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NSW Kangaroo Inquiry
Portfolio Committee No. 7 – Planning and Environment

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To the Chair,

RE: THINKK response to supplementary questions

Here we outline our responses to the ten supplementary questions posed by the committee, and we provide information on other points raised during our testimony.

1. ***Can you expand on your submission's assertion that the commercial industry began as a response to the landholders killing kangaroos?***

We have written extensively on this topic and consider it vital to understanding the current role the commercial industry plays, and why pastoralists are not, on the whole, interested in participating in a sustainable and ongoing commercial kill. We have previously provided an in-depth and clear analysis of the evolution of the industry (Boom et al., 2012), while more recently we have explored the justifications underpinning contemporary and historical conflict with kangaroos by disentangling the four purported causes for 'unnatural' increase of kangaroo populations (Croft and Witte, 2021).

In Boom *et al.* (2012) we investigated the legal history of Australia's kangaroos. We provided a detailed analysis of how the law and policy governing the killing of kangaroos has evolved over time in response to changing public perceptions. This history begins with the pre-European period and traces the impact of European colonisation, early growth of the commercial kangaroo industry, and the increased role of science and regulation upon kangaroos. The paper critiques the historical designation of kangaroos as 'pests' that need to be 'managed' and argues that such an approach is inconsistent with current scientific understanding. As this 'pest' status has fallen in importance there has been a shift in regulatory goals from damage mitigation to resource utilisation, although government planning and policy continue to cite damage mitigation alongside objectives to maintain viable populations and a sustainable and commercially viable industry.

We also refer the committee to a paper by Lunney (2010) entitled 'A history of the debate (1948-2009) on the commercial harvesting of kangaroos, with particular reference to New South Wales and the role of Gordon Grigg'. Lunney describes the transition from pest management to pest management and utilisation as sustainable resource. He describes the development and

regulation of the commercial industry as the preferred alternative to government agents in the control of the various kangaroo species' populations with reference to the pastoralist/farmer lobby. The change in purpose from damage mitigation to sustainable use as a meat and hide resource was reviewed by Gilroy (2004) when the NSW kangaroo management plan was amended to this effect. It should be noted that the impetus for this change was the inability of the KMP to audit damage mitigation. Even so, current regulation continues to allow killing of kangaroos by landholders under a 'destruction permit' for damage mitigation and the rules have been further relaxed (e.g., no carcass tags are required, and no property inspection is made) so that an audit of this program is not feasible. One of the most esteemed marsupial biologists, Hugh Tyndale-Biscoe, summarized the issue of kangaroo management in 2005 as follows: kangaroo management has three options: full protection, which is impossible from prevailing attitudes; damage mitigation, which should be to prevent future damage but that this was impossible in an unpredictable system; and commercial harvesting, which is difficult to sustain because it would founder in dry years and face a glut in wet years (Tyndale-Biscoe, 2005).

2. ***Have the KMP's changing aims over time adjusted to suit the commercial industry or vice versa?***

The KMP's aims have evolved over time to reflect changing attitudes and knowledge about kangaroos. As referred into in Question 1, the kangaroo industry developed in response to the perceived need for pest mitigation and the desire to export kangaroo products abroad (Boom et al., 2012; Lunney, 2010). As such, it needed to reconcile between the perceived need for pest mitigation and a transparent management process. However, since the primary legal purpose of the KMP is to enable the exports of kangaroo products (Gilroy 2004), it is beholden to often conflicting and changing public expectations.

Until 2002, the only aims of the KMP's were to manage kangaroos as pest species. In the NSW KMP 1998-2002, damage mitigation was the only justification for the issuing of licenses to take kangaroos commercially or non-commercially. Any commercial use was, in fact, solely the by-product of killing kangaroos to mitigate damage (Gilroy, 2004). Section 1.8 of the KMP 1998-2002 states:

> *"Applications to take kangaroos must be justified on the basis that the numbers of kangaroos are such that significant damage to crops or pastoral production or rangeland is occurring or likely to occur. Landholders thus have no prima facie right to take kangaroos independently of this need to rangelands, agricultural lands or pastoral production."*

Research culminating in the mid-1990s at the Fowlers Gap sheep station in the rangelands of norther western NSW, showed that kangaroos do not compete with livestock for food resources, and therefore negated the “pest” perception of kangaroos. Further studies of water use by kangaroos showed that their movements are not influenced by the location of artificial water dams created for livestock, even in times of drought (Letnic and Crowther, 2013; Montague-Drake and Croft, 2004). Whilst this knowledge was not common, it was reflected in regular reviews on kangaroo information commissioned by the NSW KMP team (Herbert and Elzer, 2011; Olsen and Braysher, 2000; Olsen and Low, 2006). These findings ultimately led to the removal of the pest management aim in the KMP of 2002-2006 onwards.

The KMP 2002-2006 had a single overarching goal to “maintain viable populations of kangaroos throughout their ranges in accordance with the principles of ecologically sustainable development”. Importantly, the term “ecological” is used in reference to population numbers and not their roles in the landscape (which would be the common use of ecological sustainability). This same goal remained in place for the 2007-2011 NSW KMP and 2012-2016 NSW KMP.

