Portfolio Committee No. 7 – Planning and Environment

Inquiry into the health and wellbeing of kangaroos and other macropods in New South Wales

Hearing held on 19 August 2021

Supplementary Questions

Questions for the NSW Department of Planning, Industry & Environment (DPIE)

Prosecution Guidelines

1. On p2 of the transcript, Executive Director Sharon Molloy makes reference to having very modern, up to date compliance program which includes prosecution guidelines. Please furnish a copy of the prosecution guidelines to the Inquiry.

ANSWER:

1. The prosecution guidelines are available at: www.environment.nsw.gov.au/research-and-publications/publications-search/oeh-prosecution-guidelines.

Population Growth

2. On p3 of the 19th August hearing transcript Terry Brill, Senior Team Leader, Kangaroo Management, stated that "the calculations and assumptions that were provided that the 10 per cent [kangaroo reproduction rate] is based on is contrary to the science". Testimony by DPIE states that the most appropriate method of incorporating biological constraints on rates of population growth are through the modelling of annual population estimates.
   a) Please cite the peer-reviewed scientific research and reports relied upon for making this statement.
   b) On p4 of the 19th August hearing transcript Dr Mcleod stated that "under good conditions pouch survival can approach 80 per cent or 90 per cent under some good conditions. That is why we see spectacular rates of increase under some conditions."
   c) Please cite the peer-reviewed scientific research and reports relied upon for making this statement.

ANSWER:

2. (a) Please see the Department of Planning, Industry and Environment's (the Department's) answer to Supplementary Question 5 from the 15 June 2021 hearing, including citations.

   (b-c) Frith and Sharman (1964) studied red kangaroo populations in NSW and southern Queensland. At their most southerly study site, at Toganmain in the Riverina region of NSW,

they studied kangaroos during a period of above average rainfall and pasture conditions. They examined the pouches of mature females (n= 550) for the presence of pouch young (which were placed into two age groups: 0–196 days and 197–365 days) and long teats (indicative of a young-at-foot). They concluded (p. 103) that for that population at the time, "If there were no mortality in this age group of young, the percentage of young 197–365 days old should be the same as the percentage of pouch young 0–196 days old, when corrected for the difference involved in the different lengths of time considered: 196 days against 169 days." Once this correction is made, their results indicate that there was virtually no mortality in pouch young at that time.

Frith and Calaby (p133, 1969) commented further on these results, stating "At Toganmain, a mild environment where during the sampling in 1960–61 pastoral conditions were excellent, there were precisely 14 per cent less of the older age group than the younger, showing that under these conditions there had been virtually no mortality of young at foot. Practically every young one that left the pouch lived to maturity."

This result establishes that, under good conditions, the survival of red kangaroo pouch young can exceed 80–90 per cent.

References

Frith, H. J., and Calaby, J. H. (1969). 'Kangaroos'. (F.W. Cheshire: Melbourne.)

Frith, H., and Sharman, G. (1964). Breeding in wild populations of the Red Kangaroo, *Megaleia rufa*. *CSIRO Wildlife Research* **9**, 86–114.

3. Does DPIE have similar statistics for grey kangaroos that would support the testimony that 90% young survive and are recruited into breeding populations.

ANSWER:

3. The Department is not aware of equivalent data collected for grey kangaroos. However, there are studies that indicate the survival of pouch young and young-at-foot can be high. Banks et al. (2000) observed that, in areas of Namadgi National Park in the ACT where foxes were controlled, the proportion of female eastern grey kangaroos with pouch young or young-at-foot exceeded 0.9 for long periods of the breeding period, suggesting that survival of dependent young at this time was high. Furthermore, they measured the rate of increase in these populations and found finite rates of increase of 1.60 and 1.73, indicating that recruitment was high. A further study by King et al. (2017) measured survival as a function of pouch young body condition in eastern grey kangaroos and found that survival was variable but peaked at 82 per cent for young with high body condition. Together, these studies indicate that under good conditions, the survival of pouch young can approach or exceed 80–90 per cent.

