Biodiversity and Conservation Science

2024 Commercial Kangaroo Harvest Quota Submission for Western Australia

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

January 2024

GOVERNMENT OF WESTERN AUSTRALIA

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This document is available in alternative formats on request.

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1 Proposed quotas for Western Australia for 2024

This document presents the proposed quotas for commercial kangaroo harvest in Western Australia for 2024. This document should be read and considered in conjunction with the Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2024-2028 (Management Plan).

Population estimates for 2023 indicated that western grey kangaroos remained at a relatively low density in the South-East Population Monitoring Zone (PMZ) at 0.22 individuals per km^2; falling below the no harvest threshold. The South-East PMZ has experienced below average to very much below average rainfall and extremely low pasture growth over the last 24 months (Appendix 2). Densities of western grey kangaroos were calculated for Kangaroo Management Areas within the South-East PMZ, as well as the entire South-East PMZ, and are shown in Table 1.4. The density of western grey kangaroos was 1.1 individuals per km^2 in the South Eastern Agricultural (SEA) Kangaroo Management Area and 0.38 individuals per km^2 in the Nullarbor Kangaroo Management Area. Western grey kangaroo densities at the remaining Kangaroo Management Areas were below 0.3 individuals per km^2. It is likely that higher quality habitat for western grey kangaroos exists in the coastal SEA and Nullarbor Kangaroo Management Areas of the South-East PMZ (Figure 1, DBCA 2023).

In accordance with the Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2024-2028, Action 12 (DBCA 2023), the commercial harvest rate is to be suspended if aerial surveys indicate that the western grey kangaroo population density within the South-East PMZ or within Management Areas within the PMZ has fallen below 0.33 individuals per km^2 and harvests must be reduced to a 10% of the population estimate at densities between 0.33 and 0.46 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 density thresholds. Therefore, in the South-East PMZ in 2024 regular harvest of western grey kangaroos may occur only from the SEA Kangaroo Management Area and reduced harvest may occur from the Nullarbor Kangaroo Management Area (Table 1.4). There is to be no harvest of western grey kangaroos in the remainder of the South-East PMZ in 2024. This is the third consecutive year in which harvest suspensions have been in place for the South-East PMZ, excluding the SEA Kangaroo Management Area where population densities have remained above the density thresholds. Regular harvest rates of 15% of the population estimate have been set for western grey kangaroos in the Central and South-West PMZs.

In the Central PMZ where rainfall in 2023 was very much below average, the density of red kangaroos is within the harvest reduction threshold and the quota has therefore been set at 10% of the population estimate. Regular harvest rates of 17% of the population estimate have been set for red kangaroos in the Northern and South-East PMZs.

1.1 State summary

Species	2024 Proposal			2023		
	2023 Population estimate	Harvest rate (%)	**Quota**	Quota	Harvest rate (%)	2022 Population estimate
Red kangaroo	609,155	15[a]	**89,330**	125,225	17	736,630
Western grey kangaroo	1,086,235	15[a]	**161,100**	203,240	14[a]	1,419,920
Totals	**1,695,390**		**250,430**	328,465		**2,156,550**

[a] Rate calculated from total harvest quota

1.2 Regional quotas for red kangaroos in 2024

(See Figure 1 for location of Population Monitoring Zones).

Population Monitoring Zone	2023 Population estimate ($\widehat{N}$)	2024 Proposal	
		Harvest rate (H) %	**Quota ($\widehat{N} \times H$)**
Central	203,210	10	20,320
Northern	174,470	17	29,660
South-East	231,475	17	39,350
Totals	**609,155**		**89,330**

1.3 Regional quotas for western grey kangaroos in 2024

(See Figure 1 for location of Population Monitoring Zones).

Population Monitoring Zone	**2023 Population estimate ($\widehat{N}$)**	**2024 Proposal**	
		Harvest rate (H) %	**Quota ($\widehat{N} \times H$)**
Central	218,710	15	32,805
South-East	77,255	10-15 (SEA and Nullarbor Kangaroo Management Areas only)	9,755 (SEA and Nullarbor Kangaroo Management Areas only)
South-West	790,270	15	118,540
Totals	**1,086,235**		**161,100**

1.4 South-East Kangaroo Management Area quotas for western grey kangaroos in 2024

(See Figure 1 in (DBCA, 2023) for location of Kangaroo Management Areas).

Kangaroo Management Area	**2023 Density (kangaroos per km^2)**	**2023 Population estimate ($\widehat{N}$)**	**2024 Proposal**	
			Harvest rate (H) %	**Quota ($\widehat{N} \times H$)**
South Eastern Agricultural (SEA)	1.10	44,015	15	6,600
Dundas (DU)	0.09	4,050	0	0
Nullarbor (NU)	0.38	31,550	10	3,155
Coolgardie (CO/CG)	-	-	0	0
Leonora Eastern Goldfields (LEG)	0.06	6,895	0	0

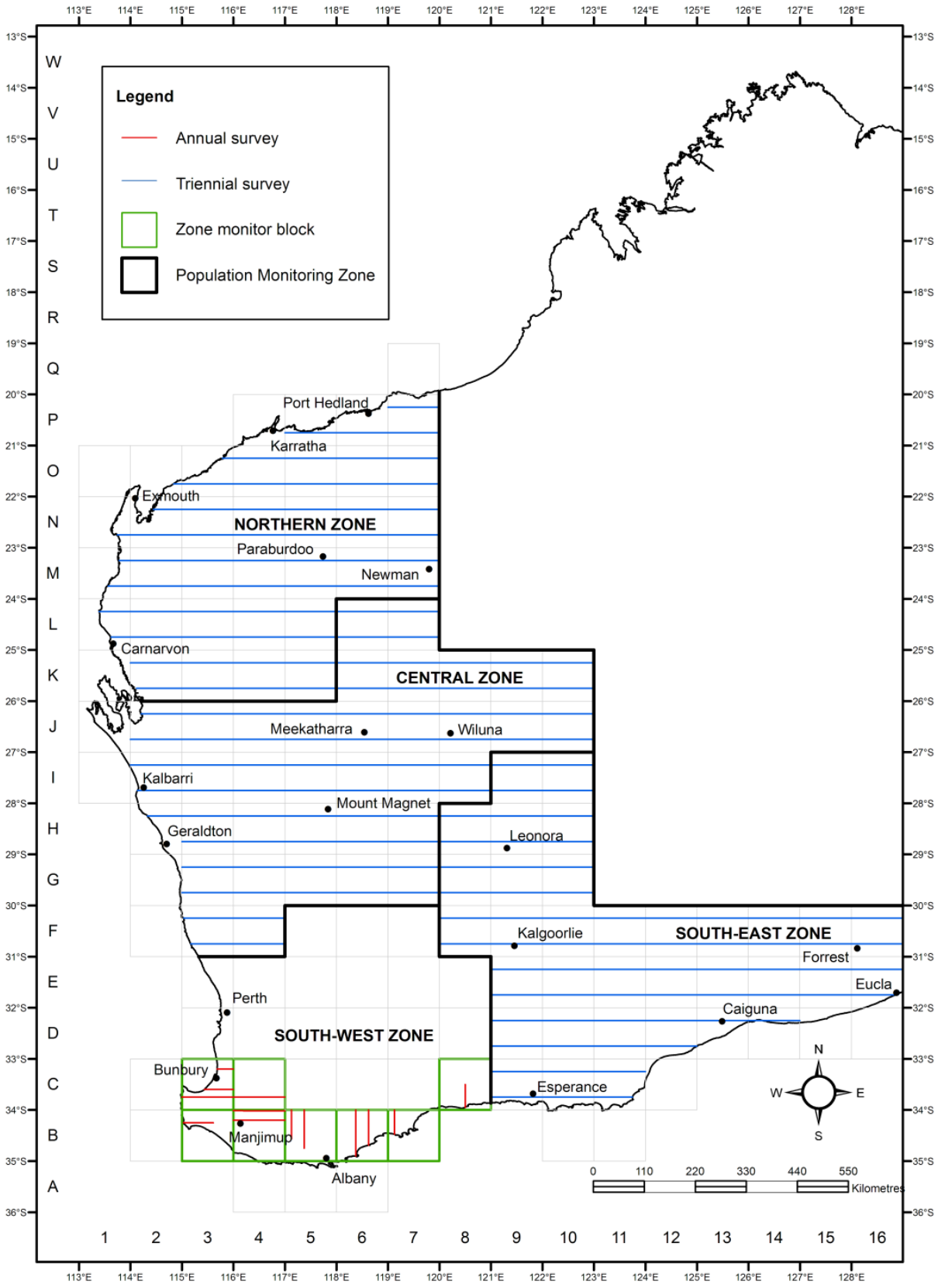

Figure 1: Kangaroo Population Monitoring Zones over the allowable harvest areas in Western Australia.

2 Aerial survey and population estimation methods

2.1 Fixed-wing aerial survey

The aerial survey program has been conducted across Western Australia since 1981 following pre-determined transect lines (Figure 1). The survey is conducted using standard 200 m fixed-width strip transect methods from a fixed-wing aircraft (Table 1; (Pople and Grigg, 1999). Correction factors are applied to account for unseen kangaroos (Table 2).

In 2023, the South-East PMZ was surveyed in full and monitor blocks were surveyed in the South-West (SW; Table 1).

Table 1 Aerial survey parameters

Altitude	250 feet (76 m) above ground level
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	Red and western grey kangaroos
Extent	Pastoral rangelands and parts of the northern and south coast agricultural regions (Figure 1).
Frequency	Whole of commercial harvest zone was surveyed triennially from 1981 to 1993 (1981, 1984, 1987, 1990, 1993). Then: • Northern Zone in 1995, 1998, 2001, 2004, 2007, 2010, 2013, 2016, 2019 and 2022. • South-East Zone in 1996, 1999, 2002, 2005, 2008, 2011, 2014, 2017, 2021 and 2023. • Central Zone in 1997, 2000, 2003, 2006, 2009, 2012, 2015, 2018 and 2022.
Monitor blocks	• Monitor blocks in the South-West Zone in 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2021, 2022 and 2023.
Methodology	Standard 200 metre fixed-width strip surveys flown at 100 knots (185 km/hr), 76 metres above ground level (see Pople and Grigg 1999). Population estimates are made using standard correction factors (Table 2) with temperature correction for all species.

Table 2: Standard fixed-wing survey correction factors used for population estimates.

Species	Correction Factor[a]			
	Open Vegetation	**Light Vegetation**	**Medium Vegetation**	**Dense Vegetation**
Red Kangaroo (*Osphranter 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]

[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, Sinclair and Scott-Kemmis (1976).

[c] From Pople and Grigg (1999).

2.2 Population estimates

The South-East and South-West PMZs were surveyed in 2023 while the Northern and Central PMZs were surveyed most recently in 2022. Population estimates for PMZs not surveyed this year were determined 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:

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

where:

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

H = commercial harvest offtake between population estimates; and

r = population growth rate for a regional rainfall category.

