



Estimates of harvest for deer, duck and quail in Victoria

Results from surveys of Victorian Game Licence holders in 2014

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Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian game Licence holders in 2014.

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Front cover photo: Hunters cleaning their ducks on the Murray Arm of the Hume Weir on the opening morning of the 2014 duck season (John Turnbull).

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Summary

Between July 2013 and June 2014, telephone surveys of licensed Victorian game hunters were conducted during the hunting seasons for deer, duck and quail to estimate the total harvest for each game type. Game Licence holders for each game type (deer, duck and quail) were randomly sampled and interviewed via telephone at intervals during the respective game seasons. 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 animals harvested. Additional information was obtained on hunting methods and locations.

Each Game Licence holder for deer hunted on 6.6 days between July 2013 and June 2014, with an average season harvest of 2.2 deer. This corresponds to an estimated 57,945 deer harvested during the 2013–2014 deer-hunting season in Victoria (95% confidence interval (CI) = 46,382–72,392). The most commonly harvested species was Sambar Deer (with an estimated total harvest of 47,129), followed by Fallow Deer (9,282).

Each Game Licence holder for ducks hunted on approximately 4.6 days during the 2014 duck hunting season, with an average season harvest of 17.3 ducks. This equates to an estimated 449,032 ducks harvested during the 2014 duck hunting season in Victoria (95%CI = 394,157–511,547). The three most commonly harvested species were Australian Wood Duck (which comprised 29% of the total harvest), Pacific Black Duck (28%), and Grey Teal (28%). The

remaining ducks harvested were Chestnut Teal (7%), Pink-eared Duck (3%), Australian Shelduck (2%), Hardhead (1%) and Blue-winged Shoveler (<1%).

Each Game Licence holder who hunted for quail hunted on approximately 0.4 days during the 2014 quail-hunting season, with an average season harvest of 0.6 quail. This equates to an estimated 16,243 quail harvested during the 2014 quail-hunting season in Victoria (95%CI = 8,699–30,330).

The total number of hunter days during the 2013–2014 hunting seasons for deer, ducks and quail was estimated to be 304,255 (95%CI = 270,887–341,733).

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 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 season is likely to minimise memory bias and non-response bias compared with the previous end-of-calendar-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.

Note: Numbers within the text have been rounded.

Introduction

In order to effectively manage game species and hunting, it is important to quantify the numbers harvested. Game Victoria¹ (Game Management Authority [GMA]) had previously conducted a mail survey of 1,000 randomly selected Game Licence holders during June of each year. There were, however, 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, GMA commissioned a series of regular telephone surveys to better address the issue of recall and non-response bias. 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 five of the six game deer species. For this report, the 2014 deer hunting reporting period was defined as 1 July 2013 to 30 June 2014. Sambar Deer (*Cervus unicolor*) could be hunted all year by stalking. Hunting for Sambar Deer using scent-trailing hounds was restricted to 1 April to 30 November. There is no limit on the number of Sambar Deer that can be taken during the open season. Hog Deer (*Axis porcinus*) could only be hunted during April, subject to additional restrictions, such as one male and one female per hunter for the whole of the season. All other species could 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*). This survey uses the same methods as telephone surveys performed during the 2009 to 2013 deer hunting seasons (Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013).

The 2014 duck-hunting season lasted 87 days, from 15 March to 9 June (Game Management Authority 2014). Eight species could legally be hunted in 2014: Pacific Black Duck (*Anas superciliosa*), Australian Wood Duck (*Chenonetta jubata*), Mountain Duck (*Tadorna tadornoides*), Grey Teal (*Anas gracilis*), Chestnut Teal (*Anas castanea*), Pink-eared Duck (*Malacorhynchus membranaceus*), Hardhead (*Aythya australis*) and Blue-winged Shoveler (*Anas rhynchos*). The daily bag limit for the 2014 season was 10 game ducks, which included a maximum of two Blue-winged Shoveler. This survey uses the same methods as telephone surveys performed during the 2005, 2006, and 2009 to 2013 duck-hunting seasons (Barker 2006; Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013).

The 2014 Stubble Quail (*Coturnix pectoralis*) hunting season lasted 12 weeks, from 5 April to 30 June. The daily bag limit for the 2014 season was 20 quail per hunter. This survey uses the same methods as telephone surveys performed during the 2008 to 2013 quail-hunting seasons (Gormley 2009; Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013).

¹ On 1 July 2014, the Game Management Authority became an independent statutory authority responsible for game hunting in Victoria, taking over from Game Victoria, Department of Environment and Primary Industries.

Methods

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 the Game Management Authority. 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 for the periods covered by that survey only. (See Appendix 2 for surveys). Therefore, although a respondent¹ 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.

The information from the respondents was used to generate an estimate for 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 who hunted was used as an estimate of the proportion of Game Licence holders who hunted. The proportion of Game Licence holders who hunted during each survey period was multiplied by the total number of Game Licence holders to give the estimated total number of hunters who actually hunted for that survey period.

For each survey period, the average harvest per hunter² 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 from the sum of the survey-specific total harvests.

Respondents who hunted were also asked to provide information on whether hunting was conducted on private land or public land (such as State Game Reserves), the name of the town nearest to where they hunted, 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.

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.

It should be noted that the number of hunting days was 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.

Deer

Samples were drawn from hunters who held a Game Licence to hunt deer from July 2013 to June 2014. Random samples of hunters were telephoned every two months over the 12-month period, making 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).

Duck

Samples were drawn from hunters who held a Game Licence to hunt ducks during the 2014 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 and the land tenure they hunted.

Quail

Samples were drawn from hunters who held a Game Licence to hunt quail during the 2014 season. A random sample of 300 licence holders was interviewed by telephone for each of April (Survey 1), May (Survey 2) and June (Survey 3). Respondents were asked to report the number of Stubble Quail harvested, the type of habitat grassland where hunting occurred (native, stubble or introduced) and whether or not dogs were used.

¹ Respondent refers to Game Licence holders who were contacted and agreed to take part in the survey.

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

Results

Deer

Summary of responses for deer surveys conducted from July 2013 to June 2014

The number of Game Licence holders endorsed to hunt deer ranged from a high of 27,349 in November – December 2013, to a low of 23,830 in January – February 2014 (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 98% of those contacted being willing to take part.

Table 1

| Deer survey | Period | Licence holders | Respondents | Respondents who hunted | Days hunted* | Deer harvested** |
|-------------|--------------|-----------------|-------------|------------------------|--------------|------------------|
| 1 | Jul–Aug 2013 | 25,688 | 200 | 64 | 308 | 116 |
| 2 | Sep–Oct 2013 | 26,617 | 200 | 49 | 243 | 75 |
| 3 | Nov–Dec 2013 | 27,349 | 200 | 28 | 89 | 31 |
| 4 | Jan–Feb 2014 | 23,830 | 200 | 15 | 66 | 17 |
| 5 | Mar–Apr 2014 | 25,865 | 200 | 61 | 283 | 66 |
| 6 | May–Jun 2014 | 27,262 | 200 | 58 | 338 | 134 |

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

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

Proportion and corresponding total number of deer licence holders that hunted during each survey period

The proportion of deer Game Licence holders who hunted in each survey period varied throughout the season (Table 2). An estimated 32% of deer Game Licence holders hunted at least once during July–August 2013, declining to a low of 8% during January–February 2014. These percentages correspond to 8,220 hunters in the July–August period and 1,787 hunters in the January–February period.

