Estimates of the 2023 deer harvest in Victoria

Results from surveys of Victorian Game Licence holders in 2023

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.

The GMA is committed to genuinely partnering with Victorian Traditional Owners and Victoria's Aboriginal community to progress their aspirations.

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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 on which Sambar Deer (*Cervus unicolor*) are being hunted using hounds. This report focuses on estimating the total recreational deer harvest for 2023. 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 recreationally by licensed hunters in Victoria during 2023.

Methods:

Holders of a Victorian Game Licence endorsed for hunting deer, and the subset holding a Game Licence endorsed for hunting Sambar Deer 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 year were used to quantify the proportion of Game Licence holders who had hunted at some stage of the year.

Results:

The total estimated deer harvest in 2023 was 137,090 (95% confidence interval (CI) = 108,700-172,800). That was 11% more than 2022 (123,400) and 59% above the average since 2009 (86,400). The small increase in overall annual deer harvest compared to 2022 can be explained by an increase in the proportion of active hunters (20%) and hunting days per active hunter (22%) being counteracted by hunter efficiency decreasing by 28%. Active hunters are Game Licence holders endorsed to hunt deer who hunted at least once in 2023.

In 2023, 60% of Game Licence holders endorsed to hunt deer were active deer hunters. This was the equal highest recorded and greater than the recorded average (50%). On average, active deer hunters harvested 4.3 deer over 10.5 days, which are both below average (5.5 deer over 11 days).

The most commonly harvested species was Sambar Deer (with an estimated total harvest of 106,500, or 78% of the harvest), followed by Fallow Deer (*Dama dama*) (27,500, or 20%) while 0.4% of the harvest was not clearly identified. This proportional harvest was similar to previous years, where typically Sambar Deer and Fallow Deer account for 77% and 18% of the deer harvest respectively. The percentage not clearly identified was much lower than previous years (2%).

In 2023 it is estimated that the total number of deer harvested using hounds was 13,600 (95% CI = 11,400-16,300). The average annual deer harvest rate using hounds per active Licence holder endorsed to hunt Sambar Deer with hounds was 8.3 (95% CI = 6.4-10.7), which is higher than the general rate per active hunter (4.3). The efficiency of deer harvest using hounds (0.37 deer per hunting day per team member) is lower than the general efficiency (0.41 deer per hunting day) in 2023. This apparent contradiction is explained by larger number of hound hunting days per active hound hunter (22.4) compared to the general number of hunting days (10.5).

Conclusions and implications:

1. The 2023 deer hunting season had the second largest estimated total harvest, and the highest since the Black Summer bushfires and the COVID-19 lockdowns. Prior to these events, the estimated total deer harvest had been increasing by 17% annually. In 2023, the increase was lower and once confidence intervals are considered, it is possible that limited, if any, growth in total deer harvest occurred.

   - While more hunters were active in 2023 (equal highest recorded and 20% increase over 2022), and they hunted for more days (22% increase compared to 2022), their hunting was less efficient (28% decrease compared to 2022 and the lowest since 2015, but similar to the long-term average).

   - The average total deer harvest per active hunter was the lowest recorded since 2017 (the first year it could be estimated) and 22% lower than the long-term average.

   - The 22% increase in hunting days per active hunter could be a result of hunters not reaching their harvest targets (due to lower efficiency) and therefore needing to hunt for longer.

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, improvements around conducting the telephone surveys resulted in many fewer ambiguous deer species and sex harvest records.

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. The particularly high harvest rate for Sambar Deer do not align with recent statewide abundance estimates. Moreover, the inclusion of demographic questions and getting more detailed data on respondents who have hound hunted during the general survey could be helpful in increasing the accuracy of the surveys.

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 2023.

Recreational deer hunting is permitted to occur in Victoria for six declared game species (Game Management Authority, 2024). In 2023, 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 2022 deer-hunting seasons (Moloney & Flesch, 2021, 2022, 2023; Moloney & Hampton, 2020; Moloney & Powell, 2019) 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.

The aim of this report was to provide estimates of the number of deer harvested by licensed recreational hunters in Victoria during 2023. 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[1] 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). If someone is selected and does not answer the phone or refuses to be surveyed, then a new respondent is randomly selected to replace them. 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. For example, 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 2023 hunting season. They were asked whether they had hunted at any stage during the 2023 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 during 2023 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.

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[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 2023) 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.

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 and hounds can be used to trail and flush deer. 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. For example, 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 2023 hound hunting season. They were asked whether they had hunted with hounds at any stage during the 2023 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 the 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 2023

The number of Game Licence holders endorsed to hunt deer increased by over 10,000 during 2023, to over 52,000 by the end of 2023 (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 2023

Deer survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted[3]	Deer harvested[4]
1	Jan–Feb	41,832	200	24	105	66
2	Mar–Apr	45,548	199	48	261	81
3	May–Jun	47,842	201	58	275	124
4	Jul–Aug	49,730	200	39	207	58
5	Sep–Oct	51,222	200	51	369	169
6	Nov–Dec	52,321	200	38	149	67

The proportion of Game Licence holders who hunted in each survey period varied across the year: approximately 14,000 Game Licence holders (29%) hunted in May–June; whereas 12% of licence holders hunted in January–February (Table 2). The proportion who hunted during other survey periods was between 19% to 26% (Table 2).

Table 2. Proportion and corresponding total number of deer licence holders who hunted in each survey period in 2023

Period	Proportion	SE	95% CI Lower	95% CI Upper	Total hunters	SE	95% CI Lower	95% CI Upper
Jan–Feb	0.12	0.023	0.08	0.17	5,020	961	3,461	7,281
Mar–Apr	0.24	0.030	0.19	0.31	10,986	1,381	8,595	14,043
May–Jun	0.29	0.032	0.23	0.36	13,805	1,529	11,119	17,141
Jul–Aug	0.20	0.028	0.15	0.26	9,697	1,393	7,328	12,833
Sep–Oct	0.26	0.031	0.20	0.32	13,062	1,579	10,315	16,539
Nov–Dec	0.19	0.028	0.14	0.25	9,941	1,451	7,478	13,215

