Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2024-2028

December 2023

GOVERNMENT OF WESTERN AUSTRALIA

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1 Introduction

Kangaroos are iconic Australian fauna found across the landscape. Two species – the red kangaroo (*Osphranter rufus,* previously known as *Macropus rufus*) and western grey kangaroo (*Macropus fuliginosus*) – are harvested for commercial use in Western Australia (WA).

The Department of Biodiversity, Conservation and Attractions (DBCA) is responsible for the administration and implementation of the *Biodiversity Conservation Act 2016* (BC Act) and *Conservation and Land Management Act 1984* (CALM Act) that together provide the legal basis for the conservation of biodiversity in WA. The utilisation of kangaroos is regulated under the BC Act and the *Biodiversity Conservation Regulations 2018* (BC Regulations) through the issue of licences and identifiers ("tags").

This Management Plan relates to the commercial harvest of red and western grey kangaroos within WA. Where the term kangaroo is used within this document it refers to these two macropod species only.

The primary goal of the Management Plan is to ensure that the commercial harvest of kangaroos is ecologically sustainable and to provide an alternative management approach for reducing the damage caused by overabundant kangaroos. This will be achieved through the application of the best available scientific information, best practice management, and monitoring of outcomes to ensure the viability and welfare of kangaroo populations is not compromised by any action undertaken in accordance with the Management Plan. The Management Plan incorporates an adaptive management approach to improve knowledge, facilitate appropriate adjustments to management and inform future programs.

The Management Plan does not provide the framework for the management of kangaroos on lands described under Part 2, Section 5 of the *Conservation and Land Management Act 1984* (e.g., national parks, nature reserves, conservation parks, state forest and timber reserves). Kangaroos cannot usually be taken for commercial purposes in these areas, which comprise a total area of about 26 million hectares or approximately 10 percent of the land area of Western Australia[1].

The Management Plan does not regulate the non-commercial culling of kangaroos for damage mitigation. Non-commercial culling of kangaroos is regulated through other provisions of the BC Act.

The Management Plan sets the framework for the commercial harvest of kangaroos in accordance with the principles of ecologically sustainable development. Management in this context assists in balancing environmental, social and economic interests by ensuring the sustainable use of a renewable resource and provides for the sustainable harvest of kangaroos for products such as meat and leather to supply Australian and international markets.

[1] In circumstances where an authority is granted to take kangaroos for commercial purposes in these areas, the principles of this Management Plan will apply.

The Management Plan will remain valid for a maximum period of five years from the date after its registration on the Federal Register of Legislation.

The purpose of this plan is to provide a management framework for the sustainable commercial harvesting of kangaroos in WA.

This plan has been developed by DBCA to satisfy the requirements for approval of a wildlife trade management plan under Section 303FO of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and to meet the legislative, policy and other requirements of the Government of Western Australia.

This plan supersedes the Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2019 – 2023.

2 Legislative framework

2.1 Commonwealth

The EPBC Act requires the development and approval of wildlife trade management plans for permits to be issued for the commercial export of wildlife products.

The EPBC Act states that the Commonwealth Minister responsible for the environment may approve a wildlife trade management plan for a maximum of five years. The EPBC Act specifies that such approval must be given only if the Minister is satisfied that:

(a) the plan is consistent with the objects of Part 13A of the EPBC Act;

(b) an assessment of the environmental impacts of the activities of the plan has been undertaken;

(c) the plan includes management controls directed towards ensuring that the impacts of the activities covered by the plan are ecologically sustainable;

(d) the activities in the plan are not detrimental to the species to which the plan relates or any relevant ecosystem; and

(e) the plan includes measures to mitigate, monitor and respond to the environmental impacts of the activity covered by the plan.

In deciding whether to approve a plan, the Minister must also have regard to whether:

(a) legislation relating to the protection, conservation or management of the specimens to which the plan relates is in force in the State or Territory concerned; and

(b) the legislation applies throughout the State or Territory concerned; and

(c) in the opinion of the Minister, the legislation is effective.

Under Regulation 9A.05 of the *Environment and Biodiversity Conservation Regulations 2000*, the Minister, in deciding whether to approve a plan, must also be satisfied that if an animal is killed, it is done in a way that is generally accepted to minimise pain and suffering. Animal welfare standards for the commercial harvesting of kangaroos are detailed in the National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes (Commercial Code). All kangaroos taken for commercial purposes must be taken in accordance with the Commercial Code or any future, nationally-endorsed code that replaces or updates this document.

2.2 Western Australia

In WA all native species, including kangaroo species and subspecies, are protected under the BC Act. The BC Act and BC Regulations make provisions for the licensing of a range of activities relating to the commercial harvesting of kangaroos. Under the BC Act, lawful authority (a licence) is required to take, possess, process, deal, import or export fauna. Licences may include conditions, such as the manner in which fauna

may be taken, or stored, including during transport, and the affixing of tags to the fauna.

Licences that relate to commercial kangaroo harvesting, processing and dealing are described in Appendix 1.

In addition to the BC Act, the following legislation (including subsidiary legislation) may also apply to activities undertaken in accordance with this Management Plan:

- *Animal Welfare Act 2002*
- *Biosecurity and Agriculture Management Act 2007*
- *Conservation and Land Management Act 1984*
- *Food Act 2008.*

Under the Management Plan the commercial harvesting of kangaroos in WA is restricted to the Kangaroo Management Areas illustrated in Figure 1. Any changes to Kangaroo Management Area boundaries will be provided to the Department of Climate Change, Energy, the Environment and Water (DCCEEW). Within the life of this Management Plan, new areas may be opened to commercial harvesting where kangaroos are deemed to be overabundant. Surveys to estimate kangaroo abundance will be undertaken prior to any new areas being opened for commercial harvesting and DCCEEW will be consulted on any proposed changes prior to implementation.

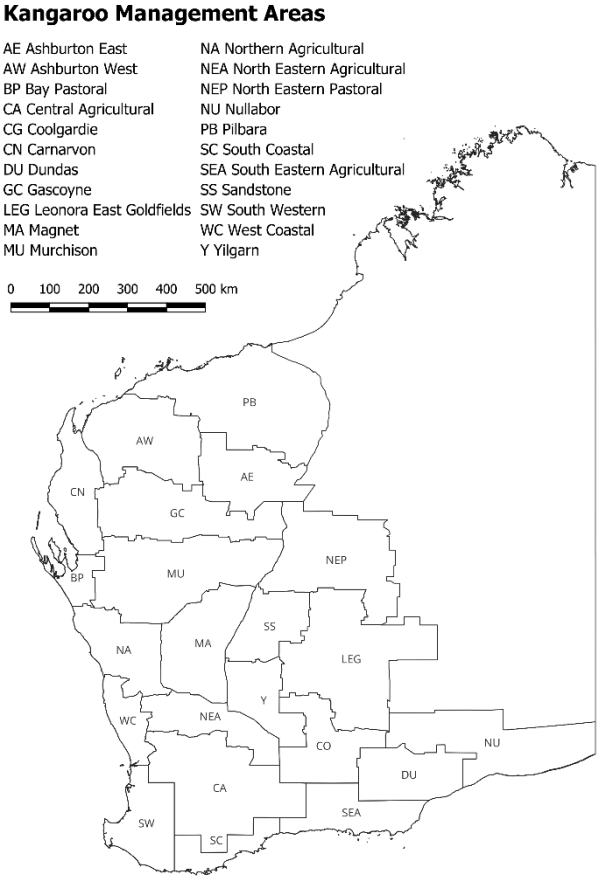

Figure 1: Kangaroo Management Areas in WA

3 Goal and aims

3.1 Goal

The overarching goal of the *Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2024-2028* is:

> **To provide for the sustainable commercial harvest of red and western grey kangaroos in accordance with the principles of ecologically sustainable development.**

The principles of ecologically sustainable development are defined in Part 1, Section 3A of the EPBC Act and Part 1, Section 4 of the BC Act.

In order to achieve the overarching goal, the Management Plan has seven aims. When the aims are combined, they set strategic directions for the management of the commercial kangaroo harvest in WA.

Under each aim are one or more actions that detail both how the aim will be delivered and operational directions for kangaroo management. A range of performance indicators for each action have also been developed so that progress towards achieving the goal and aims of the Management Plan can be measured.

3.2 Aims

The aims of the Management Plan are to:

1. Ensure humane harvest of kangaroos

Promote improved animal welfare outcomes by ensuring that the commercial harvest of kangaroos under the Management Plan is carried out in accordance with the Commercial Code.

2. Regulate the commercial harvest of kangaroos via licensing

The commercial utilisation of kangaroos will be regulated via the issue of licences and tags in accordance with the provisions of the BC Act and BC Regulations, WA Government policies, the Commercial Code and the Management Plan.

3. Promote and monitor industry compliance

The commercial kangaroo industry will be monitored to ensure compliance with the BC Act and BC Regulations, licence conditions, the requirements of the Commercial Code and the Management Plan.

4. Monitor kangaroo populations and set commercial harvest quotas

Kangaroo populations will be monitored, and commercial harvest quotas set to ensure kangaroos are utilised in accordance with the goal of the Management Plan. Direct and indirect monitoring will be undertaken in all areas where kangaroos are commercially harvested.

5. Facilitate adaptive management and research

Adaptive management experiments and studies using data from kangaroo industry returns and population data will be supported to improve understanding of kangaroos and their interaction with environmental, social and economic systems. Research into other aspects of kangaroo biology and/or harvest management will be supported to fill knowledge gaps as needed.

6. Undertake program reporting and review

Annual reporting will be undertaken to ensure outcomes are consistent with the goal, aims and actions of the Management Plan.

7. Promote community awareness and engage stakeholders

Greater understanding about the commercial utilisation of kangaroos will be promoted by engaging with industry stakeholders and providing accessible information to members of the public.

