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# ESTIMATE OF DUCK AND STUBBLE QUAIL HARVEST IN VICTORIA FOR 2022

**Results from surveys of Victorian Game  
Licence holders in 2022**

P.D. Moloney and J.S. Flesch

## Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and their deep spiritual connection to it. We honour Elders past and present, whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.



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# Estimate of duck and Stubble Quail harvest in Victoria for 2022

Results from surveys of Victorian Game Licence holders in 2022

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# Summary

## Context

To effectively manage game species, it is important to quantify the numbers harvested. Since 2009, the Victorian State Government game management agency has commissioned a series of regular telephone surveys of randomly selected Game Licence holders. Each year, three sets of telephone surveys are conducted during the various game harvest seasons for deer, duck and Stubble Quail (*Coturnix pectoralis*). This report focuses only on the duck and Stubble Quail harvests for 2022.

## Aim

The aim of this report is to provide estimates of the total harvests of ducks and Stubble Quail by Victorian Game Licence holders during the 2022 hunting seasons.

## Methods

Game Licence holders for each game type were randomly sampled and interviewed by telephone at intervals during their respective game seasons. In all surveys, respondents were asked whether they had hunted during the period for which the survey applied, and (if applicable) the number and species of birds harvested. Additional information was obtained on hunting methods and locations. Data collected during these telephone interviews were analysed to estimate the total harvest and total number of days spent hunting for ducks and Stubble Quail. Additional metrics related to hunter effort and efficiency were also estimated.

## Results

The total estimated duck harvest in 2022 was 262,600 ducks [95% confidence interval (CI) = 227,100 – 303,600], which is 19% below the average annual duck harvest estimated from previous surveys (324,000 ducks). However, this harvest is still within the typical range and is greater than the 2020 and 2021 harvests, which were affected by COVID restrictions (60,000 and 52,000, respectively). The total estimated number of duck hunting days was 96,100 days (95% CI = 81,000 – 114,000), which is 14% above the average annual duck hunting days estimated from previous surveys (84,000 days). The three most commonly harvested species were Pacific Black Duck (*Anas superciliosa*) (which comprised 38% of the total harvest), Australian Wood Duck (*Chenonetta jubata*) (26%) and Grey Teal (*Anas gracilis*) (18%). The remaining ducks harvested were Chestnut Teal (*Anas castanea*) (10%), Mountain Duck (*Tadorna tadornoides*) (8%) and Pink-eared Duck (*Malacorhynchus membranaceus*) (<1%). Hunting of Blue-winged Shoveler (*Spatula rhynchotis*) and Hardhead (*Aythya australis*) was prohibited for the 2022 season.

Holders of a Game Licence endorsed for duck hunting who actively hunted ducks during the 2022 duck hunting season, harvested an average of 23.3 ducks (95% CI = 19.5 – 27.7), over an average of 8.5 days (95% CI = 7.0 – 10.4).

The total estimated Stubble Quail harvest in 2022 was 77,600 quail (95% CI = 52,900 – 113,900), which was 50% less than the average annual Stubble Quail harvest estimated from previous surveys (155,000 quail). The total estimated number of Stubble Quail hunting days was 10,200 days (95% CI = 6600 – 15,800), which is 49% less than the average number of days estimated from previous surveys (20,000 days).

Holders of a Game Licence endorsed for Stubble Quail hunting who actively hunted Stubble Quail during the 2022 Stubble Quail season, harvested an average of 30.4 quail (95% CI = 19.3 – 48.1), over an average of 4 days (95% CI = 2.4 – 6.6).

The total number of hunter days during the 2022 hunting season for ducks and Stubble Quail was estimated to be 106,300 (95% CI = 89,300 – 123,300).