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 (one even reported 40 deer in two-months), whereas at least one-quarter of hunters did not harvest any deer in each survey period (Figure 1).The median number of deer harvested per hunter in a two-month survey ranged from 1 to 2. This is smaller than the average (mean) harvest in the same periods, which ranged from a high of 3.3 deer in September–October to a low of 1.5 in July–August (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.
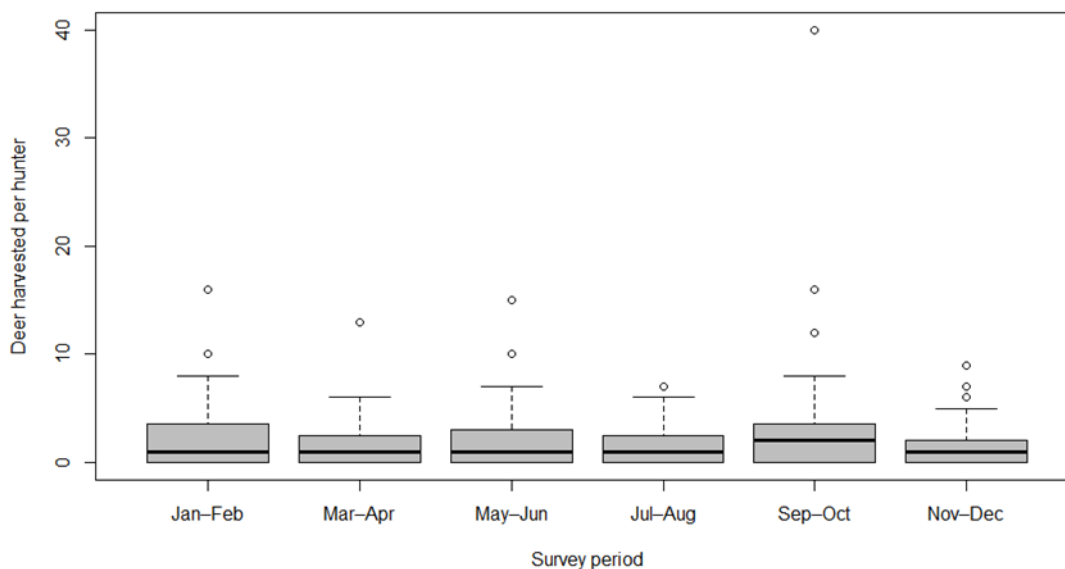
Figure 1. Boxplot of the number of deer reported harvested by individual hunters for each survey period in 2023

The bottom and top of each 'box' indicate the 25th and 75th percentiles, respectively, with the thicker 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 2023

Period	Average harvest per hunter [5]	SE	95% CI	
			Lower	Upper
Jan–Feb	2.75	0.78	1.59	4.75
Mar–Apr	1.69	0.34	1.14	2.49
May–Jun	2.14	0.38	1.51	3.03
Jul–Aug	1.49	0.29	1.02	2.18
Sep–Oct	3.31	0.86	2.01	5.46
Nov–Dec	1.76	0.35	1.19	2.61

There was an estimated total of 137,090 deer harvested from January 2023 to December 2023 (inclusive), by Game Licence holders endorsed to hunt deer (95% CI = 108,746–172,822; Table 4). Harvest was greatest in the late-summer, late-autumn-early winter and early-spring months and lowest in the late-winter and early-summer months.

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[5] Average harvest per hunter = Deer harvested divided by Respondents who hunted (Table 3. Average harvest of deer per hunter (Game Licence holders who hunted) for each survey period in 2023).

Table 4. Estimates of the total deer harvest in Victoria in 2023 by holders of a deer Game Licence

Period	Total harvest [6]	SE	95% CI	
			Lower	Upper
Jan–Feb	13,805	4,727	7,187	26,514
Mar–Apr	18,540	4,388	11,732	29,297
May–Jun	29,514	6,216	19,620	44,398
Jul–Aug	14,422	3,503	9,020	23,058
Sep–Oct	43,283	12,362	25,001	74,933
Nov–Dec	17,528	4,357	10,847	28,323
Total	**137,090**	**16,257**	**108,746**	**172,822**

From the results of the telephone survey conducted immediately after the 2023 deer-hunting season, it was estimated that 60% (95% CI = 56–41%) of Game Licence holders actually hunted for deer during 2023 (Table 5). That equates to an estimated 31,654 (95% CI = 29,245–34,262) active deer hunters[7] in 2023. The average annual deer harvest per active deer hunter was estimated to be 4.3 (95% CI = 3.4–5.5). The average number of hunting days per active deer hunter during 2023 was estimated to be 10.5 (95% CI = 9.2–12). 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 2023 by holders of a deer Game Licence who hunted at least once

Statistic	Annual estimate	SE	95% CI	
			Lower	Upper
Proportion active	0.60	0.02	0.56	0.65
Estimated active hunters	31,654	1,278	29,245	34,261
Average harvest per active hunter	4.33	0.54	3.39	5.53
Average hunting days per active hunter	10.49	0.72	9.17	12.01

Separate harvest estimates for each deer species are presented in Figure 2 and Table 6. The most frequently harvested species were Sambar Deer (78% of the total reported harvest), Fallow Deer (20%) and Red Deer (2%). No Chital Deer, Hog Deer or Rusa Deer were reported harvested in the 2023 telephone survey. At the time of this report, there were no known wild populations of Rusa or Chital Deer in Victoria.

Even though no survey respondent reported harvesting Hog Deer in 2023 during the telephone surveys, a total of 185 Hog Deer (145 stags and 40 hinds) were recorded in harvest returns. Of these, 28 were from the Snake Island, Boole Poole and Blond Bay Wildlife Reserve balloted hunts (18 stags and 10 hinds). The remainder of the deer were harvested on private property or other public lands open to deer hunting, including State Game Reserves.

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[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.
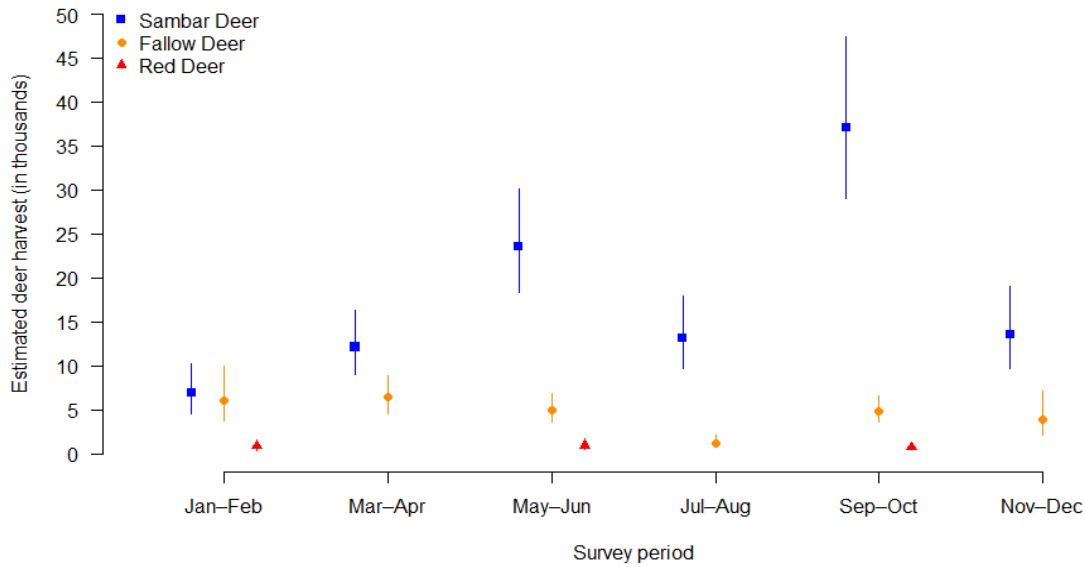
Figure 2. Estimated total deer harvest for each two-month survey period in 2023 by species.