From 2005, the kangaroo industry was placed under increasing scrutiny by animal protection organisations and academics. A very vocal animal welfare campaign in the UK, based on the welfare of joeys, resulted in the refusal of by large retail outlets to stock kangaroo meat products. Published studies (Ben-Ami et al., 2014; Croft, 2004) and reports (McLeod and Norris, 2004) confirmed that there is a grave animal welfare issue to dependent young, and possibly to adults (Ben-Ami, 2009). In 2018, California, a major export destination for leather goods banned kangaroo skins based on welfare and sustainability considerations. RSPCA Australia, a conservative animal protection organization, revised its assessment of the welfare impacts of the kangaroo industry to include a grave concern for the welfare of joeys that may only be improved through the cessation of the killing of females.

The objectives of the 2017-2021 KMP reflect increased awareness of the welfare of kangaroos. They were revised to include “to ensure kangaroo populations in NSW remain ecologically sustainable; and to ensure the methods of harvesting kangaroos for commercial use are humane.” It is crucial to note that the term “ecologically sustainable” is still not meant in the normative sense of ecosystem integrity. Rather, in the context of the KMP, it refers to sustainable populations, and not the role of kangaroos in the landscape.

The changing objectives of the NSW KMP, in relation to new science and increased awareness, indicate that while it strives to maintain independence, in practice it fails to achieve this imperative. As this inquiry has shown, the welfare of joeys and adults, the lack of certainty around population numbers, and the lack of consideration for the important role of kangaroos in the landscape, are completely at odds with the stated objectives. An explanation for this is that the needs of

maintaining a viable commercial kangaroo industry do not enable the KMP to achieve its stated goals. Therefore, we conclude that it is the commercial industry driving the KMP, and not the consideration of kangaroos and their impact on farmers.

3. ***Do you think that the NSW government or public understands what you said about an ideal carrying capacity / number of kangaroos not existing as it's a subjective value, and what is the implication of this social knowledge?***

To answer this question, it is best to start with the perspective of a production system for domesticated livestock. Management is typically based on the tenet of stocking rate which is an estimate of the number of livestock equivalents (typically dry sheep equivalent or DSE) that the pasture can support without irreversible degradation. In extensive grazing systems, as found in the western division of NSW, the application of stocking rate is not uniform. Some pastoralists fence the perimeter of their property, and ram and holding paddocks, and allow the production flock to free-range over the property aiming to achieve a relatively uniform grazing pressure by providing an extensive network of water sources. The majority of pastoralists divide the property into paddocks but some graze matrilines (ewes, their female offspring and grand-offspring, and so on) and others (the majority) graze age classes (1, 2, 3 year olds, and so on) in individual paddocks. The rams are separated and usually the castrated males (wethers) are grazed independently of the ewe flock. In all these instances stocking is at the recommended rate (estimated as some time in the past by the regulatory authority and then a matter of judgement by the manager) plus 10% to allow for annual mortality. Yet others employ rotational grazing which in effect overgrazes a paddock and then the paddock is rested to recover for some set period. The last group tend to be most hostile towards kangaroo species as they perceive that paddocks cannot be 'rested' if kangaroos move in and graze them. Oversight of stocking rates is weak and penalties for overstocking are rare. There is a conflict of interest from regulatory and industry bodies who derive income from a levy on livestock numbers not on good management.

The common feature of these production systems are that movement is constrained by fencing and purposeful segregation, mating opportunities are limited to optimal times for delivery of young, longevity is limited to productive years, excess individuals are removed (sold to markets), and disease, parasitism and predation are minimised by appropriate interventions. None of these factors apply to free-living and free-ranging kangaroo species. At most there may be an optimal time in the annual cycle for production of young (e.g., populations of grey kangaroos in temperate climate zones). In some species, age and sex classes may segregate over significant portions of their lifetime where they experience different habitat conditions (Coulson et al., 2006). Thus, the concept of a stocking rate or carrying capacity for kangaroo species' populations that occupy very large geographic ranges is complex to apply. Caughley studied the population dynamics of red

and western grey kangaroos in Kinchega National Park and surrounds in far-western NSW (Caughley, 1987). He developed the concept of a centripedal tendency where the populations never reached equilibrium with their resource base but had a tendency to move to the equilibrium point. This leads to under and over-shoots of populations that reproduce under a highly variable climate typical of the Australian rangelands. McLeod studied red kangaroos at Fowlers Gap Station in far-western NSW (McLeod, 1997). In a modelling exercise he concluded "*The results indicated that the concept of carrying capacity could be validly applied to deterministic, or low variance, environments but in stochastic environments that are characterised by a high degree of unpredictable environmental variance the concept is not useful for describing plant-herbivore dynamics*."

Thus, carrying capacity has some currency in coastal temperate regions but not the rangelands. It has been particularly applied in Canberra and surrounds with eastern grey kangaroos that are often limited in mobility through discontinuities in suitable habitat in urban and peri-urban reserves (Territory and Municipal Services, 2010). Even so, the set capacity is somewhat arbitrary and likely to be revised under adaptive management programs. While kangaroo species in the rangelands remain free-ranging, carrying capacity has little currency and should movements be restricted by cluster and barrier fencing then the result will be highly contentious debate about this concept.

