Malleefowl Monitoring in Victoria: 2019/20

Report to the Victorian Malleefowl Recovery Group

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Appendices

1. Monitoring performance: how did we do?

Table 1 shows a breakdown of the performance of the monitoring effort; another great result! (More detail is shown in Appendix A.1). The VMRG visited 1284 Malleefowl mounds during the 2019 (2019/20) breeding season (Table 1) including 19 newly listed mounds.

A total of 48 regular mounds were neither sought nor found during the 2019 season (Table 1) and these were scattered through 11 sites. Most of these (28) were in v01 Dattuck where covid-19 restrictions prevented us from completing the monitoring at half the site. There were also 2 regular mounds that were searched for but could not be found although they were found in previous years.

Overall, we managed to find 96.3% of the mounds that we set out to monitor (excluding newly added mounds, but including optional '5 year' mounds that were monitored. While that's a relatively low result for the VMRG, it's still exceptionally good by national standards.

Table 1. Performance of the monitoring effort. 'Optional old' mounds are those that were categorised as optional (5yr) before the 2018 season, whereas 'Optional new' are mounds that were added to the optional list last season. Omitted mounds are those removed from monitoring lists last season.

	Total	*Regular*	*Optional old*	*Optional new*	*Omitted*
Sought and found	1284	1145	133	6	0
New survey	9	9			
New incidental	10	10	0	0	0
Sought, NOT found	3	2	1	0	0
NOT sought or found	193	48	138	7	0
Total	1499	1214	272	13	0

Last season (2018), 6 mounds that were monitored as regular mounds were reviewed and downgraded to optional (5 year mounds) for subsequent seasons; these mounds show up in the tables as new optional mounds this season. The number of mounds on the optional list is now 285, or 19% of the mounds registered for monitoring.

49% of the optional mounds were monitored this season (139 of 285), mostly in an abbreviated way by simply taking a photo and not recording mound details. Next season it will be time to monitor all of the optional mounds again.

2. Malleefowl Breeding numbers: how did the birds do?

Of the 1284 mounds that were monitored in Victoria in 2018/19, 133 were active compared with 99 last season (2018) and 148 in the season before that (2017; these totals include mounds outside strict site boundaries). These numbers are much lower than the unusually high record of 218 set in 2012.

This year we are changing the charts to fall in line with national reporting, and also because after 20 years or so it's well and truly time for a revamp! Our new way of depicting trends also means we are able to show charts for our Little Desert and Wychitella sites which have been difficult to represent previously for a variety of reasons. We hope the new charts will provide VMRG members with more clear and concise answers to the questions they have regarding Malleefowl trends in different areas, as well as in Victoria as a whole. Note that we can still produce the old trend graphs if you want, and that we also present the individual site data in Appendix 2.

Rather than represent absolute numbers, the charts represent deviations from the long-term average number of active mounds at each site. So, if a site had a long-term average of 10 active mounds, and in a particular year it had 11 active, this would be represented as a +10% trend value for that site in that year. To estimate trends across multiple sites in a region, we averaged these trend values for all the sites and show the degree of variation in these values by displaying a statistic called the 'standard error'. Thus, each graph shows a line depicting the average of all the trend values for the group of sites, and a shaded area about the average line showing the degree of uncertainty in that value (the average plus and minus the standard error). In general terms, the grey zones around each trend value indicate how much the individual sites varied in their response: smaller grey zones indicate that the individual sites responded similarly, whereas larger grey zones indicate that they differed.

This approach uses virtually all the data collected in the past (over 1,100 counts of breeding numbers at sites involving over 28,000 mound visits and resulting in 3,324 active breeding records).

The charts are presented according to the NRM regions they are located in. The NRM regions (for Malleefowl in Victoria these are Mallee, Wimmera and North Central CMAs) are important because they are management zones and often have federal obligations concerning Malleefowl management. For the Mallee CMA we'll also break this down further into the 3 regions that traditionally have been represented in the monitoring report: the Eastern Big Desert (Wyperfeld, Paradise, Bronzewing and Wathe); the North West (Sunset Country and Hattah sites); and North East (Wandown, Annuello, Menzies and O'Brees).

Mallee CMA

Figure 1 shows the trend in active mounds at sites within the Mallee CMA (encompassing the Big Desert, Sunset Country, Annuello, Wandown and O'Brees) and suggest that while the results from the 2019 season were in line with long-term averages (LTAs) for sites (i.e. the 2019 result was close to '0' trend), and much better than the previous year in which the number of active mounds at sites was 35%

below the LTAs, there is nonetheless evidence of a general decline across several decades.

The 3 regions within the Mallee CMA that we traditionally examine in the monitoring report show quite divergent trends. In the Eastern Big Desert (Figure 2), breeding numbers have steadily improved since 2016 when it was 60% below the LTA, but was still 25% below LTA in 2019, and a long-term decline of about -3% per year is apparent. The burning of Bronzewing in 2014 caused a large decline in Malleefowl, but this has had only a minor effect on the overall trend: there are several long term sites in the Eastern Big Desert that have shown pronounced declines over the past two decades without such a clear cause (e.g. v01 Dattuck, v02 Torpeys, v03 Wathe SW, v20 Lowan).

In the North West (Figure 3), breeding numbers were close to the LTA in 2019, a substantial improvement on the previous season when they were 38% below LTA. More generally, the North West sites appear to have been severely affected by the millennium drought between 1997 and 2007 with trend values well below LTAs, but bounced back strongly when the drought broke. In the North East of the Mallee CMA the long term trend has been positive (Figure 4). 2019 numbers were in line with this trend and 25% higher than the LTA; this was welcome news following last season when breeding numbers were down 30% compared to LTAs.

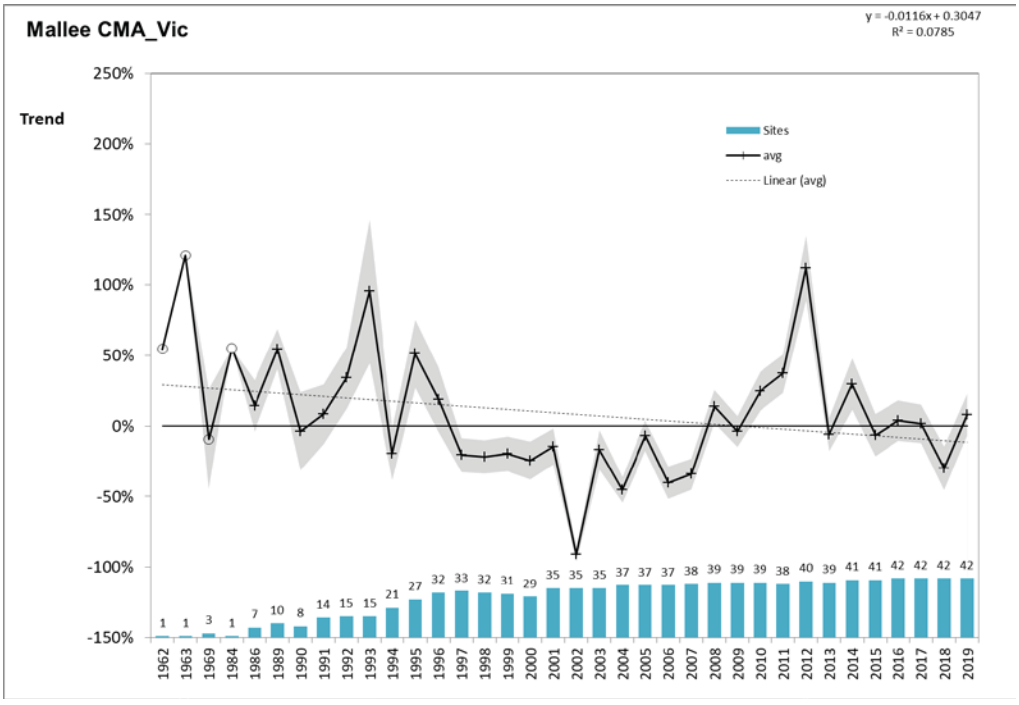
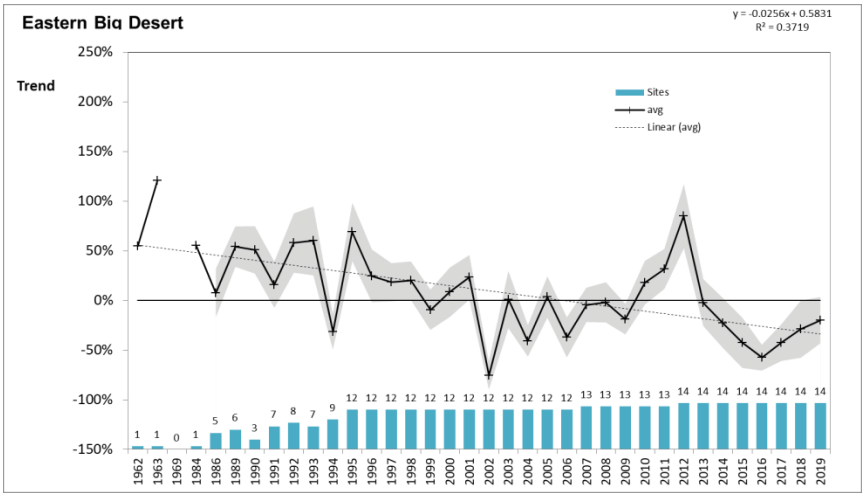
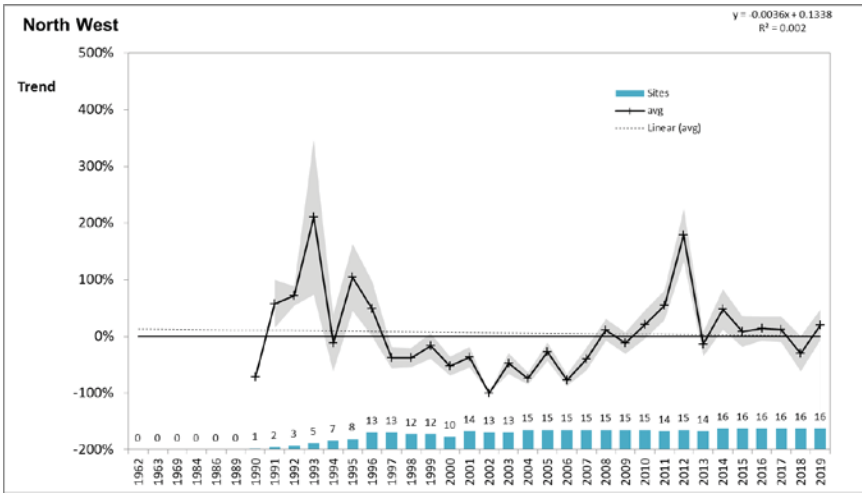
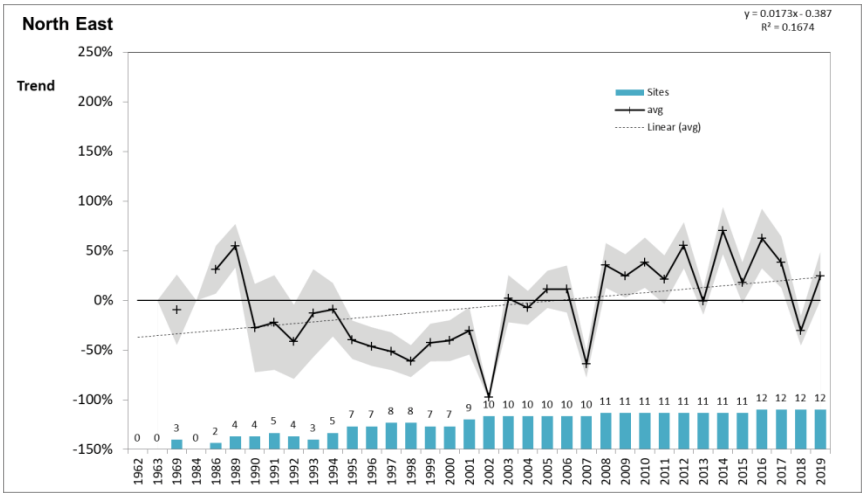


Figure 1. Trends in Malleefowl breeding numbers at 42 sites and site parts represented by 36 monitoring events spanning 58 years (including historical survey data from some sites in the 1960s). Each point (cross) shows the degree to which breeding numbers were above or below the long-term average for the sites monitored (trend). Shading indicates the standard error about the mean where multiple sites were monitored in a season. The number of sites monitored in a breeding season is shown by the histogram. The dashed line indicates a simple linear trend.



