South Australian Commercial Kangaroo Management Plan 2018-2022

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Definitions

Kangaroo – the kangaroo species that can be utilised under this management plan: the red kangaroo (*Macropus rufus*), western grey kangaroo (*M. fuliginosus*), euro (*M. robustus*) and other species as per relevant legislative amendment.

Carcass – the entire body (including the skin) of the kangaroo, excluding the head and entrails.

National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes (Commercial Code) and **National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-Commercial Purposes (Non-Commercial Code)** – the current nationally-endorsed codes, endorsed by the Natural Resource Management Ministerial Council in 2008. A reference to these codes will also apply to any subsequently nationally-endorsed codes.

Kangaroo Field Processor – a person, permitted under Section 60J of the *National Parks and Wildlife Act 1972* to harvest kangaroos for commercial purposes.

Kangaroo Meat Processor – a person, permitted under Section 58 of the *National Parks and Wildlife Act 1972* to carry out the business of processing kangaroo carcasses for human or animal consumption and is permitted to sell carcasses or skins.

Field Chiller – an appliance or structure, whether mounted on or forming part of a vehicle or otherwise, providing refrigeration facilities for the storage of the carcass of a kangaroo during the period between field processing of the carcass and the transportation of the carcass to the premises at which it is to be processed by a kangaroo meat processor.

Landholder – owner or occupier of specified lands.

Commercial Harvest Management Region (CHMR) – A designated area of the State at which commercial quota is determined. At the time of writing, regions are defined by the former Soil Conservation Board boundaries (or amalgamation thereof), and consist of four CHMRs (Eastern Agricultural, Western Agricultural, Eastern Pastoral and Western Pastoral), which are split into 13 **Commercial Harvest Sub-Regions (CHSR)**. See Figure 1.

Note: All other terms are as defined in the *National Parks and Wildlife Act 1972*.

Acronyms

NPW Act – the South Australian *National Parks and Wildlife Act 1972*

EPBC Act – the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*

DEWNR – the South Australian Department of Environment, Water, and Natural Resources

CHMR – Commercial Harvest Management Region

CHSR – Commercial Harvest Sub-Region

1 Introduction

This plan has been developed to guide the sustainable management of commercially harvested macropods in South Australia. The plan satisfies the requirements of the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as a Wildlife Trade Management Plan and meets the legislative and other requirements of the South Australian Government.

This plan relates only to the following kangaroo species within South Australia:

- red kangaroo (*Macropus rufus*)
- western grey kangaroo (*Macropus fuliginosus*)
- euro (*Macropus robustus*)
- other species as per relevant legislative amendment

Where the term kangaroo is used within this document, it refers to the macropod species mentioned above.

This plan is current for a maximum five-year period from 1 January 2018 to 31 December 2022.

In Australia, the export of kangaroo products requires Commonwealth Government approval under the EPBC Act.

Under the South Australian *National Parks and Wildlife Act 1972* (NPW Act), kangaroos are protected fauna, and the South Australian Department of Environment, Water and Natural Resources (DEWNR) is responsible for their protection. The utilisation of kangaroos in South Australia is regulated under the NPW Act and South Australian National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 (Kangaroo Harvesting Regulations), and the National Parks and Wildlife (Wildlife) Regulations 2016 (Wildlife Regulations) through the issue of permits and tags.

This plan does not provide the framework for the management of kangaroos within land dedicated or declared under Part 3 of the NPW Act and managed by DEWNR (e.g. national parks and conservation parks). Management of kangaroos on reserves occurs in line with DEWNR's Kangaroos on Reserves (population control) Policy. However, the NPW Act and DEWNR policy do allow for commercial harvest to be undertaken on parks and reserves if the requirements of the NPW Act are met.

The primary goal of this plan is to ensure an ecologically sustainable harvest of kangaroos and to provide an alternative management option for reducing the damage caused by overabundant kangaroos. This will be achieved through the application of the best available scientific knowledge, best practice management and monitoring of outcomes to ensure that the viability of kangaroo populations is not compromised by any action undertaken under this plan. This plan incorporates an adaptive approach to management, by collecting and applying reliable information to improve management over time.

This plan will set the framework for the management of the commercial kangaroo harvest following the principles of ecologically sustainable development. Management in this context assists in balancing environmental, social, and economic interests through the management of a renewable resource. This management also provides for the sustainable harvesting of kangaroos for products such as meat and leather to supply Australian and international markets. This plan prohibits the taking of kangaroos in South Australia for skins only.

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. This plan has been developed to meet the requirements of an Approved Wildlife Trade Management Plan under that Act.

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 only be given if the Minister is satisfied that:

- the plan is consistent with the objects of Part 13A of the EPBC Act
- an assessment of the environmental impacts of the activities in the plan has been undertaken
- the plan includes management controls directed towards ensuring the impacts of the activities covered by the plan are ecologically sustainable
- the activities in the plan are not detrimental to the species to which the plan relates or any relevant ecosystem
- the plan includes measures to mitigate, monitor and respond to the environmental impacts of the activity covered by the plan

In deciding whether to declare this plan as a Wildlife Trade Management Plan, the Minister must also have regard to whether:

- legislation relating to the protection, conservation, or management of the species to which the plan relates in force in the State or Territory concerned
- the legislation applies throughout the State or Territory concerned
- in the opinion of the Minister, the legislation is effective

Finally, in deciding whether to declare this plan as a Wildlife Trade Management Plan, the Minister must also be satisfied that if an animal is killed, it is done in a way that is 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 (www.environment.gov.au/biodiversity/trade-use/wild-harvest/kangaroo/practice.html), hereafter referred to as the Commercial Code. All kangaroos must be killed following this Code or any subsequent relevant nationally-endorsed code(s) that replace this document.

2.2 South Australia

All kangaroo species are protected fauna in South Australia under the NPW Act. The NPW Act, the Kangaroo Harvesting Regulations, and the Wildlife Regulations make provisions for the permitting of a range of activities relating to the commercial harvesting of kangaroos in South Australia.

Harvesting of kangaroos in South Australia requires a Management Plan approved under section 60I of the NPW Act, which states that the plan must:

- assess the likely impact of harvesting animals of that species:
    - on the species concerned
    - on the ecosystems which animals of that species form part
    - on the diversity of the species of animals and plants comprising those ecosystems
    - on the ability of the species to maintain natural genetic diversity throughout its population
- identify factors that are likely to reduce or increase the number of animals of the species to be harvested
- identify any other factors that will affect the species as a renewable resource for harvesting in the future

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- assess whether there is a need to reduce the number of animals of the species to protect the environment, crops, stock, or other property
- specify humane methods and procedures for the killing, capturing and killing and treatment after capture of animals under a permit under Division 4B (of the NPW Act)
- address any other matters that should, in the opinion of the Minister, be addressed

This plan is designed to meet these requirements and is endorsed under the NPW Act. The Kangaroo Harvesting Regulations and the Wildlife Regulations manage the operations of the kangaroo industry through the issuing of permits, tags and record keeping. Permits are issued for harvesting kangaroos (Kangaroo Field Processor, section 60J NPW Act), processing and selling kangaroo meat (Kangaroo Meat Processor, section 58 NPW Act) or kangaroo skins (Kangaroo Skin Tanner, section 58 NPW Act). Tags are issued to licensed Kangaroo Field Processors under the Kangaroo Harvesting Regulations Part 2 or any relevant updated regulation. The Kangaroo Harvesting Regulations will be remade during the life of this plan. Details on permitting structures are provided in Appendix 4. The commercial harvest is restricted to the Commercial Harvest Management Region depicted in Figure 1.

In addition to the NPW Act, this plan integrates with, and is informed by, the following pieces of legislation:

- *Native Title (South Australia) Act 1994*
- *Natural Resources Management Act 2004*
- *Pastoral Land Management and Conservation Act 1989*
- *Animal Welfare Act 1985*
- *Primary Produce (Food Safety Schemes) Act 2004*
- Commonwealth *Export Control Act 1982*
- Commonwealth *Native Title Act 1993*

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3 Goal and Aims

3.1 Goal

The overarching goal of the *South Australian Commercial Kangaroo Management Plan 2018 – 2022* is:

> **To maintain viable populations of kangaroos throughout their ranges following the principles of ecologically sustainable development.**

The principles of ecologically sustainable development are defined in section 3A of the EPBC Act.

To attain its overarching goal, this plan has seven aims, each of which encompasses a particular facet of kangaroo management. When combined these aims provide a strategic direction for ensuring an ecologically sustainable harvest of kangaroos and to provide an alternative management option for reducing the damage to land condition caused by overabundant kangaroos.

Under each aim sits one or more actions detailing 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 plan can be measured.

Throughout the life of this plan, aims will be audited annually against performance indicators, with a major assessment and review towards the end of 2022.

3.2 Aims

The aims of this management plan are to:

1. **Ensure Humane Harvest of Kangaroos**
   Promote improved animal welfare outcomes and ensure that the commercial harvest of kangaroos under this plan is carried out following the Commercial Code.
2. **Promote Community Awareness and Participation**
   Promote greater understanding of the program through communication with the public and involve the public in decisions regarding the management of the commercial utilisation of kangaroos.
3. **Manage Impacts of Kangaroos on Land Condition**
   Reduce conflicts between kangaroos and environmental, economic, and social objectives of stakeholders.
4. **Monitor Kangaroo Populations**
   Monitor kangaroo populations to ensure harvesting is not negatively affecting kangaroo populations and to set commercial quotas based on population estimates.
5. **Monitor Commercial Harvest**
   Manage the commercial utilisation of kangaroo species following the provisions of the NPW Act and Regulations, South Australian Government policies, the Commercial Code, and this plan to ensure the sustainable use of kangaroos.
6. **Facilitate Adaptive Management and Research**
   Promote adaptive management experiments and studies using historical data from kangaroo industry returns and population data to improve understanding of kangaroos and their interaction with environmental, social, and economic systems. Facilitate research into other aspects of kangaroo ecology and harvest management as required to fill knowledge gaps.
7. **Undertake Program Reporting and Review**
   Undertake regular reporting and a final program review in consultation with affected community members and stakeholders to ensure management is fully informed and to ensure outcomes remain consistent with the goal of this plan.

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4 Management Actions and Performance Indicators

4.1 Aim 1: Ensure Humane Treatment of Kangaroos

Animal welfare is of prime concern to DEWNR. The Commercial Code is the current nationally-endorsed animal welfare standard for the commercial harvest of kangaroos. Accordingly, the commercial kangaroo industry in South Australia is required (by the Kangaroo Harvesting Regulations) to comply with the Commercial Code. Any approved subsequent code(s) will similarly be adopted as the animal welfare standard for the commercial harvest of kangaroos in South Australia. Kangaroo Field Processors must demonstrate their competency concerning the Commercial Code and conditions attached to the Kangaroo Field Processor permit provide financial disincentives for shooting other than as per the Commercial Code (Aim 5).

Action 1: ***DEWNR staff will monitor compliance with the Commercial Code by commercial kangaroo industry operators.***

DEWNR authorised officers will undertake both regular unannounced and opportunistic inspections of kangaroos taken by licensed Kangaroo Field Processors and all premises registered by licensed Kangaroo Meat Processors. DEWNR has a zero tolerance to breaches of the Commercial Code, and where kangaroos have been found to be taken other than by the Commercial Code, Expiation Notices are issued, or licensees are prosecuted as appropriate. Permits may be cancelled.

Performance indicators:

1.1 All licensees who are found to have breached permit conditions (i.e. the Commercial Code) relating to animal welfare are issued with Expiation Notices or are prosecuted as appropriate.

Action 2: ***DEWNR will promote research opportunities into improving animal welfare outcomes.***

DEWNR will work with other agencies to identify and investigate animal welfare concerns in the commercial harvest of kangaroos. Research to be encouraged may include aspects of the biology and ecology of kangaroos as they relate to the commercial harvest or harvest techniques. Contributions by DEWNR may include funding and/or in-kind support such as the provision of harvest data.

