Estimates of the 2018 deer harvest in Victoria

Results from surveys of Victorian Game Licence holders in 2018

P.D. Moloney, Z. Powell

Game Management Authority

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Summary

From January to December 2018, telephone surveys of Victorian hunters were conducted to estimate the annual deer harvest. Game Licence holders endorsed to hunt deer 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 2018 deer hunting season continued the trend of increased annual harvest, compared with the previous survey years. The total harvest in 2018 (121,600, 95% confidence interval (CI) = 95,900–154,100) was 14% greater than the previous year, the previous highpoint, and was considerably greater than the average since 2009 (67,300). The increase in deer harvest was the result of the largest number of deer per licence holder recorded (3.5, 95%, CI = 2.7–4.5) combined with an increased number of Game Licence holders endorsed to hunt deer. The high number of deer per licence holder was due to relatively high efficiency (0.51 deer harvested per hunting day in 2018 compared to long run average of 0.37) paired with an average number of hunting days per licence holder (6.7 in 2018 compared to 6.8 historically).

The most commonly harvested species was Sambar Deer (with an estimated total harvest of 88,202, or 73% of the harvest), followed by Fallow Deer (30,552, or 25%). The percentage of the harvest that was Fallow Deer was much higher than the previous average (15%). It should also be noted that in 2018 the estimated number of Fallow Deer harvested was almost double the next greatest estimate.

Hound hunters (hunters using hounds to hunt Sambar Deer only) were explicitly surveyed for the first time in 2018 in order to improve accuracy in determining their level of harvest. In 2018 it is estimated that the total number of deer harvested using hounds was 14,700 (95% CI = 12,500–17,200). The average annual harvest rate per licence holder endorsed to hunt Sambar Deer with hounds was 3 (95% CI = 2.6–3.6), which is lower than the general rate (3.5). The efficiency of deer harvest using hounds (0.5) is similar to the general efficiency (0.5) in 2018.

The approach used here explicitly accounts for the possibility that not every holder of a Game Licence endorsed for deer will hunt during every survey period. The total number of Game Licence holders who hunted was estimated for each survey period and combined with 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 total harvest must be interpreted with care.

1   Introduction

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

Deer hunting occurs all year round in Victoria for five of the six game deer species (Game Management Authority 2018). The 2018 deer hunting reporting periods were defined by the calendar year. Sambar Deer (*Cervus unicolor*) can be hunted all year by stalking. Use of hounds is restricted to hunting Sambar Deer between 1 April and 30 November. There is no limit on the number of Sambar Deer that can be taken. Hog Deer (*Axis porcinus*) can only be hunted during April (excluding out of season ballot hunting) and is subject to additional restrictions, such as one male and one female per hunter. All other species can be hunted all year with no bag limit, including: Fallow Deer (*Dama dama*), Red Deer (*Cervus elaphus*), Chital Deer (*Axis axis*) and Rusa Deer (*Rusa timorensis*).

The survey methods employed here are the same as those used in the telephone surveys conducted during the 2009 to 2017 deer-hunting seasons (Gormley and Turnbull 2009; 2010; 2011; Moloney and Turnbull 2012; 2013; 2014; 2016; 2017; 2018). Additionally, in 2018, a secondary survey was conducted for those endorsed to hunt Sambar Deer with hounds.

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.

2.1   Holders of a Game Licence endorsed for hunting deer

A telephone survey was conducted every two months, involving 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 their hunting activities for that period, including the number and sex of each species harvested (see Appendix A). The answers only covered the period (i.e. two months) of that survey. Therefore, 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. During each survey, 200 respondents were interviewed, regardless of whether they had hunted or not. An additional random sample of 400 Game Licence holders endorsed to hunt deer were surveyed immediately after the conclusion of the 2018 hunting season. They were asked if they had hunted at any stage during the season. The number of active hunters was estimated using the survey question in the final survey on whether they had hunted at any stage during 2018.

Additional surveying was specifically undertaken for hunters using hounds to hunt Sambar Deer. This is documented in 2.2.

The information from the respondents was used to generate an estimate for the whole population of Game Licence holders for deer. Estimates of harvest were determined for each of the survey periods and were summed to give an estimate of the total season harvest.

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

For each survey period, the 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.

The annual harvest per Game Licence holder endorsed to hunt deer 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 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 for the corresponding Victorian Catchment Management Authority (CMA) region.

Additional details of the methods, as well as examples of the calculations, are provided in Appendix C. Information describing and interpreting boxplots is provided in Appendix D.

2.2 Holders of a Game Licence endorsed for hunting Sambar Deer using hounds

A telephone survey was conducted every two months during the hound hunting season, involving 100 respondents from a random sample of holders of a Game Licence endorsed for hunting deer using hounds (hereafter referred to as 'Game Licence holders using hounds'). Respondents were asked to report their hunting activities for that period, including the number and sex of each species harvested, if hounds were used and team size (see Appendix B). The answers only covered the period (i.e. two months) of that survey. Therefore, 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. During each survey, 100 respondents were interviewed, regardless of whether they had hunted or not. An additional random sample of 400 Game Licence holders using hounds were surveyed immediately after the conclusion of the 2018 hound hunting season. They were asked if they had hunted at any stage during the hound season. The number of active hound hunters was estimated using the survey question in the final survey on whether they had hunted at any stage during 2018.

