

2021 Quota Report

Commercial Kangaroo Harvest

South Australia



**Government
of South Australia**

Department for
Environment and Water

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Scope and Context

Legislation

All kangaroo species in South Australia are protected under the *National Parks and Wildlife Act 1972* (NPW Act), have value in ecosystem processes, and contribute to biodiversity. The NPW Act (section 60G) allows for the sustainable harvest of the following species of kangaroo:

- Red Kangaroo (*Macropus rufus*)
- Western Grey Kangaroo (*M. fuliginosus*)
- Eastern Grey Kangaroo (*M. giganteus*)
- Euro (*M. robustus*)
- Tammar Wallaby (*M. eugenii*)

The wildlife trade provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) regulate the export of kangaroo products from Australia. The harvest and export of these protected species requires a management plan endorsed under the NPW Act and a Wildlife Trade Management Plan endorsed under the EPBC Act.

As of 1 January 2020, the SA Commercial Kangaroo Management Plan 2020-2024 (Management Plan) was approved by the Minister for Environment and Water under the NPW Act and approved by the Commonwealth Minister for Environment under the EPBC Act on 13 March 2020.

In accordance with the Management Plan, harvest quotas are set annually for each species of harvested kangaroo. Quotas are detailed in the annual Quota Report endorsed by the Executive Director of National Parks and Wildlife Service and forwarded to the Commonwealth Department of Environment and Energy for information. Where quotas are set outside the standard quota parameters detailed in the Management Plan, quotas must be endorsed in writing by the Commonwealth Department of Environment and Energy prior to implementation.

This quota report has been developed in accordance with the Management Plan. The quota report provides the necessary detail on quota-setting procedures and the harvest quota for five kangaroo species for 2021. The report lists Sustainable Use Harvest Quotas for 2021, Special Land Management Quota for 2021, a summary of harvest statistics for 2019 and the incomplete year of 2020 (January-August).

Harvest regions used for quota setting

In accordance with the provisions of the Management Plan, annual harvest quotas are based on the results of direct surveys of kangaroo populations or model estimates.

Five harvest regions have been defined in the Management Plan: Western Pastoral, Eastern Pastoral, Western Agricultural, Eastern Agricultural and Southern Agricultural.

The harvest regions contain sub-regions (detailed in Table 1 and Figure 1) primarily based on the administrative boundaries of the former Soil Conservation Board districts (or an amalgamation thereof). Population estimates and commercial quotas for 2021 are derived and set at the harvest sub-region level. Sub-region quotas can be re-distributed within, but not between, each harvest region in response to spatial and temporal changes in kangaroo distribution.

Table 1: Kangaroo Harvest Regions and Sub-regions for South Australia

Harvest Region	Harvest sub-region
Eastern Pastoral	North Flinders North East Pastoral Eastern Districts Mallee
Western Pastoral	Marla-Oodnadatta, Marree (inside dog fence) Marree (outside dog fence) Kingoonya Gawler Ranges
Eastern Agricultural	South Flinders Yorke Mid North
Western Agricultural	Eyre East Eyre West
Southern Agricultural	Hills and Fleurieu Kangaroo Island Upper South East Lower South East

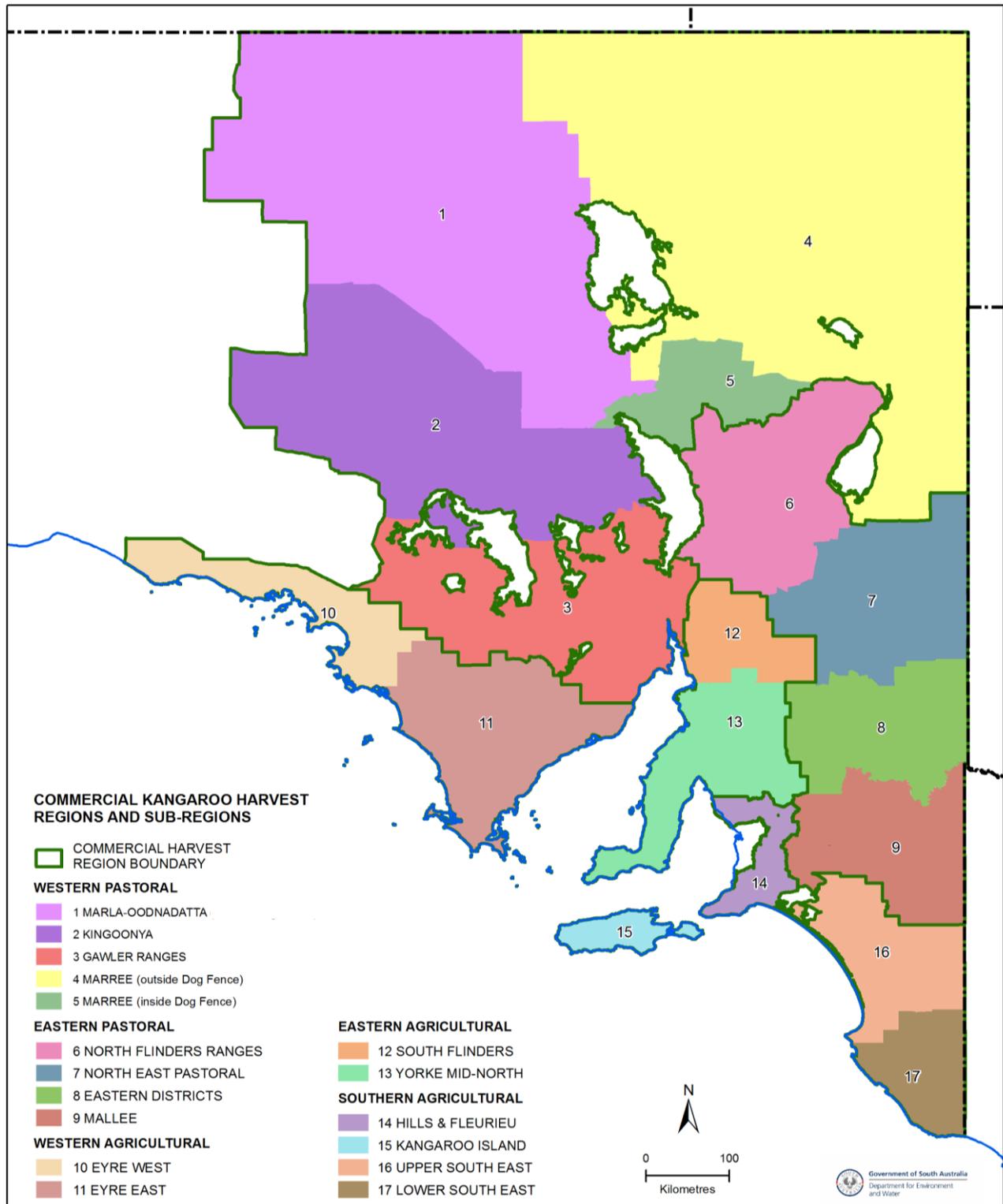


Figure 1: Map of harvest regions and sub-regions of South Australia

Kangaroo monitoring methods

A combination of fixed-wing aircraft and ground surveys (walking and driving) were used to survey kangaroo populations across South Australia between June and October 2020. Aerial survey lines have been established at regular intervals across all sub-regions where possible, and the same lines are surveyed at the same time every survey year to allow comparison of results between years. Ground surveys are employed in sub-regions where aerial survey is considered unsafe, or dense vegetation prohibits observers from effectively counting kangaroos (Table 2).