Table 2

| Period | Proportion | SE | 95%CI | | Total hunters | SE | 95%CI | |
|--------------|------------|-------|-------|-------|---------------|-----|-------|--------|
| | | | Lower | Upper | | | Lower | Upper |
| Jul–Aug 2013 | 0.32 | 0.033 | 0.26 | 0.39 | 8,220 | 847 | 6,720 | 10,055 |
| Sep–Oct 2013 | 0.25 | 0.030 | 0.19 | 0.31 | 6,521 | 809 | 5,118 | 8,309 |
| Nov–Dec 2013 | 0.14 | 0.025 | 0.10 | 0.20 | 3,829 | 671 | 2,723 | 5,384 |
| Jan–Feb 2014 | 0.08 | 0.019 | 0.05 | 0.12 | 1,787 | 444 | 1,107 | 2,887 |
| Mar–Apr 2014 | 0.31 | 0.033 | 0.25 | 0.38 | 7,889 | 842 | 6,403 | 9,719 |
| May–Jun 2014 | 0.29 | 0.032 | 0.23 | 0.36 | 7,906 | 875 | 6,369 | 9,814 |

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

Within each survey period there was large variation in the reported harvest of deer per hunter (i.e. per Game Licence holder who 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 2.3 deer per hunter in May–June 2014 to a low of 1.1 in March–April 2014 (Table 3). The total season harvest was 2.2 deer per licensed deer hunter.

Table 3

| Period | Average harvest per hunter [*] | SE | 95%CI | |
|--------------|--|------|-------|-------|
| | | | Lower | Upper |
| Jul–Aug 2013 | 1.81 | 0.46 | 1.11 | 2.97 |
| Sep–Oct 2013 | 1.53 | 0.25 | 1.11 | 2.11 |
| Nov–Dec 2013 | 1.11 | 0.30 | 0.65 | 1.88 |
| Jan–Feb 2014 | 1.13 | 0.31 | 0.67 | 1.91 |
| Mar–Apr 2014 | 1.08 | 0.22 | 0.72 | 1.61 |
| May–Jun 2014 | 2.31 | 0.44 | 1.60 | 3.34 |

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

Estimates of the total deer harvest in Victoria from July 2013 to June 2014 by holders of a deer Game Licence

An estimated 57,945 deer were harvested by deer Game Licence holders from July 2013 to June 2014 inclusive (95%CI = 46,382–72,392; Table 4). Harvest was greatest in the mid-autumn to mid-spring months and lowest in the summer months.

Table 4

| Period | Total harvest [*] | SE | 95%CI | |
|---------------------|----------------------------|--------------|---------------|---------------|
| | | | Lower | Upper |
| Jul–Aug 2013 | 14,899 | 4,103 | 8,770 | 25,310 |
| Sep–Oct 2013 | 9,981 | 2,062 | 6,686 | 14,900 |
| Nov–Dec 2013 | 4,239 | 1,378 | 2,278 | 7,889 |
| Jan–Feb 2014 | 2,026 | 744 | 1,009 | 4,067 |
| Mar–Apr 2014 | 8,535 | 1,984 | 5,445 | 13,380 |
| May–Jun 2014 | 18,266 | 4,015 | 11,933 | 27,959 |
| Total season | 57,945 | 6,602 | 46,382 | 72,392 |

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

Separate harvest estimates for each deer species are presented in Figure 2 and Table 6. No harvesting of Hog Deer, Chital Deer or Rusa Deer was reported in the survey.

Figure 1. Estimated total deer harvest for each two-month survey period, by species. Vertical bars indicate 95% confidence intervals.

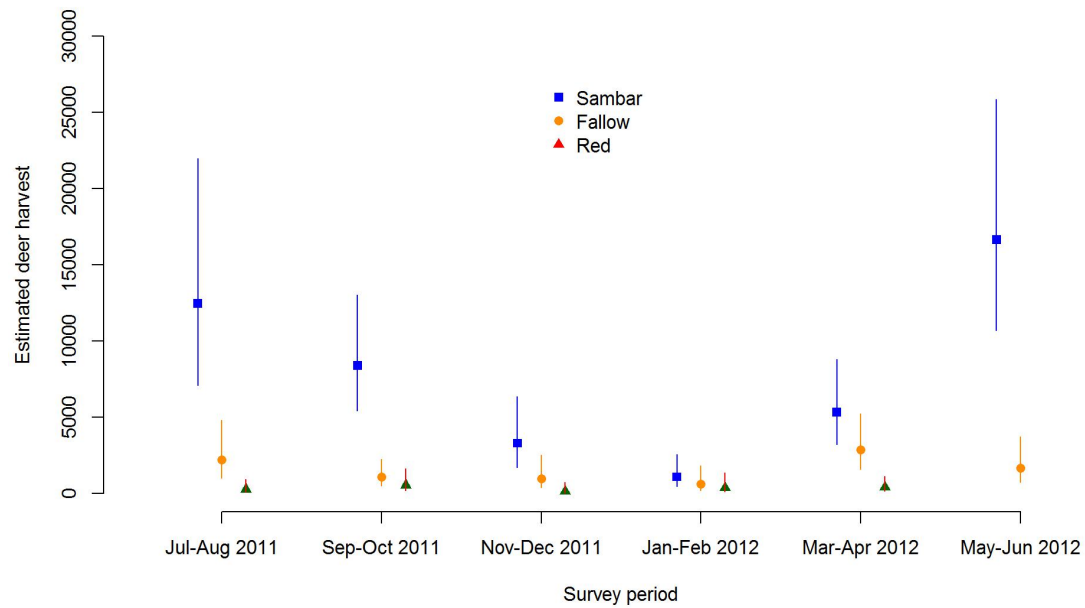


Table 5.

Estimated average harvest of deer species per Game Licence holder who hunted for each survey period

a. Sambar Deer

| Period | Reported | Total harvest | SE | 95%CI | |
|----------------------|------------|---------------|--------------|---------------|---------------|
| | | | | Lower | Upper |
| Jul–Aug 2013 | 97 | 12,458 | 3,681 | 7,067 | 21,963 |
| Sep–Oct 2013 | 63 | 8,384 | 1,901 | 5,406 | 13,004 |
| Nov–Dec 2013 | 24 | 3,282 | 1,135 | 1,698 | 6,344 |
| Jan–Feb 2014 | 9 | 1,072 | 497 | 451 | 2,547 |
| Mar–Apr 2014 | 41 | 5,302 | 1,394 | 3,194 | 8,801 |
| May–Jun 2014 | 122 | 16,630 | 3,792 | 10,697 | 25,853 |
| Total season* | 356 | 47,129 | 5,918 | 36,883 | 60,221 |

b. Fallow Deer

| Period | Reported | Total harvest | SE | 95%CI | |
|----------------------|-----------|---------------|--------------|--------------|---------------|
| | | | | Lower | Upper |
| Jul–Aug 2013 | 17 | 2,183 | 911 | 996 | 4,787 |
| Sep–Oct 2013 | 8 | 1,065 | 418 | 507 | 2,236 |
| Nov–Dec 2013 | 7 | 957 | 496 | 368 | 2,491 |
| Jan–Feb 2014 | 5 | 596 | 365 | 197 | 1,803 |
| Mar–Apr 2014 | 22 | 2,845 | 899 | 1,555 | 5,207 |
| May–Jun 2014 | 12 | 1,636 | 718 | 719 | 3,723 |
| Total season* | 71 | 9,282 | 1,645 | 6,575 | 13,102 |

c. Red Deer

| Period | Reported | Total harvest | SE | 95%CI | |
|----------------------|-----------|---------------|------------|------------|--------------|
| | | | | Lower | Upper |
| Jul–Aug 2013 | 2 | 257 | 182 | 74 | 897 |
| Sep–Oct 2013 | 4 | 532 | 327 | 176 | 1,614 |
| Nov–Dec 2013 | 1 | 137 | 139 | 26 | 712 |
| Jan–Feb 2014 | 3 | 357 | 274 | 94 | 1,352 |
| Mar–Apr 2014 | 3 | 388 | 224 | 136 | 1,111 |
| May–Jun 2014 | 0 | 0 | NA | NA | NA |
| Total season* | 13 | 1,671 | 533 | 908 | 3,077 |

* Figures subject to rounding

Reported numbers and percentages of each sex of deer species harvested

The proportion of male and female Sambar Deer harvested differed significantly (exact binomial test p -value = 0.012), with 56.7% males harvested and 43.3% females harvested (Table 6). There was no statistically significant sex bias for the harvest of Fallow Deer or Red Deer.

