WINTON WETLANDS

WINTON WETLANDS

KANGAROO MANAGEMENT PLAN

2020-2025

Winton Wetlands Kangaroo Management Plan 2020-2025

Contents

Prepared by:

Dr Lisa Farnsworth, Winton Wetlands Committee of Management

Date: 19th December 2019

1. Introduction and background

1.1. Ecological, social and economic impacts of overabundant macropods

The active management of kangaroo populations is controversial and often polarising, because kangaroos are viewed both as a national wildlife icon, valuable to tourism and the national identity, and as a potential pest species for those invested in the primary industries[1].

High-density populations of Eastern Grey Kangaroos have been associated with perceived (yet not often quantified) losses to primary industries through competition for food resources or a reduction in crop yield[2]. Kangaroos are known to graze selectively and, at times, heavily enough to have a negative effect on fauna and flora through depletion of habitat[3]. Additionally, in an increasingly urbanising environment, kangaroos are also known to heightened risk to human safety through increased risk of road traffic accidents[4].

1.2. Current Victorian kangaroo control/pet meat legislation

Within Victoria, there are two means with which landholders can gain authority to control Eastern Grey Kangaroo populations by lethal means. Landholders can apply through Department of Environment, Land, Water & Planning (DELWP) for an Authority to Control Wildlife (ATCW). An ATCW permits the control of wildlife that is damaging property, farmland or habitat, or posing a risk to the safety of people. An ATCW is required to scare, trap, move or destroy wildlife and comes with a range of conditions that must be adhered to under the *Wildlife Act 1975*. The number of ATCW's issued for Eastern Grey Kangaroos has steadily increased from 1,250 permits in 2012 (maximum number of animals destroyed 44,469) to 2,849 permits in 2018, over 150,000 kangaroos were permitted to be destroyed.[5]

Additionally, landholders can arrange for the commercial harvesting of their local kangaroo populations through the Kangaroo Pet Food Trial (KPFT) that has been implemented under the Victorian Kangaroo Harvest Management Plan. A key purpose of establishing Victoria's kangaroo harvesting program is to provide landholders with an alternative to undertaking their own legal kangaroo control. This program links landholders to registered 'harvesters' who are operating in their zone. The total sustainable kangaroo harvesting rate in Victoria is currently 10% of the estimated population. Estimated populations were calculated via statewide aerial surveys conducted in 2017 and 2018.

The total sustainable harvesting rate in New South Wales is also calculated as a percentage of the total estimated population size[6], whilst in the ACT, their culling program sets density targets of 1 kangaroo per hectare in grasslands, 0.9/ha for open woodlands and 0.5/ha for woodlands.[7]

1.3. Previous kangaroo surveys at Winton Wetlands

The only formal Eastern Grey Kangaroo surveys conducted at Winton Wetlands were completed by Steve Hamilton from Hamilton Environmental Services and Winton Wetlands staff in September 2013. These surveys utilized line transect and faecal pellet count methodology to determine that Winton Wetlands had approximately 0.13 kangaroos per hectare. No active kangaroo management was suggested at this time as densities were relatively low.

[1] Pople and Grigg 1999
[2] Coulson, 2007; Descovich et al., 2016
[3] Neave and Tanton, 1989; Meers and Adams, 2003; Barton et al., 2011; Dorrough et al., 2012; Manning et al., 2013; Howland et al., 2014; McIntyre et al., 2014; Howland et al., 2016; Snape et al., 2018
[4] Abu-Zidan et al, 2002; Coulson, 2007; Descovich et al., 2016; Brunton et al., 2018
5 DELWP, 2019
6 Office of Environment and Heritage NSW, 2011
7 ACT Government, 2017

2. Kangaroo population estimation, October 2019

2.1. Survey methods

We employed line transect methodology for surveying macropod density. This is a well-established and precise[8] methodology, successfully utilised by several ecologists to survey macropods throughout the 1980's and 1990's[9]. This was also the method employed by Hamilton (2013), so for the benefit of direct comparison, we attempted to replicate Hamilton's study methods as closely as possible.