## Conclusions and implications

1. In 2022, the duck hunting season was not subject to the COVID-19 restrictions that affected hunters in 2020 and 2021. The 2022 duck hunting season was 12 weeks in length (as prescribed), compared with 3 weeks in 2021, and the daily bag limit was reduced to four, down from the prescribed 10 birds. The seasonal arrangements for hunting Stubble Quail remained unchanged from the regulations (i.e. 3 months in length and a bag limit of 20 birds per day).
2. The amount of duck hunting rebounded to pre-COVID-19 – restriction levels in 2022, indicating that the declines in 2020 and 2021 were related to the restrictions during those years.
  - The proportion of duck hunters active at least once in 2022 was 50%, similar to the 55% in 2018 and 2019 seasons, and much greater than the 32% in the COVID-19 – affected 2020 and 2021 seasons.
  - The number of ducks harvested and the number of duck hunting days in 2022 were similar to the long-term averages, within which the COVID-19 – affected 2020 and 2021 seasons had the lowest recorded numbers.
3. The amount of Stubble Quail hunting was reduced to that in 2021, when COVID-19 restrictions were not expected to have affected the harvest.
  - The proportion of Stubble Quail hunters active at least once in 2022 was 9%, down from the 18% in 2018 and similar to the 8% in 2019, but higher than the 4% in 2020 and the 6% in 2021.
  - The number of Stubble Quail harvested (fourth lowest) and the number of Stubble Quail hunting days (third lowest), were lower than average, but much higher than in 2020, when COVID-19 restrictions impacted the season.
4. The number of Game Licence holders endorsed to hunt Stubble Quail who do hunt Stubble Quail is very low and is thus affecting the accuracy of the activity indices. Adding a question asking respondents in the end-of-season survey if they identify as a Stubble Quail hunter could help increase the accuracy. If that does not give the required improvement, then a greater number of Game Licence holders will need to be surveyed.
5. Performing telephone surveys throughout the year is likely to minimise memory bias and non-response bias. However, sources of bias will remain (due to over- and under-reporting), and the estimates of total harvest must be interpreted with care.



## Introduction

To effectively manage game species, it is important to quantify the numbers of animals harvested. Since 2009, the Victorian State Government game management agency (currently the Game Management Authority) has commissioned a series of regular telephone surveys of randomly selected Game Licence holders. Telephone surveys were conducted during the various game harvest seasons for deer, ducks and Stubble Quail (*Coturnix pectoralis*). This report focuses only on the duck and Stubble Quail harvests. Deer harvests are addressed in a separate report.

For the first time since 2018, the 2022 duck hunting season was the full 12 weeks as prescribed, running from 16 March to 13 June (Game Management Authority n.d.). Six species could legally be hunted in 2022: Pacific Black Duck (*Anas superciliosa*), Australian Wood Duck<sup>1</sup> (*Chenonetta jubata*), Mountain Duck<sup>2</sup> (*Tadorna tadornoides*), Grey Teal (*Anas gracilis*), Chestnut Teal (*Anas castanea*) and Pink-eared Duck (*Malacorhynchus membranaceus*). Hunting of Blue-winged Shoveler<sup>3</sup> (*Anas rhynchotis*) and Hardhead<sup>4</sup> (*Aythya australis*) (both declared game species) was prohibited for the 2022 season due to continuing low numbers. The bag limit for the 2022 season was four game ducks per hunter per day, reduced from the maximum prescribed daily bag limit of 10 birds.

The 2022 duck hunting survey used a similar method (i.e. telephone surveys) to those followed during the 2005, 2006 and 2009 to 2021 duck hunting seasons (Barker 2006; Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013, 2014, 2015, 2016, 2017, 2018; Moloney and Powell 2019; Moloney and Hampton 2020; Moloney and Flesch 2021). However, unlike in other years, in 2022 there was no official opening weekend (the season started on a Wednesday).

The 2022 Stubble Quail hunting season lasted 12 weeks, from 2 April to 30 June (Game Management Authority 2022). The daily bag limit for the 2022 season was 20 Stubble Quail per hunter.

The 2022 Stubble Quail hunting survey used a similar method (i.e. telephone surveys) to those followed during the 2009 to 2015, 2017 to 2019, and 2021 Stubble Quail hunting seasons (Gormley 2009; Gormley and Turnbull 2009, 2010, 2011; Moloney and Turnbull 2012, 2013, 2014, 2015, 2017, 2018; Moloney and Powell 2019; Moloney and Flesch 2021). Due to a clerical error, the 2016 Stubble Quail hunting survey used a slightly different method (Moloney and Turnbull 2016). Due to the COVID-19 restrictions in 2020, the surveys of Game Licence holders endorsed to hunt Stubble Quail started on the first weekend that hunting was allowed on public land (i.e. 16 May), and surveys were then conducted at the end of each month for the remainder of the season (i.e. three surveys in total) (Moloney and Hampton 2020).

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<sup>1</sup> Australian Wood Duck is also referred to as Wood Duck, Maned Duck and Maned Goose.

<sup>2</sup> Mountain Duck is also referred to as Australian Shelduck.

<sup>3</sup> Blue-winged Shoveler is also referred to as Australasian Shoveler.

<sup>4</sup> Hardhead is also referred to as White-eyed Duck.

# 1 Methods

## 1.1 General methodology

All surveys were conducted by the telephone survey company Marketing Skill Pty Ltd (Mt Eliza, Victoria) on behalf of the Game Management Authority (see Appendices 1 and 2). Estimates of the total harvest by Game Licence holders were based on the hunting activities reported by the survey respondents.

