Estimates of the 2021 deer harvest in Victoria

Results from surveys of Victorian Game Licence holders in 2021

P.D. Moloney and J.S. Flesch
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Game Management Authority

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

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Results from surveys of Victorian Game Licence holders in 2021

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Context:

To effectively manage game species, it is important to quantify the numbers harvested. To ascertain the levels of deer harvested, since 2009, Victorian State Government game management agencies have commissioned a series of regular telephone surveys of randomly selected holders of a Game Licence endorsed for hunting deer during the game hunting season. Additional telephone surveys were commissioned, starting in 2018, to quantify the scale on which Sambar Deer (Cervus unicolor) are being hunted using hounds. This report focuses on estimating the total recreational deer harvest for 2021. Deer killed in commercial culling activities, or as part of damage mitigation programs, are not included within this estimate.

Aims:

The aim of this report was to provide estimates of the total number of deer harvested by licensed hunters in Victoria during the 2021 hunting season.

Methods:

Holders of a Game Licence endorsed for hunting deer, and the subset holding a Game Licence endorsed for hunting Sambar Deer by using hounds, were randomly sampled and interviewed by telephone at intervals during their respective game seasons. In all surveys, respondents were asked whether they had hunted during the indicated period, and (if applicable) the number and species of deer they had harvested. Additional information was obtained on hunting methods and locations. Surveys at the end of the season were used to quantify the proportion of Game Licence holders who had hunted at some stage of the season.

Results:

The total estimated deer harvest in 2021 was 118,900 [95% confidence interval (CI) = 89,800–157,300], which is 70% larger than in 2020 and 49% above the average since 2009 (79,700). The increase in the deer harvest can be explained by a 20% increase in the number of issued Game Licences endorsed for hunting deer and a 45% increase in the number of hunting days per active hunter; hunter efficiency (deer harvest per day) remained consistent. Active hunters are holders of a Game Licence endorsed for hunting deer who hunted at least once in 2021.

In 2021, 36% of holders of a Game Licence endorsed for hunting deer were active deer hunters, compared to over 55% in 2018 and 2019. On average, active deer hunters harvested 6.6 deer over 13.6 hunting days.

The most commonly harvested species was Sambar Deer (with an estimated total harvest of 68,900, or 58% of the harvest), followed by Fallow Deer (Dama dama) (35,400, or 30%); 9% of the harvest was not clearly identified. These species percentages differed from previous years. Typically, Sambar Deer and Fallow Deer account for 80% and 16% of the deer harvest, respectively, and less than 2% of the harvest is not clearly identified.

In 2021, it is estimated that the total number of harvested deer that were harvested using hounds was 13,100 (95% CI = 10,800–15,900). The average annual rate of harvesting deer with hounds per active holder of a Game Licence endorsed for hunting Sambar Deer with scent-trailing hounds was 5.7 (95% CI = 4.4–7.2), which is less than the general harvesting rate per active hunter (6.6). The efficiency of deer harvesting using hounds (0.54 deer per hunting day per team member) was slightly higher than the general harvesting efficiency (0.48 deer per hunting day) in 2020.

Conclusions and implications:

1. The total deer harvested in the 2021 deer-hunting season increased compared with that of 2020, which was affected by the Black Summer bushfires and the COVID-19 restrictions. Compared to 2020:

   - The number of deer harvested increased by 70%.

   - The total number of deer-hunting days increased by 72%.

   - The number of deer harvested with the use of hounds increased by 35%.

   - The number of days hunting deer with the use of hounds increased by 27%.

2. While the numbers of deer harvested increased in 2021 compared with 2020, they are below the peak for prior to the Black Summer bushfires and the COVID-19 lockdowns.

   - Access to hunting areas was still restricted due to COVID-19 lockdowns.

   - However, hunter efficiency was consistent, and the number of hunting days per active hunter was the highest ever recorded.

3. Performing telephone surveys throughout the year is likely to minimise memory bias and non-response bias. However, sources of bias will remain (due to over- and under-reporting), and the estimates of the total harvest must be interpreted with care.

   - The people conducting the telephone surveys need to ensure that the number, species and sex of the harvested deer have been recorded unambiguously when possible.

1 Introduction

To effectively manage game species, it is important to quantify the numbers harvested. Since 2009, the State Government's game management agency has commissioned a series of regular telephone surveys of randomly selected Game Licence holders. Three sets of telephone surveys are conducted during the various game harvest seasons for deer, duck and quail, respectively. This report focuses only on the deer harvests.

Recreational deer hunting occurs all year round in Victoria for some species (Game Management Authority 2020). In 2021, as in previous years, the calendar year was divided into six 2-month reporting periods for deer hunting. Sambar Deer (Cervus unicolor), Fallow Deer (Dama dama), Red Deer (Cervus elaphus), Chital Deer (Axis axis) and Rusa Deer (Rusa timorensis) can be hunted all year by stalking, with no bag limit. The use of hounds is restricted to hunting Sambar Deer between 1 April and 30 November. Hog Deer (Axis porcinus) can only be hunted during April (excluding out-of-season ballot hunting), and its hunting is subject to additional restrictions, such as an annual limit of one male and one female per hunter.

The telephone survey methods employed in this study were the same as those used during the 2018 to 2020 deer-hunting seasons (Moloney and Powell 2019; Moloney and Hampton 2020; Moloney and Flesch 2021) and similar to those of the 2009 to 2017 deer-hunting seasons (Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013, 2014, 2016, 2017, 2018). Since 2018, a secondary survey has been conducted among holders of a Game Licence endorsed for hunting Sambar Deer with scent-trailing hounds.

The aim of this report was to provide estimates of the total harvest of deer harvested by licensed hunters in Victoria during the 2021 hunting season.

2 Methods

All surveys were conducted by the telephone survey company Marketing Skill Pty Ltd (Mount Eliza, Victoria) on behalf of the Game Management Authority. The estimates of total harvests by Game Licence holders were based on the hunting activities reported by the survey respondents.

2.1 Holders of a Game Licence endorsed for hunting deer

Every 2 months a telephone survey of a random sample of 200 respondents[1] from holders of a Game Licence endorsed for hunting deer (hereafter referred to as 'Game Licence holders') was conducted (Appendix 1). Respondents were asked to report on their hunting activities for the preceding 2-month period, including the number and sex of each species of deer harvested during that period. Although a respondent may have hunted during the periods covered by the March–April and May–June surveys, if they were contacted as part of the May–June Survey, information was only collected that pertained to the period covered by the May–June survey. In each survey, the 200 randomly selected respondents were interviewed, regardless of whether they had hunted or not.

For each survey period, the proportion of respondents who hunted was used as an estimate of the proportion of Game Licence holders who hunted. The proportion of the Game Licence holders surveyed who had hunted during each survey period was multiplied by the total number of Game Licence holders for that period, yielding the estimated total number of hunters for that survey period.

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[1] Respondent refers to a Game Licence holder who was contacted and agreed to take part in the survey.

For each survey period, the average harvest per hunter[2] was estimated from the total reported harvest divided by the number of respondents who hunted. The total harvest for each survey period was estimated by multiplying the average harvest per hunter by the previously estimated total number of hunters for that survey period. Finally, the total season harvest was estimated from the sum of the survey-specific total harvests.

For each survey period, the proportion of the harvest from each species was estimated. The estimated proportion for each species was multiplied by the estimated deer harvest for that survey to estimate the harvest for each species per survey. The total season harvest per species was estimated from the sum of the survey-specific total harvests for each species.

An additional random sample of 400 Game Licence holders were surveyed immediately after the conclusion of the 2021 hunting season. They were asked whether they had hunted at any stage during the 2021 deer-hunting season. This post-season survey enables us to estimate the proportion of active hunters active across the season without needing to estimate the correlation structure of active hunters between the 2-monthly surveys.

The number of active hunters over the season was estimated by multiplying the proportion of active hunters from the post-season survey by the number of Game Licence holders at the endo the season. The annual harvest per active hunter was then estimated by dividing the total harvest by the estimated number of active hunters over the season. The estimated number of hunting days per active hunter was estimated in an analogous fashion.

The annual harvest per Game Licence holder was also estimated. For each survey period, the average harvest per survey respondent was estimated by multiplying the average harvest per hunter by the proportion of the respondents that hunted. The sum of these estimates across the year provided an estimate of the annual harvest per Game Licence holder endorsed to hunt deer.

Respondents who hunted were also asked to provide information on whether hunting was conducted on private land or public land, the name of the town nearest to where they hunted, what hunting methods they had used (i.e. stalking, hounds, or gun dogs/deer-hunting dogs), and the number of days they hunted during the survey period. Regional harvest estimates were calculated by summing the reported harvest for each town, then aggregating these harvests for the corresponding Victorian Catchment Management Authority (CMA) region.

Additional details of the methods (and examples of the calculations) are provided in Appendices 1–3 and 5–6. A description and interpretation of boxplots is provided in Appendix 4.

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[2] Hunter refers to a Game Licence holder who actually went out and hunted (successfully or unsuccessfully) at some point during the period with which the survey was concerned.