Table 2: Kangaroo survey methods used in each harvest sub-region for 2020 survey.

Harvest Sub-region	Survey Method
Western Pastoral	
Marla - Oodnadatta	NA
Kingoonya	NA
Gawler Ranges	Walking
Marree (inside dog fence)	NA
Marree (outside dog fence)	NA
Eastern Pastoral	
North Flinders	NA
North East Pastoral	Aerial
Eastern Districts	Aerial
Mallee	NA
Eastern Agricultural	
South Flinders	Aerial
Yorke Mid North	Aerial/ walking
Western Agricultural	
Eyre West	NA
Eyre East	NA
Southern Agricultural	
Hills and Fleurieu	Driving
Upper South East	Aerial
Lower South East	Aerial/ Driving
Kangaroo Island	Aerial (helicopter and fixed-wing) / spotlight driving

Aerial survey

Aerial surveys for large-bodied kangaroos have been conducted annually since 1978 using standard transect lines. Surveys are conducted using standard 200 m fixed-strip width transect methodology with a fixed-wing aircraft (see Grigg et al. 1999 for further detail). Two observers (one on each side of the aircraft) count kangaroos as the aircraft maintains a speed of 185 kilometres/hour (100 knots) and 76 m (250 feet) above the ground. Raw counts are converted to density estimates for each harvest sub-region by applying species specific habitat correction factors.

During the 2020 survey period, additional surveys were conducted of Kangaroo Island in an attempt to understand the impact the large scale bush fire had on the macropod populations. A range of surveys were conducted to gather information on the spatial distribution and density of kangaroos and wallabies on the island, and to identify the best survey method for future monitoring. Surveys included a fixed-wing aircraft survey with 200 m strip width (traditional survey), fixed-wing aircraft survey with 100 m strip width and a helicopter, using a combination of observers and thermal camera. The helicopter survey was able to identify both macropod species, while the fixed-wing survey was only able to identify kangaroos due to the higher speed required to be maintained. The reduced strip width for the fixed-wing has been shown to increase precision of surveys when vegetation density is high, as it is on Kangaroo Island (see Kangaroo Island section below for more information).

Ground survey

Two types of ground surveys were used where aerial surveys were not possible; these were driving and walking surveys. Both survey methods used the line transect 'Distance' sampling method (Buckland et al. 2001, Miller 2016). The design of ground surveys is based on obtaining sufficient data for line transect analysis to typically return results with a coefficient of variance less than 25%.

Walking surveys were used to count Euros. The technique aims to assess Euro densities in targeted areas of suitable habitat within harvest sub-regions. Typically, a small sample area is surveyed in each harvest sub-region. These localised densities are used to develop regional densities for Euros, by multiplying obtained

survey densities by the amount of suitable Euro habitat in each region.

Driving surveys were used in the Hills and Fleurieu, Lower South East and Kangaroo Island sub-regions. Based on the results of last year's survey, double the transect length was driven in each sub-region during 2020 in an effort to reduce the coefficient of variation in the data. However, unlike last year, each transect was only driven once. Approximately 550-600 kilometres of transect stratified for habitat type and based on public unsealed roads was surveyed once in each sub-region. In the Hills and Fleurieu and Lower South East sub-regions the target species were Western Grey Kangaroos and Eastern Grey Kangaroos (Lower South East only), therefore based on kangaroo activity patterns, transects were surveyed either in the early morning or the late afternoon. Spotlight driving surveys were used on Kangaroo Island to survey the Tammar Wallaby as this species is most active at night.

Kangaroo population models

The 2021 Quota Report is the first report to introduce the use of population models for Red Kangaroos and Western Grey Kangaroos in established sub-regions (i.e. where long-term data exists) for South Australia. The population models have been developed in collaboration with Dr Tom Prowse of the University of Adelaide. The information below provides an overview of the models and further information will be published in a peer review journal in the coming year.

Spatial population models have been developed for Red Kangaroos and Western Grey Kangaroos separately, using 43 years of aerial monitoring data collected annually in winter between 1978 and 2020. Kangaroo population sizes are modelled across a lattice of 666 (c. 650 km²) grid cells covering approximately 437,000 km² of the South Australian landscape covered by the aerial surveys. The approach uses state-space modelling, which explicitly accounts for uncertainty in our understanding of kangaroo population dynamics due to two error components: (1) process error, which represents unexplained variation in the population growth rate; and (2) sampling error, which encompasses variation in the survey counts due to the location of the transect segments flown and surveyor error.

The models include an initial-values subcomponent which captures the relationship between spatial covariates (dominant habitat, elevation, mean annual rainfall, longitude and latitude) and the initial population estimates in each cell. Density-independent and density-dependent formulations are then used to represent two different hypotheses about the mechanisms driving

year-to-year variation in the population growth rates of Red and Western Grey Kangaroos. In the density-independent case, rainfall is used as a reliable proxy for resource availability, and the relationship between the annual kangaroo population growth rate in each cell and year is modelled as a function of standardised rainfall in two 6-month periods prior to the aerial surveys (July to December, and January to June). In the density-dependent case, current kangaroo density is additionally assumed to modify the population growth rate, such that population growth is high when kangaroo density is low (due to the reduced impact of intra-specific competition).

The dynamical models have been fitted to the aerial monitoring data (i.e., counts for Red and Western Grey Kangaroos for each 2 km² transect unit flown) using a Bayesian simulation-based inference technique. This method initiates the spatial models with arbitrary initial parameter values, and then tunes those parameters so that the model produces a close match to the observed spatio-temporal data. In so doing, historical information on the detectability of kangaroos across the landscape is used to incorporate correction factors into the model-fitting process, which acknowledges that the true kangaroo abundance in each transect segment may differ to the reported counts on average.

The spatial population models can be used to generate population-size estimates for the South Australian kangaroo harvest sub-regions, by summing modelled abundance estimates for all grid cells within a given sub-region, after applying area corrections to grid cells that overlap multiple sub-regions. Sub-region-level estimates (means \pm 95% credible intervals) can be hindcast for historical periods, and forecast for future periods under different rainfall assumptions. Model-based population-size estimates for harvest sub-regions in the year 2020 used the aerial survey data when available (i.e., 2020 data were used in the model-fitting process and directly inform estimates). However, no survey data were available for some sub-regions in 2020, in which case estimates are based on model predictions.