Line transect surveys were carried out between 7.00 am and 9.30 am by Winton Wetlands employees on three separate occasions during October 2019 (Table 1). All transects (See Table 2 and Figure 1 for details) were surveyed concurrently in order to reduce the incidence of double-counting kangaroos on the reserve. In the interests of comparison, we also utilized Hamilton's 'regional' approach to macropod population estimation, where the reserve was divided into four geographic regions- Northern, Southern, Eastern and South-Western (Figure 2).

We could then generate macropod density estimates for regions, as well as overall estimates for the entire reserve. Surveys were carried out by an observer driving slowly (25-30km/h) in a vehicle along a marked out transect line and recording any kangaroos sighted along this transect. For each kangaroo sighting, the number of individuals in the 'mob' was recorded. The distance of this mob from the observer was then calculated using a laser rangefinder and the angle (from the transect line) recorded using a standard compass (Figure 3).

All raw data for the 2019 surveys is recorded and stored on the Winton Wetlands OneDrive data cloud.[10]

Table 1. The timing and weather conditions during the three kangaroo surveys undertaken in October 2019 (data from Benalla Airport BOM weather station)

Date	Time start	Time end	Temp Range (°C)	Rainfall (24hr)	Wind speed (km/h)	Cloud cover
09/10/2019	0700	1000	3.1-19.1	0.1	5-10	nil
16/10/2019	0700	1000	11.6-18.4	1.4	calm	Cloudy (7)
23/10/2019	0700	0930	4.4-29.9	0	calm	nil

Table 2. The details of the nineteen transects surveyed in October 2019. ***Note: transect 7 from Hamilton's surveys was not sampled. Instead, we sampled a new transect number 20***

Region	Transect	Description	Length (km)	Direction (°)	Start		End	
					easting	northing	easting	northing
SW	1	Dam wall	7.068	300	412241	5965002	415307	5959493
SW	2	North Road	2.636	150	412281	5964103	413219	5961897
SW	3	Flynn's Track	1.248	60	413219	5961897	414356	5962466
SW	4	SW link track	1.373	150	414356	5962466	415107	5961303
SW	5	SW link track	1.706	160	415107	5961303	415531	5959559
SW	6	Flynn's Bike Path	2.89	340	415809	5963192	417103	5960629
S	8	Winton North Road	3.884	30	418411	5960100	421793	5965451
S	9	Firebreak (Hernans Tk)	4.712	30	419045	5961065	422321	5963601
S	10	Lunette Track	2.676	360	419772	5962320	419152	5965108
S	11	Ashmeads Swamp Rd	1.602	120	421331	5964764	422414	5963667
E	12	Humphries Lane	4.879	30	421793	5965451	425294	5967081
E	13	Boggy Bridge Road	3.554	330	421873	5965609	420459	5968661
E	14	NE Track	2.464	70	421700	5969441	423893	5970590
E	15	Firebreak alignment	1.228	160	424079	5970630	424660	5969599
E	16	Tom's track	5.037	290	424197	5966508	422691	5969956

[8] Glass *et al*., 2015
[9] (e.g. Coulson 1979; Morgan 1979; Coulson and Raines 1985; Clancy *et* al. 1997; Morgan 1979; Southwell 1994)
[10] L>Restoration Science>Terrestrial Ecology>Fauna>Native Species>Kangaroo Management>2019 Survey

E	17	Firebreak alignment	3.535	180	424660	5969599	424343	5966547
N	18	Pipeline track	10.204	45	412268	5964473	420485	5968529
SW	19	Flynn's Track	1.588	60	414356	5962466	415809	5963192
SW	20	Boardwalk alignment	2.70	10	415758	5963223	415126	5965545