The analysis of the information given by the hound hunting respondents was used in a similar way to the general Game Licence holders. However, instead of using their harvest total for the respondent for the period, the total of the harvest per team member across trips was used. This allows for the estimate to be scaled up by the number of Game Licence holders using hounds for an estimate of the total Sambar Deer harvest where hounds were used. Information related to team size, non-hound hunting harvest and other statistics were also calculated.

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

3 Results

3.1 Overall deer harvest in 2018

The number of Game Licence holders endorsed to hunt deer increased throughout 2018, from 26,112 in January to 39,099 at the end of the year (Table 1). To achieve the required sample size of respondents, slightly more than 200 licence holders were contacted each survey, with an average of 99% of those contacted being willing to take part.

The proportion of Game Licence holders who hunted in each survey period varied throughout the season: almost 11,000 (or 32% of) licence holders hunted in May–June; less than 20% of licence holders hunted in January–February and November–December (Table 2). The proportion who hunted during other survey periods was between 25% to 30% (Table 2).

Table 1. Summary of responses for deer surveys in 2018.

Deer survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted[3]	Deer harvested[4]
1	Jan-Feb	28,064	199	26	78	64
2	Mar-Apr	33,022	200	51	234	157
3	May-Jun	34,602	208	67	305	162
4	Jul-Aug	35,900	200	61	326	155
5	Sep-Oct	38,085	200	58	282	118
6	Nov-Dec	39,066	200	31	128	48

Table 2. Proportion and corresponding total number of deer licence holders who hunted in each survey period in 2018.

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
Jan–Feb	0.13	0.024	0.09	0.19	3,667	670	2,570	5,232
Mar–Apr	0.26	0.031	0.20	0.32	8,421	1,018	6,650	10,662
May–Jun	0.32	0.032	0.26	0.39	11,146	1,121	9,156	13,568
Jul–Aug	0.30	0.033	0.25	0.38	10,950	1,169	8,888	13,490
Sep–Oct	0.29	0.032	0.23	0.36	11,045	1,222	8,897	13,710
Nov–Dec	0.16	0.026	0.11	0.21	6,055	1,000	4,391	8,351

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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.

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 did not harvest any deer in each period (Figure 1). The median number of deer harvested per hunter in a two-month period was one deer. The average number of deer per hunter varied throughout the season (Table 3).

The average harvest per hunter in 2018 ranged from a high of 3.08 deer in March–April to a low of 1.55 in November–December.
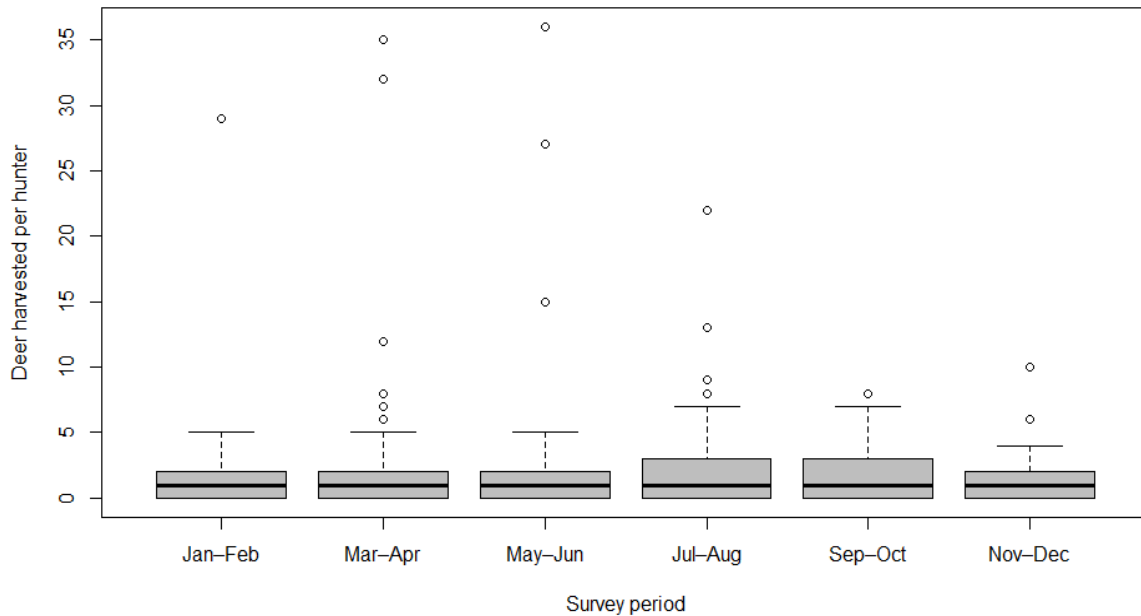
Figure 1. Boxplot of the number of deer reported harvested by individual hunters for each survey period in 2018.

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

Table 3. Average harvest of deer per hunter (Game Licence holders who hunted) for each survey period in 2018.

Period	Average harvest per hunter[5]	SE	95% CI Lower	Upper
Jan–Feb	2.46	1.10	1.06	5.70
Mar–Apr	3.08	0.93	1.73	5.49
May–Jun	2.42	0.68	1.40	4.16
Jul–Aug	2.54	0.46	1.78	3.62
Sep–Oct	2.03	0.32	1.50	2.77
Nov–Dec	1.55	0.42	0.92	2.60

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

There was an estimated total of 121,567 deer harvested from January 2018 to December 2018, inclusive, by Game Licence holders endorsed to hunt deer (95% CI = 95,913–154,081; Table 4). Harvest was greatest in the autumn to winter months and lowest in the summer months.

