

Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2014–2018



**Department of
Parks and Wildlife**



Effective for the period: 1 April 2014 – 31 December 2018

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September 2013

Cover photo: Babs and Bert Wells/DPaW

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DEFINITIONS

Dressed carcass – the entire body (including the skin) of a kangaroo, excluding the head, viscera and distal portions of the limbs.

Ecologically Sustainable Development – this plan employs the definition contained in the *Environment Protection and Biodiversity Conservation Act 1999*. In general this definition includes the precautionary principle, inter-generational equity, conservation of biological diversity and ecological integrity, and improved valuation of environmental factors.

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

Landholder – owner or occupier of specified lands.

Licensed firearm – a firearm licensed under the *Firearms Act 1973*.

Licensed processor – the holder of a Licence to Process issued under Regulation 7 of the *Wildlife Conservation Regulations 1970*.

Licensed professional shooter – the holder of a Licence to Take Kangaroos for Sale issued under Regulation 6 of the *Wildlife Conservation Regulations 1970*.

Licensed skin dealer – the holder of a Licence to Deal in Skins issued under Regulation 10 of the *Wildlife Conservation Regulations 1970*.

National Code of Practice – refers to the *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes*, which is the current National Code of Practice (National CoP) endorsed by the Natural Resource Management Ministerial Council in 2008. A reference to this Code will also apply to any future, nationally-endorsed code that replaces or updates this document.

Registered chiller unit – an approved chiller unit registered with the Department of Parks and Wildlife and used in accordance with Regulation 8A of the *Wildlife Conservation Regulations 1970*.

1. INTRODUCTION

The export of wildlife products from Australia requires Commonwealth Government approval under the [Environment Protection and Biodiversity Conservation Act 1999](#) (EPBC Act). The *Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2014–2018* (the Management Plan) has been developed to satisfy the requirements of the EPBC Act and to meet the legislative and other requirements of the Western Australian Government.

It relates to the commercial harvest of red (*Macropus rufus*) and western grey (*M. fuliginosus*) kangaroos within Western Australia (WA). Where the term kangaroo is used in this document, it refers to both the aforementioned macropod species only. The Management Plan will remain valid for a maximum five-year period from 1 January 2014 to 31 December 2018.

In WA, all native fauna is protected under the [Wildlife Conservation Act 1950](#), which is administered by the Department of Parks and Wildlife (DPaW – the Department). The shooting of kangaroos for commercial purposes requires the issue of a licence under Regulation 6 of the [Wildlife Conservation Regulations 1970](#). Within the State, the commercial kangaroo harvest is regulated via the issue of various licences and royalty tags under provisions of the Wildlife Conservation Act. This legislative framework applies throughout the State of WA.

Red and western grey kangaroos are declared as Category C3 animals throughout WA under Section 22(2) of the [Biosecurity and Agriculture Management Act 2007](#) (BAM Act). This declaration enables the Minister for Agriculture and Food to issue a management plan outlining areas and conditions under which controls may be applied. However, where such a plan involves native fauna, it must also be approved by the Minister for Environment. Currently, no management plan has been developed for either species of kangaroo under the BAM Act and kangaroos are managed under the provisions of the Wildlife Conservation Act.

The Management Plan does not provide the framework for the management of kangaroos on lands vested in the Conservation Commission of WA under the [Conservation and Land Management Act 1984](#) and managed by the Department, e.g. national parks, nature reserves, State Forest and timber reserves. Kangaroos cannot usually be taken for commercial purposes in such areas, which comprise a total area of about 26 million hectares or approximately 10 percent of the land area of WA.

The Management Plan relates only to the commercial harvest of kangaroos within WA and does not regulate the non-commercial culling of kangaroos for damage mitigation. The Department regulates the non-commercial culling of kangaroos through provisions of the Wildlife Conservation Act.

The primary goal of the Management Plan is to ensure that the commercial harvest of kangaroos 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 the viability of kangaroo populations is not compromised by any action undertaken in accordance with the Management Plan.

The Management Plan incorporates an adaptive approach to management. Adaptive management is the systematic acquisition and application of reliable information to improve management over time. The adaptive management provisions of the Management Plan facilitate the investigation of different strategies using scientifically rigorous experimentation to not only support appropriate adjustments to management practices, but also to improve knowledge and inform future program reviews.

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

2. LEGISLATIVE FRAMEWORK

2.1. Commonwealth

The relevant provisions under the EPBC Act 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 has legislative provisions requiring the development and approval of wildlife trade management plans in order for permits to be issued for the commercial export of wildlife products.

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

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

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

- (a) legislation relating to the protection, conservation or management of the specimens to which the plan relates is in force in the State or Territory concerned; and
- (b) the legislation applies throughout the State or Territory concerned; and
- (c) in the opinion of the Minister, the legislation is effective.

Finally, in resolving whether to approve a 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 harvesting of kangaroos are detailed in the [*National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes*](#). All kangaroos must be taken in accordance with this Code or any future, nationally-endorsed code that replaces or updates this document.

2.2. Western Australia

In WA, all native fauna, including all kangaroo species and subspecies, are protected under the *Wildlife Conservation Act 1950*. However, the *Wildlife Conservation Act 1950* and associated *Wildlife Conservation Regulations 1970* make provisions for the licensing of a range of activities relating to the commercial harvesting of native fauna including kangaroos.

Kangaroos may be harvested commercially only in accordance with this Management Plan under a licence issued by the Department. Moreover, under the Management Plan the commercial harvesting of kangaroos in WA is presently restricted to the Kangaroo Management Areas illustrated in Figure 1. However, within the life of this plan, new areas may be opened to commercial harvesting where kangaroos are deemed to be overabundant. Surveys to estimate kangaroo abundance will be undertaken prior to any new areas being opened for commercial harvesting and the Australian Government will be advised of any changes prior to implementation.

The licensing process as it relates to kangaroo harvesting is summarised in Figure 2 and described in more detail below. The licensing process commences when a kangaroo shooter obtains written permission from a landholder to shoot kangaroos on the landholder's property and then applies for a Licence to Take Kangaroos for Sale (Professional shooter's licence) under Regulation 6 of the *Wildlife Conservation Regulations 1970*. Other activities associated with the commercial utilisation of kangaroos require licences specific to those activities such as processors' and skin dealers' licences.

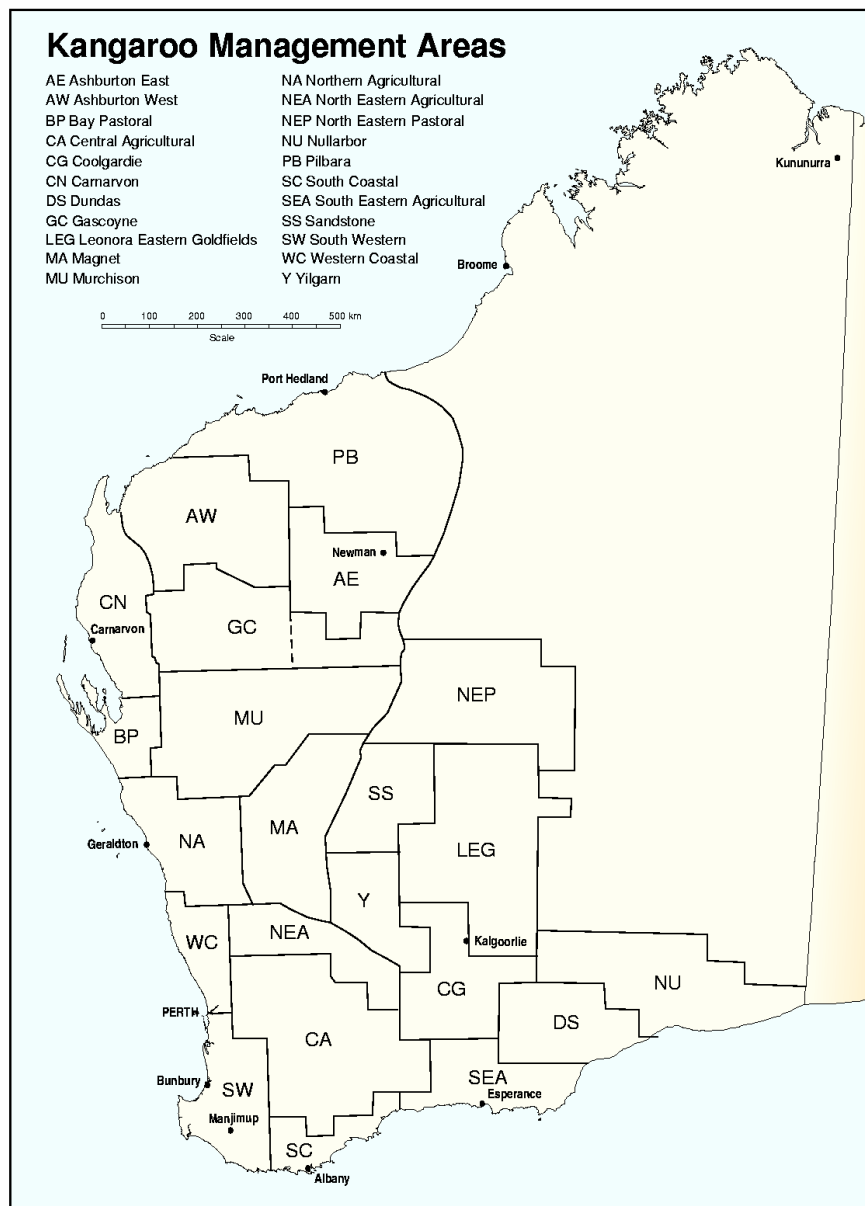
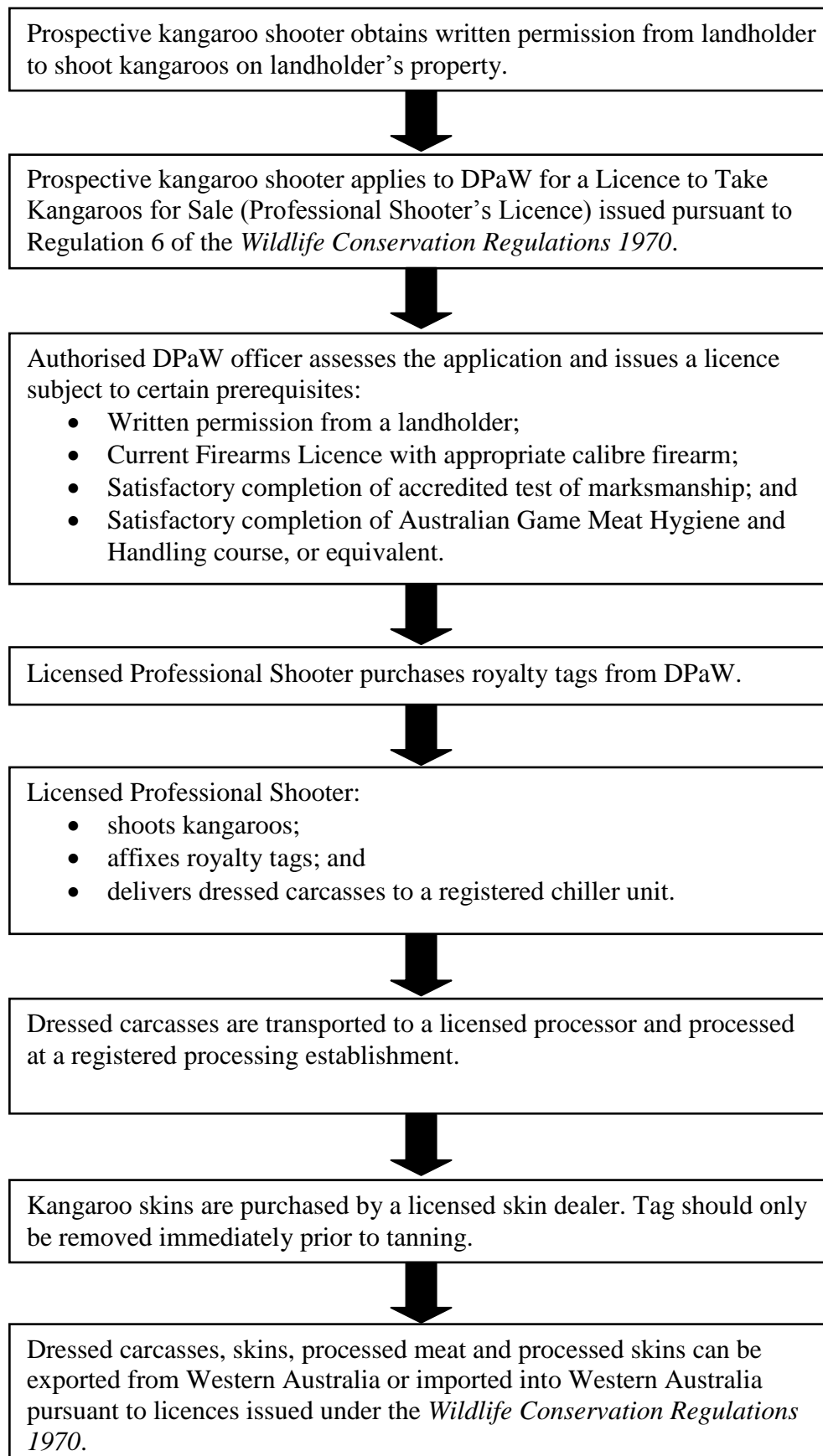


Fig. 1. Kangaroo Management Areas in Western Australia.