Four sub-regions in the established harvest area were surveyed during 2020. Survey population estimates were compared to the model estimates for these sub-regions (Appendix 1). Where management actions differed between survey and model estimates, or the model did not behave as predicted, the most conservative approach was taken. This resulted in the model estimates/ predictions being used for all sub-regions in the established harvest area except for North East Pastoral and North Flinders for Western Grey Kangaroos only.

Quota setting procedures

Proportional harvest strategy

Quotas outlined in this report represent a constant proportional harvest strategy for kangaroos in South Australia. Quotas are set at a maximum of 20% of the estimated population size for Red Kangaroos, 15% for Western Grey Kangaroos, Eastern Grey Kangaroos and Euros and 10% for Tammar Wallabies.

More conservative quota percentages have been applied to sub-regions that are not surveyed on an annual basis and where a population model does not exist.

Conservative quotas may also be applied where the coefficient of variation associated with the density estimate is greater than 25% (Action 10 of Management Plan). Some of the variation in the data can be explained by the patchy nature of kangaroos in the landscape. The coefficient of variation is calculated as the standard error (~ standard deviation on a set of independent estimates) of the density estimates across all transects for each harvest sub-region using the ratio estimate (Sinclair et al. 2006). The standard error is then divided by the mean density of kangaroos for the harvest sub-region to give the coefficient of variation, which is expressed as a percentage (the lower the percentage, the more reliable the density estimate).

Quotas for 2021 are set at the harvest region level and then further broken down into harvest sub-regions. The derivation of population estimates and quotas at the sub-region level provides added detail to allow for more accurate allocation of quota at the start of the harvest year. Quotas for each sub-region are rounded down to the nearest hundred.

Low population thresholds

In accordance with the Management Plan, thresholds based on the long-term average of populations are calculated for each harvest sub-region where sufficient data is available. If aerial survey results indicate a population has fallen below 1.5 standard deviations (SD) or 2 SD of the long-term average density for that species in that harvest sub-region, the commercial quota will be reduced or suspended for the following calendar year, respectively. This will remain in place until surveys indicate populations have increased. Low population thresholds were re-calculated using the fitted model estimates for each population model for comparison to the model estimates.

High Abundance Quota

The High Abundance Quota (HAQ) is aimed at reducing kangaroo populations during times of high abundance. The HAQ is an additional quota to the proportional quota and issued at the discretion of the Director of National Parks and Wildlife (refer Aim 4 of Management Plan for more information).

No HAQ is issued for 2021.

Special Land Management Quota

Special Land Management Quota may be set up to 1.5% of the estimated population size of each species, and is used to account for land management issues that might arise due to localised or widespread seasonal conditions. This quota component is only for the harvest of kangaroos that would otherwise be culled under Permits to Destroy Wildlife, and is designed to minimise the number of kangaroos destroyed under these permits and not utilised. Permits to Destroy Wildlife are not considered part of the quota and are reported in the Harvest Report.

Special Land Management Quota for 2021 has been set at 1.5% of the total estimated population for each species and will only be released when the commercial harvest quota for a harvest region has been fully allocated, and land management issues remain. This quota will be distributed between harvest regions where necessary. Release of this quota may warrant property or regional inspections of kangaroo density and/or potential impact(s).

Survey frequency

In accordance with the Management Plan, survey frequency has been reduced to every three years where the harvest is above the low harvest threshold (set at 1.5% of the average population estimate for each sub-region). Where the harvest is below the threshold, surveys will stop in the established harvest regions (Western Pastoral, Eastern Pastoral, Western Agricultural, Eastern Agricultural) or be reduced to every five years in the new harvest region (Southern Agricultural, refer to Aim 4 Management Plan for more information).

Sub-regions surveyed 2020

Based on a risk assessment analysis that included harvest rate, previous population density, timing of last survey, natural disasters that had occurred since last survey (e.g. bush fires) and availability of model estimates, eight sub-regions were surveyed during 2020.

Sub-regions surveyed included three 'core' sub-regions that are monitored annually to help inform the population models (North East Pastoral, South Flinders and Eastern Districts), as well as the following sub-regions: Yorke Mid North, Gawler Ranges (Euros only), Hills and Fleurieu, Upper South East, Lower South East and Kangaroo Island.

In sub-regions that were not surveyed this year, the appropriate kangaroo population model (either Red Kangaroo or Western Grey Kangaroo model) was used to predict the population density.

Euros have a consistently low harvest across all sub-regions where they are present. During 2020, Euros were surveyed in the Yorke Mid North and Gawler Ranges sub-regions. In sub-regions that were not surveyed during 2020, population estimates derived from surveys undertaken in 2018 and 2019 have been used to set quota for 2021 and the quota percentage has been reduced to 10%.

Low harvest threshold

Harvest rates have fallen below the low harvest threshold for following species in the following sub-regions as per Table 3. No further surveys will be conducted in these sub-regions until harvest rates exceed the threshold for at least one species.

Table 3: Sub-regions where kangaroo species have fallen below the Low Harvest Threshold, calculated as 1.5% of the average population estimate for each species in each sub-region.

Species	Sub-region
Red Kangaroo	Marla - Oodnadatta
	Marree (outside dog fence)
	Mallee
Western Grey Kangaroo	Mallee
	Eyre East
	Eyre West
Euro	Marree (inside dog fence)
	North Flinders
	North East Pastoral
	Eastern Districts

Adaptive Management Experiments

No adaptive management experiments were carried out during 2020.

Population estimates

Red kangaroo

The estimated size of the Red Kangaroo population across the harvest area (including the expanded harvest area as of 1 January 2020) is 1,178,888, a decrease of 24% from the previous year total of 1,552,679 and 24% lower than the long-term survey data average of 1,545,893 (1999-2019 data from model estimates).

Density estimates for 2020 were below the long-term average for all sub-regions except Gawler Ranges, North Flinders and South Flinders.

The density estimates from both the survey data and model estimate for North East Pastoral were below the first low population threshold for the second consecutive year (Figure 2). Density estimates from the population model were below the second low population threshold in Marla-Oodnadatta and Marree (Outside Dog Fence).

Quota is reduced to 10% of the population estimate in North East Pastoral and suspended in Marla-Oodnadatta and Marree (Outside Dog Fence) as per the Management Plan.