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

Table 6. Estimates of total harvest per deer species for each survey period in 2023

a. Sambar Deer

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	33	6,902	1,429	4,620	10,312
Mar–Apr	53	12,131	1,830	9,041	16,276
May–Jun	99	23,564	2,972	18,420	30,144
Jul–Aug	53	13,178	2,098	9,665	17,970
Sep–Oct	145	37,136	4,642	29,094	47,400
Nov–Dec	52	13,603	2,327	9,751	18,977
Total	**435**	**106,515**	**6,752**	**94,082**	**120,591**

b. Fallow Deer

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	29	6,066	1,560	3,694	9,961
Mar–Apr	28	6,409	1,103	4,584	8,959
May–Jun	21	4,998	814	3,641	6,863
Jul–Aug	5	1,243	341	734	2,107
Sep–Oct	19	4,866	782	3,558	6,654
Nov–Dec	15	3,924	1,213	2,171	7,093
Total	**117**	**27,506**	**2,552**	**22,942**	**32,978**

c. Red Deer

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	4	837	286	437	1,604
Mar–Apr	0	0	NA	NA	NA
May–Jun	4	952	308	513	1,768
Jul–Aug	0	0	NA	NA	NA
Sep–Oct	3	768	212	452	1,307
Nov–Dec	0	0	NA	NA	NA
Total	**11**	**2,557**	**471**	**1,788**	**3,657**

There was no statistically significant sex bias favouring males or females for the harvest (Table 7).

Table 7. Reported numbers and percentages of each sex by deer species harvested in 2023

Species	Male			Female		
	Reported	%	SE	Reported	%	SE
Sambar Deer	205	47	2	230	53	2
Fallow Deer	48	41	5	69	59	5
Red Deer	6	55	15	5	45	15

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 10.5 days during 2023, corresponding to an estimated total of 332,110 hunter days (95% CI = 297,693-370,507; Table 8) across all licence holders.

Table 8. Number of days deer were hunted by Game Licence holder for 2023

Period	Days hunted by Game Licence holders	SE	95% CI	
			Lower	Upper
Jan–Feb	21,962	4,205	15,140	31,857
Mar–Apr	59,739	7,511	46,736	76,359
May–Jun	65,455	7,249	52,718	81,271
Jul–Aug	51,471	7,395	38,895	68,113
Sep–Oct	94,505	11,422	74,635	119,663
Nov–Dec	38,979	5,691	29,323	51,815
Total hunting days	**332,110**	**18,552**	**297,693**	**370,507**
Total hunting days per active hunter	**10.49**	**0.72**	**9.17**	**12.01**

More deer hunting occurred exclusively on public land (52%) compared with exclusively on private land (33%). Despite this, similar numbers of deer were harvested on both land tenures (41% and 42% respectively) (Table 9). More Sambar Deer were harvested on public land (48%) than other land tenures. Most Fallow Deer were harvested on private land only (66%).

Table 9. Percentage of days of hunting and associated deer species harvest by land tenure in 2023

Land tenure	Days	Total Deer harvest	Sambar Deer harvest	Fallow Deer harvest	Red Deer harvest
Private land only	33.4	42.1	35.6	65.8	54.5
Public land only	52.2	41.1	47.6	15.4	45.5
Both	13.8	16.1	16.3	17.1	0.0
Not specified	0.7	0.7	0.5	1.7	0.0

The most common hunting practice was stalking without a dog on public land (41% of days). However, more deer were harvested stalking without a dog on private land (38% 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. In total 1% of hunters did not specify the land tenure where the hunting took place, which was also much less than normal.

Table 10. Percentage of days of hunting and associated deer harvest technique by land tenure in 2023

Land tenure		Scent-trailing hounds	Stalking without dog	Stalking with dog	Technique not specified	Total
Private land only	Days	0	31	2	0	33
	Deer	0	38	4	0	42
Public land only	Days	10	41	1	1	52
	Deer	15	25	1	0	41
Both	Days	0	13	0	0	14
	Deer	1	16	0	0	16
Not specified	Days	0	1	0	0	1
	Deer	0	1	0	0	1
Total	**Days**	**10**	**86**	**3**	**1**	**100**
	Deer	**15**	**79**	**5**	**0**	**100**

Total harvest was estimated to be greatest in the Goulburn Broken CMA, followed by the North East CMA and the East Gippsland CMA (Figure 3). The top five towns for the total reported number of deer harvested were (in descending order) Mansfield, Licola, Dargo, Omeo and Benalla. The top five towns for the total number of reported deer hunting days were (in descending order) Mansfield, Licola, Omeo, Warragul and Dargo.
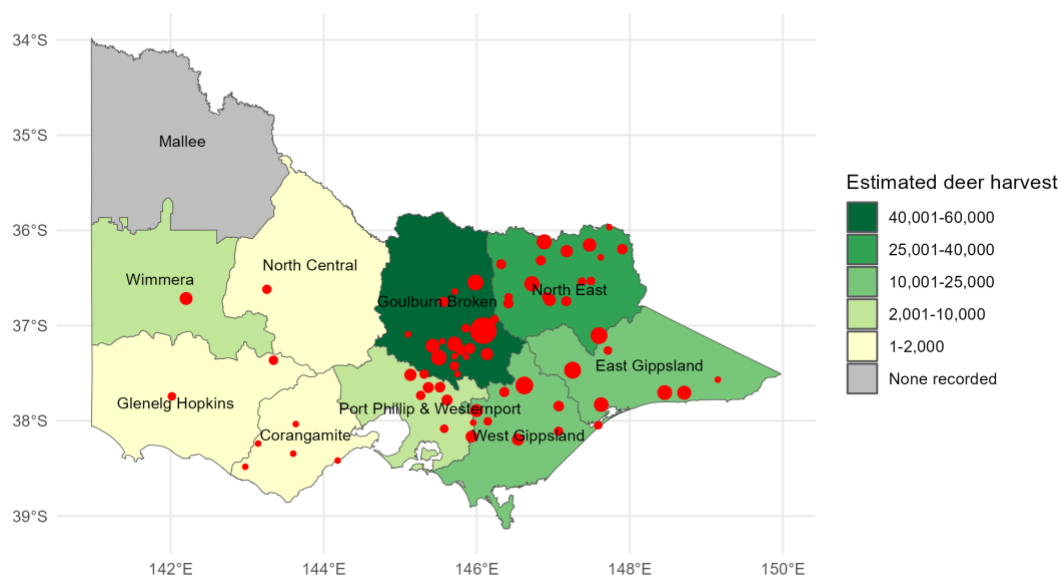
Figure 3. Estimates of total deer harvest in 2023 by CMA region