**Fig. 2.** Licensing flow chart.

LICENCE TO TAKE KANGAROOS FOR SALE (Professional shooter's² licence)

Issued under Regulation 6 of the *Wildlife Conservation Regulations 1970*

The licence holder may take kangaroos by means of a licensed firearm on private or leasehold land that falls within the area described in an open season notice and sell kangaroo carcasses to a licensed processor.

Before issuing a Professional Shooter's Licence, an authorised DPaW officer will ensure that the applicant has complied with the following prerequisites:

- Written authorisation from a landholder to take kangaroos on the landholder's property;
- Current Firearms Licence that includes an appropriate calibre firearm that complies with the National Code of Practice;
- Successful completion of accredited firearms competency testing in marksmanship; and
- Successful completion of NSW TAFE Course 5725: Australian Game Meat Hygiene and Handling, or equivalent.

Regulation 6 licences are subject to conditions¹ that include, but are not limited to:

1. ALL SHOOTING IS TO BE CARRIED OUT IN ACCORDANCE WITH THE PROVISIONS OF THE NATIONAL CODE OF PRACTICE FOR THE HUMANE SHOOTING OF KANGAROOS AND WALLABIES FOR COMMERCIAL PURPOSES (2008).
2. ONLY KANGAROOS THAT HAVE BEEN KILLED BY A SINGLE SHOT TO THE BRAIN² SHALL BE DELIVERED TO A KANGAROO PROCESSOR.
3. THE LICENSEE MUST POSSESS A CURRENT FIREARMS LICENCE THAT HAS BEEN ISSUED PURSUANT TO THE FIREARMS ACT 1973 FOR A HIGH POWERED CENTREFIRE RIFLE AS PRESCRIBED IN SCHEDULE 1 PART A OF THE NATIONAL CODE OF PRACTICE FOR THE HUMANE SHOOTING OF KANGAROOS AND WALLABIES FOR COMMERCIAL PURPOSES (2008).
4. KANGAROOS MAY ONLY BE TAKEN IN ACCORDANCE WITH THE CONDITIONS OF THE "OPEN SEASON" NOTICES PUBLISHED IN THE GOVERNMENT GAZETTE.
5. THE LICENSEE IS AUTHORISED TO SHOOT INTO THE CHILLER SPECIFIED ON THIS LICENCE, REGISTERED AS BEING LOCATED AT THE LOCATION ALSO SPECIFIED ON THIS LICENCE. NO CHANGE TO CHILLER LOCATION IS TO BE MADE UNLESS AUTHORISED BY THE DIRECTOR GENERAL.
6. THE LICENSEE HAS APPROVAL TO SHOOT ON THE STATIONS AND/OR PROPERTIES SPECIFIED ON OR ATTACHED TO THIS LICENCE. ALL WRITTEN STATION/PROPERTY APPROVALS MUST BE SUBMITTED TO THE DIRECTOR GENERAL.
7. RETURNS (FORM 3) TO BE SUBMITTED MONTHLY SO AS TO REACH THE DEPARTMENT OF PARKS AND WILDLIFE NO LATER THAN THE FIFTEENTH (15TH) DAY OF THE FOLLOWING MONTH.
8. THIS LICENCE MUST BE CARRIED BY THE LICENSEE AT ALL TIMES FOR THE PURPOSE OF PROVING THEIR AUTHORITY TO TAKE FAUNA WHEN QUESTIONED AS TO THEIR RIGHT TO DO SO BY A WILDLIFE OFFICER, ANY OTHER STATE OR LOCAL GOVERNMENT OFFICER OR ANY MEMBER OF THE PUBLIC.
9. ONLY YEAR-SPECIFIC ROYALTY TAGS APPLICABLE TO THE TERM OF THIS LICENCE AND OF THE APPROPRIATE COLOUR FOR THE KANGAROO SPECIES TAKEN SHALL BE ATTACHED TO EACH KANGAROO CARCASS.
10. KANGAROOS HELD IN A REGISTERED CHILLER OR FORWARDED OR CONSIGNED FOR SALE SHALL HAVE A ROYALTY TAG ATTACHED TO EACH CARCASS. KANGAROOS TAKEN PURSUANT TO THIS LICENCE MAY ONLY BE CONSIGNED OR SOLD TO PERSONS LICENSED AS A DEALER UNDER THE *WILDLIFE CONSERVATION REGULATIONS*.
11. THE LICENSEE SHALL ONLY CONSIGN KANGAROO CARCASSES WITH THE YEAR-SPECIFIC ROYALTY TAG APPLICABLE TO THE TERM OF THIS LICENCE ATTACHED, EXCEPT THAT IN THE MONTH OF JANUARY, THE LICENSEE CAN CONSIGN CARCASSES WITH THE PREVIOUS YEAR'S ROYALTY TAG APPLICABLE TO THAT SPECIES ATTACHED, PROVIDED THE KANGAROOS FORMING THE CONSIGNMENT WERE TAKEN IN THE PREVIOUS YEAR.
12. THIS LICENCE IS NOT TRANSFERABLE.

¹ Note: any changes to licence conditions must be consistent with the requirements set out in the Management Plan.

² One of the ways that it will be determined that a kangaroo has not been shot in accordance with this condition is if the carcass contains a bullet hole in any region of the body other than the head.

LICENCE TO DEAL IN CARCASSES OF FAUNA (Direct dealers' licence)

Issued under Regulation 8 of the *Wildlife Conservation Regulations 1970*

The licence holder may purchase or receive kangaroo carcasses from a licensed professional shooter.

Licences to Deal in Carcasses of Fauna are subject to conditions¹ that include, but are not limited to:

1. THE LICENSEE SHALL COMPLY WITH THE PROVISIONS OF THE WILDLIFE CONSERVATION ACT AND REGULATIONS AND ANY NOTICES IN FORCE UNDER THIS ACT AND REGULATIONS.
2. NO CHANGE OF CHILLER LOCATION IS TO BE MADE UNLESS AUTHORISED BY THE DIRECTOR GENERAL OR THE LOCAL DISTRICT WILDLIFE OFFICER.
3. THE DIRECTOR GENERAL (THROUGH THE LOCAL DISTRICT WILDLIFE OFFICER) SHALL BE NOTIFIED IMMEDIATELY OF ANY CHANGE OF THE PERSON IN CHARGE OF A CHILLER.
4. RETURNS (FORM 3) TO BE SUBMITTED MONTHLY SO AS TO REACH THE DEPARTMENT OF PARKS AND WILDLIFE NO LATER THAN THE FIFTEENTH (15TH) DAY OF THE FOLLOWING MONTH.
5. THIS LICENCE SHALL BE DISPLAYED IN A PROMINENT POSITION IN THE PREMISES AT THE PROPERTY SPECIFIED ON THIS LICENCE.
6. THE LICENSEE MUST COMPLY WITH ALL RELEVANT LOCAL AUTHORITY BY-LAWS.

¹ Note: any changes to licence conditions must be consistent with the requirements set out in the Management Plan.

LICENCE TO PROCESS

Issued under Regulation 7 of the *Wildlife Conservation Regulations 1970*

The licence holder may process kangaroo carcasses.

Licences to process fauna are subject to conditions¹ that include, but are not limited to:

1. THE LICENSEE SHALL COMPLY WITH THE PROVISIONS OF THE WILDLIFE CONSERVATION ACT AND REGULATIONS AND ANY NOTICES IN FORCE UNDER THIS ACT AND REGULATIONS.
2. THE LICENSEE SHALL ONLY ACCEPT KANGAROO CARCASSES WITH THE YEAR-SPECIFIC ROYALTY TAG APPLICABLE TO THE CURRENT YEAR ATTACHED AND OF THE APPROPRIATE COLOUR FOR THE KANGAROO SPECIES, EXCEPT THAT IN THE MONTH OF JANUARY, THE LICENSEE CAN ALSO ACCEPT CARCASSES WITH THE PREVIOUS YEAR'S ROYALTY TAG APPLICABLE TO THAT SPECIES ATTACHED.
3. THE LICENSEE SHALL NOT ACCEPT ANY KANGAROO CARCASS FROM AN ANIMAL THAT HAS NOT BEEN KILLED BY A SINGLE SHOT TO THE BRAIN².
4. THE LICENSEE MUST COMPLY WITH ALL RELEVANT LOCAL AUTHORITY BY-LAWS.
5. PROCESSOR RETURNS (FORM 2) TO BE SUBMITTED MONTHLY SO AS TO REACH THE DEPARTMENT OF PARKS AND WILDLIFE NO LATER THAN THE FIFTEENTH (15TH) DAY OF THE FOLLOWING MONTH.
6. RETURNS OF CARCASSES RECEIVED (FORM 3), OTHER THAN THOSE FROM A REGISTERED CHILLER FOR WHICH FORMS 3 HAVE ALREADY BEEN COMPLETED, SHALL BE SUBMITTED WITH THE RELEVANT FORM 2.
7. RECORDS OF RETURNS SHALL BE MAINTAINED AT THE PROCESSING WORKS AND BE AVAILABLE FOR INSPECTION BY OFFICERS OF DPaW.
8. THIS LICENCE SHALL BE DISPLAYED IN A PROMINENT POSITION IN THE PREMISES AT THE PROPERTY SPECIFIED ON THIS LICENCE.
9. SKINS SHALL NOT BE SOLD TO OTHER THAN LICENSED SKIN DEALERS.

¹ Note: any changes to licence conditions must be consistent with the requirements set out in the Management Plan.

² One of the ways that it will be determined that a kangaroo has not been shot in accordance with this condition is if the carcass contains a bullet hole in any region of the body other than the head.

LICENCE TO DEAL IN SKINS (Skin dealer's¹ licence)

Issued under Regulation 10 of the *Wildlife Conservation Regulations 1970*

The licence holder may receive, tan and sell kangaroo skins.

Licences to Deal in Skins are subject to conditions¹ that include, but are not limited to:

1. THE LICENSEE SHALL COMPLY WITH THE PROVISIONS OF THE WILDLIFE CONSERVATION ACT AND REGULATIONS AND ANY RELEVANT HEALTH AND LOCAL AUTHORITY BY-LAWS.
2. THE LICENSEE SHALL NOT ACCEPT ANY KANGAROO SKIN FROM ANY ANIMAL THAT HAS NOT BEEN KILLED BY A SINGLE SHOT TO THE BRAIN².
3. SKIN DEALERS RETURNS (FORMS 4 & 5) ARE TO BE SUBMITTED MONTHLY SO AS TO REACH THE DEPARTMENT OF ENVIRONMENT AND CONSERVATION NO LATER THAN THE FIFTEENTH (15TH) DAY OF THE FOLLOWING MONTH.
4. THE ROYALTY TAG IS TO REMAIN ATTACHED TO, OR IN THE CASE OF THE TAG BECOMING DETACHED, ACCOMPANY THE SKIN, UNTIL THE TANNING PROCESS HAS BEEN COMPLETED

¹ Note: any changes to licence conditions must be consistent with the requirements set out in the Management Plan.

² One of the ways that it will be determined that a kangaroo has not been shot in accordance with this condition is if the carcass contains a bullet hole in any region of the body other than the head.

LICENCE TO EXPORT OR IMPORT FAUNA

Issued under Regulation 18 (Export) and 19 (Import) of the *Wildlife Conservation Regulations 1970*

The licence holder may export or import kangaroo products.

Licences to Export or Import Fauna are subject to conditions¹ that include, but are not limited to:

1. Every consignment of kangaroo products must be accompanied by an export or import licence issued by DPaW.
2. Licenses are valid only for single consignments and for the date(s) specified on the licence.
3. Licences to export kangaroo products will be issued only if the relevant authority in the State or Territory to which the consignment is destined approves the importation of the fauna to that State or Territory.
4. The consignment specified in the licence is derived from fauna taken in accordance with an approved management program for the species specified.

NB: Export of kangaroo products from Australia requires a separate permit issued by the Commonwealth Department of the Environment.

¹ Note: any changes to licence conditions must be consistent with the requirements set out in the Management Plan.

TAGS

Under Regulation 50 of the *Wildlife Conservation Regulations 1970*, kangaroo skins or carcasses cannot be bought, sold, transported or held in possession unless a tag has been affixed to the skin or carcass.

Licensed professional shooters must attach tags to the carcass of commercially harvested kangaroos as a condition of their licence. Tags are purchased from DPaW in batches of 100.

Tags:

- Are colour-coded for the species being harvested – yellow for red kangaroos and white for western grey kangaroos;
- Are individually numbered with a year designation;
- Are issued to licensed professional shooters and are not transferable;
- Must be attached to the carcass of kangaroos that are commercially harvested;
- Have a self-locking mechanism that can be removed only by cutting the tag, skin or carcass; and
- May only be removed immediately prior to tanning.

3. BIOLOGY, ECOLOGY AND CONSERVATION OF KANGAROOS

3.1. Introduction

Kangaroos are among the most widely studied species of fauna in Australia, largely as a consequence of commercial harvesting. Information on the biology, ecology, conservation and harvesting of kangaroos has been comprehensively documented in a large number of widely available publications. It is beyond the scope of the Management Plan to reproduce this information. Accordingly, the following sections provide only a concise summary of different aspects of kangaroo biology, ecology, conservation, management and harvesting. The information provided is largely adapted from [Pople and Grigg \(1999\)](#) who provided a comprehensive overview of the commercial harvesting of kangaroos in Australia. More detailed information can be found in the publications listed in the reference section of the Management Plan.

