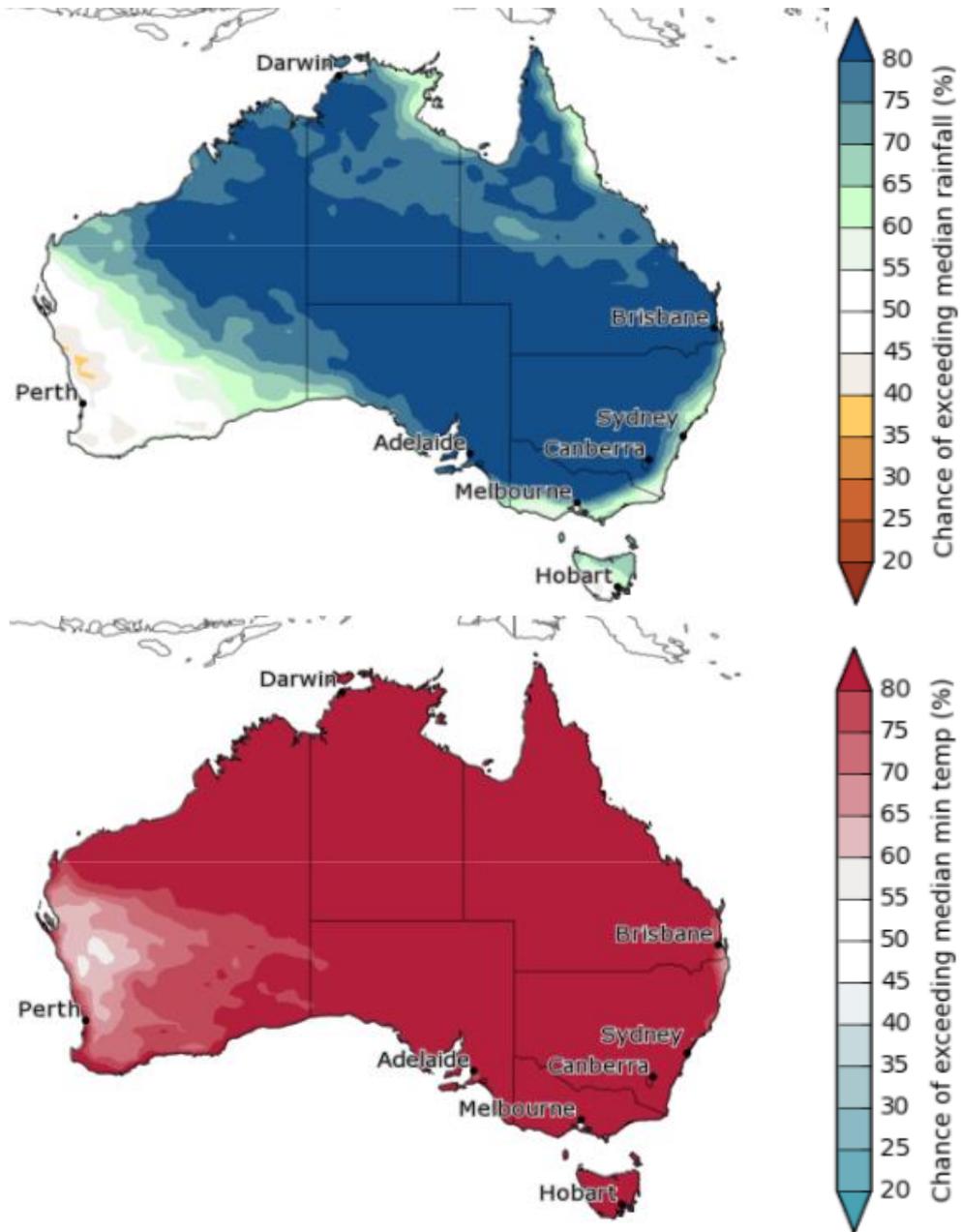


Figure 1. Rainfall (top) and minimum temperature (bottom) forecasts for June to August 2022. Sourced from www.bom.gov.au/climate/outlooks.

ESTIMATING KANGAROO POPULATION GROWTH

In any wildlife species, population dynamics are determined based on the relative rates of birth, death, immigration, and emigration. Often these rates are strongly influenced by population density through a process known as density dependence. In the ACT, female kangaroos can breed year-round. However, in practice there is a strong seasonal peak in pouch emergence that coincides with the flush of green grass available in spring (Fletcher 2006; Lucas et al. 2021). Except for under extreme conditions, juveniles rather than adults succumb to starvation when food is limited (Fletcher 2006; Portas & Snape 2018) and are also more susceptible to predation (Banks et al. 2000; Banks 2001).

Most KMUs in the ACT are generally designed to be largely 'closed' to the effects of immigration or emigration due to habitat fragmentation by urban features such as major roads, suburb boundaries, or waterways. As such, the overall population dynamics within each KMU are generally consistent where birth and death rates are stable and can thus be predicted over time with reasonable accuracy. This assumption was recently tested by Hone (2022) using ACT Government kangaroo population data. An analysis of this count data showed a significant effect of density dependence in peri-urban kangaroo populations (Figure 2). This equated to an annual population growth rate (r) described by the equation:

$$r_p = 0.317 - 0.151 \times N_t$$

where N_t is the starting density (Caughley 1980; Sibly & Hone 2002; Hone 2022). This equation was then used to estimate future population density according to a logistic population growth curve described by the equation:

$$N_{t+1} = N_t e^{r_p}$$

where N_{t+1} is the kangaroo population density following one year of logistic growth (May 1981; Deyle et al. 2013; Figure 3). This equation was found to have strong predictive capacity when applied to an independent set of kangaroo population estimates collected as part of the ACT kangaroo management program (Figure 4), with no significant difference between observed and predicted density (Hone 2022). The outcome of this review provides increased confidence in the validity of kangaroo population dynamics predictions which contribute to informing kangaroo management advice.

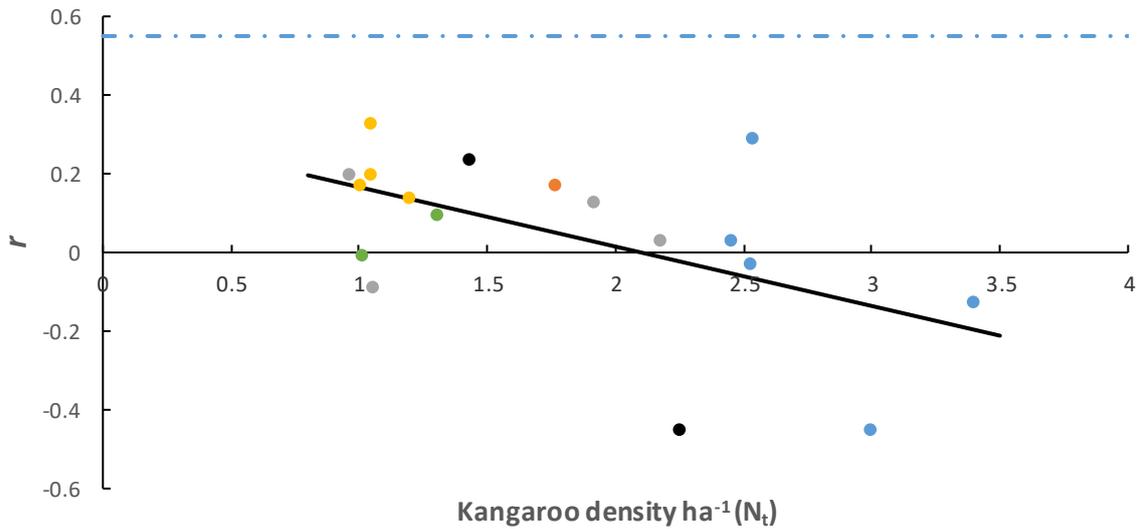


Figure 2. The relationship between kangaroo density (N_t) and annual population growth rate (r) between N_t and N_{t+1} in the absence of kangaroo management intervention. Colours indicate different KMUs used in this analysis: • Mt Painter, • Farrer Ridge, • Gungaderra, • The Pinnacle, • Crace and • Mulanggari. Dashed line indicates the maximum rate of increase for kangaroo populations (r_{max}). Reproduced from Hone (2022).

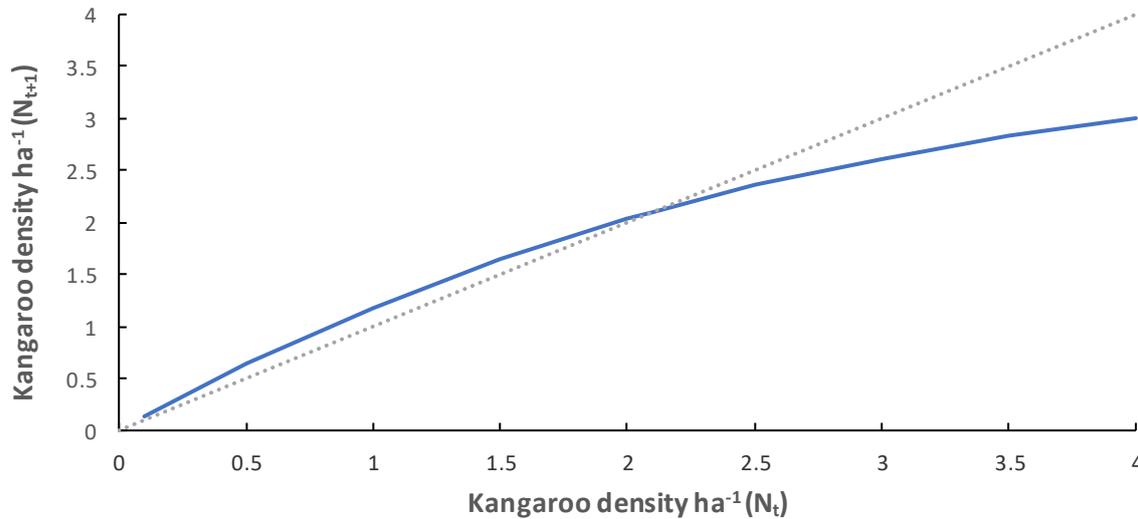


Figure 3. The relationship between initial kangaroo density (N_t) and that after 12 months of logistic population growth (N_{t+1}) based on application of the value of r derived from population data from the ACT. Reproduced from Hone (2022).

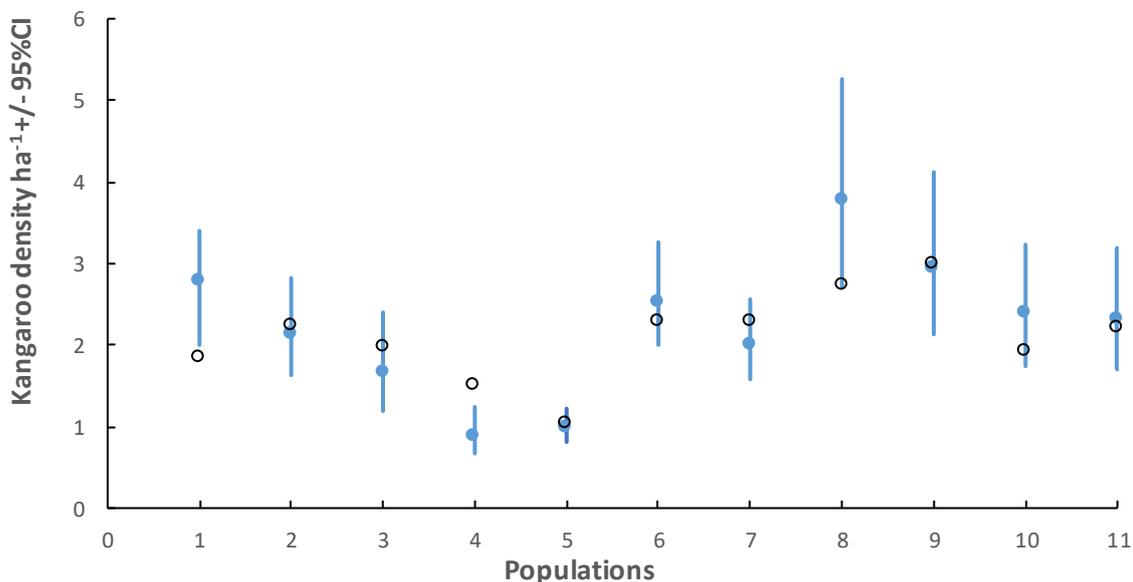


Figure 4. A comparison of predicted (open circles) and observed (solid circles and 95% CI) kangaroo density for eleven kangaroo population estimates in unmanaged reserves shows estimated kangaroo density falls within the 95% CI of the observed population density in nine of eleven cases. Predicted population growth is based on values of r and logistic growth rate equations described above. Of the two predictions which did not fall within the 95% CI of the observed value, one was an overestimate and the other an underestimate. Reproduced from Hone (2022).

The above dynamics are considered to reflect the effects of density dependent recruitment (i.e. whether juveniles enter the surveyed population) rather density dependent fecundity (i.e. whether pouch young are born at all). As the number of juveniles entering the surveyed population is likely influenced by a combination of food availability and predation pressure during weaning and early independence (spring through to late winter), the amount of grass present in the environment is likely to play a significant role in determining density dependent recruitment rates as it may influence both factors. To date, no direct association between grass height and juvenile recruitment has been explored for ACT kangaroo populations. However, successive years of above average grass growth coupled with high levels of habitat cover observed throughout 2021 and 2022 may have facilitated increased survival and recruitment of juvenile kangaroos into the surveyed population, as a result of both ample food availability and improved opportunities to escape predation.

Vehicle strike is also a significant cause of mortality in urban kangaroo populations and is known to be biased towards males in the ACT (Dunne & Doran 2021). Studies elsewhere in Australia indicate the greatest proportion of these are likely to be dispersing juveniles (Coulson 1997). Whilst the incidence of kangaroo vehicle strikes, based on ranger call-outs, reached an all-time high in the ACT during the peak of hot and dry conditions in the summer of 2019-20, significant rainfall in early 2020 coinciding with a reduction in road use in the early stages of the Covid-19 pandemic saw this number drop significantly (ACT Parks and Conservation Service, unpublished data). Kangaroo-vehicle

incidents appear to have remained at historically quite low levels to the end of 2021 and into 2022 (Figure 5).

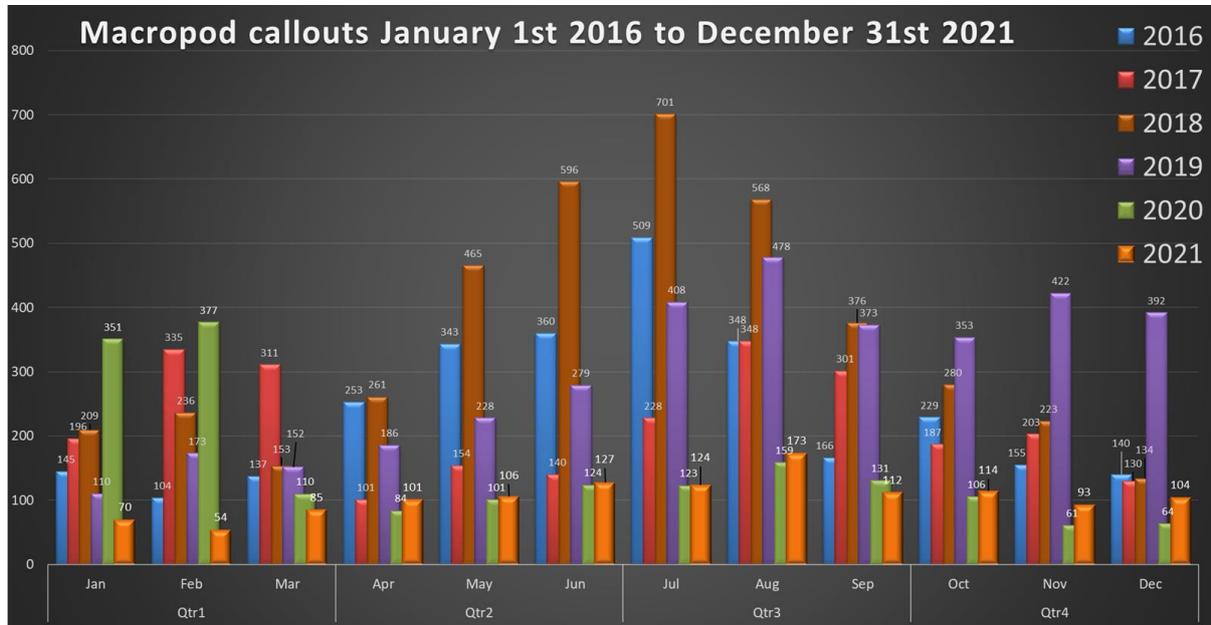


Figure 5. Monthly totals for kangaroo injuries or mortalities requiring attendance by the ACT Parks and Conservation Service on ACT roads (i.e. for euthanasia or carcass removal). Note particularly high rates of reported kangaroo-vehicle collisions during winter 2018, and a prolonged high number of incidents throughout spring and summer of 2019. The number of incidents was low for the second year running throughout 2021, likely a result of improved food availability and an ongoing reduction in the number of vehicles on the road as a result of the COVID-19 pandemic.

CALCULATING KANGAROO NUMBERS TO REMAIN

The overall goal of the kangaroo management program on conservation land is to achieve a healthy equilibrium between kangaroo grazing pressure and the productivity of the grassy layer, such that a healthy grass layer is maintained overall. To achieve this, calculations of the target number of kangaroos to remain in any given nature reserve are undertaken according to the *Nature Conservation (Eastern Grey Kangaroo) Conservation Culling Calculator Determination* (ACT Government 2018). This involves calculating the number of kangaroos to remain based on assessments of the total area of various vegetation types within a reserve (i.e. grassland, open woodland, woodland and forest classifications, based on percentage canopy cover). Following work by Fletcher (2006), an average target density of 1 kangaroo per hectare in grasslands was identified as being appropriate for achieving grassy layer outcomes consistent with maintaining conservation values in the long term. The density to remain in other vegetation types (with higher percentage cover of canopy and thus less cover of grass) is reduced as canopy cover increases. Throughout this document, unadjusted target densities calculated according to the *Nature Conservation (Eastern Grey Kangaroo) Conservation Culling Calculator Determination* are referred to as ‘calculator outputs’.

The calculator approach is effective in identifying long-term target densities for a given area of land but fails to account for variability in grass productivity or food availability in the short term (e.g.

annually) based on recent rainfall or the impacts of recent or historic grazing regimes. As such, calculator outputs are adjusted based on the outcomes of herbage mass surveys and predictions of herbage mass productivity described above to tailor management recommendations to current conditions (Snape et al. 2021). It is these adjusted target densities that are shown in Table 1 and form the basis for advice in section 4 (below).

Adjustments to target kangaroo densities based on herbage mass assessments allow smaller kangaroo populations to be retained within a KMU in response to conditions such as historic over-grazing or prolonged hot and dry spells, where limited herbage mass productivity has resulted in depleted ground layer vegetation structure. Such adjustments enable new grass growth to be retained in the system (rather than consumed by the kangaroo population) hence allowing the grassy layer and associated biodiversity values to recover to a state of improved condition in a shorter time. Similarly, under conditions associated with increased herbage mass productivity and longer grass, larger numbers of kangaroos can be sustainably maintained within a KMU reducing the need for active kangaroo management in some years.

Allowances for population growth between one year and the next is the final step of estimating kangaroo 'numbers to remain' and is considered to account for the natural increase in kangaroo population size between one year and the next based on natural breeding and recruitment of young into the surveyed population. This adjustment is made with the intent of achieving the target density of kangaroos on average throughout the year. In practice, this means the population will start slightly below the target number immediately following the cull and end up slightly above the target number before subsequent kangaroo management activities in the following year.

This adaptive and evidence-based approach, integrated with the use of other herbage mass management tools such as fences, burning, slashing and the strategic use of livestock, ensures kangaroo management approaches can remain adaptable to constantly fluctuating climatic conditions. Annual reassessments of both grassy layer vegetation condition and kangaroo population size also enable the detection of any changes in kangaroo population dynamics. Finally, such an approach enables program effectiveness to be evaluated and monitored over time both in regard to specific target thresholds for kangaroo population size and the average height of the grassy layer which acts as a surrogate for benefits to native biodiversity.

SELECTING A MANAGEMENT APPROACH

Each year, a variety of information sources are used to determine the most appropriate options for managing kangaroos as part of the broader approach to integrated management of endangered grassy ecosystems. These include the current condition of the grassy layer (based on herbage mass assessments), the current kangaroo population size (based on kangaroo population surveys), the distribution of kangaroos across the landscape (based on GPS-ed kangaroo positions or local landholder knowledge), evidence of immigration or emigration from the site (based on kangaroo-vehicle collision data), information around the population demographics (age, sex based on population survey) and other factors relevant to kangaroo management (e.g. the impacts of other herbivore species present in the area). Importantly, the 'permeability' of the kangaroo management unit itself, in terms of the likelihood of movement of kangaroos from neighbouring areas into or out of the priority landscape, is also considered in adopting a management approach.

Where management is undertaken by culling, the goal is to retain, on average, the adjusted target density for the KMU over the 12-month period ahead. This means that the number remaining after management takes place will be slightly fewer kangaroos than the adjusted target number, to account for population growth throughout the year.

The integrated use of the fertility control vaccine, GonaCon, into the long-term kangaroo management program is again recommended for 2022 at selected sites. As the application of fertility control is unlikely to reduce kangaroo grazing impacts in the short term (Woodward et al. 2006; Wimpenny et al. 2021), this technique is best applied to populations which are already maintained at their adjusted target density. The number of females to treat with fertility control in any given KMU will thereafter be dependent on site-specific population dynamics, particularly the birth and survival rate of young.

Initial recommendations are to treat approximately 70% of the adult females at each of the selected sites, with site specific target numbers being determined based on the model by Hone (2004). This level of contraception is expected to reduce population growth, and thus reduce the need for culling, but still retain sufficient breeding animals in the population to allow appropriate target densities to be achieved in response to the annual variation in climate and vegetation condition (Figure 6). Most females will have a young in the pouch at the time of treatment that will be unaffected, therefore population growth is expected to not be significantly impacted between 2022 to 2023. Any effect of the fertility control treatment on population growth will be first evident in 2024. Additional fertility control treatments and the level of culling required each year will be informed by ongoing monitoring of kangaroo density, population level fecundity (proportion of adult females carrying pouch young) and vegetation condition.

Using this information, recommendations produced by the various data-based mathematical formulas is reviewed by expert ecologists, operational program coordinators and local land managers to collectively agree on the most appropriate approach to achieve site-specific conservation outcomes. In 2022, these discussions have included consideration of the role of ecological burns, surface rocks and coarse woody debris, slashing and strategic livestock management, temporary fencing, invasive herbivore management, kangaroo culling and the use of immunocontraceptive vaccines as tools to manage the impacts of eastern grey kangaroos on achieving priority conservation outcomes across Canberra Nature Park and select areas of the broader conservation estate.

A summary of the kangaroo population management recommendations for 2022 for each KMU is provided in Tables 1 and 3.

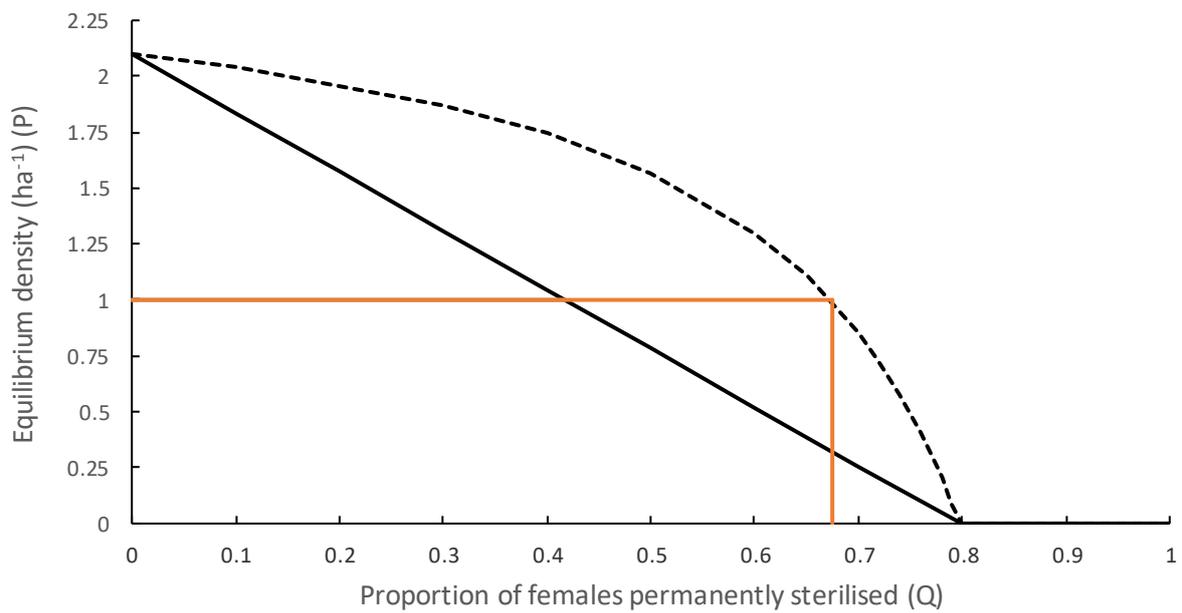


Figure 6. Predicted effects of fertility control on eastern grey kangaroo density (ha^{-1}), assuming density dependent effects on mortality (solid line) or recruitment (dashed line). Example (in orange) indicates the proportion of females which need to be permanently sterilised (Q) to be 0.673 in order to maintain an equilibrium kangaroo population density of 1 kangaroo per hectare (P). Equation assumes $K = 2.1$ kangaroos per ha, $r_{\text{max}} = 0.55$ per year, and birth rate (a) = 0.69 young per female per year. J Hone, unpublished data based on Hone (2004).

