2022 Commercial Kangaroo Harvest Quota Submission for Western Australia

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

December 2021

GOVERNMENT OF WESTERN AUSTRALIA

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Contents

Appendices

1 Proposed quotas for Western Australia for 2022

This document presents the proposed quotas for commercial kangaroo harvest in Western Australia for 2022. This document should be read and considered in conjunction with the *Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2019-2023.*

The density of western grey kangaroos in the SE Population Monitoring Zone (PMZ) decreased to 0.34 individuals per km^2 in 2021. Aerial surveys were undertaken in the SE PMZ in September 2021 and previously in 2017. The SE PMZ has experienced below average rainfall and well below average to extremely low pasture growth over the last 24 months (Appendix 2). It is likely that higher quality habitat for western grey kangaroos exists in the coastal South East Agricultural (SEA) Management Area of the SE PMZ (Figure 1, DBCA 2019), supporting higher densities. Therefore, densities of western grey kangaroos were calculated for Management Areas within the SE PMZ, as well as the entire SE PMZ, and are shown in Table 1.4.

In accordance with the *Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2019-2023*, Action 12 (DBCA 2019), the commercial harvest rate is to be suspended if aerial surveys indicate that the western grey kangaroo population density within the SE PMZ or within Management Areas within the PMZ has fallen ≤0.80 individuals per km^2. The suspensions will remain in place until surveys, or populations estimates corrected for trends in rainfall, indicate that kangaroo densities have increased above the 0.80 individuals per km^2 density threshold. Therefore, harvest of western grey kangaroos can only occur from within the SEA Kangaroo Management Area within the PMZ (Table 1.4), and there is to be no harvest of western grey kangaroos in remainder of the SE PMZ in 2022.

1.1 State Summary

Species	2022 Proposal			2021		
	2021 Population estimate[a]	Harvest rate (%)	**Quota**	Quota	Harvest rate (%)	2020 Population estimate
Red kangaroo	1,219,645	17	**207,340**	170,670	17	1,003,890
Western grey kangaroo	1,179,545	14[b]	**168,070**	211,210	15	1,408,160
Totals	**2,399,190**		**375,410**	381,880		**2,412,050**

[a] Note: aerial surveys were not conducted in 2020 due to COVID-19 border restrictions.

[b] Rate calculated from total harvest quota (excluding SE PMZ) in Table 1.3 below.

1.2 Regional Quotas for Red Kangaroos in 2022

(See Fig. 2.1 for location of regions)

Zone	2021 Population estimate ($\widehat{N}$)	2022 Proposal	
		Harvest rate (H) %	**Quota ($\widehat{N} \times H$)**
Central	593,950	17	100,970
Northern	295,280	17	50,200
South-East	330,410	17	56,170
Totals	**1,219,645**		**207,340**

1.3 Regional Quotas for Western Grey Kangaroos in 2022

(See Fig. 2.1 for location of regions)

Zone	2021 Population estimate ($\widehat{N}$)	2022 Proposal	
		Harvest rate (H) %	Quota ($\widehat{N} \times H$)
Central	437,340	15	65,601
South-East	115,895	15 (SEA Management Area only)	8,522 (SEA Management Area only)
South-West	626,310	15	93,947
Totals	**1,179,545**		**168,070**

1.4 South East Management Areas Quotas for Western Grey Kangaroos in 2022

(See Fig. 1 in DBCA 2019 for location of Management Areas)

Management Area	2021 Density (kangaroos per km^2)	2021 Population estimate ($\widehat{N}$)	2022 Proposal	
			Harvest rate (H) %	Quota ($\widehat{N} \times H$)
South Eastern Agricultural (SEA)	1.42	56,810	15	8,522
Dundas (DU)	0.13	5,790	0	0
Nullarbor (NU)	0.46	38,295	0	0
Coolgardie (CO/CG)	0.03	1,545	0	0
Leonora Eastern Goldfields (LEG)	0.11	12,445	0	0

2 Population estimation methods

Due to Covid-19 restrictions, only the SE and SW PMZs were surveyed in 2021 and no aerial surveys for kangaroos were undertaken in 2020. Population estimates have been set in accordance with the management plan using the calculation for intervening survey years, i.e. the most recent population estimate adjusted for regional rainfall and commercial harvest offtake, according to the equation:

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

where:

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

H = commercial harvest offtake between population estimates; and

r = population growth rate for a regional rainfall category.

2.1 Ground Survey

No regular quantitative ground surveys are undertaken in Western Australia. The reason for this is because 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 *Biodiversity Conservation Regulations 2018*.

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.

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. 4.1).

Frequency: continuous (see Table 4.1).

Methodology: analysis of trends in:

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

(see appendices 1 and 3)

Table 4.1. Frequency of kangaroo aerial surveys in Western Australia	
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, 2016 and 2019. • South-East Zone in 1996, 1999, 2002, 2005, 2008, 2011, 2014, 2017 and 2021. • 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, 2018 and 2021.

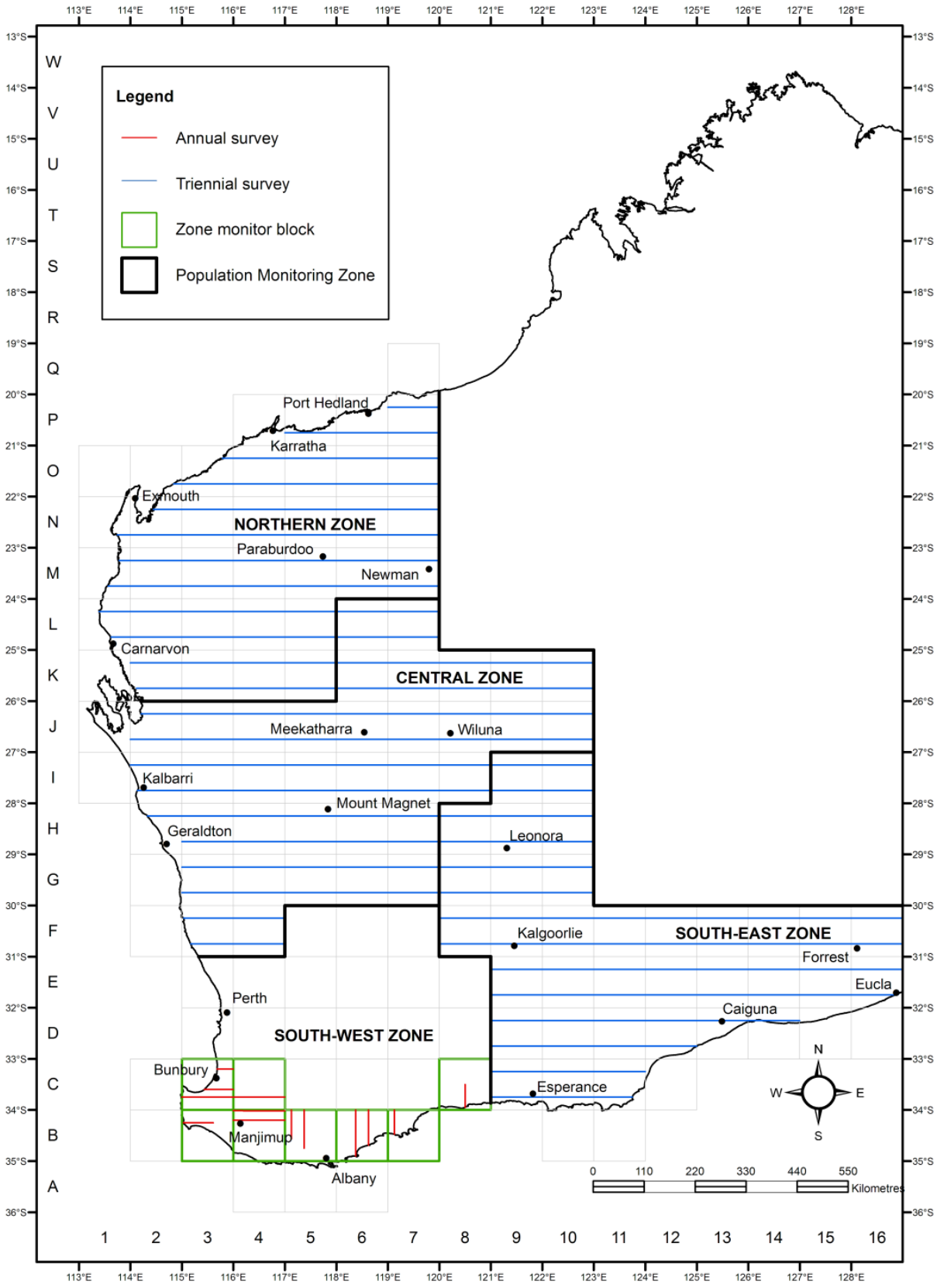

Fig. 4.1. Kangaroo Population Monitoring Zones over the allowable harvest areas in Western Australia.

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.

DBCA (2019) Management plan for the commercial harvest of kangaroos in Western Australia 2019-2023. Department of Biodiversity, Conservation and Attractions, Western Australia.

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

Appendices

Appendix 1 Harvest monitoring results for Western Australia

Harvest data for 2021, presented in the figures and tables in Appendix 1, only includes data processed prior to 31 October 2021.

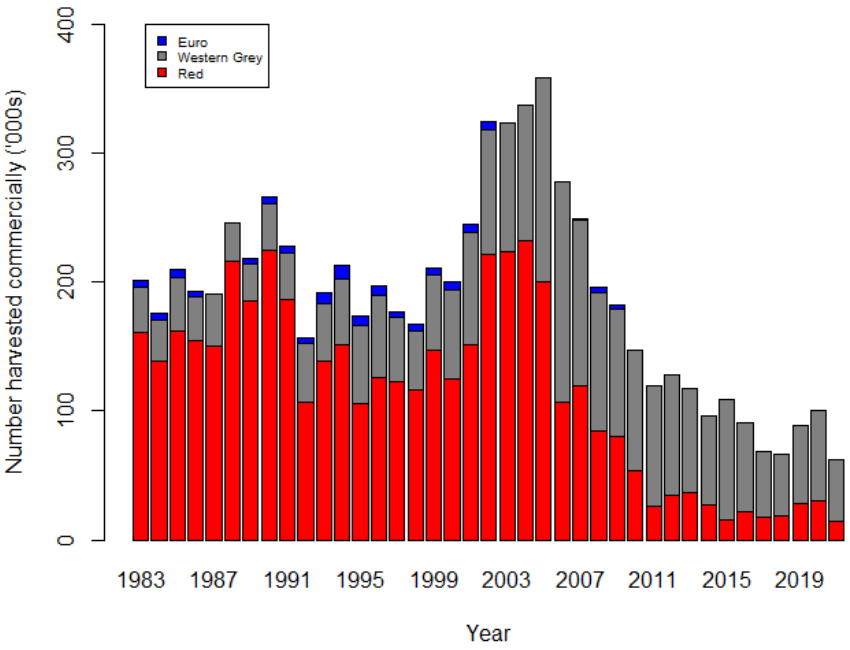

Fig. A1.1. Total commercial kangaroo harvest in Western Australia from 1983 to 2021. There was no commercial harvest of euros from 2003-2006 and from 2010-2015.