3.2. Biology and Ecology

The two kangaroo species that are the subject of the Management Plan are common and abundant over a broad area of WA as well as the Australian continent (Figs 3 and 4). Within the sheep and cattle grazing pastures of WA's rangelands, the provision of permanent watering points has meant that kangaroos are now more likely to be limited by food than water (Oliver 1986). This has had a profound effect on their distribution as well as their abundance (Newsome 1965a). It has been suggested that sheep and cattle also improved the habitat of kangaroos through facilitative grazing; creating a sub-climax pasture (Newsome 1975). These changes to the environment would have been most pronounced in the late 1800s when average sheep numbers in the rangelands of New South Wales and other parts of Australia were nearly twice what they are today (Caughley 1976). Other changes were also wrought upon Australia's rangelands following European settlement — numerous species of eutherian herbivores and predators were introduced and became established in the wild; at the same time numerous small native mammal species disappeared and many are now extinct. As Caughley (1987b) explained, not only was the habitat modified, but the ecological system was 'changed beyond recognition'. The current distribution and abundance of kangaroos may therefore bear only a vague resemblance to what it was prior to European settlement.

3.2.1 Red kangaroo (*Macropus rufus*)

The red kangaroo is the most abundant species of kangaroo. It is distributed over much of dry, inland Australia and is the only species exclusively restricted to the arid zone (Tyndale-Biscoe 2005; Fig. 3). This distribution reflects the interaction between mean annual precipitation and mean annual temperature (Caughley *et al.* 1987). In WA, red kangaroos occur at varying densities over a range that occupies about 75 percent of the State (Fig. 3) – an area of approximately 1.9 million km² (McNamara & Prince 1986). Red kangaroos occupy a wide range of habitats including mulga and mallee scrub, shrubland, woodland, grassland and even desert (Caughley 1964; Russell 1974; Johnson & Bayliss 1981; Low *et al.* 1981; Short *et al.* 1983; Croft & Clancy 2008). However, Croft and Clancy (2008), and Russell (1974) describe a preference of this species for open plains habitat.

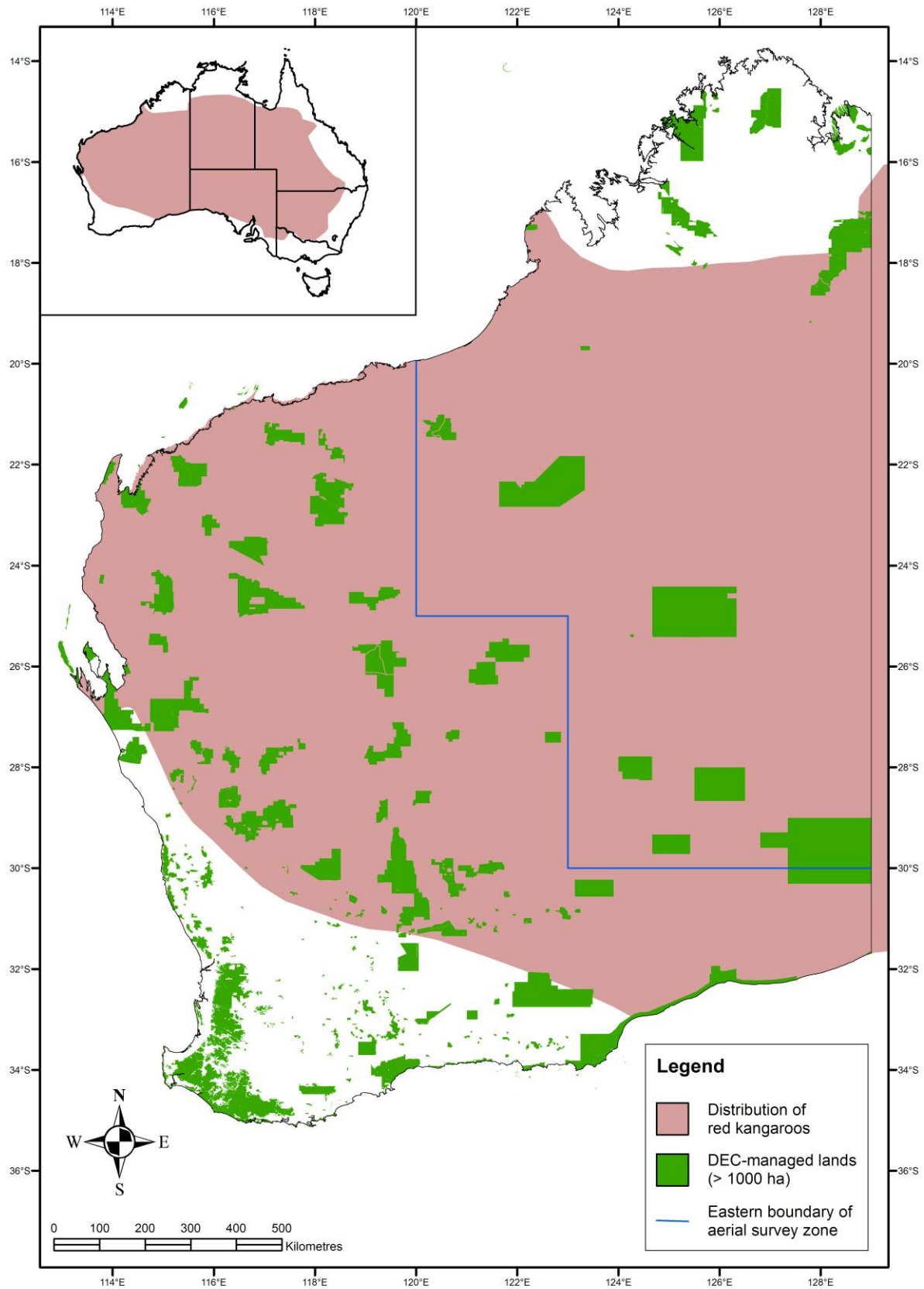


Fig. 3. Distribution of the red kangaroo (*Macropus rufus*). Note, kangaroos would not normally be culled on DPaW-managed lands. Spatial data modified from the IUCN Red List of Threatened Species (Version 2010.4) using departmental records.

Many scientists consider that vegetation clearing, provision of artificial watering points and control of dingo (*Canis lupus dingo*) populations to facilitate the grazing of domestic stock in the pastoral zone have "improved" the habitat for red kangaroo and thus resulted in a general population increase from pre-European times (Russell 1974; Newsome 1975; Caughley *et al.* 1980; Squires 1982; Grigg 1982). Conversely, intensive agriculture is not regarded as beneficial to the species (Grigg 1982; Short & Grigg 1982). However, little red kangaroo habitat has been altered by intensive agriculture.

The red kangaroo is a herbivore and its role in the ecosystem can be defined as that of a primary consumer. Several detailed dietary studies have been undertaken on this species (Griffiths & Barker 1966; Chippendale 1968; Storr 1968; Bailey *et al.* 1971; Ellis 1976), all indicating a preference for green herbage including grasses and dicotyledonous plants. Although they prefer to eat grasses and forbs, when these become scarce red kangaroos will switch to chenopods and black bluebush, and in some areas will even browse shrubs (Tyndale-Biscoe 2005).

Red kangaroos have significantly lower energy and water requirements than sheep. Munn *et al.* (2009) estimated grazing pressure attributed to red kangaroos was about 0.35 Dry Sheep Equivalents rather than the previous estimate of 0.7. Furthermore, water turnover in red kangaroos was only 13 percent that of sheep (Munn *et al.* 2009). This suggests that the relative contribution of kangaroo populations to total grazing pressure is smaller than previously thought. Consequently, reducing the abundance of kangaroo populations will afford substantially fewer benefits to grazing systems than the management of ungulate populations.

The reproductive biology of red kangaroo has been thoroughly studied (Frith & Sharman 1964; Newsome 1964a, b, 1965b; Sharman 1964; Sharman & Pilton 1964). Females come into oestrus at approximately 35-day intervals and are therefore potentially fertile throughout the year. Periods of extreme drought, however, may lead to suppression of the oestrus cycle, which is cued to body condition (Moss & Croft 1999). Females can come into breeding condition almost immediately after drought-breaking rains and pregnancy does not interrupt recurrence of oestrus. The female may give birth 33 days after mating and may mate again a day or two later. The embryo resulting from this post-partum mating remains a quiescent blastocyst until the previous young is about to leave the pouch or is lost prematurely (embryonic diapause) (Pople & Grigg 1999).

Bilton and Croft (2004) studied the lifetime reproductive success of female red kangaroos from an unharvested population and found that, on average, females achieve only 41 percent of their maximum reproductive potential. The number of droughts experienced during a female's lifetime influenced both her lifespan and reproductive output. Given the relatively high and stable population of red kangaroos in the study area, Bilton and Croft (2004) suggested that in addition to drought, the population was limited by mechanisms affecting juvenile survival.

Studies of behaviour and social organisation have been conducted by Caughley (1964) and Croft (1980). The red kangaroo is a gregarious species (Kirkpatrick 1967) and although relatively large groups may sometimes form, these groups are unstable in their composition (Croft 1980). The only enduring red kangaroo relationship is between the mother and her young. The mating system of the red kangaroo appears to be based on polygamy (Croft 1980).

Several studies have examined the movement patterns of red kangaroo (Frith 1964; Bailey 1971; Denny 1980; Croft 1980; Oliver 1986; Priddel 1987; Norbury & Norbury 1993; Norbury *et al.* 1994). These studies indicate that the majority of the population is relatively sedentary, moving distances of no more than 10 km, although a small proportion of animals may move tens or hundreds of kilometres. Individual home ranges have been found to overlap. In WA, Norbury *et al.* (1994) found that red kangaroos had very large home ranges and attributed this to the inherently poor vegetation production and the occurrence of drought during their study. These findings were quite different from those of Croft (1991) who studied red kangaroos during a non-drought period in better quality habitat and found weekly home ranges varied from 259 to 560 hectares. Natal dispersal is male-biased (Edwards *et al.* 1994) and dispersal distances tend to increase during drought (Johnson 1989).

The population dynamics of the red kangaroo have been studied in detail, largely derived from regular aerial surveys. These surveys provide a means of assessing the response of macropod populations to environmental conditions, particularly rainfall. Caughley *et al.* (1984), working in New South Wales, found that the rate of increase in numbers was related to rainfall. Populations decreased when rainfall was approximately 90 millimetres below average and, except when rainfall was extremely high, increased when rainfall exceeded the 90 millimetres below average level. The maximum annual rate of increase was approximately 45 percent *per annum*, but under average rainfall, populations increased at 30–35 percent *per annum*. In poor conditions, populations declined at a maximum rate of 55 percent *per annum*. Robertson (1986) observed a 30 percent *per annum* decline in the red kangaroo population at Kinchega National Park in western New South Wales during the 1982–83 drought. Similar population changes have been observed in South Australia by Grigg (1982).

The red kangaroo is subject to predation by the dingo. Shepherd (1981) has made direct observations of dingo predation on red kangaroos, concluding that they prefer juveniles as prey and that the dingo might be able to limit the rate of increase of red kangaroo populations. Caughley *et al.* (1980) were more definite in their conclusions concerning dingo predation, and attribute the high densities of red kangaroo in the sheep country of South Australia, Queensland and New South Wales to the elimination of the dingo from these areas.

3.2.3. Western grey kangaroo (*Macropus fuliginosus*)

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

The western grey kangaroo is, perhaps, named inappropriately because the species actually occurs across the south of the continent, with a distribution extending northwards through western New South Wales and into a small area of southern central Queensland (Fig. 4). This distribution corresponds to areas of uniform or winter rainfall (Caughley *et al.* 1987). Where the western grey kangaroo overlaps in its range with the eastern grey kangaroo, the latter is more abundant. Both species have similar habitat preferences and

the western grey kangaroo has also benefited from pastoralism, although it has been disadvantaged by intensive agriculture (Short & Grigg 1982). Neaves *et al.* (2009) examined the genetic structure of the western grey kangaroo across its range and identified five distinct genetic units – four on the mainland and one on Kangaroo Island. Three main units and two subunits occur within WA (Neaves *et al.* 2009).

Coulson and Norbury (1988) found that, like the eastern grey kangaroo, the western grey kangaroo feeds mainly on grasses. In north-western Victoria, Norbury (1987) found that western grey kangaroos ate more than 75 percent grass in a mixed pasture but, as pasture biomass declined, shifted to forbs and shrubs. Barker (1987) described a similar shift from forbs and grasses to shrubs for western greys feeding on pastures in western New South Wales and southern Queensland. This contrasted with red kangaroos and eastern grey kangaroos, which continued to feed on grasses and forbs as pasture biomass declined.

The reproductive biology of the western grey kangaroo shows some minor differences with the eastern grey kangaroo: the mean lengths of the oestrus cycle (35 days), gestation period (31 days) and pouch life (42 weeks) are shorter in the western grey kangaroo (Coulson 2008). Furthermore, western grey kangaroos do not exhibit embryonic diapause.

Both eastern and western greys are less mobile than red kangaroos. Studies of eastern grey kangaroos by Jarman and Taylor (1983) and Jarman and Southwell (1986) indicate that the species occupies well-defined, highly overlapping home ranges. Few individuals have been shown to disperse, those that do being young males. Western grey kangaroos were studied by Priddel (1987), Priddel *et al.* (1988a, b) and Arnold *et al.* (1989) and show the same general patterns, with individuals occupying relatively small home ranges that overlap extensively.

