2019 Commercial Kangaroo Harvest Quota Submission

for Western Australia

For submission under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

December 2018

GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

CONTENTS

1. PROPOSED QUOTAS FOR WESTERN AUSTRALIA FOR 2019

This document presents the proposed quotas for commercial kangaroo harvest in Western Australia for 2019. This document should be read and considered in conjunction with the *Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2019-2023.*

1.1 State Summary

Species	2019 Proposal			2018		
	2018 Population estimate[a]	Harvest rate (%)	**Quota**	Quota	Harvest rate (%)	2017 Population estimate[1]
Red kangaroo	**1,825,760**	17	**310,370**	248,920	17	1,464,330
Western grey kangaroo	**2,423,800**	15	**363,570**	340,540	15	2,270,445
Totals	**4,249,560**	~15.8	**673,940**	589,460	~15.8	3,734,775

[a, 1] Note: aerial surveys are conducted within the commercial harvest zone only, which comprises about 51% of the State of Western Australia (see Fig. 2.1 for details).

1.2 Regional Quotas for Red Kangaroos in 2019

(See Fig. 2.1 for location of regions)

Zone	2018 Population estimate[a] ($\widehat{N}$)	2019 Proposal	
		Harvest rate (H) %	**Quota ($\widehat{N} \times H$)**
Central	857,350±64,300	17	145,750
Northern	603,660	17	102,620
South-East	364,750	17	62,000
Totals	**1,825,760**	**17**	**310,370**

[a] Standard errors are provided only where a monitoring zone has been surveyed in full.

1.3 Regional Quotas for Western Grey Kangaroos in 2019

(See Fig. 2.1 for location of regions)

Zone	2018 Population estimate[a] ($\widehat{N}$)	2019 Proposal	
		Harvest rate (H) %	**Quota ($\widehat{N} \times H$)**
Central	637,660±157,800	15	95,650
South-East	816,840	15	122,525
South-West	969,300±105,250	15	145,395
Totals	**2,423,800**	**15**	**363,570**

[a] Standard errors are provided only where a monitoring zone has been surveyed in full.

2. POPULATION ESTIMATION METHODS

2.1 Fixed-wing Aerial Survey

The aerial survey program was outsourced to contractors in 2014 for the first time since the Department took over managing the survey program from the Commonwealth in 1995. During 2018, the Central Zone was surveyed in full and monitor blocks were surveyed in the South-West Zone (Fig. 2.1) using standard fixed-wing aerial survey methodology (Pople & Grigg 1999).

Table 2.1. Aerial survey parameters.

Altitude	250 feet (76 metres) AGL
Speed	100 knots
Strip width	200 metres
Survey unit	5 kilometres long by 200 metres wide = 1 km^2
Survey line	1 degree of longitude
Survey intensity	2 lines per one degree block (one degree latitude by one degree longitude)
Species	Euro, red and western grey kangaroos
Extent	Pastoral rangelands and parts of the northern and south coast agricultural regions (see Fig. 2.1).
Frequency	Whole of commercial harvest zone was surveyed triennially from 1981 to 1993 (1981, 1984, 1987, 1990, 1993). Then, in part, annually: • Northern Zone in 1995, 1998, 2001, 2004, 2007, 2010, 2013 and 2016. • South-East Zone in 1996, 1999, 2002, 2005, 2008, 2011, 2014 and 2017. • Central Zone in 1997, 2000, 2003, 2006, 2009, 2012, 2015 and 2018.
Monitor blocks	• Monitor block surveys in zones not covered by main survey in 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011 and 2012. • Monitor blocks in the South-West Zone in 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2012, 2013, 2014, 2015, 2016, 2017 and 2018.
Methodology	Standard 200 metre fixed-width strip surveys flown at 100 knots (185 km/hr), 76 metres above ground level (see Pople & Grigg 1999). Population estimates are made using standard Caughley correction factors (see Table 2.2 for details) with temperature correction for all species.

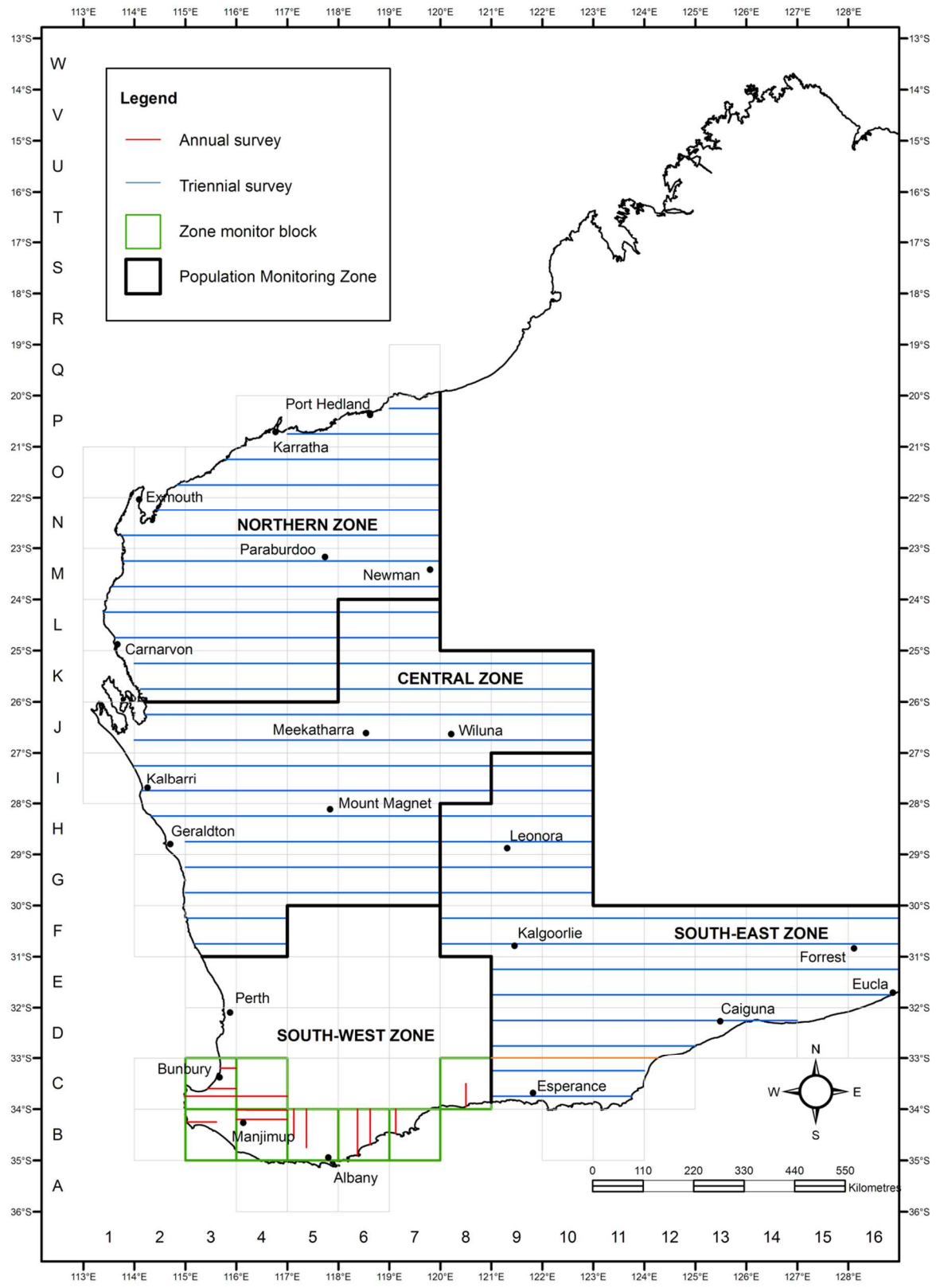

Fig. 2.1. Zone boundaries, aerial survey block codes and aerial survey flight lines.

It is not possible to count all kangaroos within the 200-metre strip when undertaking an aerial survey. This is because the aircraft is flying relatively high and fast, and vegetation may obscure kangaroos on the ground. The survey has, however, been standardised so that correction factors can be applied to account for the unseen kangaroos. These correction factors are related to the vegetation cover in the categories provided below in Table 2.2.

Standard aerial surveys produce estimates for major regions of the order of 100,000 km^2, rather than localised small areas. The State may choose to increase the survey intensity in order to get a potentially more accurate estimate for the surveyed area.

Table 2.2. Standard fixed-wing aerial survey correction factors used for population estimation.

Species	Correction Factor[a]			
	Open Vegetation	Light Vegetation	Medium Vegetation	Dense Vegetation
Red Kangaroo (*Macropus rufus*)	2.29[b]	2.36[b]	2.43[b]	2.57[b]
Western Grey Kangaroo (*Macropus fuliginosus*)	4.8[c]	4.8[c]	4.8[c]	4.8[c]
Euro (*Macropus robustus*)	4.8[c]	4.8[c]	4.8[c]	4.8[c]

[a] Used to correct raw counts to reliable population estimates. Accounts for the proportion of kangaroos missed by observers following standard counting methodologies.
[b] From Caughley *et al.* (1976).
[c] From Pople & Grigg (1999). Temporary standard as agreed by State kangaroo program managers in 1998 (giving multiplication of 2.1 to 1.8 over standard (Caughley *et al.* 1977) correction factors for Red Kangaroos). Previously multipliers of between 2 and 4 for standard (Caughley *et al.* 1976) Red Kangaroo correction factors had been promoted by the Federal Government's National Kangaroo Monitoring Unit.

2.2 Ground Survey

No regular quantitative ground surveys are undertaken in Western Australia. The reason for this being that the standard aerial survey method can be applied efficiently to most areas without any difficulties. Heavily wooded and forested areas are restricted to the south-west region of the State, an area that does not form any part of the commercial harvest zone for red kangaroos. The use of ground survey would in any case be of very limited value in the south-west due to the fragmented nature of much of the vegetation along with the extensive forested areas in the central and southern parts of the south-west. The carrying of firearms in State forest is generally prohibited and the shooting of native fauna including kangaroos without licence is prohibited under the *Wildlife Conservation Regulations 1970*.

Ground surveys are expensive to conduct and, while they can give accurate assessments of local kangaroo populations, the proportion of the natural range of either red or western grey kangaroos that can be covered effectively by ground surveys is so small as to make this survey method unsuitable for broad scale population estimates. Rather, ground surveys are better suited to smaller scale population estimates or to confirm the nature of unexplained mortality. They have been used successfully in the past when epizootic diseases such as lumpy jaw or choroid blindness have occurred.

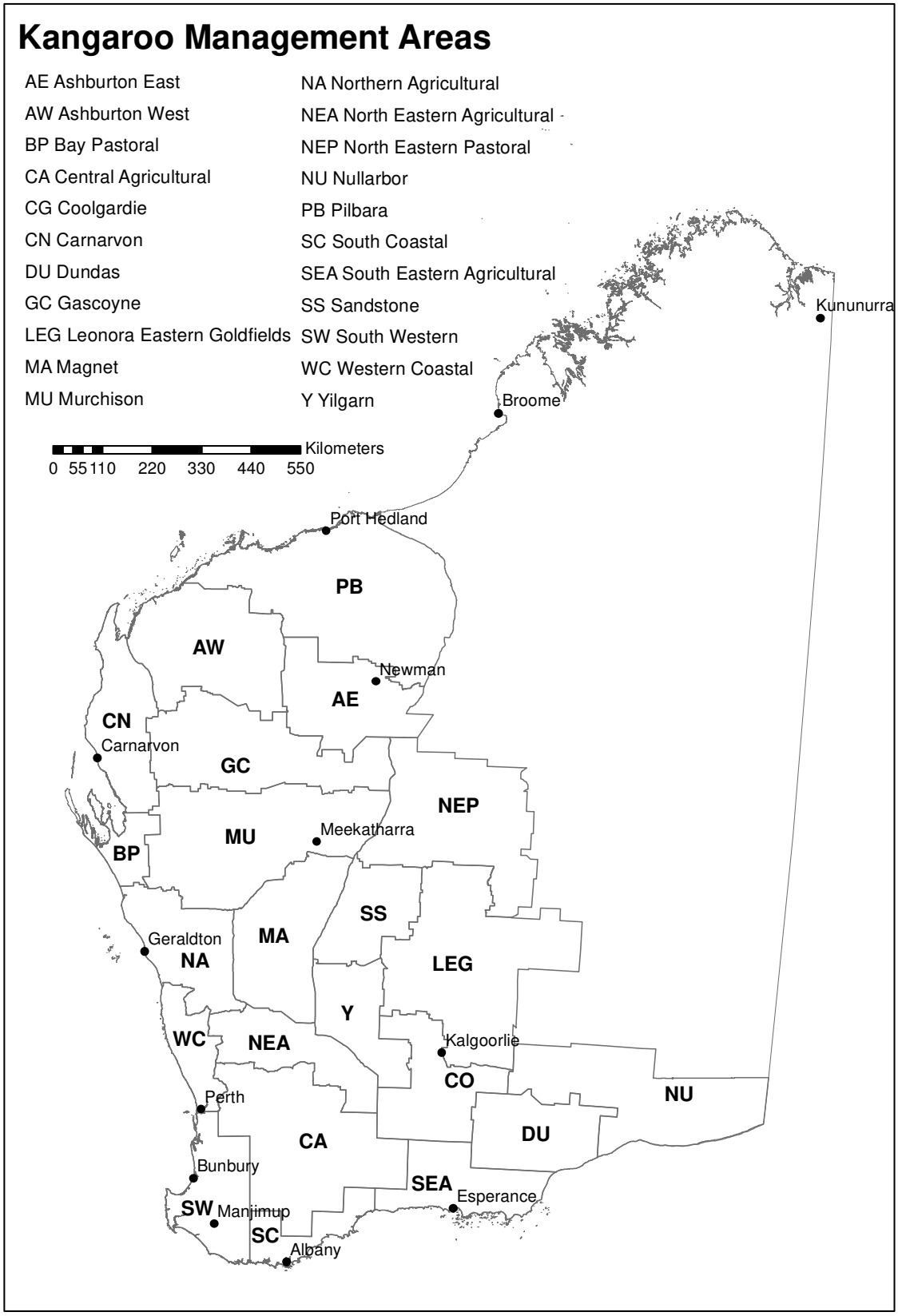

Fig. 2.2. Kangaroo Management Areas in Western Australia.