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 (Appendix 1);
- Seasonal conditions (Appendix 2);
- Current populations trends (Appendix 3);
- The proportion of 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.

Quotas are based on a proportion threshold harvesting strategy as described in the Management Plan to ensure sustainable harvest (DBCA, 2023). Under this strategy, the quota does not exceed 17% of the estimated population of red kangaroos, and 15% of the estimated population of western grey kangaroos. Low populations are further protected by the implementation of density thresholds that trigger harvest reduction to 10% of the estimated population for both species, or harvest suspension. Thresholds have been determined based on standard deviations relative to the long-term average density and are specific to species and PMZ.

Table 3: Density thresholds for Western Australia PMZs for red and western grey kangaroos.

PMZ[x]	**Density thresholds (kangaroos per km^2)**					
	Red kangaroo			Western grey kangaroo		
	17% HR (Threshold 1)	10% HR	No harvest (Threshold 2)	15% HR (Threshold 1)	10% HR	No harvest (Threshold 2)
Central	$D > 0.57^a$	$0.57^a \geq D > 0.40^b$	$D \leq 0.40^b$	$D > 0.18^a$	$0.18^a \geq D > 0.12^b$	$D \leq 0.12^b$
Northern	$D > 0.47^b$	$0.47^b \geq D > 0.36^c$	$D \leq 0.36^c$	Extralimital – no quota		
South-East	$D > 0.29^b$	$0.29^b \geq D > 0.23^c$	$D \leq 0.23^c$	$D > 0.46^b$	$0.46^b \geq D > 0.33^c$	$D \leq 0.33^c$
South-West	Vagrant – no quota			$D > 8.4^c$	$8.4^c \geq D > 6.5^d$	$D \leq 6.5^d$

x = The density thresholds for each PMZ will also apply to any Kangaroo Management Area within that PMZ.

HR = Harvest rate as a proportion of the population estimate.

D = Density estimate (kangaroos per km^2) 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 PMZ between 1995 and 2022.

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

4 Harvest monitoring

Trends in harvest data including commercial take, sex ratio and average carcass weight by sex are analysed across the commercial harvest zone (Appendix 1).

References

Caughley, G., Sinclair, R. and Scott-Kemmis, D. (1976) ‘Experiments in aerial survey’, *Journal of Wildlife Management*, 40(2), pp. 290–300.

Department of Biodiversity, Conservation and Attractions (2023) *Management plan for the commercial harvest of kangaroos in Western Australia 2024-2028.* Western Australia.

Pople, T. and Grigg, G. (1999) *Commercial harvesting of kangaroos in Australia*. Canberra: Environment Australia.

Appendices

Appendix 1 Harvest monitoring results for Western Australia

The figures and tables in Appendix 1 only include harvest data processed prior to 31 October 2023.

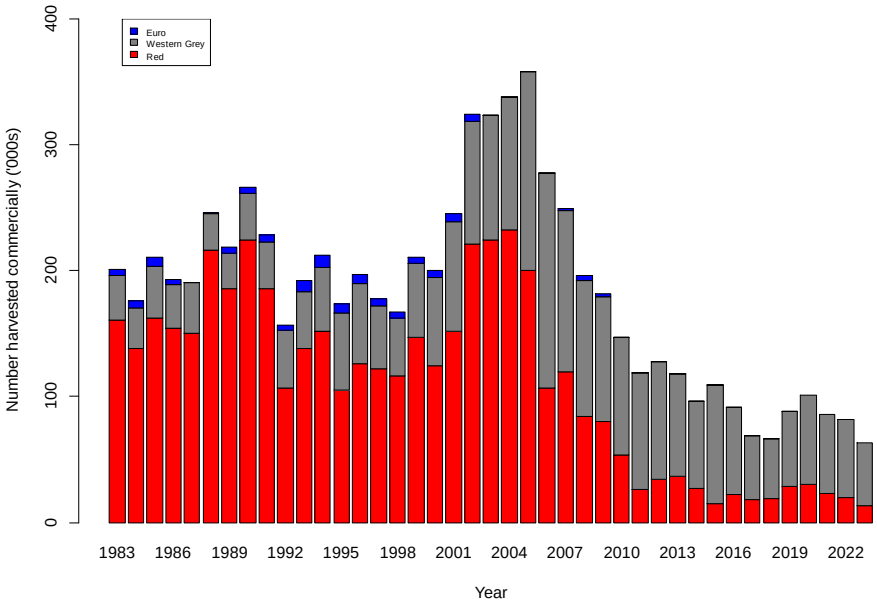

Fig. A1.1. Total commercial kangaroo harvest in Western Australia from 1983 to 2023. Commercial harvest of euros (*Macropus robustus*) did not take place between 2003-2006 and from 2010-2023.

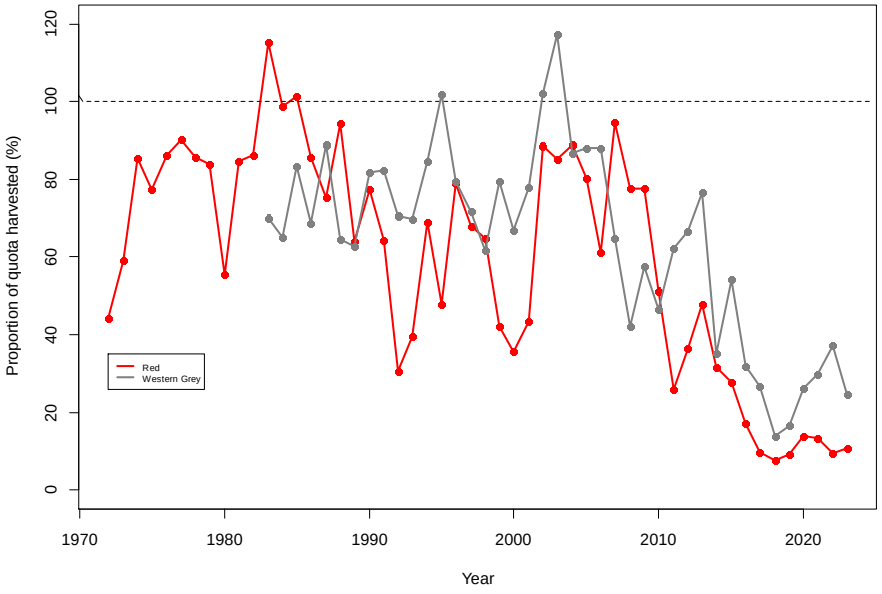

Fig. A1.2. Proportion of the commercial quota of red and western grey kangaroos harvested in Western Australia from 1972 to 2023.

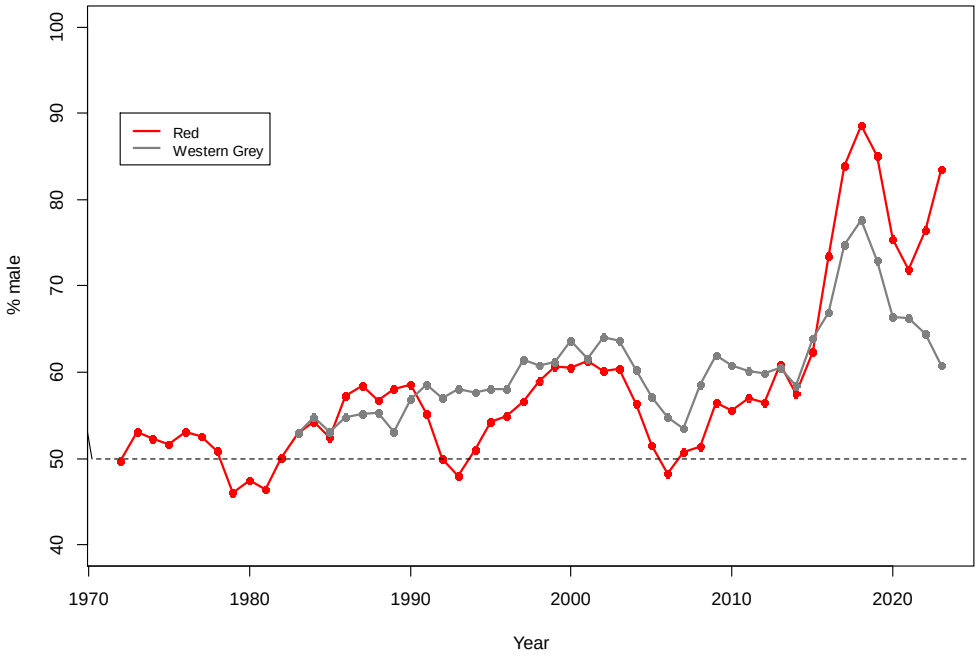

Fig. A1.3. Sex ratio of the commercial kangaroo harvest in Western Australia from 1972 to 2023.

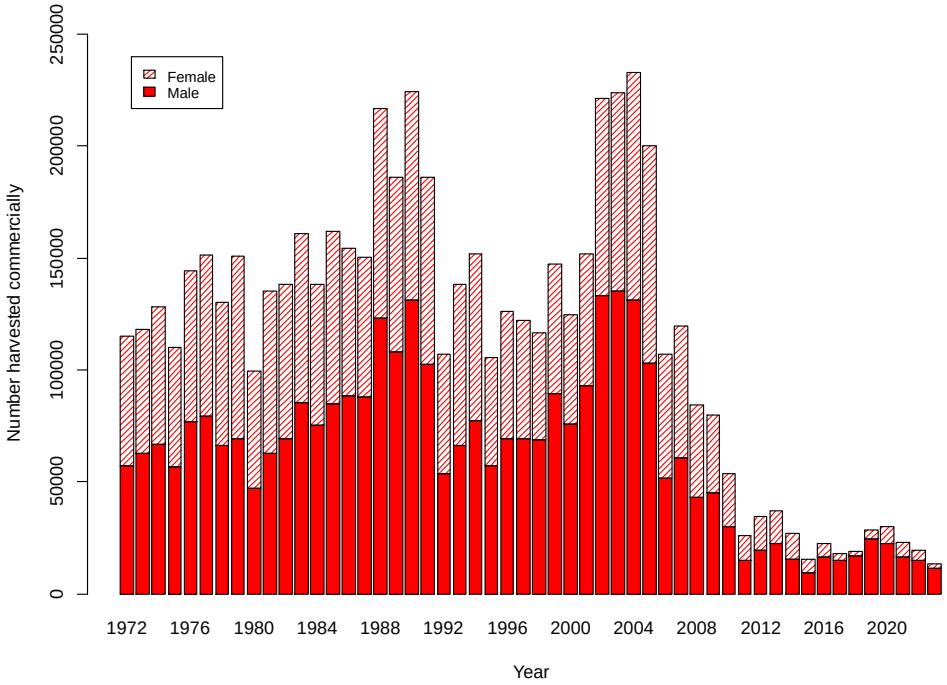

Fig. A1.4. Number and sex of red kangaroos harvested commercially in Western Australia from 1972 to 2023.