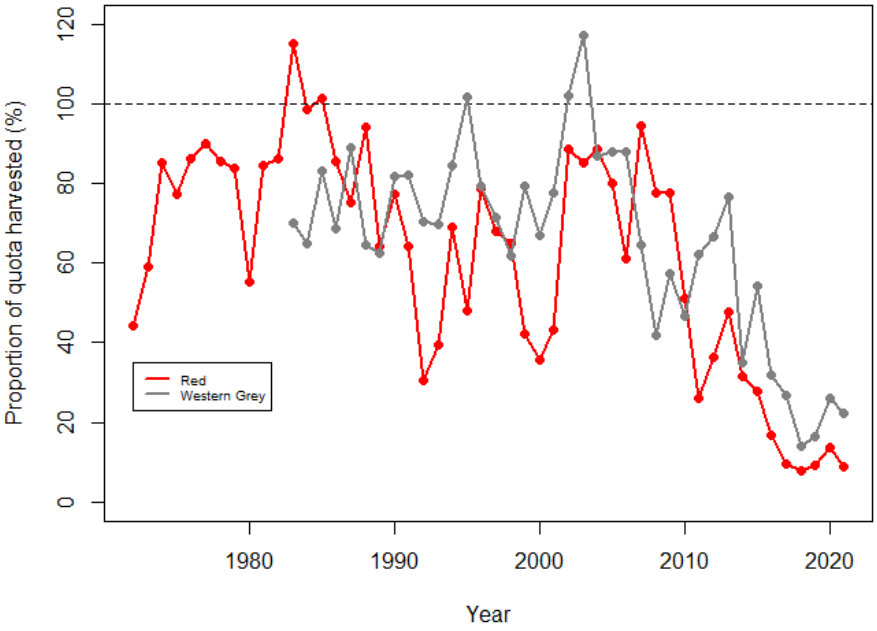

Fig. A1.2. Proportion of the commercial quota harvested in Western Australia from 1972 to 2021.

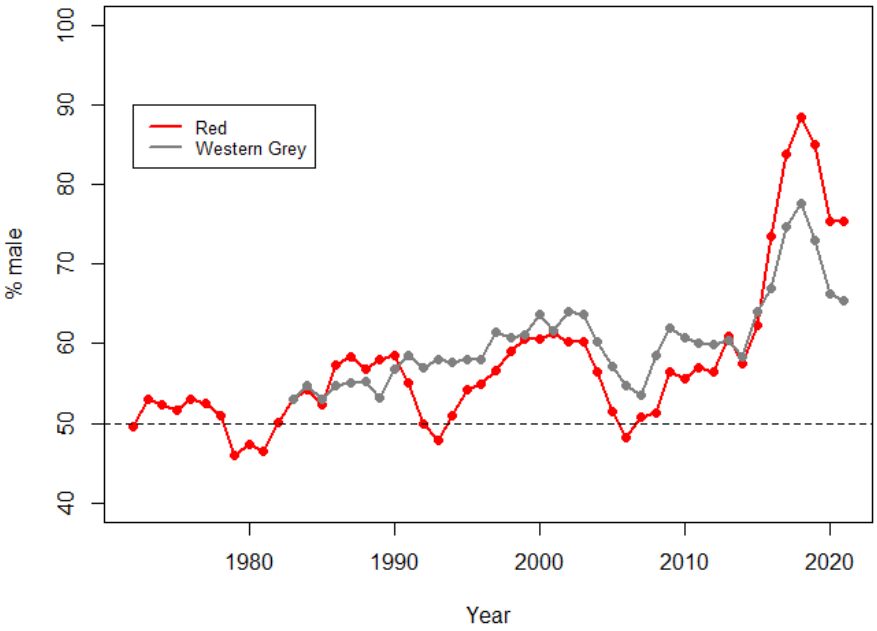

Fig. A1.3. Sex ratio of the commercial kangaroo harvest in Western Australia from 1972 to 2021.

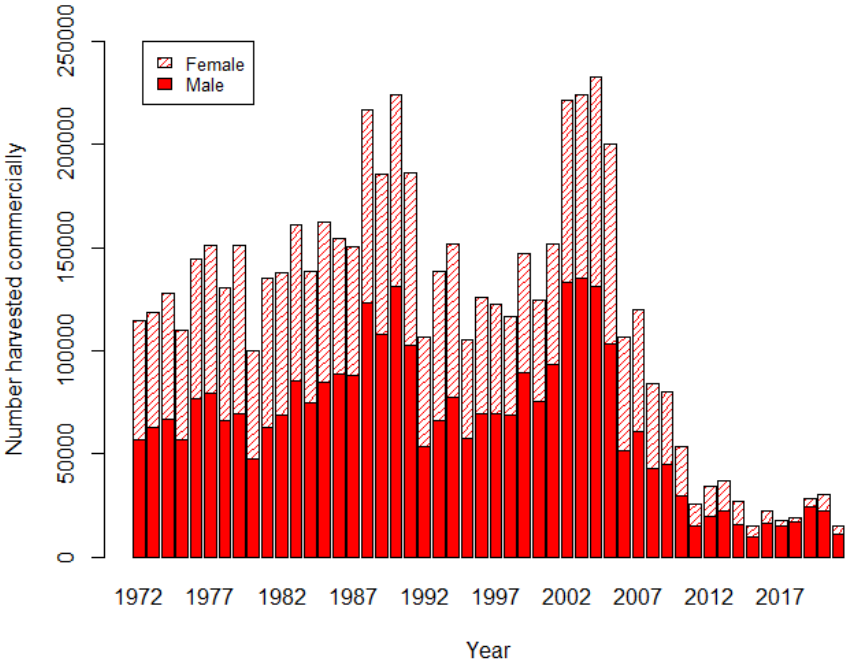

Fig. A1.4. Number of red kangaroos harvested commercially in Western Australia from 1972 to 2021.

Fig. A1.5. Average carcass weights for red kangaroos harvested commercially in Western Australia from 1995 to 2021. Carcass dressing methods (and therefore carcass weights) are not standardised.

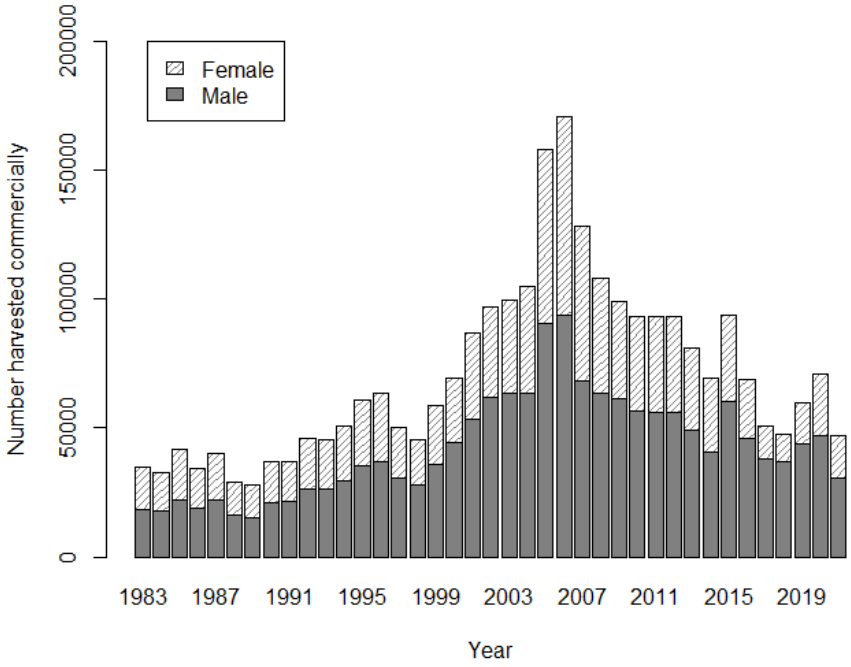

Fig. A1.6. Number of western grey kangaroos harvested commercially in Western Australia from 1983 to 2021.

Appendix 2 Rainfall and drought maps

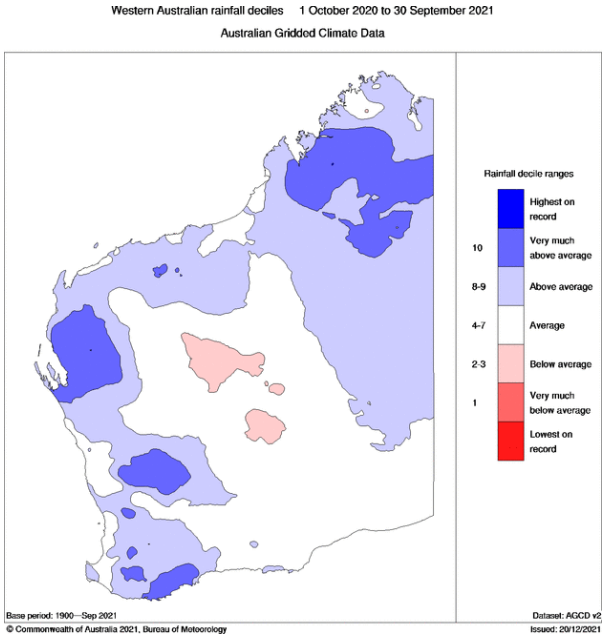

Fig. A2.1. Rainfall deciles for Western Australia for the period 1 October 2020 to 30 September 2021 (last 12 months).