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

3.2 Overall deer harvest using hounds in 2023

The number of Game Licence holders endorsed for using hounds was fairly consistent throughout 2023, from 4,919 in April-May to 5,153 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 2023 Game Licence holders endorsed to use hounds

Deer survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted	Deer harvested[8]
1	Apr–May	4,919	100	31	183	321
2	Jun–Jul	4,989	100	25	198	372
3	Aug–Sep	5,123	100	29	250	321
4	Oct–Nov	5,153	100	18	100	326

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 (18%) 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 2023

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
Apr–May	0.31	0.046	0.23	0.41	1,525	228	1,140	2,040
Jun–Jul	0.25	0.043	0.18	0.35	1,247	216	890	1,747
Aug–Sep	0.29	0.045	0.21	0.39	1,486	232	1,095	2,015
Oct–Nov	0.18	0.038	0.12	0.27	928	198	613	1,403

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 (9%) harvested more than 30 deer in a survey period, whereas 10% 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 9 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 2023 ranged from a high of 3.3 deer in October–November to a low of 1.83 in April–May.

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[8] Deer harvested indicates the total number of deer harvested by hound teams of which the respondents were members.
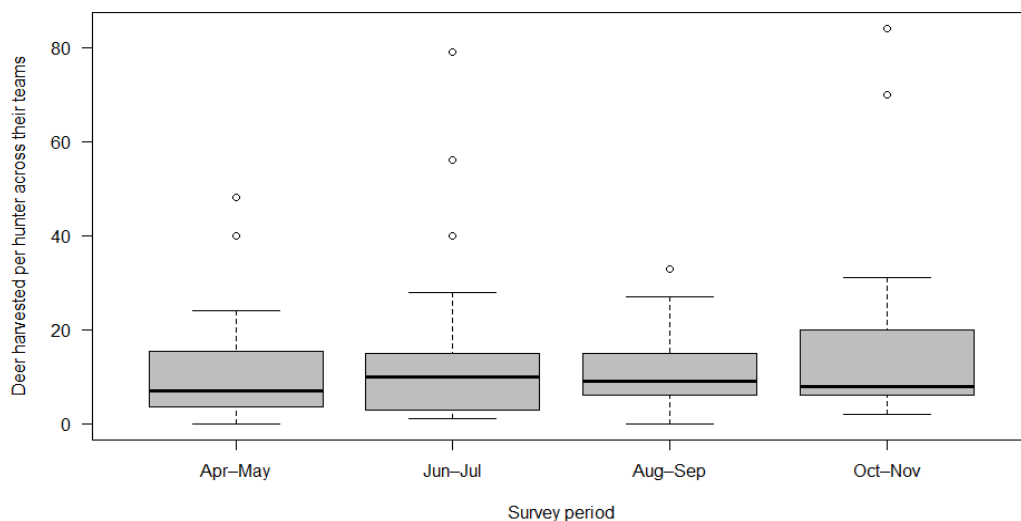
Figure 4. Boxplot of the number of deer reported harvested by scent-trailing hound teams for each survey period in 2023

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 2023

Period	Average harvest per hound hunter[9]	SE	95% CI	
			Lower	Upper
Apr–May	1.83	0.07	1.70	1.98
Jun–Jul	2.59	0.15	2.31	2.91
Aug–Sep	3.04	0.11	2.83	3.26
Oct–Nov	3.32	0.16	3.02	3.66

There was an estimated total of 13,625 deer harvested from April 2023 to November 2023, inclusive, by Game Licence holders endorsed for using hounds and who actually hunted using hounds (95% CI = 11,416—16,260; Table 14).

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[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.

Table 14. Estimates of the total deer harvest using hounds in Victoria in 2023 by holders of a deer Game Licence endorsed for using hounds

Period	Total harvest[10]	SE	95% CI Lower	Upper
Apr–May	2,794	431	2,069	3,773
Jun–Jul	3,234	592	2,266	4,615
Aug–Sep	4,515	725	3,302	6,173
Oct–Nov	3,082	675	2,016	4,711
Total	**13,625**	**1,232**	**11,416**	**16,260**

From the responses to the telephone survey undertaken immediately after the conclusion of the 2023 season for deer hunting using hounds, it was estimated that 34% (95% CI = 28%–41%) of Game Licence holders endorsed for using hounds actually hunted with hounds during 2023 (Table 15). That equates to an estimated 1,647 (95% CI = 1,358–1,997) active deer hunters using hounds[11] in 2023. The average number of deer harvested per active deer hunter using hounds was estimated to be 8.3 (95% CI = 6.4–10.7) over 2023.

Table 15. Annual estimates of deer harvested using hounds in Victoria in 2023 by active Game Licence holders endorsed for using hounds

Statistic	Annual estimate	SE	95% CI Lower	Upper
Proportion active	0.34	0.03	0.28	0.41
Estimated number of active hunters	1,647	162	1,358	1,997
Average harvest per active hunter	8.27	1.11	6.37	10.74
Average hunting days per active hunter	22.37	3.17	16.97	29.49

There was evidence of a sex bias for Sambar Deer harvested by using hounds. The proportion of the harvest that was female was 55% (95% CI = 53%–58%).

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 August - September. The total number of days of deer hunting using hounds in 2023 was 36,840 days (Table 16).

Table 16. Total number of days on which teams hunted using hounds in 2023 by survey period

Period	Days hunted	SE	95% CI Lower	Upper
Apr–May	9,002	2,231	5,579	14,526
Jun–Jul	9,878	2,691	5,847	16,689
Aug–Sep	12,808	3,101	8,022	20,448
Oct–Nov	5,153	1,784	2,665	9,966
Total number of days of hunting using hounds	**36,840**	**5,002**	**28,267**	**48,014**