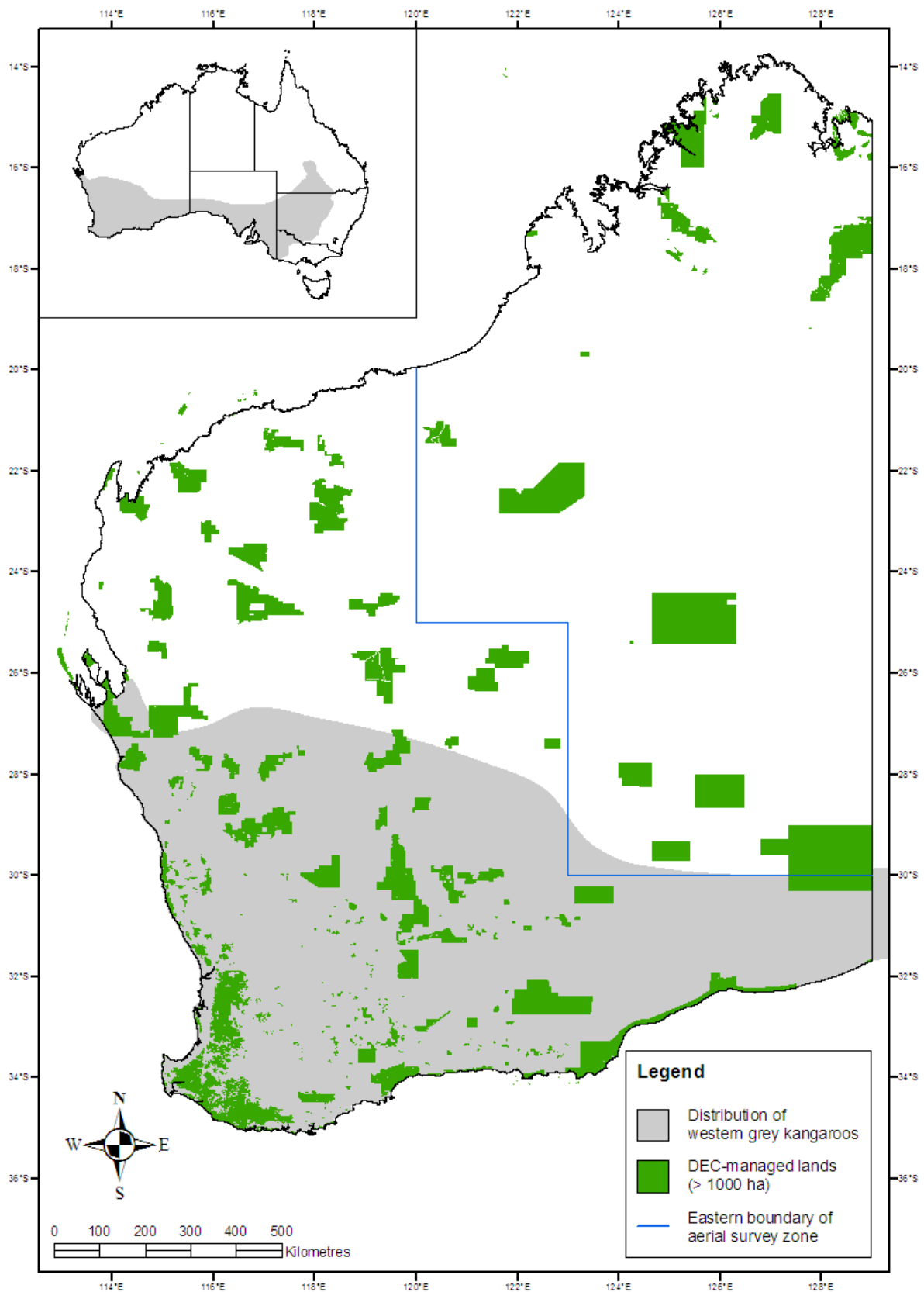


Fig. 4. Distribution of the western grey kangaroo (*Macropus fuliginosus*). Note, kangaroos would not normally be culled on DPaW-managed lands. Spatial data modified from the IUCN Red List of Threatened Species (Version 2010.4) using departmental records.

3.3. Conservation Status

The conservation status of the commercially harvested kangaroo species in WA reflects their abundance and thus their utilisation. No commercially harvested kangaroo species in WA is listed as a threatened or endangered species under either State or Commonwealth legislation (Table 1). In addition, the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (version 2012.1) identifies all of the kangaroo species subject to commercial harvesting in WA as Least Concern (Table 1). A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments – including the Government of Australia – that aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. CITES accords varying degrees of protection to more than 30,000 species of animals and plants, which are listed in the three CITES Appendices. None of the kangaroo species commercially harvested in WA is listed in any of the CITES Appendices (Table 1).

Table 1. Conservation status of kangaroo species that are the subject of the Management Plan.

Instrument	Kangaroo Species	
	Red kangaroo	Western grey kangaroo
<i>Wildlife Conservation Act 1950</i> (WA Legislation)	Not listed	Not listed
<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth Legislation)	Not listed	Not listed
IUCN Red List of Threatened Species (Version 2012.1)	Least concern	Least concern
Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Not listed	Not listed

3.4. Threats, Issues and Assessment of Impacts

In the context of commercial kangaroo harvesting in WA:

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

3.4.1. Threats and issues pertinent to the conservation status of kangaroos

The conservation status of kangaroos in WA has the potential to be threatened by a range of environmental and anthropogenic factors. Many of the potential threats, such as a changing climate, drought, disease or predation, are ecosystem or environmental processes beyond the control of the Department. Nevertheless, as evidenced by the scientific literature, these processes are not considered a long-term threat to the conservation status of kangaroos (Table 2).

Potential anthropogenic threats to the conservation status of kangaroos principally arise from the commercial harvest. However, in 40 years of commercial harvesting in WA, viable populations of the harvested kangaroo species have been maintained across their natural range. Accordingly, commercial harvesting is not considered a threat to the genetic integrity or conservation status of kangaroos in WA (Table 2).

However, to ensure that the commercial kangaroo harvest in WA remains sustainable and does not jeopardise the viability of kangaroo populations across their range in the future, the Department enacts a range of management and regulatory controls including:

(1). Undertaking regular and ongoing monitoring of kangaroo populations.

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

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

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

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

(3). Using conservative and up-to-date species correction factors.

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

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

WA will set harvest quotas for red kangaroos at ≤ 17 percent and for western grey kangaroos at ≤ 15 percent of the populations estimate. These levels are regarded as ecologically sustainable (e.g. Caughley 1987a; Hacker *et al.* 2004), and have been demonstrably sustainable in practice. See Action 11 for additional information on quota setting.

(5). Providing refuge habitat.

In WA, kangaroos would not normally be culled in conservation reserves or State Forest, a total area in excess of 26 million hectares or approximately 10 percent of the land area of the State (see Figs 3 and 4). The circumstances whereby kangaroos may be harvested from conservation reserves or State Forest include where such actions are deemed a necessary operation under the *Conservation and Land Management Act 1984*, or where an area management plan specifies that the management of overabundant populations is warranted. A necessary operation would include such things as reducing overabundant populations to prevent environmental damage or unacceptable animal welfare outcomes such as starvation. Area management plans are approved by the Conservation Commission of WA, which is independent of the Department.

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

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

Impacts on species, habitats and ecosystems resulting from actions detailed within the Management Plan are unlikely to be significant, and in some instances are expected to be positive (Table 3).

Table 2. Threats and issues pertinent to the long-term conservation of kangaroos.

Threats	Comments	Selected References
Drought	Rainfall and its impact on plant productivity is the single most important factor affecting kangaroo population dynamics where droughts can drastically reduce kangaroo numbers. However, kangaroos are well adapted to a dynamic environment and populations recover quickly after drought-driven population crashes, even with continued harvesting. Therefore drought is not considered a threat to the long-term conservation of kangaroos.	Bayliss (1987); Cairns & Grigg (1993); Cairns <i>et al.</i> (2000); Caughley <i>et al.</i> (1985); McCarthy (1996); Pople (2003); Pople, Grigg <i>et al.</i> (2010); Robertson (1986).
Climate change	Shifts in climate regimes have the potential to significantly impact on all biodiversity including the commercially harvested species of kangaroos. How human-induced changes to the climate will manifest in the future is unknown. Modelling indicates that northern WA is likely to become warmer and wetter while south-western WA warmer and drier. Vegetation associations and pasture biomass may also be significantly different from current and historical patterns. This will likely lead to variable responses across the landscape and may benefit some populations and adversely impact on others. Since rainfall is the most significant factor influencing kangaroo densities, a persistent long-term drought caused by human-induced climate change has the potential to adversely impact on the long-term conservation of kangaroos. However, the methods used for setting harvest quotas are responsive to fluctuating densities of kangaroos and will alert managers to potential problems.	Jonzén <i>et al.</i> (2010).
Disease	A range of parasites and pathogens infect kangaroos. Epidemics have caused significant short-term reductions in kangaroo numbers in particular areas, but these populations have recovered rapidly. Diseases do not appear to be important agents of mortality in kangaroos over the long-term and, therefore, are not considered to pose a threat to their conservation.	Caughley (1987a); Gilroy <i>et al.</i> (1999); Kirkpatrick (1985); Pople & Grigg (1999); Speare <i>et al.</i> (1989); Hooper <i>et al.</i> (1999); Reddacliff <i>et al.</i> (1999).
Flood	Flooding has been found to affect the short-term distribution and abundance of kangaroos and has been associated with occasional localised epizootics. Flooding is not considered a threat to the long-term conservation of kangaroos.	Choquenot (1991); Clancy <i>et al.</i> (1990).
Habitat loss and modification	The three largest species of kangaroo have benefited significantly from habitat modification: their numbers have increased and ranges extended, due principally to the expansion of grasslands and the provision of permanent sources of fresh water for livestock. Conversely, kangaroo numbers have generally declined where there is intensive agriculture, urbanisation or extensive clearing. Despite more than 200 years of heavy exploitation and clearing of the land, the larger kangaroos have maintained their populations or increased in abundance and range. Accordingly, habitat loss and modification are not considered a threat to the long-term conservation of kangaroos.	Calaby & Grigg (1989); Dawson <i>et al.</i> (2004); Pople, Grigg <i>et al.</i> (2010); Short & Grigg (1982).
Harvesting – general	In 36 years of managed harvest in Western Australia, viable populations of the harvested kangaroo species have been maintained across their natural range. Furthermore, the distributional ranges of red and western grey kangaroos have expanded. Therefore, harvesting is not considered a threat to the long-term conservation of kangaroos.	Cairns & Coombs (1992); Calaby & Grigg (1989); Dawson <i>et al.</i> (2004); Grigg & Pople (2001).

Table 2 (cont.). Threats and issues pertinent to the long-term conservation of kangaroos.

Threats	Comments	Selected References*
Harvesting – genetic	Harvesting, especially non-random or selective harvesting, has the potential to alter the genetic structure and genetic diversity of a population. However, there is no empirical or modelled evidence of genetic impacts at current levels of kangaroo harvesting. Therefore harvesting is not considered a threat to the long-term genetic integrity of kangaroo populations.	Clegg <i>et al.</i> (1998); Hacker <i>et al.</i> (2004); Hacker & McLeod (2003); Hale (2001, 2004); Neaves <i>et al.</i> (2009, 2012); Tenhumberg <i>et al.</i> (2002, 2004).
Predation	In some circumstances, dingoes (<i>Canis lupus dingo</i>) have been shown to limit kangaroo populations and there is increasing evidence for this species having a regulatory effect. Other predators such as European fox (<i>Vulpes vulpes</i>) and wedge-tailed eagle (<i>Aquila audax</i>) do not appear to exert much influence on the harvested species of kangaroo. Therefore, predation is not considered a threat to the long-term conservation of kangaroos.	Banks <i>et al.</i> (2000); Caughley <i>et al.</i> (1980); Corbert & Newsome (1987); Jarman & Denny (1976); Letnic & Koch (2010); Pople & Page (2001); Thompson (1992).

*Where applicable and/or available

Table 3. Impacts of the commercial kangaroo harvest on other species, habitats and ecosystems.

Potential Impacts	Comments	Selected References
Land degradation caused by the erosion of soil	The commercial kangaroo harvest is unlikely to cause land degradation due to the erosion of soil. Licensed Professional Shooters generally operate on pre-existing tracks and are reluctant to risk damage to their vehicles, especially punctured tyres, by traversing rough terrain. Moreover, kangaroo harvest off-cuts have been shown to contribute to soil nutrient retention and cycling, thereby improving soil quality.	Wilson & Read (2003).
Detrimental effects on water bodies, watercourses, wetlands and natural drainage systems	There is no evidence that suggests the commercial kangaroo harvest will have detrimental effects on water bodies, watercourses, wetlands and natural drainage systems.	
Vegetation clearing or modification	No vegetation is likely to be cleared or modified as a consequence of the commercial kangaroo harvest. However, the commercial harvest may provide indirect benefits to vegetation by potentially contributing to an integrated approach to reducing total grazing pressure or facilitating the retention of vegetation that provides habitat for kangaroos by private landholders.	Fisher <i>et al.</i> (2004); Grigg (1988, 1995).
Detrimental effects on threatened flora species, populations or their habitats	There is no evidence that the commercial kangaroo harvest has a detrimental effect on threatened flora species, populations or their habitats.	
Endangering, displacing or disturbing native fauna, or creating a barrier to their movement	Native fauna is unlikely to be endangered, displaced or disturbed as a consequence of the commercial kangaroo harvest. Furthermore, the commercial harvest is unlikely to create a barrier to the movement of native fauna. Kangaroo harvest off-cuts are utilised by species that scavenge, such as some raptors and corvids, thereby benefiting these species.	Read & Wilson (2004).
Detrimental effects on threatened fauna species, populations or their habitats	There is no evidence that the commercial kangaroo harvest has a direct detrimental effect on threatened fauna species, populations, or their habitats, but there may be indirect effects on threatened fauna species and/or populations (see section on introduced predators below).	
Detrimental impacts on ecological communities of conservation significance	Ecological communities of conservation significance are unlikely to be impacted by the commercial kangaroo harvest.	
Positive effects on introduced predators	Kangaroo harvest off-cuts are utilised by introduced predators, particularly foxes (<i>Vulpes vulpes</i>) and may sustain populations of these predators during periods of low prey availability. Maintenance of artificially high predator populations may in turn threaten prey populations, including endangered taxa. However, WA undertakes extensive aerial baiting programs to protect endangered fauna from fox predation and to protect livestock from wild dog predation, which would mitigate this effect.	Kay <i>et al.</i> (2000); Read & Wilson (2004); Saunders <i>et al.</i> (1995).
Positive effects on introduced herbivores	The commercial kangaroo harvest, by reducing kangaroo populations and thus competition, may allow populations of introduced herbivores such as goat (<i>Capra hircus</i>) and rabbit (<i>Oryctolagus cuniculus</i>) to increase. However, the limited magnitude of the reduction in kangaroo numbers coupled with ongoing pest animal control programs undertaken across Western Australia mitigates the potential positive effect on populations of introduced herbivores.	