Performance indicators:

2.1 Participate in a national review of the Commercial Code of Practice during the life of this plan.

2.2 Promote research into improving animal welfare outcomes for commercial harvest of kangaroos.

4.2 Aim 2: Promote Community Awareness and Participation

Management strategies for kangaroos must meet detailed legislative requirements to ensure their sustainability, and stakeholders want to see their specific management objectives met. Community awareness of, and stakeholder participation in, kangaroo management is considered a key component in the success of the program.

Action 3: ***Members of the Kangaroo Management Reference Group will be provided with relevant information and afforded the opportunity to advise DEWNR on kangaroo management issues throughout the life of this plan.***

The Kangaroo Management Reference Group (KMRG), which is convened by DEWNR, is the primary forum through which stakeholder group representatives can raise issues for discussion, as well as communicate their group's positions and interests to Government and other stakeholders on a regular basis. The current membership of KMRG encompasses representatives of animal welfare, the kangaroo industry, landholder groups, Aboriginal communities, conservation

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organisations and government stakeholder groups (both Federal and State). Members hold their appointed positions for three-year terms. The function of KMRG is to advise the Chief Executive of DEWNR on matters about the implementation and review of this plan.

Performance indicators:

3.1 KMRG is provided with relevant information as required throughout the life of this plan.

3.2 KMRG meets at least twice per year to review the progress of this plan with the plan's goal and aims.

Action 4: ***Relevant public documents will be made available on the Kangaroo Conservation and Management web page.***

The provision of information to members of the public promotes understanding of the function of this plan and assists members of the community to develop informed opinions regarding kangaroo management issues.

Performance indicators:

4.1 Throughout the life of this plan the Kangaroo Conservation and Management web page will contain the following information:

- a statement of the reasons commercial harvest is undertaken in this State
- the current and previous South Australian Commercial Kangaroo Management Plans
- current and previous annual Quota Reports
- current and previous annual Harvest Reports
- historical and current population estimates and harvest data
- contact information for the Kangaroo Management Program
- current forms for commercial kangaroo permits

4.2 Documents outlined in 4.1 and any additional relevant information, will be posted on the Kangaroo Conservation and Management web page within one month of becoming publicly available.

4.3 Publicly available kangaroo management information is distributed to interested parties within one month after such a request, in an appropriate format.

Action 5: ***Where appropriate, relevant DEWNR staff will participate in media interviews and prepare media releases.***

Participation in media interviews and preparation of media releases can be an efficient mechanism for communicating information regarding kangaroo management to a broad audience. Media releases also improve program transparency and accountability, and therefore public confidence.

Performance indicators:

5.1 Kangaroo Management Program staff will participate in relevant interviews on request from media agencies where appropriate.

5.2 Media releases are prepared when appropriate for issues of interest to the community such as population surveys (June) and the release of the quota for the next calendar year, once approved by the Minister (November).

Action 6: ***Information about the Kangaroo Management Program and other relevant information will be developed as required and distributed to relevant stakeholders.***

A communication strategy will be prepared to ensure that internal and external stakeholders are kept up to date with changes to the Kangaroo Management Program, such as seasonal advice to internal staff or changes to permit conditions to external stakeholders.

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Performance indicators:

6.1 A communication strategy will be developed for the Kangaroo Management Program, including both internal and external stakeholders. The communication strategy will include the newsletter that is currently provided to relevant kangaroo management stakeholders bi-annually.

6.2 A copy of the current information package for Kangaroo Field Processors is issued with every new Kangaroo Field Processor's permit throughout the life of this plan to make permit holders aware of relevant permit requirements and responsibilities.

Action 7: ***Involve Aboriginal stakeholders in the implementation of this plan.***

Feedback on kangaroo management strategies, and implementation of this plan will be requested from Aboriginal people. This will enable Aboriginal people to participate in decision-making related to kangaroos and the development of management strategies for kangaroos. It will also facilitate an increased understanding of Aboriginal interests among DEWNR and other stakeholders of kangaroo management. Increased understanding and awareness of Aboriginal interests in kangaroo management among the broader community will be facilitated by the inclusion of relevant information on the DEWNR Kangaroo Conservation and Management web page.

Performance indicators:

7.1 Hold specific discussions with representatives of Aboriginal communities to develop more effective ways of sharing information.

7.2 Encourage Aboriginal participation in kangaroo management.

7.3 Involve Aboriginal people in the development of the communication strategy for the Kangaroo Management Program (Action 6).

4.3 Aim 3: Manage Impacts of Kangaroos on Land Condition

Widespread changes to the environment since European settlement have changed the abundance of many native species. Many species have declined in number, and some are now threatened. Other species have been able to adapt to the changes and can exploit the opportunities provided by altered habitats. These species – including kangaroos – are now present in larger numbers, or more widespread distributions, than before.

Kangaroos can be in conflict with various land uses and the objectives for which land is being managed. When this conflict occurs, kangaroos can cause detrimental impacts that may be environmental, economic, or social in nature.

This plan adopts the ethic that the mitigation of environmental, economic, and social impacts of kangaroos should be allowed, provided it takes place in a manner that is humane and does not pose a risk to the long-term conservation of kangaroos.

The NPW Act provides for the destruction of kangaroos for the purposes of mitigating or preventing damage. This process is managed outside of the commercial harvest through the permit to destroy wildlife system and DEWNR's non-commercial destruction policy, which guide staff in the issuing of non-commercial destruction permits. A landholder can apply for a permit to destroy a specified number of kangaroos when kangaroos are causing, or are likely to cause, detrimental impacts. Kangaroos culled under a Permit to Destroy Wildlife (Kangaroos) must be killed following the Non-Commercial Code.

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Action 8: ***Educate DEWNR regional staff and land managers on best practice for combining the use of commercial and non-commercial techniques for kangaroo management.***

Performance indicators:

8.1 Develop decision-making tools to assist regional staff in providing advice to land managers on commercial vs. non-commercial kangaroo management.

8.2 Any landholder seeking a destruction permit for more than a specified number of kangaroos (determined seasonally) within a CHMR is asked to consider using the commercial harvest option in the first instance. In such circumstances, Permits to Destroy Wildlife (Kangaroos) are only offered after the commercial harvest option has been declined.

8.3 Investigate the introduction of formal training requirements (like those undertaken by Kangaroo Field Processors) for landholders requesting a non-commercial Permit to Destroy Wildlife (Kangaroos).

8.4 Investigate alternative ways to integrate commercial and non-commercial kangaroo management options to mitigate damage to land condition.

4.4 Aim 4: Monitor Kangaroo Populations and Set Quotas

Monitoring commercially harvested kangaroo populations, both directly (surveys) and indirectly (industry returns), ensures that potential negative consequences of harvesting (Appendix 2) are managed appropriately, and viable populations of kangaroos are maintained throughout their ranges.

The three currently commercially used kangaroo species – *Macropus rufus*, *M. fuliginosus*, and *M. robustus* – are widespread and abundant in South Australia (Appendix 1- Conservation Status). A great deal is known about the biology of kangaroos including their habitats, distribution, diet, and reproduction (Appendix 1), and this knowledge is continually improving. In particular, the reproductive biology of kangaroos has been researched extensively. While there are variations between the kangaroo species (e.g. gestation period, lactation period and the interval between young), these are relatively well understood and accounted for in the various quotas set for each species.

A wide range of literature relating to kangaroos and their management is currently available. Of interest is a comprehensive review prepared for the Commonwealth Government entitled *Commercial Harvesting of Kangaroos in Australia*. This review can be found on the Commonwealth Government website (http://www.environment.gov.au/resource/commercial-harvesting-kangaroos-australia) and encompasses topics including the biology of the harvested kangaroo species, the effects of harvesting on kangaroo populations, animal welfare issues and the conservation status of the harvested kangaroo species. A review of scientific literature relevant to the commercial harvest was prepared by Herbert & Elzer for the *New South Wales Commercial Kangaroo Harvest Management Plan 2012-2016* and is available on the New South Wales Kangaroo Management Program's web page (http://www.environment.nsw.gov.au/resources/nature/110641Kangaroolitreview.pdf).

Results of aerial surveys since the late-1970s show that kangaroo populations fluctuate primarily in response to rainfall and other seasonal conditions. In South Australia, as with other states that commercially harvest kangaroos, the harvest has a negligible impact on kangaroo population dynamics (Hacker & McLeod 2003).

The commercial harvest is restricted to the commercial harvest region, which covers ~63% of the State, and comprises four defined Commercial Harvest Management Regions (CHMRs): Western Pastoral, Eastern Pastoral, Western Agricultural, and Eastern Agricultural. Within each of these CHMRs lie several Commercial Harvest Sub-Regions (shown as internal boundaries on Figure 1). The Commercial Harvest Sub-Regions were based on administrative boundaries for Soil Conservation Board districts established under historical soil conservation legislation (*Soil Conservation and Land Care Act 1989*).

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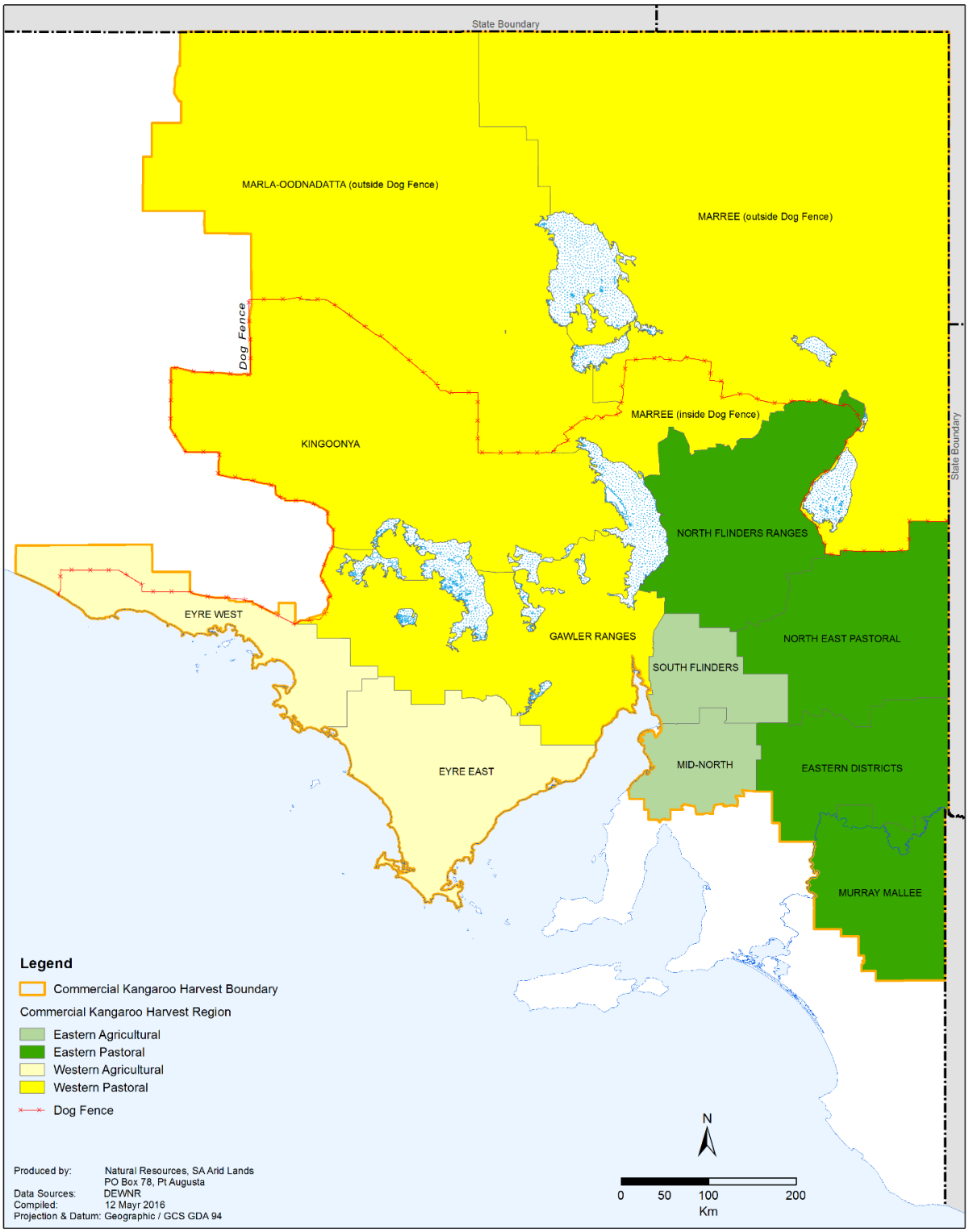

Figure 1: Current South Australian Kangaroo Commercial Harvest Management Regions (CHMR). Internal boundaries represent the Commercial Harvest Sub-Regions within each of the four CHMR.