2.2 Holders of a Game Licence endorsed for hunting deer by using hounds

Hunting Sambar Deer with the aid of scent-trailing hounds (referred to as hound hunting) is legal in Victoria between 1 April to 30 November, within permitted areas and with the appropriate licences. This differs from the use of gundogs and deer hunting dogs which can be used year-round to hunt deer (except Hog Deer) wherever hunting with dogs is permitted.

A telephone survey was conducted every 2 months during the hound hunting season and involved 100 respondents from a random sample of holders of a Game Licence endorsed for hunting deer with the use of hounds (hereafter referred to as 'Game Licence holders endorsed for using hounds') (Appendix 2). Respondents were asked to report on their hunting activities for the preceding 2-month period, including the number and sex of each species of deer harvested, whether hounds were used, and if so, the number of hunters in the team. Although a respondent may have hunted during the periods covered by Surveys 2 and 3, if they were contacted as part of Survey 3, then information was only collected that pertained to the period covered by Survey 3. In each survey, the 100 respondents were interviewed, regardless of whether they had hunted or not. An additional random sample of 400 Game Licence holders endorsed for using hounds were surveyed immediately after the conclusion of the 2021 hound hunting season. They were asked whether they had hunted with hounds at any stage during the 2021 hound hunting season. The number of 'active hound hunters' was estimated from their responses.

The information provided by the hound hunting respondents was used in a similar way to that of the general Game Licence holders. However, hound hunting usually happens in teams of two or more hunters. The personal deer harvest in a hound hunting team may not be evenly spread across all members of the team. For example, a team of three hound hunters might have harvested four deer in total, with one of the hunters harvesting three deer, another hunter one deer, and the third hunter no deer. Depending on which of three hunters was surveyed, if we had used personal harvest, the result could have been zero, one or three deer harvested. Instead, the total harvest of the team divided by the number of team members was used. Hence, for the previous example, no matter which person of that team was surveyed, the result would be $1.\bar{3}$ deer (a total of four deer divided among three team members).

3 Results

3.1 Overall deer harvest in 2021

The number of Game Licence holders endorsed to hunt deer increased by over 7000 during 2021, to almost 50,000 by the end of 2021 (Table 1).

To achieve the required sample size of respondents, slightly more than 200 Game Licence holders were contacted each survey, with an average of 98% of those contacted being willing to take part.

Table 1. Summary of responses for deer surveys in 2021

Deer survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted[3]	Deer harvested[4]
1	Jan–Feb	42,103	200	42	142	40
2	Mar–Apr	44,675	200	60	292	72
3	May–Jun	46,453	221	59	256	124
4	Jul–Aug	47,773	200	50	193	149
5	Sep–Oct	48,866	206	36	143	119
6	Nov–Dec	49,857	200	20	69	18

Table 2. Proportions and corresponding total numbers of Game Licence holders who hunted in each survey period in 2021

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
Jan–Feb	0.21	0.029	0.16	0.27	8,842	1,213	6,766	11,554
Mar–Apr	0.30	0.032	0.24	0.37	13,402	1,448	10,852	16,552
May–Jun	0.27	0.030	0.21	0.33	12,401	1,382	9,974	15,419
Jul–Aug	0.25	0.031	0.20	0.32	11,943	1,463	9,403	15,170
Sep–Oct	0.17	0.026	0.13	0.23	8,540	1,293	6,358	11,471
Nov–Dec	0.10	0.021	0.07	0.15	4,986	1,058	3,305	7,522

Within each survey period, there was great variation in the reported harvest of deer per hunter (i.e., per Game Licence holder who hunted). Some hunters harvested more than five deer in a survey period, whereas at least one-quarter of hunters did not harvest any deer in that survey period, except for the September–October survey period (Figure 1).

The median number of deer harvested per hunter in a 2-month period was 1 deer. The average number of deer per hunter in 2021 varied throughout the season, ranging from a high of 3.3 deer in the September–October period to a low of 0.9 in the November–December period (Table 3).

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[3] Days hunted indicates the combined number of days on which deer hunting took place by respondents.

[4] Deer harvested indicates total number of deer harvested by respondents.
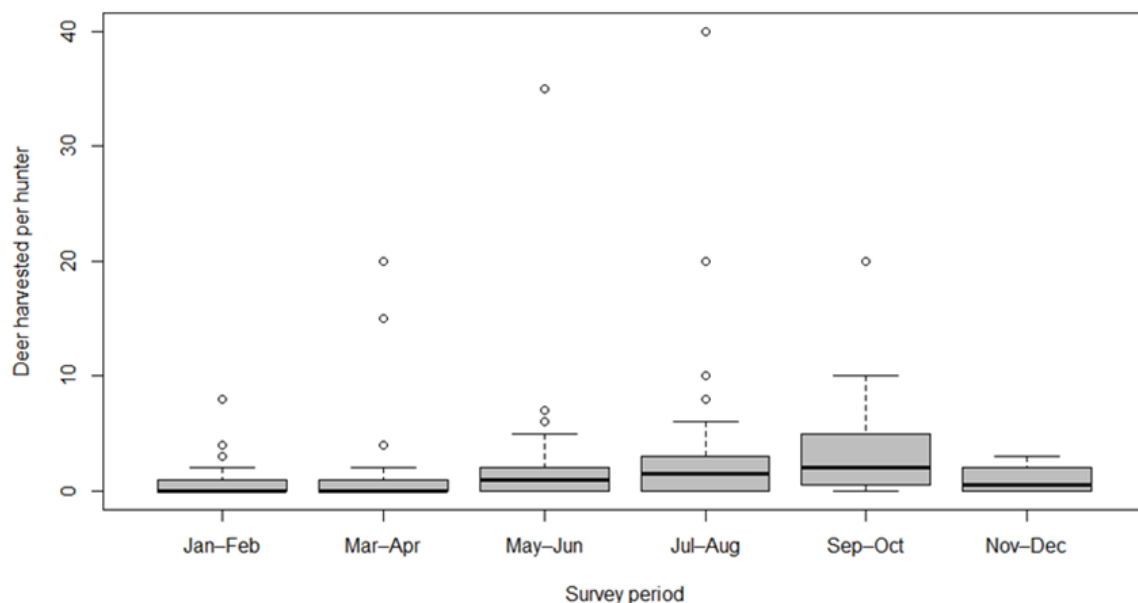
Figure 1. Boxplot of the number of deer reported as harvested by individual hunters for each survey period in 2021.

The bottom and top of each 'box' indicate the 25th and 75th percentiles, respectively, and the black horizontal line indicates the median (50th percentile) reported value.

Table 3. Average harvest of deer per hunter (Game Licence holder who hunted) for each survey period in 2021

Period	Average harvest per hunter [5]	SE	95% CI	
			Lower	Upper
Jan–Feb	0.95	0.24	0.59	1.54
Mar–Apr	1.20	0.41	0.62	2.31
May–Jun	2.10	0.62	1.20	3.69
Jul–Aug	2.98	0.89	1.68	5.29
Sep–Oct	3.31	0.67	2.23	4.90
Nov–Dec	0.90	0.23	0.55	1.47

There was an estimated total of 118,874 deer harvested from January 2021 to December 2021, inclusive, by Game Licence holders endorsed to hunt deer (95% CI = 89,816–157,334; Table 4). Harvest was greatest in the late-autumn to mid-spring months and lowest in the summer months.

From the results of the telephone survey conducted immediately after the 2021 deer-hunting season, it was estimated that 36% (95% CI = 32–41%) of Game Licence holders

actually hunted for deer during 2021 (Table 5). That equates to an estimated 18,073 (95% CI = 15,873–20,578) active deer hunters [6] in 2021. The average annual deer harvest per active deer hunter was estimated to be 6.6 (95% CI = 4.8–9.0). The average number of hunting days per active deer hunter during 2021 was estimated to be 13.6 (95% CI = 10.9–17.0). The annual average is lower than the sum of each period (Table 3) because not all active hunters hunted in each period.

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[5] Average harvest per hunter = Deer harvested divided by Respondents who hunted (Table 1).

[6] Active deer hunters are Game Licence holders who have hunted at least once in the season.

Table 4. Estimates of the total deer harvest in Victoria by Game Licence holders in 2021

Period	Total harvest [7]	SE	95% CI	
			Lower	Upper
Jan–Feb	8,421	2,404	4,865	14,575
Mar–Apr	16,083	5,792	8,112	31,887
May–Jun	26,064	8,192	14,282	47,567
Jul–Aug	35,591	11,505	19,186	66,021
Sep–Oct	28,228	7,142	17,325	45,995
Nov–Dec	4,487	1,484	2,387	8,436
Total	**118,874**	**17,088**	**89,816**	**157,334**

Table 5. Statistics for annual deer hunting by active hunters. Active hunters are Game Licence holders who hunted at least once in Victoria in 2021

Statistic	Annual estimate	SE	95% CI	
			Lower	Upper
Proportion active	0.36	0.02	0.32	0.41
Estimated number of active hunters	18,073	1,198	15,873	20,578
Average annual deer harvest per active hunter	6.58	1.04	4.83	8.95
Average no. of hunting days per active hunter	13.62	1.56	10.89	17.04

Separate harvest estimates for each deer species are presented in Figure 2 and Table 6. The most frequently harvested species were Sambar Deer (58% of the total reported harvest), Fallow Deer (30%) and Red Deer (2%). Chital Deer and Hog Deer accounted for less than 1% of the reported deer harvest. No Rusa Deer was reported harvested in the 2021 telephone survey. At the time of this report, there were no known wild populations of Rusa or Chital Deer in Victoria, and it should be noted that the two Chital Deer harvest reported were in very different regions of the state (Glenelg Hopkins and Goulburn Broken CMAs). We note that there were five hunters who reported harvesting a total of 46 deer in combinations of Sambar Deer, Fallow Deer and Red Deer in a survey period, but did not specify the numbers of each species.