References

Banks, P. B., Newsome, A. E., and Dickman, C. R. (2000). Predation by red foxes limits recruitment in populations of eastern grey kangaroos. *Austral Ecology* **25**, 283–291.

doi:10.1046/j.1442-9993.2000.01039.x

King, W. J., Festa-Bianchet, M., Coulson, G., and Goldizen, A. W. (2017). Long-term consequences of mother-offspring associations in eastern grey kangaroos. *Behavioral Ecology and Sociobiology* **71**, 77. doi:10.1007/s00265-017-2297-1

4. On p6 of the 19th August hearing transcript Dr Cairns stated that 'I think with kangaroos in eastern Australia there have been three major climatic events which have done a lot to shape the populations. They were the 1982-83 drought, the millennium drought and this most recent drought in 2017 to 2019. In between those droughts kangaroo numbers have increased and increased quite substantially. Dr Cairns can you advise as to the maximum number of joeys an eastern grey and a red kangaroo can rear from pouch to independent young adulthood in a two-year period of average or above average rainfall?

ANSWER:

4. Life history statistics are described in numerous reference texts and associated peer reviewed scientific journal articles (e.g. Dawson 1995, Tyndale-Biscoe 2005). Briefly, red kangaroo juveniles have a pouch life of approximately 235 days and a period as a young-at-foot joey (while being weaned) for approximately 125 days. The following is the maximum possible number of joeys, say following above average rainfall. Within a 12-month period, females can be rearing three young at different stages, but only suckling a maximum of two at any one time. A female giving birth can have a young-at-foot that has recently exited the pouch. There is a post-partum oestrous (the oestrous cycle is only one to two days longer than gestation), and conception leads to a delayed embryo (diapause)). The embryo resumes developing following loss of the pouch young or its permanent exit from the pouch exit, and is born shortly after. This means there can potentially be approximately 1.5 independent young in 12 months (Jonzen et al. 2010).

   Eastern grey kangaroo are slower breeders. Their juveniles have a pouch life of approximately 320 days and a period as a young-at-foot for approximately 220 days. The following is the maximum possible number of joeys for eastern grey kangaroos. Again, a female giving birth can have a young-at-foot that has recently exited the pouch. There is no post-partum oestrous (the oestrous cycle is 10-days longer than gestation) but, uncommonly, a female may mate when the pouch young is approximately six months old and a delayed embryo will result. Usually, following permanent pouch exit, females will come into oestrous, mate, conceive and then give birth approximately 12 months (or, in the case of a delayed embryo, approximately 10 months) after the previous birth. This means, potentially about one independent young (or approximately 1.1– 1.2, with a delayed embryo) in 12 months.

References

Dawson, T. J. (1995). 'Kangaroos: Biology of the Largest Marsupials.' (University of NSW Press: Sydney.)

Jonzén, N., Pople, T., Knape, J., and Sköld, M. (2010). Stochastic demography and population dynamics in the red kangaroo *Macropus rufus*. *Journal of Animal Ecology* **79**, 109–116.

Tyndale-Biscoe, H. (2005). 'Life of Marsupials.' (CSIRO Publishing: Melbourne.)

Kangaroo Movement/Migration

5. On p6 of the 19th August hearing transcript Dr Cairns stated that "that the first record of eastern grey kangaroos west of the Darling River was in 1972, so prior to that there were effectively no eastern grey kangaroos in that rangelands country west of the Darling River. But with changes in pastoral practices, particularly putting in lots of watering points, it has created an environment that suits eastern grey kangaroos."

   Please furnish the scientific evidence that the increase in water points caused the migration of grey kangaroos to the rangelands.

ANSWER:

5. Denny (1975) reported that, by consensus, in the late 1960s and early 1970s the Darling River defined the western boundary of the distribution of eastern grey kangaroos in NSW. Denny went on the report that in 1973, occasional small groups of eastern grey kangaroos could be encountered in the Wanaaring and Tibooburra areas; these groups being of individuals at the edge of, or out of their range. Matching these observations were destruction permit applications for west Darling properties, which showed initially in 1970 no requests for licences to take eastern grey kangaroos, but later requests for small number of licences for this species in 1972. These properties were on average some 230 kilometres west of the Darling River.