Figure 1. Aerial map of the twenty transects surveyed at Winton Wetlands Reserve (map from Hamilton (2013), with additional transect 20 added)

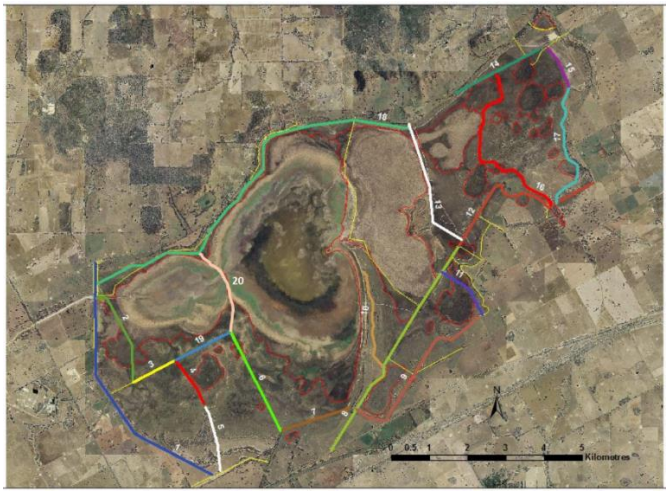


Figure 2. Map of defined 'regions' from Hamilton (2013), also used within our 2019 survey work

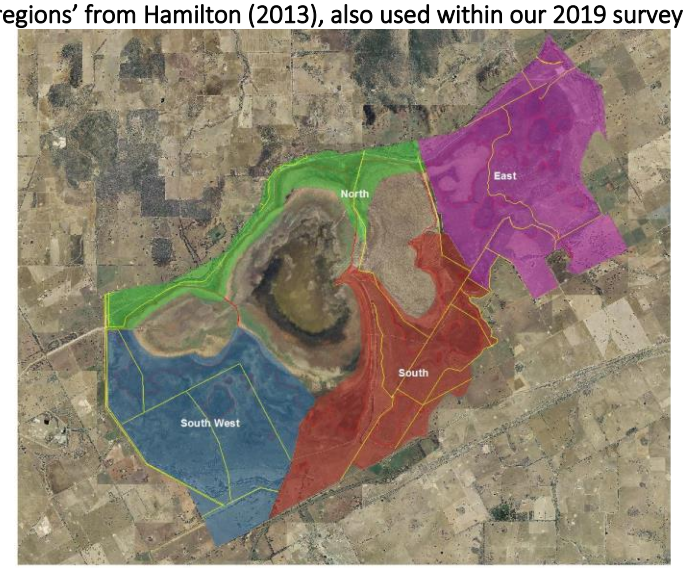
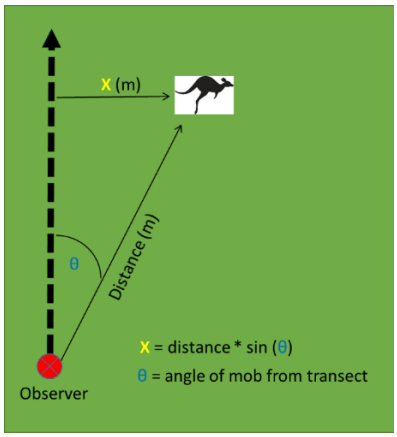


Figure 3. Illustration of survey method in the field. Observer travelling along transect in car measures distance from kangaroo mob using laser rangefinder and angle from mob using standard compass. A simple trigonometric formula allows calculation of X (m).



2.2. Survey Results

Raw data (distances, angles and mob sizes) from the surveys was entered into a Microsoft excel spreadsheet. Distance 'x' (otherwise known as the perpendicular distance (m)) was calculated for each group of macropods observed using the formula x = distance (m) * sin (θ).