Action 9: ***Kangaroo population estimates are obtained at required time intervals using standard survey methods.***

Kangaroo population estimates obtained from surveys will be used as the basis for setting commercial quotas following the procedures set out in this plan.

A combination of fixed-wing aircraft (fixed strip width transect method) and ground surveys (line transect method) have been the standard methods used across South Australia to survey kangaroo populations. Aerial survey lines have been established at regular intervals across this region, and the same lines are surveyed at the same time every year to allow comparison of results between years (for details of survey methods refer to the Quota Report on the Kangaroo Conservation and Management web page). Small-scale ground surveys are employed in steep and high hill areas due to the dangers associated with low-level flying.

The quota will be adjusted based on the most recent population estimate for each kangaroo species and will, therefore, account for all kangaroo mortalities, including those unrelated to commercial use (e.g. natural die-off events).

Performance indicators:

9.1 Population surveys will be conducted annually in Commercial Harvest Sub-Regions with at least one annual harvest equal to, or greater than 50% of the quota during the preceding five years, and conducted at least once every three years in Commercial Harvest Sub-Regions where the harvest has been less than 50% of the quota for the preceding five years.

9.2 DEWNR will continue to investigate the development of an optimal monitoring strategy for kangaroo management by reviewing both aerial and ground survey methods.

9.3 If through 9.2 improved methods of survey and analysis are identified during the life of this plan, these improved methods and analysis will be implemented. Improved methods and analysis may lead to changes in quota allocation. Changes and justification for changes to the survey, analysis or quota will be published in the Quota Report for that year.

Action 10: ***Commercial kangaroo harvest quotas will be set annually per Commercial Harvest Sub-Region using a proportional harvesting strategy with sustainable quotas for each species.***

South Australia uses a proportional harvesting strategy, which is considered safe for species that fluctuate in abundance over time (Caughley 1987; Engen *et al.* 1997; McLeod and Pople 1998). Kangaroo populations are expected to continue to fluctuate primarily in response to seasonal conditions, and the quota does not seek to achieve a specific density of kangaroos (unless undertaken as part of an approved adaptive management experiment, Action 23). Based on kangaroo population dynamics, quotas set at 15 to 20% are considered sustainable in the long-term (Caughley 1987, Hacker et al. 2004). Commercial quotas are set at a maximum of 20% of the estimated population size for red kangaroo, and 15% of the estimated population size for western grey kangaroo and euro within each Commercial Harvest Sub-Region (CHSR). More conservative quotas are set for regions that are monitored triennially (quota reduced to 10% for all species, Pople 2008), or when coefficients of variation are greater than 25%.

Population estimates and commercial quotas are currently derived and set at the level of each Commercial Harvest Sub-Region. However, for the purposes of providing flexibility to manage quotas in response to spatial and temporal changes in kangaroo distribution, Commercial Harvest Sub-Region quotas can be moved between other Commercial Harvest Sub-Regions within the same Commercial Harvest Management Region (CHMR). Quotas cannot be moved between any of the four defined CHMRs. Quotas may be shifted between Commercial Harvest Sub-Regions within the same CHMR only for approved damage mitigation reasons, and only where available quota in a Commercial Harvest Sub-Region has been fully utilised. Once all available quota for a species has been reached in a CHMR, no additional quota will be issued for that species in that CHMR until the following year (except for Special Land Management Quota, Action 12). However, within the life of this plan, new Commercial Harvest Sub-Regions may be opened, on the basis of population surveys, in areas of South Australia where commercial harvesting of kangaroos is not currently occurring. The Commonwealth Government will be advised of the quotas annually through the Quota Report before implementation.

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Performance indicators:

10.1 All commercial kangaroo harvest quotas are set by the provisions of the *South Australian Commercial Kangaroo Management Plan 2018-2022* throughout the life of the plan.

10.2 The Commonwealth Government is advised of commercial harvest quotas through the 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 Commercial Harvest Sub-Region
- details of the survey methods used and any changes to the survey method or analysis
- quotas calculated as a proportion of population estimate as per the approved Commercial Kangaroo Management Plan (including Special Quotas)
- any proposed changes to quotas
- any changes to Commercial Harvest Sub-Region or CHMR boundaries or new commercial areas, and justification based on survey results
- data showing trends in population/quota/harvest over time

10.3 If Commonwealth approval is required for quotas set above the rates specified in the plan as part of an adaptive management experiment, such approval is obtained before the additional quota is implemented.

Action 11: ***If kangaroo populations decline to specific thresholds, the commercial harvest of these particular species in the particular Commercial Harvest Sub-Regions will be reduced or suspended.***

This plan aims to accommodate fluctuations in kangaroo populations to change according to seasonal conditions. Calculating thresholds based on the long-term average population estimates or densities, and standard deviations (SDs) recognise these environmental differences (Appendix 3). Thresholds are calculated for each species in each Commercial Harvest Sub-Region using the entire data set (1978 to present). The population density data are normalised using a log-transformation, and the thresholds are calculated as the long-term average minus either 1.5 times (Threshold 1) or 2 times (Threshold 2) the standard deviation of the transformed data. The lognormal thresholds are then back-transformed to allow comparison to the untransformed population densities reported in the Quota Report. If survey results indicate a population has fallen below either threshold for that species in that Commercial Harvest Sub-Region, the commercial quota will be reduced or suspended in that Commercial Harvest Sub-Region for the following calendar year (Table 1). The reduction or suspension will remain in place until surveys indicate the population has increased above Threshold 1.

Table 1: Process for reducing or suspending quota based on most recent population density estimates for each species in each Commercial Harvest Sub-Region (CHSR). Threshold quotas will remain in place until survey results indicate that the population has increased above Threshold 1.

Population density estimate	Status	Quota Setting (Maximum)
Population density greater than 1.5 SD below average	Business as normal	Normal quota (as per Action 9 & 10)
Population density less than 1.5 SD but greater than 2 SD below average	Threshold 1 reached	Quota reduced to 10% for that species in that CHSR
Population density less than 2 SD below average	Threshold 2 reached	Quota suspended for that species in that CHSR

For Commercial Harvest Sub-Regions that are surveyed triennially (i.e., those that have an annual harvest of less than 50% of the maximum quota for the preceding five years), the quota is already set at a reduced level (i.e., 10%). In these Commercial Harvest Sub-Regions, for any survey that indicates that the population that has fallen to between 1.5 and 2

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standard deviations of the average, the quota will be set at the usual reduced level. If the triennial survey indicates that the population has fallen more than 2 standard deviations below the long-term average, the quota will be suspended, and an additional survey will be undertaken in that Commercial Harvest Sub-Region in the following year.

If commercial quotas are reduced or suspended due to low population estimates, the issuing of the non-commercial Permit To Destroy Wildlife (Kangaroos) may also be reduced or suspended.

Performance indicators:

11.1 Commercial harvest quotas are reduced if population density estimates fall below 1.5 standard deviations of the long-term average density (Threshold 1) , or suspended if population estimates fall below 2 standard deviations of the long-term average density (Threshold 2).

Action 12: ***Special Land Management Quotas will be set following the provisions of this plan.***

A Special Land Management Quota (SLMQ) for commercial CHMRs will be set annually at a maximum of 1.5% of the population of each species across all CHMRs.

SLMQ is a reserve pool of tags allocated within a CHMR for use when all commercial quota has been exhausted in the CHMR to mitigate extenuating damage. SLMQ will only be issued if warranted by climatic trends, destocking orders, kangaroo population trends, or other extenuating circumstances. SLMQ will provide for commercial utilisation of kangaroos that would be shot and left in the field under the non-commercial licensing system.

Performance indicator:

12.1 Any issue of Special Land Management Quota and the reasons for its issue are recorded and reported through annual reporting.

Action 13: ***Kangaroo populations will be monitored indirectly throughout the life of this plan.***

Indirect data on kangaroo populations will be obtained continuously throughout the life of this plan from commercial kangaroo industry returns. Permit holder returns detail the number of each species taken, average carcass weights, sex, and location of take, depending on the type of permit.

Monitoring of permit returns by DEWNR could identify significant changes in harvest per effort, which may provide an indication of population sizes and accessibility.

Performance indicators:

13.1 Sudden, sustained, or acute changes in the information provided through permit returns will be investigated to determine where practicable the cause of the change.

13.2 Collation of non-commercial destruction permits and associated numbers will occur, to support data gathered from industry returns.

4.5 Aim 5: Monitor Industry Compliance

To ensure that viable populations of kangaroos are maintained throughout their ranges, the commercial kangaroo industry in South Australia is closely regulated by a range of licensing and tag procedures provided for under the NPW Act, Kangaroo Harvesting Regulations, Wildlife Regulations, DEWNR policy and this plan. Permitting procedures are described in detail in Appendix 4. The compliance of the kangaroo industry with the above legislation and policy is essential for maintaining viable populations of kangaroos and ensuring public confidence in the management of kangaroos in South Australia.

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Action 14: ***All relevant activities are permitted following the applicable South Australian legislation and DEWNR policy.***

All applications for permits relating to the South Australian commercial kangaroo industry operations are to be assessed, processed, and issued by the provisions of the NPW Act and Regulations and relevant DEWNR policy.

Performance indicator:

14.1 A sample of commercial kangaroo permits across South Australia are assessed twice per year to determine that they are processed and issued by South Australian legislation and DEWNR policy.

Action 15: ***DEWNR will ensure that permit conditions are adequate and reflect current South Australian legislation, DEWNR policy and this plan.***

To manage commercial kangaroo operations in South Australia effectively and efficiently, permit conditions must be sufficient and consistent with Commonwealth and South Australian legislation, DEWNR policy and this plan. Accordingly, the standard permit conditions for each permit type will be reviewed, and where necessary amended, in response to changes in Commonwealth and South Australian legislation and/or DEWNR policy. All proposed amendments to permit conditions will be assessed by DEWNR's legal representatives before implementation and permit holders will be advised of changes to their permit conditions in writing. Any changes to the conditions will need to follow this plan, and the Commonwealth will be notified of any significant changes.

Performance indicators:

15.1 Permit conditions are reviewed at least annually and where necessary amended.

15.2 Permit holders are advised in writing of changes to permit conditions within one month of such changes being approved by the Kangaroo Management Program.

Action 16: ***DEWNR will ensure that all Kangaroo Field Processors are competent to achieve the standards set out in the Commercial Code, and other necessary requirements.***

To ensure that the kangaroo harvest is humane, Kangaroo Field Processors are required to demonstrate their competency with the Commercial Code before obtaining their permits. Kangaroo Field Processors must also hold a current firearms licence, complete an approved Kangaroo Field Processor's Firearms Accuracy Accreditation Course in South Australia (or another approved state), and complete the Wild Game Harvester Field Processing (Kangaroo) Course run by Primary Industries and Regions South Australia (Biosecurity SA) (or another approved course interstate). DEWNR may require that Kangaroo Field Processors undertake further training as a corrective action. All successful applicants for a Kangaroo Field Processor Permit have completed the approved accreditation.

Performance indicators:

16.1 On receipt of Kangaroo Field Processor's permit applications, the DEWNR officer assessing the applications will ensure that applicants have both a valid Firearms Accuracy accreditation, Wild Game Harvester Field Processing (Kangaroo) accreditation and a valid firearms licence (Class B7 or as directed by South Australian Police), and other licences and permits as required.

16.2 DEWNR will liaise with training providers (e.g. TAFE SA) to ensure that the Kangaroo Field Processor training syllabus is up to date with current legislation, the Commercial Code or any other standards approved nationally.