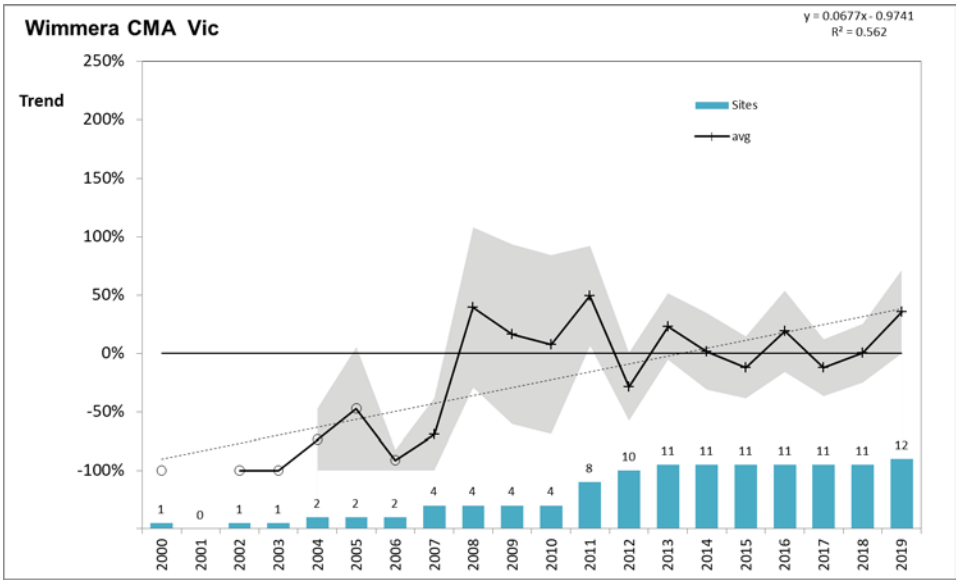




Figures 2, 3 and 4. Trends in Malleefowl breeding numbers in the Eastern big Desert (top), North west (middle) and North east (bottom) sub-regions of the Mallee CMA (see Figure 1).

Wimmera CMA

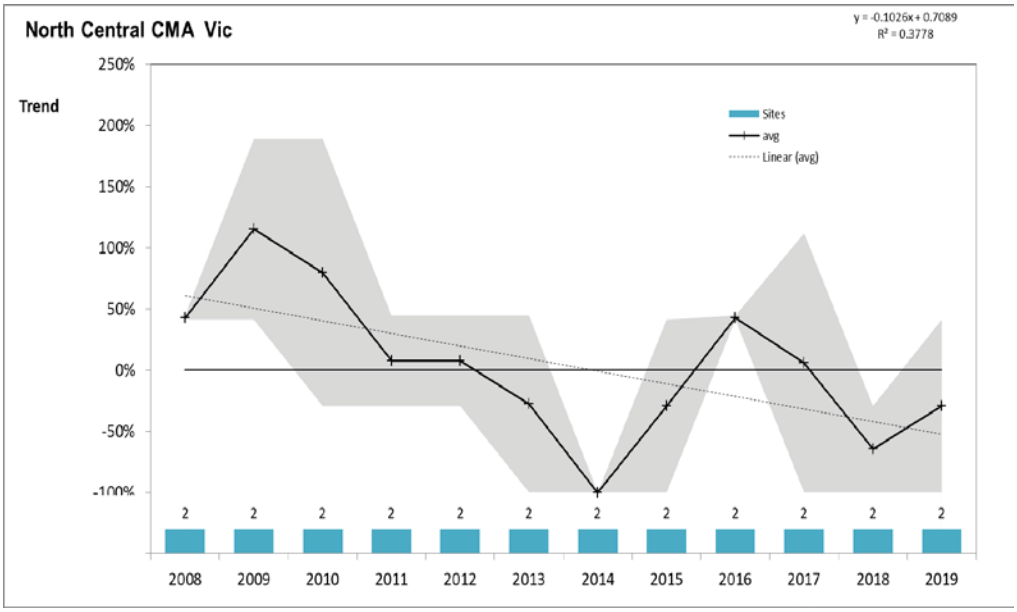
In the Wimmera, Malleefowl breeding numbers in the 2019 season were 36% above the LTA and the long-term trend has been positive since monitoring started in the early 2000s (Figure 5). The relatively low trend values before 2008 may reflect the effects of the Millennium Drought; in any case coming off such a low base has resulted in the general positive trend in breeding activity. Since 2008 when the drought broke, breeding numbers have fluctuated but suggest a relatively stable breeding population at our monitoring sites.



Figures 5. Trends in Malleefowl breeding numbers in the Wimmera CMA (see Figure 1).

North Central CMA

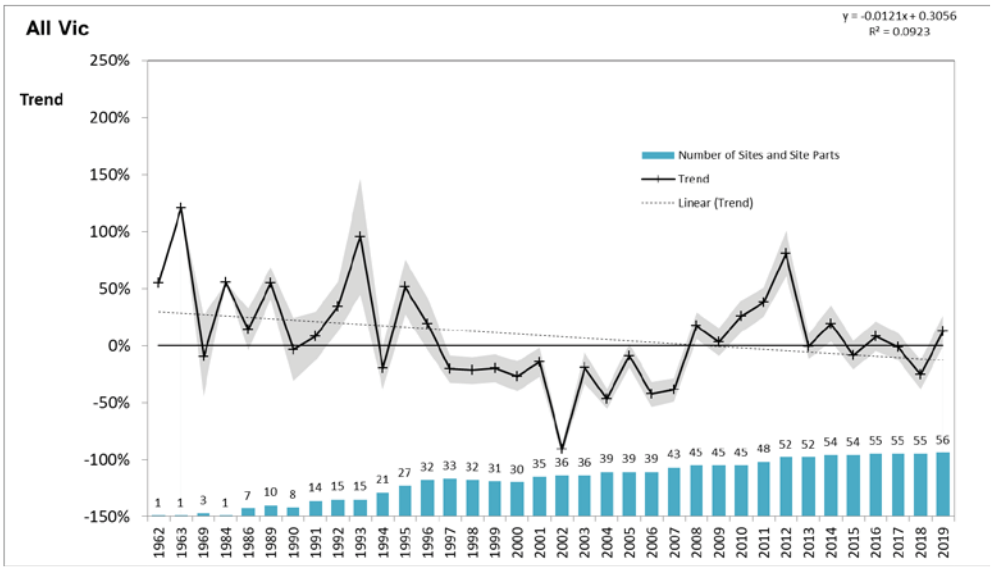
The North Central CMA is represented by 4 sites in the Wychitella group of reserves near Wedderburn. Although the VMRG started monitoring in 2005 in the Wedderburn block, it was not until 2008, after the Millennium drought, that the other 3 blocks were monitored. As most Malleefowl appear to occur in these more recent sites (especially the Wychitella and Korong Vale blocks), it makes sense to consider the breeding population trends from 2008 (Figure 6). These data suggest the breeding population is declining; the 2019 trend value was more than 50% below the LTA, and the previous season even lower. However, it should be borne in mind that the number of sites is low, as is absolute numbers of active mounds (averaging 2.1 active mounds across the 4 sites per year), meaning confidence in this trend is low (this is also reflected in the shaded areas around the trend values in Figure 6).



Figures 6. Trends in Malleefowl breeding numbers in the North Central CMA (see Figure 1).

All Victoria

The new approach to charting Malleefowl trends makes it possible to combine data to obtain state-wide trend representing all of the data we have collected (Figure 7). As most of the data has been collected in the Mallee CMA where Malleefowl are most abundant, the charts for Victoria and the Mallee CMA are similar. Nonetheless, this chart provides the first attempt at displaying the trends in Malleefowl over the state as a whole.



Figures 7. Trends in Malleefowl breeding numbers across Victorian monitoring sites (see Figure 1)

Rainfall profiles in 2019

Indicative rainfall charts for Victorian Malleefowl areas are shown in Figure 8. 2019 was once again characterised by very dry conditions in the Victorian mallee: yearly rainfall was down 57%, 41% and 29% for Mildura, Ouyen and Horsham respectively, a pattern that was very similar to last season. However, in 2019 considerably more rain fell from May to August at these three stations than in 2018, and this increase in rain at a critical time for Malleefowl probably resulted in the upturn of breeding in the Mallee and Wimmera CMAs as indicated above.

With the introduction of trend charts for the Wychitella set of reserves near Wedderburn, it is relevant to consider the rainfall pattern at that location too (Figure 8). In 2019 Wedderburn missed out on much of the May to August rain it usually receives, however it did receive heavy rains in summer (about 120 mm in December 2018 and February 2019) that may have softened the impact of the poor winter rains. There were 2 active mounds recorded in the Wychitella reserves in 2019 compared with only 1 in 2018, but the very dry winter and spring suggests that unless alternative food sources were found by these birds, few eggs would have been laid and the prospects for chicks would seem to have been very poor.

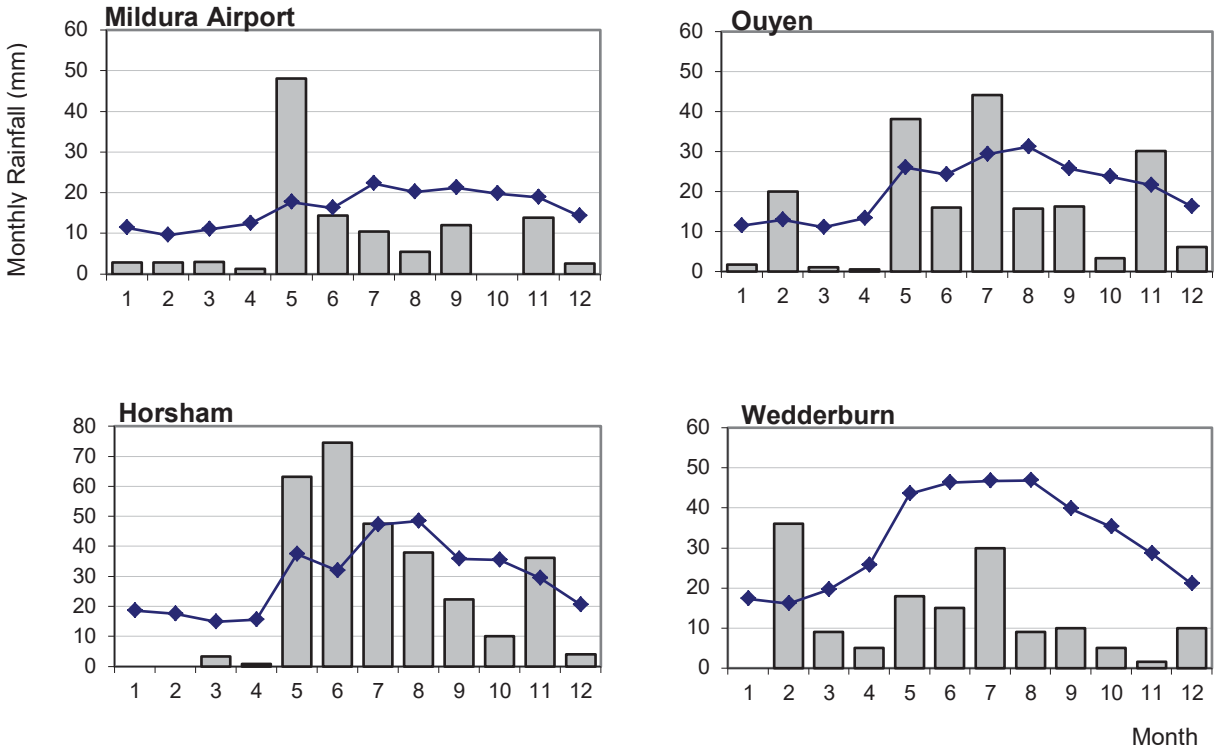


Figure 8. Rainfall at Mildura, Ouyen, Horsham and Wedderburn in 2019 (bars) and median rainfall since early 1900s (line). (Data from the Bureau of Meteorology website).

