Estimates of the 2017 deer harvest in Victoria

Results from surveys of Victorian Game Licence holders in 2017

Game Management Authority

Acknowledgements

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Estimates of harvest for deer in Victoria: results from surveys of Victorian game Licence holders in 2016.

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Front cover photo: Sambar stag resting with two hinds. (Photograph: Mike Welch)

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Summary

From January to December 2017, telephone surveys of Victorian hunters were conducted to estimate the recreational deer harvest. Holders of a Game Licence endorsed for hunting deer (hereafter referred to as 'Game Licence holders) were randomly sampled and interviewed by telephone at two-month intervals throughout the year. In all surveys, respondents were asked whether they had hunted or not during the period for which the survey applied and (if applicable) the number and species of deer harvested. Additional information was obtained on hunting methods and locations.

The 2017 deer-hunting season had a higher than average harvest, compared with the previous survey years. The total harvest in 2017 [106,275; 95% confidence interval (CI): 85,344–132,340] was considerably greater than the average since 2009 (61,621). The average number of deer harvested per Game Licence holder (3.1) was greater than the average since 2009 (2.3). This was due (in large part) to an increase in harvesting efficiency, which may in turn be due to an increase in deer populations. The average number of deer harvested per hunting day (0.58) was greater than the average since 2009 (0.35), while the effort (hunting days per Game Licence holder) was lower than average (5.5 in 2017, compared with the 6.8 average since 2009). Since 2009, the total reported number of deer harvested has increased each year by an average of around 15%. The most commonly harvested species was Sambar Deer (Cervus unicolor, with an estimated total harvest of 88,816, or 84% of the harvest), followed by Fallow Deer (Dama dama, 15,515, or 15%).

An estimated 27,517 of the 88,816 Sambar Deer were harvested by Game Licence holders endorsed for hunting deer with scent-trailing hounds, accounting for 24.9% of the total deer harvest, but only 15% of the total hunting days. For hunters using scent-trailing hounds in 2017, the efficiency was 0.92 deer per hunting day, compared with 0.51 deer per hunting day for hunters using stalking, which clearly indicates a greater efficiency for hunting using scent-trailing hounds. However, these results are based on feedback from only 23 respondents who had used scent-trailing hounds, so they need to be interpreted with care. In 2018 hunters endorsed to hunt with scent-trailing hounds will be surveyed separately to increase the sample size.

The approach used here explicitly accounts for the possibility that not every Game Licence holder will hunt during every survey period. The total number of Game Licence holders who hunted was estimated for each survey period and multiplied by the harvest per hunter to derive the total harvest for each survey period.

The methodology of performing telephone surveys throughout the year is likely to minimise memory bias and non-response bias, compared with the previous survey method of end-of-financial-year postal surveys. However, sources of bias will remain (due to over- and under-reporting), and the estimates of the total harvest must be interpreted with care.

1. Introduction

To effectively manage game species, it is important to estimate the numbers harvested. Since 2009, the State Government and its game management agency have commissioned a series of regular telephone surveys of randomly selected Game Licence holders. A set of telephone surveys was conducted during the deer harvest season (and similarly for the duck and quail harvest seasons, but this report focuses only on the deer harvest).

Deer hunting occurs all year round in Victoria for some species (Game Management Authority 2017). The 2017 deer-hunting reporting period was defined by the calendar year. Sambar Deer (Cervus unicolor) can be hunted all year by stalking, but the use of scent-trailing hounds for deer hunting is restricted to the hunting of Sambar Deer from 1 April to 30 November. There is no bag limit on the number of Sambar Deer that can be taken. Hog Deer (Axis porcinus) can only be hunted during April (other than during out-of-season ballot hunting) and is subject to additional restrictions, such as a limit of one male and one female per hunter. All other species, including Fallow Deer (Dama dama), Red Deer (Cervus elaphus), Chital Deer (Axis axis) and Rusa Deer (Rusa timorensis), can be hunted all year with no bag limit.

The survey methods employed here are the same as those used in the telephone surveys conducted during the 2009 to 2016 deer hunting seasons (Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013, 2014, 2016, 2017).

2. Methods

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

A telephone survey was conducted every two months, and involved 200 respondents[1] from a random sample of holders of a Game Licence endorsed for hunting deer (hereafter referred to as 'Game Licence holders'). Respondents were asked to report on their hunting activities, including the number and sex of each deer species harvested, within the two-month period of that survey. Therefore, although a respondent may have hunted during the periods covered by both 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. During each survey, 200 respondents were interviewed, regardless of whether they had hunted or not. To estimate how many Game Licence holders endorsed to hunt deer had hunted in 2017 an additional random sample of 400 Game Licence holders endorsed to hunt deer was conducted immediately after the conclusion of the 2017 hunting season. They were only asked whether they had hunted at any stage during the 2017 season. From their responses, the total number of active Game Licence holders who hunted during 2017, as opposed to a specific survey period, was estimated. As they were not asked questions relating to harvest, it was considered that there was limited recall bias.

The information from the respondents was used to generate an estimate of the harvest for the whole population of Game Licence holders endorsed to hunt deer. Estimates of the harvest for each of the survey periods were determined and then summed to give an estimate of the total season harvest. For each survey period, the proportion of respondents who hunted was used as an estimate of the proportion of Game Licence holders who hunted. This proportion was then multiplied by the total number of Game Licence holders for that period, yielding an estimate of the total number of Game Licence holders who hunted within 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.

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

The annual harvest per active Game Licence holder was also estimated. This statistic was estimated by dividing the estimated number of deer harvested, using the regular surveys, by the estimated number of active hunters, obtained using the end of year survey.

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

The script used by the surveyors, including all questions is provided in Appendix A. Additional details of the methods, as well as examples of the calculations, are provided in Appendix B. Information describing and interpreting boxplots is provided in Appendix C.

1. A *Respondent* refers to a Game Licence holder who was contacted and agreed to take part in the survey.
2. A *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.

3. Results

Overall deer harvest in 2017

Summary of responses for deer surveys in 2017

The number of Game Licence holders increased throughout 2017, with over 8,000 more at the end of the year (Table 1). To achieve the required sample size of respondents, slightly more than 200 Game Licence holders were contacted each survey. An average of 99% of those contacted were willing to take part.