This created a discrepancy in the estimated cumulative totals of deer harvested by species (Table 6) and in the percentage that each species contributed to the total estimated harvest. The people conducting the survey need to ensure this information is record explicitly for species and sex, where possible. Even though only one survey respondent reported harvesting Hog Deer in 2021 during the telephone surveys, a total of 135 Hog Deer (95 stags and 40 hinds) were recorded in harvest returns. Of these, 46 were from the Snake Island, Boole Poole and Blond Bay Wildlife Reserve balloted hunts (35 stags and 11 hinds). The remainder of the deer were harvested on private property or State Game Reserves.

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[7] Total harvest = Harvest per hunter (Table 3) × Total hunters (Table 2). Numbers may differ slightly due to rounding of average harvest per hunter.
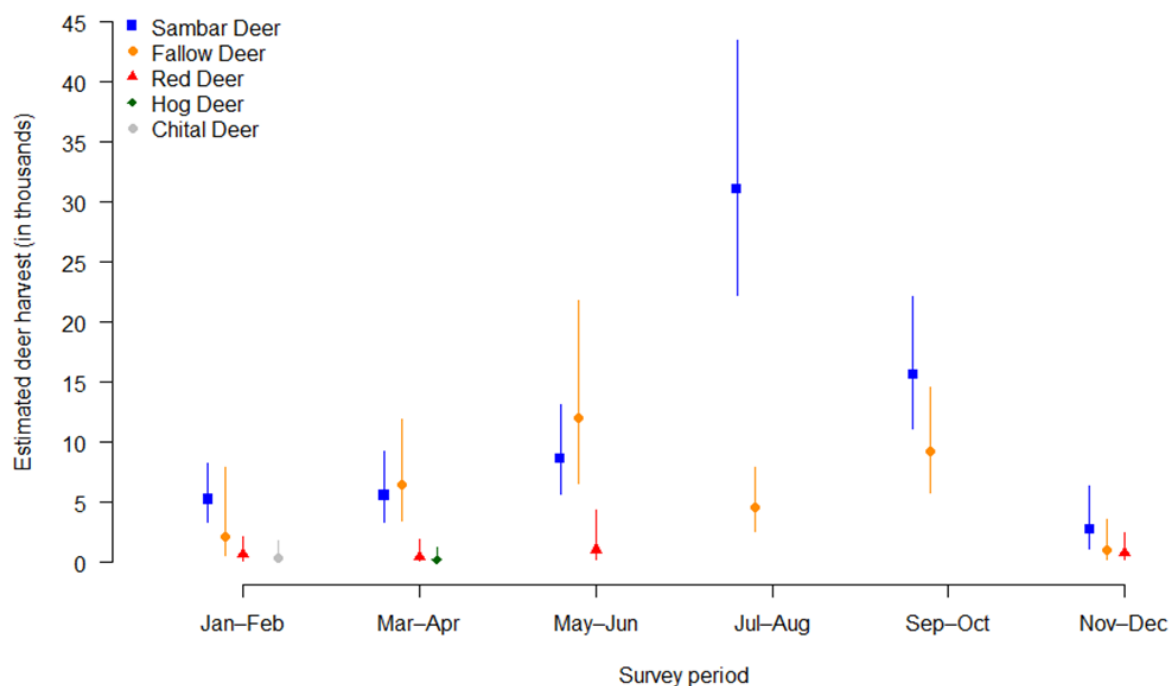
Figure 2. Estimated total deer harvest for each 2-month survey period in 2021 by species.

Vertical bars indicate 95% confidence intervals. Species were only included in surveys periods when they were reported.

Table 6. Estimated total harvest per deer species for each survey period in 2020

a. Sambar Deer.

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	25	5,263	1,238	3,339	8,294
Mar–Apr	25	5,584	1,469	3,363	9,272
May–Jun	41	8,618	1,873	5,657	13,129
Jul–Aug	130	31,052	5,348	22,211	43,413
Sep–Oct	66	15,656	2,767	11,101	22,079
Nov–Dec	11	2,742	1,245	1,174	6,405
Total	**298**	**68,916**	**6,709**	**56,971**	**83,365**

b. Fallow Deer

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	10	2,105	1,611	556	7,965
Mar–Apr	29	6,478	2,080	3,506	11,969
May–Jun	57	11,981	3,751	6,579	21,818
Jul–Aug	19	4,538	1,305	2,612	7,887
Sep–Oct	39	9,251	2,191	5,853	14,622
Nov–Dec	4	997	734	275	3,621
Total	**158**	**35,351**	**5,295**	**26,401**	**47,336**

c. Red Deer

Period	Reported harvest	Estimated harvest	SE	95% CI Lower	Upper
Jan–Feb	3	632	438	185	2,159
Mar–Apr	2	447	385	104	1,925
May–Jun	5	1,051	878	252	4,376
Jul–Aug	0	0	NA	NA	NA
Sep–Oct	0	0	NA	NA	NA
Nov–Dec	3	748	514	221	2,531
Total	**13**	**2,877**	**1,173**	**1,334**	**6,205**

d. Hog Deer

Period	Reported harvest	Estimated harvest	SE	95% CI Lower	Upper
Jan–Feb	0	0	NA	NA	NA
Mar–Apr	1	223	235	41	1,210
May–Jun	0	0	NA	NA	NA
Jul–Aug	0	0	NA	NA	NA
Sep–Oct	0	0	NA	NA	NA
Nov–Dec	0	0	NA	NA	NA
Total	**1**	**223**	**235**	**41**	**1,210**

e. Chital Deer

Period	Reported harvest	Estimated harvest	SE	95% CI Lower	Upper
Jan–Feb	2	421	362	98	1,812
Mar–Apr	0	0	NA	NA	NA
May–Jun	0	0	NA	NA	NA
Jul–Aug	0	0	NA	NA	NA
Sep–Oct	0	0	NA	NA	NA
Nov–Dec	0	0	NA	NA	NA
Total	**2**	**421**	**362**	**98**	**1,812**

There was a statistically significant sex bias favouring females for the harvest of Sambar Deer, with females representing 57% of the harvest (Table 7). There was no statistically significant sex bias for the harvest of Fallow Deer or Red Deer.

The number of days hunted in each survey period varied throughout the season, with most hunting occurring from autumn to mid-spring. Each Game Licence holder endorsed to hunt deer who was active hunted an average of 13.6 days during 2021, corresponding to a total of 246,152 hunter days (95% CI = 205,010–295,549; Table 8).

Table 7. Reported numbers and percentages of each sex for each deer species harvested in 2021

Species	Males			Females		
	Reported	%	SE	Reported	%	SE
Sambar Deer	129	43	3	169	57	3
Fallow Deer	70	44	4	88	56	4
Red Deer	6	46	14	7	54	14

Table 8. Estimated numbers of days on which deer were hunted by Game Licence holders in 2021

Period	Days hunted by Game Licence holders	SE	95% CI	
			Lower	Upper
Jan–Feb	29,893	6,635	19,449	45,946
Mar–Apr	65,226	13,255	43,973	96,750
May–Jun	53,810	10,588	36,724	78,844
Jul–Aug	46,101	9,152	31,358	67,774
Sep–Oct	33,922	9,049	20,290	56,711
Nov–Dec	17,201	5,690	9,146	32,348
Total hunting days	**246,152**	**23,019**	**205,010**	**295,549**
Total hunting days per active hunter	**13.62**	**1.68**	**11.68**	**18.29**

More deer hunting occurred exclusively on public land (58%) compared with exclusively on private land (33%), but more deer were harvested during hunting exclusively on private land than during hunting exclusively on public land (44% and 48%, respectively) (Table 9).

Most Sambar Deer were harvested during hunting on public land only (52%). Most Fallow Deer were harvested during hunting on private land only (49%).

Table 9. Percentage of days of hunting and deer harvest by land tenure in 2021

Land tenure	Days	Total Deer harvest	Sambar Deer harvest	Fallow Deer harvest	Red Deer harvest	Rusa Deer harvest
Private land only	32.6	48.5	42.3	48.7	69.2	100
Public land only	58.1	43.5	52.0	39.9	15.4	0
Both	8.4	7.9	5.7	11.4	15.4	0
Not specified	0.9	0.2	0.0	0.0	0.0	0

The recorded use of gundogs was limited to under 2% of hunting days and deer harvested. It should be noted that on almost half of the hunting days, respondents did not specify their hunting method, and these were generally days on which hunting was unsuccessful.

This uncertainty will affect the reliability of the estimate of the percentage of hunting days on which each method was used.