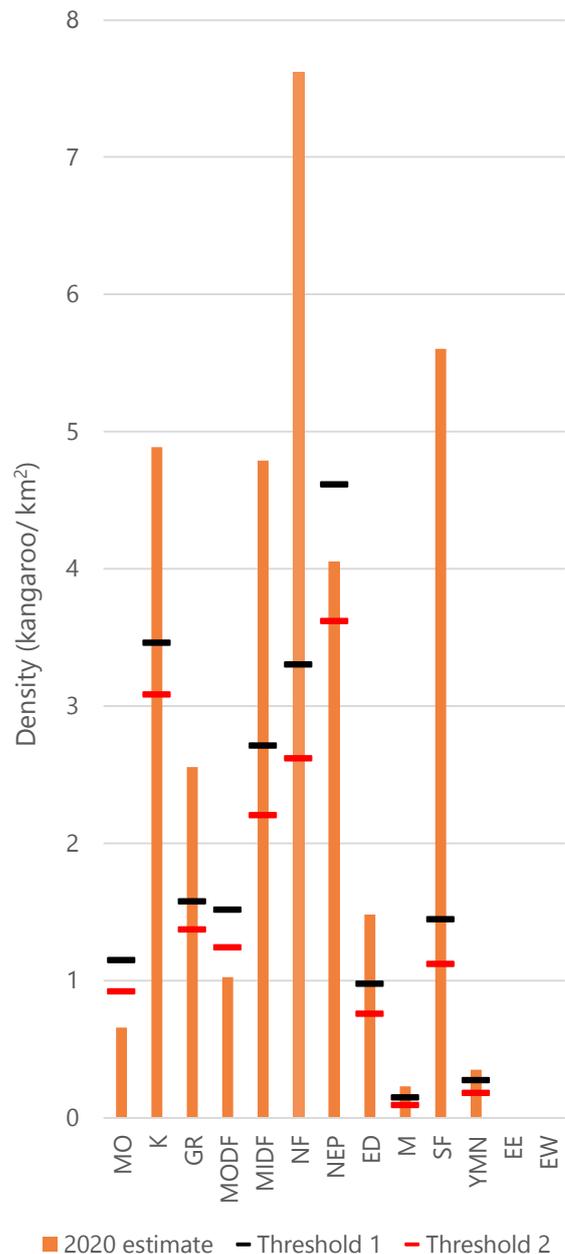


Figure 2: Red Kangaroo 2020 population density estimates for each sub-region compared to low population threshold 1 (black) and 2 (red). Estimates for NEP, ED, YMN and SF are fitted model estimates. All other estimates are model predictions. MO = Marla-Oodnadatta, K = Kingoonya, GR = Gawler Ranges, MODF = Marree (outside dog fence), MIDF = Marree (inside dog fence), NF = North Flinders, NEP = North East Pastoral, ED = Eastern Districts, M = Mallee, SF = South Flinders, YMN = Yorke Mid North, EE = Eyre East, EW = Eyre West.

Western grey kangaroo

The estimated size of the Western Grey Kangaroo population across the harvest area (including the expansions to Mallee and Yorke Mid North sub-regions but excluding Southern Agricultural region) is 846,127, a 22% decrease from the 2019 population estimate of 1,085,193 and 28% below the long-term average of 1,180,479 (1999-2019 data from model estimates). The population in the new Southern Agricultural harvest region is estimated at 208,811, a decrease of 24% from the 2019 population estimate of 276,183.

Density estimates for all sub-regions in the Southern Agricultural harvest region, except for Lower South East, are lower than 2019 estimates (Figure 3). The increased effort in the driving surveys had the intended result of reducing the coefficient of variation from 29% (Lower South East) and 34% (Hills and Fleurieu), to 23% in both sub-regions. The additional survey lines in the Lower South East observed a higher proportion of Western Grey compared to Eastern Grey Kangaroos, which has increased the density estimate for Western Grey Kangaroos compared to 2019 (see further description in Eastern Grey Kangaroo section for more information). On Kangaroo Island, there has been a decrease of 34% of the population estimate compared to 2019 (see Kangaroo Island section for further discussion).

Density estimates for 2020 were below the long-term average in Kingoonya, Gawler Ranges, North East Pastoral, Eastern Districts, Eyre West and Eyre East.

Western Grey Kangaroos have reached the second low population threshold in North East Pastoral (as determined by survey data), and the first low population threshold in Eyre West (as determined by model estimates) (Figure 4). Quota will be suspended in North East Pastoral and reduced to 10% of the population estimate in Eyre West as per the Management Plan.

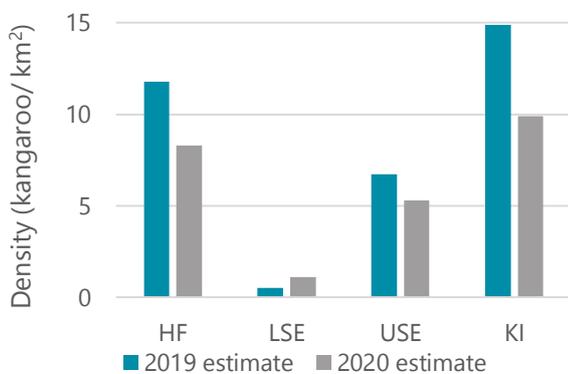


Figure 3: Density estimates 2019 (blue) and 2020 (grey) for Western Grey Kangaroos in the Southern Agricultural harvest region. HF = Hills and Fleurieu, LSE = Lower South East, USE= Upper South East, KI = Kangaroo Island.

