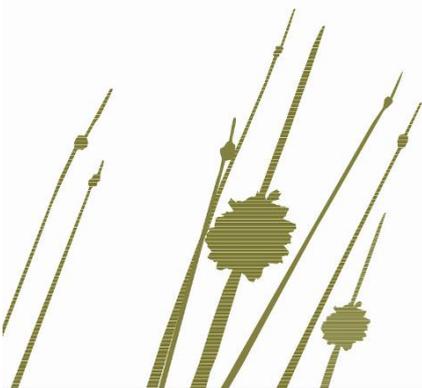


# South Australian Kangaroo Management Plan

2013-2017



Government  
of South Australia

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## DEFINITIONS

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.

Field Chiller – a refrigerated facility used for the temporary storage of kangaroo carcasses until collection and transport to a processing works. This facility may be mobile.

Landholder – owner or occupier of specified lands.

Kangaroo – the kangaroo species that can be utilised in accordance with this management plan: the red kangaroo (*Macropus rufus*), western grey kangaroo (*M. fuliginosus*) and euro (*M. robustus*).

Commercial Harvest Management Region (CHMR) – A designated area of the State at which commercial quota is determined. May be broken into sub-regions. At the time of writing, sub-regions are defined by Soil Conservation District boundaries, and compiled into four CHMRs (Eastern Agricultural, Western Agricultural, Eastern Pastoral and Western Pastoral). See Figure 1.

Note: All other definitions have the meaning prescribed 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*

KFP – Kangaroo Field Processor

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

CHMR – Commercial Harvest Management Region

## 1. INTRODUCTION

This management 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 management 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 all of the aforementioned macropod species.

This management plan is current for a maximum five-year period from 1 January 2013 to 31 December 2017.

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 (the Regulations) through the issue of various permits and tags.

This management 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. The NPW Act allows for commercial harvest to be undertaken on parks and reserves.

The primary goal of the management plan is to ensure conservation of kangaroos, to mitigate damage caused by kangaroos through commercial harvest, and to ensure that the harvest is ecologically sustainable. 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 in accordance with this plan. This management 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 commercial harvest of kangaroos to provide for the management of kangaroo populations in accordance with the principles of ecologically sustainable development. Management in this context assists in balancing environmental, social and economic interests through management of a renewable resource. This management also provides for the sustainable harvesting of kangaroos for products such as meat and leather to supply the Australian and international markets. This plan prohibits the taking of kangaroos in South Australia for skins only.

This plan adopts the ethic that the mitigation of the 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.

## 2. LEGISLATIVE FRAMEWORK

### 2.1. Commonwealth

The relevant provisions under the *Environment Protection and Biodiversity Conservation Act 1999* came into force on 11 January 2002, following the incorporation of the former *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. The EPBC Act requires the development and approval of wildlife trade management plans in order for permits to be issued for the commercial export of wildlife products. This management 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:

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

In deciding whether to declare this plan as a wildlife trade management plan, the Minister must also have regard to whether:

- a. legislation relating to the protection, conservation or management of the specimens to which the plan relates is in force in the State or Territory concerned
- b. the legislation applies throughout the State or Territory concerned
- c. 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 generally accepted to minimise pain and suffering. Animal welfare standards for the commercial and non-commercial harvesting of kangaroos are detailed in the National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes and the National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-Commercial Purposes ([www.environment.gov.au/biodiversity/trade-use/wild-harvest/kangaroo/practice.html](http://www.environment.gov.au/biodiversity/trade-use/wild-harvest/kangaroo/practice.html)). Hereafter referred to as the Commercial Code and the Non-Commercial Code respectively. All kangaroos must be killed in accordance with these Codes or any subsequent relevant nationally-endorsed codes that replace those documents.

### 2.2. South Australia

All kangaroo species are protected fauna in South Australia under the NPW Act. The NPW Act and the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 make provision 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, and this plan is endorsed under that Act. The Regulations manage the operations of the kangaroo industry and the permit and tag procedures that apply to commercial harvest. These Regulations will be remade during the life of this plan. Details on permitting structures are provided in Appendix 2.

In addition to this 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*.

### 3. GOAL AND AIMS

#### 3.1. Goal

The overarching goal of the South Australian Kangaroo Management Plan 2013 – 2017 is:

**To maintain viable populations of kangaroos throughout their ranges in accordance with the principles of ecologically sustainable development.**

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

In order to attain its overarching goal, this management plan has eight aims, each of which encompasses a particular facet of kangaroo management. When the aims are combined, they set strategic directions for achieving land management outcomes through the management of the commercial kangaroo harvest in South Australia.

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 management 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 2016.

#### 3.2. Aims

The aims of this management plan are to:

##### 1. ENSURE HUMANE TREATMENT OF KANGAROOS

Promote improved animal welfare outcomes and ensure that the commercial harvest of kangaroos under this plan is carried out in accordance with the Commercial Code.

##### 2. PROMOTE COMMUNITY AWARENESS AND PARTICIPATION

Promote greater understanding of the program through informed public and private sector participation in 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 (through both a reduction in kangaroo impacts and an increased acceptance of integrated management and the concept of living with wildlife).

##### 4. MONITOR KANGAROO POPULATIONS

Monitor kangaroo populations and set commercial quotas ensuring the goal of the management plan is achieved.

##### 5. MANAGE COMMERCIAL OPERATORS

Manage the commercial utilisation of kangaroo species in accordance with the provisions of the NPW Act and Regulations, South Australian Government policies, the Commercial Code and this management plan.

##### 6. MONITOR INDUSTRY COMPLIANCE

Monitor the kangaroo industry to ensure compliance with this management plan, permit conditions, the requirements of the NPW Act and Regulations and the Commercial Code.

##### 7. FACILITATE ADAPTIVE MANAGEMENT AND RESEARCH

Promote adaptive management experiments and studies using historical data from kangaroo industry returns and population data to improve our understanding of kangaroos and their interaction with environmental, social and economic systems. Facilitate research into other aspects of kangaroo ecology and/or harvest management as required to fill knowledge gaps.

##### 8. 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 the management plan.

## 4. MANAGEMENT ACTIONS AND PERFORMANCE INDICATORS

### 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 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 SA. Kangaroo Field Processors must demonstrate their competency in relation to the Commercial Code and conditions attached to Kangaroo Field Processor's permits provide financial disincentives for shooting other than in accordance with the Commercial Code (see discussion under Aim 5: Manage Commercial Operators). DEWNR will introduce reporting requirements for Meat Processor and Skin Tanner permit holders in the life of this plan.

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

DEWNR authorised officers undertake both regular unannounced and opportunistic inspections of kangaroos taken by licensed Kangaroo Field Processors and all premises registered by licensed meat processors. During the life of this plan, a Memorandum of Understanding between DEWNR and the Department of Agriculture, Fisheries and Forestry in relation to reporting breaches of conditions relating to animal welfare will be instigated. These agreements significantly increase the detection of kangaroo carcasses that have not been taken in accordance with permit conditions. DEWNR does not tolerate breaches of the Commercial Code, and where kangaroos have been found to be taken other than in accordance with the Commercial Code, Penalty Notices are issued or licensees are prosecuted as appropriate. Permits may be cancelled. Zero tolerance of animal welfare breaches demonstrates DEWNR's commitment to ensuring that the commercial harvest of kangaroos is humane.

Performance Indicators:

1.1 All licensees who are found to have breached permit conditions relating to animal welfare are issued with Expiation Notices or are prosecuted as appropriate.

**ACTION 2: DEWNR will facilitate research into improving animal welfare outcomes associated with mitigating the damage caused by kangaroos.**

DEWNR will work with other agencies to identify and investigate animal welfare in the commercial harvest and non-commercial culling 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 indicator:

2.1 DEWNR will participate in a national review of the Commercial and Non-Commercial Codes of Practice.

2.2 DEWNR will encourage research into improving animal welfare outcomes for commercial and non-commercial killing of kangaroos.

### 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 key kangaroo management issues throughout the life of this plan.**

The Kangaroo Management Reference Group (KMRG), which is convened by DEWNR, is the main forum through which stakeholder group representatives can raise issues for discussion, as well as communicate their group's positions and interests to Government and all other stakeholders on a regular basis. The current membership of KMRG encompasses representatives of animal welfare, the kangaroo industry, landholder groups, Aboriginal communities, conservation organisations and government stakeholder groups. Member organisations hold their appointed positions for three-year terms. The function of KMRG is to advise the Chief Executive of DEWNR on matters pertaining to the implementation and review of the South Australian Kangaroo Management Plan 2013 – 2017. Relevant information is provided to members of KMRG to ensure that they have appropriate information in order to make informed decisions as part of their advisory role.

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 progress of South Australian Kangaroo Management Plan 2013 – 2017 in relation to the goal and aims of the plan.

3.3 Build strong partnerships between regional decision-makers, kangaroo managers and NRM Boards and groups, including alignment of relevant aims and actions of the new plan with targets identified in regional NRM plans.

3.4 DEWNR will engage other government departments with an interest in assisting business growth (eg, DMITRE, DPLG) with the kangaroo industry.

**ACTION 4: Relevant public documents will be made available on the Kangaroo Management Program web page.**

The provision of information to members of the public promotes understanding of the South Australian Kangaroo Management Plan 2013 – 2017 and allows members of the community to form better-educated opinions regarding kangaroo management issues.

Performance indicator:

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

- a statement of the reasons commercial harvest is undertaken in this State
- the current and previous Commercial Kangaroo Harvest Management Plans
- historical harvest statistics
- population survey reports
- current population estimates
- current commercial quotas
- contact information for the Kangaroo Management Program
- current forms for commercial kangaroo permits.

These data, and additional relevant information will be posted on the Kangaroo Management Program web page within one month of becoming available as appropriate.

**ACTION 5: Publicly available information will be provided to interested parties on request.**

The provision of information assists to promote understanding of the Kangaroo Management Program and helps interested parties to form educated opinions in relation to kangaroo management issues.

Performance indicator:

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

**ACTION 6: 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 effective mechanism for communicating information regarding kangaroo management to a broad audience and improves program transparency and accountability and therefore public confidence.

Performance indicators:

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

6.2 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 (November).