Table 10. Percentage of total hunting days for deer harvested by hunting method and land tenure in 2021

Land tenure		Scent-trailing hounds	Stalking	Stalking with gundog	Not specified	Total
Private land only	Days	1.1	19.7	0.0	11.8	**32.5**
	Deer	2.3	45.2	0.0	1.0	**48.5**
Public land only	Days	2.5	22.1	1.1	32.4	**58.1**
	Deer	3.6	38.5	1.1	0.2	**43.5**
Both	Days	0.0	4.5	0.0	3.9	**8.4**
	Deer	0.0	7.9	0.0	0.0	**7.9**
Not specified	Days	0.0	0.0	0.0	0.9	**0.9**
	Deer	0.0	0.0	0.0	0.2	**0.2**
Total	**Days**	**3.6**	**46.3**	**1.1**	**49.1**	**100**
	Deer	**5.9**	**91.6**	**1.1**	**1.3**	**100**

Total harvest was estimated to be greatest in the North East CMA, followed by the Goulburn Broken CMA and the Port Phillip & Westernport CMA (Figure 3). The top five towns for the total reported number of deer harvested were (in descending order) Mansfield, Bright, Healesville, Wangaratta and Lakes Entrance. The top five towns for the total number of reported deer-hunting days were (in descending order) Mansfield, Wodonga, Bairnsdale, Benalla and Kinglake Central.
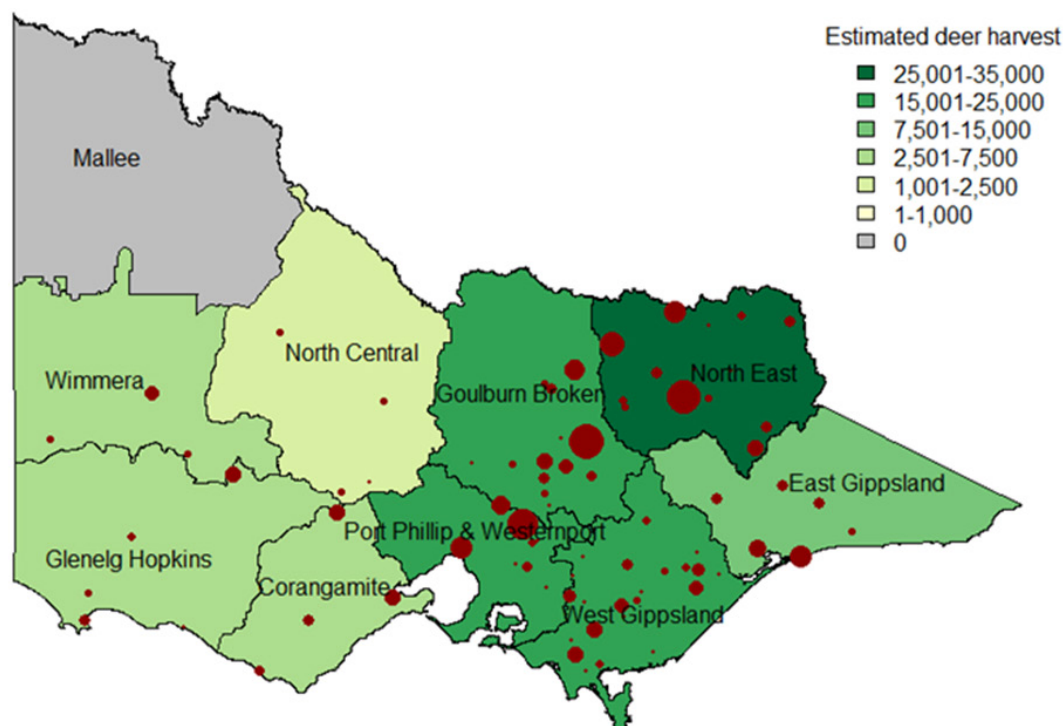
Figure 3. Estimates of the total deer harvested in 2021 by CMA region.

Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

3.2 Overall deer harvest using hounds in 2021

The number of Game Licence holders endorsed for using hounds was fairly consistent throughout 2021, from 5,258 in April–May to 5,336 at the end of the season (Table 11). To achieve the required sample size of respondents, slightly more than 100 licence holders were contacted each survey, with an average of 95% of those contacted being willing to take part.

The proportion of Game Licence holders endorsed for using hounds who actually hunted with hounds varied between surveys, with the June–July (30%) and October–November periods having a much greater proportion (28%) than the other two survey periods (Table 12).

Table 11. Summary of responses from 2021 Game Licence holders endorsed for using hounds

Deer survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted	Deer harvested[8]
1	Apr–May	5,258	100	22	163	388
2	Jun–Jul	5,289	106	32	84	228
3	Aug–Sep	5,325	100	13	94	187
4	Oct–Nov	5,336	101	28	126	328

Table 12. Total numbers (and corresponding proportions) of Game Licence holders endorsed for using hounds and who actually used hounds for each survey period in 2021

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
Apr–May	0.22	0.041	0.15	0.32	1,157	218	802	1,668
Jun–Jul	0.30	0.045	0.23	0.40	1,597	236	1,197	2,129
Aug–Sep	0.13	0.034	0.08	0.21	692	179	420	1,140
Oct–Nov	0.28	0.045	0.20	0.38	1,479	238	1,082	2,023

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[8] Deer harvested indicates the total number of deer harvested by hound teams of which the respondents were members.

Within each survey period, there was great variation in the reported number of deer harvested per hunter in the various hound hunting teams (i.e. hound team total per Game Licence holder who hunted). Some teams (7%) harvested more than 30 deer in a survey period, whereas 15% of teams harvested 1 deer or less in each period (Figure 4).

The median number of deer harvested per team in a 2-month period was eight, with a median of five hunters per team. The average number of deer per team member (as reported by hunters) varied throughout the season (Table 13). The average harvest per hunter in a team in 2021 ranged from a high of 4.0 deer in April–May to a low of 1.9 deer in June–July.
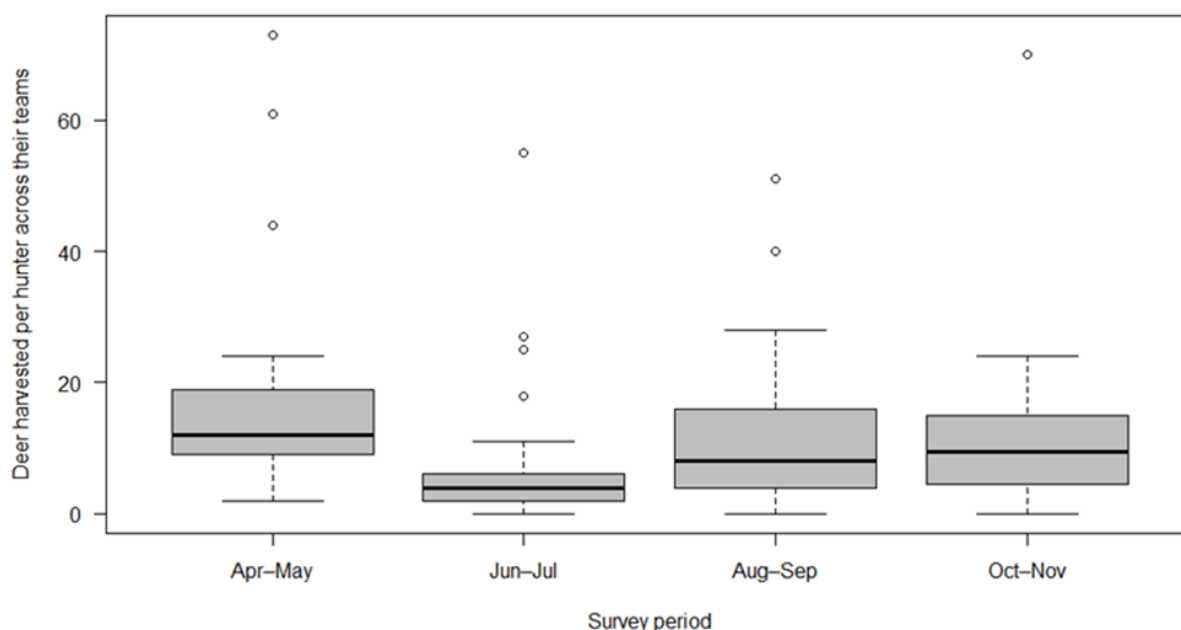
Figure 4. Boxplot of the number of deer reported harvested by hound teams for each survey period in 2021.

The bottom and top of each 'box' indicate the 25th and 75th percentiles, respectively, and the black horizontal line indicates the median (50th percentile) reported value.

Table 13. Estimates of the average number of deer harvested per team member (as reported by Game Licence holders who hunted using hounds) for each survey period in 2021

Period	Average harvest per hound hunter[9]	SE	95% CI	
			Lower	Upper
Apr–May	4.02	0.20	3.65	4.44
Jun–Jul	1.88	0.16	1.59	2.22
Aug–Sep	2.83	0.12	2.60	3.07
Oct–Nov	2.34	0.12	2.12	2.59

[9] Average harvest per hound hunter where the harvest per hunter is the sum of the deer harvested by the team divided by the number of team members for each team in which the respondent was involved.

There was an estimated total of 13,075 deer harvested from April 2021 to November 2021, inclusive, by Game Licence holders endorsed for using hounds and who actually hunted using hounds (95% CI = 10,766–15,881; Table 14). Hound hunting therefore accounted for 11% of the total deer harvest in 2021. Approximately one-third of the estimated total harvest occurred in the April–May period.