   At this time, population estimates for the northwest corner of NSW suggested that (eastern and western) grey kangaroos comprised less than one per cent of the total kangaroo estimates, with the red kangaroo predominating (Denny 1975; Caughley *et al.* 1977).

   Shepherd (1982) redefined the western boundary of the distribution with a line running north through Balranald to about Mount Hope and then pitching northwest through Wilcannia and on to Tibooburra, suggesting a westward move by this species. Prior to the last drought, a small number of eastern grey kangaroos were found west of the South Australian-NSW border (S. C. Cairns, pers. comm.)

   Caughley et al. (1984) also report on the expansion in the range of grey kangaroos. Greys were recorded just west of Wanaaring in 1962 (Caughley 1962). The two species were not distinguished taxonomically until 1972.

   Dawson (1995) reported that both grey species were not recorded at Fowlers Gap north of Broken Hill until the 1970s, following a series of wet years.

   Pople (2006) described a continued westward shift in the pattern of distribution of both species of grey kangaroos in northwestern NSW, based on aerial survey data from 1984–

2003.

Denny (1975), in part, attributed this move westward of this species to habitat destruction with the expansion of cropping in the northern Darling River basin. James *et al.* (1999), in an extensive review of the effect of water points in the rangelands, point out that where established, these structures sustain local kangaroo populations.

References

Caughley, G. (1962). The comparative ecology of the red and grey kangaroo. MSc Thesis. (University of Sydney, Sydney.)

Caughley, G., Brown, B., Dostine, P., and Grice, D. (1984). The grey kangaroo overlap zone. *Australian Wildlife Research* **11**, 1–10.

Caughley, G., Sinclair, R. G. and Wilson, G. R. (1977). Numbers, distribution and harvesting rate of kangaroos on the inland plains of New South Wales. *Australian Wildlife Research* **4***,* 99–108.

Dawson, T. J. (1995). 'Kangaroos: Biology of the Largest Marsupials.' (University of NSW Press: Sydney.)

Denny, M. J. S. (1975). The occurrence of the eastern grey kangaroo (*Macropus giganteaus* Shaw) west of the Darling River. *Search* **6**, 89–90.

James, C. D., Landsberg, J. and Morton, S. R. (1999). Provision of watering points in the Australian arid zone: a review of effects on biota. *Journal of Arid Environments* **41**, 87–121.

Pople, A. R. (2006). Modelling the spatial and temporal dynamics of kangaroo populations for harvest management. Final report to the Department of Environment and Heritage. (Anonymous: Canberra.)

Shepherd, N. C. (1982). Extension of the known range of western grey kangaroos, *Macropus fuliginosus*, and eastern grey kangaroos, *M. giganteus*, in New South Wales. *Australian Wildlife Research* **9**, 389–391.

Welfare

6. On p11 of the 19th August hearing transcript Terry Brill stated: We do not go out with shooters at night and inspect those. We do inspect in the chillers and you can determine things regarding neck shots and things like that. But I guess you are right. I guess there is a little bit of scope for interpretation or a scope for error."

7. Given the Department's other management objective is to ensure a humane outcome for kangaroo, can the Department explain how (including methodology and KPI's used) this objective is being met given there is no monitoring at the point of kill, and multiple studies indicate that young at-foot are killed inhumanely with field evidence of kangaroo remains indicating that a high percentage of adults are not shot in the head?

ANSWER:

6–7.

Monitoring of compliance is done by inspection of carcasses. The Royal Society for the Protection of Animals (RSPCA) has conducted two audits of the incidence of cruelty to kangaroos during commercial and non-commercial culling, one published in 1985 (RSPCA Australia 1985) and another in 2002 (RSPCA Australia 2002). In the 1985 study (which pre-dated the introduction of the Code of Practice), the overall percentage of head shot kangaroos in Australia was estimated to be 86 per cent, although there was considerable variation between states, with NSW at 95 per cent and Western Australia at 81 per cent. In the 2002 report, the overall percentage of animals shot in the head—which had become a requirement of the Code—had increased to 96 per cent. In NSW, compliance had increased from 95 per cent to 99 per cent.

