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Estimates of Harvest for Deer, Duck and Quail in Victoria: Results from Surveys of Victorian Game Licence Holders in 2011

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Estimates of harvest for deer, duck and quail in Victoria: Results from surveys of Victorian game licence holders in 2011

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Contents

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Summary

A telephone survey of Victorian hunters was conducted during the 2011 hunting seasons for deer, duck and quail to determine the total harvest for each game type. Game licence holders for each game type (deer, duck and quail) were randomly sampled and interviewed by telephone at intervals during the respective game seasons. For 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 animals harvested. Additional information was obtained on hunting methods and locations.

Each holder of a game licence for deer hunted for approximately seven days on average during the 2011 deer-hunting season, with an average season harvest of nearly two deer per game licence holder. Based on the total number of holders of a deer game licence, this corresponds to an estimated 40,728 deer harvested during the 2011 deer-hunting season in Victoria (95% confidence interval (CI) = 32,381–51,228). The most commonly harvested species was Sambar Deer (with an estimated total harvest of 34,000), followed by Fallow Deer (5187). Harvest estimates for Red Deer (1437) and Hog Deer (105) were based on a small number of responses.

Each holder of a game licence for ducks hunted on approximately 4.5 days during the 2011 duck-hunting season, with an average season harvest of 26 ducks per game licence holder. Based on the total number of game licence holders, this equates to an estimated 600,739 ducks harvested during the 2011 duck-hunting season in Victoria (95% CI = 528,557–682,778). The most commonly harvested species was Grey Teal (which comprised 35% of the total harvest), followed by Pacific Black Duck (26%), Australian Wood Duck (22%), Chestnut Teal (9%), Hardhead (4%), Pink-eared Duck (2%), Australian Shelduck (1%) and Australasian Shoveler (1%).

For quail, the average season harvest was 26 quail per game licence holder. Based on the total number of game licence holders, this corresponds to an estimated 678,431 quail harvested during the 2011 quail-hunting season in Victoria (95% CI = 573,511–802,546).

The approach used here explicitly accounts for the possibility that not every holder of a game licence will hunt during every survey period. The total number of game licence holders that hunted is 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 season is likely to minimise memory bias and non-response bias compared to the end of year postal survey. 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

In order to effectively manage game species, it is important to quantify the numbers harvested. The Victorian Department of Sustainability and Environment (DSE) conducts a mail survey of 1,000 randomly selected game licence holders during June each year. There are, however, a number of problems associated with mail surveys, including recall bias, rounding of harvest estimates, and non-response bias (Wright 1978). Due to concerns about the reliability of the harvest estimates from the mail survey, DSE commissioned a series of regular telephone surveys to address the issue of recall bias. The three sets of telephone surveys were conducted during the various game harvest seasons for deer, duck and quail.

Deer hunting occurs all year round in Victoria. For this report, the 2011 deer-hunting season was defined as 1 July 2010 until 30 June 2011. Sambar Deer (*Cervus unicolor*) could be hunted all year by stalking. Hunting using scent-trailing hounds was restricted to the second Saturday after Easter Sunday until 30 November. Hunting of Red Deer (*Cervus elaphus*) was restricted to the months of June and July only. Hog Deer (*Axis porcinus*) could be hunted only during April, and were subject to additional restrictions such as one male and one female per hunter. All other species, Fallow Deer (*Dama dama*), Chital Deer (*Axis axis*) and Rusa Deer (*Cervus timorensis*), could be hunted all year. This survey follows similar telephone surveys performed during the 2009 and 2010 deer hunting seasons (Gormley and Turnbull 2009, 2010).

The 2011 duck-hunting season lasted 13 weeks, from 19 March to 13 June. Eight species could legally be hunted in 2011: Pacific Black Duck (*Anas superciliosa*), Australian Wood Duck[1] (*Chenonetta jubata*), Australian Shelduck[2] (*Tadorna tadornoides*), Grey Teal (*Anas gracilis*), Chestnut Teal (*Anas castanea*), Pink-eared Duck (*Malacorhynchus membranaceus*), Hardhead[3] (*Aythya australis*), Australasian Shoveler[4] (*Anas rhynchotis*). The daily bag limit for the 2011 season was ten game ducks per hunter (with a limit of two Australasian Shoveler). These surveys follow from telephone surveys performed during the 2005, 2006, 2009 and 2010 duck-hunting seasons (Barker 2006; Gormley and Turnbull 2009, 2010).

The 2011 quail-hunting season lasted 12 weeks, from 2 April to 30 June. The daily bag limit for the 2011 season was 20 quail per hunter, with Stubble Quail (*Coturnix pectoralis*) the only native species that could legally be hunted. This survey follows similar telephone surveys performed during the 2008, 2009 and 2010 quail-hunting seasons (Gormley 2009; Gormley and Turnbull 2009, 2010).

[1] Australian Wood Duck is also referred to as Wood Duck, Maned Duck, and Maned Goose.
[2] Australian Shelduck is often referred to as Mountain Duck.
[3] Hardhead is also referred to as White-eyed Duck.
[4] Australasian Shoveler is often referred to as Blue-winged Shoveler.

2 Methods

2.1 General methodology

A similar methodology was used to estimate deer, duck and quail harvests. All surveys were conducted by the telephone survey company Marketing Skill on behalf of DSE. Estimates of total harvest by game licence holders were based on the reported hunting activities of the survey respondents.

For each game type, a series of surveys was performed throughout the corresponding season. Each survey involved telephoning a random sample of game licence holders and asking them to report their hunting activities only for the periods covered by that survey. Therefore, although a respondent[5] may have hunted during the period covered by Survey 2 and Survey 3, if they were contacted as part of Survey 3, then information was only collected that pertained to the period covered by Survey 3.

The information from the respondents was used as an estimate of the whole population of game licence holders for each game type. Estimates of harvest were determined for each of the survey periods and were summed to give an estimate of the total season harvest. For each survey period, the proportion of respondents that hunted was used as an estimate of the proportion of game licence holders that hunted. The proportion of game licence holders that hunted during each survey period was multiplied by the total number of game licence holders to give the total number of hunters for that survey period.

For each survey period, the average harvest per hunter[6] was estimated from the total reported harvest divided by the number of respondents that hunted. The total harvest for each survey period was estimated by multiplying the average harvest per hunter by the total number of hunters for that survey period, as estimated previously. Finally, the total season harvest was estimated as the sum of the survey-specific total harvests.

We also estimated the season harvest per game licence holder. 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 season provided an estimate of the total season harvest per game licence holder.

Respondents that hunted were also asked to provide information on whether hunting was conducted on private land or public land (including State Game Reserves), the name of the town nearest to where they hunted, and the number of days they hunted. Regional harvest estimates were calculated by summing the reported harvest for each nearest town and then aggregating these by the corresponding Victorian Catchment Management Authority (CMA) region.

