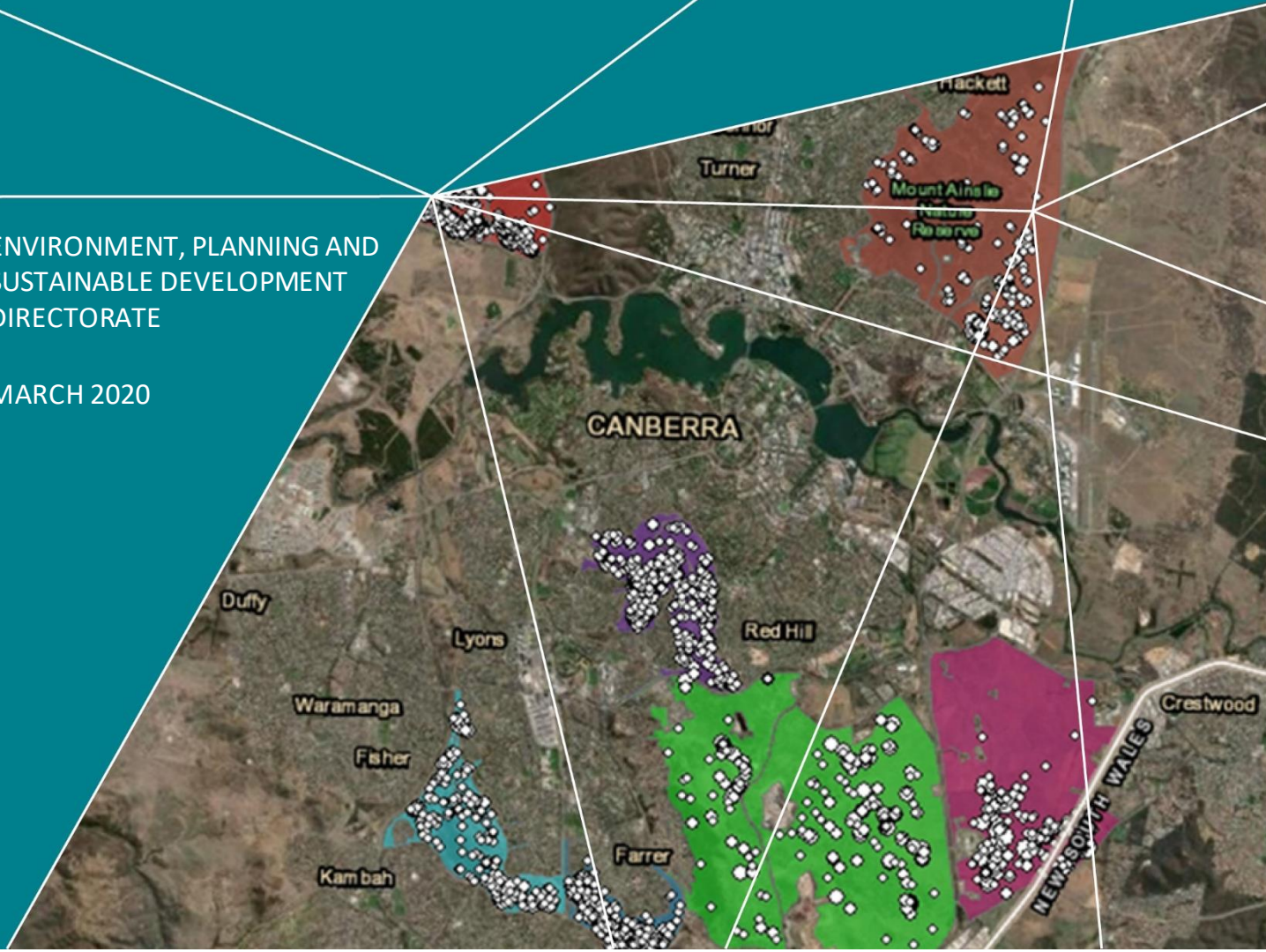


EASTERN GREY KANGAROO

CONSERVATION MANAGEMENT ADVICE 2020

ENVIRONMENT, PLANNING AND
SUSTAINABLE DEVELOPMENT
DIRECTORATE

MARCH 2020



© Australian Capital Territory, Canberra 2020

This work is copyright. Apart from any use as permitted under the Copyright Act 1968, no part may be reproduced without the written permission from: Director-General, Environment, Planning and Sustainable Development Directorate, GPO Box 158 Canberra ACT 2601.

ISBN 978-1-921117-57-2

Published by the Environment, Planning and Sustainable Development Directorate, ACT Government

Website: www.environment.act.gov.au

Disclaimer

The views and opinions expressed in this report are those of the authors and do not necessarily represent the views, opinions or policy of funding bodies or participating member agencies or organisations.

This publication should be cited as:

ACT Government (2020). Eastern Grey Kangaroo Conservation Management Advice 2020. Environment, Planning and Sustainable Development Directorate, ACT Government, Canberra.

Accessibility

The ACT Government is committed to making its information, services, events and venues as accessible as possible. If you have difficulty reading a standard printed document and would like to receive this publication in an alternative format, such as large print, please phone Access Canberra on 13 22 81 or email the Environment, Planning and Sustainable Development Directorate at epd_communications@act.gov.au. If English is not your first language and you require a translating and interpreting service, please phone 13 14 50.

If you are deaf, or have a speech or hearing impairment, and need the teletypewriter service, please phone 13 36 77 and ask for Access Canberra on 13 22 81. For speak and listen users, please phone 1300 555 727 and ask for Access Canberra on 13 22 81. For more information on these services visit the [National Relay Service](#) website.

Front cover: Survey data from kangaroo counts undertaken using the walked line transect count method, showing surveyed kangaroo groups as white circles within individual kangaroo management units.

TABLE OF CONTENTS

SUMMARY	4
INTRODUCTION	6
NATURE CONSERVATION (EASTERN GREY KANGAROO) CONSERVATION CULLING CALCULATOR.....	6
CONSERVATION CULLING FORMULA	6
A: THE TARGET NUMBER OF KANGAROOS TO REMAIN AFTER CULLING ..	6
B: THE CURRENT POPULATION	7
C: POPULATION GROWTH IN THE INTERIM TO THE NEXT CULL.....	7
EXPERT ECOLOGICAL JUDGMENT.....	7
A: THE TARGET NUMBER OF KANGAROOS TO REMAIN AFTER CULLING.....	8
B: THE CURRENT POPULATION.....	10
C: POPULATION GROWTH IN THE INTERIM TO THE NEXT CULL...	10
EXPERT ECOLOGICAL JUDGEMENT	12
CLIMATIC CONSIDERATIONS	12
LANDSCAPE CONNECTIVITY	13
SITE SPECIFIC CONSIDERATIONS.....	14
AINSLIE MAJURA KMU.....	14
ARANDA PAINTER KMU.....	18
CRACE KMU	22
DUNLOP KMU.....	26
EAST JERRABOMBERRA KMU.....	30
FARRER RIDGE KMU	34
GOOGONG WEST KMU	38
GOOROYARROO KMU.....	42
GUNGADERRA KMU.....	46
KAMA EXTENDED KMU	50
KINLYSIDE KMU.....	54
MT TAYLOR KMU	58
MULANGGARI KMU	62
MULLIGANS FLAT KMU.....	66
RED HILL KMU.....	70
THE PINNACLE KMU	74
WEST JERRABOMBERRA KMU.....	78
RESERVE PRIORITISATION FRAMEWORK.....	82
SUMMARY OF 2020 CONSERVATION MANAGEMENT ADVICE	84
REFERENCES.....	85

SUMMARY

Kangaroo populations in the ACT have thrived due to the relative abundance of suitable habitat, increased availability of water, reduction of natural predators such as dingoes, and reduced or eliminated competition from livestock in many grassy landscapes now reserved for conservation. Whilst kangaroos are recognised as critical to the normal healthy functioning of grassy ecosystems, excessive grazing pressure from kangaroos can deplete the grassy habitat required to sustain healthy populations of other grass-dependent native plant and animal species. As many areas of suitable kangaroo habitat in the ACT also contain endangered species and ecological communities listed under the Commonwealth *Environmental Protection and Biosecurity Conservation Act*, careful ongoing management of total grazing pressure across Canberra's lowland reserve network is critical - as even a temporary loss of species from any one of these patches would likely be permanent without targeted reintroduction due to the highly fragmented nature of this peri-urban landscape. The risks posed by kangaroo grazing are further exacerbated during periods of drought, when reduced rates of grass growth magnify the effect of grazing impacts at a time when reliance on grass cover by other species for shelter from hot and dry conditions is at a peak. Currently, over 70% of areas surveyed are classified as 'below threshold' in terms of grass heights necessary to maintain the full suite of biodiversity in lowland grassy ecosystems.

To manage the risk of kangaroos to conservation values, and to improve the resilience of these landscapes to the impacts of climate change (including heat waves and more frequent episodes of drought and bushfire), the ACT Government undertakes an annual conservation culling program of Eastern Grey Kangaroos as part of an integrated management approach to mitigating the impacts of excessive grazing on our protected grassy ecosystems. The conservation cull is guided by the *Eastern Grey Kangaroo: Controlled Native Species Management Plan* (2017) and is based on scientific knowledge supported by ongoing research, appropriate regulation and monitoring, and national codes of practice. Due to the recent climatic conditions experienced across the ACT, and considering the impacts of climate change on natural areas elsewhere in the Territory through the recent Ororral bushfire, kangaroo management remains of upmost importance in 2020 to protect and restore conservation values across our parks.

To inform kangaroo management, site specific target kangaroo densities are calculated each year based on landscape scale assessments of vegetation type and condition. This information is used to model both grass productivity and rates of consumption by kangaroos, to determine the appropriate number of kangaroos to retain in each management unit to achieve conservation objectives. Annual population assessments of kangaroo population size are also undertaken at each kangaroo management unit (KMU), enabling population growth rates and the number of excess kangaroos to be identified for each site (Table 1). Monitoring of the kangaroo management program's effectiveness is ongoing in keeping with its adaptive management foundation. However evidence to date demonstrates the positive overall benefits to grassy ecosystem health and resilience which stem from ongoing maintenance of sustainable kangaroo densities.

SITE	TARGET Kangaroo Population Size	CURRENT Kangaroo Population Size	Recommended NUMBER TO CULL
Ainslie Majura KMU	316	1380	1094
Aranda Painter KMU	133	340	218
Crace KMU	119	219	110
Dunlop KMU	84	208	NA
Jerrabomberra East NR	53	410	369
Farrer Ridge KMU	101	465	372
Googong West KMU	1017	1385	602
Goorooyarroo KMU	344	715	450
Gungaharra KMU	228	373	164
Kama Extended KMU	191	158	0
Kinlyside KMU	155	173	NA
Mt Taylor KMU	164	494	345
Mulanggari KMU	114	261	156
Mulligans Flat KMU	77	144	84
Red Hill KMU	122	778	667
The Pinnacle KMU	153	136	0
West Jerrabomberra KMU	515	1465	994
TOTAL			5625

Table 1. Summary of the target number of kangaroos to remain, the current population, and the recommended number to cull for the conservation estate within each of the kangaroo management units considered in 2020. Note that these numbers reflect the conservation estate only within the broader kangaroo management unit, and final adjustments to target densities based on current ecosystem condition.

INTRODUCTION

The calculation used for determining the appropriate number of Eastern Grey Kangaroos to be removed from ACT nature reserves and adjacent land for conservation reasons is in accordance with the Nature Conservation (Eastern Grey Kangaroo) Conservation Culling Calculator Determination 2018, a notifiable instrument under section 2.3 of the Eastern Grey Kangaroo: Controlled Native Species Management Plan (ACT Government, 2017a; hereafter the 'EGK: CNSMP').

The purpose of conservation management in protected areas of the ACT is to maintain densities of Eastern Grey Kangaroos at levels that retain grassland conservation values. In particular, the aim is to moderate kangaroo grazing effects to achieve a grazing regime favourable for the conservation of plants and small animals that frequent the ground-layer vegetation. A detailed description of the preferred grassy layer structural attributes (associated with the best biodiversity outcomes for different grass communities), the monitoring of grassy layer structure within potential cull reserves, and other mechanisms for managing herbage mass can be found in the Herbage Mass Management Guidelines (ACT Government, *in prep.*).

The Conservation Culling Calculator (ACT Government, 2018a) is used to derive the target density of kangaroos for each Kangaroo Management Unit (KMU). The outcome is then subject to expert ecological judgement to take into account annual variation in vegetation and climate, and the specific habitat requirements of any species of interest (e.g. threatened species) in each kangaroo management unit. The content of the conservation calculator instrument has been inserted below.

Since 2019, ecological adjustments to the base cull formula have been based on quantitative on-ground surveys of ground layer vegetation condition across priority reserves. This data is run through mathematical models which estimate patch-specific herbage mass, productivity (i.e. grass growth), and palatability to kangaroos. These models and the associated data will be published separately to this advice (Snape, *in prep.*) however relevant information is published in this report. Further details of kangaroo policy and supporting references can be found in the EGK: CNSMP.

NATURE CONSERVATION (EASTERN GREY KANGAROO) CONSERVATION CULLING CALCULATOR

CONSERVATION CULLING FORMULA

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

A: THE TARGET NUMBER OF KANGAROOS TO REMAIN AFTER CULLING

It is estimated that a density of approximately one kangaroo per hectare in grassland is likely to maintain the desired conservation environment under varying pasture growth conditions for small animals such as the Striped Legless Lizard. The corresponding figures for other vegetation types are inversely proportional to the percentage canopy cover: open woodland = 90% of grassland; woodland = 50% of grassland; and forest/open forest = 10% of grassland.

Thus, it would be calculated that a reserve comprising 100 hectares of forest, 100 hectares of open woodland and 100 hectares of grassland could sustain $10+90+100=200$ Eastern Grey Kangaroos without threatening the habitat of small ground dwelling animals.

Site specific target densities may be applied to support ecological research, when supported by a defined research project that has been approved by the Conservator of Flora and Fauna and which has gained ethics approval, if required. For example, this has been applied in the Gorooyarroo and Mulligans Flat Nature Reserves that are part of the Mulligans-Gorooyarroo Experiment (see www.mfgowoodlandexperiment.org.au).

B: THE CURRENT POPULATION

Population abundance is determined within a Kangaroo Management Unit (KMU), which is typically an area bounded by features known to inhibit kangaroo movement such as high-speed roads and the suburban edge. A KMU typically consists of multiple land tenures occupied by one kangaroo population, which is reflected in the kangaroo counts by conducting the counts across the land components rather than just the Nature Reserve. Refer to Appendix 1 of the EGK: CNSMP for methods of estimating kangaroo population abundance.

C: POPULATION GROWTH IN THE INTERIM TO THE NEXT CULL

The grassland target density is an average for the year, so the population starts the year below the target and ends the year above it. For example, if the target was 1/ha, and the annual population growth rate (PGR) was 20%, the cull should reduce the density to 0.91/ha and it will end the year at 1.10/ha.

The primary limit to kangaroo population size and PGR is the per capita availability of food. Other processes affecting PGR of local populations are motor vehicle collisions on high speed roads and the presence of foxes and dogs.

Post-cull growth rates are generally expected to be higher than those of uncultured populations because more food is available per kangaroo. As a general guideline for kangaroo populations culled to well below the maximum possible density, 0-30% annual growth is currently taken as a reasonable expectation, depending on weather and site-specific circumstances.

EXPERT ECOLOGICAL JUDGMENT

Ecologically based management requires professional judgment based on observations and current research, as well as answers from simple formulas. For example, a degraded grassland would recover faster if grazing pressure was kept lower for a few years, whereas a grassland which had grown tall for several years may benefit from higher grazing pressure for a short time.

Adjustments should also be made both between years and between reserves to allow for differences in environmental variables (for example, rainfall, pasture type, etc.) or to manage habitat for specific species. For example, monitoring indicates that the above formula can result in too much grass for Golden Sun Moths in wet years. If more kangaroos are desirable in reserves prioritised for Golden Sun Moths, refinements will be needed. Adjustment for pasture type and condition would also be appropriate, providing it is kangaroo specific, as Eastern Grey Kangaroos have different feeding preferences to livestock.

A: THE TARGET NUMBER OF KANGAROOS TO REMAIN AFTER CULLING

The vegetation and tenure composition for KMUs considered as part of the 2020 conservation culling program are shown in Table 2, alongside the calculated number of kangaroos to remain (based on the conservation culling calculator described in the previous section). Areas of a KMU not managed for conservation have a nominal target density of 0.1 kangaroos per hectare, based on assumptions regarding land management objectives (e.g. livestock production), however kangaroo management in these areas is at the discretion of the relevant land manager in accordance with the Nature Conservation (Eastern Grey Kangaroo) Rural Culling Calculator Determination (2017b). Note that culling recommendations provided for ACT Government managed conservation land in this report will deviate from those calculated by the 'conservation calculator' at some sites based on site specific considerations described in the 'expert ecological judgement' section above.



Table 2. Kangaroo management unit (KMU) land tenure and vegetation composition breakdown, with calculated long-term target numbers of kangaroos to remain within each site.

The long-term target kangaroo population for each KMU considered as part of the 2020 kangaroo management program is shown. Note that these numbers do not reflect ecological adjustments made to reflect current climatic and environmental conditions in 2020 which inform the target densities and culling recommendations outlined in Table 1. A nominal 0.1 kangaroos per hectare has been used to calculate the target density for all tenures outside of the ACT Government's conservation estate, however actual target densities for these areas are determined by the relevant land manager in accordance with the Eastern Grey Kangaroo: Controlled Native Species Management Plan (ACT Government, 2017) and associated Culling Calculator Instruments. *The target number of kangaroos to remain within Mulligans Flat and Goorooyarroo Sanctuaries are reduced to meet the objectives of the Mulligans Flat – Goorooyarroo Woodlands Experiment.

SITE	Grassland (ha)	Open Woodland (ha)	Woodland (ha)	Open Forest (ha)	Forest (ha)	Pine Forest (ha)	Conservation Land Total (ha)	Rural Lease (ha)	Public Land - Rural (ha)	Livestock Agistment (ha)	Horse Paddock (ha)	Industrial Enterprise (ha)	Pine Forest (ha)	Future Urban (ha)	Urban Park (ha)	NSW Conservation Land (ha)	Commonwealth Managed As Reserve (ha)	Verge RLHP (ha)	Grand Total (ha)	Number of Kangaroos to Remain in KMU
Ainslie Majura KMU	130.4	45.4	418.8	493.2	350.2	0.5	1438	335.0	0.0	0.0	104.9	5.5	86.5	0.0	17.6	0.0	70.9	40.7	2100	531
Aranda Painter KMU	52.0	35.0	67.7	51.0	44.2	0.0	250	29.3	0.0	0.0	42.4	0.4	0.0	34.1	4.6	0.0	0.0	20.0	381	140
Crace KMU	121.2	0.0	10.7	10.0	0.0	0.0	142	0.0	31.1	0.0	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	180	131
Dunlop KMU	81.6	34.7	0.0	0.0	0.0	0.0	116	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	116	113
East Jerrabomberra Valley KMU (incl. reserve)	354.9	0.5	1.1	0.0	0.0	0.0	357	592.6	0.0	0.0	0.0	48.3	0.0	0.0	0.0	84.5	0.0	12.5	1094	430
<i>Jerrabomberra East Nature Reserve (incl. exclosures)</i>	126.6	0.0	0.0	0.0	0.0	0.0	127	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	127	127
Farrer Ridge KMU	0.0	104.0	92.8	5.2	0.0	0.0	202	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	202	141
Googong West KMU	672.3	596.9	382.7	89.0	13.3	0.0	1754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1754	1411
Goorooyarroo Sanctuary KMU (incl. exclosures)	83.7	598.5	114.3	0.0	0.0	0.0	796	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	797	561*
Gungaharra KMU	242.7	51.4	39.1	11.6	0.0	0.0	345	7.4	0.0	0.0	0.0	6.7	0.0	0.0	4.9	0.0	0.0	0.0	364	312
Kama Extended KMU	127.6	117.4	57.5	0.0	0.0	0.0	303	740.7	0.0	0.0	0.0	0.0	0.0	61.5	0.0	0.0	0.0	2.9	1108	343
Kinlyside KMU	1.8	91.3	139.8	13.6	0.0	0.0	247	487.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	737	204
Mt Taylor KMU	9.2	187.2	92.6	31.2	13.7	0.0	334	0.0	0.0	0.0	38.4	0.0	0.0	0.0	8.1	0.0	0.0	0.0	380	233
Mulangarri KMU	99.9	57.2	0.0	0.0	0.0	0.0	157	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	161	152
Mulligans Flat KMU (incl. exclosures)	11.2	158.6	251.0	63.2	0.0	0.0	484	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	484	201*
North Mitchell KMU	18.8	3.4	0.0	0.0	0.0	0.0	22	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	23	22
Red Hill KMU	0.0	83.8	185.0	35.9	0.0	0.0	305	0.0	0.0	0.0	0.0	97.3	0.0	0.0	6.6	0.0	0.0	0.0	409	182
The Pinnacle KMU	0.5	56.8	89.9	6.8	0.0	0.0	154	76.0	0.0	112.6	0.0	3.4	0.0	0.0	0.0	0.0	0.0	19.0	365	118
West Jerrabomberra Valley KMU (incl. exclosures)	186.2	402.1	328.3	26.6	6.9	59.6	1010	686.2	0.0	0.0	0.0	224.6	78.2	7.1	1.0	0.0	0.0	2.6	2009	822

B: THE CURRENT POPULATION

The counting method used, the number of kangaroos counted, the population density, and the error associated with each of the counts undertaken to inform the 2020 conservation cull is shown in Table 3. Details of the count methods used are described in Appendix 1 of the Kangaroo Management Plan (ACT Government, 2010).

Table 3. KMU counts used to inform conservation culling advice for 2020.

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. Data in *italics* for Jerrabomberra East reflects the Jerrabomberra East and Queanbeyan Nature Reserve components only.

Site	Count Year	Count Type	Population Density	Number of Kangaroos	95% Confidence Interval (or Range)	CV (or Number of Counts)
Ainslie Majura KMU	2020	WLT	0.96	2008	1178 - 3425	27.0%
Aranda Painter KMU	2020	WLT	1.36	519	374 - 720	16.0%
Dunlop	2020	Direct	1.79	208	-	(1)
Crace KMU	2020	Direct	1.21	219	(212 - 225)	(2)
East Jerrabomberra Valley KMU	2020	WLT	0.65	712	446 - 1135	23.0%
<i>Jerrabomberra East & Qbn NR</i>	<i>2020</i>	<i>Sweep</i>	<i>3.23</i>	<i>802</i>	<i>(725 - 878)</i>	<i>(2)</i>
Farrer Ridge KMU	2020	WLT	2.30	465	362 - 597	13.0%
Googong West KMU	2020	WLT	0.79	1385	1051 - 1824	13.0%
Goorooyarroo Sanctuary KMU	2020	WLT	0.90	715	590 - 868	10.0%
Gungaharra KMU	2020	Sweep	1.02	373	(354 - 391)	(2)
Kama Extended KMU	2020	WLT	0.52	581	436 - 773	14.1%
Kinlyside KMU	2019	WLT	0.59	437	280 - 684	22.7%
Mt Taylor KMU	2020	WLT	1.48	564	417 - 763	15.3%
Mulangarri KMU	2020	Direct	1.61	261	(242 - 279)	(2)
Mulligans Flat KMU	2020	WLT	0.30	144	102 - 204	17.0%
Red Hill KMU	2020	WLT	2.55	1042	816 - 1330	12.0%
The Pinnacle KMU	2020	WLT	0.88	321	206 - 499	21.7%
West Jerrabomberra Valley KMU	2020	WLT	1.45	2917	1886 - 4512	22.0%

C: POPULATION GROWTH IN THE INTERIM TO THE NEXT CULL

A density dependent population growth model was developed for use in the calculation of population growth rates in the interim between conservation culls. Based on data available to date, the formula for predicting population growth rate within a KMU has been determined as:

$$\text{Population Growth Rate (PGR)} = -0.0718 \times \text{Population Density} + 0.2273$$

This formula was developed based on linear regression between population density and annual population growth rates in a selection of isolated (i.e. low immigration) culled and un-culled reserves, in years where culling did not take place (ACT Government, 2018b). This formula will be refined as more data becomes available.

Population growth rates at predator-proof fenced sanctuaries (e.g. Mulligans Flat and Goorooyarroo KMUs) are estimated according to site specific observations of population growth and do not use this formula. This is due to annual increases of up to 60-70% (i.e. the maximum hypothetical population increase in female biased populations with little or no natural mortality) having been routinely observed in these areas over recent years. Investigation into the use of fertility control technologies to reduce this rapid level of recruitment in fenced areas is ongoing.

Greater than usual population growth rates were observed in many kangaroo management units across the ACT between kangaroo counts in 2019 and 2020. This was likely due to the prolonged dry conditions across the ACT causing reduced access to food and water for many animals and higher levels of landscape scale movement (i.e. immigration) compared to what has typically been observed in these populations over the last decade. Increased levels of immigration were particularly evident at sites containing significant grassland areas, including the Gungahlin and Jerrabomberra Valley grassland reserves. Record numbers of kangaroo-vehicle strikes throughout 2018, and an unusually prolonged incidence of heightened collision rates throughout the spring and summer of 2019, provide further support for the impacts of ongoing hot and dry conditions on otherwise stable kangaroo populations (Figure 1).