Alternative to carrying capacity in the rangelands is the concept of total grazing pressure which is an unrealistic accounting of a the grazing by a herbivore guild where there are synergistic, neutral and competitive interactions (see a full discussion in Croft and Witte, 2021). If one applies the comparative stocking rate measure, Dry Sheep Equivalent, to the densities of cattle, sheep and the four species of kangaroo in the NSW Kangaroo Management Plan, then the majority of grazing pressure (~60%) is exerted by cattle, around 30% by sheep, and 10% or less collectively by the four species of kangaroos. This simple accounting does not include the substantial populations of goats in the rangelands of NSW, horses, donkeys, rabbits, and several other herbivores.

Accordingly, rangeland grazing systems are a complex mix of herbivore guilds, with each contributing differently to grazing pressure. This dynamic varies through time and changes as plant species prosper and decline. There is strong evidence that partitioning of resources occurs (Edwards et al., 1996) and that these grazing functions are important contributors to ecosystem health by facilitating competition among plant species and by contributing to nutrient recycling (Eldridge et al., 2021; Eldridge and Rath, 2002; Iles et al., 2010). As noted in our testimony, the kangaroos are very different foragers to sheep and cattle, being much more selective in the plant material they eat. This lies in stark contrast to the overriding impact of grazing monocultures created by the livestock industry (Eldridge et al., 2016).

Given the clear lack of utility of the carrying capacity concept for managing kangaroos in NSW, the assertion that there is a definitive target for sustainable kangaroo numbers based on carrying capacity is patently unsupported, and can only be justified by subjective assessments of what total grazing pressure should be. These subjective assertions stem from notion that there is an established and static concept of how rangeland ecosystems should look, and that any difference from that view is akin to damage. As discussed in our testimony, the notions of environmental damage and harm are subjective in themselves and not empirically quantifiable, being based on value rather than fact (Sagoff, 2020, 2009). Likewise, the term overabundance is employed in environmental management circles to imply that a population number or density is too high, without the ability to empirically show what the number/density ought to be.

In light of our comments above on carrying capacity, it should be clear that any assertion of overabundance and damage cannot be grounded in empirical fact but is rather employed as a subjective assertion driven by values. While values are vital for guiding decision making, good science policy must be cautious about ensuring they do not override empirical evidence (Yanco et al., 2019). In this case, the empirical evidence roundly shows that herbivory by the kangaroos has vital and important functional and ecological roles in rangeland and temperate ecosystems.

4. ***What are the consequences of the NSW KMP creating commercial killing quotas that pertain to population numbers, but do not reflect the ecological role of kangaroos in the landscape?***

We answer this question in two parts.

a) Basing commercial killing quotas on population numbers

Can the commercial killing of kangaroos be managed sustainably when quotas are based solely on population numbers and trends? We are of the view that there can be no confidence that the setting of sustainable yields currently meets the precautionary principle of preventing population collapse. Population surveys have been shown to incur significant error and correction factors have changed markedly over time. Furthermore, trends in population estimates are difficult to distinguish from the increasing size of management zones, potentially masking decline. Despite this, current levels of sustainable yield are entirely driven by annual trends in population estimates, rather than by biological and ecological information. This is despite sophisticated biological models of population growth being readily available and detailed knowledge of the reproductive biology of the four kangaroo species well known. Based on this latter knowledge, population growth rates under good conditions should centre around 10%. However, population estimates for management zones can often vary in the 10s or 100s of percent between years. For species that do not migrate, these estimates are shocking.

Furthermore, there is currently a 6-month lag between when estimates are made when quotas are enforced, ignoring the possibility of harsh summer conditions impacting upon kangaroo populations. As experts who have written of our concern for the lack of credible science and precautionary measures being used to justify quotas for many years, we have been dismayed at the unwillingness of those responsible for the population surveys and the setting of quotas to take independent advice.

The sustainable yield is a function of the rate at which the population reproduces itself. This can be estimated from the annual fecundity of females in the population. The values from the four species of kangaroos in the NSW kangaroo management plan differ in their reproductive biology (Table 1). Red kangaroos and common wallaroos show a similar potential increase which is higher than that eastern and western grey kangaroos since the latter have a longer age to weaning. The estimate is based on a population of 50% females at breeding age. For comparison, the maximum potential of a meat breed of sheep adapted to the arid and semi-arid rangelands, the Dorper, is higher than any of the kangaroo species.

Some studies have followed a sample of female kangaroos (red kangaroos and common wallaroos) at different ages to estimate lifetime reproductive success and modelled this across a longer set of environmental conditions. For instance, red kangaroos in far north-western NSW (Fowlers Gap station), on average achieve only 41% of their potential (see citation for a full account of red kangaroo reproduction). Other studies (eastern grey kangaroos) estimate the rate of increase from the annual change in populations. Averaged over several studies this is around 20% per annum. In a rangeland production system, the expected loss of lambs is around 10%, which is the discount applied to the estimate for the Dorper.

Species	Age at weaning (months)	Annual fecundity	Overlapping generations	Birth season	*Maximal increase (%)**	Estimated increase (%)
Red kangaroo	12	1.36	3	Continuous	68	28 (Bilton and Croft, 2004)
Common Wallaroo	12	1.32	3	Continuous	66	34 (Ashworth, 1995)
Eastern grey kangaroo	18	1.03	3	Continuous	52	20 (McCallum, 1995)
Western grey kangaroo	18	1	2	Seasonal	50	?
Dorper sheep	11	1.5	1	Continuous	75	67.5

Table 1. Note: overlapping generations only accrue in multiparous females and this may be interrupted by reproductive failure such as under prolonged drought. Primiparous females and females recommencing reproduction after drought-induced anoestrous have a single young after the full age at weaning has elapsed.