There were differences in the number and length of surveys between the duck, deer and quail surveys, as indicated in the following sections. Additional details of the methods, as well as examples of the calculations, are provided in Appendix 1.

[5] *Respondent* refers to game licence holders who were contacted and agreed to take part in the survey.

[6] *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 is concerned.

2.2 Deer

Samples were drawn from hunters who held a game licence to harvest deer. Random samples of hunters were telephoned every two months over the 12-month period to give a total of six surveys. Respondents were asked to report the number and sex of each species harvested. During each survey, 200 respondents were interviewed regardless of whether they had hunted or not. Respondents were also asked what hunting methods they used (i.e. stalking, scent-trailing hounds or gun dogs).

2.3 Duck

Samples were drawn from hunters who held a game licence to harvest ducks during the 2011 season. A random sample of 200 licence holders was interviewed by telephone immediately after opening weekend (Duck Survey 1) followed by independent random samples of licence holders at two-week intervals for the remainder of the duck season (Duck Surveys 2–7). Respondents were also asked to report the number of each species harvested.

2.4 Quail

Samples were drawn from hunters who held a game licence to harvest quail during the 2011 season. A random sample of 300 licence holders was interviewed by telephone each month for April (Survey 1), May (Survey 2) and June (Survey 3). Respondents were asked to report the number of Stubble Quail harvested, the type of grassland where hunting occurred (native, stubble or introduced) and whether dogs were used.

3 Results

3.1 Deer

The number of game licence holders with permits to hunt deer ranged from a high of 21,570 in November/December 2010, to a low of 18,652 in January/February 2011 (Table 1). In order to achieve the required sample size of respondents, slightly more than 200 licence holders were contacted each survey, with an average of 97.2% of those contacted willing to take part.

Table 1: Summary of responses for deer surveys.

Deer Survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted	Deer harvested
1	Jul–Aug 2010	20,393	200	81	467	152
2	Sep–Oct 2010	21,178	200	73	304	91
3	Nov–Dec 2010	21,570	200	21	64	23
4	Jan–Feb 2011	18,652	200	20	51	3
5	Mar–Apr 2011	19,741	200	51	224	47
6	May–Jun 2011	21,011	200	53	256	78

Days hunted indicates the combined number of days that hunting took place and *Deer harvested* indicates total number of deer harvested, respectively, by respondents within each survey period.

The proportion of game licence holders that hunted in each survey period varied throughout the season (Table 2). An estimated 41% of deer game licence holders hunted at least once during July–August 2010, declining to a low of 10% during January–February 2011. These percentages correspond to 8,259 hunters in the July–August period and 1,865 hunters in the January–February period (Table 2).

Table 2: Proportion and corresponding total number of deer licence holders that hunted, for each survey period.

			95% CI		Total		95% CI	
Period	Proportion	SE	Lower	Upper	hunters	SE	Lower	Upper
Jul–Aug 2010	0.41	0.035	0.34	0.48	8,259	708	6,984	9,767
Sep–Oct 2010	0.37	0.034	0.30	0.44	7,730	721	6,441	9,277
Nov–Dec 2010	0.11	0.022	0.07	0.16	2,265	468	1,518	3,380
Jan–Feb 2011	0.10	0.021	0.07	0.15	1,865	396	1,236	2,814
Mar–Apr 2011	0.26	0.031	0.20	0.32	5,034	608	3,976	6,374
May–Jun 2011	0.27	0.031	0.21	0.33	5,568	656	4,424	7,008

Within each survey period there was large variation in the reported harvest of deer per hunter (i.e. per game licence holder that hunted), with some hunters harvesting more than 10 deer in a survey period (Figure 1). The average number of deer harvested per hunter ranged from a high of 1.88 deer per hunter during July–August 2010 to a low of 0.15 in January–February 2011 (Table 3).

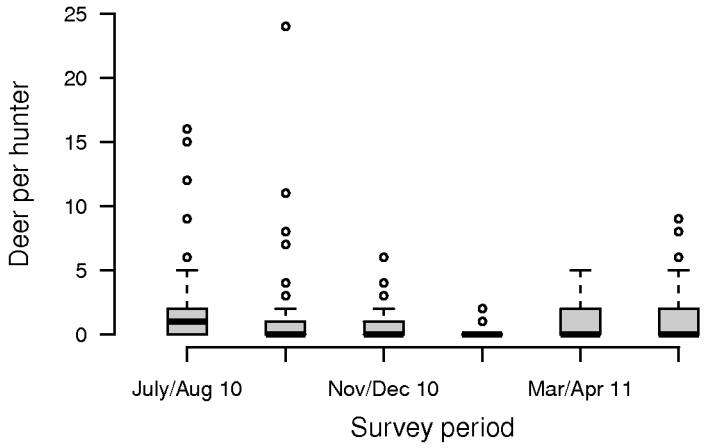

Figure 1: Boxplot of the number of deer reported harvested by individual hunters for each survey period. The bottom and top of each 'box' indicates the 25th and 75th percentile, respectively, with the black horizontal line indicating the median reported value.

Table 3: Average harvest of deer per hunter (game licence holders who hunted) for each survey period.

	Average harvest		95% CI	
Period	**per hunter**	**SE**	**Lower**	**Upper**
Jul–Aug 2010	1.88	0.33	1.33	2.65
Sep–Oct 2010	1.25	0.34	0.74	2.11
Nov–Dec 2010	1.10	0.38	0.57	2.11
Jan–Feb 2011	0.15	0.11	0.04	0.54
Mar–Apr 2011	0.92	0.19	0.61	1.38
May–Jun 2011	1.47	0.29	1.00	2.16

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

There was an estimated total of 40,728 deer harvested by all deer game licence holders from July 2010 through June 2011 inclusive (95% CI = 32,381–51 ,228; Table 4). Harvest was greatest in the winter months and lowest in the summer months.

Table 4: Estimates of the total deer harvest in Victoria from July 2010 until June 2011, by holders of a deer game licence.

Survey	Total harvest	SE	95% CI Lower	95% CI Upper
Jul–Aug 2010	15,499	3,057	10,568	22,729
Sep–Oct 2010	9,636	2,773	5,543	16,751
Nov–Dec 2010	2,481	997	1,162	5,295
Jan–Feb 2011	280	213	74	1,052
Mar–Apr 2011	4,639	1,123	2,906	7,405
May–Jun 2011	8,194	1,880	5,256	12,774
Total Season	**40,728**	**4,782**	**32,381**	**51,228**

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

The total average season harvest was 1.97 deer per game licence holder (95% CI = 1.57–2.48; Table 5). Note that for each survey period the average deer harvest per game licence holder (Table 5) is much lower than the average deer harvest per hunter (Table 3), as the former includes those respondents who did not hunt during the survey period.