**ACTION 7: Relevant information regarding permitting arrangements and kangaroo management policies will be developed as required and distributed to relevant stakeholders.**

Permit holders will be provided with written information relevant to their permit arrangements to promote voluntary compliance with the permit framework. Regular newsletters will be provided to all stakeholders.

Performance indicators:

7.1 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.

7.2 A newsletter containing information relevant to permit holders and other stakeholders (including updates to permit conditions, KMRG decisions, and other DEWNR kangaroo policies) is prepared and forwarded to relevant kangaroo management stakeholders bi-annually.

**ACTION 8: Involve Aboriginal stakeholders in the implementation of this plan**

Feedback on kangaroo management strategies, and implementation of this management 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 management website.

Performance indicators:

- 8.1 Investigate alternative business models to encourage Aboriginal participation in kangaroo management.
- 8.2 Seek Aboriginal involvement in management decisions through inclusion in the KMRG.
- 8.3 Hold specific discussions with representatives of aboriginal communities to develop more effective ways of sharing information and developing partnerships.

### **AIM 3: MANAGE IMPACTS OF KANGAROOS ON LAND CONDITION**

Widespread changes to the environment since European settlement have changed the natural balance of 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, whereby 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.

#### **ACTION 9: DEWNR will issue permits to landholders for the destruction of kangaroos for damage mitigation purposes.**

Key objectives of the permit to destroy wildlife framework are to:

- Promote an integrated management approach that includes non-lethal techniques as appropriate to help achieve a reduction in impacts
- Manage permitting to effectively integrate both long-term and short-term economic, social, environmental and equitable considerations
- Work together with landholders, community and industry to promote early action planning, clear identification of management objectives and develop appropriate integrated management strategies for wildlife
- Ensure that animals destroyed under permits are killed humanely in accordance with Non-Commercial Code.

Performance indicators:

- 9.1 Issue Permits to Destroy Wildlife to landholders to mitigate detrimental impacts of kangaroos.
- 9.2 Any landholder of an appropriate property size seeking a destruction permit for more than 25 animals within a current commercial quota allocation is offered a commercial harvesting permit in the first instance. Permits to Destroy Wildlife (non-commercially) are only offered after a commercial harvest permit has been declined.
- 9.3 DEWNR will investigate the introduction of formal training requirements (similar to those undertaken by Kangaroo Filed Processors) for landholders requesting non-commercial Permits to Destroy Wildlife.
- 9.4 DEWNR will develop decision making tools, informed by current survey, climatic and other data, to assist regional staff in permit issue.
- 9.5 DEWNR will develop a mapping facility to allow landowners to determine whether they fall within the commercial harvest regions.

### **AIM 4: MONITOR KANGAROO POPULATIONS AND SET QUOTAS**

Monitoring commercially harvested kangaroo populations, both directly and indirectly, is essential to effectively maintaining viable populations of kangaroos throughout their ranges.

The three currently commercially utilised kangaroo species – *Macropus rufus*, *M. fuliginosus* and *M. robustus* – are widespread and abundant in South Australia. The 2011 population estimate for these kangaroo species in Commercial Harvest Management Regions (CHMRs - Figure 1) totalled approximately 2.3 million.

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 interval between young), these are relatively well

understood and accounted for in the various quotas set for each species. In addition, there is abundant information from direct and indirect monitoring of kangaroos.

Results of aerial surveys since the mid-1970s show that kangaroo populations fluctuate primarily in response to rainfall and other seasonal conditions.

A wide range of literature relating to kangaroos and their management is currently available. Of particular interest is a comprehensive review prepared for the Commonwealth Government entitled *Commercial Harvesting of Kangaroos in Australia*. This review is available on the Commonwealth Government website ([www.environment.gov.au/biodiversity/trade-use/wild-harvest/kangaroo/harvesting/index.html](http://www.environment.gov.au/biodiversity/trade-use/wild-harvest/kangaroo/harvesting/index.html)) 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 recent 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 webpage.

**ACTION 10: Population surveys will be conducted annually in regions with an average annual harvest of greater than 50% of the maximum quota for the past five years, and at least once every three years in regions with an average annual harvest of less than 50% of the maximum quota for the past five years.**

Kangaroo population estimates obtained from surveys (direct monitoring) will be used as the basis of setting commercial quotas following the procedures set out in this management plan.

There are two standard survey techniques that may be employed for direct monitoring of kangaroo populations.

1. Broad-scale aerial surveys using fixed-wing aircraft (fixed strip-width transect survey methodologies).
2. Small-scale surveys conducted on foot (line transect survey methodology). This technique is employed due to the dangers associated with low level flying in steep terrain, but has high associated costs. Fixed-wing aircraft are used across SA to annually survey kangaroo populations. 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.

Some terrain is too steep to be safely surveyed using fixed-wing aircraft so walking surveys are used instead. During the life of this plan, methodology of walking surveys will be reviewed, and more efficient survey methods may be trialled and implemented, all the while ensuring continuity of data comparison.

For the three species currently harvested commercially – *M. rufus*, *M. fuliginosus*, and *M. robustus* – the quota will be adjusted based on the most recent population estimate and will therefore account for all kangaroo mortalities, including those unrelated to commercial use.

Performance indicators:

10.1 Kangaroo population estimates are obtained at required time intervals using standard survey methodology throughout the life of this plan.

10.2 DEWNR will continue to investigate development of an optimal monitoring strategy for kangaroo management.

**ACTION 11: Commercial kangaroo harvest quotas will be set in accordance with the provisions of the South Australian Kangaroo Management Plan 2013 – 2017.**

The commercial quota for a species is the maximum number that can be utilised commercially in a calendar year. Quotas will be set for each commercially harvested kangaroo species for which current population estimates are available in specific Commercial Harvest Management Regions (CHMR). The Commonwealth Government will be advised of the quotas prior to implementation.

Based on kangaroo population dynamics, quotas set at 15 to 20 percent are considered sustainable in the long-term (Caughley 1987, Hacker et al. 2004). 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 (see Action 23). regional quotas are set at a maximum of 20% of estimated population size for red kangaroo, and 15% of estimated population size for western grey kangaroo and euro. More conservative quotas are set for regions that are not monitored annually.

There are currently four defined CHMRs in South Australia: Western Pastoral, Eastern Pastoral, Western Agricultural, and Eastern Agricultural.

Within each of these defined harvest management regions lie a number of sub-regions (shown as internal boundaries on Figure 1). These management sub-regions are based on the old administrative boundaries of Soil Conservation Board districts.

Population estimates and commercial quotas are currently derived and set at the level of each management sub-region (i.e. old Soil Conservation Board boundaries). However, for the purposes of providing flexibility to manage quotas in response to spatial and temporal changes in kangaroo distribution, sub-region quotas can be moved between other sub-regions within the same CHMR. Quotas cannot be moved between any of the four defined harvest regions. Quota is distributed across these sub-regions as per the surveyed densities of animals. Quotas may be shifted between sub-regions within the same CHMR only for approved damage

mitigation reasons, and only where available quota in a sub-region has been fully utilised. Once all of the 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 (with the possible exception of Special Land Management Quota – see action 14). The boundaries of these regions will be updated during the life of this plan to align with the more commonly used and widely recognised Natural Resource Management Board and Group boundaries (or another suitable boundary). However, within the life of this plan new commercial kangaroo harvesting 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.

Performance indicators:

11.1 All commercial kangaroo harvest quotas are set in accordance with the provisions of the South Australian Kangaroo Management Plan 2013 – 2017 throughout the life of the plan.

11.2 The Commonwealth Government is advised of commercial harvest quotas for the following calendar year by 30 November.

The Quota Report will contain the following information:

- population estimates for each species in each harvest region and method of survey used
- quotas calculated as a proportion of population estimate as per the approved Kangaroo Management Plan (including Special Quotas)
- any proposed changes to quotas
- any changes to sub-region boundaries or new commercial areas, and justification based on survey results
- data showing trends in population/quota/harvest

11.3 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.

11.4 The Quota Report is made available to the public via the Kangaroo Management Program web page.

**ACTION 12: If kangaroo populations decline to specific trigger points, the commercial harvest of particular species in particular sub-regions will be reduced or suspended.**

This management plan aims to accommodate fluctuations in kangaroo populations to change according to seasonal conditions. Calculating trigger points based on long-term average populations or densities, and standard deviations, recognises these environmental differences. ‘Standard deviation’ is a statistical measure of how much the population changes relative to its average – in erratic environments, the population changes much more and the standard deviation is larger than in environments that are more stable. This means that the ‘standard deviation’ is different for each species in each sub-region. The standard deviations will be recalculated after each survey to ensure all available information is utilised. Appendix 3 provides additional information on the use of population thresholds in harvest management.

If survey results indicate a population has fallen below the long term average density for that species in that harvest region, the commercial quota will be reduced or suspended for the following calendar year. The suspension will remain in place until surveys indicate populations have increased.

**Reduction in quota** – when populations are below the long-term average by between 1.5 and two standard deviations.

- The annual quota for the following calendar year (commencing January, year 1) will be calculated at ten percent of the population estimate for that species in that sub-region.
- If the next survey indicates populations have increased to less than 1.5 standard deviations below the average, or are above average, the commercial quota will be calculated at the usual percent of the new estimate for the following calendar year (January, year 2).
- However, if the survey indicates populations have further declined and are more than two standard deviations below the average, the commercial quota will be suspended.

**Suspension of quota** – when populations are more than two standard deviations below the long-term average density.

- There will be no annual quota for the following calendar year (commencing January, year 1) for that species in that sub-region.
- If the next survey indicates populations have increased to between 1.5 and two standard deviations below the average, a commercial quota will be set at ten percent for that species in that sub-region for the following year (commencing January, year 2).
- If the next survey indicates populations have increased to less than 1.5 standard deviations below the average, or are above average, the commercial quota will be calculated at the usual percent of the new estimate for the following calendar year (commencing January, year 2).

- However, if the survey indicates that populations have not increased or have further declined, the harvest suspension will remain in place and no commercial quota will be set for that species in that sub-region for the following calendar year (commencing January, year 2).