From the responses to the telephone survey undertaken immediately after the conclusion of the 2021 season for deer hunting using hounds, it was estimated that 44% (95% CI = 38%–52%) of Game Licence holders endorsed for using hounds actually hunted with hounds during 2021 (Table 15). That equates to an estimated 2,311 (95% CI = 1,980–2,697) active deer hunters using hounds[10] in 2021. The average number of deer harvested per active deer hunter using hounds was estimated to be 5.7 (95% CI = 4.4–7.2) over 2021.

Table 14. Estimates of the total deer harvested using hounds in Victoria in 2021 by holders of a deer Game Licence endorsed for using hounds

Period	Total harvest[11]	SE	95% CI	
			Lower	Upper
Apr–May	4,655	907	3,189	6,795
Jun–Jul	2,995	512	2,148	4,176
Aug–Sep	1,957	513	1,181	3,244
Oct–Nov	3,468	585	2,498	4,816
Total	**13,075**	**1,300**	**10,766**	**15,881**

Table 15. Annual estimates of deer harvested using hounds in Victoria in 2021 by active Game Licence holders endorsed for using hounds

Statistic	Annual estimate	SE	95% CI	
			Lower	Upper
Proportion active	0.44	0.04	0.38	0.52
Estimated number of active hunters	2,311	182	1,980	2,697
Average harvest per active hunter	5.66	0.72	4.42	7.25
Average hunting days per active hunter	10.57	1.91	7.44	15.01

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[10] Active deer hunters using hounds are those Game Licence holders endorsed for using hounds and who have hunted at least once during the season.

[11] Total harvest = Harvest per hunter (Table 13) × Total hunters (Table 12). Numbers may differ slightly due to rounding of average harvest per hunter.

There was significant evidence of a sex bias favouring females in the Sambar Deer harvested with the use of hounds. The proportion of the harvest that was female was 53% (95% CI = 50%–56%).

The average number of hunting days with the use of hounds in each survey period varied throughout the season, with most hunting using hounds occurring in April–May. The total number of days of deer hunting using hounds in 2021 was 24,424 days (Table 16).

The total deer harvested using hounds was estimated to be greatest in the Goulburn Broken CMA region, followed by the North East CMA region and the West Gippsland CMA region (Figure 5). The top five towns for the total reported number of deer harvested using hounds were (in descending order) Mansfield, Myrtleford, Eildon, Dargo and Licola. The top five towns for the total number of reported deer-hunting days using hounds were (in descending order) Mansfield, Myrtleford, Dargo, Eildon and Licola.

Table 16. Total number of days on which teams hunted using hounds in 2021 by survey period

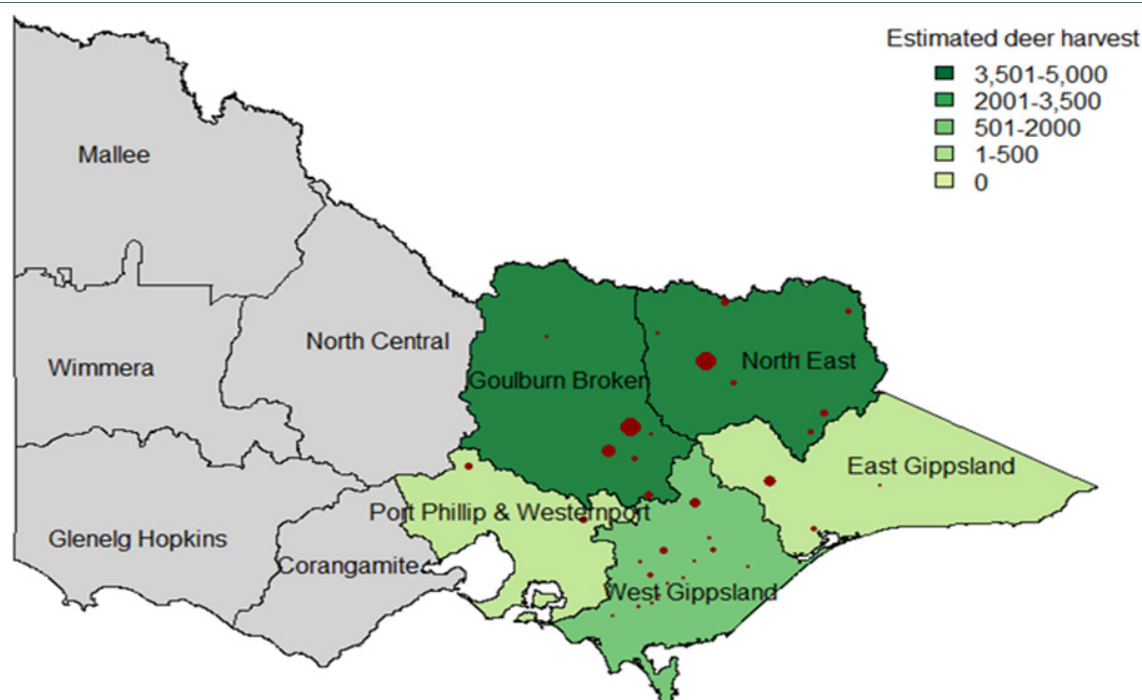| Period	Days hunted	SE	95% CI	
			Lower	Upper
Apr–May	8,571	2,617	4,774	15,386
Jun–Jul	4,191	1,224	2,393	7,342
Aug–Sep	5,006	2,245	2,163	11,583
Oct–Nov	6,657	1,853	3,896	11,373
Total number of days of hunting using hounds	**24,424**	**4,101**	**17,615**	**33,865**

Figure 5. Estimates of total deer harvested using hounds in 2021 by CMA region.

Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

4   Discussion

The management of the COVID-19 pandemic continued in 2021 and involved a series of movement restrictions in Victoria. This appeared to have resulted in a reduction in the estimated deer harvest compared with pre–COVID-19 levels. The reduction was due to reduced hunter activity, because the hunter efficiency remained steady, while the number of Game Licence holders was at a record high level.

4.1   Deer harvest in 2021

A total of 118,900 deer were estimated to have been harvested in Victoria during the 2021 calendar year (95% CI = 89,800–157,300). The 2021 estimate was 70% greater than the 2020 estimate (69,900) and almost 50% greater than the average since 2009 (79,700). Prior to 2020 (the season impacted by the Black Summer bushfires and COVID-19 restrictions), the estimated Victorian deer harvest had been increasing annually at rate of 17% (Moloney et al., 2022). The 2021 deer harvest was the third largest on record since the surveys began in 2009 (Table 17, Figure 6) and was similar to the 2018 estimate (121,600), but noticeably lower than the peak deer harvest in 2019 (173,800). In that context, the 2021 deer harvest can be seen as a step towards returning to the previous trend of increasing annual deer harvests.

The final number of Game Licence holders endorsed to hunt deer in 2021 (49,857) was the largest recorded to date and was 20% larger than the number in 2020 (41,056). The proportion of hunters who actively hunted in 2021 (36%) was similar to that of 2020 (35%). In each year for the period 2017–2019 (the previous years for which this statistic was available), 52–60% of licence holders were active at some point during the year (Table 17). The average percentage of Game Licence holders who were active hunters in any 2-month period in 2021 was 22%. In 2020 the average percentage was only 15%, whereas for 2017 to 2019 that figure ranged from 20% to 29%, which is similar to the 2021 figure.

Hunter efficiency has been consistent over the past 4 years. The efficiency of hunters in 2021 was 0.48 deer harvested per hunting day, which is 24% greater than the average efficiency for the 13 years of the surveys, and very similar to the efficiency estimated for the previous 3 years (Table 17).

The 2021 season had 246,200 total hunting days, the second largest number of hunting days since the telephone surveys began and an increase of 72% from 2020. The mean number of hunting days per active hunter in 2021 (13.6) was the largest since 2017, when the statistic could first be calculated, and 45% larger than 2020. Hence, the majority of the increase in hunting days in 2021 was due to the increase in hunting days per active hunter; to a lesser degree it was due to the increase in the number of Game Licence holders endorsed to hunt deer.

The estimated deer harvest per Game Licence holder in 2021 was 2.53, which is almost exactly the average since the surveys began and 41% greater than in the previous year. The estimated deer harvest per active hunter in 2021 was 6.6, which was the second largest since 2017, when the statistic could first be calculated, 15% greater than the average, and 34% greater than in 2020. In 2017 to 2020 (the previous years for which this statistic was available), the estimated value was between 4.9 and 6.8 deer per active hunter.