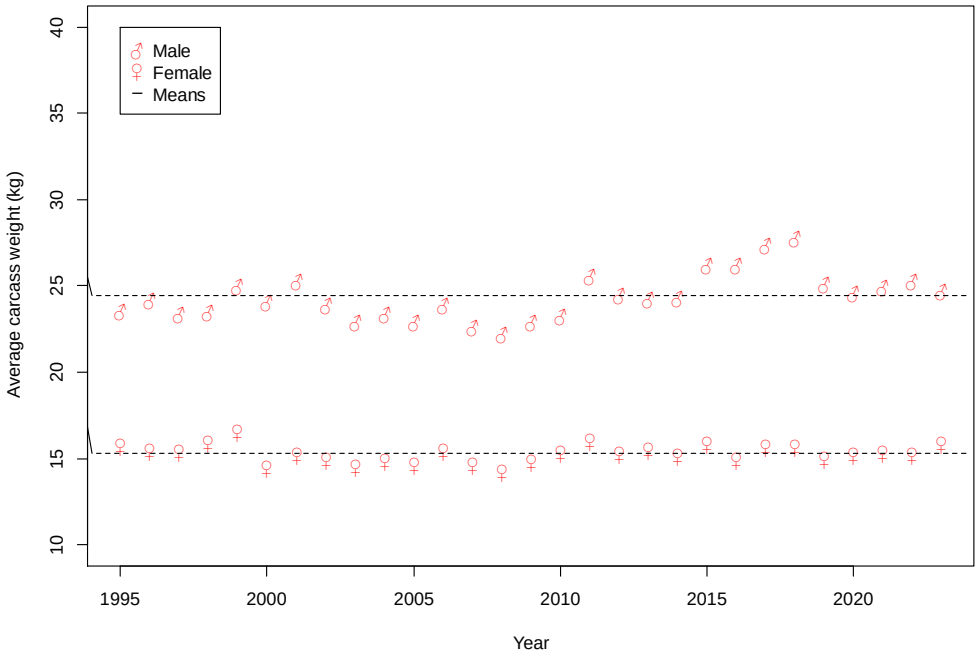

Fig. A1.5. Average carcass weights for red kangaroos harvested commercially in Western Australia from 1995 to 2023. Carcass dressing methods (and therefore carcass weights) are not standardised.

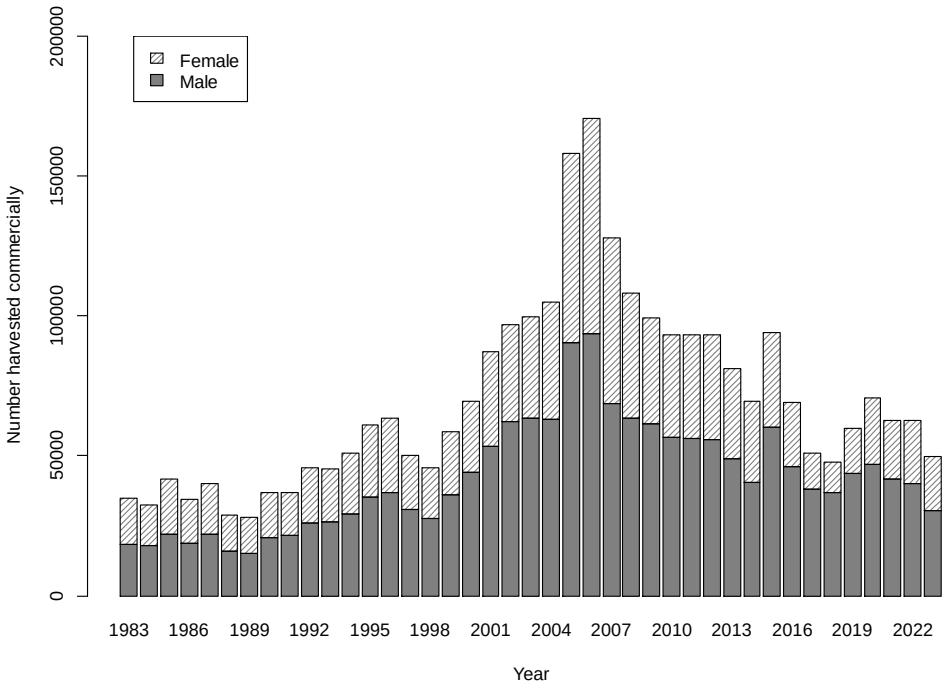

Fig. A1.6. Number and sex of western grey kangaroos harvested commercially in Western Australia from 1983 to 2023.

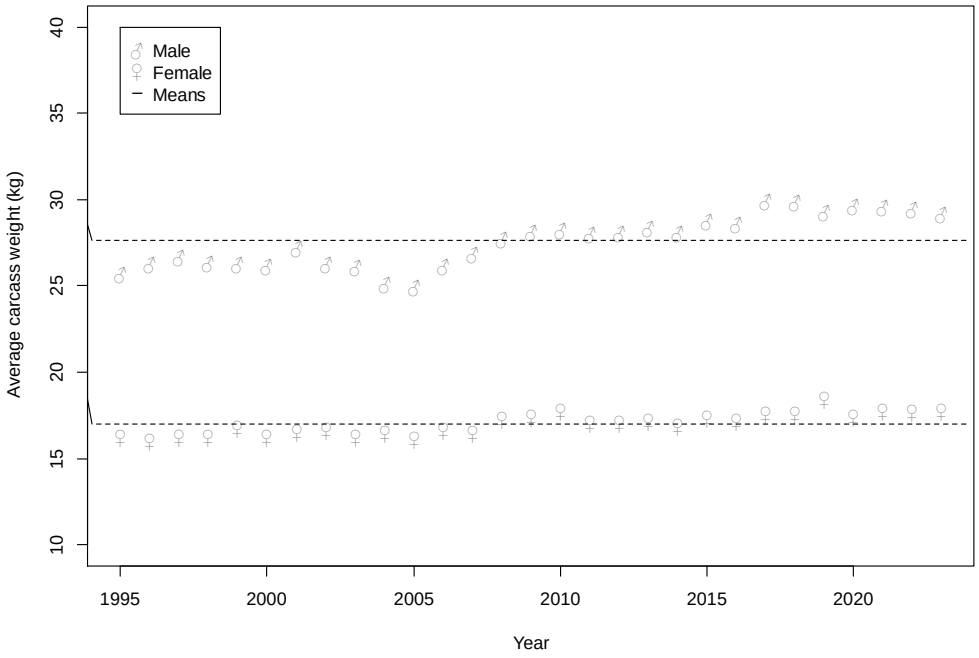

Fig. A1.7. Average carcass weights for western grey kangaroos harvested commercially in Western Australia from 1995 to 2023. Carcass dressing methods (and therefore carcass weights) are not standardised.

Appendix 2 Rainfall and drought maps

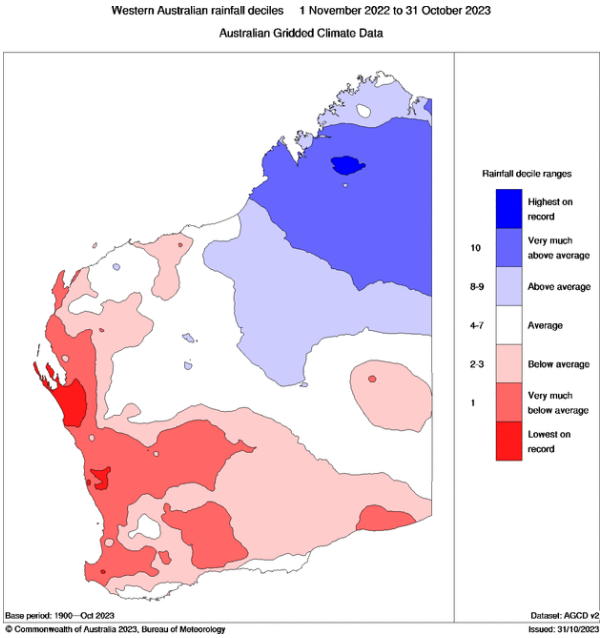

Fig. A2.1. Rainfall deciles for Western Australia for the period 1 November 2022 to 31 October 2023 (last 12 months).

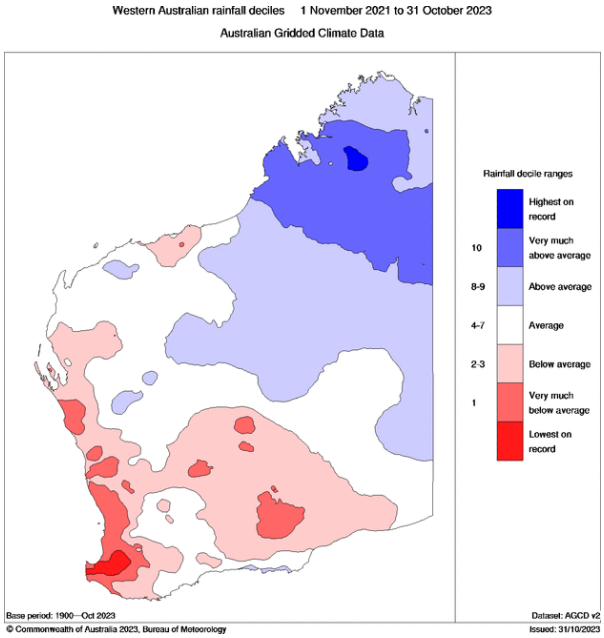

Fig. A2.2. Rainfall deciles for Western Australia for the period 1 November 2021 to 31 October 2023 (last 24 months).

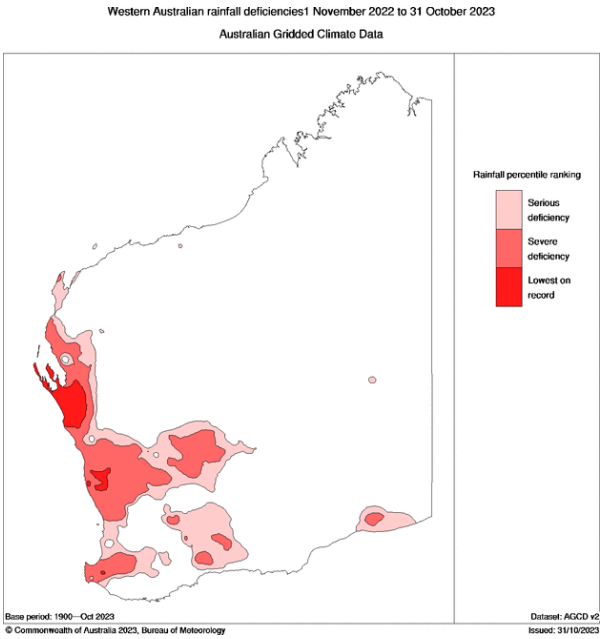

Fig. A2.3. Drought map for Western Australia for the period 1 November 2022 to 31 October 2023 (last 12 months).

