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Results from surveys of Victorian Game Licence holders in 2022

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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Estimates of the 2022 deer harvest in Victoria

Results from surveys of Victorian Game Licence holders in 2022

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Context:

To effectively manage game species, it is important to quantify the numbers harvested. Since 2009, to ascertain the levels of deer harvested, the Victorian State Government game management agencies have commissioned a series of regular telephone surveys of randomly selected holders of Game Licences endorsed for hunting deer. Additional telephone surveys were commissioned, starting in 2018, to quantify the scale Sambar Deer (*Cervus unicolor*) are being harvested using hounds. This report focuses on estimating the total recreational deer harvest for 2022. 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 recreational hunters in Victoria during the 2022 hunting season.

Methods:

Holders of a Victorian 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, species and sex 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 2022 was 123,376 (95% confidence interval (CI) = 98,177-155,042), 49% above the average since 2009 (82,802) but similar to 2018 (121,567) and 2021 (118,874). The similarity in overall annual deer harvest compared to 2021 can be explained by an increase in the proportion of active hunters (39%) and efficiency (19% increase in deer harvested per hunting day) being counteracted by the overall number of hunting days decreasing by 12%. Active hunters are Game Licence holders endorsed to hunt deer who hunted at least once in 2022.

In 2022, 50% of Game Licence holders endorsed to hunt deer actively hunted, similar to the recorded average (48%). On average, active deer hunters harvested 4.9 deer over 8.6 days, which are both below average (5.7 deer and 11.1 days respectively).

The most commonly harvested species was Sambar Deer (with an estimated total harvest of 76,178, or 62% of the total deer harvest), followed by Fallow Deer (*Dama dama*) (41,180, or 33%) while 4% of the harvest was not clearly identified. These species percentages differed from previous years. Typically, Sambar Deer and Fallow Deer account for 77% and 18% of the deer harvest respectively and 2% of the harvest is not clearly identified.

In 2022 it is estimated that the total number of deer harvested using hounds was 12,428 (95% CI = 10,135-15,239) or 10% of the total deer harvest. The average annual deer harvest rate using hounds per active Game Licence holder endorsed to hunt Sambar Deer with hounds was 6.4 (95% CI = 4.9-8.3), which is higher than the general rate per active hunter (4.9). The efficiency of deer harvest using hounds (0.39 deer per hunting day per team member) is lower than the overall efficiency (0.57 deer per hunting day) in 2022. This apparent contradiction is explained by a larger number of hound hunting days per active hound hunter (16.6) compared to the general number of hunting days (8.6).

Conclusions and implications:

1. The 2022 deer hunting season was the first since the Black Summer bushfires and the COVID-19 lockdowns and so free from any direct impact of these events. Prior to these events, the estimated total deer harvest had been increasing by 17% annually. In 2022 the increase was substantially lower and once confidence intervals are considered; it is likely no real growth in total deer harvest occurred.
    - While more hunters were active in 2022 (41% increase over 2020 and 2021), and their hunting was more efficient (18% increase over 2020 and 2021), they hunted for fewer days (15% and 40% decrease over 2020 and 2021 respectively).
    - Given the 24% increase in Game Licence holders endorsed to hunt deer since 2017 (when annual active hunter numbers could be estimated), the total deer harvest increase of 4% higher than the average since 2017, is small. This is explained by, compared to the long-term averages: the proportion of active hunters in 2022 was average; the efficiency in 2022 was 40% higher; the average harvest per active hunter in 2022 was 15% down; and the average deer hunting days per active hunter was 23% down.
    - This could be a result of hunters reaching their harvest target earlier (due to higher efficiency) and therefore not needing to hunt for as long.
2. 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 total harvest must be interpreted with care. In addition, it is important that the people conducting the telephone surveys need to ensure that the number and sex of each harvested deer is unambiguously recorded.
3. The effect of respondents reporting very high harvest rates that could be a result of activities that are not recreational hunting, or perhaps hunting in teams rather than individual harvests, needs to be explored, as they are potentially positively biasing the estimates.

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 during 2022.

Recreational deer hunting occurs all year round in Victoria for some species (Game Management Authority 2020). In 2022, 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 only between 1 April and 30 November. Hog Deer (*Axis porcinus*) can only be hunted during April (excluding out-of-season ballot hunting), and hunting this species is further 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 2021 deer-hunting seasons (Moloney & Powell, 2019; Moloney & Hampton 2020; Moloney & Flesch, 2021, 2022) and similar to those of the 2009 to 2017 deer hunting seasons (Gormley & Turnbull, 2009, 2010, 2011; Moloney & 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. See Section 2.2 for a definition of scent-trailing hounds.

The aim of this report was to provide estimates of the number of deer harvested by licensed recreational hunters in Victoria during 2022. Other metrics on hunter effort, success and locations were also collected.

2 Methods

All surveys were conducted by the telephone survey company Marketing Skill Pty Ltd (Mount Eliza, Victoria) on behalf of the Victorian 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 surveys, 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.

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 2022 hunting season. They were asked whether they had hunted at any stage during the 2022 deer-hunting season. This post-season survey enables us to estimate the proportion of active hunters across the season without needing to estimate the correlation structure of active hunters between the 2-monthly surveys.

The number of active hunters during 2022 was estimated by multiplying the proportion of active hunters from the post-season survey by the number of Game Licence holders at the end of 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.

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

[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.

The annual harvest per Game Licence holder (i.e., all people who held a valid Game Licence endorsed for deer hunting in 2022) 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 (used later in this report) is provided in Appendix 4.

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 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 2022 hound hunting season. They were asked whether they had hunted with hounds at any stage during the 2022 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 $1.\overline{3}$ deer (a total of four deer divided among three team members).

3 Results

3.1 Overall deer harvest in 2022

The number of Game Licence holders endorsed to hunt deer increased by over 10,000 during 2022, to over 50,000 by the end of 2022 (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 2022

Deer survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted [3]	Deer harvested [4]
1	Jan–Feb	39,914	200	38	97	127
2	Mar–Apr	43,512	200	38	133	114
3	May–Jun	45,883	200	51	203	100
4	Jul–Aug	48,029	200	43	215	83
5	Sep–Oct	49,568	200	36	197	96
6	Nov–Dec	50,478	200	23	83	26

The proportion of Game Licence holders who hunted in each survey period varied across the year: approximately 12,000 Game Licence holders (26%) hunted in May–June, whereas 12% of licence holders hunted in November–December (Table 2). The proportion who hunted during other survey periods was between 18% to 22% (Table 2).

Table 2. Proportion and corresponding total number of deer licence holders who hunted in each survey period in 2022

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
Jan–Feb	0.19	0.028	0.14	0.25	7,584	1,107	5,705	10,081
Mar–Apr	0.19	0.028	0.14	0.25	8,267	1,207	6,219	10,990
May–Jun	0.26	0.031	0.20	0.32	11,700	1,414	9,240	14,815
Jul–Aug	0.22	0.029	0.17	0.28	10,326	1,395	7,933	13,441
Sep–Oct	0.18	0.027	0.13	0.24	8,922	1,347	6,649	11,973
Nov–Dec	0.12	0.023	0.08	0.17	5,805	1,139	3,966	8,496

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 reported harvesting more than 10 deer in a survey period, whereas at least one-quarter of hunters did not harvest any deer in two-thirds of the survey periods (Figure 1). The median number of deer harvested per hunter in a 2-month survey ranged from 0 to 2. This is much smaller than the average harvest in the same periods, which ranged from a high of 3.34 deer in January–February to a low of 1.13 in November–December (Table 3).