Table 3. Impacts of the commercial kangaroo harvest on other species, habitats and ecosystems.

Potential Impacts	Comments	Selected References
Introduction and/or dispersal of invasive weeds	There is no evidence that commercial kangaroo harvesters contributes to the introduction and/or dispersal of invasive weeds more than other land users.	

Where applicable and/or available

4. GOALS AND AIMS

4.1. Goal

The overarching goal of the *Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2014–2018* is:

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

The principles of ecologically sustainable development are defined in [Part 1, Section 3A of the EPBC Act](#) and are:

- (a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations;
- (b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- (c) the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;
- (d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making;
- (e) improved valuation, pricing and incentive mechanisms should be promoted.

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

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

4.2. Aims

The aims of the Management Plan are to:

1. REGULATE THE COMMERCIAL HARVEST OF KANGAROOS

The commercial utilisation of kangaroos will be regulated via the issue of various licences and royalty tags in accordance with the provisions of the *Wildlife Conservation Act and Regulations*, Western Australian Government policies, the *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes* and the Management Plan.

2. ENSURE KANGAROOS ARE KILLED HUMANELY

Improved animal welfare outcomes will be promoted by ensuring that the commercial harvest of kangaroos is carried out in accordance with the *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes*.

3. MONITOR INDUSTRY COMPLIANCE

The commercial kangaroo industry will be monitored to ensure compliance with the *Wildlife Conservation Act and Regulations*, licence conditions, the requirements of the *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes*; and the Management Plan.

4. MONITOR KANGAROO POPULATIONS AND SET HARVEST QUOTAS

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

5. FACILITATE ADAPTIVE MANAGEMENT AND RESEARCH

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

6. UNDERTAKE PROGRAM REPORTING AND REVIEW

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

7. RAISE COMMUNITY AWARENESS AND ENGAGE THE STAKEHOLDERS

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

5. MANAGEMENT ACTIONS AND PERFORMANCE INDICATORS

AIM 1: REGULATE THE COMMERCIAL HARVEST OF KANGAROOS

In order to ensure that the commercial kangaroo harvest is adequately regulated and that kangaroo populations are managed sustainably, commercial activities will require the authority of various licences and tagging procedures as provided for under the *Wildlife Conservation Act* and *Regulations*. The legislative basis for licensing and licensing procedures is described in detail in Section 2.2.

ACTION 1: All relevant activities are licensed in accordance with Western Australian legislation and departmental policies.

All applications for licences relating to commercial kangaroo industry operations in WA are to be assessed, processed and issued in accordance with the provisions of the *Wildlife Conservation Act 1950*, the *Wildlife Conservation Regulations 1970* and relevant departmental policies.

Performance Indicator 1: Random audits of licences issued for commercial activities are conducted annually to ensure licences are being issued in accordance with WA legislation and departmental policies.

Performance Indicator 2: Databases are maintained to ensure licensee information is current and accurate.

ACTION 2: Licence conditions are applied as required.

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

Performance Indicator 3: Licence conditions are reviewed annually and where necessary amended.

Performance Indicator 4: Licensees are advised in writing of any changes to licence conditions within one month of such changes being approved by the Director of Nature Conservation or his delegate.

AIM 2: ENSURE KANGAROOS ARE KILLED HUMANELY

The Department is committed to promoting and maintaining the highest possible standards in animal welfare. The *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Commercial Purposes 2008* (the National CoP) is the current, nationally-endorsed animal welfare standard for the commercial harvest of kangaroos in Australia. Additionally, any approved revisions to the National COP will be adopted as the animal welfare standard for the commercial harvest of kangaroos in WA.

ACTION 3: The Department will ensure that the commercial industry operates under the most up-to-date National Code of Practice for kangaroo harvesting.

Compliance with the National CoP is a requirement for licensed professional shooters. Furthermore, licensed processors cannot receive kangaroo carcasses unless kangaroos have been shot in accordance with the National CoP. Conditions on professional shooters' and processors' licenses provide financial disincentives for shooting other than in accordance with the National CoP.

Performance Indicator 5: Licence conditions for professional shooters and processors will stipulate that kangaroos cannot be shot, sold or received unless they have been taken in accordance with the National CoP.

Performance Indicator 6: Copies of the National CoP will be made available from the department's website.

Performance Indicator 7: The Department will participate in and support any revisions to the current, nationally-endorsed Code of Practice.

ACTION 4: The Department will work with the Professional Shooters' Association of WA and any other shooter representative body to ensure that all licensed professional shooters are competent and able to achieve the standards of marksmanship required under the National CoP.

In order to ensure that the kangaroo harvest is humane, prospective professional shooters are required to demonstrate they can achieve the standards of marksmanship required under the National CoP prior to obtaining their licences. The accreditation program is a one-off practical test of marksmanship conducted under field conditions by independent examiners who are registered with the Department. During the life of the Management Plan, the Department will raise the matter of increasing the frequency of testing with the Kangaroo Management Advisory Committee. Additionally, prospective professional shooters must have completed NSW TAFE Course 5725: Australian Game Meat, Hygiene and Handling prior to being issued with a licence.

Performance Indicator 8: All prospective professional shooters must have completed an accredited test of marksmanship and completed NSW TAFE Course 5725: Australian Game Meat, Hygiene and Handling as a prerequisite before being issued with a professional shooters' licence.

AIM 3: MONITOR INDUSTRY COMPLIANCE

Monitoring industry compliance with the provisions of Western Australian legislation, government policies and the goal and aims of the Management Plan is essential to ensure the commercial harvest is managed sustainably and for maintaining public confidence in the management of the kangaroo industry.

ACTION 5: The Department will undertake both regular and opportunistic monitoring of compliance by commercial operators.

In order to assess industry compliance, authorised officers will, on both a regular and opportunistic basis, inspect kangaroos taken by licensed professional shooters and all premises registered for processing kangaroos. The inspecting officers will check to ensure that the kangaroos have been taken in accordance with the Wildlife Conservation Act and Regulations, the Management Plan, and the National CoP.

Performance Indicator 9: All kangaroo processing works are inspected by authorised departmental officers at least annually during the life of the Management Plan to ensure compliance with Western Australian legislation.

Performance Indicator 10: Twenty percent of active chillers are inspected by authorised departmental officers annually during the life of the Management Plan to ensure compliance with Western Australian legislation.

(Note: An active chiller is one that is identified on the returns from licensed professional shooters where there is at least one shooting day of effort during the year assigned to it.)

Performance Indicator 11: The vehicles of licensed professional shooters loaded with kangaroo carcasses are inspected opportunistically during the life of the Management Plan to ensure compliance with Western Australian legislation.

Performance Indicator 12: Develop and implement improved procedures for reporting on actions included under Performance Indicators 9 to 11.

ACTION 6: Activities not in accordance with Western Australian legislation and the Management Plan will be investigated and, where an offence has been committed and it is appropriate, prosecuted.

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

Performance Indicator 13: Reports of unlicensed activities and activities in breach of legislation are investigated to the fullest extent possible and, where sufficient evidence is available, offenders are issued with expiation notices or prosecuted as appropriate.

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

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

Performance Indicator 14: During the life of the Management Plan, all incoming industry returns are scrutinised and discrepancies are investigated and resolved.

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

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

Performance Indicator 15: A compliance database is maintained.

AIM 4: MONITOR KANGAROO POPULATIONS AND SET HARVEST QUOTAS

Monitoring populations of commercially harvested species is essential to safeguard them from overharvesting and to ensure that the commercial harvest is sustainable over the long term. Kangaroo population estimates obtained from aerial surveys will be used as the basis for setting commercial harvest quotas following the procedures set out in the Management Plan.

ACTION 10: Aerial surveys will be conducted annually, with each Population Monitoring Zone being surveyed on a triennial basis (see Fig. 5).

The commercial harvest region in WA is divided into four Population Monitoring Zones (PMZ) (Figure 5). Aerial surveys from fixed-wing aircraft will be used to estimate the size of kangaroo populations within each PMZ. Survey lines have been established at regular intervals across the harvest region (Figure 5) and the same lines are surveyed during the same season each survey period to allow comparison of results between years.

The Northern, Central and Southeast PMZs will be surveyed on a triennial basis due to spatial scale, whereas monitor blocks will be surveyed in the Southwest PMZ annually. For the Northern, Central and Southeast PMZs, in the intervening years between aerial surveys, population estimates will be calculated using the most recent population estimate adjusted for regional rainfall and commercial harvest offtake according to the equation:

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

where:

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

H = commercial harvest offtake between population estimates; and

r = population growth rate for a regional rainfall category.

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

Performance Indicator 16: Aerial surveys are undertaken annually and population estimates are calculated in accordance with the Management Plan.

ACTION 11: Commercial harvest quotas will be set and managed in accordance with the provisions of the Management Plan.

The commercial quota for a species is the maximum number of individuals that can be commercially harvested in a calendar year. Harvest strategies that track fluctuations in animal abundance are considered to have a low risk of overharvesting (Engen *et al.* 1997) and have been used to set harvest quotas for kangaroos in Australia for many years [Pople and Grigg \(1999\)](#). Commercial quotas will be set at ≤ 17 percent of the population estimate for red kangaroos and ≤ 15 percent for western grey kangaroos. Harvest rates of this magnitude are regarded as sustainable for kangaroos over the long term (Caughley 1987a; Hacker *et al.* 2004).

Quotas will be set for each commercially harvested kangaroo species and allocated to each Population Monitoring Zone (Fig. 5), based on the most current population estimate for that zone and using habitat correction factors accepted at that time. The Australian Government will be advised of the annual quotas prior to implementation, in order to obtain approval for the proposed level of harvesting and allow the export of kangaroo-derived products.

Licensed professional shooters purchase royalty tags from the Department each year. Tags are issued to licensed professional shooters commensurate with activity levels. Tags are colour coded for each species of commercially harvested kangaroo – yellow for red kangaroos and white for western grey kangaroos. Each tag has a year stamp and is individually numbered. Harvest returns will be monitored continually throughout the year. When the tag allocation in any particular year reaches 75 percent of the statewide quota, daily action including maintaining up-to-date harvest statistics will be undertaken to monitor the harvest. Tag allocation controls and both specific and generalised closure notifications will be implemented to ensure that the statewide quota is never exceeded.

Quotas will be managed at the regional level. The harvest in each region will be closely monitored and when the harvest for a particular region is close to reaching the quota for that region then the commercial harvest will cease in that region. Furthermore, the Department will close the harvest in a management area or region if it considers continued harvest pressure will pose a conservation risk to kangaroos in that area or region, whether by potentially exceeding the quota or for some other reason.

Performance Indicator 17: Commercial harvest quotas are set in accordance with the Management Plan.

Performance Indicator 18: Regional quotas and the statewide quotas are never exceeded.

Table 4. Relationship between Population Monitoring Zones and Kangaroo Management Areas.