Slightly different methodology was used for estimating duck and Stubble Quail harvests for 2022 compared to other years (e.g. Moloney and Powell 2019). For ducks, surveys were performed after the end of the first week of the season (the season opened on a Wednesday) and from then on fortnightly throughout the 12-week season. The main difference is that historically, the season started on a Saturday and there was a specific “Opening weekend” survey. For Stubble Quail, surveys were performed for the opening weekend and then every month thereafter throughout the 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. Therefore, although a respondent<sup>5</sup> may have hunted during the periods covered by Surveys 2 and 3, if they were contacted as part of Survey 3, then only information that pertained to the period covered by Survey 3 was collected. An additional random sample of 400 Game Licence holders were surveyed immediately after the conclusion of the duck and Stubble Quail hunting seasons. The number of active hunters was estimated using the survey question in the final survey on whether they had hunted at any stage of the 2022 duck hunting season and Stubble Quail hunting season, respectively.

Survey responses were used to generate an estimate of the harvest 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 all Game Licence holders who hunted. This proportion was multiplied by the total number of Game Licence holders, yielding the estimated total number of active hunters for that survey period.

For each survey period, the average harvest per hunter<sup>6</sup> was estimated from the total reported harvest divided by the number of respondents who hunted. The total harvest for each survey period was estimated by multiplying the average harvest per hunter by the previously estimated total number of active hunters for that survey period. Finally, the total season harvest was estimated from the sum of the survey-specific total harvests.

The average season harvest per Game Licence holder was also estimated. For each survey period, the average harvest per survey respondent was estimated by multiplying the average harvest per hunter by the proportion of respondents who hunted. The sum of these estimates across the season provided an estimate of the total season harvest per Game Licence holder.

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 on which 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 and Stubble Quail surveys, as indicated in the following sections. Additional details of the methods, as well as examples of the calculations, are provided in Appendix 3. A description and interpretation of boxplots is provided in Appendix 4.

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<sup>5</sup> Respondent refers to a Game Licence holder who was contacted and agreed to take part in the survey.

<sup>6</sup> 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.

## 1.2 Duck

Samples were drawn from hunters who held a Game Licence endorsed for duck hunting during the 2022 season. An independent random sample of 200 licence holders was interviewed by telephone immediately after the first part-week (the season commenced on a Wednesday) (Duck Survey 1), and this was followed up by surveys of independent random samples of licence holders at 2-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. An additional independent random sample of 400 Game Licence holders endorsed to hunt ducks was surveyed immediately after the conclusion of the duck hunting season. They were asked whether they had hunted duck at any stage during the season.

## 1.3 Stubble Quail

Samples were drawn from hunters who held a Game Licence to hunt Stubble Quail during the 2022 Stubble Quail hunting season. A random sample of 300 licence holders was interviewed by telephone after the opening weekend (Survey 1) and in April (excluding opening weekend; Survey 2), May (Survey 3) and June (Survey 4). Respondents were asked to report the number of Stubble Quail harvested, the type of grassland where hunting occurred (native, stubble or introduced) and whether or not dogs were used. An additional random sample of 400 Game Licence holders was surveyed immediately after the conclusion of the Stubble Quail hunting season. They were asked whether they had hunted quail at any stage during the season.

When a Game Licence holder is endorsed for hunting duck, they are automatically endorsed for hunting Stubble Quail (you can be endorsed for hunting Stubble Quail without being endorsed for hunting duck). Therefore, the number of Game Licence holders endorsed for hunting Stubble Quail (from which our sample is drawn) is not representative of the number of self-reported Stubble Quail hunters<sup>7</sup>. In the 2022 Stubble Quail hunter survey, all respondents were asked whether they hunt quail, even if they did not necessarily hunt Stubble Quail during the 2022 Stubble Quail season. This information was used to increase the precision of the estimates for the Stubble Quail harvest and the total number of quail-hunting days.

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<sup>7</sup> Self-reported Stubble Quail hunters are Game Licence holders endorsed to hunt Stubble Quail who say that they may actually hunt Stubble Quail, regardless of whether they hunted Stubble Quail this season.

## 2 Results

### 2.1 Duck

The number of Game Licence holders endorsed to hunt ducks remained relatively constant throughout the season (Table 3.1). In order to achieve the required sample size of respondents, slightly more than 200 licence holders were contacted each survey, with typically 98% of those contacted being willing to take part.