The total average season harvest was 3.5 deer per Game Licence holder (95% CI = 2.7–4.5; Table 5). 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.

Table 4. Estimates of the total deer harvest in Victoria in 2018 by holders of a deer Game Licence.

Period	Total harvest[6]	SE	95% CI	
			Lower	Upper
Jan–Feb	9,026	4,372	3,670	22,197
Mar–Apr	25,923	8,432	13,923	48,264
May–Jun	26,950	8,090	15,153	47,929
Jul–Aug	27,822	5,877	18,474	41,903
Sep–Oct	22,470	4,327	15,459	32,661
Nov–Dec	9,376	2,962	5,123	17,160
Total	**121,567**	**14,755**	**95,913**	**154,081**

Table 5. Estimates of average harvest of deer per Game Licence holder in each survey period in 2018.

Period	Average harvest[7]	SE	95% CI	
			Lower	Upper
Jan–Feb	0.32	0.16	0.13	0.79
Mar–Apr	0.78	0.26	0.42	1.46
May–Jun	0.78	0.23	0.44	1.39
Jul–Aug	0.78	0.16	0.51	1.17
Sep–Oct	0.59	0.11	0.41	0.86
Nov–Dec	0.24	0.08	0.13	0.44
Total	**3.49**	**0.44**	**2.74**	**4.45**

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

Using a telephone survey immediately after the 2018 deer season ended, it was estimated that 52% (95% CI = 45%–59%) of Game Licence holders actually hunted for deer during 2018. That equates to an estimate of 20,136 (95% CI = 17,605–23,031) active deer hunters in 2018. The average deer harvest per active deer hunter was estimated to be 6 (95% CI = 4.6–7.9).

Separate harvest estimates for each deer species are presented in Figure 2 and Table 6. The most frequently harvested species was Sambar Deer, comprising 73% of the total reported harvest, followed by Fallow Deer (25%) and Red Deer (2%).

No Chital Deer, Hog Deer or Rusa Deer were reported harvested in the 2018 telephone survey. Even though no respondent reported harvesting Hog Deer in 2018, a total of 160 Hog Deer (120 stags and 40 hinds) were recorded at checking stations, with an additional 26 Hog Deer (17 stags and 9 hinds) harvested on Sunday Island (which is managed by a private cooperative).
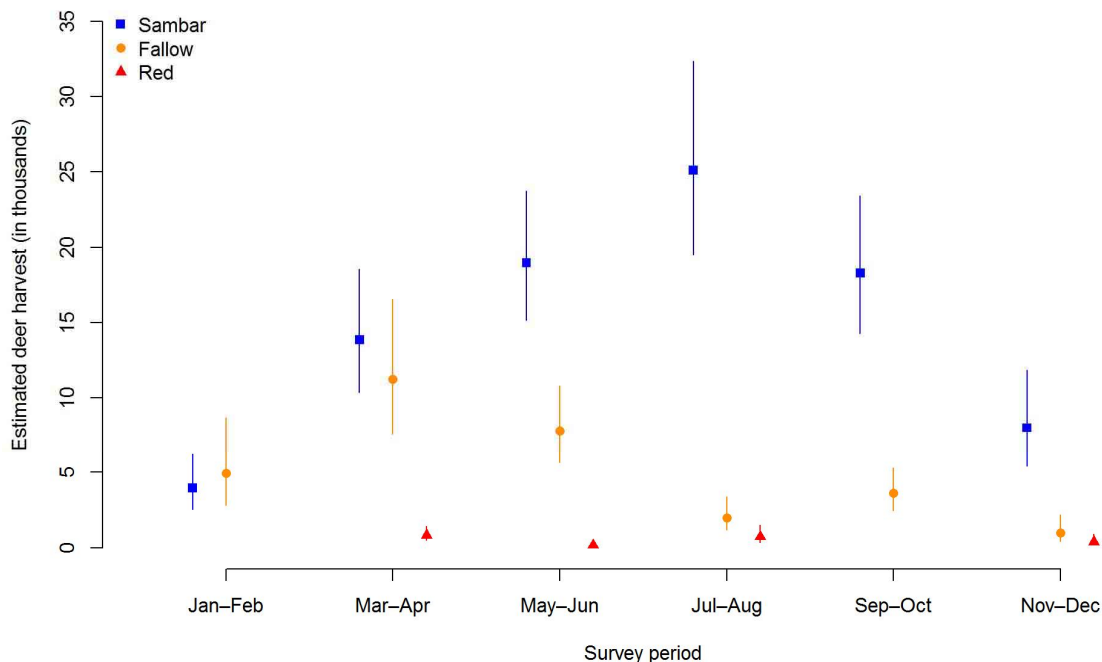
Figure 2. Estimated total deer harvest for each two-month survey period in 2018 by species.

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

Table 6. Estimates of the total harvest per deer species for each survey period in 2018

a. Sambar Deer.