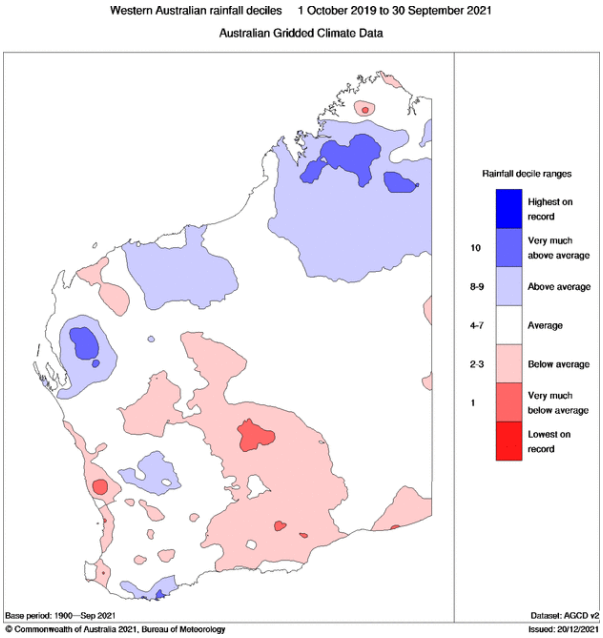

Fig. A2.2. Rainfall deciles for Western Australia for the period 1 October 2019 to 30 September 2021 (last 24 months).

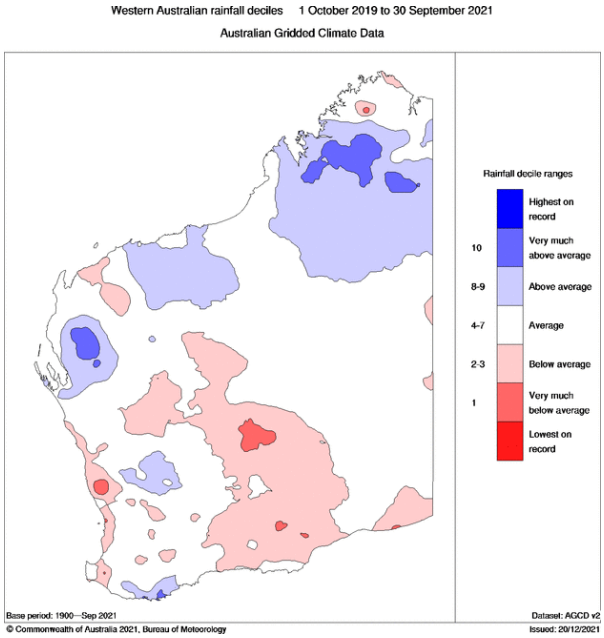

Fig. A2.2. Rainfall deciles for Western Australia for the period 1 October 2019 to 30 September 2021 (last 24 months).

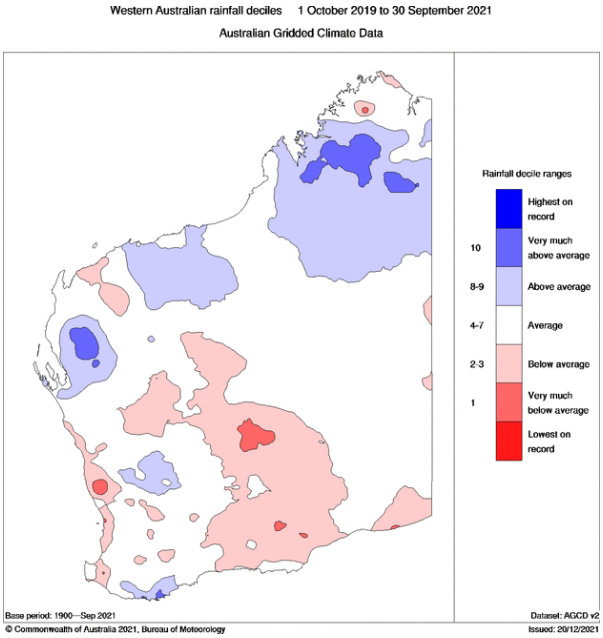

Fig. A2.2. Rainfall deciles for Western Australia for the period 1 October 2019 to 30 September 2021 (last 24 months).

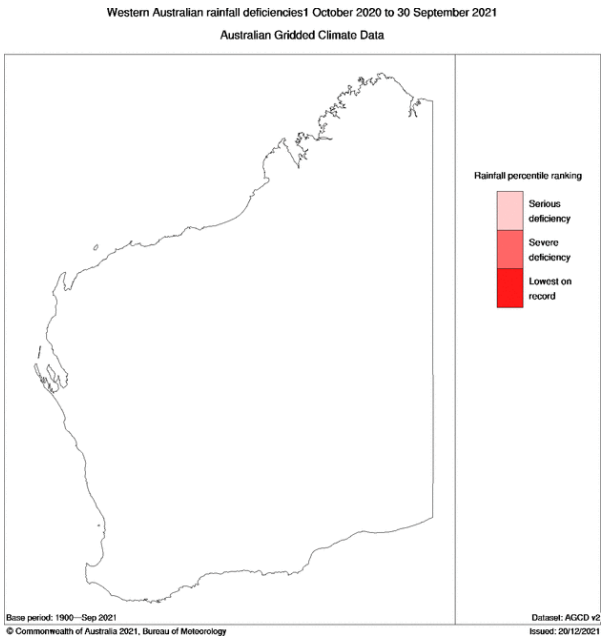

Fig. A2.3. Drought map for Western Australia for the period 1 October 2020 to 30 September 2021 (last 12 months).

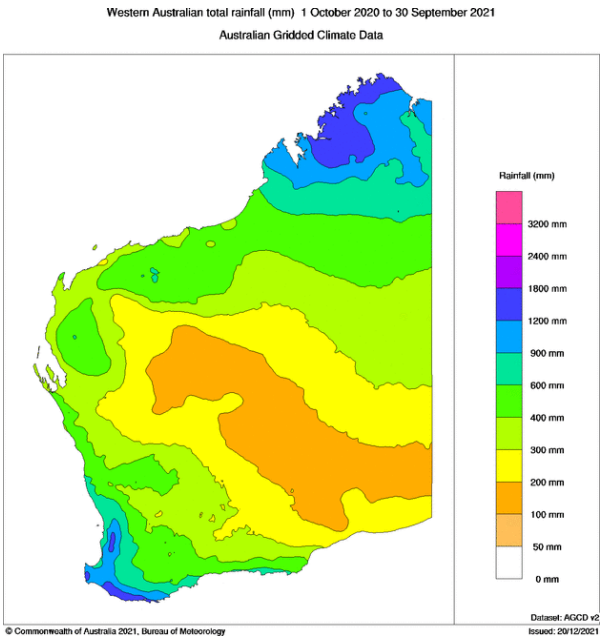

Fig. A2.5. Rainfall totals for Western Australia for the period 1 October 2020 to 30 September 2021 (last 12 months).

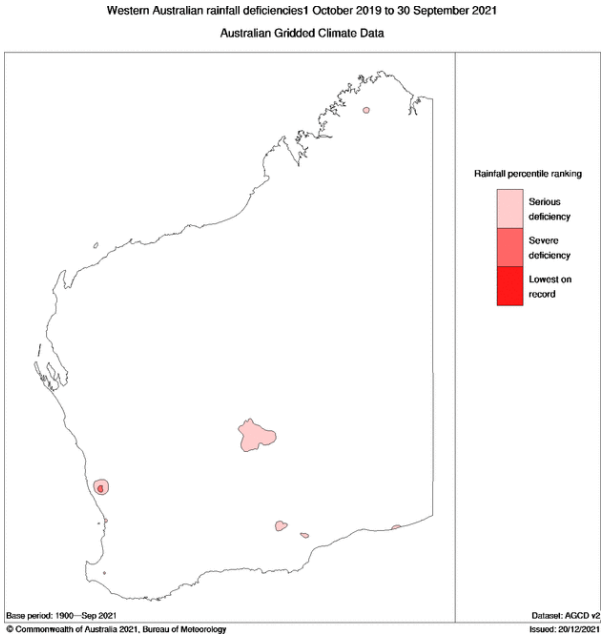

Fig. A2.4. Drought map for Western Australia for the period 1 October 2019 to 30 September 2021 (last 24 months).

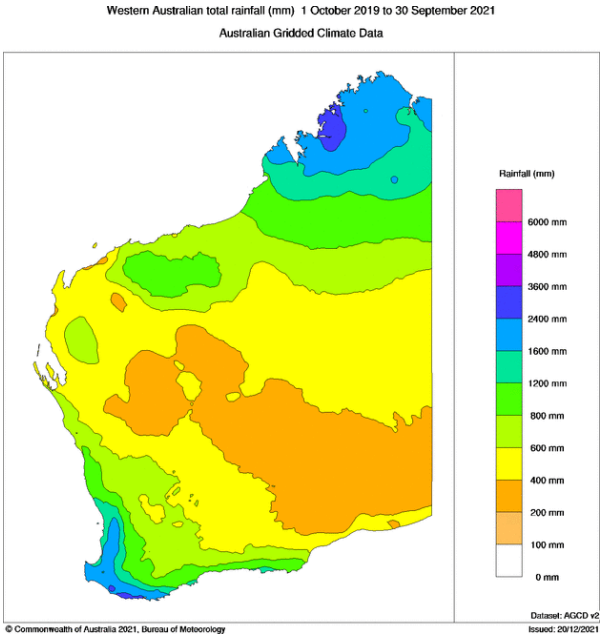

Fig. A2.6. Rainfall totals for Western Australia for the period 1 October 2019 to 30 September 2021 (last 24 months).

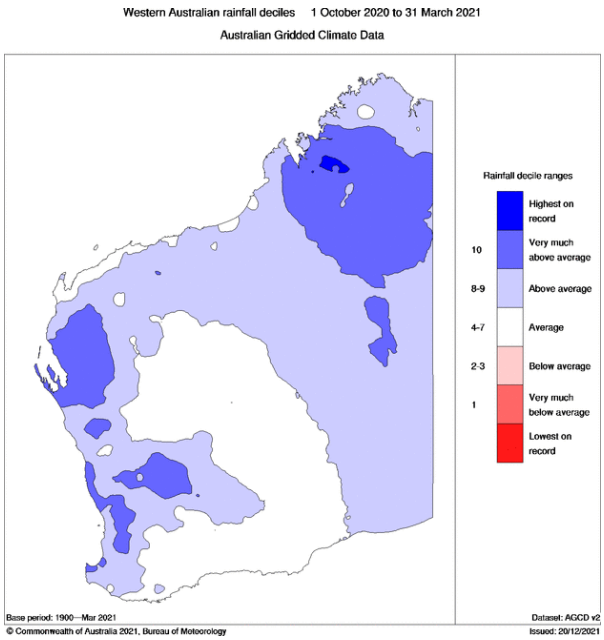

Fig. A2.7. Summer rainfall deciles for Western Australia for the period 1 October 2020 to 31 March 2021.