The deer harvest and hunting day totals in 2021 are possibly still being affected by the COVID-19 restrictions. While these totals increased compared with 2020, which had more restrictions and also the immediate aftermath of the Black Summer bushfires, they were still below the peak of 2019. The proportion of hunters who were active was the same as in 2020, both much lower than in previous years. However, those who were active hunted on more days than in previous years, while efficiency remained high in 2021, suggesting that, if hunter activity returns to pre-2020 levels, then the harvest numbers may return to pre-2020 levels as well.
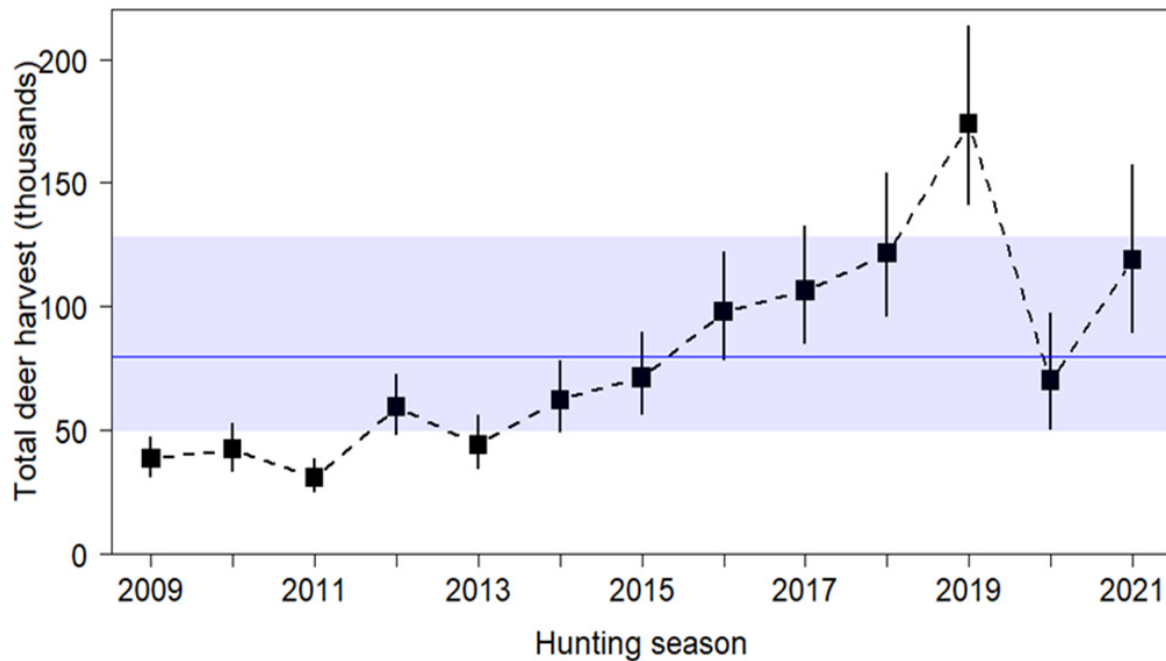
Figure 6. Estimates of total deer harvested (in thousands) from 2009 to 2021.

The square is the estimated total harvested for each season; the solid vertical line indicates the 95% confidence interval; the blue line is the average deer harvest from 2009 to 2020; the shaded area is the 95% confidence interval for the average deer harvest from 2009 to 2020.

As in previous years, Sambar Deer was the most commonly harvest deer species in 2021, followed by Fallow Deer and Red Deer, with the other species coming up in the surveys occasionally (Table 18). While the Sambar Deer harvest was estimated to be 13% higher than average, the Fallow Deer and Red Deer estimates were 140% and 98% higher than average respectively. Even though only one survey respondent reported harvesting Hog Deer in 2021, a total of 135 Hog Deer were reported harvested (see Section 3.1).

Table 17. Deer harvested and hunting days per Game Licence holder for 2009–2021[12]

Year	Licences[13]	Total harvest	Total hunting days	Deer harvested per Game Licence holder	Hunting days per Game Licence holder	Deer harvested per hunting day	Proportion of active hunters
2009	19,849	38,284	150,321	2.14	8.38	0.25	NA
2010	21,570	42,133	149,002	2.12	7.56	0.28	NA
2011	23,170	30,753	135,278	1.43	6.30	0.23	NA
2012	24,777	59,206	169,721	2.62	7.54	0.35	NA
2013	27,349	43,985	135,854	1.76	5.47	0.32	NA
2014	30,244	62,166	186,215	2.22	6.68	0.33	NA
2015	32,870	71,141	201,547	2.36	6.77	0.35	NA
2016	34,822	97,776	207,614	3.12	6.63	0.47	NA
2017	36,968	106,275	184,317	3.11	5.45	0.58	0.55
2018	39,066	121,567	237,594	3.49	6.71	0.51	0.59
2019	41,985	173,784	344,604	4.48	8.86	0.50	0.60
2020	41,056	69,914	143,488	1.80	3.68	0.49	0.35
2021	49,857	118,874	246,152	2.53	5.33	0.48	0.36
Average	**31,144**	**79,681**	**191,670**	**2.55**	**6.57**	**0.40**	**0.52**

Table 18. Comparison of the 2009–2021 harvests of the six game deer species

Year	Chital Deer	Fallow Deer	Hog Deer	Red Deer	Rusa Deer	Sambar Deer
2009	0	4,871	81	682	0	32,453
2010	0	6,085	454	1,396	0	34,108
2011	0	4,001	105	737	0	25,913
2012	0	9,788	102	555	0	48,048
2013	0	6,426	0	926	0	36,355
2014	0	7,870	0	745	0	51,390
2015	0	14,488	138	939	0	55,094
2016	129	15,059	0	1,713	0	80,875
2017	181	15,515	154	1,609	0	88,816
2018	0	30,552	0	2,101	0	88,202
2019	0	30,307	183	3,277	0	131,258
2020	0	11,372	0	1,365	200	50,635
2021	421	35,351	223	2,877	0	68,916
Average	**56**	**14,745**	**111**	**1,456**	**15**	**60,928**

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[12] Deer harvested and hunting days per Game Licence holder in 2020 are reported here for comparison with the results of surveys prior to 2017, when the deer harvested and hunting days per active hunter could be calculated.

[13] The number of Game Licence holders endorsed to hunt deer at the end of that year.

4.2 Deer harvest using hounds in 2021

A total of 13,075 deer were estimated to have been harvested using hounds in Victoria during the 2021 calendar year (95% CI = 10,766–15,881). The 2021 deer harvest using hounds was 20% smaller than the average of previous seasons (Table 19, Figure 7). The deer harvest per active hunter using hounds was the second lowest recorded and 16% smaller than the average of previous seasons.

The 2021 total number of days spent hunting with hounds (24,424) was 34% less than the average of previous seasons (Table 19). The hunting days per active hunter using hounds was the second lowest recorded and 30% less than the average of previous seasons.

In 2021, hunter efficiency using hounds increased to 0.54, a 20% increase from the average of previous seasons (Table 19).

The lower-than-average deer harvest and hunting days per active hunters using hounds was a result of the reduced proportions of active hunters per survey period compared with previous years and the lower-than-average number of hunting days even when Game Licence holders were active. The percentage of active hunters using hounds in any 2-month period in 2021 was 23% (similar to the 2020 statistic of 21%). In the 2 years prior to the Black Summer bushfires and COVID-19 restrictions, the percentages were 31% and 39%. The percentage of hunters who used hounds at least once during the 2021 season was 44, which is 9% less than the average of previous seasons (Table 19).

Table 19. Comparison of deer harvests using scent-trailing hounds from 2018 to 2021.

Year	Proportion of active hunters	Total harvest	Total hunting days	Deer per active hunter	Hunting days per active hunter	Deer per hunting day
2018	0.52	14,670	36,416	5.69	14.14	0.40
2019	0.46	24,866	54,828	10.53	23.22	0.45
2020	0.48	9,694	19,216	4.04	8.01	0.50
2021	0.44	13,075	24,424	5.66	10.57	0.54
Average	**0.47**	**15,576**	**33,721**	**6.48**	**13.98**	**0.47**

4.3 Comparing deer harvest methods in 2021

It should be noted that the survey of Game Licence holders endorsed for using hounds also asked about any hunting by stalking they had undertaken during the same period. The responses from this cohort showed that a greater proportion hound hunted (23%) than stalked (14%), while 5% did both within the 2-month period. The responses also showed that the harvest rate was similar for each method (2.7 deer harvested per team member using hounds, compared with 3 deer harvested per active hunter using stalking) over the same period of time. Game Licence holders using hounds spent an average of 8.9 days hunting deer, including with use of hounds (5.1 days) and stalking (3.8 days).

In 2021, Game Licence holders endorsed to hunt deer using hounds were slightly more efficient when using hounds than hunters in general. When using hounds, their efficiency was 0.54 deer harvested per team member per hunting day. From the survey of the general Game Licence holders endorsed to hunt deer, their efficiency was 0.48 deer harvested per hunting day. However, the average efficiency of Game Licence holders endorsed for using hounds was greater when they were stalking (0.78 deer per day) than when they were using hounds and compared with Game Licence holders in general.

4.4 Assumptions

The estimates of the harvest for each deer species were derived based on the assumption that the samples of respondents were representative of the entire population of Victorian Game Licence holders endorsed to hunt deer. This assumption may have been violated due to several factors, such as bias due to particular reasons for non-response [due to exceeded bag limit, or (conversely) not harvesting anything, memory recall (respondents not remembering their harvest)], and deliberate over- or under-reporting (knowingly incorrectly reporting numbers). Any bias due to non-response is likely to have been negligible, because the response rate for all surveys was generally above 95% (i.e. very high). Memory bias can inflate estimates of total harvest, in some cases by as much as 40% (Wright 1978; Barker 1991). It is likely, however, that the sampling strategy of telephone interviews after each 2-month period would have ensured that both memory bias and non-response bias were kept low (compared with postal surveys and complete end-of-season surveys) (Barker 1991; Barker et al. 1992). Nevertheless, some bias likely remains, and the estimates of total harvest should be interpreted with care.