Individual Site trends

Histograms showing site trends will be available for download from the NMMD (National Malleefowl Monitoring database) along with all the usual database reports that comprise the appendices of previous monitoring reports.

3. Changes to data recorded in the field

There were no major changes to the Cybertracker sequence this season and everyone used the Samsung smartphones successfully.

4. Lerp

Lerp abundance on mounds was the second highest recorded since we started noting lerp on mounds in 2006 (Figure 9): 13% of mounds had lerp on them in 2019 when mounds were monitored (mostly October-December). This was a similar result to last season, but there was a shift in where lerp was most abundant. Last season (2018), lerp were most abundant in the Sunset Country sites where 33% of mounds showed some lerp and 17% of mounds showed abundance, but in 2019 this had shrunk to 8% and 2% respectively. In 2019 it was the Hattah sites had the most lerp where 42% of mounds showed some lerp and 20% of mounds showed abundance (Figure 10). Numbers were much lower in other regions.

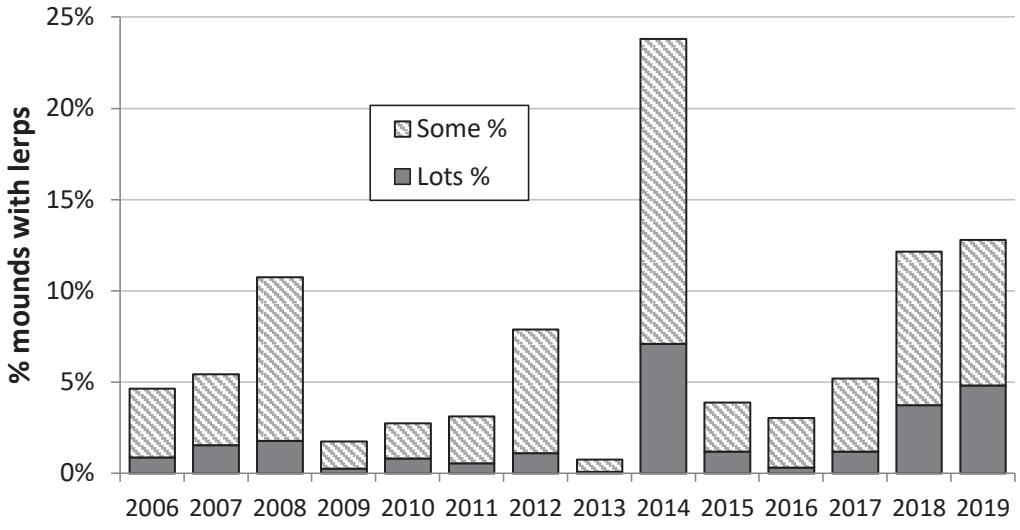


Figure 9. Proportion of mounds on which lerp were detected in each season since 2006.

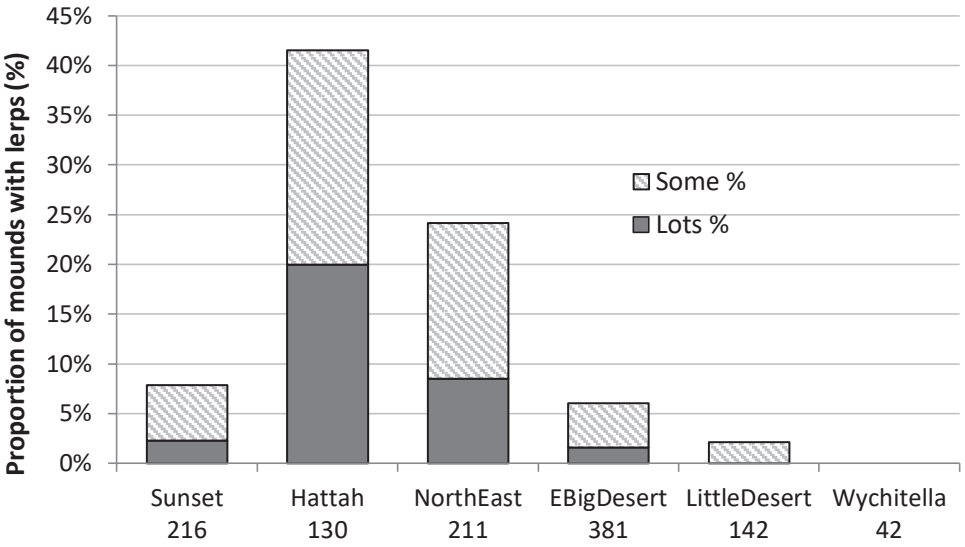


Figure 10. Regional breakdown of lerp occurrence on mounds in the 2018 season.

5. Fox scats

Fox scats were collected at 452 mounds in 2019 and weighed a total of 6.5 kg, a result that is higher than last season (Table 2). Figure 11 shows the average weight of fox scats collected per mound monitored since the mid-1990s for the same set of 20 sites and provides a better comparison across the years of data during which many sites have been added. The graph shows that there was a steep decline in fox scat weights between 1996 and 2000 which coincides with the decline of rabbits due to RHD and consequent adjustments to fox populations. Since 2000, there was an increasing trend peaking in 2012, after which the amount of fox scat collected has declined.

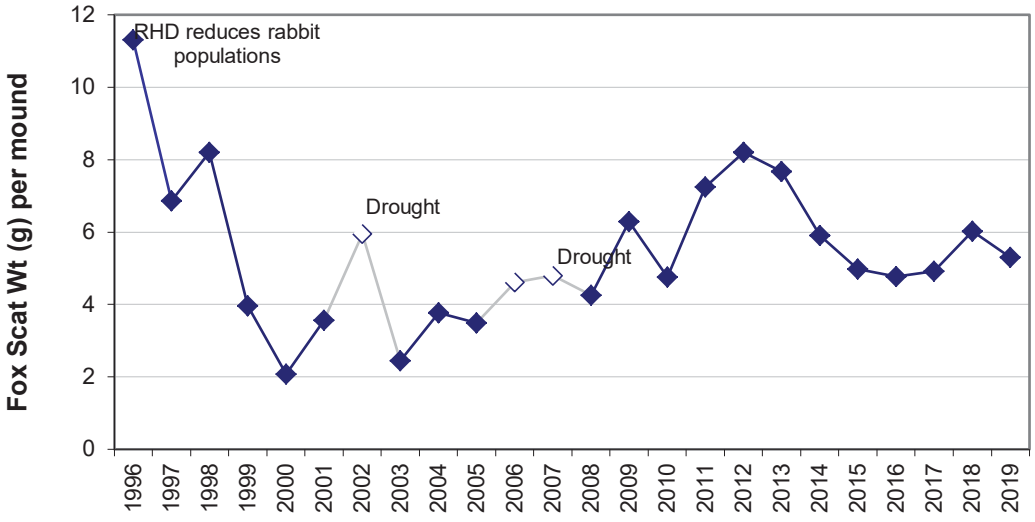


Figure 11. Trends in the average fox scat weight per monitored mound at 20 sites over 24 years. No attempt has been made to control for biases due to variations in the proportion of active mounds (more likely to be marked with fox scats) or changes in the proportion of very old and inconspicuous mounds.

Table 2. The total weight of fox scats, the number of mounds at which fox scats were collected, for both 2019 and the previous year (italics). Malleefowl scats and feathers were also collected in 2019 but are not tabulated here.

Grid	Name		2019 Wt (g)	2019 Count	*2018 Wt (g)*	*2018 Count*
v01	Dattuck	-	42	7	*135*	*14*
v02	Torpeys				*374*	*18*
v03	Wathe SW	-	280	26	*620*	*46*
v04	Bronzewing	-	643	38	*849*	*59*
v05	Stokies (Colignan)	-	81	7	*181*	*12*
v07	Annuello				*84*	*7*
v08	Powerline	+	104	6	*79*	*8*
v09	Mt Hattah	+	48	4	*32*	*3*
v11	Mopoke	+	84	5	*33*	*5*
v12	Pheeneys	+	740	6	*57*	*6*
v13	Bambill	-	291	25	*500*	*24*
v14	Menzies	-	208	12	*352*	*19*
v15	Wandown	-	187	26	*372*	*21*
v16	South Bore				*123*	*20*
v17	OneTreePlain	+	112	5	*23*	*2*
v18	WashingMachine		23	4		
v19	Underbool	+	41	3	*9*	*2*
v20	Lowan	-	19	2	*215*	*20*
v21	Dumosa	-	140	15	*236*	*19*
v22	Dennying				*120*	*4*
v23	Moonah		1135	59	*1022*	*59*
v24	Kiata	-	31	2	*100*	*7*
v25	LDL Sanctuary				*128*	*8*
v26	Hattah Tracks	-	305	18	*347*	*19*
v27	O'Brees	-	80	10	*130*	*7*
v28	Nurcoung				*96*	*6*
v29	Wedderburn	-	19	3	*20*	*3*
v30	Hattah South		128	4		
v31	Skinners Flat	+	14	2	*12*	*3*
v32	Wychitella	+	35	4	*27*	*5*
v33	Korong Vale	-	22	1	*7*	*1*
v34	Paradise	-	295	24	*456*	*21*
v35	Broken Bucket	+	94	4	*89*	*7*
v36	Boughtons WH					
v37	Wisemans				*131*	*10*
v38	Tooan				*48*	*5*
v39	Oldfields					
v40	Iluka				*5*	*2*
v41	Mali Dunes	+	51	3	*27*	*3*
v42	Cooack	-	0	7	*8*	*1*
			5252	*332*	*7047*	*476*

Which brings us, as always, to reiterate (this time in Rockwell condensed font):

⌘ ⌘ ⌘

Please be systematic with fox scat collection.

Search each mound surface very carefully <u>for a full minute</u> to be to absolutely sure we get all the scats (as emphasised in the manual and at training weekends).

⌘ ⌘ ⌘

6. Participation and in-kind contribution

We have not attempted to add up all the hours contributed by volunteers this year but assume that it was similar to last year, with the exception that half of v01 Dattuck was not monitored due to the pandemic restrictions. Thus, we estimate that we totalled about 1278 about monitoring hours in the field, 752 hours driving to and from monitoring sites (including passenger time), and about 400 hours in support activities (i.e. preparing data and equipment, posting equipment, uploading and managing data on the NMMD, installing, checking and downloading camera traps and processing photos, attending committee meetings, training weekends and reporting back meetings). Thus, we estimate a total of about 2,430 hours contributed by VMRG in 2019.

In the past we have valued this contribution at $34.86/hr following estimates of what volunteering may be worth in Victoria*. However, a fairer estimate for the VMRG dollar contribution the Malleefowl monitoring program is arguably the replacement value: what would it cost to undertake all these activities if volunteers were not involved? To estimate this in a recent journal article (Benshemesh et al. 2020) we used the base rate for a university employed research assistant (grade 1) of $54.72 per hour as a fair estimate of replacement value, although this is still a low rate compared to what consultants may charge. In addition, VMRG members travelled a total of over 38,000 kilometres over the year getting to and from monitoring sites; accounting for the associated vehicle expenses at $0.65/km adds at least another $24,700 to the replacement value of VMRG activities.