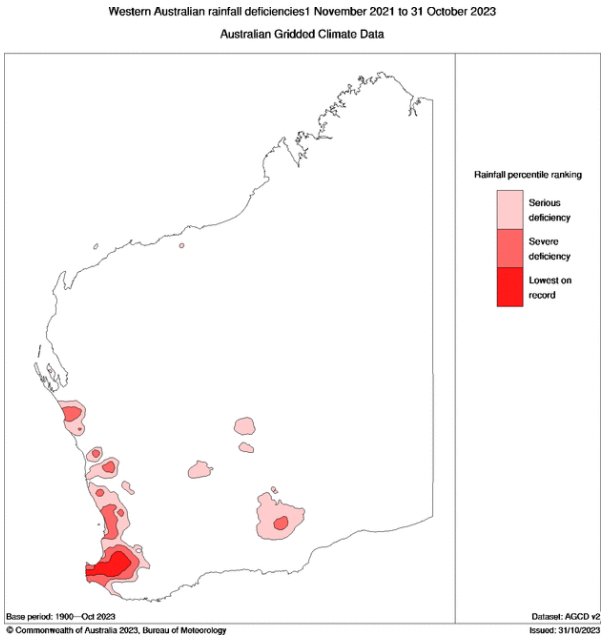

Fig. A2.4. Drought map for Western Australia for the period 1 November 2021 to 31 October 2023 (last 24 months).

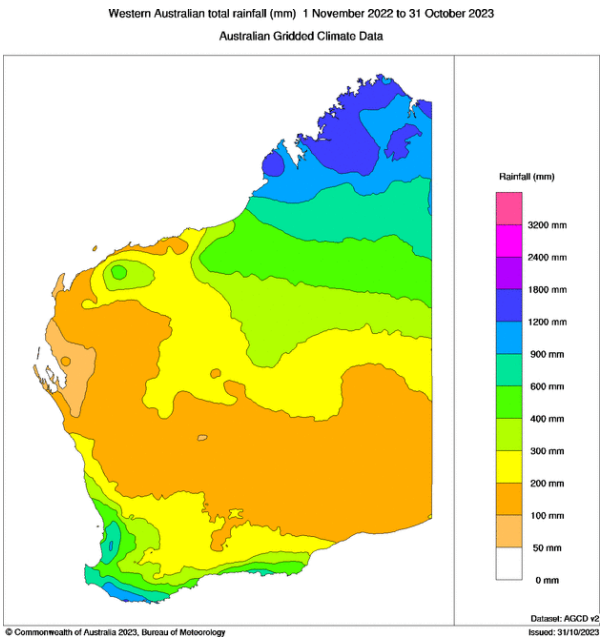

Fig. A2.5. Rainfall totals for Western Australia for the period 1 November 2022 to 31 October 2023 (last 12 months).

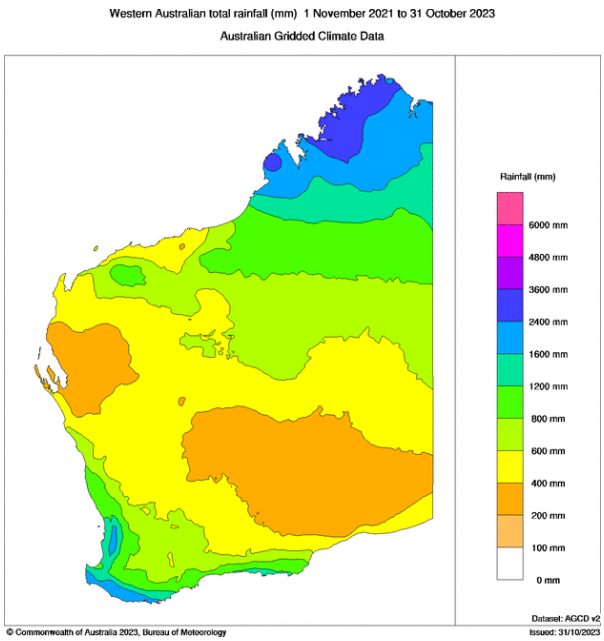

Fig. A2.6. Rainfall totals for Western Australia for the period 1 November 2021 to 31 October 2023 (last 24 months).

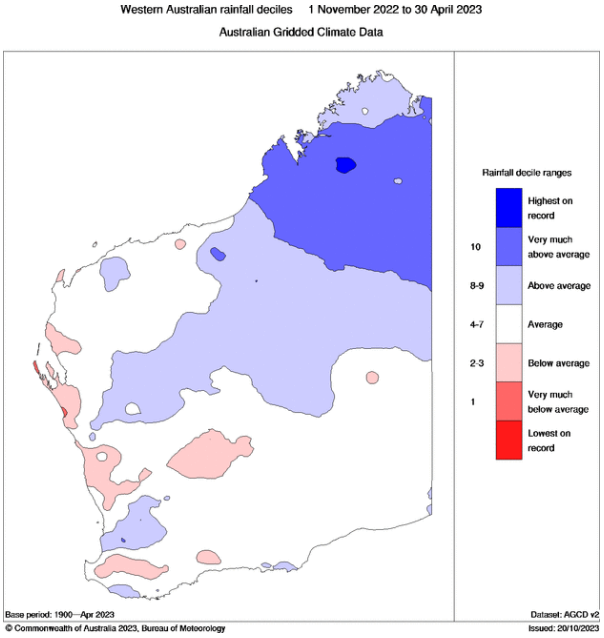

Fig. A2.7. Summer rainfall deciles for Western Australia for the period 1 November 2022 to 30 April 2023.

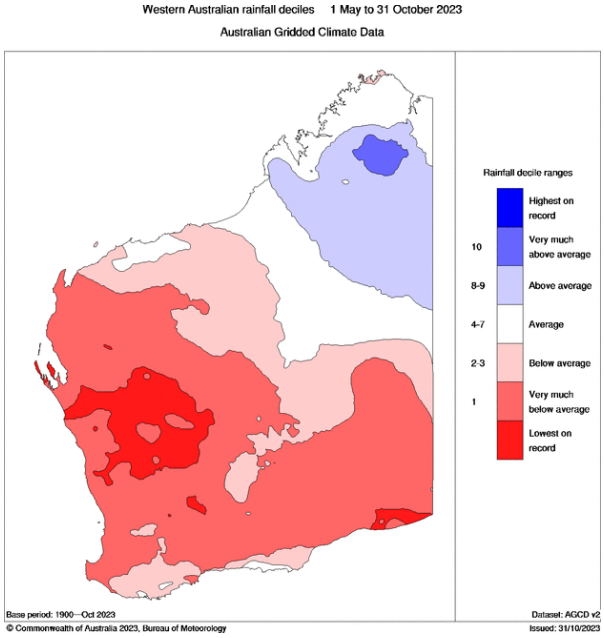

Fig. A2.8. Winter rainfall deciles for Western Australia for the period 1 May 2023 to 31 October 2023.

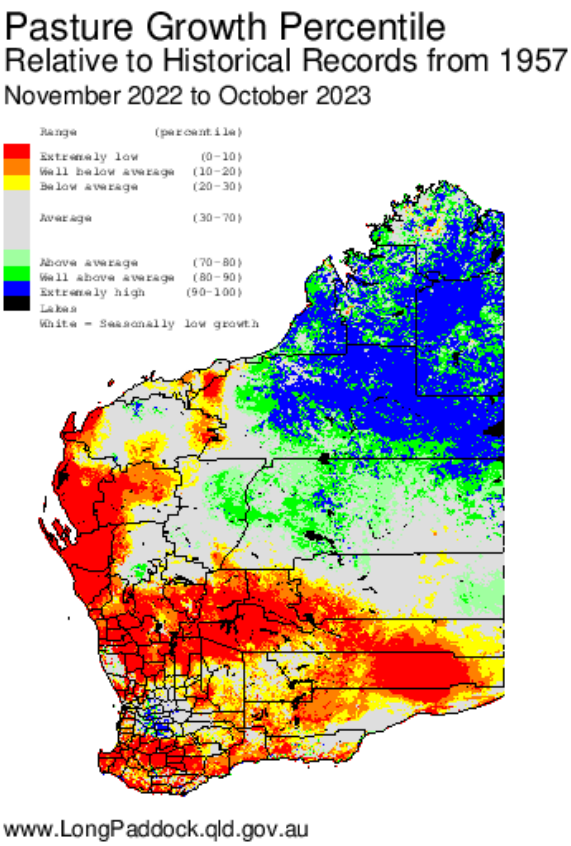

Fig. A2.9. Pasture growth in Western Australia for the period November 2022 to October 2023 (last 12 months).

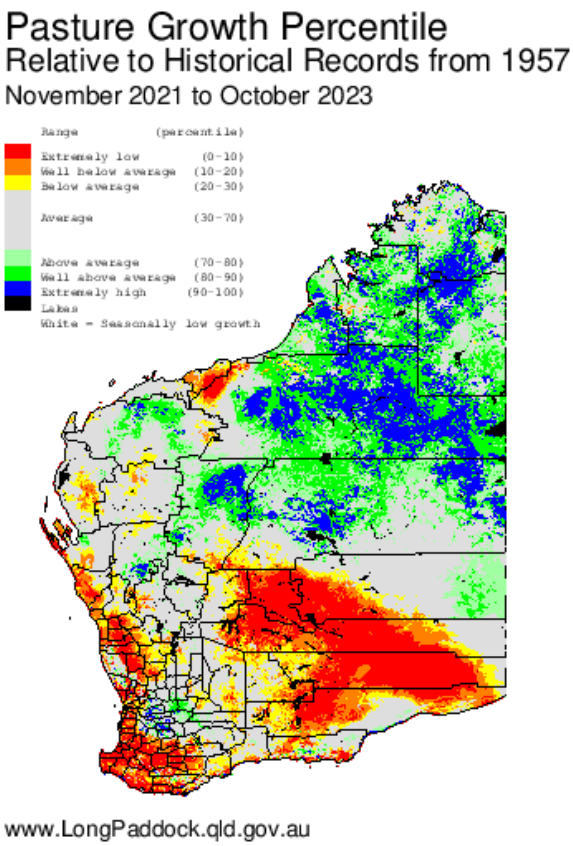

Fig. A2.10. Pasture growth in Western Australia for the period November 2021 to October 2023 (last 24 months).

Appendix 3 Regional population estimates

Harvest data for 2023 presented in the figures and tables in Appendix 3 only includes data processed prior to 31 October 2023.