It should be noted that the number of hunting days was only an approximate estimate of total effort. Note, someone who hunted for 2 hours and someone else who hunted for 12 hours were both recorded as having hunted for 1 day. It is also important to note that the methodology explicitly accounts for the possibility that not every Game Licence holder hunted in every survey period (see Gormley and Turnbull 2010). Therefore, the estimate of total season bag per Game Licence holder is the sum of the 'harvest per Game Licence holder', not the sum of the 'harvest per hunter'.

The uncertainty in the estimates of total harvest (as indicated by the CIs) was due to two factors. First, there was variation in the reported numbers of animals harvested between respondents who had hunted (see Figure 1 and Figure 4). For example, within a given survey period, some respondents indicated that they hunted unsuccessfully, whereas others took multiple trips and indicated a total harvest of more than five deer during the same period. The second source of uncertainty was due to sampling of hunters, rather than taking a complete census; however, the degree of sampling uncertainty was reduced by having sample sizes of 200 respondents per deer-hunting survey. Statistically, these sample sizes are considered adequate for providing reasonable estimates.

The spatial distributions of the deer harvest should also be interpreted with care. Grouping the harvest by CMA provides a broad-scale view of the distribution of the harvest. Grouping by smaller regions would provide a finer-scale representation, but this would be at the cost of increased bias in many regions. Because the data are from a sample of Game Licence holders rather than a complete census, it is likely that some areas that were actually hunted are shown as having a zero harvest if no respondents that hunted those areas were contacted. This would be increasingly likely at finer spatial scales. Furthermore, respondents were only asked to report the nearest town to where they hunted, not the actual location. It is, therefore, possible that the nearest town was in a different CMA region than that of the hunting location.

The analysis of Sambar Deer harvested using hounds required an assumption that the respondents were independent within a survey period, that is, the respondents within a survey were not part of the same team during that survey period. If they were, then there is a potential that we double-counted their harvest, increasing the estimated average harvest.

References

Barker, R.J. (1991). Nonresponse bias in New Zealand waterfowl harvest surveys. *Journal of Wildlife Management* **55**, 126–131.

Barker, R.J., Geissler, P.H. and Hoover, B.A. (1992). Sources of nonresponse to the federal waterfowl hunter questionnaire survey. *Journal of Wildlife Management* **56**, 337–343.

Game Management Authority. (2020). *Game Hunting in Victoria*. http://www.gma.vic.gov.au (accessed 10 January 2022).

Gormley, A.M. and Turnbull, J.D. (2009). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2009*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 196. Department of Sustainability and Environment, Heidelberg, Victoria.

Gormley, A.M. and Turnbull, J.D. (2010). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2010*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 210. Department of Sustainability and Environment, Heidelberg, Victoria.

Gormley, A.M. and Turnbull, J.D. (2011). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2011*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 224. Department of Sustainability and Environment, Heidelberg, Victoria.

Moloney, P.D. and Flesch, J.S. (2021). *Estimates of the 2020 deer harvest in victoria: results from surveys of Victorian Game Licence holders in 2020*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Moloney, P.D., Gormley, A.M., Toop, S.D., Flesch, J.S., Forsyth, D.M., Ramsey, D.S.L. and Hampton, J.O. (2022). Bayesian modelling reveals differences in long-term trends in the harvest of native and introduced species by recreational hunters in Australia. *Wildlife Research*.

Moloney, P.D. and Hampton, J.O. (2020). *Estimates of the 2019 deer harvest in Victoria: results from surveys of Victorian Game Licence holders in 2019*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Moloney, P.D. and Powell, Z. (2019). *Estimates of the 2018 deer harvest in Victoria: results from surveys of Victorian Game Licence holders in 2018*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Moloney, P.D. and Turnbull, J.D. (2012). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2012*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 239. Department of Sustainability and Environment, Heidelberg, Victoria.

Moloney, P.D. and Turnbull, J.D. (2013). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2013*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 251. Department of Environment and Primary Industries, Heidelberg, Victoria.

Moloney, P.D. and Turnbull, J.D. (2014). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2014*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Moloney, P.D. and Turnbull, J.D. (2016). *Estimates of harvest for deer in Victoria: results from surveys of Victorian Game Licence holders in 2014 and 2015*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Moloney, P.D. and Turnbull, J.D. (2017). *Estimates of deer harvest in Victoria: results from surveys of Victorian Game Licence holders in 2016*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Moloney, P.D. and Turnbull, J.D. (2018). *Estimates of the 2017 deer harvest in Victoria: results from surveys of Victorian Game Licence holders in 2017*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Wright, V.L. (1978). Causes and effects of biases on waterfowl harvest estimates. *Journal of Wildlife Management* **42**, 251–262.

Appendices

Appendix 1: Questionnaire for Game Licence holder endorsed to hunt deer

Survey details:

Period of survey _____ (1 to 6)   Date of interview: __(dd) / __(mm) / 2021

Non-responsive: ☐ (tick box)

Survey questions:

1. What is the main species of deer that you hunt? (Sambar, Fallow, Red, Chital, Hog, Rusa)?

2. What is your main hunting method? (Stalking, Stalking with a gundog, Hound hunting, Bow hunting, Spotlighting)

3. Have you been deer hunting in the past 2 months? (Jan and Feb)   Yes ☐   No ☐   (Tick box.)
(If 'Yes', proceed to question 4, if 'No', say, "Thank you for taking part in this survey.")

4. How many deer hunting trips have you taken over this 2-month period?   ☐

(Each trip needs to be treated separately for questions 5–11.)

5. On how many days did you go hunting?

6. How many deer did you harvest?
[When a hunter says he has harvested deer by hound hunting (scent trailing hounds), check that it was what the individual got and not the group.]

6. Did you shoot and lose any deer?   If yes, how many?

7. What species were the deer?
- Sambar
- Fallow
- Red
- Hog
- Chital
- Rusa

8. What was the sex of the deer?

   Number of males?   Number of females?

9. How were the deer taken?
   - Stalking with a rifle
   - Stalking with a rifle and gundog
   - Scent-hounds
   - Bow
   - Crossbow
   - Shotgun
   - Muzzle loader

10. Did you hunt on private land or public land?   Public ☐ Private ☐ Both ☐

11. What was the closest major town to the area in which you hunted?

Appendix 2: Questionnaire for Game Licence holder endorsed to hunt deer using hounds

Survey details:

Period of survey _____ (1 to 4)   Date of interview: __(dd) / __(mm) / 2021

Non-responsive: ☐ (tick box)

Survey questions:

1. Have you been hound hunting in the past 2 months? (Oct and Nov)   Yes ☐   No ☐ (Tick box)
(If 'Yes', proceed to question 2, if 'No', go to Q 10.   If no to that, say "Thank you for taking part in this survey.")

2. How many hound hunting trips have you taken over this 2-month period?   ☐
(Indicate number in box)

(Each trip needs to be treated separately for questions 3–8.)

3. On how many days did you go hunting?

4. How many hunters in your team?

5. How many deer did your team harvest?

6. How many deer did you harvest?

7. What was the sex of the deer?
Number of males?   Number of females?

8. Did you hunt on private land or public land? Public ☐ Private ☐ Both ☐

9. What was the closest major town to the area in which you hunted?

10. Have you been deer hunting without hounds in the past 2 months? Yes ☐   No ☐

11. How many non-hound hunting trips have you taken over this 2-month period?

12. How many days did you go hunting?

13. How many deer did you harvest?

Appendix 3: Definitions and calculations

Common definitions used

SD = standard deviation of the data; it represents the variation in the numbers reported.

SE = standard error of the mean; it represents the variation in the estimated mean.

CV = coefficient of variation; it is calculated as: CV = SE ÷ mean. This provides an indication as to how much uncertainty is in the estimate relative to the mean.

Calculations

For each survey j, we surveyed n_j respondents, of which h_j had hunted. The proportion of respondents who hunted in each period j is given by:

$$p_j = \frac{h_j}{n_j}$$ e.g. for Deer Survey 4 in 2015, we obtained: $\frac{70}{200} = 0.350$.

The total number of hunters for each survey period (H_j) was estimated by multiplying the total number of licence holders (L) by the proportion of respondents who reported having hunted during that survey period (p_j), as found previously:

$$H_j = p_j L$$ e.g. for Deer Survey 4 in 2015, we obtained: $0.35 \times 30{,}908 = 10{,}818$.

The estimated average harvest per hunter (w_j) is the total reported harvest for survey j (y_j) divided by the total number of respondents who hunted (h_j):

$$w_j = \frac{y_j}{h_j}$$ e.g. for Deer Survey 4 in 2015, we obtained: $\frac{215}{70} = 3.07$.

The total harvest for each survey period (W_j) was estimated by multiplying the average harvest per hunter (w_j) by the total number of hunters (H_j):

$$W_j = w_j H_j$$ e.g. for Deer Survey 4 in 2015, we obtained: $3.07 \times 10{,}808 = 33{,}226$.