3. CRITERIA USED IN SETTING QUOTAS

The proposed quota is set in accordance with Actions 9-12 of the Management Plan and takes into consideration information available on:

- historical commercial harvest statistics (see Appendix 1);
- seasonal conditions (see Appendix 2);
- current population trends (see Appendix 3);
- the proportion of the habitat and population not subject to harvesting;
- current land use practice and trends in land use; and
- significance of the non-commercial take relative to the population estimates, commercial quota and commercial harvest

4. HARVEST MONITORING

Species: red and western grey kangaroo.
Extent: commercial harvest zone (see Fig. 2.1).
Frequency: continuous (see section 2.1).
Methodology: analysis of trends in:

- commercial take;
- sex ratio;
- average weight by sex

(see appendices 1 and 3).

5. REFERENCES

Caughley G., Sinclair R. and Scott-Kemmis D. (1976) Experiments in aerial survey. *Journal of Wildlife Management* **40**, 290-300.

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

Pople T. and Grigg G. (1999) 'Commercial harvesting of kangaroos in Australia.' (Environment Australia: Canberra). Available online at: http://www.environment.gov.au/biodiversity/trade-use/wild-harvest/kangaroo/harvesting/index.html

APPENDIX 1. HARVEST MONITORING RESULTS FOR WESTERN AUSTRALIA

Harvest data for 2018, presented in the figures and tables in Appendix 1, only includes data processed prior to 30 September 2018.

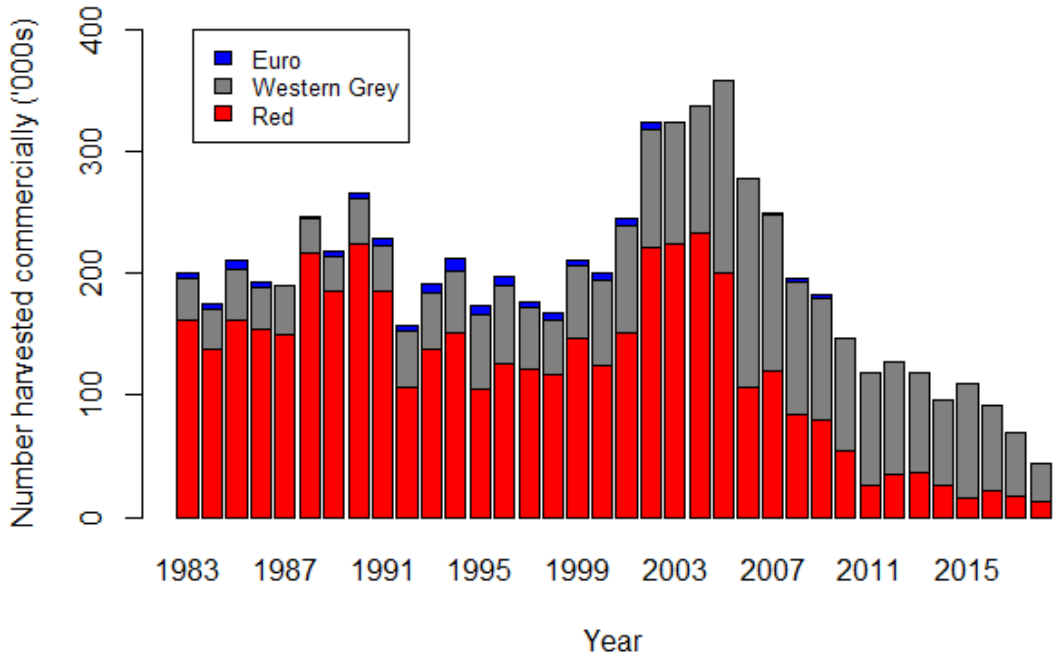

Fig. A1.1. Total commercial kangaroo harvest in Western Australia from 1983 to 2018. There was no commercial harvest of euros from 2003-2006 and from 2010-2015.

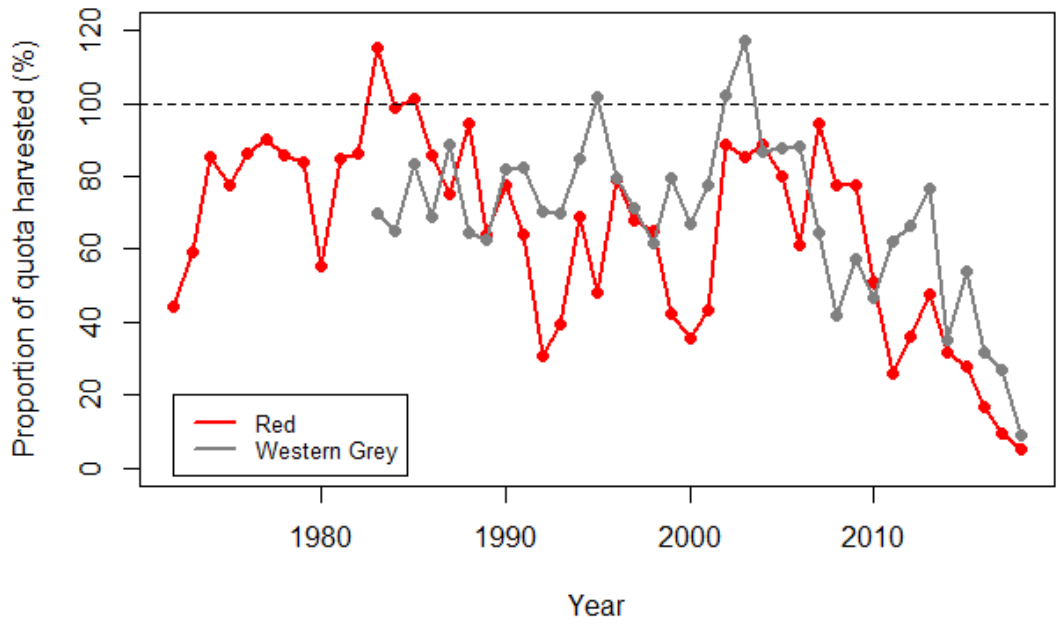

Fig. A1.2. Proportion of the commercial quota harvested in Western Australia from 1972 to 2018.

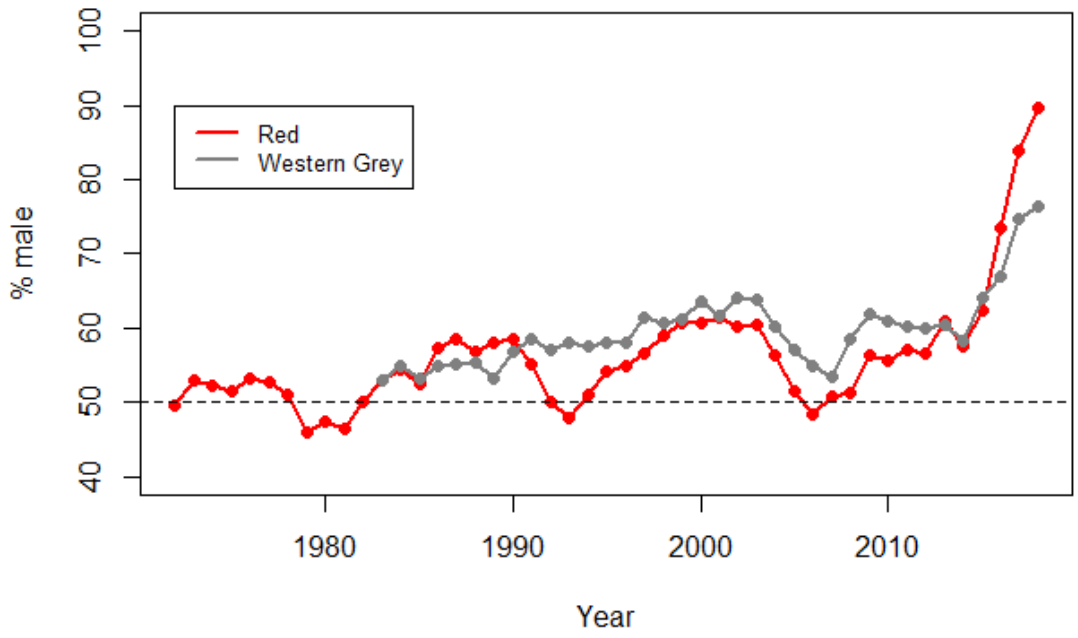

Fig. A1.3. Sex ratio of the commercial kangaroo harvest in Western Australia from 1972 to 2018.

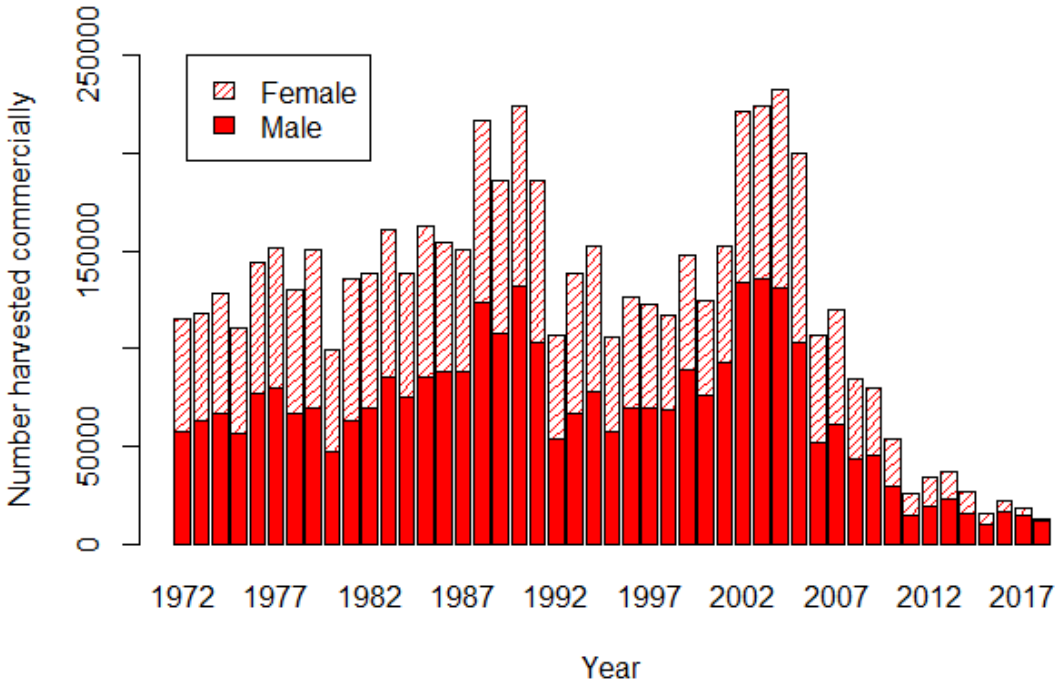

Fig. A1.4. Number of red kangaroos harvested commercially in Western Australia from 1972 to 2018.