Table 6

| Species | Males | | | Females | | |
|-------------|-------|-------|--------|---------|-------|--------|
| | n | % | (SE) | n | % | (SE) |
| Sambar Deer | 203 | 57.5% | (2.6) | 150 | 42.5% | (2.6) |
| Fallow Deer | 32 | 47.8% | (6.1) | 35 | 52.2% | (6.1) |
| Red Deer | 6 | 50.0% | (14.4) | 6 | 50.0% | (14.4) |

Days hunted per active Game Licence holder

The number of days hunted in each survey period varied throughout the season, with most hunting occurring from mid-autumn to mid-spring. Each Game Licence holder who hunted deer, hunted an average of 6.6 days from July 2013 to June 2014, corresponding to a total of 174,603 hunter days (95%CI = 146,599–207,956; Table 7).

Table 7

| Period | Days hunted | SE | 95%CI | |
|--------------------------------------|----------------|---------------|----------------|----------------|
| | | | Lower | Upper |
| Jul–Aug 2013 | 1.54 | 0.24 | 1.14 | 2.09 |
| Sep–Oct 2013 | 1.22 | 0.20 | 0.88 | 1.67 |
| Nov–Dec 2013 | 0.45 | 0.11 | 0.28 | 0.70 |
| Jan–Feb 2014 | 0.33 | 0.09 | 0.19 | 0.57 |
| Mar–Apr 2014 | 1.42 | 0.19 | 1.08 | 1.85 |
| May–Jun 2014 | 1.69 | 0.28 | 1.23 | 2.32 |
| Total days per licence holder | 6.64 | 0.48 | 5.76 | 7.65 |
| Total hunting days | 174,603 | 15,604 | 146,599 | 207,956 |

Percentage of days hunted and associated deer harvest by land tenure

More deer hunting occurred exclusively on public land (62.5%) compared with exclusively on private land (27.9%), with correspondingly similar proportions of deer harvested (Table 8).

Table 8

| Land tenure | Days | Deer harvested |
|-------------------|-----------------|----------------|
| Private land only | 27.9% (48,714) | 30.1% (17,441) |
| Public land only | 62.5% (109,127) | 62.4% (36,158) |
| Both | 9.1% (15,888) | 7.1% (4,114) |

Percentage of days hunted and associated deer harvest by hunting method

Stalking was the preferred hunting method, being used on 40.4% of the hunting days and accounting for 64.2% of the reported harvest. Stalking with a gundog was similarly productive. Hunting with scent-trailing hounds was the most productive hunting method, with the proportion of the harvest being nearly double the respective proportion of days (Table 9). It should be noted that the hunting method was not specified for 42.2% of the hunting days, and this was associated with 1.1% of the harvest.

Table 9

| Hunting method | Days | Deer |
|-----------------------|----------------|----------------|
| Stalking | 40.4% (70,540) | 64.2% (37,201) |
| Stalking with gundog | 4.4% (7,683) | 5.9% (3,419) |
| Scent-trailing hounds | 13.0% (22,699) | 28.7% (16,630) |

Percentage of days hunted and associated deer harvest by hunting method and land tenure

While stalking was the preferred hunting method on both private and public land, it was more productive on private land (accounting for approximately 14% of the surveyed hunting days but nearly 28% of the surveyed harvest) (Table 10). The majority (85%) of the hunting days using scent-trailing hounds was on public land only. While this accounted for 11% of the total hunting days, it contributed 25% of the surveyed harvest.

Table 10

| Hunting method | Private only | | Public only | | Both | | Total | |
|-----------------------|--------------|-------|-------------|-------|------|------|-------|-------|
| | Days | Deer | Days | Deer | Days | Deer | Days | Deer |
| Stalking | 14.3% | 27.6% | 22.8% | 31.9% | 3.2% | 4.8% | 40.4% | 64.2% |
| Stalking with gundog | 1.8% | 1.4% | 2.6% | 4.6% | 0.0% | 0.0% | 4.4% | 5.9% |
| Scent-trailing hounds | 0.6% | 0.9% | 11.0% | 25.5% | 1.4% | 2.3% | 13.0% | 28.7% |

Estimated total deer harvest by CMA region from July 2013 to June 2014

Total deer harvest was estimated to be greatest in the Goulburn Broken CMA region, followed by the North East CMA region and the East Gippsland CMA region (Figure 2). No deer were reported harvested in the Mallee CMA. The top five towns for total reported number of deer harvested were (in descending order) Mansfield, Benalla, Myrtleford, Dargo and Eildon. The top five towns for total number of reported deer hunting days were (in descending order) Mansfield, Benalla, Myrtleford, Eildon and Dargo.

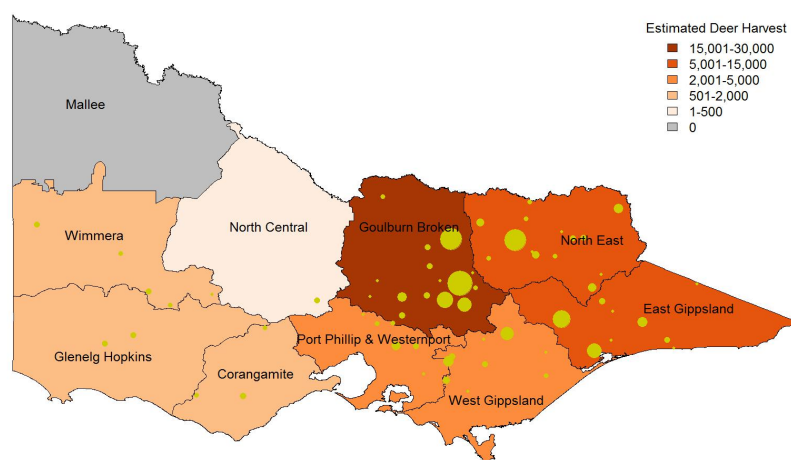


Figure 2. Yellow circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

Duck

Summary of responses for duck surveys in 2014

The number of Game Licence holders endorsed to hunt ducks remained relatively constant throughout the season, increasing from 25,758 at opening weekend to 26,261 at the end of the season (Table 11).

Table 11

| Deer Survey | Period | Licence holders | Respondents | Respondents who hunted | Days hunted* | Ducks harvested** |
|-------------|-----------------|-----------------|-------------|------------------------|--------------|-------------------|
| 1 | 15 Mar – 17 Mar | 25,758 | 200 | 121 | 197 | 692 |
| 2 | 18 Mar – 29 Mar | 25,758 | 200 | 54 | 147 | 543 |
| 3 | 30 Mar – 12 Apr | 25,943 | 200 | 49 | 115 | 493 |
| 4 | 13 Apr – 26 Apr | 25,943 | 200 | 45 | 91 | 329 |
| 5 | 27 Apr – 12 May | 26,126 | 200 | 37 | 125 | 492 |
| 6 | 13 May – 26 May | 26,126 | 200 | 34 | 96 | 408 |
| 7 | 27 May – 9 Jun | 26,261 | 200 | 47 | 143 | 501 |

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

** Ducks harvested indicates total number of ducks harvested by respondents.

Proportion and corresponding total number of duck licence holders who hunted in each survey period in 2014

The proportion of duck Game Licence holders who hunted duck in each survey period varied throughout the season: 61% of licence holders hunted during opening weekend, corresponding to 15,584 hunters (Table 12). The proportion that hunted during other survey periods varied from 17% to 27%, corresponding to between 4,441 and 6,955 duck hunters, respectively (Table 12).