Northern Population Management Zone

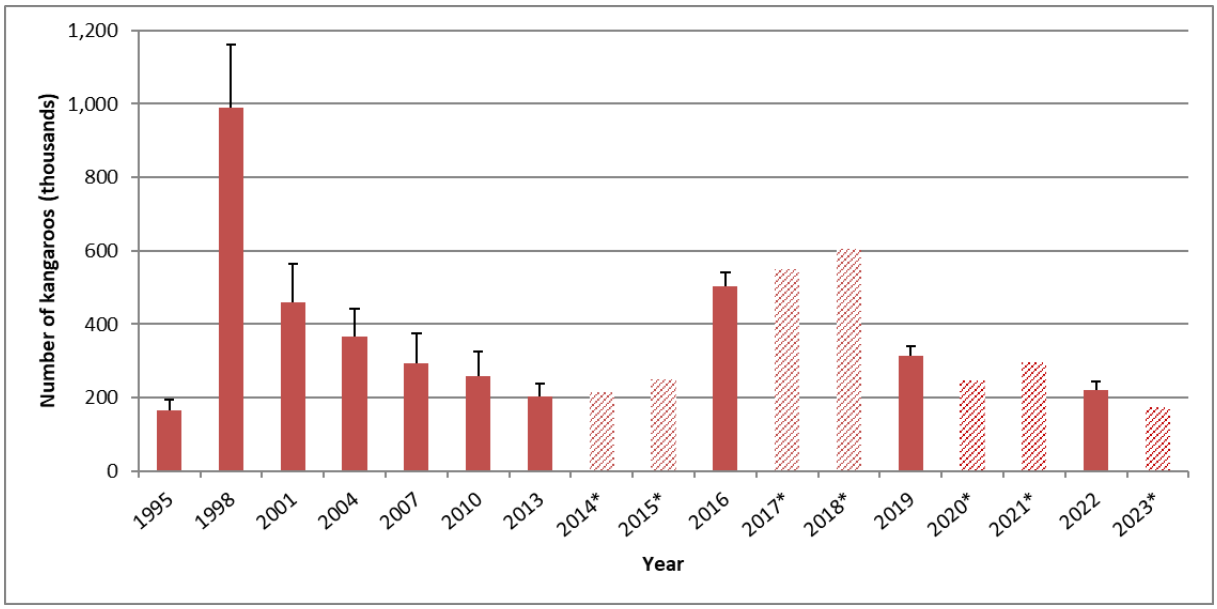

Fig. A3.1.1. Population estimates for red kangaroos in the Northern PMZ. Note, all estimates use standard habitat correction factors. Temperature corrections are applied to post-1993 data. Estimates for years where the PMZ was not surveyed in full (*) are based on estimates from surveys in previous years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

Table A3.1.1. Red kangaroo population estimates for the Northern Population Management 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	na
2016	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	313,850±27,200	4311	Below average	0.8
2020	247,630	1,562	Above average[d]	1.2
2021	295,280	0	Above average	1.2
2022[b]	221,850±22,555	3761[c]	Below average[d]	0.8
2023	174,470			

[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 PMZ was flown in August 2022.

[c] The commercial harvest off-take in the Northern PMZ between 1 January 2023 and 31 October 2023.

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

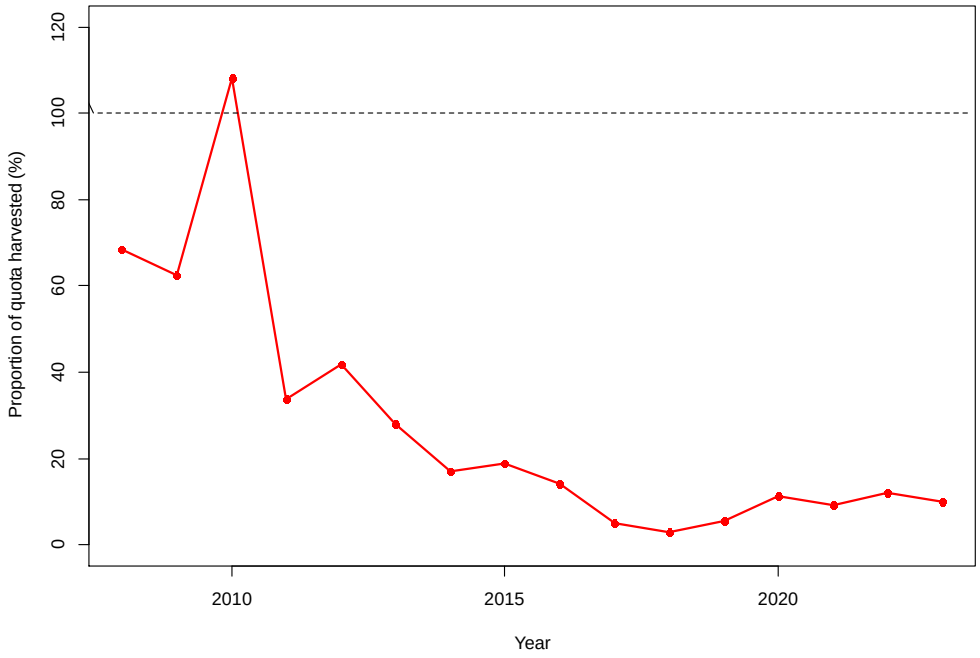

Fig. A3.1.2. Proportion of the Northern Population Management Zone commercial quota harvested from 2008 to 2023.

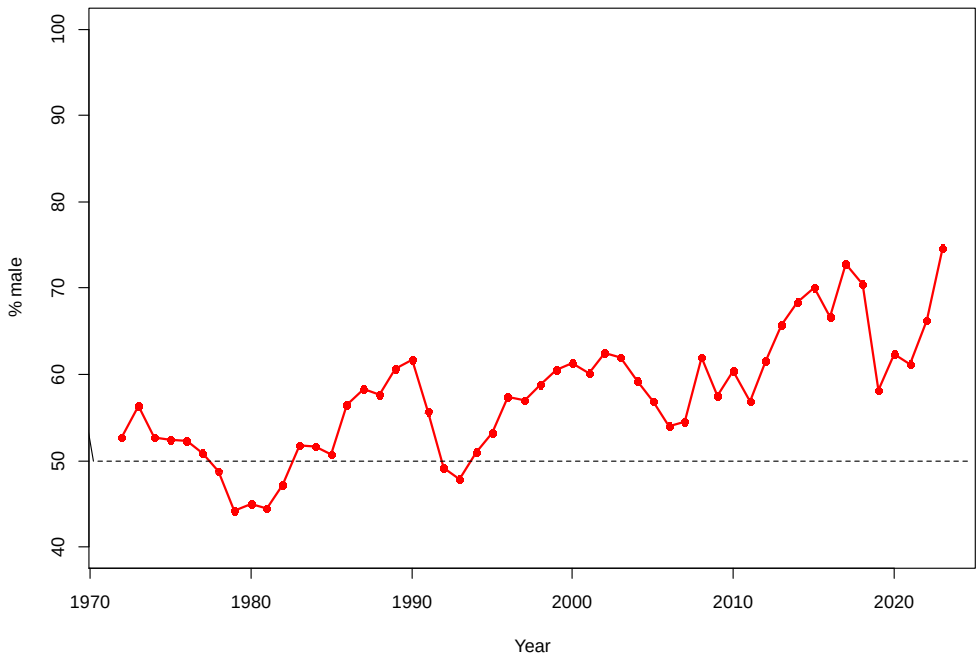

Fig. A3.1.3. Sex ratio of the commercial red kangaroo harvest in the Northern Population Management Zone from 1972 to 2023.

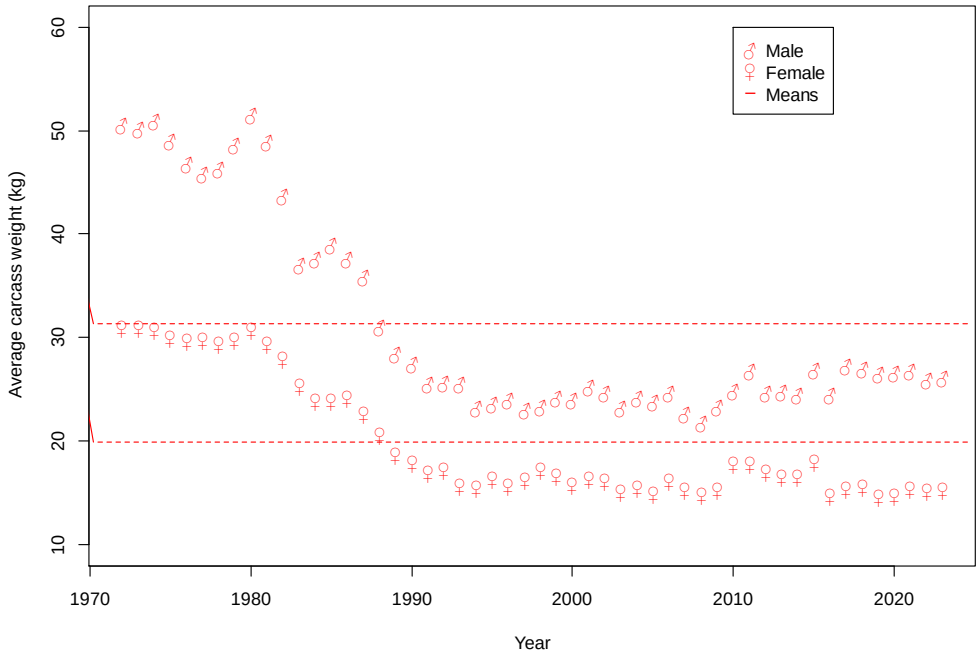

Fig. A3.1.4. Average carcass weights of the commercial red kangaroo harvest in the Northern Population Management Zone from 1972 to 2023. Carcass dressing methods (and therefore carcass weights) are not standardised.

Central Population Management Zone

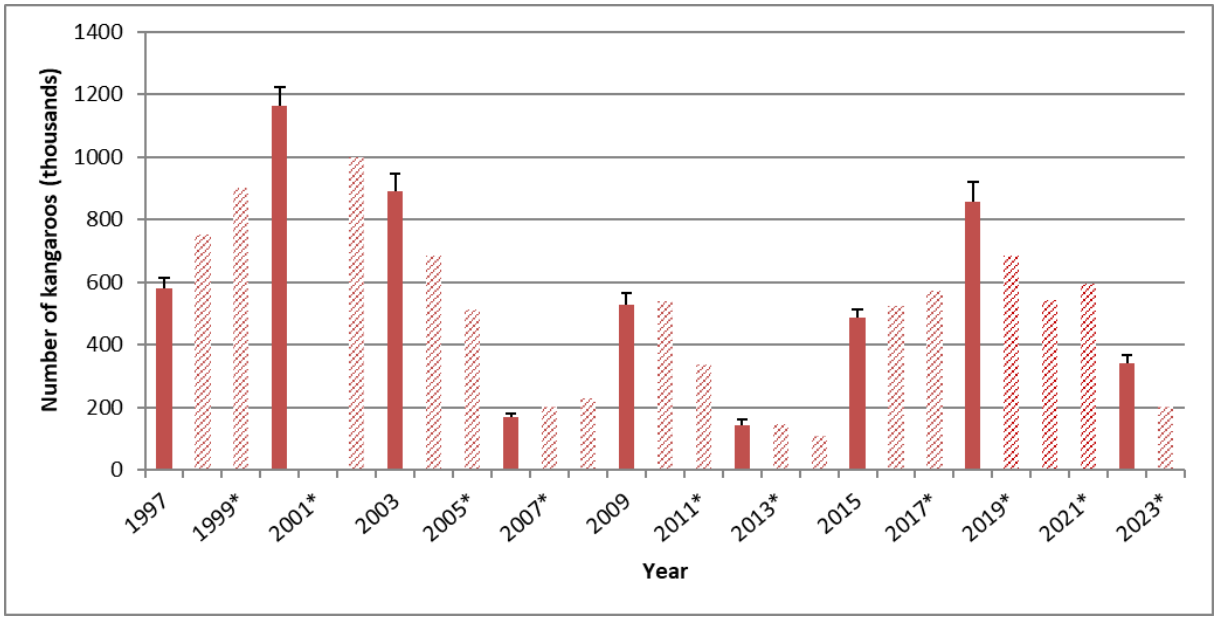

Fig. A3.2.1. Population estimates for red kangaroos in the Central Population Management Zone of Western Australia. Note, all estimates use standard habitat and temperature correction factors. Estimates for years where the PMZ was not surveyed in full (*) are based on estimates from surveys in previous years and/or monitor block surveys, and are scaled according to trends in regional rainfall.