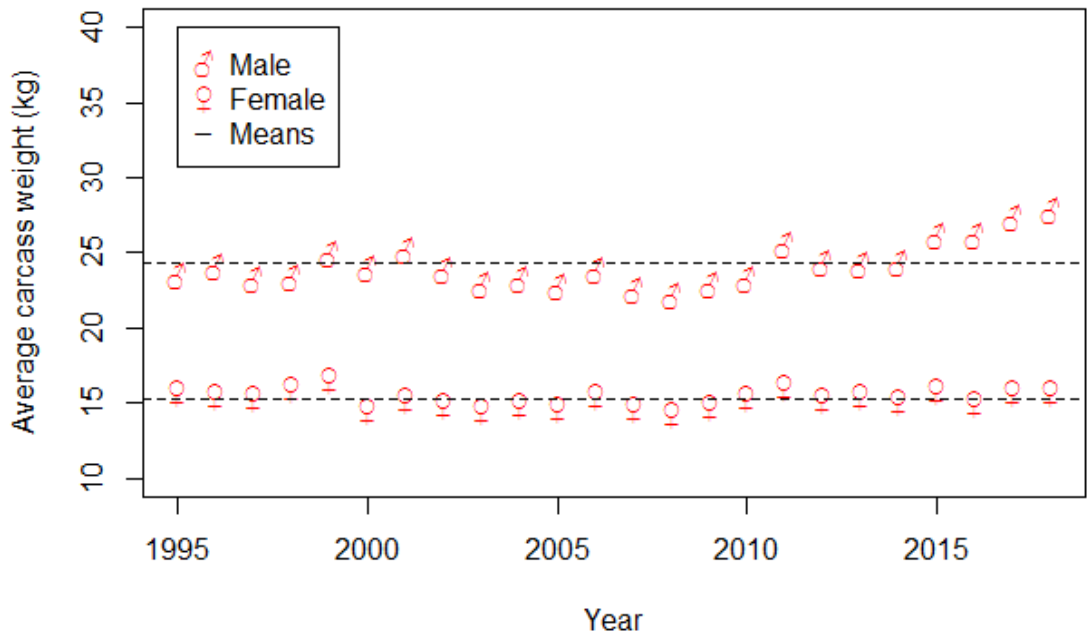

Fig. A1.5. Average carcass weights for red kangaroos harvested commercially in Western Australia from 1995 to 2018. Carcass dressing methods (and therefore carcass weights) are not standardised.

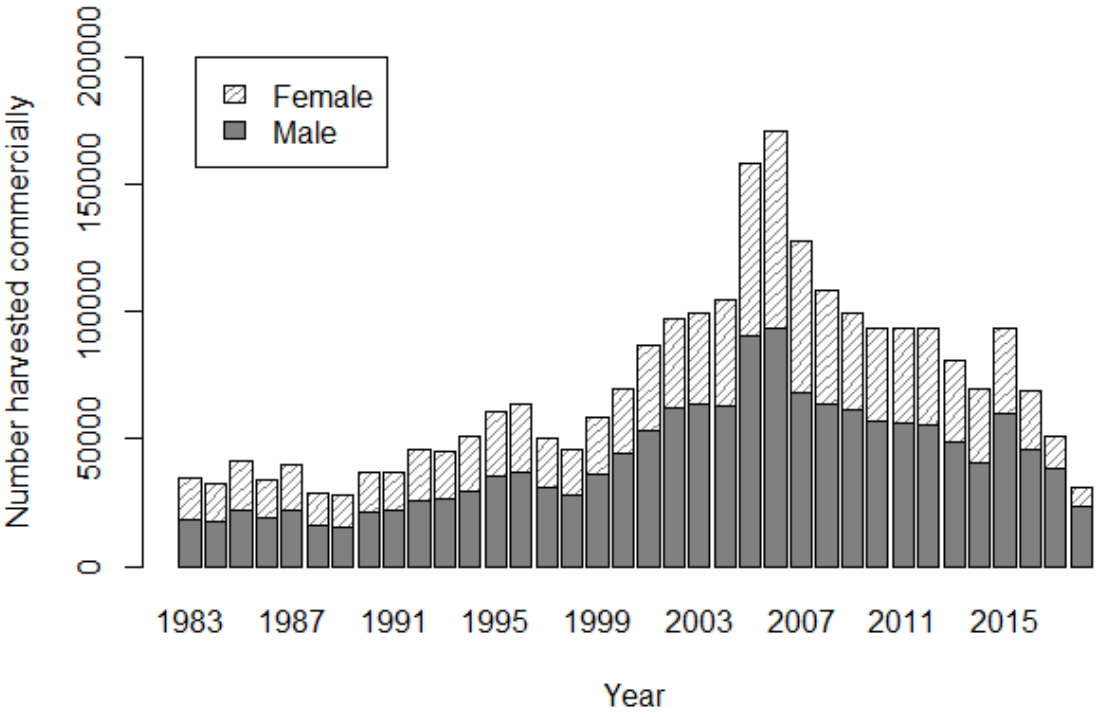

Fig. A1.6. Number of western grey kangaroos harvested commercially in Western Australia from 1983 to 2018.

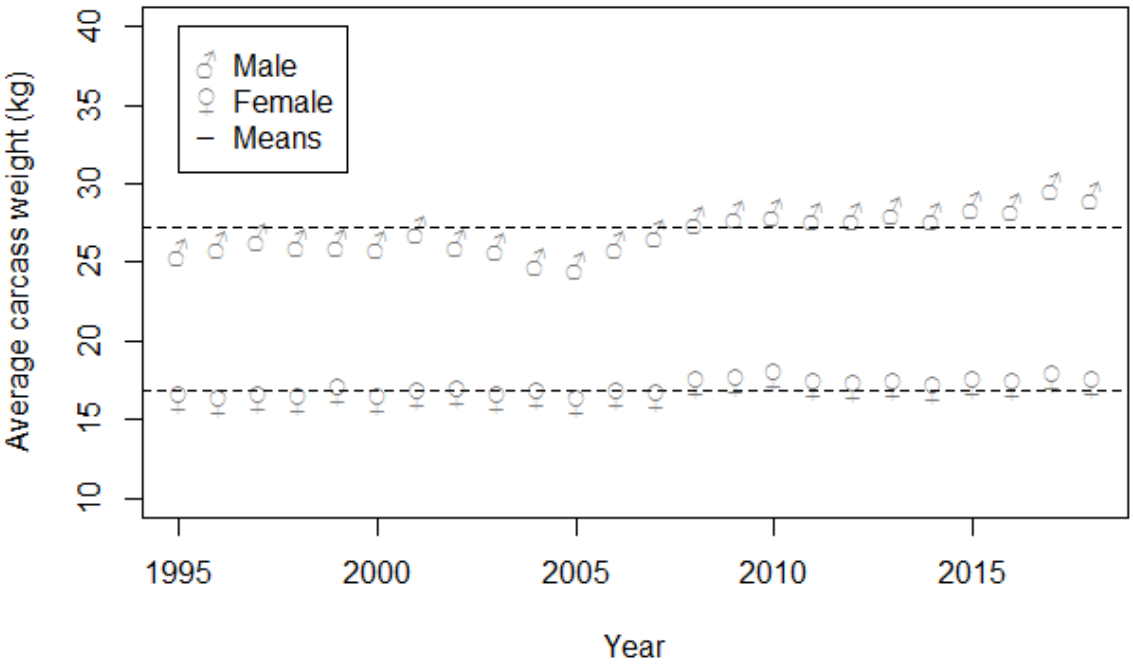

Fig. A1.7. Average carcass weights for western grey kangaroos harvested commercially in Western Australia from 1995 to 2018. Carcass dressing methods (and therefore carcass weights) are not standardised.

APPENDIX 2. RAINFALL AND DROUGHT MAPS

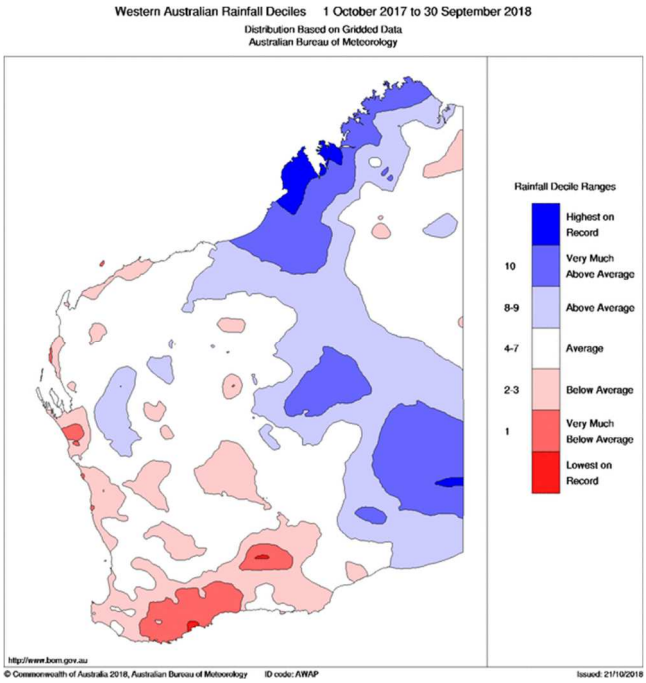

Fig. A2.1. Rainfall deciles for Western Australia for the period 1 October 2017 to 30 September 2018 (last 12 months).

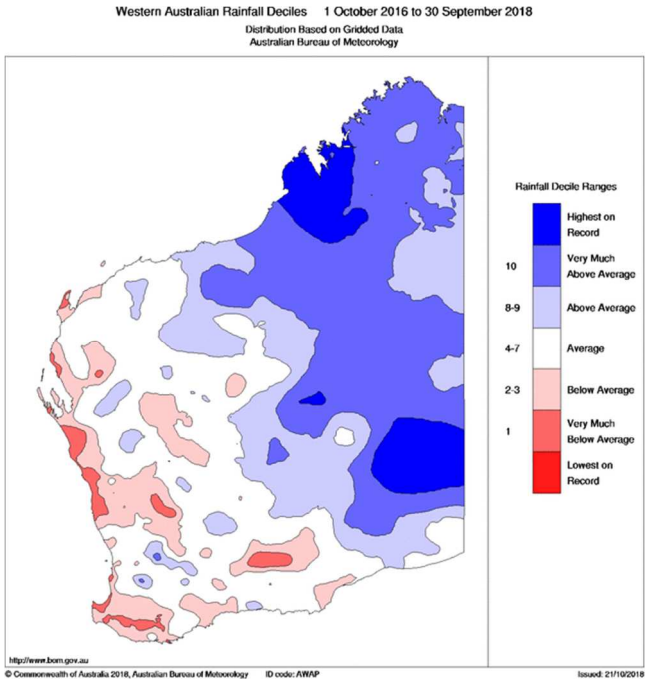

Fig. A2.2. Rainfall deciles for Western Australia for the period 1 October 2016 to 30 September 2018 (last 24 months).

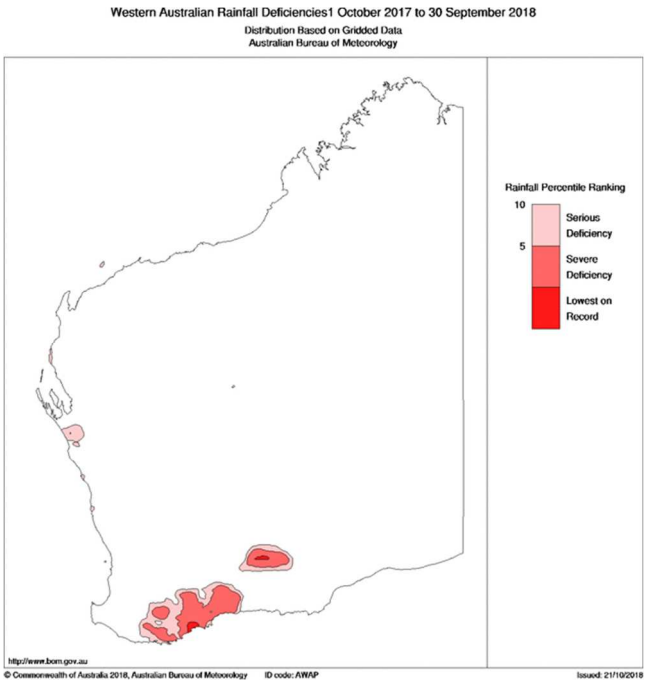

Fig. A2.3. Drought map for Western Australia for the period 1 October 2017 to 30 September 2018 (last 12 months).

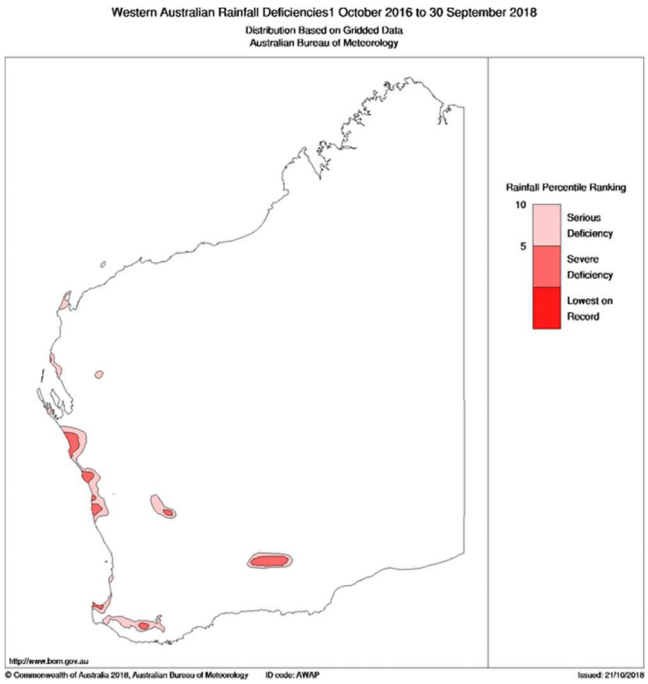

Fig. A2.4. Drought map for Western Australia for the period 1 October 2016 to 30 September 2018 (last 24 months).