3.3 Management actions and performance indicators

Aim 1: Ensure humane harvest of kangaroos

The department is committed to promoting and maintaining high standards in animal welfare. The *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes 2020* is the current, nationally-endorsed animal welfare standard for the commercial harvest of kangaroos in Australia. Any approved revisions to the Commercial Code will be adopted as the animal welfare standard for the commercial harvest of kangaroos in WA. Applicants seeking to be licensed as prospective commercial kangaroo shooters are required to demonstrate they can achieve the standards of marksmanship required under the Commercial Code prior to obtaining a licence to take kangaroos.

ACTION 1: The department will ensure that the commercial kangaroo industry operates in accordance with the most up-to-date Commercial Code.

Compliance with the Commercial Code is a requirement for persons licensed to take kangaroos under the BC Act and BC Regulations and the Management Plan. Under licence conditions, licensed processors and dealers may not lawfully receive kangaroo carcasses unless kangaroos have been shot in accordance with the Commercial Code. Non-compliance with the licence conditions will result in penalties and/or other sanctions.

> **Performance Indicator 1**: Licence conditions for the commercial taking, processing and dealing of kangaroos will stipulate that kangaroos cannot be shot, sold or received unless they have been taken in accordance with the Commercial Code.
>
> **Performance Indicator 2:** Copies of the Commercial Code will be made available from the department's website.

Performance Indicator 3: The department will participate in and support any revisions to the nationally-endorsed Commercial Code.

ACTION 2: The department will consult with the Sporting Shooters' Association of Australia- WA and any other shooter representative body to ensure that all licenced commercial kangaroo shooters are competent and able to achieve the standards of marksmanship required under the Commercial Code.

Prospective commercial kangaroo shooters must pass a skills test. The test is a practical assessment of marksmanship conducted under field conditions by independent examiners who are registered with the department. Additionally, prospective commercial kangaroo shooters must have completed accredited vocational training in Game Harvester Skill Set or equivalent prior to being issued with a licence. Commercial kangaroo shooters who have not been active on their licence for at least five years must re-complete skills testing.

Performance Indicator 4: All prospective commercial kangaroo shooters must have completed an accredited test of marksmanship and completed accredited vocational training in Game Harvester Skill Set as a prerequisite before being issued with a licence to take fauna for commercial products.

Aim 2: Regulate the commercial harvest of kangaroos via licensing

In order to ensure that the commercial kangaroo harvest is adequately regulated, commercial activities will require the authority of licences, and operators must adhere to tagging procedures as provided for under the BC Act and the BC Regulations.

ACTION 3: All relevant industry activities are licensed in accordance with the BC Act and the BC Regulations and departmental policies.

All applications for licences relating to commercial kangaroo industry activities in WA are to be assessed, processed and issued in accordance with the provisions of the BC Act and BC Regulations and relevant departmental policies.

Performance Indicator 5: Audits of licences issued for commercial activities are conducted annually to ensure licences are being issued appropriately in accordance with relevant legislation and departmental policies.

Performance Indicator 6: Databases are maintained to ensure licensee information is current and accurate.

ACTION 4: Licence conditions are applied as required.

Licence conditions must be effective and consistent with relevant Western Australian legislation, departmental policies and the goal and aims of the Management Plan. Accordingly, licence conditions for each licence type will be reviewed, and where necessary amended, in response to changes in relevant legislation and/or departmental policies. Licensees will be advised of any changes to their licence conditions in writing.

Performance Indicator 7: Licence conditions are reviewed as required and amended where necessary.

Performance Indicator 8: Licensees are advised in writing of any changes to licence conditions within one month of such changes being approved by the CEO or delegate.

Aim 3: Promote and monitor industry compliance

Industry compliance is essential to ensure the commercial harvest is managed sustainably and to maintain public confidence in the management of the kangaroo industry. Industry compliance is promoted through liaison and education with commercial kangaroo shooters and processors and monitored through inspections of processing establishments and active chillers to ensure compliance with legislative requirements.

ACTION 5: The department will undertake liaison with and monitoring of commercial kangaroo licence holders for compliance with the BC Act and BC Regulations, the Management Plan and licence conditions.

In order to assess industry compliance, authorised officers will, on both a regular and opportunistic basis, inspect kangaroos taken by, and processed by commercial kangaroo licence holders and premises registered for processing kangaroos. The inspecting officers will check to ensure that the kangaroos have been taken in accordance with the Commercial Code.

Given the large geographic area the industry operates across, and the mobile and sporadic nature of commercial kangaroo shooting operations, in-person compliance inspections can be difficult to undertake. To promote industry compliance the department will supplement unannounced, targeted inspections with proactive liaison with commercial shooters including phone calls, emails, dissemination of educational materials discussing and highlighting the importance for compliance within the industry and consequences of non-compliance, and pre-arranged visits to active kangaroo processing establishments and active chillers.

Performance Indicator 9: All active kangaroo processing establishments are inspected by authorised departmental officers annually to ensure compliance with legislative requirements.

Performance Indicator 10: Inspection[2] of at least thirty percent of active chillers[3] by authorised departmental officers annually to ensure compliance with legislative requirements.

Performance Indicator 11: Contact is made with at least fifty percent of licence holders to educate and promote industry compliance.

ACTION 6: Activities not in accordance with the BC Act, the BC Regulations and commercial kangaroo licences will be investigated and, where an offence has been committed and it is appropriate, prosecuted.

[2] Inspection includes an in-person attempt to inspect a premise even if access was not achieved.

[3] Note: An active chiller is one that is identified on the returns from licensed commercial kangaroo shooters where there is at least one shooting day of effort during the year assigned to it.

Investigation and prosecution of activities that are in breach of legislative requirements are essential for maintaining public, industry and stakeholder confidence in the effectiveness of the Management Plan as a mechanism for maintaining the sustainability and humaneness of the commercial kangaroo harvest.

> **Performance Indicator 12:** Reports of unlicensed activities and activities in breach of legislation and licence conditions are investigated to the fullest extent possible and, where sufficient evidence is available, offenders are issued with expiation notices or prosecuted as appropriate.

ACTION 7: The accuracy of industry returns will be monitored continually during the life of the Management Plan.

It is a licence condition that commercial kangaroo industry licensees submit monthly returns to the department. The data obtained from these returns are essential for monitoring whether the industry is harvesting kangaroos within approved quotas and for reporting. In addition, the data from industry returns are utilised for indirect monitoring of kangaroo populations.

> **Performance Indicator 13:** Incoming industry returns are reviewed, and discrepancies are investigated.

ACTION 8: A compliance database will be maintained and improved to support investigations and inspections.

A compliance database for use in investigations and inspections of the commercial industry will be maintained for use by staff involved with kangaroo management. The database facilitates compliance reporting to DCCEEW and other stakeholders and easy access to information for relevant authorised departmental officers.

> **Performance Indicator 14:** A compliance database will be maintained and improved to support investigations and inspections.

Aim 4: Monitor kangaroo populations and set commercial harvest quotas

Monitoring populations of commercially harvested species is essential to ensure that the commercial harvest is sustainable over the long term. The commercial harvest region in WA is divided into four Population Monitoring Zones (PMZ) (Figure 2). These four PMZ encompass the Kangaroo Management Areas described in Section 2.2 (Table 1 shows the relationship between PMZ and the Management Areas).

The harvest quota for a species is the maximum number of individuals that can be commercially harvested in a calendar year. Kangaroo population estimates obtained from aerial surveys will be used as the basis for setting commercial harvest quotas for each of the PMZ.

Proportional threshold harvesting is one strategy for reducing the risk of over-harvesting (Engen, Lande and Saether, 1997). Proportional harvesting strategies have been well studied and are considered safe and efficient for fluctuating populations (Caughley, 1987; Engen, Lande and Saether, 1997). Kangaroo harvest quotas in WA are consequently based on a proportion of the estimated population size. WA’s

program of regularly monitoring and estimating abundance allows for any other agents of mortality acting on kangaroo populations (e.g., drought, disease, roadkill, non-commercial culling) to be detected and accounted for in the setting of annual commercial harvest quotas.

