Calculation of the number of kangaroos to cull.

INTRODUCTION

Since 2009, the ACT Government has conducted an annual cull of eastern grey kangaroos in selected nature conservation areas to prevent over-abundant populations from impacting on endangered ecological communities as a result of over grazing. All policies for kangaroo management in the ACT, including this conservation culling, are explained in the ACT Kangaroo Management Plan (KMP). This note uses non-technical language to explain one aspect of how the policy is being put into practice at present. It explains how the policy for conservation culling is translated into numbers of kangaroos to be culled. Repeated reference is made to the KMP, which is unusual among policy documents for the extent of explanation it provides and the number of references it gives to the scientific literature. Thus, readers with a particular interest in the issue are encouraged to start by consulting the KMP. It is available from http://www.tams.act.gov.au by searching for 'kangaroos'. Illustrated, user-friendly guides to other kangaroo policy issues can also be found there.

The purpose of conservation culling of kangaroos in ACT reserves is to maintain *grassland conservation densities* of kangaroos (defined on p 106 of the KMP). In particular the aim is ***to achieve a grazing regime favourable for the conservation of small animals that depend on the ground-layer vegetation***. The phrase '*animals that depend on'* is used deliberately to include species such as some birds that depend on ground layer vegetation without necessarily being regarded as living in it. In meeting this aim, it is expected that the conservation requirements for plant biodiversity will also be met.

This is not treating kangaroos as pests

Grazing is important to the conservation of grassy ecosystems, and eastern grey kangaroos are regarded as being central to the healthy functioning of these ecosystems. Thus the calculation of the number to cull begins with the calculation of the number of kangaroos that need to be retained in the reserve. Under no circumstances are all, or nearly all kangaroos in a reserve intended to be culled, as explained below. Nor is there any plan for culling in the majority of the ACT. Culling is being conducted in a minority of the 39 urban nature conservation areas (including 34 nature reserves and 5 planned nature reserves).

Damage reduction?

Most of the culling is no longer reacting to existing damage. As much as possible the culling is being managed as a preventative program. By culling a small population annually, rather than delaying for years, or reacting to damage, fewer animals are culled over the long term, and environmental damage can be avoided.

Conservation requirements and ecological context

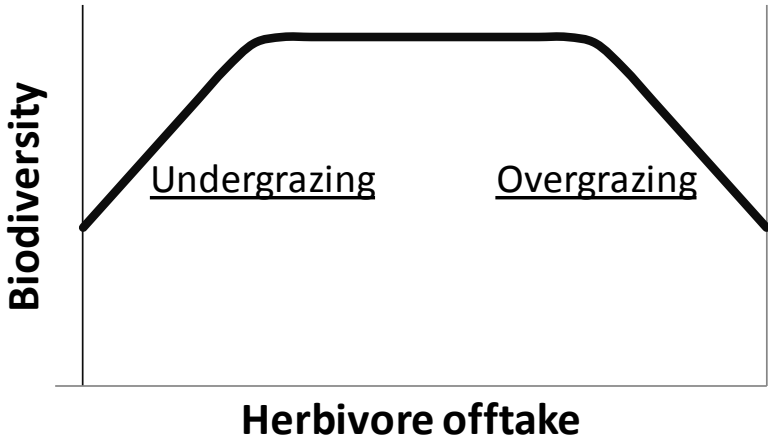
Within the lowlands of the ACT are remnants of ecological communities listed nationally as endangered. The remaining areas of land supporting lowland natural temperate grassland and yellow-box red-gum woodland are now only fragments of the natural extent of the grassy ecosystems. The main threat to these communities has been agricultural and urban development associated with human population growth. It is a high priority to conserve and manage well the remaining fragments.

The environment of these endangered ecological communities has been changed in important ways, including by the removal of large predators such as Thylacines and dingoes. Hunting by Aborigines and early Europeans has also been suppressed.