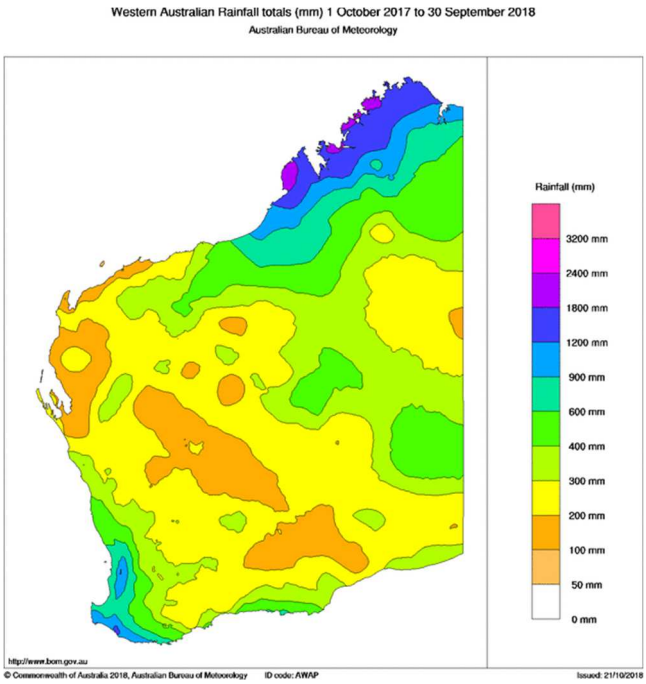

Fig. A2.5. Rainfall totals for Western Australia for the period 1 October 2017 to 30 September 2018 (last 12 months).

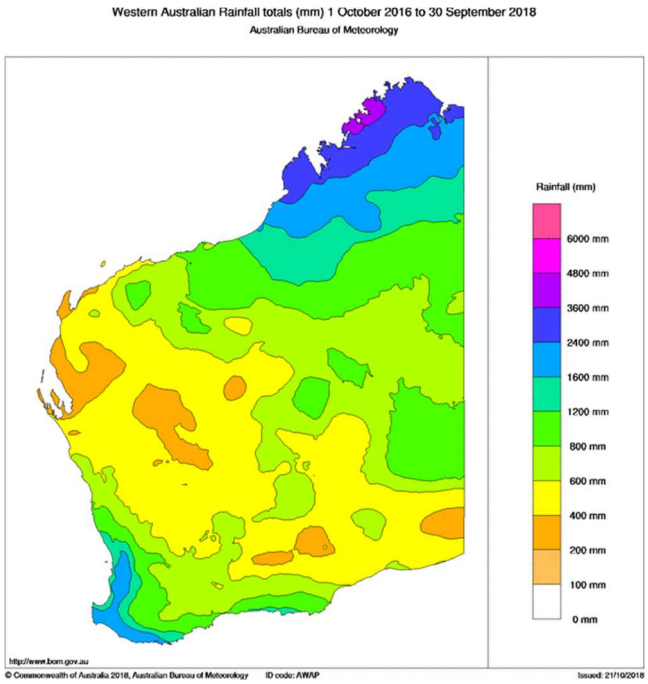

Fig. A2.6. Rainfall totals for Western Australia for the period 1 October 2016 to 30 September 2018 (last 24 months).

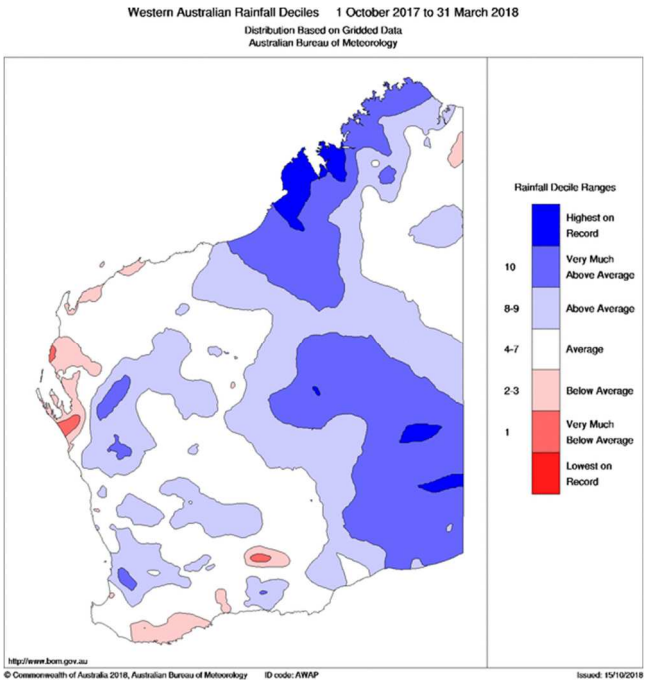

Fig. A2.7. Summer rainfall deciles for Western Australia for the period 1 October 2017 to 31 March 2018.

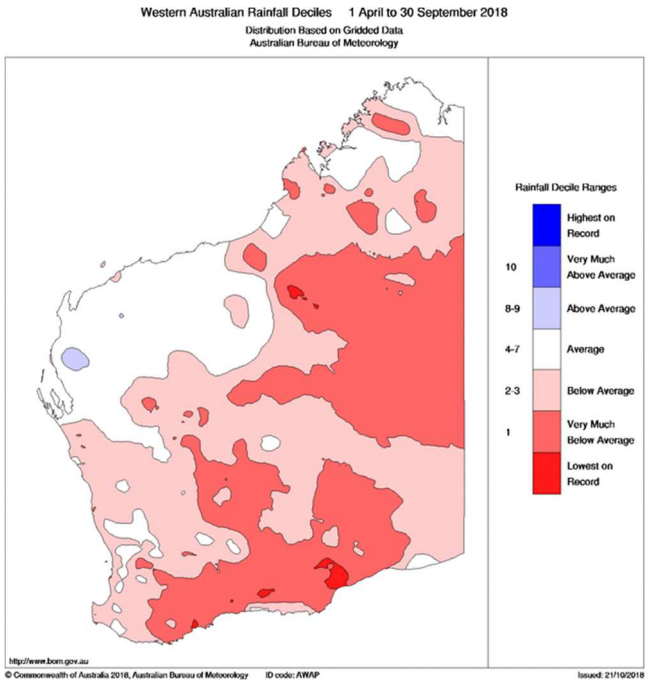

Fig. A2.8. Winter rainfall deciles for Western Australia for the period 1 April to 30 September 2018.

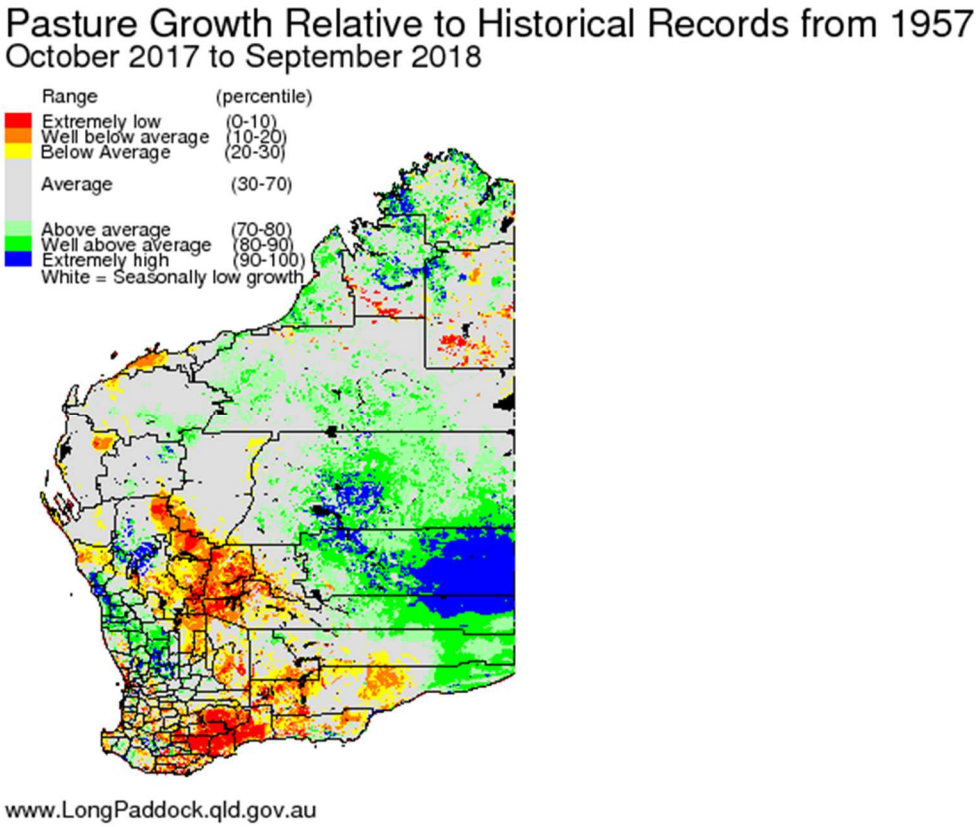

Fig. A2.9. Pasture growth in Western Australia for the period October 2017 to September 2018 (last 12 months).

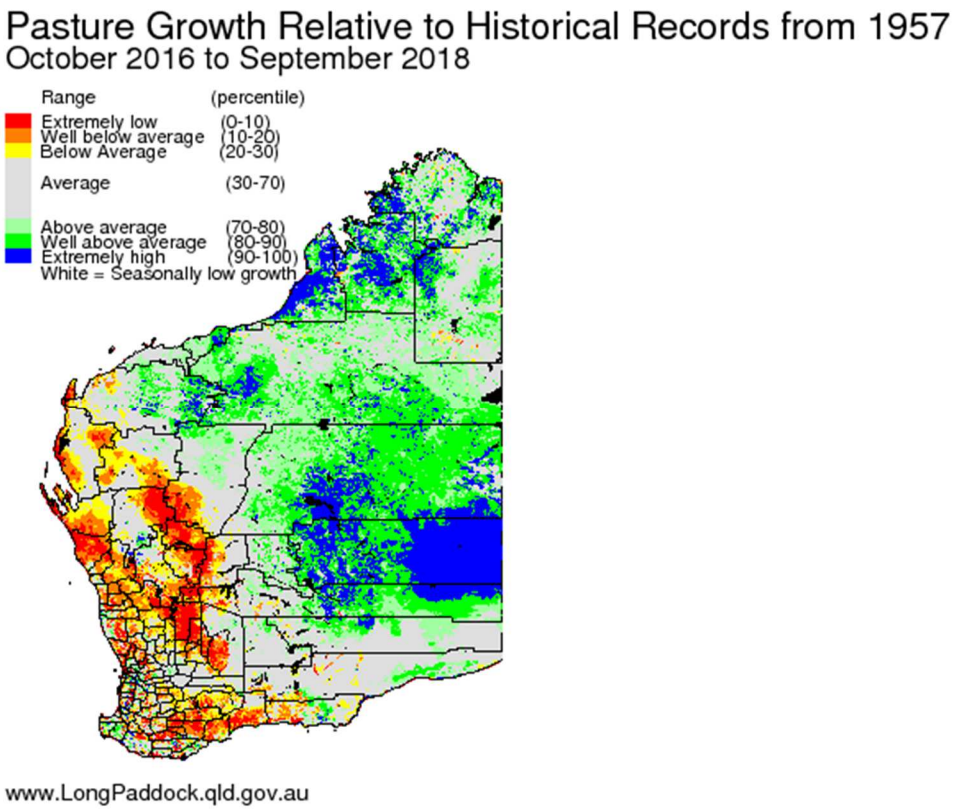

Fig. A2.10. Pasture growth in Western Australia for the period October 2016 to September 2018 (last 24 months).

APPENDIX 3. REGIONAL DENSITY AND POPULATION ESTIMATES

Harvest data for 2018, presented in the figures and tables in Appendix 3, only includes data processed prior to 30 September 2018.

3.1 Northern Zone

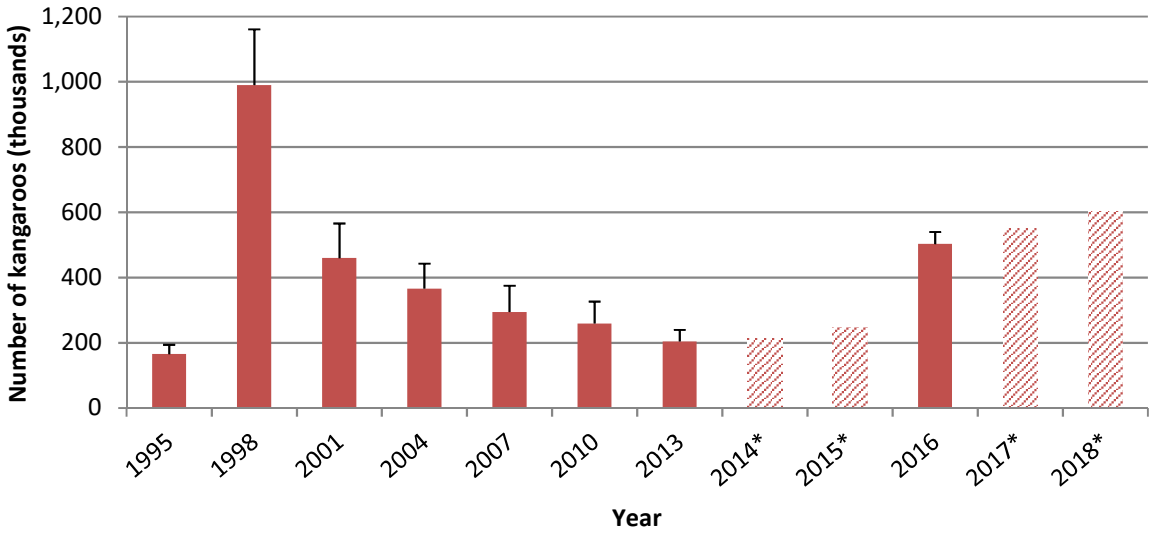

Fig. A3.1.1. Population estimates for red kangaroos in the Northern Zone. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based on estimates from surveys in previous years and are scaled according to trends in rainfall.