Table 12

| Period | Proportion | SE | 95%CI | | Total hunters | SE | 95%CI | |
|-----------------|------------|-------|-------|-------|---------------|-----|--------|--------|
| | | | Lower | Upper | | | Lower | Upper |
| 15 Mar – 17 Mar | 0.61 | 0.035 | 0.54 | 0.68 | 15,584 | 890 | 13,934 | 17,429 |
| 18 Mar – 29 Mar | 0.27 | 0.031 | 0.22 | 0.34 | 6,955 | 809 | 5,542 | 8,728 |
| 30 Mar – 12 Apr | 0.25 | 0.030 | 0.19 | 0.31 | 6,356 | 789 | 4,988 | 8,099 |
| 13 Apr – 26 Apr | 0.23 | 0.030 | 0.17 | 0.29 | 5,837 | 766 | 4,518 | 7,541 |
| 27 Apr – 12 May | 0.19 | 0.027 | 0.14 | 0.25 | 4,833 | 717 | 3,619 | 6,455 |
| 13 May – 26 May | 0.17 | 0.027 | 0.13 | 0.23 | 4,441 | 694 | 3,276 | 6,022 |
| 27 May – 9 Jun | 0.24 | 0.030 | 0.18 | 0.30 | 6,171 | 787 | 4,811 | 7,917 |

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

Within each survey period, there was large variation in the reported harvest of ducks per hunter (i.e. per Game Licence holder who hunted). Some hunters harvested more than 30 ducks in a survey period, whereas some did not harvest any ducks. The average number of ducks harvested varied throughout the season (Table 13). The average harvest per hunter was 5.7 ducks on Saturday and Sunday of the opening weekend.

Table 13

| Period | Average harvest* | SE | 95%CI | |
|-----------------|------------------|------|-------|-------|
| | | | Lower | Upper |
| 15 Mar – 17 Mar | 5.72 | 0.51 | 4.81 | 6.80 |
| 18 Mar – 29 Mar | 10.06 | 1.59 | 7.39 | 13.68 |
| 30 Mar – 12 Apr | 10.06 | 1.27 | 7.86 | 12.88 |
| 13 Apr – 26 Apr | 7.31 | 1.43 | 5.00 | 10.68 |
| 27 Apr – 12 May | 13.30 | 2.16 | 9.69 | 18.25 |
| 13 May – 26 May | 12.00 | 1.96 | 8.73 | 16.50 |
| 27 May – 9 Jun | 10.66 | 1.46 | 8.16 | 13.92 |

* Average harvest per hunter = Ducks harvested divided by Respondents who hunted (Table 12).

Estimates of the duck harvest in Victoria in 2014 by holders of a duck Game Licence

An estimated 89,123 ducks were harvested during opening weekend (95%CI = 72,503–109,552), which constituted almost 20% of the total seasonal harvest. This was more than 25% larger than the estimate for any fortnight. The harvest throughout the remainder of the season varied considerably between surveys, with fortnightly estimates ranging from 42,676 to 69,933 ducks harvested. The total season harvest estimate was 449,032 (95%CI = 394,157–511,547; Table 14). The total season average harvest per licence holder was 17.3 (95%CI = 15.2–19.7).

Table 14

| Period | Total harvest* | SE | 95%CI | |
|---------------------|----------------|---------------|----------------|----------------|
| | | | Lower | Upper |
| 15 Mar – 17 Mar | 89,123 | 9,410 | 72,503 | 109,552 |
| 18 Mar – 29 Mar | 69,933 | 13,723 | 47,778 | 102,362 |
| 30 Mar – 12 Apr | 63,949 | 11,336 | 45,302 | 90,274 |
| 13 Apr – 26 Apr | 42,676 | 10,041 | 27,078 | 67,261 |
| 27 Apr – 12 May | 64,270 | 9,539 | 48,124 | 85,833 |
| 13 May – 26 May | 53,297 | 12,052 | 34,404 | 82,566 |
| 27 May – 9 Jun | 65,784 | 12,299 | 45,744 | 94,602 |
| Season total | 449,032 | 29,895 | 394,157 | 511,547 |

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

Reported numbers of ducks harvested by hunters, proportion of the total harvest, and estimated total 2014 harvest for each duck species

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 15). The most frequently harvested species was Australian Wood Duck, comprising 29% of the total reported harvest, followed by Pacific Black Duck (28%) and Grey Teal (28%). The remaining five species made up 14% of the total harvest.

Table 15

| Species | Reported harvest | Proportion of harvest | SE | Estimated harvest | SE | 95%CI | |
|----------------------|------------------|-----------------------|-------|-------------------|-------|--------|---------|
| | | | | | | Lower | Upper |
| Australian Wood Duck | 1,011 | 0.29 | 0.008 | 131,282 | 9,405 | 78,397 | 219,841 |
| Blue-winged Shoveler | 32 | 0.01 | 0.002 | 4,155 | 782 | 1,842 | 9,376 |
| Chestnut Teal | 230 | 0.07 | 0.004 | 29,866 | 2,752 | 16,690 | 53,444 |
| Grey Teal | 979 | 0.28 | 0.008 | 127,126 | 9,136 | 75,856 | 213,049 |
| Hardhead | 49 | 0.01 | 0.002 | 6,363 | 997 | 3,012 | 13,440 |
| Mountain Duck | 65 | 0.02 | 0.002 | 8,440 | 1,179 | 4,154 | 17,148 |
| Pacific Black Duck | 983 | 0.28 | 0.008 | 127,646 | 9,170 | 76,174 | 213,898 |
| Pink-eared Duck | 109 | 0.03 | 0.003 | 14,154 | 1,633 | 7,406 | 27,051 |

Days hunted per Game Licence holder for 2014

Each Game Licence holder hunted an average of 4.6 days during the 2014 duck hunting season (Table 16). When multiplied by the total number of Game Licence holders who hunted in each survey period, this equated to a total of 118,800 hunter days (95%CI = 102,812–137,274).

Table 16

| Period | Days hunted | SE | 95%CI | |
|---------------------------------|----------------|--------------|----------------|----------------|
| | | | Lower | Upper |
| 15 Mar – 17 Mar | 0.99 | 0.07 | 0.86 | 1.13 |
| 18 Mar – 29 Mar | 0.74 | 0.20 | 0.43 | 1.25 |
| 30 Mar – 12 Apr | 0.58 | 0.11 | 0.39 | 0.85 |
| 13 Apr – 26 Apr | 0.46 | 0.13 | 0.26 | 0.78 |
| 27 Apr – 12 May | 0.63 | 0.12 | 0.44 | 0.89 |
| 13 May – 26 May | 0.48 | 0.14 | 0.27 | 0.85 |
| 27 May – 9 Jun | 0.72 | 0.28 | 0.34 | 1.51 |
| Total per licence holder | 4.57 | 0.42 | 4.08 | 5.13 |
| Total hunting days | 118,800 | 8,773 | 102,812 | 137,274 |

Percentage of days hunted and associated duck harvest by land tenure

Similar duck hunting effort was expended on public land (51.9%) and private land (47.2%), with a greater proportion of ducks harvested solely on private land (48.5% on public land versus 50.5% on private land) (Table 17).