These data were used in conjunction with the Distance (Buckland *et al*., 2003) software package to model how detectability decreases with increasing distance from the transect. This allows estimation of total population density of macropods in the surveyed area (Table 3). These density estimates could then be extrapolated to the total area of available habitat on the reserve.

2.3. DISTANCE density and abundance estimate

Table 3. Eastern Grey Kangaroo density and abundance estimates calculated during each of three surveys (9th, 16th and 23rd October 2019) using the conventional distance sampling software DISTANCE (Buckland *et al*. 2003). ^ indicates insufficient data collected and therefore no analyses

Survey date	Region	Area (ha)	Effort[a] (km)	N[b]	Model[c]	P[d]	Density[e] (no./ha)	Density[f] CI	CV[g] (%)	Abundance[h]	Abundance[i] CI	ESW[j] (m)
09/10/2019	**All**	**6428**	**64.9**	**88 (748)**	**-X/Cos**	**0.24**	**0.30**	**0.18-0.52**	**27**	**2553**	**1496-4359**	**129**
	SW	1817	18.5	30 (167)	-X/Cos	0.33	0.28	0.12-0.64	43	502	216-1167	115
	E	2016	20.7	37 (327)	-X/Cos	0.39	0.30	0.13-0.72	41	613	260-1447	211
	N	640	12.9	8 (38)	HR/Cos	1	0.06	0.03-0.13	35	38	16-86	286
	S	1955	12.87	13 (216)	Uni/Cos	0.34	0.70	0.14-3.40	79	1354	276-6646	120
16/10/2019	**All**	**6428**	**64.9**	**120 (785)**	**-X/Poly**	**0.25**	**0.44**	**0.25-0.77**	**28**	**4624**	**2646-8080**	**106**
	SW	1817	18.5	33 (186)	-X/Cos	0.36	0.25	0.12-0.53	43	465	223-968	131
	E	2016	20.7	44 (237)	-X/Cos	0.32	0.35	0.13-0.91	45	700	268-1829	136
	N	640	12.9	8 (35)	-X/Cos	0.40	0.16	0.03-0.80	81	102	20-509	159
	S	1955	12.87	35 (327)	-X/Cos	0.28	0.98	0.24-4.06	61	1911	460-7391	96
23/10/2019	**All**	**6428**	**61.4**	**78 (404)**	**-X/Cos**	**0.28**	**0.25**	**0.13-0.49**	**34**	**2102**	**1064-4151**	**125**
	SW	1817	18.5	24 (64)	HR/Cos	0.77	0.08	0.03-0.24	50	151	53-435	178
	E	2016	17.17*	29 (192)	-X/Cos	0.37	0.32	0.14-0.75	40	652	282-1505	165
	N	640	12.9	2 (5)	^	^	^	^	^	^	^	^
	S	1955	12.87	23 (143)	HR/Cos	0.30	0.57	0.06-5.22	74	1117	122-10218	102

[a] The distance of line transects surveyed within each of the regions, "All" is all data pooled together from that survey event

[b] The number of kangaroo 'mobs' or clusters, with the total number of Eastern Grey Kangaroos observed during each survey in parentheses

[c] The most suitable detection function model and adjustments used to calculate Eastern Grey Kangaroo density and abundance (Buckland *et al*. 2003). –X = negative exponential, HR= Hazard-rate, Uni= Uniform, Cos= cosine adjustments, Poly= Polynomial adjustments

[d] The unconditional probability of detecting a kangaroo within the surveyed area (Buckland *et al*. 2003)

[e] The estimated density of Eastern Grey Kangaroo

[f] The 95% confidence interval for the density estimate

[g] The coefficient of variation (percentage) of the density estimate

[h] The estimated abundance of Eastern Grey Kangaroo within the surveyed area

[i] The 95% confidence interval for the abundance estimate

[j] The Effective Strip Width (ESW) in metres where there is an unconditional probability of detecting an Eastern Grey Kangaroo in the surveyed area (Buckland *et al.* 2003)

There were too few (n=19 total over 3 survey days) Black tailed Swamp Wallabies (BTWs) sighted in order to conduct any analyses.