Thus, we conservatively estimate the replacement value of the VMRG activities in 2019/20 to be about $157,700.

*estimate for volunteer hour value from: Ironmonger, D. (2012). The Economic Value of Volunteering in Victoria. The Department of Planning and Community Development (Ed.): Victorian Government.

7. Concluding comments

The VMRG collects excellent data and makes a critically important contribution to Malleefowl conservation. The information the VMRG collects makes it possible to assess trends in Malleefowl populations and measure the effectiveness of management interventions, which due to its scale and on-going nature, is perhaps only achievable through the efforts of a voluntary, citizen-science workforce. Without question, the VMRG continues to lead the way in Malleefowl monitoring

and conservation, and the efficiency and accuracy of the works collectively undertaken, and the efforts contributed by so many individuals, are a credit to the VMRG and an inspiration to other citizen science groups.

This season, breeding numbers were low, though considerably better than last season. Although 2019 was another dry year, rainfall tended to be greater than last year when it mattered most during the winter immediately prior to breeding. Fox numbers do not appear to be especially high compared with past data. We, and no doubt the mallee farmers, hope for good winter rains in 2020 and that the monitoring by the VMRG will show further improvements in Malleefowl breeding numbers. Data collected will be included in larger analyses of the conservation status of Malleefowl at the species level. This information will help inform management decisions to improve the trajectory of Malleefowl across Australia.

- *New graphs*

This year we decided to change our reporting charts to a more comprehensive style that includes virtually all the data collected in current and past years. Previously, our analyses only included sub-sets of sites that had consistently been monitored over set periods of time, thereby providing only a patchwork of trend information in time and space from which it was difficult to distil an overview. The current approach avoids these problems and has allowed us to develop charts that are more comprehensive and readable.

However, the approach is far from perfect and the results should be regarded as indicative rather than definitive; we may well refine our approach in future years to make it better. Next year we expect our partners at University of Melbourne/NESP, particularly Darren Southwell, to undertake a more rigorous analysis of trends and this will be an opportunity to both compare methods and improve the approach we use in annual reporting.

- *National and NRM reports*

Our new method of charting trends has also been used by the National Malleefowl Recovery Group (NMRG) to report to the Australian Government Department of Agriculture, Water and Environment (DAWE) on Malleefowl breeding trends in 17 NRMs across Australia in which monitoring sites have been established. The NMRG has also produced reports to 10 NRMs that, together with DAWE, have provided funds to support the NMRG. These reports have all been modelled on an abbreviated form of the Victorian report, and represent an important milestone for Malleefowl conservation both because it is the first time annual reporting has been undertaken outside Victoria, and because of the partnerships and opportunities for conservation that these developments represent.

- *Monitoring paper*

Dr Darren Southwell, Prof. Michael McCarthy, Prof. Richard Barker and I published a journal article on Malleefowl trends and the volunteer monitoring effort across Australia. The paper looked at data collected between 1990 and 2017 using a similar analysis to the previous trend analysis we produced in 2007. We found that over this

27 year period, Malleefowl were declining in WA and SA, but seemed relatively stable in Vic. In NSW there was an apparent increase in Malleefowl, but the data was very limited in both spatial and temporal extent and this result was unlikely to represent state-wide trends (it probably just reflected the recolonization of a few sites that were burnt a decade or so before monitoring commenced). In Appendix 2 we reproduce the Abstract and first page of the paper (copyright restrict us from publicly distributing copies of the full article for 12 months). Anyone wanting to see the full article should contact me (JB) directly.

- *Update on the motion-sensitive camera project*

Our 48 cameras traps (with solar panels, batteries and stakes) installed in 2015 at six sites in the Vic mallee (Wathe v03, Menzies v14, Wandown v15, Lowan v20, Dumosa v21, and Paradise v34) are still going strong, although more are failing as they age, and requiring more maintenance. Nonetheless, the cameras provide important insights into the trends in various animals that might affect Malleefowl numbers such as foxes, cats, goats, pigs, rabbits and kangaroos.

In the past year, VMRG members swapped the memory cards at all cameras in the field during monitoring and processed photos that were collected during the 2018 monitoring. In the field, everything seemed to go smoothly; although as mentioned already there have been a number of camera failures. These faulty cameras are being repair or replaced by Mick Webster and Tony Murnane who have been on several trips to the mallee to fix camera traps. Should you come across a faulty camera, it would be very useful if you would let Mick and Tony know as soon as possible so that they can schedule the repair. Graeme Tonkin and Tim Burnard also did a large amount of camera repairs at the Cooack/Nurcoung/Tooan AMPE sites where there were many problems with the camera.

The photo processing by VMRG members went very well and 13 people volunteered their services again and did a really great job again, processing about 55,000 photos. To ensure accuracy, our process involves two independent people inspecting each photo; where both people don't agree on the contents of a photo a third independent person is consulted for an opinion. We are currently preparing the 2019 photos for sorting so if you are interested, please let us know.

- *LiDAR and AM project*

The Mallee CMA undertook Lidar surveys of our sites at v07 Annuello and v15 Wandown in preparation for these sites becoming part of the AM Predator Experiment in which the CMA will undertake fox baiting and possibly cat management at Annuello but leave Wandown unbaited (as it has been for many years). The LiDAR surveys were necessary to ensure we know of all the mounds at the sites as predator management is initiated. Few new mounds were discovered even though it's been many years since we last searched these sites, confirming one of the central assumptions of our monitoring method (that the birds tend to reuse mounds rather than build anew) and suggesting that our results are generally reliable. In addition to the two known sites, a new site in Annuello was scanned with LiDAR; this site is to the east of v07 and contains at least 40 likely mounds but has

yet to be groundtruthed. We will probably ground truth these potential mounds later this year, although there is currently the opportunity to get a start on this if anyone needs an excuse to visit the mallee over the next couple of months! Anybody interested being involved in the ground-truthing/monitoring effort of the new site should let a committee member know.

- *Other monitoring news*
  - Alys Young who many of you met at the 2018 forum has submitted her thesis and been awarded her MSc. Alys, a student of Darren Southwell, evaluated the usefulness of satellite data that indicates plant growth for understanding Malleefowl trends. Her interesting and high quality work shows that some forms of these data are better predictors of Malleefowl breeding numbers than winter rainfall. This is very important work for understanding of Malleefowl trends and is expected to lead to improved models and predictions. Alys is currently working on publishing her findings in a scientific journal.
  - Jessica Keem, another student of Darren's working on a Malleefowl related project, has pretty much finished her field work and is concentrating on analyses and write-up. Jessica's project is looking at fox density and the effectiveness of baiting methods on foxes using genetic and modelling techniques at both Victorian AMPE sites (Annuello/Wandown in the Mallee, and Cooack/Nurcoung in the Wimmera). She is also using our camera trap data and her field work has involved collecting fresh fox scats in a rigorous way at these sites. Iestyn Hocking and Miranda Thorpe in particular have been very helpful in retrieving the latest camera data from these sites for Jessica. Jessica's work is very important because surprisingly little is actually known about the effectiveness of baiting on foxes, and her work will hopefully lead to much more effective fox control where it is needed.
  - We have a new national coordinator, Dr Dani Teixeira! Before Tim Burnard retired as national coordinator (he really did it this time), he recruited Dani who was finishing her PhD on Red-tailed Black Cockatoos, and secured funding for the position from NRM agencies and the Australian Government for the position. Like Tim, Dani will probably have a rather low profile in Vic because the VMRG is strong and well organised, but she will no doubt work towards assisting us in any way she can as she coordinates the national effort. Dani has worked in conservation research and management for many years, in both government and the non-profit sector, and her extensive experience and knowledge will benefit all of our efforts to conserve Malleefowl.
  - Vale Peter Stokie! It's just over a year since Peter's untimely passing. Writing this report has been a reminder of this great loss as Peter was involved in the Vic monitoring report for many years. Site v05, previously Colignan and Peter and Ann's favourite site, has been renamed v05 Stokies as a memorial to their great contribution to Malleefowl, the VMRG, and all of us whose lives were touched by them.

Appendix 1. 2019/20 Mound Inspection Report for All Victorian Sites

Mounds that will be included in future annual lists.

	Sites	1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Sought and found	1145	20	47	72	90	15	53	17	16		16	25	39	19	88	45	27	26	19	48	34	8	65	10	7	29	17	27	10	6	10	11	7	63	10	11	49	22	10		13	28	16
New incidental	19						1								11					1			1											1				2			1	1	
Sought, NOT found	2						1																		1													1	1			1	
NOT sought or found	48	28		1			3					1			2					1		2				1										4		1		4			
Total	1214	48	47	73	90	15	58	17	16		16	26	39	19	101	45	27	26	19	50	34	10	66	10	8	30	17	27	10	6	10	11	7	64	10	15	49	25	10	4	14	29	16

Previously Marked Mounds that will be checked every 5th year.

	Sites	1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Sought and found	133	1	10	20	19		3	2		4				2	13		2	2			6	7	5			1	2	1		3		2	2	12	3		5	5				1	
New incidental																																											
Sought, NOT found	1																																				1						
NOT sought or found	138	31		12		1	5				2	3		8	7	1	3		3	12	2	1	1	8	1			4	2		9	6	1	8		1		4	1	1		
Total	272	32	10	32	19	1	8	2		4	2	3		10	20	1	5	2	3	12	8	8	6	8	1	1	2	5	2	3	9	8	3	20	3	1	6	9	1	1		1	

Newly Marked Mounds that will be checked every 5th year.

	Sites	1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Sought and found	6													1													1			1				2								1	
New incidental																																											
Sought, NOT found																																											
NOT sought or found	7						1											1	1	1						1		1																1
Total	13						1							1				1	1	1						1	1	1		1				2								1	1

Mounds that will be omitted from annual lists (erroneous records, and mounds well outside grid boundaries).

	Sites	1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Sought and found	4																											4															
New incidental																																											
Sought, NOT found																																											
NOT sought or found																																											
Total	4																											4															
Grand Total	1499	80	57	105	109	16	67	19	16	4	18	29	39	30	121	46	32	29	23	63	42	18	72	18	9	32	20	33	12	10	19	19	10	86	13	16	55	34	11	5	14	31	17

Appendix 2. Recent monitoring paper highlighting VMRG

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Citizen scientists reveal nationwide trends and drivers in the breeding activity of a threatened bird, the malleefowl (*Leipoa ocellata*)

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[b] Quantitative and Applied Ecology Group, School of BioSciences, University of Melbourne, Parkville, Vic 3010, Australia
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ARTICLE INFO

Keywords:
Poisson regression
Megapodes
Incubator mounds
Mallee
Volunteers
Interval censoring

ABSTRACT

Citizen scientists regularly collect monitoring data for threatened species to improve the spatial and temporal resolution of sampling. Such programs should adopt robust data assurance measures and statistical approaches to reduce observer bias and better inform uncertainty estimates while supporting management decisions. In this study, we estimated trends and drivers of malleefowl (*Leipoa ocellata*) breeding activity within a Bayesian hierarchical modelling framework using 1823 site × years of nest count data collected by volunteers in Australia. Our modelling suggests malleefowl breeding activity decreased 4.8% annually in South Australia (−0.050; 95%CIs −0.062, −0.037), decreased 2.1% annually in Western Australia (−0.022; 95%CI −0.040, −0.004), was stable in Victoria (−0.001; 95%CI −0.010, 0.009) and increased 4.8% annually in New South Wales (0.047; 95%CI 0.009, 0.086). We found strong evidence for positive associations between winter rainfall (0.084; 95%CI 0.004, 0.165), time since fire (0.288; 95%CI 0.179, 0.399) and an interaction between time since fire and the proportion of a site burnt (0.292; 95%CI 0.173, 0.410). Malleefowl breeding activity was negatively associated with patch size (−0.255; 95% CI −0.642, 0.020) and the proportion of a site burnt (−0.191; 95% CI −0.363, −0.030), suggesting small reserves are important for conservation and the extent and frequency of fire should be managed cautiously. While our index of fox abundance decreased as baiting effort increased (−0.484; 95%CI −0.640, −0.317), there was little evidence for this benefiting malleefowl. This study demonstrates how volunteers can play a vital role understanding population trends and informing conservation of a threatened species at a national scale.