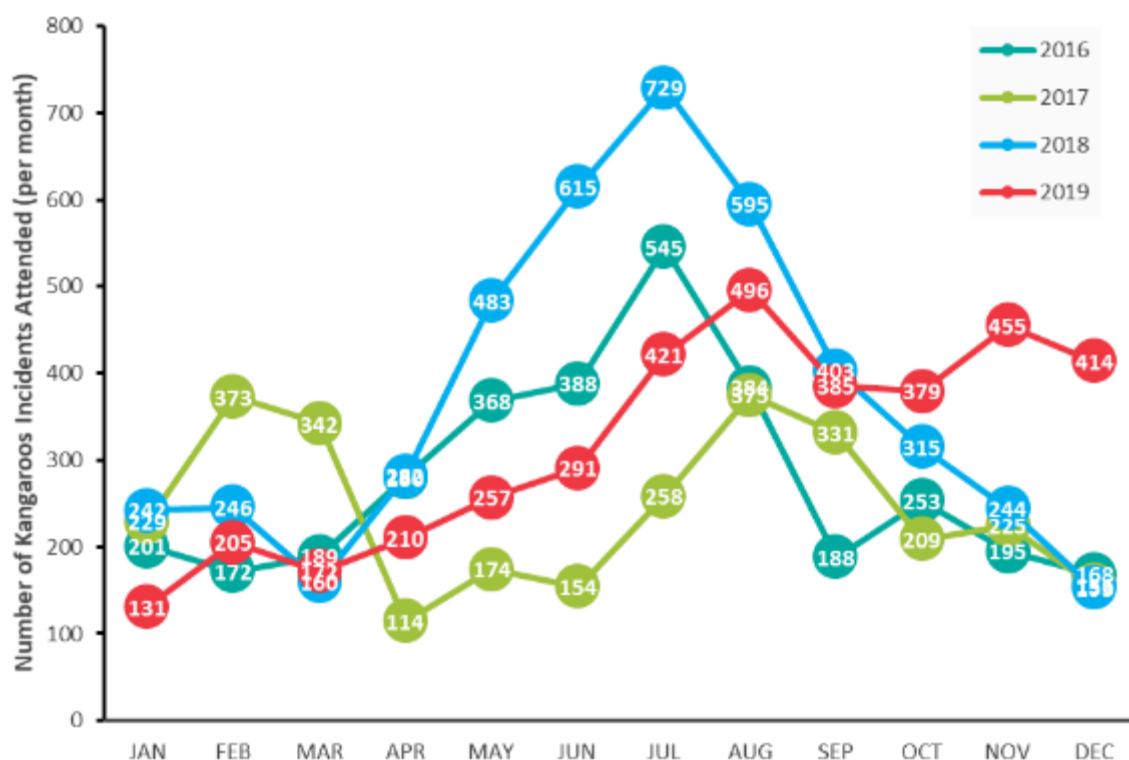


Figure 1. Monthly totals for kangaroo injuries or mortalities requiring attendance by the ACT Parks and Conservation Service on ACT roads (i.e. for euthanasia or carcass removal). Note particularly high rates of reported kangaroo-vehicle collisions during 2018, and a prolonged high number of incidents throughout spring and summer of 2019.

In response to these recent observations, and to ensure management effectiveness, population growth rates for those sites which have demonstrated repeated incidence of significant immigration have also been manually set at 60% for the 2020-2021 management period. The ongoing requirement for this temporary adjustment will be re-evaluated in 2021, ensuring that adaptive kangaroo management at each site continues to reflect contemporary population dynamics.

EXPERT ECOLOGICAL JUDGEMENT

CLIMATIC CONSIDERATIONS

Grass growth is most heavily influenced by climatic conditions, with a combination of warm sunny days and frequent rainfall providing the optimum grass growth conditions. The Bureau of Meteorology provides monthly forecasts of rainfall and temperature for a three-month period ahead. The May to July forecasts for 2020 rainfall and temperature are shown in Figure 2. A 65% chance of exceeding the median rainfall for this period is predicted for the ACT (i.e. a slight increase in the chance of experiencing above median rainfall conditions) in association with an 70% chance of exceeding the median maximum temperature (i.e. above median maximum temperatures are quite likely). Predictions beyond this time are not available. Given the low predictive capacity of these forecasts for Autumn in South-Eastern Australia, and residual impacts of the prolonged dry conditions throughout 2019 on grass condition and threatened species populations, continued careful management of total grazing pressure will be important in key habitat areas.

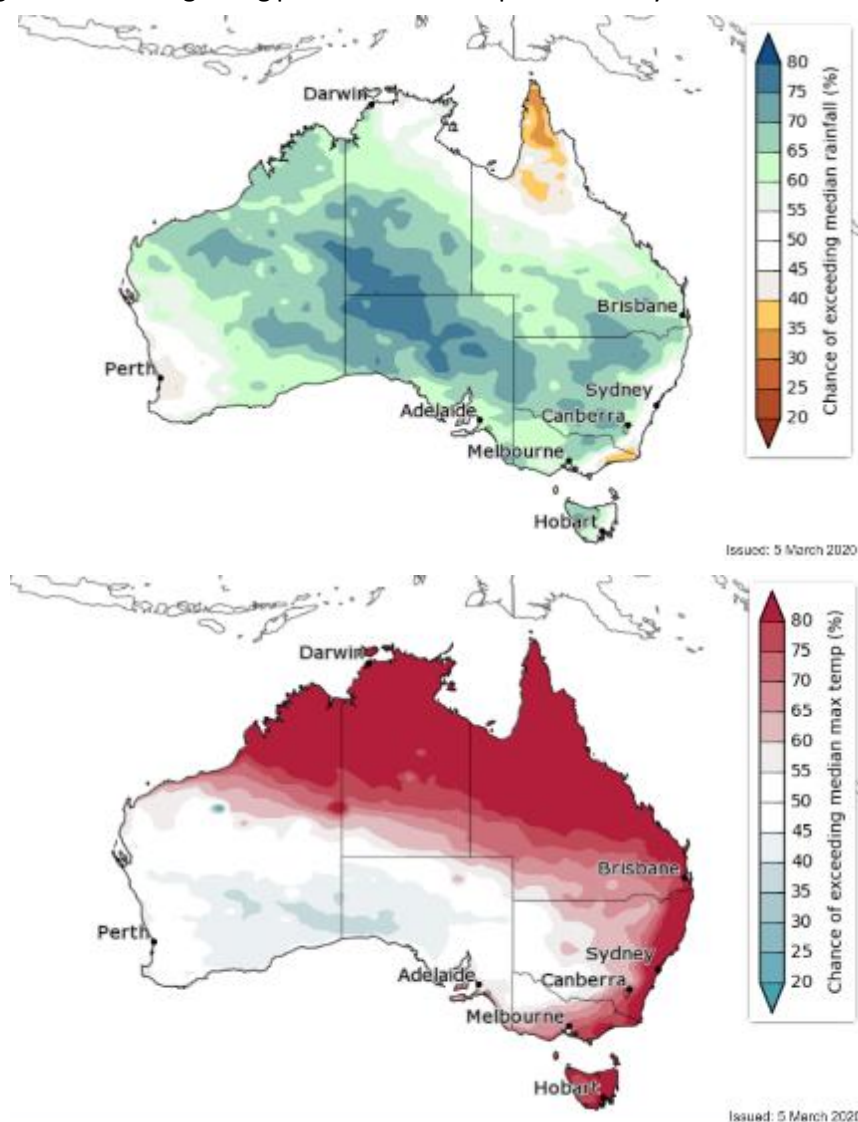


Figure 2. Rainfall (top) and temperature (bottom) forecasts for May to July 2020. Sourced from www.bom.gov.au/climate/outlooks.

LANDSCAPE CONNECTIVITY

Research undertaken by ACT Government has previously demonstrated that landscape features such as high-speed roads, suburbs, lakes and rivers generally act as barriers to kangaroo movement across the peri-urban areas of the ACT with kangaroos maintaining small home ranges (0.5 – 1 km²) within areas of suitable habitat (ACT Government 2017). Notwithstanding these findings, rates of kangaroo-vehicle collisions remain high and are probably increasing in the ACT, especially in recent years when food availability has been limited in many areas due to prolonged hot and dry conditions. With higher than usual rates of immigration observed in population surveys during 2019-20, data collected around hot spots for kangaroo-vehicle collisions (Figure 3) may assist land managers in understanding key areas of kangaroo movement between adjacent KMUs. This information is included here such that best practice approaches to managing individual kangaroo management units can be informed by landscape scale context.

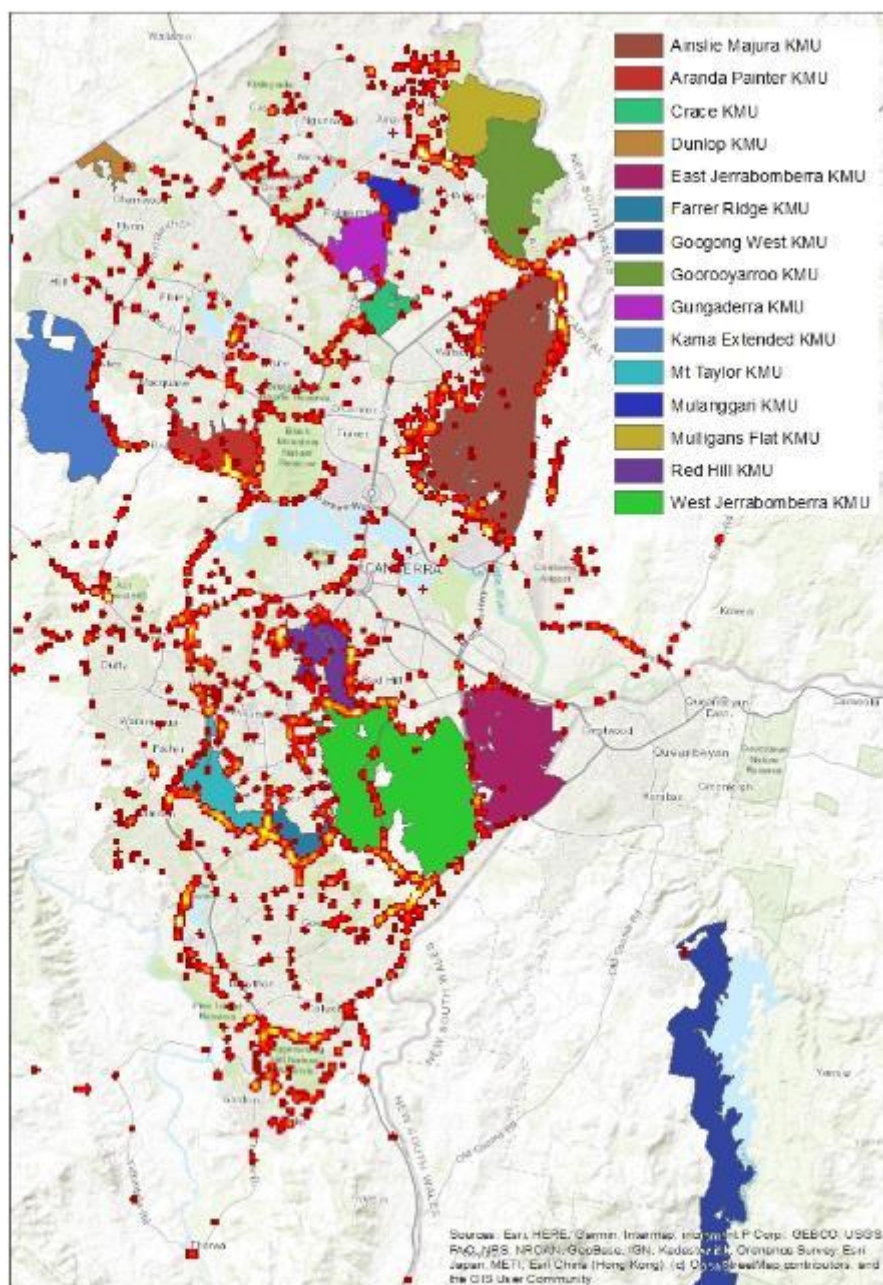


Figure 3. Kangaroo injuries or mortalities requiring attendance by the ACT Parks and Conservation Service on ACT roads between 1 July 2019 and 12 March 2020. Lighter colours indicate areas of with higher densities of incidents.

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) and have 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.

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 Weeder park care groups, in collaboration with the ACT Parks and Conservation Service, have invested significant effort over many years in mapping rabbit warrens, undertaking weeding and erosion control, and planting tube stock in an effort to re-establish structural complexity at this site. Temporary fencing has been installed in some areas to protect key habitat against overgrazing by high kangaroo numbers, and such actions may continue across the site in 2020. Rabbit control efforts will also continue at this site in 2020.

Culling advice

The results of the 2020 counts for the Ainslie Majura KMU are shown in Table 3. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 4. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating numbers to cull is shown in Figures 5 and 6, showing grass heights to be 'extremely low' in all but one management polygon which was classified as 'below threshold'. Based on these observations, continued conservation culling towards the target kangaroo density is recommended for Ainslie Majura KMU in 2020 (Table 5).

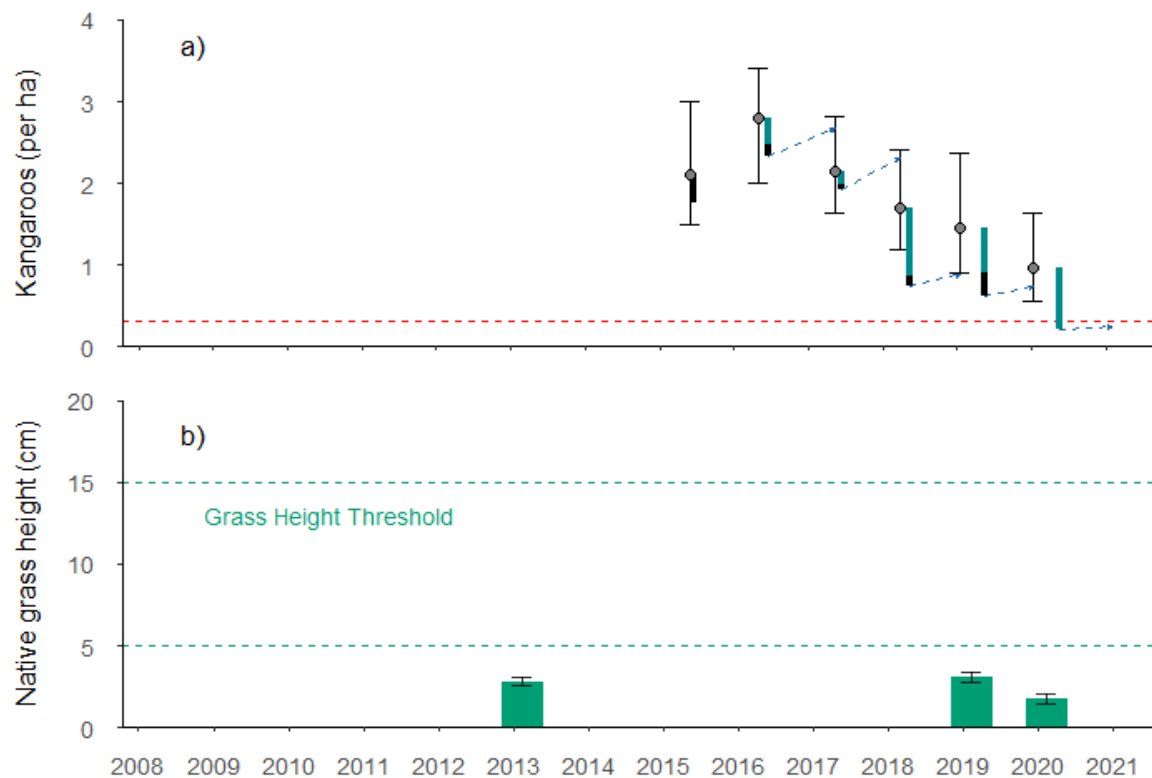


Figure 4. Changes in kangaroo density and ground level vegetation for Ainslie Majura KMU

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 other non-Government culling programs. The line shown for 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.

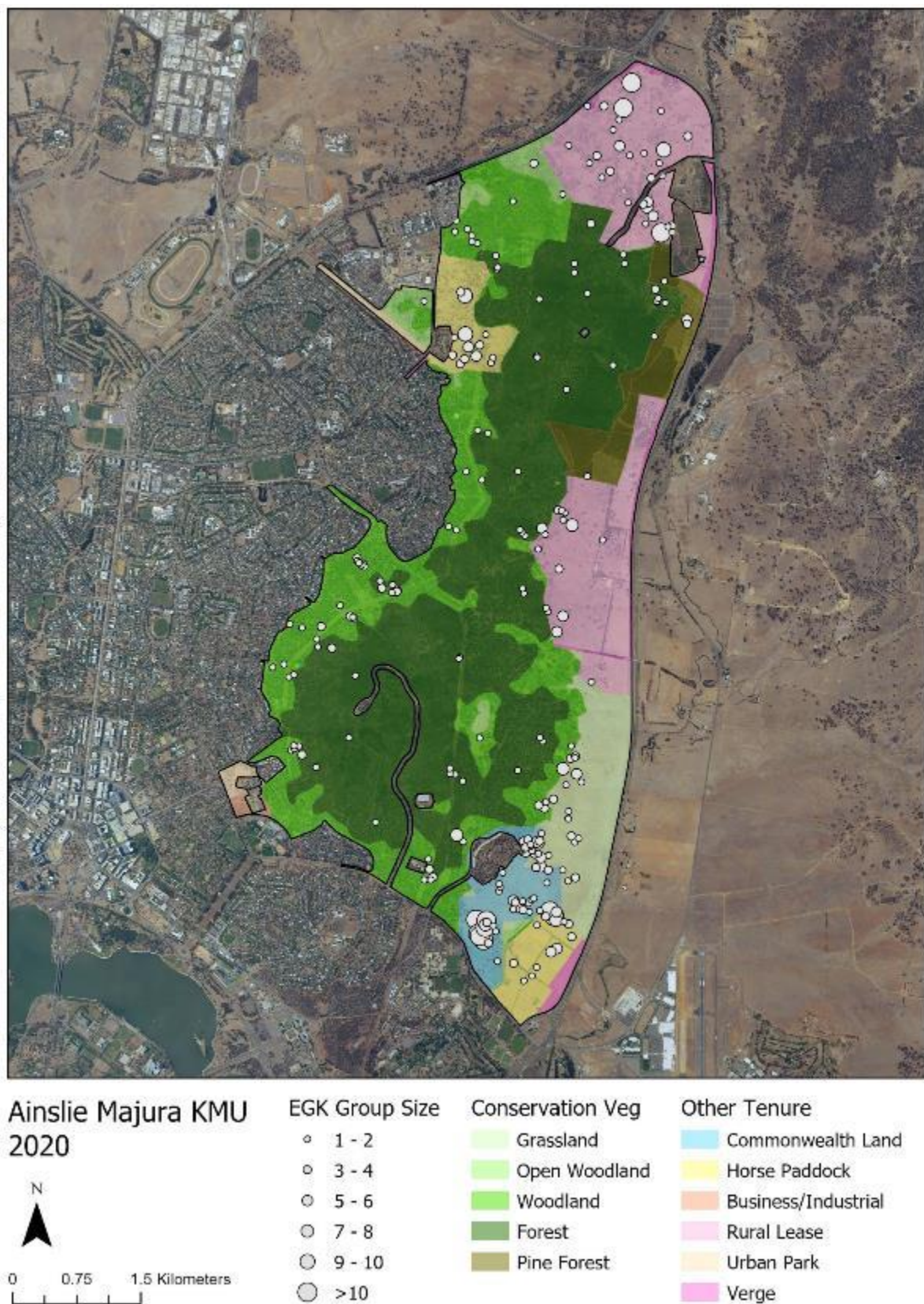


Figure 5. Map of Ainslie Majura KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.

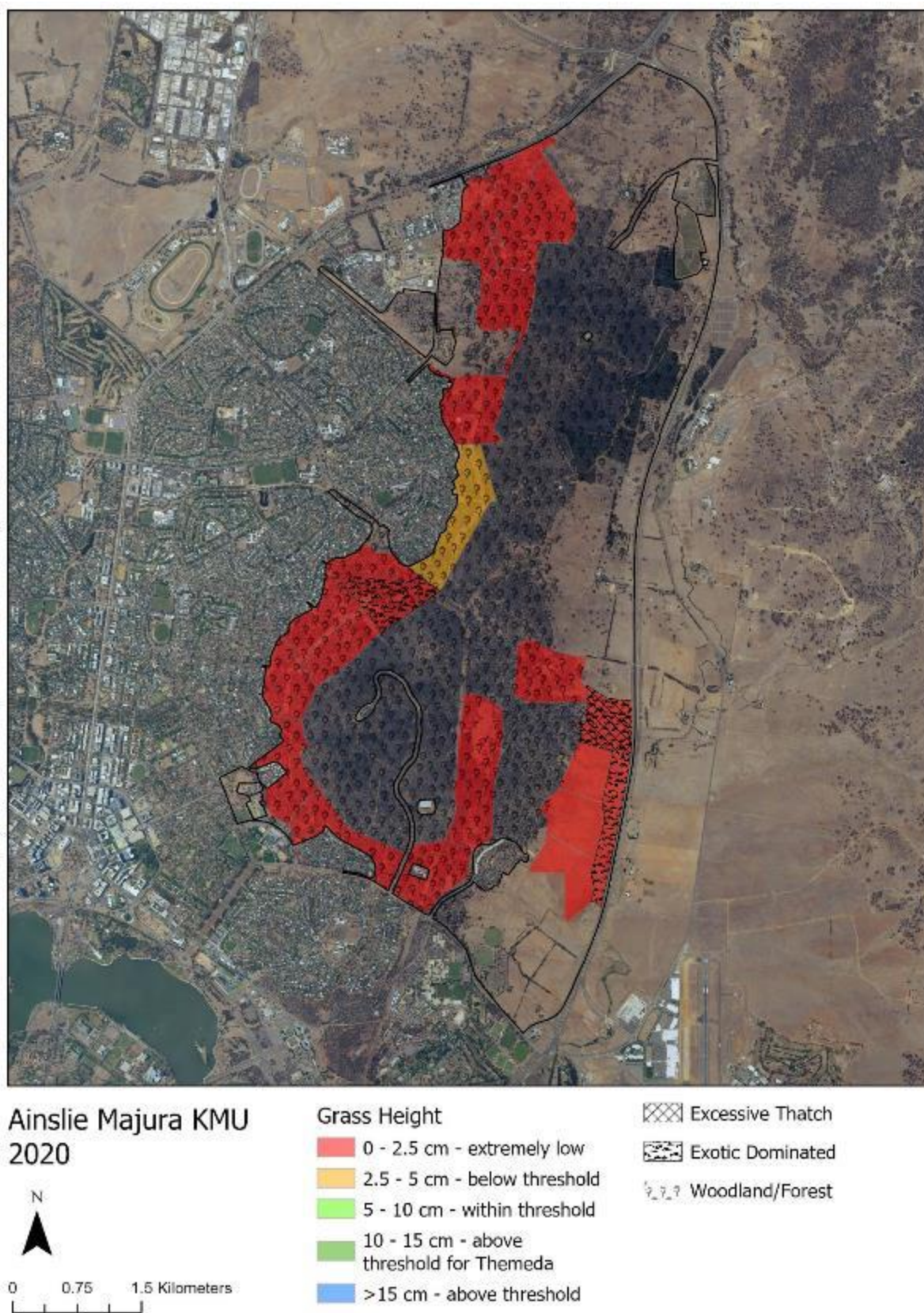


Figure 6. Map of Ainslie Majura KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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. Vegetation in and around Mt Painter Nature Reserve is predominantly open woodland and land 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 have previously been considered separately in terms of kangaroo management, but evidence of increased animal movement between these two areas in recent years (including high rates of kangaroo-vehicle collisions on Bindubi Street) have 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.

Kangaroo management has been undertaken within the former Mt Painter KMU since 2010, achieving a kangaroo density consistent with the conservation objectives of the site. However higher than anticipated kangaroo population growth rates were indicative of high levels of immigration and confounded management efforts, hence culling efforts should now focus on the Aranda Snow Gums component of this KMU.

Culling advice

The results of the 2020 counts for the Aranda Painter KMU are shown in Table 3. 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 numbers to cull is shown in Figures 8 and 9, showing areas of 'below threshold' grass heights in the open area around the Snowgums. Based on these observations, a conservation cull is recommended for Aranda Painter KMU in 2020, with a focus on the Aranda Snowgums component of the KMU (Table 5).