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	28	3,949	919	2,518	6,194
Mar–Apr	84	13,869	2,072	10,365	18,559
May–Jun	114	18,965	2,177	15,154	23,733
Jul–Aug	140	25,130	3,254	19,518	32,356
Sep–Oct	96	18,281	2,318	14,272	23,415
Nov–Dec	41	8,009	1,611	5,420	11,834
Total	**503**	**88,202**	**5,333**	**78,354**	**99,288**

b. Fallow Deer

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	35	4,936	1,451	2,808	8,678
Mar–Apr	68	11,228	2,245	7,617	16,550
May–Jun	47	7,819	1,297	5,661	10,798
Jul–Aug	11	1,974	544	1,162	3,356
Sep–Oct	19	3,618	709	2,473	5,293
Nov–Dec	5	977	416	438	2,176
Total	**185**	**30,552**	**3,130**	**25,006**	**37,326**

c. Red Deer

Period	Reported harvest	Estimated harvest	SE	95% CI	
				Lower	Upper
Jan–Feb	0	0	NA	NA	NA
Mar–Apr	5	826	232	481	1,416
May–Jun	1	166	91	61	452
Jul–Aug	4	718	282	342	1,507
Sep–Oct	0	0	NA	NA	NA
Nov–Dec	2	391	176	168	908
Total	**12**	**2,101**	**415**	**1,432**	**3,082**

There was a statistically significant sex bias favouring females for the harvest of Sambar Deer and Fallow Deer (Table 7). There was no statistically significant sex bias for the harvest of Red Deer as the number reported was too small. There was no record of Hog Deer, Chital Deer or Rusa Deer being harvested in the surveys.

The average number of days hunted in each survey period varied throughout the season, with most hunting occurring from late autumn to mid-spring. Each Game Licence holder endorsed to hunt deer hunted an average of 6.7 days during 2018, corresponding to a total of 237,594 hunter days (95% CI = 212,473–265,686; Table 8).

Table 7. Reported numbers and percentages of each sex of each deer species harvested in 2018.

Species	Males			Females		
	Reported	%	SE	Reported	%	SE
Sambar Deer	225	0.45	0.02	278	0.55	0.02
Fallow Deer	67	0.36	0.04	118	0.64	0.04
Red Deer	5	0.42	0.14	7	0.58	0.14

Table 8. Number of days on which deer were hunted per Game Licence holder for 2018.

Period	Days hunted per Game Licence holder	SE	95% CI	
			Lower	Upper
Jan–Feb	0.39	0.10	0.24	0.65
Mar–Apr	1.17	0.06	1.06	1.30
May–Jun	1.47	0.05	1.36	1.58
Jul–Aug	1.63	0.10	1.45	1.84
Sep–Oct	1.41	0.07	1.28	1.55
Nov–Dec	0.64	0.06	0.54	0.76
Total hunting days per licence holder	**6.71**	**0.19**	**6.35**	**7.09**
Total hunting days	**237,594**	**13,558**	**212,4723**	**265,686**

More deer hunting occurred exclusively on public land (56%) compared with exclusively on private land (30%), with correspondingly similar proportions of deer harvested (Table 9). Most Sambar Deer were harvested on public land (57%). Most Fallow Deer were harvested on private land only (76%).

Table 9. Comparison of the number of days on which deer were hunted and associated deer harvest with respect to land tenure in 2018.

Land tenure	Days	Deer harvest	Sambar Deer	Fallow Deer	Red Deer
Private land only	29.5%	41.8%	28.6%	75.7%	66.7%
Public land only	55.9%	44.7%	56.7%	13.0%	33.3%
Both	14.6%	13.5%	14.7%	11.4%	0.0%
Not specified	0.0%	0.0%	0.0%	0.0%	0.0%

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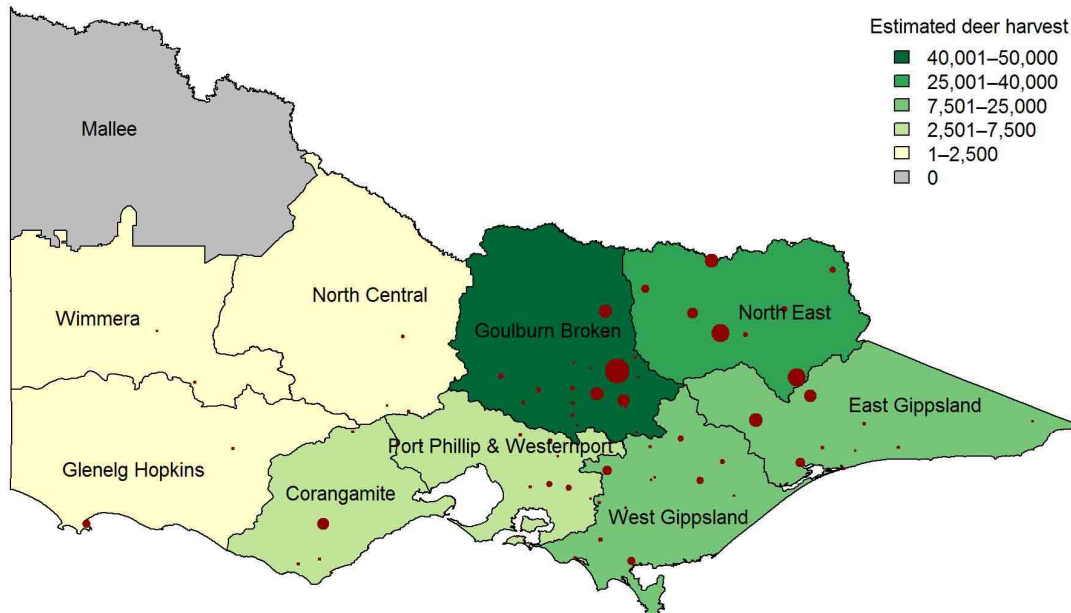

Figure 3. Estimates of total deer harvest in 2018 by CMA region.