[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.

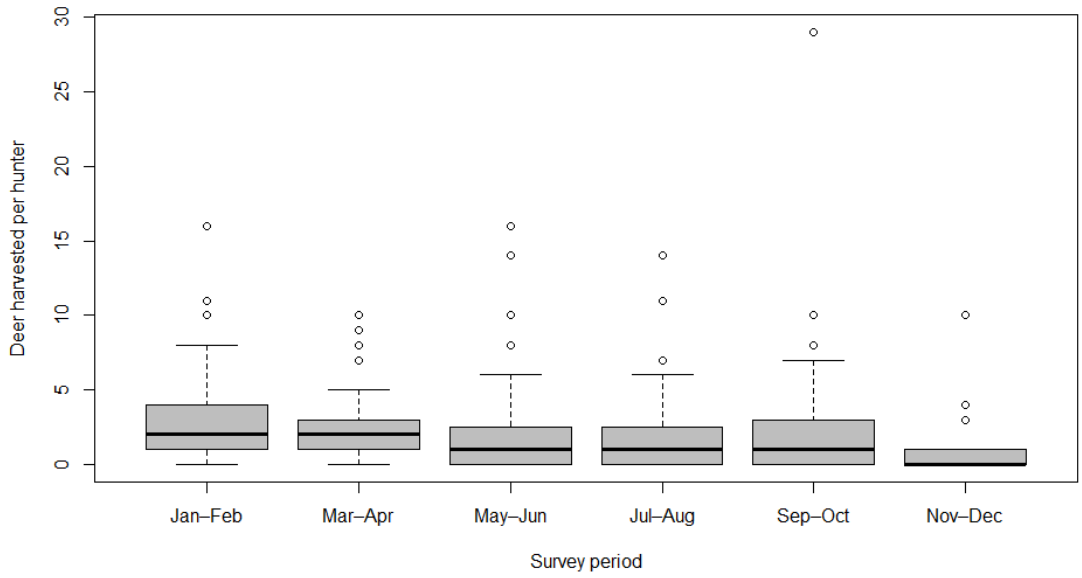

Figure 1. Boxplot of the number of deer reported harvested by individual hunters for each survey period in 2022.

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

Table 3. Average harvest of deer per hunter (Game Licence holders who hunted) for each survey period in 2022

Period	Average harvest per hunter [5]	SE	95% CI	
			Lower	Upper
Jan–Feb	3.34	0.56	2.41	4.64
Mar–Apr	3.00	0.44	2.25	4.00
May–Jun	1.96	0.48	1.22	3.14
Jul–Aug	1.93	0.46	1.22	3.05
Sep–Oct	2.67	0.86	1.44	4.94
Nov–Dec	1.13	0.48	0.51	2.51

There was an estimated total of 123,376 deer harvested from January 2022 to December 2022, inclusive, by Game Licence holders endorsed to hunt deer (95% CI = 98,177–155,042; Table 4). Harvest was similar for much of the year with a small dip in winter and a larger decline at the end of the year (November to December).

[5] Average harvest per hunter = Deer harvested divided by Respondents who hunted (Table 3).

Table 4. Estimates of the total deer harvest in Victoria by Game Licence holders in 2022

Period	Total harvest [6]	SE	95% CI	
			Lower	Upper
Jan–Feb	25,345	5,653	16,456	39,036
Mar–Apr	24,802	5,151	16,580	37,102
May–Jun	22,942	6,248	13,581	38,753
Jul–Aug	19,932	5,431	11,796	33,679
Sep–Oct	23,793	8,472	12,088	46,833
Nov–Dec	6,562	3,070	2,744	15,693
Total	**123,376**	**14,430**	**98,177**	**155,042**

From the results of the telephone survey conducted immediately after the 2022 deer-hunting season concluded, it was estimated that 50% (95% CI = 45–41%) of Game Licence holders actually hunted for deer during 2022 (Table 5). This equates to an estimated 25,239 (95% CI = 22,884–27,836) active deer hunters[7] in 2022. The average annual deer harvest per active deer hunter was estimated to be 4.9 (95% CI = 3.8–6.3). The average number of hunting days per active deer hunter during 2022 was estimated to be 8.6 (95% CI = 6.8–10.8). The annual average is lower than the sum of each period (Table 3) because not all active hunters hunted in each period.

Table 5. Estimates of annual deer hunting in Victoria in 2022 by holders of a deer Game Licence who hunted at least once

Statistic	Annual estimate	SE	95% CI	
			Lower	Upper
Proportion active	0.50	0.03	0.45	0.55
Estimated number of active hunters	25,239	1,262	22,884	27,836
Average annual deer harvest per active hunter	4.89	0.62	3.81	6.27
Average no. of hunting days per active hunter	8.57	1.02	6.79	10.81

Separate harvest estimates for each deer species are presented in Figure 2 and Table 6. The most frequently harvested species were Sambar Deer (62% of the total reported harvest), Fallow Deer (33%) and Red Deer (1%). No Chital Deer, Hog Deer or Rusa Deer were reported harvested in the 2022 telephone survey. At the time of this report, there were no known wild populations of Rusa or Chital Deer in Victoria. We note that there were six hunters who reported harvesting a total of 23 deer in combinations of Sambar Deer and Fallow 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.

Even though no survey respondent reported harvesting Hog Deer in 2022 during the telephone surveys, a total of 166 Hog Deer (134 stags and 32 hinds) were recorded in harvest returns. Of these, 24 were from the Snake Island, Boole Poole and Blond Bay Wildlife Reserve balloted hunts (21 stags and 3 hinds). The remainder of the deer were harvested on private property, State Game Reserves or other areas of public land where Hog Deer hunting is permitted.

[6] Total harvest = Harvest per hunter (Table 3) × Total hunters (Table 2). Numbers may differ slightly due to rounding of average harvest per hunter.

[7] Active deer hunters are Game Licence holders endorsed to hunt deer that have hunted at least once the season.