For Commercial Harvest sub-regions that are surveyed triennially (i.e., those that have average annual harvest of less than 50% of the maximum quota), quota is already set at a reduced level. In these sub-regions, for any survey that indicates a population that has fallen to between 1.5 and 2 standard deviations of the average, quota will be set at the usual reduced level. Even if future surveys show an increase in population, this reduced quota will remain in place until such time that the average quota uptake is greater than 50%, and surveys occur annually. If the triennial surveys indicate that the population has fallen more than two standard deviations below the long term average, quota will be suspended, and an additional survey will be undertaken in that sub-region in the following year.

If commercial quotas are reduced or suspended due to low population estimates, issuing of non-commercial permits to destroy wildlife may also be reduced or suspended.

Performance indicators:

12.1 Commercial harvest quotas are reduced if population estimates fall below 1.5 standard deviations of the long-term average density, or suspended if population estimates fall below two standard deviations of the long-term average.

**ACTION 13: Special Land Management Quotas will be set in accordance with the provisions of the South Australian Kangaroo Management Plan 2013 – 2017.**

A Special Land Management Quota (SLMQ) for commercial CHMRs will be set annually at a maximum of 1.5 percent 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 normal non-commercial licensing system.

Performance indicator:

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

**ACTION 14: 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 and data on 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:

14.1 A system will be developed to automatically analyse industry returns for unusual changes in information.

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

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

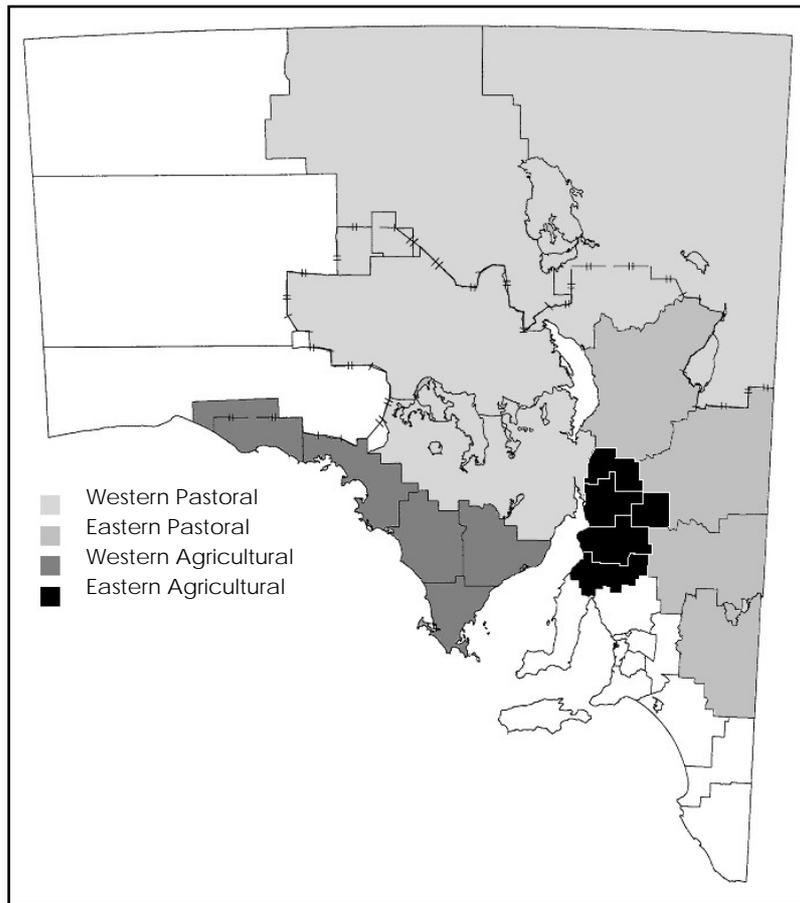


Figure 1: Current South Australian Kangaroo Commercial Harvest Management Regions (CHMR)

**AIM 5: MANAGE COMMERCIAL OPERATORS**

In order 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 and Regulations. Permitting procedures are described in detail in Appendix 2. Under this management plan the commercial harvesting of kangaroos in South Australia is presently restricted to the Commercial Harvest Management Regions illustrated in Figure 1, and to red kangaroos (*Macropus rufus*), western grey kangaroos (*M. fuliginosus*) (not including the Kangaroo Island sub-species), and euros (*M. robustus*).

**ACTION 15: All relevant activities are permitted in accordance with the applicable South Australia legislation and DEWNR policy.**

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

Performance indicator:

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

**ACTION 16: Permit conditions are effective and reflect current South Australia legislation, DEWNR policy and the South Australian Kangaroo Management Plan 2013 – 2017.**

To effectively and efficiently manage commercial kangaroo operations in South Australia, permit conditions must be effective and consistent with Commonwealth and South Australian legislation, DEWNR policy and the South Australian Kangaroo Management Plan 2013 – 2017. 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. The introduction of minimum carcass weights, consistent with regulation 37(1a) of the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003, is one such possible amendment. All proposed amendments to permit conditions will be assessed by DEWNR's legal representatives prior to implementation and permit holders will be advised of changes to their

permit conditions in writing. Any changes to the conditions will need to be in accordance with this management plan and the Commonwealth will be notified of any significant changes.

Performance indicators:

- 16.1 Permit conditions are reviewed at least annually and where necessary amended.
- 16.2 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 17: DEWNR will ensure that all Kangaroo Field Processors are competent to achieve the standards set out in the Commercial Code, and other necessary requirements**

In order to ensure that the kangaroo harvest is humane, Kangaroo Field Processors are required to demonstrate their competency in relation to the Commercial Code prior to obtaining their permits. Accreditation includes holding a current Firearms Licence, having successfully completed an approved Kangaroo Field Processor's Firearms Accuracy Accreditation course in South Australia (or another approved state), and having successfully completed the Game Meat Field Hygiene Course run by Biosecurity SA. DEWNR may require that kangaroo field processors undertake further training as a corrective action. All successful applicants for a Kangaroo Field Processor's Permit have completed the approved accreditation.

Performance indicators:

- 17.1 On receipt of Kangaroo Field Processor's permit applications, the authorised DEWNR officer assessing the applications will ensure that applicants have both a valid South Australian Kangaroo Field Processor accreditation and a valid Firearms Licence (Class B5 or B7 or as directed by South Australian Police), and other licences and permits as required.
- 17.2 DEWNR will liaise with training providers to ensure that Kangaroo Field Processor training syllabus includes best practice methods on the humane destruction of joeys.

**ACTION 18: DEWNR will implement changes to legislation and to the sealed tag system to streamline and simplify the tag nomination process.**

Continuing actions from *South Australia's 2008-2012 Kangaroo Conservation and Management Plan* to review the sealed tag system will occur during the life of this plan. At the close of the last management plan, DEWNR was investigating the sale of sealed tags directly to the kangaroo field processor [A3]. This change was to be accompanied by other changes to the administration of sealed tags and industry returns.

DEWNR will monitor technological developments in the area of tagging within commercial industries where location of harvest is recorded. This information can improve the knowledge of kangaroo populations and can enhance other monitoring techniques. This information could also enhance departmental knowledge more frequently when quota allocations are nearing full allocation.

During the life of this plan, DEWNR will review and remake the Regulations. This review may recommend changes to the administration of harvesting, or to the species available for harvest.

Performance indicators:

- 18.1 Efficiency of the sealed tag system changes implemented at the start of this plan will be reviewed six monthly during the first year, then annually.
- 18.2 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.

**AIM 6: MONITOR INDUSTRY COMPLIANCE**

Monitoring commercial kangaroo industry compliance with the provisions of South Australian legislation, DEWNR policy, the goal and aims of the South Australia Commercial Kangaroo Harvest Management Plan 2013 - 2017 and permit conditions is essential to effectively maintaining viable populations of kangaroos throughout their ranges and to ensuring public confidence in the management of kangaroos in South Australia.

**ACTION 19: DEWNR staff will undertake both regular and opportunistic monitoring of compliance by commercial kangaroo industry operators.**

In order 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 in accordance with the NPW Act and Regulation, the South Australian Kangaroo Management Plan 2013 – 2017 and permit conditions. Assessments to ensure compliance with the current Commercial Code will be a priority. Biosecurity SA (Meat Hygiene) also undertakes 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 Department of Agriculture, Fisheries and Forestry (DAFF) in relation to inspection of carcass at processing plants registered for the export of meat

products for human consumption that reflects the AQIS Meat Notice 2009/16 (or any subsequent notice that replaces it) and guidelines developed by DEWNR. Under this agreement, information pertaining to possible breaches of DEWNR permit conditions are reported by (DAFF) and, where appropriate, further investigated by DEWNR (or interstate agencies as appropriate).

Performance indicators:

19.1 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.

19.2 All kangaroo processing works in South Australia are inspected at least every four months 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.

19.3 Memoranda of Understanding are developed with Biosecurity SA (Meat Hygiene) and the Department of Agriculture, Fisheries and Forestry by the end of 2013.

**ACTION 20: Activities not in accordance with the South Australian Kangaroo Management Plan 2013 – 2017 and SA legislation will be investigated and where an offence has been committed and it is appropriate, prosecuted.**

Investigation and prosecution of activities in breach of the South Australian Kangaroo Management Plan 2013 – 2017 and South Australian legislation is essential for delivery of the 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:

20.1 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.

**ACTION 21: 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 industry is harvesting kangaroos within approved quotas and for reporting to the Commonwealth Government, industry and the public. In addition, the data from industry returns are utilised in indirect monitoring of kangaroo populations.

Performance indicator:

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

Audits of industry returns encompass manual assessment of returns; application of the customised licensing database utilised by DEWNR (which includes numerous validation rules that assist in ensuring the integrity of data); and extensive verbal and written communication between DEWNR staff and industry operators.

**ACTION 22: 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.

Performance indicator:

22.1 Compliance records are maintained.

Relevant compliance information is recorded and maintained, including reports of alleged breaches of the NPW Act and/or permit conditions, investigation activities undertaken and outcomes of investigations. Data input is accurate and timely.

## **AIM 7: 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 particular aspects of kangaroo ecology or harvest management can also assist in ensuring that kangaroo populations are maintained at sustainable levels across their range 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 effective management of the commercial harvest.

**ACTION 23: 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.**

Previous kangaroo management programs have obtained a wide range of information relating to the commercial harvesting of kangaroos in South Australia. This information will be analysed to provide data on

trends in kangaroo populations, utilisation rates, average weights and other specific information relating to the commercial harvest.