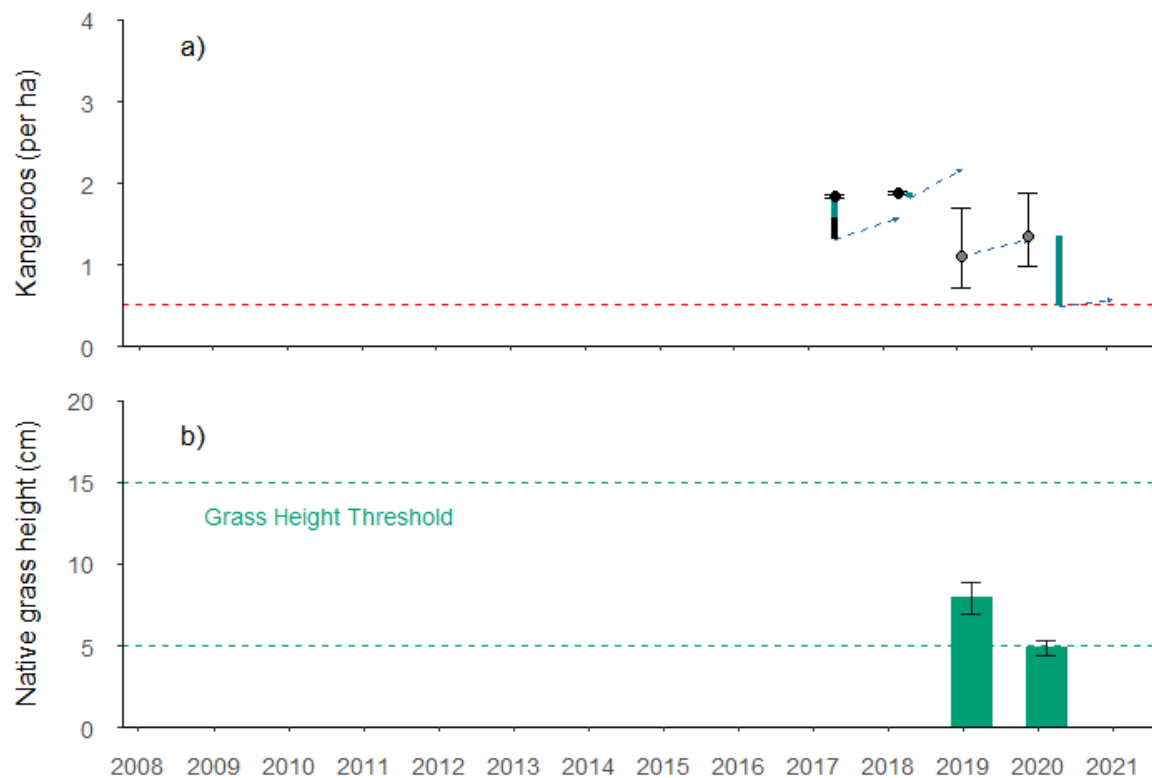


Figure 7. Changes in kangaroo density and average native grass height for Aranda Painter KMU.

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 and black bars representing other non-Government culling programs. The line shown for 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 in (b) indicates the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.

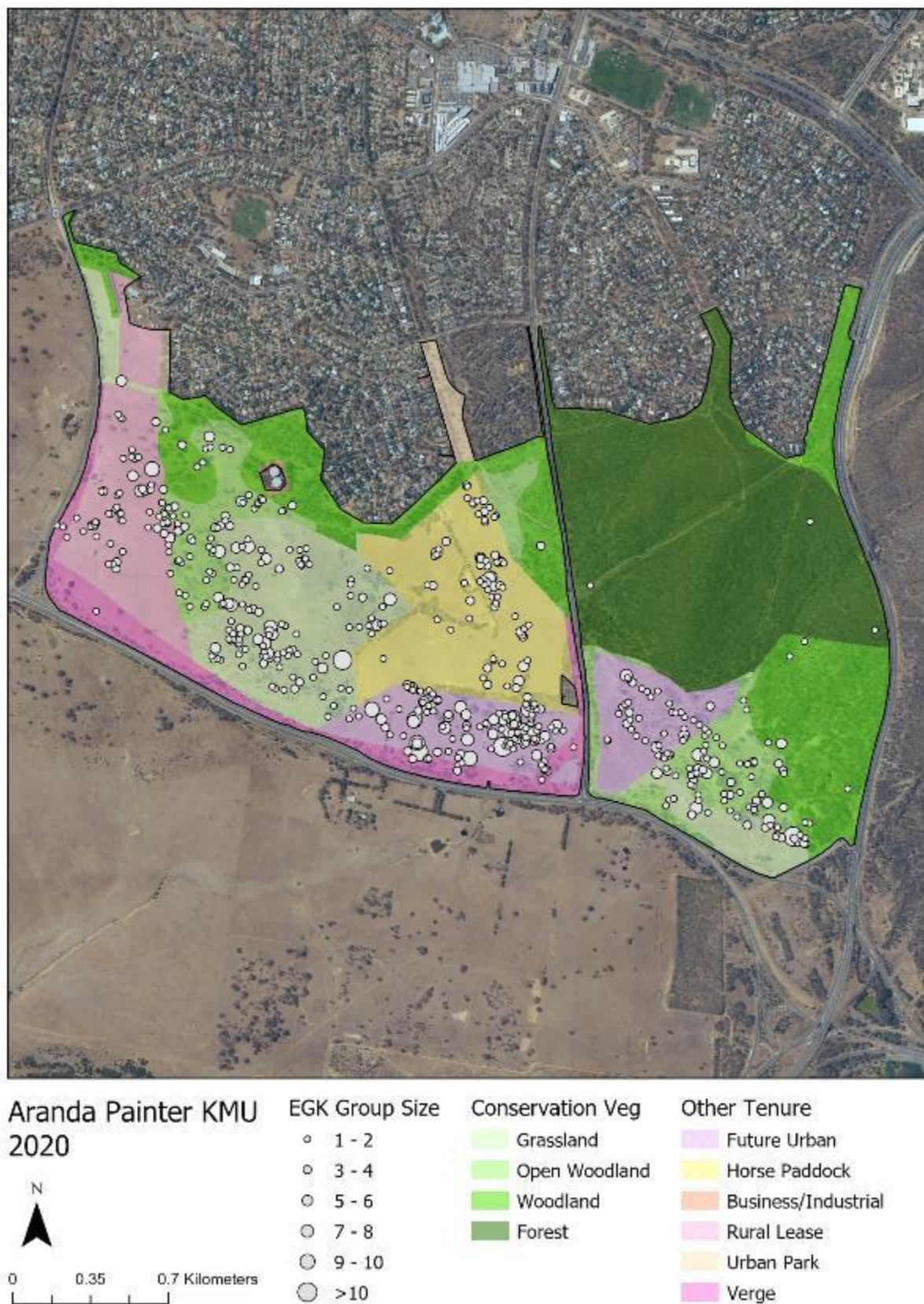


Figure 8. Map of Aranda Painter KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.

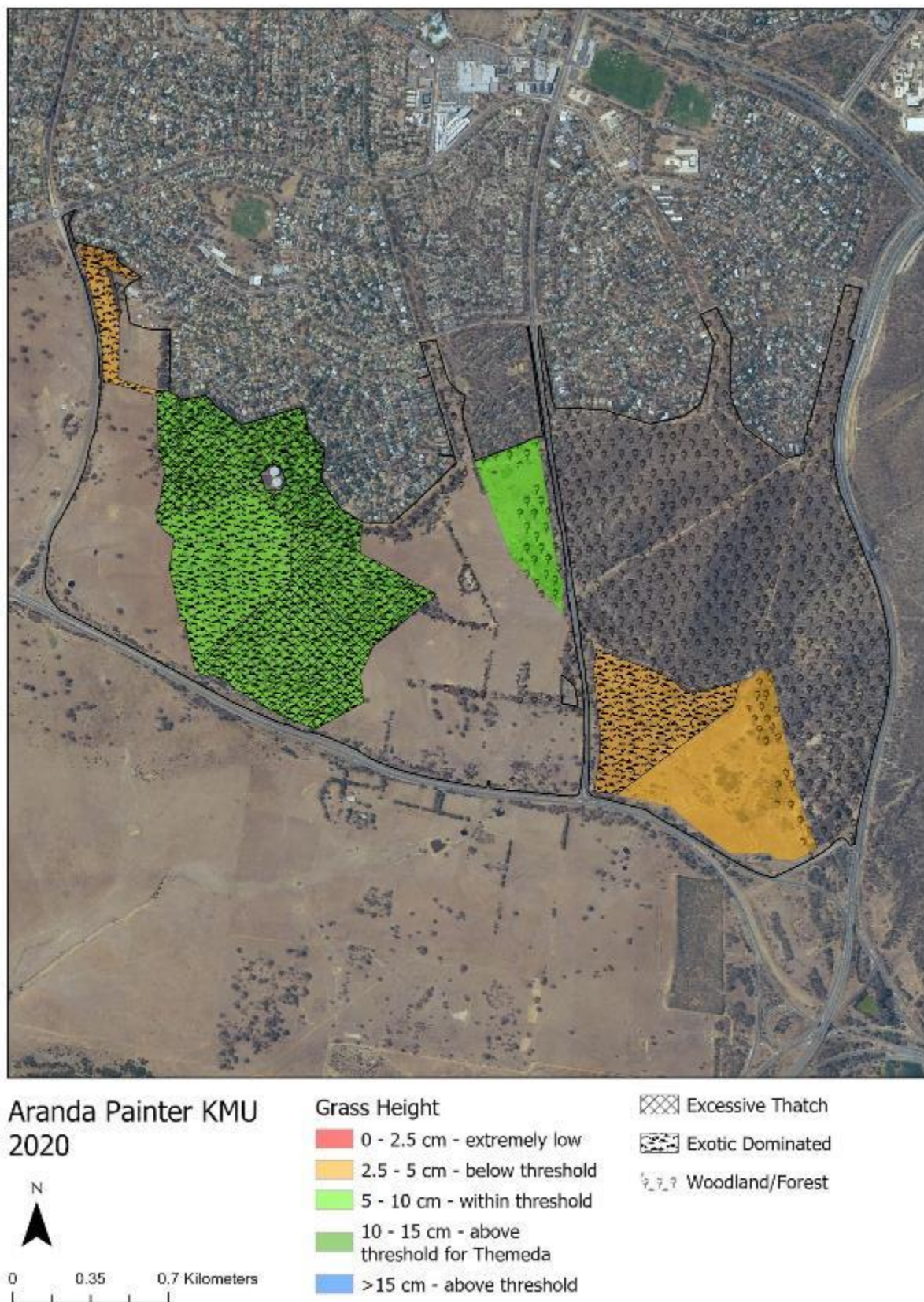


Figure 9. Map of Aranda Painter KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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. It is currently a research site for the Grasslands Restoration Project, and hence experimental use of complementary herbage mass management tools (e.g. fire, slashing and grazing by livestock) is likely to be ongoing dependent on herbage mass condition. The site also includes areas identified as asset protection zones, in which herbage mass is kept below a set fuel standard (often through livestock grazing) in order to manage the risk of wildfire to life and property.

For over a decade, kangaroo density has been effectively managed at this site to maintain a variable grassy layer structure. Reasonably low and consistent rates of population increase, combined with a resilient grassland structure, have enabled less frequent culls to consistently achieve conservation objectives at this site. Higher than anticipated growth rates of kangaroos in the last two years likely represent an increase in immigration rates from outside of the KMU as a result of dry conditions and a lack of resources in adjacent kangaroo habitat.

Culling advice

The 2020 count for Crace KMU is shown in Table 3. 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 numbers to cull is shown in Figures 11 and 12, showing a mix of polygons classified as 'extremely low', 'below threshold' and 'within threshold' in terms of grass height. Due to the impact of dry conditions during 2019, increased population growth rates and an overall reduction in the condition of the grassy layer, a conservation cull is recommended for Crace KMU in 2020 (Table 5).

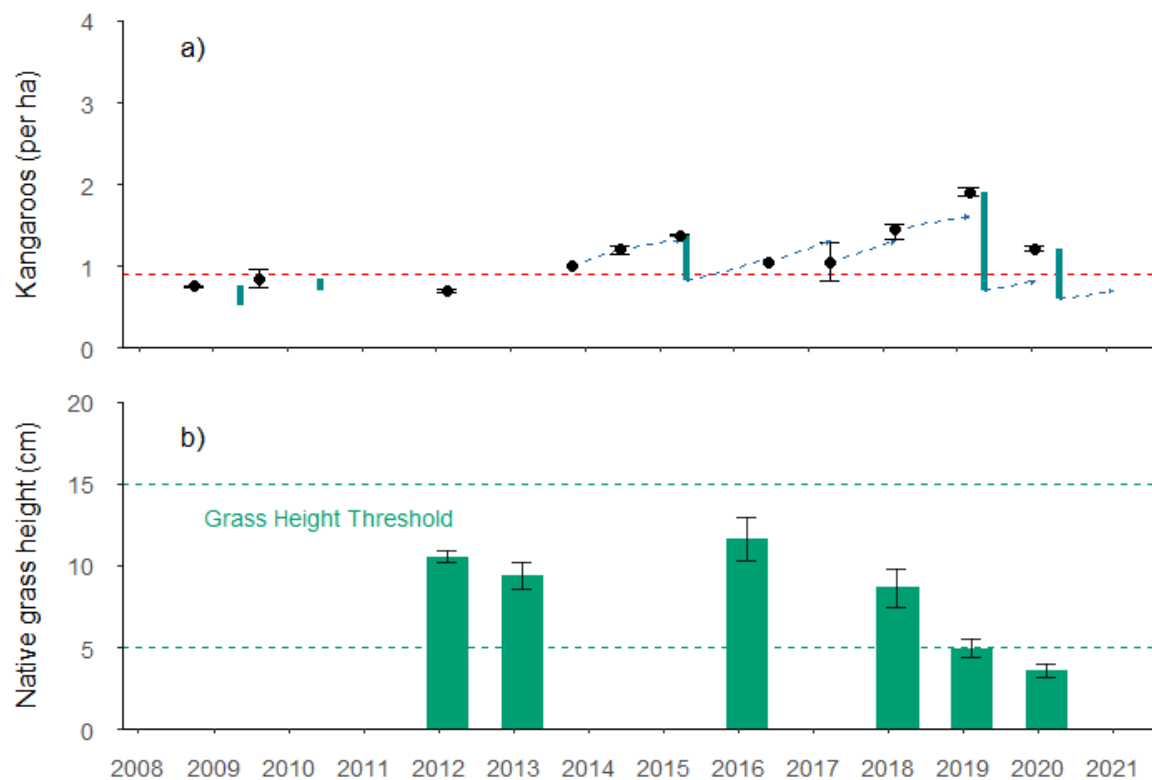


Figure 10. Changes in kangaroo density and average native grass height for Crace KMU.

a) Changes in kangaroo density Kangaroo density assessed via direct 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. The line shown for 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.



Crace KMU 2020

Conservation Veg

- Grassland
- Woodland
- Forest

Other Tenure

- Business/Industrial
- Public Land - Rural

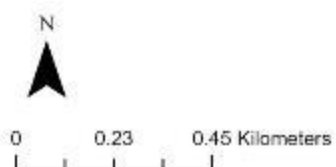


Figure 11. Map of Crace KMU showing canopy strata and land tenure.

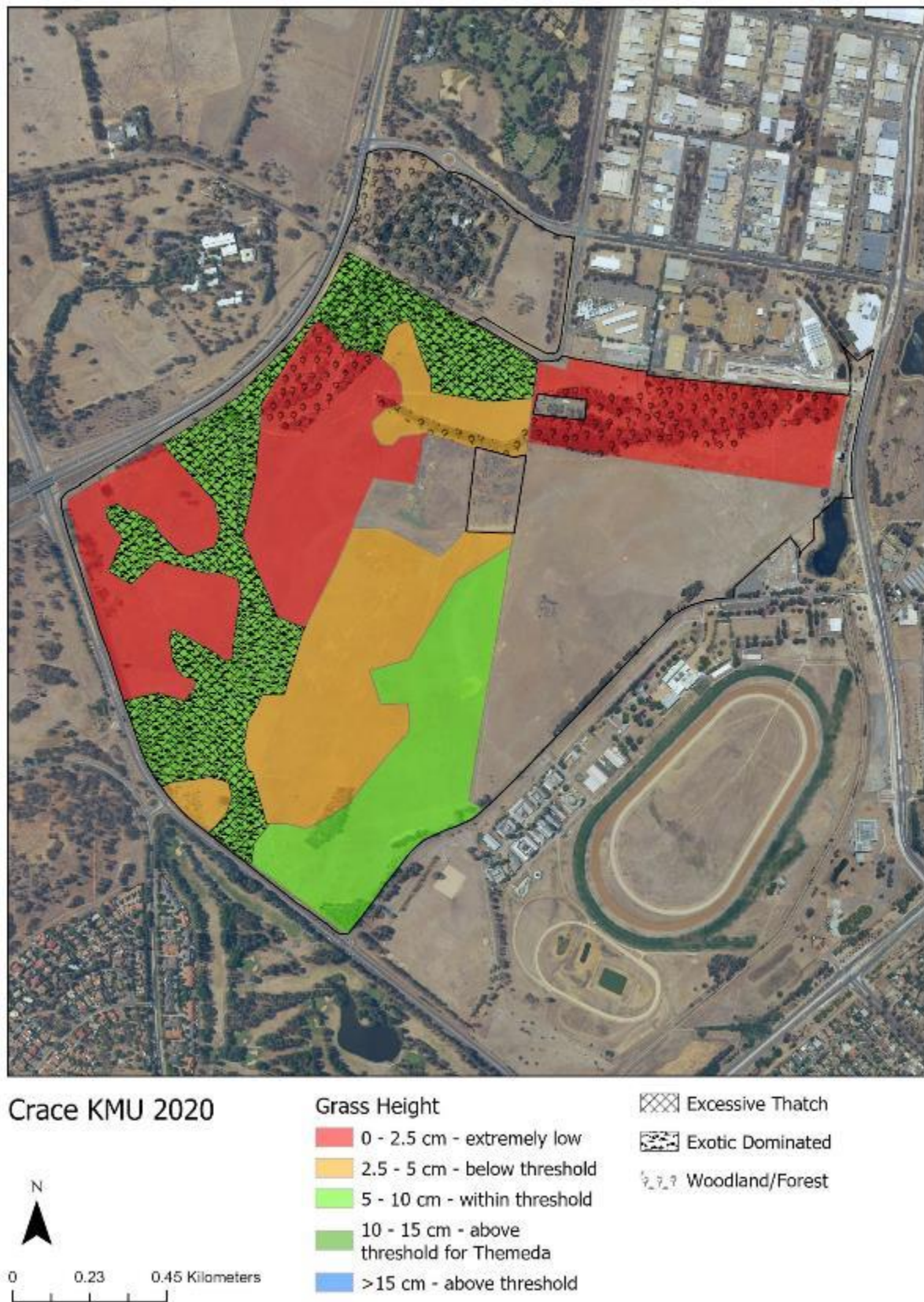


Figure 12. Map of Crace KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

DUNLOP KMU

Background

Dunlop KMU is located in the 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 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. It is currently a research site for the Grasslands Restoration Project, and hence experimental use of complementary herbage mass management tools (e.g. fire, slashing and grazing by livestock) is likely to be ongoing dependent on herbage mass condition.

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. As kangaroo numbers have now been above the target density for three consecutive years, with declines evident in the average grass height across this site, the ongoing use of sheep grazing to maintain ecological condition will need to be monitored closely.

Culling advice

The results of the 2020 count for the Dunlop KMU are shown in Table 3. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 13. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating numbers to cull is shown in Figures 14 and 15, showing the majority of polygons to be 'within threshold' for grass heights with one 'below threshold' exception. 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 5) – although kangaroo density is above the target number and the impacts of total grazing pressure (including the ongoing requirement for sheep grazing) should continue to be monitored closely.

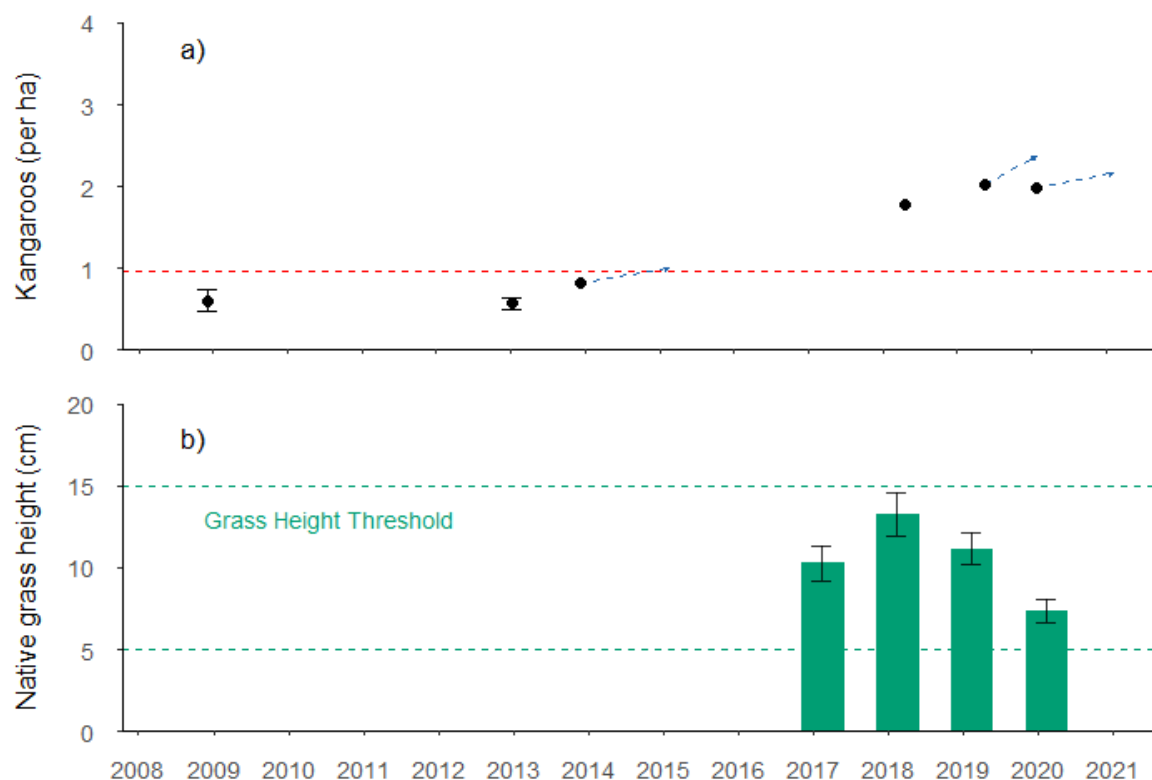


Figure 13. Changes in kangaroo density and average native grass height for Dunlop KMU.

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. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.



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

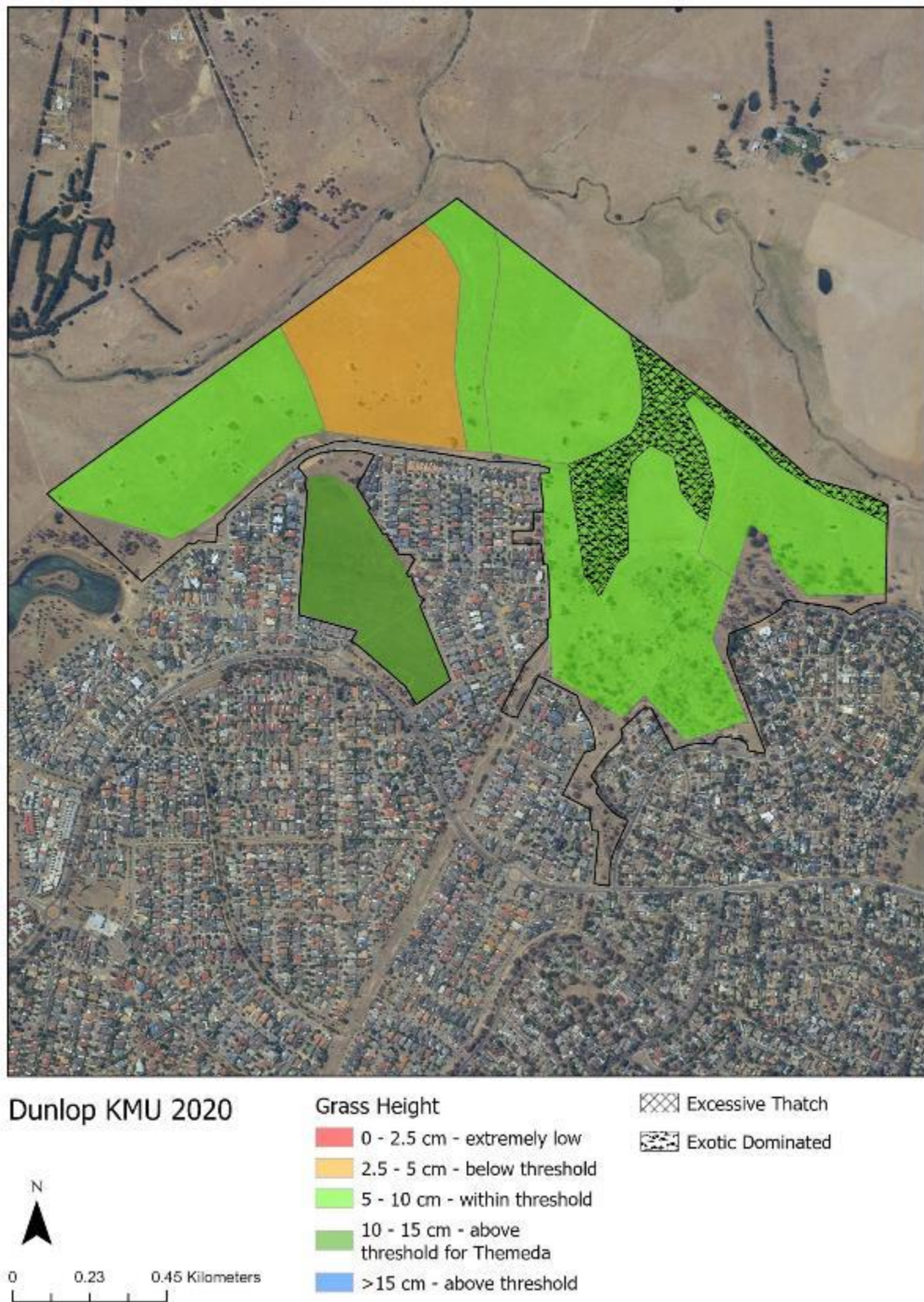


Figure 15. Map of Dunlop KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

EAST JERRABOMBERRA KMU

Background

The Jerrabomberra East KMU is in the east of the ACT, bordered by the Monaro Highway to the south-west, Lanyon Drive to the south-east, and Canberra Avenue and Hindmarsh Drive to the north. To the east, the site is contiguous with the Queanbeyan Nature Reserve (in NSW), which shares a population of kangaroos which readily move across the border. The KMU is almost exclusively grassland, and includes the Bonshaw environmental offset, rural leases and horse paddocks. The density of kangaroos at this site in 2014 (6.98 kangaroos ha⁻¹) is the highest ever recorded in Australia, and has been associated with decline in grassy layer condition at this site since 2012.