**Maximal increase assumes that all juveniles survive and that there is no mortality in the population. This never occurs and is purely a reflection of biological constraints on population growth.*

The realised rate of increase can be positive in a good run of seasons and negative in a period of drought. The estimates in Table 1 are production of young to weaning. However, across the four kangaroo species there may be significant juvenile mortality. This is a function of nutrition, predation (vulnerable to fox and wedge-tailed eagles), disease and misadventure (e.g., roadkill, fence entanglement). Juvenile kangaroos require a higher quality of forage than adults as typified by research on red kangaroos (Dawson et al., 2021). Recruitment of juveniles into the adult population is therefore typically limited to a good run of seasons not every year of a reproducing female's lifetime.

The sustainable yield of the kangaroo management plan (KMP) is further complicated by the bias in the age and sex of individuals killed. In the 2020 annual report of the NSW KMP there is a male bias (NSW Department of Planning Industry & Environment, 2021): red kangaroo (64.1% male), common wallaroo (96.3%), eastern grey kangaroo (68.8%), western grey kangaroo (68%). Furthermore, there is an age bias which is in part a function of the minimum size limit imposed on the commercial industry. This age can be estimated for red kangaroos from age/weight functions [males (Croft et al., 2011), females (Dawson et al., 2021)]. The average carcass weight of female red kangaroos was 18.5 kg (~28 kg live weight) and that of males was 27.6 kg (~42 kg liveweight) which gives ages of 5 years or older for females, and 4 years for males. Thus, the pool of individuals killed in the KMP is not a random sample of the total population but a much smaller subset of age/sex classes. To estimate sustainable yield from this subset requires sophisticated modelling.

We take two lessons from the above: (1) any increase in the estimated population in a management zone from one year to the next that exceeds around 60% is not by reproduction but must be due to immigration into the management zone (there are many instances of this in the historical data presented in the 2020 report), (2) the yield is from a subset of the population and not the total population. These individuals take some years to replace and a whole age cohort may be missing after drought when reproduction ceases (Newsome, 1977).

We strongly recommend that a proper independent review of population estimates and the setting of sustainable quotas be a priority of the committee, and call for all licences to kill kangaroos be suspended until such time that the killing can be agreed to meet scientific standards, as in fisheries, and that all other areas of concern can be addressed (including enforcement and animal welfare).

b) The important ecological role of kangaroos

The NSW KMP includes a section labelled 'Ecological sustainability'. This does not consider the role of a kangaroo species in an ecosystem (e.g., food web) but merely addresses sustainability of the population. For instance, this heading opens with:

> *"Kangaroo populations are monitored using best practice survey methods for the terrain (Payne 2008). Monitoring is undertaken for each species and for each management zone. Population monitoring data are used as the basis for setting quotas and monitoring population health."*

The removal of kangaroo carcasses from an ecosystem and their utilisation in distant domestic and international markets depletes the resources embodied in these carcasses from the ecosystem and, without replacement, is ultimately unsustainable and likened to a process of slow mining. This issue is particularly acute in Australia because of the concentration of the population in an urban fringe and the proclivity to export agricultural products resulting in little *in situ* use in the rangelands and agricultural lands. Furthermore, volcanic activity has ceased and there is little renewal of soils. For the NSW rangelands, at best there is transport of sediment from inland flowing rivers and translocation of topsoils in dust storms from west to east.

The KMP addresses this issue in Table 3 (p. 11) under the heading "*Reduction in soil quality and land stability*". The conclusion is "*There is no evidence to demonstrate a reduction in soil quality or land stability as a consequence of the commercial kangaroo harvest as harvesters generally operate on already-formed tracks. Moreover, kangaroo harvest off cuts have been shown to contribute to soil nutrient retention and cycling, thereby improving soil quality*." For the latter, Wilson and Read (Wilson and Read, 2003) are cited, which was a study boldly entitled "Kangaroo harvesters: fertilising the rangelands". The harvest offcuts represented 26% of the male and 31% of the total female body mass. Thus the majority of the kangaroo is exported and used *ex situ*. The rationalisation is at best a glass third full approach.

The various kangaroo species provide ecosystem services in addition to contributing to grazing and grazing diversity. They create diggings (hip-holes) that may beneficially modify the chemical and physical properties of soils through entrapment of faeces and litter, and soil turnover (Eldridge and Rath, 2002). At a high density (70 kangaroos km^{-2}) in a peri-urban mesic environment, the grazing of eastern grey kangaroos was not detrimental to soil health (Eldridge et al., 2021). Thus they are not responsible for nutrient depletion. However, in another study, the grazing by red kangaroos and eastern grey kangaroos at a relatively high density (not measured) significantly reduced the soil nutrient (total carbon and nitrogen, available phosphorus) pool relative to grazing exclusions at a site with low kangaroo species' density (Morris and Letnic, 2017). These authors

argued this would mute vegetation responses to rainfall. Therefore, to the extent that these nutrients are embodied in the kangaroos, they should be retained *in situ* to maintain ecosystem function. For example on a flood plain, grazing eastern grey kangaroos contributed to local retention of energy (in the carbon pool) and the formation of energy sinks from faecal deposition within feeding sites that was considered beneficial (Iles et al., 2010).