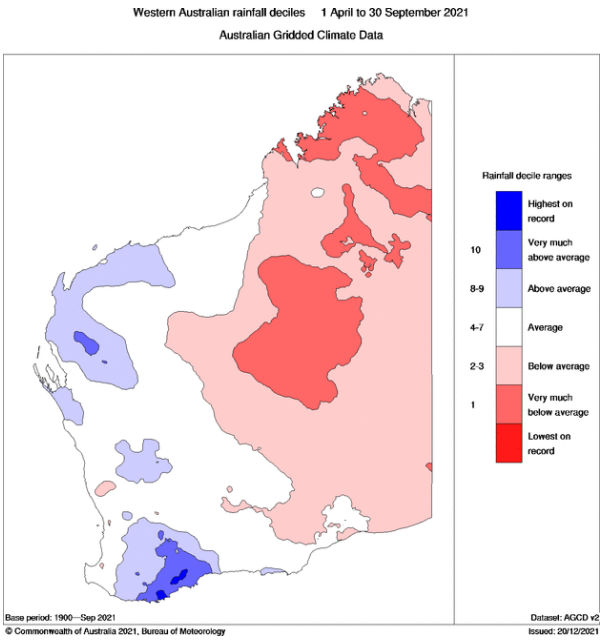

Fig. A2.8. Winter rainfall deciles for Western Australia for the period 1 April to 30 September 2021.

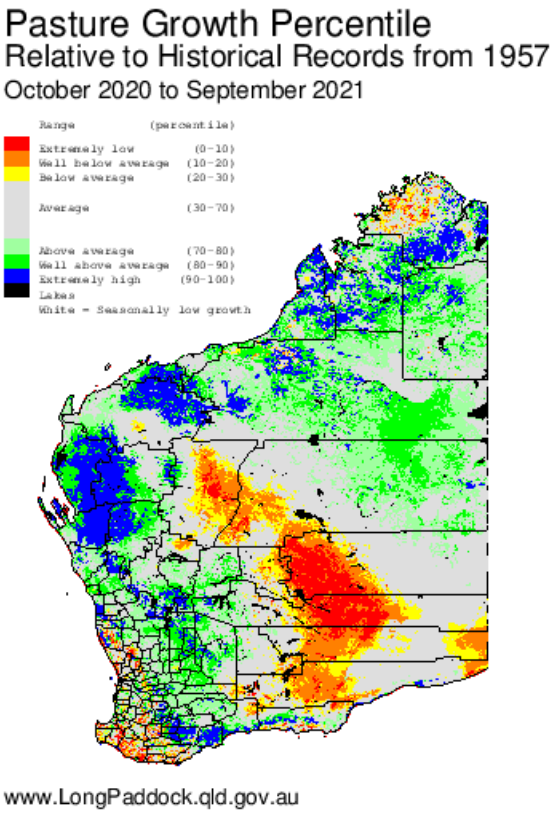

Fig. A2.9. Pasture growth in Western Australia for the period October 2020 to September 2021 (last 12 months).

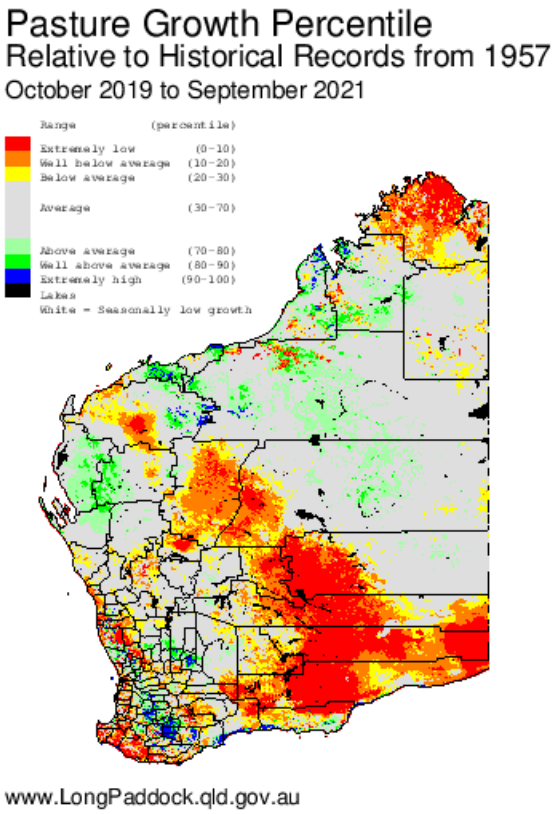

Fig. A2.10. Pasture growth in Western Australia for the period October 2019 to September 2021 (last 24 months).

Appendix 3 Regional population estimates

Harvest data for 2021, presented in the figures and tables in Appendix 3, only includes data processed prior to 31 October 2021.

Northern Zone

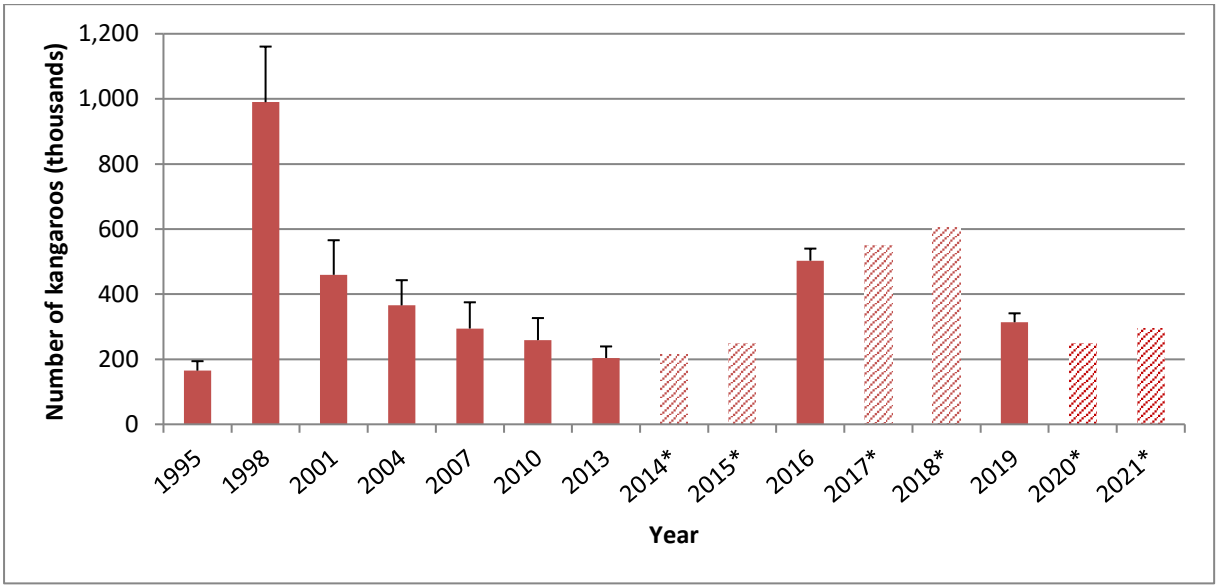

Fig. A3.1.1. Population estimates for red kangaroos in the Northern Zone. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based on estimates from surveys 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] ($\widehat{N}_t$)	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	na
2016[b]	502,800±37,100	2,495	Average	1.1
2017	550,340	1,561	Average	1.1
2018	603,660	3334	Very much below average	na
2019[b]	313,850±27,200	4311	Below average	0.8
2020	247,630	1,562 [c]	Above average[d]	1.2
2021	295,280			

[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 Northern Zone was flown in June/July 2019.

[c] The commercial harvest off-take in the Northern Zone between 1 January 2021 and 31 October 2021.

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

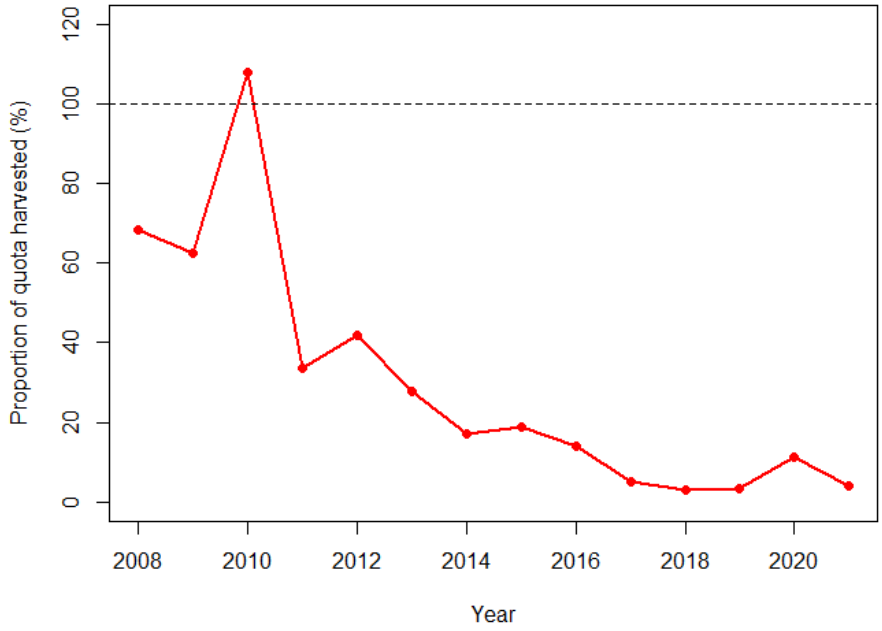

Fig. A3.1.2. Proportion of the Northern Zone commercial quota harvested from 2008 to 2021.