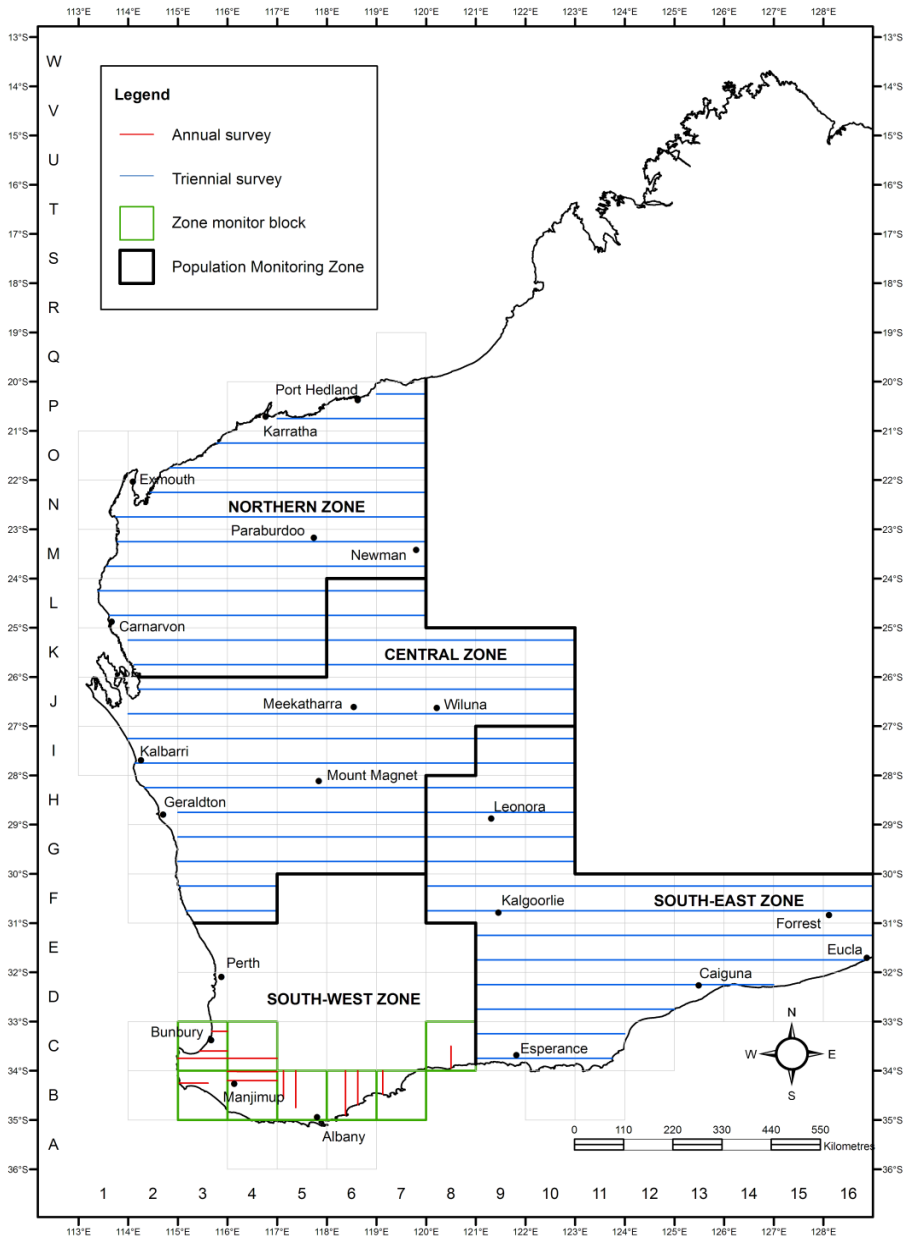

Figure 2: Aerial survey flight lines and PMZ.

Table 1: Relationship between PMZ and Kangaroo Management Areas

Northern Zone Management Areas	Central Zone Management Areas	South-east Zone Management Areas	South-west Zone Management Areas
Ashburton East Ashburton West Carnarvon Gascoyne Pilbara	Bay Pastoral Magnet Murchison North Eastern Pastoral Northern Agricultural North East Agricultural Sandstone Yilgarn	Coolgardie Dundas Leonora East Goldfields Nullarbor South East Agricultural	Central Agricultural South Coastal South Western Western Coastal

ACTION 9: Aerial surveys from fixed-wing aircraft will be used to estimate the size of kangaroo populations within each PMZ. Survey lines have been established at regular intervals across the harvest region (Figure 2) and the same lines are surveyed during the same season each survey period to allow comparison of results between years.

The northern, central and south-east PMZs will be surveyed at least triennially while the south-west will be surveyed annually. In the intervening years between aerial surveys, population estimates will be calculated using the most recent population estimate adjusted for regional rainfall and commercial harvest offtake, according to the equation:

$$\widehat{N}_{i+1} = (\widehat{N}_i - H) \times r,$$

where:

$\widehat{N}_i$ = the most recent population estimate;

H = commercial harvest offtake between population estimates; and

r = population growth rate for a regional rainfall category.

Rainfall category for PMZ	r
Above average (decile rainfall >7)	1.20 to 1.30 (+20 to +30%)
Average (decile rainfall 4–7)	1.10 (+10%)
Below average (decile rainfall <4)	0.80 to 0.60 (–20 to –40%)

The department will investigate improved methods of survey and statistical analysis during the implementation of this Management Plan. Any alternative methods will be trialled, compared, and correlated with existing methods. If improved methods for survey or statistical analysis are identified, they may be implemented. Changes to the survey or statistical analysis, and justification for these changes will be published in the Quota Report for that year.

> **Performance Indicator 15:** Aerial surveys are undertaken triennially for the central, northern and south-east population monitoring zones, and annually for the south-west PMZ. Population estimates are calculated in accordance with the Management Plan.

ACTION 10: Commercial harvest quotas will be set and managed in accordance with the provisions of the Management Plan.

Quotas will be set for each commercially harvested kangaroo species and allocated to each PMZ. Quotas will be based on the most current population estimate for that zone and calculations will use habitat correction factors accepted at that time. DCCEEW will be advised of the annual quotas prior to implementation.

Quotas established under the Management Plan will be managed at the PMZ level. The harvest in each PMZ will be monitored and when the harvest for a particular PMZ is close to reaching the quota then the commercial harvest will cease in that zone. Furthermore, the department will close the harvest in a management area or monitoring zone if it considers continued harvest pressure will pose a conservation risk to kangaroos in that Kangaroo Management Area or PMZ, whether by potentially exceeding the quota or for some other reason.

The department retains the capacity to manage quotas at the Kangaroo Management Area level if required (through the allocation of tags and spatial and temporal closures in specific Kangaroo Management Areas), without the need to prescribe set quotas for each Kangaroo Management Area each year. The department may also decrease quotas to maintain the viability of kangaroo populations and to meet the other objectives of the Management Plan, where analysis of scientific information supports this action.

Performance Indicator 16: Commercial harvest quotas are set in accordance with the Management Plan.

Performance Indicator 17: PMZ quotas and the state-wide quotas are never exceeded.

Performance Indicator 18: DCCEEW is advised of commercial harvest quotas via a quota report for the following calendar year by 30 November.

The quota report will contain the following information:

- population estimates for each species in each PMZ;
- details of the survey methods used and any changes to the survey method or analysis;
- quotas calculated as a proportion of the population estimate;
- any proposed changes to quotas;
- any changes to commercial harvest Kangaroo Management Areas or boundaries and
- data showing trends in population, quota utilisation and harvest offtake over time.

Performance Indicator 19: The quota report will be made available to the public via the department's website.

ACTION 11: Harvest data will be analysed during the preparation of the quota submission.

Harvest returns from commercial kangaroo licence holders are received monthly and are used to provide additional indirect data on kangaroo populations. Harvest returns detail the number of each species taken, average carcass weights, sex of animals taken, and location of take. Analysis of sex ratios and carcass weights will occur during

the preparation of the quota submission, which potentially can alert managers to problems with the commercial harvest. Significant changes in harvest data may provide an indication of population status or changes in harvest practices.

> **Performance Indicator 20** Sudden, sustained or acute changes in the information provided through harvest returns will be investigated to identify possible causes of the change.

If necessary, management action will be taken to ensure the viability of the kangaroo population is maintained over the long term. Actions may include reducing or suspending the commercial harvest or increasing survey intensity at the next survey.

ACTION 12: The commercial quota for a particular species will be reduced or suspended within a Kangaroo Management Area or PMZ if population densities fall below pre-determined trigger points.

Under the proportional threshold harvesting strategy, density thresholds are established that 'trigger' a management response. Typically, the harvest rate is reduced, or the harvest is suspended at specific densities to reduce the risk of over-harvesting.

The Management Plan aims to accommodate natural fluctuations in kangaroo densities that change according to seasonal conditions. Calculating trigger points based on standard deviations from the long-term average density accounts for natural changes in kangaroo populations will enable the identification of changes that are unusual. In this context, standard deviation is a statistical measure of how much the population varies relative to its average density. In erratic environments such as the arid inland areas of WA, population densities fluctuate much more widely as a proportion of their long-term average density than in more stable environments such as the south-west. This means that the standard deviation will be different for each species.

It is important to note that the density estimates of kangaroos over much of WA, particularly in rangelands areas, are significantly lower than in eastern Australia. Average densities in many areas of WA are of the order of one kangaroo per km^2 or lower, with average red kangaroo density estimates at the PMZ level ranging from less than 0.4 kangaroos per km^2 to a high of around three kangaroos per km^2.

Under this Management Plan, the commercial harvest rate will be reduced or suspended if aerial surveys indicate that the population density within any particular PMZ has fallen to a predetermined density threshold for that zone. Any suspensions or reductions will remain in place until surveys, or population estimates corrected for trends in rainfall, indicate that kangaroo densities have increased above no harvest density thresholds.

> **Performance Indicator 21:** Commercial kangaroo harvest rates will be reduced, or the commercial kangaroo harvest suspended if density estimates reach the thresholds identified in Table 2. Any suspensions or reductions will remain in place until surveys or data indicates that kangaroo densities have increased above density thresholds.

Table 2: Density thresholds for WA PMZ for red and western grey kangaroos.

PMZ[x]	Density thresholds (kangaroos per km^2)					
	Red kangaroo			Western grey kangaroo		
	17% HR (Threshold 1)	10% HR	No harvest (Threshold 2)	15% HR (Threshold 1)	10% HR	No harvest (Threshold 2)
Central	$D > 0.57^a$	$0.57^a \geq D > 0.40^b$	$D \leq 0.40^b$	$D > 0.18^a$	$0.18^a \geq D > 0.12^b$	$D \leq 0.12^b$
Northern	$D > 0.47^b$	$0.47^b \geq D > 0.36^c$	$D \leq 0.36^c$	Extralimital – no quota		
South-East	$D > 0.29^b$	$0.29^b \geq D > 0.23^c$	$D \leq 0.23^c$	$D > 0.46^b$	$0.46^b \geq D > 0.33^c$	$D \leq 0.33^c$
South-West	Vagrant – no quota			$D > 8.4^c$	$8.4^c \geq D > 6.5^d$	$D \leq 6.5^d$

x = The density thresholds for each PMZ will also apply to any Kangaroo Management Area within that PMZ.

HR = Harvest rate as a proportion of the population estimate.