The counter argument to leaving carcasses to lie *in situ* is canvassed in the KMP under the heading "*Positive effects on introduced predators".* Full carcasses or 'harvest offcuts' are consumed by native (Australian ravens, wedge-tailed eagles) and introduced scavengers (foxes, cats, pigs). Except for cats, all of these are considered threats to sheep grazing enterprises. The KMP notes this effect but argues "*Presently harvest off cuts are widely and randomly dispersed across the landscape. It is unlikely that the commercial kangaroo harvest will have more significant effects on threatened flora and fauna than would roadkill carcasses."* There is in fact no evidence that the offcuts are randomly dispersed and logically if roadkill carcasses are acceptable then the additional threat from shot carcasses needs to be assessed and/or roadkill managed.

We argue that if the ecosystem as a whole is examined under ecological sustainability, not simply the population ecology, then the service of mammalian grazers and their place in food webs gains its rightful importance. Accommodation of the kangaroo fauna rather than suppression is more beneficial, as accepted by some graziers, albeit silenced by the opprobrium of their peers (Tyndale-Biscoe, 2005).

5. Have schemes like your proposed Alternative NSW KMP been used before and what were the outcomes?

Compensation schemes for management of human-wildlife conflict and coexistence are well established internationally, with numerous examples (Dickman et al., 2011; Fox et al., 2016; Morehouse et al., 2018). Previous research has identified that wildlife management programs that include non-lethal tools and methods to deter wildlife from production landscapes, as well as compensation schemes for damages caused by wildlife, are far more effective than lethal control (Boronyak et al., 2021; Hasselerharm et al., 2021; Schurch et al., 2021; Stone et al., 2017). Compensation schemes also create a way to gather information relating to the true costs of living alongside wildlife. While mitigation policies based on top-down damage compensation can be successful in some circumstances and are worth exploring, participatory approaches that engage different stakeholder groups in discussion aimed at sharing a deep understanding of the problem and co-creating potential solutions has recently proven very effective at resolving conflicts in pastoral and production landscapes (Boronyak et al., 2021; Jordan et al., 2020; Marino et al., 2021).

Furthermore, wildlife-friendly labelling and certification is a market mechanism that provides a financial incentive to improve ecological stewardship by retaining wildlife in the landscape through demand created by new markets. Wildlife friendly management programs favourably enable pastoralists and crop farmers to coexist with wildlife, including grazing herbivores and predators, but also kangaroos (Edwards et al., 1996). We support exploration of compensation schemes and participatory schemes that may assist coexistence with kangaroos; schemes that may include non-lethal mitigation tools (e.g., guardian dogs), education on adopting sustainable and wildlife-friendly farming practices, and fencing maintenance. Key to success is engagement of all stakeholders (Boronyak et al., 2020), the setting of clear and transparent goals (Simmons, 2017; Yanco et al., 2019), the establishment of mechanisms to collect sociological and ecological empirical evidence (Laverty et al., 2019), and independent oversight.

6. Why do you think killing of kangaroos in agricultural circles remains the norm?

It remains the norm for reasons explained in our answer to Question 1. The desire to eradicate indigenous people and wildlife was entrenched during colonisation and the legacy of this remains strong through the declaration that kangaroos are pests (Boom et al., 2012; Croft and Witte, 2021; Lunney, 2010).

However, there is growing awareness of the benefits of coexistence with kangaroos and an increasing willingness in the farming sector to try different methods. We speak with many farmers who have not managed their kangaroos for many years and they report that their farms can remain profitable and, in fact, can become more resilient during drought as they manage their own grazing livestock and land in different ways. Without government support, these coexisting farmers efforts and knowledge remain isolated. Farmers who wish to advocate for these alternatives are vilified and afraid to speak up. Government support is needed to legitimise their efforts and to support their desire to produce food sustainably and in harmony with the environment and wildlife.

7. In everyday practice, what does co-existence between kangaroos and humans look like in the agricultural context?

We believe the answer to this question lies in the detail we have provided in answers to other questions, specifically Questions 5, 6, and 8, and in our original submission. However, there are existing examples of long-term coexistence with kangaroo on working farms (e.g., Fowlers Gap) that highlight the scientific support for coexistence. As noted in our answer to Question 6, there are many other examples of farmers coexisting with kangaroos out there but their knowledge has been ignored and those farmers ostracised. We would also implore the government to invest in learning from indigenous stakeholders on coexistence, and the vital reorientation of sustainable farming practice that the “living with country” philosophy can provide.

8. What do you think are the largest areas of opportunity when it comes to co-existence between humans and kangaroos and wildlife acceptance by landholders and what has prevented this from happening so far?

We answer this question in two parts.

a) Opportunities

- Engagement with coexistence models developed internationally, including compensation schemes and participatory schemes (Boronyak et al., 2021, 2020; Jordan et al., 2020).
- Collection of sociological and ecological empirical evidence to transparently support coexistence strategies (Hasselerharm et al., 2021; van Eeden et al., 2019; L. M. van Eeden et al., 2020, 2020).
- Adoption of One Health frameworks to parameterise relationships between people, livestock, wildlife, and the environment (Yanco, 2021).
- Engagement in education and communication programs in rural communities to support more expansive views of sustainable living (Yanco et al., 2021).

b) Barriers

- Ongoing government support for exclusion and eradiation of kangaroos.
- Ongoing government support for the commercial killing of kangaroos.
- Ongoing government endorsement of killing practices that incur significant welfare harm and promote the objectification of other animals.
- Lack of government support for farmers wishing to engage in coexistence practices.
- Lack of independence of decision making on kangaroo welfare and conservation.