**Table 3.1: Summary of responses for duck surveys in 2022.**

Duck survey	Period	Licence holders	Respondents	Respondents who hunted	Days hunted <sup>8</sup>	Ducks harvested <sup>9</sup>
1	16 – 20 March	22,422	200	56	119	296
2	21 March – 3 April	22,422	200	50	128	256
3	4 – 17 April	22,677	200	43	111	358
4	18 April – 1 May	22,677	200	33	106	306
5	2 – 15 May	22,806	200	40	105	301
6	16 – 29 May	22,806	201	36	107	290
7	30 May – 13 June	22,880	201	45	173	511

The proportion of Game Licence holders endorsed to hunt duck who hunted in each survey period was consistent after March. During the opening 5 days, 28% of surveyed licence holders hunted, corresponding to approximately 6278 hunters altogether (Table 3.2). For the remainder of the season, around a fifth of the Game Licence holders endorsed to hunt duck hunted in each survey period.

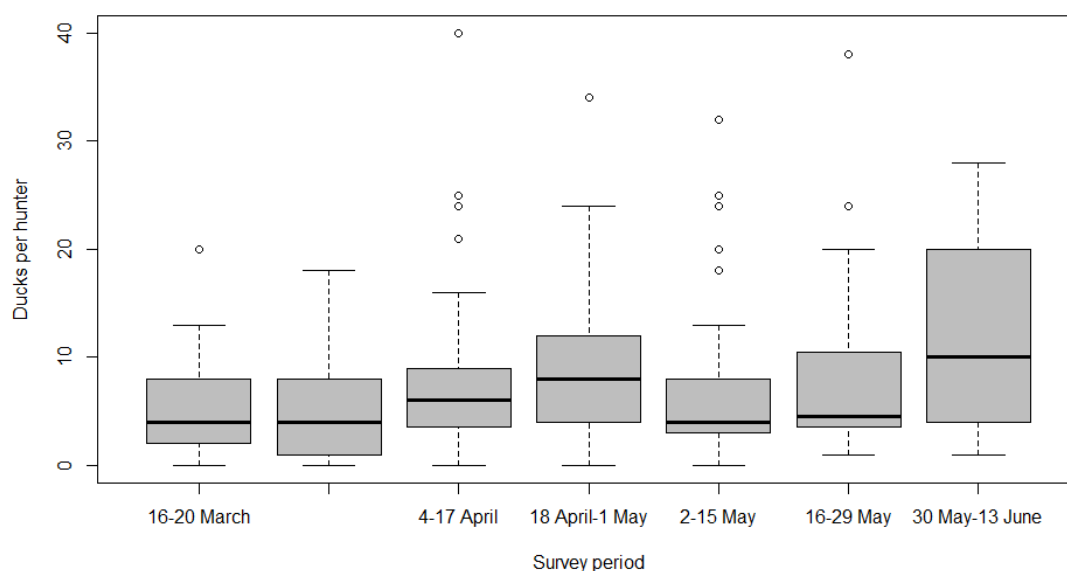
<sup>8</sup> Days hunted indicates the combined number of days on which duck hunting took place by respondents.

<sup>9</sup> Ducks harvested indicates total number of ducks harvested by respondents.

**Table 3.2: Proportion and corresponding total number of game licence holders endorsed to hunt duck who hunted in each survey period in 2022.**

Period	Proportion	SE	95% CI bound		Total hunters	SE	95% CI bound	
			Lower	Upper			Lower	Upper
16-20 March	0.28	0.032	0.22	0.35	6,278	712	5,031	7,835
21 March-3 April	0.25	0.031	0.20	0.32	5,606	687	4,413	7,120
4-17 April	0.22	0.029	0.17	0.28	4,876	659	3,746	6,346
18 April-1 May	0.16	0.026	0.12	0.22	3,742	595	2,745	5,101
2-15 May	0.20	0.028	0.15	0.26	4,561	645	3,462	6,010
16-29 May	0.18	0.027	0.13	0.24	4,085	617	3,043	5,482
30 May-13 June	0.22	0.029	0.17	0.29	5,122	673	3,964	6,619

The reported harvest of ducks per hunter (i.e. per Game Licence holder who hunted) was greatest in the final two weeks of the season (11.4 ducks per hunter). Some hunters harvested more than 15 ducks in a survey period, whereas some did not harvest any ducks (Figure 3.1). The average number of ducks harvested per hunter was lowest in March (~5 ducks per hunter) and consistent throughout April and May (~8 ducks per hunter) (Table 3.3).



**Figure 3.1: Boxplot of the number of ducks reported harvested by individual hunters for each survey period in 2022.**

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

**Table 3.3: Average harvest of ducks per active hunter (Game Licence holders who hunted) for each survey period in 2022.**

Period	Average harvest per hunter <sup>10</sup>	SE	95% CI bound	
			Lower	Upper
16-20 March	5.29	0.64	4.17	6.70
21 March-3 April	5.12	0.68	3.96	6.63
4-17 April	8.33	1.21	6.27	11.05
18 April-1 May	9.27	1.29	7.07	12.16
2-15 May	7.53	1.23	5.48	10.34
16-29 May	8.06	1.27	5.93	10.95
30 May-13 June	11.36	1.17	9.29	13.88

There were an estimated 33,185 ducks harvested during the opening 5 days (95% CI = 24,001–45,883), which constituted 13% of the total seasonal harvest (Table 3.4). The harvest in the last survey period (15 days) of the season was the largest (58,168), accounting for 22% of the total seasonal harvest. The total seasonal harvest estimate was 262,567 (95% CI = 227,075 – 303,606; Table 3.4).