D = density estimate (kangaroos per km^2) from aerial surveys. Threshold densities were calculated as 1.0, 1.5, 2 or 3 standard deviations from the mean of density estimates for full surveys of a PMZ between 1995 and 2022. Note that PMZ are surveyed on a triennial basis, other than South-West that is surveyed annually.

a = 1.0 standard deviation (sd); b = 1.5 sd; c = 2.0 sd; d = 3.0 sd.

Regular harvest (Threshold 1): Where aerial surveys indicate that the population density of a kangaroo species within a PMZ is greater than Threshold 1 (Table 2), the quota for the next calendar year will be calculated as a harvest rate of not greater than 17 percent of the population estimate for red kangaroos and 15 percent for western grey kangaroos.

Harvest reduction: Where aerial surveys indicate that the population density of a kangaroo species within a PMZ is less than or equal to Threshold 1 and greater than Threshold 2, the quota for the next calendar year will be calculated as a harvest rate of not greater than 10 percent of the population estimate. This harvest rate will remain in effect until aerial surveys or annual trends in rainfall indicate that population densities have increased above Threshold 1.

Harvest suspension (Threshold 2): Where aerial surveys indicate that the population density of a kangaroo species within a PMZ is less than Threshold 2, no commercial quota will be approved for the following calendar year. The harvest suspension will remain in force until population estimates indicate that kangaroo densities have increased above Threshold 2.

Note: the density thresholds tabled above will be kept under continual review during the life of the Management Plan and may be revised as new information is acquired. Any modification to the above figures will be identified in the annual quota document submitted to DCCEEW.

Aim 5: Facilitate adaptive management and research

The ability to adapt the management program is essential for the delivery of the Management Plan and for maintaining public, industry and stakeholder confidence in

the effectiveness of the Management Plan and as a mechanism to maintain the sustainability of kangaroo populations, as well as the commercial industry.

Research into particular aspects of kangaroo ecology, harvest management or land use practices can also assist in ensuring that the commercial harvest is sustainable over the long term. While there has been a large body of research on the ecology and management of kangaroos, there are information gaps which, when filled, may lead to improved management of the commercial harvest.

ACTION 13: The department will respond to changes as they arise. Changes made to the management program will be communicated to all relevant stakeholders.

> **Performance Indicator 22:** Changes to the kangaroo management program will be communicated to relevant stakeholders via the department's website and directly to stakeholders where appropriate.

ACTION 14: The department will support research into the ecology and harvest management of kangaroos.

Research relating to the commercial kangaroo harvest in WA may be undertaken by a range of individuals or organisations including tertiary students, university professionals, consultants or departmental staff. The department will work with researchers and research organisations to identify and investigate issues relevant to the commercial harvest of kangaroos. Such research may include aspects of the biology and ecology of kangaroos as they relate to the commercial harvest, harvest techniques or changes in land use practice that may significantly impact kangaroo populations.

Consideration of research findings and the results of analyses of harvest data are useful for the development of future management plans as well as for facilitating the adaptive management of kangaroo populations. The results of such analyses will be published in appropriate forums.

> **Performance Indicator 23:** During the life of the Management Plan, the department will support research on harvested species of kangaroos or commercial harvest management as appropriate.

ACTION 15: Where practicable, the department will support management experiments to test deliberate management interventions.

The department will consider proposals to undertake deliberate management experiments to improve aspects of management, conservation and commercial utilisation of kangaroos. All proposals will be presented to the Kangaroo Management Advisory Committee (see Action 17) and reviewed through the department's scientific research approval process, including but not limited to assessment against the following criteria:

- the proponents' awareness of relevant background information;
- whether the proposal considers alternative models and hypotheses;
- whether the proposal is scientifically rigorous and statistically valid;
- whether the proposal incorporates a monitoring program;

- that there is substantial evidence that the risk of permanent damage to kangaroo populations is low;
- that the proposal is consistent with the goal of the Management Plan and relevant Western Australian legislation;
- that the proposal includes consideration of how management may be modified to accommodate the new knowledge gathered from the intervention; and
- that the proposal includes a commitment to publish results of the experiments in an appropriate forum.

All experiments that affect the commercial utilisation of kangaroos must also demonstrate how the experiment provides for reasonable business planning and investment.

> **Performance Indicator 24:** All proposals to undertake active adaptive management experiments are reviewed and assessed by the department in accordance with the criteria outlined in the Management Plan.

Aim 6: Undertake program reporting and review

Regular reporting and program review are essential for evaluating whether the goals and objectives of the Management Plan have been achieved; and for maintaining stakeholder confidence in the effectiveness of the Management Plan as a mechanism to ensure that kangaroo populations are not over-harvested, and the commercial industry is managed sustainably over the long term.

Previous kangaroo management programs have generated a wide range of information relating to the commercial harvesting of kangaroos in WA. This information will be analysed to provide data on trends in kangaroo populations, utilisation rates and demographic information to provide context to annual survey and harvest information. Other specific information relating either to the commercial harvest or to kangaroo populations more generally may also be analysed.

> **Performance Indicator 25:** As a minimum, trends in population estimates, harvest tallies, carcass weights and sex ratios will be analysed annually and published on the department's website in annual and quota reports.

ACTION 16: A report will be prepared annually and submitted to DCCEEW.

An annual report detailing the operation of the Management Plan over the previous year will be prepared and submitted to DCCEEW. The report will provide information on harvest statistics, industry compliance and an assessment of actions against the Management Plan performance indicators.

> **Performance Indicator 26:** An annual report will be provided to DCCEEW by 31 March of the following year.
>
> The annual report will include the following information:
>
> 1. Harvest statistics for each species taken in each PMZ including:
>
> - numbers of kangaroos taken;
> - sex ratio of the harvest; and,

- average carcass weights of harvested animals for each sex taken.

2. Industry compliance statistics including:
    - number of premises inspected;
    - number of active chillers inspected;
    - percentage of licence holders contacted for promotion of industry compliance;
    - number of Caution Notices issued and reason for issue;
    - number of alleged offences investigated and outcomes;
    - number of prosecutions undertaken (offence and outcome); and
    - any joint surveillance/enforcement activities completed with other agencies.
3. Any unusual situations that arose (e.g., disease outbreaks, drought conditions, market factors, etc).
4. Any research or adaptive management experiments that were undertaken or sponsored by the department.
5. An assessment of actions against the Management Plan performance indicators.

Aim 7: Promote community awareness and engage stakeholders

The harvesting of wildlife can be contentious and there are many stakeholders in the commercial kangaroo industry. Consequently, community awareness of and stakeholder engagement in kangaroo management is considered a key component to the success of the program.

ACTION 17: A Kangaroo Management Advisory Committee (KMAC) will be convened to provide stakeholders in the industry with relevant information and to afford the opportunity to advise the department on key kangaroo management issues throughout the life of the Management Plan.

KMAC, which is convened by the department, is the main forum through which stakeholder group representatives can raise issues for discussion, as well as communicate their groups' positions and interests to Government on a regular basis. Stakeholder groups presently represented on KMAC encompass the kangaroo industry, landholder groups, primary producers and Government. Member organisations hold their appointed positions indefinitely. KMAC provides an opportunity for all stakeholder organisations to actively participate in directing the future development of the commercial kangaroo industry in WA.

Performance Indicator 27: KMAC meets at least once per year to review the progress of the Management Plan in relation to the goal and aims of the plan.

Performance Indicator 28: KMAC is provided with annual updates on the commercial harvest and issue of tags throughout the life of the Management Plan.

Performance Indicator 29: KMAC is provided with other relevant information as required or as necessary throughout the life of the Management Plan.

ACTION 18: Relevant documents will be made available from the department's website and other publicly available information will be made available on request.

The timely provision of information promotes improved understanding of kangaroo management, the objectives of the Management Plan, and allows members of the community to make better-informed judgements regarding kangaroo management issues.

> **Performance Indicator 30:** Throughout the life of the Management Plan, the department's website will contain the following information as a minimum standard:
>
> - current Management Plan;
> - current quota report;
> - current annual report submitted to DCCEEW;
> - information sheets on kangaroo biology and management;
> - Commercial Code; and
> - relevant contact information.

Additional relevant information will be posted on the department's website as available and appropriate.

> **Performance Indicator 31:** Publicly available information on kangaroo management is provided to interested parties as soon as practicable on request.

ACTION 19: Where appropriate, relevant departmental staff will participate in media interviews and prepare media releases.

Participation in media interviews and the preparation of media releases can be an effective mechanism for communicating information regarding kangaroo management to a broad audience. Moreover, it improves program transparency and accountability, and therefore public confidence.

> **Performance Indicator 32:** Relevant departmental staff will participate in interviews with the media where appropriate.
>
> **Performance Indicator 33:** Media releases are prepared for issues of interest to the community when appropriate.

ACTION 20: Information about the kangaroo management program and other relevant information will be developed as required and distributed to relevant stakeholders.

Relevant information regarding licensing arrangements will be developed and distributed to all licensees as required. Licensees and operators will be provided with written information relevant to their licensing arrangements to assist in achieving a high level of compliance with the licensing framework.

> **Performance Indicator 34:** As a minimum, all first time commercial kangaroo licence holders, or those who have not held a valid licence during the term of the current Management Plan, will be provided with an up-to-date information pack to make licence holders aware of relevant requirements and responsibilities.

Appendix 1 Licences for the commercial take, processing and dealing in kangaroos

This section contains detail on the various licences related to kangaroo management.

Licences are issued under the *Biodiversity Conservation Act 2016* and BC Regulations. Licence conditions are reviewed regularly and may change during the life of this Management Plan. Any changes to the conditions will need to be in accordance with this Management Plan, and relevant parties will be notified.