Table A3.1.1. Red kangaroo population estimates for the Northern Zone in years following a full aerial survey of the zone.

Year	Population estimate[a] ($\widehat{N_i}$)	Commercial harvest off-take (H)	Zone Rainfall Category	Population growth rate (r)
2013	203,820 ± 35,588	9,789	Average	1.1
2014	213,434	7,435	Above average	1.2
2015	247,200	6,755	Average	n/a
2016[b]	502,800 ± 37,100	2,495	Average	1.1
2017	550,340	1,561[c]	Average[d]	1.1
2018	603,660[a]			

[a] $\widehat{N}_{i+1} = (\widehat{N}_i - H) \times r$ where: $\widehat{N}_i$ = the most recent population estimate; H = commercial harvest off-take between population estimates; and, r = population growth rate for a regional rainfall category in accordance with Action 10 of the management plan.
[b] The most recent full survey of the Northern Zone was flown in June/July 2016.
[c] The commercial harvest off-take in the Northern Zone between 1 January 2018 and 30 September 2018.
[d] Rainfall in the Northern Zone for the preceding 12 months was considered to be average for the zone overall (Figs A2.1 – A2.10).

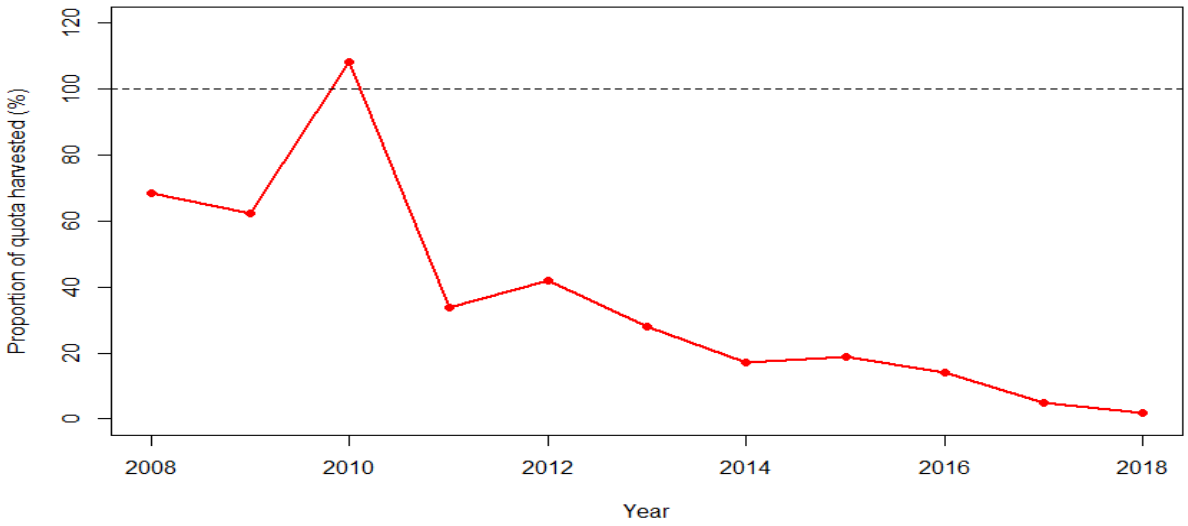

Fig. A3.1.2. Proportion of the Northern Zone commercial quota harvested from 2008 to 2018.

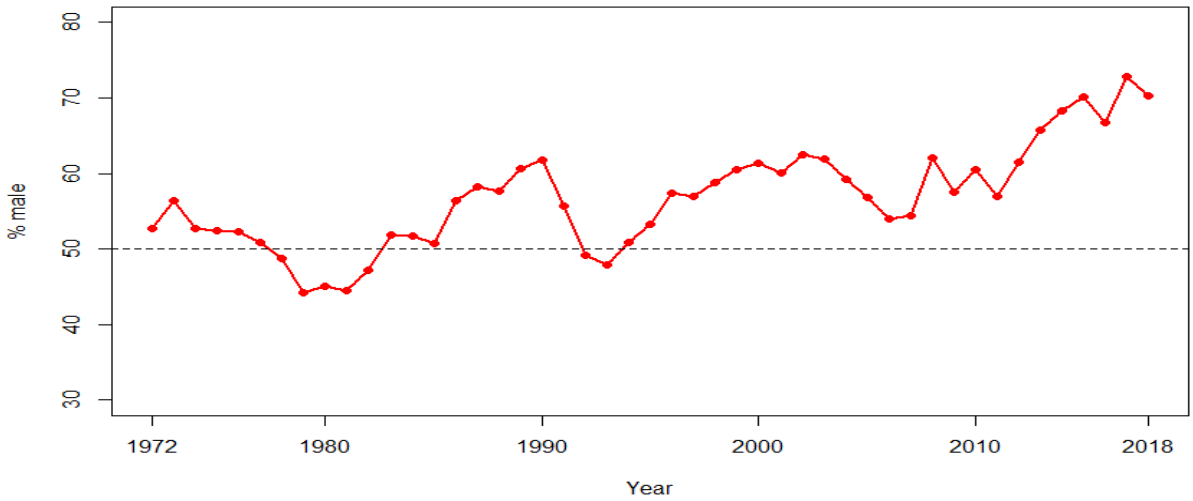

Fig. A3.1.3. Sex ratio of the commercial red kangaroo harvest in the Northern Zone from 1972 to 2018.

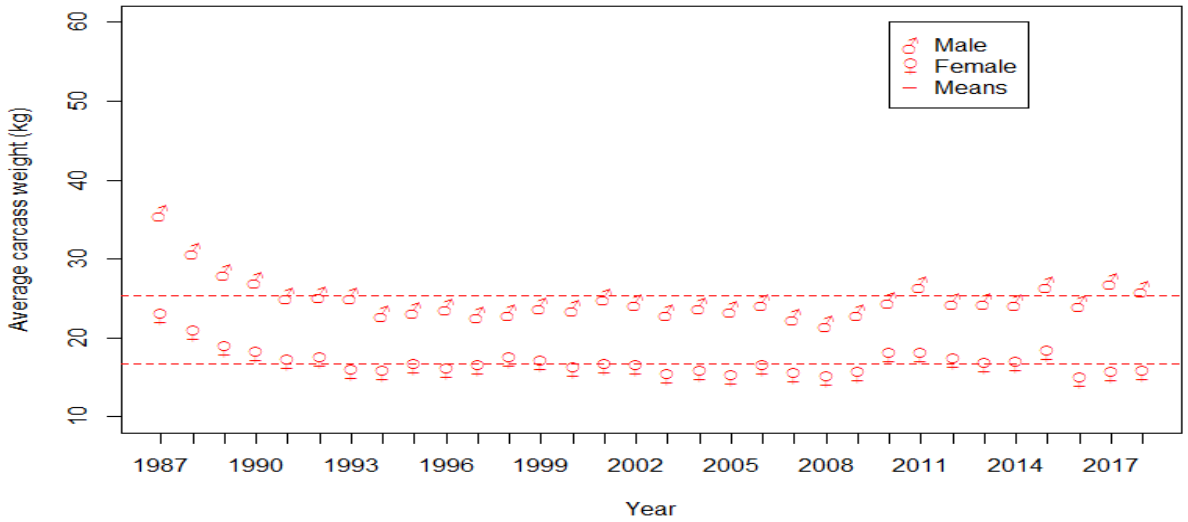

Fig. A3.1.4. Average carcass weights of the commercial red kangaroo harvest in the Northern Zone from 1987 to 2018. Carcass dressing methods (and therefore carcass weights) are not standardised.

3.2 Central Zone

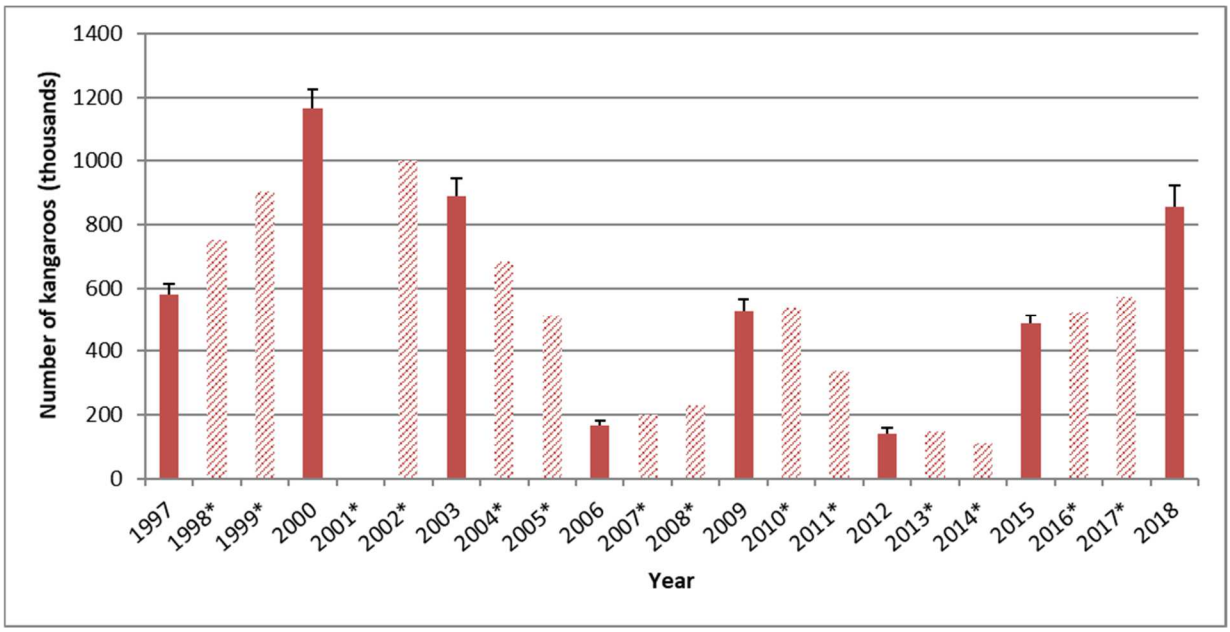

Fig. A3.2.1. Population estimates for red kangaroos in the Central Zone of Western Australia. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based on estimates from surveys in previous years and/or monitor block surveys, and are scaled according to trends in regional rainfall.

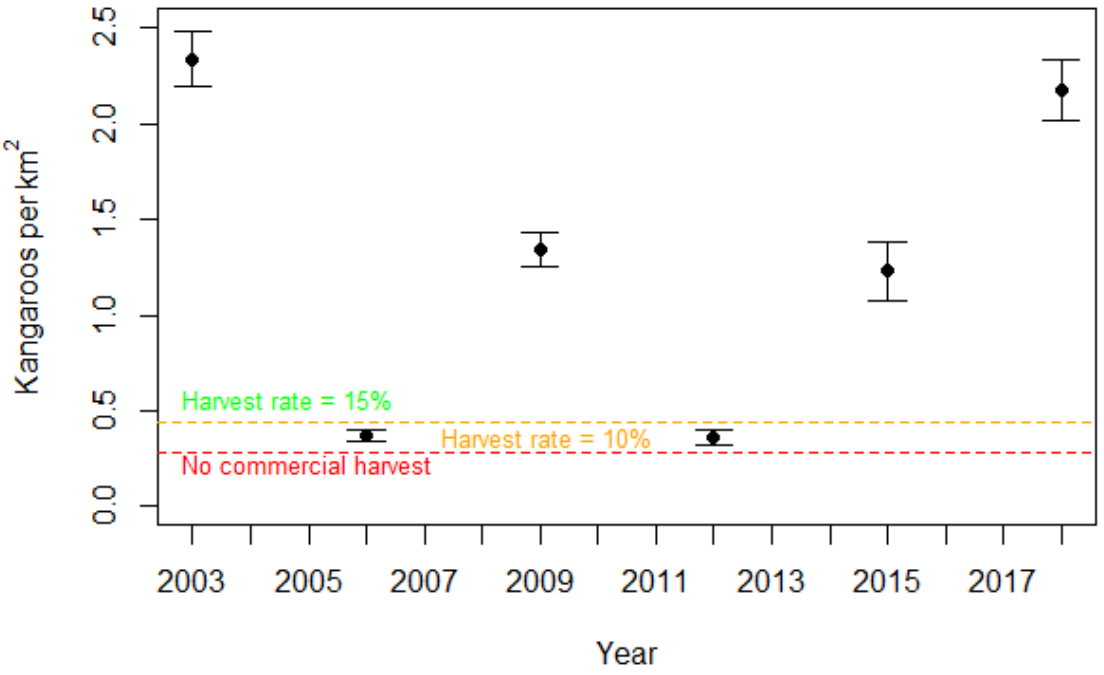

Fig. A3.2.2. Aerial survey density estimates with standard errors for red kangaroos in the Central Zone from 2003 to 2018. All estimates use standard habitat correction factors (Table 2.2) and temperature corrections. Trigger point thresholds are included as horizontal lines. The Central Zone is surveyed triennially.