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

3.2 Overall Sambar Deer harvest using hounds in 2018

The number of Game Licence holders endorsed to hunt Sambar Deer using hounds increased throughout 2018, from 4,482 in April (at the start of the season) to 5,002 in November, at the end of the season (Table 10). To achieve the required sample size of respondents, slightly more than 100 licence holders were contacted each survey, with an average of 96% of those contacted being willing to take part.

The proportion of Game Licence holders endorsed to use hounds who hunted with hounds was consistent for the first three survey periods (about a third hunted), while it dropped in the final survey period (to about a fifth hunted) (Table 11).

Table 10. Summary of responses from 2018 Game Licence holders endorsed to used hounds.

Deer survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted	Sambar Deer harvested[8]
1	Apr–May	4,548	99	33	157	332
2	Jun–Jul	4,746	100	33	218	517
3	Aug–Sep	4,909	100	35	258	856
4	Oct–Nov	4,993	100	21	124	288

Table 11. Proportion and corresponding total number of Game Licence holders endorsed to used hounds who hunted with hounds in each survey period in 2018.

Period	Proportion	SE	95% CI		Total hunters	SE	95% CI	
			Lower	Upper			Lower	Upper
Apr–May	0.33	0.047	0.25	0.44	1,516	215	1,149	2,000
Jun–Jul	0.33	0.047	0.25	0.44	1,566	223	1,186	2,068
Aug–Sep	0.35	0.048	0.27	0.46	1,718	234	1,317	2,241
Oct–Nov	0.21	0.041	0.14	0.31	1,049	203	719	1,528

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

Within each survey period, there was great variation in the reported harvest of deer per hunter's hound hunting teams (i.e. hound team total per Game Licence holder who hunted). Some teams (12%) harvested more than 40 deer in a survey period, whereas 5% did not harvest any deer in each period (Figure 4).

The median number of deer harvested per team in a two-month period was 10 deer. The average number of deer per team member (totalled by hunter) varied throughout the season (Table 12). The average harvest per hunter in a team in 2018 ranged from a high of 3.47 deer in August–September to a low of 1.63 in April–May.
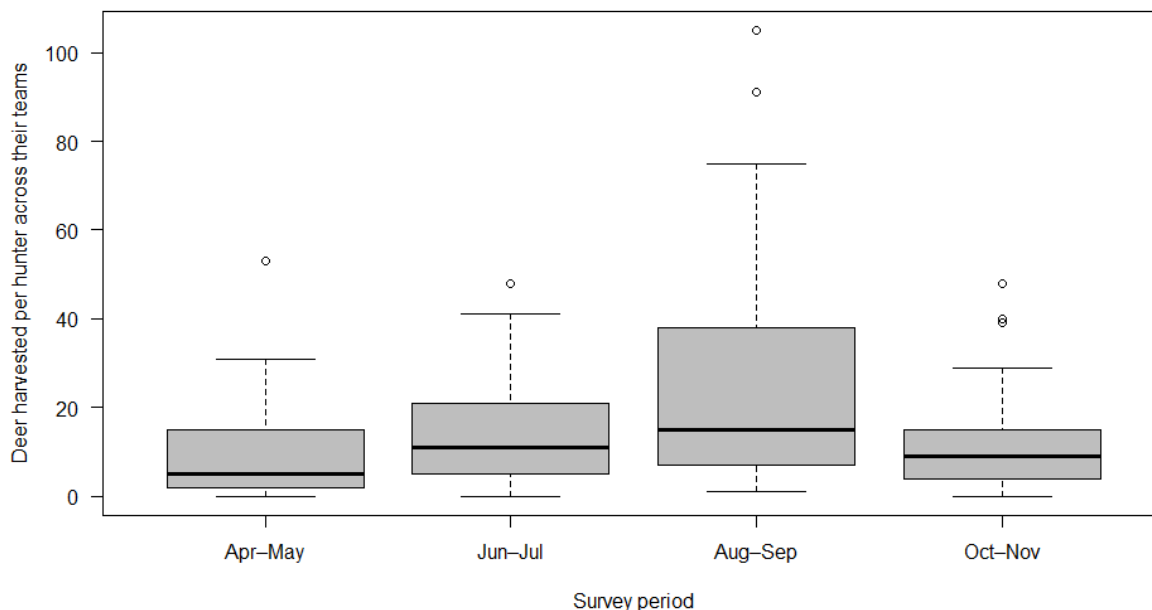
Figure 4. Boxplot of the number of Sambar Deer reported harvested by hound teams for each survey period in 2018.

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 12. Average harvest of Sambar Deer per team member (summed by hunter, Game Licence holders who hunted using hounds) for each survey period in 2018.

Period	Average harvest per hound hunter[9]	SE	95% CI	
			Lower	Upper
Apr–May	1.63	0.08	1.48	1.79
Jun–Jul	2.62	0.06	2.50	2.74
Aug–Sep	3.47	0.16	3.17	3.80
Oct–Nov	2.03	0.09	1.86	2.22

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

There was an estimated total of 14,670 deer harvested from April 2018 to November 2018, inclusive, by Game Licence holders endorsed to hunt deer using hounds (95% CI = 12,525–17,183; Table 13). Harvest was greatest in the winter months and lowest in the later spring months. The total average season harvest was 3.0 deer per Game Licence holder using hounds (95% CI = 2.6–3.6; Table 14).