4. SUMMARY OF 2022 KANGAROO MANAGEMENT ADVICE

Calculations of the number of kangaroos to cull from a kangaroo management unit are calculated according to (a) the adjusted target density (derived from herbage mass assessments), (b) the current population density, and (c) predictions of population growth in accordance with the *Controlled Native Species (Eastern Grey Kangaroo) Conservation Culling Calculator* (2018). A summary of the key elements informing the calculation of kangaroo management advice for 2022 are provided in Table 3.

Table 3. Management areas, calculator output and adjusted target kangaroo densities, recent kangaroo counts and predicted population growth information used to determine kangaroo management requirements within the ACT Government managed conservation areas for each kangaroo management unit (KMU).

Columns marked (a) to (c) refer to the components of the kangaroo management formula referred to in the *Nature Conservation (Eastern Grey Kangaroo) Conservation Culling Calculator*. Recommended numbers to contracept are based on Hone (2004) in populations with sex ratios reflecting 54% females to 46% males. Kangaroo densities are number of kangaroos per hectare. Areas managed by ACT Government for conservation include nature reserve, areas managed as nature reserve (including environmental offset sites), and road verges adjacent to nature reserves. †Adjusted target density capped to allow recovery to density determined by calculator output within 1-2 years; * adjusted target density capped at ecological carrying capacity of 2.10 kangaroos/ha based on Hone (2022); NS, new site. No culling is recommended for Dunlop KMU due to ongoing livestock grazing across this site. No culling is recommended at East Jerrabomberra Valley KMU as grazing by kangaroos within conservation areas is being actively encouraged due to above threshold average grass heights in some areas.

SITE	Total Area of KMU (ha)	Area Managed by ACT Government for Conservation (ha)	CALCULATOR OUTPUT for Conservation Area Number (and Density)	(a) ADJUSTED TARGET for Conservation Area Number (and Density)	Values Below Relate Only to Areas Managed for Conservation by ACT Government					
					(b) Population (and Density) at 2022 Count	(c) Expected PGR based on POST CULL Population Density	Number to remain, allowing for population growth in the interim to the	Recommended Number to Cull in 2022	Recommended Number to Contracept in 2022	Operational Priority based on risk to values and prior investment?
Ainslie Majura KMU	2100	1438	465 (0.32)	644 (0.45)	1898 (1.32)	0.24	575	1323	-	High
Aranda Painter KMU	381	250	127 (0.51)	221 (0.88)	323 (1.29)	0.18	200	123	-	Med
Crace KMU	180	142	162 (0.90)	298 (2.10)*	130 (0.72)	0.21	298	0	-	-
Dunlop KMU	116	116	113 (0.97)	241 (2.08)	278 (2.40)	0.00	241	NA	-	-
East Jerrabomberra Valley KMU	1384	400	338 (1.00)	840 (2.10)*	788 (1.97)	0.55	640	NA	-	-
Farrer Ridge KMU	202	202	141 (0.70)	219 (1.08)	143 (0.71)	0.21	200	0	53	-
Googong West KMU	1747	1747	1404 (0.80)	1521 (0.87)	1398 (0.80)	0.55	1153	245	-	Med
Goorooyarroo Sanctuary KMU	797	796	561 (0.71)	1001 (1.26)	923 (1.16)	0.55	764	159	-	High
Gungaharra KMU	364	345	328 (0.90)	482 (1.40)	258 (0.71)	0.21	455	0	-	-
Kama Extended KMU	1541	405	332 (0.82)	409 (1.01)	397 (0.98)	0.55	312	85	-	Med
Mt Taylor KMU	381	334	228 (0.68)	164 (0.49)†	919 (2.75)	0.22	144	775	-	Low, NS
Mulanggari KMU	158	155	152 (0.96)	152 (2.04)	197 (1.25)	0.13	315	0	56	-
Mulligans Flat KMU	484	484	201 (0.42)	252 (0.52)	348 (0.72)	0.55	189	160	82	High
Red Hill KMU	407	303	172 (0.56)	121 (0.40)†	1300 (4.29)	0.12	106	1194	-	Med, NS
The Pinnacle KMU	365	154	99 (0.64)	181 (1.18)	157 (1.02)	0.16	168	0	-	-
West Jerrabomberra Valley KMU	1971	1010	722 (0.71)	1528 (1.51)	1293 (1.28)	0.55	1162	131	-	Med
TOTAL								4195	191	

5. SITE SPECIFIC CONSIDERATIONS

AINSLIE MAJURA KMU

Background

The Ainslie-Majura KMU is situated in northern Canberra, surrounded by the suburbs of Ainslie and Hackett to the west, the Federal Highway to the north, Majura Parkway to the west, and Fairburn Avenue to the south. It is comprised of the Mt Ainslie and Mt Majura Nature Reserves (and adjoining environmental offsets), government horse paddocks, several private rural leases, and an area of Commonwealth land. The area is predominantly dry forest with open grassy areas at the base of the western slopes. The KMU is expected to have little immigration/emigration, although kangaroos are known to move into the suburbs to graze during the night (resulting in high rates of kangaroo-vehicle collisions in this area). Kangaroos have also been recorded moving across road-bridges over the Majura Parkway. Over-grazing of the understorey vegetation at this site by kangaroos (and to a lesser extent rabbits) has been an issue at this site for over a decade. However, collaborative efforts to decrease the density of kangaroos across both government and non-government managed land have been underway since 2016 and have achieved significant reductions in overall kangaroo density at this site.

Site-specific considerations

The Ainslie Majura KMU contains significant areas of critically endangered Yellow Box - Red Gum Grassy Woodland, as well as several rare orchid species and populations of the Golden Sun Moth. The Friends of Mount Majura and Mount Ainslie Weeders, in collaboration with the ACT Parks and Conservation Service, have invested significant effort over many years in mapping and treating rabbit warrens, undertaking weeding and erosion control, and planting tube stock and seeding nodes, in an effort to re-establish structural complexity at this site. This work will continue at this site in 2022.

Temporary fencing has previously been installed in the West Majura Grasslands environmental offset area to protect key threatened species habitat from the impacts of overgrazing by kangaroos. With kangaroo density having been reduced in this area in recent years, and with recent above-average rainfall conditions, grass heights have now recovered in this area and are in fact now above threshold levels. Kangaroo exclosures will hence be opened up in 2022, and herbage mass disturbance measures (e.g. slashing) introduced to increase heterogeneity in grass structure and improve palatability for kangaroo grazing.

Kangaroo management recommendations

The results of the 2022 counts for the Ainslie Majura KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 7. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 8 and 9. Kangaroo density in 2022 is well above projected densities based on 2021 observations and hence are well above target population densities. Based on these observations, ongoing management of kangaroos by culling is recommended for the Ainslie Majura KMU in 2022 across both conservation and non-conservation tenured land (Table 3). Culling activity in 2022 should avoid further density reduction in grassland conservation areas to the east of Mount Ainslie. Instead, kangaroo management should be attempted in alternative areas of the broader KMU where this can be safely achieved. Higher than

anticipated population growth rates at this site in future may indicate immigration from adjoining areas and if observed should prompt further consideration of alternative approaches to maintain sustainable kangaroo densities at this KMU.

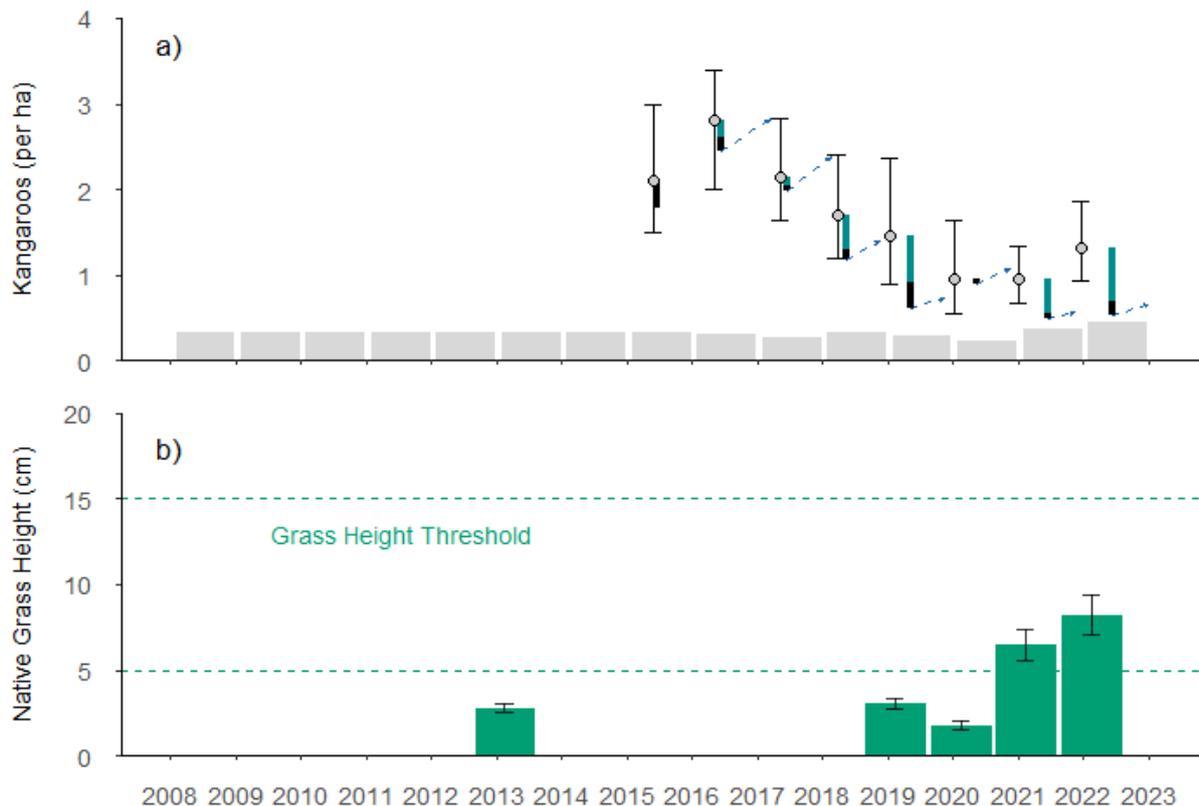
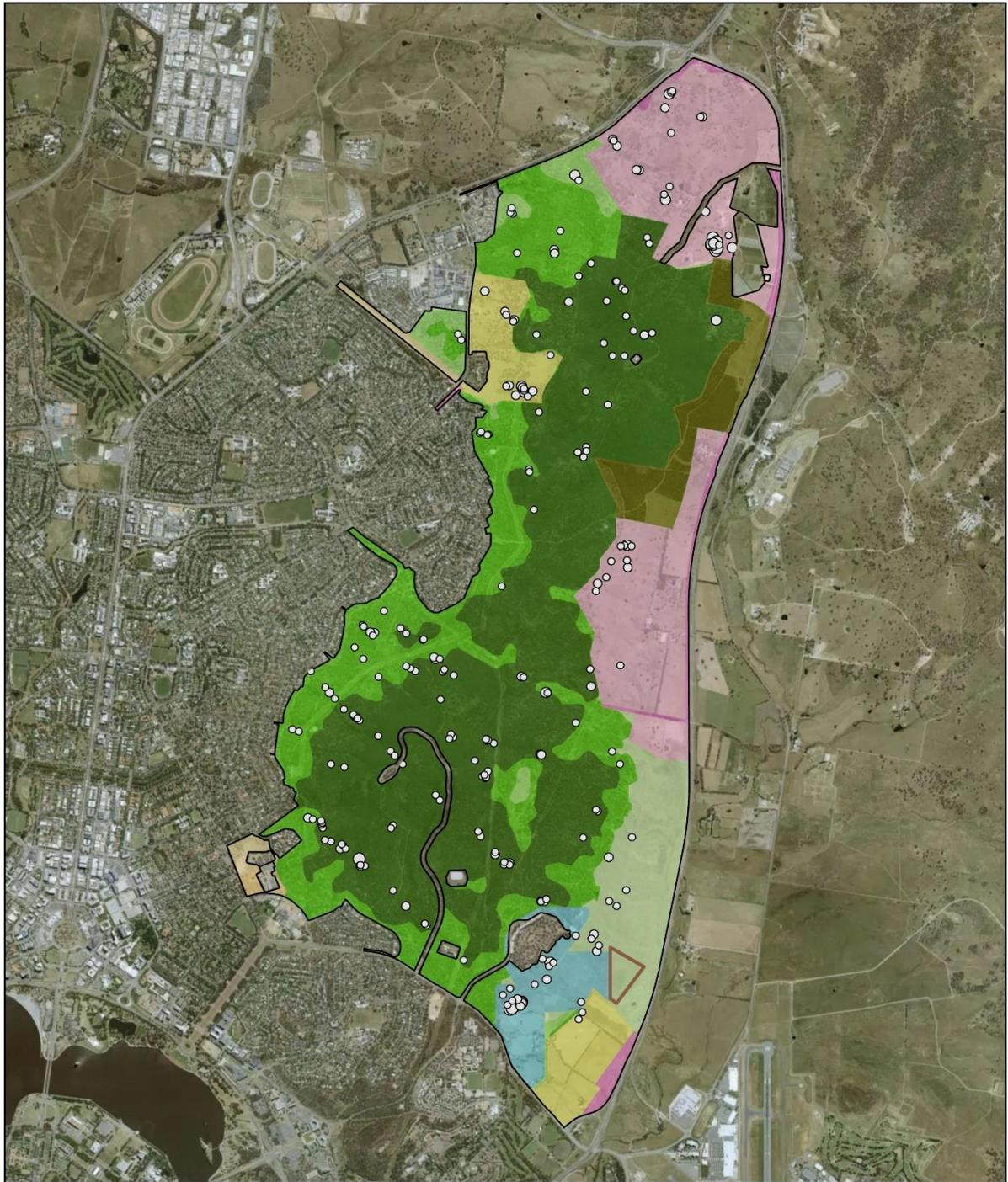


Figure 7. Changes in kangaroo density and native grass heights for Ainslie Majura KMU

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals based on the walked line transect count method being used (○). Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program and black bars representing management outside of ACT Parks and Conservation Service managed lands. The vertical line shown for 2022 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments related to grassy layer condition and other relevant factors.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



**Ainslie Majura KMU
2022**



0 0.75 1.5 Kilometers

EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8

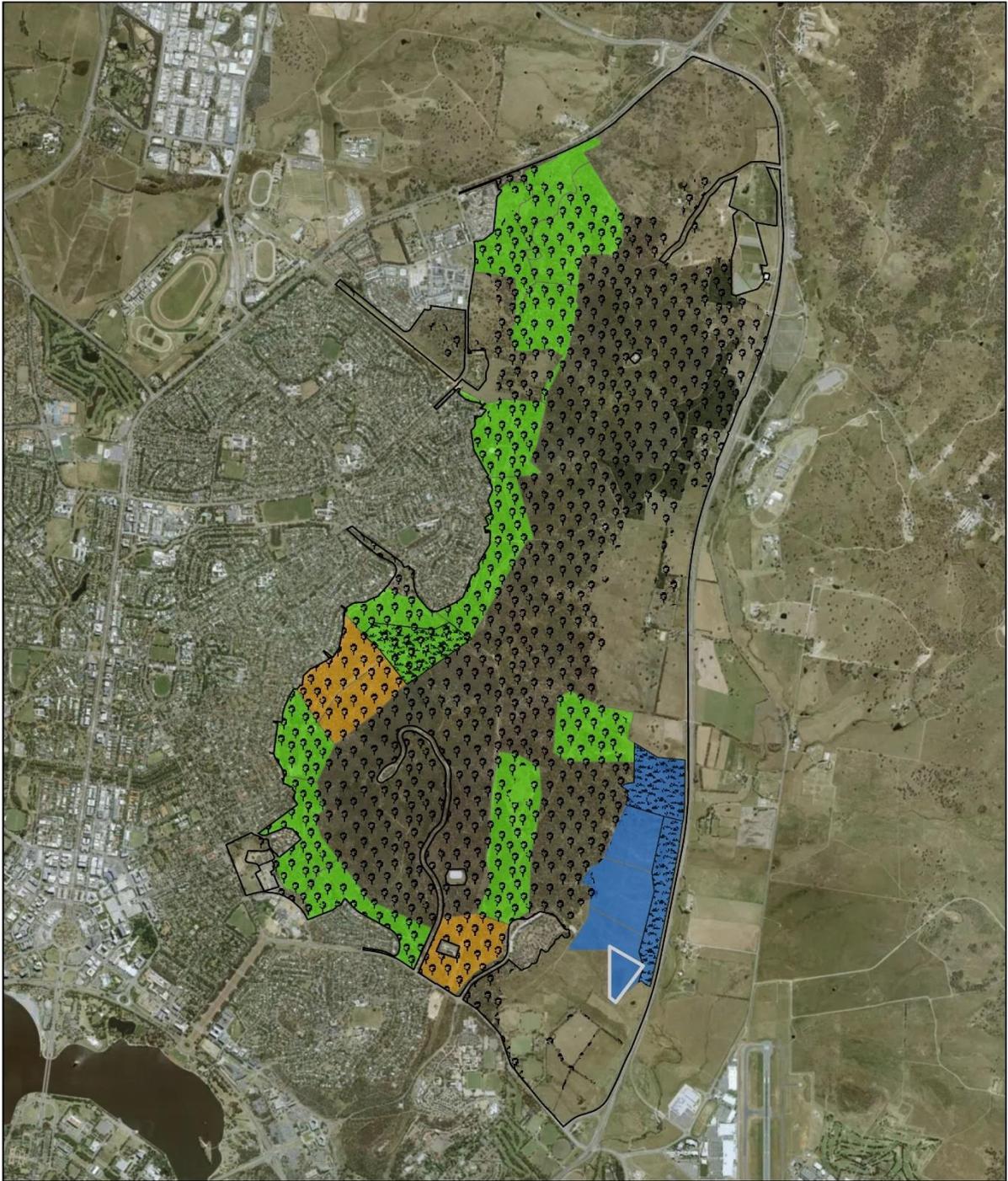
Conservation Veg

- Grassland
- Open Woodland
- Woodland
- Forest
- Pine Forest
- Temporary Kangaroo Enclosure

Other Tenure

- Business/Industrial
- Commonwealth Land
- Horse Paddock
- Rural Lease
- Urban Park
- Verge

Figure 8. Map of Ainslie Majura KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Ainslie Majura KMU
2022



0 0.75 1.5 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest
- Temporary Kangaroo Enclosure

Figure 9. Map of Ainslie Majura KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

ARANDA PAINTER KMU

Background

The Aranda and Mount Painter KMU makes up part of the Belconnen hills reserve network. The two reserves and their adjoining horse paddock and areas of rural lease, community garden and areas earmarked for future urban development are divided by Bindubi Street, with Gungahlin Drive to the east, Coulter Drive to the west, William Hovell Drive the south, and the suburbs of Cook and Aranda to the north. This KMU may be impacted by the duplication of William Hovell Drive to the south in 2022-23 and the development of the suburb of Whitlam. Vegetation in and around Mt Painter Nature Reserve is predominantly open woodland and land historically cleared for grazing, whilst the Aranda Bushlands and Snowgums component of the KMU is comprised of dense forest and open grassland respectively. Mt Painter and Aranda Bushland KMUs were initially considered separately in terms of kangaroo management, but evidence of high animal movement between these two areas (including high rates of kangaroo-vehicle collisions on Bindubi Street) led to them being considered as a single management unit since 2019.

Site specific considerations

Aranda Bushland and Mt Painter Nature Reserves each contain areas of critically endangered Yellow Box - Red Gum Grassy Woodland and are important for the protection of several rare plant species and declining woodland birds. Aranda Snow Gums, in the south east of the KMU, are heritage listed whilst the Wildflower Triangle within the Mt Painter Nature Reserve is managed to protect a range of rare plants, as well as life and property through fire fuel management. Erosion control, weeding and revegetation efforts are undertaken across the KMU by the Friends of Mt Painter and the Friends of Aranda Bushland. Rabbit populations and invasive plant species will continue to be managed alongside ongoing issues of erosion at this site throughout 2022.

Kangaroo management has been undertaken within the former Mt Painter KMU since 2010, achieving a kangaroo density consistent with the conservation objectives of that site. However as higher than anticipated kangaroo population growth rates indicated a significant risk of immigration on achieving management outcomes, the Aranda Nature Reserve was added to the KMU in 2019. Operational constraints to date have limited capacity to manage kangaroo populations to achieve the new combined target density since this modification to the KMU and as a result, populations have continued to increase gradually over time. Increasing populations of Common Wombats are also being observed at this site, further adding to total grazing pressure within this landscape.

Kangaroo management recommendations

The results of the 2022 counts for the Aranda Painter KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 10. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 11 and 12, showing within or above threshold native grass heights despite kangaroo populations being above target densities. To maintain these improvements in grassy layer structure, and subject to operational constraints, a conservation cull is recommended for Aranda Painter KMU in 2022 (Table 3) with a focus on reducing kangaroo population densities in the Aranda Bushlands component of the KMU. Where appropriate, management efforts should be undertaken as part of a collaborative approach with neighbouring landholders in this KMU. The use of fertility control isn't being considered within Aranda Painter KMU at this time.