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

[11] 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 3.5). The top five towns for the total reported number of deer harvested using hounds were (in descending order) Mansfield, Myrtleford, Dargo, Licola and Benambra. The top five towns for the total number of reported deer hunting days using hounds were (in descending order) Mansfield, Dargo, Licola, Myrtleford and Bairnsdale.
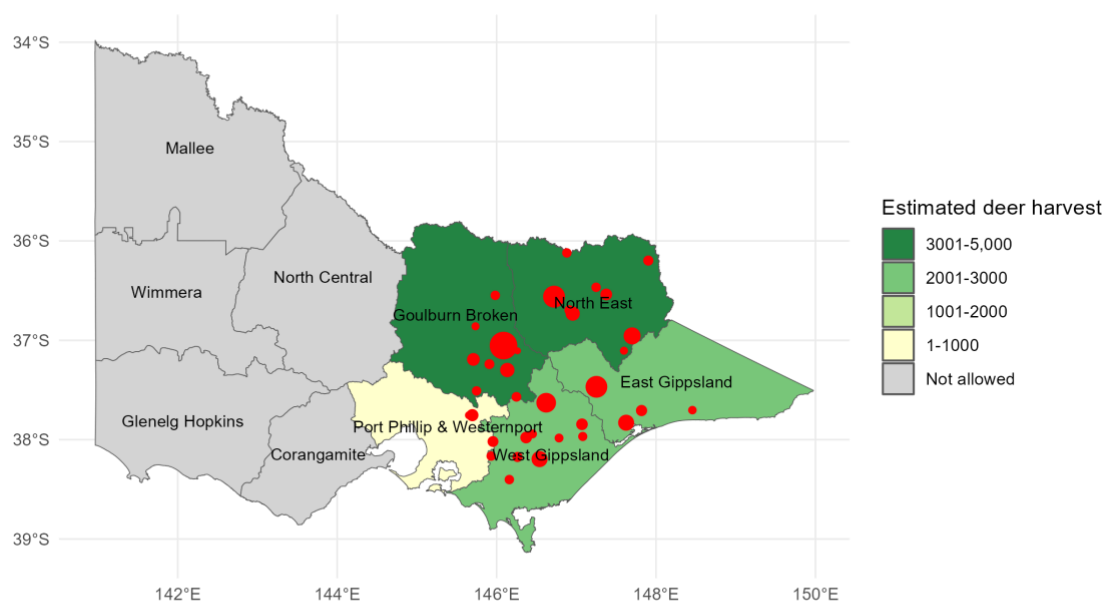
Figure 5. Estimates of total deer harvest using scent-trailing hounds in 2023 by CMA region

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

4 Discussion

4.1 Deer harvest in 2023

A total of 137,090 deer were estimated to have been harvested in Victoria during the 2023 calendar year (95% CI = 108,746–172,822). The 2023 estimate was 11% greater than the 2022 estimate (123,400) and 59% greater than the average since 2009 (86,400). 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 2023 deer harvest was the second largest on record since the surveys began in 2009 (Table 17 Figure 6), but 21% lower than the peak deer harvest estimate in 2019 (173,800).

The final number of Game Licence holders endorsed to hunt deer in 2023 (52,321) was the largest recorded to date, continuing the trend that has happened every year except 2020 which was impacted by COVID-related restrictions on people movement. The proportion of hunters who actively hunted in 2023 (60%) matched the highest recorded activity rate (from 2019, Table 17).

Hunter efficiency in 2023 was 0.41 deer harvested per hunting day, which is the lowest recorded since 2016, but equal to the average since the surveys started in 2009 (Table 17).

The 2023 season had 332,100 total hunting days, the second largest number of hunting days since the telephone survey began and an increase of 54% from 2022. The mean number of hunting days per active hunter in 2023 (10.5) was the median since 2017, when the statistic could first be calculated, and 22% greater than 2022, which is the lowest recorded.

The estimated deer harvest per Game Licence holder in 2023 was 2.82, which is 9% more than the average since the surveys began and very similar to the previous year (Table 17). The estimated deer harvest per active hunter in 2023 was 4.3 which 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 2023 (60%) was high compared to other years that statistic is available (Table 17). So, whilst active hunters harvested 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 2023

Each black square represents the estimated total harvest for each season; the solid vertical line through each black square indicates the 95% confidence interval for estimated harvest in that season; the blue line is the average deer harvest from 2009 to 2023; the shaded area is the 95% confidence interval for the average deer harvest from 2009 to 2023.

Table 17. Comparison of Deer harvests of 2009 to 2023[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	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
2023	52,321	137,090	332,110	2.82	6.83	0.41	0.60	4.33	10.49
Average	**35,092**	**86,422**	**202,672**	**2.58**	**6.46**	**0.41**	**0.50**	**5.53**	**11.03**

[12] Deer harvested and hunting days per Game Licence holder in 2023 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.

Table 18. Comparison of the 2009–2023 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
2023	0	27,506	0	2,557	0	106,515
Average	**49**	**17,358**	**96**	**1,523**	**13**	**64,984**

As in previous years, Sambar Deer were the most commonly harvest deer species in 2023, followed by Fallow Deer and Red Deer, with the other species not being reported in the 2023 survey (Table 18). Even though no survey respondent reported harvesting Hog Deer in 2023, a total of 185 Hog Deer were reported harvested (see Section 3.1). This is consistent with previous years, as the proportion of Hog Deer hunters is low, and on average we have reporting of Hog Deer harvested in the telephone surveys half the time, even though we know Hog Deer were harvested through the harvest returns for Hog Deer.

Improvements to the way the surveys are conducted have meant that the issue of ambiguous deer species and sex in harvest totals was all but eliminated in the 2023 surveys.

4.2 Deer harvest using hounds in 2023

A total of 13,625 deer were estimated to have been harvested using hounds in Victoria during the 2023 calendar year (95% CI = 11,416-16,260). The 2023 deer harvest using hounds was 9% smaller than the average of previous seasons (Table 19, Figure 7). The deer harvest per active hunter using hounds (8.27 deer per active hunter) was 22% greater than the average.

The 2023 total number of days spent hunting with hounds (36,840) was 8% above average compared to previous seasons (Table 19). The hunting days per active hunter using hounds was the second highest recorded and 54% higher than the average of previous seasons.