The study by McLeod and Sharp (2014) specifically examined the humaneness of methods used to euthanise dependent young. To the best of our knowledge, this is the only field study that has recorded the procedures of commercial shooters and monitored compliance with the Code at the point of kill. They found that currently used euthanasia methods, when applied correctly, are effective and humane. They state "For unfurred pouch young, decapitation (with or without cervical dislocation) and blunt trauma to the head are unlikely to cause suffering. With partially furred and fully furred in-pouch joeys, the most suitable method that is currently available is blunt trauma to the head. Blunt trauma to the head is also recommended for joeys at the in/out stage of development that are in the pouch when the mother is shot or can easily be caught by the harvester. Young-at-foot are very mobile, and gunshot is the most suitable method for the euthanasia."

There is only one scientific study (Sharp 2015) that recorded the accuracy of commercial kangaroo harvesters in the field at the point of kill. Sharp found that "Of the 278 adult kangaroos that were shot, 9 of these (3.2 per cent) were not killed with a clean head shot. Of these 9 animals, one escaped wounded (and could not be found) while the others were quickly killed with one or two quick subsequent shots (or with blunt trauma to the head when a further shot (or shots) at close range was too dangerous)."

Collectively, these studies indicate that compliance with the Code is high and that claims suggesting that dependent young are killed inhumanely or that a high proportion of adults are not shot in the head are misleading or unsubstantiated.

References

RSPCA Australia (1985). 'Incidence of Cruelty to Kangaroos: Report to the Australian National Parks and Wildlife Service'. (RSPCA Australia: Canberra, ACT.)

RSPCA Australia (2002). Kangaroo Shooting Code Compliance. A survey of the extent of compliance with the requirements of the Code of Practice for the Humane Shooting of Kangaroos. Commonwealth of Australia, Canberra, ACT.

McLeod, S. R., and Sharp, M. (2014). Improving the humaneness of commercial kangaroo harvesting. PRJ-004103. Rural Industries Research and Development Corporation, Canberra,

ACT. Available at: https://agrifutures.com.au/product/improving-the-humaneness-of-commercial-kangaroo-harvesting/

Sharp, T. (2015). Commercial kangaroo harvesting: the animal welfare implications for dependent young. University of New South Wales, School of Biological Science.

8. On p15 Terry Brill stated "shooters don't miss", however evidence was given in Submission 404 in which two kangaroo carers outline years of data involving the collection of hundreds of kangaroo heads which provided evidence that up to 40% of kangaroos do not receive a brain case shot (instant death)? How does DPIE respond to this evidence?

ANSWER:

8. Please see the response to question 7 above that refers to the findings of Sharp (2015). This is the only peer-reviewed field study that has recorded commercial kangaroo shooters' compliance with the Code. She found that the proportion of kangaroos that were killed by a single shot to the head was high (96.8 per cent).

9. Can the DPIE confirm whether any compliance officers have been harmed or injured whilst performing monitoring or other tasks involved with compliance checks in the commercial kangaroo industry?

ANSWER:

9. No compliance officers have been seriously injured or harmed undertaking commercial kangaroo management program compliance inspections or surveillance.

   The Department is committed to providing a safe and healthy workplace environment as far as reasonably practicable for all staff and visitors. It ensures the health and safety of its workers by maintaining a structured health and safety management system. Risk management and safety assurance processes are at the centre of its management system and governance arrangements ensure safety risks are managed and effective processes implemented.

   It is the Department's objective to prevent injuries and ill health from occurring in the workplace by identifying and eliminating, as far as is reasonably practicable, the associated risks. The Department's safety risk analysis indicates it is not possible to eliminate risks associated with placing staff in isolated situations with members of the public and high-powered firearms.