During this survey, 748, 785 and 404 Eastern Grey Kangaroo were counted by observers across the approximately 60-65kms of transect surveyed. These EASTERN GREY Kangaroos were in 88, 120 and 78 clusters, respectively. Eastern Grey Kangaroos were observed in relatively small groups, with the average cluster size for each survey ranging from 5 to 9 Eastern Grey Kangaroos per cluster.

Eastern Grey Kangaroo density estimates for the whole reserve "All"= all transects included in analyses) ranged from 0.25-0.44 Eastern Grey Kangaroo/ha. These density estimates appear to be reasonable, given the modest values for the coefficient of variation (27-34%). Pooled data averaged across the three surveys was used to generate an overall mean Eastern Grey Kangaroo density for the reserve of 0.33 Eastern Grey Kangaroo/ha and there is a 95% chance that Eastern Grey Kangaroo density across the whole reserve was 0.19-0.60 Eastern Grey Kangaroo/ha. Based on the density of 0.33 and the availability of approximately 8700ha of land (i.e. very little water) on the reserve, we believe that the reserve currently carries approximately 3,000 Eastern Grey Kangaroo. This is likely to be an overestimate, as the region areas calculated during Hamilton's study (and used in ours) were during a wetter period (less ha of dry land available). In reality the land area available within each study region is larger and hence density less than what we've estimated.

From a regional perspective, the southern region showed relatively high Eastern Grey Kangaroo densities (0.57-0.98 Eastern Grey Kangaroo/ha) compared with other regions. The northern region had consistently low densities and in the 23rd October survey, had too little data for meaningful analyses (Table 3). Eastern and South-Western regions were more consistent with 0.30-0.35 Eastern Grey Kangaroo/ha and 0.08-0.28 Eastern Grey Kangaroo/ha respectively.

Estimated Eastern Grey Kangaroo abundances across the whole reserve ranged from 2102-4634 Eastern Grey Kangaroo. Pooled data from all three surveys was used to generate an overall mean estimated abundance of 3096 and we can be 95% confident that there is 2646-6116 EASTERN GREY KANGAROOs on the reserve (Table 3). Abundances calculated for the northern region were low, with one instance where there was insufficient raw sighting data to generate meaningful estimates (Table 3). Abundances in the eastern region were very consistent, ranging from 613 to 700 Eastern Grey Kangaroo (Table 3). Abundances of Eastern Grey Kangaroo in the south were relatively high, ranging from 1117-1911 Eastern Grey Kangaroo, while relative to region area (ha), the South-West abundances were low, ranging from 151-502 Eastern Grey Kangaroo (Table 3).

2.4. Comparison with 2013 survey and kangaroo densities elsewhere in Victoria/Australia

As we replicated the methods of Hamilton's 2013 survey, we were able to directly compare the results of the two surveys (2013 vs 2019). In 2013, Hamilton recorded an overall mean Eastern Grey Kangaroo density of 0.133 Eastern Grey Kangaroo/ha. In the 2019 survey we estimated a density of 0.33 Eastern Grey Kangaroo/ha of Eastern Grey Kangaroos on the reserve which is more than double the density that was estimated six years ago. The reasons for these differences are unclear, however a comparison of the survey time of day (7.00 am- 9.30 am in 2019 versus 8.00 am- as late as 1.00pm and 4.00pm in 2013) may illustrate Hamilton's survey may well have underestimated the density of kangaroos detected at the reserve on the basis that they are largely crepuscular and are inactive (hard to detect) after the early morning.

Nevertheless, the Eastern Grey Kangaroo densities reported in this survey (0.33 Eastern Grey Kangaroo/ha) are relatively low compared to areas where active kangaroo management is the norm. In the ACT, Eastern Grey Kangaroos have been recorded at densities as high as 7 Eastern Grey Kangaroo/ha (Jerrabomberra Nature Reserve) and are largely >1 Eastern Grey Kangaroo/ha across all of the kangaroo management areas in the territory (ACT Government, 2017).