In the absence of top predators, in the temperate climatic zone, large herbivores like deer and eastern grey kangaroos can increase in abundance to the point that they maintain the ground layer vegetation in an eaten down condition. The ground layer vegetation may also be the home of small animals such as insects, frogs, reptiles, and birds. In some places these include

threatened species such as grassland earless dragons, striped legless lizards, and hooded robins. When eaten down, the grassy ecosystems no longer provide food (such as plentiful insects) for these animals, nor shelter from their predators (such as native birds of prey). This can lead to a decline in their populations and localised extinction. To protect the populations of small animals and the health of the ecosystem, kangaroo grazing needs to be kept at moderate levels (Figure 1). In this sense the culling is filling the role of the missing predators.

Figure 1: The aim of the conservation culling policy is to moderate grazing pressure and reduce



the risk of biodiversity losses due to either undergrazing or overgrazing.

Access to scientifically based evidence

The ACT Government has access to reports from kangaroo research carried out all over Australia, and has made a significant contribution itself through the local research it has supported. This has included the first population dynamics study of the eastern grey kangaroo species, and the first for any kangaroo in a temperate environment. Research has also been conducted on kangaroo movement behaviour, fertility control, fecundity, and body condition. Research partners have documented the conservation effects of kangaroo grazing. A substantial body of knowledge is now available on which kangaroo management decisions can be based.

Chapter 3 of the KMP deals with kangaroo ecology generally and Chapter 5 identifies conservation impacts. Research that demonstrates kangaroo impacts in the ACT has been available for many years (for birds Neave and Tanton 1989). After the KMP was published, the results of other scientific investigations of kangaroo grazing and biodiversity have begun to become more accessible (McIntyre *et al*. 2010, Barton *et al*. 2011; Diamond *et al*. 2012, Manning *et al*. 2012) and there are ongoing PhD research projects not yet complete. Taken together, these studies verify that the effects on biodiversity of heavy grazing by kangaroos are at least as great as they appeared to be when the KMP was written.

Can a native species have an impact on other native species?

It is sometimes claimed that kangaroos, being a native species, could do no harm to another native species. Section 3.8.4 (p 51) of the KMP gives examples to the contrary, of native species having detrimental conservation effects. One example similar to that of kangaroos, is that the loss of grizzly bears and wolves from most of the lower 48 states of the USA enabled deer populations to increase, causing over-browsing of certain forest plant species and leading to deer culling programs. Wolves and bears are now being re-introduced into some areas.

Alternatives to culling

The ACT Government has contributed more than any other state or territory to research into the development of kangaroo fertility control. After many years, some very encouraging results have recently emerged. Further research will proceed through the (nationally funded) Invasive Animals

Co-operative Research Centre. For more information go to www.environment.act.gov.au and search for 'kangaroo research'.

DECIDING HOW MANY TO CULL

There is no way to know how many kangaroos there were in pre-human times or pre-European times. Rather we must be guided by research on the habitat requirements of grassland dependent animals and plants. Field measurement and ecological modelling have suggested some starting figures for the ideal numbers of kangaroos and amounts of ground layer vegetation. They are specific to each site, and will be adjusted in future on the basis of increased knowledge.

A separate calculation of the number to cull is carried out each year, for each reserve. A formula is used to help calculate the number of kangaroos to be killed as follows:
(A) the **number 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) Calculating the number to remain

The number to remain is the 'grassland conservation density' (see above and KMP p106). On current knowledge it is estimated that a density of one kangaroo per hectare in grassland is likely to provide the desired conservation environment in average pasture growth conditions, with the corresponding figures for other vegetation types being inversely proportional to the percentage canopy cover, i.e. 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 ha Forest, 100 ha Open Woodland and 100 ha Grassland could sustain 10+90+100=200 eastern grey kangaroos without threatening the small ground dwelling animals. But ecologically-based management requires professional judgment as well as answers from 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 more severe grazing pressure for a short time. In a similar way, adjustment for pasture type would be appropriate, providing it is kangaroo specific. (Eastern grey kangaroos have different feeding preferences to livestock.)