Action 17: ***DEWNR will consider improvements to the sealed tag system as appropriate.***

DEWNR will monitor technological developments in how kangaroos are tagged and how industry returns are provided to DEWNR. Improvements in these areas will allow DEWNR to monitor the quota taken more efficiently and effectively.

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Performance indicator:

17.1 Monitor technological developments in tagging systems, and consider trials of electronic (or other technologies) tags, along with technological advances in other aspects of kangaroo management.

Action 18: ***DEWNR staff will undertake both regular and opportunistic monitoring of compliance by commercial kangaroo industry operators.***

To assess industry compliance, authorised DEWNR officers will, on a regular and opportunistic basis, inspect kangaroo harvesting sites, kangaroos taken by Kangaroo Field Processors and all premises registered by Kangaroo Meat Processors and Skin Tanners. The inspecting officers will check to ensure the kangaroos have been taken following the NPW Act and Kangaroo Harvesting Regulations, this plan, and permit conditions. Assessments to ensure compliance with the current Commercial Code will be a priority. Biosecurity SA (Meat Hygiene) also undertakes regular checks of field chillers and processing plants for compliance with food and health policies. Biosecurity SA (Meat Hygiene) will report any observed breaches of permit conditions to DEWNR for further investigation. Likewise, DEWNR officers will inform Biosecurity SA (Meat Hygiene) staff of suspected breaches of their legislation. DEWNR will develop a Memorandum of Understanding with Biosecurity SA (Meat Hygiene) to formalise these relationships.

DEWNR will develop a Memorandum of Understanding with the Commonwealth Department of Agriculture and Water Resources in relation to inspection of carcass at processing plants registered for the export of meat products for human consumption that reflects the Meat Notice 2009/16 (or any subsequent notice that replaces it) and guidelines developed by DEWNR. Under this agreement, information about possible breaches of DEWNR permit conditions are reported by the Department of Agriculture and Water Resources and, where appropriate, further investigated by DEWNR (or interstate agencies as appropriate).

Performance indicators:

18.1 Chiller premises are inspected at least annually during the life of this plan by DEWNR staff and/or staff of Biosecurity SA to ensure compliance with South Australian legislation and permit conditions. Chiller premises that are registered but known to be non-operational may not require regular inspection.

18.2 All kangaroo processing works in South Australia are inspected at least three times a year during the life of this plan by DEWNR staff and/or staff of Biosecurity SA to ensure compliance with South Australian legislation and permit conditions.

18.3 Memoranda of Understanding are developed with Biosecurity SA (Meat Hygiene) and the Department of Agriculture and Water Resources during the life of this plan.

Action 19: ***Activities not following this plan and South Australian legislation will be investigated and where an offence has been committed, appropriate compliance action will be taken.***

Investigation and prosecution of activities in breach of the *South Australian Commercial Kangaroo Management Plan 2018-2022* and South Australian legislation are essential for delivery of this plan. Good compliance also maintains public, industry and stakeholder confidence in the effectiveness of the plan as a mechanism for maintaining the viability of kangaroo populations, and thus the commercial kangaroo industry.

Performance indicator:

19.1 Reports of unlicensed activities and activities in breach of permit conditions are investigated, and where sufficient evidence is available, offenders are prosecuted and/or issued with Expiation Notices as appropriate.

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Action 20: ***The accuracy of industry returns will be continually monitored during the life of this plan.***

It is a permit condition that commercial kangaroo industry operators submit regular returns to DEWNR. The data obtained from these returns are essential for monitoring whether the industry is harvesting kangaroos within approved quotas and for reporting to the Commonwealth Government, industry, and the public. Also, the data from industry returns are used to monitor the kangaroo populations indirectly. Audits of industry returns encompass the manual assessment of returns; application of the customised licensing database utilised by DEWNR and extensive verbal and written communication between DEWNR staff and industry operators.

Performance indicator:

20.1 During the life of this plan, incoming industry returns are scrutinised, and discrepancies are investigated and resolved where possible.

Action 21: ***A compliance database will be maintained to support investigations, inspections, and audits.***

A compliance database for use in kangaroo management investigations and inspections will be maintained for use by staff involved with kangaroo management. The database facilitates compliance reporting to the Commonwealth Government and other stakeholders, and easy access to information for relevant authorised DEWNR officers. Relevant compliance information is recorded and maintained, including reports of alleged breaches of the NPW Act, Regulations and/or permit conditions, investigation activities undertaken and outcomes of investigations. Data input is accurate and timely.

Performance indicator:

21.1 Compliance records are maintained.

4.6 Aim 6: Facilitate Adaptive Management and Research

Adaptive management experiments and studies using historical data from kangaroo industry returns and population data are essential to improving our understanding of kangaroos and their interaction with environmental, social, and economic systems, and thereby effectively maintaining viable populations of kangaroos throughout their ranges. Research into aspects of kangaroo ecology or harvest management can also assist in ensuring that kangaroo populations are maintained at sustainable levels across their ranges in 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 more efficient management of the commercial harvest.

Action 22: ***Historical data relating to the commercial kangaroo harvest in South Australia will be analysed during the life of this plan to identify trends; this analysis will be considered in future kangaroo management programs.***

The kangaroo management program has obtained a wide range of information relating to the commercial harvesting of kangaroos in South Australia. The analysis of this information is a continued action from the previous plan (*South Australian Kangaroo Management Plan 2013-2017*). A collaboration with The University of Adelaide has been formed, and a Ph.D. project has commenced. The data will be analysed to provide information on the trends in kangaroo populations, utilisation rates, average weights and other specific information relating to the commercial harvest. Consideration of research findings and the results of any analysis are essential in not only the development of future plans but also for facilitating the adaptive management of kangaroo populations, which in turn will aid in maintaining viable populations of kangaroos. The appropriate forum for reporting the new information will vary according to the type of research or analysis. At a minimum, the results of any research undertaken using DEWNR data should be provided to DEWNR, and ideally be made available on the Kangaroo Conservation and Management web page. The analysis of historical data relating to the commercial kangaroo harvest in South Australia may be undertaken by a range of individuals or organisations including tertiary students, university professionals, consultants or DEWNR.

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Performance indicators:

22.1 Analysis of historical kangaroo harvest and management data is undertaken during the life of this plan.

22.2 The results of analysis and research using historical kangaroo harvest and management data are published in an appropriate forum.

Action 23: ***Where practicable, adaptive management experiments will be performed to test deliberate management interventions during the life of this plan.***

Under active adaptive management, management activities are conducted as a deliberate experiment. Alternative strategies are viewed as treatments and are implemented through statistically valid experimental design; monitoring is the data-collection step of the experiment. Active adaptive management can establish cause-and-effect relationships between activities and changes in ecological conditions. The appropriate forum for dissemination will vary according to the type of research and the target audience. However, it is expected that any research conducted as an active adaptive management experiment following the provisions of this plan will be made available for the information of the Kangaroo Management Reference Group and DEWNR for inclusion on the Kangaroo Conservation and Management web page. Commonwealth approval is required if the adaptive management experiment will result in a harvest rate that is more than the harvest rate set out in this plan.

As per the criteria outlined below, all active adaptive management experiment proposals must have monitoring programs incorporated. Monitoring programs must be maintained during the life of the experiment. All monitoring must be conducted following any conditions imposed with the approval.

All proposals for adaptive management must be approved following the provisions of this plan before implementation. Proposals to undertake adaptive management trials will be assessed by:

- whether the proposal is following the goal of this plan
- whether the proposal is consistent with legislation for kangaroo management (or whether legislation requires amendment for the trial to occur)
- whether the proposal is scientifically rigorous and statistically valid
- whether the proposal incorporates an adequate monitoring and review program
- whether the proposal addresses adaptive management or research areas for kangaroos
- whether the proposal will engage stakeholder input or feedback.

Performance indicators:

23.1 All proposals to undertake active adaptive management experiments are reviewed and assessed by DEWNR in accordance with the criteria outlined in this plan.

23.2 All necessary approvals – including animal care and ethics – are obtained before commencement of experiments testing deliberate management interventions.

23.3 All adaptive management experiments are continuously monitored and conducted according to approved conditions.

23.4 Results of all experiments testing deliberate management interventions are published in an appropriate forum.

Action 24: ***Where knowledge gaps exist, DEWNR will facilitate research into the biology and ecology of commercially harvested kangaroo species.***

DEWNR will work with external research organisations to identify and investigate issues relevant to the commercial harvest of kangaroos. Research may include aspects of the biology, ecology, disease, and genetics of kangaroos as they relate to the commercial harvest, survey techniques, or the impact of commercial harvesting processes on numbers of non-native predators and scavengers. Contributions by DEWNR may include funding and/or in-kind support such as the provision of harvest data.

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Performance indicator:

24.1 Issues associated with the ecology of harvested species and the management of the commercial harvest are identified, and research proposals are sought from universities and other research institutions during the life of this plan.

4.7 Aim 7: Undertake Program Reporting and Review

Regular program review and associated reporting are essential to maintain viable populations of kangaroos throughout their ranges; they ensure management outcomes remain consistent with the aims of the plan, and that management is fully informed.

Action 25: ***DEWNR will review and remake the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003.***

Continuing from the previous plan, the review and remake of the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 will be completed during the life of this plan. The remake of the Kangaroo Harvesting Regulations will allow for the alignment of the regulations to the new tag system implemented during 2015. The regulations are now in the final sun-set period and will be required to be remade by 1 September 2018. DEWNR will ensure that thorough consultation occurs during this review.

Performance indicators

25.1 The National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 are reviewed and remade by 1 September 2018.

Action 26: ***An annual report on the South Australian Commercial Kangaroo Management Plan 2018 – 2022 will be prepared and submitted to the Commonwealth.***

An annual report detailing the operation of this plan for the previous calendar year will be prepared and submitted to the Commonwealth. This report will provide information on the previous year's quotas and harvest rates, any use of special quotas and details of research involvement. This report will also identify whether any adaptive management experiments were undertaken and provide details about compliance actions undertaken within the guidelines of this plan. Finally, this report will audit the aims of the plan against the performance indicators so that progress towards achieving the goal of the plan can be measured.

Performance indicators

26.1 An annual report on the operation of the *South Australian Commercial Kangaroo Management Plan 2018 - 2022* for the previous calendar year is submitted to the Commonwealth by 31 March of the following year. At the time of writing this report is entitled the Commercial Kangaroo Harvest Report.

The Harvest Report will include the following information:

- actual harvest, by region and species, compared to quotas
- any Special Land Management Quotas utilised
- sex bias and average weights for each species in each Commercial Harvest Sub-Region
- non-commercial cull statistics within the Commercial Harvest Sub-Regions
- compliance statistics:
    - number of premises inspected
    - number of penalty notices issued and the reason for the issue
    - number of alleged offenses investigated and outcomes
    - number of prosecutions undertaken (offense and outcome)
    - any joint surveillance/enforcement activities completed.
- any unusual situations that arose (e.g. flood/disease outbreak, market factors)

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- any experiments or research undertaken or sponsored by DEWNR
- assessment of performance against the performance indicators

26.2 All annual reports prepared during the life of this plan are posted on the Kangaroo Conservation and Management web page.

Action 27: ***The review of the South Australian Commercial Kangaroo Management Plan 2018-2022 will commence no later than twelve months before the expiry of this plan.***

The review of this plan will commence no later than twelve months before the plan expires and will assess the success of the plan in achieving its goal and aims. The aim of the review will be to improve on the current plan in the development of subsequent plans.

Performance indicators:

27.1 The success of the current plan in achieving its goal is assessed by measuring DEWNR's performance against the performance indicators in the plan.

27.2 A review of the plan commences by November 2021.

27.3 A report on the results of the plan review is submitted to the Commonwealth and is placed on the Kangaroo Conservation and Management web page. The report should summarise the results of the final review including an explanation of any proposed changes to the plan. It should also include an assessment of DEWNR performance against the performance indicators. The report should be submitted to the Commonwealth by 31 October 2022.