Table A3.2.1. Red kangaroo population estimates for the Central Zone in years following a full aerial survey of the zone.

Year	Population estimate[a] ($\widehat{N_t}$)	Commercial harvest off-take (H)	Zone Rainfall Category	Population growth rate (r)
2012	141,765	7,333	Average	1.1
2013	147,875	10,704	Below average	0.8
2014	109,737	12,842	Above average	n/a
2015	485,000±29,000	7,886	Average	1.1
2016	524,800	3,399	Average	1.1
2017	573,540[a]	2,599 [c]	Average [d]	n/a
2018 [b]	857,350±64,300			

[a] $\widehat{N}_{t+1} = (\widehat{N}_t - H) \times r$ where: $\widehat{N}_t$ = the most recent population estimate; H = commercial harvest off-take between population estimates; and, r = population growth rate for a regional rainfall category in accordance with Action 10 of the management plan.
[b] The most recent full survey of the Central Zone was flown in July 2018.
[c] The commercial harvest off-take in the Central Zone between 1 January 2018 and 30 September 2018.
[d] Rainfall in the Central Zone for the preceding 12 months was considered to be average for the zone overall (Figs A2.1 – A2.10).

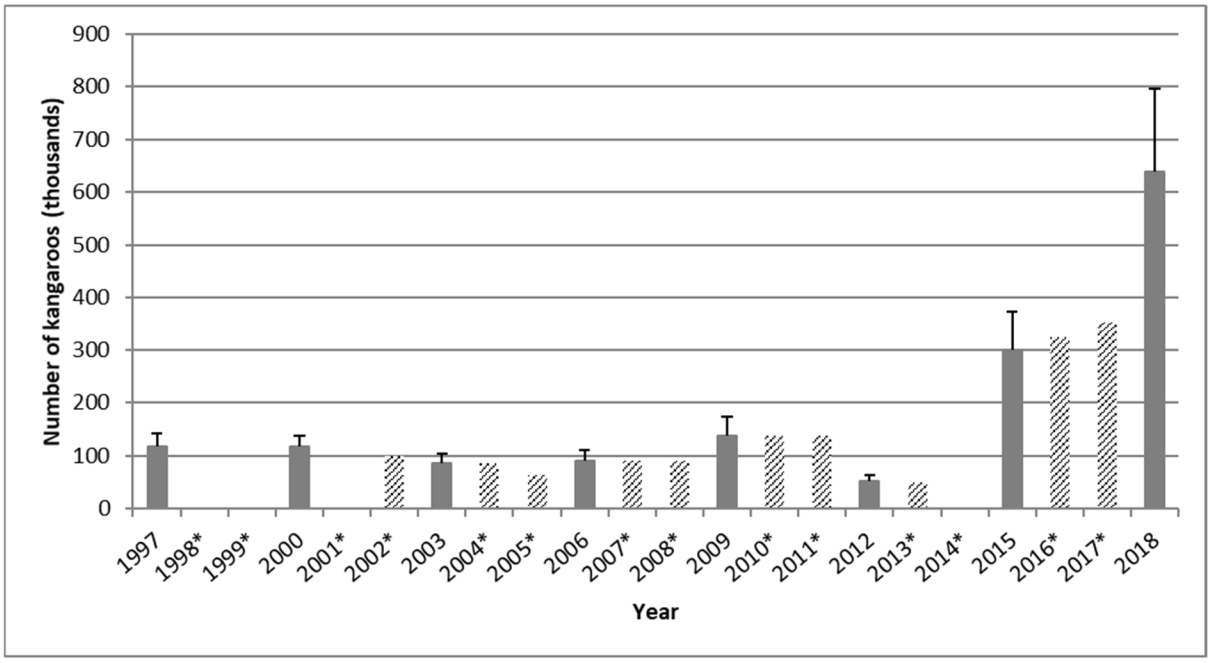

Fig. A3.2.3. Population estimates for western grey kangaroos in the Central Zone of Western Australia. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based on estimates from surveys in previous years and/or monitor block surveys, and are scaled according to trends in regional rainfall.

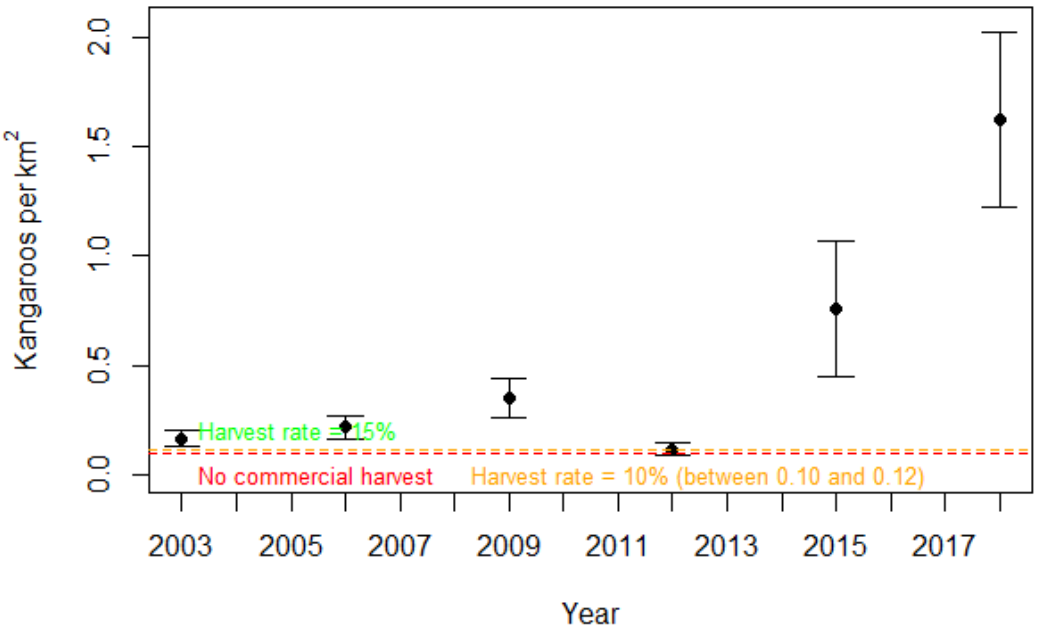

Fig. A3.2.4. Aerial survey density estimates with standard errors for western grey kangaroos in the Central Zone from 2003 to 2018. All estimates use standard habitat correction factors (Table 2.2) and temperature corrections. Trigger point thresholds are included as horizontal lines. The Central Zone is surveyed triennially.

Table A3.2.2. Western grey kangaroo population estimates for the Central Zone in years following a full aerial survey of the zone.

Year	Population estimate[a] ($\widehat{N}_t$)	Commercial harvest off-take (H)	Zone Rainfall Category	Population growth rate (r)
2012	51,193	5,178	Average	1.1
2013	50,616	4,716	Below average	0.8
2014	36,720	5,504	Above average	n/a
2015	300,100±72,500	5,631	Average	1.1
2016	323,900	3,313	Average	1.1
2017	352,645[a]	2,762[c]	Average[d]	n/a
2018[b]	637,660±157,800			

[a] $\widehat{N}_{t+1} = (\widehat{N}_t - H) \times r$ where: $\widehat{N}_t$ = the most recent population estimate; H = commercial harvest off-take between population estimates; and, r = population growth rate for a regional rainfall category in accordance with Action 10 of the management plan.
[b] The most recent full survey of the Central Zone was flown in July 2018.
[c] The commercial harvest off-take in the Central Zone between 1 January 2018 and 30 September 2018.
[d] Rainfall in the Central Zone for the preceding 12 months was considered to be average for the zone overall (Figs A2.1 – A2.10).

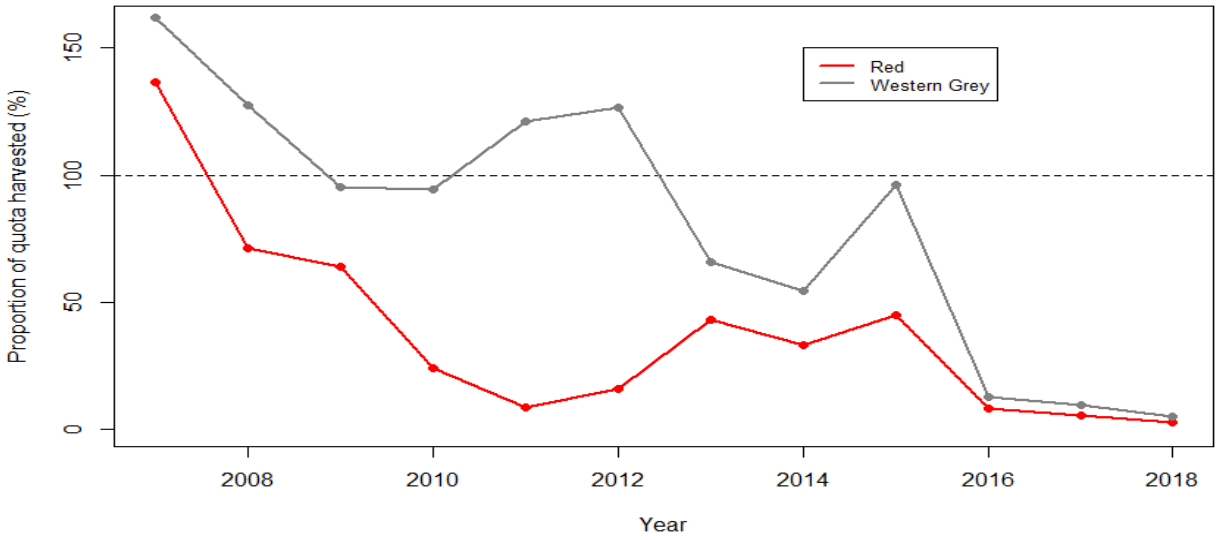

Fig. A3.2.5. Proportion of the Central Zone commercial quota harvested from 2008 to 2018.

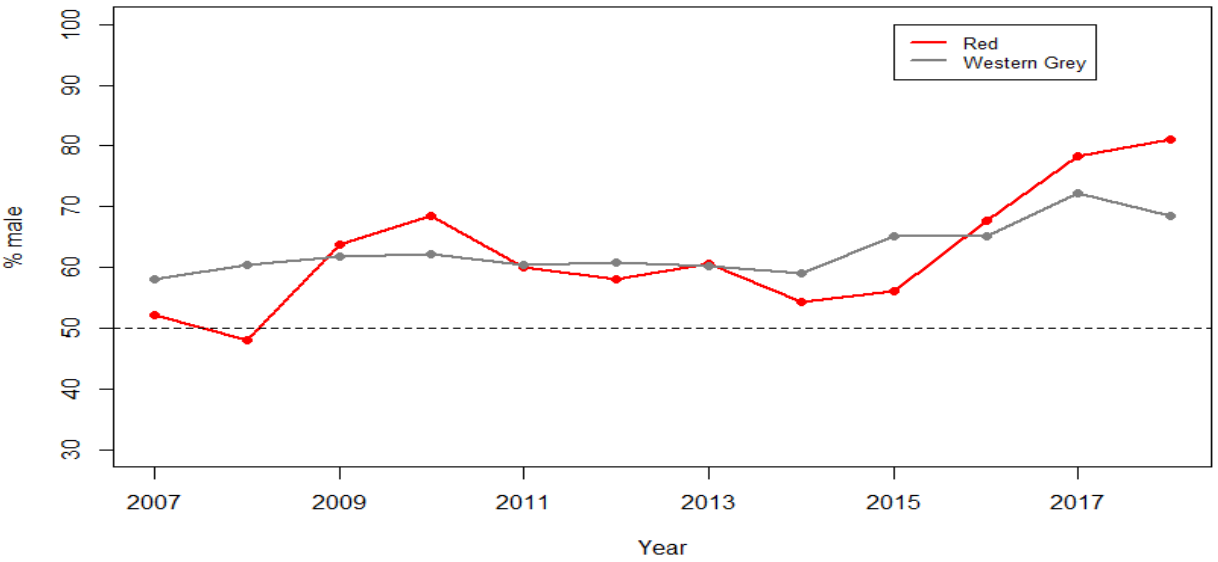

Fig. A3.2.6. Sex ratio of the commercial red and western grey kangaroo harvest in the Central Zone from 2007 to 2018.