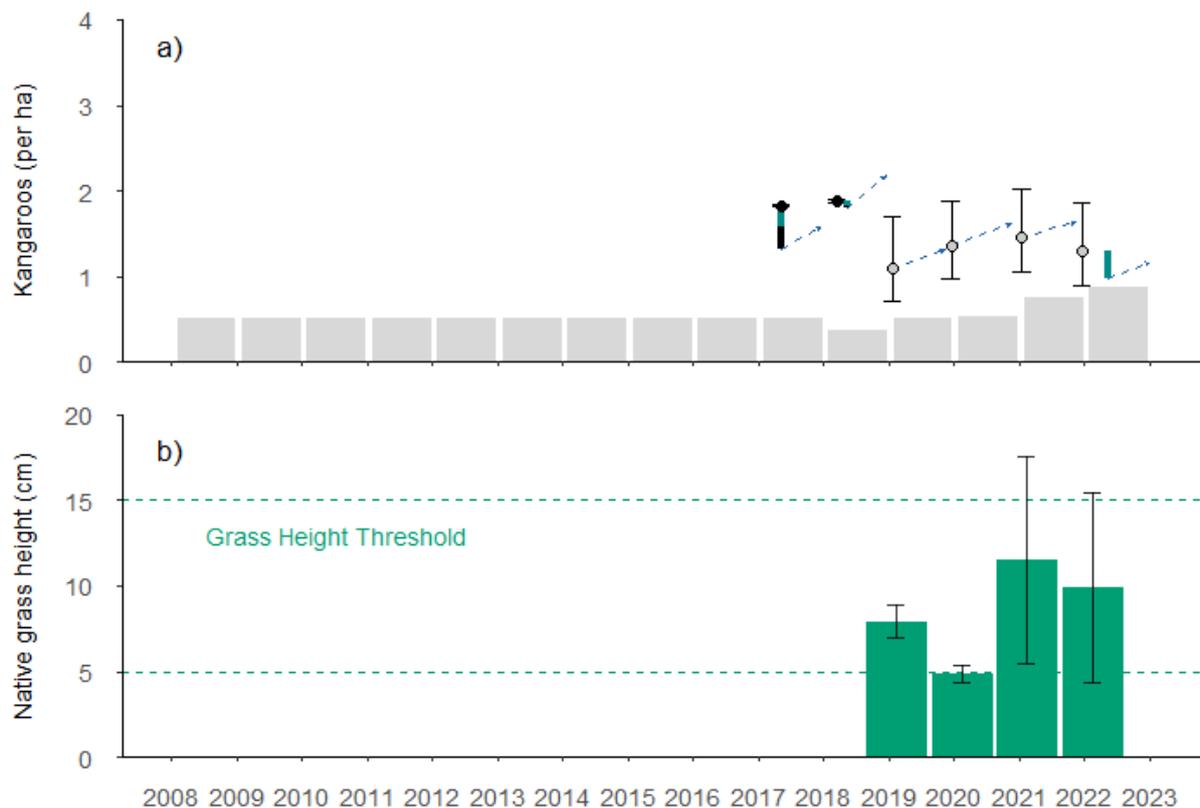
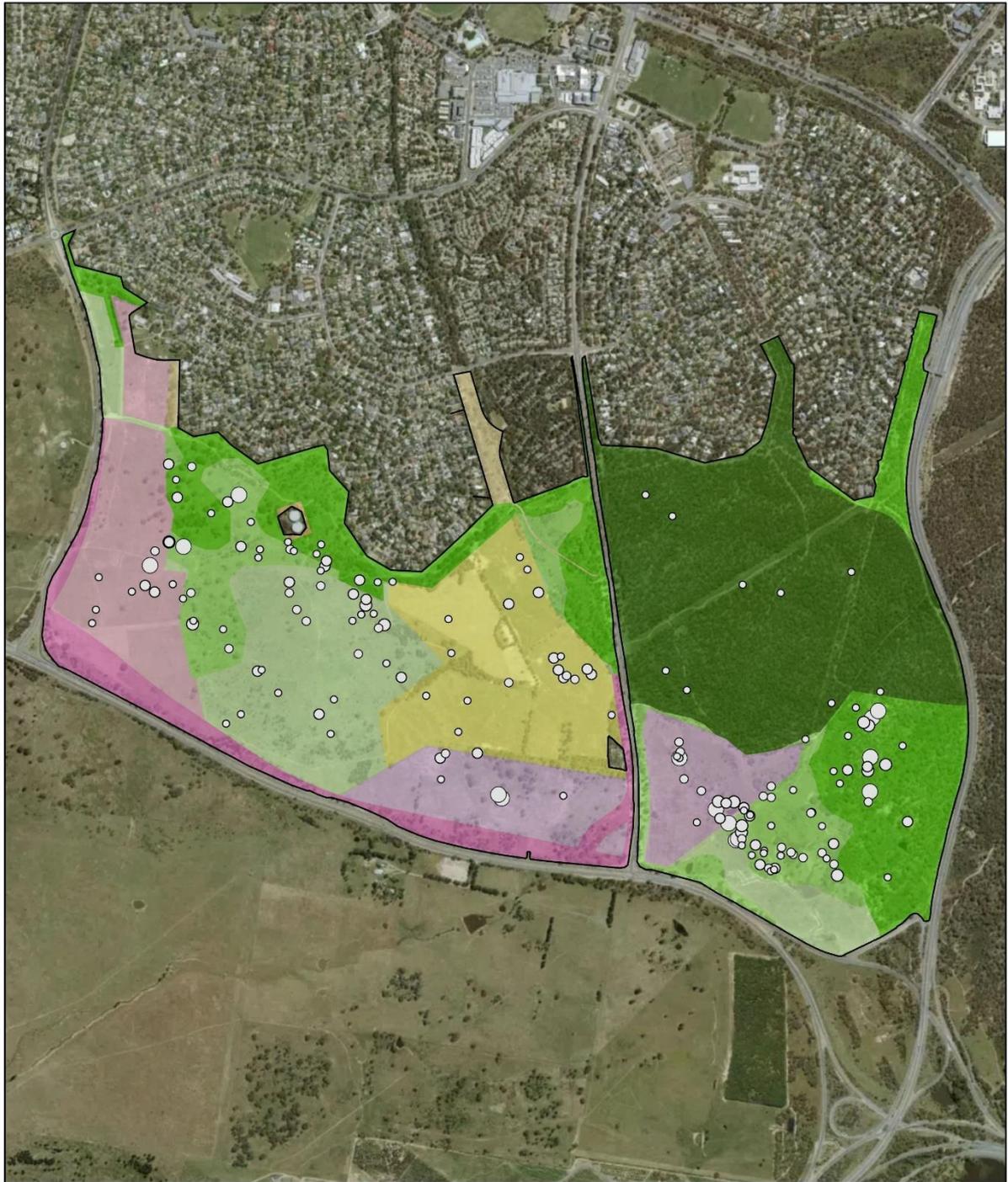


Figure 10. Changes in kangaroo density and average native grass heights for Aranda Painter KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals based on the walked line transect count method being used (\circ). Earlier sweep counts are depicted as the mean \pm the maximum and minimum number counted across repeat counts in one survey (\bullet). Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program and black bars representing management outside of ACT Parks and Conservation Service managed lands. The line shown for 2022 is the recommended density to be removed from the conservation estate only. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



Aranda Painter KMU
2022



0 0.3 0.6 Kilometers

EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10

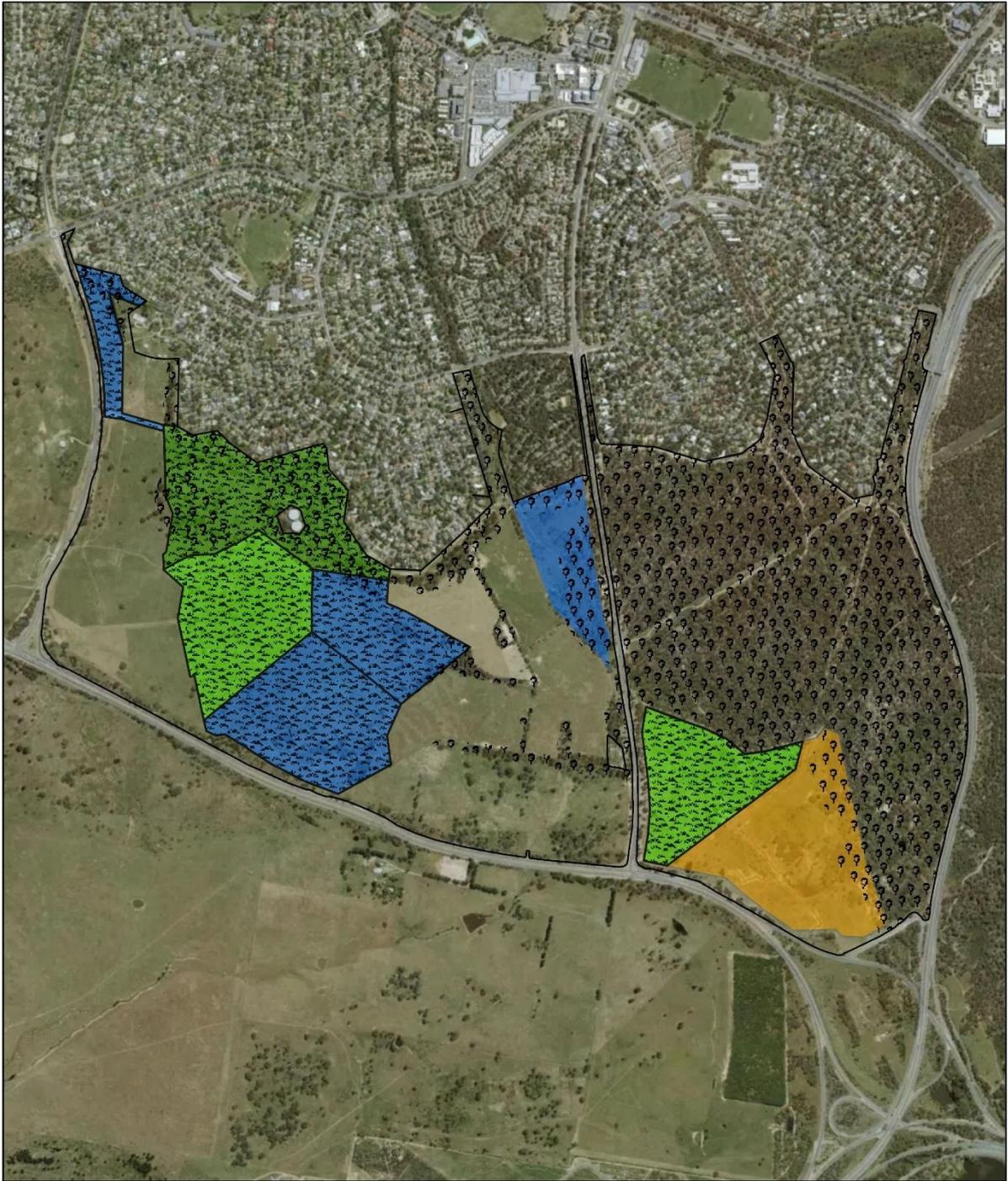
Conservation Veg

- Grassland
- Open Woodland
- Woodland
- Forest

Other Tenure

- Business/Industrial
- Future Urban
- Horse Paddock
- Rural Lease
- Urban Park
- Verge

Figure 11. Map of Aranda Painter KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Aranda Painter KMU
2022



0 0.3 0.6 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest

Figure 12. Map of Aranda Painter KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

CRACE KMU

Background

Crace KMU is located in the south of the Gungahlin Valley and is bounded by Gungahlin Drive in the west, the Barton Highway in the south, Randwick and Flemington roads to the east and the suburb of Mitchell to the north. The KMU includes Crace Grasslands Nature Reserve as well as areas of rural lease and land used for commercial purposes. The area is predominantly grassland with some woodland plantations. Rates of immigration and emigration are considered likely to be low, although some passage of animals through the Barton Hwy underpass from the Kaleen Horse Paddocks and beyond is possible.

Site specific considerations

Crace KMU contains large areas of critically endangered Natural Temperate Grassland and is key habitat for threatened species such as the Striped Legless Lizard, Golden Sun Moth, Button Wrinklewort, Hoary Sunray and Perunga Grasshopper. Pink-tailed Worm Lizards are also being translocated into Crace Grasslands in 2022. Temporary fencing was installed to aid in the establishment of translocated Button Wrinklewort populations which have now expanded beyond their reintroduction site. Rabbits and invasive plants are managed in this landscape as part of an integrated land management program, and experimental rock plots have been installed to reduce fine-scale grazing impacts by kangaroos and improve habitat structure for native plants and animals. Removal of exotic trees is also planned for 2022, which may increase the availability of grassy habitat at this site.

Crace Grassland also includes a number of asset protection zones, in which herbage mass is required to be maintained below a set fuel standard (often achieved using livestock grazing) in order to manage the risk of wildfire to life and property. Efforts to improve fence alignment to reduce the impact of hazard reduction grazing on high quality native grassland will be made in 2022.

For over a decade, kangaroo density has been effectively managed at this site to maintain a variable grassy layer structure consistent with the protection of biodiversity values. With the exception of during extremely hot and dry years, the intact and resilient grassy layer within Crace KMU has meant conservation objectives could be achieved with small relatively low levels of active kangaroo management. With two consecutive years of above-average rainfall, grass heights remain within threshold heights in 2022.

Kangaroo management recommendations

The 2022 count for Crace KMU is shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 13. The vegetation structure used for calculating kangaroo management recommendations is shown in Figures 14 and 15, showing all polygons to be within or above grass height thresholds. Due to the increased carrying capacity of Crace KMU in response to improved grass height conditions, no conservation cull is recommended for Crace KMU in 2022 (Table 3).

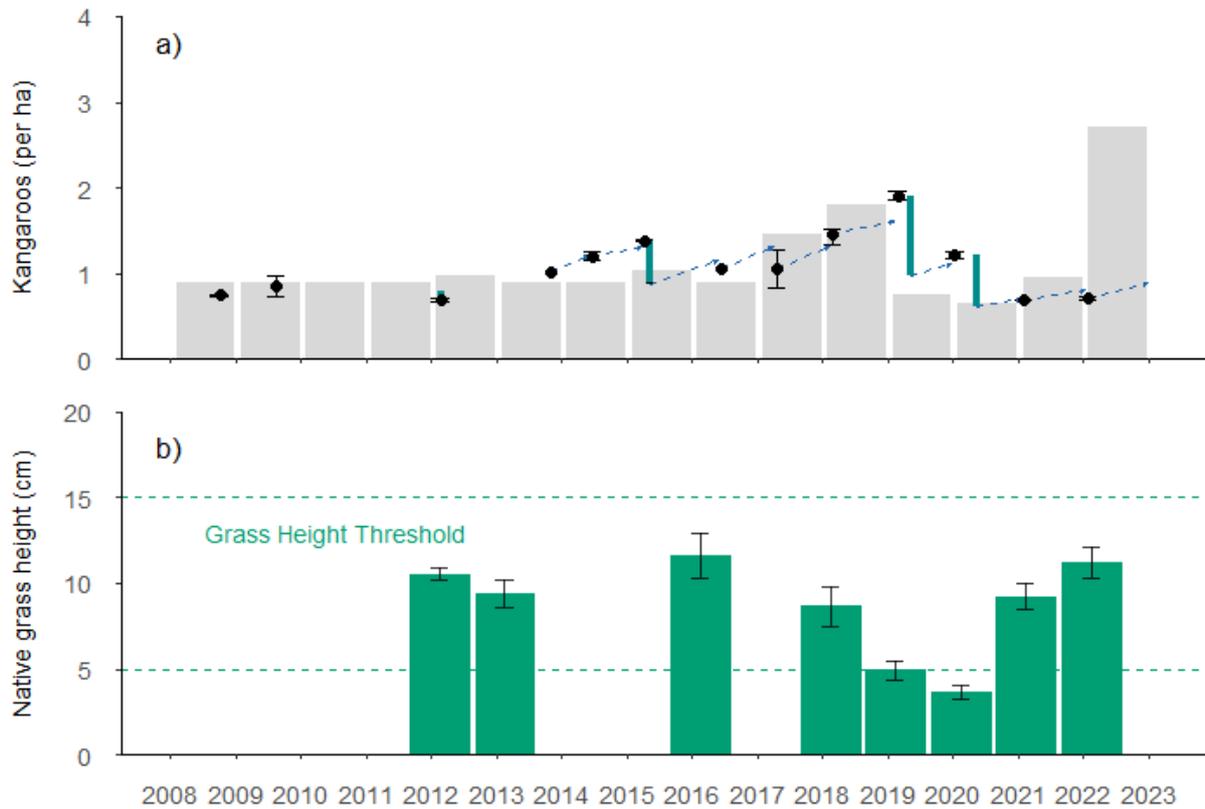


Figure 13. Changes in kangaroo density and average native grass heights for Crace KMU.

a) Changes in kangaroo density Kangaroo density assessed via direct counts (●) are depicted as the mean ± the maximum and minimum number counted across repeat counts in one survey. Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass ± standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



Crace KMU 2022

Conservation Veg

- Grassland
- Woodland
- Forest

Other Tenure

- Business/Industrial
- Public Land - Rural



0 0.15 0.3 Kilometers

Figure 14. Map of Crace KMU showing canopy strata and land tenure.



Crace KMU 2022



0 0.15 0.3 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest

Figure 15. Map of Crace KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

DUNLOP KMU

Background

Dunlop KMU is located in the north-west of Canberra, between the suburbs of Dunlop and Fraser and the ACT – NSW border. The area is comprised predominantly of grassland and open woodland and is contiguous with adjoining areas managed for conservation to the south west, and rural lease to the north east. Given this connectivity, there is expected to be high kangaroo immigration and emigration into and out of this site, including across the creek to adjoining rural land in NSW.

Site specific considerations

Dunlop KMU contains areas of critically endangered Natural Temperate Grassland and Box-Gum Woodland and is key habitat for threatened species such as the Golden Sun Moth and Canberra Raspy Cricket.

In 2017, a (livestock) grazing management plan was developed for this site with the aim of providing additional grazing pressure to maintain a variable grassy layer structure and to reduce the prevalence of annual grasses. Kangaroo numbers have now been above the target density for five consecutive years at this site, however average grass heights have remained within threshold to date. The ongoing use of sheep grazing to maintain ecological condition should continue to be monitored closely by Parks and Conservation Service staff in 2022, in addition to the impacts of stray goats. Kangaroo management on neighbouring lands, in addition to kangaroo populations sitting at or above ecological carrying capacity, is likely preventing further growth of the kangaroo population in this landscape at this time.

Additional fencing has been proposed along the river corridor adjacent to Dunlop KMU in 2022, which will further enable land managers to better manage the impacts of total grazing pressure (including stray goats) at this site.

Kangaroo management recommendations

The results of the 2022 count for the Dunlop KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 16. The vegetation structure used for calculating kangaroo management recommendations is shown in Figures 17 and 18, showing all polygons to be 'within' or 'above' threshold for native grass heights. As livestock grazing continues to be used to manage herbage mass at this site, no conservation cull is recommended for Dunlop KMU at this time (Table 3). Kangaroo density is above the target number however and the impacts of total grazing pressure (including the ongoing requirement for sheep grazing) should continue to be monitored closely. The use of fertility control is not being considered for Dunlop KMU at this time.

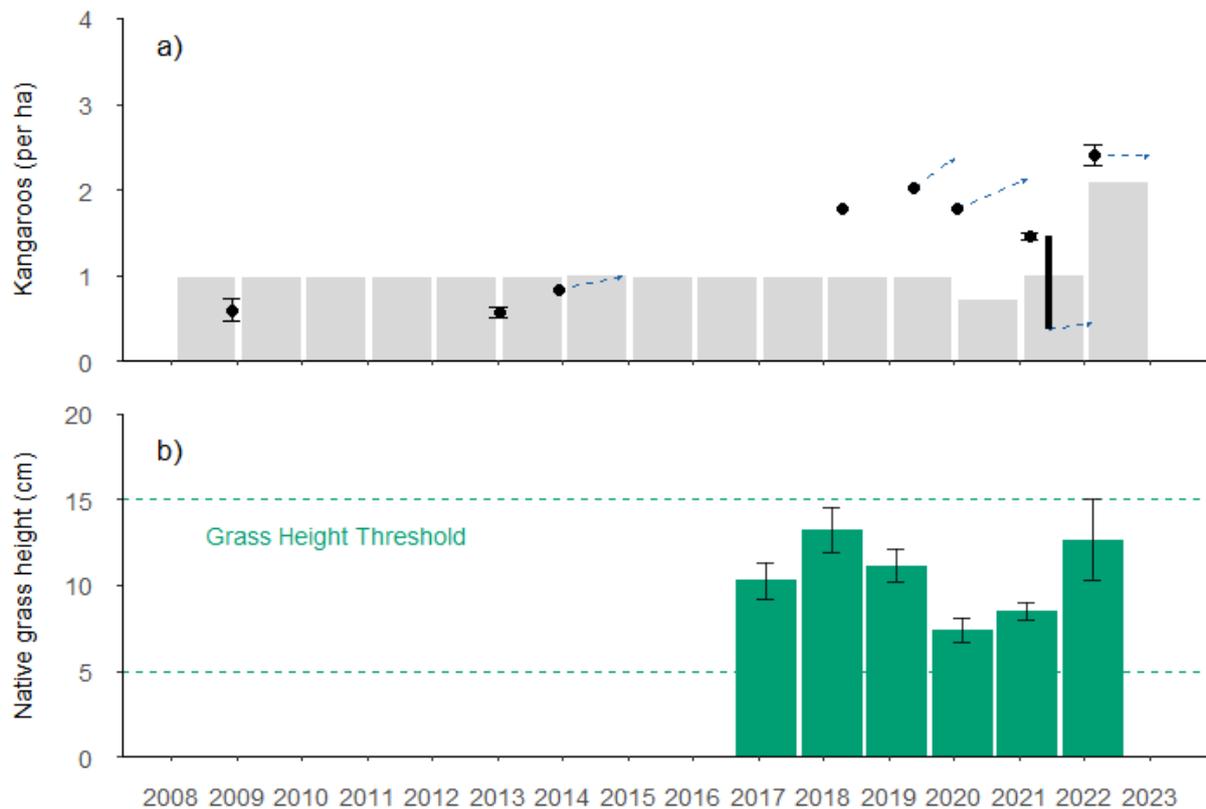
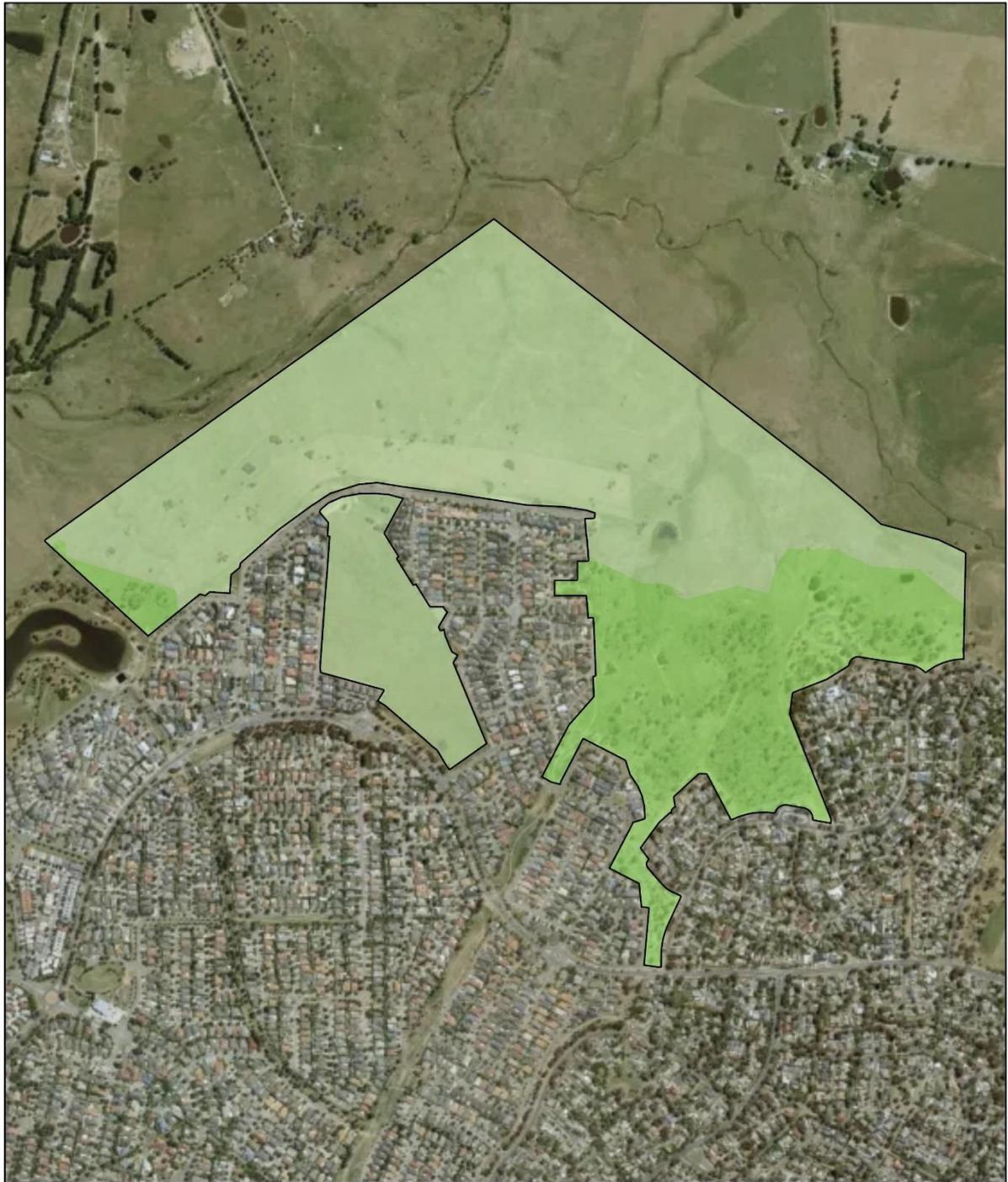


Figure 16. Changes in kangaroo density and average native grass heights for Dunlop KMU.

a) Changes in kangaroo density Kangaroo density assessed using sweep counts (●) are depicted as the mean \pm the maximum and minimum number counted across repeat counts in one survey (where performed). Blue dotted arrows indicate the predicted population growth for the site in each year (not accounting for any kangaroo management on adjoining land). The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 - 15cm) associated with maximised biodiversity outcomes.



Dunlop KMU 2022

Conservation Veg

Grassland

Open Woodland



0 0.15 0.3 Kilometers



Figure 17. Map of Dunlop KMU showing canopy strata on conservation land.



Dunlop KMU 2022

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest



0 0.15 0.3 Kilometers

Figure 18. Map of Dunlop KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

EAST JERRABOMBERRA KMU

Background

The East Jerrabomberra KMU is in the east of the ACT, bordered by the Monaro Highway to the south-west, the suburb of Jerrabomberra (and development area for South Jerrabomberra) to the south and east, and the suburb of Symonston and Canberra Avenue to the north. AMTECH environmental offsets site (to the north) was added to this KMU in 2022, after the land between Lanyon Drive and the South Jerrabomberra development area was added in 2021 to reflect apparently high immigration rates from adjoining populations. Upgrades to the Monaro Highway may impact on this KMU through 2022-23.

East Jerrabomberra KMU is almost exclusively grassland, and includes the Bonshaw and AMTECH environmental offset sites in addition to a number of ACT and NSW rural leases, NSW government and privately managed conservation land, and horse paddocks.

Site specific considerations

The Jerrabomberra East KMU contains areas of Natural Temperate Grasslands, as well as populations of Golden Sun Moth, Perunga Grasshopper, Button Wrinklewort, Striped Legless Lizard, and the critically endangered Canberra Grassland Earless Dragon and Ginninderra Peppercress. Temporary fencing was installed within Jerrabomberra East Grasslands in 2019 to protect critical habitat areas, adding to the existing kangaroo grazing management infrastructure. These will be open to allow kangaroo grazing in 2022.