Table 5: Estimated average harvest of deer per game licence holder in each survey period.

Period	Average harvest	SE	95% CI Lower	95% CI Upper
Jul–Aug 2010	0.76	0.15	0.52	1.11
Sep–Oct 2010	0.46	0.13	0.26	0.79
Nov–Dec 2010	0.12	0.05	0.05	0.25
Jan–Feb 2011	0.02	0.01	0.00	0.06
Mar–Apr 2011	0.24	0.06	0.15	0.38
May–Jun 2011	0.39	0.09	0.25	0.61
Total Season	**1.97**	**0.23**	**1.57**	**2.48**

Average harvest per game licence holder = *Deer harvested* divided by *Respondents* (Table 1).

Separate harvest estimates for each deer species are presented in Table 6 and Figure 2. No Chital Deer or Rusa Deer were reported harvested. Estimates of Hog Deer and Red Deer were based on only a few reported harvest records, and therefore should be viewed with caution. In general, harvest was highest in the winter months and lowest in the summer months.

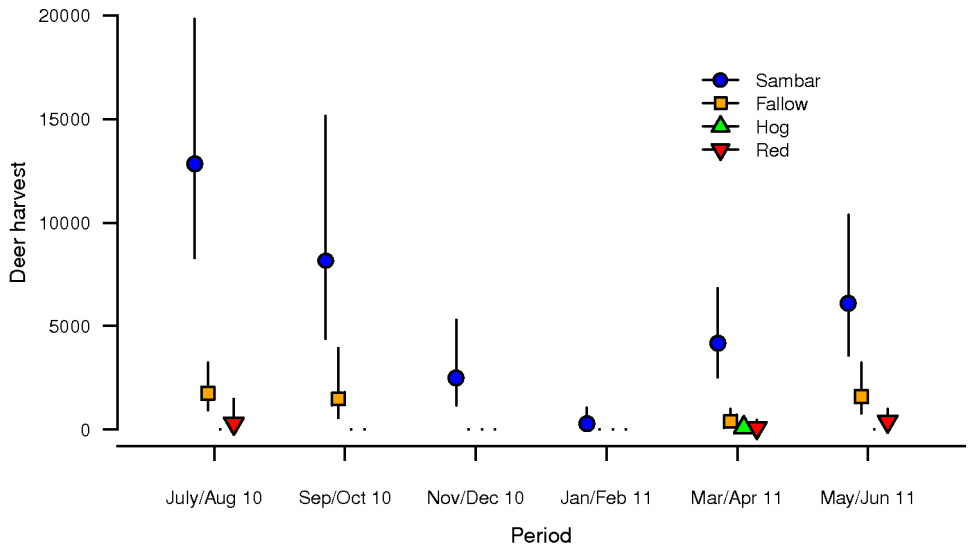

Figure 2: Estimated total deer harvest for each two-month survey period, by species. Vertical bars indicate 95% CIs.

Table 6: The number of each deer species reported harvested by hunters, and estimated total 2011 harvest.

a. Sambar Deer

			95% CI	
Period	**Reported**	**Total harvest**	**Lower**	**Upper**
Jul–Aug 2010	126	12,848	8,324	19,829
Sep–Oct 2010	77	8,154	4,386	15,156
Nov–Dec 2010	23	2,481	1,162	5,295
Jan–Feb 2011	3	280	74	1,052
Mar–Apr 2011	42	4,146	2,521	6,817
May–Jun 2011	58	6,093	3,574	10,388
Annual Total		**34,000**	**26,248**	**44,042**

b. Fallow Deer

			95% CI	
Period	**Reported**	**Total harvest**	**Lower**	**Upper**
Jul–Aug 2010	17	1,733	933	3,219
Sep–Oct 2010	14	1,482	559	3,929
Nov–Dec 2010	0	0	NA	NA
Jan–Feb 2011	0	0	NA	NA
Mar–Apr 2011	4	395	157	992
May–Jun 2011	15	1,576	770	3,225
Annual Total		**5,187**	**3,375**	**7,971**

c. Hog Deer

			95% CI	
Period	**Reported**	**Total harvest**	**Lower**	**Upper**
Jul–Aug 2010	0	NA	NA	NA
Sep–Oct 2010	0	NA	NA	NA
Nov–Dec 2010	0	NA	NA	NA
Jan–Feb 2011	0	NA	NA	NA
Mar–Apr 2011	1	105	20	554
May–Jun 2011	0	NA	NA	NA
Annual Total		**105**	**20**	**554**

NB: Hog Deer are only permitted to be hunted during April.

d. Red Deer

			95% CI	
Period	**Reported**	**Total harvest**	**Lower**	**Upper**
Jul–Aug 2010	9	918	260	3,234
Sep–Oct 2010	0	0	0	0
Nov–Dec 2010	0	0	0	0
Jan–Feb 2011	0	0	0	0
Mar–Apr 2011	*1	99	19	509
May–Jun 2011	4	420	122	1,452
Annual Total		**1,437**	**564**	**3,660**

*NB: Red Deer are only permitted to be hunted in June and July.

For Sambar Deer, similar proportions of stags and hinds were harvested (Table 7). For Fallow Deer, a greater proportion of males were harvested (59%). For Red Deer and Hog Deer, the reported numbers were too small to make any conclusions in terms of sex-specific harvest.

Table 7: Reported numbers and percentages of each sex of deer species harvested. Standard errors for the percentages are shown in parentheses.

	Stags		Hinds	
Species	**n**	**% (SE)**	**n**	**% (SE)**
Sambar Deer	170	51.7% (2.8)	159	48.3% (2.8)
Fallow Deer	30	58.8% (6.9)	21	41.2% (6.9)
Hog Deer	1	100.0% (NA)	0	0.0% (NA)
Red Deer	7	53.8% (13.8)	6	46.2% (13.8)

The number of days hunted in each survey period varied throughout the season, with most hunting occurring in winter. Each deer licence holder hunted an average of 6.83 days during the 2011 deer-hunting season, corresponding to a total of 140,471 hunter days (95% CI = 119,975–164,468; Table 8).

Table 8: Days hunted per game licence holder.

	Days		95% CI	
Period	**hunted**	**SE**	**Lower**	**Upper**
Jul–Aug 2010	2.34	0.28	–	–
Sep–Oct 2010	1.52	0.18	–	–
Nov–Dec 2010	0.32	0.08	–	–
Jan–Feb 2011	0.26	0.07	–	–
Mar–Apr 2011	1.12	0.18	–	–
May–Jun 2011	1.28	0.21	–	–
Total days per licence holder	**6.83**	**0.44**	**6.02**	**7.75**
Total hunting days	**140,471**	**11,322**	**119,975**	**164,468**

NB: 95% CIs were only calculated for total days.