In Victoria, Eastern Grey Kangaroo densities estimated during aerial surveys in 2018 were 0.117/ha for the north-east region (the region in which the reserve lies). This is less than half of the density observed within the reserve in 2019.

In south-east NSW, Eastern Grey Kangaroo densities ranged from 0.240 Eastern Grey Kangaroo/ha in the Gundagai survey block to 0.584 Eastern Grey Kangaroo/ha in the Braidwood survey block. These densities were calculated using data from aerial surveys conducted in spring 2018 (Cairns et al., 2019). These densities are comparable to what we've observed at the wetlands in 2019.

3. Macropod management actions at Winton Wetlands

3.1 Is there a need for active kangaroo management at Winton Wetlands?

Winton Wetlands Committee of Management do not feel there is a need for active kangaroo management on the reserve. Estimated kangaroo densities at Winton Wetlands (0.3 Eastern Grey Kangaroo/ha) are less than half of the 0.9-1 kangaroo per hectare recommended by the ACT Government for the management of grassland/open woodland vegetation (ACT Government, 2017). Perhaps most importantly, our estimated density of 0.3 Eastern Grey Kangaroo/ha is less than the 'socially acceptable' carrying capacity of kangaroos (0.5 kangaroos/hectare) and is within the range of kangaroo densities calculated for the NE Victoria region (0.045-0.301 Eastern Grey Kangaroo/ha), estimated during state-wide aerial surveys conducted in Victoria by DELWP in 2017 and 2018 (Moloney et al., 2018). This, combined with our highly successful revegetation strategy lends further support to the notion that kangaroos need not be culled (Farnsworth, 2017).

3.2 Road safety improvements being implemented

Figure 4. Map of old fencing wire (red lines) removed from Winton Wetlands Reserve throughout 2019

To date, over 12km of old fencing has been removed, with particular focus on fence removal along Lake Mokoan Road (Figure 4). The aims of this removal are 1) to reduce the amount of 'funnelling' of kangaroos between fences along the main access roads and reduce the risk of road traffic accidents caused by macropods and 2) reduce the risk of macropods being snagged in old unused fence lines throughout the reserve.

3.3 Ongoing macropod population monitoring at Winton Wetlands

Macropod population monitoring should continue at the wetlands on an annual basis, in early spring. This will allow us to track annual changes in the population density and adjust our management activities when/where necessary. Methods used in this and Hamilton (2013) study are easily replicated and staff requirements and costs are minimal. WWCOM owns 3 laser rangefinders and 3 compasses that can be used for future surveys. It took 27 staff hours total to complete the field component of the survey work (three staff for three hours per morning for 3 mornings). The three vehicles used would only use a

maximum of a tank of fuel each. So overall ongoing annual costs of the survey are likely to be approximately $1000-$1500 including staff pay.

4. Research requirements

4.1 Understanding the impact of native and feral herbivores on our revegetation work and on natural regeneration of native vegetation

It is very easy to simply label kangaroos as the 'problem', where in reality the true definition of the problem (from all stakeholder's perspectives) is not 'overabundant kangaroos' (Coulson, 2007). Instead, the problems are more accurately defined as things like decreased neighbouring crop yield, failure of regeneration of red gum seedlings, increased road accidents etc. It is important to clearly define these potential problems, explore whether kangaroos are indeed the *cause* of these through research and if so, plan to manage the kangaroo population to reduce the 'problem' (not to just reduce the kangaroo population). Whilst acknowledging the presence of a variety of herbivores on the reserve, we have little understanding of the impact of herbivory on our restoration efforts.