Table 1

Deer Survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted*	Deer harvested**
1	Jan–Feb	28,888	194	34	125	32
2	Mar–Apr	30,824	200	47	119	66
3	May–Jun	33,556	199	69	277	184
4	Jul–Aug	34,643	200	52	239	140
5	Sep–Oct	36,243	200	57	179	118
6	Nov–Dec	36,968	204	36	148	81

* Days hunted indicates the combined number of days that hunting took place by respondents.

** Deer harvested indicates total number of deer harvested by respondents.

Proportion and corresponding total number of Game Licence holders who hunted in each survey period in 2017

The proportion of Game Licence holders who hunted in each survey period varied throughout the season: almost 12,000 (35% of) licence holders hunted in May–June, but less than 20% of licence holders hunted in each of January–February and November–December (Table 2). The proportion who hunted during other survey periods was approximately 25% (Table 2).

Table 2

Period	Proportion	SE	95%CI		Total hunters	SE	95%CI	
			Lower	Upper			Lower	Upper
Jan–Feb	0.18	0.027	0.13	0.24	5,063	789	3,738	6,858
Mar–Apr	0.24	0.030	0.18	0.30	7,244	924	5,647	9,292
May–June	0.35	0.034	0.29	0.42	11,635	1,132	9,619	14,073
Jul–Aug	0.26	0.031	0.21	0.33	9,007	1,074	7,135	11,370
Sep–Oct	0.28	0.032	0.23	0.35	10,329	1,157	8,299	12,856
Nov–Dec	0.18	0.027	0.13	0.24	6,524	987	4,858	8,760

Average harvest of deer per hunter (Game Licence holders who hunted) for each survey period in 2017

Within each survey period, there was great variation in the reported harvest of deer per hunter (i.e. per Game Licence holder who hunted). Some hunters harvested more than 10 deer in a survey period, whereas at least one-quarter of the hunters did not harvest any deer in all survey periods bar the July–August period (Figure 1). The median number of deer harvested per hunter in a two-month period was one deer. The average number of deer harvested per hunter varied throughout the season (Table 3). The average deer harvested per hunter per 2 month-period in 2017 ranged from a high of 2.7 deer in July–August to a low of 0.9 in January–February.

Table 3

Period	Average harvest per hunter who hunted*	SE	95%CI	
			Lower	Upper
Jan–Feb	0.94	0.23	0.59	1.50
Mar–Apr	1.40	0.30	0.93	2.13
May–June	2.67	0.49	1.87	3.81
Jul–Aug	2.69	0.59	1.76	4.13
Sep–Oct	2.07	0.42	1.39	3.08
Nov–Dec	2.25	0.78	1.16	4.35

* Average harvest per hunter = Deer harvested divided by respondents who hunted (Table 1).

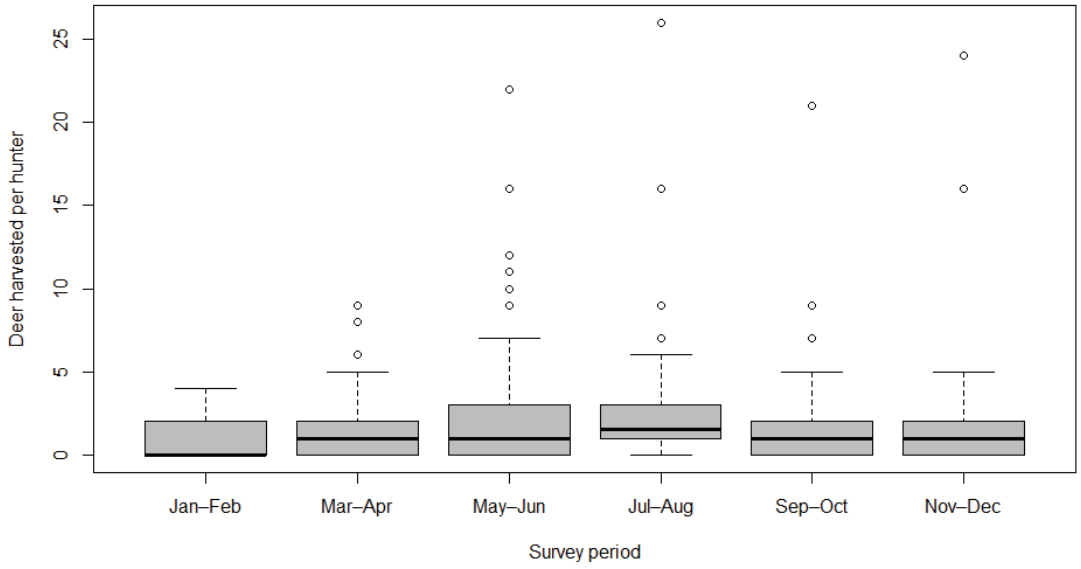

Figure 1. Boxplot of the number of deer reported as harvested by individual hunters for each survey period in 2017.
The bottom and top of each 'box' indicate the 25th and 75th percentiles, respectively, with the thick black horizontal line indicating the median (50th percentile) reported value.

Estimates of the total deer harvest in Victoria in 2017 by Game Licence holders

There was an estimated total of 106,275 deer harvested from January 2017 to December 2017, inclusive, by Game Licence holders (Table 4; 95% CI: 85,344–132,340). The harvest was greatest in the late-autumn to mid-spring months and lowest in the summer months.

Table 4

Period	Total harvest*	SE	95%CI	
			Lower	Upper
Jan–Feb	4,765	1,369	2,744	8,274
Mar–Apr	10,172	2,544	6,277	16,485
May–June	31,026	6,440	20,744	46,404
Jul–Aug	24,250	6,076	14,952	39,331
Sep–Oct	21,383	4,978	13,631	33,545
Nov–Dec	14,678	5,552	7,168	30,058
Season total	**106,275**	**11,931**	**85,344**	**132,340**

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

Estimates of the average harvest of deer per Game Licence holder for each survey period in 2017

The total average season harvest was 3.1 deer per Game Licence holder (Table 5; 95% CI: 2.5–3.9). Note that, for each survey period, the average deer harvest per Game Licence holder (Table 5) 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. From the telephone survey conducted immediately after the 2017 deer-hunting season ended, it was estimated that 55% (95% CI: 50–60%) of Game Licence holders actually hunted for deer during 2017. That equates to an estimate of 20,354 (95% CI: 18,629–22,240) licenced active deer hunters in 2017. The average deer harvest per active deer hunter was estimated to be 5.2 (95% CI: 4.1–6.6).