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 Peppercreep. Temporary fencing has been installed within Jerrabomberra East Grasslands to protect critical habitat areas, whilst the permanent kangaroo enclosure would require significant maintenance to be effective in this regard. The site is also a research site for the Grasslands Restoration Project, and hence experimental use of complementary herbage mass management tools (e.g. fire, slashing, placement of surface rock) is likely to be ongoing dependent on herbage mass condition. Management interventions, particularly the use of fire to promote green pick, is being used to encourage grazing by kangaroos on the adjacent Bonshaw environmental offset.

To date, the majority of kangaroos continue to use the East Jerrabomberra Grassland component of the broader KMU, although increasing numbers of kangaroos are now observed in Bonshaw. As population estimates continue to be comparable between sweep counts at Jerrabomberra East Nature Reserve and the KMU more broadly, culling advice continues to be focused on managing impacts at the Jerrabomberra East Nature Reserve only.

Significant levels of immigration over multiple years from outside of the broader KMU have hampered efforts to reduce kangaroo numbers to the desired level to date. As such, installation of a barrier fence is a prerequisite to further attempts to manage kangaroos by culling at this site. The predicted population growth rate has also been set at 60% for this KMU for the 2020-21 management period, reflecting the likely movement of animals outside of the Nature Reserve (but within the broader KMU) into the main area of conservation concern.

Culling advice

The results of the 2020 counts in the Jerrabomberra East KMU and the Jerrabomberra East Nature Reserve are shown in Table 3. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 16. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating numbers to cull is shown in Figures 17 and 18, showing all polygons to be either 'extremely low' or 'below threshold' in terms of grass height. Due to the highly significant conservation values present at this site and declining grassy layer condition, a conservation cull is recommended for the Jerrabomberra East KMU in 2020 (Table 5). Installation of a barrier fence to limit ongoing immigration is considered prerequisite to further attempts to manage kangaroos by culling at this site.

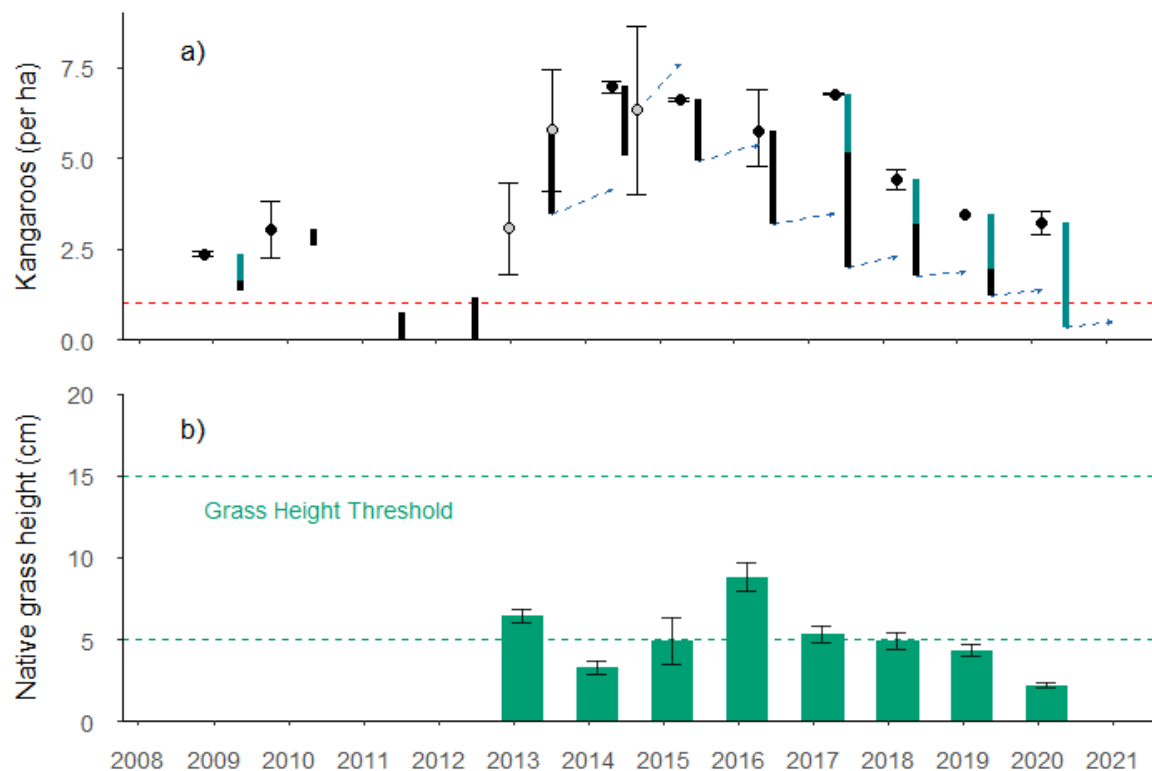


Figure 16. Changes in kangaroo density and average native grass height for East Jerrabomberra KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the pellet count (\circ) or walked line transect count (\bullet) methods were used. Sweep counts (\bullet) 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 other non-Government culling programs. The line shown for 2020 is the recommended cull density only. 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 dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.

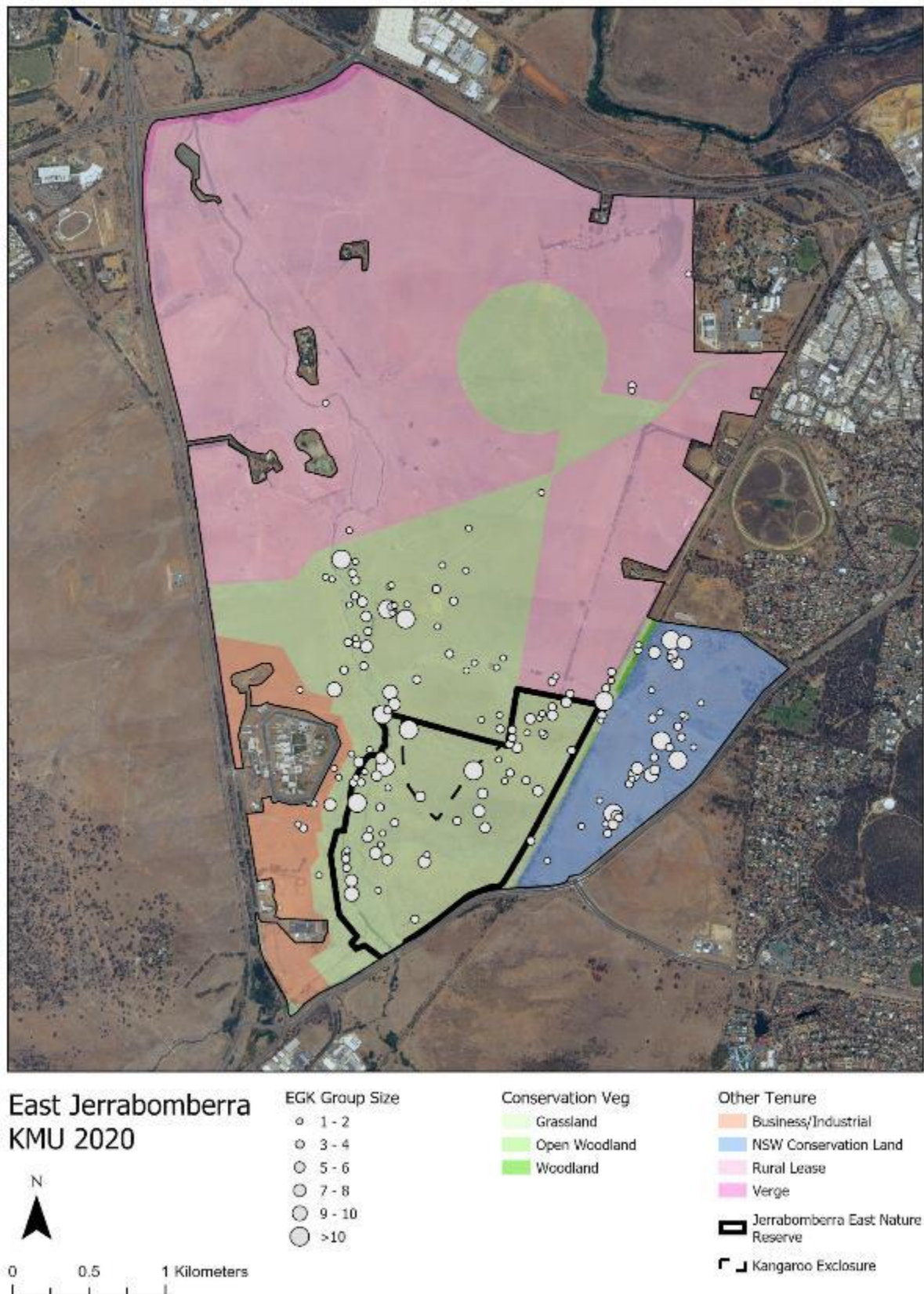


Figure 17. Map of East Jerrabomberra KMU (and Jerrabomberra East Nature Reserve), showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.

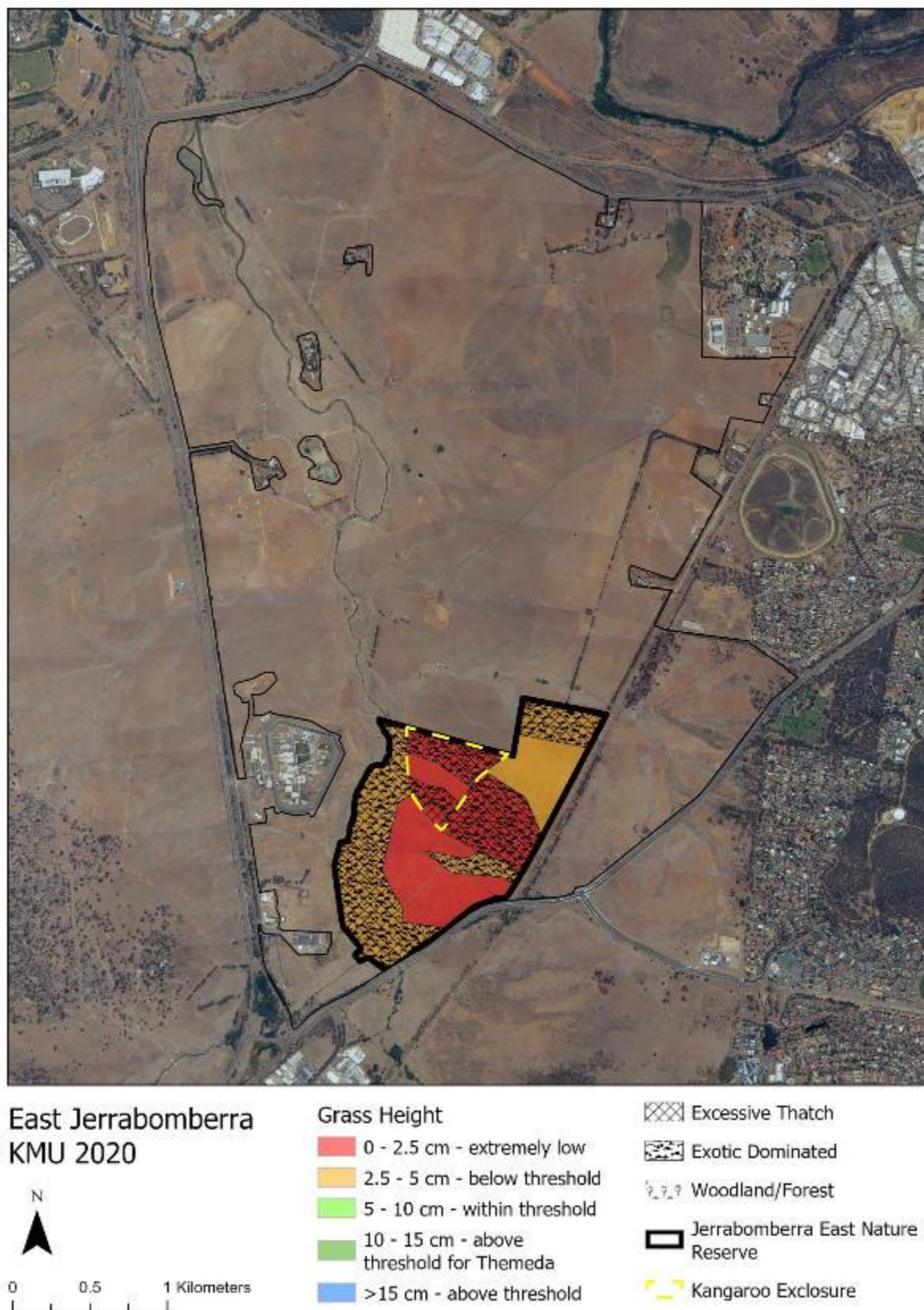


Figure 18. Map of East Jerrabomberra KMU (and Jerrabomberra East Nature Reserve therein), showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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.

Kangaroo management has not been undertaken previously within this KMU, and its population has remained well above target densities for conservation. The very low herbage mass conditions at this reserve indicate that the kangaroo population is likely limited by food, in addition to road-based mortality.

Culling advice

The results of the 2020 counts for the Farrer Ridge KMU are shown in Table 3. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 19. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating numbers to cull is shown in Figures 20 and 21, showing all polygons to be classified as 'extremely low' or 'below threshold' in term of grass height. Subject to prioritisation considerations and operational factors, a conservation cull is considered necessary in the Farrer Ridge KMU (Table 5) to enable restoration of the grassy layer.

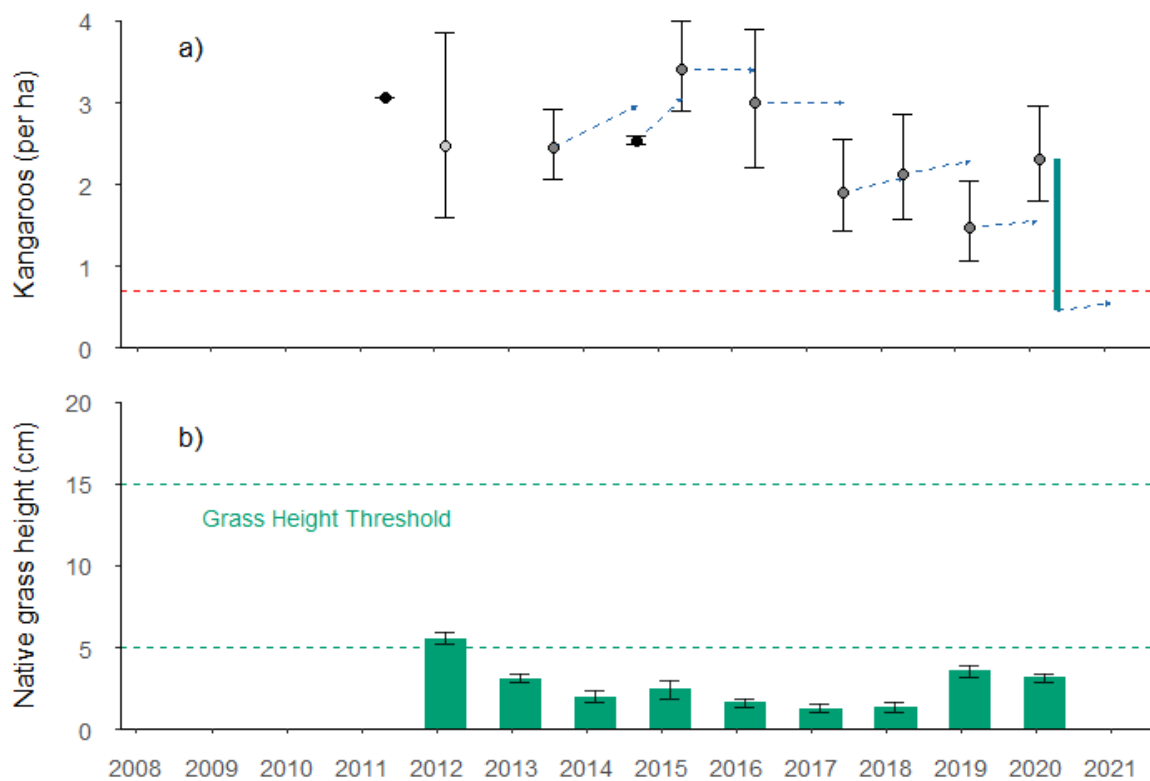


Figure 19. Changes in kangaroo density and average native grass height for Farrer Ridge KMU.

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. 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 2020 is indicated by the green vertical line. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.



Figure 20. Map of Farrer Ridge KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.

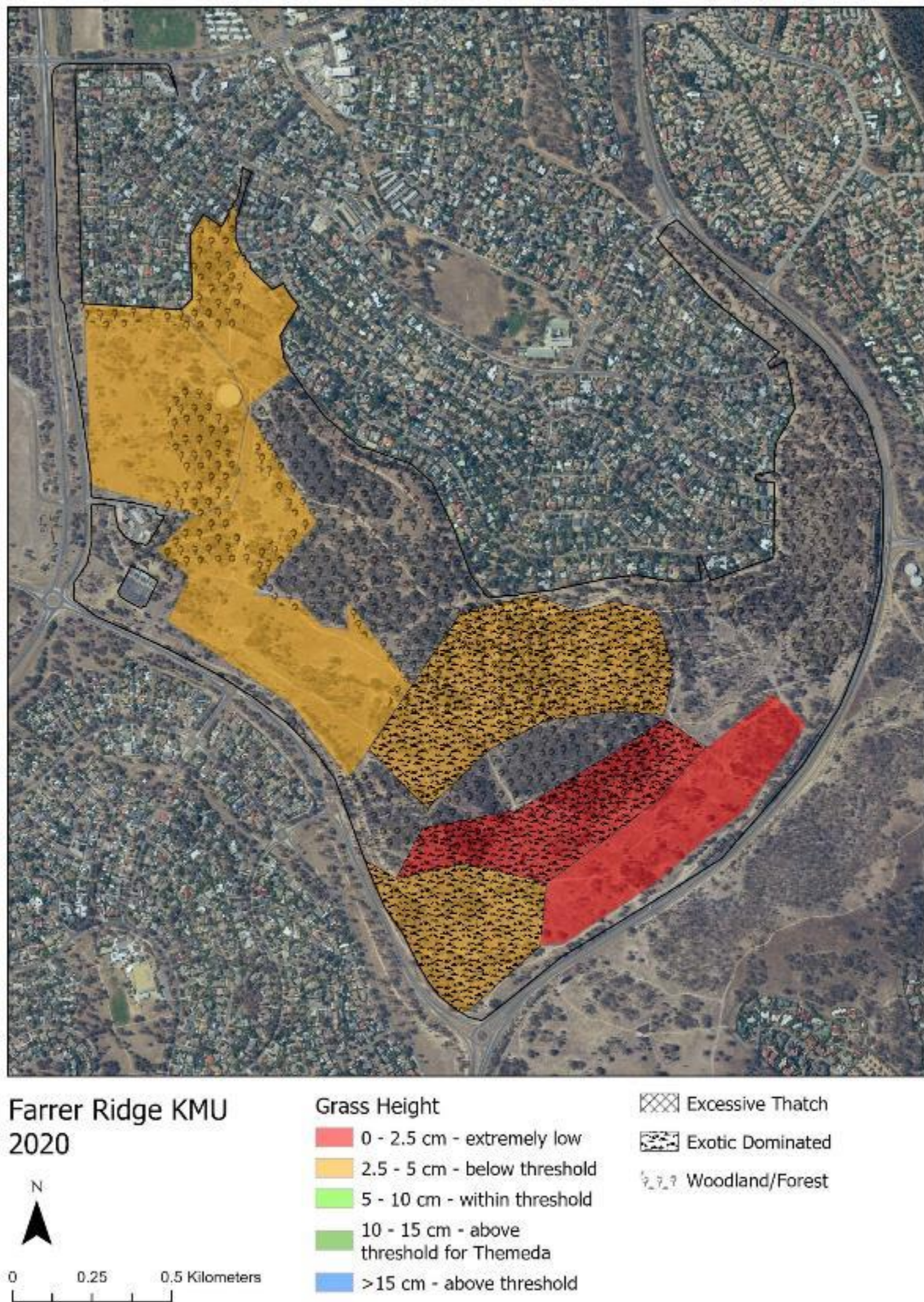


Figure 21. Map of Farrer Ridge KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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 has the potential to be very high, given the KMU is adjoining rural lease on all sides which provide continuous kangaroo habitat, however studies involving fitting kangaroos with tracking collars at this site (ACT Government, unpublished) have shown individuals 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).

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 recent development for the Googong township, areas adjoining Googong Nature Reserve are undergoing 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.

Conservation culls have been undertaken within the Googong KMU for the past three years as part of a staged, multi-year approach to reducing the kangaroo population to the target conservation density. Management efforts to date have been effective in reducing kangaroo density to the long-term conservation target, and in enabling some early restoration of the grassy layer. Increases in population growth rates, likely resulting from the improved condition of the grassy layer at this site encouraging higher immigration, have prompted the population growth rate to be set at 60% for the 2020-21 management period based on recent observations.

Culling advice

The results of the 2020 count at Googong West KMU are shown in Table 3. 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 numbers to cull is shown in Figures 23 and 24, showing polygons with a mix of 'extremely low', 'below threshold' and 'within threshold' grass heights across this site. Due to the impact of dry conditions during 2019 and increased population growth rates, a conservation cull is recommended at Googong KMU in 2020 to maintain target densities of kangaroos at this site (Table 5).

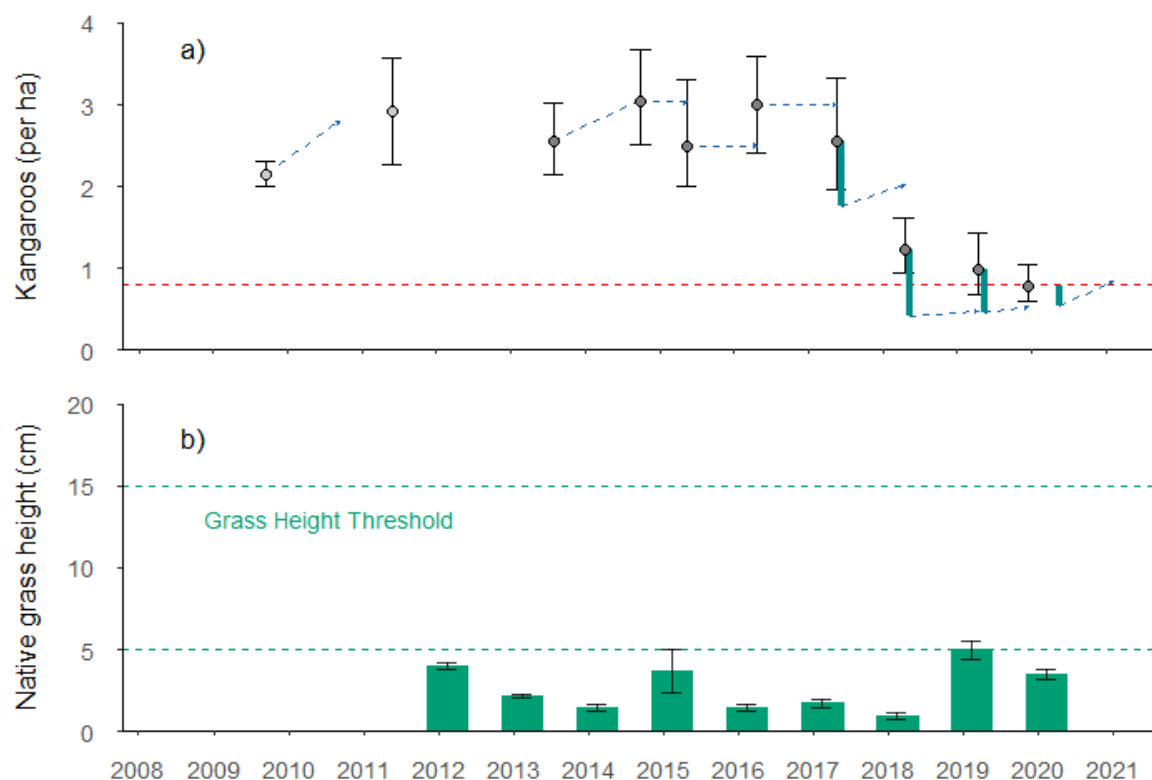


Figure 22. Changes in kangaroo density and average native grass height for Googong West KMU.