1. Introduction

Monitoring is crucial to conservation because it informs the status and trends of populations, determines whether management interventions are effective, and can raise much needed political and community support (Possingham et al., 2012). However, effective monitoring should: have clear, well-defined objectives (Scheele et al., 2018); be designed with adequate statistical power to detect levels of change that are significant from a conservation standpoint (Southwell et al., 2019); provide appropriate data consistently through space and time (Likens, 1989); be sustained long-term and over an appropriate geographic scale (Lindenmayer and Likens, 2018); have the capacity to store and analyse the data collected (Robinson et al., 2018), and; produce results that inform management decisions (Lindenmayer and Likens, 2018). Although these steps are well-recognised, many species are not monitored at all, and for those that are, the quality of monitoring is often poor (Legge et al., 2018; Scheele et al., 2019).

Incorporating citizen scientists into biodiversity monitoring programs is an increasingly popular way to overcome scale and cost barriers to successful monitoring. Citizen scientist programs are generally designed to use simplified, standardised protocols repeated across many monitoring sites to gather data across large temporal and/or spatial scales (Dickinson et al., 2010). This allows data to be collected at reduced cost, vastly improving power to detect ecological patterns at large-scales, such as broad-scale population trends (Barlow et al., 2015), species range shifts (van Strien et al., 2013) and patterns of migration (Hurlbert and Liang, 2012). As a result, the number of citizen science programs has increased substantially in recent decades, with hundreds now operating around the globe to track the status and trends of a range of taxa, including butterflies, reptiles, mammals and birds

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[1] Both authors contributed equally.

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Appendix 3. Map showing monitoring sites in Victoria

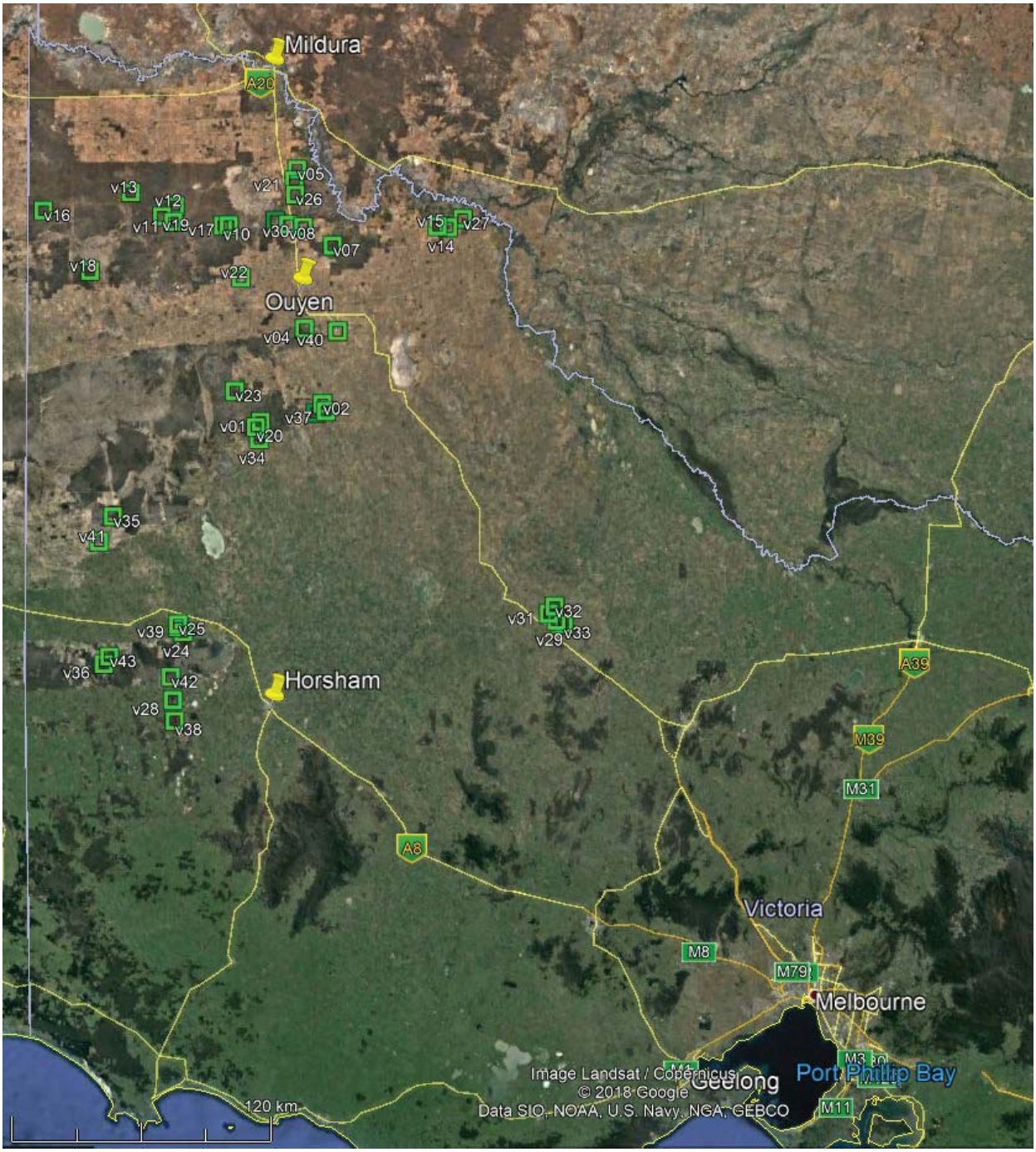
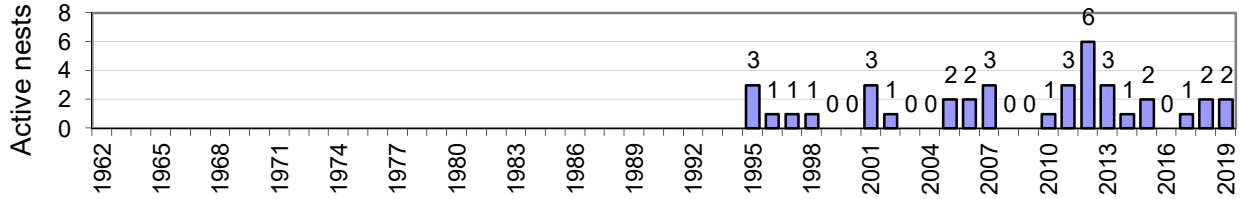


Figure 9. Location of the 42 Malleefowl monitoring sites in Victoria managed by the VMRG (green squares). Over 1300 mounds are monitored each year over a total area of about 170 km2. Image from Google Earth.

Appendix 4. Site Trends

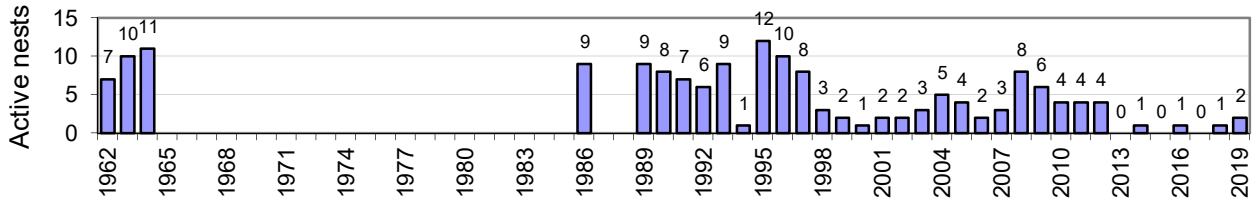
01 Dattuck

Eastern Big Desert



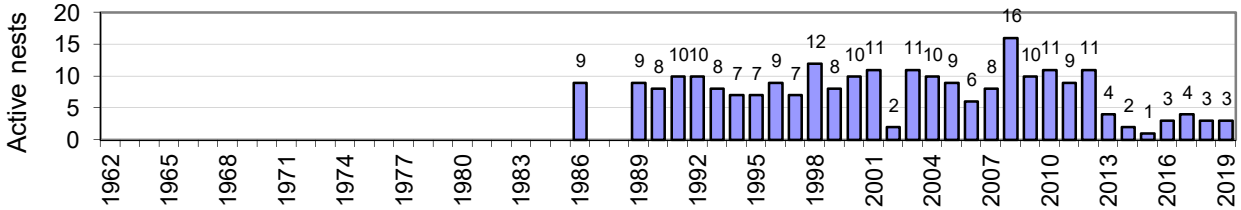
02 Torpey's

Eastern Big Desert



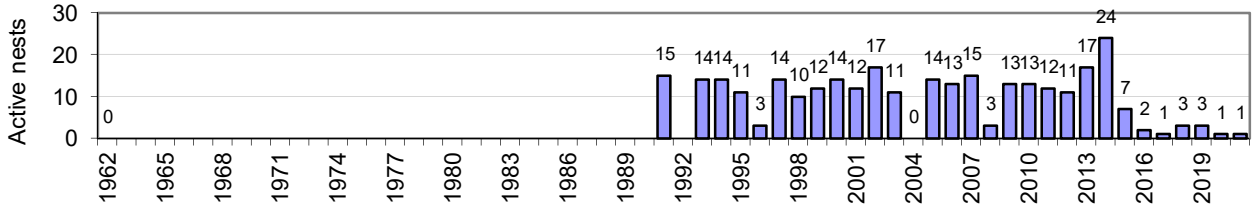
03 Wathe SW

Eastern Big Desert



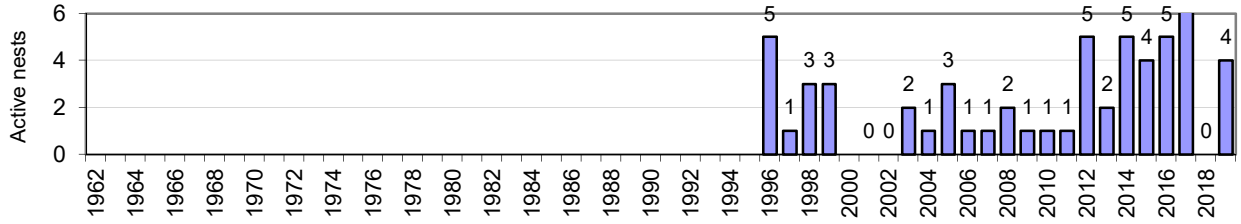
04 Bronzewing

Eastern Big Desert



05 Colignan

North West



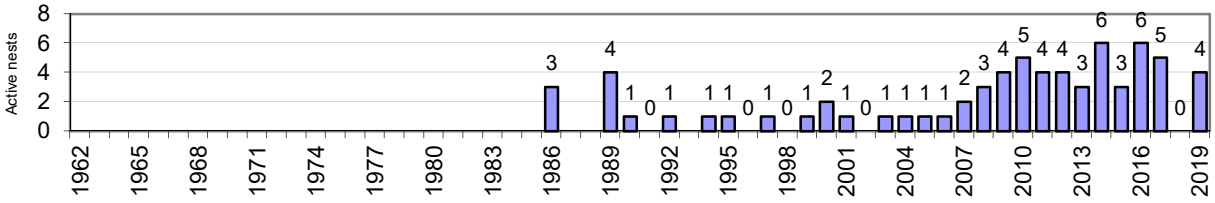
Season

Appendix 4. Site Trends

07 Annuello

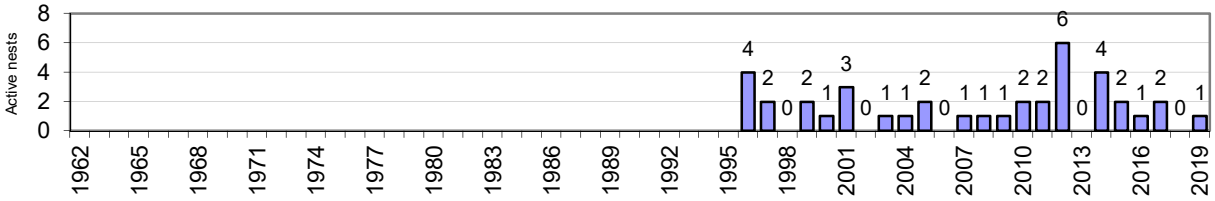
Note: active mounds in 07 part C not shown