Historically, the majority of kangaroos in this landscape resided on the East Jerrabomberra Grassland Reserve component of the broader KMU. Management interventions, particularly the use of fire to promote palatable green pick, have been used successfully to encourage grazing by kangaroos in the adjacent Bonshaw environmental offset and reduce direct grazing pressure on Jerrabomberra East reserve. As a result of the above average rainfall observed in recent years, and a reduced density of kangaroos grazing within East Jerrabomberra Grassland Reserve due culling and changed land use on neighbouring lands, grass heights in this area are now in excess of that preferred by the Grassland Earless Dragon, which is a focal species for conservation in this landscape. As such, additional herbage mass intervention measures (such as ecological burns and targeted livestock grazing) will aim to be introduced to increase grass height heterogeneity and improve palatability for kangaroos in 2022 in key areas. Such interventions will accompany ongoing management of invasive plants and rabbits. Increasing numbers of Common Wombats, in addition to planned livestock grazing in Bonshaw, also contribute to total grazing pressure within conservation areas of this KMU.

Kangaroo management recommendations

The results of the 2022 counts in the Jerrabomberra East KMU and component areas are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition within the Jerrabomberra East Nature Reserve over recent years are shown in Figure 19. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 20 and 21, showing all polygons to be within or above threshold in terms of grass height. In light of the distribution of kangaroos across the landscape in 2022, with high densities associated with areas outside of the ACT managed conservation estate, a conservation cull is not recommended for the Jerrabomberra East KMU in 2021 (Table 3). This is despite the culling formula recommending a cull of 148 animals. Instead, management of kangaroo densities on adjoining lands should be prioritised for 2022. Population

growth rate equivalent to a r of 0.55 has been assumed for this KMU based on recent observations of kangaroo population dynamics.

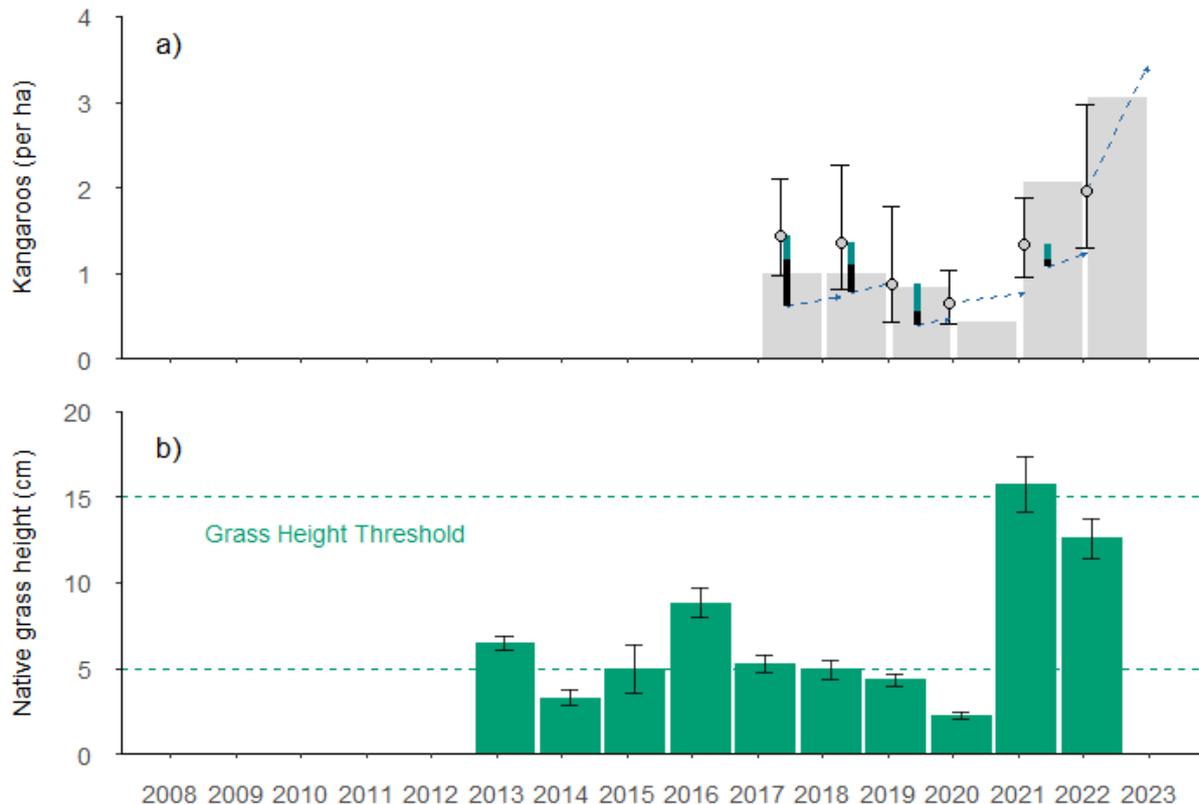
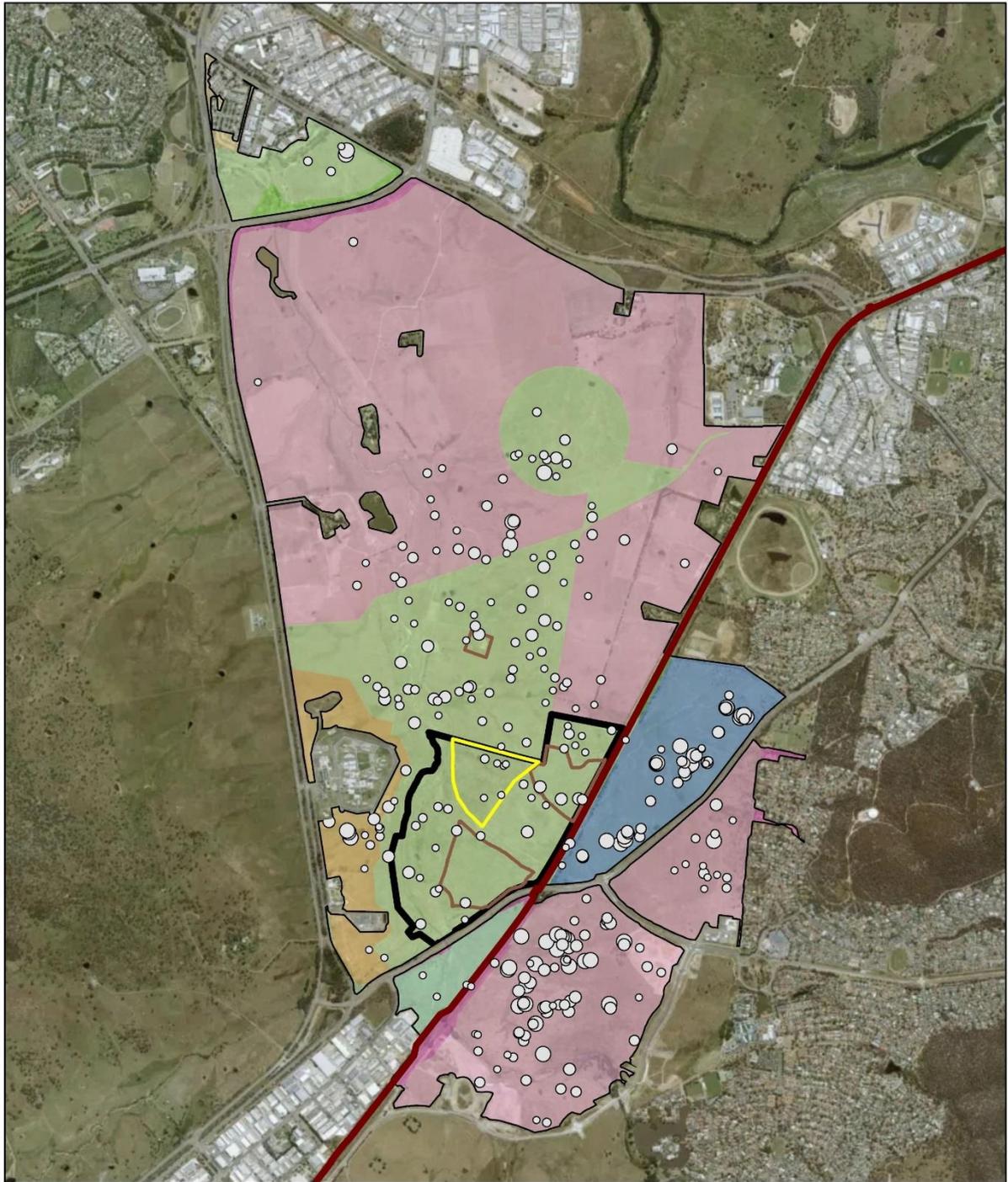


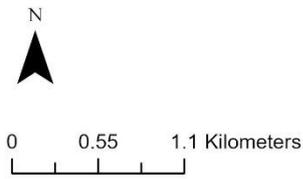
Figure 19. Changes in kangaroo density and average native grass heights within the East Jerrabomberra KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the walked line transect count (\odot) method was used. Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program. The line shown for 2022 is the recommended cull density for ACT conservation land only. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



East Jerrabomberra
KMU 2022

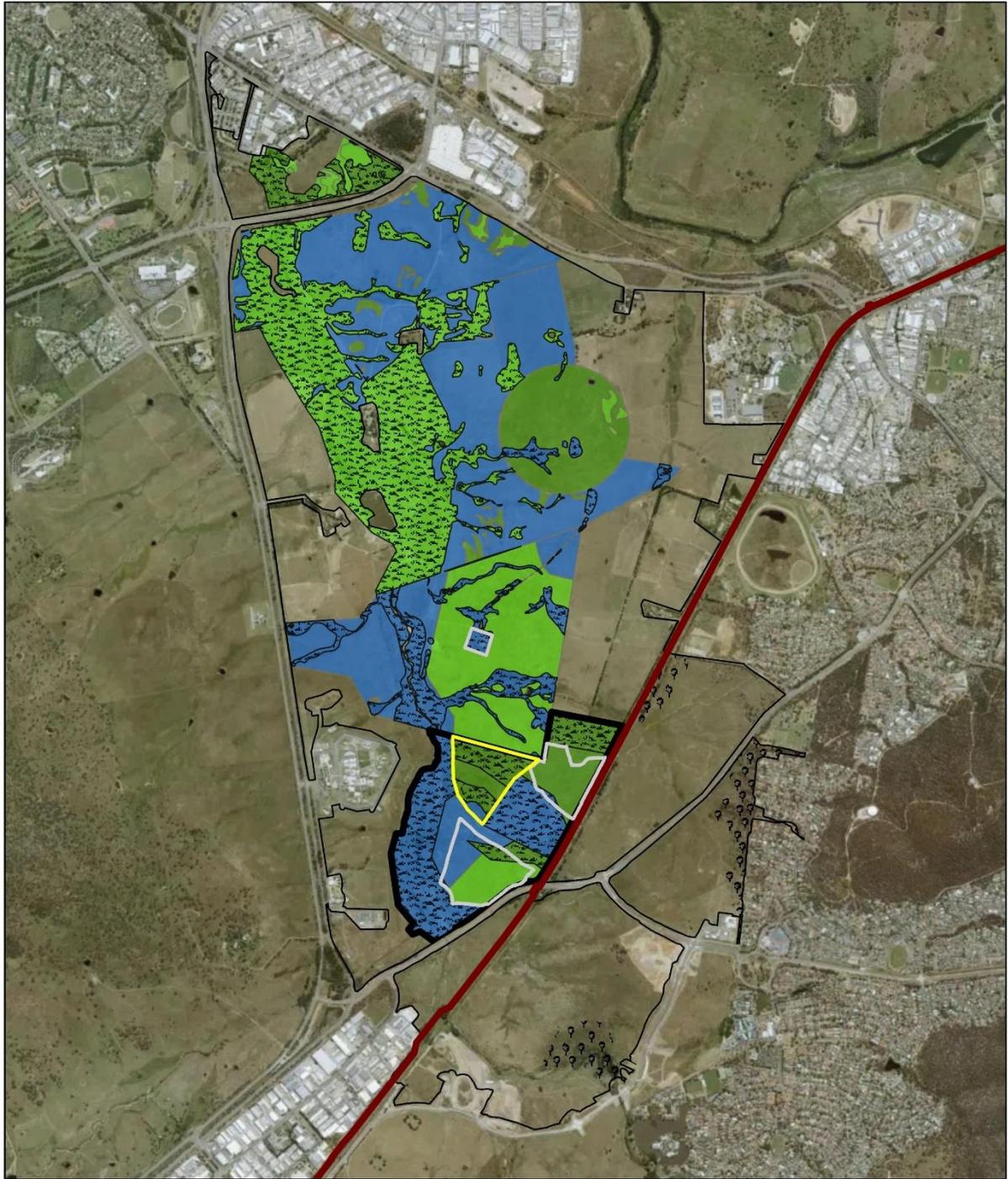


- EGK Group Size**
- 1 - 2
 - 3 - 4
 - 5 - 6
 - 7 - 8
 - 9 - 10
 - ▭ ACT Border

- Conservation Veg**
- Grassland
 - Open Woodland
 - Woodland
 - Kangaroo Exclosure
 - Temporary Kangaroo Exclosure
 - Jerrabomberra East Nature Reserve

- Other Tenure**
- Business/Industrial
 - Livestock Agistment
 - NSW Conservation Land
 - Rural Lease
 - Urban Park
 - Verge

Figure 20. Map of East Jerrabomberra KMU (and Jerrabomberra East Grassland Reserve therein), showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



East Jerrabomberra
KMU 2022



0 0.55 1.1 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold
- ACT Border

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest
- Kangaroo Exclosure
- Temporary Kangaroo Exclosure
- Jerrabomberra East Nature Reserve

Figure 21. Map of East Jerrabomberra KMU (and Jerrabomberra East Grassland Reserve therein), showing current grassy layer condition relative to threshold grass height targets within conservation areas.

FARRER RIDGE KMU

Background

The Farrer Ridge KMU is in Canberra's south, separated from the Mt Taylor KMU by Athllon Drive and from Wanniasa Hills KMU by Erindale Drive. To the north and south it is bordered by the suburbs of Farrer and Wanniasa respectively. Farrer Ridge KMU consists fully of areas managed for conservation (the sub-station and PCS depot are behind kangaroo-proof fences) and is predominantly a woodland ecosystem. Despite particularly high rates of kangaroo-vehicle collisions on roads surrounding this KMU, the net immigration/emigration rate of animals moving between neighbouring KMUs is considered likely to be fairly low.

Site specific considerations

The vegetation within Farrer Ridge Nature Reserve includes critically endangered Yellow Box – Red Gum Grassy Woodlands, as well as populations of the Small Purple Pea and Hoary Sunray. It is likely also part of an important movement corridor for declining woodland birds. The Farrer Ridge park care group has been undertaking management of woody weeds for many years, assisting the Parks and Conservation Service with erosion control, and undertaking plantings to restore vegetation diversity.

Kangaroo management was undertaken for the first time at this site in 2021. Previously the kangaroo population has remained well above the target density consistent with achieving conservation objectives. Limited food availability coupled with high rates of vehicle strike on surrounding roads and a population at or above ecological carrying capacity likely prevented further increases in population density at this site in the past. With population density now reduced, increased rates of immigration from surrounding unmanaged kangaroo populations (Wanniasa Hills KMU and Mt Taylor KMU) may be observed in drier years.

Kangaroo management recommendations

The results of the 2022 counts for the Farrer Ridge KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 22. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 23 and 24, showing grass heights within threshold across all management polygons. Given the increase in the target density of kangaroos at this site as a result of improved ground layer vegetation conditions, no additional kangaroo culling is recommended for the Farrer Ridge KMU in 2022 (Table 3). The use of fertility control is recommended for Farrer Ridge KMU to maintain kangaroo populations at or near long-term target densities into the long term.

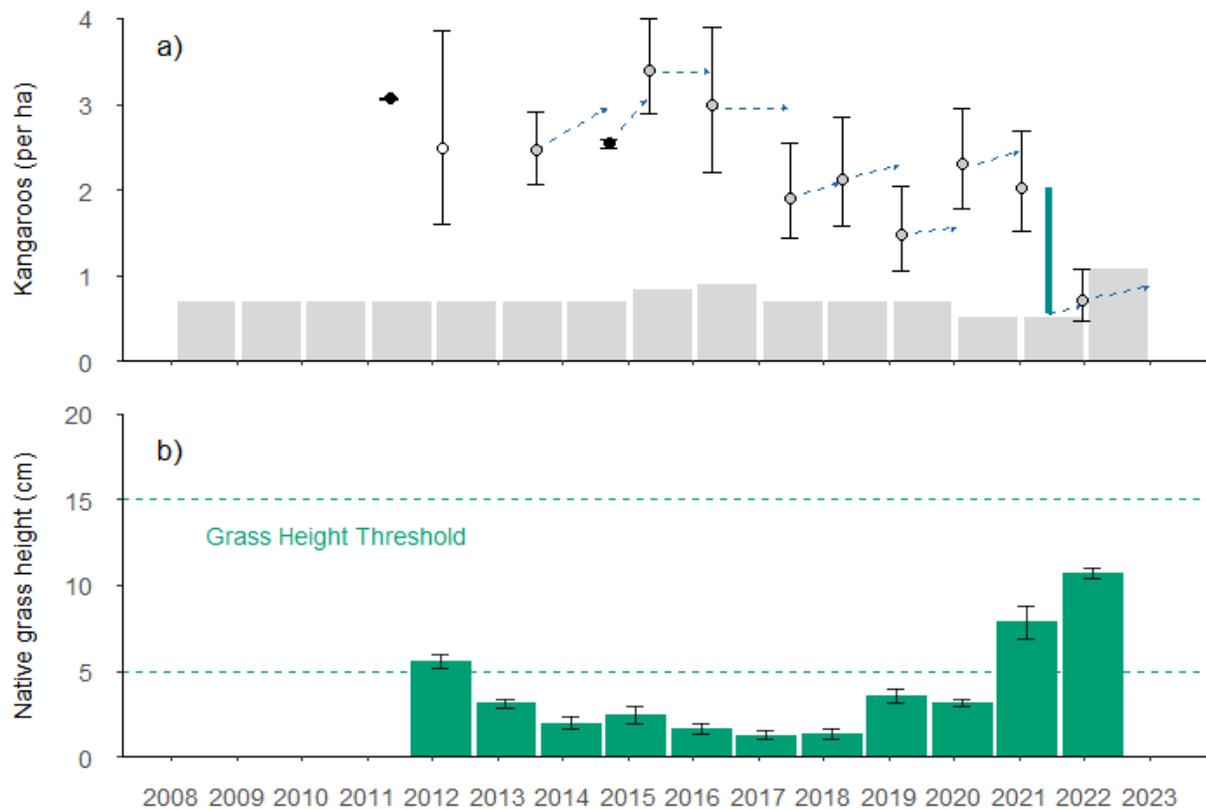


Figure 22. Changes in kangaroo density and average native grass heights for Farrer Ridge KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the walked line transect count (○) and driven line transect (○) methods were used. Sweep counts (●) are depicted as the mean \pm the maximum and minimum number counted across repeat counts in one survey. The proposed kangaroo cull for 2022 is indicated by the green vertical line. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



Farrer Ridge KMU
2022



0 0.2 0.4 Kilometers

EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 9 - 10

Conservation Veg

- Open Woodland
- Woodland
- Forest

Figure 23. Map of Farrer Ridge KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Farrer Ridge KMU
2022



0 0.2 0.4 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest

Figure 24. Map of Farrer Ridge KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

GOOGONG WEST KMU

Background

Googong West KMU comprises the western part of the Googong Nature Reserve, an ACT managed area of Commonwealth land within New South Wales. It consists largely of open woodland and woodland communities, all of which is managed for conservation and as an important water catchment area for the ACT. Immigration and emigration at this site have the potential to be very high, given the KMU is adjoining rural lease on all sides which provides continuous kangaroo habitat. However, studies involving fitting kangaroos with tracking collars at this site in the past (ACT Government, unpublished) have shown individuals historically exhibit strong site fidelity and avoid moving onto rural properties.

The management of kangaroos at Googong is undertaken in accordance with the ACT Kangaroo Management Plan (2010) as sites in NSW are outside of the legislative scope of the more recent *Eastern Grey Kangaroo: Controlled Native Species Management Plan (2017)*. As such, whilst the approach taken is consistent with kangaroo management for conservation within nature reserves in the ACT, it is not formally considered a component of the ACT's conservation culling program.

Site specific considerations

Googong West KMU contains significant areas of Yellow Box - Red Gum Grassy Woodland as well as several rare or threatened plant and animal species including the Pink-tailed Worm-lizard. As part of the environmental offsetting process for the development for the Googong township, areas adjoining Googong Nature Reserve have undergone environmental restoration programs, including the addition of surface rock to extend and connect habitat for the Pink-tailed Worm-lizard. Within the reserve, active management programs are ongoing to control the density and impacts of rabbits, hares, deer, and pigs. Rabbit management is also undertaken to protect built assets, and coarse woody debris is being installed to prevent unauthorised visitor access and provide habitat enhancement.

Kangaroo management for conservation has been undertaken within the Googong KMU since 2017. As might be expected based on the positioning of the site within the broader landscape, high levels of immigration are likely responsible for annual rates of increase equivalent to a r of 0.55 at this site. Despite this challenge, an improvement in the grassy layer condition has been observed within recent years. Ongoing culling to account for significant population growth is anticipated to be required in the long term to continue to manage grazing pressure at this site.

Kangaroo management recommendations

The results of the 2022 count at Googong West KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 25. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 26 and 27, showing a mix of polygons 'above', 'within' and 'below' grass height thresholds associated with achieving conservation outcomes. To maintain recent improvements in grass heights and continue to improve grassy layer structure across this landscape, a conservation cull is recommended at Googong KMU in 2022 to maintain target densities of kangaroos at this site (Table 3). The use of fertility control is not being considered for Googong KMU at this time.