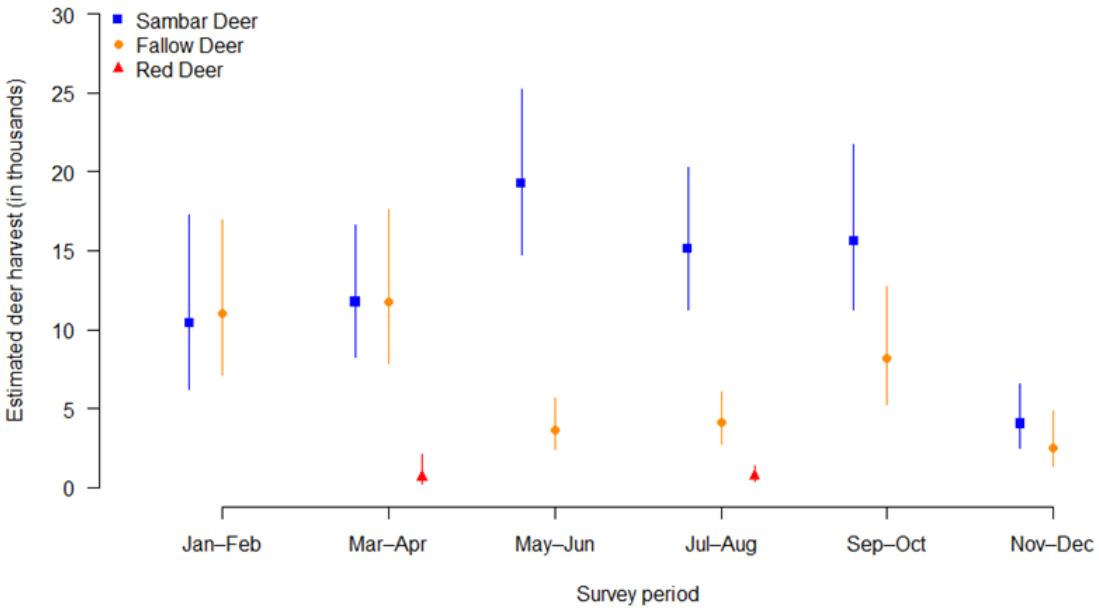

Figure 2. Estimated total deer harvest for each two-month survey period in 2022 by species.

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

Table 6. Estimates of total harvest per deer species for each survey period in 2022

a. Sambar Deer

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	52	10,378	2,752	6,226	17,297
Mar–Apr	54	11,748	2,100	8,299	16,632
May–Jun	84	19,271	2,651	14,734	25,204
Jul–Aug	63	15,129	2,282	11,275	20,301
Sep–Oct	63	15,614	2,639	11,237	21,696
Nov–Dec	16	4,038	1,019	2,481	6,572
Total	**332**	**76,178**	**5,677**	**65,839**	**88,140**

b. Fallow Deer

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	55	10,976	2,472	7,098	16,974
Mar–Apr	54	11,748	2,448	7,843	17,597
May–Jun	16	3,671	811	2,393	5,630
Jul–Aug	17	4,082	838	2,741	6,081
Sep–Oct	33	8,179	1,867	5,258	12,722
Nov–Dec	10	2,524	855	1,323	4,814
Total	**185**	**41,180**	**4,205**	**33,729**	**50,278**

c. Red Deer

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	0	0	NA	NA	NA
Mar–Apr	3	653	428	202	2,107
May–Jun	0	0	NA	NA	NA
Jul–Aug	3	720	246	376	1,381
Sep–Oct	0	0	NA	NA	NA
Nov–Dec	0	0	NA	NA	NA
Total	**6**	**1,373**	**494**	**693**	**2,719**

There was a statistically significant sex bias favouring females for the harvest of Fallow Deer (Table 7). In contrast, there was no statistically significant sex bias for the harvest of Sambar Deer or Red Deer.

Table 7. Reported numbers and percentages of each sex by deer species harvested in 2022

Species	Males			Females		
	Reported	%	SE	Reported	%	SE
Sambar Deer	156	47	3	176	53	3
Fallow Deer	71	38	4	114	62	4
Red Deer	2	33	19	4	67	19

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 8.6 days during 2022, corresponding to a total of 216,269 hunter days (95% CI = 175,191–266,980; Table 8).

Table 8. Number of days deer were hunted by Game Licence holder for 2022

Period	Days hunted by Game Licence holders	SE	95% CI	
			Lower	Upper
Jan–Feb	19,358	4,791	12,004	31,219
Mar–Apr	28,935	7,636	17,401	48,116
May–Jun	46,571	9,415	31,459	68,943
Jul–Aug	51,631	12,624	32,196	82,798
Sep–Oct	48,824	13,045	29,182	81,688
Nov–Dec	20,948	6,629	11,434	38,379
Total hunting days	**216,269**	**23,311**	**175,191**	**266,980**
Total hunting days per active hunter	**8.57**	**1.02**	**6.79**	**10.81**

More deer hunting occurred exclusively on public land (47%) compared with exclusively on private land (23%), with more deer harvested on exclusively private land (39%compared with 32% on public land) (Table 9). More Sambar Deer were harvested on public land (37%) than other land tenures; however, over a quarter of the Sambar Deer harvested did not have the land tenure specified. Most Fallow Deer were harvested on private land only (52%).

Table 9. Percentage of days of hunting and associated deer species harvest by land tenure in 2022

Land tenure	Days	Total Deer harvest	Sambar Deer harvest	Fallow Deer harvest	Red Deer harvest	Species unclear[8]
Private land only	22.8	39.2	29.5	51.9	83.3	65.2
Public land only	46.6	31.9	36.7	23.8	0.0	34.8
Both	7.2	10.4	8.1	15.7	16.7	0.0
Not specified	23.4	18.5	25.6	8.6	0.0	0.0

The most common hunting method was stalking without a dog on public land (37% of days). However, more deer were harvested whilst stalking without a dog on private land (34% of deer). In total, the proportion of days for each hunting method was similar to the proportion of deer harvested (Table 10). The proportion of hunters that did not specify their hunting technique was 1%, which was much smaller than previous years, but more hunters did not specify the land tenure where the hunting took place (21%), which was much greater than normal.

[8]The hunter harvested multiple species on a single trip but did not specify how many of their total harvest belonged to each species.

Table 10. Percentage of days of hunting and associated deer harvest technique by land tenure in 2022

Land tenure		Scent-trailing hounds	Stalking without dog	Stalking with dog	Technique not specified	Total
Private land only	Days	0	20	2	0	**22**
	Deer	0	34	5	0	**39**
Public land only	Days	8	37	2	0	**47**
	Deer	5	24	3	0	**32**
Both	Days	0	7	2	0	**9**
	Deer	0	9	1	0	**10**
Not specified	Days	6	14	0	0	**21**
	Deer	8	10	0	0	**18**
Total	**Days**	**15**	**78**	**6**	**1**	**100**
	Deer	**13**	**77**	**10**	**0**	**100**

The total harvest was estimated to be greatest in the Goulburn Broken CMA, followed by the North East CMA and the West Gippsland CMA (Figure 3). The top five towns for the total reported number of deer harvested were (in descending order) Mansfield, Eildon, Omeo, Whitfield and Bairnsdale. The top five towns for the total number of reported deer hunting days were (in descending order) Mansfield, Licola, Bairnsdale, Dargo and Eildon.