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Appendix 1: Biology, Ecology, and Conservation of Kangaroos

Biology and ecology

Impacts of European settlement on kangaroo populations

The larger-bodied macropods that are the subject of this management plan have been advantaged by European settlement. These kangaroo populations in South Australia are considered secure and widespread. Many changes have been brought about in the last 200-plus years of European settlement. These include widespread changes to the landscape, through replacement of native vegetation in many areas with agricultural and urban land uses. In places where native vegetation has not been widely cleared (e.g. pastoral rangelands) the landscape has still been modified by settlement, through measures such as the provision of watering points for the stock, and construction of a dingo-proof fence across Australia to protect sheep in the southern rangelands from Dingo predation.

These changes have altered the natural distribution and abundance of kangaroos. The species to which this plan relates have all been advantaged by these changes and in many places are present in higher abundances than they were previously. Increased pasture, greater availability of water and reduced predator pressure have all contributed to an increased abundance of the three species (Pople & Grigg 1999).

There are large populations of each of the harvested species in Australia and South Australia. The kangaroo population across Australia that is used for the commercial harvest has been estimated to have fluctuated between 15 and 35 million animals over the past 25 years (numbers of red kangaroo, western grey kangaroo, and eastern grey kangaroo combined; Department of the Environment and Heritage 2007). In the commercially harvested parts of South Australia, populations range up to numbers exceeding three million red kangaroos and one-and-a-half million western grey kangaroos (Pople et al. 2010a). Localised surveys of euro suggest that there are currently around 500,000 euros in the commercially harvested area of South Australia.

Systematics

A kangaroo is a marsupial from the Family Macropodidae. This family contains kangaroos, wallabies and tree kangaroos. At the time of writing, only three species of the genus *Macropus* are the subject of this plan:

- *Macropus rufus* (Desmarest, 1822), the red kangaroo – the largest of all kangaroos and the largest surviving marsupial.
- *Macropus fuliginosus* (Desmarest, 1817), the western grey kangaroo – two subspecies: *Macropus fuliginosus fuliginosus* of Kangaroo Island and the mainland *Macropus fuliginosus melanops*, which has a range of different forms. Only the main land subspecies is subject to this plan. The western grey kangaroo was identified as a separate species from the eastern grey kangaroo in 1972 (Kirsch & Poole 1972).
- *Macropus robustus* (Gould, 1841), the euro – a smaller macropod with four subspecies. The subspecies that is subject to this plan is *Macropus robustus erubescens*. In other parts of Australia, *M. robustus* is referred to as common wallaroo or hill kangaroo, however, in this plan, the name euro is used.

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Conservation status

The commercially harvested kangaroo species that are the subject of this plan are widespread and secure.

This secure nature is reflected in the fact that they are:

- Not listed as threatened in South Australia (under Schedules 7, 8 and 9 of the NPW Act)
- Not listed as threatened in Australia (under the EPBC Act)
- Lower Risk – least concern with a stable population on an international scale (IUCN Red List 2017)
- Not listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2017)

Species Distribution

The red kangaroo is particularly well-adapted to the arid environment of central Australia and has a distribution covering most of the continent west of the Great Dividing Range, but excluding Cape York, Arnhem Land, the Kimberley region, the southwest corner and Tasmania (Pople & Grigg 1999) (Figure 2). Red kangaroos prefer more open habitats with scattered trees (Pople 1989), such as grassland, open scrub, mulga, low shrublands and open woodlands.

Within South Australia, the highest densities of red kangaroo coincide with the area of sheep grazing rangelands (Cairns et al. 1991). Over the time that aerial surveys have been flown in South Australia, the area of highest red kangaroo density has been just south of Lake Frome in the north-eastern section of the pastoral zone (Pople et al. 2006). The long-term monitoring data also suggest a westward shift in the range of the red kangaroo (Pople et al. 2010a) over the period that kangaroo surveys have been conducted.

The western grey kangaroo is found along the southern part of Australia, excluding Tasmania, and extending into New South Wales and Queensland at the eastern end of its distribution (Pople & Grigg 1999) (Figure 3). The western grey kangaroo is associated with less arid environments than the red kangaroo and is affiliated with semi-arid mallee scrub, shrub woodland, and forests (Pople & Grigg 1999). Western grey kangaroos mainly exploit mosaic environments with areas of shrub interspersed with open habitats and cleared areas.

Within South Australia, the western grey kangaroo is found in the southern half of the state and on Kangaroo Island (although this is a separate subspecies and is not covered by this plan). Aerial survey data have revealed that western grey kangaroo densities are consistently highest in the Gawler Ranges and the south-eastern section of the South Australian pastoral zone (Pople et al. 2006). This distribution is complementary to that of red kangaroos, with high western grey kangaroo densities occurring in areas where red kangaroo numbers are low. Over the last 20 years, the western grey kangaroo has had a northwards expansion in its distribution and has become more common in the northern parts of the South Australian pastoral zone (Pople et al. 2010a).

The euro has a widespread distribution covering most of mainland Australia, except for the most southern and northern parts of the country (Pople & Grigg 1999) (Figure 4). However, within this wide distribution, the presence of euros is patchy and localised, reflecting their preferences for rocky and hilly habitat. Euros can be found in a wide range of habitats but prefer areas where steep escarpments, rocky hills or stony rises are available to them. The euro can build up to localised high densities when conditions are favorable.

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Biology of the Red Kangaroo *Macropus rufus*

Red kangaroos are opportunistic breeders and will breed throughout the year except in periods of extreme drought. This species exhibits a reproductive technique called embryonic diapause, where a viable embryo can be carried in the uterus for many months with its development arrested at the stage of a blastocyst (e.g. 70-100 cells). A blastocyst will remain in diapause while there is another young in the pouch, or when environmental conditions are poor. This reproductive strategy reduces the time between breeding events. Largely a gregarious species, the red kangaroo has a polygamous mating system (i.e. one male, many females). The species exhibits sexual dimorphism, with males larger than females.

The red kangaroo grazes grasses and dicotyledonous plants and browses chenopods and shrubs when necessary (Tyndale-Biscoe 2005). The red kangaroo is dependent upon the presence of green herbage for breeding. As the supply of green pick dwindles, breeding is reduced.

Red kangaroos have sedentary populations that move within home ranges of variable size (typical weekly home range size may be up to 560 hectares or 5.6km^2 (Croft 1991). Red kangaroos range more widely in response to drought and can move a long way to access the better feed. Movements of up to 30km to obtain fresh pasture growth in response to rainfall have been recorded (Croft 1991). Occasional long-distance movements (i.e. >100km) of mature individuals of both sexes have been recorded (Bailey & Best 1992). Long-distance movements of red kangaroos to access better feed have also been found in the long-term aerial monitoring dataset for South Australia (Pople et al. 2006).

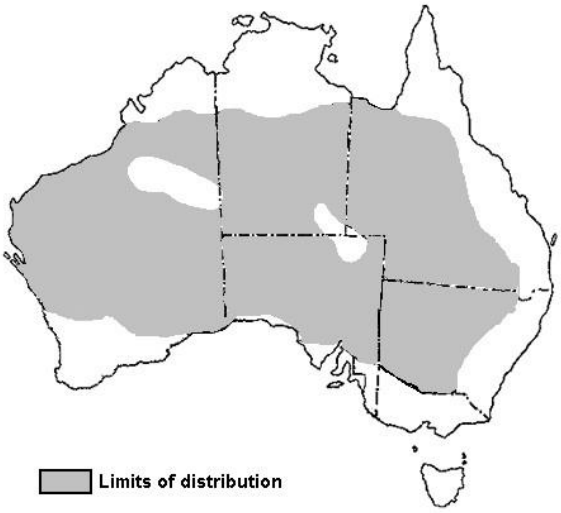

Figure 2: Distribution of red kangaroo (*Macropus rufus*) determined from aerial survey (Pople & Grigg 1999).

Biology of the Western Grey Kangaroo *Macropus fuliginosus*

Like the red kangaroo, the western grey kangaroo will breed year round except in very poor seasons. Breeding peaks in spring and summer have been recorded (Hacker et al. 2004). However, unlike in red kangaroos, embryonic diapause is not found in this species, so the species is not as able to rapidly increase in response to favorable conditions. Western grey kangaroos are sexually dimorphic in body size, with males larger than females.

Western grey kangaroos feed mainly on grasses and also browse on some selected shrubs (Coulson & Norbury 1988). While red kangaroos will move a long way to access the better feed, western grey kangaroos do not do this and are more sedentary with small individual home ranges (Priddel 1987). Dispersing individuals tend to be young males.

The western grey kangaroo has higher water requirements than the red kangaroo (Dawson 1995), and so an expansion of available water in pastoral areas has enabled an expansion of this species into more arid areas.

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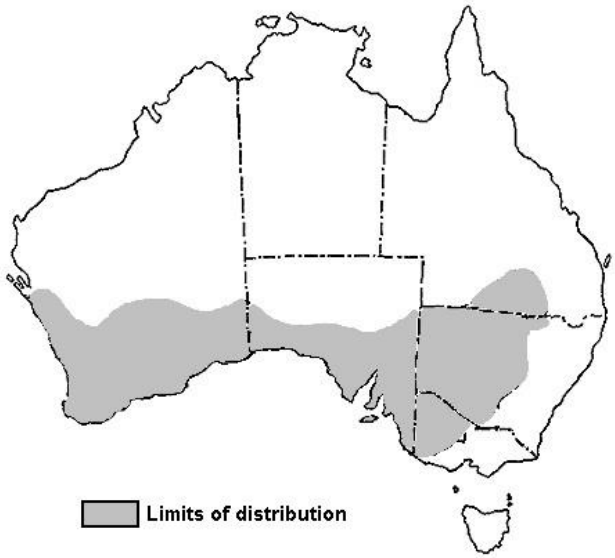

Figure 3: Distribution of western grey kangaroo (*Macropus fuliginosus*) determined from aerial survey (Pople & Grigg 1999).

Biology of the Euro *Macropus robustus*

Euros are opportunistic breeders, with continuous breeding possible throughout the year. Breeding is reduced during dry conditions and may cease during prolonged drought. Like red kangaroos, embryonic diapause occurs in this species. The euro exhibits marked sexual dimorphism, with mature males attaining twice the weight of mature females.

The euro feeds mainly on grasses and shrubs. The species is relatively sedentary, and individuals occupy small stable home ranges. The euro exhibits a less gregarious social structure than red and western grey kangaroos.

Euros are found in mountains and rocky hill habitat. Because this habitat type is not continuous across the landscape, the distribution of euro is likewise patchy (Dawson 1995). The steep escarpments, rocky hills and stony rises favored by euro (Olsen & Braysher 2000) are less frequently cleared for agriculture, and thus this species is less affected by land-use changes.

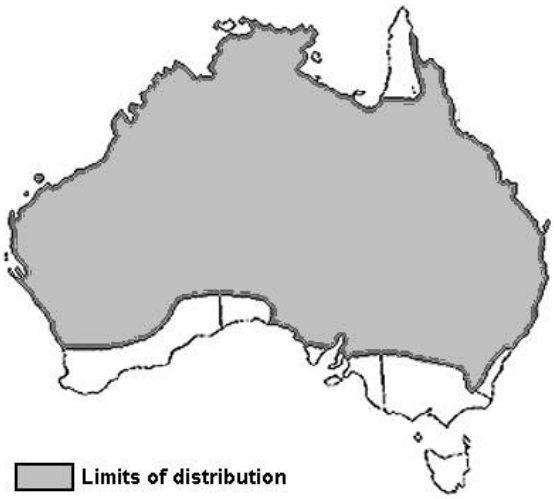

Figure 4: Distribution of euro (*Macropus robustus*) (Pople & Grigg 1999). Note that distribution is patchy within the range, based on the availability of suitable habitat.

Appendix 2: Threats to Kangaroos

Threats to kangaroos

Detailed legislative requirements in the NPW Act and the EPBC Act require that threats which may impact negatively on kangaroo populations or the sustainability of harvest must be detailed and considered in this plan. This section provides a summary and assessment of such threats.

Threats to kangaroos are either biological or anthropogenic threats. Possible current and future threats to kangaroos and their ability to be used as a sustainable resource are detailed below.

Biological threats

Biological threats are factors that have the potential to regulate kangaroo populations (Table 2).

Table 2: Biological threats that may regulate kangaroo populations.