**Table 3.4: Estimates of the total duck harvest in Victoria in 2022 by holders of a Game Licence endorsed for duck.**

Period	Total harvest <sup>11</sup>	SE	95% CI bound	
			Lower	Upper
16-20 March	33,185	5,523	24,001	45,883
21 March-3 April	28,700	5,192	20,191	40,796
4-17 April	40,592	8,089	27,572	59,760
18 April-1 May	34,696	7,366	22,991	52,360
2-15 May	34,323	7,454	22,535	52,277
16-29 May	32,904	7,220	21,511	50,331
30 May-13 June	58,168	9,732	42,000	80,558
Total	262,567	19,481	227,075	303,606

Game Licence holders hunted an average of 4.2 days each during the 2022 duck hunting season (Table A5.2). When multiplied by the total number of Game Licence holders in each survey period, this equalled a total of 96,102 hunter days (95% CI = 81,045 – 113,957; Table 3.5).

<sup>10</sup> Average harvest per hunter = Ducks harvested divided by Respondents who hunted (Table 3.1).

<sup>11</sup> Total harvest = Harvest per hunter (Table 3.3) × Total hunters (Table 3.2). Numbers may differ slightly due to rounding of average harvest per hunter.

**Table 3.5: Total days on which ducks were hunted in 2022.**

Period	Days hunted	SE	95% CI bound	
			Lower	Upper
16-20 March	13,341	2,381	9,429	18,876
21 March-3 April	14,350	2,994	9,576	21,505
4-17 April	12,586	2,904	8,053	19,669
18 April-1 May	12,019	3,071	7,342	19,675
2-15 May	11,973	2,914	7,482	19,160
16-29 May	12,141	3,447	7,034	20,954
30 May-13 June	19,693	4,148	13,090	29,626
<b>Total hunting days</b>	<b>96,102</b>	<b>8,371</b>	<b>81,045</b>	<b>113,957</b>

Using a telephone survey immediately after the 2022 duck hunting season ended, it was estimated that 50% (95% CI = 45% – 55%) of Game Licence holders endorsed to hunt ducks actually hunted for ducks during the 2022 duck hunting season. That equates to an estimate of 11,282 (95% CI = 10,224 – 12,449) active duck hunters in the 2022 duck hunting season. The average duck harvest per active duck hunter was estimated to be 23.3 (95% CI = 19.5 – 27.7). The average number of duck hunting days per active duck hunter was estimated to be 8.5 (95% CI = 7 – 10.4) (Table 3.6).



**Table 3.6: Estimates of the overall average harvest per active duck hunter<sup>12</sup> in Victoria in 2022 by holders of a Game Licence endorsed for duck hunting, and the average hunting days per active hunter.**

Annual statistic	Estimate	SE	95% CI bound	
			Lower	Upper
Proportion active	0.50	0.02	0.45	0.55
Estimated active hunters	11282	567	10224	12449
Average harvest per active hunter	23.27	2.09	19.53	27.73
Average hunting days per active hunter	8.52	0.86	7.00	10.37

The total harvest was estimated for each species by multiplying the total estimated duck harvest by the proportion of the total harvest for that species (Table 3.7). The most frequently harvested species was Pacific Black Duck, comprising 38% of the total reported harvest, followed by Australian Wood Duck (26%) and Grey Teal (18%). The remaining three species comprised 18% of the total harvest.

**Table 3.7: Reported numbers of ducks harvested by hunters, proportions of the total harvest, and estimates of total 2022 harvest for each duck species.**

Species	Reported harvest	Proportion of harvest	SE	Estimated harvest	SE	95% CI bound	
						Lower	Upper
Australian Wood Duck	614	0.26	0.009	68,632	5,621	39,600	118,947
Blue-winged Shoveler <sup>13</sup>	0	NA	NA	NA	NA	NA	NA
Chestnut Teal	233	0.10	0.006	26,044	2,521	14,354	47,257
Grey Teal	425	0.18	0.008	47,506	4,096	27,037	83,470
Hardhead <sup>14</sup>	0	NA	NA	NA	NA	NA	NA
Mountain Duck	184	0.08	0.006	20,567	2,109	11,149	37,942
Pacific Black Duck	883	0.38	0.010	98,700	7,779	57,526	169,345
Pink-eared Duck	10	0.00	0.001	1,118	362	396	3,158

<sup>12</sup> Active duck hunter is defined as a Game Licence holder endorsed to hunt ducks who hunted for ducks at least once during the 2022 duck season.