In 2023, hunter efficiency using hounds decreased to 0.37, the lowest recorded and a 19% 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 (34%), 26% 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 above 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.
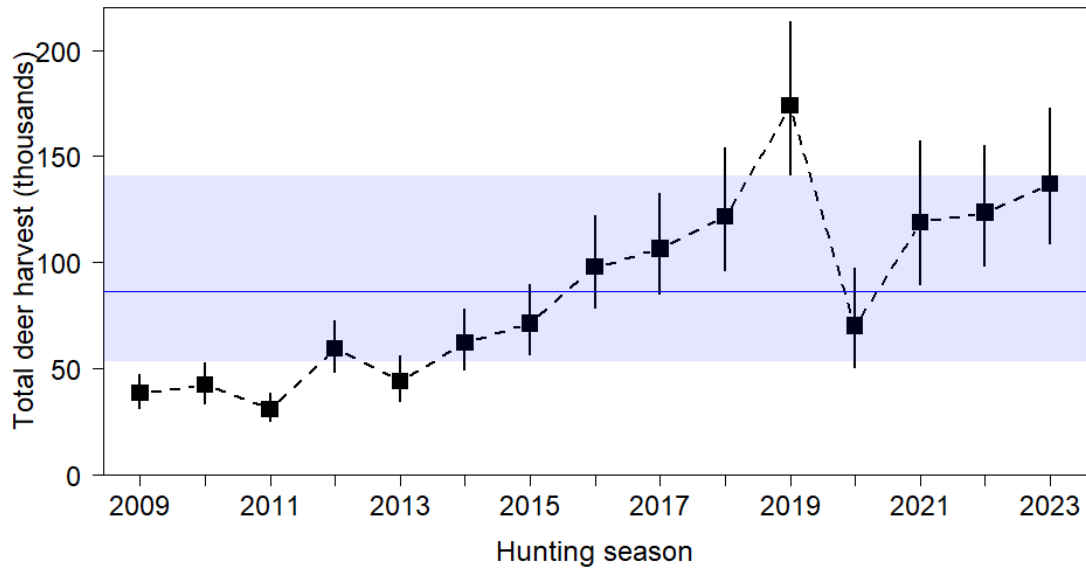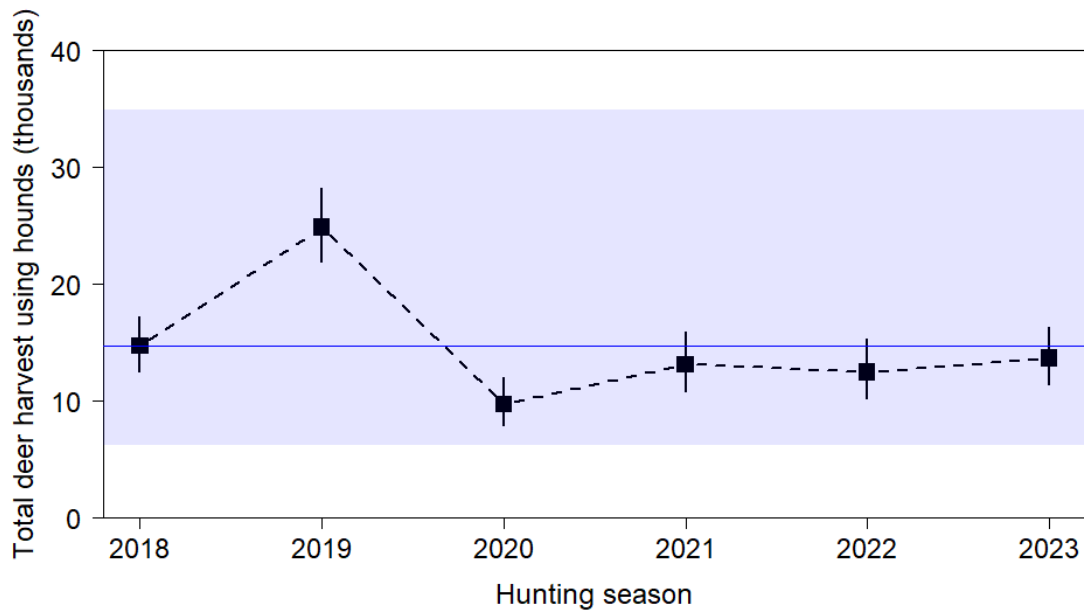
Figure 7. Estimates of total deer harvests using hounds (in thousands) from 2018 to 2023

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 2023; the shaded area is the 95% confidence interval for the average deer harvest from 2018 to 2023.

Table 19. Comparison of deer harvests using scent-trailing hounds from 2018 to 2023

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
2023	0.34	13,625	36,840	8.27	22.37	0.37
Average	**0.44**	**14,726**	**33,989**	**6.76**	**15.81**	**0.44**

4.3 Comparing deer harvest methods in 2023

The survey of Game Licence holders endorsed for using hounds also asked about any stalking they had done during the same period. This allows us to directly compare the harvest, hunting and efficiency rates. Of the active hunters from the hound hunting surveys, more stalked (64%) than hound hunted (55%), while 19% did both within the 2-month period (Table 20). The average harvest per hunter was largest for hunters who used both methods (4.2 deer) compared hunters that used only one method (2.6 deer per team member using hounds and 2.4 deer with stalking). Active Game Licence holders endorsed to use hounds spent an average of 6.9 days hunting deer.

The surveys in 2023 suggest that stalking is more efficient that hound hunting in a per person sense. The overall efficiency from the general survey was 0.41 deer harvested per hunting day (Table 17). The hound hunting efficiency from the hound hunter survey was 0.37 deer harvested per team member per hunting day (Table 19). The overall efficiency of hunters endorsed to use hounds, but that only used stalking during the survey period, was 0.56 deer per day (Table 20). That means hunters who could have hunted with hounds, but chose to exclusively stalk, performed better than other hunters. These results are surprising, given that typically hound hunting (88% of hunts successful (Hampton et al., 2023)) is more efficient than stalking (6% of hunts successful (Comte et al., 2023)). As a unit, hound hunter teams are more efficient (1.9 deer per team per day), but, the average team consists of 5.3 hunters.

Table 20. Comparison of hound hunting and stalking from hound hunting data in 2023

Hunting method	Number of respondents	Proportion of respondents	Deer harvest using hound hunting per active hound hunter	Hound hunting efficiency	Deer harvest using stalking per active stalker	Stalking efficiency	Deer harvest per active hunter	Hunting efficiency
Both hound hunting and stalking	35	0.09	2.8	0.40	1.4	0.39	4.2	0.40
Hound hunting only	68	0.17	2.5	0.35	NA	NA	2.5	0.35
Stalking only	84	0.21	NA	NA	2.8	0.56	2.8	0.56
Overall	**187**	**0.47**	**2.6**	**0.37**	**2.4**	**0.52**	**3.0**	**0.43**

4.4 Comparison to the Victorian deer estimate

The statewide deer monitoring program recently produced estimates of deer across Victorian public-tenured land from surveys in 2021 to 2023 (Cally & Ramsey, 2023). It estimated that the total deer abundance on public-tenured land was 191,153 (90% CI = 146,732-255,490). The estimated 2023 deer harvest of 137,090 would mean that a very high proportion of the Victorian deer population was harvested, even allowing for extra deer located on non-public tenured lands. If we look at the estimated harvest on public land alone (Table 21), the proportion of harvest to abundance for Fallow and Red Deer is approximately 0.1. This indicates a sustainable harvest, as the estimated maximum removal rate[14] is 0.34 for Fallow Deer, and while there isn't an estimate for Red Deer in Australia, other deer species are between 0.30-0.46 (Hone et al., 2010). However, the overall harvest is dominated by Sambar Deer, which would not be sustainable at a proportion of 0.5, given the estimated maximum removal rate is 0.40 (Hone et al., 2010) and the estimated annual growth rate of Sambar Deer in Victoria is 15% (Watter et al., 2020). If the upper bound of the Sambar Deer population estimate on public land (Cally & Ramsey 2023) was used instead of the mean, the harvest proportion would be 0.39, which is at the estimated maximum removal rate for Sambar Deer.