Note that, for each survey period, the average Sambar Deer harvest per hound team member (Table 14) was much lower than the average deer harvest per Game Licence holder who hunted using hounds (Table 12), because the former included those respondents who did not hunt with hounds during the survey period.

Table 13. Estimates of the total Sambar Deer harvest using hounds in Victoria in 2018 by holders of a deer Game Licence.

Period	Total harvest[10]	SE	95% CI	
			Lower	Upper
Apr–May	2,473	371	1,846	3,314
Jun–Jul	4,099	592	3,092	5,433
Aug–Sep	5,965	858	4,506	7,895
Oct–Nov	2,133	425	1,449	3,139
Total	**14,670**	**1,185**	**12,525**	**17,183**

Table 14. Estimates of average harvest of Sambar Deer per Game Licence holder using hounds in each survey period in 2018.

Period	Average harvest[11]	SE	95% CI	
			Lower	Upper
Apr–May	0.54	0.08	0.41	0.73
Jun–Jul	0.86	0.12	0.65	1.14
Aug–Sep	1.22	0.17	0.92	1.61
Oct–Nov	0.43	0.09	0.29	0.63
Total	**3.05**	**0.24**	**2.61**	**3.57**

Using the telephone survey immediately after end of the 2018 hound season ended, it was estimated that 28% (95% CI = 23%–33%) of Game Licence holders endorsed to use hounds actually hunted for Sambar Deer with hounds during 2018. That equates to an estimate of 1,381 (95% CI = 1,172–1,627) active hound hunters in 2018. The average deer harvest per active deer hunter using hounds was estimated to be 10.6 (95% CI = 8.5–13.3).

There was a statistically significant sex bias favouring females for the harvest of Sambar Deer using hounds (p-value < 0.0001). The proportion of the harvest that was female was

55% (95% CI = 43%–47%). It should be noted that this is the same proportion of female Sambar Deer harvest by hunters using stalking or hound hunting.

The average number of days hunted in each survey period varied throughout the season, with most hunting occurring from late-autumn to mid-spring. Each Game Licence holder endorsed to hunt deer using hounds hunted an average of 7.6 days during 2018 (Table 15).

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

[11] Average harvest per Game Licence holder endorsed to use hounds.

Table 15. Number of days Sambar Deer were hunted using hounds per Game Licence holder for 2018.

Period	Average harvest[12]	SE	95% CI	
			Lower	Upper
Apr–May	1.59	0.30	1.10	2.29
Jun–Jul	2.18	0.42	1.50	3.18
Aug–Sep	2.58	0.47	1.81	3.68
Oct–Nov	1.24	0.33	0.74	2.08
Total hunting days per licence holder	**7.59**	**0.78**	**6.21**	**9.27**

Total harvest of Sambar Deer using hounds was estimated to be greatest in the North East CMA, followed by the Goulburn Broken CMA and the East Gippsland CMA (Figure 5). The top five towns for the total reported number of Sambar Deer harvested with the aid of hounds were (in descending order) Mansfield, Bright, Omeo, Dargo and Wodonga. The top five towns for the total number of reported deer hunting days using hounds were (in descending order) Mansfield, Dargo, Myrtleford, Eildon and Wodonga.
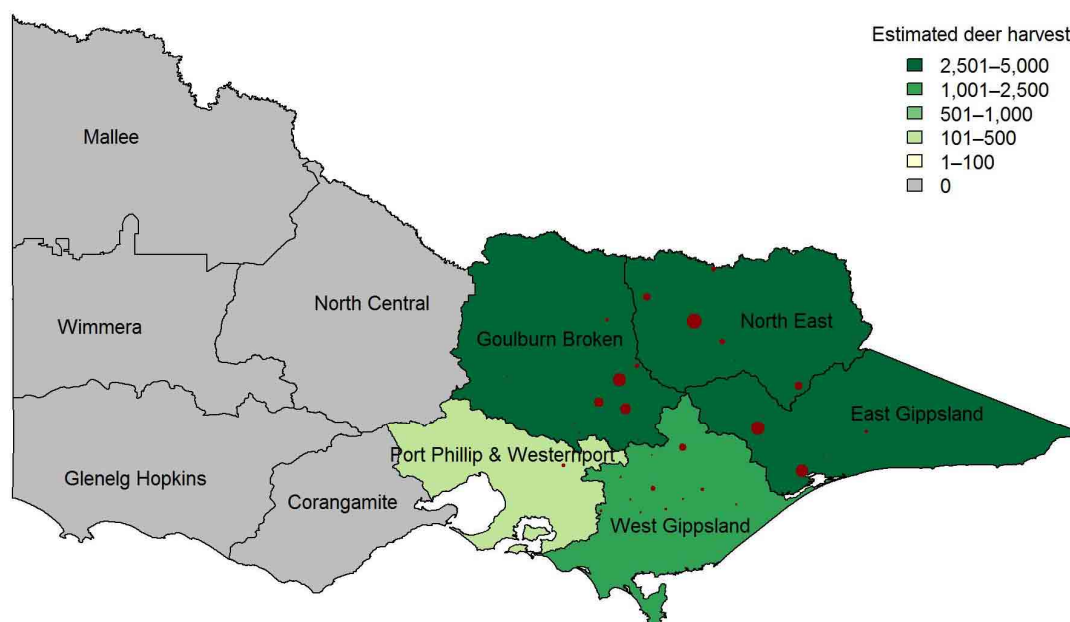

Figure 5. Estimates of total Sambar Deer harvest using hounds in 2018 by CMA region

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

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[12] Average harvest per Game Licence holder endorsed to use hounds.