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

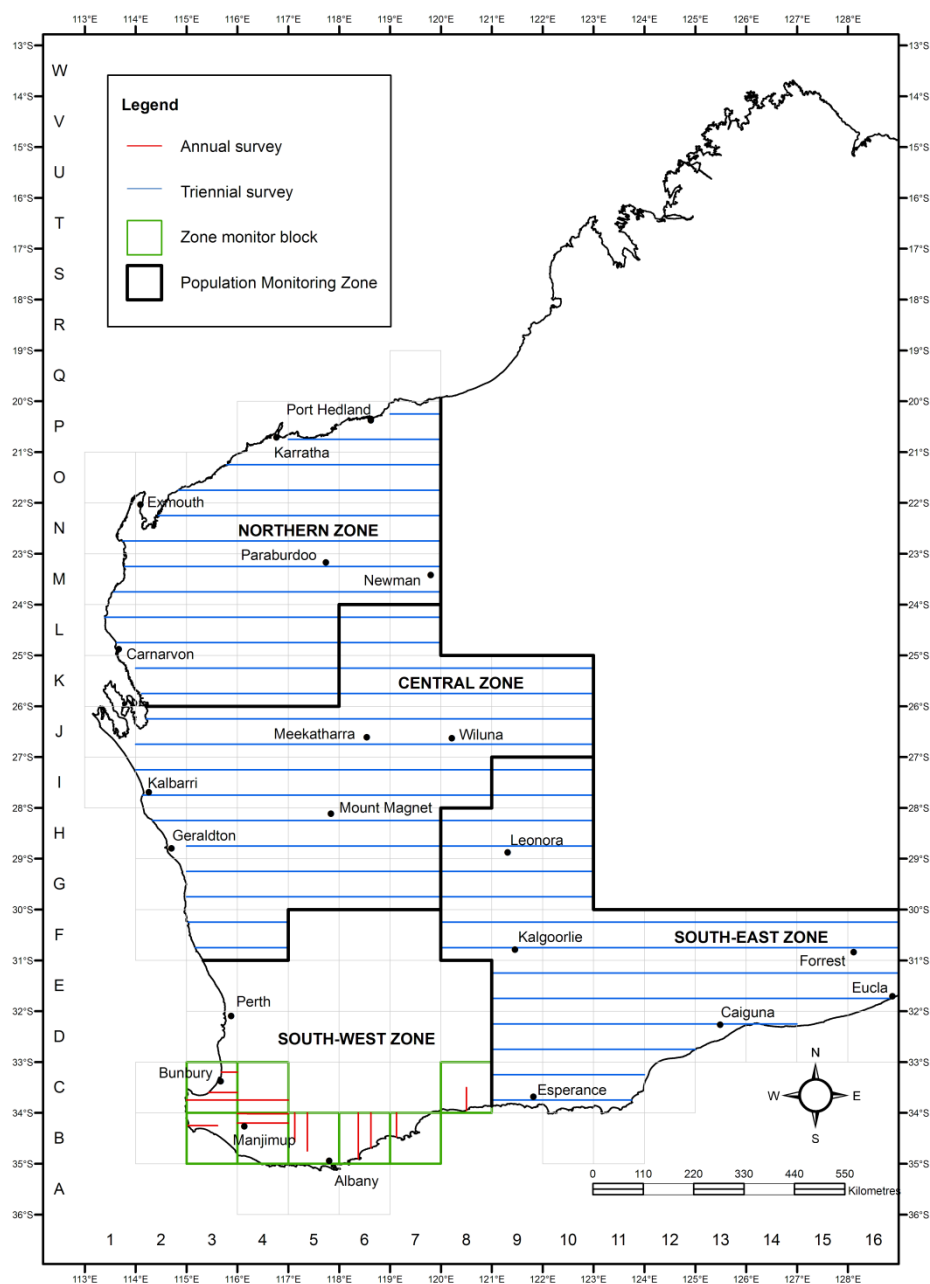


Fig. 5. Aerial survey flight lines and Population Monitoring Zones.

Any changes to Kangaroo Management Area boundaries (Fig. 1) will be detailed in the quota submission to the Australian Government. The Department retains the capacity to manage quotas at the Kangaroo Management Area level if required (through the allocation of royalty tags and spatial and temporal closures in specific management areas and monitoring zones), without the need to prescribe set quotas for each Kangaroo Management Area each year.

Not all kangaroo species are harvested in each Kangaroo Management Area (Fig. 1). It is important to note that the most recent scientific information available is considered when determining annual quotas and that analysis of this information may result in quotas being decreased in order to maintain the viability of kangaroo populations and to meet the other objectives of the Management Plan.

Performance Indicator 19: The Australian Government is advised of commercial harvest quotas for the following calendar year by 30 November.

The quota submission will contain the following information:

- population estimates for each species in each Population Monitoring Zone and the method of survey used;
- quotas calculated as a proportion of the population estimate;
- any proposed changes to quotas;
- any changes to commercial harvest management areas; and
- charts showing trends in populations, quota utilisation and harvest offtake.

Performance Indicator 20: Following endorsement by the Australian government department responsible for administering the EPBC Act, the quota submission will be made available to the public via the Department's website.

ACTION 12: Harvest data will be analysed during the preparation of the quota submission.

Harvest returns are received monthly and scrutinised for any discrepancies on a continual basis (see Performance Indicator 13). Additionally, analysis of sex ratios and carcass weights will occur during the preparation of the quota submission, which potentially can alert managers to problems with the commercial harvest. Significant changes in average carcass weights and sex ratios may provide an indication of population status or selective harvest pressure.

Performance Indicator 21: Sudden or acute changes in the average carcass weights are investigated to identify possible causes of the change.

If average carcass weights show significant departures from long-term trends, potential causes will be identified and investigated. Management action will be taken if required to ensure the viability of the kangaroo population is maintained over the long term. Actions may include reducing or suspending the commercial harvest or increasing survey intensity at the next survey.

Performance Indicator 22: Sudden or acute changes in the sex ratios of harvested kangaroos are investigated to identify possible causes of the change.

The sex ratio of the harvest for each species is usually maintained at ≥ 50 percent male for each calendar year. Where the sex ratio falls below 50 percent male, possible contributing factors will be examined. If necessary, management action will be taken to ensure the viability of the kangaroo population is maintained over the long term. Actions may include reducing or suspending the commercial harvest or increasing survey intensity at the next survey.

ACTION 13: The commercial quota for a particular species will be reduced or suspended within a Population Monitoring Zone if population densities fall below pre-determined trigger points.

In 2008, the Administrative Appeals Tribunal of Australia, in reviewing a wildlife trade management plan for kangaroos in New South Wales (AATA 2008a,b,c) expressed their concern that the plan did not encompass a specific response to an unusual decline in kangaroo numbers and determined that the plan should incorporate concrete measures to suspend the harvest in response to this scenario. In their decision, they concluded that the plan should be amended to include such a provision and identified a trigger point of a 30 percent population decline (approximately twice the harvest rate), which was acknowledged as being somewhat arbitrary. However, kangaroo populations are known to decline by as much as 30–60 percent over three months during drought (Robertson 1986) and have recovered from such fluctuations in the face of continued harvest pressure in the past. A trigger point set at a 30 percent population decline underestimates natural fluctuations in kangaroo populations and the ability of kangaroos to recover from such declines.

Proportional threshold harvesting is one strategy for reducing the risk of over-harvesting (Engen *et al.* 1997). Using this strategy, density thresholds are established that ‘trigger’ a management response. Typically, the harvest rate is reduced or the harvest is suspended at specific densities to reduce the risk of over-harvesting. However, care must be taken when quantifying trigger points as threshold policies can induce cyclic behaviour in an otherwise stable exploited population as a consequence of the combination of harvest pressure and excessively protective threshold densities. This behaviour may be of significant concern in terms of both the conservation and management of exploited populations (Da Silveira Costa & Faria 2011).

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

It is important to note that the density estimates of kangaroos over much of Western Australia, particularly in rangelands areas, are significantly lower than in eastern Australia. Average densities in many areas are of the order of 1 kangaroo per square kilometre or lower, with average red kangaroo density estimates at the population

monitoring zone level ranging from less than 0.4 kangaroos per square kilometre to a high of around 3 kangaroos per square kilometre.

Furthermore, it is considered that the kangaroo densities experienced over the last 40 years of commercial harvesting are significantly higher than they would have been prior to the commencement of widespread sheep grazing in the rangelands. The Department recognises that as part of the cessation of sheep grazing in many rangeland areas, the dismantling of artificial water points and less intensive wild dog control, kangaroo densities are moving back to levels approaching pre-European settlement densities. It has been established that kangaroo densities are routinely much lower in areas subject to dingo predation compared with adjacent areas where dingoes are controlled (Pople *et al.* 2000), but it is difficult to estimate with any certainty how much lower historic population levels would have been in the presence of dingoes and in the absence of artificial water sources and livestock grazing.

Under this Management Plan, the commercial harvest rate will be reduced or the commercial harvest suspended if aerial surveys indicate that the population density within any particular PMZ has fallen to a predetermined density threshold for that zone. Any suspensions or reductions will remain in place until surveys indicate that kangaroo densities have increased above density thresholds.

Performance Indicator 23: Commercial harvest rates will be reduced or the commercial kangaroo harvest suspended if density estimates reach the thresholds identified in the table below. Any suspensions or reductions will remain in place until surveys indicate that kangaroo densities have increased above density thresholds.

Zone	Density thresholds (kangaroos per km ²)					
	Red kangaroos			Western grey kangaroos		
	17% HR (Threshold 1)	10% HR	No harvest (Threshold 2)	15% HR (Threshold 1)	10% HR	No harvest (Threshold 2)
Central	$D > 0.44^a$	$0.44^a \geq D > 0.28^b$	$D \leq 0.28^b$	$D > 0.12^b$	$0.12^b \geq D > 0.10^c$	$D \leq 0.10^c$
Northern	$D > 0.42^b$	$0.42^b \geq D > 0.31^c$	$D \leq 0.31^c$	Extralimital – no quota		
South East	$D > 0.35^c$	$0.35^c \geq D > 0.25^d$	$D \leq 0.25^d$	$D > 0.98^c$	$0.98^c \geq D > 0.80^d$	$D \leq 0.80^d$
South West	Vagrant – no quota			$D > 7.7^c$	$7.7^c \geq D > 5.8^d$	$D \leq 5.8^d$

HR = Harvest rate as a proportion of the population estimate
D = density estimate (kangaroos per km²) from aerial surveys
Threshold densities were calculated as 1.0, 1.5, 2 or 3 standard deviations from the mean of density estimates for full surveys of a Population Monitoring Zone between 1995 and 2012. Note that zones are surveyed on a triennial basis.

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

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

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

Harvest suspension: Where aerial surveys indicate that the population density of a kangaroo species within a PMZ is below Threshold 2, no commercial quota will be approved for the following calendar year. Furthermore, no further tags will be issued to licensed professional shooters operating in that particular PMZ for the remainder of the current calendar year. The harvest suspension will remain in force until aerial surveys indicate that population densities have increased above Threshold 2.

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

AIM 5: 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. Research into particular aspects of kangaroo ecology or harvest management can also assist in ensuring that the commercial harvest is sustainable over the long term. While there has been a large body of research on the ecology and management of kangaroos, there are information gaps which, when filled, may lead to improved management of the commercial harvest.

ACTION 14: Historical data relating to the commercial kangaroo harvest in WA will be analysed during the life of the Management Plan. Trends in harvest statistics will be evaluated and the results of this analysis will be considered in the development of future kangaroo management programs.

Previous kangaroo management programs have generated a wide range of information relating to the commercial harvesting of kangaroos in WA. This information will be analysed to provide data on trends in kangaroo populations, utilisation rates, average weights and other specific information relating either to the commercial harvest or to kangaroo populations more generally.

The analysis of historical data relating to the commercial kangaroo harvest in WA may be undertaken by a range of individuals or organisations including tertiary students, university professionals, consultants or departmental staff. Data analysis research proposals must be accompanied by a project plan that clearly identifies the goals and objectives of the proposed research and outlines performance indicators that enable an assessment of the success (or otherwise) of the research.

Consideration of research findings and the results of analyses of historical harvest data are useful for the development of future management plans as well as for facilitating the adaptive management of kangaroo populations. The results of such

analyses will be published in appropriate forums, which will vary according to the type of research or analysis.

Performance Indicator 24: As a minimum, trends in population estimates, harvest tallies, carcass weights and sex ratios will be analysed annually and published on the department's website in annual and quota reports.

ACTION 15: Where practicable, management experiments will be performed to test deliberate management interventions during the life of the Management Plan.

Under such 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 to undertake active adaptive management experiments will be reviewed by the Kangaroo Management Advisory Committee and will be critically assessed by the Department with reference to the following criteria:

- the proponents' awareness of relevant background information;
- whether the proposal considers alternative models and hypotheses;
- whether the proposal is scientifically rigorous and statistically valid;
- whether the proposal incorporates a monitoring program;
- that there is substantial evidence that the risk of permanent damage to kangaroo populations is low;
- that the proposal is consistent with the goal of the Management Plan and relevant Western Australian legislation; and
- that the proposal includes consideration of how management may be modified to accommodate the new knowledge gathered from the intervention.

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

Performance Indicator 25: All proposals to undertake active adaptive management experiments are reviewed and assessed by the Department in accordance with the criteria outlined in the Management Plan.

Performance Indicator 26: All necessary approvals are obtained prior to the commencement of any experiments that test deliberate management interventions.

Approval from the Australian Government will be sought in circumstances where adaptive management experiments are likely to exceed the harvest rate determined by quotas.

Performance Indicator 27: All adaptive management experiments are continuously monitored and conducted according to approval conditions.

As identified above, all active adaptive management experiment proposals must include a monitoring program. 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.

Performance Indicator 28: 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 the Management Plan will be made available to the Kangaroo Management Advisory Committee (KMAC – see Aim 7) and the Department for inclusion on the Department’s website.

ACTION 16: The Department will facilitate research into the ecology and harvest management of kangaroos.

The Department will work with external research organisations to identify and investigate issues relevant to the commercial harvest of kangaroos. Such research may include aspects of the biology and ecology of kangaroos as they relate to the commercial harvest, or harvest techniques. Contributions by the Department may include funding and/or in-kind support such as the provision of harvest data.

Performance Indicator 29: During the life of Management Plan, the Department will support research on the ecology of harvested species of kangaroos or commercial harvest management as appropriate.

AIM 6: UNDERTAKE PROGRAM REPORTING AND REVIEW

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

ACTION 17: A report will be prepared annually and submitted to the Commonwealth.

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

Performance Indicator 30: An annual report will be provided to the Commonwealth by 31 March of the following year.

The annual report will include the following information:

1. Harvest statistics for each species taken in each Population Monitoring Zone (Fig. 5) including:

- Numbers of kangaroos taken;
- Sex ratio of the harvest; and;
- Average carcass weights of harvested animals for each sex taken.

2. Industry compliance statistics including:

- number of premises inspected;
- number of Caution Notices issued and reason for issue;
- number of alleged offences investigated and outcomes;
- number of prosecutions undertaken (offence and outcome); and
- any joint surveillance/enforcement activities completed with other agencies.