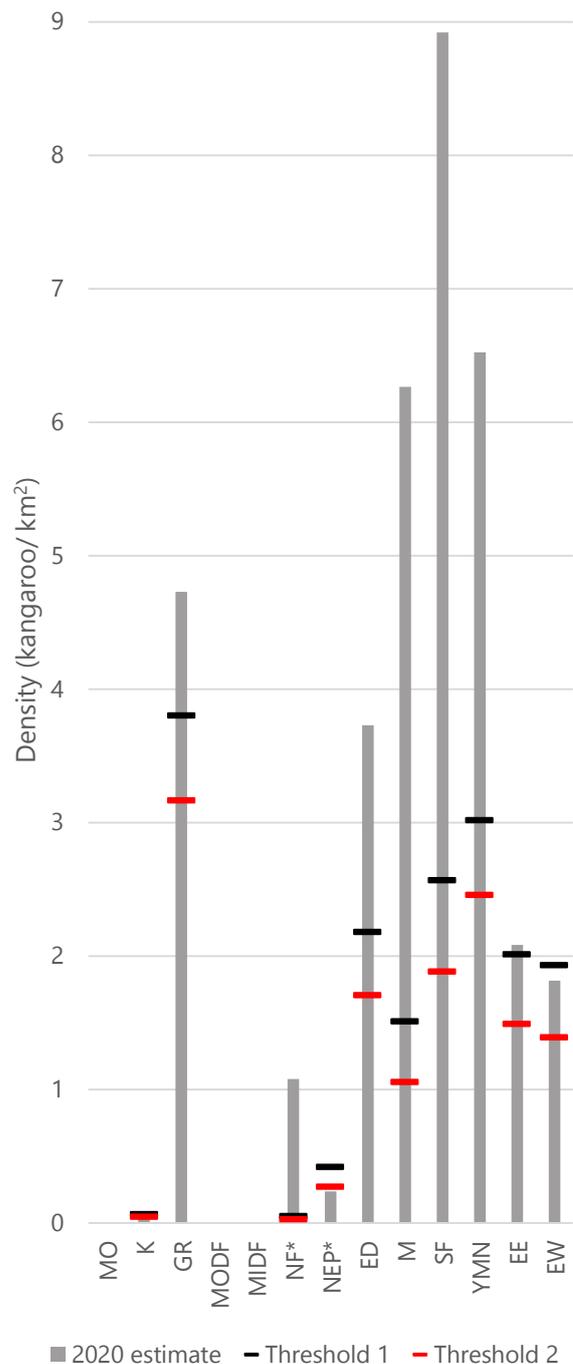


Figure 4: Western Grey Kangaroo 2020 population density estimates for each sub-region compared to low population threshold 1 (black) and 2 (red). Estimates for ED, YMN and SF are fitted model estimates. *Estimate is calculated from survey data and associated survey population thresholds. All other estimates are model predictions. MO = Marla-Oodnadatta, K = Kingoonya, GR = Gawler Ranges, MODF = Marree (outside dog fence), MIDF = Marree (inside dog fence), NF = North Flinders, NEP = North East Pastoral, ED = Eastern Districts, M = Mallee, SF = South Flinders, YMN = Yorke Mid North, EE = Eyre East, EW = Eyre West.

Euro

During 2020, two sub-regions were surveyed for Euros - Gawler Ranges and Yorke Mid North (Figure 5). Other population estimates have come from data collected during 2018 and 2019.

The estimated size of the Euro population across the commercial harvest area is 517,108, a decrease of 9% from the 2019 estimate of 570,021 and 8% above long-term average of 479,078 (1999 -2019).

Densities from the 2020 surveys were above long-term averages for both Gawler Ranges and Yorke Mid North.

Quota for Euros will be suspended in North East Pastoral, based on the low 2019 density estimate and information from DEW staff that Euros have declined in the region. Euros were not surveyed in North East Pastoral in 2020 as the harvest rate has fallen below the low harvest threshold.

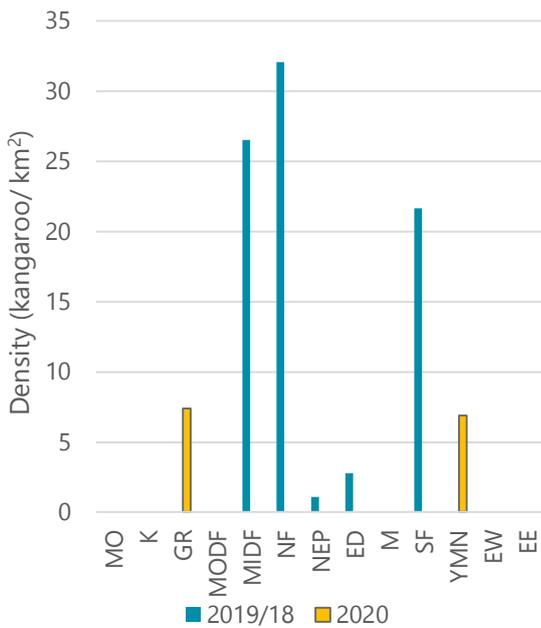


Figure 5: Population density estimates for Euros in the sub-regions surveyed 2018/19 in blue and surveyed 2020 in yellow. MO = Marla-Oodnadatta, K = Kingoonya, GR = Gawler Ranges, MODF = Marree (outside dog fence), MIDF = Marree (inside dog fence), NF = North Flinders, NEP = North East Pastoral, ED = Eastern Districts, M = Mallee, SF = South Flinders, YMN = Yorke Mid North, EE = Eyre East, EW = Eyre West.

Eastern grey kangaroo

Based on 2019 survey results, twice as many survey transects were surveyed during 2020 in an effort to reduce the coefficient of variation in the data collected. The additional transects did reduce the coefficient of variation, however, the new transects also produced lower densities of kangaroos than the lines established during 2019, and counted proportionally more Western Grey Kangaroos than Eastern Grey Kangaroos (2019 - 91% EG to 9% WG; 2020 - 74% EG to 26% WG). Furthermore, the sub-region was re-stratified during 2020 to better represent the land use types and kangaroo densities present across the sub-region.

The 2020 population estimate for Eastern Grey Kangaroos is 3.0 /km², which equates to a population estimate of 34,883 across the sub-region.

The 2020 estimate appears to be a large drop in population compared to the 2019 estimate of 5.37/ km² or 61,826 kangaroos. As a direct comparison to the 2019 survey, the 2020 data was re-analysed using only transects established during 2019 and stratification as per the 2019 analysis. The analysis produced a higher proportion of Eastern Grey Kangaroos observed compared to Western Grey Kangaroos (88% EG, 12% WG), which confirms that the new transects are detecting more Western Grey than Eastern Grey Kangaroos. The analysis produced an Eastern Grey Kangaroo density of 4.3/ km², which equates to a population estimate of 49,152 across the sub-region. Although the 2020 Eastern Grey Kangaroo population estimate is lower than the 2019 estimate, there does not appear to have been a dramatic reduction of 43% of the 2019 estimate, but possibly closer to 20%. However, given that transect lines were surveyed twice last year and the highest number observed for each transect was used, whereas this year transects were only surveyed once, the percentage reduction is likely to be less than 20%. These results indicate that further refinement of the survey method is required.

Kangaroo Island

During late 2019 and early 2020, a bush fire burnt approximately 50% of Kangaroo Island. Harvest was suspended on the island during January 2020. A number of survey methods were used during 2020 to determine the effect of the fire on the Western Grey Kangaroo and Tamar Wallaby populations, and develop a credible population estimate for both species. Below is an overview of the survey methods used and the results produced for Tamar Wallabies and Western Grey Kangaroos (for more information see Lethbridge 2020).

Based on the survey results, a reduced sustainable use quota will be set at 10% of the population estimate for Western Grey Kangaroos and 7% of the population estimate for Tamar Wallabies on Kangaroo Island for 2021.

Tamar wallaby

Day time helicopter survey with thermal camera and observers produced a density of 2.8-3.6/ km², however, approximately 80% of wallabies were seen sheltering in dense shrub land, and made counting difficult (Table 4). The spotlight survey produced a density estimate of 9.6/ km² and appeared to provide a better indication of wallaby density, as animals were more active and easier to count at night time. The spotlight survey also had a lower coefficient of variation associated with the estimate compared to the helicopter estimates, therefore the spotlight estimate has been used in this report to produce a population estimate.

The spotlight survey from 2019 produced a density estimate of 16.1/ km², which, compared to the 2020 spotlight survey estimate of 9.6/ km² suggests a population reduction of approximately 40% post fire.