10. In the Hearing the DPIE could not answer the question of how many joeys are killed in the commercial industry and acknowledged that this data was not collected or recorded – why doesn't DPIE record the number of joeys killed?

ANSWER:

10. The Department does not collect data on the number of dependent young euthanised by kangaroo harvesters. Information is, however, collected on the gender of the kangaroos harvested. This data shows that typically less than one third of kangaroos harvested are female. In 2019, only 22 per cent of kangaroos harvested were females and in 2020 only 32 per cent of kangaroos harvested were female.

    The National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes (the Code) underpins the animal welfare outcomes for commercially harvested kangaroos. The Code is a national document that guides regulation of humane harvesting practices for the commercial kangaroo industry across Australia.

    Appendix 5 and 6 of the Code ensure dependent young are euthanised quickly and humanely according to the most appropriate methods. The Code is underpinned by a range of advisory and education materials to help harvesters understand and comply. In NSW, a hard copy of the Code and factsheets were distributed to all harvesters licensed in 2021 to ensure that they are aware of, and understand, their obligations under the Code.

    The 2020 review of the Code gathered extensive and diverse input from leading animal welfare and kangaroo harvesting experts, state and federal governments, kangaroo and pastoral industries, harvesters, animal welfare groups and the public. The revisions removed ambiguity and addressed the minimisation of harm to dependent young.

Population and Population Trends and Sustainability

11. On p8 of the transcript, the Hon Catherine Cusack stated: How many kangaroos do you actually see versus what the methodology tells you is the kangaroo population? Can you just give us some indication from the raw data how many kangaroos are actually observed? I am trying to get a feeling for what is the size of the number of what is actually seen versus what that then extrapolates into the size of that number."

ANSWER:

11. ***Western Plains fixed wing surveys - 2020***

The tables below show the raw observations made by observers for red and grey kangaroos in the 2020 Western Plains kangaroo surveys, along with the population estimates for 2020 derived from the raw counts. These figures are broken down into grey kangaroos and red kangaroos, noting greys include both eastern and western greys.

The raw counts are divided by the product of the actual area sampled and the detection probability to determine the density of kangaroos.

Table 1: Raw data showing the numbers of individual kangaroos observed in across the western plains during the 2020 survey and the corresponding population estimate derived from those raw counts.

Kangaroo species	Raw counts of individual kangaroos	Kangaroo population estimates from 2020 surveys
Grey kangaroo	7,525	3,118,439
Red kangaroo	9,604	2,924,368

Central Tablelands helicopter surveys – 2020

Cairns et. al. (2020) provide the raw counts of eastern grey kangaroos from the 2020 central tablelands kangaroo surveys. These are summarised in the table below and presented along with the population estimates for the Central Tablelands kangaroo management zone.

Table 2: Raw data showing the numbers of individual eastern grey kangaroos observed in each of the Central Tablelands kangaroo management zones during the 2020 helicopter survey and the corresponding population estimate derived from those raw counts.

Kangaroo management zone	Number of transects	Survey effort (km)	Raw counts of eastern grey kangaroos	Population estimate
Central Tablelands North	105	2,425	2,906	777,350
Central Tablelands South	70	525	1,719	488,270
Total	**175**	**2,950**	**4,625**	**1,265,620**

Raw counts for all the helicopter surveys are available in the published reports for the surveys. Helicopter survey reports are published on the Department's website.

References

Cairns, S. C., Bearup, D. and Lollback, G. (2020). Design and analysis of helicopter surveys of kangaroo populations in the Central Tablelands North and Central Tablelands South kangaroo management zones, 2020, *Unpublished Report to the Biodiversity and Conservation Division, New South Wales Department of Planning, Industry and Environment on the consultancy*

12. Considering the questioning applied to raw counts of wallaroos used to obtain population estimates, and given Dr Cairns said that the results remain proportional, can DPIE please provide the calculations that show how 508 wallaroos increased to 300,000?