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.

Performance indicators:

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

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

Consideration of research findings and the results of any analysis are essential in not only the development of future Commercial Kangaroo Harvest Management Plans, but also for facilitating the adaptive management of kangaroo populations, which in turn will aid in maintaining viable populations of kangaroos throughout their ranges. The appropriate forum 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 from the Kangaroo Management Program web page.

**ACTION 24: Where practicable, 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.

All proposals for adaptive management must be approved in accordance with the provisions of this plan prior to implementation. Proposals to undertake adaptive management trials will be assessed on the basis of:

- Whether the proposal is in accordance with the goal of this management 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 priority adaptive management or research areas for kangaroos
- Whether the proposal will engage stakeholder input or feedback.

At the time of writing, a new commercial harvest region is being trialled, in the south-east of South Australia. This trial will continue for three years, unless earlier assessment determines that the commercial harvest region is not viable.

Performance indicators:

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

24.2 All necessary approvals – including animal care and ethics – are obtained prior to commencement of experiments testing deliberate management interventions.

Commonwealth approval is required if the adaptive management experiment will result in a harvest rate that is in excess of the harvest rate set out in this plan.

24.3 All adaptive management experiments are continuously monitored and conducted according to approval conditions.

As per the criteria outlined above, 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 in accordance with any conditions imposed with the approval.

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

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 in accordance with 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 Management Program web page.

**ACTION 25: DEWNR will facilitate research into the ecology and harvest management of kangaroos.**

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 and ecology 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.

Performance indicator:

25.1 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.

### **AIM 8: UNDERTAKE PROGRAM REPORTING AND REVIEW**

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

#### **ACTION 26: DEWNR will review and remake the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003.**

The National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 will be due to be remade in 2013, with a possible sunset period of up to three years. Therefore these Regulations will be remade during the life of this management plan. DEWNR will ensure that thorough consultation occurs during this review. Remaking these Regulations may include changes to make the sealed tag process more efficient (see Action 18), and extending the scope of the commercial kangaroo harvest to include other macropod species.

Performance indicators

26.1 The National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 are reviewed and remade by 2016.

#### **ACTION 27: An annual report on the South Australia Kangaroo Management Plan 2013 – 2017 will be prepared and submitted to the Commonwealth.**

An annual report detailing the operation of the South Australian Kangaroo Management Plan 2013 – 2017 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 auspices of this plan. Finally, this report will audit plan aims against performance indicators so that progress towards achieving the goal of the management plan can be measured.

Performance indicators

27.1 An annual report on the operation of the South Australia Commercial Kangaroo Harvest Management Plan 2013 - 2017 for the previous calendar year is submitted to the Commonwealth by end of March of the following year.

The Annual 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 sub-region
- non-commercial cull statistics within the commercial harvest sub-region
- compliance statistics:
  - number of premises inspected
  - number of penalty notices issued and reason for issue
  - number of alleged offences investigated and outcomes
  - number of prosecutions undertaken (offence and outcome)
  - any joint surveillance/enforcement activities completed.
- any unusual situations that arose (e.g. flood/disease outbreak, market factors)
- any experiments or research undertaken or sponsored by DEWNR
- assessment of performance against the performance indicators.

27.2 All annual reports prepared during the life of this plan are posted on the Kangaroo Management Program web page.

#### **ACTION 28: The review of the South Australian Kangaroo Management Plan 2013 – 2017 will commence no later than twelve months prior to the expiry of this plan.**

The review of the South Australian Kangaroo Management Plan 2013 – 2017 will commence no later than twelve months prior to the expiry of this plan in order to assess the success of the plan in achieving its goal. The review will be conducted with the aim of improving on the current plan in the development of subsequent plans.

Performance indicators:

28.1 The success of the current plan in achieving its goal is assessed by measuring performance indicators.

28.2 A review of the plan commences by November 2016.

28.3 A report on the results of the plan review is submitted to the Commonwealth and is placed on the Kangaroo Management Program web page. The report should summarise the results of the final review including an explanation of any proposed changes to the management plan. It should also include an assessment of DENWR performance against the performance indicators. The report should be submitted to the Commonwealth by 31 October 2017.

## 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 generally 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 provision of watering points for 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 exposed to 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. 2010). 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 management 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 *Macropus fuliginosus melanops*, which has a range of different forms. 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 management 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.

#### Conservation status

The commercially harvested kangaroo species that are the subject of this management 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 on an international scale (Australasian Marsupial & Monotreme Specialist Group 1996 a, b and c)
- Not listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2007).

#### Distribution of each species

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 south-west 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 range of the red kangaroo (Pople et al. 2010) 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 in the eastern end of its distribution (Pople & Grigg 1999) (Figure 3). The western grey kangaroo is generally 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 can particularly 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 that is not covered by this management 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. 2010).

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 favourable.

### 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 generally have sedentary populations that move within home ranges of variable size (typical weekly home range size may be up to 560 hectares or 5.6 km<sup>2</sup> (Croft 1991). Red kangaroos range more widely in response to drought and can move a long way to access better feed. Movements of up to 30km to access 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).

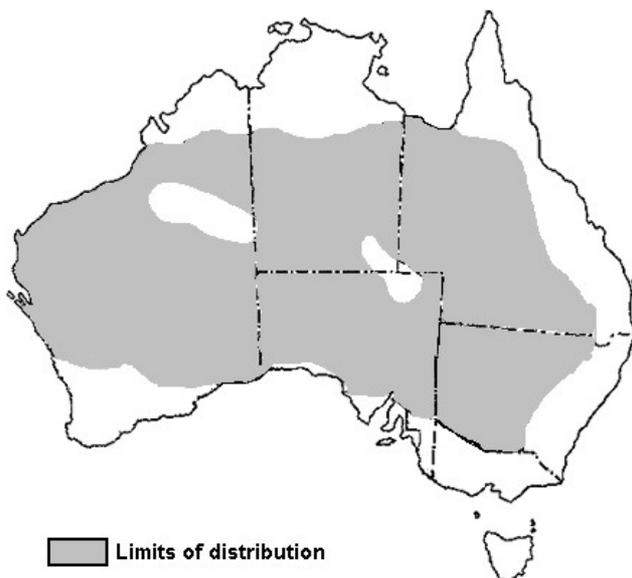


Figure 2: Distribution of red kangaroo (*Macropus rufus*) determined from aerial survey (Pople & Grigg 1999).

### 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 respond with population increase following good conditions. western grey kangaroos are sexually dimorphic in body size, with males larger than females.

Western grey kangaroos feed mainly on grasses, and also browses on some selected shrubs (Coulson & Norbury 1988). While red kangaroos will move a long way to access 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.

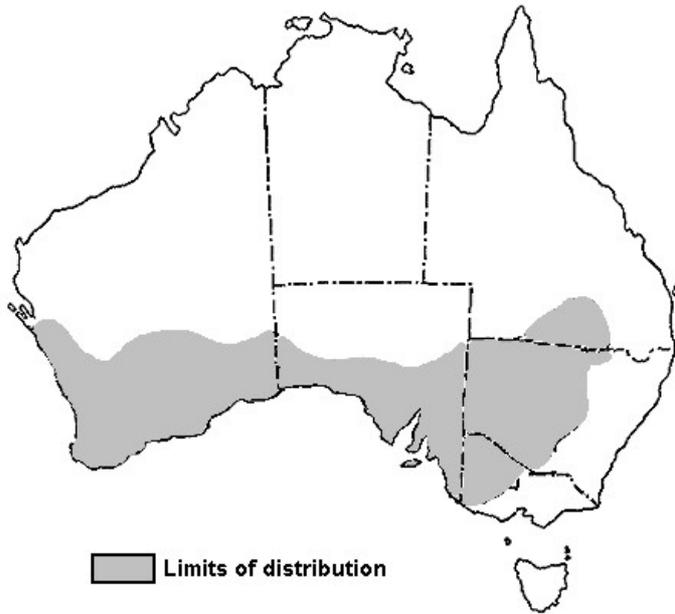


Figure 3: Distribution of western grey kangaroo (*Macropus fuliginosus*) determined from aerial survey (Pople & Grigg 1999).

#### **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 favoured by euro (Olsen & Braysher 2000) are less frequently cleared for agriculture, and thus this species is generally less affected by land-use changes.

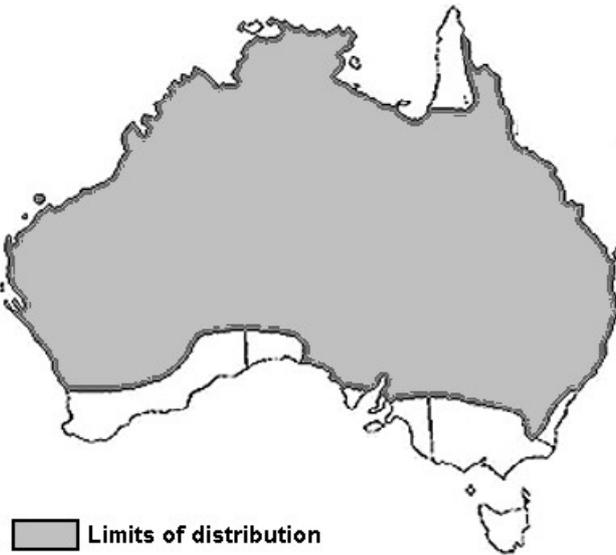


Figure 4: Distribution of euro (*Macropus robustus*) (Pople & Grigg 1999). Note that distribution is patchy within the range, based on the availability of suitable habitat.

### Threats to kangaroos

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

Threats to kangaroos can be considered as 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 can be considered as factors that have the potential to regulate kangaroo populations.