9. What are your thoughts on the NSW Farmers Federation submission stating that aerial surveys underestimate the numbers of kangaroos as national parks are not included?

We addressed the concern over the reliability of population numbers as part of our answer to Question 4. We also support the testimony of Ray Mjadwesch and Claire Galea who provided clear and detailed analysis of why population assessments likely represent a significant overestimate of kangaroo numbers. In regard to the claim that kangaroo populations are underestimated because national parks are not surveyed, we would point the NSW Farmers Federation to KMP and purpose of the aerial count and estimates – the goal is to set harvest quotas for kangaroo management zones. Commercial killing is not allowed in national parks, hence counting in national parks would contribute to the overestimation of sustainable harvest totals. However, there are already aspects of the methodology used to estimate population numbers that already grossly inflate numbers.

Counting the number of the four commercially killed kangaroo species is challenging, given the vast size of the commercial kill zones. We believe that current methods used to estimate the population of the four species are flawed and inaccurate. Concerns arise over the representativeness of surveying kangaroos from the air and the mathematics used to account for unobserved kangaroos and to calculate populations estimates. Population estimates for management zones are predominantly based on aerial surveys of transects in each zone to count kangaroos. Not all kangaroos present on the transects are observable by air, so corrections to accommodate missed kangaroos are used. Average densities observed on transects (kangaroos/km^2) are then used to calculate total estimates for management zones (area of zone multiplied by average density). The use of correction formula has been roundly criticised because the formula are routinely changed, correction formula have increasingly predicted unobserved kangaroos over time, and correction factors do not utilise best available science and remain unproven in scientific literature. Furthermore, by using the entire area of management zones to estimate population sizes assumes uniformity in kangaroo density across regions which ignores vast areas where kangaroos are absent.

The combination of these issues leads to overestimation of numbers, and therefore over-allocation of commercial shooting quotas. Large fluctuations in population estimates reported by the government between years cannot be explained by climatic conditions or movement, and do not correspond with the reproductive biology of the commercially killed species. We question the validity of population estimates and are concerned by regional population depletions, particularly in times of drought (Pople, 2008).

Kangaroos face multiple threats including commercial and non-commercial shooting, extreme weather events (i.e., drought, fire, and flooding), habitat destruction, disease, vehicle strike, entanglement in fencing, and restriction of movement by exclusion fencing. These factors seriously impact the health and welfare of kangaroos. Local and regional extinctions have been observed in 2019 and 2020, with kangaroo populations further decimated by devastating bushfires, floods, and drought. Wildfires impacted an estimated 4.96 million macropods including kangaroos, wallabies, and pademelons. Kangaroos that were not killed by the fires suffered from injuries, predation, and lack of access to food and water. This occurred on top of ongoing and excessive land clearance rates in NSW, removing woodland kangaroo habitat in temperate and semi-arid regions and limiting resource availability. Despite rhetoric to the contrary, there is no evidence to support the notion that land clearance and the installation of water points has not benefitted kangaroos, because the presence of kangaroos depends on habitat, not water availability (Letnic and Crowther, 2013; Montague-Drake and Croft, 2004).

In light of these issues (current overestimation of population numbers, multiple threats), we believe that kangaroo numbers in the management zones of NSW are inflated. That some kangaroos persist in national parks has little bearing on population estimates, primarily because the purpose of national parks is to conserve wildlife, including kangaroos, but also because migration and movement of kangaroos outside of national parks is negligible.

10. ***Can you comment on Kangaroo Management Taskforce stating that "large increases in kangaroo populations, or irruptions, have significant implications for both natural resource management and sustainable agriculture while the starvation of millions of kangaroos during drought is an untenable animal welfare outcome for our beloved national icon"?***

We answer this question in two parts.

a) That kangaroo populations irrupt and impact on NRM and agriculture

Let us consider this question firstly in terms of the plausibility of irruption, and then impact on agriculture. Quantitative evidence for irruptions of kangaroo populations is lacking and not supported by knowledge of the reproductive biology of the different species (see evidence provided in Question 4), nor evidence from *in situ* tracking of populations (as opposed to changes in population estimates from aerial counts, which we have already declared as inaccurate). The kangaroos are, for the most part, slow breeders and juvenile recruitment is low and constrained by environmental and climatic conditions.