Table 17

| Land tenure | Days | Duck harvest |
|-------------------|----------------|-----------------|
| Private land only | 47.2% (56,073) | 50.5% (226,761) |
| Public land only | 51.9% (61,657) | 48.5% (217,780) |
| Both | 1.0% (1,188) | 1.0% (4,490) |

Estimated total duck harvest in 2014 by CMA region.

Total harvest was estimated to be greatest in the Goulburn Broken CMA region, followed by North Central CMA CMA, Corangamite CMA and the West Gippsland CMA CMA (Figure 3). The top five towns for the total reported number of ducks harvested were (in descending order) Sale, Geelong, Shepparton, Bairnsdale and Bendigo. The top five towns for total number of reported duck hunting days were (in descending order) Sale, Geelong, Shepparton, Kerang and Bairnsdale.

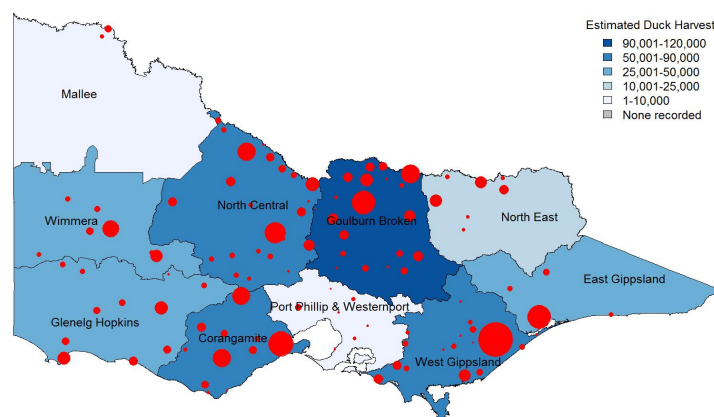


Figure 3. Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

Quail

Summary of responses for quail surveys in 2014

The number of Game Licence holders endorsed to hunt quail was consistent throughout the season (Table 18). In order to achieve the required sample size of respondents, slightly more than 300 licence holders were contacted each survey, with an average of 98.8% of those contacted being willing to take part.

Table 18

| Quail survey | Period | Licence holders | Respondents | Respondents who hunted | Days hunted* | Quail harvested** |
|--------------|--------|-----------------|-------------|------------------------|--------------|-------------------|
| 1 | April | 28,613 | 300 | 27 | 52 | 78 |
| 2 | May | 28,859 | 300 | 13 | 25 | 18 |
| 3 | June | 29,065 | 300 | 14 | 36 | 73 |

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

** Quail harvested indicates total number of quail harvested by respondents.

Proportion and corresponding total number of quail licence holders who hunted in each survey period in 2014

The proportion of Game Licence holders endorsed to hunt quail who hunted quail halved after the first survey period, from 9% to 4%. There were an estimated 2,575 Game Licence holders who hunted quail in April, and 1,251 and 1,356 in the subsequent months (Table 19).

Table 19

| Period | Proportion | SE | 95%CI | | Total hunters | SE | 95%CI | |
|--------|------------|-------|-------|-------|---------------|-----|-------|-------|
| | | | Lower | Upper | | | Lower | Upper |
| April | 0.09 | 0.017 | 0.06 | 0.13 | 2,575 | 473 | 1,802 | 3,679 |
| May | 0.04 | 0.012 | 0.03 | 0.07 | 1,251 | 339 | 742 | 2,108 |
| June | 0.05 | 0.012 | 0.03 | 0.08 | 1,356 | 354 | 820 | 2,243 |

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

Within each survey period there was large variation in the reported harvest per hunter (i.e. per Game Licence holder who hunted), with some hunters harvesting more than 10 quail and more than half harvesting zero quail within a given survey period. The average number of quail harvested per hunter during a one-month period varied from 1 to 5 (Table 20).

Table 20

| Period | Average harvest per hunter* | SE | 95%CI | |
|--------|-----------------------------|------|-------|-------|
| | | | Lower | Upper |
| April | 2.89 | 0.85 | 1.64 | 5.09 |
| May | 1.38 | 1.07 | 0.36 | 5.30 |
| June | 5.21 | 2.96 | 1.85 | 14.67 |

* Average harvest per hunter = Quail harvested divided by Respondents who hunted (Table 18).

Estimates of the 2014 quail harvest in Victoria by licensed quail hunters

There were an estimated 16,243 quail harvested by holders of a Game Licence for quail during the 2014 quail season (95%CI = 8,699–30,330). The May harvest was substantially lower than the April and June harvests (Table 21).

Table 21

| Period | Total harvest* | SE | 95%CI | |
|---------------------|----------------|--------------|--------------|---------------|
| | | | Lower | Upper |
| April | 7,439 | 2,586 | 3,837 | 14,424 |
| May | 1,732 | 1,420 | 425 | 7,061 |
| June | 7,072 | 4,414 | 2,298 | 21,765 |
| Season total | 16,243 | 5,309 | 8,699 | 30,330 |

* Total harvest = Harvest per hunter (Table 20) × Total hunters (Table 19). Numbers may differ slightly due to rounding of average harvest per hunter.

Days quail hunted per Game Licence holder

The number of hunting days in May was about half that of April, with June being intermediate. On average, each active quail Game Licence holder hunted on 0.4 days during the 2014 season, corresponding to 10,852 hunter days (95%CI = 7,193–16,374; Table 25).

Table 22

| Period | Days hunted | SE | 95%CI | |
|---------------------------------|---------------|--------------|--------------|---------------|
| | | | Lower | Upper |
| April | 0.17 | 0.04 | 0.11 | 0.28 |
| May | 0.08 | 0.03 | 0.05 | 0.15 |
| June | 0.12 | 0.04 | 0.07 | 0.22 |
| Total per licence holder | 0.38 | 0.06 | 0.27 | 0.52 |
| Total hunting days | 10,852 | 2,303 | 7,193 | 16,374 |

Percentage of days hunted and associated quail harvest by land tenure in 2014

Most quail hunting was conducted on private land (88.5% of the hunting days), accounting for 95.3% of the harvested quail (Table 23). A small proportion of hunting was conducted in State Game Reserves (9.7%) or both private land and State Game Reserves during the same hunting trip (1.8%).

Table 23

| Land tenure | Days | | | Quail harvest | | |
|--------------------------|----------------------|----------------------|-----------------------|----------------------|----------------------|---------------|
| | No dog | Dog used | Total | No dog | Dog used | Total |
| Private land only | 42.5% | 46.0% | 88.5% | 50.9% | 44.4% | 95.3% |
| State Game Reserves only | 7.1% | 2.7% | 9.7% | 1.2% | 3.6% | 4.7% |
| Both | 1.8% | 0.0% | 1.8% | 0.0% | 0.0% | 0.0% |
| Total | 51.3% (5,567) | 48.7% (5,285) | 100.0% (8,463) | 52.1% (8,463) | 47.9% (7,780) | 100.0% |

Percentage of hunting days and associated quail harvest per habitat type in 2014

Most quail hunting and quail harvest took place on stubble (74.3% and 54.4%, respectively), or combinations including native grasslands (a total of 18.6% and 43.8%, respectively; Table 24).

Table 24

| Grassland | Days | Quail harvest |
|-----------------------------|----------------------|----------------------|
| Introduced grass | 7.1% (270) | 1.8% (292) |
| Native grass | 8.0% (868) | 7.7% (1,250) |
| Introduced and native grass | 5.3% (575) | 14.8% (2,404) |
| Stubble | 74.3% (8,063) | 54.4% (8,836) |
| Stubble and native | 5.3% (575) | 21.3% (3,460) |

Estimated total quail harvest in 2014 by CMA region

The total quail harvest was greatest in the Port Phillip and Westernport CMA regions, followed by North Central CMA region and Corangamite CMA region (Figure 4). The top five towns for total reported number of quail harvested were (in descending order) Werribee, Charlton, Cressy, Tatura and Ballarat. The top five towns for total number of reported quail hunting days were (in descending order) Horsham, Charlton, Ballarat, Werribee and Eildon.