3. Any unusual situations that arose (e.g. disease outbreaks, drought conditions, market factors, etc).

4. Any research or adaptive management experiments that were undertaken or sponsored by the Department.

5. An assessment of actions identified in the Management Plan against the performance indicators.

AIM 7: RAISE COMMUNITY AWARENESS AND ENGAGE THE STAKEHOLDERS

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

ACTION 18: Members of the Kangaroo Management Advisory Committee will be provided with relevant information and afforded the opportunity to advise the Department on key kangaroo management issues throughout the life of the Management Plan.

The Kangaroo Management Advisory Committee (KMAC), which is convened by the Department, is the main forum through which stakeholder group representatives can raise issues for discussion, as well as communicate their group's positions and interests to Government on a regular basis. Stakeholder groups presently represented on KMAC encompass the kangaroo industry, landholder groups, primary producers and government. Member organisations hold their appointed positions indefinitely. KMAC provides an opportunity for all stakeholder organisations to actively participate in directing the future development of the commercial kangaroo industry in WA. During the life of the Management Plan, the Department will raise for discussion the matter of including an animal welfare representative on KMAC.

Performance Indicator 31: KMAC meets at least once per year to review the progress of the Management Plan in relation to the goal and aims of the plan.

Performance Indicator 32: KMAC is provided with annual updates on the commercial harvest and issue of tags issue throughout the life of the Management Plan.

Performance Indicator 33: KMAC is provided with other relevant information as required or as necessary throughout the life of the Management Plan.

ACTION 19: Relevant documents will be made available from the Department's website and other publicly available information will be made available on request.

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

Performance Indicator 34: Throughout the life of the Management Plan, the Department's website will contain the following information as a minimum standard:

- The current management plan;
- the current quota submission document;
- the current annual report submitted to the Commonwealth;
- information sheets on kangaroo biology and management; and
- relevant contact information.

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

Performance Indicator 35: Publicly available information on kangaroo management is provided to interested parties as soon as practicable on request.

ACTION 20: Where appropriate, relevant departmental staff will participate in media interviews and prepare media releases.

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

Performance Indicator 36: Relevant departmental staff will participate in interviews with the media where appropriate.

Performance Indicator 37: Media releases are prepared for issues of interest to the community when appropriate.

ACTION 21: Relevant information regarding licensing arrangements will be developed and distributed to all licensees as required.

Licensees and operators will be provided with written information relevant to their licensing arrangements to assist in achieving a high level of compliance with the licensing framework.

Performance Indicator 38: As a minimum, all prospective kangaroo shooters who are issued with a *Licence to Take Kangaroos for Sale* for the first time, or

who have not held a valid licence during the term of the current Management Plan, will be provided with written information on the following:

- prerequisites for obtaining a licence
- licence conditions;
- regulations for taking kangaroos for damage mitigation;
- open and closed season areas for red and western grey kangaroos;
- a copy of the National Code of Practice; and
- Fauna Notes 29 (western grey kangaroo) and 31 (red kangaroo) and any revisions thereof that are available on the department's website.

REFERENCES

- AATA (2008a). Wildlife Protection Association of Australia Inc. and Minister for the Environment, Heritage and the Arts and Director-General of the Department of Environment and Climate Change (NSW) (Party Joined) [2008] AATA 717 (15 August 2008).
- AATA (2008b). Wildlife Protection Association of Australia Inc. and Minister for the Environment, Heritage and the Arts and Director-General of the Department of Environment and Climate Change (NSW) (Party Joined) [2008] AATA 846 (23 September 2008)
- AATA (2008c). Wildlife Protection Association of Australia Inc. and Minister for the Environment, Heritage and the Arts and Director-General of the Department of Environment and Climate Change (NSW) (Joined Party) [2008] AATA 1079 (2 December 2008)
- Anderson, D.R. and Southwell, C. (1995). Estimates of macropod density from line transect surveys relative to analyst expertise. *Journal of Wildlife Management* **59**, 852-857.
- Arnold, G.W., Steven, D.E. and Weeldenburg, J.R. (1989). The use of surrounding farmland by western grey kangaroos living in a remnant of wandoo woodland and their impact on crop production. *Australian Wildlife Research* **16**, 85-93.
- Bailey, P.T. (1971). The red kangaroo, *Megaleia rufa* (Desmarest), in north-western New South Wales. I. Movements. *CSIRO Wildlife Research* **16**, 11-28.
- Bailey, P.T., Martensz, P.N. and Barker, R. (1971). The red kangaroo, *Megaleia rufa* (Desmarest), in north-western New South Wales. II. Food. *CSIRO Wildlife Research* **16**, 29-39.
- Banks, P.B., Newsome, A.E. and Dickman, C.R. (2000). Predation by red foxes limits recruitment in populations of eastern grey kangaroos. *Austral Ecology* **25**, 283-291.
- Barker, R.D. (1987). The diet of herbivores in the sheep rangelands. In 'Kangaroos: their ecology and management in the sheep rangelands of Australia'. (Eds G. Caughley, N. Shepherd and J. Short.) pp. 69-83.(Cambridge University Press: Cambridge).
- Bayliss, P. (1987). Kangaroo dynamics. In 'Kangaroos: their ecology and management in the sheep rangelands of Australia'. (Eds G. Caughley, N. Shepherd and J. Short.) pp. 119-134. (Cambridge University Press: Cambridge.)
- Bilton A.D. and Croft D.B. (2004). Lifetime reproductive success in a population of female red kangaroos *Macropus rufus* in the sheep rangelands of western New South Wales: environmental effects and population dynamics. *Australian Mammalogy* **26**, 45-60.
- Cairns, S.C. and Coombs, M.T. (1992). The monitoring of the distributions of commercially harvested species of macropod in New South Wales. Unpublished report to the Australian National Parks and Wildlife Service.

- Cairns, S.C. and Grigg, G.C. (1993). Population dynamics of red kangaroos (*Macropus rufus*) in relation to rainfall in the South Australian pastoral zone. *Journal of Applied Ecology* **30**, 444–458.
- Cairns, S.C., Grigg, G.C., Beard, L.A., Pople, A.R. and Alexander, P. (2000). Western grey kangaroos (*Macropus fuliginosus*) in the South Australian pastoral zone: populations at the edge of their range. *Wildlife Research* **27**, 309–318.
- Calaby, J.H. and Grigg, G.C. (1989). Changes in macropodoid communities and populations in the past 200 years, and the future. In 'Kangaroos, wallabies and rat-kangaroos'. (Eds G. Grigg, P. Jarman and I. Hume) pp. 813–820. (Surrey Beatty & Sons: Sydney).
- Caughley, G. (1964). Density and dispersion of two species of kangaroo in relation to habitat. *Australian Journal of Zoology* **12**, 238–249.
- Caughley, G. (1976). Wildlife management and the dynamics of ungulate populations. In 'Applied biology, Vol. 1'. (Ed. T.H. Coaker) pp. 183–246. (Academic Press: London).
- Caughley, G. (1987a). 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).
- Caughley, G. (1987b). Introduction to the sheep rangelands. In 'Kangaroos: their ecology and management in the sheep rangelands of Australia'. (Eds G. Caughley, N. Shepherd and J. Short.) pp. 1–13. (Cambridge University Press: Cambridge).
- Caughley, G. and Grigg, G.C. (1981). Surveys of the distribution and density of kangaroos in the pastoral zone of South Australia, and their bearing on the feasibility of aerial survey in large and remote areas. *Australian Wildlife Research* **8**, 1–11.
- Caughley, G., Grigg, G.C. and Smith, L. (1985). The effect of drought on kangaroo populations. *Journal of Wildlife Management* **49**, 679–685.
- Caughley, G., Grigg, G.C., Caughley, J. and Hill, G.J.E. (1980). Does dingo predation control the densities of kangaroos and emus? *Australian Wildlife Research* **7**, 1–12.
- Caughley, G., Short, J., Grigg, G.C. and Nix, H. (1987). Kangaroos and climate: an analysis of distribution. *Journal of Animal Ecology* **56**, 751–761.
- Caughley, G., Sinclair, R. and Scott-Kemmis, D. (1976). Experiments in aerial survey. *Journal of Wildlife Management* **40**, 290–300.
- Caughley, J., Bayliss, P. and Giles, J. (1984). Trends in kangaroo numbers in western New South Wales and their relation to rainfall. *Australian Wildlife Research* **11**, 415–422.
- Chippendale, G.M. (1968). The plants grazed by red kangaroos, *Megaleia rufa* (Desmarest), in central Australia. *Proceedings of the Linnean Society of New South Wales* **93**, 98–110.

- Choquenot, D. (1991). Short and medium-term effects of flooding on kangaroo density on an inland river system. Unpublished report to the Australian National Parks and Wildlife Service, Canberra.
- Clancy, T.F., Southwell, C., Weaver, K., McRae, P.D. and McDonnell, J.M. (1990). Post-flood die-off of kangaroos in southwestern Queensland. Unpublished report to the Queensland Department of Environment.
- Clegg, S., Hale, P. and Moritz, C. (1998). Molecular population genetics of the red kangaroo (*Macropus rufus*): mt DNA variation. *Molecular Ecology* **7**, 679-686.
- Corbert, L.K. and Newsome, A.E. (1987). The feeding ecology of the dingo. III. Dietary relationships with widely fluctuating prey populations in arid Australia: an hypothesis of alternation of predation. *Oecologia* **74**, 215-227.
- Coulson, G. (2008). Western grey kangaroo. In 'The Mammals of Australia.' Third edn. (Eds S Van Dyck and R Strahan) pp. 333-334. (Reed New Holland: Sydney).
- Coulson, G. and Norbury, G. (1988). Ecology and management of western grey kangaroos (*Macropus fuliginosus*) at Hattah-Kulkyne National Park. Arthur Rylah Institute for Environmental Research Technical Report Series no. 72.
- Croft, D.B. (1980). Behaviour of red kangaroos, *Macropus rufus* (Desmarest 1822), in north-western NSW, Australia. *Australian Mammalogy* **4**, 5-58.
- Croft, D.B. (1991). Home range of the red kangaroo *Macropus rufus*. *Journal of Arid Environments* **20**, 83-98.
- Croft, D.B. and Clancy, T.F. (2008). Red kangaroo. In 'The Mammals of Australia.' Third edn. (Eds S. Van Dyck and R. Strahan) pp. 352-354. (Reed New Holland: Sydney).
- Da Silveira Costa, M.I. and Faria, L.D.B. (2011). Induced oscillations generated by protective threshold policies in the management of exploited populations. *Natural Resource Modeling* **24**, 183-206.
- Dawson, T.J., McTavish, K.J. and Ellis, B.A. (2004). Diets and foraging behaviour of red and eastern grey kangaroos in arid shrub land: is feeding behaviour involved in the range expansion of the eastern grey kangaroo into the arid zone? *Australian Mammalogy* **26**, 169-178.
- Denny, M.J.S. (1980). Red kangaroo arid zone studies. Unpublished report to the Australian National Parks and Wildlife Service, Canberra.
- Edwards, G.P., Croft, D.B. and Dawson, T.J. (1994). Observations of differential sex/age class mobility in red kangaroos (*Macropus rufus*). *Journal of Arid Environments* **27**, 169-177.
- Ellis, B.A. (1976). Diet selection in two native and introduced herbivores in an Australian rangeland region. *Australian Rangeland Journal* **1**, 78.

- Engen, S., Lande, R. and Saether, B-E. (1997). Harvesting strategies for fluctuating populations based on uncertain population estimates. *Journal of Theoretical Biology* **186**, 201-212.
- Fisher, A., Hunt, L., James, C., Landsberg, J., Phelps, D., Smyth, A. and Watson, I. (2004). 'Review of total grazing pressure management issues and priorities for biodiversity conservation in rangelands: a resource to aid NRM planning.' (Desert Knowledge CRC and Tropical Savannas Management CRC: Alice Springs).
- Frith, H.J. (1964). Mobility of the red kangaroo, *Megaleia rufa*. *CSIRO Wildlife Research* **9**, 1-19.
- Frith, H.J. and Sharman, G. (1964). Breeding in wild populations of the red kangaroo, *Megaleia rufa*. *CSIRO Wildlife Research* **9**, 86-114.
- Gilroy, J., Curran, G. and Gay, E. (1999). Dealing with an epidemic in macropods. In 'Proceedings of the Australian Rangeland Society Centenary Symposium'. (Australian Rangeland Society: Sydney).
- Griffiths, M. and Barker, R. (1966). The plants eaten by sheep and by kangaroos grazing together in a paddock in south-western Queensland. *CSIRO Wildlife Research* **11**, 145-167.
- Grigg, G. (1984). Are kangaroos really under threat? *Australian Natural History* **21**, 123-129.
- Grigg G.C. (1988). Kangaroo harvesting and the conservation of the sheep rangelands. *Australian Zoologist* **24**, 124-128.
- Grigg, G. (1995). Kangaroo harvesting for conservation of rangelands, kangaroos and graziers. In 'Conservation Through Sustainable Use of Wildlife'. (Eds G.C. Grigg, P.T. Hale and D. Lunney.) pp. 161-165. (Centre for Conservation Biology, The University of Queensland: Brisbane).
- Grigg, G.C. and Pople, A.R. (2001). Sustainable use and pest control: kangaroos, a case study. In 'Conservation of Exploited Species'. (Eds J.D. Reynolds, G. Mace and K.H. Redford.) (Cambridge University Press: Melbourne).
- Hacker, R. and McLeod, S. (2003). 'Living with kangaroos: a guide to kangaroos and their management in the Murray-Darling Basin.' (New South Wales Department of Agriculture: Orange).
- Hacker, R., McLeod, S., Druhan, J., Tenhumberg, B. and Pradhan, U. (2004). Kangaroo management options in the Murray-Darling Basin. Report to Murray-Darling Basin Commission. (Murray-Darling Basin Commission: Canberra).
- Hale, P.T. (2001). Kangaroo genetics: impacts of harvesting. (New South Wales National Parks and Wildlife Service: Dubbo). Available from: <http://www.nationalparks.nsw.gov.au/PDFs/genetics.pdf>.