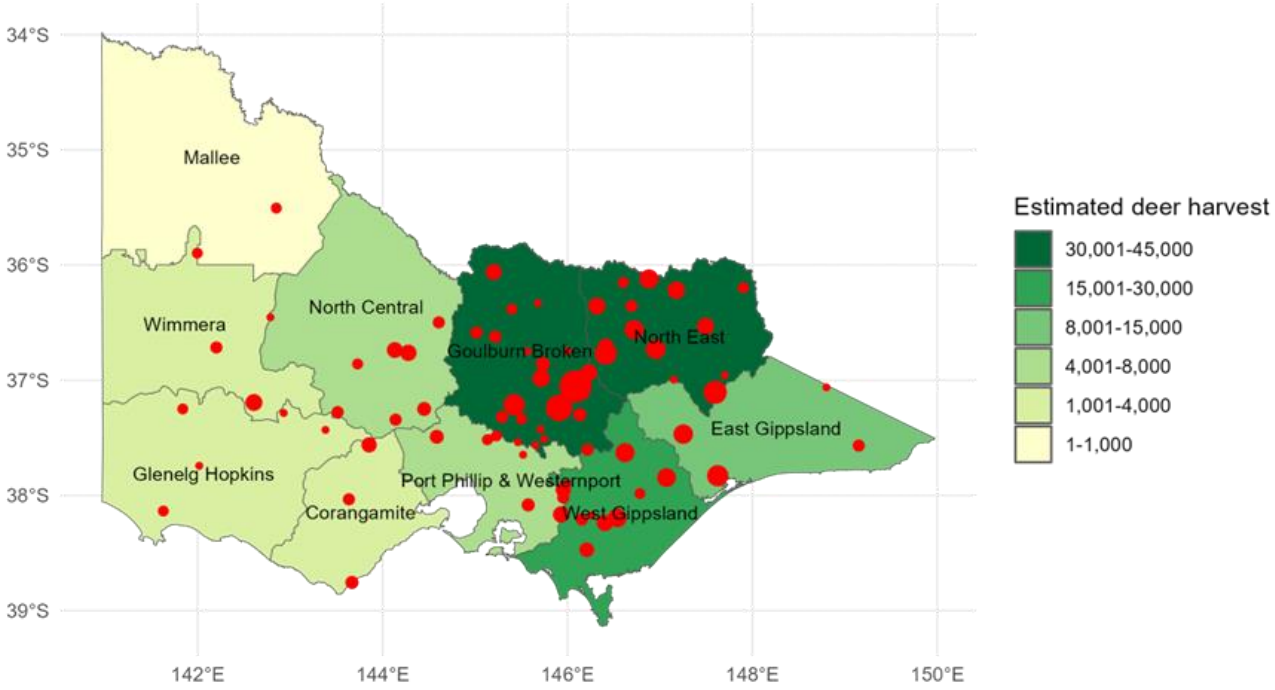

Figure 3. Estimates of total deer harvest in 2022 by CMA region.

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

3.2 Overall deer harvest using hounds in 2022

The number of Game Licence holders endorsed for using hounds was fairly consistent throughout 2022, from 4,991 in April-May to 5,144 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.

Table 11. Summary of responses from 2022 Game Licence holders endorsed to use hounds

Deer survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted	Deer harvested[9]
1	Apr–May	4,991	100	25	197	220
2	Jun–Jul	5,081	100	26	145	284
3	Aug–Sep	5,133	100	10	99	217
4	Oct–Nov	5,144	100	27	193	342

The proportion of Game Licence holders endorsed for using hounds who actually hunted with hounds was consistent for three of the four surveys, with the August-September (10%) period having a much lower proportion than the average of 26% of other survey periods (Table 12).

Table 12. Proportion and corresponding total number of Game Licence holders endorsed for using hounds and who actually used hounds for each survey period in 2022

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
Apr–May	0.25	0.043	0.18	0.35	1,248	216	891	1,748
Jun–Jul	0.26	0.044	0.19	0.36	1,321	223	951	1,835
Aug–Sep	0.10	0.030	0.06	0.18	513	154	289	913
Oct–Nov	0.27	0.044	0.20	0.37	1,389	228	1,008	1,913

Within each survey period, there was some 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 (11%) harvested more than 30 deer in a survey period, whereas 18% 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 8 deer. 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 2022 ranged from a high of 4.3 deer in October–November to a low of 1.5 in April–May.

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

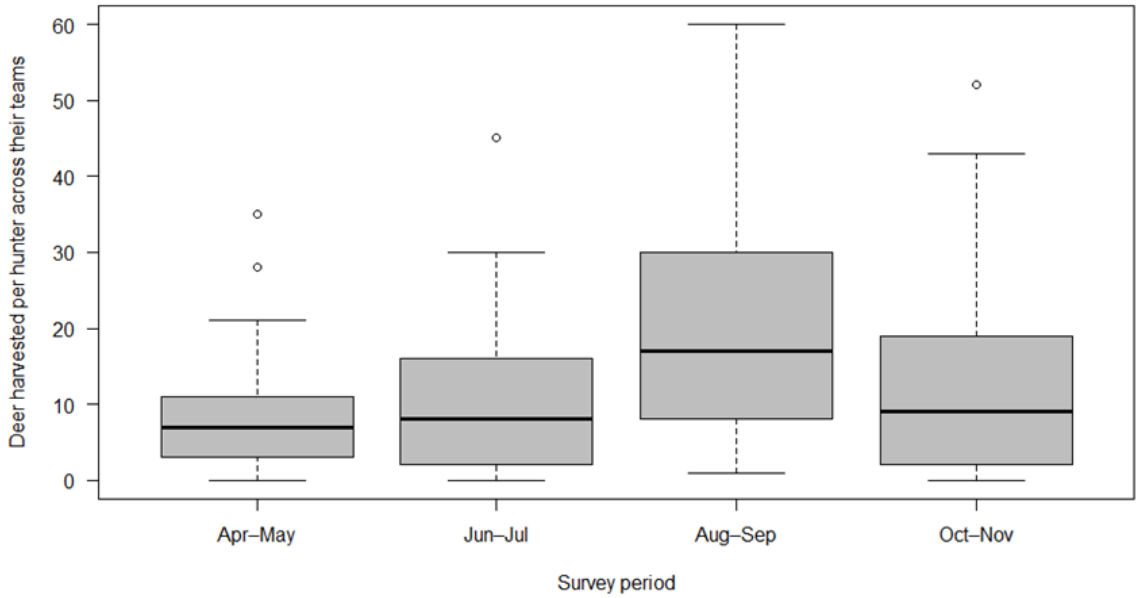

Figure 4. Boxplot of the number of deer reported harvested by scent-trailing hound teams for each survey period in 2022.

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

Table 13. Average harvest of deer per team member (summed by hunter, Game Licence holders who hunted using scent-trailing hounds) for each survey period in 2022.

Period	Average harvest per hound hunter[10]	SE	95% CI	
			Lower	Upper
Apr–May	1.53	0.05	1.43	1.63
Jun–Jul	2.04	0.07	1.91	2.18
Aug–Sep	3.66	0.09	3.49	3.83
Oct–Nov	4.28	0.20	3.91	4.69

There was an estimated total of 12,428 deer harvested from April 2022 to November 2022, inclusive, by Game Licence holders endorsed for using hounds and who actually hunted using hounds (95% CI = 10,135—15,239; Table 14). Approximately half of the estimated total harvest occurred in the October—November period.

[10] 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.

Table 14. Estimates of the total deer harvest using hounds in Victoria in 2022 by holders of a deer Game Licence endorsed for using hounds

Period	Total harvest[11]	SE	95% CI	
			Lower	Upper
Apr–May	1,905	336	1,351	2,685
Jun–Jul	2,696	464	1,928	3,770
Aug–Sep	1,878	565	1,054	3,344
Oct–Nov	5,949	1,017	4,266	8,296
Total	**12,428**	**1,297**	**10,135**	**15,239**

From the responses to the telephone survey undertaken immediately after the conclusion of the 2022 season for deer hunting using hounds, it was estimated that 40% (95% CI = 33%—47%) of Game Licence holders endorsed for using hounds actually hunted with hounds during 2022 (Table 15). That equates to an estimated 1,943 (95% CI = 1,637—2,306) active deer hunters using hounds12 in 2022. The average number of deer harvested per active deer hunter using hounds was estimated to be 6.4 (95% CI = 4.9—8.3) over 2022.