Environmental Conditions – Drought	Rainfall distribution can determine kangaroo densities, as populations move in response to localised rainfall and subsequent new plant growth. Droughts limit the amount of food available and therefore the carrying capacity of the habitat. Kangaroo populations naturally decline in times of poor environmental conditions (or drought) due to starvation (biased towards mature males and juveniles) and suppressed reproductive activity. The reproductive strategies of kangaroos allow for rapid recovery of populations following the end of drought conditions.	Caughley *et al.* 1985; Robertson 1986; Bayliss 1985; Bayliss 1987; Cairns & Grigg 1993; McCarthy 1996; Cairns *et al.* 2000; Pople 2003; Dawson *et al.* 2007; Pople *et al.* 2010b
Environmental Conditions – Flood	Flooding events will limit the short-term movement of kangaroos. Where access to forage is cut off through flooding, starvation is a threat. When access to forage is still available, other biological needs may be somewhat limited (e.g. dispersal events such as those undertaken by young males moving or establishing territories, may be temporally limited during flooding events). Some kangaroo diseases are linked with flooding events (see below).	Hale 2004
Disease	Disease by itself is not considered a significant mortality factor, and tends to have a compensatory mortality effect in combination with conditions such as overcrowding, malnutrition, and flooding. Diseases can be linked to flooding events (e.g. when the resultant outbreak of biting insects can transmit arbovirus among kangaroo populations), although such infections are not necessarily terminal. The impact of kangaroo diseases tends to be localised.	Kirkpatrick 1985; Caughley 1987; Speare *et al.* 1989; Hopper *et al.* 1999; Pople & Grigg 1999; Roberts *et al.* 2010; Barnes *et al.* 2007; Parameswaran *et al.* 2009
Predation	Dingoes (*Canis lupus dingo*), wedge-tailed eagles (*Aquila audax*), and foxes (*Vulpes vulpes*) can predate on kangaroos, although only dingoes will predate upon large adult kangaroos. In South Australia, densities of red kangaroos differ on either side of the dingo-proof fence, in part due to the presence of dingoes. North of the dingo-proof fence kangaroo numbers are significantly lower than in the fenced sheep rangelands, suggesting that Dingo predation may play a role in regulating kangaroo populations. South	Pople et al. 2000; Caughley *et al.* 1980; Corbett & Newsome 1987; Thompson 1992; Banks *et al.* 2000; Pople & Page 2001; Letnic & Crowther 2012; Fillios

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	of the dingo-proof fence predation is not a significant source of kangaroo mortality and is limited to fox and eagle predation on juvenile kangaroos.	*et al.* 2010; Purcell 2010
Climate change	The potential effects of climate change on kangaroos are not well documented, however potential effects may include changes in forage availability, fecundity, species distribution, movement patterns and an increase die-off of individuals due to extreme heat events, which may increase due to climate change. While climate change may be considered anthropogenically caused, the effects are biological, and so it is included here under biological threats to kangaroos, rather than in anthropogenic threats to kangaroos.	Goldie & van Wensveen 2003; Ritchie & Bolitho 2008; Dunlop & Brown 2008; Jonzen *et al.* 2010

Anthropogenic threats to kangaroos

Anthropogenic threats to kangaroos are those that result from human activities (Table 3).

Table 3: Anthropogenic threats that may regulate kangaroo populations.

Habitat loss	Since European settlement, clearance of native habitat has occurred. Increased areas of land used for agriculture and pastoralism, combined with increased availability of water and control of predators, has benefited kangaroos. More intensive land use, such as intensive agriculture and urban development, can lead to contractions in the range of kangaroos. Intensive development is not a common land use within the commercial harvest zone and across the distributions of kangaroos in South Australia and is therefore considered to be a low threat to the harvested kangaroo species in South Australia	Short & Grigg 1982; Calaby & Grigg 1989; Pople *et al*. 2010a
Human predation	Commercial harvest, non-commercial destruction for damage mitigation and traditional hunting by Aboriginal people are the three methods of human predation. Harvest and hunting take place at levels that are considered sustainable for kangaroos (see Impacts of commercial harvest below).	
Socio-economic changes	Changes in the relative value of meat products, or the extent to which kangaroos are considered as a valuable resource, may influence the extent to which the quota is taken. However, the maximum harvest defined by sustainable harvest quotas will ensure that harvest remains at sustainable levels.	

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Impacts of commercial harvest

Under South Australian and Commonwealth environment legislation, commercial harvest of kangaroos can take place only where it is ecologically sustainable for kangaroos. At a broad level, this translates to ensuring that commercial harvest will not be detrimental to kangaroos. At a finer scale, this means knowing the potential impacts of harvest on kangaroos and developing and implementing management controls that prevent, mitigate and/or minimise these effects. In accordance with the requirements of the NPW Act and the EPBC Act, this section details the potential impacts of harvest on kangaroos, and on habitats and ecosystems of which kangaroos form part, and details the management controls that are in place to prevent and minimise these impacts and ensure the sustainability of commercial harvest.

Harvesting

Commercial harvesting has occurred for almost 40 years, and it is clear from the extensive monitoring and research that has been conducted over that time that harvest is demonstrably sustainable (e.g. see Pople & Grigg 1999; Olsen & Low 2006). Kangaroo populations naturally increase and decrease as rainfall varies. During drought conditions, population numbers will stay low until conditions improve and the availability of food increases.

Potential negative effect mitigated by:

- **Action 9:** Regular monitoring and setting of quotas to allow for fluctuations in populations.
- **Action 10:** A proportional harvest strategy is used that allows for fluctuating populations (Caughley 1977) and is robust to bias or uncertainty in population estimates (Milner-Gulland et al. 2001).
- **Action 10:** Commercial harvest quotas are set at levels that are ecologically sustainable for kangaroo populations (Caughley 1987; Pople et al. 2010a), even when combined with other mortality factors (including predation).
- Commercial harvest is patchy within management regions and properties, leaving areas of unharvested refuge habitat.
- **Action 11:** If kangaroo populations fall below thresholds calculated from the long-term population data, such as during a drought, harvesting will be reduced or suspended as nessassary.
- Economic threshold density below which it is not financially viable to harvest (see Hacker et al. 2004).
- The knowledge that harvesting mortality during drought is compensatory, not additive – harvesting removes animals that would die of natural causes during steep population declines, i.e. larger, older males (Pople & McLeod 2000).
- A process for developing management responses to evaluate and minimise risk to kangaroo populations in an adaptive approach to management, should the current ongoing drought conditions continue for an extended period.

Population demographics

Commercial harvesting may affect the demography (e.g. size, growth, distribution and birth and death rates) of harvested kangaroo populations by selecting the larger kangaroos, which tend to be the older males (Allendorf et al. 2008). Commercially harvested populations may have a lower average age compared to that of unharvested populations. The average size of kangaroos in harvested populations may be lower, and populations contain a higher proportion of young animals than unharvested populations, but these differences are lessened during drought when older animals are lost from unharvested populations (Pople 1996).

The sex bias (i.e. the percentage of harvested kangaroos that are male) has increased from 60-70% male to 92-97% male for red and western grey kangaroos (DEWNR 2017). The increase in sex-bias is due, in part, to some meat processing plants only accepting male carcasses. The sex bias of the euro harvest has historically been higher due to the small size of female euros, but the sex-bias has also increased from 75-95% male to 99% male (DEWNR 2017). However, a recent analysis of the size skulls of the commercially harvested kangaroo species since the early 1800's has not produced any evidence to indicate that harvesting has reduced the average size of kangaroos at a species distribution scale (Prowse et al. 2015). Overall, the demographic impacts of harvest appear to be of little conservation concern (Pople & Grigg 1999), but further research may be required in the future.

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Potential negative effect mitigated by:

- Environmental conditions tend to determine the structure of populations, suggesting that natural influences on population structure are stronger than the influences of harvesting. Both harvested and unharvested populations show unstable age distributions and a female sex bias (Newsome 1977; Pople 1996).
- Kangaroos have high fecundity and the ability to reproduce quickly following losses due to drought or harvesting (Appendix 1).
- Populations of kangaroos are not isolated in the landscape, and dispersing individuals can contribute to restocking a harvested population.
- The extent of harvesting is patchy, and refugia (e.g. areas that are not harvested) or areas that are lightly harvested occur across the harvested area.
- **Action 13:** Harvest sex bias and the size of harvested kangaroos are monitored through the regular collection of harvest returns from permit holders.
- **Action 24:** Where knowledge gaps exist, DEWNR will promote research into effects of harvesting on the population demographics of harvested kangaroo species.

Populations genetics

The genetic diversity and fitness of animal populations may be influenced by the selective removal of individuals that display a particular physical characteristic before they can contribute to the next generation (Allendorf et al. 2008; Coltman 2008). Consequently, there is the potential that the selective harvest of kangaroos (i.e. harvest efforts biased towards older, larger males) may lead to changes in the population genetic structure.

Potential negative effect mitigated by:

- **Action 11:** Harvesting at current rates has been assessed using genetic theory, empirical data and modeling, with the conclusion that it has negligible impacts on kangaroo genetics under present conditions (Hale 2001, 2004 Tenhumberg et al. 2004).
- Dispersal of individuals between populations (Clegg et al. 1998; Neaves et al. 2009) and patchiness of harvest allow for gene flow between populations, which helps to prevent genetic changes in a population.
- Speices exhibit high levels of genetic diversity and limited genetic structure across their distributions (e.g. Neaves et al. 2009).
- **Action 25:** Where knowledge gaps exist, DEWNR will promote research into effects of harvesting on the genetic structure and diversity of harvested kangaroo species.

Humane killing

Commercial harvest involves the shooting of individual kangaroos and when required, the destruction of pouch young. As such, harvest carries a risk of animals not being killed humanely.

Potential negative effect mitigated by:

- **Action 1**: All kangaroos killed under permit in South Australia must be killed humanely following the Commercial Code.
- **Action 1:** Compliance with the Commercial Code is monitored routinely, and breaches are penalized.
- **Action 17:** Kangaroo Field Processors must pass mandatory firearms accuracy accreditation specific to kangaroo shooting before receiving a permit.
- **Action 17:** All Kangaroo Field Processors are provided with a copy of the Commercial Code to ensure their awareness of the Commercial Code.
- **Action 19:** Compliance with Commonwealth and State policy and legislation for animal welfare.

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- **Action 9:** Landholders applying for non-commercial destruction permits are required to show knowledge of the firearm specifications and shooting requirements for kangaroos in the Non-Commercial Code.
- **Action 9:** Introduction (during the life of this plan) of self-assessment tools for non-commercial destruction permit applicants, so that they can test their competency to shoot following the requirements of the Non-Commercial Code.
- All persons engaged to cull kangaroos on reserves must have successfully passed a firearms accuracy accreditation course specific to kangaroo shooting and are aware of the correct method of shooting a kangaroo under the Non-Commercial Code.

Impact of harvesting on habitats and ecosystems

Impacts of the commercial harvest on habitats and ecosystems may be positive or negative in nature. Impacts on habitats from the commercial harvest are more likely to be positive than negative, due to biodiversity benefits resulting from total grazing pressure management. These include an increase in the regeneration of native vegetation, increased recruitment (although for some arid-zone plant species recruitment may be most closely linked to episodic rainfall events) and a reduction in the extent of non-palatable weed species.

Kangaroo harvest allows for kangaroo grazing pressure to be managed as a component of total grazing pressure (Grigg 1995). When managed in combination with sustainable stocking practices and management of feral herbivores this would likely reduce the effects of overgrazing in some areas.

Potential negative impacts of harvesting on habitats and ecosystems include potential damage to vegetation and soil structure through Kangaroo Field Processors driving off-track and the food source and potential disease risk provided by offcuts of the commercial harvest.

Offcuts of commercial harvest are produced when Kangaroo Field Processors dress a carcass at the site of the shooting. Several carcasses may be dressed at the one site, leaving small piles of offcuts called dumps (Wilson & Read 2003). These dumps can provide a food resource for predators such as foxes or birds of prey (Read & Wilson 2004). However, they can also provide positive impacts such as improved soil nutrition, and as a food resource for native scavengers.