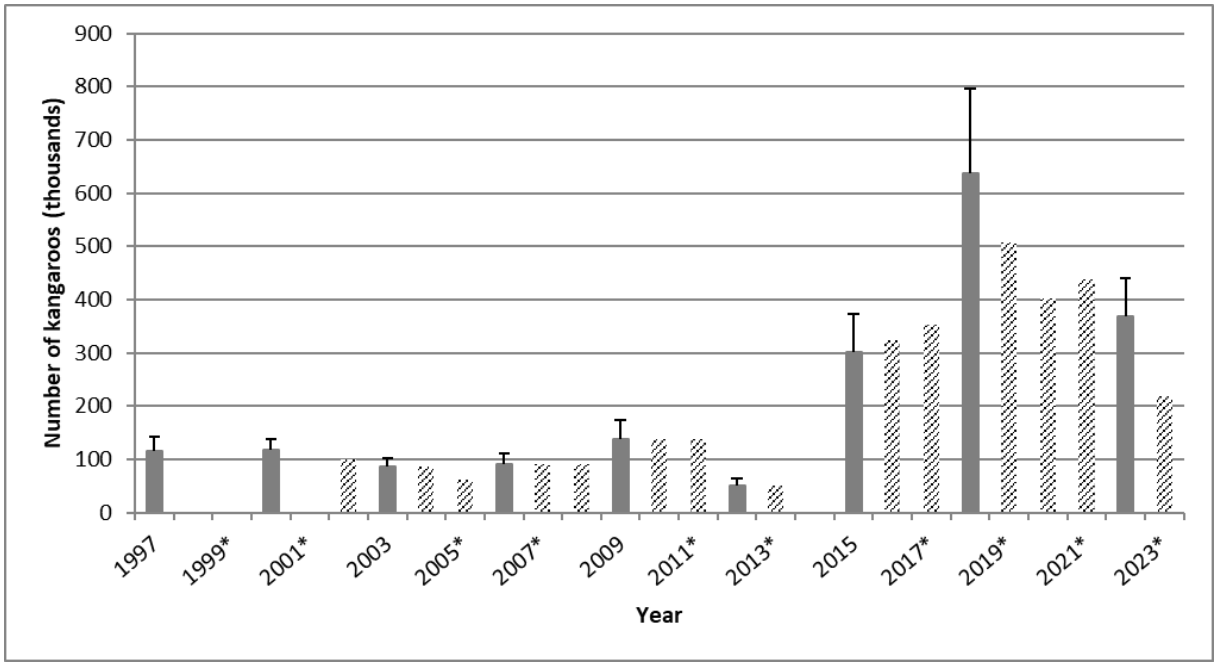

Fig. A3.2.2. Population estimates for western grey kangaroos in the Central Population Management Zone of Western Australia. Note, all estimates use standard habitat and temperature correction factors. Estimates for years where the PMZ was not surveyed in full (*) are based on estimates from surveys 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 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	857,350±64,300	3,335	Below average	0.8
2019	683,210	4,992	Below average	0.8
2020	542,575	2,621	Average	1.1
2021	593,950	1925	Above average	1.2
2022[b]	341,870	3181[c]	Very much below average[d]	0.6
2023	203,210			

[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 Central PMZ was flown in September 2022.

[c] The commercial harvest off-take in the Central PMZ between 1 January 2023 and 31 October 2023.

[d] Rainfall in the Central PMZ for the preceding 12 months was considered to be very much below average for the zone overall (Figs A2.1 – A2.10).

Table A3.2.2. Western grey kangaroo population estimates for the Central Population Management 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	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	1.1
2021	437,340	3,825	Above average	1.2
2022[b]	369,330	4807[c]	Very much below average[d]	0.6
2023	218,710			

[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 Central PMZ was flown in September 2022.

[c] The commercial harvest off-take in the Central PMZ between 1 January 2023 and 31 October 2023.

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

Fig. A3.2.3. Proportion of the Central Population Management Zone commercial quota harvested from 2008 to 2023.

Fig. A3.2.4. Sex ratio of the commercial red and western grey kangaroo harvest in the Central Population Management Zone from 2007 to 2023.

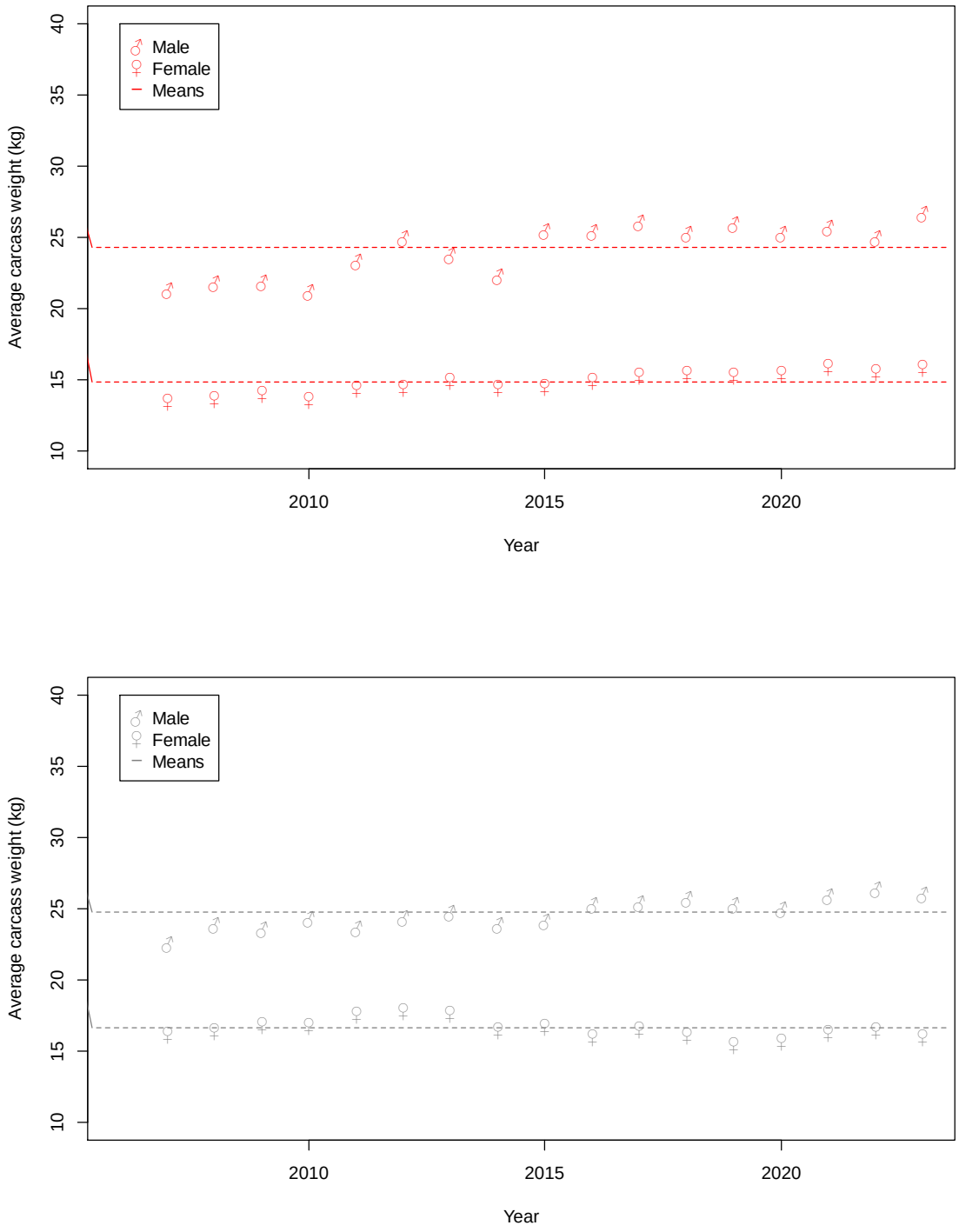

Fig. A3.2.5. Average carcass weights of the commercial red and western grey kangaroo harvest in the Central Zone from 2007 to 2023. Carcass dressing methods (and therefore carcass weights) are not standardised.

South-East Population Monitoring Zone

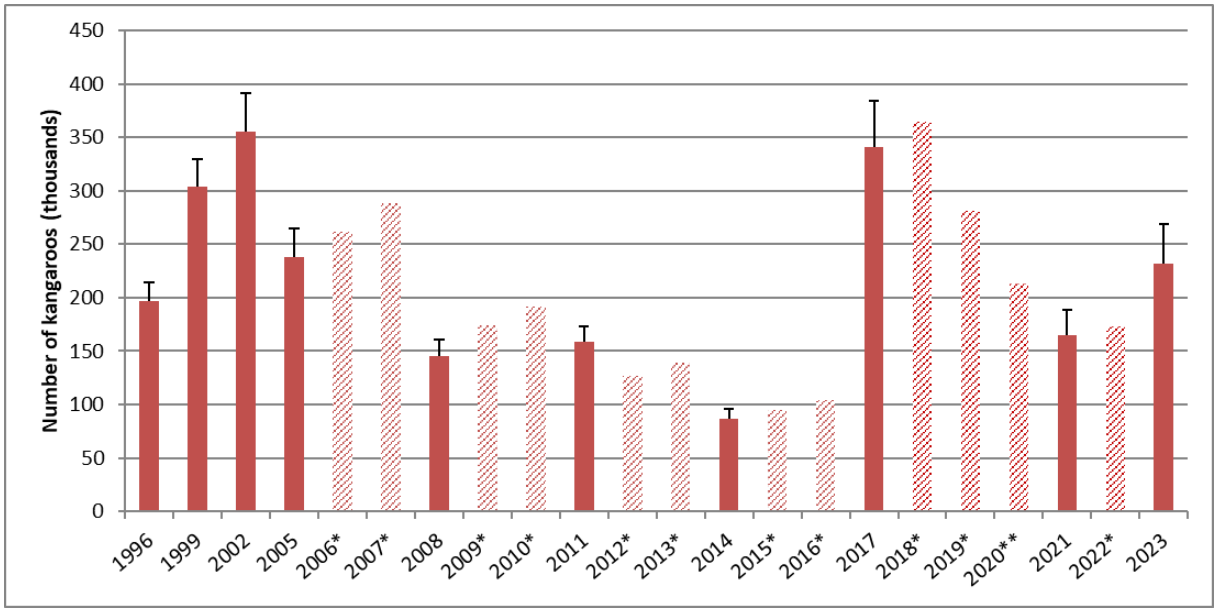

Fig. A3.3.1. Population estimates for red kangaroos in the South-East Population Management Zone of Western Australia. Note, all estimates use standard habitat and temperature correction factors. Estimates for years where the PMZ was not surveyed in full (*) are based on estimates from surveys in previous 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.