Table 15. Annual estimates of deer harvested using hounds in Victoria in 2022 by active Game Licence holders endorsed for using hounds

Statistic	Annual estimate	SE	95% CI	
			Lower	Upper
Proportion active	0.40	0.03	0.33	0.47
Estimated number of active hunters	1,943	170	1,637	2,306
Average harvest per active hunter	6.40	0.87	4.90	8.34
Average hunting days per active hunter	16.58	2.63	12.17	22.59

There was significant evidence of a sex bias for Sambar Deer harvested by using hounds. The proportion of the harvest that was female was 56% (95% CI = 53%—59%).

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 and October—November. The total number of days of deer hunting using hounds in 2022 was 32,209 days (Table 16).

Table 16. Total number of days on which teams hunted using hounds in 2022 by survey period

Period	Days hunted	SE	95% CI	
			Lower	Upper
Apr–May	9,832	2,654	5,847	16,535
Jun–Jul	7,367	2,029	4,336	12,517
Aug–Sep	5,082	2,272	2,201	11,734
Oct–Nov	9,928	2,694	5,888	16,740
Total number of days of hunting using hounds	**32,209**	**4,856**	**24,008**	**43,212**

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

[12] Active deer hunters using hounds are Game Licence holders endorsed to hunt deer using hounds and who have hunted at least once this season.

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, Dargo, Myrtleford, Bright and Licola. The top five towns for the total number of reported deer hunting days using hounds were (in descending order) Dargo, Mansfield, Myrtleford, Eildon and Licola.

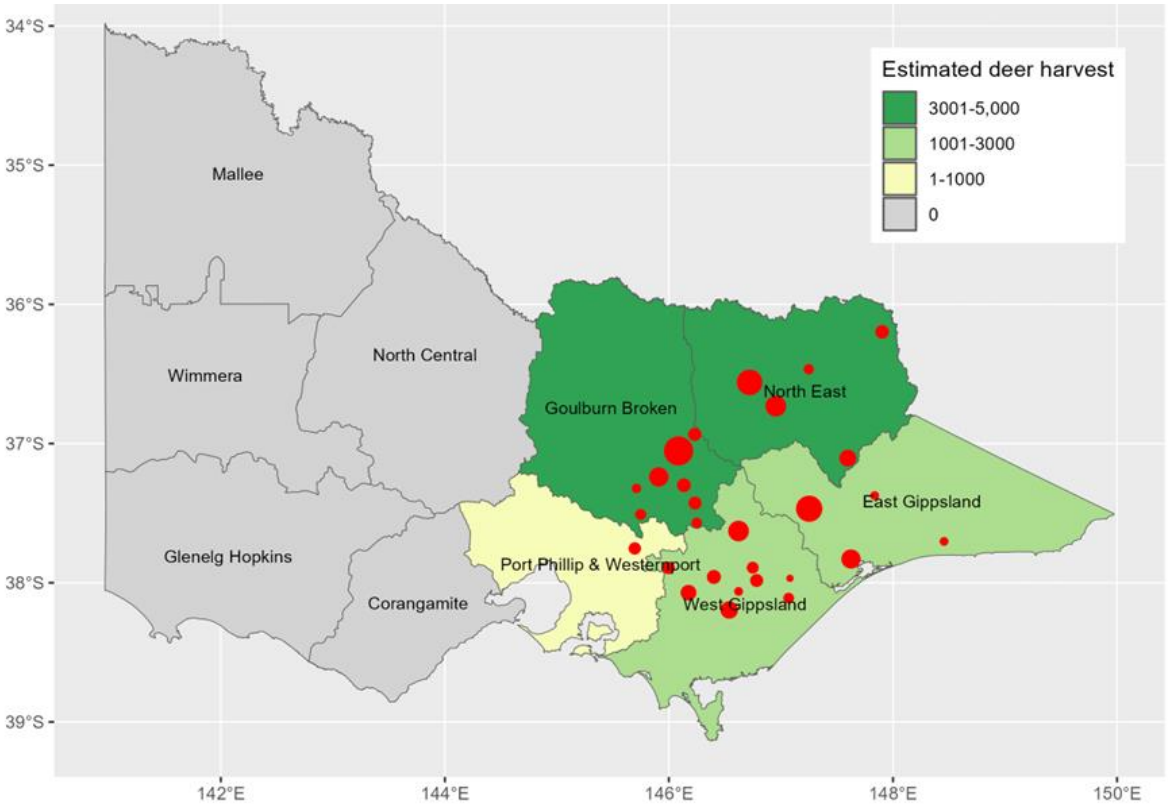

Figure 5. Estimates of total deer harvest using scent-trailing hounds in 2022 by CMA region

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

4 Discussion

4.1 Deer harvest in 2022

A total of 123,376 deer were estimated to have been harvested in Victoria during the 2022 calendar year (95% CI = 98,177–155,042). The 2022 estimate was similar to the 2021 estimate (118,900) and 40% greater than the average since 2009 (82,800, Figure 6). 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 a rate of 17% (Moloney et al., 2022). The 2022 deer harvest was the second largest on record since the surveys began in 2009 (Figure 6, Table 17) and is similar to the 2018 estimate (121,600) and 2021 (as above), but 30% lower than the peak deer harvest in 2019 (173,800). In that context, the 2022 deer harvest may represent the new steady level of the annual deer harvests in Victoria.

The final number of Game Licence holders endorsed to hunt deer in 2022 (50,478) was the largest recorded to date but similar to the 2021 number (49,857). The proportion of hunters who actively hunted in 2022 (50%) was similar to that from 2017 to 2019 (the previous years for which this statistic was available) of 52–60% and larger than the 35% in the intervening post-Black Summer bushfire and COVID-19 years (Table 17).

Hunter efficiency in 2022 was 0.57 deer harvested per hunting day, which is the second highest estimate and 44% greater than the average efficiency and 15% greater than the efficiency estimated for the (very consistent) previous 4 years (Table 17).

The 2022 season had 216,300 total hunting days, the fourth largest number of hunting days since the telephone survey began and a decrease of 12% from 2021. The mean number of hunting days per active hunter in 2022 (8.6) was the lowest since 2017, when the statistic could first be calculated, and 15% lower than 2021.

The estimated deer harvest per Game Licence holder in 2022 was 2.73, which is slightly above average since the surveys began and 8% more than the previous year (Table 17). The estimated deer harvest per active hunter in 2022 was 4.9 and was the smallest since 2017, when the statistic could first be calculated. These seemingly contradictory findings are explained by the proportion of active hunters. The proportion of active hunters in 2022 (50%) was average compared to other years that statistic is available (Table 17). However, it is an increase of 39% from 2021. So, whilst active hunters hunted less, there were more of them, which resulted in the overall totals being similar.