Table 21. Comparison of statewide public land deer abundance and harvest estimates on public land

Cohort	Abundance estimate	Harvest estimate	Harvest proportion[15]
Sambar	123,061	60,939	0.50
Fallow	48,932	5,217	0.11
Red	12,672	1,163	0.09
Total	**191,153**	**67,319**	**0.35**

These high proportions suggest that there may be some over-estimation of the recreational deer harvest; some of the very high daily deer harvests reported may be more reasonable for a person spotlighting as part of control activities, a hound team total, or deer hunting in a different jurisdiction (e.g. New South Wales). While spotlighting of deer on private property 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 (no respondents in 2023 gave spotlighting as their method). If the harvest given was for a team of hound hunters, then it should be scaled to reflect the harvest per hunter, but currently we don't know if respondents have given their total or the team total, so no correction can be made. If the hunting occurred in a different jurisdiction, then it should not be included in the Victorian deer harvest (the 7 respondents gave hunting locations that were in New South Wales in 2023 were reclassified as "non-active" and their harvest and hunting days removed), but it is possible that some others may have been missed if the location they gave was unclear.

To gain some idea of the impact false inclusions 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) the estimated total annual harvest would be reduced by 1% to 130,200. If we removed extreme outliers (as defined by Tukey (1977)) from each survey, then the estimated total annual harvest would be reduced by 21% to 103,300. 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 9% to 118,500. 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 hounding only survey estimate to get an overall deer harvest. Doing this

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[14] The estimated maximum removal rate is the maximum annual proportion of animals to remove to stop population growth.

[15] The harvest proportion is the estimated harvest divided by the estimated abundance.

reduced the estimated total annual harvest by 5% to 123,800. 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 4.3). There is potential to run a validation on the plausibility of some of the metrics to help determine outliers. Recruiting a group of hunters with various hunting styles (methods and species), experience and locations who agree to document their hunting activity (times, locations, method used and harvest) contemporaneously for a year as well as maybe even non-harvested deer sightings may provide more accurate data for testing discrepancies. An app or website could be created for them to use and record their effort and success, including GPS co-ordinates and images. These data could then be analysed to better understand the likelihood of different harvest rates under different circumstances.
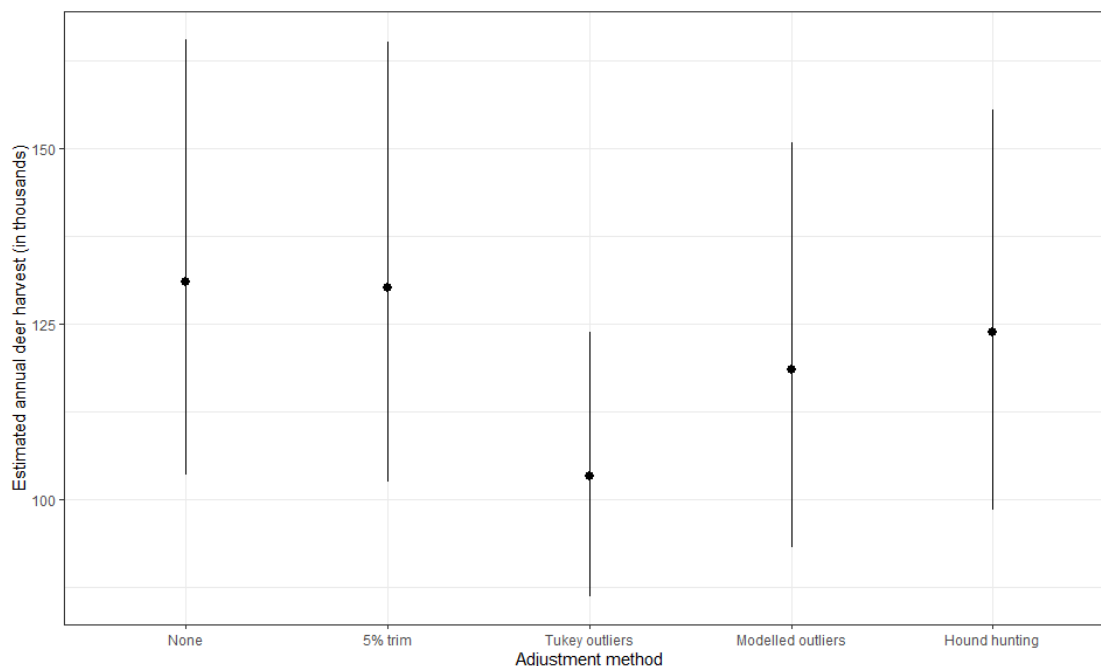

Figure 8. Estimates of total deer harvests (in thousands) in 2023 under different adjustment regimes

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, 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 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 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 3.1 and Figure 3.4). 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 5 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 distribution 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 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:

1. **What is the main species of deer you hunt?**
   a. Sambar
   b. Fallow
   c. Red
   d. Rusa
   e. Chital
   f. Hog

2. **What is your main hunting method?**
   a. Stalking
   b. Stalking with a gundog
   c. Hound hunting
   d. Bowhunting
   e. Muzzle loader
   f. Spotlighting

3. **Have you hunted deer in last 2 months?**
   a. Yes with hounds - proceed to question 4 in the hound hunting survey
   b. Yes stalking – continue to question 4.
   c. No – end the survey and thank them for their time.

4. **How many deer hunting trips were taken in the last 8 weeks?**
   Enter number _____

5. **Starting with trip 1, how many days was this hunting trip?**
   Enter number _____

6. **Did you hunt with a gundog?**

7. **What was the number of each species of deer you harvested? Enter the number for each species)**

    a. Sambar _____

    b. Fallow _____

    c. Red   _____

    d. Rusa   _____

    e. Chital _____

    f. Hog   _____

8. **Number of males of each species you harvested? (enter number of males)**

    a. Sambar _____

    b. Fallow _____

    c. Red   _____

    d. Rusa   _____

    e. Chital _____

    f. Hog   _____

9. **Number of females for each species you harvested? (enter number of females)**

    a. Sambar _____

    b. Fallow _____

    c. Red   _____

    d. Rusa   _____

    e. Chital _____

    f. Hog   _____

10. **Did you shoot and lose any deer? (if so, enter number and species)**

    a. Sambar _____

    b. Fallow _____

    c. Red   _____

    d. Rusa   _____

    e. Chital _____

    f. Hog   _____

11. How were the deer taken?

      a. Stalking

      b. Stalking with a gundog

      c. Bowhunting

      d. Muzzle loader

      e. Spotlighting

12. What type of bullets did you use on this trip?

      a. Copper (monolithic)

      b. Lead (copper jacketed)

13. What was the nearest major town to where you hunted on this trip? Enter the name of the town. Please ensure it is a town (eg, Bairnsdale) and not a region (eg, Gippsland)

      Enter town name _____

14. Did you hunt predominantly on private land or public land on this hunting trip?

      a. Public Land

      b. Private land

Repeat questions 5-14 for each trip taken.