Fauna taking (commercial products) licence

Commercial Kangaroo SHOOTER

Licence	**Licence issued under regulation 23 of the Biodiversity Conservation Regulations 2018 (Regulations).** **This licence authorises the licence holder to take fauna by means of a firearm on land for which there is commercial quota, field dress the carcasses into a form suitable for sale (undertake initial processing) and transport and sell the carcasses to a licensed Kangaroo Processer or Dealer.**
Accreditation	The applicant must hold a current Western Australian Firearms Licence that includes an appropriate calibre firearm that complies with the Commercial Code. The applicant must have successfully completed an accredited firearms competency test in marksmanship. Successful completion of the Game Harvester Skill Set or an equivalent accredited course.
Relevant detail	The licence holder may only shoot kangaroos on land on which they have written authorisation of the landholder. All kangaroos must be shot following the Commercial Code. Only kangaroos that have been killed by a single shot to the brain shall be delivered to a kangaroo processor. The licence holder may process in the field to the extent of evisceration and removal of head, tail and limbs. The licence holder must affix to each kangaroo carcass a commercial use identifier (tag) issued in accordance with the Regulations. The licence holder must attach the appropriate tag for each species of kangaroo that is harvested. The licence holder must keep records of kangaroos that are harvested, and supply harvest returns to the department in the approved format.

Further detail	For further detail see the department's website.

Fauna processing licence

Commercial Kangaroo PROCESSOR

Licence	**Licence issued under regulation 37 of the Biodiversity Conservation Regulations 2018.** **This licence permits the licence holder to undertake the processing of kangaroo carcasses at a specified establishment.**
Accreditation	The applicant must have thorough knowledge of relevant sections of the *Biodiversity Conservation Act 2016* and BC Regulations. The applicant must have all authorities and licences required under local authority by-laws.
Relevant detail	The licence holder shall only accept kangaroo carcasses from a person licensed to take fauna for commercial products. The licence holder shall only accept kangaroo carcasses that have been killed with a single shot to the brain. The licence holder shall only accept kangaroo carcasses with an affixed identifier (tag). The licence holder must keep records of kangaroo carcasses received and processed and supply returns to the department in the approved format.
Further detail	For further detail see the department's website.

Fauna dealing (general dealer's) licence

Commercial Kangaroo DEALER/SKIN DEALER

Licence	**Licence issued under regulation 38 of the Biodiversity Conservation Regulations 2018.** **This licence permits the licence holder to deal (purchase or supply) kangaroo carcasses or products, including skins.**
Accreditation	The applicant must have thorough knowledge of the relevant sections of the *Biodiversity Conservation Act 2016* and BC Regulations.

	The applicant must have all authorities and licences required under local authority by-laws.
Relevant detail	The licence holder shall only accept kangaroo carcasses or skins from a person licensed to take or deal in fauna for commercial products. The licence holder shall only accept kangaroo carcasses or skins from kangaroos that have been killed with a single shot to the brain. The licence holder shall only deal in kangaroo carcasses or skins with an affixed identifier (tag). The identifier (tag) is to remain attached to the skin until the tanning process has started. The licence holder must obtain the relevant licences for import and export of kangaroo carcasses or skins, issued under the *Biodiversity Conservation Act 2016*, for consignments of kangaroo products that enter or leave WA. The licence holder must keep records of kangaroo carcasses and skins received and processed and supply returns to the department in the approved format.
Further detail	For further detail see the department's website.

Fauna importing and exporting licences

Import Licence	**Licence issued under regulation 40 of the Biodiversity Conservation Regulations 2018.** This licence permits the licence holder to import fauna of a specified species into WA. The fauna to be imported under the licence has been, or will be, lawfully taken under a law of another State or Territory.
Export Licence	**Licence issued under regulation 41 of the Biodiversity Conservation Regulations 2018.** This licence permits the licence holder to export fauna of a specified species from the state of WA to other Australian States or Territories. The relevant authority in the State or Territory to which the consignment is destined, approves the importation of the fauna to that State or Territory.

	Note that export of kangaroo products from Australia requires a separate export permit issued by DCCEEW.
Further detail	For further detail see the department's website.

Appendix 2 Biology, ecology and conservation of kangaroos

A2.1 Introduction

Kangaroos are among the most widely studied species of fauna in Australia. Information on the biology, ecology, conservation and harvesting of kangaroos has been comprehensively documented in many widely available publications. It is beyond the scope of the Management Plan to reproduce this information. Accordingly, the following sections provide a summary of different aspects of kangaroo biology, ecology, conservation, management and harvesting. The information provided is largely adapted from Pople and Grigg (1999) who provided a comprehensive overview of commercial harvesting of kangaroos in Australia.

A2.2 Impacts of European settlement on kangaroo populations

Changes to land management practices following European settlement resulted in an increase in the distribution and abundance of red and western grey kangaroos throughout Australia (Newsome, 1965b). Vegetation clearing, grazing by domestic and introduced herbivores, provision of artificial watering points, and control of dingo (*Canis familiaris*) and wild dog populations in the pastoral zone "improved" the habitat for red and western grey kangaroos and thus resulted in a general population increase from pre-European times (Russell, 1974; Newsome, 1975; Caughley *et al.*, 1980, 1980; Squires, 1982; Grigg, 1984; Dawson *et al.*, 2023). Sheep grazing has declined in many Western Australian rangeland areas since the 1970s (Hennig, 2004; Foran *et al.*, 2019), and therefore the associated removal of artificial water points and reduced wild dog and dingo control has likely led to a trend in kangaroo densities approaching pre-European settlement.

Intensive agriculture is not regarded as beneficial to either red or western grey kangaroos (Short and Grigg, 1982; Grigg, 1984). However, little red kangaroo habitat has been altered by intensive agriculture.

A2.3 Biology and ecology of the red kangaroo (*Osphranter rufus*)

The red kangaroo is the most abundant species of kangaroo. It is distributed over much of dry, inland Australia and is the only species exclusively restricted to the arid zone (Tyndale-Biscoe, 2005; Figure 3). This distribution reflects the interaction between mean annual precipitation and mean annual temperature (Caughley *et al.*, 1987). In WA, red kangaroos occur at varying densities over a range that occupies about 75 percent of the state (Figure 3) – an area of approximately 1.9 million km^2 (McNamara and Prince, 1986). Rainfall has been shown to be a driving factor of red kangaroo population densities (Caughley, Bayliss and Giles, 1984; Dawson *et al.*, 2023).

Red kangaroos are known to occupy a wide range of habitats including mulga and mallee scrub, shrubland, woodland, grassland and desert (Caughley, 1964; Russell, 1974; Johnson and Bayliss, 1981; Low *et al.*, 1981; Short *et al.*, 1983; Croft and

Clancy, 2008), however studies suggest a preference for open plains habitat (Russell, 1974; Croft and Clancy, 2008).

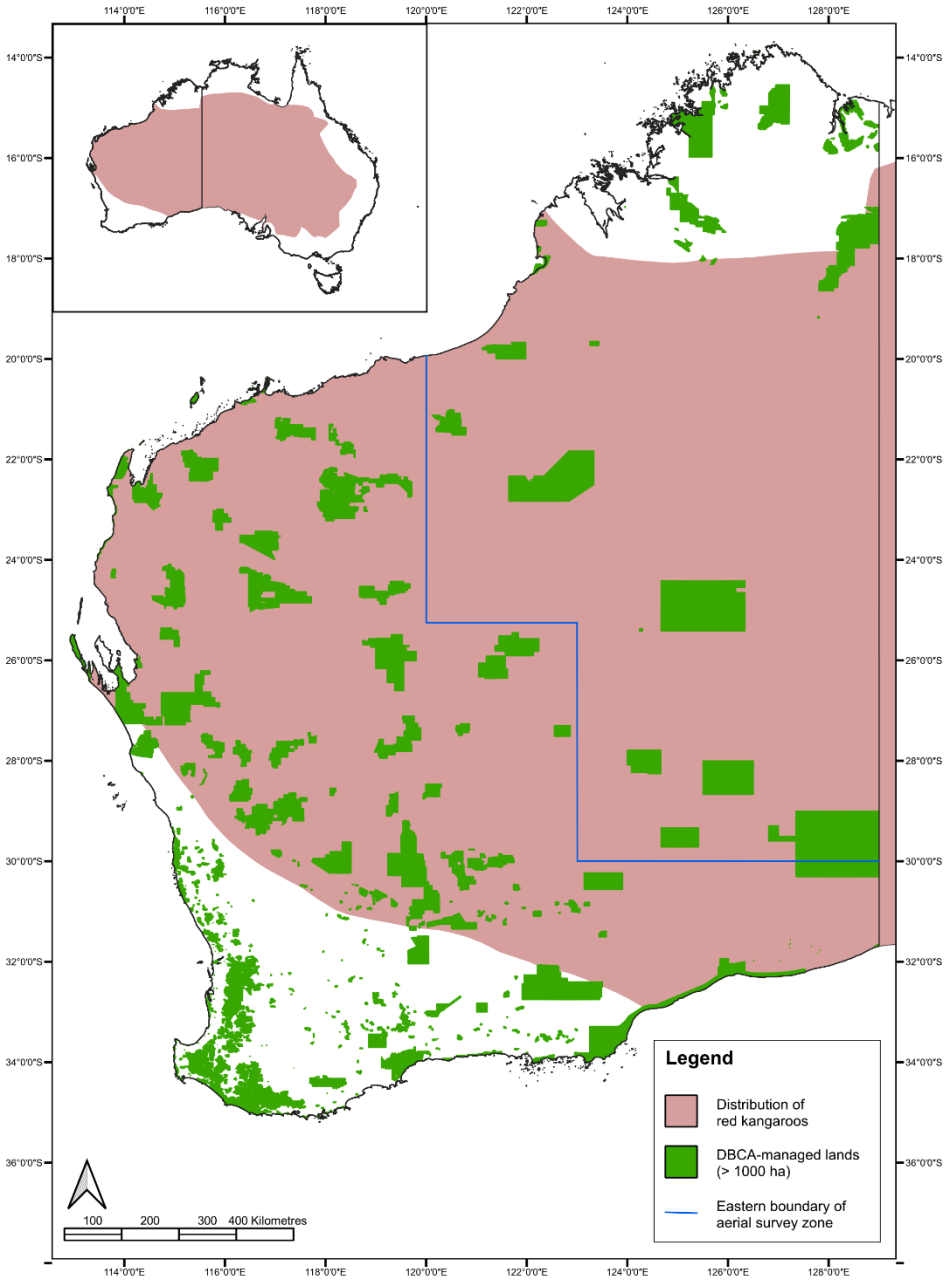

Figure 3: Distribution of the red kangaroo (Osphranter rufus). Note, kangaroos will not normally be harvested from department managed lands. Spatial data modified from the IUCN Red List of Threatened Species (Version 2022.2) using departmental records.