The helicopter survey provided critical information on the spatial distribution of wallabies across the island. Two key hotspots were present for the species, one towards the north coast, just out of the fire scar and another to the south near Hanson Bay and Vivonne Bay area. A third key area may also be developing on Dudley Peninsula. Outside of these hot spots wallabies appeared to be in low densities.

Table 4: Survey methods, results (density per km²) and coefficient of variation as a percentage (CV %) for Tamar Wallabies on Kangaroo Island.

Survey method	Density/ km ²	CV %
Helicopter (observers)	3.6	87.0
Helicopter (thermal camera)	2.8	50.7
Driving spotlight	9.6	27.8

Western grey kangaroo

Helicopter and fixed-wing surveys provided very similar results, estimating the density of Western Grey Kangaroos to be 6.6-10.4/ km² (Table 5). The reduction in strip width for the fixed-wing survey had the intended result of reducing the coefficient of variation of the data. The driving spotlight survey showed a density of 5.2/ km², but with a higher coefficient of variation than the aerial surveys. Aerial surveys are the national standard for large bodied kangaroos, and the lower coefficient of variation associated with the aerial survey results suggests that these are more robust than spotlight surveys for kangaroos. The thermal camera helicopter survey and fixed-wing survey at 100 m strip width produced the same density estimate of 9.9/ km², therefore this density has been used in this report to produce a population estimate for Western Grey Kangaroos.

Both aerial surveys showed that kangaroos were spread across the island, although fewer were present in the burnt areas on the west side of the island. Compared to the 2019 fixed-wing survey estimate of 14.9/ km², the 2020 survey indicates a 34% reduction in the Western Grey Kangaroo population on Kangaroo Island.

Table 5: Survey methods, results (density per km²) and coefficient of variation as a percentage (CV %) for Western Grey Kangaroos on Kangaroo Island.

Survey method	Density/ km ²	CV %
Helicopter (observers)	6.6	12.0
Helicopter (thermal)	9.9	23.3
Fixed-winged (200 m strip)	10.4	36.9
Fixed-winged (100 m strip)	9.9	25.2
Driving spotlight	5.2	37.6

Harvest statistics

Harvest 2019

In 2019, the commercial kangaroo harvest in South Australia was 99,289 (data from 2019 Commercial Kangaroo Harvest Report for South Australia). This figure represents 13% of the approved quota of 752,100 (including Special Land Management Quota, Table 6).

Table 6: Harvest summary calculated for 2019 from meat processor returns. Note that a Special Land Management Quota for the Eastern Agricultural Harvest Region of 1,600 Red Kangaroos in was released during 2019.

Species	Quota	Harvest	% Quota Harvested
Red Kangaroo	501,200	68,711	14
Western Grey Kangaroo	170,900	24,565	14
Euro	80,000	6,013	8
TOTAL	752,100	99,289	13

Of the four harvest regions in the South Australian commercial harvest area, the Eastern Agricultural harvest region had the greatest percentage of quota harvested for Red Kangaroos (95%), Western Grey Kangaroos (47%), and Euros (37%). The extent of harvest for each harvest region and species is shown in Table 7.

Table 7: Harvest statistics for 2019 from field processor returns. Excludes Special Land Management Quota.

Harvest Region	Red Kangaroos			Western Grey Kangaroos			Euro		
	Quota	Harvest	Harvest %	Quota	Harvest	Harvest %	Quota	Harvest	Harvest %
Western Pastoral	262,000	27,552	11	60,400	3,634	6	22,200	1,400	6
Eastern Pastoral	203,800	18,827	9	47,600	4,536	10	46,900	1,727	4
Western Agricultural	0	0	NA	24,200	1,054	4	0	0	NA
Eastern Agricultural	22,700	21,594	95	32,500	15,349	47	7,900	2,888	37
Total	488,500	67,973	14	164,700	24,573	15	77,000	6,015	8

Harvest January to August 2020

A total of 74,027 kangaroos were harvested by field processors during the first eight months of 2020 (1 January 2020 – 31 August 2020; Table 8). This represents 14% of the combined kangaroo harvest quota for the year. Based on current harvest rates, the projected harvest for 2020 for all species is 108,609 (recognising the quota for Eastern Grey Kangaroos is anticipated to be fully harvested). This will represent 21% of the combined quotas.

The harvest projection for 2020 (as shown in Table 8) represents an increase from the 2019 harvest of 99,289 (calculated from field processor returns).

A harvest summary for each species in each harvest region for the 2020 year-to-date (1 January – 31 August) is shown in Table 9. Harvest on Kangaroo Island was suspended for the 2020 quota year after extensive bush fires occurred on the island early 2020, therefore no commercial harvest took place during 2020.

Table 8: Harvest statistics for 2020 from field processor returns. Excludes Special Land Management Quota.

Species	Quota	Actual (1 Jan - 31 Aug)		Projected (1 Jan – 31 Dec)	
		Harvest	Harvest as % of Quota	Harvest	Harvest as % of Quota
Red Kangaroo	269,800	38,864	14	58,296	22
Western Grey Kangaroo	170,400	25,494	15	38,241	22
Euro	57,500	3,115	5	4,672	8
Eastern Grey Kangaroo	7,400	6,554	89	7,400	100
Tammar Wallaby	8,700	0	-	0	-
Total	513,800	74,027	14	108,609	21

Table 9: Harvest region harvest summary calculated from field processor returns for 1 January to 31 August 2020. Excludes Special Land Management Quota.

Harvest Region	Red Kangaroos			Western Grey Kangaroos			Euro			Eastern Grey Kangaroos		
	Quota	Harvest	Harvest %	Quota	Harvest	Harvest %	Quota	Harvest	Harvest %	Quota	Harvest	Harvest %
Western Pastoral	159,900	15,829	10	30,800	1,941	6	19,300	362	2	-	-	-
Eastern Pastoral	77,700	13,145	17	33,600	3,371	10	29,000	977	3	-	-	-
Western Agricultural	-	-	-	24,200	2,180	9	-	-	-	-	-	-
Eastern Agricultural	32,200	9,890	31	43,000	12,169	28	9,200	1,776	19	-	-	-
Southern Agricultural	-	-	-	38,800	5,833	15	-	-	-	7,400	6,554	89
Total	269,800	38,864	14	170,400	25,494	15	57,500	3,115	5	7,400	6,554	89

Between 1997 and 2019 the combined harvest of all three macropod species in South Australia has ranged between 98,500 and 326,600, representing a 14 – 52% utilisation of the annual kangaroo harvesting quota. Harvest of kangaroos in South Australia peaked in 1995 at approximately 360,000. Since this time, the combined State harvest has declined significantly, while quotas have fluctuated between 328,000 and 938,000.