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 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.

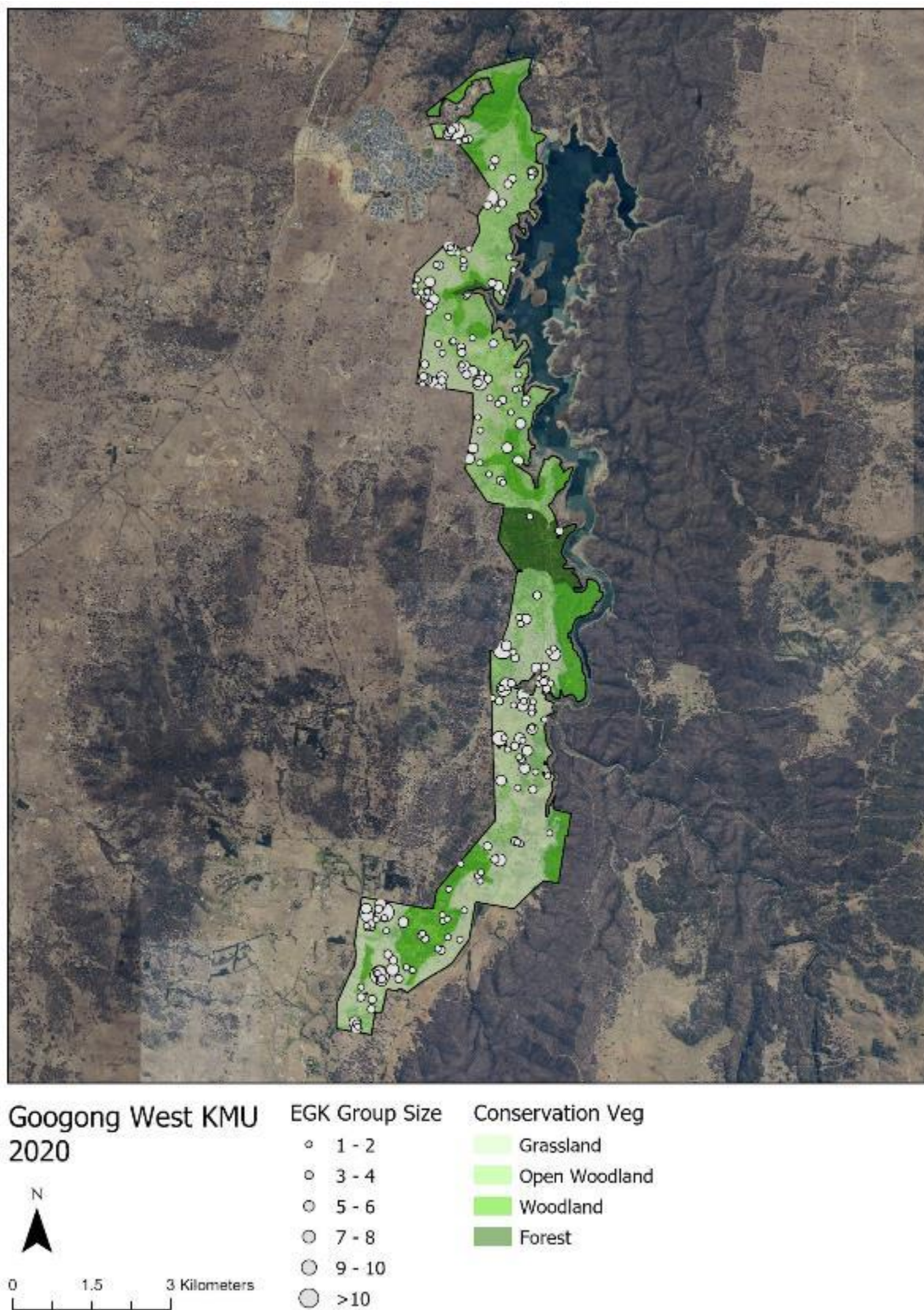


Figure 23. Map of Googong West KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.

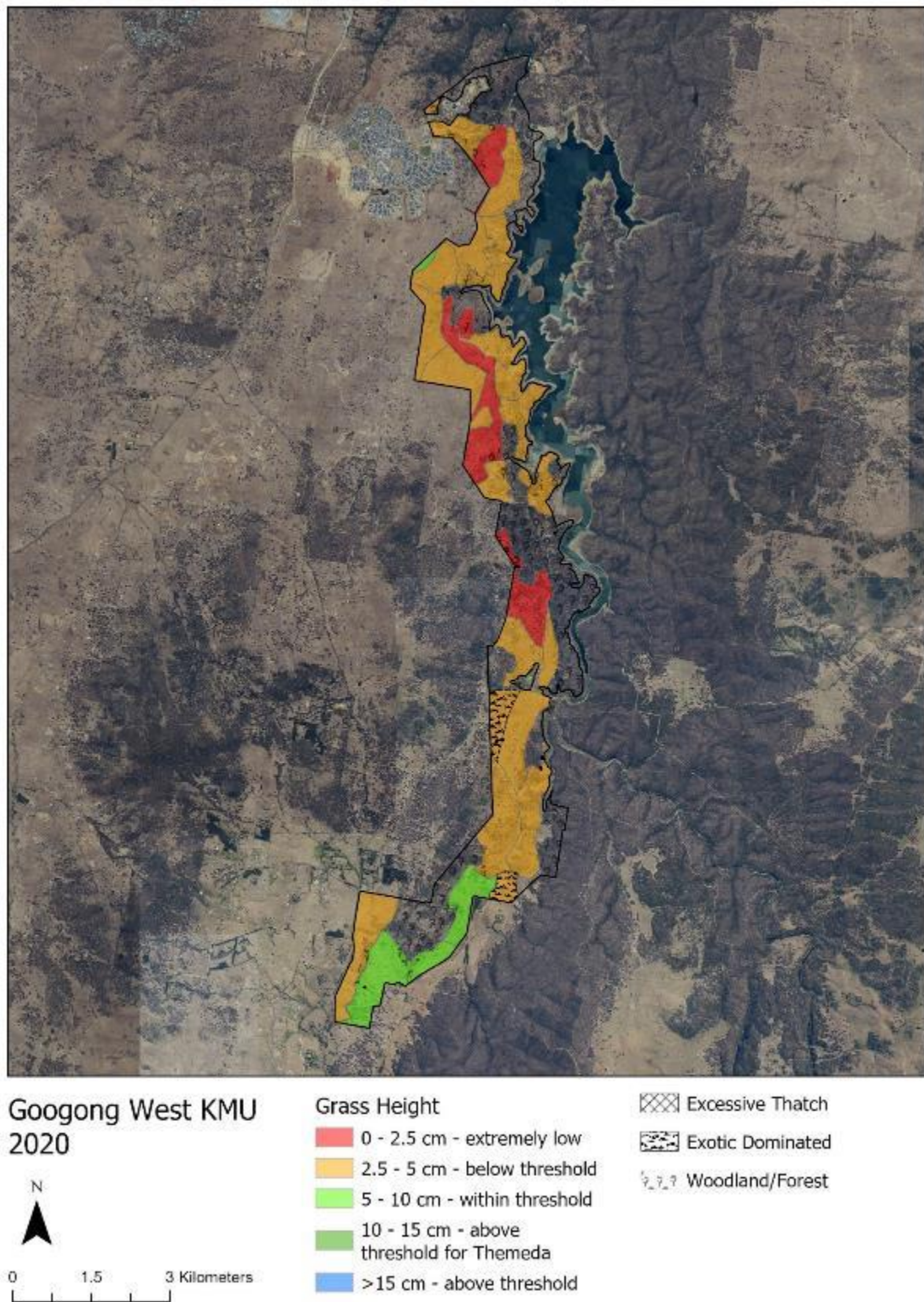


Figure 24. Map of Googong West KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

GOOROoyARROO KMU

Background

Goorooyarroo Sanctuary 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. As of early 2019, the KMU has been fully enclosed by a predator (and kangaroo) proof fence and hence immigration and natural mortality are likely to be negligible going forward resulting in high population growth rates.

Site specific considerations

Goorooyarroo Sanctuary 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 – Goorooyarroo Woodland Experiment, although experimental kangaroo exclosure fences were not maintained during the construction of the predator proof fence and so will require repair in 2020. A rabbit eradication program is underway, with very low numbers of rabbits likely remaining within the Sanctuary. Livestock grazing (cattle) will likely continue to be used in areas of Throsby where required to meet grassy layer objectives set out under the Environmental Offsets Management Plan, particularly in areas dominated by exotic grasses which are not palatable to kangaroos. However, kangaroos will continue to be the preferred grazer in this system. Slashing and ecological or cultural burns may also be employed within the Sanctuary as required.

Kangaroo density has been managed within the Goorooyarroo KMU since 2010. High population growth rates observed in the past were likely due to high immigration from adjoining habitat in NSW. With the completion of the Sanctuary fence in 2019, high population growth rates of up to 60% are likely due to reduced rates of mortality, especially once feral predators are removed.

Culling advice

The results of the 2020 count at Goorooyarroo KMU are shown in Table 3. 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 numbers to cull is shown in Figures 26 and 27, showing predominantly a mix of 'extremely low' and 'below threshold' grass heights across most of the original reserve but predominantly 'within threshold' grass heights, and one 'above threshold' polygon, across the areas managed as Environmental Offsets. To increase the proportion of the Sanctuary which falls within grass height thresholds associated with maximum biodiversity benefits, conservation culling is recommended for Goorooyarroo KMU in 2020 (Table 5), with particular effort being made to reduce the density of kangaroos within the experimental kangaroo exclosures.

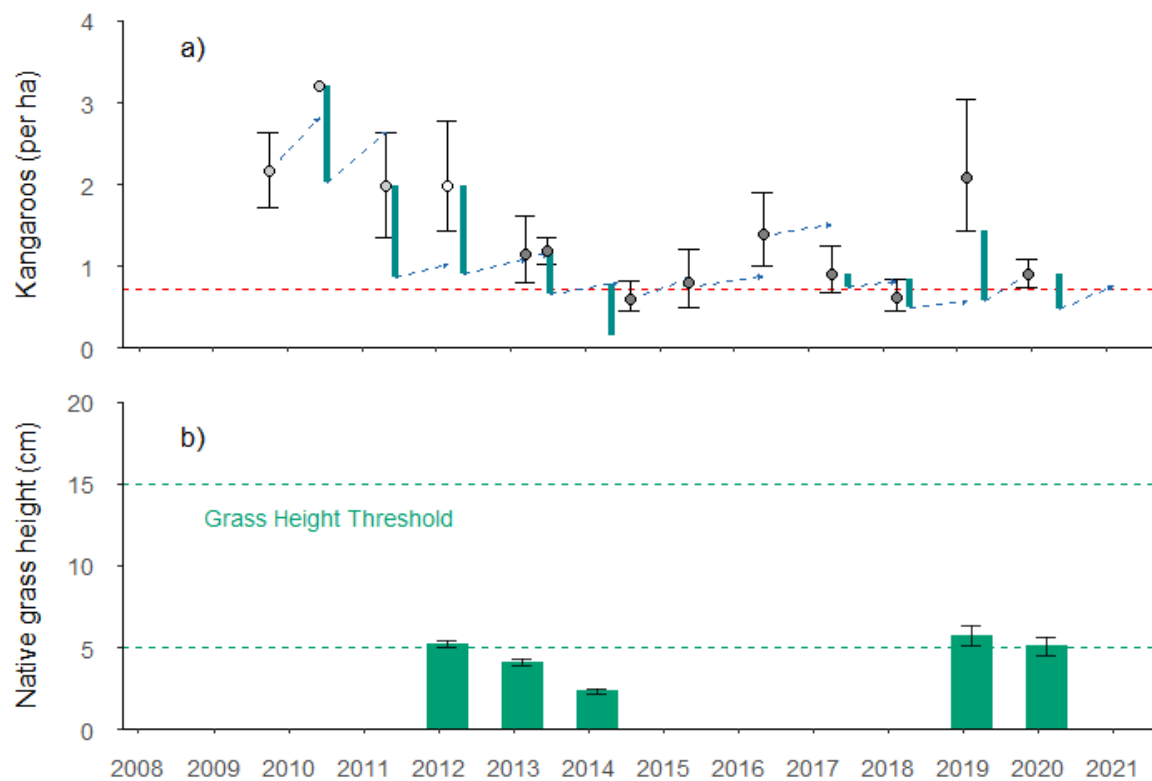


Figure 25. Changes in kangaroo density and average native grass height for Goorooyarroo KMU.

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 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.



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

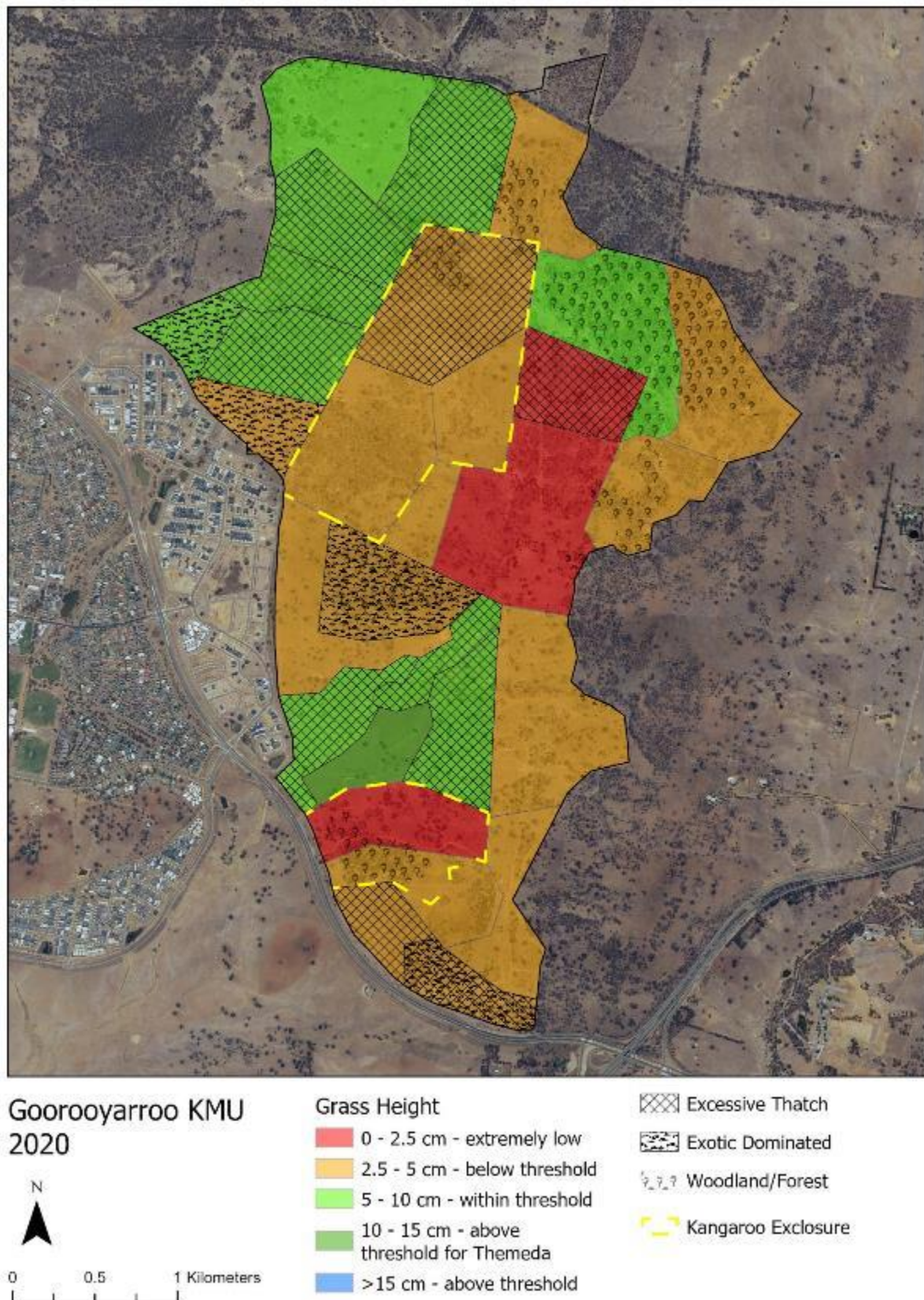


Figure 27. Map of Goorooyarroo KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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. It is also a research site for the Grasslands Restoration Project, and hence experimental use of complementary herbage mass management tools (e.g. fire, slashing and grazing by livestock) is likely to be ongoing, dependent on herbage mass condition. 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.

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. Little management has been required since, however a significant increase in population density between 2018 and 2019 counts prompted a conservation cull to be undertaken in 2019.

Culling advice

The results of the 2020 count at Gungaderra KMU are shown in Table 3. 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 numbers to cull is shown in Figures 29 and 30, showing polygons with a mix of 'below threshold' and 'within threshold' grass heights across this site. The exotic dominated polygon encompassing the swampy area of this KMU remains in an 'above threshold' state. To maintain appropriate grassy layer condition at this site, a conservation cull is recommended for the Gungaderra KMU in 2020 (Table 5).

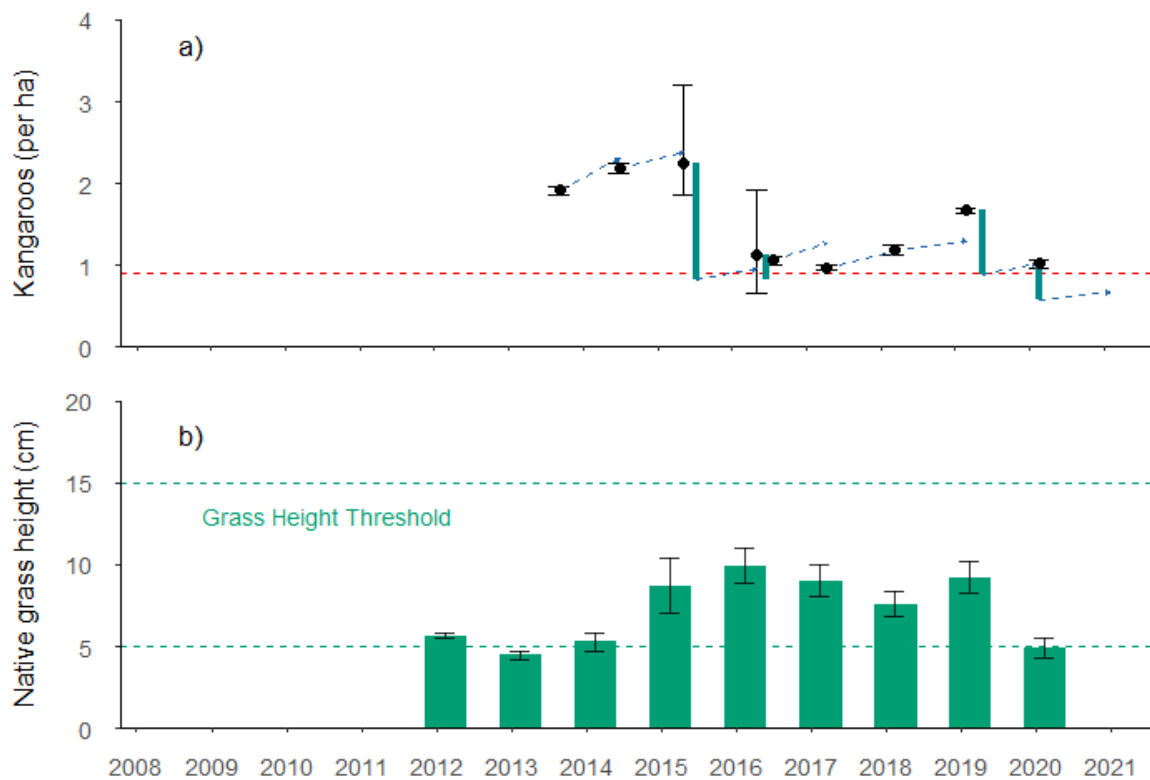


Figure 28. Changes in kangaroo density and average native grass height for Gungaderra KMU.

a) Changes in kangaroo density Kangaroo density from sweep counts (●) are depicted as the mean \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 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.



Figure 29. Map of Gungaderra KMU showing canopy strata and land tenure.

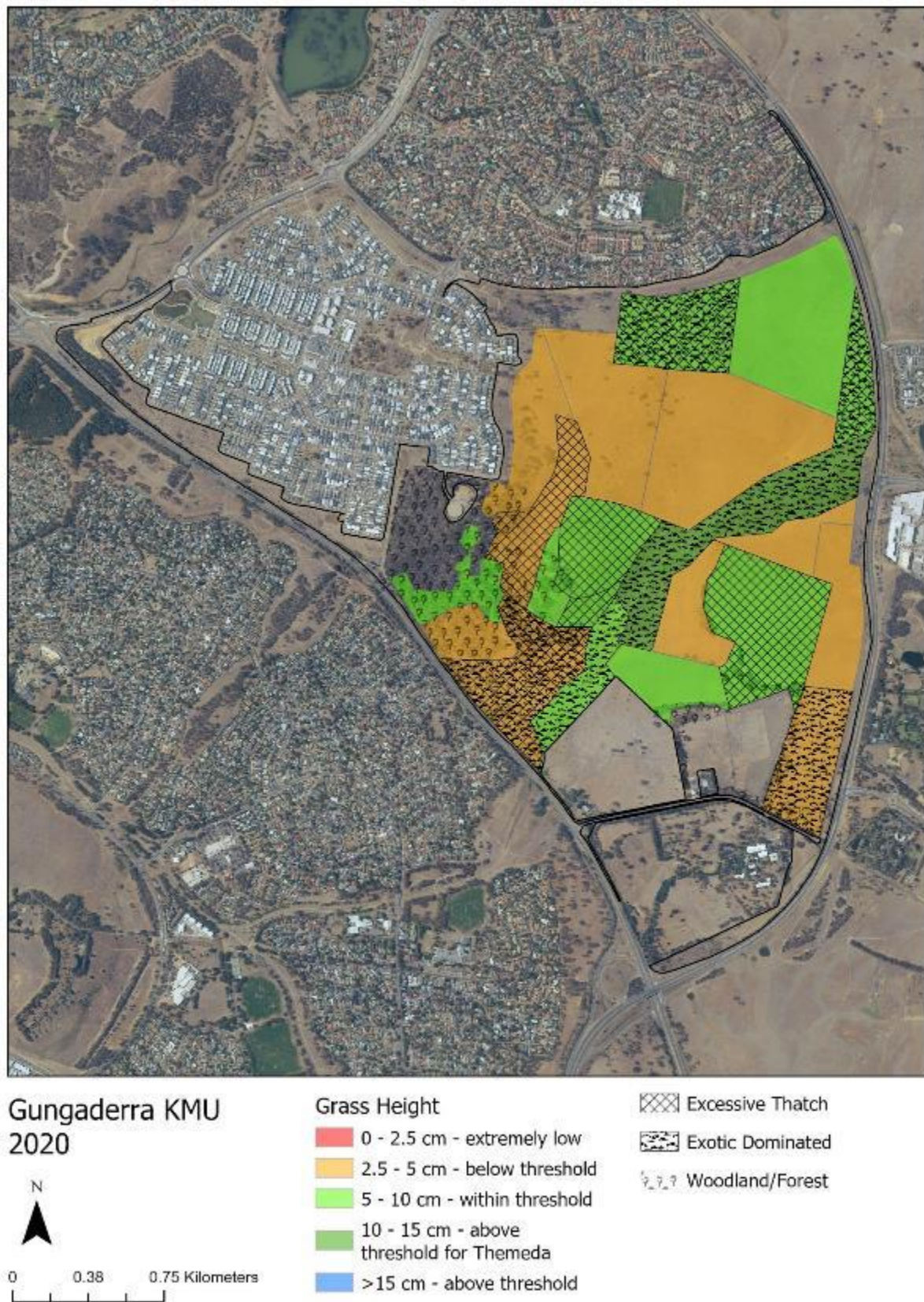


Figure 30. Map of Gungaderra KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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 Nature Reserve and a 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. A reasonably low kangaroo density throughout this landscape has traditionally prevented significant fluctuations in population size due to immigration, despite the KMU having no effective boundary to kangaroo movement to the west. The boundary of this KMU was modified in 2020 to reflect land use changes in this landscape.

Site specific considerations

The Kama Nature Reserve 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, and ecological burns has been undertaken, and the area is also a research site for the Grasslands Restoration Project. Strategic livestock grazing is undertaken in areas dominated by exotic grasses in the north of Kama Nature Reserve as part of the management of weeds and fire fuel loads. Fallow deer monitoring and control forms part of the management of total grazing pressure within this landscape.