The red kangaroo is a herbivore with a preference for green herbage including grasses and dicotyledonous plants (Griffiths and Barker, 1966; Chippendale, 1968; Storr, 1968; Bailey, Martensz and Barker, 1971; Ellis, 1976), although they will browse chenopods and shrubs when necessary (Tyndale-Biscoe, 2005).

Red kangaroos are opportunistic breeders and females are potentially fertile throughout the year except during periods of extreme drought (Frith and Sharman, 1964; Newsome, 1964a, 1964b, 1965a; Sharman, 1964; Sharman and Pilton, 1964; Moss and Croft, 1999). Females can come into breeding condition almost immediately after drought-breaking rains. The gestation period is approximately 33 days and mating may take place again a day or two later. The mating system of the red kangaroo appears to be based on polygamy (Croft, 1980).

The red kangaroo is a gregarious species (Kirkpatrick, 1967) and while relatively large groups may sometimes form, these groups are unstable in their composition (Croft, 1980). Studies into the movement patterns of red kangaroos indicate that the majority of the population is sedentary, rarely moving distances greater than 10 km, with the exception of a small proportion of animals that move tens or hundreds of kilometres (Frith, 1964; Bailey, 1971; Croft, 1980; Denny, 1980; Oliver, 1986; Priddel, 1987; Norbury and Norbury, 1993; Norbury, Norbury and Oliver, 1994). Dispersal of younger individuals is male-biased (Edwards, Croft and Dawson, 1994) and dispersal distances tend to increase during drought (Johnson, 1989).

Individual home ranges have been found to overlap. In WA, red kangaroos have been found to occupy very large home ranges averaging 1,810 ha for females and 3,610 ha for males (Norbury, Norbury and Oliver, 1994). This was attributed to the inherently poor vegetation production and occurrence of drought during their study. These findings were quite different from those of Croft (1991) who studied red kangaroos during a non-drought period in better quality habitat and found weekly home ranges varied from 259 to 560 ha.

A2.4 Biology and ecology of the western grey kangaroo (*Macropus fuliginosus*)

Eastern and western grey kangaroos have probably diverged from a common ancestor quite recently with only subtle biological and ecological differences between the two species. The western grey kangaroo was only confirmed as a separate species from the eastern grey kangaroo in 1972 (Kirsch and Poole, 1967, 1972). Consequently, the two species are very similar in most aspects of their biology (Coulson, 2008).

The western grey kangaroo occurs across the south of Australia extending northwards through western New South Wales and into a small area of southern central Queensland. In WA the species is found from Shark Bay in the northwest and extends east to Laverton and south to the Nullarbor Plain (Figure 4). This distribution corresponds to areas of uniform or winter rainfall (Short *et al.*, 1983; Caughley *et al.*, 1987).

Western grey kangaroos are found in a variety of habitats including mallee, open forest, shrubland and heath. They display a preference for habitat heterogeneity, likely due to the species requirement for open vegetation for grazing and denser vegetation for shelter (Short *et al.*, 1983). The diet is varied but dominated by grasses with a shift to forbs and shrubs as pasture biomass declines (Barker, 1987; Norbury, 1987; Coulson and Norbury, 1988; Wann and Bell, 1997).

The peak breeding season is from November to February with young emerging from the pouch in late winter to early summer (Mayberry *et al.*, 2010), however the species is potentially fertile throughout the year, except in periods of extreme drought. They have an oestrus cycle of 35 days, gestation period of 31 days and pouch life of 42 weeks (Coulson, 2008). Western grey kangaroos do not exhibit embryonic diapause (Poole and Catling, 1974).

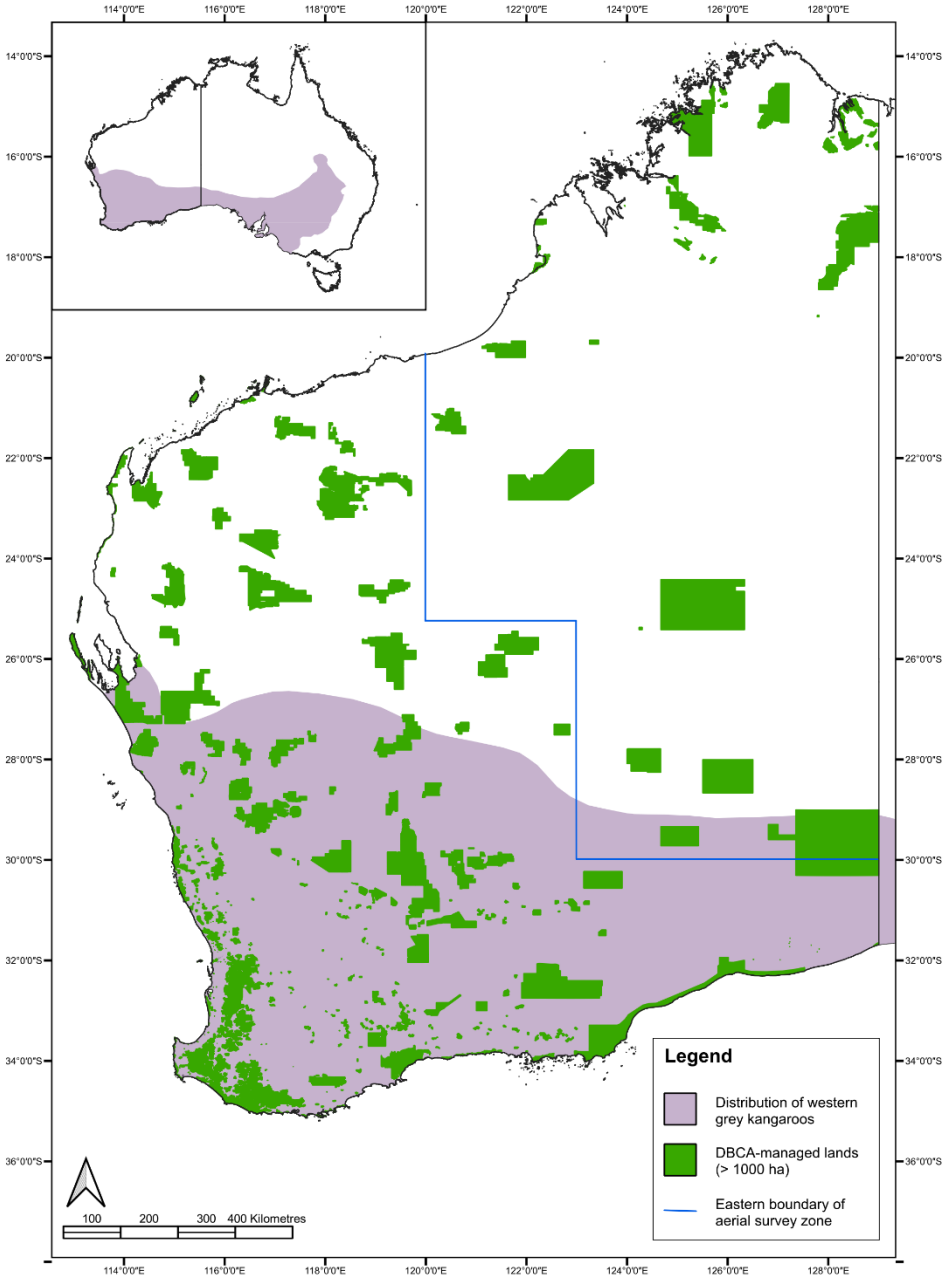

Figure 4: Distribution of the western grey kangaroo (Macropus fuliginosus). Note, kangaroos will not normally be harvested on department managed lands. Spatial data modified from the IUCN Red List of Threatened Species (Version 2022.2) using departmental records.

Western grey kangaroos are less mobile than red kangaroos with most individuals remaining sedentary; movements of greater than 6 km are rarely recorded even when food sources are depleted during drought (Priddel, Shepherd and Wellard, 1988; Priddel, Wellard and Shepherd, 1988). They occupy well defined, highly overlapping home ranges (Priddel, Shepherd and Wellard, 1988), feeding and resting in small groups of unstable composition (Arnold, Steven and Grassia, 1990). Home range fidelity is strong with few individuals shown to disperse; those that do are typically young males (Arnold *et al.*, 1992).

A2.5 Population estimates and monitoring history of kangaroos in Western Australia

Aerial surveys to monitor red and western grey kangaroos have been conducted since 1995. The northern, central, and south east PMZs have been surveyed triennially commencing in 1995, 1996 and 1997 respectively, while surveys in the south west PMZ commenced in 2004 and are conducted annually.