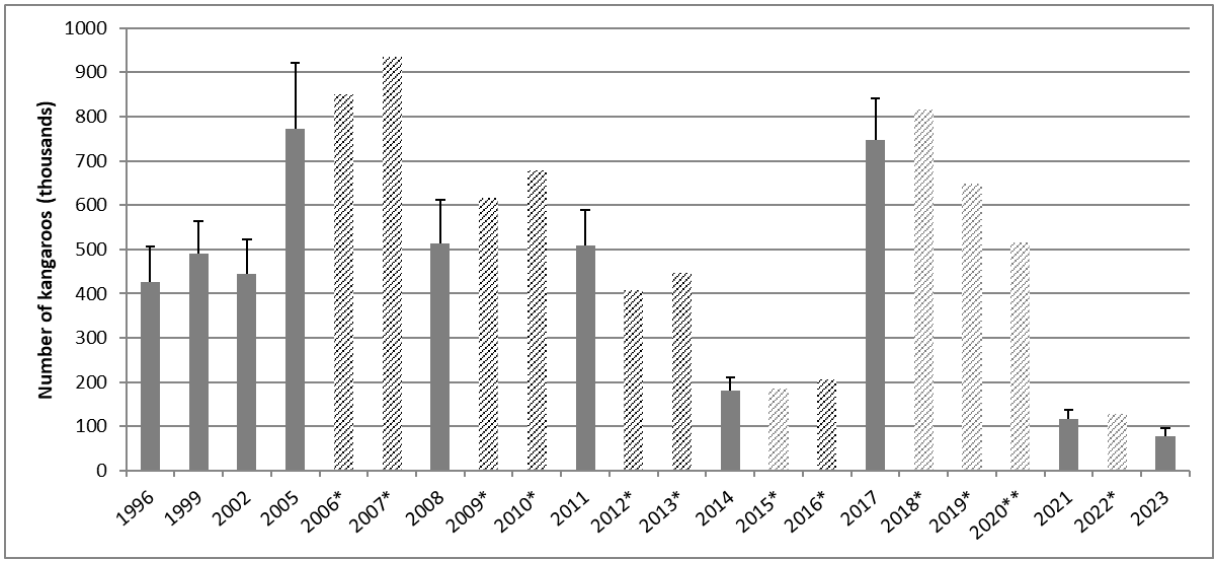

Fig. A3.3.2. Population estimates for western grey kangaroos in the South-East Population Management Zone of Western Australia. Note, all estimates use standard habitat and temperature correction factors. Estimates for years where the PMZ was not surveyed in full (*) are based on estimates from surveys 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 Population Management 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	213,685	9,660	Average	1.1
2021	165,360±23,530	8,171	Average	1.1
2022	172,910	6,494[c]	Below average[d]	0.8
2023[b]	231,475±37,515			

[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 PMZ was flown in August 2023.

[c] The commercial harvest off-take in the South-East PMZ between 1 January 2023 and 31 October 2023.

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

Table A3.3.2. Western grey kangaroo population estimates for the South-East Population Management 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	515,760	3,820	Average	1.1
2021	115,895±20,760	506	Average	1.1
2022	126,930	1,771[c]	Below average[d]	0.8
2023[b]	77,255±18250			

[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 PMZ was flown in August 2023.

[c] The commercial harvest off-take in the South-East PMZ between 1 January 2023 and 31 October 2023.

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

Fig. A3.3.3. Proportion of the South-East Population Management Zone commercial quota harvested from 2008 to 2023. Note, no red kangaroos were harvested in 2015.

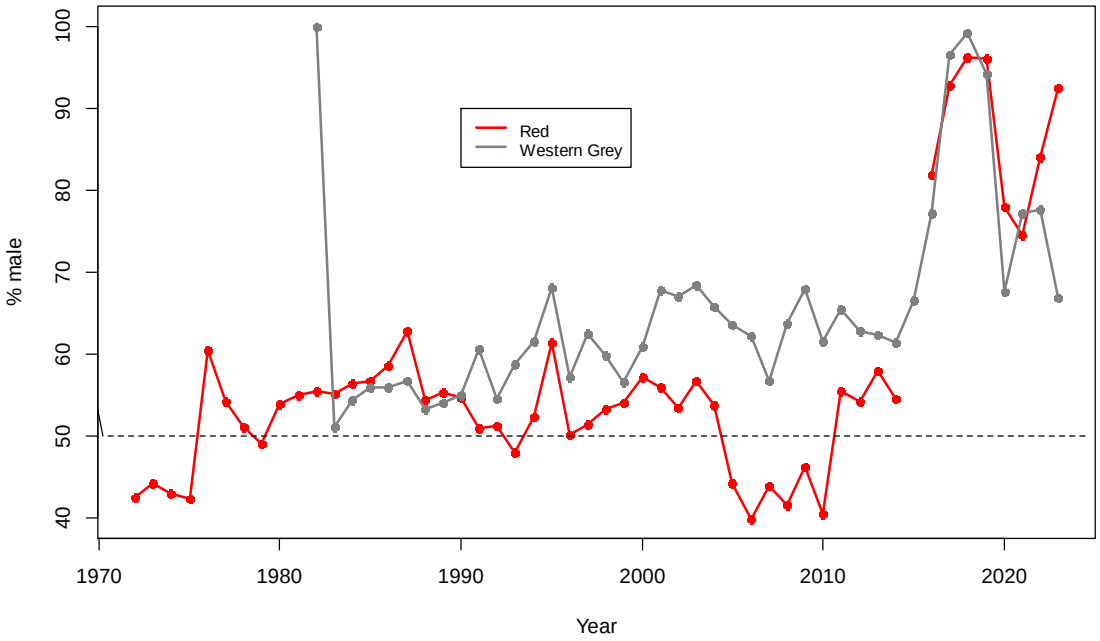

Fig. A3.3.4. Sex ratio of the commercial harvest of red and western grey kangaroos in the South-East Population Management Zone from 1972 to 2023. Note, no red kangaroos were harvested in 2015.

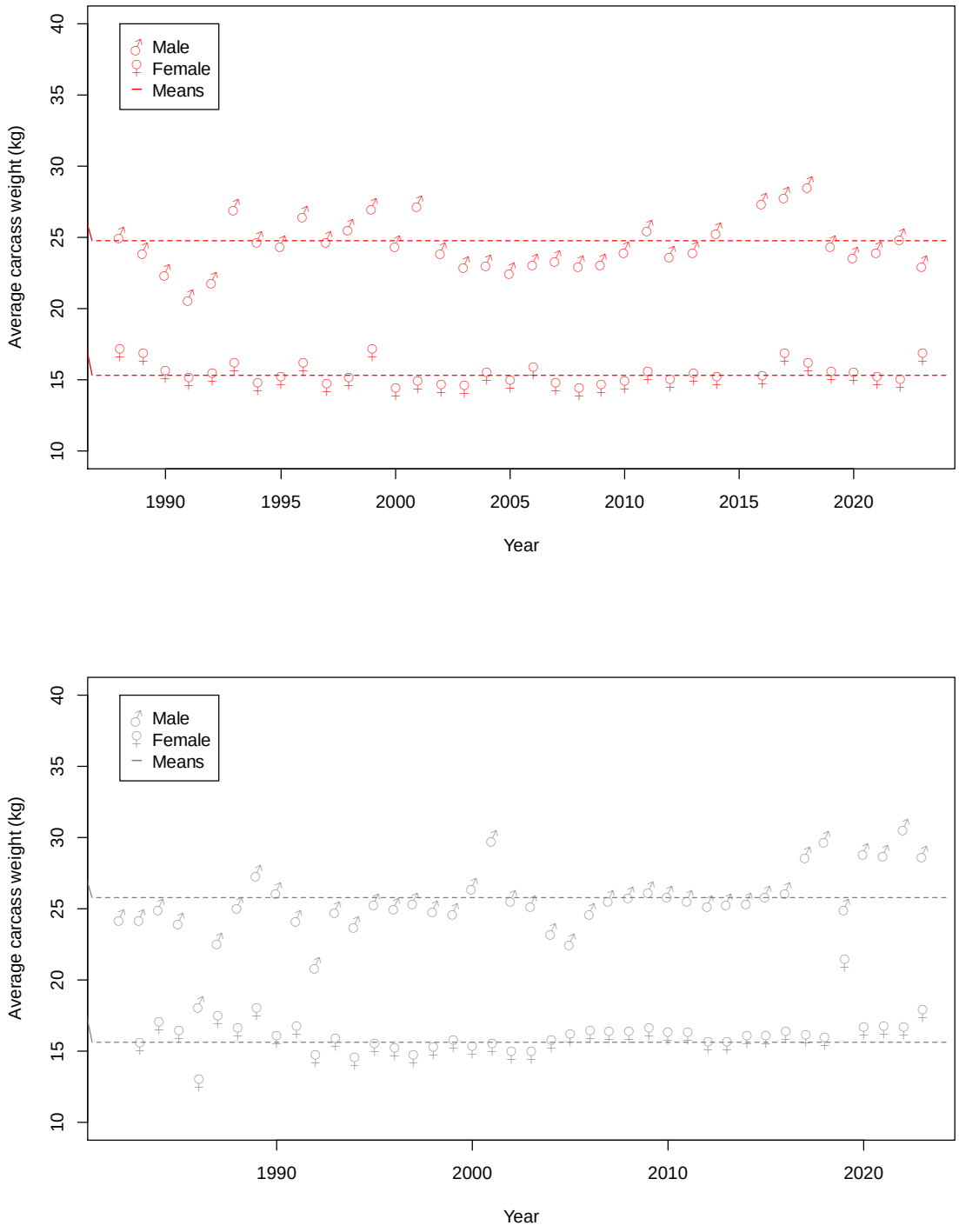

Fig A3.3.5. Average carcass weights of the commercial red and western grey kangaroo harvest in the South-East Population Management Zone. Carcass dressing methods (and therefore carcass weights) are not standardised.