Student research could focus on collecting information around a number of key study questions including:

- The use of different vegetation types by local herbivores (kangaroos, wallabies, rabbits, hares, stock)
- Impacts of herbivory on establishment and survivorship of River Red Gum (from seed)
- Impacts of herbivory on long-term re-establishment of native grass species

We are currently in talks with researchers from the University of Melbourne (Dr Lauren Bennett and Dr Sabine Kasel) with regards to supervising a student intern study looking at faecal pellet counts (FPCs) for Eastern Grey Kangaroos, rabbits/hares and BTWs within different vegetation types in order to quantify the extent to which each species uses different vegetation types, including revegetation areas and areas with new seedlings. Meers and Adams (2003) completed a similar method at the Reef Hills State Park. The FPC study would also provide WWCOM with the ability to compare the Eastern Grey Kangaroo densities generated using different methods (FPC versus line transect methods). The student would also review the most cost effective 'fenced exclusion study' method (e.g. Allcock and Hik, 2004) and provide WWCOM with some recommendations as to how to design and carry out such a study which would allow us to tease apart the impact of each species on various aspects of the native vegetation.

Appendix I: Raw data collection sheet pro forma (from Hamilton 2013)

Transect Number	Section	Start Time	Finish Time	Species	Number	Distance (m)	Angle (°)
				K or W			
				K or W			
				K or W			
				K or W			

References

Abu-Zidan, F., Parmar, K. and Rao, S. (2002). Kangaroo-related motor vehicle collisions. *Journal of Trauma-injury Infection and Critical Care* **53**: 360-363.

ACT Government (2017). Eastern Grey Kangaroo: Controlled Native Species Management Plan. Environment and Planning Directorate, ACT Government, Canberra, Canberra, Australian Capital Territory

Allcock, K.G. and Hik, D.S. (2004). Survival, growth and escape from herbivory are determined by habitat and herbivore species for three Australian woodland plants. *Oecologica* **138**: 231-241.

Barton, P.S., Manning, A.D., Gibb, H., Wood, J.T., Lindenmayer, D.B., Cunningham, S.A. (2011). Experimental reduction of native vertebrate grazing and addition of logs benefit beetle diversity at multiple scales. *Journal of Applied Ecology* **48**: 943-951

Brunton, E.A., Srivastava, S.K. and Burnett, S. (2018) Spatial ecology of an urban eastern grey kangaroo (Macropus giganteus) population: local decline driven by kangaroo–vehicle collisions. *Wildlife Research* **45:** 685-695.

Buckland ST, Anderson DR, Burnham KP, and Laake JL (2003). *Distance Sampling: Estimating Abundance of Biological Populations*. Chapman and Hall, London. 446 pp.

Cairns, S.C., Bearup, D. and Lollback, G. (2019). Design and analysis of helicopter surveys of kangaroo populations in the South East NSW kangaroo management zone, 2018. A report to the New South Wales Office of Environment and Heritage.

Clancy T, Pople A, and Gibson L (1997). Comparison of helicopter line transects with walked line transects for estimating desnities of kangaroos. *Wildlife Research* **24:** 397-409.

Coulson, G. M., and Raines, J. A. (1985). Methods for small-scale surveys of grey kangaroos. *Australian Wildlife Research* **12**, 119–125.

Coulson, G.M. (2007). Exploding kangaroos: assessing problems and setting targets in Pest or Guest: the zoology of overabundance, Pp 174 – 181, edited by Daniel Lunney, Peggy Eby, Pat Hutchings and Shelley Burgin. 2007. Royal Zoological Society of New South Wales, Australia.

Descovich, K., Tribe, A., McDonald, I.J. and Phillips, C.J.C. (2016) The eastern grey kangaroo: current management and future directions. *Wildlife Research* **43**:576-589.

Department of Environment, Land, Water and Planning (2019). Authorities to control wildlife (ATCW) data. Victorian Government Publication, Melbourne, Victoria.