More deer hunting occurred on public land (73.6%) than on private land (24.1%), with correspondingly similar proportions of deer harvested (Table 9).

Table 9: Percentage of days hunted and associated deer harvest by land tenure.

Land tenure	**Days**	**Deer**
Private Land	24.1%	22.9%
Public Land	73.6%	74.1%
Both	2.3%	3.0%
Total	**100.0%**	**100.0%**

Stalking was the preferred hunting method, being used in 63.4% of the hunting days and accounting for 47.7% of the reported harvest. Hunting with scent-trailing hounds was the most productive hunting method, being used in 18.8% of the hunting days but accounting for 40.6% of the reported harvest (Table 10). It should be noted that the hunting method was not specified in 11.2% of the hunting days.

Table 10: Percentage of days hunted and associated deer harvest for hunting methods.

Hunting Method	Days	Deer
Stalking	63.4%	47.7%
Stalking with gundog	6.6%	9.7%
Scent-trailing hounds	18.8%	40.6%
Not specified	11.2%	2.0%
Total	**100.0%**	**100.0%**

Total harvest was estimated to be greatest in the Goulburn Broken CMA and the North East CMA, followed by the East Gippsland CMA and the West Gippsland CMA (Figure 3). There was no reported harvest in the Mallee CMA or North Central CMA from the survey respondents.

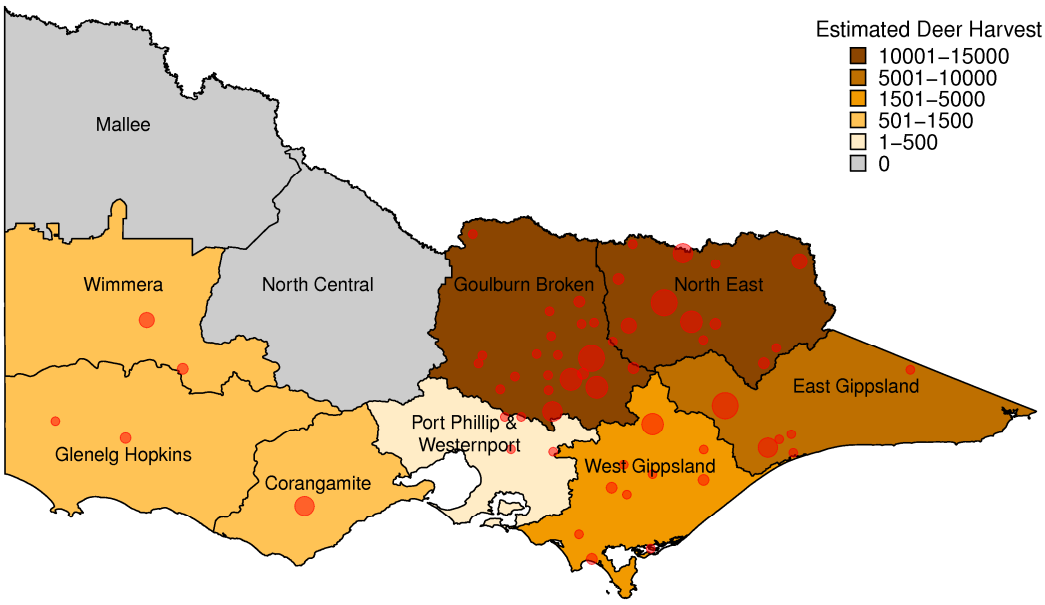

Figure 3: Estimated total deer harvest by CMA region. Red circles indicate the nearest town to harvest locations, with larger symbols representing larger reported harvests.

3.2 Duck

The number of game licence holders with permits to hunt ducks remained relatively constant throughout the season, increasing from 21,992 at opening weekend to 23,716 at the end of May (Table 11). In order to achieve the required sample size of respondents, slightly more than 200 licence holders were contacted each survey, with an average of 97.6% of those contacted willing to take part.

Table 11: Summary of responses for duck surveys in 2011.

Duck Survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted	Ducks harvested
1	19 Mar–20 Mar	21,992	200	124	203	1,139
2	21 Mar–3 Apr	23,249	200	66	152	790
3	4 Apr–17 Apr	23,249	200	55	146	726
4	18 Apr–1 May	23,249	200	41	87	527
5	2 May–15 May	23,554	200	34	94	694
6	16 May–29 May	23,554	200	52	90	604
7	30 May–13 Jun	23,716	200	58	124	718

Days hunted indicates the combined number of days that were hunted and *Ducks harvested* indicates total ducks harvested respectively by the respondents, within each survey period.

The proportion of game licence holders that hunted in each survey period varied throughout the season: 62% of licence holders hunted during opening weekend, corresponding to approximately 13,600 hunters (Table 12). The proportion that hunted during other survey periods varied from 17% to 33%, corresponding to between 4,000 and 7,600 duck hunters, respectively (Table 12).

Table 12: Proportion, and corresponding total number, of game licence holders that hunted in each survey period.

Duck				95% CI		Total		95% CI	
Survey	Period	Proportion	SE	Lower	Upper	hunters	SE	Lower	Upper
1	19 Mar–20 Mar	0.62	0.034	0.56	0.69	13,635	755	12,234	15,196
2	21 Mar–3 Apr	0.33	0.033	0.27	0.40	7,672	773	6,300	9,343
3	4 Apr–17 Apr	0.28	0.032	0.22	0.34	6,393	734	5,109	8,001
4	18 Apr–1 May	0.21	0.029	0.16	0.27	4,766	664	3,632	6,253
5	2 May–15 May	0.17	0.027	0.13	0.23	4,004	626	2,953	5,429
6	16 May–29 May	0.26	0.031	0.21	0.33	6,124	731	4,851	7,731
7	30 May–13 Jun	0.29	0.032	0.23	0.36	6,878	761	5,540	8,538

Within each survey period there was large variation in the reported harvest of ducks per hunter (i.e. per game licence holder that hunted), with some hunters harvesting more than 100 ducks in a survey period (Figure 4). The average number of ducks per hunter varied throughout the season (Table 13). The average harvest per hunter was 9.19 ducks on opening weekend, and ranged from 11.62 to 20.41 for the two-week survey periods.