Table 5

Period	Average harvest per Game Licence holder*	SE	95%CI	
			Lower	Upper
Jan–Feb	0.16	0.05	0.09	0.29
Mar–Apr	0.33	0.08	0.20	0.53
May–June	0.92	0.19	0.62	1.38
Jul–Aug	0.70	0.18	0.43	1.14
Sep–Oct	0.59	0.14	0.38	0.93
Nov–Dec	0.40	0.15	0.19	0.81
Annual total	**3.11**	**0.34**	**2.50**	**3.86**

* Average harvest per Game Licence holder = Deer harvested divided by respondents (Table 1).

Estimates of the total deer harvested for each two-month survey period in 2017, by species

Separate harvest estimates for each deer species are presented in Figure 2 and Table 6a–e. The most frequently harvested species was Sambar Deer, comprising 84% of the total reported harvest, followed by Fallow Deer (15%) then Red Deer (2%). Chital Deer and Hog Deer accounted for less than 1% of the reported deer harvest each. No Rusa Deer were reported harvested in the 2017 telephone survey. At the time of this report, there were no known wild population of Rusa or Chital Deer in Victoria. Only one survey respondent reported harvesting Hog Deer in 2017 and as a result, any statistical analysis of Hog Deer in this report does not reflect that actual take of Hog Deer during the 2017 season. For 2017, a total of 203 Hog Deer (164 stags and 39 hinds) were recorded at checking stations, and an additional 38 Hog Deer (21 stags and 17 hinds) were harvested on Sunday Island (which is managed by a private cooperative).

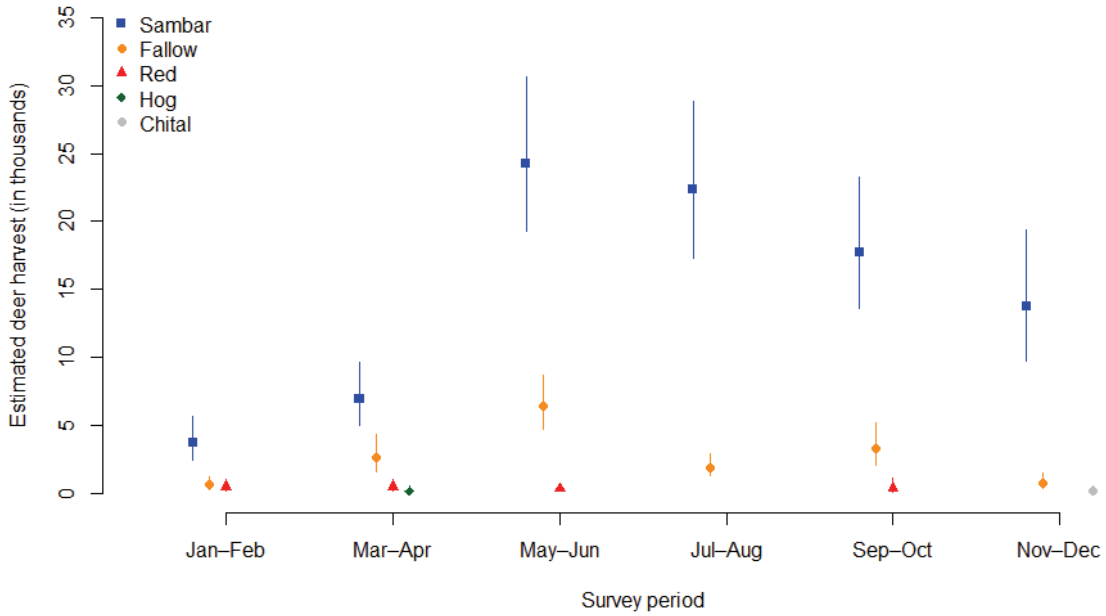

Figure 2: Estimated total deer harvest for each two-month survey period in 2016 by species.
Vertical bars indicate 95% confidence intervals. Species were only included in surveys periods when they were reported.

Table 6a: Sambar Deer

Species	Reported harvest	Estimated harvest	SE	95%CI	
				Lower	Upper
Jan–Feb	25	3,723	809	2,443	5,672
Mar–Apr	45	6,936	1,176	4,986	9,648
May–June	144	24,281	2,879	19,262	30,609
Jul–Aug	129	22,345	2,914	17,323	28,821
Sep–Oct	98	17,759	2,451	13,567	23,246
Nov–Dec	76	13,772	2,435	9,765	19,425
Annual total	**517**	**88,816**	**5,546**	**78,594**	**100,366**

Table 6b: Fallow Deer

Species	Reported harvest	Estimated harvest	SE	95%CI	
				Lower	Upper
Jan–Feb	4	596	220	296	1,199
Mar–Apr	17	2,620	691	1,576	4,357
May–June	38	6,408	1,011	4,712	8,713
Jul–Aug	11	1,905	404	1,263	2,874
Sep–Oct	18	3,262	790	2,043	5,209
Nov–Dec	4	725	274	354	1,483
Annual total	**92**	**15,515**	**1,553**	**12,758**	**18,868**

Table 6c: Red Deer

Species	Reported harvest	Estimated harvest	SE	95%CI	
				Lower	Upper
Jan–Feb	3	447	187	203	982
Mar–Apr	3	462	198	207	1,032
May–June	2	337	145	150	757
Jul–Aug	0	0	NA	NA	NA
Sep–Oct	2	362	231	115	1,137
Nov–Dec	0	0	NA	NA	NA
Annual total	**10**	**1,609**	**385**	**1,013**	**2,556**

Table 6d: Hog Deer

Species	Reported harvest	Estimated harvest	SE	95%CI	
				Lower	Upper
Jan–Feb	0	0	NA	NA	NA
Mar–Apr	1	154	112	43	552
May–June	0	0	NA	NA	NA
Jul–Aug	0	0	NA	NA	NA
Sep–Oct	0	0	NA	NA	NA
Nov–Dec	0	0	NA	NA	NA
Annual total	**1**	**154**	**112**	**43**	**552**

Table 6d: Chital Deer

Species	Reported harvest	Estimated harvest	SE	95%CI	
				Lower	Upper
Jan–Feb	0	0	NA	NA	NA
Mar–Apr	0	0	NA	NA	NA
May–June	0	0	NA	NA	NA
Jul–Aug	0	0	NA	NA	NA
Sep–Oct	0	0	NA	NA	NA
Nov–Dec	1	181	107	62	528
Annual total	**1**	**181**	**107**	**62**	**528**

Reported numbers and percentages of each sex of each deer species harvested in 2017

There was a statistically significant sex bias favouring females for the harvest of Fallow Deer and Sambar Deer (Table 7). No statistically significant sex bias for the harvest of Chital Deer, Hog Deer or Red Deer was detectable because harvest numbers were so small.