- **Environmental conditions** are a key factor, regulating pasture biomass and therefore affecting forage availability. Rainfall distribution can determine kangaroo densities, as populations move in response to localised rain activity and subsequent new plant growth. Severe lack of rainfall, drought, limits the amount of food available and therefore the carrying capacity of habitat. Kangaroo populations decline in times of poor environmental conditions or drought. This decline is in the form of individual deaths due to starvation (biased towards mature males and juveniles (Bayliss 1985), and suppressed reproductive activity. The embryonic diapause exhibited by red kangaroos means that female kangaroos can simultaneously have three young in different stages of development at one time: a young-at-foot, a pouch joey, and a fertilised embryo in diapause. Such reproductive strategies allow for rapid recovery of kangaroo populations following the end of drought conditions, and red kangaroos can respond to favourable conditions and start breeding within a couple of days of fresh pasture growth.
- **Severe rainfall events** leading to flooding will limit kangaroo movements on some scale. 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 temporarily limited during flooding events). Some kangaroo diseases are linked with flooding events, and are summarised below.
- **Disease** will impact on individuals within a population in response to stresses on the population (Speare et al. 1989). Disease by itself is not considered an important 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.
- **Predation** by Dingoes (*Canis lupus dingo*), Wedge-tailed Eagles (*Aquila audax*), and foxes (*Vulpes vulpes*) will impact on kangaroos, although only Dingoes will predate upon large adult kangaroos. In South Australia the red kangaroo population densities on either side of the dingo-proof fence differs markedly due to the presence of Dingoes (Pople et al. 2000). North of the dingo-proof fence kangaroo numbers

are significantly lower than in the fenced sheep rangelands, suggesting that Dingo predation may be regulating, as well as limiting, kangaroo populations. South of the dingo-proof fence predation is not a major source of kangaroo mortality, and is limited to fox and eagle predation on juvenile kangaroos.

- **Climate change** potential scenarios have been synthesised by the Australian Greenhouse Office (2006). Southern South Australia is likely to become warmer, with more hot days and fewer cold nights. The number of days where temperatures are higher than 35°C will increase. Droughts are likely to become more frequent and more severe. While few studies have investigated the impacts of climate forecast models on specific native species, some generalisations can be gleaned from the literature. Higher temperatures could lead to more heat stress and deaths of individual kangaroos in summer months, although these impacts are likely to be localised in nature, and to vary between particular locations. Conversely, increases in carbon dioxide concentrations in the atmosphere may lead to increased pasture production (Goldie & van Wensveen 2003) and greater forage availability for kangaroos. These impacts on forage availability are likely to vary spatially across South Australia. While the particular outcomes for kangaroos, and indeed future climate change, are uncertain, the regular monitoring of kangaroo populations, and taking an adaptive approach to management, will help determine and manage for the impact of climate on kangaroo populations. (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.)

### Anthropogenic threats to kangaroos

Anthropogenic threats to kangaroos are those that result from human activities.

- 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.
- **Human predation** includes commercial harvest, non-commercial destruction for damage mitigation and traditional hunting by Aboriginal people. Harvest and hunting take place at levels that are considered sustainable for kangaroos, and population monitoring suggests that rainfall remains the main driver of kangaroo populations. Management controls that ensure the sustainability of harvest are outlined in *Impacts of commercial harvest*, detailed in the following pages.
- **Socio-economic changes** have the potential to impact on kangaroo populations. Changes in the relative value of meat products, or the extent to which kangaroos are seen 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. Changes to the economic viability and resilience of rural communities on a broad scale may impact on the kangaroo industry by: new individuals seeking employment in the industry, increased competition for access to harvesting properties, increased investigations and compliance demands, and the willingness of landholders to accommodate kangaroos on their land. These factors will not pose a threat to the conservation of kangaroos as harvest size will remain restricted by annual sustainable harvest quotas.

### 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 impacts. 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.

### Impacts of harvesting on kangaroos

Commercial harvest has the potential to impact on kangaroo populations, either directly through overharvesting, or indirectly via demographic or genetic impacts on harvested populations. However, it is clear from the 30-plus years of harvesting kangaroos in Australia, and the extensive monitoring and research that has been conducted over that time, that harvest is demonstrably sustainable in terms of population numbers, species distributions and genetic diversity. Scientists and ecologists repeatedly publish evidence of sustainability (e.g. see Pople & Grigg 1999). The endorsement of management plans under legislation, and the upholding of management plans following review by the Administrative Appeals Tribunal (e.g. for South Australia in 2004), demonstrate the sustainability of harvest. A recent formal review of literature and data related to harvesting concluded that there was 'little doubt that current rates of harvest are sustainable' (Olsen & Low 2006).

The potential impacts of commercial harvest on kangaroos and management responses are detailed below.

### **Sustainability of harvest**

Harvest at unsustainable levels could impact on the conservation of kangaroo populations.

The sustainability of harvest in South Australia is promoted by:

- Setting commercial harvest quotas that are based on the direct monitoring of kangaroo populations.
- Use of conservative species correction factors (Grigg & Pople 1999) that lead to population estimates that underestimate the true size of kangaroo populations. Further, recent revision of correction factors in New South Wales (Cairns & Gilroy 2001) suggests that the factors used in South Australia may considerably underestimate population size in some areas (Pople et al. 2010).
- Use of a proportional harvest strategy that is appropriate for fluctuating populations (Caughley 1977) and is robust to bias or uncertainty in population estimates (Milner-Gulland et al. 2001).
- Commercial harvest quotas are set at levels that are ecologically sustainable for kangaroo populations (Caughley 1987). Quotas are sustainable when combined with other mortality factors (including dingo predation north of the dingo-proof fence). The fact that populations are monitored regularly (in most instances, annually) and that quotas are set based on these population estimates, allows for quota setting to incorporate animals that are lost through other mortality factors.
- Commercial harvest is patchy within management regions and properties, leaving areas of unharvested refuge habitat.
- State harvest quotas are not completely utilised in South Australia, with harvest tending to equal around 30-70% of the available quota. Actual harvest rates (i.e. the percentage of the kangaroo population that is actually harvested) have been between 5-12%, compared to the sustainable quotas of 15-20% that have been set (Pople et al. 2010).
- The industry is unlikely to overharvest, as it is not currently viable at kangaroo densities that would be low enough to threaten the conservation of the species.

### **Sustainability of harvest during drought conditions**

Rainfall – through its impact on pasture biomass – is the key regulator of kangaroo populations (see Pople & Grigg 1999). Kangaroo populations decline with the onset of drought conditions and stay low until conditions improve and the availability of food increases. To meet the goal of this plan, it is important that commercial harvest is still sustainable for kangaroo populations during times of drought.

The sustainability of harvest during drought conditions is supported by:

- A harvesting strategy that is sustainable during, and after, drought conditions (Pople 2003).
- Quotas set on regular direct monitoring of kangaroo populations. This monitoring allows for quotas to be set with account of the substantial adult mortality that occurs with the onset of drought conditions.
- The fact that annual harvest quotas have not been completely utilised in recent years, and that there is an economic threshold density below which it is not financially viable to harvest (see Hacker et al. 2004). This means that during times of drought and low kangaroo populations, field processors may cease operating in some areas as it is not financially viable for them to harvest. This provides an added degree of refuge for kangaroo populations during times of drought. This extent of refuge and the density below which it is uneconomic to harvest is dependent upon current market prices. If market forces and prices were to significantly increase, formal regulation of this threshold density at which harvest ceases may be required through a threshold harvesting strategy (Engen et al. 1997, Milner-Gulland et al. 2001).
- Knowledge that harvesting mortality during drought is compensatory not additive – harvesting removes animals that would die of natural causes during steep population declines (Pople & McLeod 2000). Harvesting tends to remove larger, older, male kangaroos, which are the animals that are generally lost from kangaroo populations with the onset of drought conditions (Pople 1996).
- 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 of time.

### **Potential demographic impacts of harvesting**

Demography includes the characteristics of populations such as size, growth, distribution and vital statistics including birth and death rates. Commercial harvest of kangaroos has the potential to impact on the demography of harvested kangaroo populations. As Field Processors are paid for carcasses on a per kilogram basis, they preferentially target the larger kangaroos, which tend to be the older males in populations of these sexually dimorphic species.

Commercially harvested populations may have a lower average age compared to that of unharvested populations. The average size of kangaroos in harvested populations is 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.

The sex bias (i.e. the percentage of harvested kangaroos that are male) of commercial harvest of kangaroos in South Australia varies between each of the harvested species, and also varies between different harvest regions. The sex bias typically varies between 50-60% for red kangaroo, and 60-70% for western grey kangaroo. The sex bias of euro harvest is higher due to the small size of female euros, and the harvest is typically 75-95% male. However, this species is less intensely harvested than the other two species, making up less than 10% of the total harvest in South Australia. The sex bias of harvest varies with the density of kangaroo populations, with Field Processors generally targeting proportionately more females as kangaroo populations decline. In some parts of South Australia, there is a strong relationship between the sex bias of harvest and population size (Pople et al. 2006). In other parts of South Australia the relationship is weak, which limits the applicability of this information for indirect monitoring of kangaroo population trends. Use of this information for indirect monitoring of kangaroo populations will be investigated through *Aim 4: Monitor kangaroo populations* and *Aim 7: Facilitate adaptive management and research*.

The demographic impacts of harvest appear to be of little conservation concern (Pople & Grigg 1999). Many of the same demographic effects have been identified in unharvested populations (Pople 1996).

The potential demographic impacts of harvesting are minimised because:

- Both harvested and unharvested populations show unstable age distributions and a female sex bias (Newsome 1977; Pople 1996). Environmental conditions tend to determine the structure of populations, suggesting that natural influences on population structure are stronger than the influences of harvesting. Demographic impacts of commercial harvest are mirrored in unharvested kangaroo populations following drought (i.e. populations displaying a female sex bias and few large adults).
- Kangaroos have a high fecundity and the ability to reproduce quickly following losses due to drought or harvesting (see *Biology and Ecology* section). Populations of kangaroos are not isolated in the landscape, and dispersing individuals are able to contribute to restocking a harvested population.
- 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.

Both harvest sex bias and the size of harvested kangaroos are monitored through the regular collection of harvest returns. Ways to use this information to guide management will be investigated under this plan (see *Aim 4: Monitor kangaroo populations*).

#### **Potential genetic impacts of harvesting**

The genetic diversity and fitness of animal populations may be influenced by the removal of individuals that display a particular physical characteristic before they can contribute to the next generation. Consequently, there is the potential that the selective harvest of kangaroos (i.e. harvest efforts biased towards older, larger individuals) may lead to genetic impacts.