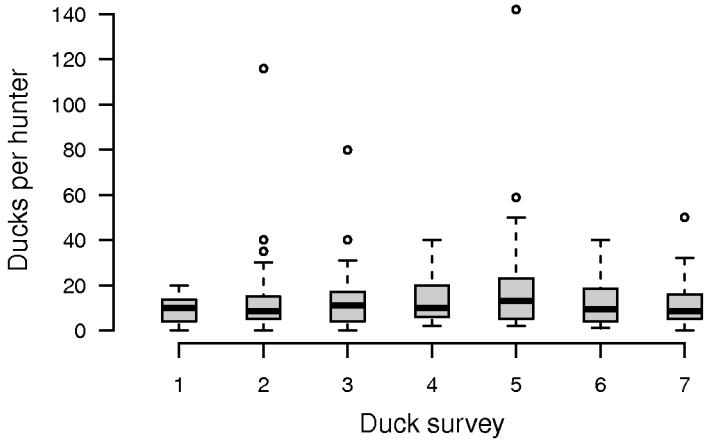

Figure 4: Boxplot of the number of ducks reported harvested by individual hunters in each survey period. The bottom and top of each 'box' indicates the 25th and 75th percentile, respectively, with the black horizontal line indicating the median reported value.

Table 13: Average harvest of ducks per hunter (i.e. game licence holders who hunted) for each survey period.

Duck Survey	Period	Average harvest per hunter	SE	95% CI	
				Lower	Upper
1	19 Mar–20 Mar	9.19	0.55	8.17	10.33
2	21 Mar–3 Apr	11.97	1.90	8.78	16.31
3	4 Apr–17 Apr	13.20	1.76	10.17	17.13
4	18 Apr–1 May	12.85	1.41	10.38	15.92
5	2 May–15 May	20.41	4.42	13.39	31.12
6	16 May–29 May	11.62	1.18	9.53	14.15
7	30 May–13 Jun	12.38	1.52	9.74	15.73

Average harvest per hunter = *Ducks harvested* divided by *Respondents who hunted* (Table 11).

There were an estimated 125,244 ducks harvested during opening weekend (95% CI = 106,764–146,923). The harvest throughout the season remained relatively constant. The total season harvest estimate was 600,739 (95% CI = 528,557–682,778; Table 14).

Table 14: Estimates of the duck harvest in Victoria in 2011 by holders of a duck game licence.

Duck Survey	Period	Total harvest	SE	95% CI Lower	95% CI Upper
1	19 Mar–20 Mar	125,244	10,218	106,764	146,923
2	21 Mar–3 Apr	91,834	17,277	63,716	132,359
3	4 Apr–17 Apr	84,394	14,867	59,910	118,884
4	18 Apr–1 May	61,261	10,846	43,415	86,444
5	2 May–15 May	81,732	21,895	48,786	136,927
6	16 May–29 May	71,133	11,124	52,451	96,469
7	30 May–13 Jun	85,140	14,068	61,721	117,446
	Total Season	**600,739**	**39,277**	**528,557**	**682,778**

Total harvest = *Harvest per hunter* (Table 13) × *Total hunters* (Table 12).

The total average season harvest per licence holder was estimated to be 25.99 (95% CI = 22.91–29.49; Table 15). Note that for each survey period the *average duck harvest per game licence holder* is lower than the *average duck harvest per hunter*, as the former includes those respondents who did not hunt during the survey period, whereas the latter is conditional on those that hunted.

Table 15: Estimated harvest of ducks per game licence holder in each survey period.

Duck Survey	Period	Average harvest	SE	95% CI Lower	95% CI Upper
1	19 Mar–20 Mar	5.70	0.46	4.85	6.68
2	21 Mar–3 Apr	3.95	0.74	2.74	5.69
3	4 Apr–17 Apr	3.63	0.64	2.58	5.10
4	18 Apr–1 May	2.64	0.46	1.87	3.71
5	2 May–15 May	3.47	0.92	2.08	5.79
6	16 May–29 May	3.02	0.47	2.23	4.09
7	30 May–13 Jun	3.59	0.59	2.60	4.95
	Total Season	**25.99**	**1.68**	**22.91**	**29.49**

Average harvest per game licence holder = *Ducks harvested* divided by *Respondents* (Table 11).

Total harvest estimates for each species were obtained by multiplying the total estimated duck harvest by the percentages of total harvest for that species (Table 16). Grey Teal comprised 35% of the total reported harvest, followed by Pacific Black Duck (26%), Australian Wood Duck (22%) and Chestnut Teal (9%). Other species comprised 8% of the total harvest.

Table 16: Reported numbers of ducks harvested by hunters, proportion of the total harvest, and estimated total 2011 harvest for each duck species.

Species	Reported harvest	Proportion of harvest	SE	Estimated harvest	SE	95% CI Lower	95% CI Upper
Pacific Black Duck	1,354	0.26	0.006	156,484	10,856	136,612	179,248
Australian Wood Duck	1,150	0.22	0.006	132,908	9,345	115,817	152,521
Australian Shelduck	70	0.01	0.002	8,090	1,096	6,211	10,538
Grey Teal	1,826	0.35	0.007	211,034	14,347	184,735	241,078
Chestnut Teal	431	0.09	0.004	49,812	3,983	42,596	58,249
Pink-eared Duck	109	0.02	0.002	12,597	1,450	10,061	15,774
Australasian Shoveler	42	0.01	0.001	4,854	811	3,507	6,718
Hardhead	222	0.04	0.003	25,657	2,376	21,406	30,752

Each game licence holder hunted an average of 4.5 days during the 2011 duck hunting season (Table 17). When multiplied by the total number of game licence holders in each survey period, this equals a total of 103,450 hunter days (95% CI = 91,223–117,315).

Table 17: Days hunted per game licence holder.

Duck Survey	Period	Average	SE	95% CI Lower	95% CI Upper
1	19 Mar–20 Mar	1.02	0.06	–	–
2	21 Mar–3 Apr	0.76	0.10	–	–
3	4 Apr–17 Apr	0.73	0.10	–	–
4	18 Apr–1 May	0.44	0.07	–	–
5	2 May–15 May	0.47	0.09	–	–
6	16 May–29 May	0.45	0.06	–	–
7	30 May–13 Jun	0.62	0.08		
	Total per licence holder	**4.48**	**0.22**	**4.07**	**4.93**
	Total hunting days	**103,450**	**6,646**	**91,223**	**117,315**

NB: 95% CIs were only calculated for total days.

More duck hunting was conducted on public land (53.5%) than on private land (45.5%), with similar proportions of ducks harvested (Table 18). Total harvest was estimated to be greatest in the North Central CMA, followed by the Corangamite CMA (Figure 5).

Table 18: Percentage of days hunted and associated duck harvest on private and public land.