<sup>13</sup> Game Licence holders were not permitted to harvest Blue-winged Shoveler (*Spatula rhynchotis*), also referred to as Australasian Shoveler, in 2022.

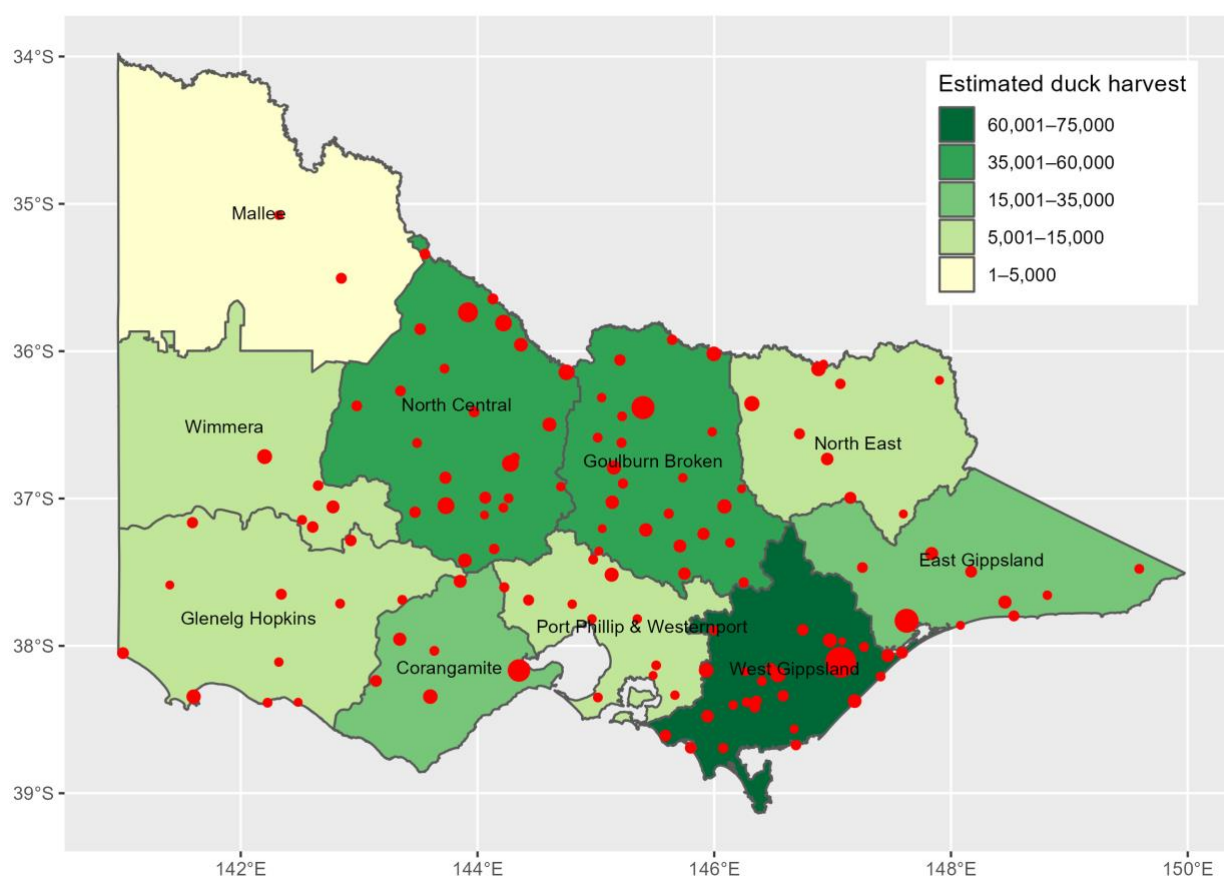
<sup>14</sup> Game Licence holders were not permitted to harvest Hardhead (*Aythya australis*), also referred to as White-eyed Duck, in 2022.

During the survey period, greater duck hunting effort was expended on private land (55%) than on public land (41.8%), with similar proportions to those for the ducks being harvested solely on private land (56.7%) and solely on public land (40.9%) (Table 3.8).