Potential negative impacts of harvesting on habitats and ecosystems are minimised through:

- The presence of offcuts in ecosystems is minimised through full carcass only shooting in South Australia.
- The impacts of offcuts tend to be localised in nature.

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Appendix 3: Setting and applying harvest thresholds

South Australia has adopted the harvest thresholds method used in New South Wales and described in the *New South Wales Commercial Kangaroo Harvest Management Plan 2017-20*22. The following explanation on harvest threshold setting by SR McLeod and AR Pople (2011), is taken from the NSW Commercial Kangaroo Harvest Management Plan.

Setting thresholds for proportional threshold harvest strategies

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). A proportional harvest strategy is currently used to set quotas for the commercial harvest of kangaroos in Australia (Pople & Grigg 1999). This harvest strategy tracks fluctuations in population abundance and adjusts quotas accordingly, and has been found to have a low risk of overharvesting (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 thus lower the risk of over-harvesting by reducing harvest mortality at times of low population size.

Harvest strategies that use thresholds will not necessarily result in substantially lower yields. Research on proportional threshold harvesting (Lande et al. 1997) indicated that average yield may even be increased if thresholds are set optimally. However, a drawback of threshold harvesting is that it may increase variance in annual yield since there may be some years when no harvesting is allowed if the population remains below the lowest threshold. Nevertheless, proportional threshold harvesting has been shown to be superior, in terms of reducing depletion and extinction while maintaining yield, to other harvesting strategies including proportional harvesting.

Threshold abundance levels can be set in a number of ways. Using a time series of abundance data, the threshold can be set at the minimum observed abundance (Deroba & Bence 2008). A potential disadvantage of this method is that the time series needs to be sufficiently long to be representative of the conditions (environmental and anthropogenic) that influence a population's abundance, and so establish a reliable threshold. For example, if a rare event caused abundance to fall to a historically low level that is unlikely to occur again, the threshold might be set too low. Furthermore, if abundance falls below the threshold, which can happen even in the absence of harvesting, should the threshold be adjusted to the new low abundance or not? The somewhat arbitrary nature of the threshold can make management actions unclear when abundance falls below the threshold.

Alternatively, the threshold can be based on statistical properties of a time series of the population's abundance. For example, a time series of abundance estimates can be plotted as a histogram (Figure 5). In this example, the distribution of abundance follows an approximately lognormal distribution with a mean of 15.2 kangaroos per square kilometre and a standard deviation of 5.8 kangaroos per square kilometre. In the long term, kangaroo density is expected to follow a lognormal distribution. This distribution can also be represented using z-scores. The z-score transformation quantifies the variables in terms of standard deviations from the mean. The z-score transformation also standardises the variables so that the mean of the distribution is zero and the standard deviation is one. The area under the curve between two z-scores represents the probability that an element of the distribution is the specified number of standard deviations from the mean (Figure 6). In terms of setting harvesting thresholds, a threshold set at a z-score of -1.5 would represent the lowest 6.7 percent of the distribution, while a z-score of two represents the lowest 2.3 percent of the distribution.

The advantage of this method of setting the threshold over a more arbitrary method is that the threshold is unlikely to be biased by a single low abundance. Additionally, as more survey data are added to the time series of abundance for a population, the estimates of the population's mean and standard deviation become more robust.

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Applying this method of setting thresholds to red kangaroos in NSW's harvest zone 2 (Figure 7) indicates an initial threshold of 7.8 red kangaroos per square kilometre and a lower threshold of 6.4 red kangaroos per square kilometre. If the annual aerial survey indicates that the population of red kangaroos is below 7.8 kangaroos per square kilometre, the annual quota is reduced from 17 to 10 percent of the estimated population size. If the survey indicates that the population abundance of red kangaroos is below 6.4 kangaroos per square kilometre, then all harvesting in the zone will cease until at least the next survey when the annual harvest quota is reappraised. Thus, thresholds allow the population to fluctuate within its normal range in abundance, but prevent harvest mortality from depleting the population when it is at low abundance.

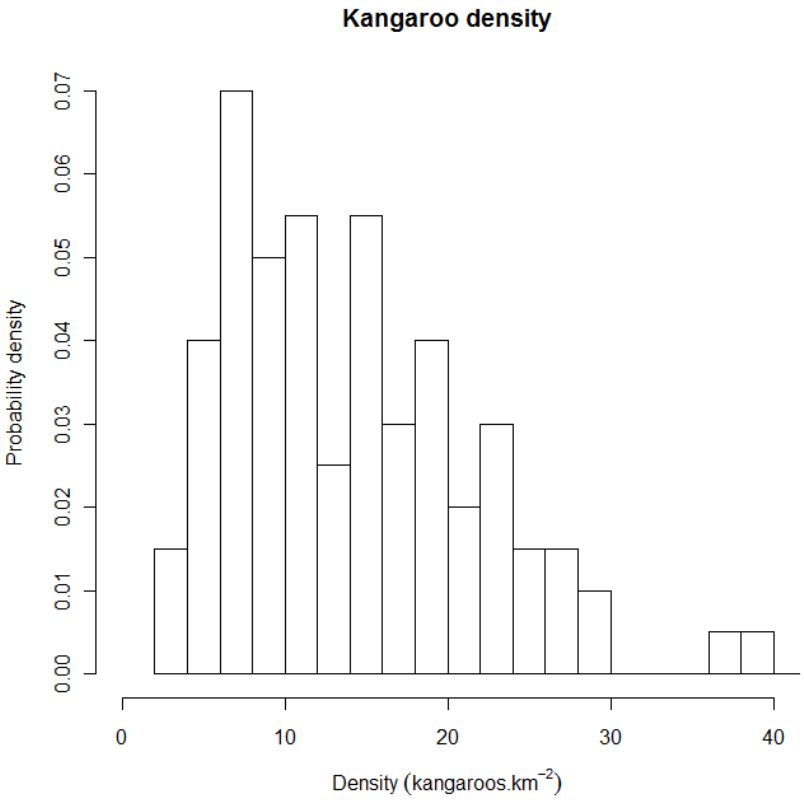

Figure 5: Histogram of a theoretical population of kangaroos.

Density is estimated by aerial survey and the frequency of estimated densities is converted to probability densities. The distribution of kangaroo densities is approximately lognormal.

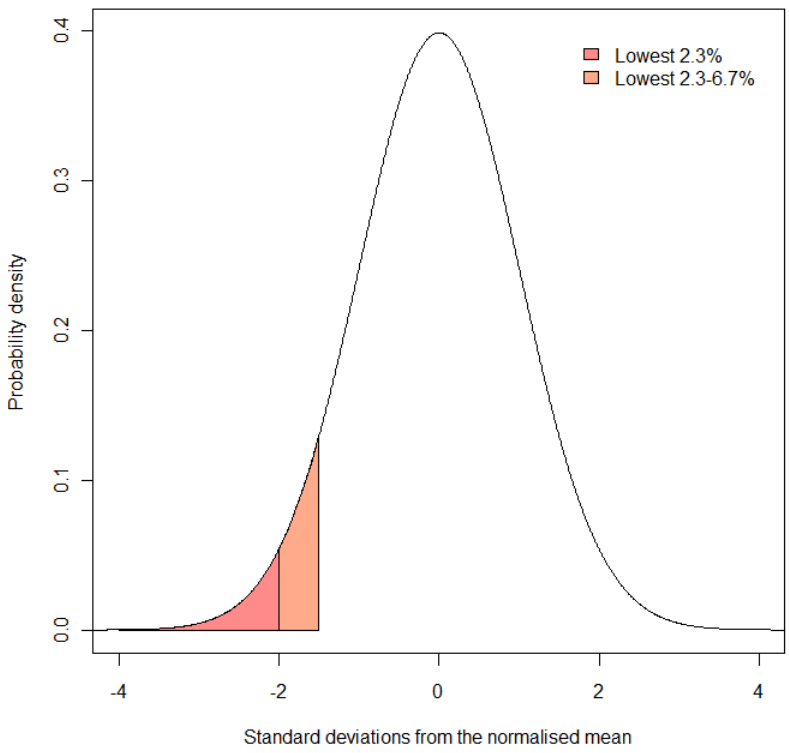

Figure 6: A theoretical distribution after z-score transformation.

The mean of the distribution is zero and the standard deviation is one. Areas under the distribution represent probabilities. The orange shaded region represents the probability that a sample is between 1.5 and two standard deviations below the mean (and represents 4.4 percent of the area). The red-shaded region represents the probability that a sample is more than two standard deviations below the mean (and represents 2.3 percent of the area).

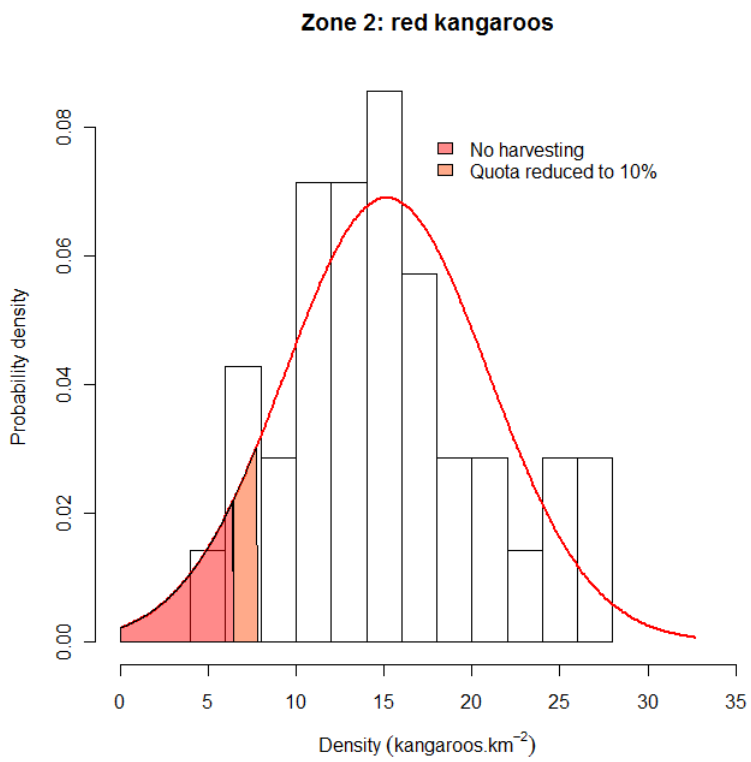

Figure 7: Example of setting harvest thresholds for red kangaroos in NSW's Zone 2.

The red line represents a normal probability distribution of the observed data with a mean of 15.2 kangaroos per square kilometre and a standard deviation of 5.8 kangaroos per square kilometre. The upper range of the orange region (7.8 kangaroos per square kilometre) represents the threshold within which harvest rate is reduced from 17 percent to 10 percent. This lower rate is maintained unless density falls below 6.4 kangaroos per square kilometre, at which point harvesting ceases (red region). The thresholds were calculated after log-transforming the data.

The following section shows how model simulations can be used to examine the relative effects of different thresholds applied to harvesting a theoretical population of red kangaroos.

Reducing the risk of overharvesting: an example using red kangaroos

The recommended strategy to minimise the risk of overharvesting is to reduce harvest rate as density declines, with changes in harvest rate triggered at predetermined density thresholds. Appropriate thresholds can be considered by harvesting a simulated population of kangaroos (e.g. Milner-Gulland et al. 2001). An appropriate population model for red kangaroos was developed by Caughley (1987) and various forms of the model have continued to be used for assessing strategies for managing the kangaroo harvest (e.g. Hacker et al. 2004; Pople 2003, 2008).

Briefly, changes in kangaroo numbers are modelled as a function of pasture biomass which, in turn, is determined by recent rainfall, past pasture biomass and the density of kangaroos (and livestock) consuming the pasture. Harvesting obviously reduces kangaroo numbers, but the reduced density results in higher pasture biomass and therefore higher rates of increase of kangaroos. This improvement in environmental conditions for a population, which without harvesting has no long-term trend, is a basic requirement for the sustainability of a harvest. The population can be simulated 10,000 times over a 20 year period. Each run is different as, every three months, rainfall is drawn from a probability distribution using the average and standard deviation for rainfall in western NSW and thus reflects the uncertain food supply in this arid environment. Population size is also estimated with uncertainty by aerial surveys, and so this too was drawn from a probability distribution using the average and standard deviation associated with aerial surveys (Pople 2008). The population was harvested at an annual rate of 15 percent or less if it was below a particular threshold.