Therefore the first step in determining the number of kangaroos to remain after culling is to consistently and objectively map the tree density, as Grassland, Open Woodland, Woodland, etc, and measure the area of each culling site which is occupied by each of these vegetation types. This mapping has been done by computerised image analysis from recent aerial photography (Fletcher *et al* 2013). The same mapping can also be used for stratification of the sampling design for kangaroo counting (below).

Where one kangaroo population ranges between different landuses, it should be recognised that the calculation described above is only applicable to the conservation component. See 'Kangaroo Management Units'.

(B) *The size of each kangaroo population*

Kangaroo Management Units

Urban and peri-urban nature reserves are small (often 1–3 sq km) and the kangaroo population may occupy both the nature reserve and any adjoining open space areas such as rural leases, golf courses or horse paddocks. To count the kangaroo population on only one of the component areas at a time would be unreliable, due to the movement of kangaroos between them. Therefore the population in a **Kangaroo Management Unit (KMU)** is counted, typically an area bounded by high speed roads and the suburban edge, or other features known to inhibit kangaroo movement (Figure 2). Typically the kangaroo population moves readily between the component areas and grazes more intensively in different components at different times of day, season and year.

Where wildlife populations are shared between nations, states or landowners, discussion, cooperation, and pragmatic compromise are required. For example, the 'grassland conservation density' specified above is several times higher than the kangaroo density on the average rural property, so which should be used to determine how many kangaroos in the KMU should be culled? No simple answer will be correct. To calculate the cull (inevitably affecting the population ranging over the entire KMU) based on either the rural standard or the conservation standard, would give the wrong answer for the other landuse. The best solution will be one that takes account of more than just kangaroos and culling. Numerous strategies and 'tools' are potentially available to assist with the co-operation, including simple things like conducting the cull of the shared population mainly where the lower density is desired, and using livestock for brief periods of conservation grazing to target an additional grazing effect to the areas where it will have greatest benefit.