Table 7

Species	Males			Females		
	Reported	%	SE	Reported	%	SE
Sambar Deer	227	0.44	0.02	290	0.56	0.02
Fallow Deer	35	0.38	0.05	57	0.62	0.05
Red Deer	4	0.40	0.15	6	0.60	0.15
Hog Deer	1	1.00	NA	0	0.00	NA
Chital Deer	1	1.00	NA	0	0.00	NA

Number of days on which deer were hunted per Game Licence holder for 2017

The average number of days on which deer were hunted in each survey period varied throughout the season, with most hunting occurring from late autumn to mid-spring. Each Game Licence holder hunted an average of 5.45 days during 2017, corresponding to a total of 184,317 hunter days (Table 8; 95% CI: 156,116–217,614).

Table 8

Period	Days hunted	SE	95%CI	
			Lower	Upper
Jan–Feb	0.64	0.12	0.45	0.92
Mar–Apr	0.60	0.10	0.43	0.82
May–June	1.39	0.19	1.07	1.82
Jul–Aug	1.20	0.19	0.87	1.63
Sep–Oct	0.90	0.13	0.67	1.19
Nov–Dec	0.73	0.14	0.50	1.06
Total per licence holder	**5.45**	**0.37**	**4.77**	**6.21**
Total hunting days	**184,317**	**15,644**	**156,116**	**217,614**

Comparison of number of days on which deer were hunted and associated deer harvest with respect to land tenure in 2017

More days of deer hunting occurred exclusively on public land (62%) compared with exclusively on private land (28%), with correspondingly similar proportions of deer harvested (Table 9). Most of the Sambar Deer harvested were harvested exclusively on Public land (65%). Most of the Fallow Deer harvested were also harvested exclusively on public land (50%), but the rate was much lower than for Sambar Deer.

Table 9

Land tenure	Days	Total Deer harvest	Sambar Deer	Fallow Deer	Red Deer	Hog Deer	Chital Deer
Private land only	28.2%	28.5%	26.1%	40.2%	40.0%	0.0%	100.0%
Public land only	61.5%	62.5%	64.8%	50.0%	60.0%	100.0%	0.0%
Both	7.2%	5.5%	5.8%	4.3%	0.0%	0.0%	0.0%
Not specified	3.1%	3.5%	3.3%	5.4%	0.0%	0.0%	0.0%

Estimated total deer harvest in 2017 by Catchment Management Authority Regions

Total harvest was estimated to be greatest in the North East Catchment Management Authority (CMA), followed by the Goulburn Broken CMA and the West Gippsland CMA (Figure 3). The top five towns with respect to the total reported number of deer harvested were (in descending order) Myrtleford, Mansfield, Bright, Dargo and Licola. The top five towns with respect to the total number of reported deer hunting days were (in descending order) Mansfield, Myrtleford, Licola, Dargo and Omeo.

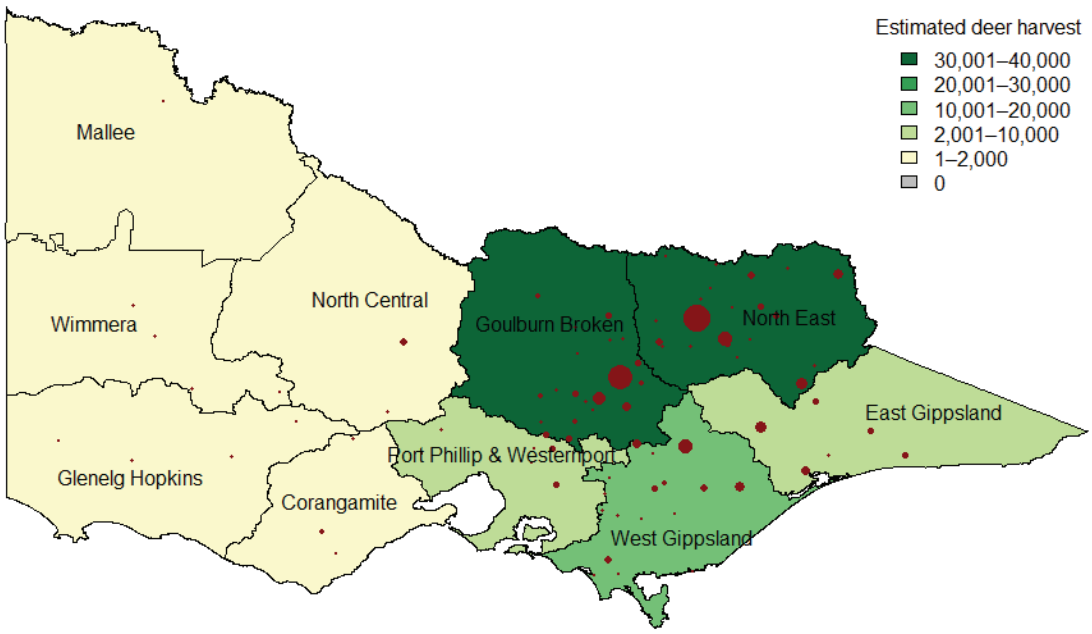

Figure 3: Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

Sambar Deer harvest using scent-trailing hounds in 2017

Summary of responses to deer surveys in 2017 by Game Licence holders who hunted using scent-trailing hounds

The number of holders of Game Licences endorsed for hunting Sambar Deer using scent-trailing hounds increased slightly throughout 2017, from 4,343 in April to 4,829 in November (Table 10). While we know how many respondents said that using scent-trailing hounds was their main method of hunting (a total of 57 respondents for the year), we do not know how many Game Licence holders with licences endorsed for hunting deer using scent-trailing hounds were actually surveyed. In addition, as only one person was surveyed in each of the spring survey periods, standard deviations could not be calculated, so we could not determine the overall deer harvest using scent-trailing hounds for those periods with confidence intervals. For 2018, hunters endorsed to hunt with scent-trailing hounds will be surveyed separately to increase the sample size.