4   Discussion

4.1   Deer harvest in 2018

A total of 121,567 deer were estimated to have been harvested in Victoria during the 2018 calendar year (95% CI = 95,913–154,081).

The deer harvest was the largest on record (Table 16, Figure 6). The 2018 estimate was 81% larger than the average harvest (67,329), and 14% larger than the next highest estimated deer harvest (2017), using this survey method. The majority of the increase in 2018 was from the estimated Fallow Deer harvest doubling from 2017, while the Sambar Deer harvest remained similar to 2017.

The most commonly harvested species in 2018 was Sambar Deer (88,202), followed by Fallow Deer (30,552) and Red Deer (2,101). There were no Chital Deer, Hog Deer or Rusa Deer reported harvested by surveyed Game Licence holders in 2018. Even though no survey respondent reported harvesting Hog Deer in 2018, a total of 160 Hog Deer 120 stags and 40 hinds) were recorded at checking stations, with an additional 26 Hog Deer 17 stags and 9 hinds) harvested on Sunday Island (which is managed by a private cooperative).

The 2018 season had the largest number of hunting days, 35% larger than average. The average number of hunting days per Game Licence holder in 2018 was in line with the long-term average. The number of hunting days is largest from late-autumn to mid-spring.

The average number of deer harvested per Game Licence holder in 2018 was 3.49, the largest recorded, 43% greater than average and 12% more than the next highest year (2016). The efficiency of hunters in 2018 was 0.51 deer harvested per hunting day. That was the second highest efficiency on record, 45% greater than the average.

From 2009 to 2018, 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 has also been increasing (by 10% per year on average).

Most Sambar deer were harvested from public land, while most Fallow and Red Deer were taken from private property (Table 9). Deer harvests for Sambar and Fallow Deer were skewed towards females.
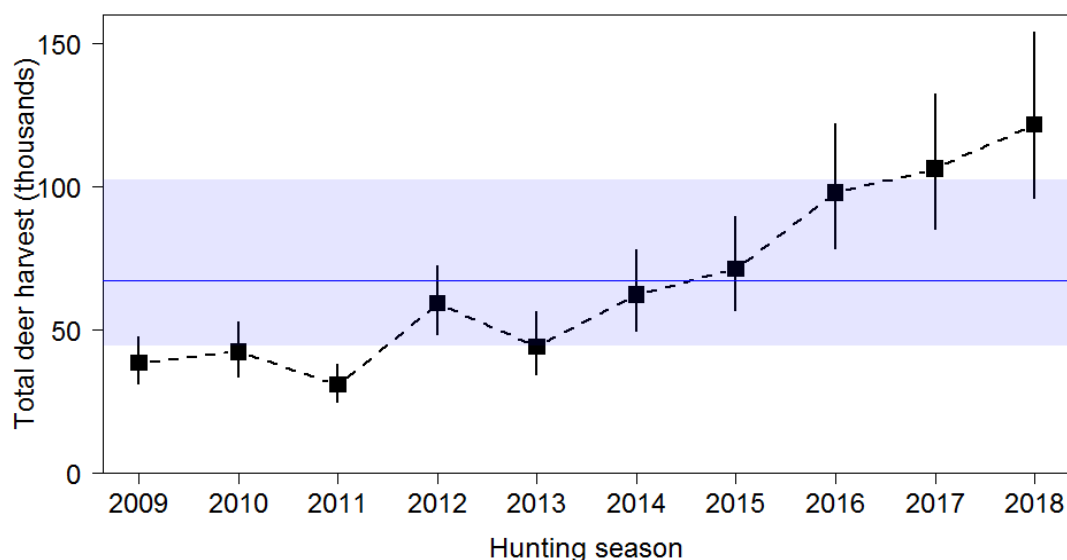

Figure 6. Estimates of total deer harvests (in thousands) from 2009 to 2018.
The square is the estimated total harvest for each season; the solid vertical line indicates the 95% confidence interval; the blue line is the average deer harvest from 2009 to 2018; the shaded area is the 95% confidence interval for the average deer harvest from 2009 to 2018.

Table 16. Comparison of the deer harvests of 2009 to 2018.

Year	Chital Deer	Fallow Deer	Hog Deer	Red Deer	Sambar Deer	Total harvest	Total hunting days	Deer per licence holder	Hunting days per licence	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	6.30	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
2018	0	30,552	0	2,101	88,202	121,567	237,594	3.49	6.71	0.51
Average	**31**	**11,466**	**103**	**1,140**	**54,125**	**67,329**	**175,746**	**2.43**	**6.75**	**0.37**

4.2 Sambar Deer harvest in 2018 using hounds

The survey was revised for 2018 to improve the accuracy in relation to estimating the harvest of Sambar Deer with hounds by specifically surveying hound hunters as a separate subset of all deer hunters. It is estimated that 14,670 of the Sambar Deer harvest were harvested using hounds, with the average harvest per licence of 3.1 deer over 7.6 days. Around 30% of Game Licence holders endorsed to hunt deer using hounds actively hunted in 2018, with the average harvest per team member being 10.6 deer over the season.

Game Licence holders endorsed to hunt deer using hounds are less efficient individually than those who stalk with 0.4 deer harvest per team member per hunting day compared to 0.51 deer harvested per hunting day respectively.