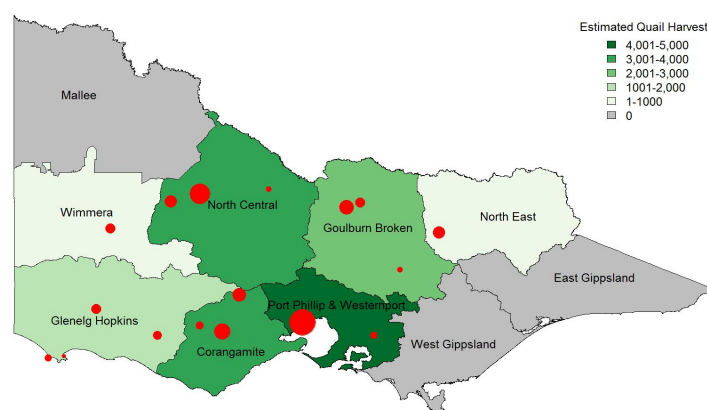


Figure 4. Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.

Discussion

Deer

A total of 57,945 deer were estimated to have been harvested in Victoria during the season from July 2013 to June 2014 (95%CI = 46,382–72,392). The most commonly harvested species was Sambar Deer (47,129), followed by Fallow Deer (9,282). Due to the very small harvest of Red Deer reported by surveyed Game Licence holders, it is difficult to make any inference from the survey about the harvest of that species, except that it is likely to be small (<2,000). Even though no survey respondent had successfully hunted Hog Deer in 2014, a total of 122 Hog Deer (96 stags and 26 hinds) were recorded at checking stations, with an additional 75 Hog Deer (30 stags and 45 hinds) harvested on Sunday Island (a private cooperative).

The 2014 season harvest of 57,945 deer was higher than in previous years (Figure 5). The 2014 estimate was 16% larger than the next highest estimated harvest (2013) using this survey method (Table 25). The 2014 season had the largest number of hunting days and the second largest deer harvested per licence holder of the surveys to date. The efficiency of hunters (i.e. deer harvested per hunting day) in the last two seasons (2013 and 2014) was the equal highest recorded since the surveys began in 2009. Most deer hunting occurred from mid-winter to mid-spring, which coincides with the hound-hunting period and reduced hunting over the hotter months.

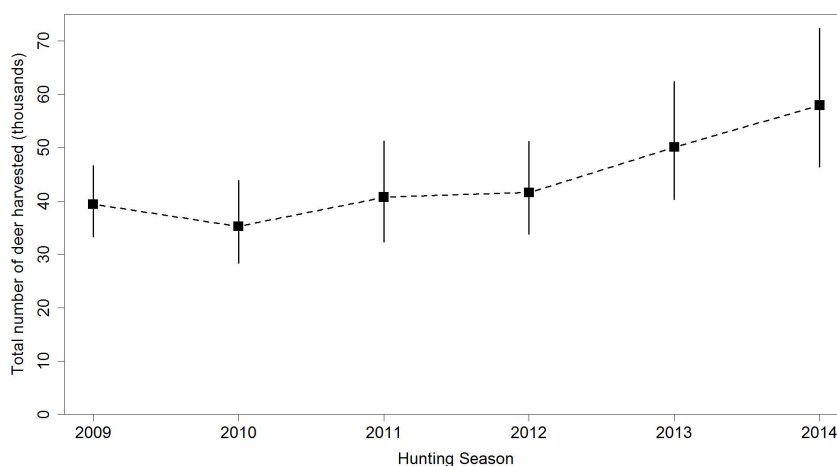


Figure 5. Estimated total deer harvests (in thousands) from 2009 to 2014. The square is the estimate for each season, while the vertical line is its 95% confidence interval.

Table 25. Comparison of deer harvests, 2009 to 2014 (data based on all licensed deer hunters)

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Harvest by species | | | | | | |
| Fallow Deer | 4,299 | 5,006 | 5,187 | 7,900 | 6,138 | 9,282 |
| Hog Deer* | 81 | 454 | 105 | 102 | – | – |
| Red Deer | 670 | 767 | 1,437 | 773 | – | 1,671 |
| Sambar Deer | 34,368 | 28,762 | 34,000 | 32,826 | 42,847 | 47,129 |
| Total harvest | 39,418 | 35,278 | 40,728 | 41,601 | 50,112 | 57,945 |
| Hunting days | 125,428 | 149,930 | 140,471 | 152,051 | 150,910 | 174,603 |
| Deer per licence holder | 2.43 | 1.86 | 1.97 | 1.93 | 2.13 | 2.20 |
| Hunting days per licence holder | 7.75 | 7.91 | 6.83 | 7.04 | 6.43 | 6.64 |
| Deer per hunting day | 0.31 | 0.24 | 0.29 | 0.27 | 0.33 | 0.33 |

Note: The 2009, 2010, 2011, 2012 and 2013 estimates are from Gormley and Turnbull (2009), Gormley and Turnbull (2010), Gormley and Turnbull (2011), Moloney and Turnbull (2012) and Moloney and Turnbull (2013), respectively.

* Small sample size does not reflect an accurate estimate.

Duck

A total of 449,032 ducks were estimated to have been harvested in Victoria during the 2014 season (95%CI = 394,157–511,547), 6% more than in the 2013 harvest (422,294), but a 25% reduction on the peak harvest in 2011 (600,739) (Table 26 and Figure 6). The number of Pink-eared Duck harvested was the lowest since 2011. Both Chestnut and Grey Teal harvests decreased in 2014. The harvest of Australian Wood Duck, Mountain Duck and Pacific Black Duck were all higher in 2014 than in 2013. The estimated hunting days per licence holder returned to 2011–2012 levels, while ducks harvested per licence holder remained similar to last season (2013). However, hunter efficiency (ducks per hunting day) was the lowest since 2011, when the daily bag limit was left unmodified at 10 ducks (Table 26).

Table 26. Comparison of duck harvests, 2009–2014 (data based on all licensed duck hunters)

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---------------------------------|---------|---------|---------|---------|---------|---------|
| Harvest by species | | | | | | |
| Australian Wood Duck | 131,084 | 112,390 | 132,908 | 150,150 | 106,553 | 131,282 |
| Blue-winged Shoveler | NA | 216 | 4,854 | 1,319 | 7,104 | 4,155 |
| Chestnut Teal | 13,176 | 14,354 | 49,812 | 23,506 | 39,804 | 29,866 |
| Grey Teal | 20,919 | 26,011 | 211,034 | 110,574 | 135,947 | 127,126 |
| Hardhead | NA | 324 | 25,657 | 30,222 | 7,349 | 6,363 |
| Mountain Duck | 2,173 | 5,936 | 8,090 | 9,234 | 2,694 | 8,440 |
| Pacific Black Duck | 55,150 | 96,487 | 156,484 | 160,704 | 92,714 | 127,646 |
| Pink-eared Duck | NA | 0 | 12,597 | 21,587 | 30,129 | 14,154 |
| Total harvest | 222,302 | 270,574 | 600,739 | 508,256 | 422,294 | 449,032 |
| Hunting days | 76,659 | 85,801 | 103,450 | 109,718 | 91,748 | 118,800 |
| Ducks per licence holder | 11.10 | 12.54 | 26.02 | 21.19 | 17.24 | 17.29 |
| Hunting days per licence holder | 3.98 | 3.98 | 4.48 | 4.60 | 3.75 | 4.57 |
| Ducks per hunting day | 2.78 | 3.16 | 5.81 | 4.63 | 4.60 | 3.78 |

Note: The 2009, 2010, 2011, 2012 and 2013 estimates are from Gormley and Turnbull (2009), Gormley and Turnbull (2010), Gormley and Turnbull (2011), Moloney and Turnbull (2012) and Moloney and Turnbull (2013), respectively.