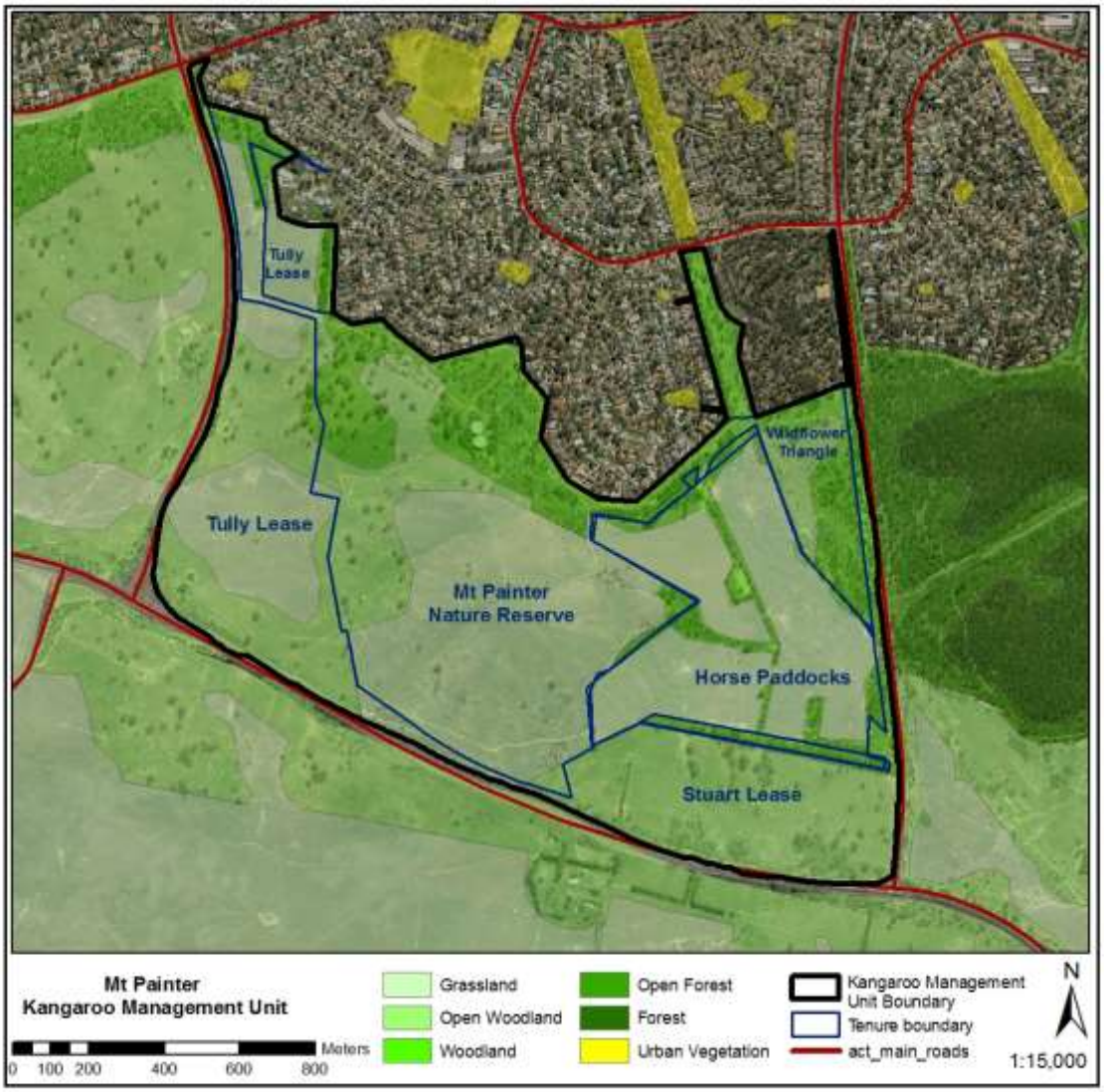


Figure 2: Example of KMU, showing multiple land tenures and vegetation classification
The Mt Painter Kangaroo Management Unit (KMU) is bounded by suburbs and three high speed roads (≥ 80kph). It comprises a number of land tenures separated by stock fences, including those named in blue on the map, all of which are inhabited by the one kangaroo population. This figure also illustrates the vegetation mapping used to stratify the sampling for the pellet and line

transect methods. The vegetation classification is shown as a semi-transparent layer over an aerial photo.

Counting methods

KMP Appendix 1 is an explanation of the kangaroo counting methods used in Australia with examples from the ACT. In brief, simply counting the individual kangaroos is possible in some cases (Direct Counts) while other sites require a larger number of people to 'Sweep Count' the area. Repeat counts are used to evaluate the reliability of both methods. 'Line Transect Counts' (one of the 'Distance' family of methods, and the most widely used survey method in the world for wildlife populations) involve the measurement of range and bearing to kangaroos seen from pre-determined routes through the area, and computation of the 'detection function' for each vegetation type on each site to express the probability of kangaroo groups being recorded as a function of distance from the survey transects. 'Pellet counts' are advantageous in wooded areas and where kangaroos are using separate foraging and resting areas because the kangaroos themselves do not have to be seen. Instead the density (No./ha) of kangaroo faecal pellets is measured, then converted to kangaroo density by comparison with a calibration site where the kangaroos can be counted directly. Pellet counts require a statistical sampling design, and both pellet counts and line transect counts are 'stratified' (statistically sub-divided) using the vegetation classes mentioned above.

(C) Allowing for kangaroo population growth

The grassland conservation 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 was 20%, the cull should reduce the density to 0.91/ha and it will end the year at 1.10/ha.