Table 10

Deer Survey	Period	Licence holders	Respondents[1]	Respondents who hunted[2]	Days hunted[3]	Deer harvested[4]
1	*					
2	Apr	4343	4	2	10	8
3	May–Jun	4608	8	5	38	39
4	Jul–Aug	4695	28	14	105	82
5	Sep–Oct	4801	11	1	2	5
6	Nov	4829	6	1	16	24

* No hunting with scent-trailing hounds in this survey period. Hound hunting is only permitted between April and November each year.

1 Number of respondents who said that their main hunting method was using scent-trailing hounds.

2 Number of respondents who hunted using scent-trailing hounds.

3 Days hunted indicates the combined number of days on which deer hunting by respondents using scent-trailing hounds took place.

4 Deer harvested indicates total number of deer harvested by respondents using scent-trailing hounds.

Average harvest of Sambar Deer per hunter using scent-trailing hounds (Game Licence holders who hunted using scent-trailing hounds) for each survey period in 2017

Within each survey period, there was great variation in the reported harvest of deer per hunter (i.e. per Game Licence holder who hunted using scent-trailing hounds). Some hunters harvested more than 10 deer in a survey period, while all hunters using scent-trailing hounds harvested at least one deer in that period (Figure 4.). The average number of deer per hunter using scent-trailing hounds varied throughout the season (Table 11), ranging from a high of 24 deer in November to a low of 4 in April. It should be noted that the estimates for September–October and November were based on only one respondent each, and are therefore very unreliable estimates.

Table 11

Period	Average harvest per hunter	SE	95%CI	
			Lower	Upper
Apr	4.00	0.50	3.13	5.11
May–June	7.80	2.78	3.96	15.37
Jul–Aug	5.86	1.88	3.17	10.82
Sep–Oct	5.00	NA	NA	NA
Nov	24.00	NA	NA	NA

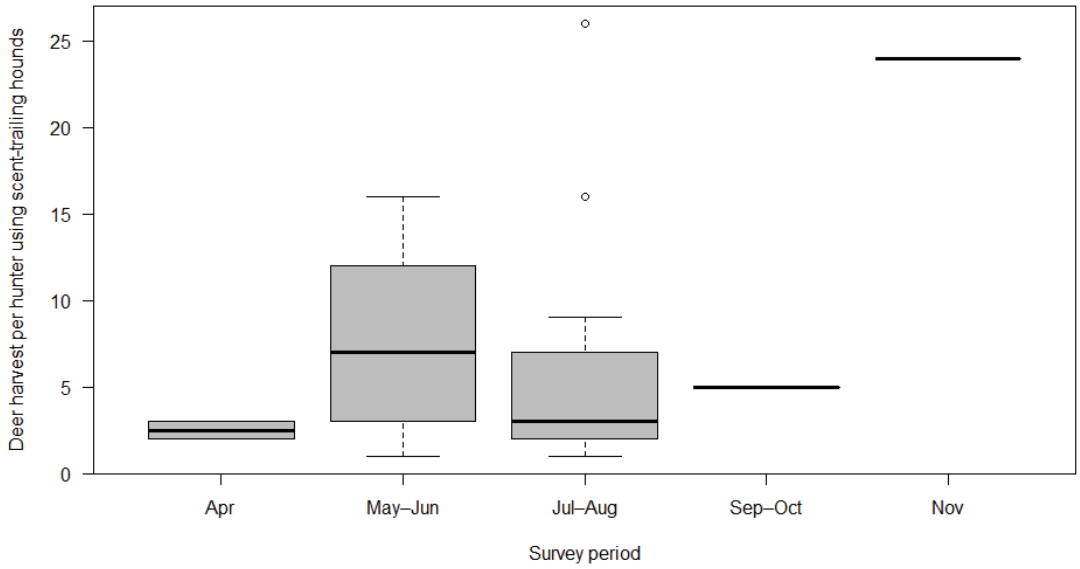

Figure 4. Boxplot of the number of Sambar Deer reported as harvested by individual hunters using scent-trailing hounds for each survey period in 2017.

Reported numbers of each sex of Sambar Deer harvested using scent-trailing hounds in 2017

Of the 158 deer reported as harvested using scent-trailing hounds there were 64 stags, compared with 94 hinds. There was a statistically significant sex bias for the harvesting of Sambar Deer hinds for hunting using scent-trailing hounds.

Number of days on which Sambar Deer were hunted per Game Licence holder who hunted using scent-trailing hounds in 2017

The average number of days of hunting with scent-trailing hounds varied throughout the season, with the greatest hunting rate occurring in November (16 per month), and the lowest in September–October (2 hunting days per month) (Table 12). It should be noted that the estimates for September–October and November were based on only one respondent each and are therefore very unreliable estimates. Changes to how hunters will be surveyed in 2018 will seek to address this.

Table 12

Period	Days hunted	SE	95%CI	
			Lower	Upper
Apr	5.0	1.00	3.39	7.37
May–June	7.6	1.86	4.74	12.19
Jul–Aug	7.5	1.22	5.46	10.31
Sep–Oct	2.0	NA	NA	NA
Nov	16.0	NA	NA	NA

Comparison of the number of days on which deer were hunted using scent-trailing hounds, and associated deer harvest, with respect to land tenure in 2017

The overwhelming majority of Sambar Deer hunting using scent-trailing hounds occurred exclusively on public land (82%), with the rest occurring approximately equally on private only or on both private and public land. A similarly large proportion of the Sambar Deer harvested using scent-trailing hounds occurred exclusively on public land (Table 13; 84%).