2021 Quotas

Commercial kangaroo harvesting quotas for the 2021 quota year for South Australia are shown in Table 10. The 2021 harvest region quotas for each species are shown in Tables 11-15. Harvest quotas and annual harvests since 1979 for all Red Kangaroos, Western Grey Kangaroos and Euros combined are shown in (Figure 6). The highest recorded annual quotas are 555,000 for Red Kangaroos (1997), 280,000 for Western Grey Kangaroos (1997), and 103,000 for Euros (1997).

Table 10: Commercial kangaroo harvesting quotas for 2021, and comparison with the 2020 quota. Quotas do not include Special Land Management Quota.

Species	2020	2021	% Change 2020-2021
Red Kangaroo	269,800	196,500	-27%
Western Grey Kangaroo	170,400	149,300	-12%
Euro	57,500	53,100	-8%
Eastern Grey Kangaroo	7,400	5,200	-30%
Tammar Wallaby	8,700	2,900	-67%
Total Quota	513,800	407,000	-21%

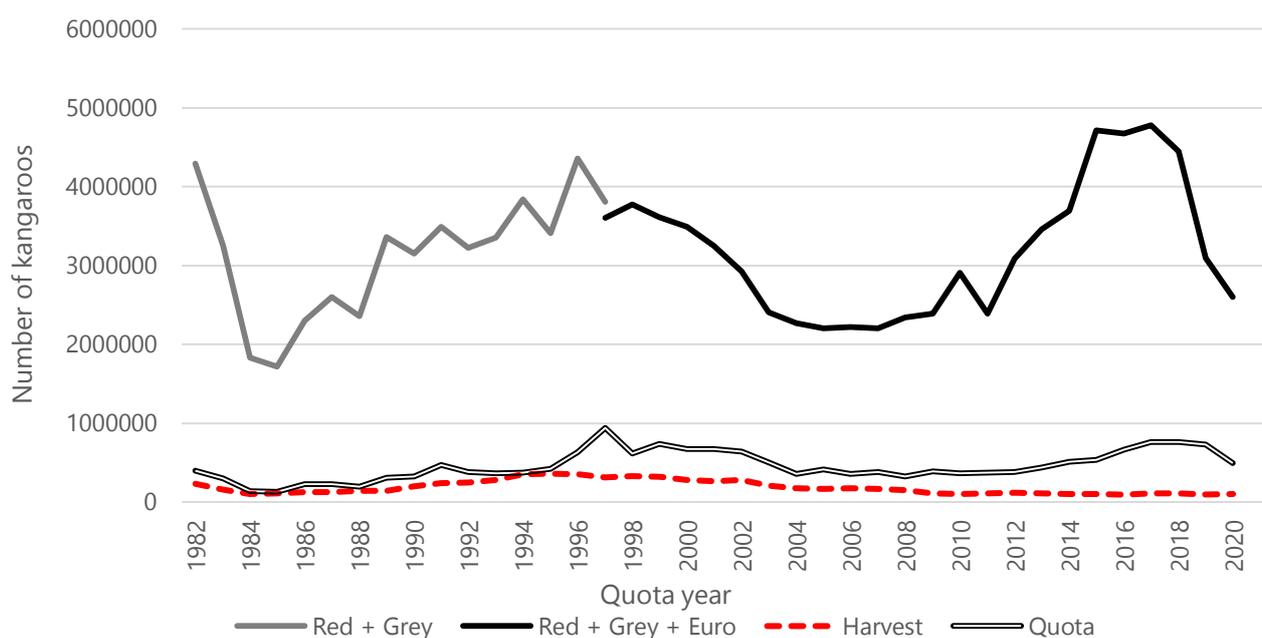


Figure 6: Red Kangaroo, Western Grey Kangaroo and Euro combined population estimate, quota and harvest for South Australia between 1982 and 2021 Quota Years. Red Kangaroo and Western Grey Kangaroo population estimates are generated from the population models, however quotas have not been recalculated and are what was historically issued. Population surveys for Euros commenced during 1997 and population estimates were used to calculate quotas from 1997 onwards. Prior to 1997, conservative quotas were set for Euros and harvest was very low. Figure excludes data from the Southern Agricultural harvest region for Western Grey Kangaroos.

Regional harvest quotas for 2021

Table 11: Red Kangaroo population estimates for 2020 and harvest quotas for 2021. Population densities and estimates are produced from Red Kangaroo population model.

Harvest region	Area (km ²)	Pop density /km ²	Pop estimate	Harvest %	Quota
Western Pastoral					108,200
Marla – Oodnadatta ¹	128,908	0.7**	38,422	0	0
Kingoonya	73,392	4.9	354,319	20	70,800
Gawler Ranges	45,811	2.6	117,020	20	23,400
Marree (inside dog fence)	14,680	4.8	70,304	20	14,000
Marree (outside dog fence) ¹	177,517	1.0**	90,797	0	0
Eastern Pastoral					73,600
North Flinders	34,622	7.6	263,980	20	52,700
North East Pastoral	31,448	4.1*	128,937	10	12,800
Eastern Districts ²	22,920	1.5	35,541	20	7,100
Mallee ¹	23,994	0.2	5,463	20	1,000
Eastern Agricultural					14,700
South Flinders ²	11,883	5.6	66,606	20	13,300
Yorke Mid North ²	22,217	0.4	7,499	20	1,400
Western Agricultural					NA
Eyre West	22,459	NA	NA	NA	NA
Eyre East	31,164	NA	NA	NA	NA
Total	641,015		1,178,888		195,500
Special Land Management Quota³					17,600
Total quota available for 2021					214,100

¹ Model population prediction scaled to 45% suitability for Marla-Oodnadatta and 50% suitability for Marree (outside dog fence).

² Sub-region surveyed during 2020, survey data was incorporated into the population model to produce a model fitted estimate

³ Special Land Management Quota has been set at 1.5% of the total population estimate for the commercial harvest area.

* Red kangaroo population in the North East Pastoral sub-region has reached the second low population threshold, therefore quota has been reduced to 10% as per the Management Plan.

** Red kangaroo populations in Marla-Oodnadatta and Marree (outside dog fence) sub-regions have reached the second low population threshold, therefore quotas have been suspended as per the Management Plan.

Table 12: Western Grey Kangaroo population estimates for 2020 and harvest quotas for 2021. Population densities and estimates are produced from Western Grey Kangaroo population model.