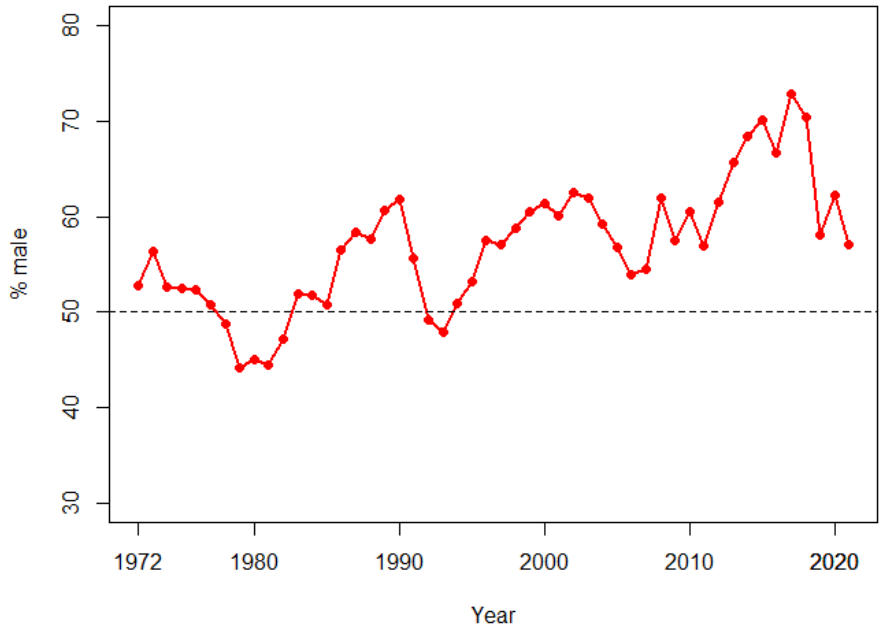

Fig. A3.1.3. Sex ratio of the commercial red kangaroo harvest in the Northern Zone from 1972 to 2021.

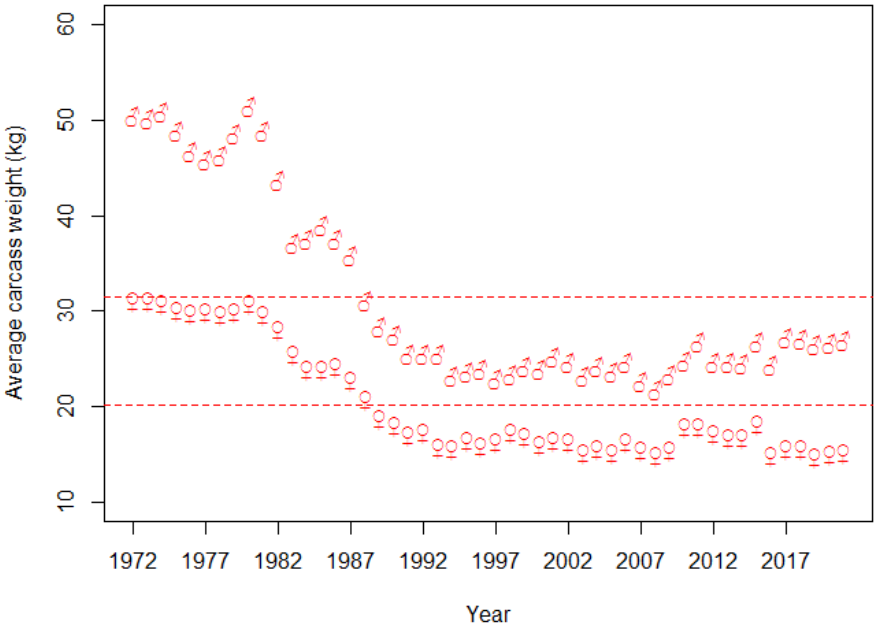

Fig. A3.1.4. Average carcass weights of the commercial red kangaroo harvest in the Northern Zone from 1972 to 2021. Carcass dressing methods (and therefore carcass weights) are not standardised.

Central Zone

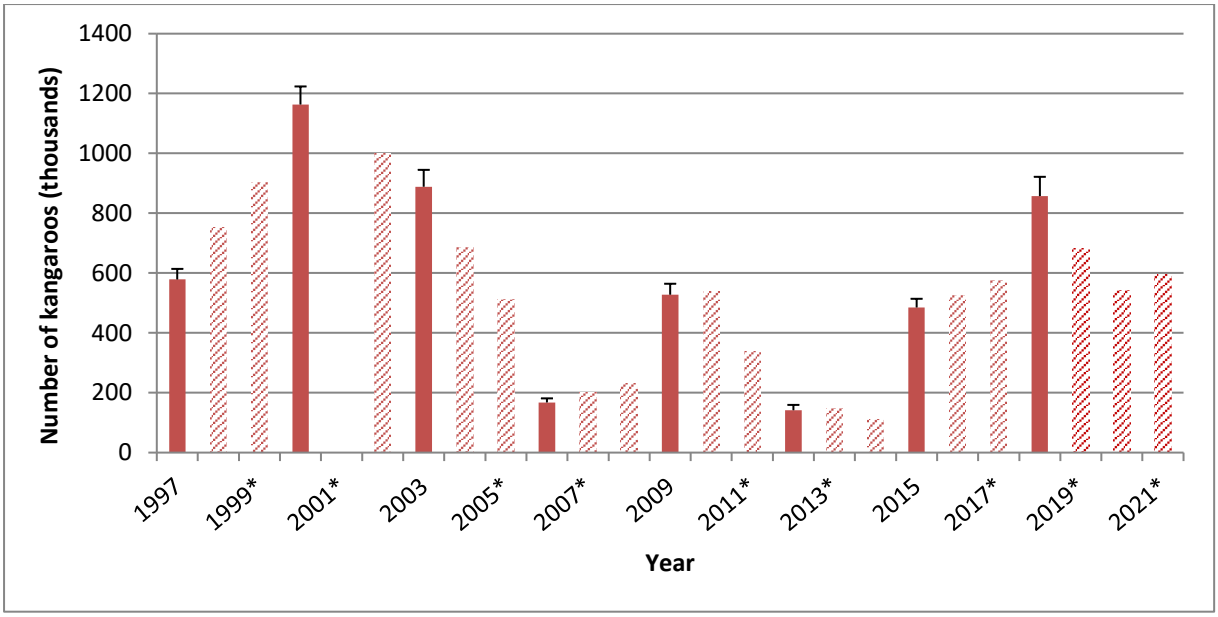

Fig. A3.2.1. Population estimates for red kangaroos in the Central Zone of Western Australia. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based on estimates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

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	na
2015	485,000±29,000	7,886	Average	1.1
2016	524,800	3,399	Average	1.1
2017	573,540	2,599	Average	na
2018[b]	857,350±64,300	3,335	Below average	0.8
2019	683,210	4,992	Below average	0.8
2020	542,575	2,621[c]	Average[d]	1.1
2021	593,950			

[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 due to Covid19 delays and restrictions.

[c] The commercial harvest off-take in the Central Zone between 1 January 2021 and 31 October 2021.

[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).

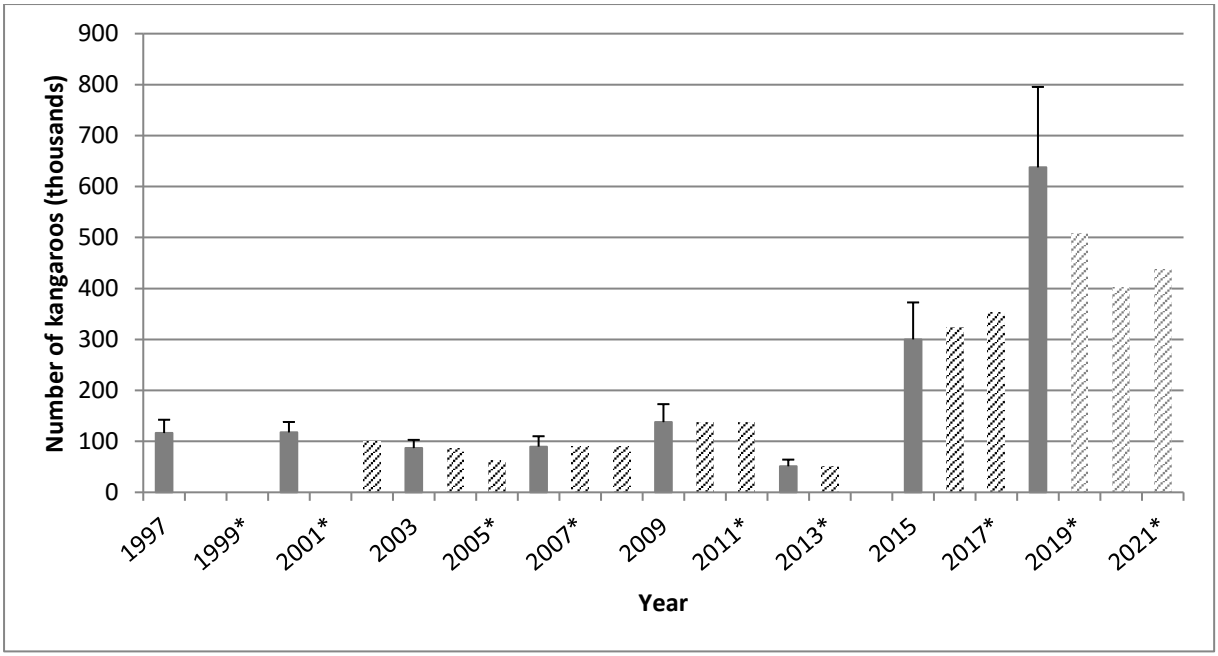

Fig. A3.2.2. Population estimates for western grey kangaroos in the Central Zone of Western Australia. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based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

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	na
2015	300,100±72,500	5,631	Average	1.1
2016	323,900	3,313	Average	1.1
2017	352,645	2,762	Average[d]	na
2018[b]	637,660±157,800	2,679	Below average	0.8
2019	507,985	5,219	Below average[d]	0.8
2020	402,210	4,632[c]	Average[d]	1.1
2021	437,340			

[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 due to Covid19 delays and restrictions.

[c] The commercial harvest off-take in the Central Zone between 1 January 2021 and 31 October 2021.

[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).