Table 13

Land tenure	Days	Deer harvest
Private land only	6.4%	10.8%
Public land only	81.9%	84.2%
Both	7.0%	3.2%
Total	**95.3%**	**98.1%**

Comparison of the number of days on which deer were hunted and associated deer harvest with respect to hunting method and land tenure in 2017

Stalking was the preferred hunting method, being used on 83% of the hunting days and accounting for 72% of the reported harvest. It is estimated that 31.5% of the total Sambar Deer harvested between 1 April to 30 November (when hunting with hounds is permitted), where taken with the use of scent-trailing hounds. For the whole year, 30% of the Sambar Deer harvested were taken with the use of scent-trailing hounds. Thus, it is estimated that 26,645 Sambar Deer were harvested using scent-trailing hounds. Scent-trailing hounds hunting accounted for 24.9% of the total deer harvest, but only 15% of total hunting days (Table 14). For hunting using scent-trailing hounds, the efficiency was 0.92 deer per hunting days, compared with 0.51 deer per hunting days for stalking.

Some spotlighting on private land was also reported in the 2017 surveys. However, as spotlighting is not recreational hunting the spotlighting harvest results are not included. Noting, that some agents removing problem deer may also be holders of a Game Licence endorsed for deer – hence the cross over.

Table 14

Land tenure	Private only		Public only		Both		Total	
Hunting method	Days	Deer	Days	Deer	Days	Deer	Days	Deer
Scent-trailing hounds	1.0%	2.7%	12.9%	21.4%	1.1%	0.8%	15.0%	24.9%
Stalking	27.2%	25.8%	48.0%	41.1%	6.1%	4.7%	83.1%	71.6%
Total	**28.2%**	**28.5%**	**60.9%**	**62.5%**	**7.2%**	**5.5%**	**96.3%**	**96.5%**

Note: This table compares all deer harvested. Changes to the survey in 2018 will allow comparison of Sambar Deer harvest only by stalking or scent-trailing hounds.

Location of reported Sambar Deer harvest using scent-trailing hounds in 2017

The reported Sambar Deer harvest using scent-trailing hounds was greatest in the North East CMA, followed by the Goulburn Broken CMA (Figure 5). Only the most eastern CMAs had reports of hunters using scent-trailing hounds. Hunting Sambar Deer with the use of hounds is restricted to the eastern side of the state, bounded by the Princess Freeway on the south and the Hume Highway on the west (with some exclusions). In addition, hound hunting is excluded from reserved public land. The top five towns with respect to the total reported number of deer harvested using scent-trailing hounds were (in descending order) Myrtleford, Mansfield, Matlock, Omeo and Wandiligong. It should be noted that Sambar Deer hunting with scent-trailing hounds is not permitted in the western half of the State, where few Sambar Deer are present.

Figure 5: Red circles indicate the nearest towns to harvest locations, with symbol size proportional to reported harvest.

NOTE: In 2018, the methodology will change, the survey for all hunters endorsed to hunt deer will continue and a separate survey for hunters endorsed to hunt deer with the aid of scent-trailing hounds will be conducted. This will provide more accurate information on harvest levels and hunting methods applied.

4. Discussion

Deer harvests in 2017

A total of 106,275 deer were estimated to have been harvested in Victoria during the 2017 calendar year (95% CI: 85,344–132,340).

The deer harvest was the largest on record since the harvest methodology was adopted in 2009 (Table 15, Figure 6). The 2017 estimate was 73% larger than the average harvest, and 9% larger than the next highest estimated deer harvest (2016) obtained using this survey method.

The most commonly harvested species in 2017 was Sambar Deer (88,816), followed by Fallow Deer (15,515) and Red Deer (1609). Due to the very small harvest of Chital Deer and Hog Deer reported harvested by surveyed Game Licence holders, it is difficult to make any inference about the harvest of those species. There are no known wild populations of Chital Deer in Victoria, and the one that was recorded may have been an escapee or misidentified or, harvested from interstate and has been misreported; however, this is the second consecutive year in which a Chital Deer has been reported. Even though only one survey respondent reported harvesting Hog Deer in 2017, a total of 203 Hog Deer (164 stags and 39 hinds) were recorded at checking stations, and an additional 38 Hog Deer (21 stags and 17 hinds) were harvested on Sunday Island (which is managed by a private cooperative).

An annual report on the seasonal Hog Deer harvest is produced by the Game Management Authority and can be found at www.gma.vic.gov.au

The 2017 season had the third largest number of hunting days: 9% larger than average. However, the average number of hunting days per Game Licence holder in 2017 was 19% lower than the 2009–2017 average and the second lowest since the surveys began. The number of hunting days was largest from late autumn to mid-spring.

The average number of deer harvested per Game Licence holder in 2017 was 3.11, which is the second largest recorded, 34% greater than the average since 2009, and within 1% of the next highest year (2016). The efficiency of hunters in 2017 was 0.58 deer harvested per hunting day, which is the highest efficiency on record, 78% greater than the average, and 22% more than the next highest year (2016). These increases could be due to an increase in deer populations or changes to deer habitat, such as landscape burning, allowing them to be hunted more efficiently. However, there are no current estimates of the deer populations in Victoria and limited research on deer behavioural traits because of habitat modification.

Table 15: Comparison of annual deer harvests from 2009 to 2016.

	Harvest by species						Overall			
Year	Chital Deer	Fallow Deer	Hog Deer	Red Deer	Sambar Deer	Total harvest	Total hunting days	Deer per licence holder	Hunting days per licence holder	Deer per hunting day
2009	0	4,871	81	682	32,453	**38,284**	150,321	2.14	8.38	0.25
2010	0	6,085	454	1,396	34,108	**42,133**	149,002	2.12	7.56	0.28
2011	0	4,001	105	737	25,913	**30,753**	135,278	1.43	6.3	0.23
2012	0	9,788	102	555	48,048	**59,206**	169,721	2.62	7.54	0.35
2013	0	6,426	0	926	36,355	**43,985**	135,854	1.76	5.47	0.32
2014	0	7,870	0	745	51,390	**62,166**	186,215	2.22	6.68	0.33
2015	0	14,488	138	939	55,094	**71,141**	201,547	2.36	6.77	0.35
2016	129	15,059	0	1,713	80,875	**97,776**	207,614	3.12	6.63	0.47
2017	181	15,515	154	1,609	88,816	106,275	184,317	3.11	5.45	0.58
Average	**34**	**9,345**	**115**	**1,034**	**50,339**	**61,302**	**168,874**	**2.32**	**6.76**	**0.35**