ANSWER:

12. Tablelands surveys are focused in high and medium density strata. Calculations are performed for each kangaroo management zone for each of the high and medium density strata. The population estimates for each strata, in each zone, are then summed to give a population estimate for the kangaroo management zone for quota setting.

The surveys count kangaroos in clusters and numbers of individuals within each cluster. The number of individuals is not counted directly. Instead the raw count of individuals (508) is

derived from the number of clusters and the average number per cluster.

The individual zone estimates can also be summed for reporting as is the case with the 299,190 population estimate from 2019.

The following nomenclature are used in formulas below. The values given are for the Glen Innes zone – high density strata:

- Number of clusters (c)= 69 (see table 5 in Cairns et. al. 2020)
- Average cluster size (S)= 1.60870 (from Distance 7.3 software Cairns pers. com.)
- Distance of survey transect (L) = 225 (see Table 2 and 3 in Cairns et. al. 2020)
- Half width of survey transect (w)= 150 m
- Area of high-density strata = 4774 km^2
- Average probability of detecting wallaroos on the survey strip (P_a) = 0.35472 (Distance 7.3 Software but rounded values appear in Table 5 in Cairns et. al. 2020)
- Correction factor (CF) = 1.85.

For a raw count of 69 clusters with an average of 1.60870 wallaroos per cluster detected on 225 kilometres of survey transect with a half-width of 150 metres, an average probability of detecting wallaroos on the survey strip of 0.35472 and a correction factor of 1.85, the density (D) of wallaroos would be estimated to be:

- $D = (c \times S)/(2wLP_a) \times CF = (69 \times 1.60870)/(2x0.15x225x0.35472)x1.85 = 8.576$ wallaroos per km^2.

Given that the area of the Glen Innes – High density strata is 4774 km^2, then the total number of wallaroos (N) in the Glen Innes – High density strata can be estimated as:

- $N = D \times A = 8.576 \times 4774 = 40{,}944$ wallaroos.

The table at Tab A shows the calculation results for each of the zones and strata, and the calculation of total wallaroos for the Northern Tablelands region from the 2019 surveys. For further detail on the calculations used to estimate the tablelands' wallaroo populations please see the various reports authored by Cairns et. al. on the Department's website.

References

S. C. Cairns, D. Bearup and G. W. Lollback. (2020). Design and analysis of helicopter surveys of kangaroo populations of the Northern Tablelands kangaroo management zones, 2019, *Unpublished Report to the Biodiversity and Conservation Division, New South Wales Department of Planning, Industry and Environment on the consultancy*

13. If hypothetically 650 wallaroos were sighted, could DPIE please provide the calculations, the population estimate and the subsequent quota?

ANSWER:

13. Please refer to the response to question 12 above.

    The quota would be 15 per cent of the population estimate for each kangaroo management zone, assuming none of the zones fall below the thresholds for reduction in the proportional quota.

14. Given the 2017-2021 Management Plan states that 'if there is any concern about kangaroo population trends the quota can be reduced or suspended', can DPIE provide specificadvice on what criteria would be used by the Department to conclude that there was a concern regarding population trends?

ANSWER:

14. The harvest strategy used in NSW reduces the risk of over-harvest during periods when there is a downward trend in population size (McLeod and Pople 2018). When populations fluctuate widely, harvest strategies that track changes in population size have been found to reduce the likelihood of overharvest (Lande et. al. 1995). This harvest strategy, referred to as a proportional harvesting strategy, tracks fluctuations in abundance and adjusts quotas according to changes in population size and has been found to have a low risk of overharvest (Engen et. al. 1997). Proportional threshold harvesting is a modification of proportional harvesting and sets a threshold in population abundance, below which the proportion of the population that can be harvested is reduced eventually to zero. Harvest thresholds further lower the risk of over-harvesting by reducing harvest mortality at times of low population size.