Documented and peer-reviewed evidence for the impact of grazing by kangaroos on agriculture is relatively sparse. Studies conducted in the 1990s by CSIRO observed that the impact of kangaroo grazing in the wheat belt of WA was negligible and constrained to property boundaries (Arnold et al., 1991, 1989). As we stated in our submission, after 10 years of data analysis from semi-arid NSW, including two drought periods, the conclusion was reached that competition between sheep and red kangaroos for resources is negligible, and that increased productivity from sheep would be unlikely if red kangaroos were killed (McLeod, 1996, p. 106):

> *"The current justification for culling red kangaroos in the rangelands is to minimise the effect of competition between domestic stock and kangaroos for native pasture* (Shepherd and Caughley, 1987)*. The present study indicates that under most conditions, red kangaroos have a negligible effect on the productivity of sheep and that culling at these times is unjustified. During times of drought, culling is justified but significant increases in sheep productivity should not be expected."*

Unfortunately, much of the assumed impact relies on anecdotal information and does not consider the complex land use decisions that may lead to landscape susceptibility to drought conditions. As a response to this, we strongly advocate for participatory schemes that engage farming communities and key stakeholders like the Kangaroo Management Taskforce with independent scientific experts to work together assist farmers to find sustainable solutions for coexistence and improved landscape resilience.

b) That starving wildlife is an untenable animal welfare outcome

There is currently no clear obligation to intervene on behalf of wild animal welfare. Ethical and philosophical discussion of *why* and *when* we must mitigate poor welfare of wild animals is currently in its infancy (Soryl et al., 2021). What is clear, however, is that the expectation that wild animals should always experience good welfare is unsupported by any reasoned argument. All wild animals, and all people, experience poor welfare at times in their lives. However, the possibility, or experience, of poor welfare is not used to negate the agency and autonomy of people, nor should it be used to negate the agency and autonomy of other animals. Attentiveness to individuals, their families, and their culture is of paramount concern, as the welfare of a mob of kangaroos is also a matter of ethical and spiritual inquiry. While there may be positions supporting intervention built around consequentialist ethics ("for the greater good") or else deontological ethics ("duty to address human-caused environmental impacts on wild animals"), these have been routinely argued against in scientific discourse (Batavia et al., 2020; Vucetich and Nelson, 2007) and more widely (Mathews, 2012). Hence, the inquiry on kangaroos must be wary of arguments that seek to weaponise welfare on behalf of other objectives (Mathews, 2013; Ramp, 2013).

If an argument could be made to intervene, the question of *how* matters greatly. The commercial killing industry is not in a position to address concern over mass wild animal welfare for three very clear reasons: (i) as a profit driven industry it seeks to take only the healthiest individuals, (ii) interferes with natural selection, and (iii) the method of killing incurs poor welfare outcomes for those shot, their young, and survivors.

Further points of note arising from discussions during our testimony:

1. The rate of new and emerging infectious diseases (disease-causing agents that rapidly increase in geographical range, host range, or prevalence) is globally increasing (Tompkins et al., 2015). Covid-19 has highlighted the need to manage the human-wildlife interface carefully, systematically, and hygienically. A survey of 1,410 human diseases found 61% to be of potentially zoonotic origin (Karesh et al., 2005), and wild animals are linked to 75% of emerging human diseases (Brown, 2004). Crossover seems mostly

linked to human contact with wildlife through the wildlife trade from remote locations. Problematically, contamination of kangaroo meat is logistically unavoidable because carcass guts are eviscerated (butchered) in the field by minimally trained shooters (THINKK, n.d.). Carcasses are transported in the open air, gathering dust and flies and stored in remote chillers until collection by the meat processing companies. Shot kangaroos can sometimes be processed up to 14 days after deposition in chillers. As wild-caught animals, kangaroos carry parasites and diseases that threaten human health, but products are not tested for zoonotic pathogens like *Salmonella spp.* and *Toxoplasma gondii,* which can have serious long-term human health implications. Russia banned contaminated kangaroo meat imports in 2009, 2012, and 2014. In response, processors have been applying lactic acid to decontaminate meat, a process that is banned in the European Union. However, best practice in meat production requires that the entire process of production, from evisceration in the field, transport, cold storage, and butchering, should be hygienic, with minimal opportunities for contamination. Reliance on dousing of carcasses in acids to decontaminate meat is entirely unsatisfactory. We recommend that hygiene standards be improved by using closed refrigerated trucks to transport kangaroos from the point of kill to the chillers, and that trained butchers supervise the degutting of shot kangaroos. For evidence and details of hygiene concerns with kangaroo meat (both fillet and mince), please see *Addendum 2* for testing data and analysis collected over a number of years by Dr Dror Ben-Ami.

2. The loss of individuals to road mortality can affect the population structure, growth rate, and persistence of animal populations (Fahrig, 2007; Fahrig and Rytwinski, 2009; Ramp and Ben-Ami, 2006; Roger et al., 2011). Historic and recent examples highlight that abundant species are not immune to becoming threatened or locally extirpated. Common species can readily succumb to population pressures, yet legislation and management have been particularly slow in recognising both their ecological importance and the precariousness of common species status. How these individuals are replaced has not been addressed, and it is clear that road mortality influences the dynamics of animal populations far from roads (Ramp and Roger, 2008; Roger et al., 2012). Efforts to mitigate road collisions have proven elusive primarily because of complacency (Ramp et al., 2016) and because the most effective solutions are found when modification of road design and raising awareness (Rytwinski et al., 2016), rather than increasing persecution of wildlife (Ramp, 2010). Although collisions between animals and vehicles can result in loss of human life and damage to vehicles, the number of animals killed or maimed incurs a major welfare cost to wildlife. Furthermore, welfare costs to wildlife rescuers and rehabilitators have been linked to significant and ongoing mental harm, termed *compassion fatigue*

(Englefield et al., 2018). It is clear that vehicle collisions are a major source of mortality for many wildlife populations in NSW, including kangaroos. However, the suggestion that further reduction of kangaroos is the answer to reducing collision rates remains a strategy unsupported by scientific evidence, is unethical, and lies well outside social norms of compassion.