It is easy to under-recognise population growth. It surprises many people that the kangaroo population in Canberra has increased strongly in recent decades. Kangaroos are continuing to reach new sites in the urban area, and subsequently to increase gradually within each site. The population growth rate (PGR) typically observed during drought was 17–20% annual increase. Such PGRs well below the maximum of which the species is capable, result from the combined effects of food limitation, foxes, motor vehicle collisions and domestic dogs. After the drought, higher rates were expected but in a number of cases, these years of long grass were associated with reduced population growth rates. However the capability of the species for higher PGR has been demonstrated many times. For example in the presence of foxes but not vehicle traffic or dogs, the kangaroo population at Belconnen Naval Transmission Station grew at up to 57% per year. Although the food supply is the major limiting factor, it seems likely from this and various other evidence, that in the urban area 'predation' by cars may be significantly limiting the growth rate of kangaroo populations. Fox predation is also likely to be important (fox density is high in the urban area).

Post-cull growth rates are likely to be higher than those of unculled populations and in some locations this effect is greater due to immigration from adjoining unculled areas. 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. The ACT Government has commenced work to enable this rate to be reviewed in future by examining series of annual counts from the same sites in relation to known sources of change such as rainfall, and culling on adjoining areas.

There are often circumstances where net emigration may apply; that is where the culled population is likely to be a source of kangaroos moving out onto adjoining farmland (which is almost invariably culled to lower density than the reserve). It is appropriate to apply expert judgment to allow for the effects of immigration or emigration in deciding the number to cull. The

level of coordination between landholders and the quality of any kangaroo fencing are important considerations in this decision.

WHAT HAPPENS TO THE KANGAROO POPULATION AS A RESULT OF THIS?

Repeated application of this program reduces the kangaroo population compared to what it would have been otherwise. For example the unculled kangaroo population at Red Hill has increased steadily in recent years (Figure 3) whereas even inside the protective fox and cat-proof fence at Mulligans Flat Woodland Sanctuary, by early 2013 the kangaroo density was close to the desired 1/ha as a result of culling (Figure 4). Another feature evident from the charts is that smaller and fewer culls were applied where kangaroos were fewer and population growth was lower, eg at Kama Nature Reserve (Figure 5) probably due to kangaroos moving out onto adjoining rural property (where they are managed to lower density). In other areas, culling was undertaken more often, eg at the Callum Brae woodland (Figure 6) as this site is affected by immigration from an adjoining unculled area. If culling is interrupted or insufficient for any reason, as has occurred at Wanniassa Hills Nature Reserve (Figure 7), little reduction in kangaroo density can be expected. If density is little changed, a benefit to biodiversity is not likely.

CONCLUSION

The papers referenced above confirm the scientific rationale given in the KMP for the conservation culling policy – kangaroo density must be kept below the unmanaged level to conserve the biodiversity of the grassy ecosystems. It is evident from charts such as Figures 2 – 6 that the conservation culling program is being managed in a consistent fashion based on ecological objectives (provided broadly in the KMP). It is also evident that in the several reserves where culling takes place, kangaroo populations are being reduced compared to what they would have been without culling, leaving a managed population in each reserve.