    The thresholds for each kangaroo management zone are based on statistical properties of the time series of kangaroo abundances within each zone. Specifically, two thresholds are set at -1.5 and -2.0 standard deviations (SD) below the mean of the distribution of abundances. If the population size falls below the -1.5 SD level, the harvest rate is reduced to 10 per cent of the estimated population size. If the population size falls below the -2.0 SD level, commercial harvesting within the zone is stopped until the population recovers, and abundance exceeds the lower level.

References

Engen, S., Lande, R., and Sæther, B.-E. (1997). Harvesting strategies for fluctuating populations based on uncertain population estimates. *Journal of theoretical Biology* **186**, 201–212.

Lande, R., Engen, S., and Sæther, B.-E. (1995). Optimal harvesting of fluctuating populations with a risk of extinction. *American naturalist* **145**, 728–745.

McLeod, S. R., and Pople, A. R. (2018). Managing the harvest of kangaroos using a proportional harvest strategy. In 'Advances in Conservation Through Sustainable Use of Wildlife: Proceedings of a Conference Held in Brisbane, Australia 30th August to 1st September 2016'. (Eds G. Baxter, N. Finch, and P. Murray.) pp. 102–110. (The University of Queensland: Gatton,

Queensland.)

15. Please explain if and how the Department can rely on detecting a reduction in numbers before a local population is dramatically reduced particularly given the wide fluctuations in your population estimates from one year to the next?

ANSWER:

15. Kangaroo populations are regularly surveyed to assess state and trend. The distance sampling method is a widely accepted technique used by ecologists worldwide for estimating the abundance of animals in a region. Mark–Recapture Distance Sampling (MRDS) methods are used for density and abundance estimation when the conventional distance assumption of certain detection at distance zero fails, as they allow detection at distance zero to be estimated and incorporated into the overall probability of detection to better estimate density and abundance. The survey methods used can reliably detect changes in population size.

    Between broad-scale aerial surveys, harvest statistics are used as an additional source of information for monitoring changes in population state.

16. Please explain why or why not it does/ does not take into account other forms of kangaroo mortality (eg. car strike, non-commercial killing, exclusion fencing), which is a common practice for other management regimes?

ANSWER:

16. The Department does not model or predict the changes in kangaroo populations from month to month or year to year but rather undertakes a rigorous survey annually on the Western Plains and triennially on the tablelands. Surveys use best available scientific techniques for the purpose. The surveys estimate the actual population that are in the area at the time of the surveys. These population estimates are used as the basis for setting conservative commercial kangaroo harvest quotas.

    This approach to surveying and managing the population considers any mortality that occurs within the population, including any mortality due to the causes given in the question, however large or small that mortality might be.

17. What evidence does the Department rely on for broad-scale movements that would result in the large differences observed in abundance estimates?
    a) On p12 of the transcript Dr Pople stated that: “The 60 to 80 number refers to a number of clusters of animals, not actually individual animals. It is a rule of thumb.”
    b) Can you confirm that DPIE relies on “rules of thumb” for certain methodologies, and if so, list each of these.
    c) How many macropods make up a “cluster”?

d) If DPIE relies on Dr Pople's "rule of thumb" that a minimum of 60-80 clusters are needed to be sighted in order to make a population density estimate, yet Dr Cairns uses sightings as low as 54 individual animals to determine population densities, is there an inconsistency in these two approaches that may lead to inaccurate population estimates?

ANSWER:

17.

a) The 60–80 figure is a generally recommended minimum sample size of clusters to use when undertaking distance sampling (Buckland et al. 2015), to allow reliable modelling of the detection function. A cluster is a group of animals (including singletons) and the distance, or the distance class, is recorded at the group's centre. The distribution of perpendicular distances is then used to model detection probability. Detection functions can be modelled on sample sizes less than 60, but their reliability will depend on the distribution of distances, as well as sample size. The latter is not a definite limit. It is often possible to pool samples (e.g. across years or areas of similar habitat) to better model detection probability. There is extensive literature on distance sampling with numerous examples of its use in aerial surveys.

b) There are general recommendations or suggestions (i.e. rules of thumb) for many aspects of sampling populations to estimate abundance. These range from selecting observers who do not get air sick to sampling at least 10 replicate lines to reliably estimate variance. Once an initial survey has been undertaken, it can be refined to improve aspects, such as variance and sample size, to model detection probability.