Land tenure	Days	Duck harvest
Private land	45.5%	44.7%
Public land	53.5%	54.1%
Both	1.0%	1.2%
Total	**100.0%**	**100.0%**

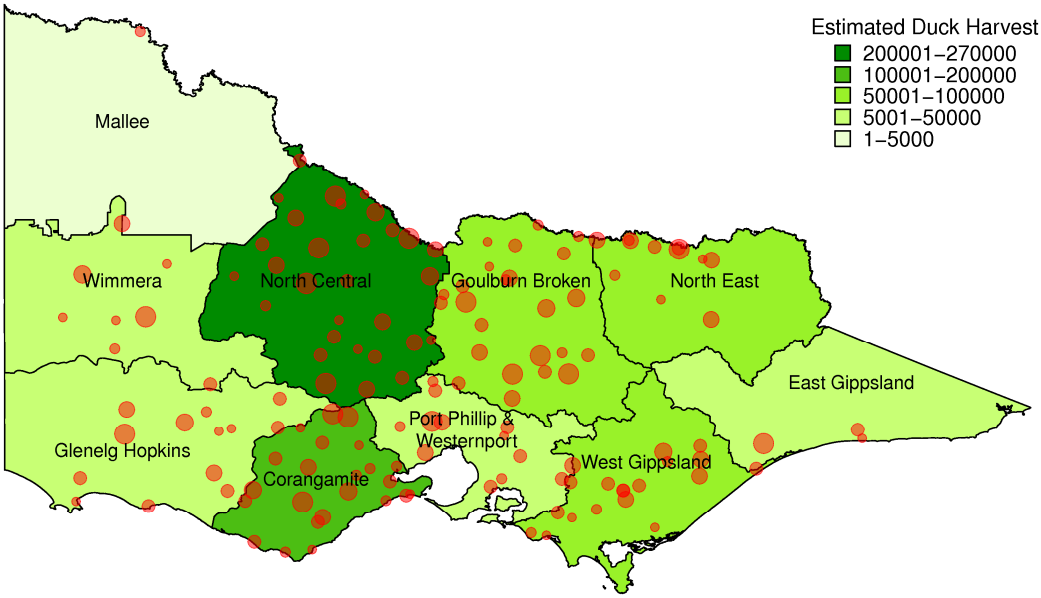

Figure 5: Estimated total duck harvest by CMA region. Red circles indicate the nearest town to harvest locations, with larger symbols representing larger reported harvests.

3.3 Quail

The number of game licence holders with permits to hunt quail remained relatively constant throughout the season (Table 19). In order to achieve the required sample size of respondents, slightly more than 300 licence holders were contacted each survey, with an average of 96% of those contacted willing to take part.

Table 19: Summary of responses for quail surveys.

Quail Survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted	Quail harvested
1	April	25,501	300	80	201	2,758
2	May	26,015	300	75	172	2,469
3	June	26,283	300	69	168	2,624

Days hunted indicates the combined number of days that were hunted and *Quail harvested* indicates the total quail harvested, respectively, by respondents within each survey period.

The proportion of game licence holders that hunted in each monthly survey period ranged from 23% to 27%. These percentages correspond to between 6,045 and 6,800 hunters in any one-month period (Table 20).

Table 20: Proportion of respondents that hunted, and estimated total number of licence holders that hunted, for each survey period.

			95% CI		Total		95% CI	
Period	Proportion	SE	Lower	Upper	hunters	SE	Lower	Upper
April	0.27	0.026	0.22	0.32	6,800	651	5,639	8,200
May	0.25	0.025	0.21	0.30	6,504	650	5,349	7,908
June	0.23	0.024	0.19	0.28	6,045	639	4,917	7,431

Within each survey period there was large variation in the reported harvest per hunter (i.e. per game licence holder that hunted), with some hunters harvesting up to 200 quail and others zero quail within a survey period (Figure 6). The average number of quail harvested per hunter during a one-month period varied from 32 to 38 (Table 21).

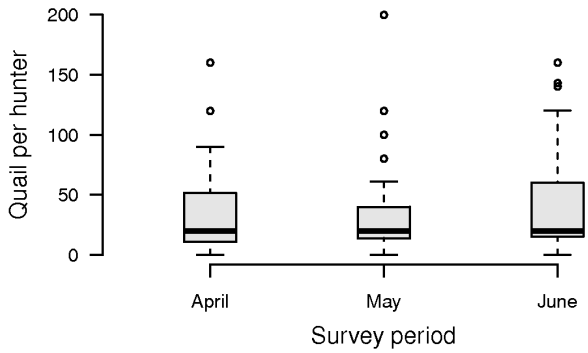

Figure 6: Boxplot of the number of quail reported harvested by individual hunters in each survey period. The bottom and top of each 'box' indicates the 25th and 75th percentile, respectively, with the black horizontal line indicating the median reported value.

Table 21: Average harvest of quail per hunter (i.e. game licence holders who hunted) for each survey period.

	Average harvest		95% CI	
Period	per hunter	SE	Lower	Upper
April	34.48	3.77	27.85	42.68
May	32.92	3.47	26.79	40.45
June	38.03	4.30	30.49	47.44

Average harvest per hunter = *Quail harvested* divided by *Respondents who hunted* (Table 19).

There were an estimated 678,431 quail harvested by all holders of a game licence for quail during the 2011 quail season (95% CI = 573,511–802,546), with similar levels of harvest in each month (Table 22).

Table 22: Estimates of the 2011 quail harvest in Victoria by licensed quail hunters.

Period	Total harvest	SE	95% CI Lower	95% CI Upper
April	234,439	34,063	176,603	311,217
May	214,103	31,102	161,293	284,205
June	229,889	35,590	170,027	310,826
Total Season	**678,431**	**58,260**	**573,511**	**802,546**

Total harvest = *Harvest per hunter* (Table 21) × *Total hunters* (Table 20).

The total average season harvest was 26.17 quail per game licence holder (95% CI = 22.16–30.91; Table 23). Note that for each survey period, the *average quail harvest per game licence holder* is lower than the *average quail harvest per hunter*, as the former averages across those respondents who did not hunt during the survey period, whereas the latter is conditional on those that hunted.

Table 23: Estimated harvest of quail per game licence holder.

Period	Average harvest	SE	95% CI Lower	95% CI Upper
April	9.19	1.33	6.93	12.20
May	8.23	1.17	6.24	10.86
June	8.75	1.35	6.48	11.80
Total Season	**26.17**	**2.23**	**22.16**	**30.91**

Average harvest = *Quail harvested* divided by *Respondents* (Table 19).

The number of days hunted each month varied throughout the season. On average, each quail licence holder hunted on 1.8 days during the 2011 season, corresponding to 46,719 hunter days (95% CI = 38,833–56,208; Table 24).

Table 24: Days hunted per game licence holder.

Period	Average	SE	95% CI Lower	95% CI Upper
April	0.67	0.08	–	–
May	0.57	0.07	–	–
June	0.56	0.08	–	–
Total days per licence holder	**1.80**	**0.14**	**0.78**	**1.35**
Total hunting days	**46,719**	**4,417**	**38,833**	**56,208**

NB: 95% CIs were only calculated for total days.