North East



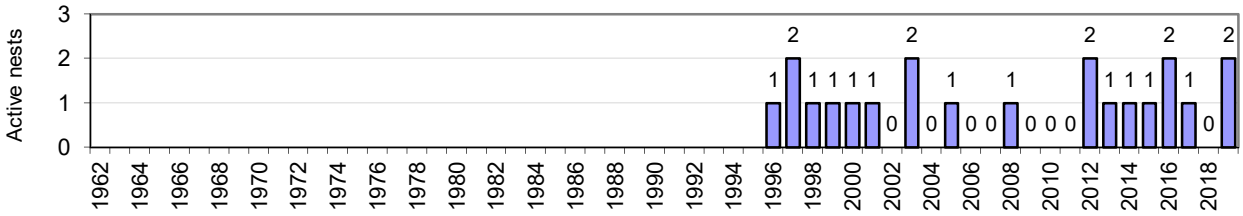
08 Powerline

North West



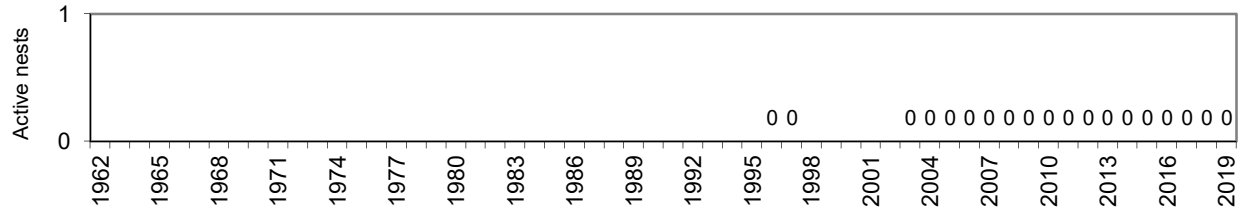
09 Mt Hattah

North West



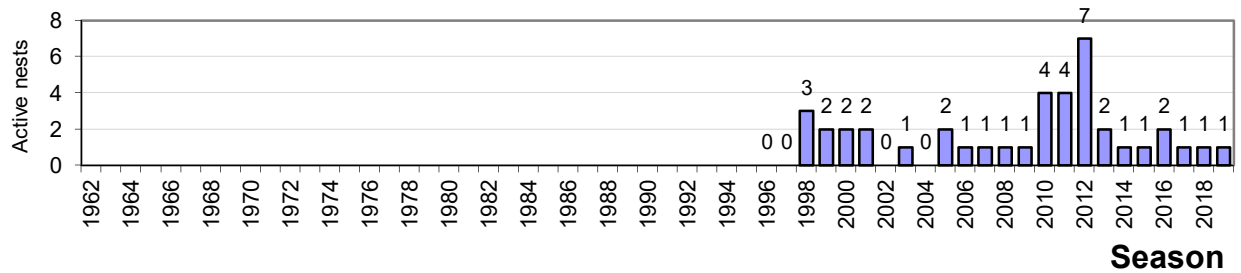
10 1 Tree BNT

North West



11 Mopoke

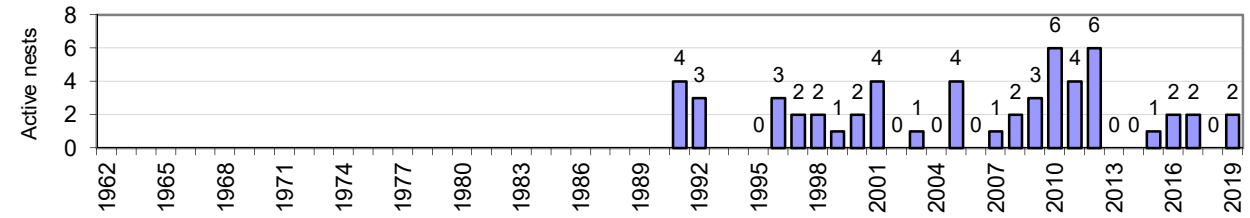
North West



Appendix 4. Site Trends

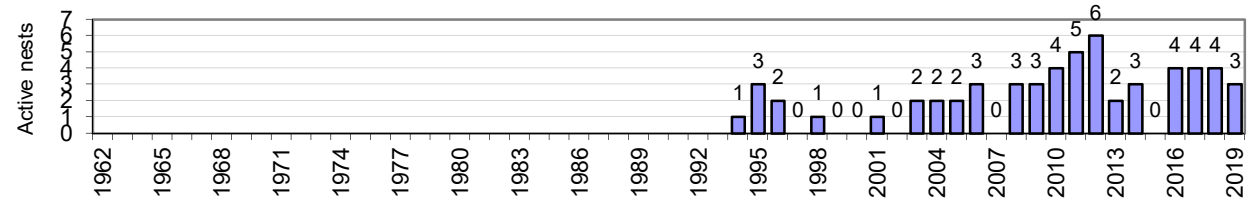
12 Pheeneys

North West



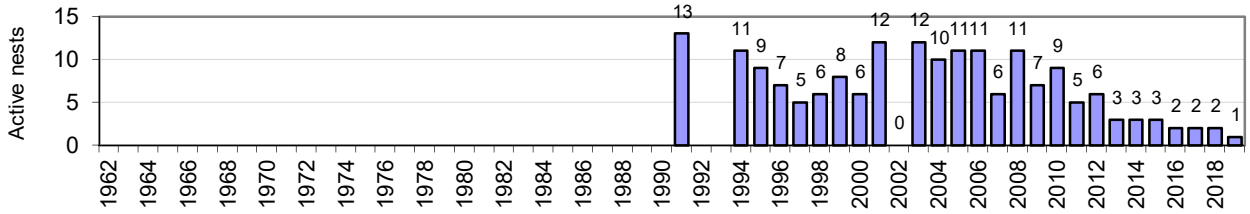
13 Bambill

North West



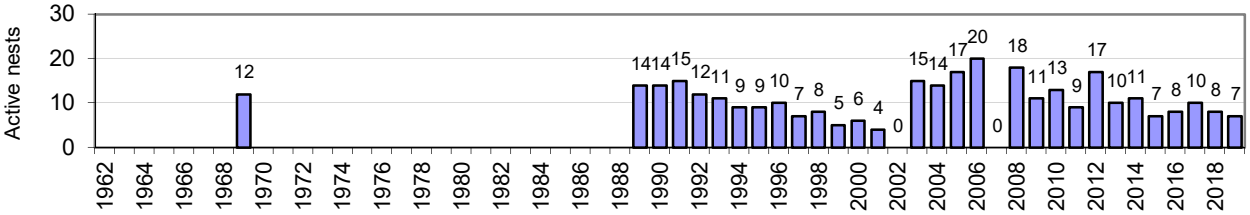
14 Menzies

North East



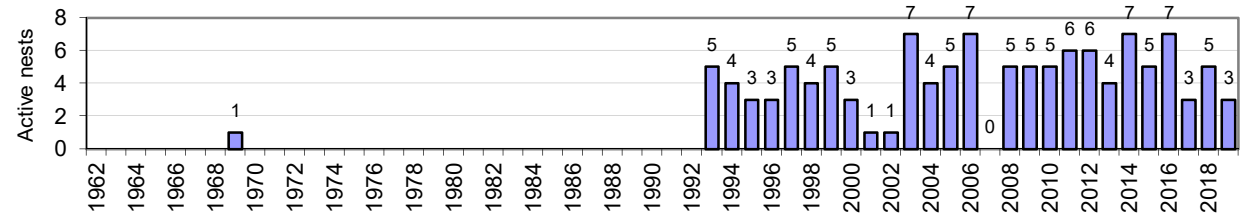
15 Wandown Part A

North East



15 Wandown Part B

North East



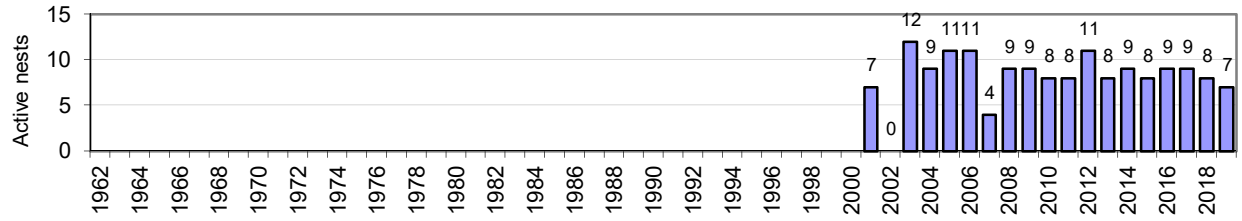
Season

Appendix 4. Site Trends

15 Wandown Part C

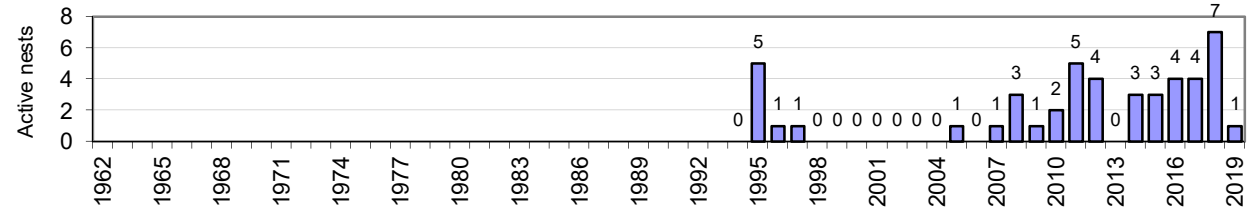
Note: active mounds in 15 part D not shown