c) A cluster is well described in the distance sampling literature. It is the sighting object of interest, which may be a single animal or a group. It is a tight rather than a loose aggregation of animals. For macropods, cluster size is usually less than 10 individuals, but it varies with many factors including density, vegetation, time of day and species. What is important in surveys is that cluster size is recorded accurately along with the distance to, or distance class for, the cluster centre.

d) The vast majority of aerial surveys in NSW record large numbers of clusters (i.e. many more than 60) that are more than sufficient for modelling detection probability. Again, the adequacy of a sample size of 54 will depend on the frequency distribution of distances, and pooling samples can be used to improve the modelling. There is no inconsistency as there is a single approach to seek a large sample size with contingencies for the few cases where sample size is low.

   Modelling detection probability provides for correction of aerial counts of kangaroos for visibility bias. Thus, there is adjustment for factors that affect visibility such as vegetation, observer, species and animal behaviour. It is well recognised that raw counts in transects on aerial surveys are incomplete because animals are missed (Williams et al. 2002). Historically, various methods have been used to determine correction factors for aerial counts of kangaroos in strip transects. Line transect methods, particularly when combined

with mark recapture, are currently the best methods for providing survey-specific correction of aerial counts.

References

Buckland, S. T., Rexstad, E. A., Marques, T. A., and Oedekoven, C. S. (2015). 'Distance sampling: methods and applications.' (Springer.)

Williams, B. K., Conroy, M. J., and Nichols, J. D. (2002). 'Analysis and management of animal populations: modelling, estimation, and decision making.' (Academic Press: San Diego, CA.)

Climate change

18. Given the current and imminent consequences of climate change, how will the management of the commercial hunt for 2022-2026 be changed to reduce the risks of unintended consequences?

ANSWER:

18. Regular population monitoring coupled with conservative quotas set under a proportional harvest strategy, as outlined in the response to question 14 above and the draft NSW Kangaroo Harvest Management Plan 2022–2026, provides a safeguard against harvesting causing the population to fall below viable levels. This safeguard will be in place regardless of climate change or any other external impacts on the kangaroo population.

Tab A Calculation results for each of the zones and strata, and the calculation of total wallaroos for the Northern Tablelands region from the 2019 surveys

Zone	Density Strata	No. of Clusters (c)	Ave no. wallaroos per cluster (from Distance 7.3) (S)	Probability of detection (Pa)	Distance of Survey Transect (km) (L)	Half width of survey transect (km)	Correction Factor	Density wallaroos per km2	Area (km^2)	Population Estimate
Glen Innes	High	69	1.60870	0.35472	225	0.15	1.85	8.57642773	4,774	40,944
	Medium	50	2.02000	0.3176	255	0.15	1.85	7.690439736	12,467	95,877
Armidale	High	30	1.80000	0.31642	277.5	0.15	1.85	3.792427786	9,078	34,428
	Medium	60	1.96670	0.31642	165	0.15	1.85	13.93772757	5,945	82,860
Upper Hunter	High	33	1.81820	0.2758	175	0.15	1.85	7.666087227	3,552	27,230
	Medium	42	1.44620	0.30976	300	0.15	1.85	4.030709797	4,431	17,860
									TOTAL	**299,198**
Source		*Table 5 (Cairns et. al. 2020)*	*Distance 7.3 Software*	*Distance 7.3 Software (rounded values appear in Table 5)*	*Table 2 & 3 (Cairns et. al. 2020)*		*Table 1 (Cairns et. al. 2020)*		*Table 1 (Cairns et. al. 2020)*	

References

S. C. Cairns, D. Bearup and G. W. Lollback. (2020). Design and analysis of helicopter surveys of kangaroo populations of the Northern Tablelands kangaroo management zones, 2019, *Unpublished Report to the Biodiversity and Conservation Division, New South Wales Department of Planning, Industry and Environment on the consultancy*