It should be noted that the survey of Game Licence holders endorsed to hunt deer using hounds were also asked about any stalking they also did during the same period. The respondents showed that more of them stalked (35%) than hound hunted (31%), while 12% did both within the two-month period. It also showed that while stalking they also harvested more deer (1 per hunter versus 0.76 per team member) over the same period of time. Game Licence holders endorsed to hunt deer using hounds spent an average of 3.52 days hunting deer combining use of hounds (1.9 days) and stalking (1.63 days).

4.3 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% (Wright 1978; Barker 1991). It is likely, however, that the sampling strategy of telephone interviews after each 2-month period would have ensured that both memory bias and non-response bias were kept low (compared with postal surveys and complete end-of-season surveys) (Barker 1991; Barker, Geissler, and Hoover 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 hunts in every survey period (see Gormley and Turnbull 2010). Therefore, the estimate of total season bag per Game Licence holder is the sum of the 'harvest per Game Licence holder', not the sum of the 'harvest per hunter'.

The uncertainty in the estimates of total harvest (as indicated by the confidence intervals) was due to two factors. First, there was variation in the reported numbers of animals harvested between respondents who had hunted (see Figure 1 and Figure 4). For example, within a given survey period, some respondents indicated that they hunted unsuccessfully, whereas others took multiple trips and indicated a total harvest of more than 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 the Game Licence holder endorsed to hunt deer. Statistically, these sample sizes are considered adequate to provide reasonable estimates.

The spatial distributions of the deer harvest should also be interpreted with care. Grouping the harvest by CMA provides a broad-scale view of the distribution of the harvest. Grouping by smaller regions would provide a finer-scale representation, but this would be at the cost of increased bias in many regions. Because the data are from a sample of Game Licence holders rather than a complete census, it is likely that some areas that were actually hunted 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 that harvest, increasing the average harvest rate. However, the chances of this are relatively low given 100 out of a potential 4500 to 5000 Game Licence holders endorsed to hunt deer with hounds.

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.

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Appendix A

Questionnaire for Game Licence holder endorsed to hunt deer

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)

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)

5. How many days did you go hunting?

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

7. What species were the deer?

Sambar   Fallow   Red   Hog   Chital   Rusa

8. What was the sex of the Deer Male / Female

9. How were the deer taken?
Stalking
Scent- Hounds
Stalking with a Gundog
Bow

10. Did you hunt on private land or public land?   Public / Private / both

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

Appendix B

Questionnaire for Game Licence holder endorsed to hunt deer using hounds

1. Have you been hound hunting in the past two Months? (name months)   Yes ☐   No ☐ (tick box, if 'Yes', proceed to question 2, if 'No' Go to Q 10.

2. How many hound hunting trips have you taken over this 2 month period?   ☐

(indicate number in box)

(Each trip needs to be treated separately for question 3 - 8)

3. How many days did you go hunting?

4. How many hunters in your team?

5. How many deer did your team harvest?

6. How many deer did you harvest?

7. What was the sex of the Deer

8. Did you hunt on private land or public land?

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

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

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

(Each trip needs to be treated separately for question 12 - 13)

12. How many days did you go hunting?

13. How many deer did you harvest?

Appendix C

Common definitions used

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

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

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

Calculations

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

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

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

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

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

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

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

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

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

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

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

$$SE(p_j) = \sqrt{\frac{p_j(1-p_j)}{n_j}}$$
e.g. for Deer Survey 4 in 2015, we obtained: $\sqrt{\frac{0.35 \times 0.65}{200}} = 0.034$.

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

$$SE(w_j) = \frac{SD(w_j)}{\sqrt{h_j}}$$, e.g. for Deer Survey 4 in 2015, we obtained: $\frac{4.55}{\sqrt{70}} = 0.54$.

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

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

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

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

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

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

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

upper limit (UL) $= \widehat{X} \times r$

lower limit (LL) $= \widehat{X} \div r$, 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

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

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

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 D

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 D1 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).
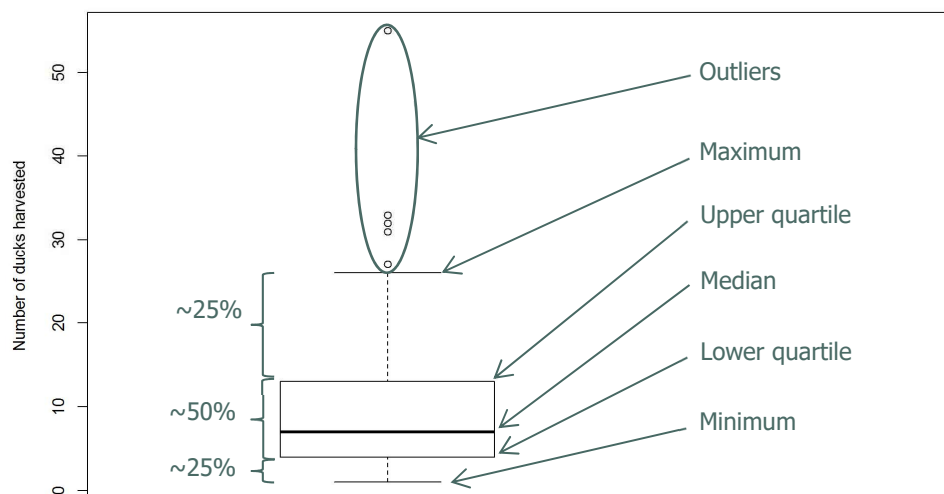

Figure D1. Example boxplot, with labels