Kangaroos have been managed at this site since 2009 to protect the largely *Themeda* (kangaroo grass) dominated grassy layer within Kama Nature Reserve. Since 2012, the population density within Kama Extended KMU has remained stable at a level consistent with achieving conservation objectives, and thus monitoring and management 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, there is a possibility of increases in kangaroo population density across the landscape which will require careful monitoring and a potential increase in management effort by ACT Government to protect biodiversity values in coming years.

Culling advice

The results of the 2020 counts for the Kama Extended KMU are shown in Table 3. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 31. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating numbers to cull is shown in Figures 32 and 33, showing that polygons are predominantly 'within threshold' grass heights across this site with one 'below threshold' exception. Based on current kangaroo density within this KMU, no conservation cull is recommended for Kama Extended KMU in 2020 (Table 5).

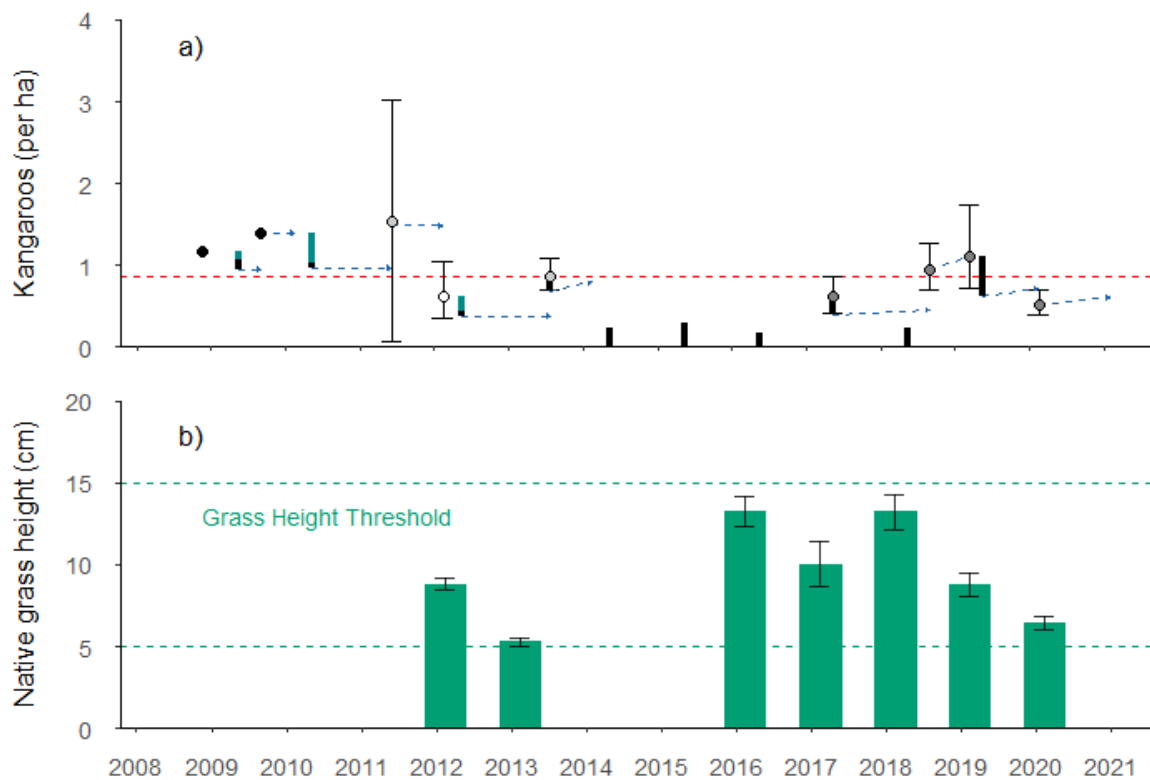


Figure 31. Changes in kangaroo density and average native grass height for Kama Extended KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the pellet count (\odot), walked line transect count (\bullet) or driven line transect count (\circ) methods were used. Total counts (either direct or sweep counts, \bullet) 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 other non-Government culling programs. 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 dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.

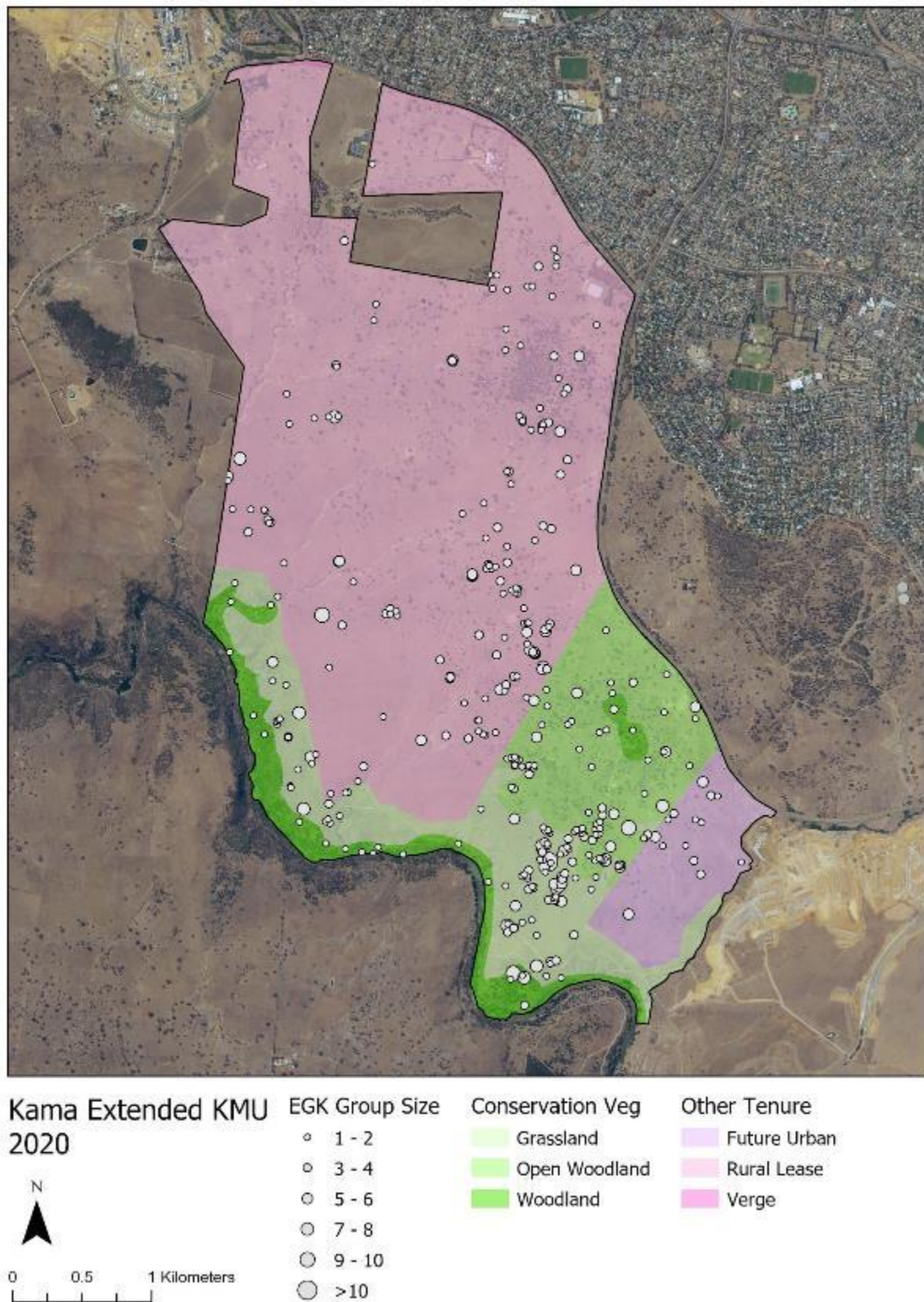


Figure 32. Map of Kama Extended KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.

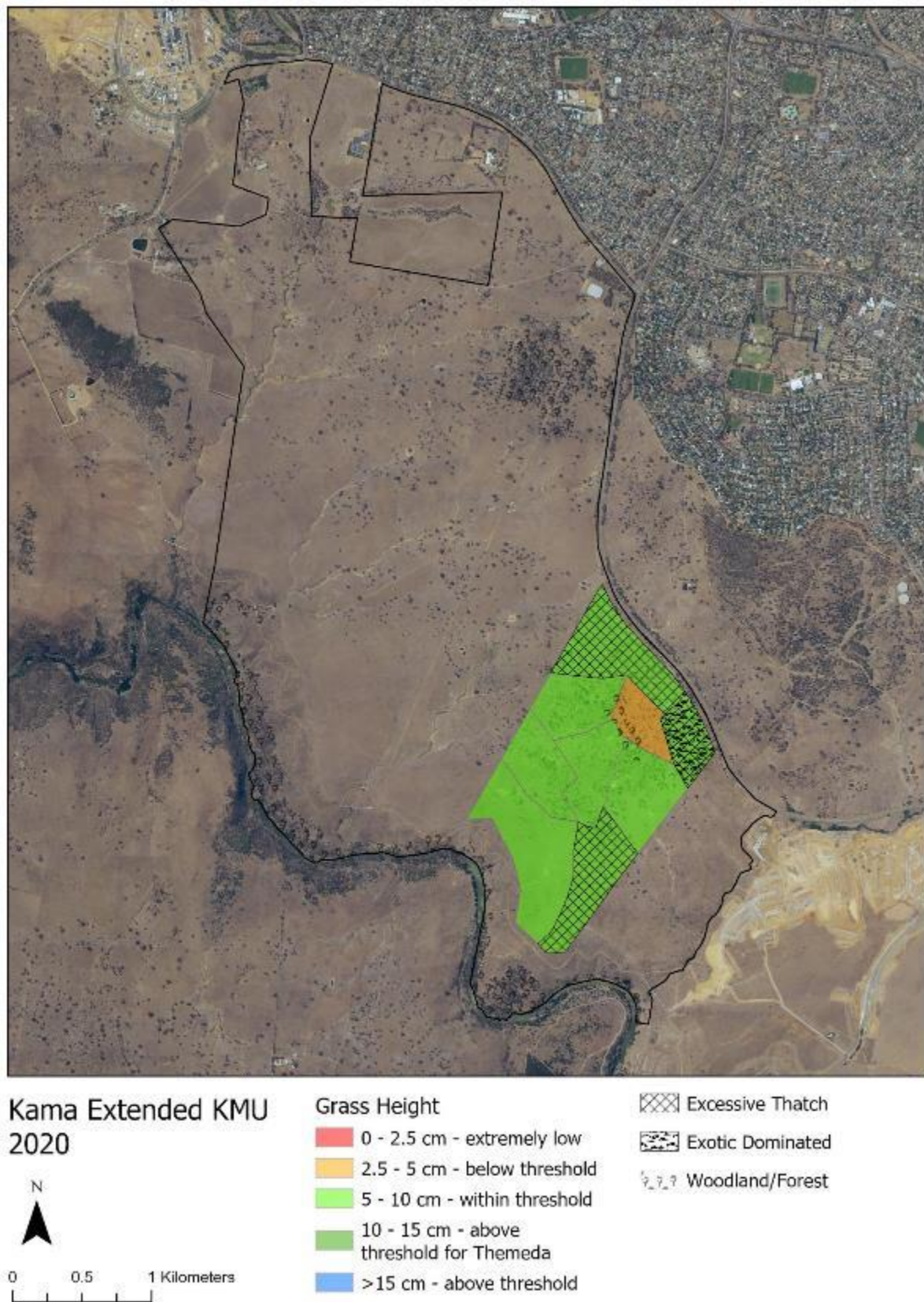


Figure 33. Map of Ainslie Majura KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

KINLYSIDE KMU

Background

The Kinlyside KMU is situated in the north of Canberra, between the suburb of Casey and the village of Hall. It is comprised of Kinlyside Nature Reserve and adjoining rural leases. The Barton Highway acts as a barrier to kangaroo movement to the south west, however the remaining boundaries of the KMU are contiguous with adjacent rural lease and hence there is little barrier to immigration into the site. The area is currently jointly managed for conservation by the Parks and Conservation Service (under the Environmental Offsets program) and the neighbouring rural land managers, and hence livestock grazing will be an ongoing component of the total grazing pressure across this site.

Site specific considerations

The Kinlyside Nature Reserve contains critically endangered Yellow Box – Red Gum Grassy Woodland and is also considered important habitat for the Golden Sun Moth and Pink-tailed Worm-lizard. Due to ongoing contribution of livestock to total grazing pressure, no conservation culling has been undertaken at this site to date. Kangaroo management is undertaken under a damage mitigation authorisation however, to maintain appropriate total grazing pressure in the broader landscape.

Culling advice

The results of the 2020 counts for the Kinlyside KMU are shown in Table 3 and changes in kangaroo density at this site over recent years are shown in Figure 34. Ground layer vegetation is yet to be mapped across the conservation component of this KMU as it has been in others, but the vegetation composition used to calculate target densities is shown in Figure 35. A conservation cull is not recommended for this site in 2020 (Table 5) based on the ongoing contribution of livestock to total grazing pressure and the current kangaroo density being below the target set to achieve conservation objectives.

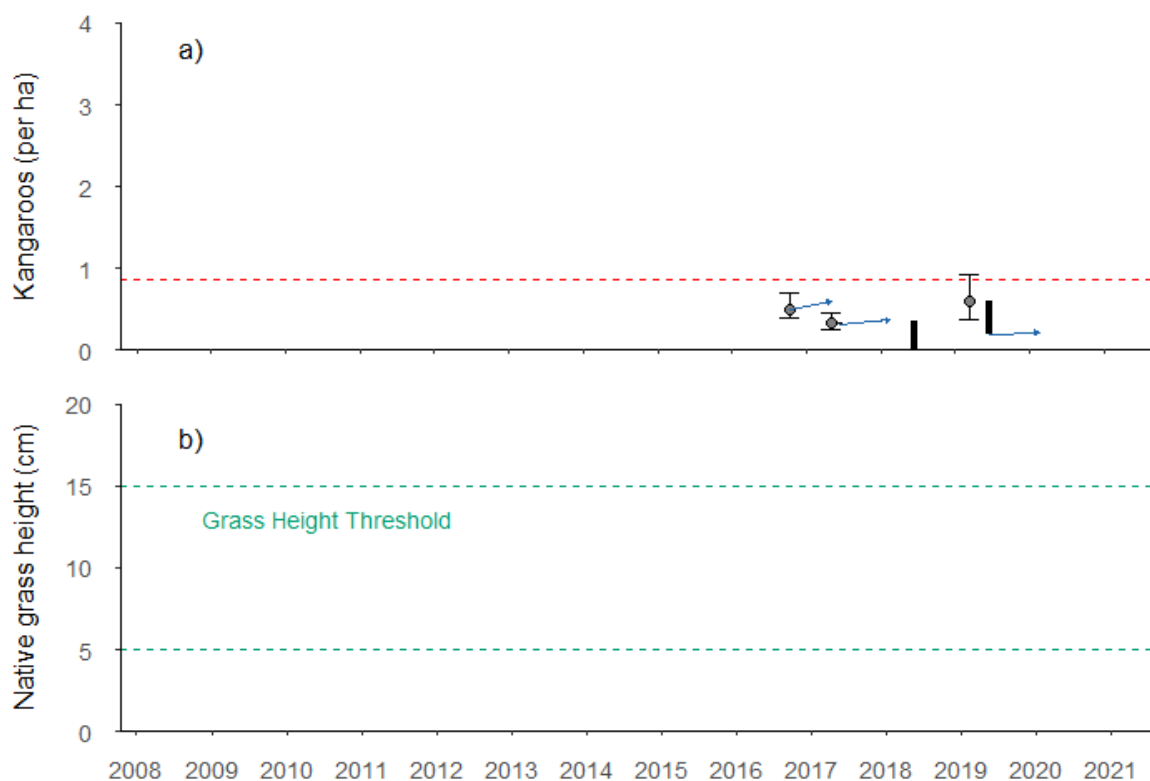


Figure 34. Changes in kangaroo density and average native grass height for Kinlyside Extended KMU.

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, noting no conservation culls have been undertaken to date at this site. The density of damage mitigation culls within the KMU in years where no density estimation was completed are shown along the x axis. Blue arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

b) Average native grass height There is no available data on native grass heights for this site so far. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.

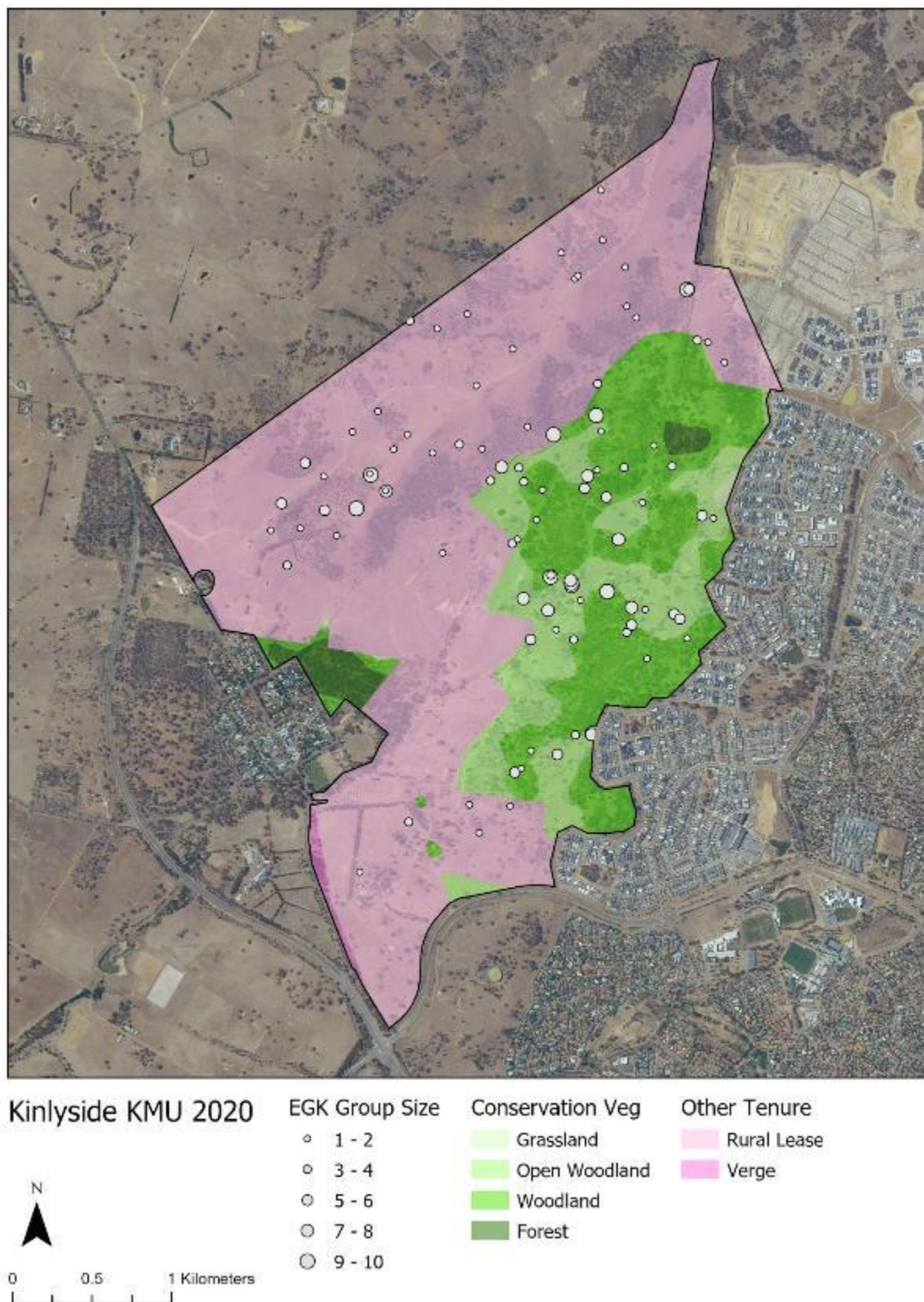


Figure 35. Map of Kama Extended KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



An open tussock structure enables a proliferation of native flowers to germinate. Scenes like this depict the careful balancing act of achieving an appropriate mix of grass heights, necessary to support native grassy layer biodiversity.

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 Athlon Drive. The particularly high level of kangaroo-vehicle collisions which occur along both Sulwood and Athlon 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 parkcare group regularly undertake management of weeds and erosion on this site.

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.

Culling advice

The results of the 2020 counts for the Mt Taylor KMU are shown in Table 3. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 36. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating numbers to cull is shown in Figures 37 and 38, showing all polygons to have 'below threshold' grass heights. Subject to prioritisation considerations and operational factors, a conservation cull is considered necessary in the Mt Taylor KMU (Table 5) to enable restoration of the grassy layer.



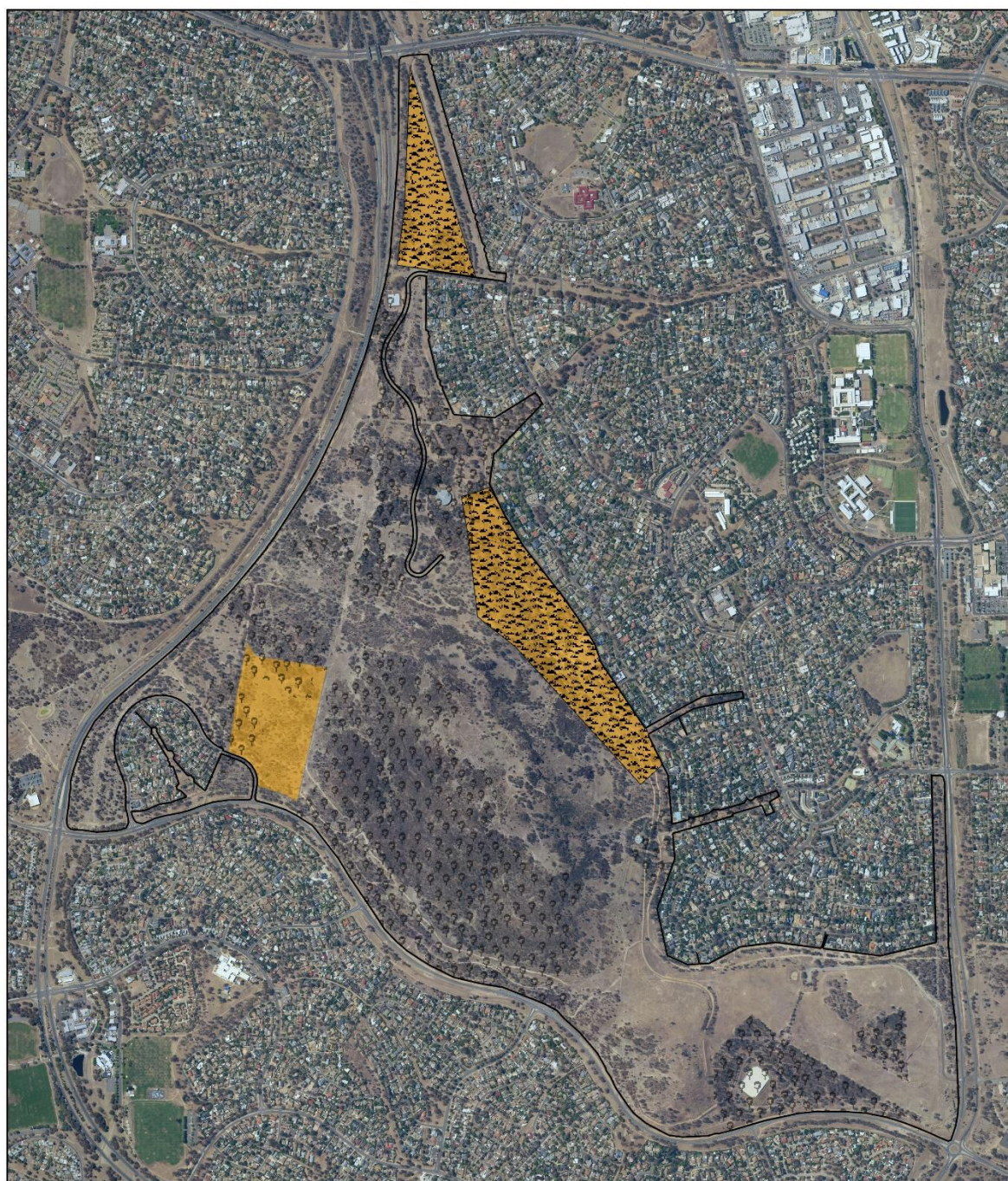
Figure 36. Changes in kangaroo density and average native grass height for Mt Taylor KMU.

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 (●). Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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, or 'safe operating environment', associated with maximised biodiversity outcomes.



Figure 37. Map of Mt Taylor KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Mt Taylor KMU 2020



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 38. 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. It is also a research site for the Grasslands Restoration Project, and hence experimental use of complementary herbage mass management tools (e.g. fire, slashing and grazing by livestock) is likely to be ongoing dependent on herbage mass condition. 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.

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. Population growth rates were noticeably higher between counts in 2019 and 2020 however, mirroring observations made across numerous other grassland sites during the same time period, possibly reflecting higher rates of landscape scale movement by kangaroos as a result of prolonged dry conditions.