The estimate of the total harvest was calculated as the sum of the estimated harvest for each survey period:

$$W_{TOT} = W_1 + W_2 + W_3 + W_4 + W_5 + W_6 .$$

Standard errors (SEs) for the proportion of respondents who hunted are given by:

$$SE(p_j) = \sqrt{\frac{p_j(1 - p_j)}{n_j}}$$

e.g. for Deer Survey 4 in 2015, we obtained: .

$$\sqrt{\frac{0.35 \times 0.65}{200}} = 0.034$$

Standard errors for the average harvest per hunter are given by:

$$SE(w_j) = \frac{SD(w_j)}{\sqrt{h_j}}$$

e.g. for Deer Survey 4 in 2015, we obtained: $\frac{4.55}{\sqrt{70}} = 0.54$.

The standard error for the total estimated harvest per survey period (W_j) was found by determining the coefficient of variation (CV) for each p_j and w_j and then calculating the square root of the sum of their squares to find the combined CV (assuming independence).

$$CV(w_j) = \frac{SE(w_j)}{w_j}, \text{ and } CV(p_j) = \frac{SE(p_j)}{p_j}$$

$$CV(W_j) = \sqrt{\left(CV(w_j)\right)^2 + \left(CV(p_j)\right)^2}$$

$$SE(W_j) = CV(W_j) \times W_j .$$

The standard error of the total harvest was calculated as follows:

$$SE(W_{TOT}) = \sqrt{\left(SE(W_1)\right)^2 + \left(SE(W_2)\right)^2 + \cdots + \left(SE(W_6)\right)^2} .$$

Confidence intervals were computed on the natural logarithm scale and back-transformed to ensure that lower limits were ≥0. A consequence is that the confidence intervals were asymmetric and could not be reported as the estimate plus or minus a fixed value. For some estimates, denoted as, 95% confidence interval limits were calculated using:

upper limit (*UL*)

lower limit (*LL*) , where:

$$r = \exp\left(1.96\sqrt{\ln\left(1 + CV^2\right)}\right),$$

e.g. for the total deer harvest in 2015 we have

$$CV = \frac{8,349}{71,142} = 0.117$$

Therefore, upper and lower confidence limits are given by:

$$UL = 71,142 \times 1.26 = 89,471$$

$$LL = 71,142 \div 1.26 = 56,567.$$

Appendix 4: Explanation of what goes into a boxplot

A boxplot is a way of displaying key points of the data and is especially good for comparing groups of data. It is sometimes referred to as a box-and-whisker plot. A boxplot shows the following key points:

- outliers, signified by hollow circles

- minimum, signified by the horizontal line below the box (smallest value, excluding outliers)

- lower quartile (Q1), signified by the horizontal line at the bottom of the box
  (25% of the data is at this point or below)

- median, signified by the thick horizontal line in the box (50% of the data is at this point or below)

- upper quartile (Q3), signified by the horizontal line at the top of the box
  (75% of the data is at this point or below)

- maximum, signified by the horizontal line above the box (largest value, excluding outliers)

- interquartile range (IQR; difference between the upper and lower quartiles)

- whiskers—the lines that go from the minimum or maximum to the box.

Outliers are values that are very large (or small) compared with the rest of the data. An outlier is defined as any point that is either below Q1 – 1.5 × IQR or above Q3 + 1.5 × IQR, which means that any point that lies more than one-and-a-half times the length of the box outside the box is an outlier.

The boxplot indicates the spread of the data. The data is broken into quarters: approximately 25% of the data are in the range between a whisker and the nearest edge of the box, and approximately 25% of the data are in the range between an edge of the box and the median line. Thus, approximately half the data are thus contained within the box. Any unusual data are highlighted as outliers. As an example, using duck hunting, Figure A4.1 shows a boxplot indicating that most hunters harvested between 5 and 13 ducks, and a quarter harvested between 13 and 27 ducks. A number of outliers harvested more than 27 ducks, including one who harvested over 50 ducks. Sometimes there are no whiskers because the minimum (or maximum) is the same as the lower (or upper) quartile (see Figure A4.1, which indicates that at least 25% of Game Licence Holders who hunted were unsuccessful).
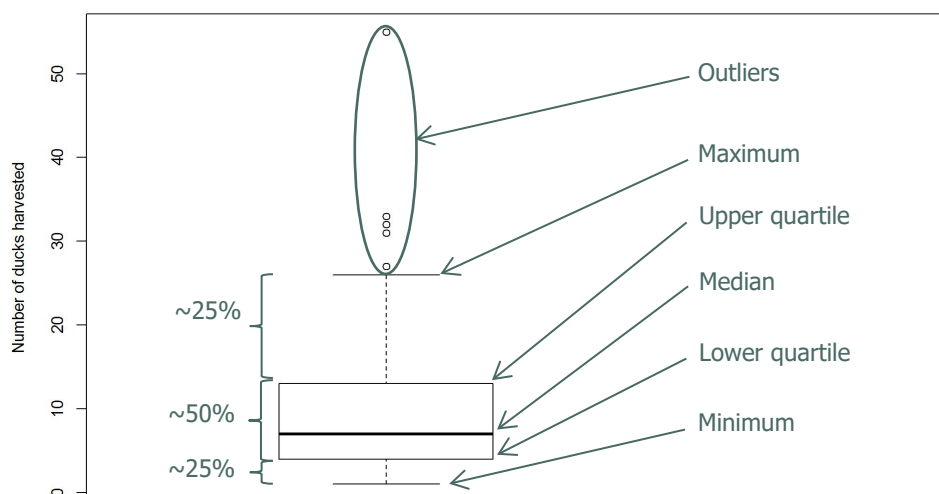

Figure A4.1. Example boxplot, with labels

Appendix 5: Harvest rates per Game Licence endorsed for hunting deer

The total average season harvest was 2.5 deer per Game Licence holder (95% CI = 1.9–3.3; Table A5.1). Note that, for each survey period, the average deer harvested per Game Licence holder (Table A5.1) was much lower than the average deer harvested per Game Licence holder who hunted (Table 3), because the former included those respondents who did not hunt during the survey period.

Table A5.1. Estimates of average harvest of deer per Game Licence holder in each survey period in 2021

Period	Average harvest [14]	SE	95% CI	
			Lower	Upper
Jan–Feb	0.20	0.06	0.12	0.35
Mar–Apr	0.36	0.13	0.18	0.71
May–Jun	0.56	0.18	0.31	1.02
Jul–Aug	0.74	0.24	0.40	1.38
Sep–Oct	0.58	0.15	0.35	0.94
Nov–Dec	0.09	0.03	0.05	0.17
Total	**2.53**	**0.36**	**1.92**	**3.35**

Each Game Licence holder endorsed to hunt deer hunted an average of 5.3 days during 2021 (Table A5.2), corresponding to a total of 246,152 hunter days (95% CI = 205,010–295,549).

Table A5.2. Number of days on which deer were hunted per Game Licence holder for 2021

Period	Days hunted	SE	95% CI	
			Lower	Upper
Jan–Feb	0.71	0.12	0.51	1.00
Mar–Apr	1.46	0.25	1.04	2.04
May–Jun	1.16	0.19	0.84	1.59
Jul–Aug	0.96	0.15	0.71	1.31
Sep–Oct	0.69	0.15	0.45	1.06
Nov–Dec	0.34	0.09	0.21	0.56
Total hunting days per licence holder	**5.33**	**0.41**	**4.59**	**6.20**

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[14] Average harvest per Game Licence holder = Deer harvested divided by Respondents (Table 1).

Appendix 6: Harvest rates per Game Licence holders endorsed for using hounds

The total average season harvest was 2.5 deer per Game Licence holder using scent-trailing hounds (95% CI = 2–3; Table A6.1). Note that, for each survey period, the average deer harvest per hound team member (Table A6.1) was much lower than the average deer harvest per Game Licence holder who hunted using hounds (Table 13), because the former included those respondents who did not hunt with hounds during the survey period.

Table A6.1. Estimates of average harvest of deer per Game Licence holder using hounds in each survey period in 2021

Period	Average harvest[15]	SE	95% CI	
			Lower	Upper
Apr–May	0.89	0.17	0.61	1.29
Jun–Jul	0.57	0.10	0.41	0.79
Aug–Sep	0.37	0.10	0.22	0.61
Oct–Nov	0.65	0.11	0.47	0.90
Total	**2.47**	**0.25**	**2.03**	**3.00**

The average number of hound hunting days in each survey period varied throughout the season, with most hunting occurring from late autumn to mid-spring. Each Game Licence holder endorsed to hunt deer using hounds hunted an average of 4.6 days during 2021 (Table A6.2).

Table A6.2. Number of days on which deer were hunted using hounds per Game Licence holder endorsed for using hounds for 2021

Period	Days hunted	SE	95% CI	
			Lower	Upper
Apr–May	1.63	0.39	1.02	2.59
Jun–Jul	0.79	0.20	0.49	1.29
Aug–Sep	0.94	0.34	0.47	1.88
Oct–Nov	1.25	0.28	0.80	1.94
Total hunting days per licence holder	**4.61**	**0.63**	**3.54**	**6.01**

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[15] Average harvest per Game Licence holder endorsed for using hounds.