Harvesting at current rates has been assessed, with the conclusion that it has negligible impacts on kangaroo genetics under present conditions (Hale 2001, 2004; Tenhumberg et al. 2004). This is based on genetic theory, empirical data and modelling.

Potential genetic impacts of harvesting on kangaroos are minimised through:

- The size of kangaroo populations in relation to the numbers removed through harvesting. The proportional harvest quotas of 20% for red kangaroos, and 15% for western grey kangaroos and euros that will be applied under this plan are well within the 30% harvest levels that Hale (2001, 2004) found to give rise to stable genetic diversity.
- Dispersal of individuals between populations, and the patchiness of harvest and presence of refugia and lightly harvested areas in the landscape (e.g. due to their remoteness or the fact that they are financially unviable), allow for gene flow between populations, which helps to prevent genetic changes in a population.
- The large geographic ranges of genetic kangaroo populations relative to the size of the harvested area. This is in part due to the migration of individuals across large distances.

#### **Ensuring animals are killed humanely**

Commercial harvest involves the shooting of individual kangaroos and the destruction of pouch young. As such, harvest carries a risk of animals not being killed humanely. This management plan is committed to the humane treatment of kangaroos. *Aim 1: Ensure humane treatment of kangaroos* clearly sets out the ways in which humane treatment of kangaroos is prescribed by this management plan.

The humane destruction of kangaroos is ensured through:

- Presence of Commonwealth and State policy and legislation for animal welfare, including the Commercial Code.
- All kangaroos killed under permit in South Australia must be killed humanely in accordance with the Commercial Code.
- DEWNR has a zero-tolerance approach to breaches of the Commercial Code.

- Kangaroo Field Processors must successfully pass mandatory firearms accuracy accreditation specific to kangaroo shooting prior to receiving a permit. This accreditation tests their theoretical understanding and their ability to shoot in accordance with the requirements of the Commercial Code .
- All kangaroo Field Processors are provided with a copy of the Commercial Code to ensure their awareness of the Commercial Code.
- Compliance with the Commercial Code is monitored routinely through a compliance program that aims to detect non-compliance and enforce compliance. There are penalties for not shooting in accordance with the Commercial Code, providing an incentive for the industry and landholders to comply.

This management plan will also promote the humane treatment of kangaroos through management actions other than commercial harvest, including: Non-Commercial Code (or a synopsis of the Non-Commercial Code) to ensure their awareness of the Non-Commercial Code.

- Landholders applying for non-commercial destruction permits are required to show awareness of the firearm specifications listed in the Non-Commercial Code . Landholders are able to list another shooter on the permit if there is a risk that they do not have the competency to shoot in accordance with the Non-Commercial Code.
- Introducing self-assessment tools for non-commercial destruction permit applicants, so that they can test their competency to shoot in accordance with 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.

### **Impact of harvesting on habitats and ecosystems**

Impacts of commercial harvest on habitats and ecosystems may be positive or negative in nature. Impacts on habitats from 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 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. When managed in combination with sustainable stocking practices and management of feral herbivores this would be likely to help 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 Field Processors driving off-track and the food source and potential disease risk provided by offcuts of commercial harvest.

Offcuts of commercial harvest are produced when Field Processors dress a carcass at the site of shooting. Several carcasses may be dressed at the one site, leaving small piles of offcuts called dumps (Wilson & Read 2003). These offcut dumps can provide a food resource for feral predators such as foxes. 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.

## Appendix 2. 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 Permits to Destroy Wildlife. The issue of commercial harvest quotas to properties via a Commercial Harvesting Authority is also shown.

Permits are issued in accordance with 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 management plan and the Commonwealth will be notified of any significant changes.

### Commercial Harvesting Authority

<b>Authority</b>	Authorises the harvesting of kangaroos on specified land in accordance with section 60J of the <i>National Parks and Wildlife Act 1972</i> and this management plan. Kangaroos are subtracted from commercial quota allocations for a particular harvest region.
<b>Relevant detail</b>	Land must be located within an area with a current commercial quota allocation The quota is notified in writing to the owner of the specified lands and accepted by the owner of the specified lands. The quota is valid for a particular period of time, as specified on the authority. The quota is valid for particular lands, as specified on the authority. The quota is valid for particular species, as specified on the authority.
<b>Further detail</b>	For further detail see the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003, or any amended versions of these regulations.
<b>Proposed changes</b>	Quota issue may change during the life of this plan, changing from a property-focused system.

### Kangaroo Field Processor

<b>Permit</b>	Holds a permit issued under section 60J of the <i>National Parks and Wildlife Act 1972</i> in accordance with the <i>Kangaroo Harvesting Regulations</i> . 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.
<b>Accreditation</b>	The applicant must hold a current Firearms Licence (Class B5 or B7 or as otherwise recommended by SAPOL). The applicant must have successfully completed an approved Kangaroo Field Processors Firearms Accuracy Accreditation Course in South Australia, or another state. The applicant must have successfully completed the Game Meat Field Hygiene Course run by Primary Industries and Resources South Australia.
<b>Relevant detail</b>	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 in accordance with allocated quotas and sealed tags, and must shoot no more than the total available number of each species as indicated by a valid commercial harvesting authority. All kangaroos must be shot in accordance with the Commercial Code The permit holder must affix to each kangaroo carcass a commercial use, sealed tag issued in accordance with regulations. A 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 land 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. The permit holder may sell kangaroos only in the format approved under regulation 36 of the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 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.
<b>Further detail</b>	For further detail see the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003, or any amended versions of these regulations.
<b>Proposed changes</b>	Commercial harvesting authorities have been issued to individual properties (or consortia of properties) indicating the available quota for harvest. This system changes during the life of this plan.

## Kangaroo Meat Processor

<b>Permit</b>	Holds a permit issued under section 58 of the <i>National Parks and Wildlife Act 1972</i> . Permit allows for the permit holder to keep and sell kangaroo meat products and skins.
<b>Accreditation</b>	The applicant must have a thorough knowledge of the <i>National Parks and Wildlife Act 1972</i> and regulations under this Act. The permit holder must be accredited by Primary Industries and Resources South Australia.
<b>Relevant detail</b>	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 in accordance with 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). The permit holder must obtain import or export permits, issued under the <i>National Parks and Wildlife Act 1972</i> for consignments of kangaroo products that enter or leave South Australia. (NB: 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.
<b>Further detail</b>	For further detail see the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 and the Wildlife Variation Regulations 2003, or any amended versions of these regulations.
<b>Proposed changes</b>	During the life of this plan, this is likely to change to a system that allows for Field Processors to sell carcasses to a licensed kangaroo meat processor of their choice.

## Kangaroo Skin Tanner

<b>Permit</b>	Holds a permit issued under section 58 of the <i>National Parks and Wildlife Act 1972</i> . Permit allows for the permit holder to keep and sell kangaroo skins.
<b>Accreditation</b>	The applicant must have a thorough knowledge of the <i>National Parks and Wildlife Act 1972</i> and regulations under this Act.
<b>Relevant detail</b>	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 in accordance with 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 <i>National Parks and Wildlife Act 1972</i> , for consignments of kangaroo products that enter or leave South Australia. (NB: 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.
<b>Further detail</b>	For further detail see the National Parks and Wildlife (Kangaroo Harvesting) Regulations 2003 and the Wildlife Variation Regulations 2003, or any amended versions of these regulations.

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

<b>Permit</b>	Holds a permit issued under section 53(1)(c) of the <i>National Parks and Wildlife Act 1972</i> . 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.
<b>Accreditation</b>	Permit holder, or the person listed on the permit to shoot kangaroos, must hold a current firearms licence. Permit holder, or the person listed on the permit to shoot kangaroos, must have an understanding of

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the Non-Commercial Code, and must have the marksmanship skills to shoot kangaroos in accordance with the Non-Commercial Code.

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**Relevant detail**

Kangaroos must be shot in accordance with the Non-Commercial Code.

Where a permit holder is unable to shoot in accordance with the Non-Commercial Code, or wishes to list another person to conduct the shooting, they are able to 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 in accordance with 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 actually destroyed to DEWNR in the approved format.

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## Appendix 3: Setting and applying harvest thresholds

South Australia is adopting harvest thresholds as used in New South Wales, and described in the *New South Wales Commercial Kangaroo Harvest Management Plan 2012-2016*. 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 overharvest (Engen et. al. 1997). Proportional threshold harvesting is a modification of proportional harvesting and sets a threshold in population abundance, below which the proportion of the population that can be harvested is reduced eventually to zero. Harvest thresholds 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 per cent of the distribution, while a z-score of two represents the lowest 2.3 per cent 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.

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 per cent 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.

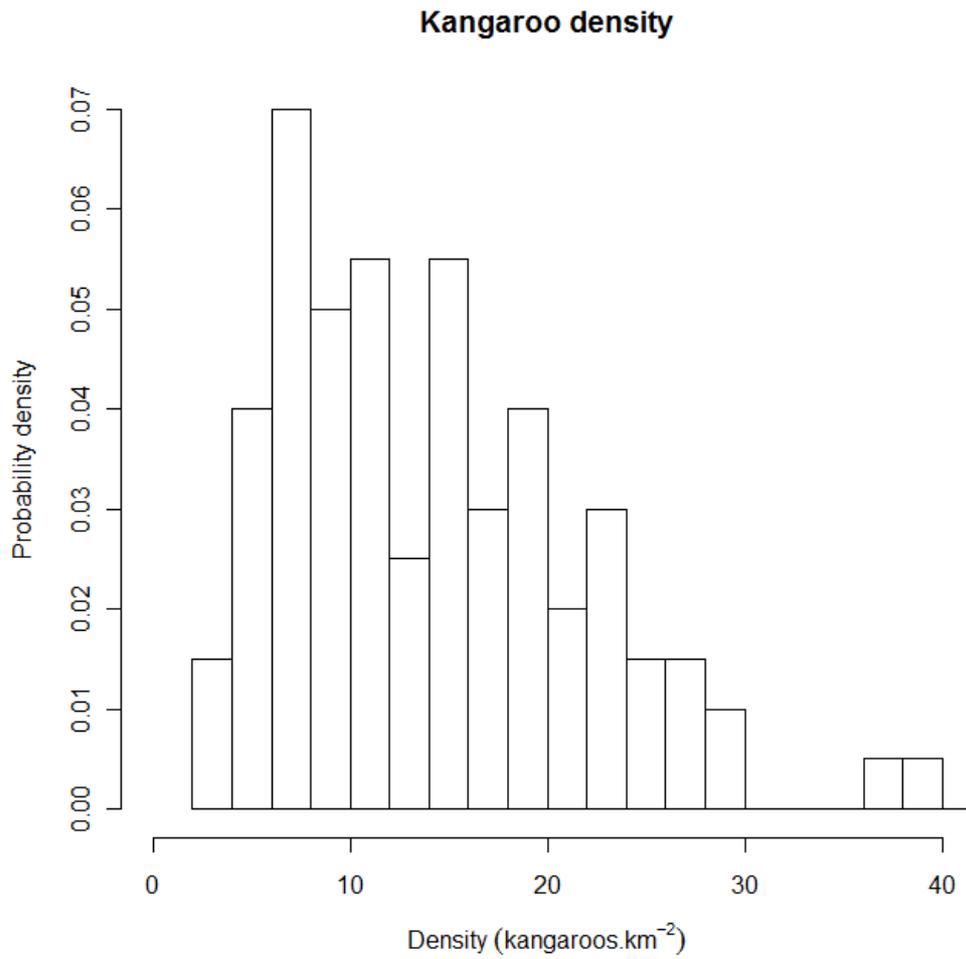


Figure 5: Histogram of a theoretical population of kangaroos.