Department of Environment, Land, Water and Planning (2019). Victorian Kangaroo Harvest Management Plan 2019. Victorian Government Publication, Melbourne, Victoria.

Dorrough, J., McIntyre, S., Brown, G., Stol, J., Barrett, G., Brown, A. (2012). Differential responses of plants, reptiles and birds to grazing management, fertilizer and tree clearing. *Austral Ecology* **37**: 569-582.

Farnsworth, L.M. (2017). Winton Wetlands Revegetation Review 2017. Report prepared for WWCOM.

Glass, R., Forsyth, D.M., Coulson, G. and Festa-Bianchet, M. (2015). Precision, accuracy and bias of walked line-transect distance sampling to estimate eastern grey kangaroo population size. *Wildlife Research* **42**: 633-641.

Hamilton, S.D. (2013). Winton Wetlands-Macropod Survey 2013. Report prepared for WWCOM by Hamilton Environmental Services, Tatong.

Howland,B.,Stojanovic,D.,Gordon,I.J.,Manning,A.D.,Fletcher,D.,and Lindenmayer, D. B. (2014). Eaten out of house and home: impacts of grazing on ground-dwelling reptiles in Australian grasslands and grassy woodlands. *PLoSOne* **9**(12).

Howland,B., Stojanovic,D., Gordon,I. J., Radford,J., Manning,A. D., and Lindenmayer, D. B. (2016). Birds of a feather flock together: using trait groups to understand the effect of macropod grazing on birds in grassy habitats. *Biological Conservation* **194**: 89 –99.

Manning, A.D., Cunningham, R.B., Lindenmayer, D.B. (2013). Bringing forward the benefits of coarse woody debris in ecosystem recovery under different levels of grazing and vegetation density. *Biological Conservation* **157**: 204-214.

McIntyre, S., Cunningham, R.B., Donnelly, C.F., Manning, A.D. (2014). Restoration of eucalypt grassy woodland: effects of experimental interventions on ground-layer vegetation. *Australian Journal of Botany* **62**: 570-579.

Meers, T. and Adams, R. (2003). The impact of grazing by Eastern Grey Kangaroos (Macropus giganteus) on vegetation recovery after fire at Reef Hills Regional Park, Victoria. *Ecological management and Restoration* **4 (2)**: 126-132

Moloney, P.D., Ramsey, D.S.L., and Scroggie, M.P. (2018). State-wide abundance of kangaroos in Victoria: results from the 2018 aerial survey. Arthur Rylah Institute for Environmental Research Technical Report Series No. 296. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Morgan DG (1979). Density changes in black-faced kangaroo (*Macropus fuliginosus*) populations at Wyperfeld National Park, 1972-78. *Bulletin of the Australian Mammalogy Society* **6:** 51-2.

Neave, H.M., Tanton, M.T. (1989). The effects of grazing by kangaroos and rabbits on the vegetation and the habitat of other fauna in the Tidbinbilla Nature Reserve, Australian Capital Territory. *Australian Wildlife Research* **16**:337-351.

Office of Environment and Heritage (NSW) (2011). New South Wales Commercial Kangaroo Harvest Management Plan 2012–2016, Office of Environment and Heritage, Department of Premier and Cabinet (NSW), Sydney.

Pople, A. R., and Grigg, G. (1999). 'Commercial Harvesting of Kangaroo in Australia.' (Environment Australia: Canberra.)

Snape M., Caley P., Baines G. and Fletcher D (2018). Kangaroos and Conservation: Assessing the effects of kangaroo grazing in lowland grassy ecosystems. Environment, Planning and Sustainable Development Directorate, ACT Government, Canberra.

Southwell, C. (1987). Activity pattern of the eastern grey kangaroo, Macropus giganteus. *Mammalia* **51**: 211–223.

Southwell, C. (1994). Evaluation of walked transect counts for estimating macropod density. *The Journal of Wildlife Management* **58**: 348–356.