South-West Population Management Zone

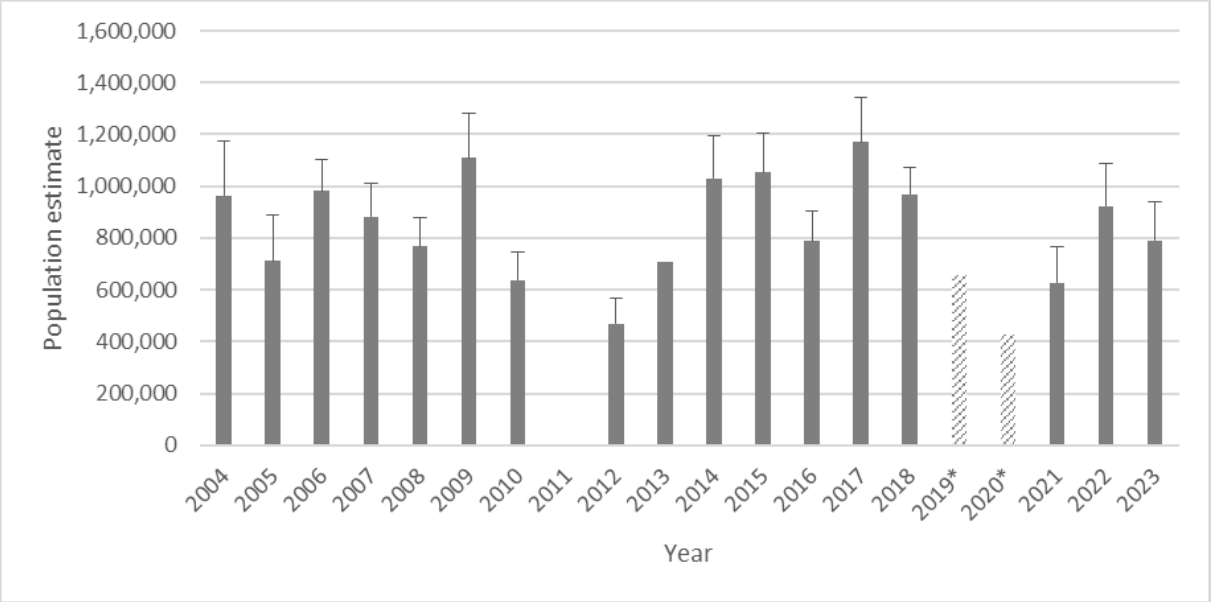

Fig. A3.4.1. Aerial survey population estimates with standard errors for western grey kangaroos in South-West Population Management Zone monitor blocks from 2004-2023. Note, all estimates use standard habitat and temperature correction factors. No aerial surveys were undertaken in the South-West PMZ 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 PMZ 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 Population Management 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 made for kangaroos occupying the unsurveyed portion of the South-West PMZ (i.e. for the purpose of the quota calculation, the density in the unsurveyed areas is treated as zero). However, western grey kangaroos are harvested in the unsurveyed parts of the South-West PMZ.

Table A3.4.1. Western grey kangaroo population estimates for the South-West Population Management 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	Above average[d]	1.2
2021	626,310±140,240	38,685	Average	1.1
2022	923,660±161,780	43,197[c]	Below average[d]	0.7
2023[b]	790,270±147,518			

[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-West PMZ was flown in October 2023.

[c] The commercial harvest off-take in the South-West PMZ between 1 January 2023 and 31 October 2023.

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

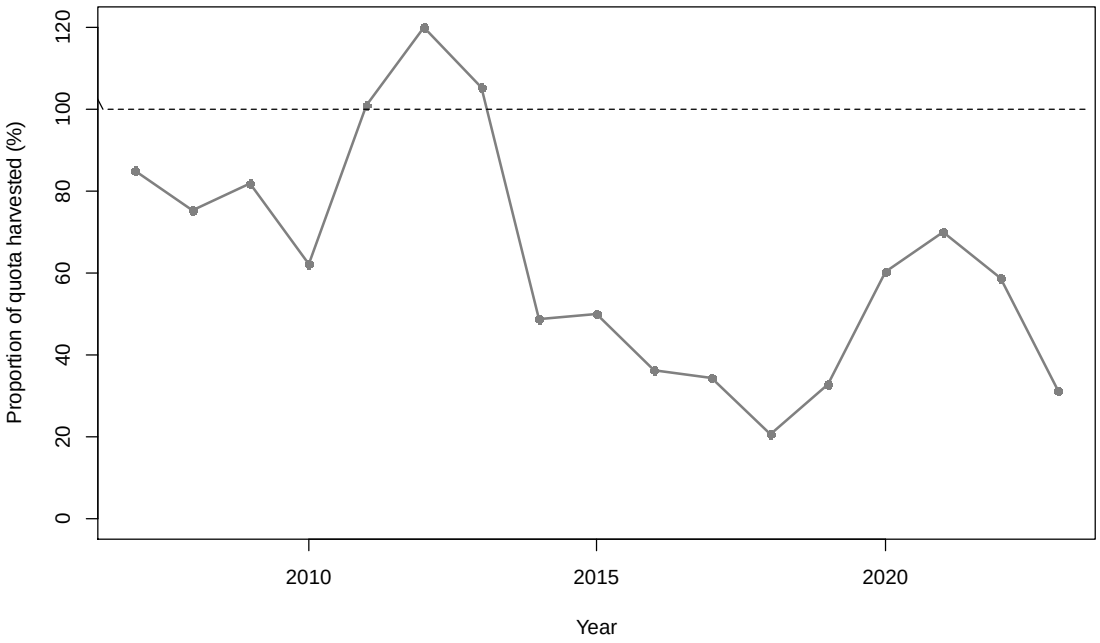

Fig. A3.4.2. Proportion of the South-West Population Management Zone regional commercial quota harvested from 2008 to 2023.

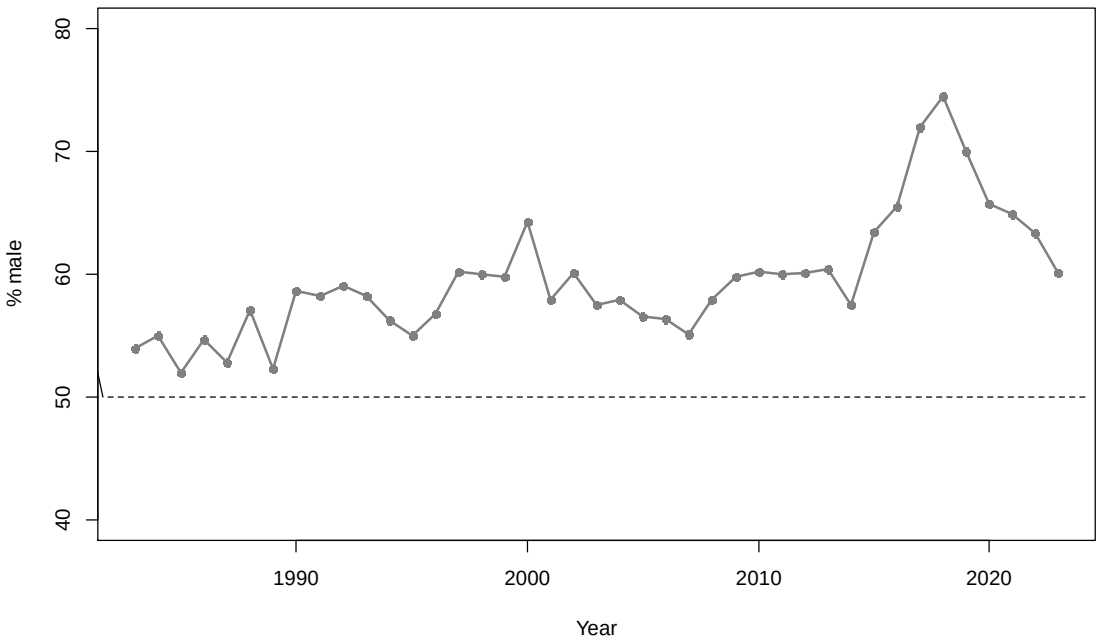

Fig. A3.4.3. Sex ratio of the commercial harvest of western grey kangaroos in the South-West Population Management Zone from 1983 to 2023.

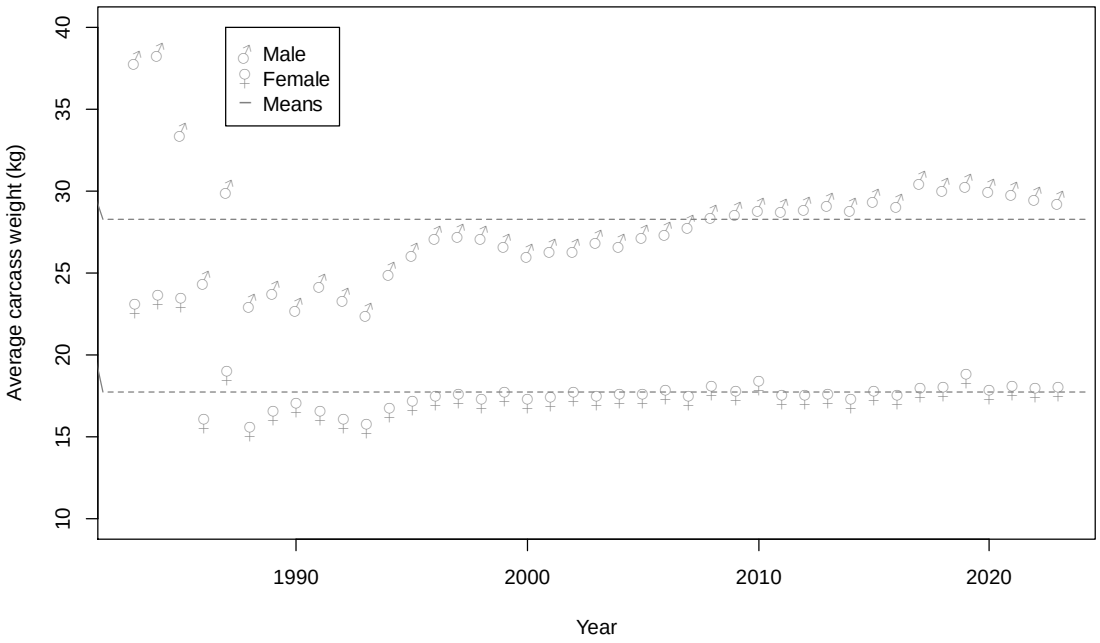

Fig A3.4.4. Average carcass weights of the commercial western grey kangaroo harvest in the South-West Population Management Zone. Carcass dressing methods (and therefore carcass weights) are not standardised.