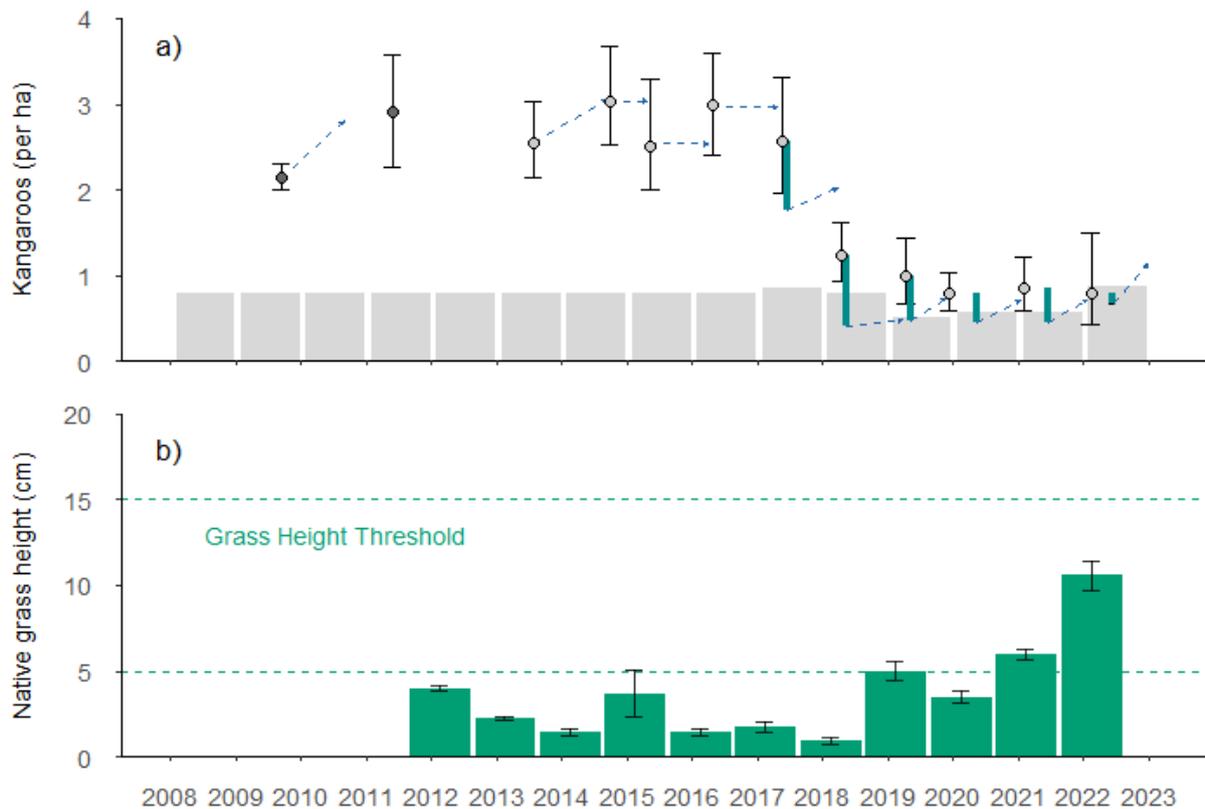
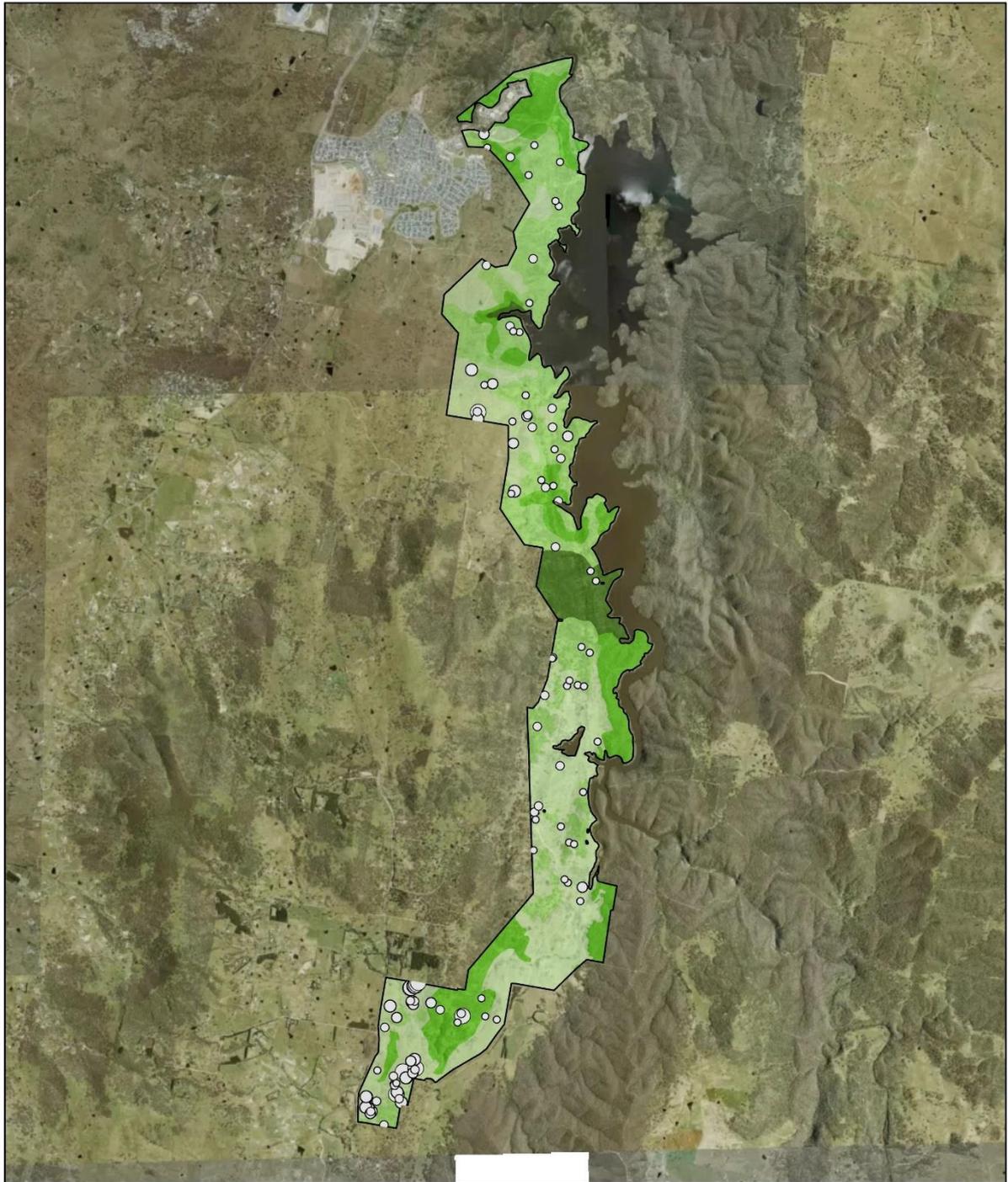


Figure 25. Changes in kangaroo density and average native grass height for Googong West KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the pellet count (●) or walked line transect count (○) methods were used. Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program. The line shown for 2022 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



**Googong West KMU
2022**



0 1 2 Kilometers

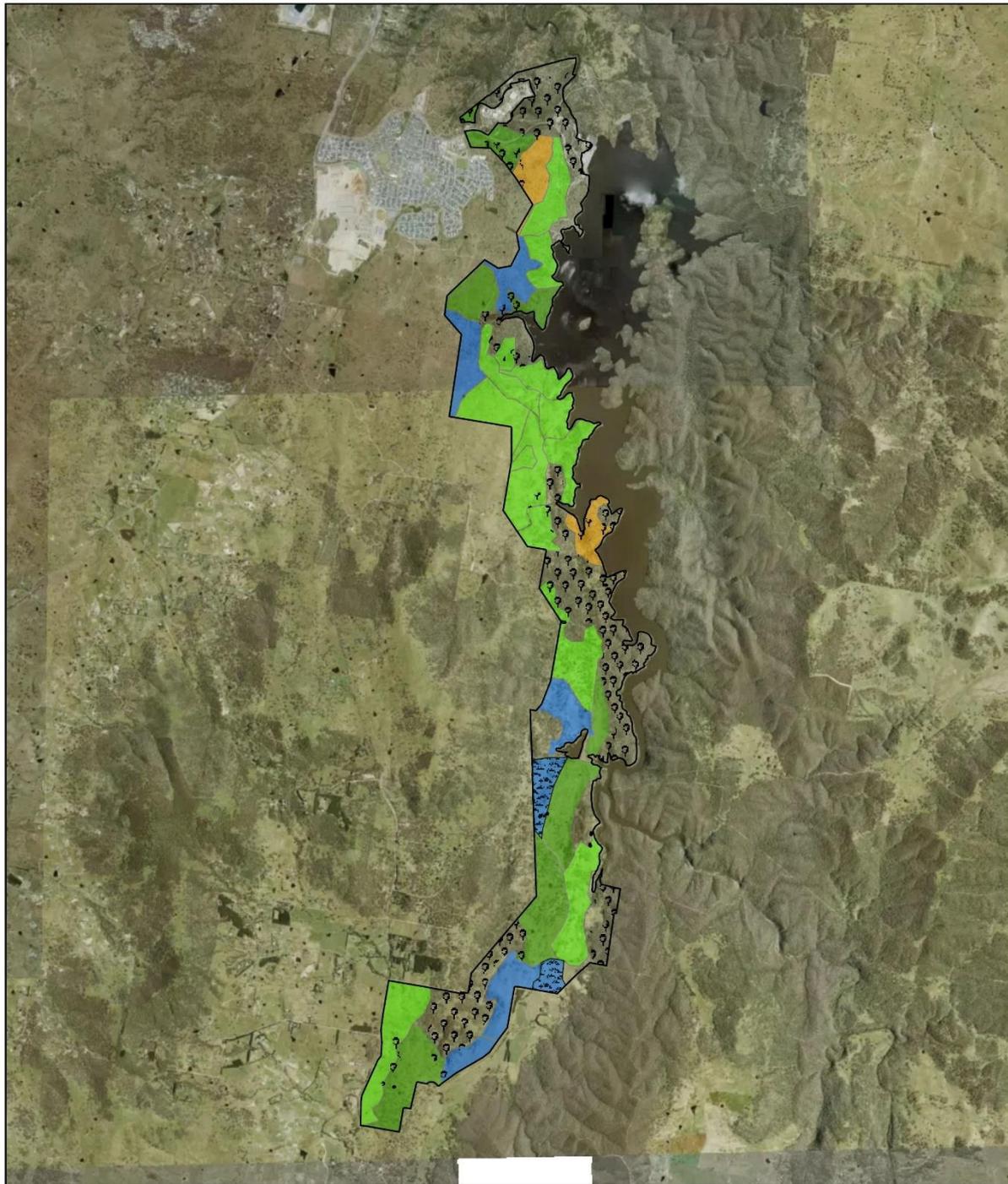
EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10

Conservation Veg

- Grassland
- Open Woodland
- Woodland
- Forest

Figure 26. Map of Googong West KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Googong West KMU
2022



0 1 2 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- 🌳 🌲 🌴 Woodland/Forest

Figure 27. Map of Googong West KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

GOOROOPYARROO KMU

Background

Goorooyaroo KMU is situated in the north-eastern area of the ACT and is comprised predominantly of open woodland, with smaller areas of grassland towards the suburb of Throsby. The KMU has been fully enclosed by a predator (and kangaroo) proof fence since early 2019 and hence immigration and natural mortality are likely to be negligible resulting in population growth rates in the vicinity of the maximum rate of increase for eastern grey kangaroos ($r = 0.55$). Such rates of increase are consistent with observed population dynamics at this site.

Site specific considerations

Goorooyaroo KMU contains critically endangered Yellow Box - Red Gum Grassy Woodland as well as populations of the Golden Sun Moth, Hoary Sunray, Superb Parrot and Striped Legless Lizard. It also a research site for the ongoing Mulligans Flat – Goorooyaroo Woodland Experiment, which includes the use of experimental kangaroo grazing exclosures which aim to maintain kangaroo densities at approximately 10% of those set from the remainder of the Sanctuary. Rabbits are now eradicated from this site, and other introduced vertebrate pest species such as foxes, cats and hares are very rare. Slashing and ecological or cultural burns are also employed within the Sanctuary as required.

Kangaroo density has been managed within the Goorooyaroo KMU since 2010. High population growth rates observed in the past were likely due to high immigration from adjoining habitat in NSW. However, high annual rates of increase are now routinely observed, due most likely to the loss of predation and mortality pressure in this enclosed environment. Allowing for this, kangaroo management in recent years has been effective in achieving improved grassy layer condition in this management unit.

Kangaroo management recommendations

The results of the 2022 count at Goorooyaroo KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 28. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 29 and 30, showing all polygons to have 'within' and 'above' threshold grass heights across the landscape. To maintain this heterogeneous grassy layer structure and maintain sustainable populations of kangaroos within the predator proof Sanctuary fence, conservation culling is recommended for Goorooyaroo KMU in 2022 (Table 3), with particular effort being made to reduce the density of kangaroos within the experimental kangaroo exclosures.

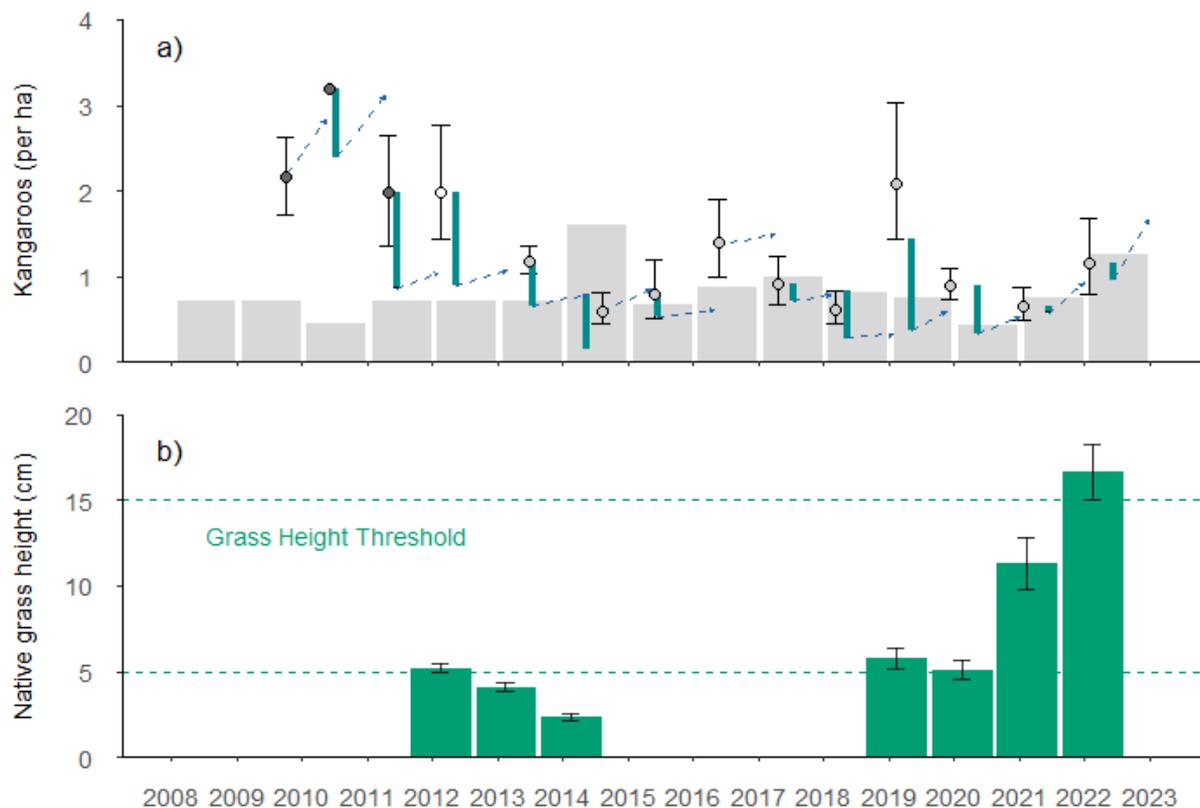
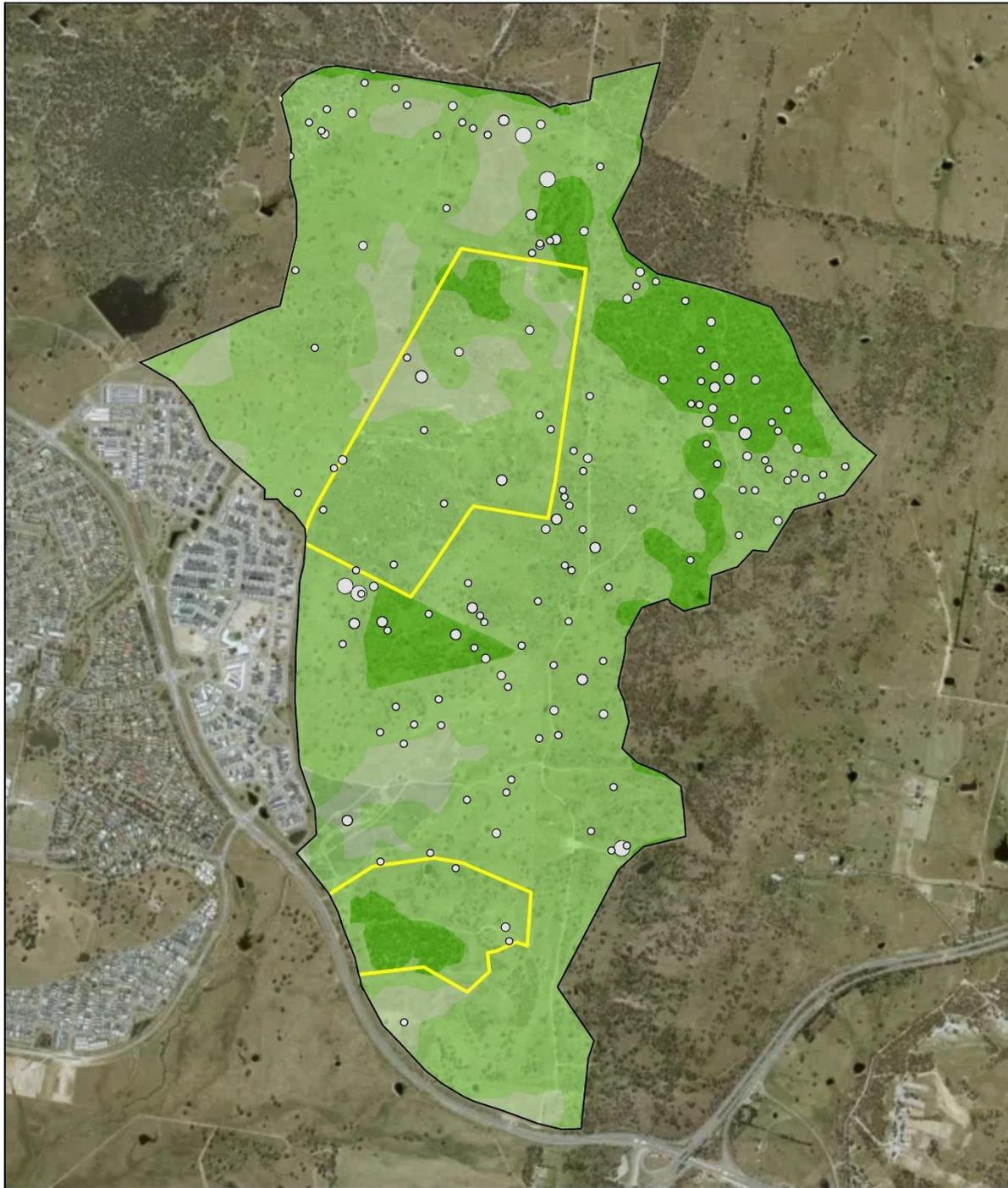


Figure 28. Changes in kangaroo density and average native grass height for Goorooyarro KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the pellet count (●), walked line transect count (○) or driven line transect count (●) methods were used. Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program. The line shown for 2022 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean for herbage mass polygons outside of the kangaroo exclosures. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



Goorooyarroo KMU
2022



0 0.4 0.8 Kilometers

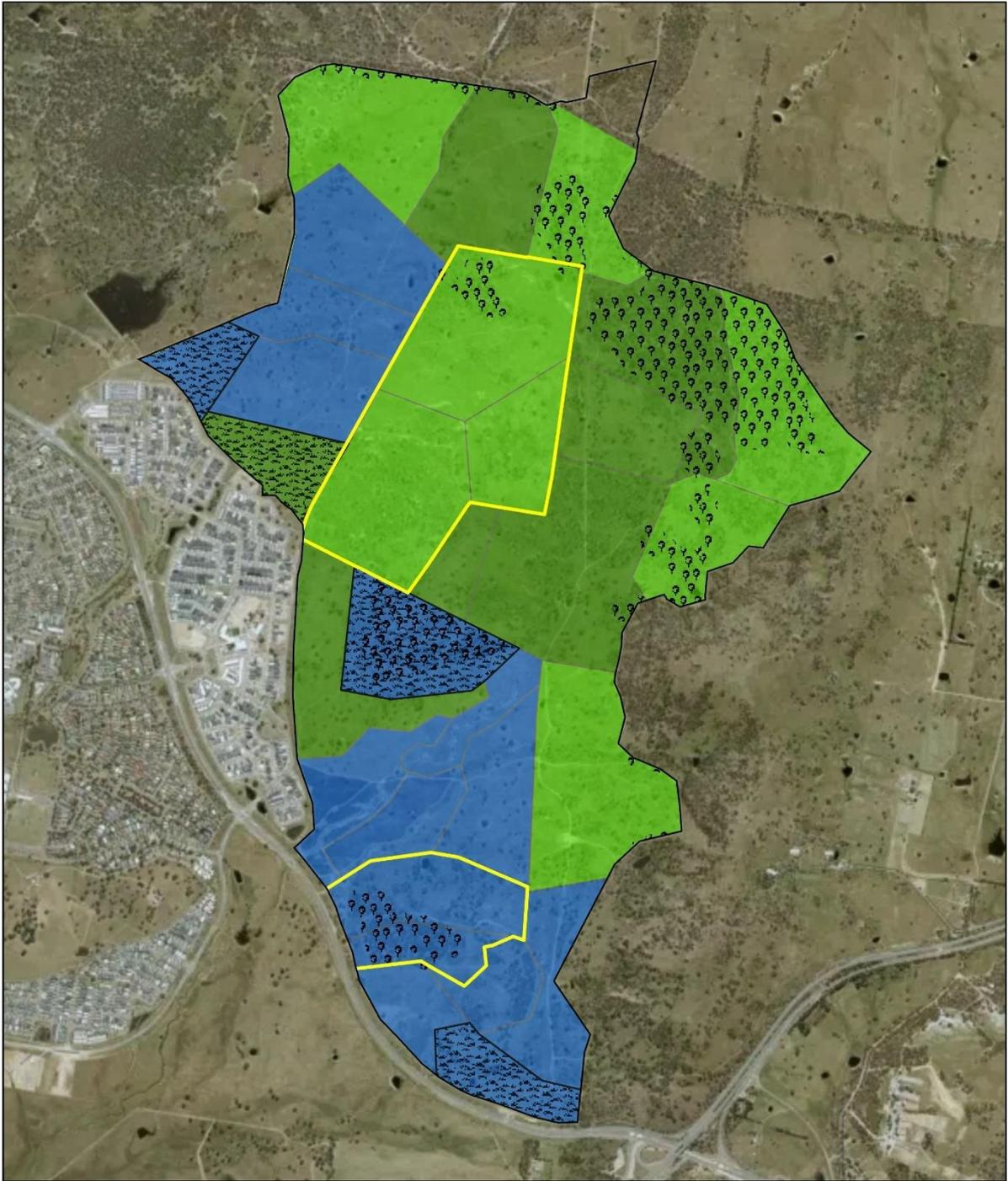
EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10

Conservation Veg

- Grassland
- Open Woodland
- Woodland
- Kangaroo Exclosure

Figure 29. Map of Goorooyarroo KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Goorooyarroo KMU
2022



0 0.4 0.8 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest
- Kangaroo Exclosure

Figure 30. Map of Goorooyarroo KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

GUNGADERRA KMU

Background

Gungaderra KMU is located in the Gungahlin Valley and is bounded by Gungahlin Drive in the east, the Barton Highway in the south, the suburb of Crace in the west and the suburb of Palmerston to the north. The KMU includes Gungaderra Grasslands Nature Reserve, as well as an area of rural lease, land used for commercial purposes (radio station), and the woodland of Gungahlin Hill. Immigration and emigration are considered likely to be low, although there is evidence (in the form of a kangaroo-vehicle collision hot-spot) of kangaroos occasionally crossing to or from Mulanggari KMU on the opposite side of Gungahlin Drive.

Site specific considerations

Gungaderra KMU contains large areas of Natural Temperate Grassland as well as Yellow Box - Red Gum Grassy Woodland. It is key habitat for threatened species such as the Striped Legless Lizard, Golden Sun Moth and Perunga Grasshopper. The site also includes areas identified as asset protection zones, in which herbage mass is kept below set fuel standards (often through livestock grazing) in order to manage the risk of wildfire to life and property. Ongoing management of invasive plants will continue throughout 2022, as will routine rabbit management. Herbage mass disturbance (such as ecological burns) will be applied strategically through the landscape to ensure variable grassy layer habitat structure is maintained, to reduce the incidence of exotic annual grasses, and to promote improved floristic diversity in the ground layer vegetation.

Kangaroos have been managed within Gungaderra KMU since 2015, when a large initial cull was undertaken to reduce population density to a level considered to be consistent with maintaining conservation values at the site. Relatively small amounts of active kangaroo management have been required since, apart from in particularly hot and dry years such as those observed in 2019 and 2020 where a decline in the condition of the grassy layer was observed.

Kangaroo management recommendations

The results of the 2022 count at Gungaderra KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 31. The vegetation structure used for calculating kangaroo management recommendations is shown in Figures 32 and 33, showing polygons which have either within or above threshold grass heights. Based on current adjusted target kangaroo densities and the condition of the grassy layer measured in spring 2021 no conservation cull is recommended for the Gungaderra KMU in 2022 (Table 3).