Data collected from aerial surveys is used to estimate the population size of the species within population monitoring zones. In the intervening years between aerial surveys, population estimates were calculated using the most recent population estimate adjusted for regional rainfall and commercial harvest offtake.

Populations of both species of kangaroo have been shown to fluctuate over time (Figure 5). In 2022 the population estimate for western grey kangaroos was 1,419,920 and the population estimate for red kangaroos was 736,630.

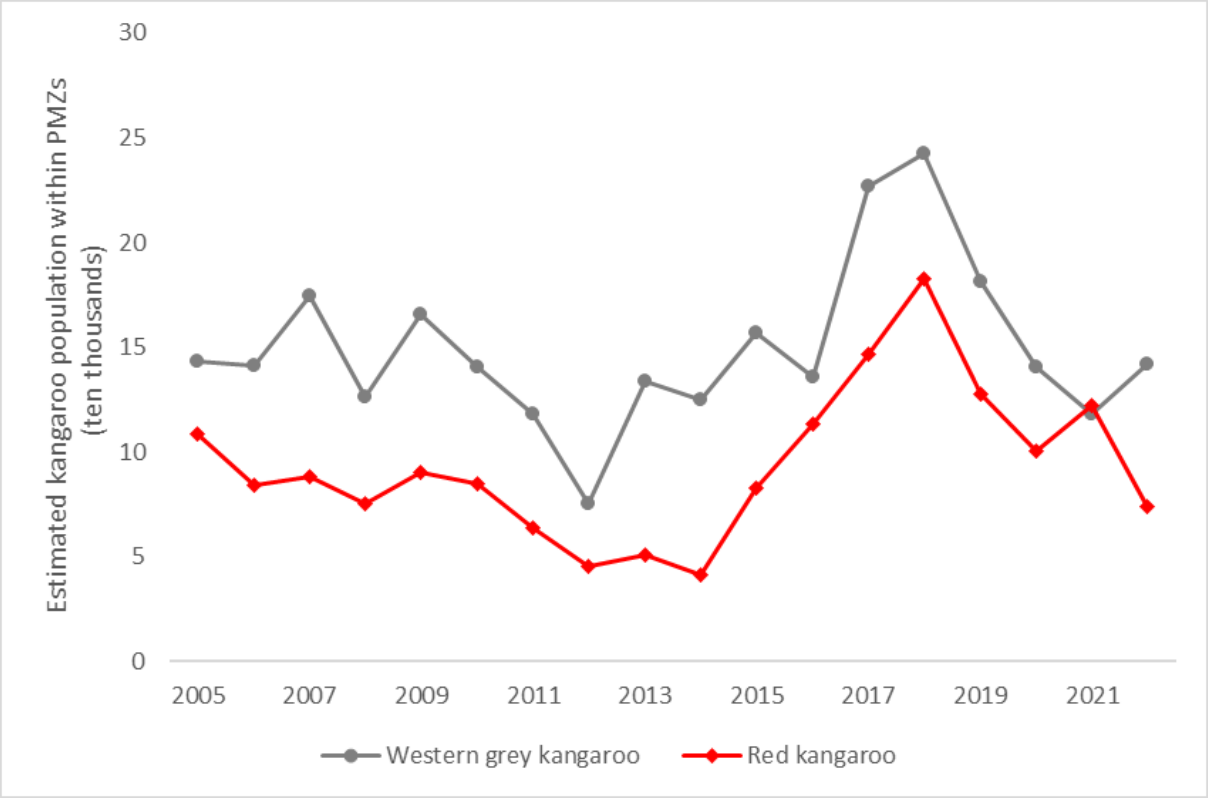

Figure 5: Population estimates of western grey and red kangaroos across all PMZs.

A2.6 Conservation status

The conservation status of the commercially harvested kangaroo species in WA reflects their abundance and therefore their utilisation. The listing status under State and Commonwealth legislation and international lists and agreements for red and western grey kangaroos is as follows:

- Not listed as threatened or endangered in WA (BC Act 2016)
- Not listed as threatened in Australia (EPBC Act)
- Listed as Least Concern on the IUCN Red List (2022)
- Not listed under Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2023).

Appendix 3 Threats and assessment of impacts

In the context of commercial kangaroo harvesting in WA:

- threats to the conservation status of harvested kangaroo species are limited;
- issues relating to the conservation and harvesting of kangaroos are well understood; and,
- assessments of the impacts of harvesting on kangaroos, as well as other species, habitats and ecosystems, are comprehensive.

A3.1 Threats to kangaroos

Kangaroo populations in WA have the potential to be impacted by a range of environmental and anthropogenic factors. The extent of the impact can vary. Environmental factors include changing climate, drought, disease and predation. Potential anthropogenic threats to the conservation status of kangaroos principally arise from the commercial harvest and other human-mediated practices such as habitat loss and modification.

Table 3 outlines the threats that may impact kangaroo populations and the likely risk of those threats to their long-term conservation status.

Table 3: Threats and issues pertinent to the long-term conservation of kangaroos

Threats	**Comments**	**Selected References**
Drought	Rainfall and its impact on plant productivity is the single most important factor affecting kangaroo population dynamics. Droughts can drastically reduce kangaroo numbers. However, kangaroos are well adapted to a dynamic environment and populations recover quickly after drought-driven population crashes, even with continued harvesting. Therefore, drought is not considered a threat to the long-term conservation of kangaroos.	(Caughley, Grigg and Smith, 1985; Robertson, 1986; Bayliss, 1987; Cairns and Grigg, 1993; McCarthy, 1996; Cairns *et al.*, 2000; Pople, 2003; Pople, Grigg, *et al.*, 2010).
Flood	Flooding has been found to affect the distribution and abundance of kangaroos and has been associated with occasional localised epizootic disease however these effects have been short-term. Flooding is not considered a threat to the long-term conservation of kangaroos.	(Clancy *et al.*, 1990; Choquenot, 1991).
Climate change	Shifts in climate regimes have the potential to significantly impact all biodiversity including the commercially harvested species of kangaroos. Modelling indicates that northern WA is likely to become warmer and wetter while south-western WA warmer and drier. Rainfall patterns and therefore vegetation associations and pasture biomass may also be significantly different from current and historical patterns. This will likely lead to variable responses across the landscape and may benefit some populations and adversely impact others. While the potential effects of climate change on kangaroos are not well understood, the methods used for setting harvest quotas are responsive to fluctuating densities of kangaroos and will alert managers to potential problems.	(Jonzén *et al.*, 2010).

Threats	Comments	Selected References
Habitat loss and modification	Red and western grey kangaroos have benefited from habitat modification: their numbers have increased, and ranges extended, due principally to the expansion of grasslands and the provision of permanent sources of fresh water for livestock. Conversely, kangaroo numbers have generally declined where there is intensive agriculture, urbanisation or extensive clearing. Despite more than 200 years of heavy exploitation and clearing of the land, the larger kangaroos have maintained their populations or increased in abundance and range. Accordingly, habitat loss and modification are not considered a threat to the long-term conservation of kangaroos.	(Short and Grigg, 1982; Calaby and Grigg, 1987; Dawson, McTavish and Ellis, 2004; Pople, Grigg, *et al.*, 2010).
Disease	A range of parasites and pathogens infect kangaroos. Epidemics have caused significant short-term reductions in kangaroo numbers in particular areas, but these populations have recovered rapidly. Diseases do not appear to be important agents of mortality in kangaroos over the long-term and, therefore, are not considered to pose a threat to their long-term conservation.	(Kirkpatrick, 1985; Caughley, 1987; Speare *et al.*, 1989; Gilroy, Curran and Gay, 1999; Hooper *et al.*, 1999; Reddacliff *et al.*, 1999).
Harvesting – general	In over forty years of managed harvest in WA, viable populations of the harvested kangaroo species have been maintained across their natural range. Furthermore, the distributional ranges of red and western grey kangaroos have expanded. Therefore, harvesting is not considered a threat to the long-term conservation of kangaroos.	(Calaby and Grigg, 1987; Cairns and Coombs, 1992; Grigg and Pople, 2001; Dawson, McTavish and Ellis, 2004; Wilson and Edwards, 2019; McLeod and Sharp, 2020; Read *et al.*, 2021).
Harvesting – genetic	Harvesting, especially non-random or selective harvesting, has the potential to alter the genetic structure and genetic diversity of a population. The safeguards in place to protect the genetic diversity of harvested kangaroos include conservative harvest quotas and protected areas where harvesting is prohibited. Several studies have examined genetic diversity of harvested macropod populations and there is no evidence to suggest that current harvesting practices are a threat to the long-term genetic integrity of kangaroo populations.	(Clegg, Hale and Moritz, 1998; Hale, 2001, 2004; Tenhumberg *et al.*, 2002, 2004; Hacker and McLeod, 2003; Hacker *et al.*, 2004; Neaves *et al.*, 2009, 2012; McLeod and Sharp, 2020).
Predation	Dingoes and wild dogs have been shown to have a regulatory effect on kangaroo populations in some circumstances. Other predators such as European fox (*Vulpes vulpes*) and wedge-tailed eagle (*Aquila audax*) do not appear to exert much influence on the harvested species of kangaroo. Predation is not considered a threat to the long-term conservation of kangaroos.	(Jarman and Denny, 1976; Caughley *et al.*, 1980; Corbett and Newsome, 1987; Thompson, 1992; Banks, Newsome and Dickman, 2000; Pople and Page, 2001; Letnic and Koch, 2010).

A3.2 Management and regulatory controls

Commercial harvesting is not considered a threat to the genetic integrity or conservation status of kangaroos in WA. In over 40 years of commercial harvesting in WA, viable populations of the harvested kangaroo species have been maintained across their natural range. However, to ensure that the commercial kangaroo harvest in WA remains sustainable and does not jeopardise the viability of kangaroo populations across their range in the future, the department enacts a range of management and regulatory controls including:

Undertaking regular and ongoing monitoring of kangaroo populations.