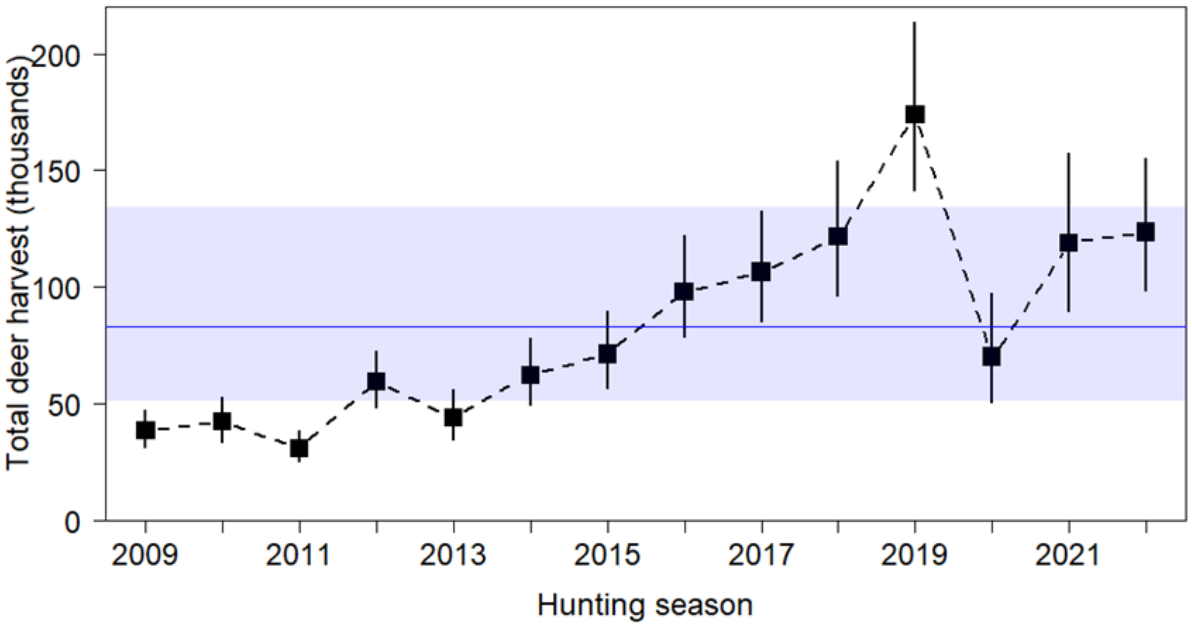

Figure 6. Estimates of total deer harvests (in thousands) from 2009 to 2022.

The square is the estimated total harvest for each season; the solid vertical line indicates the 95% confidence interval; the blue line is the average deer harvest from 2009 to 2022; the shaded area is the 95% confidence interval for the average deer harvest from 2009 to 2022.

Table 17. Comparison of Deer harvests of 2009 to 2022[13]

Year	Licences[14]	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	Deer harvest per active hunter	Hunting days per active hunter
2009	19,849	38,284	150,321	2.14	8.38	0.25	NA	NA	NA
2010	21,570	42,133	149,002	2.12	7.56	0.28	NA	NA	NA
2011	23,170	30,753	135,278	1.43	6.30	0.23	NA	NA	NA
2012	24,777	59,206	169,721	2.62	7.54	0.35	NA	NA	NA
2013	27,349	43,985	135,854	1.76	5.47	0.32	NA	NA	NA
2014	30,244	62,166	186,215	2.22	6.68	0.33	NA	NA	NA
2015	32,870	71,141	201,547	2.36	6.77	0.35	NA	NA	NA
2016	34,822	97,776	207,614	3.12	6.63	0.47	NA	NA	NA
2017	36,968	106,275	184,317	3.11	5.45	0.58	0.55	5.20	9.06
2018	39,066	121,567	237,594	3.49	6.71	0.51	0.52	6.00	11.80
2019	41,985	173,784	344,604	4.48	8.86	0.50	0.60	6.80	13.60
2020	41,056	69,914	143,488	1.80	3.68	0.49	0.35	4.90	10.06
2021	49,857	118,874	246,152	2.53	5.33	0.48	0.36	6.58	13.62
2022	50,478	123,376	216,269	2.73	4.64	0.57	0.50	4.89	8.57
Average	**33,862**	**82,802**	**193,427**	**2.56**	**6.43**	**0.41**	**0.48**	**5.73**	**11.12**

As in previous years, Sambar Deer was the most commonly harvest deer species in 2022, followed by Fallow Deer and Red Deer, with the other species not coming up in the 2022 survey (Table 18). While the Sambar Deer harvest was estimated to be 23% higher than average, the Fallow Deer estimates were the highest recorded, 148% higher than the average and 16% higher than the previous record (in 2021). Even though no survey respondent reported harvesting Hog Deer in 2022, a total of 166 Hog Deer were reported harvested (see Section 3.1).

Multiple hunters reported harvesting Sambar Deer and Fallow Deer in a survey period but did not specify the numbers of each species, meaning the percentage that each species contributed to the

[13] Deer harvested and hunting days per Game Licence holder in 2022 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.

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

total estimated harvest could not include these individuals. The people conducting the survey need to ensure this information is recorded explicitly for species and sex, where possible.

Table 18. Comparison of the 2009–2022 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
2022	0	41,180	0	1,373	0	76,178
Average	**52**	**16,633**	**103**	**1,450**	**14**	**62,017**

4.2 Deer harvest using hounds in 2022

A total of 12,428 deer were estimated to have been harvested using hounds in Victoria during the 2022 calendar year (95% CI = 10,135–15,239). The 2022 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 (6.4 deer per active hunter) was average compared previous seasons.

The 2022 total number of days spent hunting with hounds (32,209) was similar to the average compared to previous seasons (Table 19). The hunting days per active hunter using hounds was the second highest recorded and 19% higher than the average of previous seasons.

In 2022, hunter efficiency using hounds decreased to 0.39 deer per hunting day, a 17% decrease from the average of previous seasons (Table 19).

The lower-than-average hound hunting deer harvest and hound hunting efficiency was a result of the smallest recorded proportion of active hound hunters (only 40%, 16% less than the average of previous seasons (Table 19)), combined with the second largest number of hunting days per active hunter. Given the estimated hound hunting deer harvest per active hunter was average, it could be that to get the desired seasonal harvest, the hound hunters had to hunt for longer, as Sambar Deer were not as easy to detect and/or harvest. The reason for this is unclear but could be due to changes in deer demographics.

Table 19. Comparison of deer harvests using scent-trailing hounds from 2018 to 2022.