**Table 3.8: Percentage of days hunted and associated duck harvest by land tenure in 2022.**

Land tenure	Days (%)	Duck harvest (%)
Private land only	55.0	56.7
Public land only	41.8	40.9
Both	3.2	2.4
<b>Total</b>	<b>100.0</b>	<b>100.0</b>

Total harvest was estimated to be greatest in the West Gippsland CMA, followed by the North Central CMA and the Goulburn Broken CMA (Figure 3.2). The top five towns for the total reported number of ducks harvested were (in descending order) Sale, Bairnsdale, Shepparton, Geelong and Kerang. The top five towns for the total number of reported duck hunting days were (in descending order) Sale, Bairnsdale, Shepparton, Kerang and Geelong.



**Figure 3.2: Estimates of total duck harvest in 2022 by CMA region. Red circles indicate the nearest town to harvest locations, with symbol size proportional to reported harvest.**

## 2.2 Stubble Quail

The number of Game Licence holders endorsed to hunt Stubble Quail remained relatively constant throughout the season, increasing from 27,114 at opening weekend to 27,591 at the end of the season (Table 3.9). In order to achieve the required sample size of respondents, slightly more than 300 licence holders were contacted each survey, with typically 98% of those contacted being willing to take part.

**Table 3.9: Summary of responses for Stubble Quail surveys in 2022.**

Stubble Quail survey	Period	Licence holders	Respondents	Stubble Quail hunters <sup>15</sup>	Respondents who hunted	Days hunted <sup>16</sup>	Quail harvested <sup>17</sup>
1	Opening weekend	27,114	300	114	9	13	85
2	April <sup>18</sup>	27,114	301	100	12	23	250
3	May	27,394	300	97	11	48	332
4	June	27,591	299	99	12	28	185

The percentage of endorsed Game Licence holders who hunted Stubble Quail was consistent in each survey period of the season. About 4% of licence holders hunted in each survey period, corresponding to approximately 1000 hunters (Table 3.10).

**Table 3.10: Proportion and corresponding total number of Stubble Quail licence holders who hunted in each survey period in 2022.**

Period	Proportion	SE	95% CI bound		Total hunters	SE	95% CI bound	
			Lower	Upper			Lower	Upper
Opening weekend	0.03	0.010	0.02	0.06	813	267	434	1,523
April <sup>18</sup>	0.04	0.011	0.02	0.07	1,081	306	628	1,862
May	0.04	0.011	0.02	0.06	1,004	297	569	1,772
June	0.04	0.011	0.02	0.07	1,107	313	643	1,907

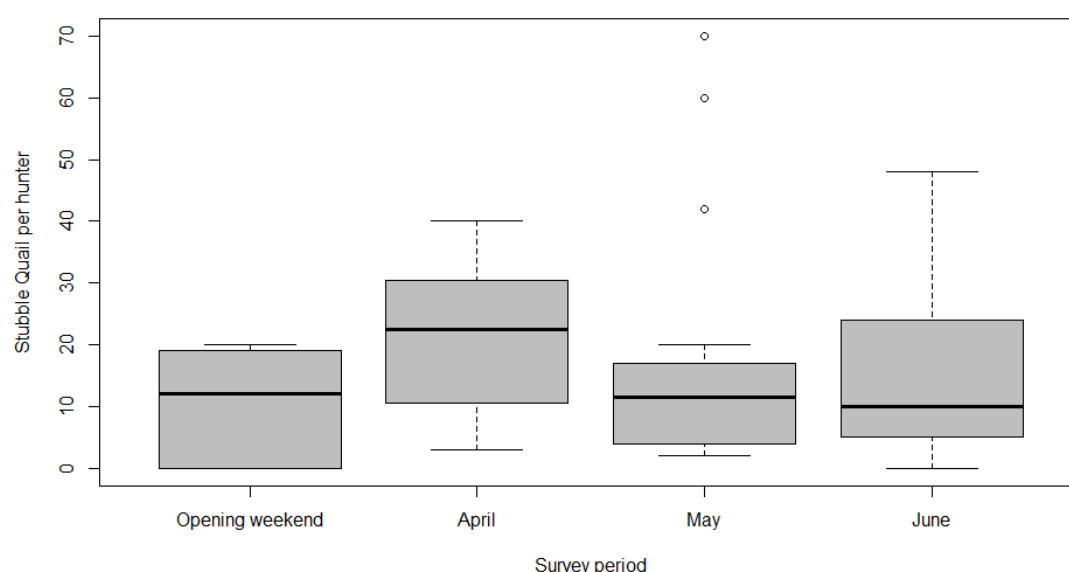
<sup>15</sup> Respondents who self-report as Stubble Quail hunters.

<sup>16</sup> Days hunted indicates the combined number of days on which Stubble Quail hunting took place by respondents.

<sup>17</sup> Stubble Quail harvested indicates total number of Stubble Quail harvested by respondents.

<sup>18</sup> April after the opening weekend.