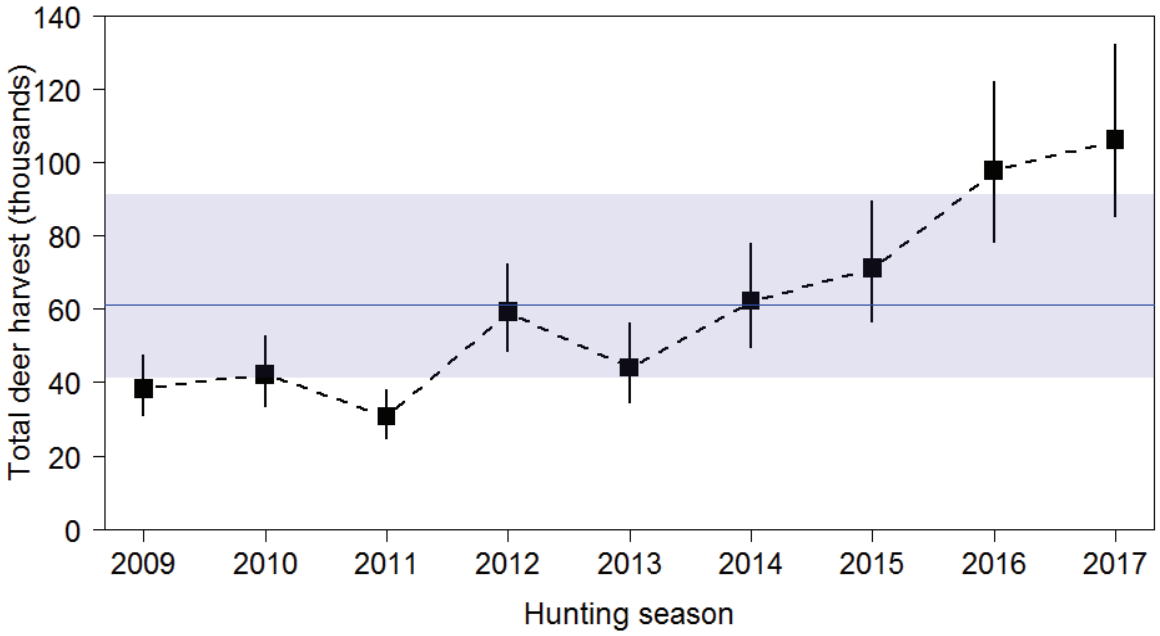

Figure 6. Estimates of the total deer harvests (in thousands) from 2009 to 2017.
The filled squares are the estimated total harvests for each season; the solid vertical lines indicate the 95% confidence intervals; the blue line is the average deer harvest from 2009 to 2017; the shaded area is the 95% confidence interval for the average deer harvest from 2009 to 2017.

From 2009 to 2017, the average increase in deer harvested was 15% per year. The increase in total number of hunting days was 5% per year. Thus, the increase in the quantity of deer harvested was larger than the increase in hunting days, which means that hunter efficiency was also increasing (by 11% per year, on average). It is estimated that 26,645 (30%) of the Sambar Deer harvest were harvested using scent-trailing hounds. Game Licence holders who hunted deer using scent-trailing hounds were more efficient than those who used stalking. However, it is possible that the deer harvests recorded by those using scent-trailing hounds were for the group rather than the individual, and therefore the figures may be inflated. For 2018, the methodology will change and separate surveys will be conducted for hunters endorsed to hunt with scent-trailing hounds. This will allow for an increase in data and a more accurate analysis.

It should be noted that the number of hunting days is only an approximate estimate of the total effort. For example, someone who hunted for two hours and someone else who hunted for 12 hours in one day were each recorded as having hunted for one day.

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. This assumption may have been violated due to several factors, such as the reasons for non-response (exceeding bag limit or, conversely, not harvesting anything), memory recall (respondents not remembering their harvest), and deliberate over- or under-reporting (knowingly reporting numbers 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% (Wright 1978; Barker 1991). It is likely, however, that the sampling strategy of telephone interviews after each two-month period would have ensured that both memory bias and non-response bias were kept low (compared with that for 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 is important to note that the methodology explicitly accounts for the possibility that not every Game Licence holder hunted in every survey period (see Gormley and Turnbull 2010). Thus, the estimate of the total season bag per Game Licence holder was obtained from the sum of the harvest 'per Game Licence holder', not the sum of the harvest 'per hunter' for each survey period.

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 had hunted unsuccessfully, whereas others took multiple trips and reported a total harvest of more than five deer during the same period. The second source of uncertainty was due to the sampling of hunters, rather than taking a complete census; however, the degree of sampling uncertainty was reduced by having sample sizes of 200 respondents per deer hunting survey period. Statistically, these sample sizes are considered adequate for providing reasonable estimates.

The spatial distributions of the deer harvest should also be interpreted with care. Grouping the harvest by CMA provides a broad-scale view of the distribution of the harvest. Grouping by smaller regions would provide a finer-scale representation, but this would be at the cost of increased bias in many regions. Because the data are from a sample of Game Licence holders rather than a complete census, it is likely that some areas that were actually hunted are shown as having a zero harvest if no respondents who hunted in 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 to that of the hunting location.

The number of Sambar Deer harvested using scent-trailing hounds should also be interpreted with care. Grouping the harvest by hunting method allows for an insight into the amount and efficiency of hunting being done with scent-trailing hounds and stalking. However, the number of holders of Game Licences specifically endorsed for hunting Sambar Deer with scent-trailing hounds who either didn't hunt in each survey period, or who hunted without scent-trailing hounds, was not recorded. That information would be required for more reliable estimates of the Sambar Deer harvest, including confidence intervals and secondary statistics, such as total days spent hunting with scent-trailing hounds. Because the data are from a sample of Game Licence holders rather than a complete census, it is likely that some areas in which scent-trailing hounds were used are shown as having a zero harvest if no respondents who hunted in those areas were contacted. In 2018, the methodology will change, the survey for all hunters endorsed to hunt deer will continue and a separate survey for hunters endorsed to hunt deer with the aid of scent-trailing hounds will be conducted. This will provide more accurate information on harvest levels and hunting methods applied.

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Appendix 1

Survey questions script

Victorian Deer Hunting Survey 2017

Introduction: Hi my name is _____and I am calling on behalf of the Game Management Authority.