North East



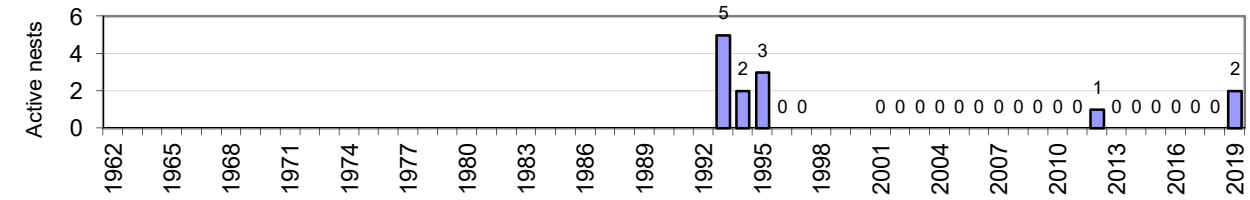
16 South Bore

North West



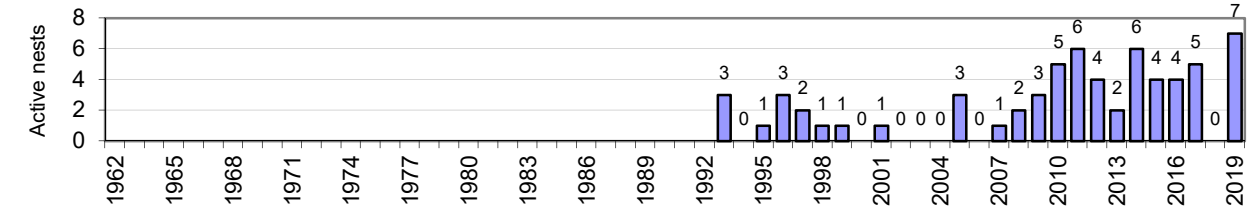
17 One Tree Plain

North West



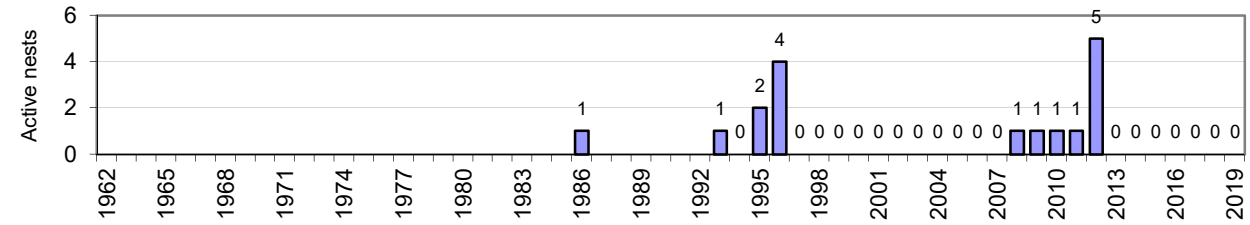
18 Washing Machine

North West



19 Cowangie/Underbool

North West

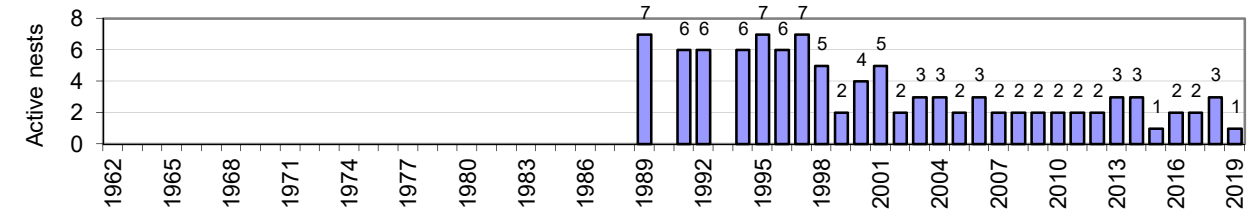


Season

Appendix 4. Site Trends

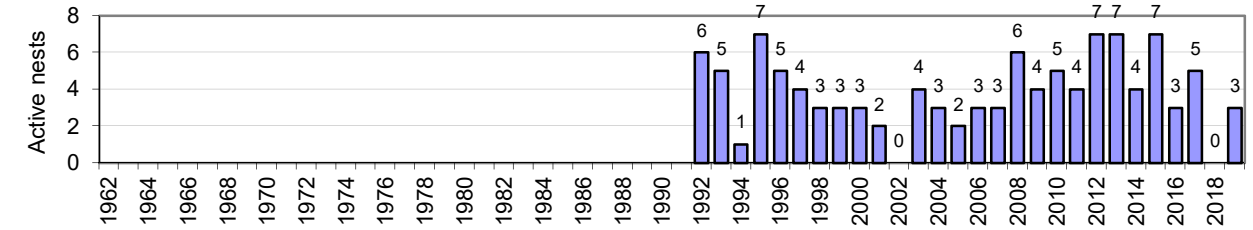
20 Lowan

Eastern Big Desert



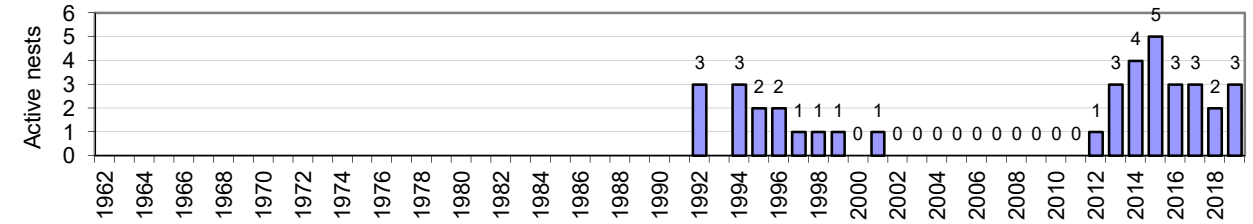
21 Dumosa

North West



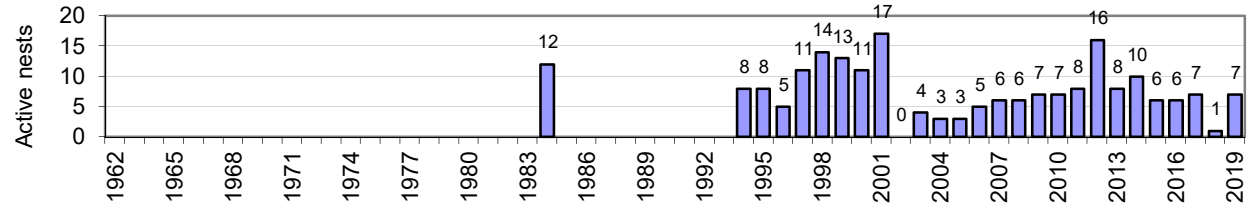
22 Denning

North West



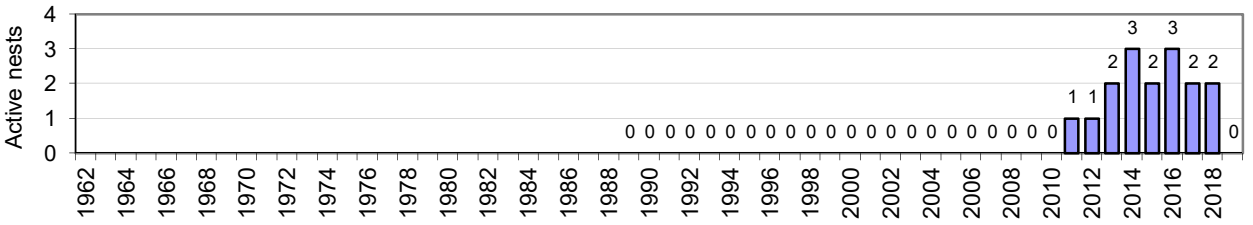
23 Moonah

Eastern Big Desert



24 Kiata

North East

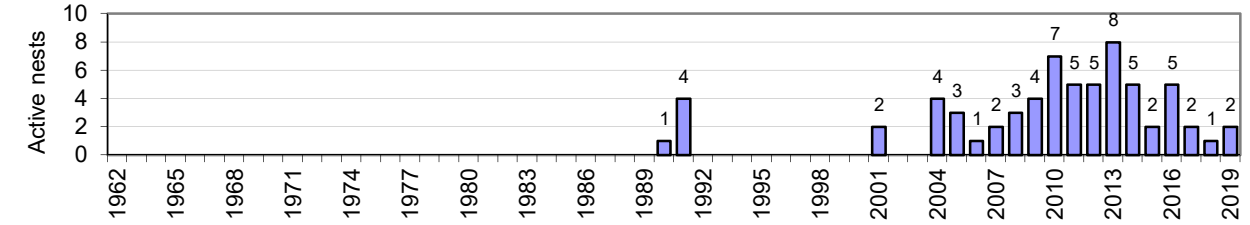


Season

Appendix 4. Site Trends

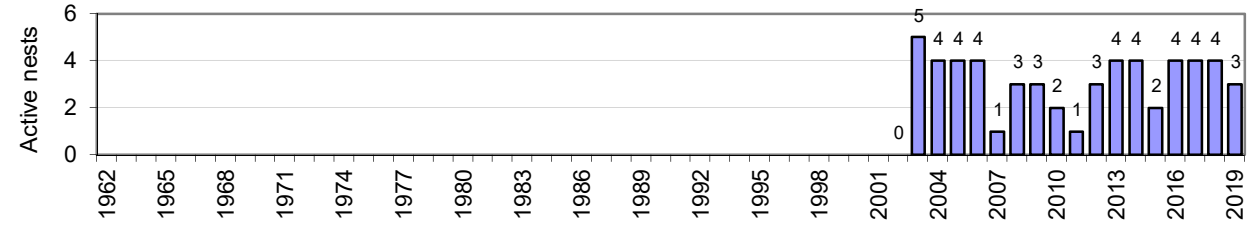
26 Hattah Tracks

North West



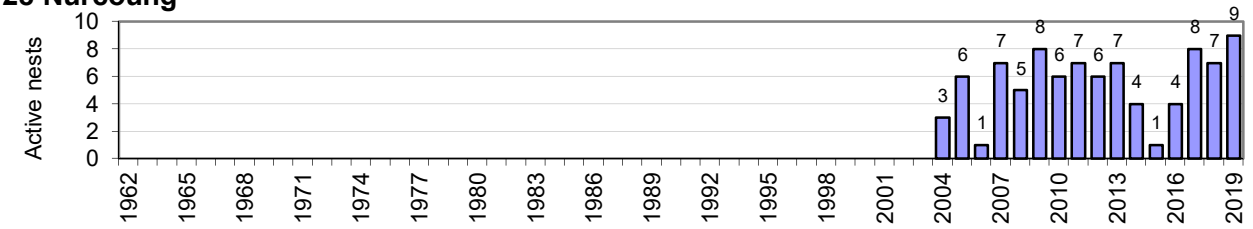
27 O'Brees

North East



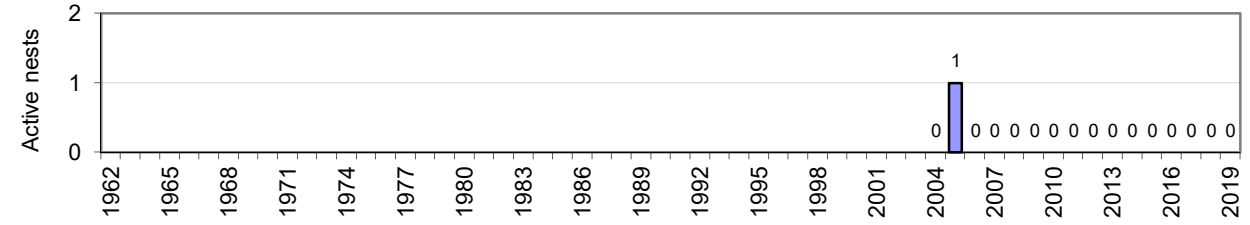
28 Nurcoung

Little Desert



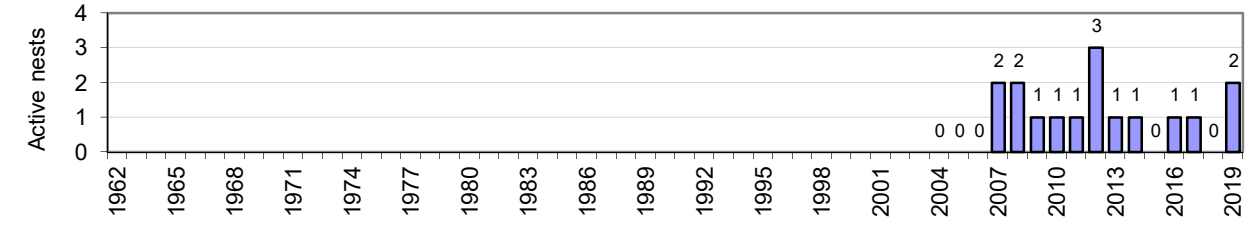
29 Wedderburn

Wychitella NCR