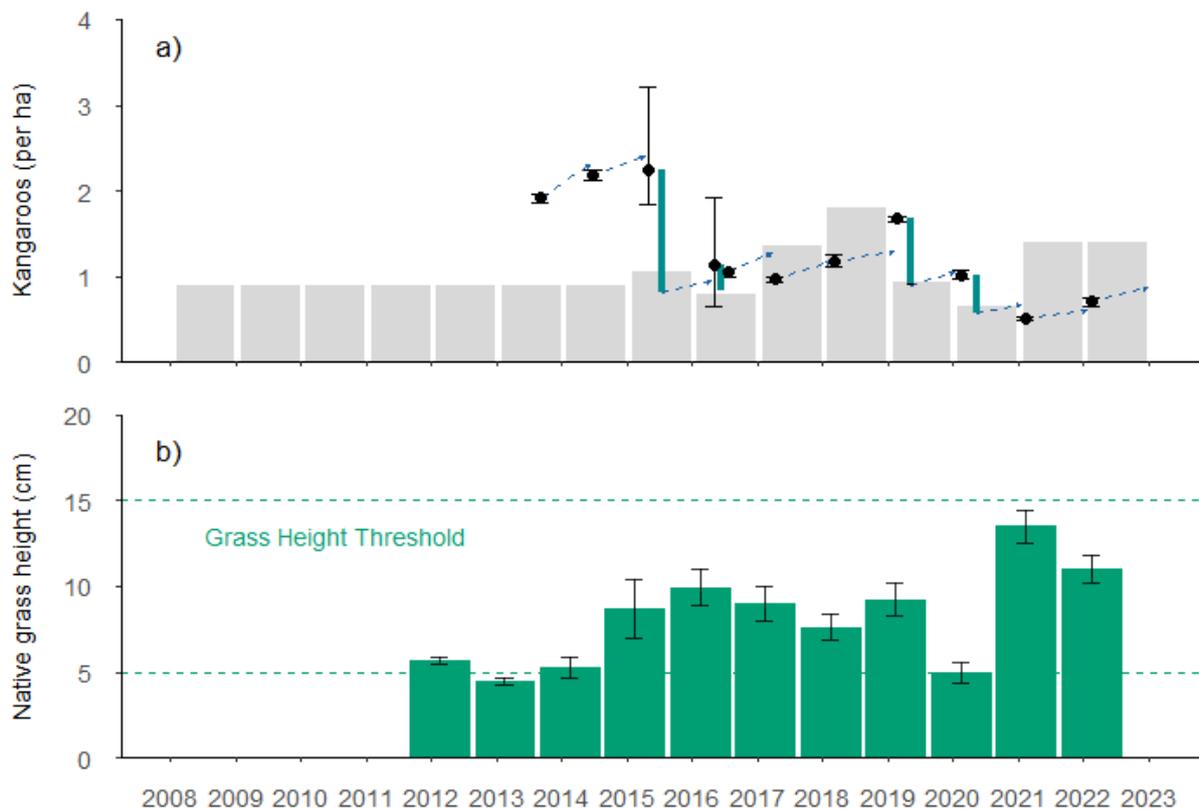
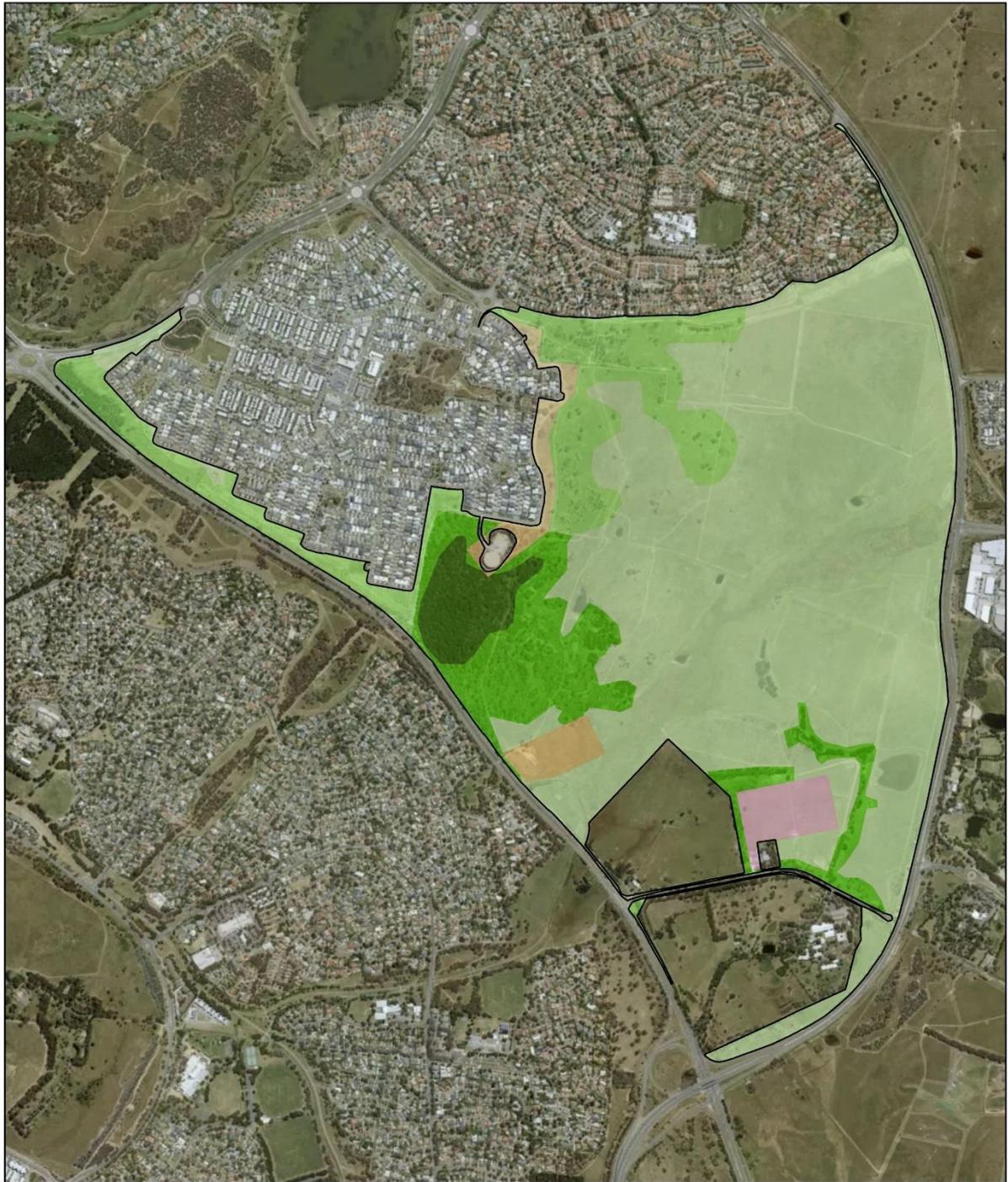


Figure 31. Changes in kangaroo density and average native grass height for Gungaderra KMU.

a) Changes in kangaroo density Kangaroo density from sweep counts (●) are depicted as the mean ± the maximum and minimum number counted across repeat counts in one survey. Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass ± standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



Gungaherria KMU
2022



0 0.3 0.6 Kilometers

Conservation Veg

- Grassland
- Open Woodland
- Woodland
- Forest

Other Tenure

- Business/Industrial
- Rural Lease
- Urban Park

Figure 32. Map of Gungaherria KMU showing canopy strata and land tenure.



Gungaharra KMU
2022



0 0.3 0.6 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest

Figure 33. Map of Gungaharra KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

KAMA EXTENDED KMU

Background

The Kama Extended KMU is found in the west of the ACT between William Hovell Drive to the north and the Molonglo River to the south. It is currently bounded to the east by the suburb development for Whitlam and joins to contiguous grazing land to the west. The area is comprised of the Kama section of the Molongolo River Reserve, flanked by land currently grazed by livestock under the management of the Suburban Land Agency. It is comprised of a mix of grassland and open woodland vegetation. The boundary of this KMU was modified in 2021 to encompass additional rural leases to the east, such that it now abuts a new 'Ginninderry KMU' which is currently being established. Further land will be lost from this KMU throughout 2022 as the development of Whitlam continues, which will likely increase kangaroo densities on adjoining land.

Site specific considerations

The Kama KMU contains critically endangered Yellow Box – Red Gum Grassy Woodland and Natural Temperate Grassland and is an important site for the protection of declining woodland birds. Habitat restoration involving the addition of surface rocks, reintroduction of threatened reptile species, reseeded of scraped landscapes, and ecological burns has been undertaken within conservation areas. Strategic livestock grazing is undertaken in areas dominated by exotic grasses in the north of the Kama conservation area as part of the management of weeds and fire fuel loads, and ecological burns are also planned for several locations within this landscape. Fallow deer monitoring and control forms part of the management of total grazing pressure within this region.

Kangaroos have been managed at this site since 2009 to protect the largely *Themeda* (kangaroo grass) dominated grassy layer within the Kama conservation area. Since 2012, the population density within Kama Extended KMU has remained within sustainable numbers, likely due to active kangaroo management on neighbouring properties. As such, monitoring and management by ACT Government has been intermittent in response to a functionally intact grassy layer. With significant proportions of this KMU having been withdrawn from rural lease in recent years, and conversion of some areas of this KMU to suburbs, increases in kangaroo population density across the landscape are now being observed which will require careful monitoring and a potential increase in management effort by ACT Government to protect biodiversity values on conservation land in coming years.

Kangaroo management recommendations

The results of the 2022 counts for the Kama Extended KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 34. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 35 and 36, showing that polygons are 'within' or 'above' threshold grass heights across surveyed areas of this site. Based on the growing density of kangaroos in this landscape, a conservation cull is recommended for Kama Extended KMU in 2022 where operational capacity allows (Table 3). Such actions should accompany kangaroo management on non-conservation land where altered land use is likely responsible for local increases in kangaroo density. The current condition of the grassy layer within the conservation estate, coupled with the current spatial distribution of kangaroos across this site, means kangaroo management within conservation areas of this KMU should be considered a low priority.

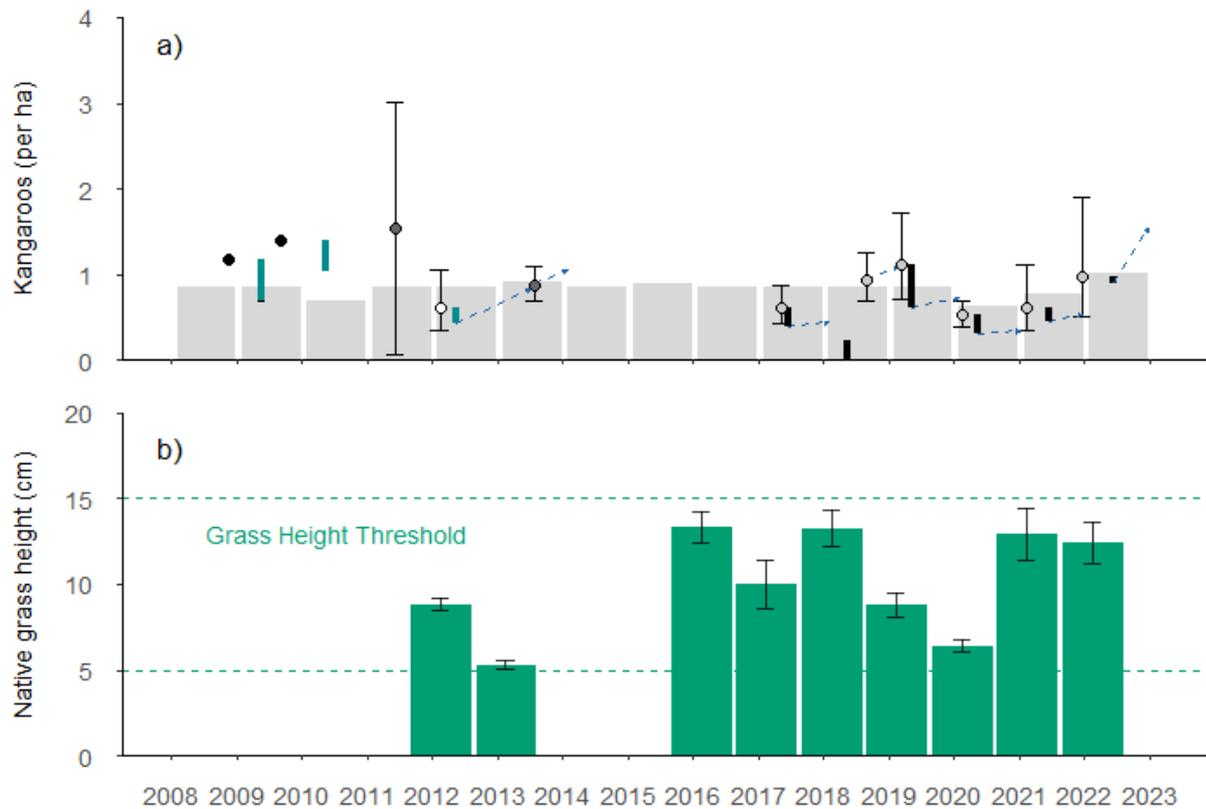
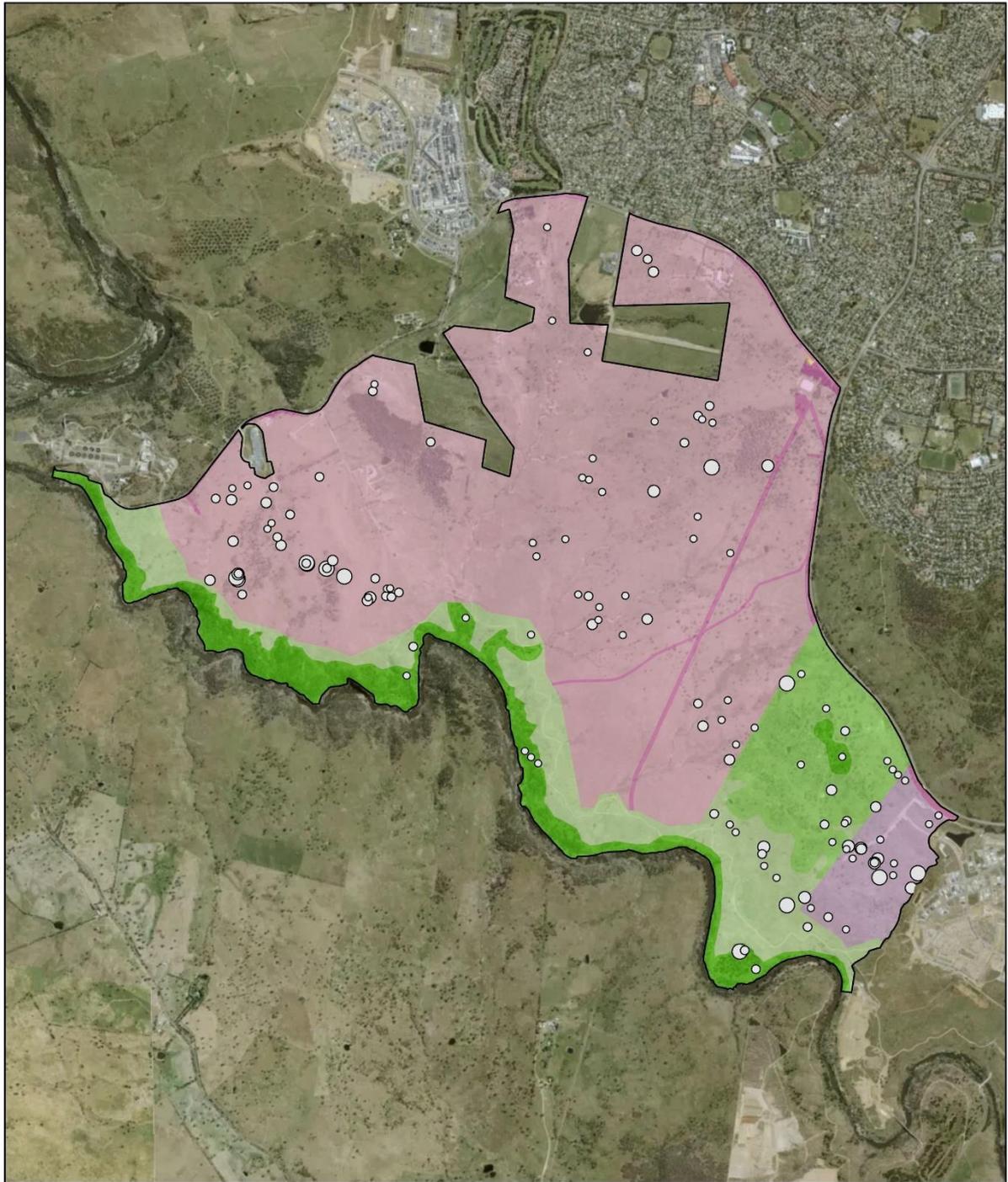


Figure 34. Changes in kangaroo density and average native grass height for Kama Extended KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the pellet count (●), walked line transect count (○) or driven line transect count (●) methods were used. Total counts (either direct or sweep counts, ●) are depicted as the mean \pm the maximum and minimum number counted across repeat counts in one survey. Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program and black bars representing management outside of ACT Parks and Conservation Service managed lands. The density of damage mitigation culls within the KMU in years where no density estimation was completed are shown along the x axis. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



**Kama Extended KMU
2022**



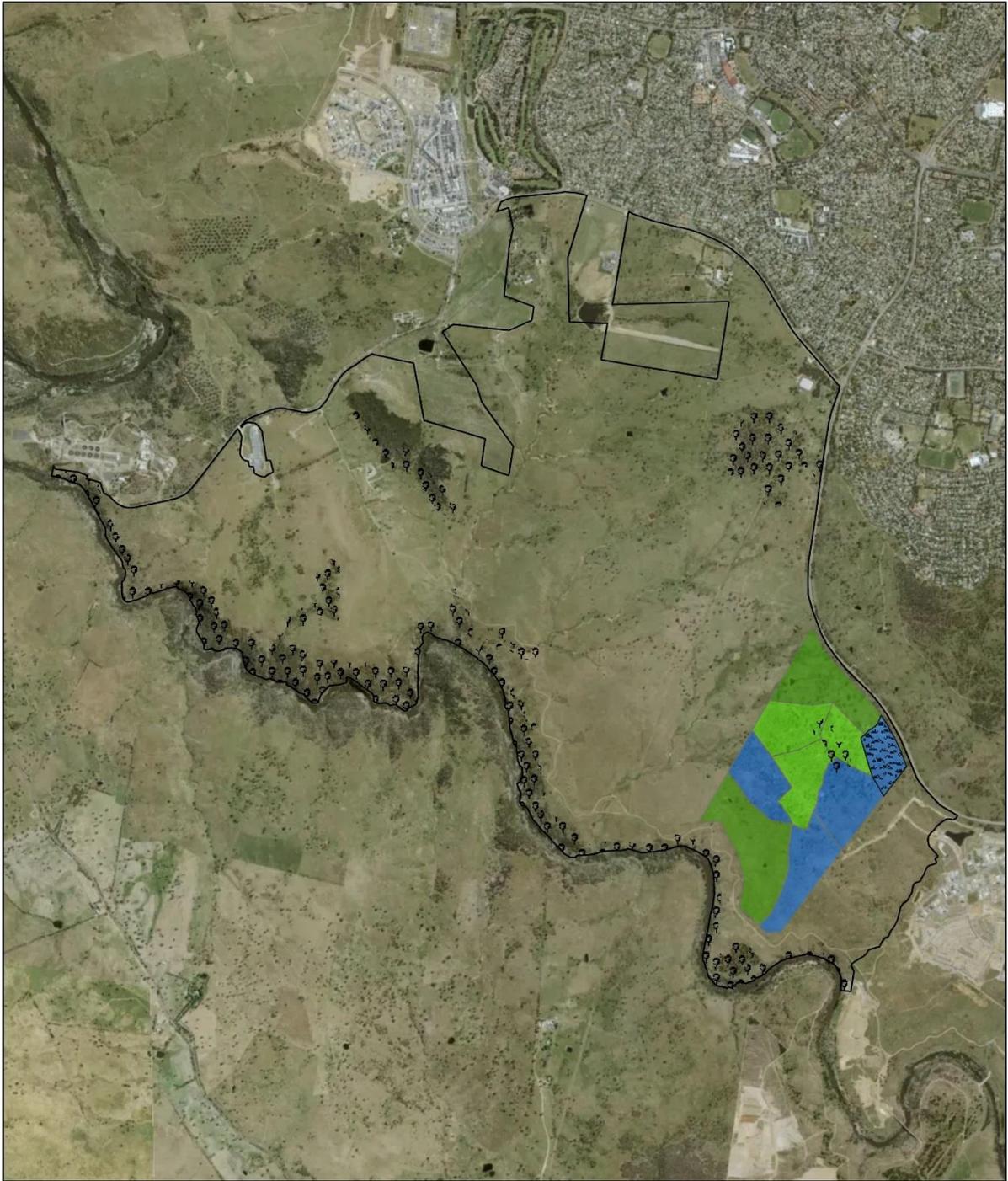
0 0.6 1.2 Kilometers

- EGK Group Size**
- 1 - 2
 - 3 - 4
 - 5 - 6
 - 7 - 8
 - 9 - 10

- Conservation Veg**
- Grassland
 - Open Woodland
 - Woodland

- Other Tenure**
- Business/Industrial
 - Future Urban
 - Rural Lease
 - Verge

Figure 35. Map of Kama Extended KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Kama Extended KMU
2022



0 0.6 1.2 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest

Figure 36. Map of Ainslie Majura KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

MT TAYLOR KMU

Background

The Mt Taylor KMU is situated in the south of Canberra, and forms part of the corridor of nature reserves between Woden and Tuggeranong including Cooleman Ridge, Farrer Ridge and Wanniasa Hills. It is comprised predominantly of woodland vegetation spanning the Mt Taylor Nature Reserve and the adjoining horse paddock. It is bordered to the west by a kangaroo-proof fence running along the Tuggeranong Parkway, to the south by Sulwood Drive and the suburb of Kambah, to the north by the suburb of Torrens and to the east by Athllon Drive. The particularly high level of kangaroo-vehicle collisions which occur along both Sulwood and Athllon Drives is likely a major mortality source for individuals within this population and also indicates some level of animal movement between adjacent KMUs.

Site specific considerations

The Mt Taylor Nature Reserve contains areas of Box-Gum Grassy Woodland as well as populations of Small Purple Pea and possibly Pink-tailed Worm-lizard. The Friends of Mount Taylor park care group regularly undertake management of weeds and erosion on this site, in partnership with the ACT Parks and Conservation Service.

Kangaroo management has not been undertaken at this site to date, despite significant evidence of depleted ground layer structure leading to erosion issues and the incursion of weeds across the area. The consistently high kangaroo density observed at this site from intermittent surveys since 2010 indicate that this population is likely limited by food, in addition to road-based mortality.

Kangaroo management recommendations

The results of the 2022 counts for the Mt Taylor KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 39. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 40 and 41, showing all two of three polygons remain below threshold with regards to grass heights. As such, a conservation cull is considered necessary in the Mt Taylor KMU in 2022 (Table 3) subject to operational feasibility, to enable restoration of the grassy layer.