We are conducting a survey of licensed Deer Hunters over 2017 that will provide information on hunting practices and harvest information as part of the continued process to improve game management in Victoria.

I was hoping you had time to answer a few quick questions.

Survey details:

Period of Survey _____ (1 to 6) Date of interview: dd / mm / 2017

Non-responsive: ☐ (tick box)

Survey questions:

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

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

3. Have you been deer hunting in the past two Months? (name months) Yes ☐ No ☐ (tick box, if 'Yes', proceed to question 4, if 'No' "Thank you for taking part in this survey, if you would like to discuss or view the outcomes of this data, please contact John Turnbull 02 60 437 986)

4. How many Deer hunting trips have you taken over this 2 month period? ☐ (indicate number in box)

(Each trip needs to be treated separately for question 5 - 11)

	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6	Trip 7
5. How many days did you go hunting?	☐	☐	☐	☐	☐	☐	☐
6. How many deer did you harvest?	☐	☐	☐	☐	☐	☐	☐
7. What species were the deer?	Sambar Fallow Red Hog Chital Rusa	Sambar Fallow Red Hog Chital Rusa	Sambar Fallow Red Hog Chital Rusa	Sambar Fallow Red Hog Chital Rusa	Sambar Fallow Red Hog Chital Rusa	Sambar Fallow Red Hog Chital Rusa	Sambar Fallow Red Hog Chital Rusa
8. What was the sex of the Deer	Male No. Female No.	Male No. Female No.	Male No. Female No.	Male No. Female No.	Male No. Female No.	Male No. Female No.	Male No. Female No.
9. How were the deer taken?	Stalking Scent- Hounds Stalking with a Gundog Bow	Stalking Scent- Hounds Stalking with a Gundog Bow	Stalking Scent- Hounds Stalking with a Gundog Bow	Stalking Scent- Hounds Stalking with a Gundog Bow	Stalking Scent- Hounds Stalking with a Gundog Bow	Stalking Scent- Hounds Stalking with a Gundog Bow	Stalking Scent- Hounds Stalking with a Gundog Bow
10. Did you hunt on private land or public land?	Public ☐ Private ☐ Both ☐	Public ☐ Private ☐ Both	Public ☐ Private ☐ Both	Public ☐ Private ☐ Both	Public ☐ Private ☐ Both	Public ☐ Private ☐ Both	Public ☐ Private ☐ Both ☐
11. What was the closest major town to the area you hunted?	_____ _	_____	_____ _	_____ _	_____ _	_____ _	_____ _

Appendix B

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:

$\mathrm{SE}(w_j) = \frac{\mathrm{SD}(w_j)}{\sqrt{n_j}}$, 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).

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

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

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

The standard error of the total harvest was calculated by:

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

Confidence intervals were computed on the natural logarithm scale and back-transformed to ensure that lower limits were ≥0. A consequence is that the confidence intervals were asymmetric and cannot be reported as the estimate plus or minus a fixed value. In general, for some estimates denoted as $\hat{X}$, 95% confidence interval limits were calculated using:

upper limit $= \hat{X} \times r$

lower limit $= \hat{X} \div r$, 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

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

$$r = \exp\left(1.96\sqrt{\ln\left(1 + 0.117^2\right)}\right) = 1.26$$

Therefore, Upper and Lower Confidence Intervals are given by:

$$UL = 71{,}142 \times 1.26 = 89{,}471$$
$$LL = 71{,}142 \div 1.26 = 56{,}567.$$

Appendix C

Explanation of what goes into a boxplot

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

- outliers, signified by hollow circles
- minimum, signified by the horizontal line below the box (smallest value, excluding outliers)
- lower quartile (Q1), signified by the horizontal line at the bottom of the box (25% of the data is at this point or below)
- median, signified by the thick horizontal line in the box (50% of the data is at this point or below)
- upper quartile (Q3), signified by the horizontal line at the top of the box (75% of the data is at this point or below)
- maximum, signified by the horizontal line above the box (largest value, excluding outliers)
- interquartile range (IQR; difference between the upper and lower quartiles)
- whiskers—the lines that go from the minimum or maximum to the box.

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

The boxplot indicates the spread of the data. The data is broken into quarters: approximately 25% of the data are in the range between a whisker and the nearest edge of the box, and approximately 25% of the data are in the range between an edge of the box and the median line. Thus, approximately half the data are thus contained within the box. Any unusual data are highlighted as outliers. As an example, Figure C1 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).

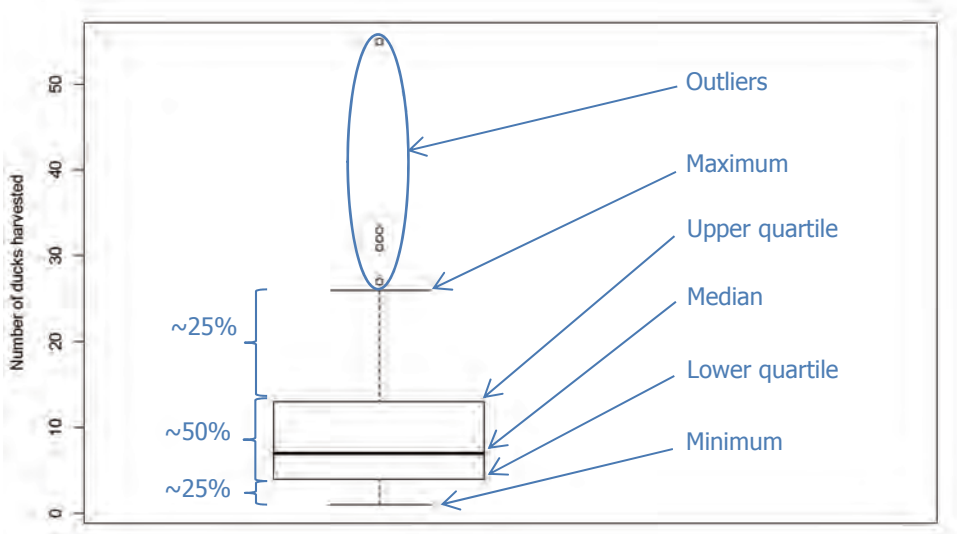

Figure C1: Example boxplot, with labels.

Notes