30 Hattah South

North West

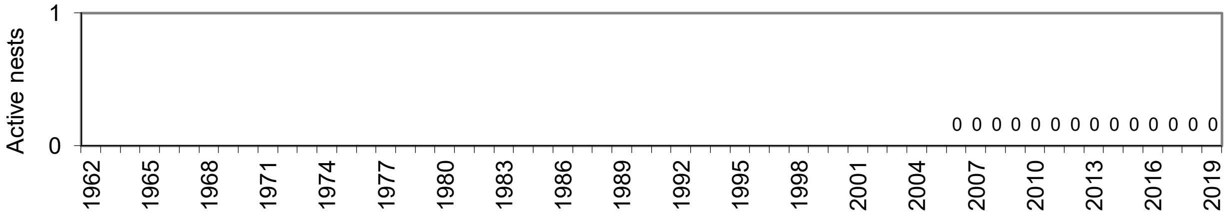


Season

Appendix 4. Site Trends

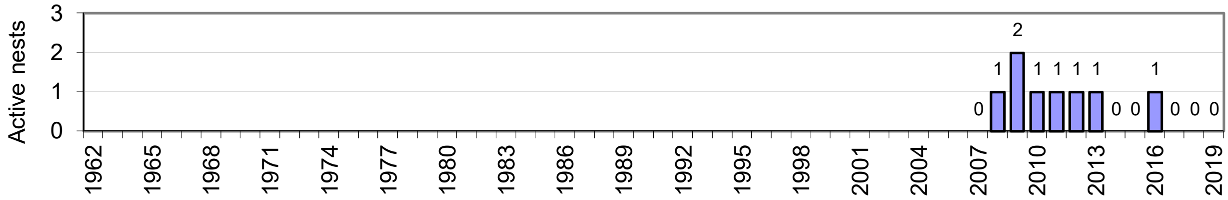
31 Skinners Flat

Wychitella NCR



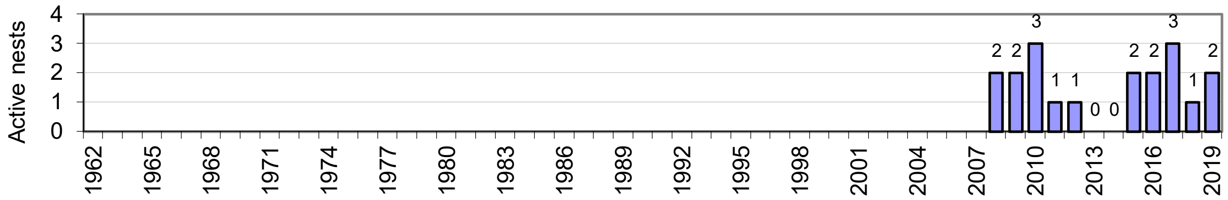
32 Wychitella

Wychitella NCR



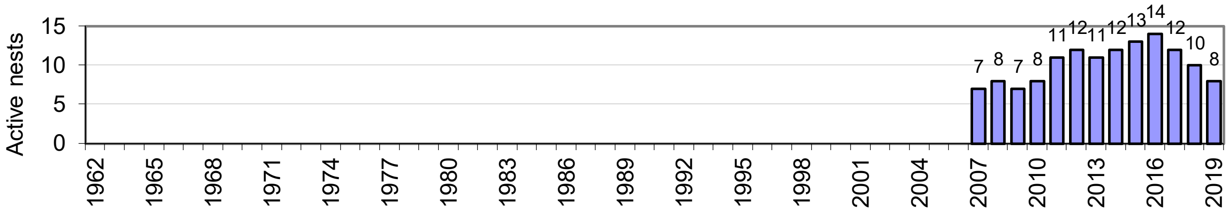
33 Korong Vale

Wychitella NCR



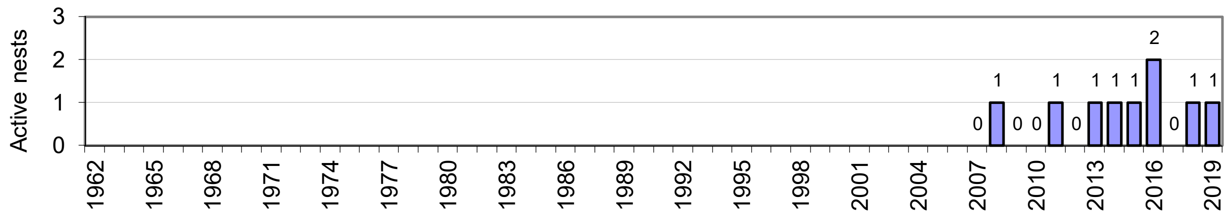
34 Paradise

Eastern Big Desert



35 Broken Bucket

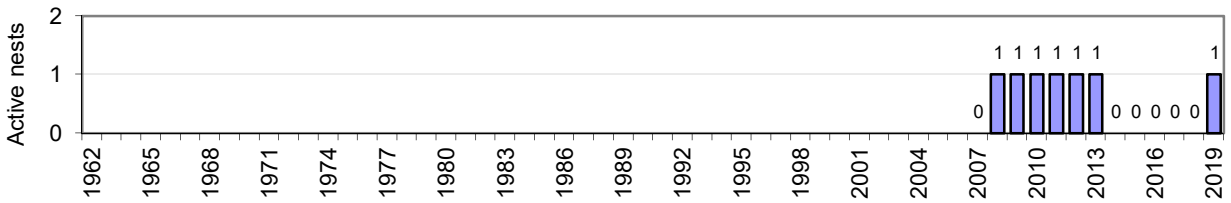
Western Big Desert



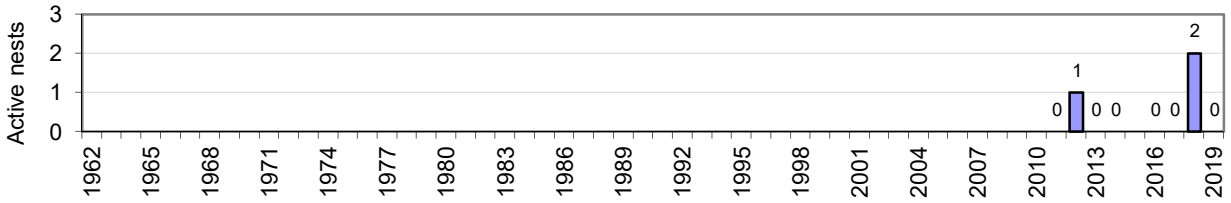
Season

Appendix 4. Site Trends

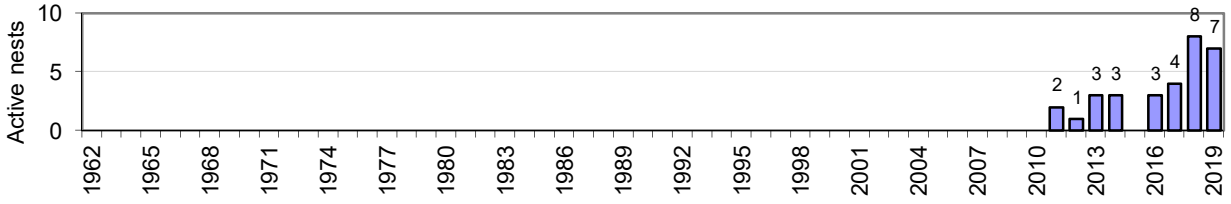
36 Boughtons WH



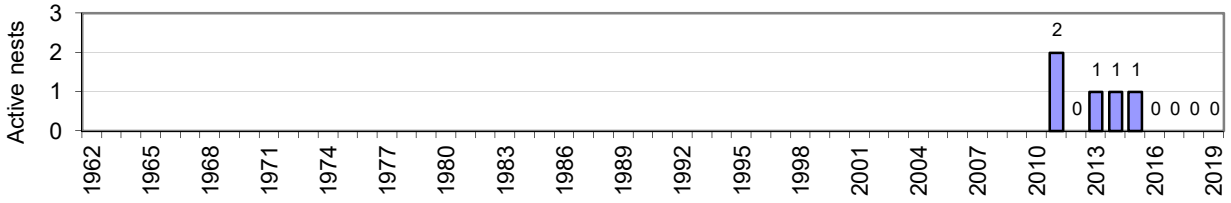
37 Wisemans



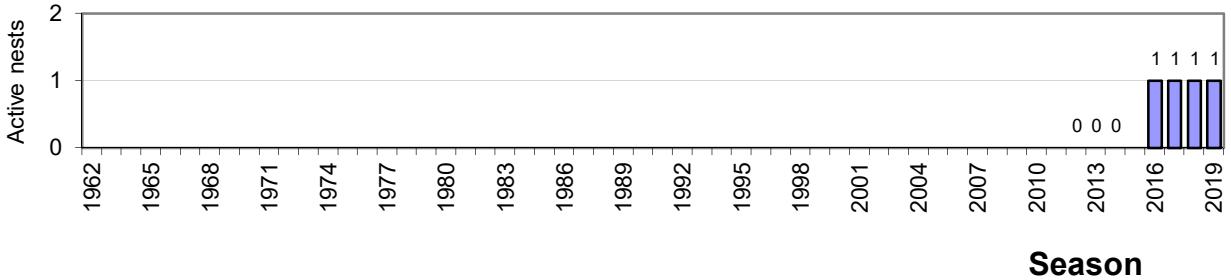
38 Tooan



39 Oldfields



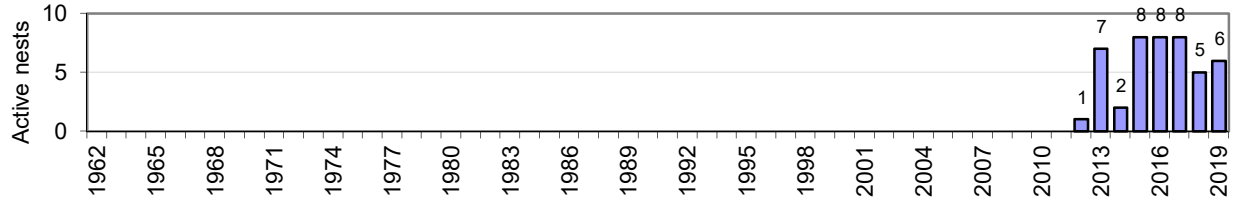
40 Iluka



Appendix 4. Site Trends

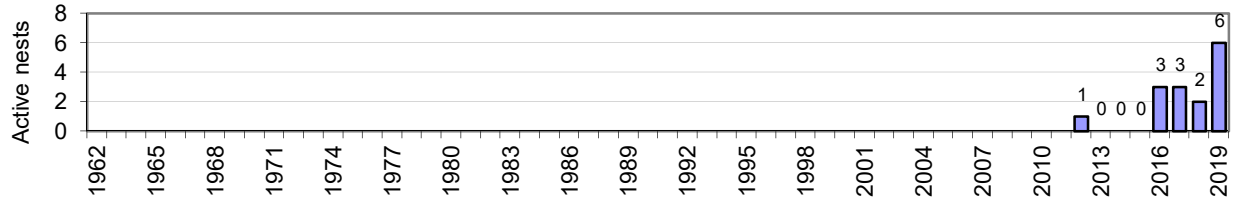
41 Mali Dunes

Little Desert



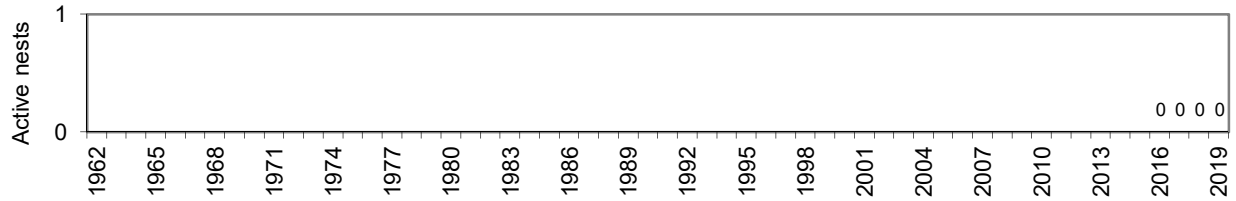
42 Cooak

Little Desert



43 Thorpes

Little Desert



Season