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
2022	0.40	12,428	32,209	6.40	16.58	0.39
Average	**0.46**	**14,947**	**33,419**	**6.46**	**14.50**	**0.46**

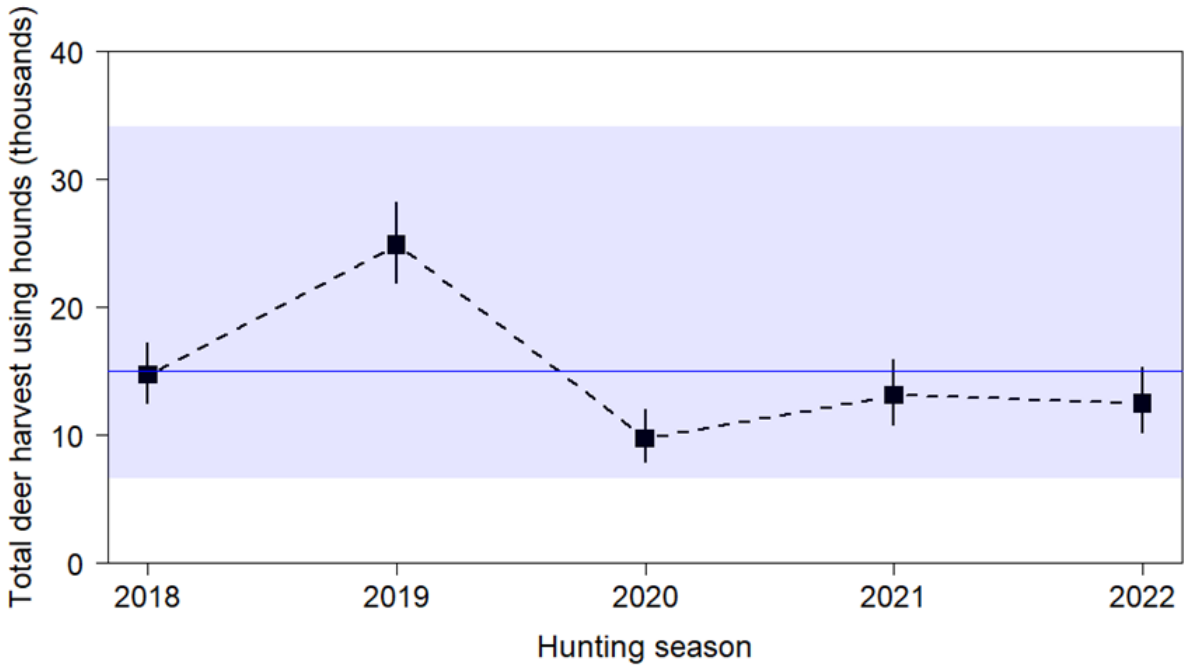

Figure 7. Estimates of total deer harvests using hounds (in thousands) from 2018 to 2022

The square is the estimated total harvest for each season; the solid vertical line indicates the 95% confidence interval; the blue line is the average deer harvest using hounds from 2018 to 2022; the shaded area is the 95% confidence interval for the average deer harvest from 2018 to 2022.

4.3 Comparing deer harvest methods in 2022

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, of active hunters, a greater proportion stalked (66% in total) than hound hunted (53% in total), while 19% did both within the 2-month period (Table 20). The responses also showed that the harvest rate differed for each method (2.8 deer harvested per team member when using hounds, compared with 2.3 deer harvested using stalking and 6.8 deer harvested if they did both) over the same period of time. Active Game Licence holders endorsed to use hounds spent an average of 6.6 days hunting deer.

In 2022, Game Licence holders endorsed to hunt deer using hounds were less efficient when using hounds to hunt deer compared to the overall efficiency rate. When using hounds, their efficiency was 0.39 deer harvested per team member per hunting day (Table 19). From the survey of the general Game Licence holders endorsed to hunt deer, the efficiency was 0.57 deer harvested per hunting day (Table 17). However, the average efficiency of Game Licence holders endorsed for using hounds that used both methods in a single 2-month period are more efficient than the general hunters. Not only is their overall efficiency higher (0.63 deer per day), but they are also more efficient at each method (0.55 and 0.78 deer per day for hound hunting and stalking respectively, Table 20).

Table 20. Comparison of hound hunting and stalking from hound hunting data only in 2022

Hunting method	Number of respondents	Proportion of respondents who were active method	Proportion of active hunters	Deer harvest using hound hunting per active hound hunter	Hunting days using hound hunting per active hound hunter	Hound hunting efficiency	Deer harvest using stalking per active stalker	Hunting days using stalking per active stalker	Stalking efficiency	Deer harvest per active hunter	Hunting days per active hunter	Hunting efficiency
Both hound hunting and stalking	32	0.08	0.19	3.9	7.1	0.55	3.0	3.8	0.78	6.8	10.9	0.63
Hound hunting only	56	0.14	0.34	2.1	7.3	0.29	0.0	0.0	NA	2.1	7.3	0.29
Stalking only	77	0.19	0.47	0.0	0.0	NA	2.0	4.3	0.46	2.0	4.3	0.46
Overall	**165**	**0.41**	**1.00**	**2.8**	**7.2**	**0.38**	**2.3**	**4.2**	**0.54**	**3.0**	**6.6**	**0.45**

4.4 Over influential records

During the analysis of the 2022 deer harvest surveys, it was noticed that some data points seemed to have an outside influence of the overall estimates of deer. Initial concerns arose when it was noted that one respondent reported harvesting seven Fallow Deer in a single day during the second survey (March-April). This seemed like a very high harvest for a recreational hunter stalking, but may be more reasonable for a person spotlighting. While spotlighting of deer on private property as part of a deer control program is legal (with the permission of the landholder), it is not considered as part of the recreational deer harvest and therefore would not be included in this report. This led to us questioning how many other reports from respondents should not be included in the total, due to being a non-recreational harvest (e.g., spotlighting) or reflected hound hunting harvests from teams, rather than individual deer harvests.

To gain some idea of the impact this false inclusion may be having on the overall deer harvest estimate, we looked at several ways of excluding data in a systematic fashion using outliers and data trimming. If we used a 5% trimmed mean (where we exclude the top and bottom 5% of harvest estimates), then the estimated total annual harvest would be reduced by 22% to 96,600. If we removed extreme outliers (as defined by Tukey 1977) from each survey, then the estimated total annual harvest would be reduced by 27% to 89,900. If we modelled the harvest responses to incorporate the number of hunting days, then excluded any data that was outside the 95% confidence interval, then the estimated total annual harvest would be reduced by 16% to 103,800. If we remove the instances of hound hunting from the general survey, we can estimate the non-hound hunting annual deer harvest, and then add the hound hunting only survey estimate to get an overall deer harvest. Doing this reduced the estimated total annual harvest by 3% to 119,600. Currently it is unclear which, if any, of these methods should be used in the future to correct for outliers and misinterpreting of the questions around recreational deer hunting. However, it is clear that these discrepancies can alter the estimates (Figure 8).