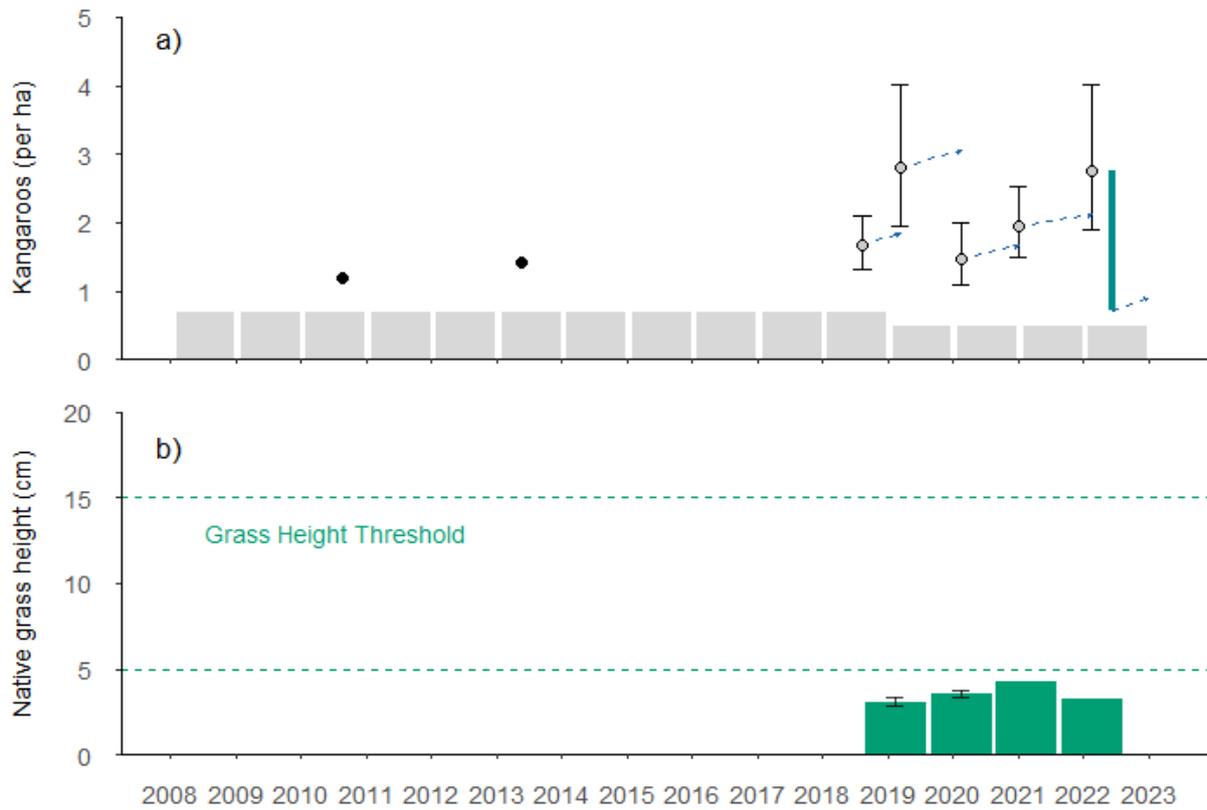


Figure 39. Changes in kangaroo density and average native grass height for Mt Taylor KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals based on the walked line transect method being used (●). Kangaroo culls are indicated by vertical lines, noting no conservation culls have been undertaken to date at this site. The line shown for 2022 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



Mt Taylor KMU 2022

EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10

Conservation Veg

- Grassland
- Open Woodland
- Woodland
- Forest

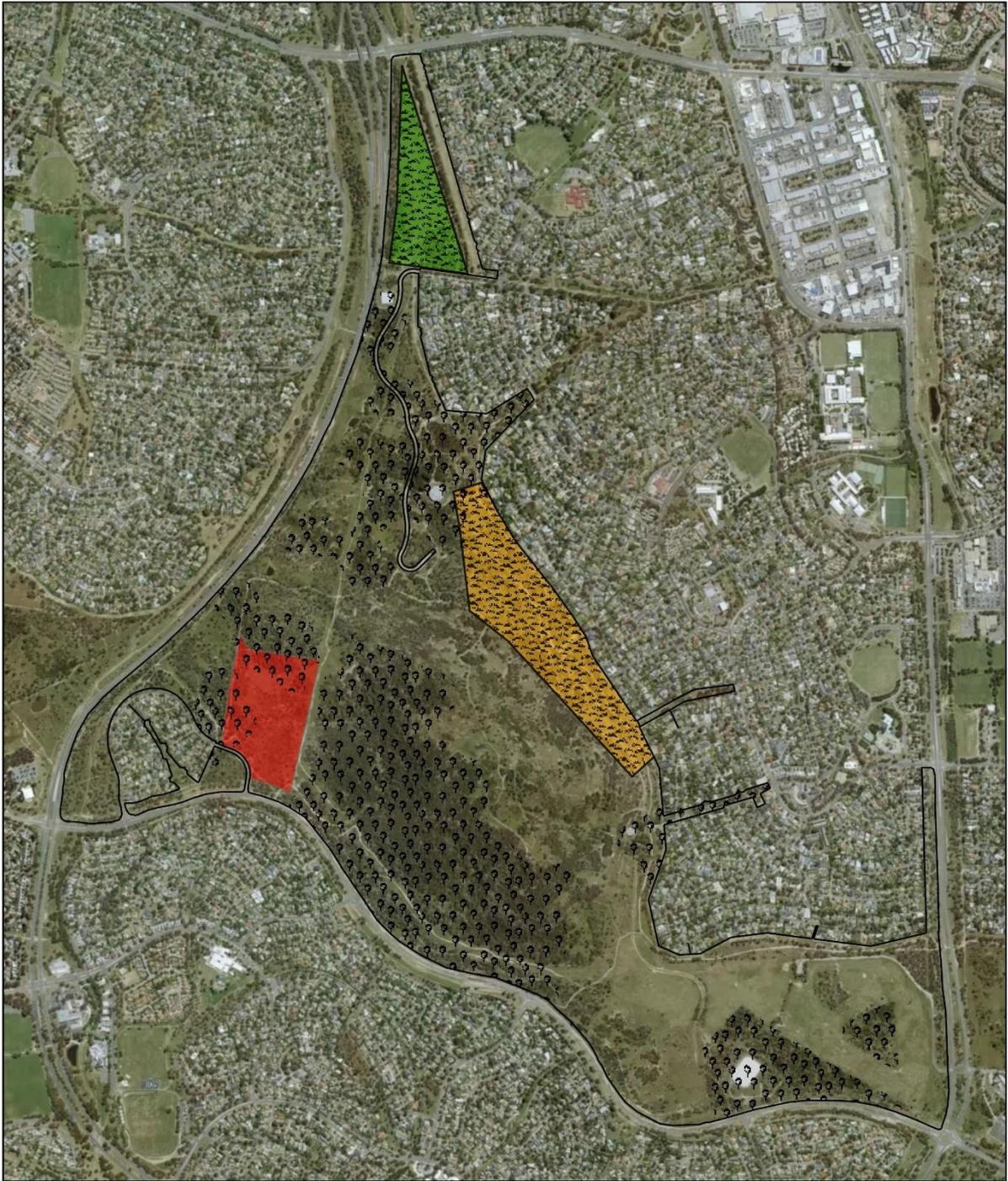
Other Tenure

- Horse Paddock
- Urban Park



0 0.3 0.6 Kilometers

Figure 40. Map of Mt Taylor KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Mt Taylor KMU 2022

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest



0 0.3 0.6 Kilometers

Figure 41. Map of Mt Taylor KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

MULANGGARI KMU

Background

Mulanggari KMU is a grassy woodland ecosystem located in the north of the Gungahlin Valley. It is bounded by Gungahlin Drive to the south-west, Gungahlin town centre to the north and the suburb of Franklin to the south east. It is comprised almost entirely of nature reserve. Immigration and emigration are considered likely to be low, although there is evidence (in the form of a kangaroo-vehicle collision hot-spot) of kangaroos occasionally crossing to or from Gungaderra KMU on the opposite side of Gungahlin Drive.

Site specific considerations

Mulanggari KMU contains large areas of Natural Temperate Grassland as well as a Yellow Box – Red Gum Grassy Woodland. It is key habitat for threatened species such as the Striped Legless Lizard, Golden Sun Moth and Hoary Sunray. The Pink-tailed Worm Lizard is also being introduced to this site in 2022. The site also includes areas identified as asset protection zones, in which herbage mass is kept below the fuel standards (often through livestock grazing) in order to manage the risk of wildfire to life and property. Management of invasive plants and rabbits will continue on this site throughout 2021, with ecological burns planned to increase habitat heterogeneity.

Kangaroo management has been undertaken at Mulanggari since 2014, although monitoring at this site was initiated in 2008. Due to low population growth rates being typical at this site, culling has been limited and intermittent in response to varying condition of the grassy layer. In some years it has been constrained by operational factors related to topography and the proximity of the site to the urban edge.

Kangaroo management recommendations

The results of the 2022 counts at Mulanggari KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 42. The vegetation structure used for calculating kangaroo management recommendations is shown in Figures 43 and 44, showing all polygons with grass heights 'within' or 'above' threshold levels. Based on the current condition of the grassy layer and increased adjusted kangaroo target density, no conservation cull is recommended for Mulanggari KMU in 2022 (Table 3). Subject to operational capacity, the use of GonaCon contraceptive vaccine should be considered for this site in 2022 to aid in reducing the need for culling to maintain sustainable populations of kangaroos in the long term.

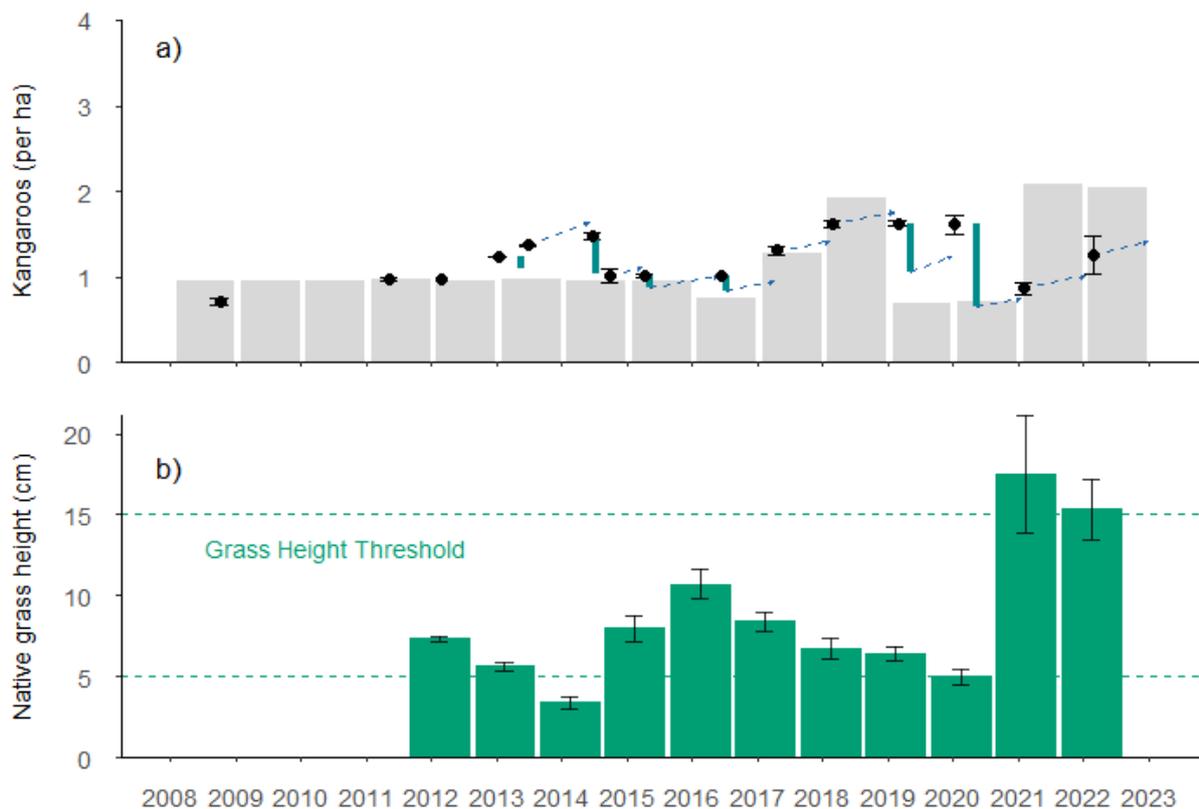


Figure 42. Changes in kangaroo density and average native grass heights for Mulanggari KMU.

a) Changes in kangaroo density Kangaroo density based on direct counts (●) are depicted as the mean ± the maximum and minimum number counted across repeat counts in one survey. Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass ± standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



Mulanggari KMU
2022

Conservation Veg

- Grassland
- Open Woodland

Other Tenure

- Business/Industrial



0 0.15 0.3 Kilometers

Figure 43. Map of Mulanggari KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Mulanggari KMU
2022



0 0.15 0.3 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest

Figure 44. Map of Mulanggari KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

MULLIGANS FLAT KMU

Background

Mulligans Flat KMU is situated in north-east ACT and is comprised predominantly of woodland vegetation. The KMU is synonymous with the Mulligans Flat Woodland Sanctuary, in that it is surrounded on all sides by a predator (and kangaroo) proof fence. As such, the population is not subject to fluctuations through immigration or emigration, and survival and recruitment are high.

Site specific considerations

Mulligans Flat KMU is comprised largely of critically endangered Yellow Box – Red Gum Grassy Woodland as well as populations of Hoary Sunray and Austral Toadflax. It also contains reintroduced populations of Eastern Bettongs, Eastern Quolls, Bush Stone-curlews, New Holland Mice and Eastern Chestnut Mice as part of the Mulligans Flat – Gurooyaroo Woodland Experiment. Kangaroo exclosures are also maintained as part of this experiment which aim to maintain kangaroo densities at approximately 10% of those set from the remainder of the Sanctuary.

The absence of predators in the sanctuary has enabled an increase in the abundance of Swamp and Red Necked Wallabies within the sanctuary, adding significantly to total grazing pressure. A trial of GonaCon contraceptive vaccine has demonstrated mixed effectiveness as a tool for managing these wallaby species longer term, with ongoing management and monitoring required. The absence of predators has also contributed to significantly higher population growth rates for kangaroos equivalent to a maximum hypothetical rate of increase (r) of around 0.55. This observation indicated that use of contraception in kangaroo populations may also be a cost-effective means of managing abundance at this site longer term.

Rabbits and hares, along with introduced predator species, have been eradicated from the sanctuary, and an invasive plant management program will continue in 2021.

Kangaroo management recommendations

The results of the 2022 count at Mulligans Flat KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 45. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 46 and 47, showing grass heights in the majority of polygons being 'within' grass height thresholds. To maintain these conditions and allow for further improvements, a conservation cull is recommended for Mulligans Flat KMU in 2022 (Table 3) as part of an integrated program to manage macropod herbivory more broadly. Particular effort should be made to reduce the density of kangaroos within the experimental kangaroo exclosures. The use of GonaCon contraceptive vaccine is also recommended for this site in 2022 to aid in reducing the need for culling to maintain sustainable populations of kangaroos in the long term.

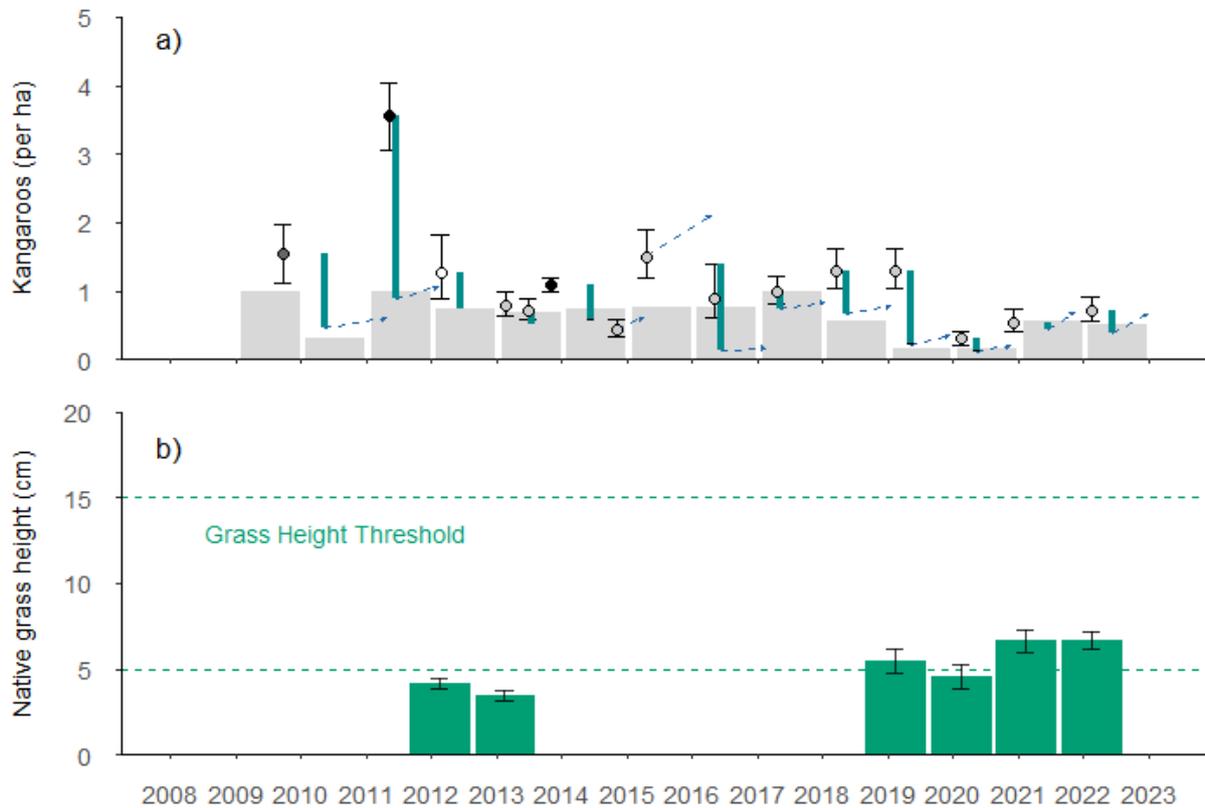


Figure 45. Changes in kangaroo density and average native grass height for Mulligans Flat KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the pellet count (●), walked line transect count (○) or driven line transect count (○) methods were used. A sweep count (●) is depicted as the mean \pm the maximum and minimum number counted across repeat counts in one survey. Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program. The line shown for 2022 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean for herbage mass polygons outside of the kangaroo exclosures. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. Previous data showing average grass heights is also shown where available but may not be representative of the whole site. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



Mulligans Flat KMU
2022



0 0.3 0.6 Kilometers

EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10

Conservation Veg

- Grassland
- Open Woodland
- Woodland
- Forest
- Kangaroo Exclosure

Figure 46. Map of Mulligans Flat KMU, showing canopy strata, land tenure, and position of surveyed kangaroos (and wallabies) across the landscape.



Mulligans Flat KMU
2022



0 0.3 0.6 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest
- Kangaroo Exclusion

Figure 47. Map of Mulligans Flat KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

RED HILL KMU

Background

The Red Hill KMU is situated in the inner south of Canberra, bordered by the suburbs of Deakin and Forrest to the north, Red Hill to the east, Garran to the south, and Hughes to the west. It is separated from the adjacent Mount Mugga Mugga Reserve (and the West Jerrabomberra KMU) to the south by Hindmarsh Drive. The KMU is comprised of the Red Hill Nature Reserve and the Federal Golf Course and is made up predominantly of woodland vegetation. The high incidence of kangaroo-vehicle collisions on Hindmarsh Drive and Kent Street (which separates the Red Hill KMU from the irrigated lawns of the Royal Australian Mint) is likely a major source of mortality for this population, and also indicates some movement of animals between Red Hill KMU and adjacent areas of suitable habitat.

Site specific considerations

The Red Hill KMU contains significant areas of Yellow Box – Red Gum Grassy Woodland as well as populations of the Button Wrinklewort and other rare plants. The Red Hill Regenerators contribute significant time and expertise to the conservation of this woodland ecosystem. Rabbit management and ongoing management of invasive plants are planned for 2022 at this site, as well as some possible restoration of ground layer vegetation.

Despite evidence of over-grazing by high kangaroo densities at this high priority site, kangaroo management is yet to be attempted at Red Hill KMU. The consistently high densities of kangaroos at this site over time indicate that the population is likely limited by food availability, as well as road-based mortality. Due to the high excess of kangaroos at this site, and the close proximity of suburbs and other areas frequented by the public (e.g. the Federal Golf Course and the lookout), kangaroo management at this site is likely to require a staged approach over multiple years to reduce numbers to levels consistent with conservation objectives.

Kangaroo management recommendations

The results of the 2022 counts for the Red Hill are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 48. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating numbers to cull is shown in Figures 49 and 50, showing most polygons to be 'within' threshold in terms of grass heights after two years of above average rainfall conditions. To retain these improvements and allow further restoration of understorey vegetation in this area, a conservation cull is recommended for Red Hill KMU in 2022 (Table 3). Given the size of the recommended cull, reducing the kangaroo population to sustainable densities at this site is anticipated to be undertaken over a number of years, and should be undertaken with a focus on public safety and kangaroo welfare. Given the location of the KMU, such an undertaking will likely require coordination of management effort with neighbouring land managers.

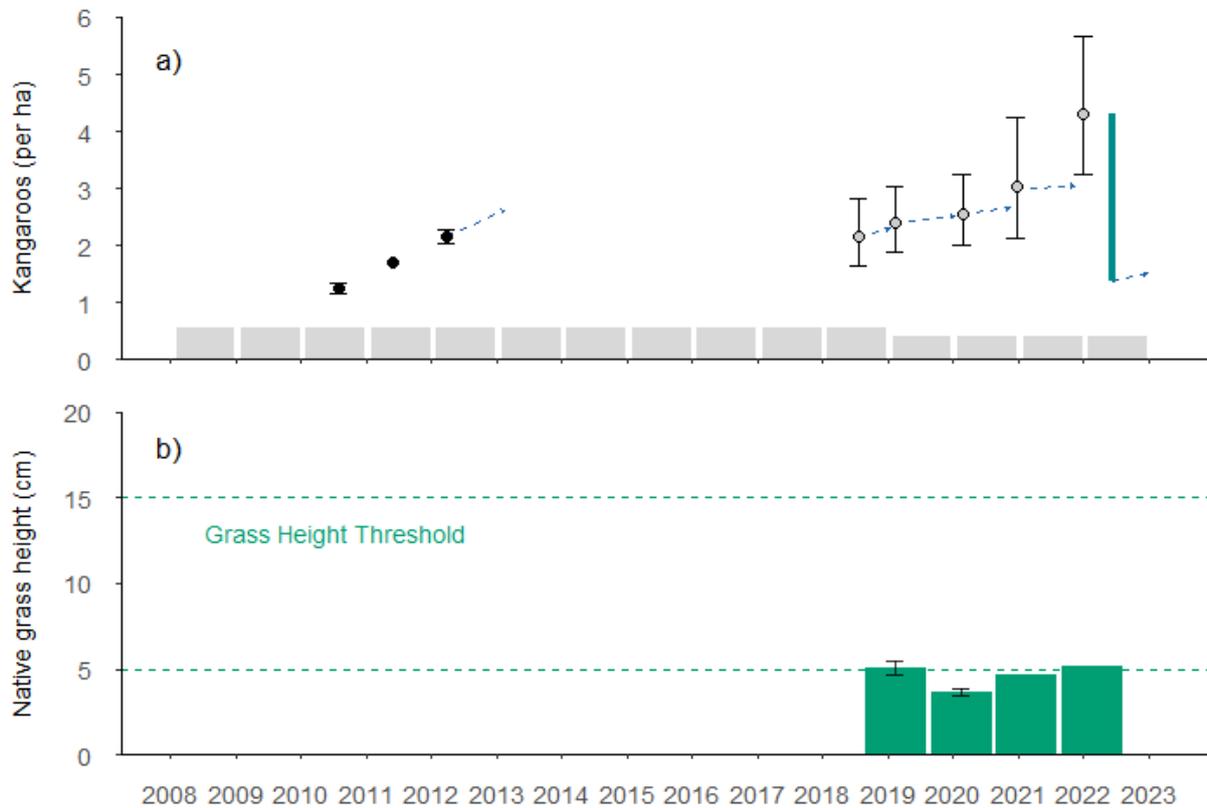


Figure 48. Changes in kangaroo density (a) and average native grass heights (b) for Red Hill KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the walked line transect count method was used (●). Total counts (either direct or sweep counts, ●) are depicted as the mean \pm the maximum and minimum number counted across repeat counts in one survey. Kangaroo culls are indicated by vertical lines, noting no conservation culls have been undertaken to date at this site. The line shown for 2022 is the recommended cull density on the conservation estate only. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



Red Hill KMU 2022

EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10

Conservation Veg

- Open Woodland
- Woodland
- Forest

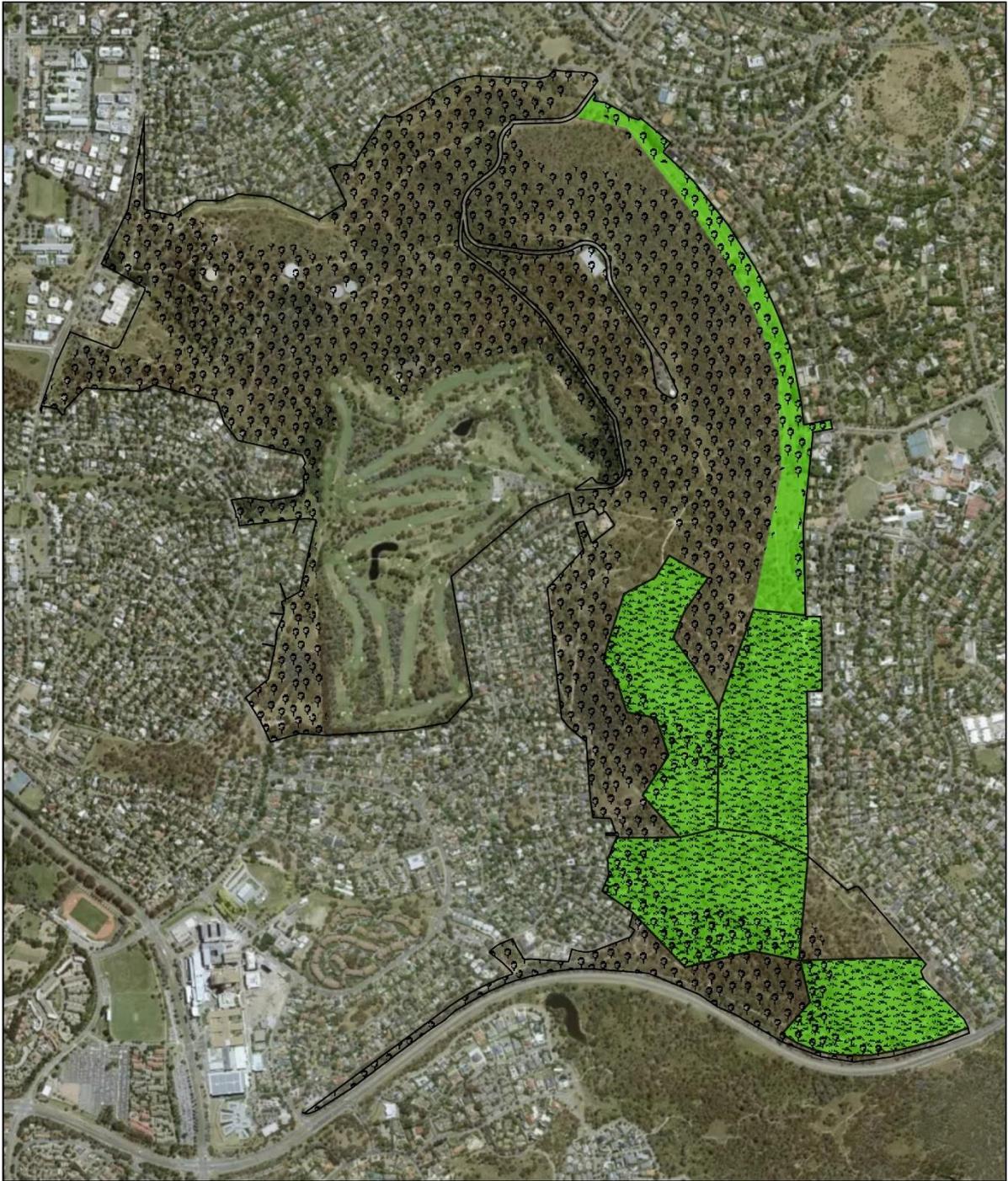
Other Tenure

- Business/Industrial
- Urban Park



0 0.25 0.5 Kilometers

Figure 49. Map of Red Hill KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Red Hill KMU 2022

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest



0 0.25 0.5 Kilometers

Figure 50. Map of Red Hill KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

THE PINNACLE KMU

Background

The Pinnacle KMU is situated in the Belconnen hills network of reserves, bordered by William Hovell Drive to the south and west, Coulter Drive to the east, and Springvale Drive and the suburb of Hawker to the north. The KMU is comprised of The Pinnacle Nature Reserve, agisted territory land, and horse paddocks. The area is predominantly open woodland. Immigration to the area is expected to be low due to significant human-built barriers to kangaroo movement, although occasional passage of animals between the Aranda Painter KMU and the Kama Extended KMU is likely.