The strictly standardised survey techniques employed in WA for the broad-scale monitoring and estimation of kangaroo populations are widely regarded as best practice, both in Australia and overseas (Caughley, Sinclair and Scott-Kemmis, 1976; Caughley and Grigg, 1981; Anderson and Southwell, 1995; Southwell *et al.*, 1995; Pople, 2004, 2008; Pople *et al.*, 2006; Finch *et al.*, 2021).

Indirect monitoring is also undertaken using harvest statistics but is currently used only to supplement direct monitoring from aerial surveys. Predictive models using harvest statistics, rainfall and other data are not yet considered sufficiently advanced to replace direct monitoring (Pople, Evans, *et al.*, 2010; Pople, Grigg, *et al.*, 2010).

Managing the commercial harvest using a proportional harvesting strategy based on regular estimates of abundance.

Proportional harvesting strategies have been well studied and are considered safe and efficient for fluctuating populations (Caughley, 1987; Engen, Lande and Saether, 1997). Moreover, WA's program of regularly monitoring and estimating abundance allows for any other agents of mortality acting on kangaroo populations (e.g., drought, disease, roadkill, non-commercial culling) to be detected and accounted for in the setting of annual commercial harvest quotas.

Proportional threshold harvesting is considered the optimal strategy to maintain a viable yield and minimise any adverse risks to the sustainability of the harvested species (Engen, Lande and Saether, 1997; Pople, 2004, 2008). Using this strategy thresholds are set under which the proportion of the population to be harvested, (i.e., the quota) is reduced and finally ceased to avoid any risk of over harvesting. WA adopts a proportional threshold harvesting strategy for the commercial harvest of macropods.

Using conservative species correction factors.

The department uses correction factors for calculating population estimates from aerial survey data that are generally regarded as conservative because they tend to underestimate kangaroo abundance.

Setting commercial harvest quotas at levels that are considered ecologically sustainable for kangaroo populations.

WA will set harvest quotas for red kangaroos at ≤17 percent and for western grey kangaroos at ≤15 percent of the populations' estimate. These levels are regarded as ecologically sustainable (e.g. Caughley, 1987; Hacker *et al.*, 2004) and have been demonstrably sustainable in practice.

Providing refuge habitat.

In WA, conservation reserves and state forest, a total area in excess of 26 million hectares or approximately 10 percent of the land area of the state (see Figures 3 and 4) is exempt from commercial harvesting. Additionally, kangaroos would not normally be culled in these areas unless such actions are deemed a necessary operation under the *Conservation and Land Management Act 1984*, or where an area management plan specifies that the management of overabundant populations is warranted.

The department also has limited management responsibilities for unallocated Crown Land (UCL) and unmanaged reserves (UMR) outside the metropolitan area and townsites. The area of UCL and UMR for which the department has limited management responsibilities totals about 90 million hectares. The commercial harvesting of kangaroos would not normally occur on UCL and UMR. Additionally, the commercial kangaroo harvest is patchy within Kangaroo Management Areas and individual properties, leaving many other areas unharvested or providing refuge habitat (see Tenhumberg *et al.*, 2004).

A3.3 Assessment of the impacts of commercial kangaroo harvest on other species, habitats, and ecosystems

Impacts on species, habitats and ecosystems resulting from actions detailed within the Management Plan are unlikely to be significant, and in some instances are expected to be positive.

Table 4: Impacts of the commercial harvest of kangaroos on other species, habitats, and ecosystems.

Potential Impacts	**Comments**	**Selected References***
Land degradation caused by the erosion of soil	The commercial kangaroo harvest is unlikely to cause land degradation due to the erosion of soil. Licensed commercial kangaroo shooters generally operate on pre-existing tracks and are reluctant to risk damage to their vehicles, especially punctured tyres, by traversing rough terrain.	(Wilson and Read, 2003).
Detrimental effects on water bodies, watercourses, wetlands and natural drainage systems	There is no evidence that suggests the commercial kangaroo harvest will have detrimental effects on water bodies, watercourses, wetlands and natural drainage systems.	
Vegetation clearing or modification	No vegetation is likely to be cleared or modified as a consequence of the commercial kangaroo harvest. However, the commercial harvest of kangaroos may provide indirect	(Grigg, 1988, 1995; Fisher *et al.*, 2004;

Potential Impacts	Comments	Selected References*
	benefits to vegetation by reducing total grazing pressure or facilitating the retention of vegetation that provides habitat for kangaroos by private landholders.	Rees, Kingsford and Letnic, 2017).
Detrimental effects on threatened flora species, populations or their habitats	There is no evidence that the commercial kangaroo harvest has a detrimental effect on threatened flora species, populations or their habitats.	
Endangering, displacing or disturbing native fauna, or creating a barrier to their movement	Native fauna is unlikely to be endangered, displaced or disturbed as a consequence of the commercial kangaroo harvest. Furthermore, the commercial harvest is unlikely to create a barrier to the movement of native fauna. Kangaroo harvest off-cuts are utilised by species that scavenge, such as some raptors and corvids, thereby benefiting these species.	(Read and Wilson, 2004).
Detrimental effects on threatened fauna species, populations or their habitats	There is no evidence that the commercial kangaroo harvest has a direct detrimental effect on threatened fauna species, populations, or their habitats, but there may be indirect effects on threatened fauna species and/or populations (see section on introduced predators below).	
Detrimental impacts on ecological communities of conservation significance	Ecological communities of conservation significance are unlikely to be impacted by the commercial kangaroo harvest.	
Positive effects on introduced predators	Kangaroo harvest off-cuts are utilised by introduced predators, particularly foxes and may sustain populations of these predators during periods of low prey availability. Maintenance of artificially high predator populations may in turn threaten prey populations, including endangered taxa. However, WA undertakes extensive aerial baiting programs to protect endangered fauna from fox predation and to protect livestock from wild dog predation, which would mitigate this effect.	(Saunders *et al.*, 1995; Kay *et al.*, 2000; Read and Wilson, 2004).
Positive effects on introduced herbivores	The commercial kangaroo harvest, by reducing kangaroo populations and thus competition, may allow populations of introduced herbivores such as goat (*Capra hircus*) and rabbit (*Oryctolagus cuniculus*) to increase. However, the limited magnitude of the reduction in kangaroo numbers coupled with ongoing pest animal control programs undertaken across WA mitigates the potential positive effect on populations of introduced herbivores.	
Introduction and/or dispersal of invasive weeds	There is no evidence that commercial kangaroo harvesters contribute to the introduction and/or dispersal of invasive weeds more than other land users.	

**Where applicable and/or available.*

Appendix 4 Setting and applying harvest thresholds

Proportional threshold harvesting is a safe and efficient strategy to reduce the risk of over-harvesting from a naturally fluctuating population (Caughley, 1987; Engen, Lande and Saether, 1997). It involves a program of monitoring to track population densities and set harvest quotas as a proportion of the population estimate based on the density recorded. Typically, the harvest rate is reduced, or the harvest is suspended at specific densities (harvest thresholds) to reduce the risk of over-harvesting. Proportional threshold harvesting is used by the Western Australian Government to set quotas for the commercial harvest of kangaroos in WA.

The Management Plan seeks to accommodate natural fluctuations in kangaroo densities that change according to seasonal conditions. To achieve this, harvest thresholds have been set using the statistical properties of a time series of the population's estimated abundance (see Mcleod and Pople, 2011 in Department of Planning and Environment, 2022). The harvest thresholds shown in Table 2 were determined based on standard deviations (1.0, 1.5, 2.0 and 3.0) from the long term mean of kangaroo abundance, estimated from surveys conducted between 1995 and 2022. This method prevents the threshold becoming biased by a single low abundance. Additionally, the population mean, and standard deviation become more robust as more survey data are added to the time series. Application of harvest thresholds in this way allows the population to fluctuate within the average observed range of abundance (normal range) while the provision of management triggers prevents harvest mortality from depleting the population when abundance is low.

In erratic environments such as the arid inland area of WA, population densities fluctuate much more widely as a proportion of their long-term average density than in more stable environments such as the south-west. The standard deviation has been calculated for each species in each PMZ resulting in harvest thresholds that are specific to the population. It is important to note that the density estimates of kangaroos over much of WA, particularly in rangelands areas, are significantly lower than in eastern Australia. Average densities in many areas are of the order of one kangaroo per km^2 or lower, with average red kangaroo density estimates at the PMZ level ranging from less than 0.4 kangaroos per km^2 to a high of around three kangaroos per km^2. In comparison, long term average density estimates of red kangaroos in New South Wales range from 2.9 – 12.0 kangaroos per km^2 (Department of Planning and Environment, 2023).

Land use practices can also influence the densities of kangaroos across both the broader landscape and at local scales. It is considered that the kangaroo densities experienced over the last 40 years of commercial harvesting are significantly higher than they would have been prior to the commencement of widespread sheep grazing in the rangelands. The department recognises that as part of the cessation of sheep grazing in many rangeland areas, the dismantling of artificial water points and less intensive wild dog control, kangaroo densities are moving back to levels approaching pre-European settlement densities. It has been established that kangaroo densities

are routinely much lower in areas subject to dingo predation compared with adjacent areas where wild dogs and dingoes are controlled (Pople *et al.*, 2000; Dawson *et al.*, 2023). Furthermore, while there is a high control effort for dingoes across much of WA, in many areas the effect of this control is inconsistent and sometimes negligible (Kennedy *et al.*, 2021). Provision of artificial water sources and the subsequent dismantling of these water sources can also affect local kangaroo densities. It is difficult to estimate with any certainty how much lower historic population levels would have been in the presence of dingoes and in the absence of artificial water sources and livestock grazing.

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