Harvest region	Area (km ²)	Pop. density/ km ²	Pop. estimate	Harvest %	Quota
Western Pastoral					33,200
Marla – Oodnadatta	128,908	NA	NA	NA	NA
Kingoonya	73,392	0.1	5,846	15	800
Gawler Ranges	45,811	4.7	216,627	15	32,400
Marree (inside dog fence)	14,680	NA	NA	NA	NA
Marree (outside dog fence)	177,517	NA	NA	NA	NA
Eastern Pastoral					39,600
North Flinders ⁴	34,622	1.1	37,392	10	3,700
North East Pastoral ²	31,448	0.2**	7,520	0	0
Eastern Districts ¹	22,920	3.7	89,542	15	13,400
Mallee	23,994	6.3	150,347	15	22,500
Eastern Agricultural					36,700
South Flinders ¹	11,883	8.9	105,987	15	15,800
Yorke Mid North ¹	22,217	6.5	139,345	15	20,900
Western Agricultural					10,800
Eyre West	22,459	2.1*	63,447	10	6,300
Eyre East	31,164	1.8	30,073	15	4,500
Southern Agricultural					29,000
Hills and Fleurieu ³	7,137	8.3	56,114	15	8,400
Lower South East ³	11,508	1.1	12,345	15	1,800
Upper South East ²	18,238	5.3	96,812	15	14,500
Kangaroo Island ²	4,398	9.9	43,540	10	4,300
Total	682,296		1,054,937		149,300
Special Land Management Quota⁵					15,800
Total quota available for 2021					165,100

¹ Sub-region surveyed during 2020, survey data was incorporated into the population model to produce a fitted estimate.

² 2020 survey data population estimate was used for North East Pastoral, Upper South East and Kangaroo Island.

³ Driving surveys were used to determine population estimates in the Hills and Fleurieu and Lower South East sub-regions. Driving transects were stratified based on habitat type and densities applied across habitat blocks, excluding settled areas.

⁴ Survey estimate for 2019 has been used for North Flinders and quota reduced to 10% due to an unexplained increase in population density by the model for 2020.

⁵ Special Land Management Quota has been set at 1.5% of the total population estimate for the commercial harvest area.

* Western Grey Kangaroo population in the Eyre West sub-region has reached the second low population threshold, therefore quota has been reduced to 10% as per the Management Plan.

** Western Grey Kangaroo population in North East Pastoral sub-region has reached the second low population threshold, therefore quotas have been suspended as per the Management Plan.

Table 13: Euro population estimates for 2020 and harvest quotas for 2021.

Harvest region	Area (km ²)	% Area suitable	Pop density /km ²	Pop estimate	Harvest %	Quota
Western Pastoral						15,900
Marla - Oodnadatta	128,908	0	NA	NA	NA	NA
Kingoonya	73,392	0	NA	NA	NA	NA
Gawler Ranges ¹	45,811	25	7.4	84,521	12	10,100
Marree (inside dog fence)	14,680	15	26.5	58,353	10	5,800
Marree (outside dog fence)	177,517	0	NA	NA	NA	NA
Eastern Pastoral						28,500
North Flinders	34,622	25	32.1	277,409	10	27,700
North-East Pastoral	31,448	15	1.1	5,236	0	0
Eastern Districts	22,920	15	2.8	9,523	9	800
Mallee	23,994	0	NA	NA	NA	NA
Eastern Agricultural						8,700
South Flinders	11,883	20	21.6	51,406	10	5,100
Yorke Mid North ¹	22,217	20	6.9	30,659	12	3,600
Western Agricultural						0
Eyre West	22,459	0	NA	NA	NA	NA
Eyre East	31,164	0	NA	NA	NA	NA
Total	636,736			517,108		53,100
Special Land Management Quota²						7,700
Total quota available for 2021						60,800

¹ Sub-regions surveyed during 2020. Population estimates for other sub-regions were collected during 2018 and 2019.

² Special Land Management Quota has been set at 1.5% of the total population estimate for the commercial harvest area.

Table 14: Eastern Grey Kangaroo population estimates for 2020 and harvest quotas for 2021.

Harvest region	Area (km ²)	Pop density /km ²	Pop estimate	Harvest %	Quota
Southern Agricultural					
Hills and Fleurieu	7,137	NA	NA	NA	NA
Upper South East	18,238	NA	NA	NA	NA
Lower South East ¹	11,508	3.0	34,883	15	5,200
Kangaroo Island	4,398	NA	NA	NA	NA
Total	41,281		34,883		5,200
Special Land Management Quota²					500
Total quota available for 2021					5,700

¹ Driving surveys were used to determine population estimate. Driving transects were stratified, based on habitat type and densities applied across habitat blocks, excluding large towns.

² Special Land Management Quota has been set at 1.5% of the total population estimate for the commercial harvest area.

Table 15: Tammar Wallaby population estimates for 2020 and harvest quotas for 2021.

Harvest region	Area (km ²)	Pop density /km ²	Pop estimate	Harvest %	Quota
Southern Agricultural					
Hills and Fleurieu	7,137	NA	NA	NA	NA
Upper South East	18,238	NA	NA	NA	NA
Lower South East	11,508	NA	NA	NA	NA
Kangaroo Island ¹	4,398	9.6	42,221	7	2,900
Total	41,281		42,221		2,900
Special Land Management Quota²					600
Total quota available for 2021					3,500

¹ Spotlight driving surveys were used to determine population estimate. Driving transects were stratified, based on habitat type and densities applied across habitat blocks, excluding large towns.

² Special Land Management Quota has been set at 1.5% of the total population estimate for the commercial harvest area.

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Appendix 1

Table A1: Results of model and survey density estimates for Red Kangaroos and Western Grey Kangaroos as they relate to management actions, full quota issued, reduced quota issued (population below first low population threshold) or harvest suspended (population below second low population threshold). In sub-regions where the model and survey estimate produced different management actions, the more conservative management action was used. Results used in this quota report are highlighted in bold.

Harvest region	Last Survey	Red kangaroo		Western Grey Kangaroo	
		Survey Result	Model Result	Survey Result	Model Result
Western Pastoral					
Marla - Oodnadatta	2019	NA	Suspend harvest	NA	-
Kingoonya	2019	NA	Full quota	NA	Full quota
Gawler Ranges	2019	NA	Full quota	NA	Full quota
Marree (inside dog fence)	2019	NA	Full quota	NA	-
Marree (outside dog fence)	2018	NA	Suspend harvest	NA	-
Eastern Pastoral					
North Flinders	2019	NA	Full quota	2019 estimate¹	Full quota
North-east Pastoral	2020	Reduced quota	Reduced quota	Suspend harvest	Full quota
Eastern Districts	2020	Full quota	Full quota	Full quota	Full quota
Murray Mallee	2019	NA	Full quota	NA	Full quota
Eastern Agricultural					
South Flinders	2020	Full quota	Full quota	Full quota	Full quota
Yorke Mid North	2020	Full quota	Full quota	Full quota	Full quota
Western Agricultural					
Eyre West	2017	-	-	NA	Reduced quota
Eyre East	2017	-	-	NA	Full quota

¹ 2019 survey estimate was used for Western Grey Kangaroos in North Flinders sub-region due to an unexplained increase in the predicted model estimate for 2020 of 2.4/ km². Quotas have been reduced to 10% of the 2019 population estimate.

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