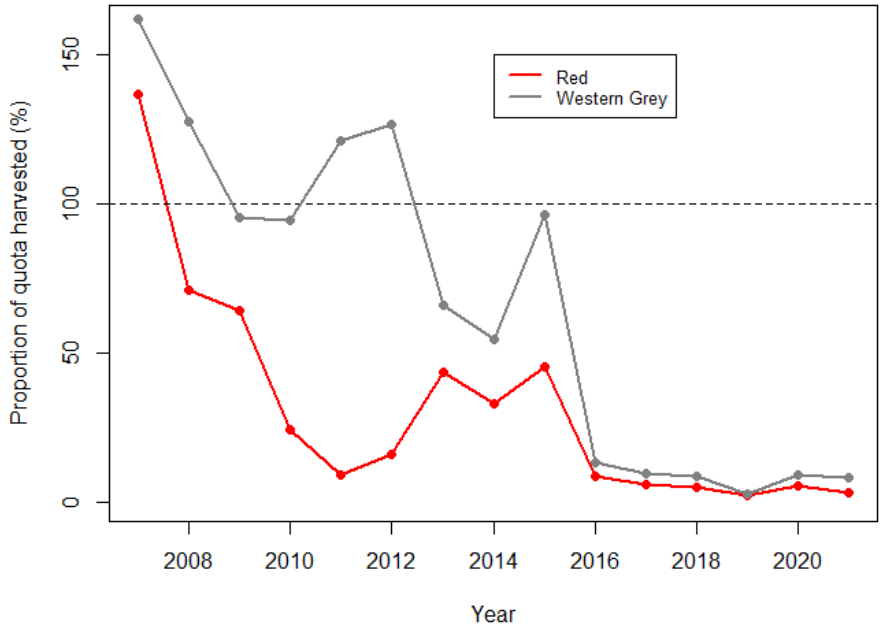

Fig. A3.2.3. Proportion of the Central Zone commercial quota harvested from 2008 to 2021.

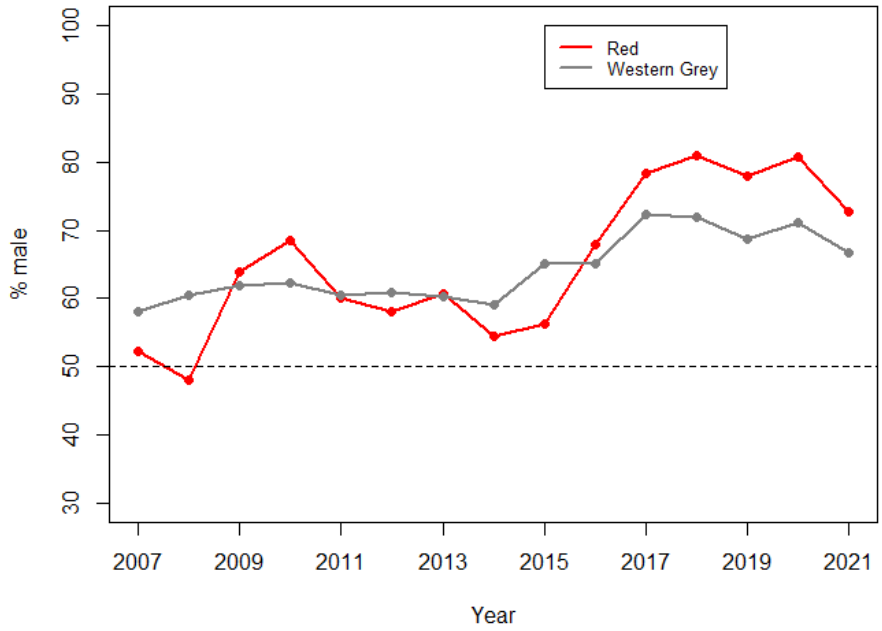

Fig. A3.2.4. Sex ratio of the commercial red and western grey kangaroo harvest in the Central Zone from 2007 to 2021.

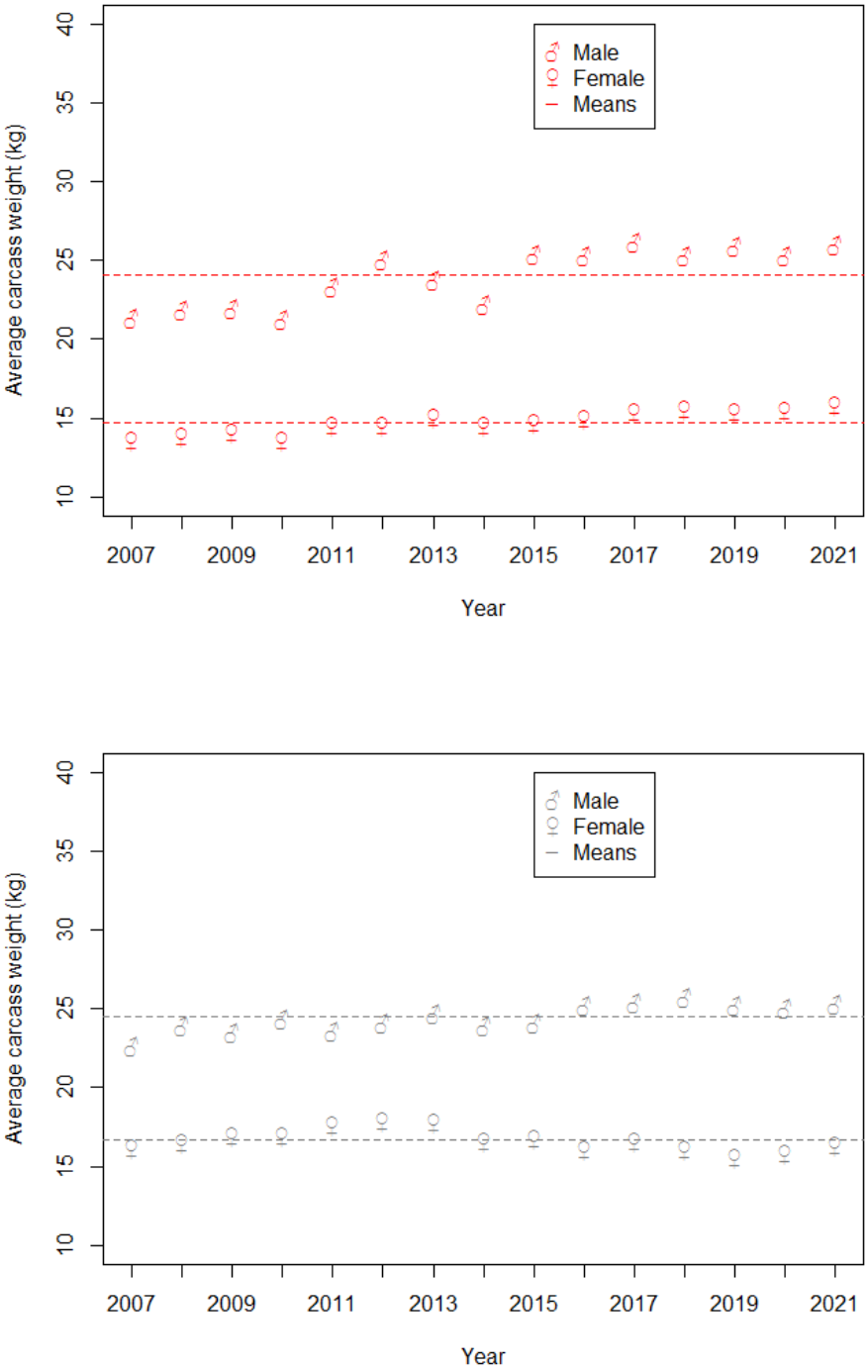

Fig. A3.2.5. Average carcass weights of the commercial red and western grey kangaroo harvest in the Central Zone from 2007 to 2021. Carcass dressing methods (and therefore carcass weights) are not standardised.

South-East Zone

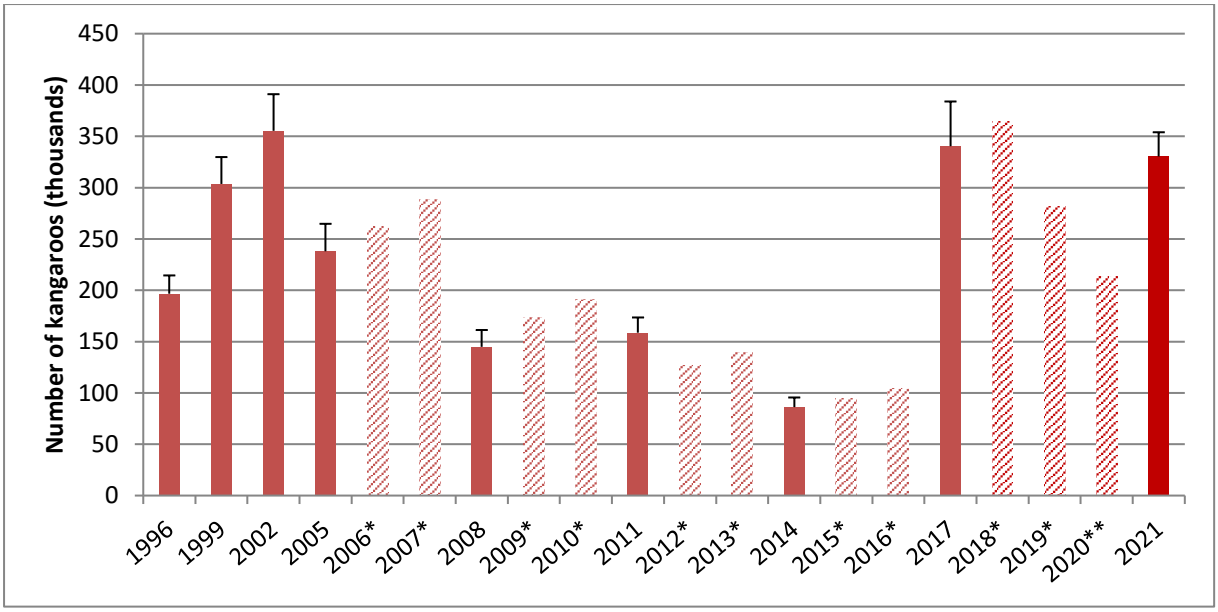

Fig. A3.3.1. Population estimates for red kangaroos in the South-East Zone of Western Australia. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based on estimates from surveys in previous years and/or monitor block surveys, and are scaled according to trends in regional rainfall. **The 2020 aerial survey was not conducted due to Covid-19 restrictions.