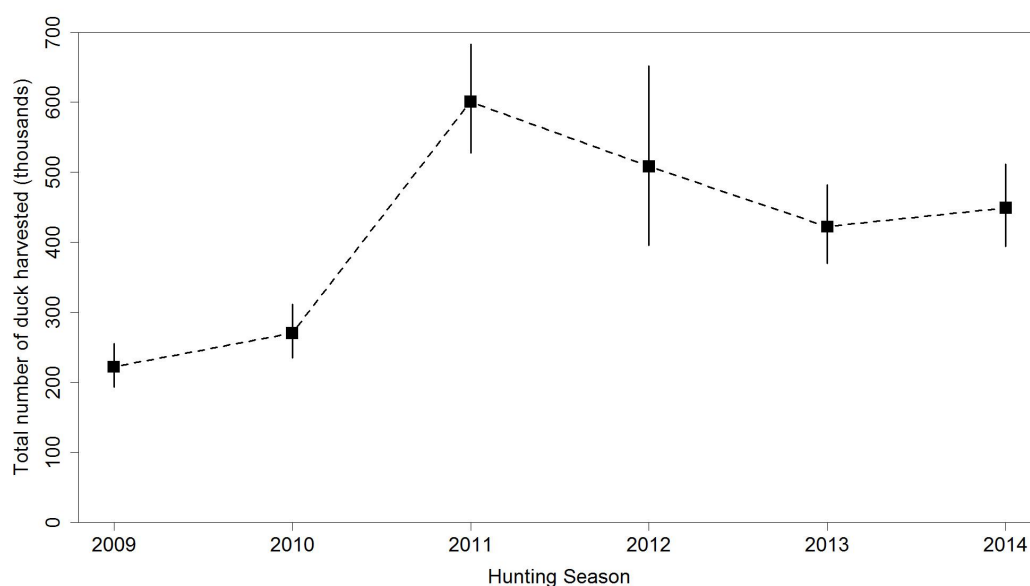


Figure 6. Estimated total duck harvests (in thousands) from 2009 to 2014. The square is the estimate for each season, while the vertical line is its 95% confidence interval.

Quail

The total of 16,243 quail estimated to have been harvested in Victoria during the 2014 season (95%CI = 8,699–30,330) is a large decrease from the 2013 harvest of 184,123, i.e. more than 11 times smaller than the previous season (Figure 7). Furthermore, it is less than 20% of the smallest harvest this method of survey has recorded (Table 27). The hunter surveys from the first month of the 2014 season (April) indicate low number of stubble quail harvested and a low number of hunting days. The results of the next month were even lower, potentially due to the probability of harvesting stubble quail being too low to warrant the effort to go hunting. Given quail are a 'boom-or-bust' species, it is possible that the low harvest and hunter effort in 2014 was due to low numbers of quail present and a lack of breeding combined with a higher than normal mortality, caused by environmental factors, and therefore lower quail numbers. Even when hunters did hunt, their return was less than half the previous low recorded in 2010.

Table 27. Comparison of quail harvests, 2009–2014 (data based on all licensed quail hunters)

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---------------------------------|---------|--------|---------|---------|---------|--------|
| Total harvest | 189,155 | 86,302 | 678,431 | 129,711 | 184,123 | 16,243 |
| Hunting days | 24,648 | 24,739 | 46,719 | 22,262 | 21,958 | 10,852 |
| Quail per licence holder | 7.89 | 3.59 | 26.17 | 4.80 | 6.69 | 0.56 |
| Hunting days per licence holder | 1.03 | 1.03 | 1.80 | 0.82 | 0.98 | 0.38 |
| Quail per hunting day | 7.97 | 3.48 | 14.52 | 5.81 | 8.39 | 1.47 |

Note: The 2009, 2010, 2011, 2012 and 2013 estimates are from Gormley and Turnbull (2009), Gormley and Turnbull (2010), Gormley and Turnbull (2011), Moloney and Turnbull (2012) and Moloney and Turnbull (2013), respectively.

Due to the structure of Game Licences in Victoria, not every holder of a Game Licence endorsed 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 who 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.

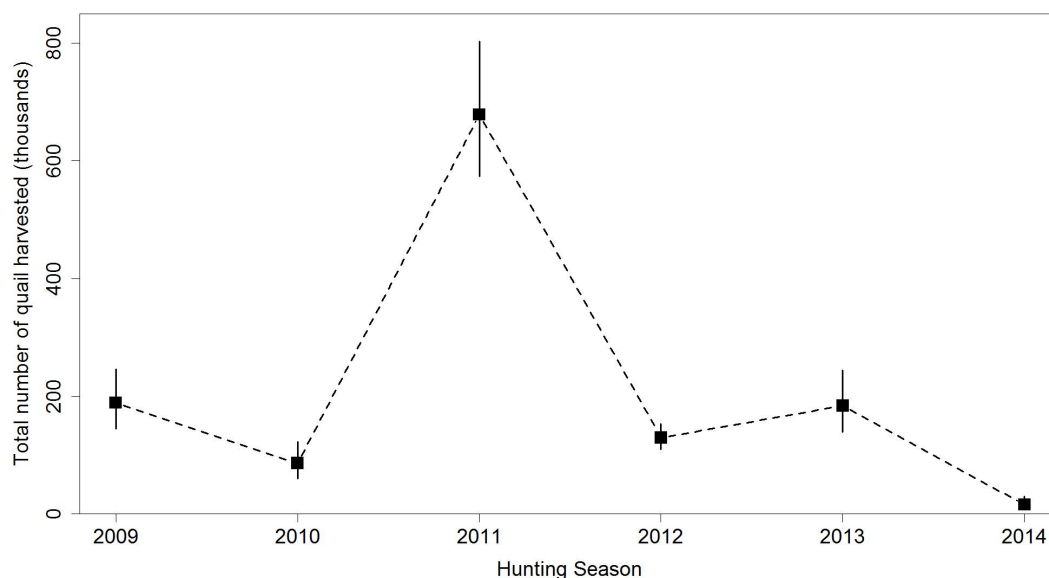


Figure 7. Estimated total quail harvests (in thousands) from 2009 to 2014. The square is the estimate for each season, while the vertical line is its 95% confidence interval.

Locations with the most hunting days

Combining deer, duck and quail, Mansfield had the most hunting days during July 2013 to June 2014, followed by Sale, Benalla, Myrtleford and Eildon. This assumed that all hunting days were equal, even though the time spent hunting on any particular day could vary considerably for each respondent, and according to game species. Mansfield, Sale and Horsham had the highest estimated hunting days for deer, duck and quail, respectively.

Assumptions

The estimates of harvest for each game type were derived with the assumption that the samples of respondents were representative of the entire population of Victorian Game Licence holders. This assumption may have been violated due to several factors, such as 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 (i.e. reported numbers are knowingly reported incorrectly). Bias due to non-response is likely to have been 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, would have ensured that both memory bias and non-response bias were 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.

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 that had hunted. 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 of more than 50 ducks during the same period. The second source of uncertainty was 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 respondents per survey for quail. Statistically these sample sizes are considered adequate to provide reasonable estimates.