Most quail hunting was conducted on private land (97.2% of the hunting days), resulting in 96.9% of the harvested quail (Table 25). A very small proportion of hunting was conducted in State Game Reserves (0.9%) or both private land and State Game Reserves during the same hunting trip (1.8%). Dogs were used to hunt quail on 73% of days hunted and in 74% of the harvest. Most

quail hunting, and quail harvest, took place on stubble grasslands, or combinations of stubble and introduced and/or native grasslands (Table 26). The total quail harvest was greatest in the North Central CMA followed by the Corangamite CMA, the Goulburn Broken CMA, and the Glenelg Hopkins CMA (Figure 7).

Table 25: Percentage of days hunted and associated quail harvest by land tenure.

	Days	Quail harvest
Private land only	97.2%	96.9%
State Game Reserves only	0.9%	1.0%
Private land and State Game Reserves	1.8%	2.1%

Table 26: Percentage of days hunted and associated quail harvest per grassland type.

Grassland	Days	Quail harvest
Introduced grass	7.8%	8.2%
Native grass	5.0%	4.8%
Introduced and native grass	0.7%	0.5%
Stubble	58.4%	57.8%
Stubble and native	15.7%	15.0%
Stubble and introduced	10.9%	12.1%
Stubble, native and introduced	1.3%	1.3%
Unspecified	0.2%	0.2%
Total	**100.0%**	**100.0%**

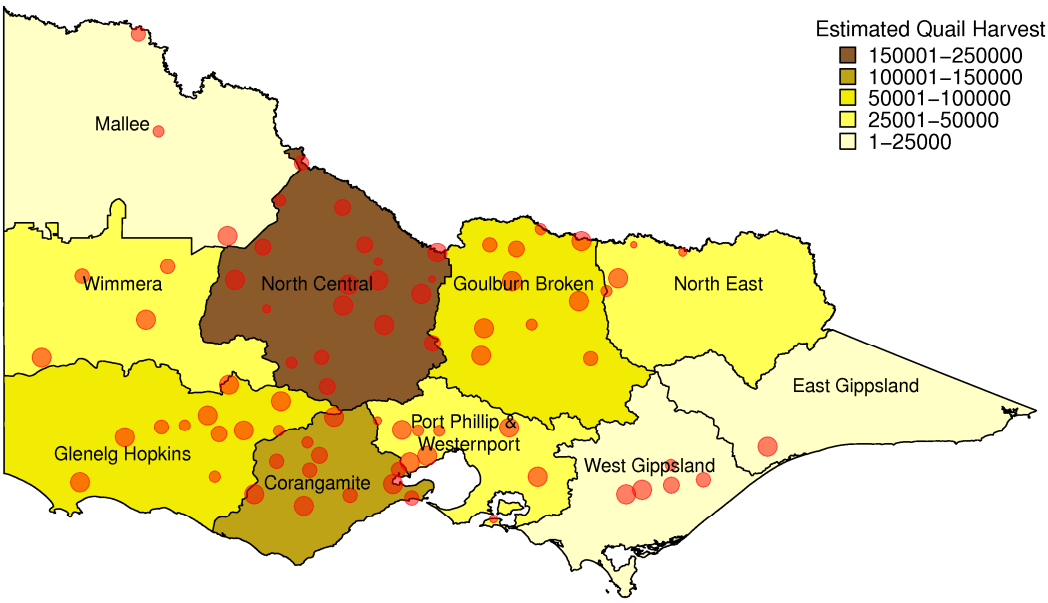

Figure 7: Estimated total quail harvest by CMA region. Red circles indicate the nearest town to harvest locations, with larger symbols representing larger reported harvest.

4 Discussion

4.1 Deer

A total of 40,728 deer were estimated to have been harvested in Victoria during the 2011 season (95% CI = 32,381–51,228). The most commonly harvested species was Sambar Deer (34,000), followed by Fallow Deer (5187). Due to the very small harvests of Red Deer and Hog Deer reported by surveyed game licence holders, it is difficult to make any inference about the estimated harvests of those species except that they are likely to be very small (<2000). The harvest of Hog Deer is strongly regulated, with the actual number of animals legally harvested recorded at checking stations. In 2011, 111 Hog Deer were recorded at checking stations, with an additional 42 Hog Deer harvested on Sunday Island, a private cooperative. We note that although the estimated harvest of Hog Deer is based on one reported deer, the 95% CI contains the total known harvest of 153 Hog Deer.

The 2011 season harvest of 40,728 deer is higher than the 2010 harvest (35,278) but similar to the 2009 harvest (39,418; Table 27). The increase in harvest from 2010 is despite fewer days hunted per licence holder and a lower number of total hunter days (i.e. aggregated across all game licence holders). The increased harvest in 2011 occurred despite a reduced hunting effort, with an average of 3.5 hunting days per deer, compared to 4.3 in 2010. Whether this reflects greater abundance of deer and/or better hunting conditions is unclear.

Table 27: Comparison of deer harvest with previous years.

	2009*	2010*	2011
Total harvest	39,418	35,278	40,728
Hunter days	125,428	149,930	140,471
Deer per licence holder	2.43	1.86	1.97
Days hunted per licence holder	7.75	7.91	6.83
Days hunted per deer	3.0	4.3	3.5

*The 2009 and 2010 estimates are from Gormley and Turnbull (2009) and Gormley and Turnbull (2010), respectively.

4.2 Duck

A total of 600,739 ducks were estimated to have been harvested in Victoria during the 2011 season (95% CI = 528,557–682,778), more than three times the 2010 harvest (270,574; Table 28). The largest increase was in the harvest of Grey Teal. The increased harvest in 2011 is unsurprising given the differences between the seasons. The 2011 duck-hunting season lasted 13 weeks compared to ten weeks in 2010 and seven weeks in 2009, resulting in an increase in the days hunted per game licence holder from 4 to 4.5. The daily bag limit in 2011 was also higher, set at ten ducks per hunter per day compared to eight in 2010 and five in 2009. The total season harvest per game licence holder in 2011 was more than double 2010, with c. 26 ducks per game licence holder, compared to 12.5 in 2010. The average number of ducks per hunting day increased from 2.8 in 2009 to 3.2 in 2010, to 5.8 in 2011. This increase reflects the higher bag limit as well as the relatively higher abundance of ducks. There was a higher rainfall in the months prior to the start of the season than was seen in the two previous years, resulting in improved breeding conditions and increased abundance of some species such as Grey Teal compared to recent years (Purdey and Loyn 2011). The annual summer waterbird count estimated 80% of wetlands had water coverage of greater than 75% in 2011 (Purdey and Loyn 2011) compared with 26% in 2010 (Purdey and Loyn 2010).

Finally, there was also an increase in the number of game licence holders (c. 23,000 in 2011 compared with c. 21,800 in 2010 and c. 20,000 in 2009), resulting in an increase in total hunter days.