Site specific considerations

The Pinnacle KMU contains areas of Yellow Box – Red Gum Grassy Woodland as well as populations of the Pink-tailed Worm-lizard and several rare plants. The Friends of the Pinnacle contribute significant time and expertise to the conservation of this woodland ecosystem. Fire fuel management is undertaken within asset protect zones of The Pinnacle KMU, usually through grazing by livestock, to protect life and property in accordance with the annual Bushfire Operational Plan. Revegetation works have also been undertaken in the reserve, including through the use of kangaroo exclusion fences.

Kangaroo management has been undertaken in The Pinnacle KMU since 2012, with conservation culling over a number of years eventually achieving the desired kangaroo density which has been maintained with little or no annual culling since 2015. In recent years, the majority of kangaroos appear to be grazing outside of the areas within this KMU managed for conservation. Ecological burns are hence being employed to manage weeds and open up the grassy layer structure in an effort to encourage grazing by kangaroos in the conservation components of this landscape.

Kangaroo management recommendations

The results of the 2022 counts for The Pinnacle KMU are shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 51. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating kangaroo management recommendations is shown in Figures 52 and 53, showing all polygons to be within threshold for native grass heights. Based on the distribution of kangaroos across this landscape currently and the increased adjusted target kangaroo density, no conservation cull is recommended for The Pinnacle KMU in 2022 (Table 3). Management efforts should rather be undertaken as part of a collaborative approach with neighbouring landholders in this KMU, to reduce kangaroo density in the broader landscape but ensure sustainable levels of kangaroo grazing within the conservation estate.

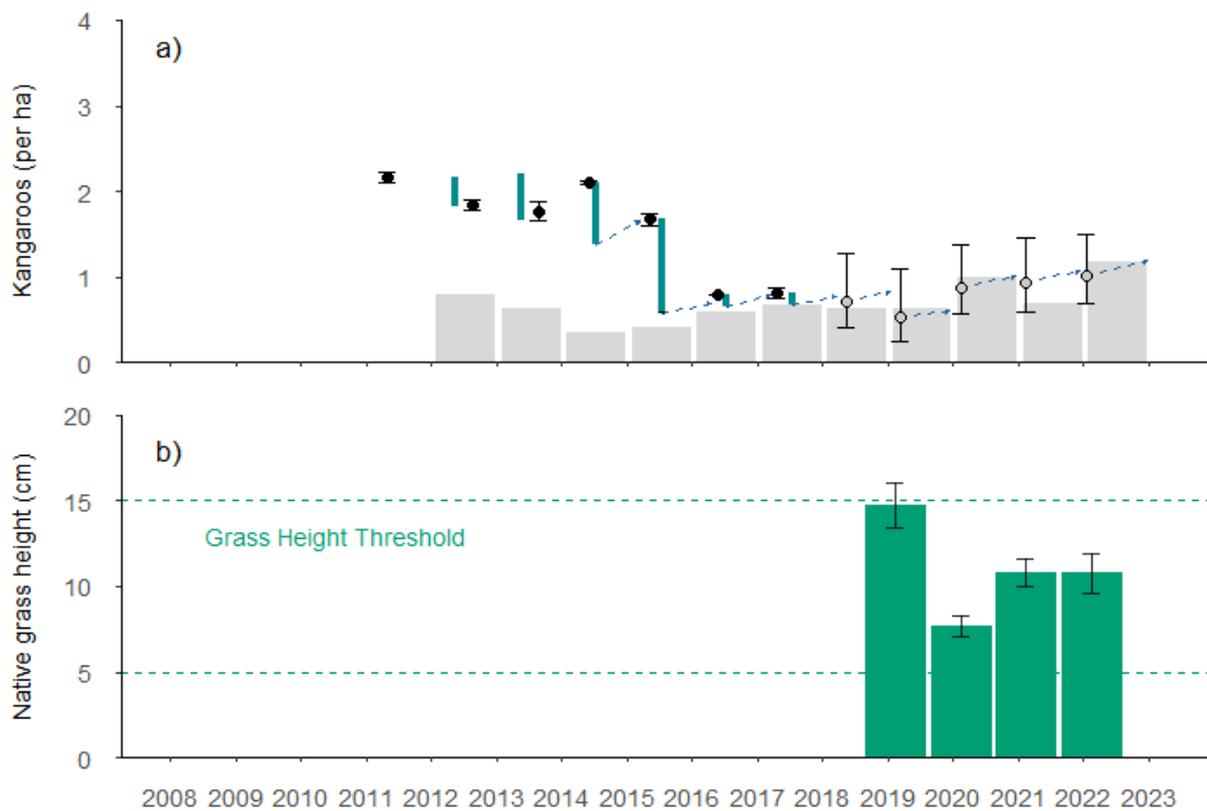


Figure 51. Changes in kangaroo density and average native grass height for The Pinnacle KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the walked line transect count method was used (○). Sweep counts (●) are depicted as the mean \pm the maximum and minimum number counted across repeat counts in one survey. Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



The Pinnacle KMU
2022



0 0.25 0.5 Kilometers

EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10

Conservation Veg

- Grassland
- Open Woodland
- Woodland
- Forest

Other Tenure

- Business/Industrial
- Livestock Agistment
- Rural Lease
- Verge

Figure 52. Map of The Pinnacle KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



The Pinnacle KMU
2022



0 0.25 0.5 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest

Figure 53. Map of The Pinnacle KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

WEST JERRABOMBERRA KMU

Background

The West Jerrabomberra KMU is in the south eastern section of Canberra Nature Park and includes a mix of woodland and grassland habitat. The KMU is comprised of the Callum Brae, West Jerrabomberra, Mount Mugga Mugga and Isaacs Ridge Nature Reserves, as well as multiple rural leases, commercial pine forest, horse paddocks and the quarry. It is bordered by the Monaro Hwy to the south and east, Hindmarsh Drive to the north, Long Gully Lane to the south and the suburbs of O'Malley and Isaacs to the west. The previous attempt to manage this broader area as two separate KMUs divided by Mugga Lane proved ineffective due to significant immigration between sites, and hence they have been effectively managed as one continuous management unit since 2019.

Site specific considerations

The West Jerrabomberra KMU contains significant areas of both critically endangered Natural Temperate Grassland and Yellow Box – Red Gum Grassy Woodlands, as well as populations of the listed Perunga Grasshopper, Pink-tailed Worm Lizard, the endangered Golden Sun Moth and Grassland Earless Dragon, and several rare plants. It also provides habitat for declining woodland bird species, including the Glossy Black Cockatoo. Invasive plant and rabbit numbers are being actively managed within component reserves during 2022.

The impacts of kangaroo grazing in the wooded areas of the KMU have been significant for over a decade, however high immigration rates between component reserves have previously confounded efforts to manage kangaroo impacts at a localised scale (i.e. within Callum Brae Nature Reserve). Despite apparently high levels of immigration into the site in 2019-20, and again in 2021-22, a collaborative effort to manage kangaroos in this landscape by component land managers has been effective in reducing population densities and improving the condition of the grassy layer overall. Kangaroo surveys now indicate lower densities of animals within the West Jerrabomberra Grassland Reserve, with higher densities of animals found on rural leases and the woodlands of Mugga Mugga and Isaacs Ridge Nature Reserves.

Ecological burning and strategic livestock grazing (sheep) will continue to be deployed throughout 2022 to open up the grassy layer and encourage kangaroos to increase their use of the grassland areas of the conservation estate, such that they are effective in maintaining appropriate grazing pressure into the future.

Kangaroo management recommendations

The results of the 2022 count West Jerrabomberra KMU is shown in Table 2. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 54. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating numbers to cull is shown in Figures 55 and 56, showing a mix of 'within' and 'above' grass height threshold polygons across this landscape. Based on current kangaroo densities and grassy layer condition, conservation culling is recommended only in the woodland components west of Mugga Lane within West Jerrabomberra KMU in 2022 (Table 3). Alternatively, a collaborative management approach should be pursued with neighbouring landholders to encourage increased kangaroo grazing on the conservation estate.

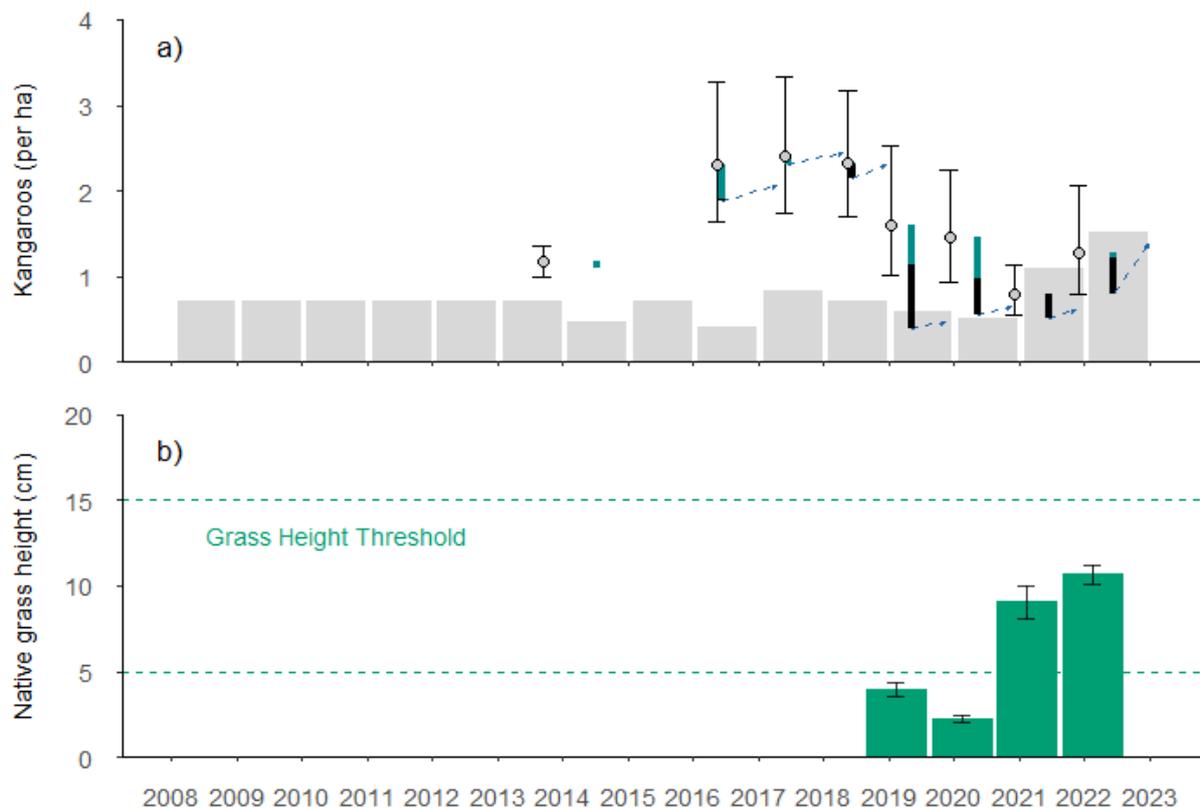
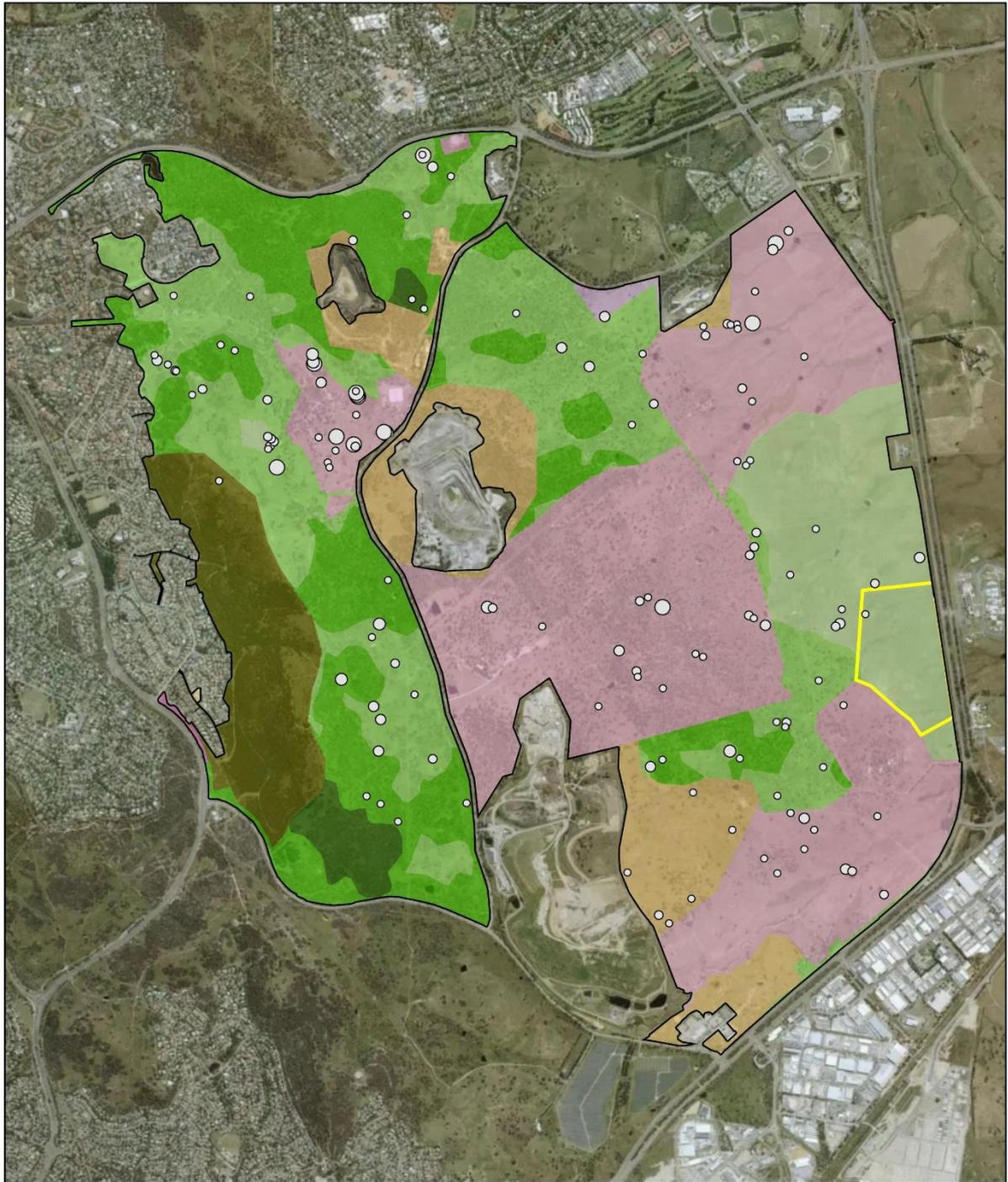


Figure 54. Changes in kangaroo density and average native grass height for West Jerrabomberra KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals based on the walked line transect count method being used (\odot). Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program and black bars representing management by non-Government entities. Blue dotted arrows indicate the predicted population growth for the site in each year. The grey shaded bars demonstrate the changing target density of Eastern Grey Kangaroos over time, based on ecological adjustments.

b) Average native grass height Native grass heights are depicted as the mean height of native grass \pm standard error of the mean. Systematic monitoring of standardised herbage mass polygons was initiated in 2019. The dashed green lines indicate the upper and lower bounds of the grass height threshold (5 – 15cm) associated with maximised biodiversity outcomes.



West Jerrabomberra
KMU 2022



0 0.55 1.1 Kilometers

EGK Group Size

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10

Conservation Veg

- Grassland
- Open Woodland
- Woodland
- Forest
- Pine Forest
- Kangaroo Exclosure

Other Tenure

- Business/Industrial
- Future Urban
- Rural Lease
- Urban Park
- Verge

Figure 55. Map of West Jerrabomberra KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



West Jerrabomberra
KMU 2022



0 0.55 1.1 Kilometers

Grass Height

- 0 - 2.5 cm - extremely low
- 2.5 - 5 cm - below threshold
- 5 - 10 cm - within threshold
- 10 - 15 cm - above threshold for Themeda
- >15 cm - above threshold

- Excessive Thatch
- Exotic Dominated
- Woodland/Forest
- Kangaroo Exclosure

Figure 56. Map of West Jerrabomberra KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

6. RESERVE PRIORITISATION FRAMEWORK

A Reserve Prioritisation Framework has been developed to assist the ACT Parks and Conservation Service in the prioritisation of land management activities across the conservation estate. The framework firstly considers the extent of endangered ecological community (combined areas of Yellow Box – Red Gum Grassy Woodland and Natural Temperate Grassland, log transformed to give an extent score) and the threatened species known to be present at the site (with species being allocated a score between 1-3 based on their conservation status and dependence on appropriate grassy layer structure). The scores from these two factors are summed to give an overall 'Biodiversity Score' for the site. Secondly, a 'Strategic Conservation Importance' score was assigned for each site to reflect the importance of the area in terms of factors such as landscape connectivity, or as key habitat for an endangered species (e.g. Canberra Grassland Earless Dragon). Thirdly, a 'Relative Risk' score was given to reflect the perceived resilience of the area to inappropriate grassy layer structure, with smaller, more isolated sites being given a higher score in this category due to the risk of permanent localised extinction of species resulting from loss of habitat without potential for recolonization. Finally, a score for 'Prior and Ongoing investment' was assigned in recognition of the value added by complementary land management activities, including previous investment in revegetation works, kangaroo management, erosion or pest plant and animal control, as well as the ongoing contribution of community volunteers through park care activities. This prioritisation framework will be continually refined as more information (especially around the presence of particular grassy layer dependent species) becomes available, however the current version can be found in Table 4. The use of such a framework aims to provide transparency in the decision-making process around conservation land management activities and enable strategic use of limited available resources.

EASTERN GREY KANGAROO CONSERVATION MANAGEMENT ADVICE 2022

Table 4. Reserve Prioritisation Framework considering a range of conservation related factors which contribute to strategic decision making around conservation land management activities within the ACTs conservation estate. Areas for adjacent environmental offset areas have been added to reserve totals where appropriate. *Values for some reserves are combined to reflect their contribution to one kangaroo management unit (KMU).

Site Name	Yellow Box - Red Gum Grassy Woodland (ha)	Natural Temperate Grassland (ha)	Total Endangered Ecological Community (ha)	Extent of Endangered Ecological Community (Log transformation of EEC ha)	Button Wrinklewort (score 3)	Grassland Earless Dragon (score 3)	Ginnenderra Peppercress (score 2)	Golden Sun Moth (score 2)	Perunga Grasshopper (score 2)	Pink-tailed Worm-lizard (score 2)	Small Purple Pea (score 2)	Striped Legless Lizard (score 3)	Canberra Raspy Cricket (score 2)	Key's Matchstick Grasshopper (score 2)	Horay Sunray (score 1)	Threatened Orchids (score 1)	Scarlet Robin (score 1)	Hooded Robin (score 1)	Superb Parrot (score 1)	Brown Treecreeper (score 1)	Varied Sitella (score 1)	White-winged Triller (score 1)	Biodiversity Values (0-34)	Strategic Conservation Importance (0-3)	Relative Risk (0-3)	Prior and Ongoing Investment (0-3)	TOTAL SCORE
*West Jerrabomberra KMU	438.0	177.8	615.8	6	0	3	0	2	2	2	2	3	2	0	1	0	1	0	0	0	0	0	24	3	2	3	32
Jerrabomberra East Nature Reserve	0.0	43.9	44.0	4	3	3	2	2	2	0	0	3	2	0	0	0	0	0	0	0	0	0	21	3	3	2	29
*Ainslie Majura KMU	654.4	19.0	673.4	7	3	0	0	2	2	0	0	3	0	0	1	1	1	0	1	0	1	0	22	2	2	3	29
Goorooyaroo Nature Reserve	583.1	0.0	583.1	6	0	0	0	2	2	0	0	3	0	0	1	0	1	0	1	0	1	0	17	3	3	3	26
Crace Nature Reserve	1.2	36.3	37.5	4	3	0	2	2	2	0	0	3	2	0	0	0	0	0	0	0	0	0	18	2	3	2	25
Mulligans Flat Nature Reserve	652.3	0.0	652.3	6	0	0	0	2	2	0	0	0	0	2	1	0	1	0	1	0	0	0	15	3	3	3	24
Molongolo River Reserve	256.7	0.0	256.7	6	0	0	0	2	2	2	0	0	0	0	1	0	1	0	0	0	1	1	16	3	1	3	23
Mulanggari Nature Reserve	19.3	12.0	31.3	3	0	0	0	2	2	0	0	3	2	0	0	0	0	0	1	0	0	0	13	2	3	2	20
Red Hill Nature Reserve	211.1	0.0	211.1	5	3	0	0	0	2	0	0	0	0	0	0	0	1	0	1	0	1	1	14	1	2	3	20
Gungaderra Nature Reserve	25.7	37.8	63.6	4	0	0	0	2	2	0	2	3	0	0	0	0	0	0	0	0	0	0	13	2	3	2	20
Kama Nature Reserve	113.1	36.6	149.7	5	0	0	0	0	0	2	0	3	0	0	1	0	1	0	1	0	0	1	14	2	1	2	19
Kinlyside Nature Reserve	113.4	0.0	113.4	5	0	0	0	2	0	2	0	0	0	0	0	0	1	0	1	0	1	1	13	1	1	2	17
The Pinnacle Nature Reserve	68.4	0.0	68.4	4	0	0	0	0	0	2	0	0	2	0	0	0	1	0	1	0	0	0	10	1	2	2	15
Black Mountain Nature Reserve	7.9	0.0	7.9	2	0	0	0	0	0	2	2	0	0	0	1	1	1	0	0	0	0	0	9	2	2	2	15
North Mitchell Grassland	2.1	3.8	5.9	2	0	0	2	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	7	3	3	1	14
Farrer Ridge Nature Reserve	83.5	0.0	83.5	4	0	0	0	0	0	2	2	0	0	0	1	0	1	0	0	0	0	0	10	1	2	0	13
Mount Taylor Nature Reserve	53.1	0.0	53.1	4	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	8	1	2	2	13
Dunlop Nature Reserve	24.5	77.0	101.5	5	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	9	1	1	1	12
Jarramlee Nature Reserve	19.1	3.8	22.9	3	0	0	0	2	0	0	0	0	2	0	0	0	1	0	0	0	0	1	9	1	1	0	11
Tuggeranong Hill Nature Reserve	132.8	0.0	132.8	5	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	8	1	2	0	11
Wanniassa Hills Nature Reserve	44.4	0.0	44.4	4	0	0	0	0	0	0	2	0	0	0	1	0	1	0	0	0	0	0	8	1	2	0	11
Cooleman Ridge Nature Reserve	78.4	0.0	78.4	4	0	0	0	0	0	2	0	0	0	0	1	0	1	0	0	0	0	0	8	1	1	0	10
Percival Hill Nature Reserve	21.2	1.1	22.3	3	0	0	0	0	0	0	0	3	0	0	1	0	1	0	0	0	0	0	8	1	1	0	10
Urambi Hills Nature Reserve	114.3	0.0	114.3	5	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	8	1	1	0	10
*Aranda Painter KMU	51.3	4.4	55.7	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5	1	1	2	9
Jerrabomberra Wetlands Nature Reserve	9.8	0.0	9.8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	1	8
Mount Pleasant Nature Reserve	33.7	0.0	33.7	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	1	2	0	8
Gossan Hill Nature Reserve	11.4	0.0	11.4	2	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	4	1	2	0	7
McQuoids Hill Nature Reserve	18.2	0.0	18.2	3	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	5	1	1	0	7
Bruce Ridge Nature Reserve	13.3	0.0	13.3	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4	1	2	0	7
O'Connor Ridge Nature Reserve	8.9	0.0	8.9	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	1	2	0	6
Kowen Escarpment Nature Reserve	8.0	0.0	8.0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	1	2	0	6
Oakey Hill Nature Reserve	0.5	0.0	0.5	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	0	5
Googong Foreshores	-	-	-	3	3	0	0	2	2	2	0	2	0	0	0	0	1	1	0	1	0	1	18	2	1	2	23

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