Culling advice

The results of the 2020 counts at Mulanggari KMU are shown in Table 3. 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 numbers to cull is shown in Figures 40 and 41, showing a mix of polygons with 'below threshold' and 'within threshold' grass heights. Due to the impact of dry conditions and increased population growth rates during 2019, a conservation cull is recommended for Mulanggari KMU in 2020 (Table 5).

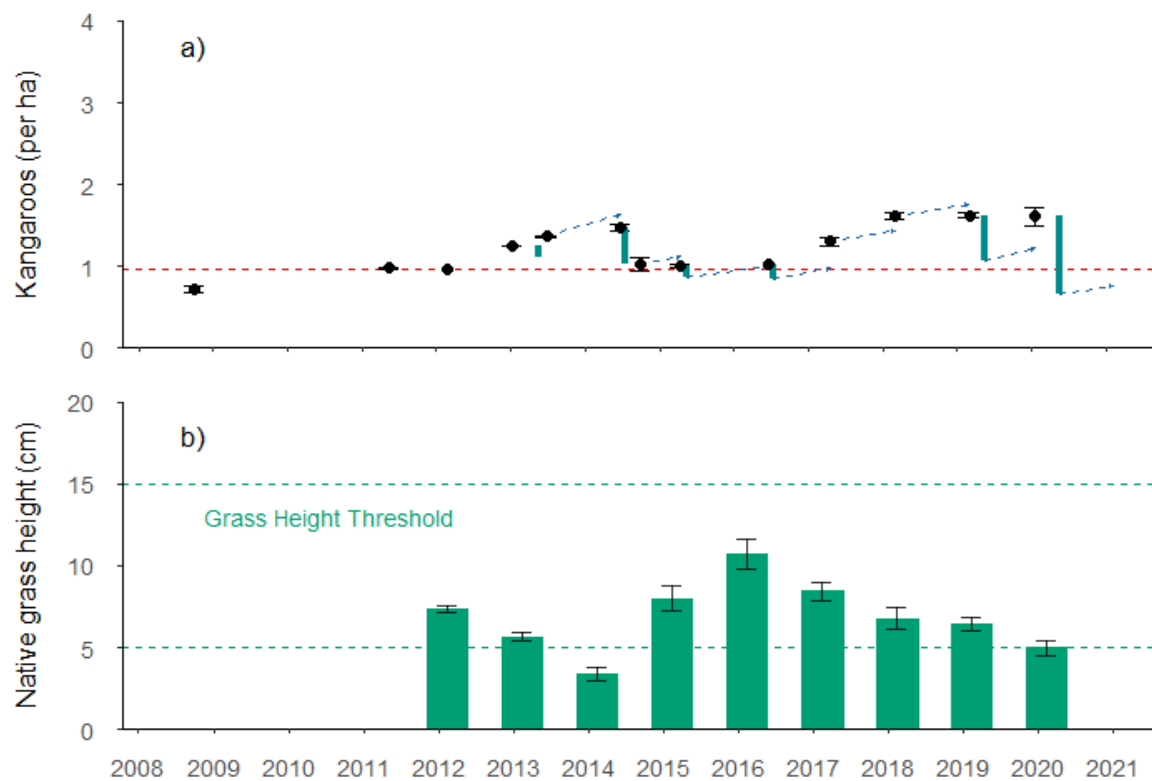


Figure 39. Changes in kangaroo density and average native grass height for Mulanggari KMU.

a) Changes in kangaroo density Kangaroo density based on direct 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. The line shown for 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.



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

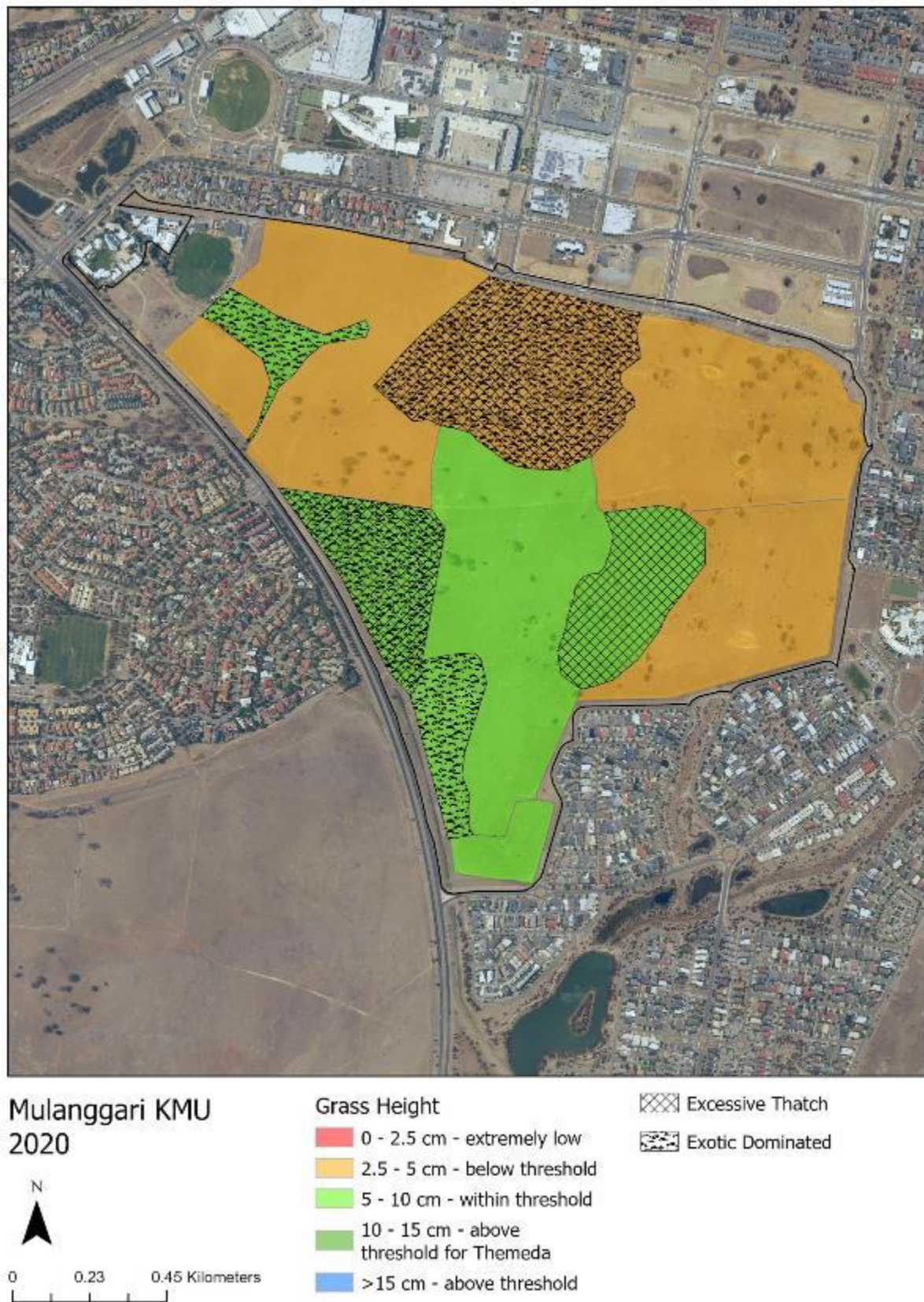


Figure 41. Map of Mulanggarri KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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 and New Holland Mice as part of the Mulligans Flat – Goorooyaroo Woodland Experiment. Kangaroo exclosures are also maintained as part of this experiment, nominally at 10-50% of the typical target density, however exclosures have been open throughout the 2019-20 summer to enable wildlife to access water during prolonged hot and dry conditions.

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 is currently underway to assess the capacity for this tool to be used in the management of these species longer term, as part of an integrated management approach. The absence of predators has also contributed to significantly higher population growth rates for kangaroos (up to 60-70% per annum) compared to at unfenced sites – suggesting that use of contraception in kangaroo populations may also be a cost-effective means of managing abundance at this site. Rabbits and hares have now been eradicated from the sanctuary.

Culling advice

The results of the 2020 count at Mulligans Flat KMU are shown in Table 3. Changes in kangaroo density and ground layer vegetation condition at this site over recent years are shown in Figure 42. The distribution of surveyed kangaroos across the landscape and the vegetation structure used for calculating numbers to cull is shown in Figures 43 and 44, showing grass heights in the majority of polygons being 'extremely low' or 'below threshold' with the exception of two *Aristida ramosa* dominated polygons which have limited palatability to kangaroos and are considered 'within threshold'. Based on this, conservation culling is recommended for Mulligans Flat KMU in 2020 (Table 5), with particular effort being made to reduce the density of kangaroos within the experimental kangaroo exclosures.

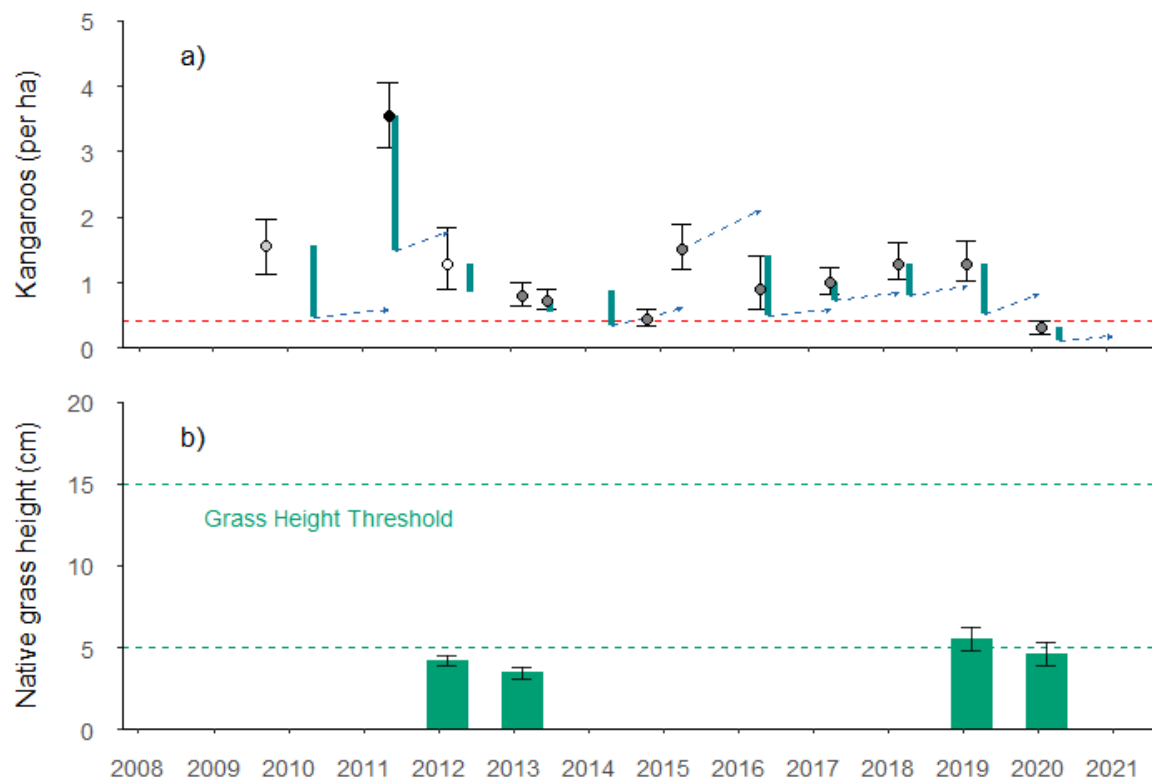


Figure 42. Changes in kangaroo density and average native grass height for Mulligans Flat KMU.

a) Changes in kangaroo density Kangaroo density is shown as the mean \pm 95% confidence intervals where the pellet count (\circ), walked line transect count (\bullet) or driven line transect count (\circ) methods were used. A sweep count (\bullet) 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 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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 indicative representative average grass heights is also shown where available but may not be directly comparable to more recent data. The dashed green lines indicate the upper and lower bounds of the grass height threshold, or 'safe operating environment', associated with maximised biodiversity outcomes.

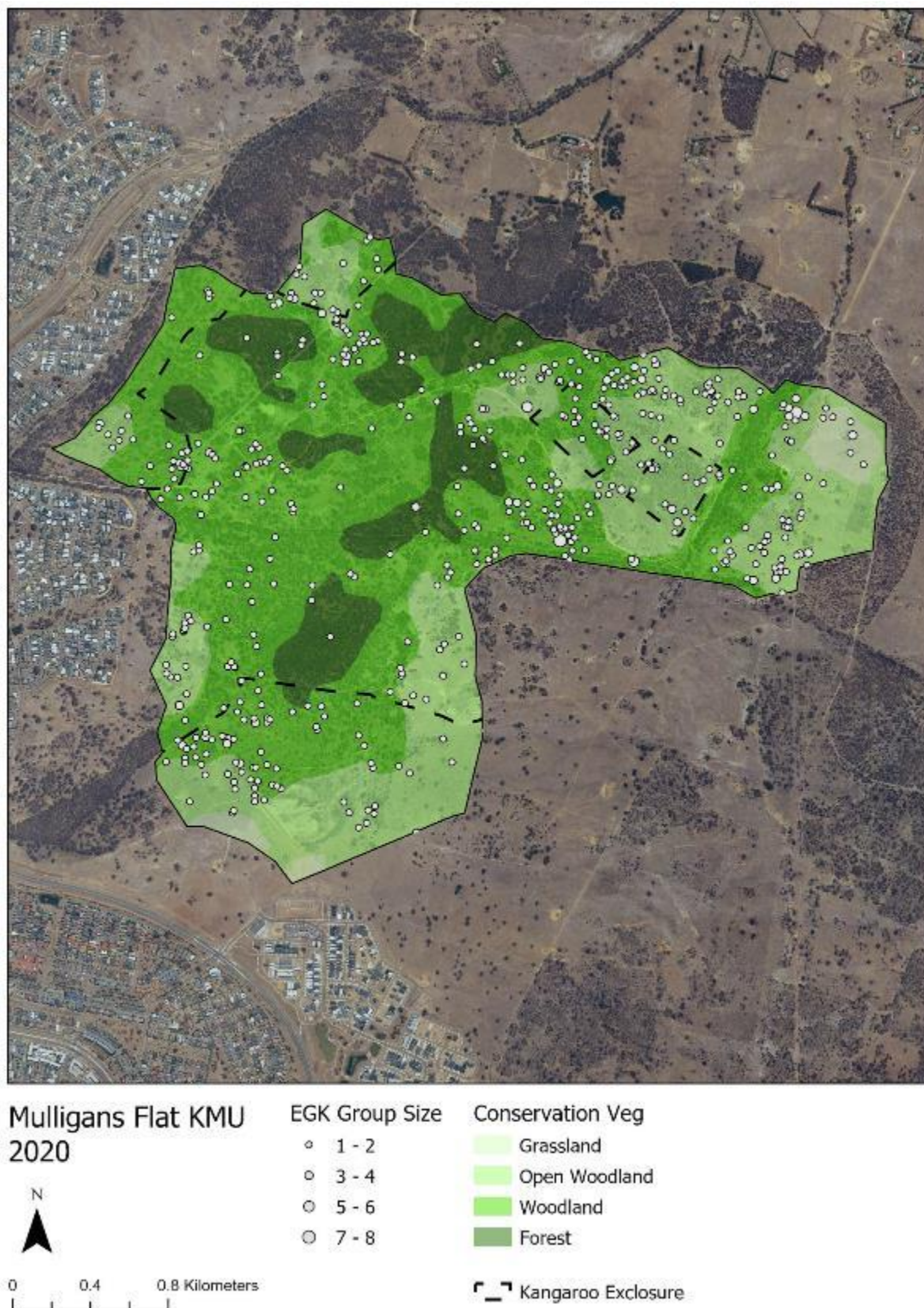


Figure 43. Map of Mulligans Flat KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.

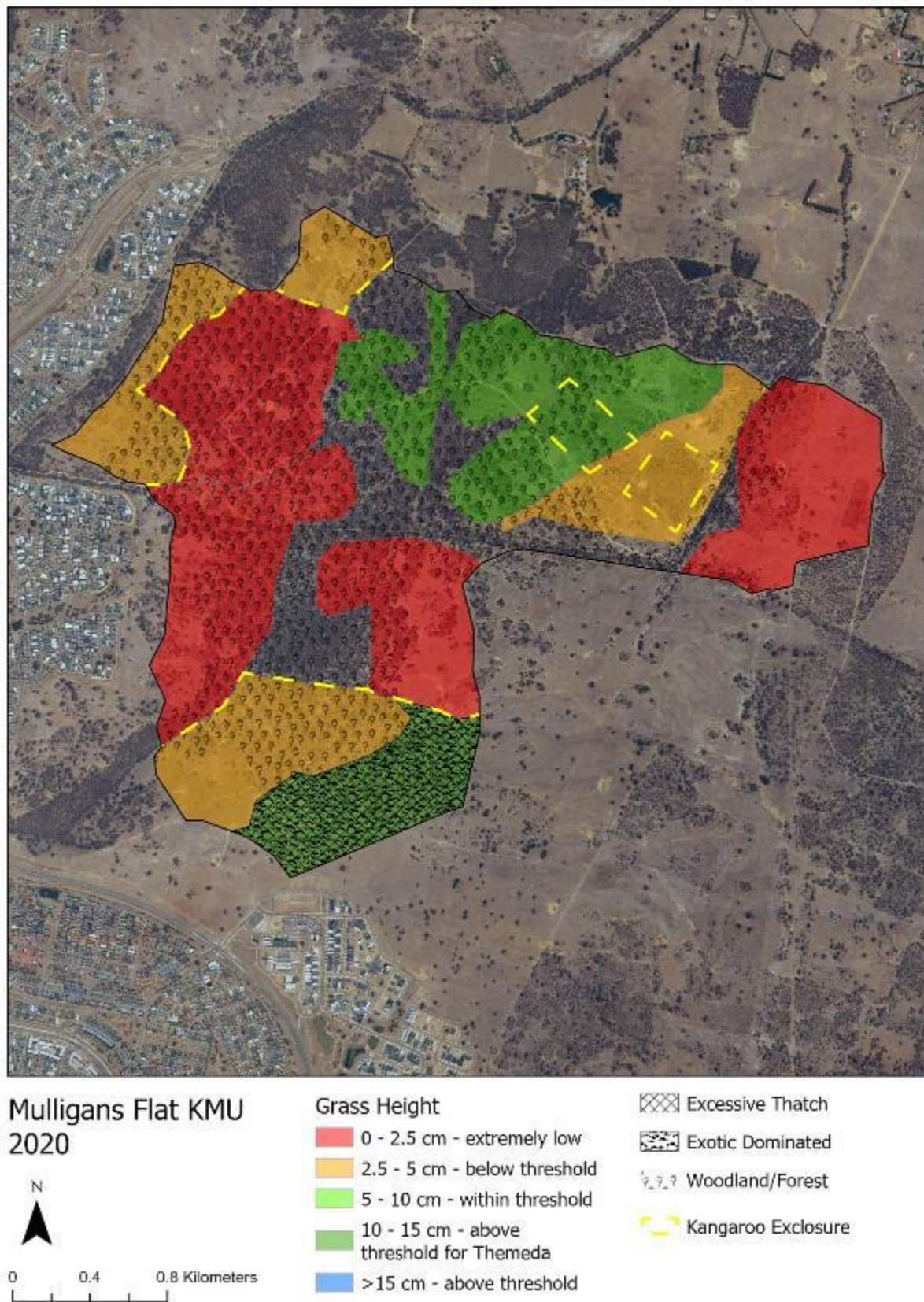


Figure 44. Map of Mulligans Flat KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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.

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.

Culling advice

The results of the 2020 counts for the Red Hill are shown in Table 3. 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 numbers to cull is shown in Figures 46 and 47, showing all polygons to be 'below threshold' grass heights. Subject to operational capacity, a conservation cull is recommended for Red Hill KMU in 2020 (Table 5) to reduce the ongoing risk of erosion and enable restoration of ground layer vegetation.

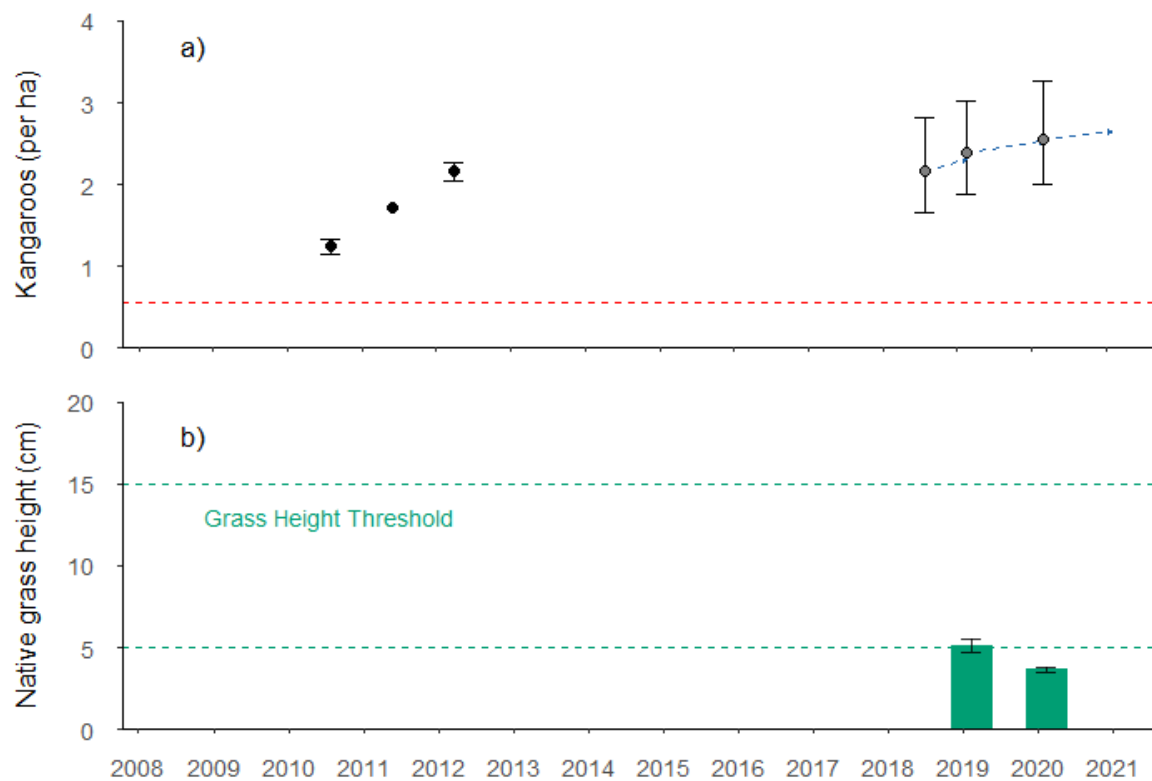


Figure 45. Changes in kangaroo density (a) and average native grass height (b) for Red Hill KMU.

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. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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, or 'safe operating environment', associated with maximised biodiversity outcomes.



Figure 46. Map of Red Hill KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.

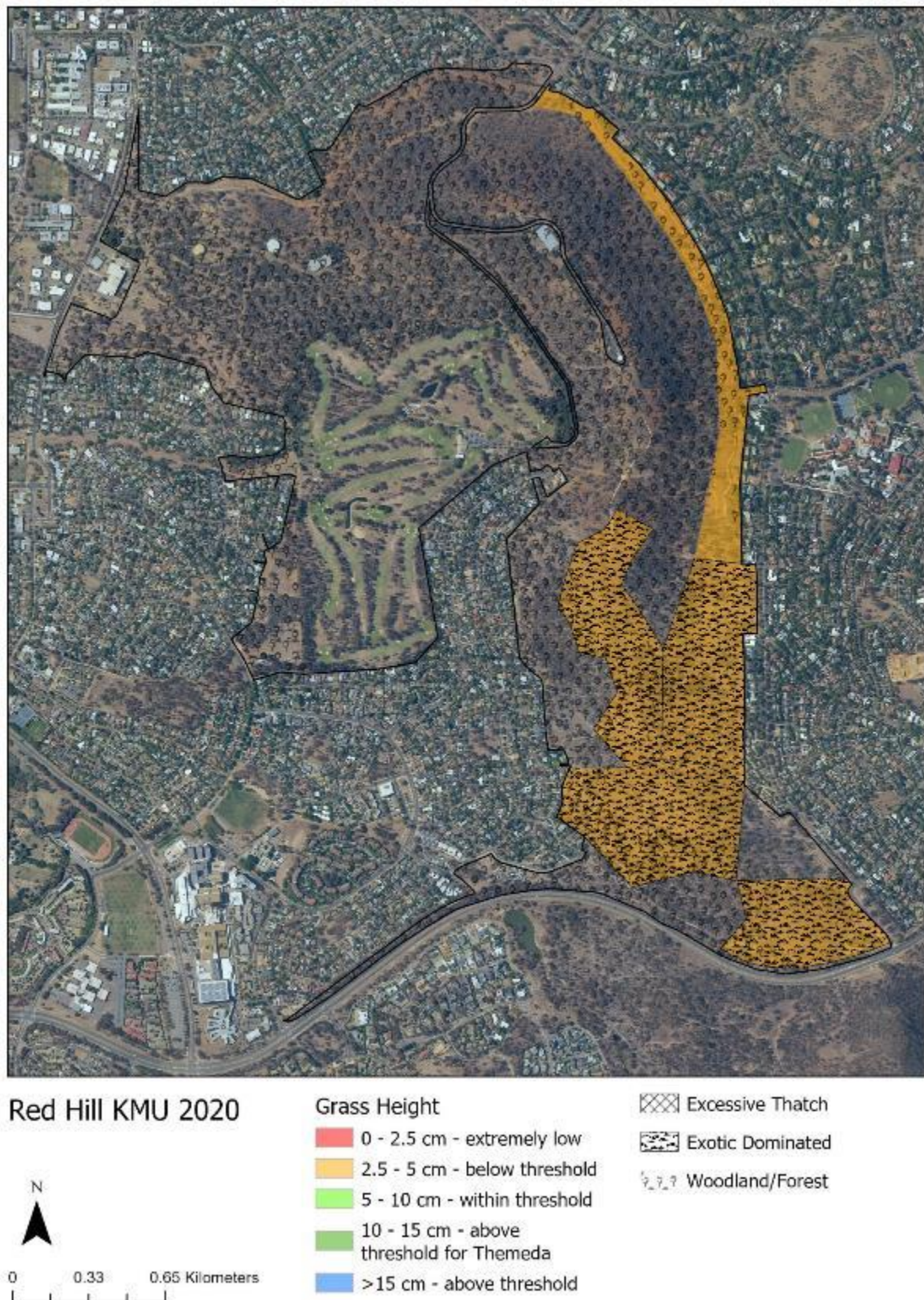


Figure 47. Map of Red Hill KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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.