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	Average	1.1
2015	94,800	7,781	Above average	1.2
2016	104,400	5,580	Above average	na
2017	340,450±43,470	8,857	Average	1.1
2018	364,750	12,801	Below average	0.8
2019	281,560	14,452	Below average	0.8
2020[e]	213,685	9,660 [c]	Average[d]	1.1
2021[b]	330,410±23,540			

[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 September 2021.

[c] The commercial harvest off-take in the South-East Zone between 1 January 2021 and 31 October 2021.

[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).

[e] Due to Covid-19 restrictions including WA border closure the SE Zone was not flown in 2020.

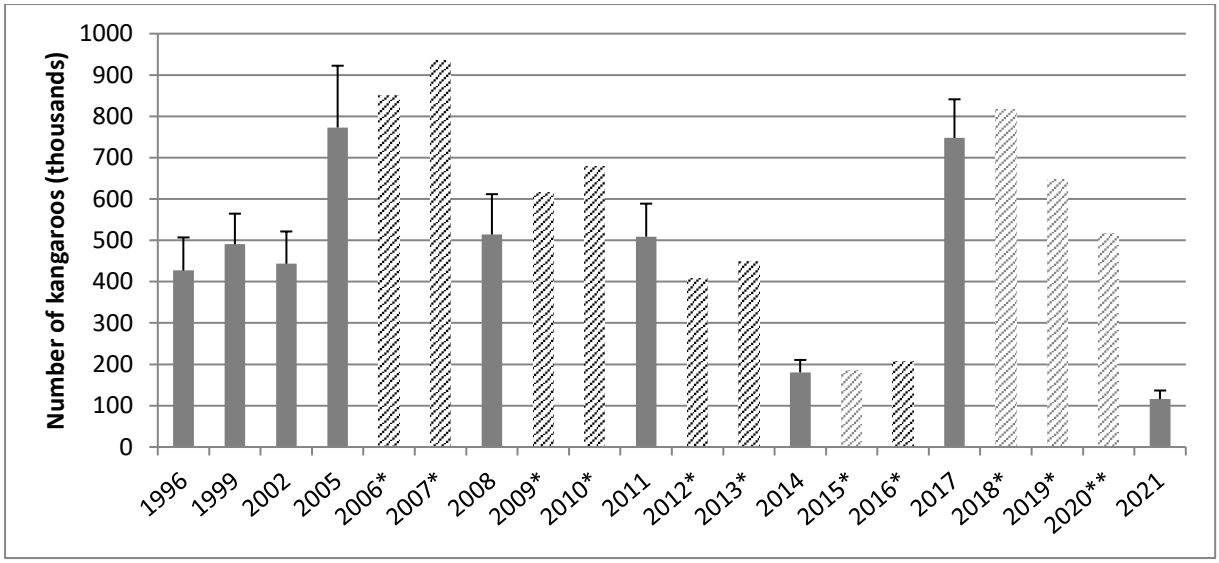

Fig. A3.3.2. Population estimates for western grey kangaroos in the South-East Zone of Western Australia. Note, all estimates use standard habitat correction factors (Table 2.2). Temperature corrections are applied to post-1993 data. Estimates for years where the zone was not surveyed in full (*) are based on estimates from surveys in previous years and/or monitor block surveys, and are scaled according to trends in regional rainfall. **The 2020 aerial survey was not conducted due to Covid-19 restrictions.

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	747,700±93,400	5,117	Average	1.1
2018	816,840	5,548	Below average	0.8
2019	647,620	2,919	Below average	0.8
2020[e]	515,760	3,820 [c]	Average[d]	1.1
2021[b]	115,895±20,760			

[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 September 2021.

[c] The commercial harvest off-take in the South-East Zone between 1 January 2021 and 31 October 2021.

[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).

[e] Due to Covid-19 restrictions including WA border closure the SE Zone was not flown in 2020.

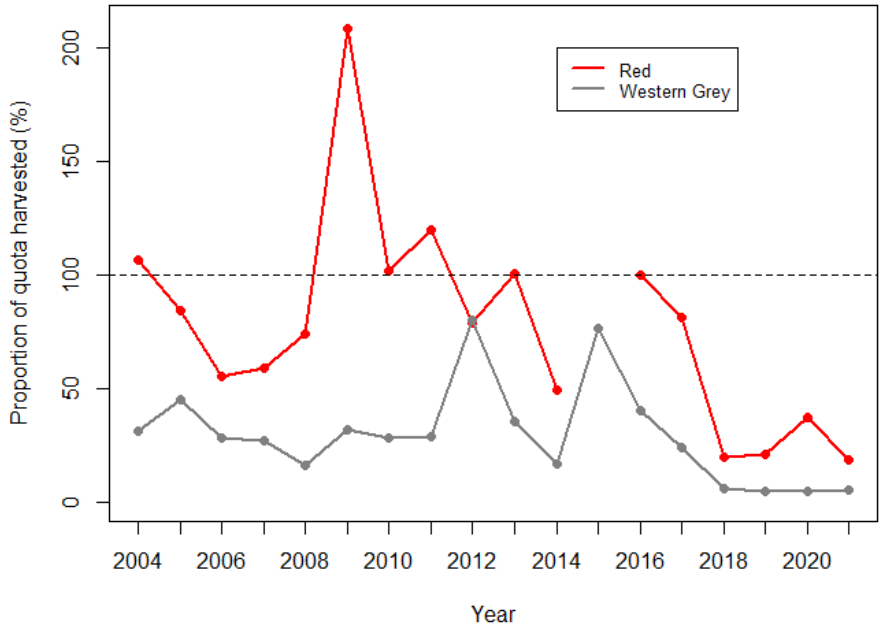

Fig. A3.3.3. Proportion of the South-East Zone commercial quota harvested from 2008 to 2021. Note, no red kangaroos were harvested in 2015.

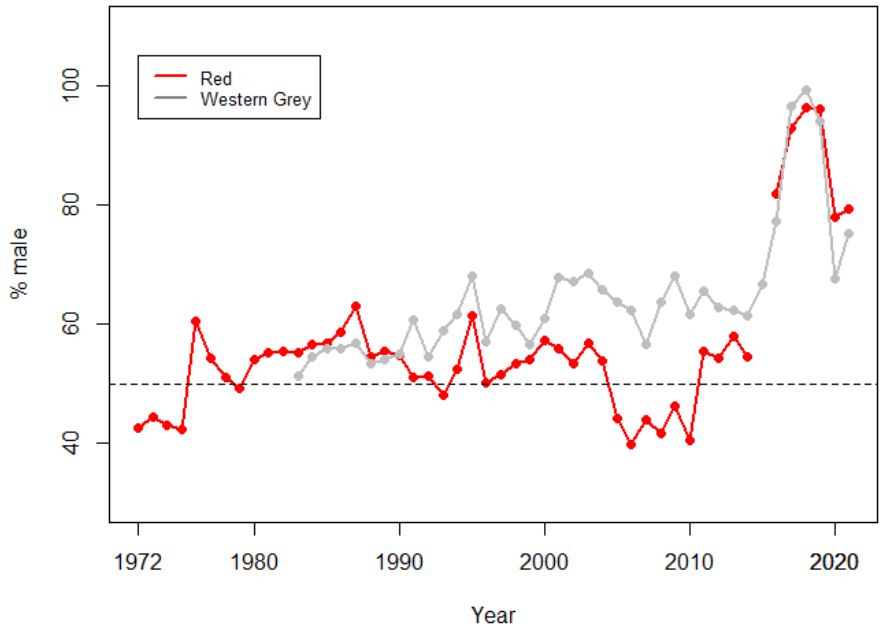

Fig. A3.3.4. Sex ratio of the commercial harvest of red and western grey kangaroos in the South-East Zone from 1972 to 2021. Note, no red kangaroos were harvested in 2015.

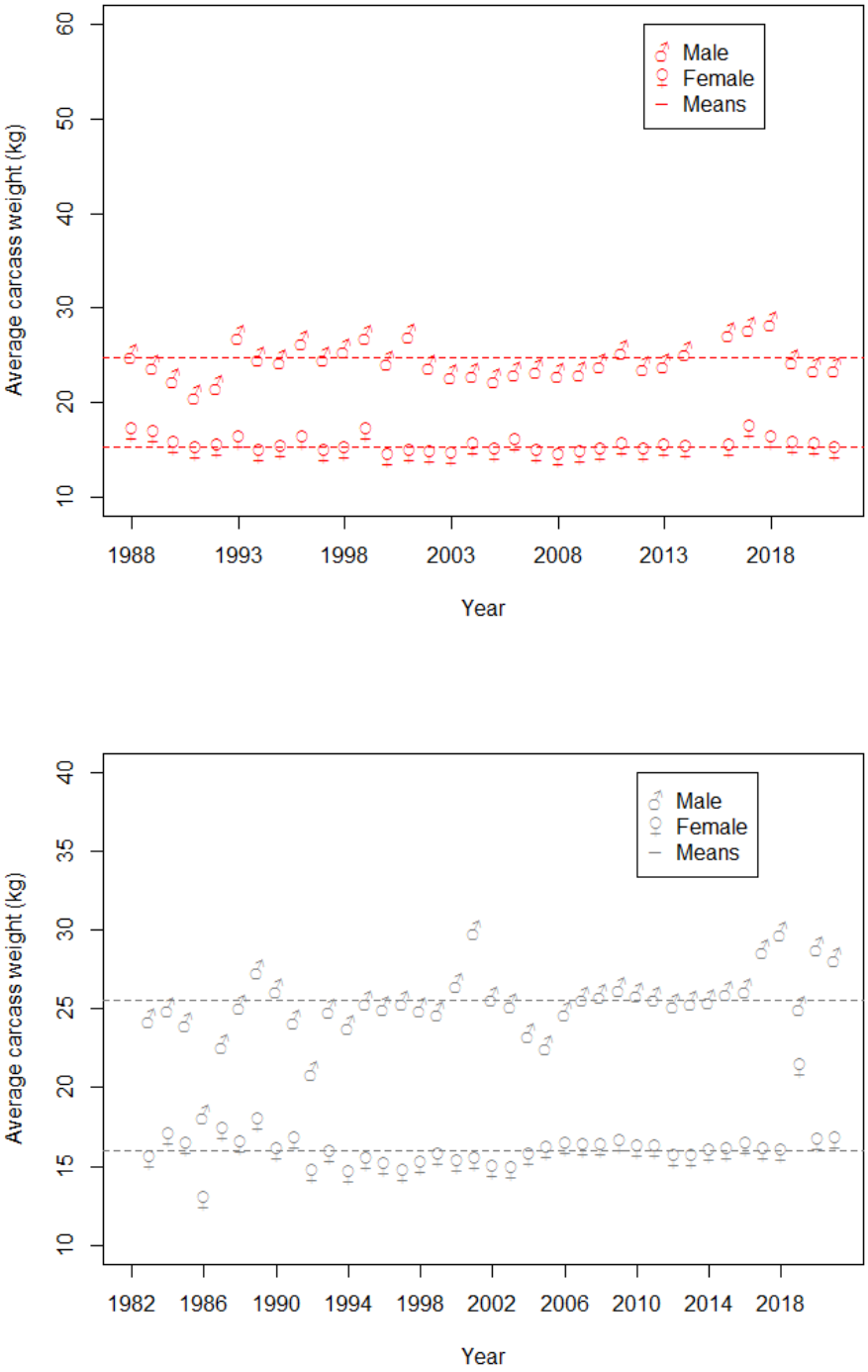

Fig A3.3.5. Average carcass weights of the commercial red and western grey kangaroo harvest in the South-East Zone. Carcass dressing methods (and therefore carcass weights) are not standardised.