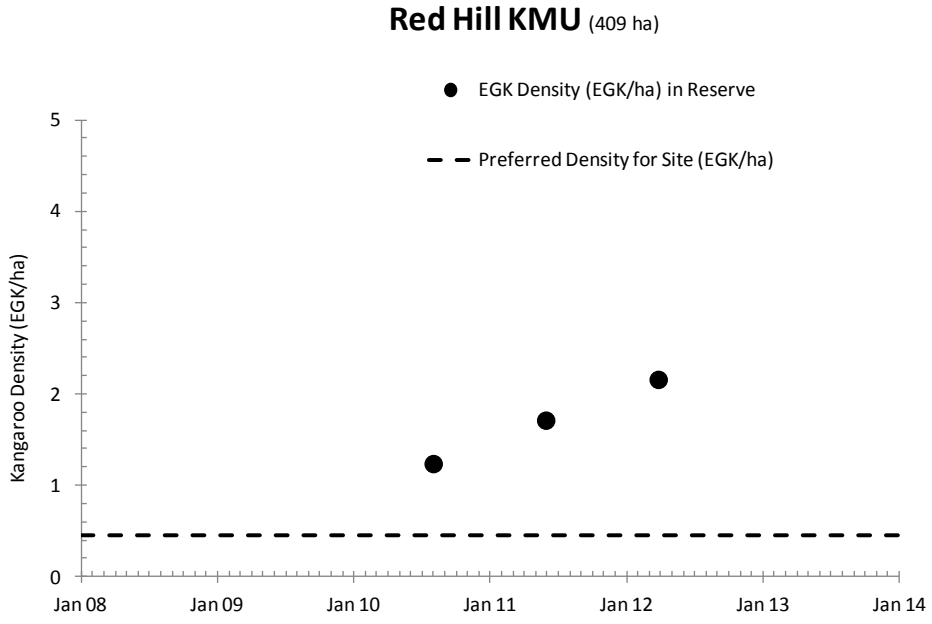


Figure 3: Density of Eastern Grey Kangaroos at Red Hill

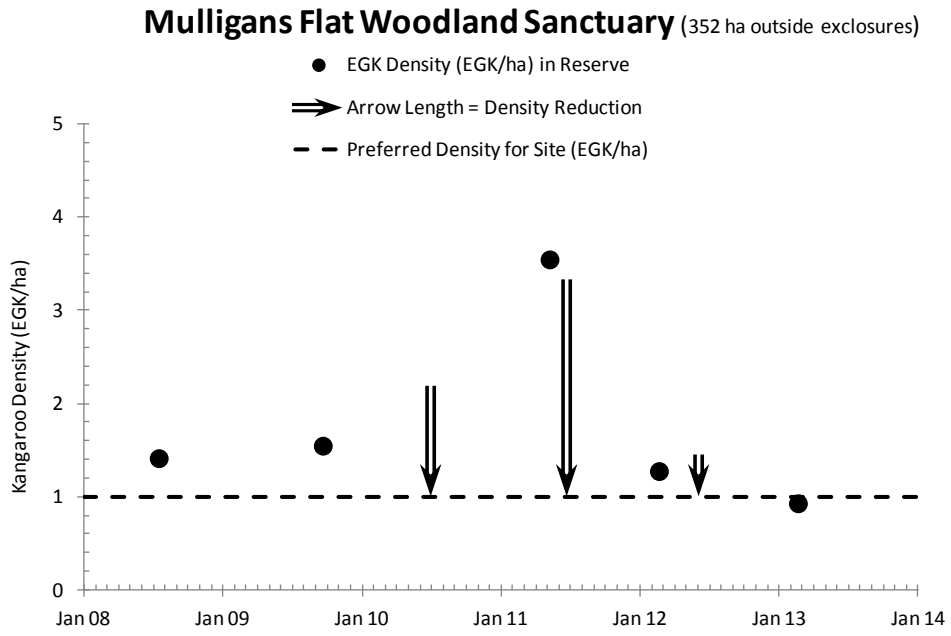


Figure 4: Density of Eastern Grey Kangaroos at Mulligans Flat Woodland Sanctuary (inside fence) showing magnitude of culls, and preferred kangaroo density.