Table 28: Comparison of duck harvest with previous years.

	2009*	2010*	2011
Harvest by species			
Pacific Black Duck	55,150	96,487	156,484
Australian Wood Duck	131,084	112,390	132,908
Australian Shelduck	2,173	5,936	8,090
Grey Teal	20,919	26,011	211,034
Chestnut Teal	13,176	14,354	49,812
Pink-eared Duck	NA	0	12,597
Australasian Shoveler	NA	216	4,854
Hardhead	NA	324	25,657
Total harvest	**222,302**	**270,574**	**600,739**
Hunter days	76,659	85,801	103,450
Ducks per licence holder	11.10	12.54	26.02
Days hunted per licence holder	3.98	3.98	4.48
Ducks per hunting day	2.78	3.16	5.81

*The 2009 and 2010 estimates are from Gormley and Turnbull (2009) and Gormley and Turnbull (2010), respectively.

4.3 Quail

A total of 678,431 quail were estimated to have been harvested in Victoria during the 2011 season (95% CI = 573,511–802,546), a substantial increase on the 2010 harvest of 86,302 (Table 29). This increase is partly explained by nearly double the number of total hunter days (46,719 in 2011 compared with 24,739 in 2010). Most of the increased harvest is due to the substantial increase in the number of quail harvested per hunting day, up from 3.5 in 2010 to 14.5 in 2011. Anecdotal evidence suggests that the timing and extent of rainfall in 2011 resulted in thousands of hectares of cropping land that were only partially stripped, providing ideal feeding and breeding habitat for stubble quail, and therefore contributed to much higher densities.

Table 29: Comparison of quail harvest with previous years

	2009*	2010*	2011
Total harvest	189,155	86,302	678,431
Hunter days	24,648	24,739	46,719
Quail per licence holder	7.89	3.59	26.17
Days per licence holder	1.03	1.03	1.80
Quail per hunting day	7.97	3.48	14.52

*The 2009 and 2010 estimates are from Gormley and Turnbull (2009) and Gormley and Turnbull (2010), respectively.

It should be noted that the number of hunting days is only an approximate estimate of total effort: someone who hunted for two hours and someone else who hunted for 12 hours are both recorded as having hunted for one day.

Due to the structure of game licences in Victoria, not every holder of a game licence permitted to hunt quail will hunt quail. The price of a game licence for *Game birds including duck* is the same as a game licence for *Game birds not including duck*. Anyone that wants to hunt ducks automatically has quail included in their licence. For many hunters, duck hunting will be their primary activity. Hence, a high proportion of game licence holders will be permitted to hunt quail even though they may not intend to do so. This does not affect the estimates of quail harvest, because the calculations explicitly account for the proportion of quail game licence holders who did not actually hunt quail.

4.4 Assumptions

The estimates of harvest for each game type are derived under the assumption that the samples of respondents are representative of the entire population of Victorian game licence holders. This assumption may be violated due to a number of factors such as reasons for non-response (exceeded bag limit, or conversely did not harvest anything), memory recall (respondents cannot remember their harvest), and deliberate over- or under-reporting (reported numbers are knowingly reported incorrectly). Bias due to non-response is likely to be negligible as 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-week period in the case of ducks and quail, and every two months for deer, will ensure that both memory bias and non-response bias will be kept low when compared with postal surveys and complete end-of-season surveys (Barker 1991; Barker et al. 1992). Nevertheless, some bias likely remains and the estimates of total harvest should be interpreted with care.

It 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) is due to two factors. Firstly, there is variation in the reported numbers of animals shot between respondents that had hunted (see Figure 1, Figure 4 and Figure 6). For example, within a given survey period for duck hunting, some respondents indicated that they hunted unsuccessfully, whereas others took multiple trips and indicated a total harvest more than 50 ducks during that period. The second source of uncertainty is due to taking samples of hunters rather than a complete census. However, the degree of sampling uncertainty is reduced by having sample sizes of 200 respondents per survey for deer and ducks and 300 for quail.

The spatial distributions of the deer, duck and quail harvest should also be interpreted with care. Grouping the harvest by a relatively large region (CMA) provides a broad-scale view of the distribution of harvest. Grouping by smaller regions would provide a finer scale representation, but this would come at a 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 would be 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.

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Appendix 1

Common definitions used

SD = standard deviation of the data. Represents the variation in the numbers reported.

SE = standard error of the mean. Represents the variation in the estimated mean.

CV = Coefficient of variation. Calculated as: CV = SE ÷ Average. 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 that hunted in each period j is given as:

$$p_j = \frac{h_j}{n_j}$$ e.g., for duck survey 3, we obtain: $\frac{55}{200} = 0.275$

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 that reported having hunted during that survey period (p_j), as found previously:

$$H_j = p_j L$$ e.g., for duck survey 3, we obtain: $0.275 \times 23{,}249 = 6{,}393$

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 that hunted (h_j):

$$w_j = \frac{y_j}{h_j}$$ e.g., for duck survey 3, we obtain: $\frac{726}{55} = 13.20$

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 duck survey 3, we obtain: $13.20 \times 6{,}393 = 84{,}394$

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

$$W_{TOT} = W_1 + W_2 + W_3 + W_4$$

Standard errors (SE) for the proportion of respondents that hunted are given as:

$$\mathrm{SE}(p_j) = \sqrt{\frac{p_j(1-p_j)}{n_j}}$$ e.g., for duck survey 3, we obtain: $\sqrt{\frac{0.28(0.72)}{200}} = 0.032$

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

$$\mathrm{SE}(w_j) = \frac{\mathrm{SD}(w_j)}{\sqrt{h_j}}$$ e.g., for duck survey 3, we obtain: $\frac{13.08}{\sqrt{55}} = 1.76$

The standard errors for the total estimated harvest per survey period (W_j) is found by determining the Coefficient of Variation (CV) of p_j and w_j and then adding their sum of squares to find the combined CV (assuming independence).

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

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

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

The standard error of the total harvest is calculated as:

$$\mathrm{SE}(W_{TOT}) = \sqrt{(\mathrm{SE}(W_1))^2 + (\mathrm{SE}(W_2))^2 + \ldots + (\mathrm{SE}(W_7))^2}$$

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

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

$$\textit{lower limit} = \hat{X} \div r, \quad \text{where:}$$

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

e.g., for the total duck harvest we have

$$CV = \frac{39{,}285}{601{,}436} = 0.065$$

$$r = \exp\left(1.96\sqrt{\ln\left(1 + 0.065^2\right)}\right) = 1.14$$

Therefore, Upper and Lower Confidence Intervals are given by:

$$UL = 601{,}436 \times 1.14 = 683{,}489$$

$$LL = 601{,}436 \div 1.14 = 529{,}234$$

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