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

Survey details:

1. **Have you been hound hunting in the last two months? If 'no', proceed to question 11.**

2. **How many hound hunting trips have you been on in the last 2 month?**
   Enter number _____

3. **Starting with trip 1, how many days was of this hunting trip?**
   Enter number _____

4. **How many hunters were in your team on this trip?**
   Enter number _____

5. **How many deer did your team harvest on this hunting trip?**
   Enter number _____

6. **How many deer did you personally (not your team) harvest on this hunting trip?**
   Enter number _____

7. **What were the numbers of male deer (stags/bucks) and female deer (hinds/does) that you harvested?**
   Enter numbers M: _____   F:_____

8. **Did you shoot and lose any deer? (if so, how many?)**
   Enter number _____

9. **Did you hunt predominantly on private land or public land on this hunting trip?**
   a. Public
   b. Private

10. **What was the nearest major town to where you hunted? Enter the name of the town. Please ensure it is a town (eg, Bairnsdale) and not a region (eg, Gippsland)**
    Enter town name _____

Repeat questions 3-10 for each hound hunting trip taken

11. **Have you been deer hunting without hounds in the past four weeks? If 'Yes', proceed to question 4 of the Deer Hunting (stalking) survey. If 'No', end the survey and thank them for their time.**

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).

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

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

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

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

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

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 $Q1 - 1.5 \times IQR$ or above $Q3 + 1.5 \times IQR$, 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).
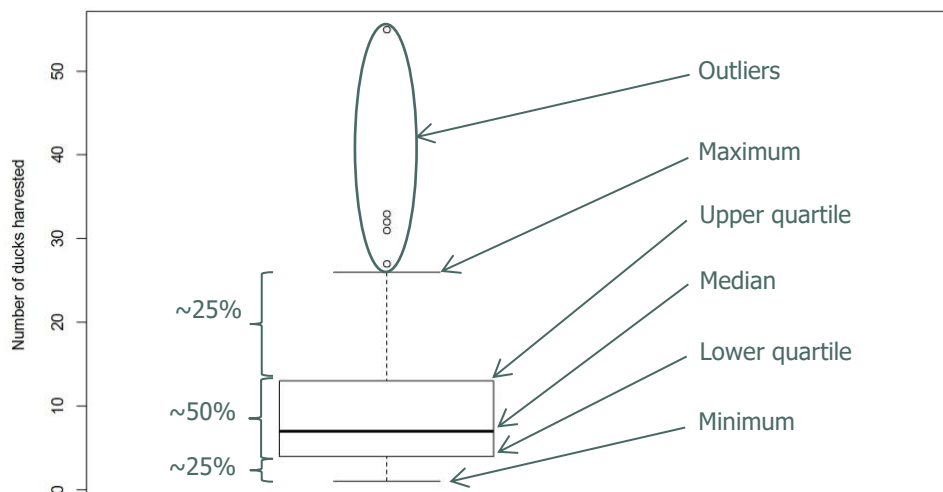

Figure A4.1. Example boxplot, with labels

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

The total average season harvest was 2.8 deer per Game Licence holder (95% CI = 2.2–3.5; Table A1). Note that, for each survey period, the average deer harvest per Game Licence holder (Table A1) was much lower than the average deer harvest per Game Licence holder who hunted (Table 3. Average harvest of deer per hunter (Game Licence holders who hunted) for each survey period in 2023), because the former included those respondents who did not hunt during the survey period.

Table A1 Estimates of average harvest of deer per Game Licence holder in each survey period in 2023

Period	Average harvest [16]	SE	95% CI	
			Lower	Upper
Jan–Feb	0.33	0.11	0.17	0.63
Mar–Apr	0.41	0.10	0.26	0.64
May–Jun	0.62	0.13	0.41	0.93
Jul–Aug	0.29	0.07	0.18	0.46
Sep–Oct	0.84	0.24	0.49	1.46
Nov–Dec	0.34	0.08	0.21	0.54
Total	**2.82**	**0.33**	**2.25**	**3.55**

Each Game Licence holder endorsed to hunt deer hunted an average of 6.8 days (95% CI = 5.7–8.2; Table A2) during 2023, corresponding to a total of 332,110 hunter days (95% CI = 297,693–370,507; Table 8. Number of days deer were hunted by Game Licence holder for 2023).

Table A2. Number of days deer were hunted per Game Licence holder for 2023

Period	Days hunted	SE	95% CI	
			Lower	Upper
Jan–Feb	0.52	0.13	0.32	0.85
Mar–Apr	1.31	0.35	0.78	2.19
May–Jun	1.37	0.23	0.99	1.89
Jul–Aug	1.03	0.19	0.72	1.48
Sep–Oct	1.84	0.39	1.23	2.77
Nov–Dec	0.74	0.15	0.51	1.09
Total hunting days per licence holder	**6.83**	**0.63**	**5.70**	**8.19**

[16] 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 2.7 deer per Game Licence holder using scent-trailing hounds (95% CI = 2.3–3.2; Table A3). Note that, for each survey period, the average deer harvest per scent-trailing hound team member (Table A3) 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 A3. Estimates of average harvest of deer per Game Licence holder using scent-trailing hounds in each survey period in 2023

Period	Average harvest[17]	SE	95% CI	
			Lower	Upper
Apr–May	0.57	0.09	0.42	0.77
Jun–Jul	0.65	0.12	0.45	0.93
Aug–Sep	0.88	0.14	0.64	1.20
Oct–Nov	0.60	0.13	0.39	0.91
Total	**2.70**	**0.24**	**2.26**	**3.21**

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 7.3 days during 2023 ((95% CI = 6.0–9.0; Table A4).

Table A4. Number of days deer were hunted using scent-trailing hounds per Game Licence holder for 2023

Period	Days hunted	SE	95% CI	
			Lower	Upper
Apr–May	1.83	0.36	1.25	2.69
Jun–Jul	1.98	0.42	1.32	2.98
Aug–Sep	2.50	0.46	1.75	3.58
Oct–Nov	1.00	0.27	0.59	1.69
Total hunting days per licence holder	**7.31**	**0.77**	**5.95**	**8.98**

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