- Hale, P.T. (2004). Genetic effects of kangaroo harvesting. *Australian Mammalogy* **26**, 75-86.
- Hooper, P.T., Lunt, R.A., Gould, A.R., Hyatt, A.D., Russell, G.M., Kattenbelt, J.A., Blacksell, S.D., Reddacliff, L.A., Kirkland, P.D., Davis, R.J. Durham, P.J.K., Bishop, A.L. and Waddington, J. (1999). Epidemic of blindness in kangaroos – evidence of a viral aetiology. *Australian Veterinary Journal* **77**, 529-536.
- IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <<http://www.iucnredlist.org>>. Downloaded 12 April 2011.
- Jarman, P.J. and Denny, M.J.S. (1976). Red kangaroos and land use along the New South Wales, Queensland and South Australian borders. In 'Agriculture, forestry and wildlife: conflict or coexistence?' (Ed. P.J. Jarman) pp. 56-67. (University of New England: Armidale).
- Jarman, P.J. and Southwell, C.J. (1986). Grouping, associations, and reproductive strategies in eastern grey kangaroos. In 'Ecological aspects of social evolution'. (Eds D.I. Rubenstein and R.W. Wrangham) pp. 399-428. (Princeton University Press: Princeton, NJ).
- Jarman, P.J. and Taylor, R.J. (1983). Ranging of eastern grey kangaroos and wallaroos on a New England pastoral property. *Australian Wildlife Research* **10**, 33-38.
- Johnson C.N. (1989) Dispersal and philopatry in the Macropodoids. In 'Kangaroos, wallabies and rat-kangaroos. Vol. 2.' (Eds G.C. Grigg, P.J. Jarman and I.D. Hume) pp. 593-601. (Surrey Beatty & Sons: Chipping Norton).
- Johnson, C.N. and Bayliss, P.G. (1981). Habitat selection by sex, age and reproductive class in the red kangaroo, *Macropus rufus*, in western New South Wales. *Australian Wildlife Research* **8**, 465-474.
- Jonzén N., Pople T., Knappe J. and Sköld M. (2010). Stochastic demography and population dynamics in the red kangaroo *Macropus rufus*. *Journal of Animal Ecology* **79**, 109-116.
- Kay, B., Gifford, E., Perry, R. and van der Ven, R. (2000). Trapping efficiency for foxes (*Vulpes vulpes*) in central New South Wales: age and sex biases and the effects of reduced fox abundance. *Wildlife Research* **27**, 547-552.
- Kirkpatrick, T.H. (1967). The red kangaroo in Queensland. *Queensland Agricultural Journal* **93**, 484-486.
- Kirkpatrick, T.H. (1985). Biology for management. In 'The kangaroo keepers'. (Ed. H.J. Lavery.) pp. 135-160. (University of Queensland Press: Brisbane).
- Kirsch, J.A.W. and Poole, W.E. (1967). Serological evidence for speciation in the grey kangaroo, *Macropus giganteus* Shaw 1790 (Marsupalia: Macropodidae). *Nature* **215**, 1097-1098.

Kirsch, J.A.W. and Poole, W.E. (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.

Letnic M. and Koch F. (2010). Are dingoes a trophic regulator in arid Australia? A comparison of mammal communities on either side of the dingo fence. *Austral Ecology* **35**, 167-175.

Low, W.A., Müller, W.J., Dudzinski, M.L. and Low, B.S. (1981). Population fluctuations and range community preference of red kangaroos in central Australia. *Journal of Applied Ecology* **18**, 27-36.

McCarthy, M.A. (1996). Red kangaroo (*Macropus rufus*) dynamics: effects of rainfall, density dependence, harvesting and environmental stochasticity. *Journal of Applied Ecology* **33**, pp. 45-53.

McNamara, K.J. and Prince, R.I.T. (1986). Kangaroo management in Western Australia. Western Australian Wildlife Management Program No.3. (Department of Conservation and Land Management: Perth).

Munn A.J., Dawson T.J., McLeod S.R., Croft D.B., Thompson M. B. and Dickman C.R. (2009). Field metabolic rate and water turnover of red kangaroos and sheep in an arid rangeland: an empirically derived dry-sheep-equivalent for kangaroos. *Australian Journal of Zoology* **57**, 23-28.

Moss G.L. and Croft D.B. (1999). Body condition of the red kangaroo (*Macropus rufus*) in arid Australia: The effect of environmental condition, sex and reproduction. *Australian Journal of Ecology* **24**, 97-109.

Neaves L.E., Zenger K.R., Prince R.I.T and Eldridge M.D.B. (2012). Impact of Pleistocene aridity oscillations on the population history of a widespread, vagile Australian mammal, *Macropus fuliginosus*. *Journal of Biogeography* **39**, 1545-1563.

Neaves L.E., Zenger K.R., Prince R.I.T., Eldridge M.D.B. and Cooper D.W. (2009). Landscape discontinuities influence gene flow and genetic structure in a large, vagile Australian mammal, *Macropus fuliginosus*. *Molecular Ecology* **18**, 3363-3378.

Newsome, A.E. (1964a). Anoestrus in the red kangaroo, *Megaleia rufa* (Desmarest). *Australian Journal of Zoology* **12**, 9-17.

Newsome, A.E. (1964b). Oestrus in the lactating red kangaroo, *Megaleia rufa* (Desmarest). *Australian Journal of Zoology* **12**, 315-321.

Newsome, A.E. (1965a). The distribution of red kangaroos, *Megaleia rufa* (Desmarest), about sources of persistent food and water in central Australia. *Australian Journal of Zoology* **13**, 289-299.

Newsome, A.E. (1965b). Reproduction in natural populations of the red kangaroo, *Megaleia rufa* (Desmarest), in central Australia. *Australian Journal of Zoology* **13**, 735-759.

Newsome, A.E. (1975). An ecological comparison of the two arid-zone kangaroos of Australia and their anomalous prosperity since the introduction of ruminant stock to their environment. *Quarterly Review of Biology* **50**, 389-424.

Norbury, G.L. (1987). Diet selection by western grey kangaroos in relation to declining food availability. In 'Herbivore nutrition research'. (Ed. M. Rose.) pp. 75-76. (Australian Society for Animal Production: Brisbane).

Norbury, G.L. and Norbury, D.C. (1993). The distribution of red kangaroos in relation to range regeneration. *The Rangeland Journal* **15**, 3-11.

Norbury, G.L., Norbury, D.C. and Oliver, A.J. (1994). Facultative behaviour in unpredictable environments: mobility of red kangaroos in arid Western Australia. *Journal of Animal Ecology* **63**, 410-418.

Oliver, A. (1986). Social organisation and dispersal in the red kangaroo. PhD thesis. (Murdoch University: Perth).

Pople, A. (2004). Population monitoring for kangaroo management. *Australian Mammalogy* **26**, 37-44.

Pople, A.R. (2008). Frequency and precision of aerial surveys for kangaroo management. *Wildlife Research* **35**, 340-348.

Pople, A.R. and Page, M. (2001). Management of artificial watering points on National Parks in western Queensland. Report for the Queensland National Parks and Wildlife Service.

Pople, A.R., Cairns, S.C., Menke, N. and Payne, N. (2006). Estimating the abundance of eastern grey kangaroos (*Macropus giganteus*) in south-eastern New South Wales, Australia. *Wildlife Research* **33**, 93-102.

Pople, A.R., Evans, M., Farroway, L., Gilroy, J., Grigg, G.C., Lundie-Jenkins, G. and 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 M. Eldridge) pp. 371-397. (CSIRO: Melbourne).

Pople, A., Grigg, S.C., Cairns, S.C., Beard, L.A., and 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, A.R., Grigg G.C., Phinn, S.R., Menke, N., McAlpine, C. and Possingham, H. (2010). Reassessing the spatial and temporal dynamics of kangaroo populations. In 'Macropods: the biology of kangaroos, wallabies and rat-kangaroos.' (Eds G. Coulson and M. Eldridge) pp. 197-218. (CSIRO: Melbourne).

Pople, T. (2003). Harvest management of kangaroos during drought. Report to the New South Wales National Parks and Wildlife Service. Available from: (http://www.nationalparks.nsw.gov.au/npws.nsf/Content/PDFs/NSWNPWS_drought_harvestmanagement_colour.pdf).

- Pople, T. and Grigg, G. (1999). Commercial harvesting of kangaroos in Australia. (Department of the Environment and Heritage: Canberra). Available from: (<http://www.deh.gov.au/biodiversity/trade-use/wild-harvest/kangaroo/harvesting/index.html>).
- Priddel, D. (1987). The mobility and habitat utilization of kangaroos. In 'Kangaroos: their ecology and management in the sheep rangelands of Australia'. (Eds G. Caughley, N. Shepherd and J. Short.) pp. 100-118. (Cambridge University Press: Cambridge).
- Priddel, D., Shepherd, N. and Wellard, G. (1988a). Home ranges of sympatric red kangaroos, *Macropus rufus*, and western grey kangaroos, *M. fuliginosus*, in western New South Wales. *Australian Wildlife Research* **15**, 405-411.
- Priddel, D., Wellard, G. and Shepherd, N. (1988b). Movements of sympatric red kangaroos, *Macropus rufus*, and western grey kangaroos, *M. fuliginosus*, in western New South Wales. *Australian Wildlife Research* **15**, 339-346.
- Read, J.L., and Wilson, D. (2004). Scavengers and detritivores of kangaroo harvest offcuts in arid Australia. *Wildlife Research* **31**, 51-56.
- Reddacliff, L. A., Kirkland, P. D., Philby, A., Davis, R., Vogelnest, L., Hulst, F., Blyde, D., Deykin, A., Smith, J., Hooper, P., Gould, A.R. and Hyatt, A. (1999). Experimental reproduction of viral chorioretinitis in kangaroos. *Australian Veterinary Journal* **77**, 522-528.
- Robertson, G.G. (1986). The mortality of kangaroos in drought. *Australian Wildlife Research*, **13**, 349-354.
- Russell, E.M. (1974). The biology of kangaroos (Marsupalia - Macropodidae). *Mammal Review* **4**, 1-59.
- Saunders, G., Coman, B., Kinnear, J. and Braysher, M. (1995). 'Managing vertebrate pests: foxes'. (Bureau of Resource Sciences: Canberra).
- Sharman, G.B. (1964). The female reproductive system of the red kangaroo, *Megaleia rufa*. *CSIRO Wildlife Research* **9**, 50-57.
- Sharman, G.B. and Pilton, P.E. (1964). The life history and reproduction of the red kangaroo (*Megaleia rufa*). *Proceedings of the Zoological Society of London* **142**, 29-48.
- Shepherd, N.C. (1981). Predation of red kangaroos, *Macropus rufus*, by the dingo, *Canis familiaris dingo* (Blumenbach), in north-western New South Wales. *Australian Wildlife Research* **8**, 255-262.
- Short, J. and Grigg, G.C. (1982). The abundance of kangaroos in suboptimal habitats: wheat, intensive pastoral and mallee. *Australian Wildlife Research* **9**, 221-228.
- Short, J., Caughley, G., Grice, D. and Brown, B. (1983). The distribution and abundance of kangaroos in relation to environment in Western Australia. *Australian Wildlife Research* **10**, 435-451.

- Southwell, C.J., Weaver, K.E., Cairns, S.C., Pople, A.R., Gordon, A.N., Sheppard, N.W. and Broers, R. (1995). Abundance of macropods in north-eastern New South Wales, and the logistics of broad-scale ground surveys. *Wildlife Research* **22**, 757-766.
- Speare, R., Donovan, J.A., Thomas, A.D. and Speare P.J. (1989). Diseases of free-ranging Macropodoidea. In 'Kangaroos, wallabies and rat-kangaroos'. (Eds G. Grigg, P. Jarman and I. Hume.) pp. 705-734. (Surrey Beatty and Sons: Sydney).
- Squires, V.R. (1982). Competitive interactions in the dietary preference of kangaroos, sheep, cattle and goats in inland Australia. *Journal of Arid Environments* **5**, 337-345.
- Storr, G.M. (1968). Diet of kangaroos (*Megaleia rufa* and *Macropus robustus*) and merino sheep near Port Headland, Western Australia. *Journal of the Royal Society of Western Australia* **51**, 25-32.
- Tenhumberg, B., Tyre, A.J., Pople, A.P. and Possingham, H.P. (2002). Evolutionary responses to selective harvesting in a stochastic environment. Report to the Murray-Darling Basin Commission. (Murray-Darling Basin Commission: Canberra).
- Tenhumberg, B., Tyre, A.J., Pople, A.P. and Possingham, H.P. (2004). Do harvest refuges buffer kangaroos against evolutionary responses to selective harvesting? *Ecology* **85**, 2003-2017.
- Thompson, P.C. (1992). The behavioural ecology of dingoes in north-western Australia. III. Hunting and feeding behaviour, and diet. *Wildlife Research* **19**, 531-541.
- Tyndale-Biscoe, H. (2005). 'Life of marsupials.' (CSIRO: Melbourne).
- Wilson, D. and Read, J.L. (2003). Kangaroo harvesters: fertilising the rangelands. *The Rangeland Journal* **25**, 47-55.