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. Compared to habitat use identified during the 2019 counts, which was strongly biased towards the areas managed as livestock agistment and horse paddocks, kangaroos appear to have increased their use of the conservation land within this KMU in 2020.

Culling advice

The results of the 2020 counts for The Pinnacle KMU are shown in Table 3. 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 all polygons to be 'below threshold' grass heights. Based on current kangaroo density and grass condition within this KMU, no conservation cull is recommended for The Pinnacle KMU in 2020 (Table 5).

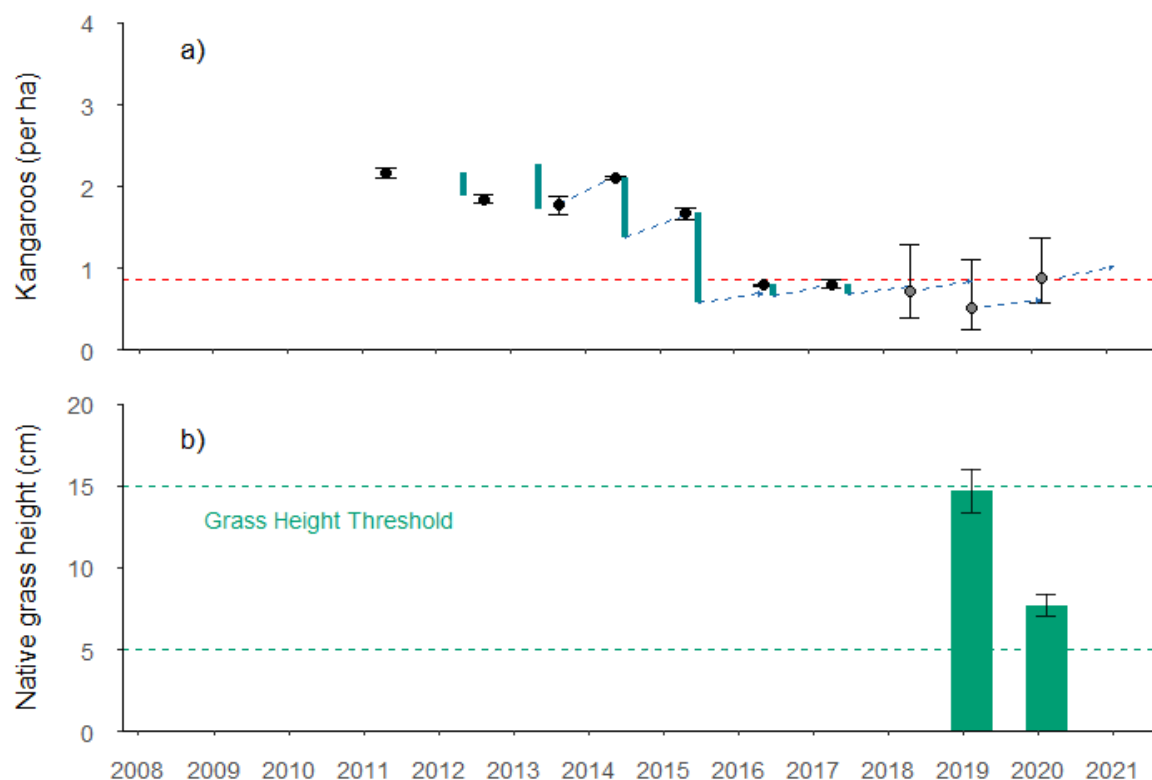


Figure 48. Changes in kangaroo density and average native grass height for The Pinnacle KMU.

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. The line shown for 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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, or 'safe operating environment', associated with maximised biodiversity outcomes.

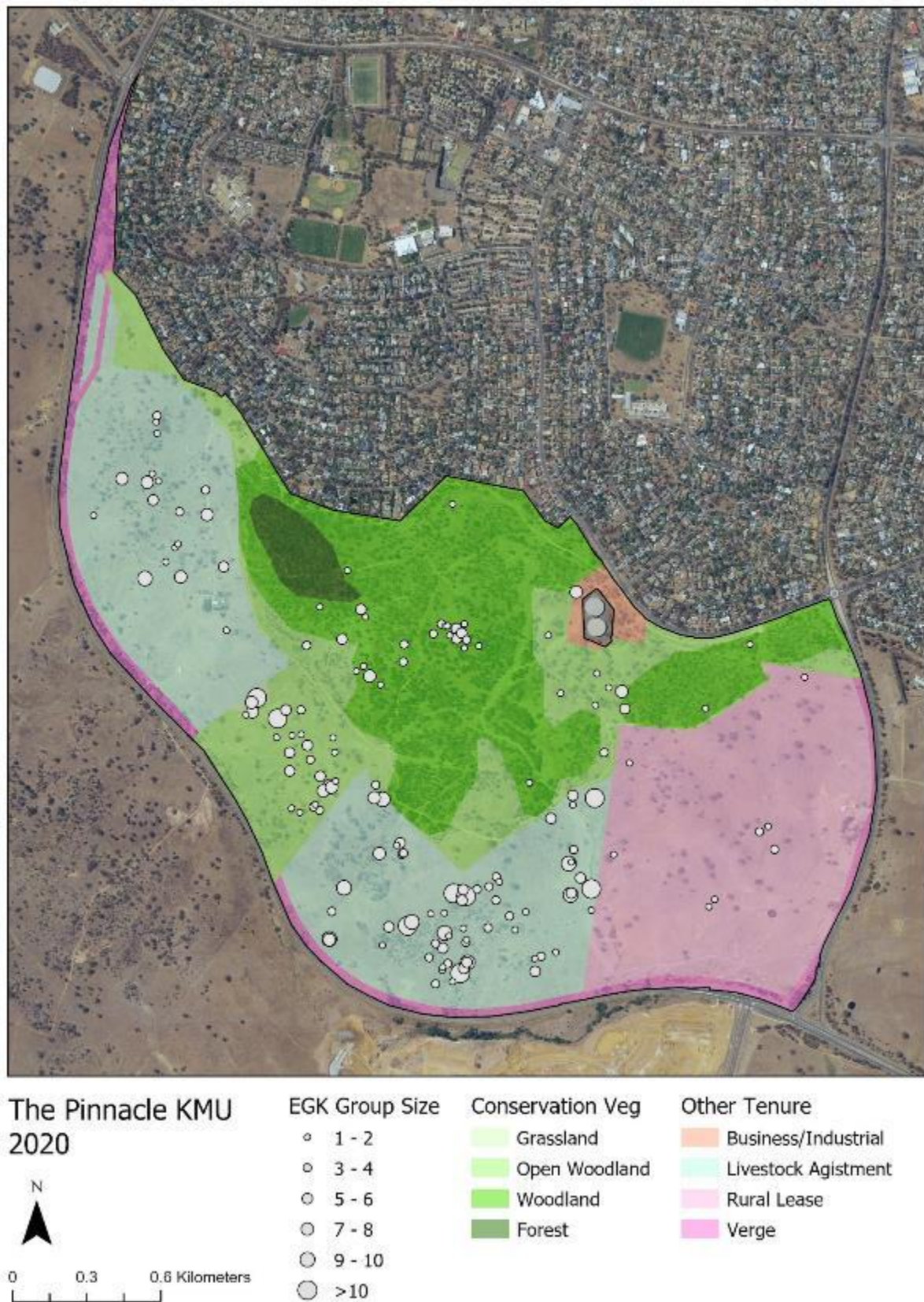


Figure 49. Map of The Pinnacle KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.



Figure 50. 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 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. The grasslands of this KMU are an active research site for the ACT Governments [Grasslands Restoration Project](#), and hence experimental use of complementary herbage mass management tools (e.g. fire, slashing and grazing by livestock) is likely to be ongoing dependent on herbage mass condition. Revegetation works have been undertaken in the Isaacs Ridge offset area to restore the shrub layer at this site, and rabbit numbers are also being actively managed within component reserves during 2020.

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). Even with the assimilation of a larger combined KMU, immigration into this landscape since management was undertaken in 2019 appears to have been significant and hence ongoing monitoring will be critical to ensure removal of excess kangaroos is effective in improving the conservation status of species and communities at this site.

Culling advice

The results of the 2020 count West Jerrabomberra KMU is shown in Table 3. 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 numbers to cull is shown in Figures 52 and 53, showing all polygons to be classified as having 'extremely low' grass heights outside of the grassland areas which are in a mix of 'below threshold' and 'within threshold' states. Based on current kangaroo densities and grassy layer condition, a conservation cull is recommended as a priority to protect critical conservation values across West Jerrabomberra KMU in 2020 (Table 5).

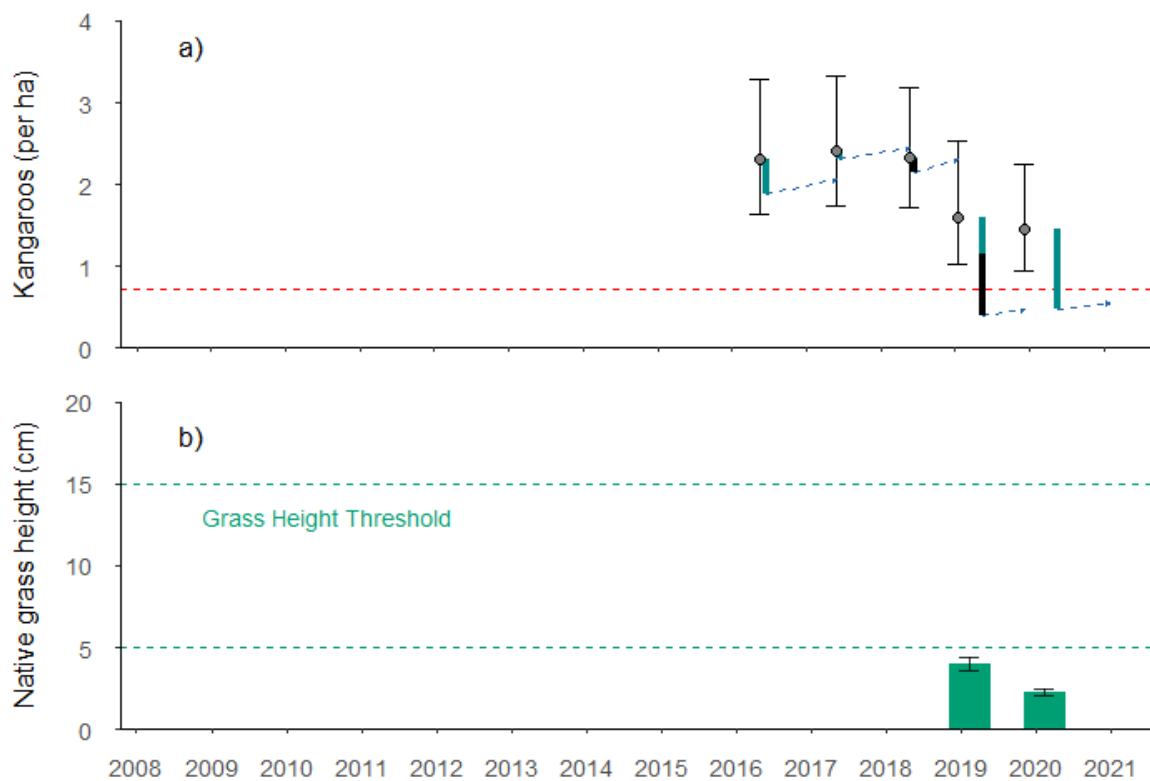


Figure 51. Changes in kangaroo density and average native grass height for West Jerrabomberra KMU.

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 (●). Kangaroo culls are indicated by vertical lines, with green bars showing the density removed during the conservation culling program and black bars representing other non-Government culling programs. The line shown for 2020 is the recommended cull density only. Blue dotted arrows indicate the predicted population growth for the site in each year. The dashed red line demonstrates the long-term target density for Eastern Grey Kangaroos.

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, or 'safe operating environment', associated with maximised biodiversity outcomes.

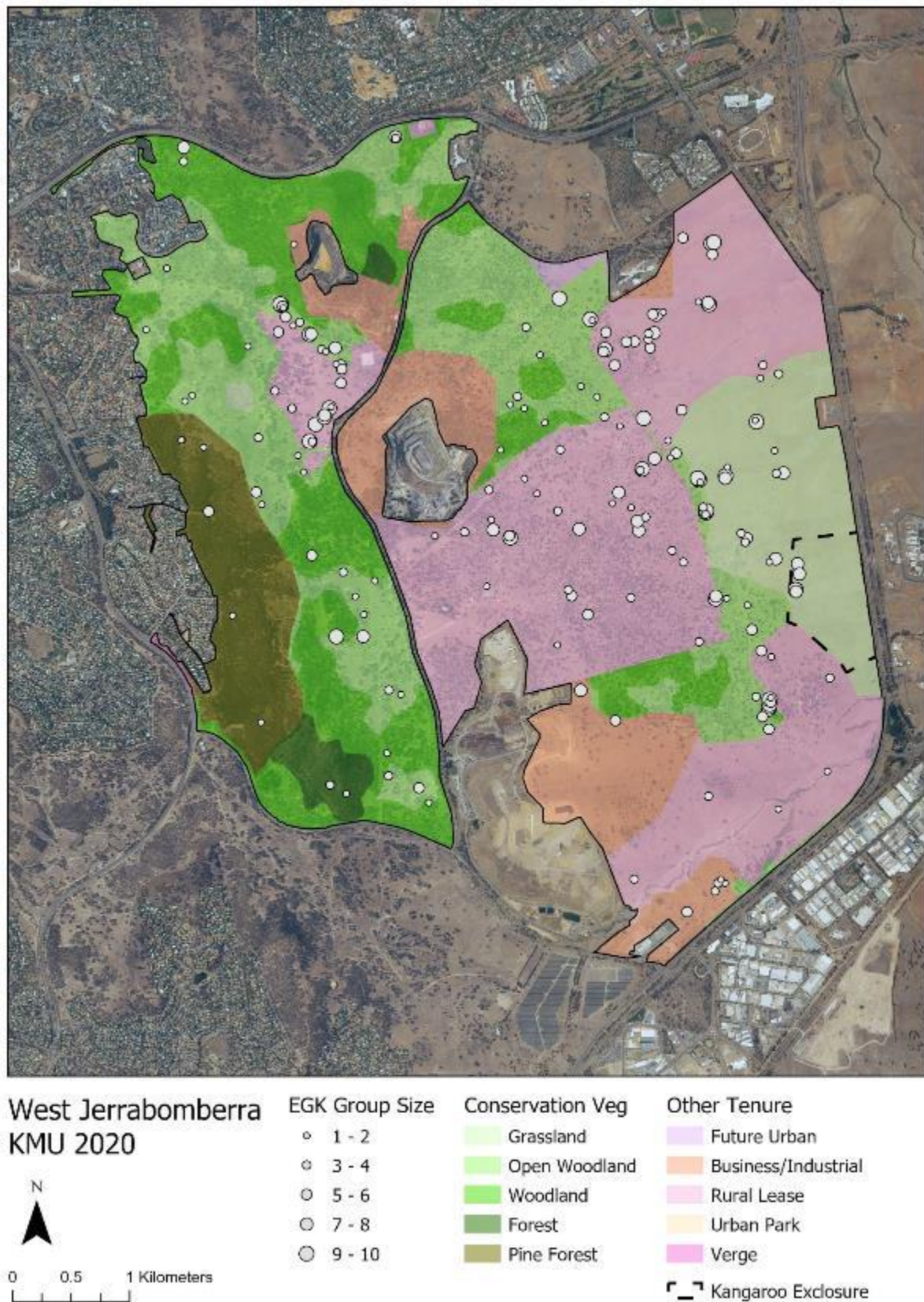


Figure 52. Map of West Jerrabomberra KMU, showing canopy strata, land tenure, and position of surveyed kangaroos across the landscape.

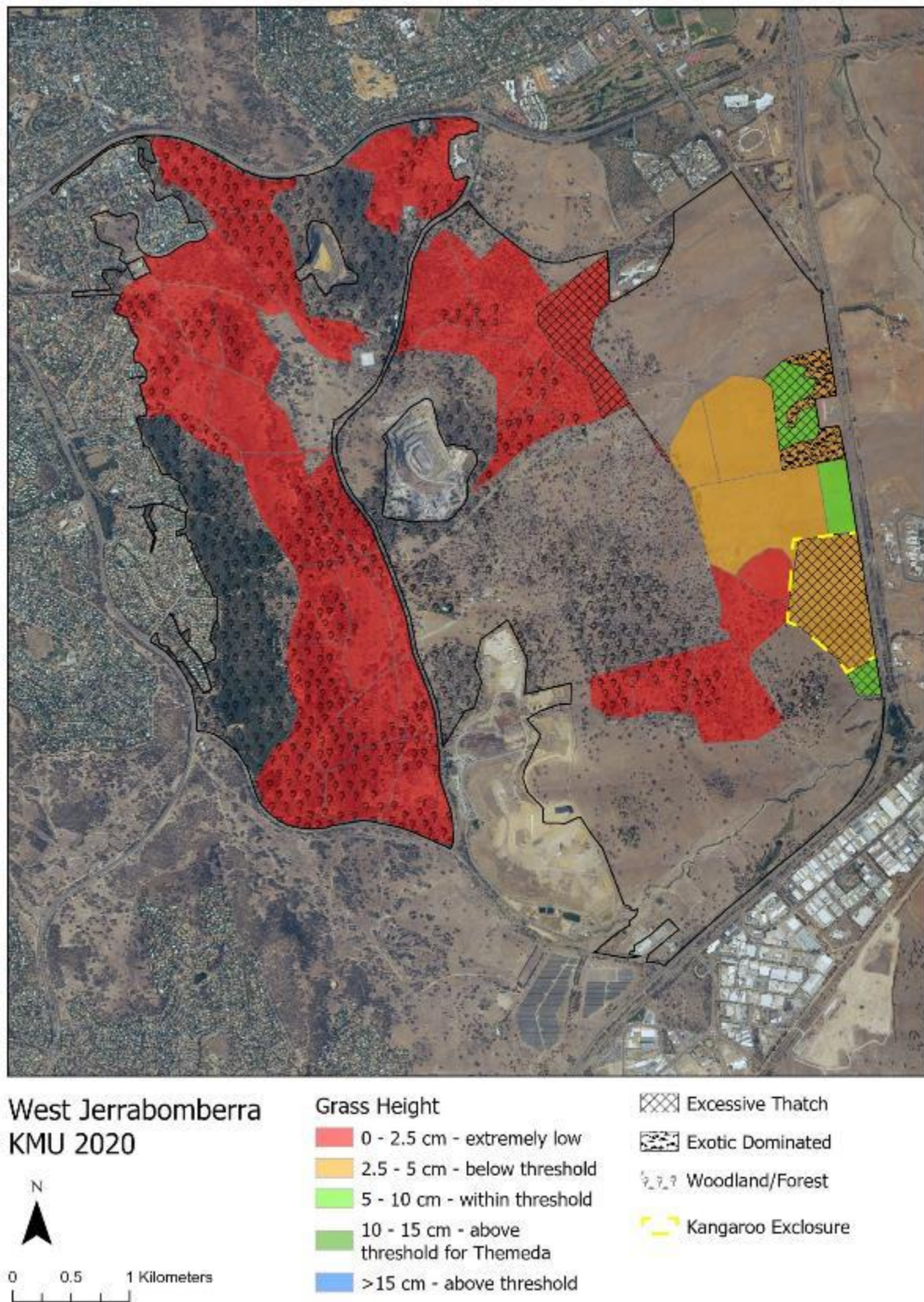


Figure 53. Map of West Jerrabomberra KMU, showing current grassy layer condition relative to threshold grass height targets within conservation areas.

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.

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
Goorooyarroo 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

SUMMARY OF 2020 CONSERVATION MANAGEMENT ADVICE

Table 5. Management areas, long-term and adjusted target kangaroo densities, recent kangaroo counts and predicted population growth information used to determine the number of kangaroos to cull within the conservation areas managed by ACT Government for each kangaroo management unit (KMU).

Columns marked (a) to (c) refer to the components of the culling calculation formula referred to in the 'Calculating the number of kangaroos to cull' section of this document. 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. *Minimum target density to reasonably expect recovery to long-term target density (i.e. that set by the Calculator) in two years; † based on calculations for the Jerrabomberra East Nature Reserve (127 ha) only; NA, no cull due to ongoing livestock grazing; NS, new site.

SITE	Total Area of KMU (ha)	Area Managed by ACT Government for Conservation (ha)	Conservation Area TARGET Number (and Density) based on Calculator	(a) Conservation Area TARGET Number (and Density) for 2020, considering ecological adjustments. * Indicates minimum allowed	Values Below Relate Only to Areas Managed for Conservation by ACT Government				
					(b) Population (and Density) at 2020 Count	(c) Expected PGR based on adjusted TARGET Density (a)	Number to remain after 2020 cull, allowing for population growth in the interim to the next cull	Recommended Number to Cull in 2020	Operational Priority based on risk to values and prior investment?
Ainslie Majura KMU	2100	1438	465 (0.32)	316 (0.22)*	1380 (0.96)	0.21	286	1094	High
Aranda Painter KMU	381	250	127 (0.51)	133 (0.53)	340 (1.36)	0.19	122	218	Med
Crace KMU	180	142	162 (0.90)	119 (0.66)*	219 (1.21)	0.18	109	110	High
Dunlop KMU	116	116	113 (0.97)	84 (0.72)	208 (1.79)	0.18	77	NA	-
East Jerrabomberra KMU	1094	127	127 (1.00)	53 (0.42)	410 (3.23)†	0.60	41	369	High
Farrer Ridge KMU	202	202	141 (0.70)	101 (0.50)*	465 (2.30)	0.19	92	372	Low, NS
Googong West KMU	1754	1754	1411 (0.80)	1017 (0.58)*	1385 (0.79)	0.60	783	602	Med
Goorooyarroo KMU	797	797	566 (0.71)	344 (0.43)	715 (0.90)	0.60	265	450	High
Gungaderra KMU	364	345	328 (0.90)	228 (0.66)	373 (1.02)	0.18	209	164	High
Kama Extended KMU	1108	303	262 (0.86)	191 (0.63)*	158 (0.52)	0.18	175	0	-
Kinlyside KMU	737	247	155 (0.63)	-	173 (0.70)^	0.18	142	NA	-
Mt Taylor KMU	380	334	228 (0.68)	164 (0.49)*	494 (1.48)	0.19	149	345	Low, NS
Mulanggari KMU	161	157	155 (0.96)	114 (0.71)*	261 (1.61)	0.18	105	156	High
Mulligans Flat KMU	484	484	201 (0.42)	77 (0.16)	144 (0.30)	0.60	60	84	High
Red Hill KMU	409	305	172 (0.56)	122 (0.40)*	778 (2.55)	0.20	111	667	Med, NS
The Pinnacle KMU	365	154	99 (0.64)	153 (0.99)	136 (0.88)	0.16	142	0	-
West Jerrabomberra KMU	2009	1010	722 (0.71)	515 (0.51)*	1465 (1.45)	0.19	470	994	High
TOTAL								5625	

REFERENCES

- ACT Government (2010). *ACT Kangaroo Management Plan*. Canberra: ACT Government.
- ACT Government (2017a). *Eastern Grey Kangaroo: Controlled Native Species Management Plan*. Canberra: ACT Government.
- ACT Government (2017b). *Nature Conservation (Eastern Grey Kangaroo) Rural Culling Calculator Determination 2017*. ACT Government.
- ACT Government (2018a). *Nature Conservation (Eastern Grey Kangaroo) Conservation Culling Calculator Determination 2018*. Canberra: ACT Government.
- ACT Government (2018b). Eastern Grey Kangaroo Conservation Culling Advice 2018.
https://www.environment.act.gov.au/_data/assets/pdf_file/0016/1242610/Cull-Recommendations-Report-UPDATE-180827-Web-Accessible-Pdf2.pdf