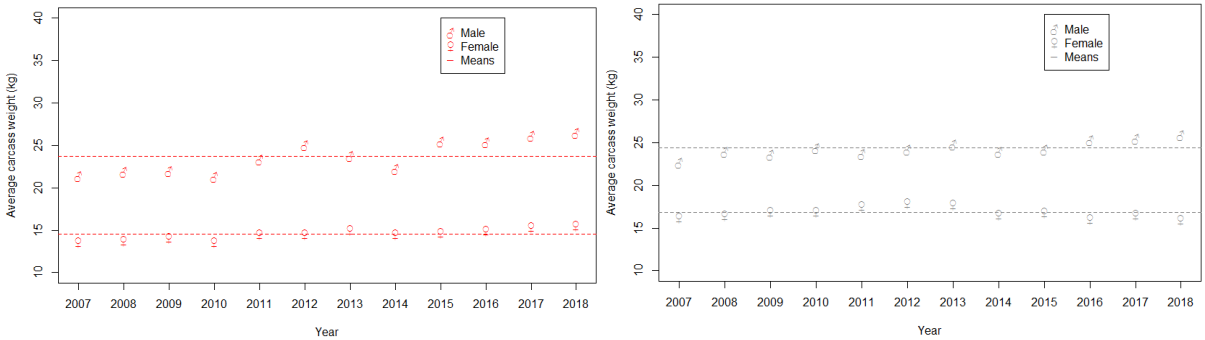

Fig. A3.2.7. Average carcass weights of the commercial red and western grey kangaroo harvest in the Central Zone from 2007 to 2018. Carcass dressing methods (and therefore carcass weights) are not standardised.

3.3 South-East Zone

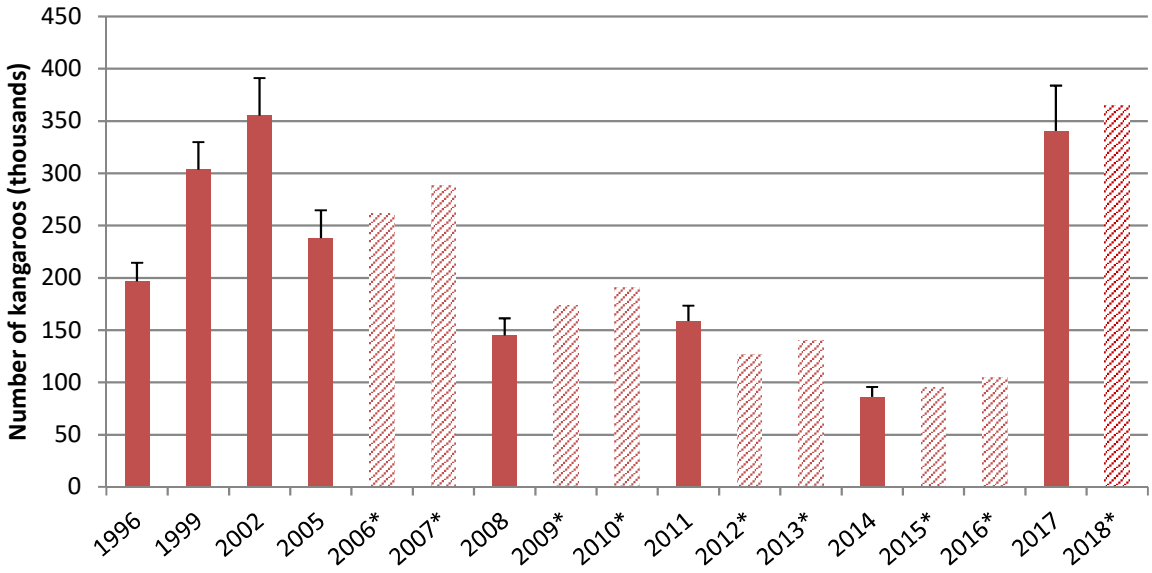

Fig. A3.3.1. Population estimates for red kangaroos in the South-East Zone of Western Australia. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based on estimates from surveys in previous years and/or monitor block surveys, and are scaled according to trends in regional rainfall.

Table A3.3.1. Red kangaroo population estimates for the South-East Zone in years following a full aerial survey of the zone.

Year	Population estimate[a] ($\widehat{N_t}$)	Commercial harvest off-take (H)	Zone Rainfall Category	Population growth rate (r)
2014	86,200 ± 17,250	0[c]	Average	1.1
2015	94,800	7,781	Above average	1.2
2016	104,400	5,580	Above average	na
2017[b]	340,450 ± 43,470	8,857[c]	Average[d]	1.1
2018	364,750[a]			

[a] $\widehat{N}_{i+1} = (\widehat{N}_t - H) \times r$ where: $\widehat{N}_t$ = the most recent population estimate; H = commercial harvest off-take between population estimates; and, r = population growth rate for a regional rainfall category in accordance with Action 10 of the management plan.
[b] The most recent full survey of the South-East Zone was flown in July/August 2017.
[c] The commercial harvest off-take in the South-East Zone between 1 January 2018 and 30 September 2018.
[d] Rainfall in the South-East Zone for the preceding 12 months was considered to be average for the zone overall (Figs A2.1 – A2.10).

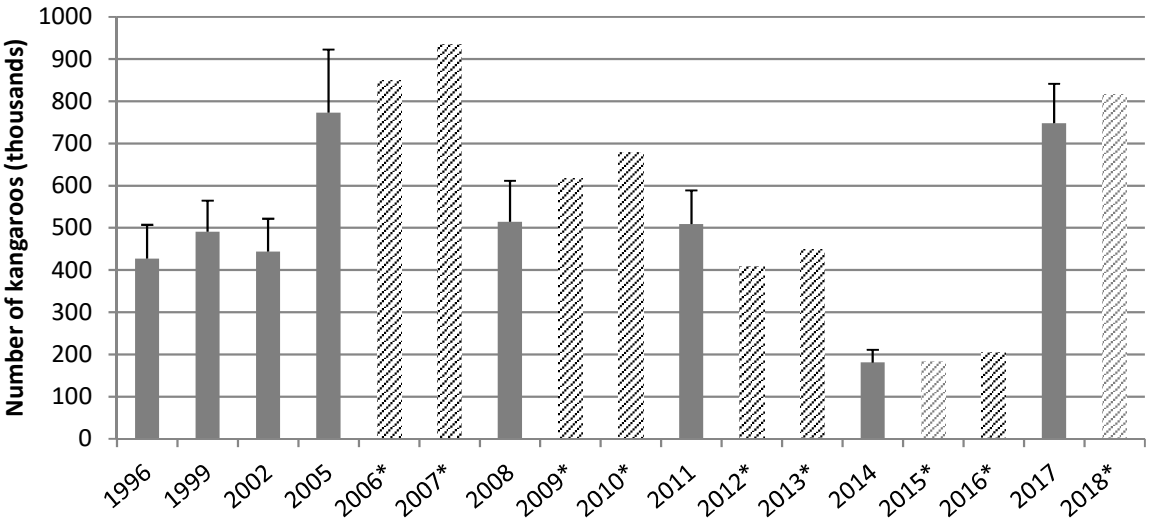

Fig. A3.3.2. Population estimates for western grey kangaroos in the South-East Zone of Western Australia. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based on estimates from surveys in previous years and/or monitor block surveys, and are scaled according to trends in regional rainfall.

Table A3.3.2. Western grey kangaroo population estimates for the South-East Zone in years following a full aerial survey of the zone.

Year	Population estimate[a] ($\widehat{N_t}$)	Commercial harvest off-take (H)	Zone Rainfall Category	Population growth rate (r)
2014	179,400 ± 51,751	14,743	Average	1.1
2015	181,100	9,679	Above average	1.2
2016	205,700	4,304	Above average	na
2017[b]	747,700 ± 93,400	5,117[c]	Average[d]	1.1
2018	816,840[a]			

[a] $\widehat{N}_{t+1} = (\widehat{N}_t - H) \times r$ where: $\widehat{N}_t$ = the most recent population estimate; H = commercial harvest off-take between population estimates; and, r = population growth rate for a regional rainfall category in accordance with Action 10 of the management plan.

[b] The most recent full survey of the South-East Zone was flown in July/August 2017.

[c] The commercial harvest off-take in the South-East Zone between 1 January 2018 and 30 September 2018.

[d] Rainfall in the South-East Zone for the preceding 12 months was considered to be average for the zone overall (Figs A2.1 – A2.10).

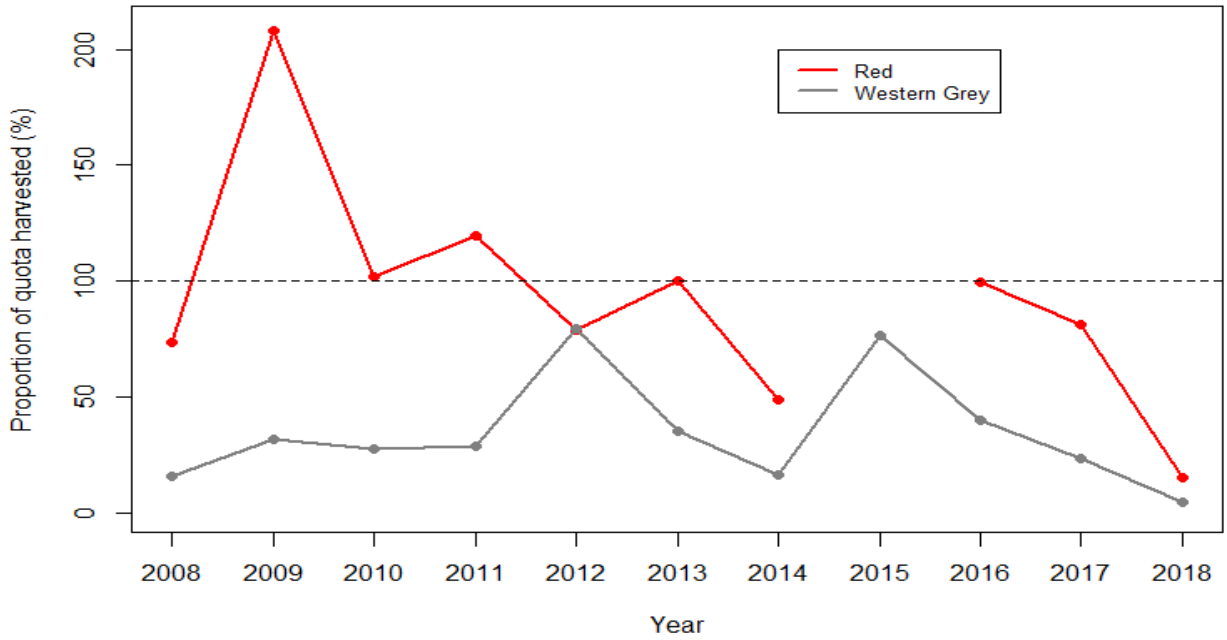

Fig. A3.3.3. Proportion of the South-East Zone commercial quota harvested from 2008 to 2018. Note, no red kangaroos were harvested in 2015.

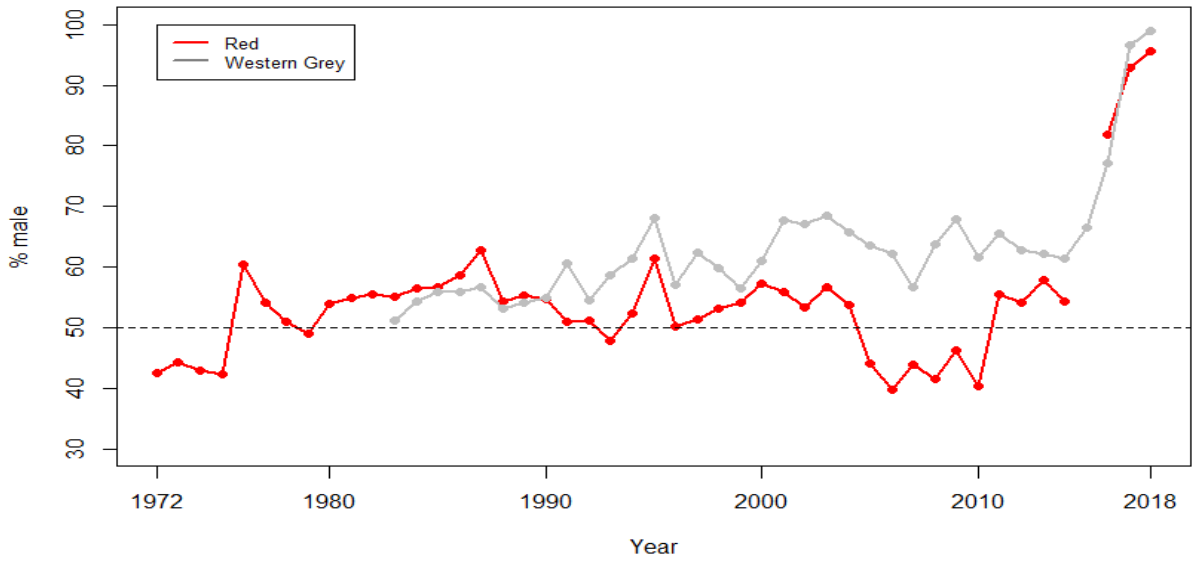

Fig. A3.3.4. Sex ratio of the commercial harvest of red and western grey kangaroos in the South-East Zone from 1972 to 2018. Note, no red kangaroos were harvested in 2015.