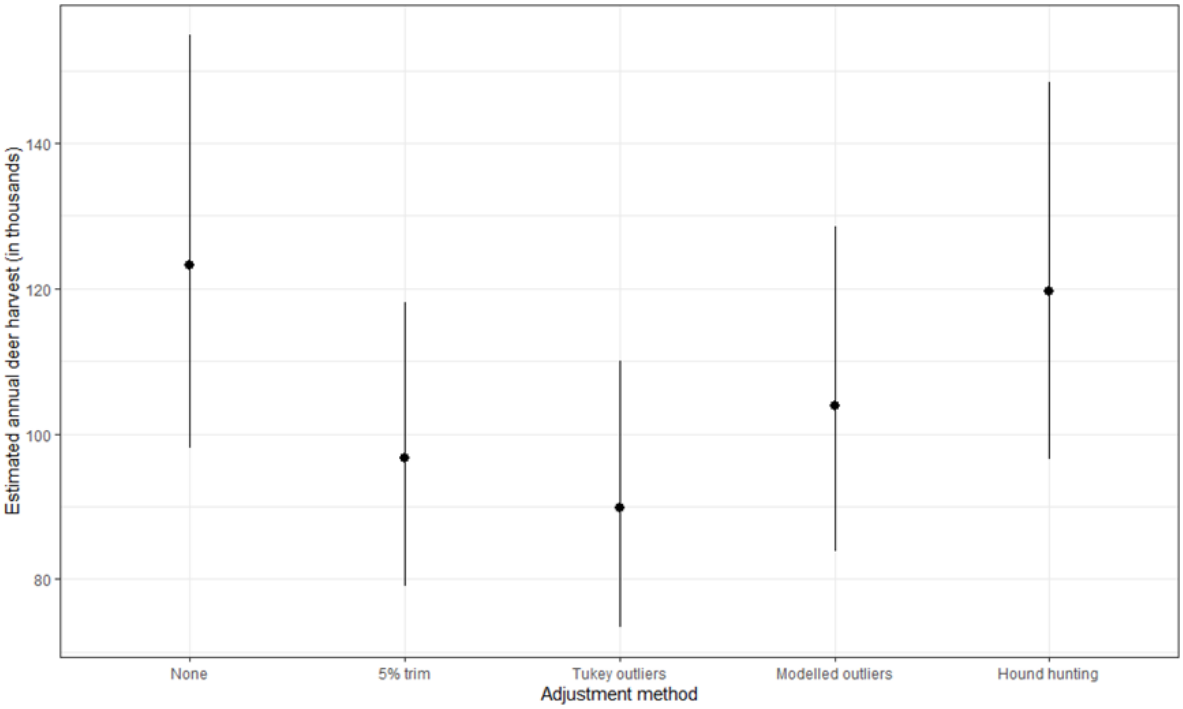

Figure 8. Estimates of total deer harvests (in thousands) in 2022 under different adjustment regimes

The point is the estimated total harvest for each regime; the solid vertical line indicates the 95% confidence interval.

4.5 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 the reasons for non-response [exceeded bag limit (for Hog Deer only), or (conversely) did not harvest anything], memory recall (respondents not remembering their harvest), and deliberate over- or under-reporting (reported numbers knowingly being reported incorrectly). 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% (Barker, 1991; Wright, 1978). 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, Geissler, & Hoover, 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 is only an approximate estimate of total effort. For example, someone who hunted for two hours and someone else who hunted for 12 hours were both recorded as having hunted for one day.

It is important to note that the methodology explicitly accounts for the possibility that not every Game Licence holder hunts in every survey period (see Gormley & 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 confidence intervals) 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 hunters, rather than taking a complete census; however, the degree of sampling uncertainty was reduced by having sample sizes of 200 respondents per survey for deer. Statistically, these sample sizes are considered adequate to provide 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 within 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 than 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.

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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) / 2022

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) / 2022

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:

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

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:

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

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).

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

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

$$\mathrm{SE}(W_j) = \mathrm{CV}(W_j) \times W_j .$$

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

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

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.

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 contained within the box. Any unusual data are highlighted as outliers. As an example, using duck-hunting data, 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 1, which indicates that at least 25% of Game Licence Holders who hunted were unsuccessful in some survey periods).

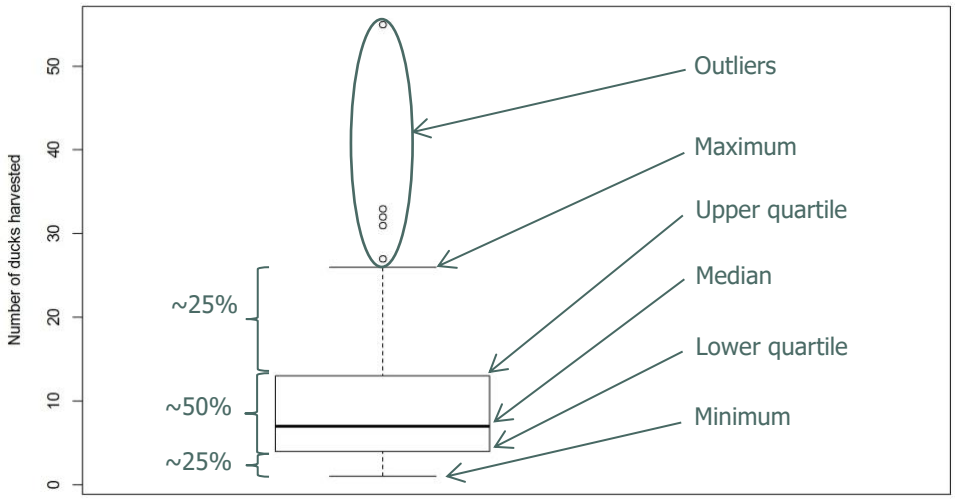

Figure A4.1. Example boxplot, with labels

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

The total average season harvest was 2.7 deer per Game Licence holder (95% CI = 2.2–3.4; Table A5.1). Note that, for each survey period, the average deer harvest per Game Licence holder (Table A5.1) was much lower than the average deer harvest 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 2022

Period	Average harvest [15]	SE	95% CI	
			Lower	Upper
Jan–Feb	0.64	0.14	0.41	0.98
Mar–Apr	0.57	0.12	0.38	0.85
May–Jun	0.50	0.14	0.30	0.84
Jul–Aug	0.42	0.11	0.25	0.70
Sep–Oct	0.48	0.17	0.24	0.94
Nov–Dec	0.13	0.06	0.05	0.31
Total	**2.73**	**0.31**	**2.18**	**3.42**

Each Game Licence holder endorsed to hunt deer hunted an average of 4.6 days during 2022, corresponding to a total of 216,269 hunter days (95% CI = 175,191–266,980; Table A5.2).

Table A5.2. Number of days deer were hunted per Game Licence holder for 2022

Period	Days hunted	SE	95% CI	
			Lower	Upper
Jan–Feb	0.48	0.10	0.33	0.71
Mar–Apr	0.66	0.15	0.43	1.02
May–Jun	1.01	0.16	0.74	1.39
Jul–Aug	1.07	0.22	0.72	1.60
Sep–Oct	0.98	0.22	0.64	1.51
Nov–Dec	0.42	0.10	0.26	0.67
Total hunting days per licence holder	**4.64**	**0.40**	**3.91**	**5.50**

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

Appendix 6: Harvest rates per Game Licence holder endorsed for hunting deer using scent-trailing hounds

The total average season harvest was 2.4 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 scent-trailing hound team member (Table A6.1) was much lower than the average deer harvest per Game Licence holder who hunted using scent-trailing 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 scent-trailing hounds in each survey period in 2022

Period	Average harvest[16]	SE	95% CI	
			Lower	Upper
Apr–May	0.38	0.07	0.27	0.54
Jun–Jul	0.53	0.09	0.38	0.74
Aug–Sep	0.37	0.11	0.21	0.65
Oct–Nov	1.16	0.20	0.83	1.61
Total	**2.43**	**0.25**	**1.99**	**2.98**

The average number of scent-trailing 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 hunted an average of 6.3 days during 2022 (Table A6.2).

Table A6.2. Number of days deer were hunted using scent-trailing hounds per Game Licence holder for 2022

Period	Days hunted	SE	95% CI	
			Lower	Upper
Apr–May	1.97	0.41	1.32	2.94
Jun–Jul	1.45	0.32	0.95	2.21
Aug–Sep	0.99	0.33	0.53	1.86
Oct–Nov	1.93	0.42	1.27	2.93
Total hunting days per licence holder	**6.34**	**0.74**	**5.05**	**7.96**

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

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