South-West Zone

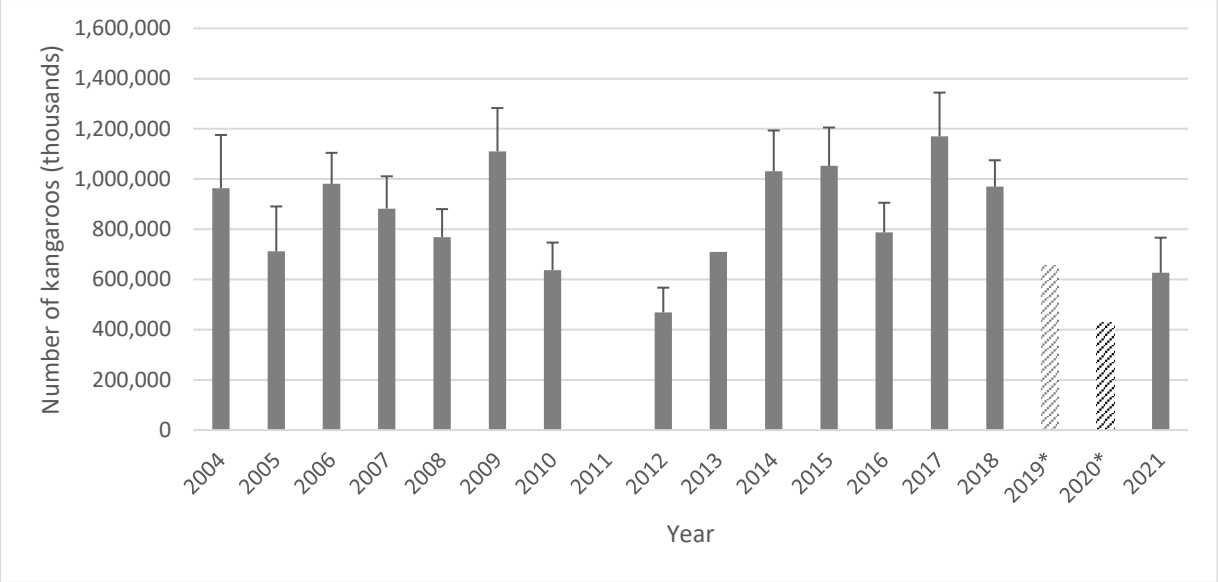

Fig. A3.4.1. Aerial survey population estimates with standard errors for western grey kangaroos in South-West Zone monitor blocks from 2004-2021. All estimates use standard habitat correction factors (Table 2.2) and temperature corrections. No aerial surveys were undertaken in the South-West Zone from 1988-2003, in 2011, 2019 and 2020. 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. 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.

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.

Table A3.4.1. Western grey kangaroo population estimates for the South-West 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)
2018	969,300±105,250	31,617	Below average	0.7
2019	656,380	43,645[c]	Below average	0.8
2020	490,190	36,874 [c]	Above average[d]	1.2
2021 [b]	626,310±140,240			

[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-West Zone was flown in October 2021.

[c] The commercial harvest off-take in the South-West Zone between 1 January 2021 and 31 October 2021.

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

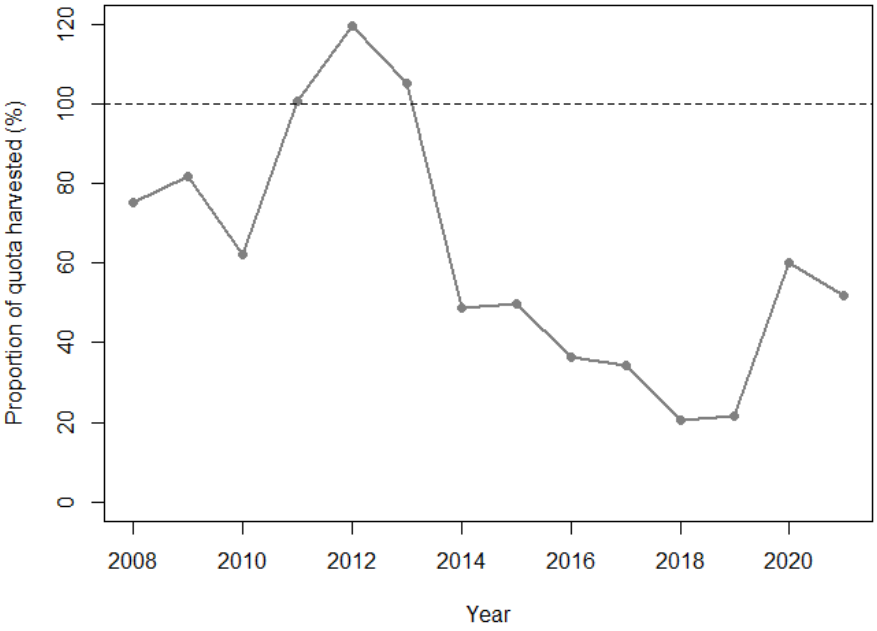

Fig. A3.4.2. Proportion of the South-West Zone regional commercial quota harvested from 2008 to 2021.

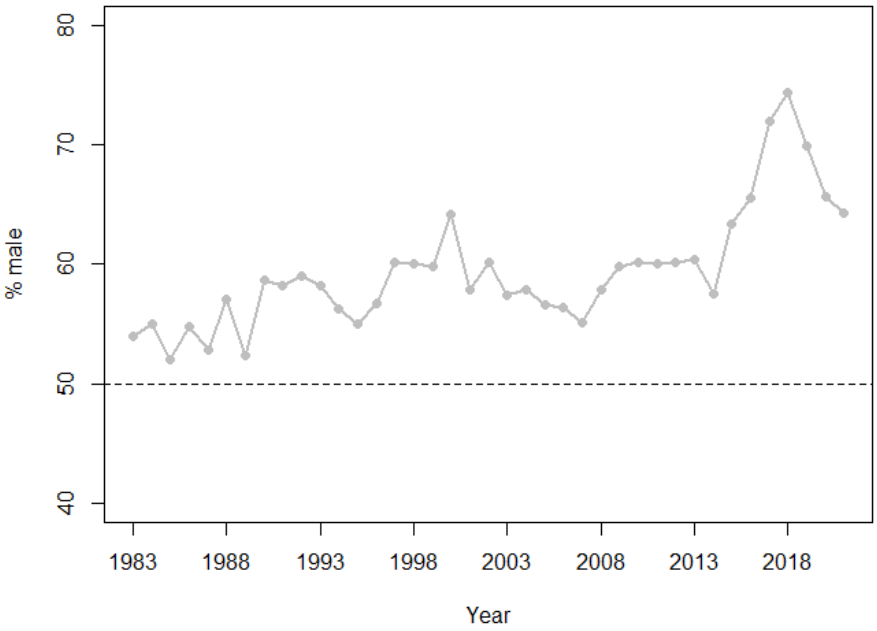

Fig. A3.4.3. Sex ratio of the commercial harvest of western grey kangaroos in the South-West Zone from 1983 to 2021.

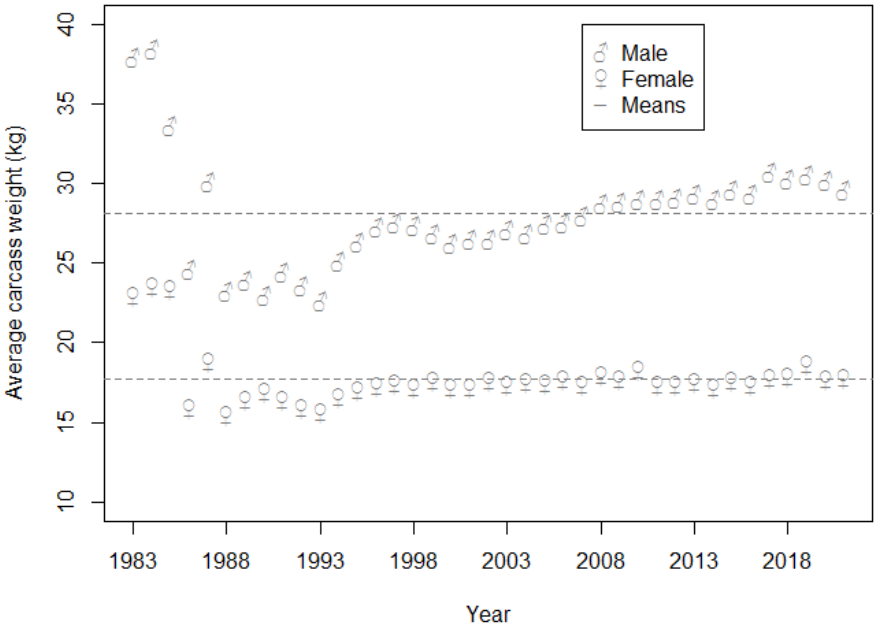

Fig A3.4.4. Average carcass weights of the commercial western grey kangaroo harvest in the South-West Zone. Carcass dressing methods (and therefore carcass weights) are not standardised.