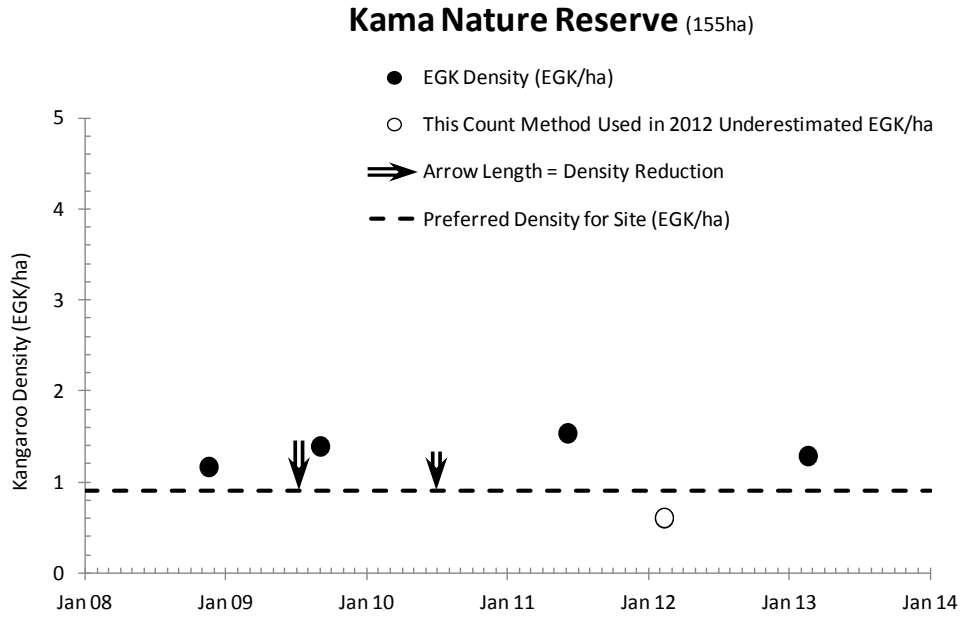


Figure 5: Density of Eastern Grey Kangaroos at Kama Nature Reserve showing magnitude of culls, and preferred kangaroo density.

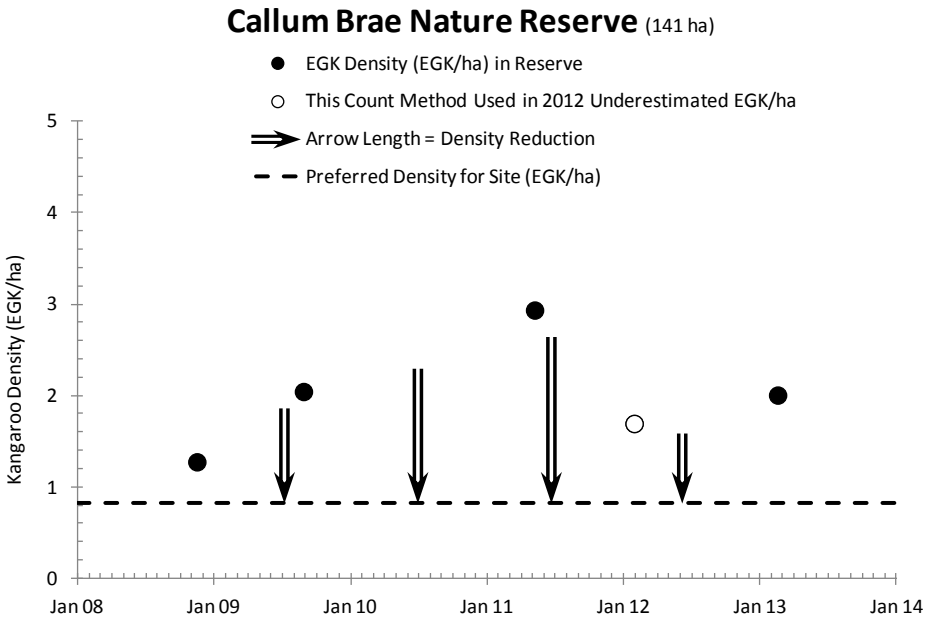


Figure 6: Density of Eastern Grey Kangaroos at Callum Brae Nature Reserve showing magnitude of culls, and preferred kangaroo density.