3. The statement that kangaroos of any species "eat out the whole country" is a ludicrous and unscientific overgeneralisation. The pasture and shrub layers used by mammalian herbivores comprise palatable and unpalatable species of plants (Koerner et al., 2018). The palatable species may have different digestibility and so different species express preferences among these, as has been widely shown for the kangaroos (Dawson and Ellis, 1996, 1994). Furthermore, some plant species have protections against herbivory (e.g., spines, high salt content (Belovsky et al., 1991)), some may be overshadowed by other vegetation and are out of reach of the herbivore, and some may have a growth form (e.g., long swards) that large-mouthed bulk feeders such as cattle can accommodate, but small mouthed and specialised feeders like kangaroos cannot. Thus, to suggest that kangaroos of any species consume anything and everything is nonsense. The UNSW Arid Zone Research Station at Fowlers Gap in far north-western NSW has produced decades of research highlighting these scientific principles, a fact that is well known to UNSW Sydney faculty. UNSW research on the physiology, behaviour and ecology of all four kangaroo species in the NSW Kangaroo Management Plan universally refutes gross embellishment of kangaroo foraging (Dawson, 2012; Edwards et al., 1996). Despite this, recent work conducted on grazing of kangaroos has attempted to show otherwise (Letnic and Crowther, 2013; Mills et al., 2020) but is reliant on extremely weak methodology (primarily on kangaroo dung sampling which is a measure of presence, but not dwell time) and makes no attempt to distinguish among different kangaroos (i.e., assumes they are all the same) (Morris and Letnic, 2017). Reliance on the dingo fence as the pinnacle of experimental research has been roundly criticised by rangeland ecology experts (Croft and Witte, 2021). However, areas to the south and east of Sturt National Park and into adjoining pastoral properties, where kangaroo populations are supported, show clear prosperity in the density and cover of chenopod shrubs and curly Mitchell grass, with substantial recovery in the Park beyond the scars of past livestock overgrazing (around watering points and in holding paddocks) (Montague-Drake and Croft, 2004). Furthermore, Sturt NP is home to a number of threatened mammal species (Kloecker, 2010), endangered plant communities (https://www.environment.nsw.gov.au/research-and-publications/publications-search/sturt-national-park-plan-of-management accessed 22/6/2021), and a Ramsar site with a number of endangered plants

(https://www.environment.gov.au/water/wetlands/publications/ris-lake-pinaroo accessed 22/6/2021), all despite the presence of kangaroos. Finally, we know of no scientific evidence that plant species have become endangered due to kangaroos.

4. The productivity of kangaroo species as a source of meat in often misrepresented as an instantaneous value rather than a lifetime (to point of killing) value. For instance, Wilson and Edwards (Wilson and Edwards, 2019) provide an detailed analysis of the comparative meat yield from kangaroos and beef cattle and their environmental costs. They address productivity as "they [kangaroos] do grow more slowly and further allowances need to be made to the comparison, p.219". The THINKK group made a detailed analysis of the productivity of male red kangaroos (50 kg liveweight as preferred by the commercial industry) and Dorper sheep (Croft et al., 2011). We do not reproduce the detail of our analysis here, but our summary was:

   "Thus it is clear that a specialised meat sheep for the rangelands like the Dorper will reach about 45 kg in a year whereas a male red kangaroo may take around 5 years to reach the same weight (or about 2 years to reach 25 kg). On the basis of lifetime not instantaneous energy use, red kangaroos are likely to use more total energy than sheep in yielding the same amount of meat. In an environment with low primary productivity like the rangelands, going slow (the kangaroo strategy) may be evolutionarily sound but production on the ephemeral bounty described in (Freudenberger et al. 1997) favours a fast grower like sheep. Since both species of grey kangaroo have slower growth to weaning than red kangaroos or common wallaroos (1.5 vs 1 year), the total energy use of grey kangaroos for a given meat yield is likely to be even more. The point we make is that meat sheep have been selected for meat production and kangaroos (of any species) have not. With an appropriate lifetime analysis, sheep produce weight for weight a meat product at similar or more likely lower total energy consumption than kangaroos."

   The lesson here is beware of simplistic analyses of the economic and ecological benefits of kangaroo meat production.

5. During our testimony there may have been some confusion around the difference between *exclusion fencing* (which completely prevents the movement of wildlife and encourages their eradication within enclosed production lands) and *livestock fencing* (fences that restrict movement of livestock but which allow movement of wildlife and limit entanglement). Exclusion fencing is a concept that we wholeheartedly do not support. The primary motivation of exclusion fencing is not just the eradication of dingoes, but also the

removal of all wildlife, particularly kangaroos. In our experience, farms with exclusion fencing actively shoot and poison wildlife to reduce their populations to zero. However, in our testimony and original submission we did refer to the notion that the repair of livestock fences should be considered as part of compensation schemes. Where it can be shown that farmers proactively and peacefully support wildlife on their lands, we would support the consideration of livestock fencing repair costs (but not exclusion fencing) being compensated through a government coexistence initiative where it can also be directly shown that wildlife are the source of damage (i.e., not from trees or livestock).

If further clarity on these issues is required, we would be most willing to provide further advice.

Sincerely,

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