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: $CV = SE \div \text{Average}$. 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:

$$p_j = \frac{h_j}{n_j} \quad \text{e.g. for Duck Survey 3, we obtain: } \frac{49}{200} = 0.245.$$

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:

$$H_j = p_j L \quad \text{e.g. for Duck Survey 3, we obtain: } 0.245 \times 25943 = 6356.$$

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):

$$w_j = \frac{y_j}{h_j} \quad \text{e.g. for Duck Survey 3, we obtain: } \frac{493}{49} = 10.06.$$

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):

$$W_j = w_j H_j \quad \text{e.g. for Duck Survey 3, we obtain: } 10.06 \times 6356 = 63949.$$

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

$$W_{TOT} = W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7.$$

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

$$SE(p_j) = \sqrt{\frac{p_j(1-p_j)}{n_j}} \quad \text{e.g. for Duck Survey 3, we obtain: } \sqrt{\frac{0.245 \times 0.755}{200}} = 0.030.$$

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

$$SE(w_j) = \frac{SD(w_j)}{\sqrt{h_j}} \quad \text{e.g. for Duck Survey 3, we obtain: } \frac{8.913}{\sqrt{49}} = 1.27.$$

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).

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

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

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

The standard error of the total harvest is calculated as:

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

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:

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

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

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

e.g. for the total duck harvest we have

$$CV = \frac{31668}{449032} = 0.071$$

$$r = \exp\left(1.96\sqrt{\ln(1 + 0.071^2)}\right) = 1.15.$$

Therefore, Upper and Lower Confidence Intervals are given by:

$$UL = 449032 \times 1.15 = 515508$$

$$LL = 449032 \div 1.15 = 391128.$$

Appendix 2

Victorian Deer Hunting Survey

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

We are conducting a survey of licensed Deer Hunters over a 12 month period that will provide information on hunting practices and harvest information as part of the continued process to improve game management in Victoria.
I was hoping you had time to answer a few quick questions.

Survey details:

Period of Survey _____ (1 to 6) Date of interview: dd / mm / 2014

Non-responsive: ☐ (tick box)

Survey questions:

1. Have you been Deer hunting in the past two Months? (name months) Yes ☐ No ☐ (tick box, if 'Yes', proceed to question 2, if 'No' "Thank you for taking part in this survey, if you would like to discuss or view the outcomes of this data, please contact Customer Service Centre on 136 186)
2. How many Deer hunting trips have you taken over this 2 week period? _____ (indicate number in box)

| | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 | Trip 7 |
|---|---|---|---|---|---|---|---|
| 3. How many days did you go hunting? | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| 4. How many deer did your harvest? | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| 5. What species were the deer? | Sambar Fallow Red Hog Male No. Female No. | Sambar Fallow Red Hog Male No. Female No. | Sambar Fallow Red Hog Male No. Female No. | Sambar Fallow Red Hog Male No. Female No. | Sambar Fallow Red Hog Male No. Female No. | Sambar Fallow Red Hog Male No. Female No. | Sambar Fallow Red Hog Male No. Female No. |
| 6. What was the sex of the Deer | Stalking Scent- Hounds Gundogs | Stalking Scent- Hounds Gundogs | Stalking Scent- Hounds Gundogs | Stalking Scent- Hounds Gundogs | Stalking Scent- Hounds Gundogs | Stalking Scent- Hounds Gundogs | Stalking Scent- Hounds Gundogs |
| 7. How were the deer taken? | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> |
| 8. Did you hunt on private land? | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> |
| 9 What was the closest major town to the area you hunted? | ----- | ----- | ----- | ----- | ----- | ----- | ----- |

Victorian Duck Hunting Survey

Introduction: Hi my name is _____ and I am calling about duck season on behalf of the Game Management Authority.

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

(*use if asked to explain why*) The survey of licensed Duck Hunters over the open season will provide information on hunting practices and harvest information as part of the continued process to improve game management in Victoria.

Survey details:

Period of Survey _____ (1 to 6) Date of interview: dd / mm / 2014

Non-responsive: ☐ (tick box)

Survey questions:

1. Have you been Duck hunting in the two weeks prior to last Sunday? Yes ☐ No ☐ (tick box, if 'Yes', proceed to question 2, if 'No' "Thank you for taking part in this survey, if you would like to discuss or view the outcomes of this data, please contact Customer Service Centre on 136 186)

2. How many Duck hunting trips have you taken over this 2 week period? (indicate number in box)

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

| | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 | Trip 7 |
|--|--|--|--|--|--|--|--|
| 3. How many days did you go hunting? | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| 4. How many ducks did your harvest? | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| 5. What species were the duck? <i>Include number of each species</i> | Black duck Wood duck Mountain duck Grey Teal Chestnut Teal Pink Ear Aust Shoveler Hardhead Other | Black duck Wood duck Mountain duck Grey Teal Chestnut Teal Pink Ear Aust Shoveler Hardhead Other | Black duck Wood duck Mountain duck Grey Teal Chestnut Teal Pink Ear Aust Shoveler Hardhead Other | Black duck Wood duck Mountain duck Grey Teal Chestnut Teal Pink Ear Aust Shoveler Hardhead Other | Black duck Wood duck Mountain duck Grey Teal Chestnut Teal Pink Ear Aust Shoveler Hardhead Other | Black duck Wood duck Mountain duck Grey Teal Chestnut Teal Pink Ear Aust Shoveler Hardhead Other | Black duck Wood duck Mountain duck Grey Teal Chestnut Teal Pink Ear Aust Shoveler Hardhead Other |
| 6. What type of land did you hunt on? "Can register more than one choice" | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land |
| 7. What was the closest major town to the area you hunted? | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| 8. How much do you think your trip cost you? | ----- | ----- | ----- | ----- | ----- | ----- | ----- |

Victorian Quail Hunting Survey

Introduction: Hi my name is _____ and I am calling about Stubble Quail season on behalf of the Game Management Authority.

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

(*use if asked to explain why*) The survey of licensed Quail Hunters over the open season will provide information on hunting practices and harvest information as part of the continued process to improve game management in Victoria.

Survey details:

Period of Survey _____ (1 to 6) Date of interview: dd / mm / 2014

Non-responsive: ☐ (tick box)

Survey questions:

(Questions 1, 2 and 10 only require one answer, whilst questions 2 – 9 may require multiple answers)

1. Have you been Quail hunting last month. (name month) Yes ☐ No ☐ (tick box, if 'Yes', proceed to question 2, if 'No' "Thank you for taking part in this survey, if you would like to discuss or view the outcomes of this data, please contact Customer Service Centre on 136 186)
2. How many Quail hunting trips did you take last month? (indicate number in box)

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

| | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 | Trip 7 |
|--|---|---|---|---|---|---|---|
| 3. How many days did you go hunting? | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| 4. How many Quail did your harvest? | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| 5. Did you use a dog to assist in the hunt? | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> | Yes <input type="checkbox"/> No <input type="checkbox"/> |
| 6. What type of land did you hunt on? "Can register more than one choice" | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land | State Game Reserve Private land Public land |
| 7. What type of grasslands was the hunt on? "Can register more than one choice" | Stubble Native Grass Introduced grass | Stubble Native Grass Introduced grass | Stubble Native Grass Introduced grass | Stubble Native Grass Introduced grass | Stubble Native Grass Introduced grass | Stubble Native Grass Introduced grass | Stubble Native Grass Introduced grass |
| 8. What was the closest major town to the area you hunted? | ----- | ----- | ----- | ----- | ----- | ----- | ----- |

(The final question relates to harvest over the opening weekend)

10. Did you go hunting on the opening Saturday? Yes ☐ No ☐ (tick box)

(if 'Yes')

(Indicate number in box)

Did you go hunting on the opening Sunday? Yes ☐ No ☐ (tick box)

(if 'Yes')

(Indicate number in box)