Extinction is highly unlikely for this simulated population unless there is some combination of low numbers, catastrophic weather and unsustainable harvesting (i.e. much greater than 15 percent). A more useful measure of threshold performance is the probability of the population dropping to a relatively low density. This can be calculated as the proportion of the 10,000 simulation runs where the population falls below particular densities. Thresholds can be expressed in terms of standard deviations (SDs) below long-term average density for a kangaroo management zone. That way, the aim of the threshold harvest strategy is to keep the harvested population above historically low density.

The effect of reducing harvest rate at varying SDs below the long-term average density for the simulated kangaroo population is shown in Figure 5. Reducing the threshold not surprisingly reduces the probability of very low density, but the decline in probability from no threshold (15 percent harvest) to no harvest is smooth. There is, therefore, no obvious optimum with the choice being somewhat arbitrary. Notably, even an unharvested population has some chance of declining to very low density.

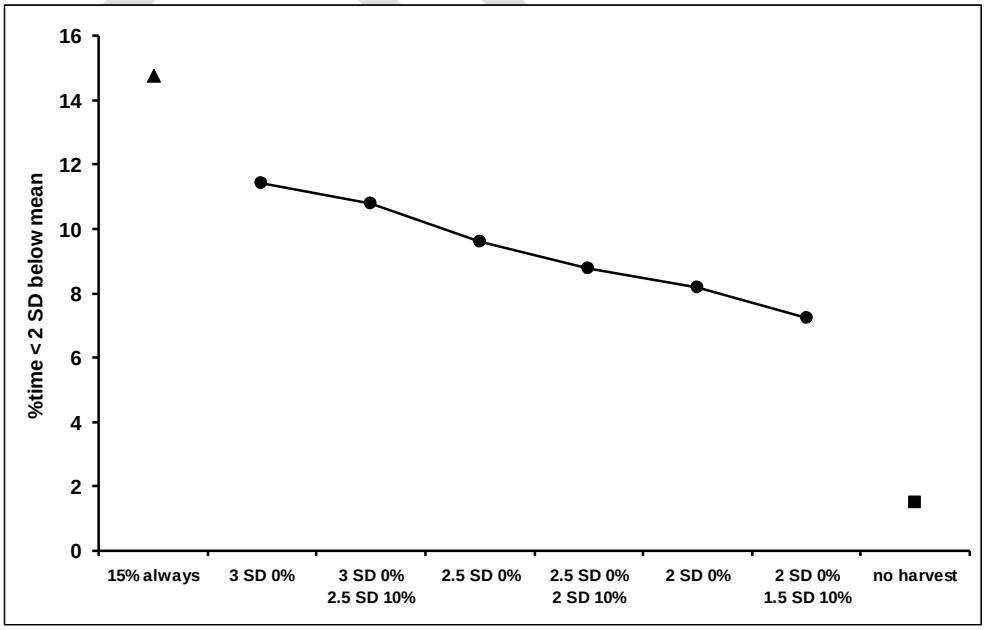

Figure 8: 10,000 simulations for a population fluctuating over 20 years.

Standard deviation (over time) was calculated from a lognormal distribution. Mean population size was about eight kangaroos per square kilometre. Density was about four kangaroos per square kilometre at two standard deviations below the mean.

Other factors that could be considered in setting thresholds is the time spent below some relatively low density (e.g. Figure 6), and the long-term average and variability in harvest offtake (including years with zero offtake) (Pople 2003). For these simulations, average harvest offtake was similar among the thresholds shown in Figures 5 and 6, but variability in the annual harvest increased slightly as the threshold was reduced.

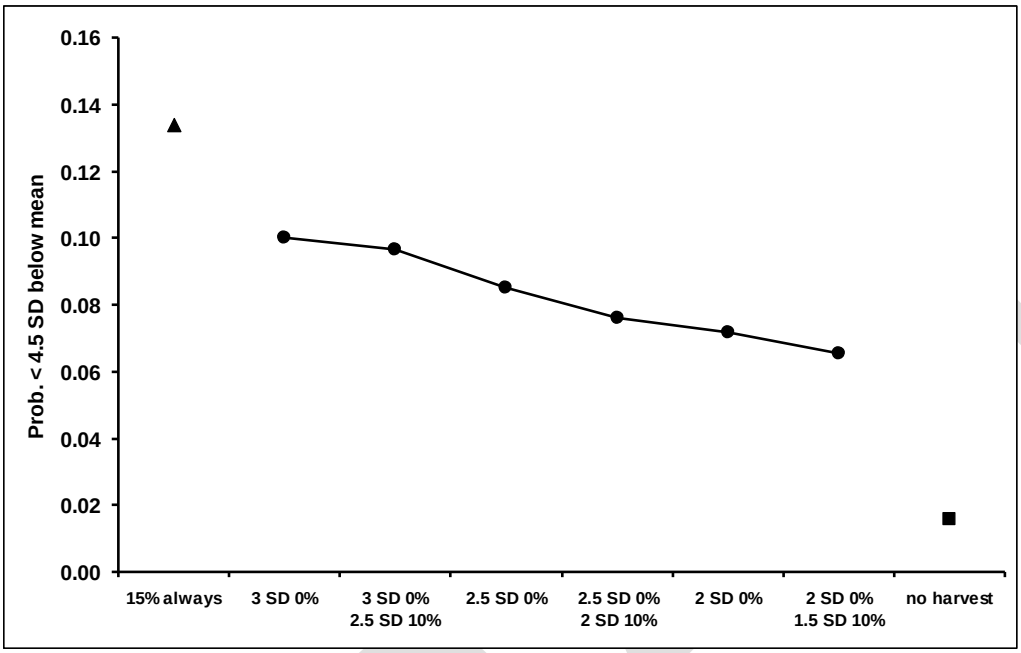

Figure 9: Simulated population as described for Figure 8.

Density was about two kangaroos per square kilometre at 4.5 standard deviations below the mean.

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Appendix 4. Permit types and detail

This section contains detail on the various permit types related to kangaroo management, including Field Processor, Meat Processor and Skin Tanner Permits, and Permit to Destroy Wildlife.

Permits are issued under the *National Parks and Wildlife Act 1972* and subordinate regulations. Permit conditions are reviewed regularly and may change during the life of this plan. Any changes to the conditions will need to be in accordance with this plan, and the Commonwealth will be notified of any significant changes.

Kangaroo Field Processor

Permit	Holds a permit issued under section 60J of the *National Parks and Wildlife Act 1972* and the *Kangaroo Harvesting Regulations*. The permit allows for the permit holder to take kangaroos by means of a firearm on land for which there is a commercial quota, field-dress the carcasses into a form suitable for sale, and sell the carcasses to a Kangaroo Meat Processor.
Accreditation	The applicant must hold a current Firearms Licence (Class B7 or as otherwise recommended by SAPOL). The applicant must have completed an approved Kangaroo Field Processors Firearms Accuracy Accreditation Course in South Australia or another state. The applicant must have completed the Game Meat Field Hygiene Course run by Primary Industries and Resources South Australia or an accredited interstate course.
Relevant detail	The permit holder may shoot kangaroos only on land on which they have the landholder's permission to shoot. The permit holder may shoot kangaroos only following allocated quotas and sealed tags. All kangaroos must be shot following the Commercial Code The permit holder must affix to each kangaroo carcass a commercial use, sealed tag issued in accordance with regulations. Royalty for each tag must be paid to DEWNR. Each uniquely-numbered tag is subtracted from the quota and allows for an individual carcass to be tracked through the processing chain. The permit holder must attach the appropriate tag for each species of kangaroo that is harvested, and the tag must be valid for the sub-harvest region on which the kangaroo is taken. The tags are self-locking and can only be removed from the carcass or skin when it is processed by an accredited processor. The permit holder may sell kangaroos only in the format approved under regulation 36 of the Kangaroo Harvesting Regulations for sale to persons holding a Kangaroo Meat Processor permit. The permit holder must keep records of kangaroos that are harvested, and supply harvest returns to DEWNR in the approved format.
Further detail	For further detail see the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 and National Parks and Wildlife (Wildlife) Regulations 2016, or any amended versions of these regulations.

Kangaroo Meat Processor

Permit	Holds a permit issued under section 58 of the *National Parks and Wildlife Act 1972*. The permit allows for the permit holder to keep and sell kangaroo meat products and skins.
Accreditation	The applicant must have a thorough knowledge of the *National Parks and Wildlife Act 1972* and regulations under this Act. The permit holder must be accredited by Primary Industries and Resources South Australia.
Relevant detail	The permit holder may purchase kangaroo carcasses only from a Kangaroo Field Processor in South Australia, or from an accredited dealer that has obtained carcasses through an accredited interstate kangaroo harvest program. The permit holder must purchase or accept only those kangaroo carcasses that have a sealed tag affixed (both for carcasses taken within South Australia, or imported from another state).

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	The permit holder must obtain import or export permits, issued under the *National Parks and Wildlife Act 1972* for consignments of kangaroo products that enter or leave South Australia. (N.B.: export of kangaroo products from Australia requires a separate export permit issued by the Commonwealth). The permit holder must keep records of carcasses and skins that are purchased and sold, and supply returns to DEWNR in the approved format.
Further detail	For further detail see the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 and the Wildlife Variation Regulations 2003, and National Parks and Wildlife (Wildlife) Regulations 2016, or any amended versions of these regulations.

Kangaroo Skin Tanner

Permit	Holds a permit issued under section 58 of the *National Parks and Wildlife Act 1972*. The permit allows for the permit holder to keep and sell kangaroo skins.
Accreditation	The applicant must have a thorough knowledge of the *National Parks and Wildlife Act 1972* and regulations under this Act.
Relevant detail	The permit holder may purchase kangaroo skins only from a Kangaroo Meat Processor in South Australia, or from an accredited dealer that has obtained carcasses through an accredited interstate kangaroo harvest program. The permit holder must purchase or accept only those kangaroo skins that have a sealed tag affixed (both for carcasses taken within South Australia, or imported from another state). The permit holder must obtain import or export permits, issued under the *National Parks and Wildlife Act 1972*, for consignments of kangaroo products that enter or leave South Australia. (N.B.: export of kangaroo products from Australia requires a separate export permit issued by the Commonwealth). The permit holder must keep records of skins that are purchased and sold, and supply returns to DEWNR in the approved format.
Further detail	For further detail see the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 and the Wildlife Variation Regulations 2003, and National Parks and Wildlife (Wildlife) Regulations 2016, or any amended versions of these regulations.

Permit to Destroy Wildlife (Non-Commercial/Damage mitigation)

Permit	Holds a permit issued under section 53(1)(c) of the *National Parks and Wildlife Act 1972*. The permit allows for the permit holder to destroy a specified number of kangaroos that are causing, or are likely to cause, damage to the environment, or to stock, crops or other property.
Accreditation	The permit holder, or the person listed on the permit to shoot kangaroos, must hold a current firearms license. The permit holder, or the person listed on the permit to shoot kangaroos, must have an understanding of the Non-Commercial Code and must have the marksmanship skills to shoot kangaroos following the Non-Commercial Code.
Relevant detail	Kangaroos must be shot following the Non-Commercial Code. Where a permit holder is unable to shoot following the Non-Commercial Code or wishes to list another person to conduct the shooting, they can list another person on the permit to conduct the shooting. Carcasses must be left in the field or disposed of in accordance with carcass management options approved by DEWNR. Carcasses can be used for personal purposes with personal use tags that are issued against a specific permit under the Kangaroo Harvesting Regulations. Where carcasses are to be used, a valid personal use sealed tag must be attached to each carcass after shooting and must remain on the carcass or skin until it is used. A royalty must be paid to DEWNR for each personal use tag. The permit holder must provide a return of the number of animals destroyed to DEWNR in the approved format.

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