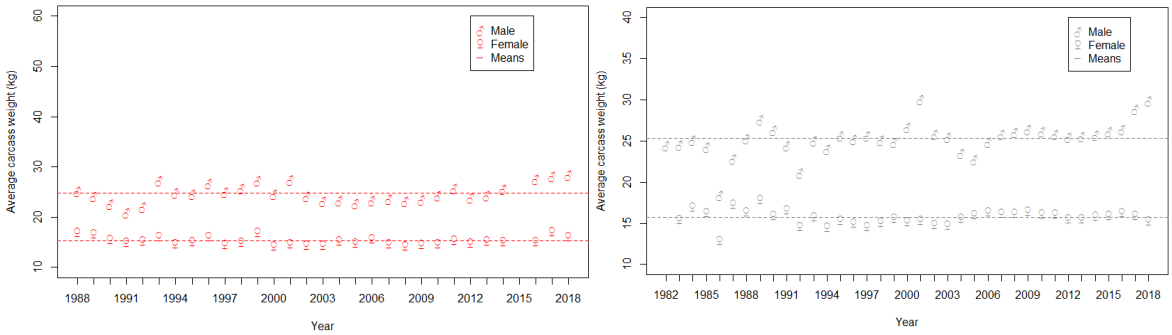

Fig A3.3.5. Average carcass weights of the commercial red and western grey kangaroo harvest in the South-East Zone. Carcass dressing methods (and therefore carcass weights) are not standardised.

3.4. South-West Zone

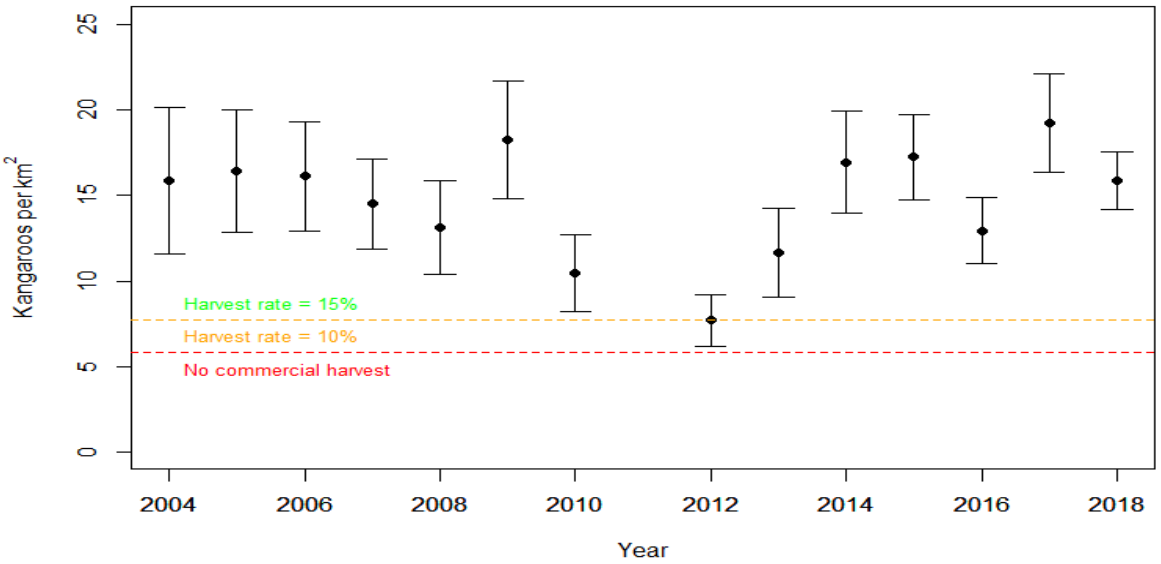

Fig. A3.4.1. Aerial survey density estimates with standard errors for western grey kangaroos in South-West Zone monitor blocks from 2004-2018. All estimates use standard habitat correction factors (Table 2.2.) and temperature corrections. Trigger point thresholds are included as horizontal lines. No aerial surveys were undertaken in the South-West Zone from 1988-2003 and in 2011.

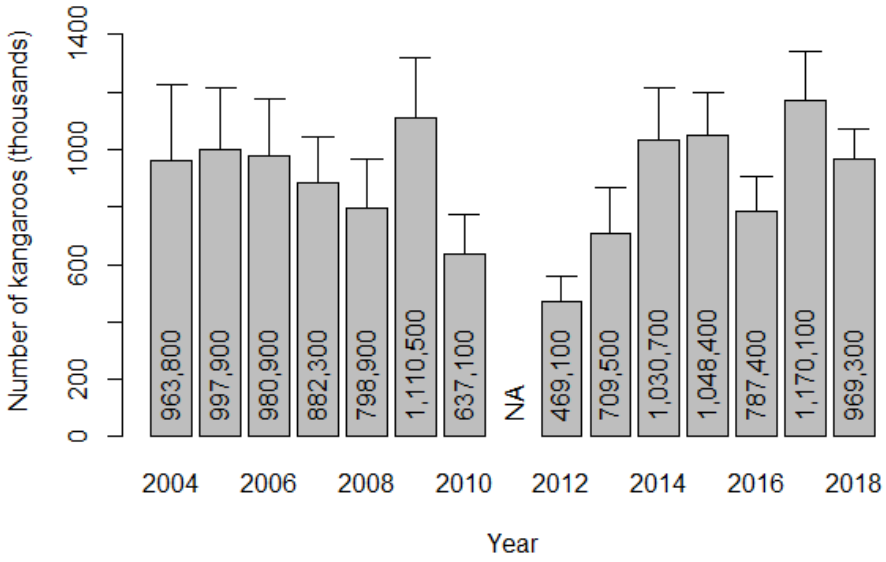

Fig. A3.4.2. Aerial survey population estimates with standard errors for western grey kangaroos in South-West Zone monitor blocks from 2004-2018. All estimates use standard habitat correction factors (Table 2.2.) and temperature corrections. No aerial surveys were undertaken in the South-West Zone from 1988-2003 and in 2011. New transects were added in 2013 which increased the aggregate area of the monitor blocks. Consequently, adjustments have been made to population estimates in prior years.

Note that population estimates for the South-West Zone are a product of the mean kangaroo density in the monitor blocks and the aggregate area of the monitor blocks. No additional allowance is being made for kangaroos occupying the unsurveyed portion of the South-West Zone (*i.e.* for the purpose of the quota calculation, the density in the unsurveyed areas is treated as being zero). However, western grey kangaroos are harvested in the unsurveyed parts of the South-West Zone.

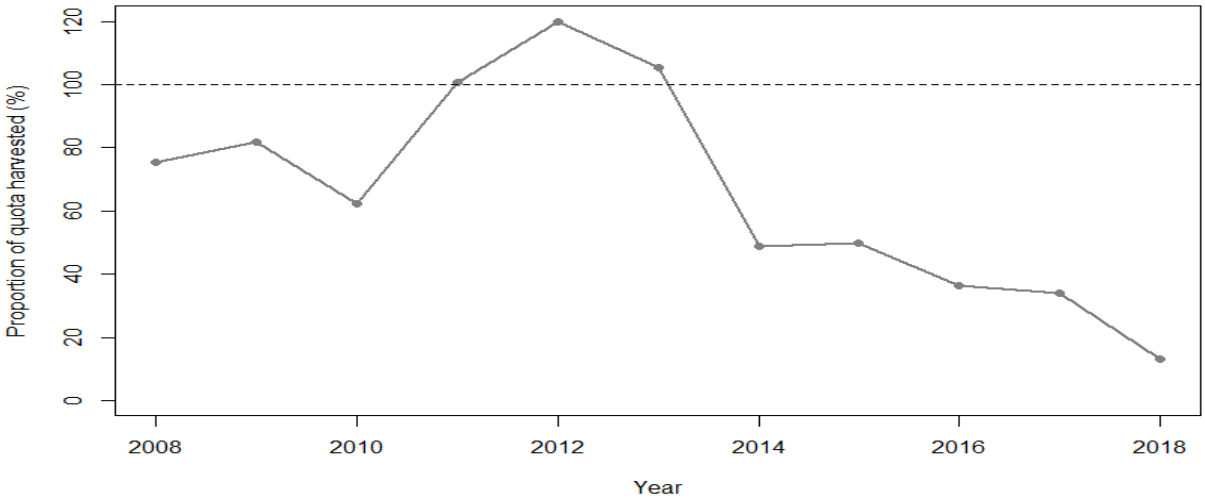

Fig. A3.4.3. Proportion of the South-West Zone regional commercial quota harvested from 2008 to 2018.

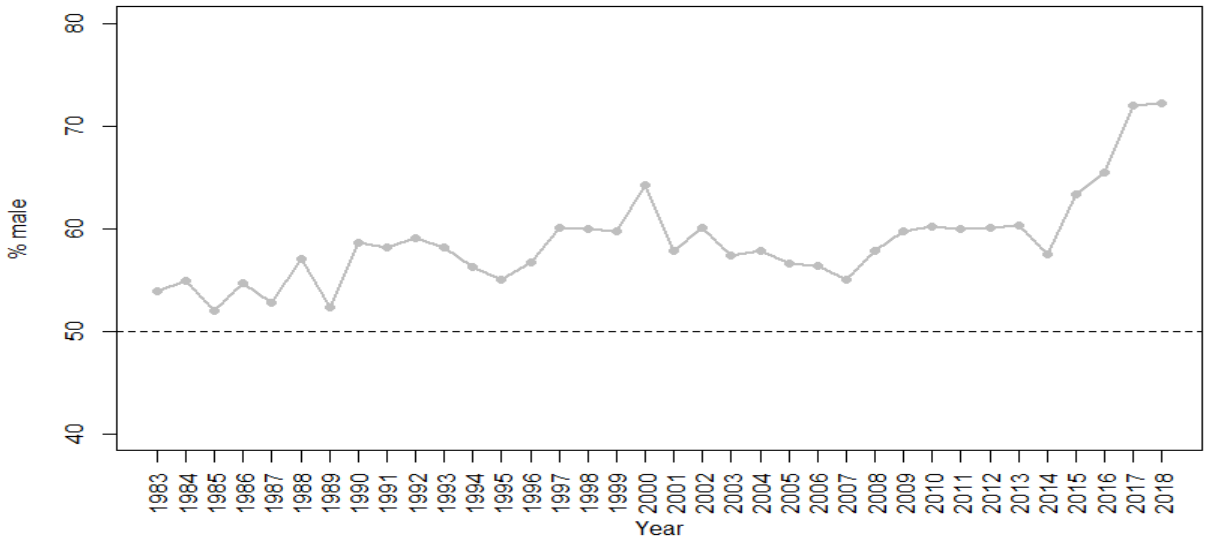

Fig. A3.4.4. Sex ratio of the commercial harvest of western grey kangaroos in the South-West Zone from 1983 to 2018.

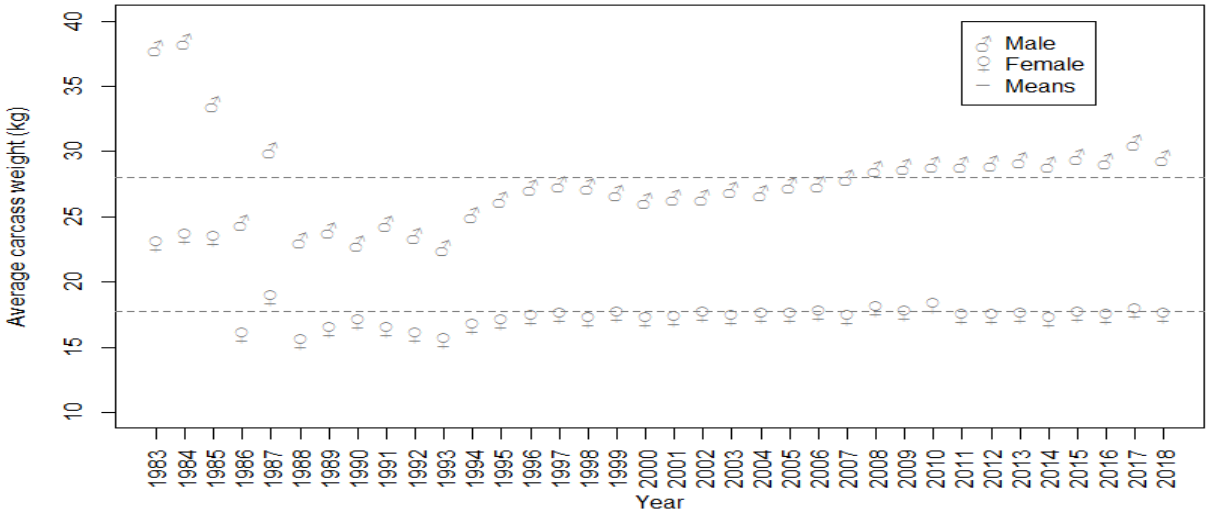

Fig A3.4.5. Average carcass weights of the commercial western grey kangaroo harvest in the South-West Zone. Carcass dressing methods (and therefore carcass weights) are not standardised.