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.

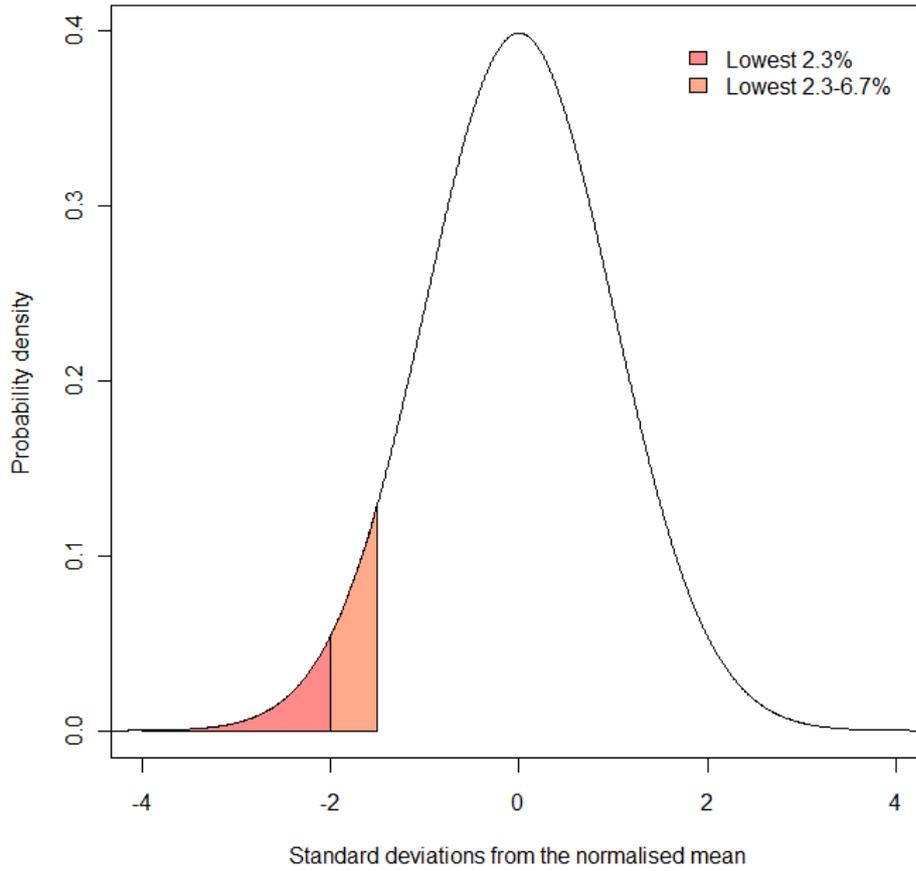


Figure 6: A theoretical distribution after z-score transformation.

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 per cent 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 per cent of the area).

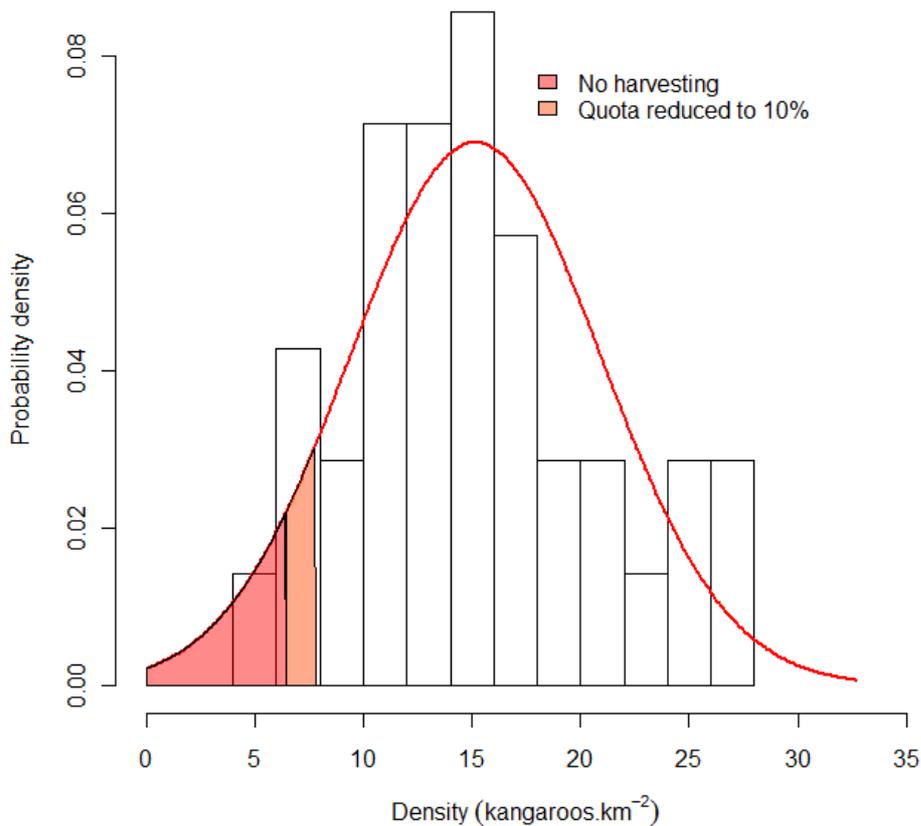
**Zone 2: red kangaroos**

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 per cent to 10 per cent. 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 overharvest 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 per cent 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 per cent). 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 per cent 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.

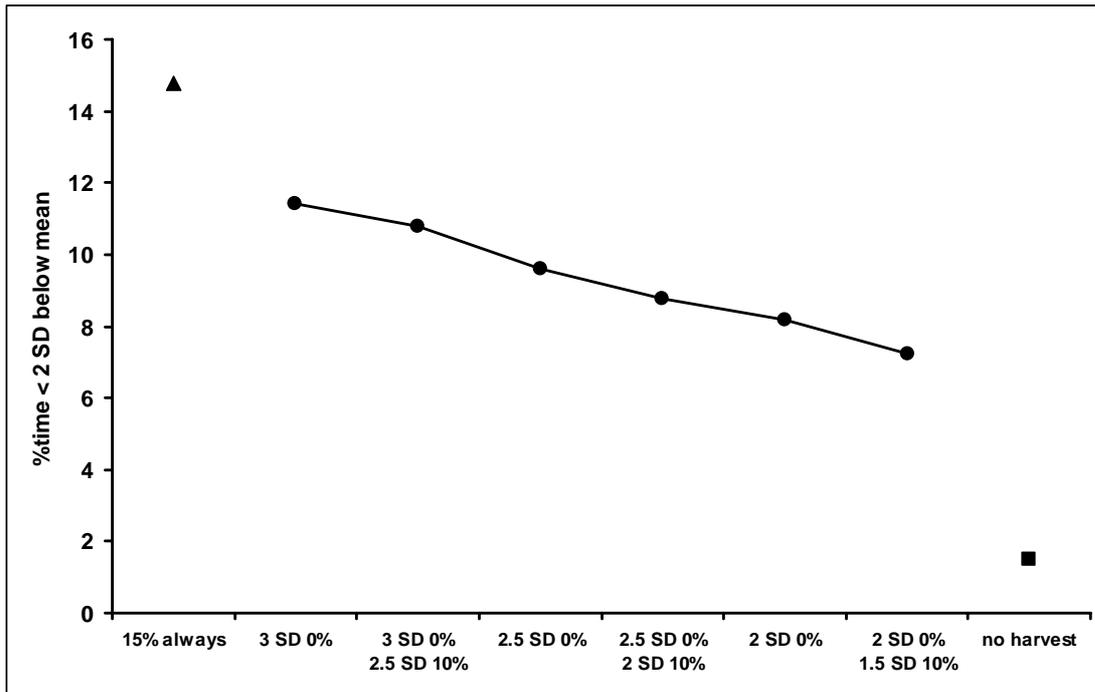


Figure 8: 10,000 simulations for a population fluctuating over 20 years.

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.