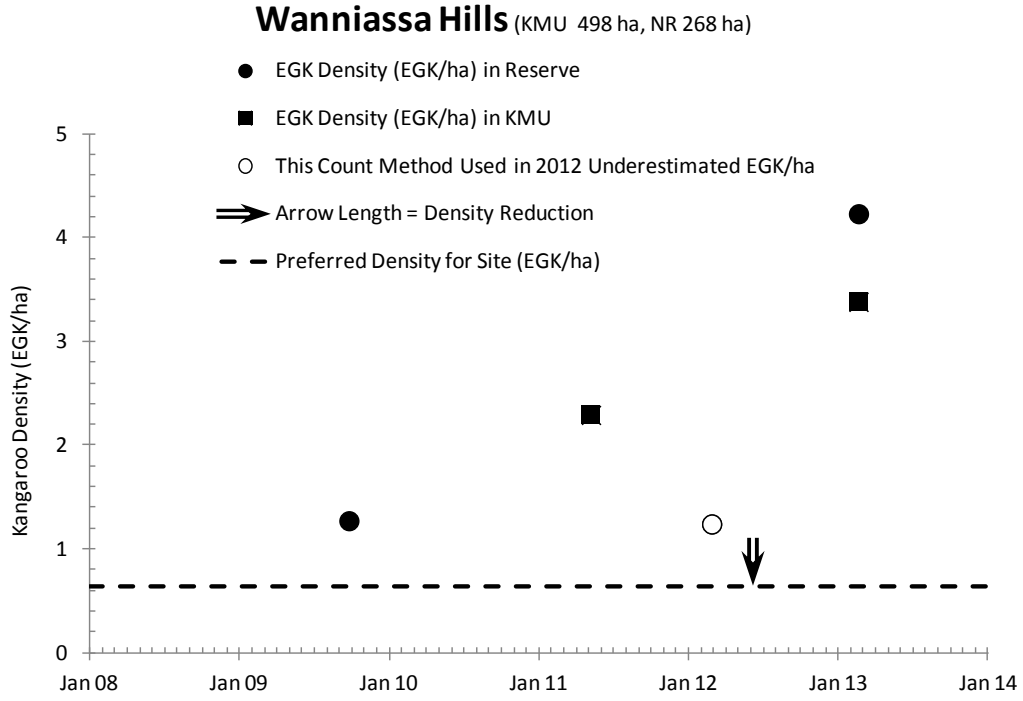


Figure 7: Density of Eastern Grey Kangaroos at Wanniassa Hills Nature Reserve – effectively an unculled site.

REFERENCES

Note: The KMP contains many relevant references. The asterisked sources below were published more recently than the KMP.

Banks PB, Newsome AE and Dickman CR 2000. Predation by red foxes limits recruitment in populations of eastern grey kangaroos, *Austral Ecology* 25: 283–291.

*Barton PS, Manning A D, Gibb H, Wood, JT, Lindenmayer, DB, and Cunningham SA. 2011. Experimental reduction of native vertebrate grazing and addition of logs benefit beetle diversity at multiple scales. *Journal of Applied Ecology* **48:** 943–951.

*Dimond WJ, Osborne WS, Evans M, Gruber B, and Sarre SD. Back to the brink – population decline of the endangered grassland earless dragon (*Tympanocryptis pinguicolla*) following its rediscovery. 2012. *Herpetological Conservation and Biology* **7**: 132–149.

Fletcher D 2007. Managing Eastern Grey Kangaroos *Macropus giganteus* in the Australian Capital Territory: reducing the overabundance – of opinion, in *Pest or Guest: the Zoology of Overabundance*, eds D Lunney, P Eby, P Hutchings and S Burgin (Royal Zoological Society of New South Wales, Mosman, NSW): pp. 117–128.

Fletcher D, Wimpenny C, and Howland B, 2013 in press. *A Map of Vegetation Structure at Canberra*. Technical Report 28. Environment and Sustainable Development Directorate, ACT Government.

*Manning A, Cunningham S. and Lindenmayer D. 2012. Bringing forward the benefits of coarse woody debris in ecosystem recovery under different levels of grazing and vegetation density. *Biological Conservation* **157:** 204–214

*McIntyre S, Stol J, Harvey J, Nicholls AO, Campbell M, Reid A, Manning AD and Lindenmayer D. 2010. Biomass and floristic patterns in the ground layer vegetation of box-gum grassy eucalypt woodland in Goorooyarroo and Mulligans Flat Nature Reserves, Australian Capital Territory *Cunninghamia* **11:** 319–357

Neave HM and Tanton MT 1989. The effects of grazing by kangaroos and rabbits on the vegetation and the habitat of other fauna in the Tidbinbilla Nature Reserve, Australian Capital Territory, *Australian Wildlife Research* **16**: 337–351.