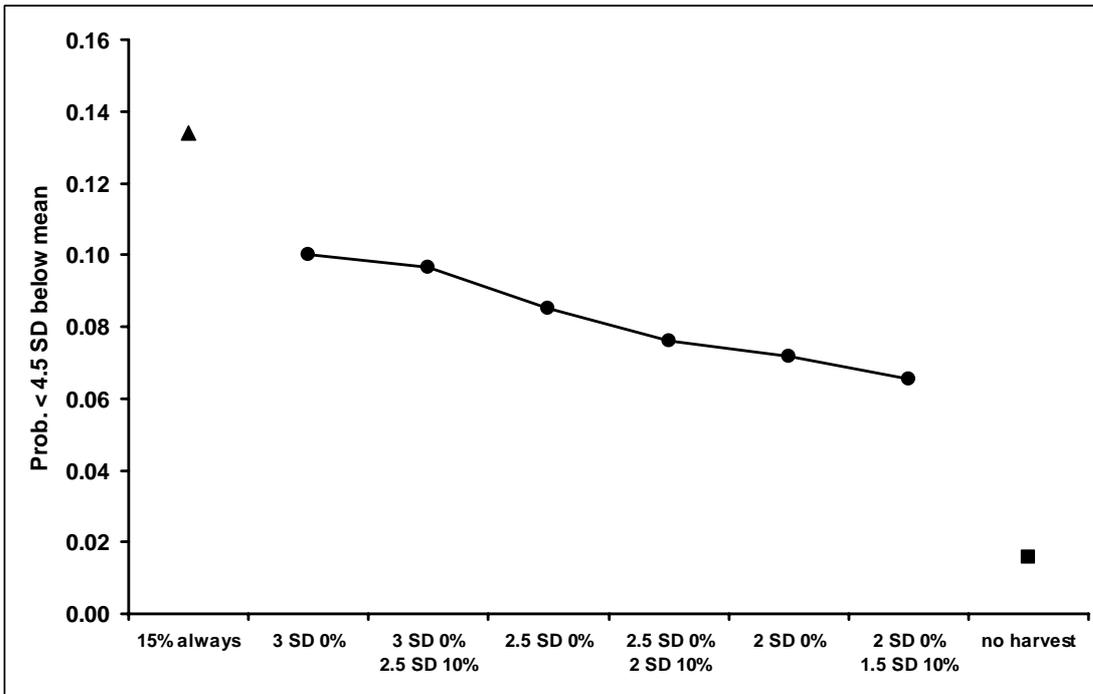


Figure 9: Simulated population as described for Figure 8.

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

## REFERENCES

- Australasian Marsupial & Monotreme Specialist Group. 1996 a. *Macropus rufus*. In: IUCN 2006. *2006 IUCN Red List of Threatened Species*. [online] URL: <http://www.iucnredlist.org>. Downloaded on 09 May 2007.
- Australian Greenhouse Office. 2006. Climate change impacts and risk management: a guide for business and government. (Department of the Environment and Heritage, Canberra).
- Bailey P & Best L. 1992. A red kangaroo, *Macropus rufus*, recovered 25 years after marking in north-western New South Wales. *Australian Mammalogy*, 15: 141.
- Bayliss P. 1985. The population dynamics of Red and Western grey kangaroos in arid New South Wales, Australia. 1: Population dynamics and rainfall. *Journal of Animal Ecology*, 54: 111-125.
- Cairns SC & Gilroy J. 2001. Re-appraisal and enhancement of the current methodology used in the estimation of kangaroo populations in western New South Wales. (West 2000, Dubbo).
- Cairns SC, Pople AR & Grigg GC. 1991. Density distributions and habitat associations of Red Kangaroos (*Macropus rufus*) and Western grey kangaroos (*Macropus fuliginosus*) in the pastoral zone of South Australia. *Wildlife Research*, 18: 377-402.
- Caughley G. 1977. Analysis of Vertebrate Populations. (Wiley & Sons, London).
- Caughley G. 1987. Ecological relationships. In 'Kangaroos: their Ecology and Management in the Sheep Rangelands of Australia'. (Eds G Caughley, N Shepherd and J Short) pp. 159-187. (Cambridge University Press, Cambridge).
- CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). 2007. *The CITES Appendices I, II and III*. [online] URL: <http://www.cites.org>. Downloaded on 09 May 2007.
- Coulson G & Norbury G. 1988. Ecology and Management of Western grey kangaroos (*Macropus fuliginosus*) at Hattah, Kulkyn National Park. Arthur Rylah Institute for Environmental Research, Technical Report Series No. 72. (Department of Conservation, Forests and Lands: Melbourne).
- Croft DB. 1991. Home range of the Red kangaroo, *Macropus rufus*. *Journal of Arid Environments*, 20: 83-98.
- Dawson TJ. 1995. Kangaroos: Biology of the largest Marsupials. (University of NSW Press, Sydney).
- Deroba JJ & Bence JR. 2008. A review of harvest policies: Understanding relative performance of control rules. *Fisheries Research* 94:210-223.
- Engen S, Lande R & Saether BE. 1997. Harvesting strategies for fluctuating populations based on uncertain population estimates. *Journal of Theoretical Biology*, 186: 201-212.
- Goldie N & van Wensveen M. 2003. Agriculture: adapting to climate change. *ECOS*, 115: 14-15.
- Hacker R, McLeod S, Druhan J, Tenhumberg B & Pradhan U. 2004. Kangaroo management options in the Murray-Darling Basin. (Murray-Darling Basin Commission, Canberra).
- Hale PT. 2001. Kangaroo genetics: impacts of harvesting. (New South Wales National Parks and Wildlife Service, Dubbo, NSW).
- Hale PT. 2004. Genetic effects of kangaroo harvesting. *Australian Mammalogy*, 26: 75-86.
- Kirsch JAW & Poole WE. 1972. Taxonomy and distribution of the Grey Kangaroos, *Macropus giganteus* (Shaw) and *Macropus fuliginosus* (Desmarest), and their subspecies (Marsupalia: Macropodidae). *Australian Journal of Zoology*, 20: 315-339.
- Lande R, Engen S & Saether B-E. 1995. Optimal harvesting of fluctuating populations with a risk of extinction. *American Naturalist* 145:728-745.
- Lande R, Saether B-E & Engen S. 1997. Threshold harvesting for sustainability of fluctuating resources. *Ecology* 78:1341-1350.
- McLeod, SR & AR Pople. 2011. New South Wales Commercial Harvest Management Plan 2012-2016. NSW Government.
- Milner-Gulland EJ, Shea K, Possingham H, Coulson T & Wilcox C. 2001. Competing harvesting strategies in a simulated population under uncertainty. *Animal Conservation*, 4: 157-167.
- Newsome AE. 1977. Imbalance in the sex ratio and age structure of the Red Kangaroo, *Macropus rufus*, in central Australia. In 'The Biology of Marsupials'. (Ed D Gilmour) pp. 221-233. (Macmillan, London).
- Olsen P & Braysher M. 2000. Situation Analysis Report: Current state of scientific knowledge on kangaroos in the environment, including ecological and economic impact and effect of culling. Report to the Kangaroo Management Advisory Committee, NSW.
- Olsen P & Low T. 2006. Situation Analysis Report: Update on current state of scientific knowledge on kangaroos in the environment, including ecological and economic impact and effect of culling. Report to the Kangaroo Management Advisory Committee, NSW.
- Pople A 1989. Habitat associations of Australian Macropodoidea. In 'Kangaroos, Wallabies and Rat Kangaroos'. (Eds G Grigg, P Jarman & I Hume) pp. 755-766. (Surrey Beatty and Sons, Sydney).
- Pople AR. 1996. Effects of harvesting upon the demography of red kangaroos in western Queensland. PhD thesis, The University of Queensland.
- Pople A 2003. 'Harvest management of kangaroos during drought.' Unpublished report to New South Wales National Parks and Wildlife Service, Dubbo, NSW.

- Pople AR. 2008. Frequency and precision of aerial surveys for kangaroo management. *Wildlife Research* 35: 340-348.
- Pople AR, Evans M, Farroway L, Gilroy J, Grigg GC, Lundie-Jenkins G, Payne N. 2010. 'Using harvest statistics to monitor temporal variation in kangaroo density and harvest rate' in *Macropods: the Biology of Kangaroos, Wallabies and Rat-kangaroos*. (Eds G Coulson and MDB Eldridge) pp. 371-397. (Melbourne: CSIRO Publishing)
- Pople A & Grigg G. 1999. Commercial harvesting of kangaroos in Australia, Department of the Environment and Heritage. (<http://www.environment.gov.au/biodiversity/trade-use/wild-harvest/kangaroo/harvesting/index.html>)
- Pople AR, Grigg GC, Cairns SC, Beard LA & Alexander P. 2000. Trends in the numbers of Red Kangaroos and Emus on either side of the South Australian dingo fence: evidence for predator regulation? *Wildlife Research*, 27: 269-276.
- Pople AR, Grigg GC, Phinn SR, Menke N, McAlpine C, Possingham HP. 2010. 'Reassessing spatial and temporal dynamics of kangaroo populations' in *Macropods: the Biology of Kangaroos, Wallabies and Rat-kangaroos*. (Eds G Coulson and MDB Eldridge) pp. 197-210. (Melbourne: CSIRO Publishing)
- Pople AR & McLeod SR. 2000. Kangaroo management and the sustainable use of rangelands. In 'Management for Sustainable Ecosystems'. (Eds PT Hale, A Petrie, D Moloney & P Sattler) pp. 78-86. (Centre for Conservation Biology, The University of Queensland, Brisbane).
- Pople AR, Phinn SR, Grigg GC, Possingham HP, Menke N & McAlpine C. 2006. Spatial patterns of kangaroo density across the South Australian pastoral zone over 26 years: aggregation during drought and suggestions of long distance movement. In 'Modelling the spatial and temporal dynamics of kangaroo populations for harvest management' (Pople AR). Final report to the Department for Environment and Heritage, Canberra. (The Ecology Centre, University of Qld).
- Priddel D. 1987. The mobility and habitat utilisation of kangaroos. In 'Kangaroos: Their Ecology and Management in the Sheep Rangelands of Australia'. (Eds G Caughley, N Shepherd, & J Short.) pp 100-118. (Cambridge University Press, Cambridge).
- Speare R, Donovan JA, Thomas AD & Speare PJ. 1989. Diseases of free-ranging Macropodoidea. In 'Kangaroos, Wallabies and Rat Kangaroos'. (Eds G Grigg, P Jarman & I Hume) pp. 705-734. (Surrey Beatty and Sons, Sydney).
- Tenhumberg B, Tyre D, Pople A & Possingham H. 2004. Evolutionary responses to selective harvesting in a stochastic environment. *Ecology*, 85: 2003-2017.
- Tyndale-Biscoe H. 2005. Life of marsupials. (CSIRO Publishing, Carlton).
- Wilson D & Read JL. 2003. Kangaroo harvesters: fertilising the rangelands. *Rangelands Journal*, 25(1): 47-55.