Within each survey period, there was large variation in the reported harvest of Stubble Quail per hunter (i.e. per Game Licence holder who hunted). Some hunters harvested more than 20 Stubble Quail in a survey period, whereas 9% of people who hunted did not harvest any Stubble Quail (Figure 3.3). The average number of Stubble Quail per hunter varied throughout the season (Table 3.11). In April and May, average harvest per hunter was approximately 30 Stubble Quail, while in June it was half that amount).



**Figure 3.3: Boxplot of the number of Stubble Quails reported harvested by individual hunters for each survey period in 2022.**

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

**Table 3.11: Average harvest of Stubble Quail per hunter (Game Licence holder who hunted) for each survey period in 2022.**

Period	Average harvest per hunter <sup>19</sup>	SE	95% CI bound	
			Lower	Upper
Opening weekend	9.44	3.11	5.03	17.73
April <sup>18</sup>	20.83	3.51	15.01	28.92
May	30.18	5.71	20.90	43.59
June	15.42	4.44	8.87	26.81

<sup>19</sup> Average harvest per hunter = Stubble Quail harvested divided by Respondents who hunted (Table 3.9).

There were an estimated 77,590 Stubble Quail harvested by all holders of a Game Licence endorsed for hunting Stubble Quail during the 2022 Stubble Quail season (95% CI = 52,862 – 113,884). The opening weekend Stubble Quail harvest per hunter was approximately a tenth of that during the season. Including the opening weekend in the April harvest, the April and May totals (approximately 30,000 Stubble Quail each) were greater than the June harvest total (Table 3.12).

**Table 3.12: Estimates of the total Stubble Quail harvest in Victoria in 2022 by holders of a Game Licence endorsed for Stubble Quail.**

Period	Total harvest <sup>20</sup>	SE	95% CI bound	
			Lower	Upper
Opening weekend	7,682	3,670	3,159	18,682
April <sup>18</sup>	22,520	7,491	11,935	42,494
May	30,316	10,782	15,413	59,628
June	17,071	7,029	7,860	37,078
<b>Total</b>	<b>77,590</b>	<b>15,338</b>	<b>52,862</b>	<b>113,884</b>

Stubble Quail hunters had a total of 10,214 hunter days (95% CI = 6,621 – 15,755) days during the 2022 Stubble Quail hunting season (Table 3.13).

<sup>20</sup> Total harvest = Harvest per hunter (Table 3.11) × Total hunters (Table 3.10). Numbers may differ slightly due to rounding of average harvest per hunter.

**Table 3.13: Days on which Stubble Quail were hunted per self-reported Stubble Quail hunter for 2022.**

Period	Days hunted		SE	95% CI bound	
				Lower	Upper
Opening weekend	1,175	578	472	472	2,927
April	2,072	891	924	924	4,646
May	4,383	1,694	2,109	2,109	9,108
June	2,584	1,109	1,154	1,154	5,784
Total hunting days	10,214	2,287	6,621	6,621	15,755

From a telephone survey immediately after the 2022 Stubble Quail hunting season ended, it was estimated that 9% (95% CI = 7 – 12%) of Game Licence holders actually hunted for Stubble Quail during the 2022 Stubble Quail hunting season (Table 3.14). The estimated number of active Stubble Quail hunters in the 2022 Stubble Quail hunting season was 2549 (95% CI = 1979 – 3283). The average active Stubble Quail hunter was estimated to have harvested 30.4 Stubble Quail (95% CI = 19.3 – 48.1) over an average of 4 hunting days (95% CI = 2.4 – 6.6) during the Stubble Quail hunting season.

**Table 3.14: Estimates of the overall average harvest by active Stubble Quail hunters<sup>21</sup> in Victoria in 2022.**

Annual statistic	Estimate	SE	95% CI bound	
			Lower	Upper
Proportion active quail hunters	0.09	0.01	0.07	0.12
Estimated active quail hunters	2548.96	330.64	1978.82	3283.38
Average harvest per active hunter	30.44	7.20	19.27	48.08
Average hunting days per active quail hunter	4.01	1.04	2.43	6.60

Most Stubble Quail hunting was conducted on private land (84.8% of the hunting days), with the remaining hunting occurring on public land (Table 3.15). A similar percentage (91.3%) of the harvested Stubble Quail reported in the telephone surveys was on private land. The percentage of Stubble Quail hunting days where dogs were used (19.6%) was similar to the percentage of Stubble Quail harvested using dogs (26.1%; Table 3.15). The majority of Stubble Quail hunting and Stubble Quail harvesting took place on stubble (70.5% and 77.7%, respectively, Table 3.16).

**Table 3.15: Percentage of days of Stubble Quail hunting and associated Stubble Quail harvest by land tenure and dog usage in 2022.**

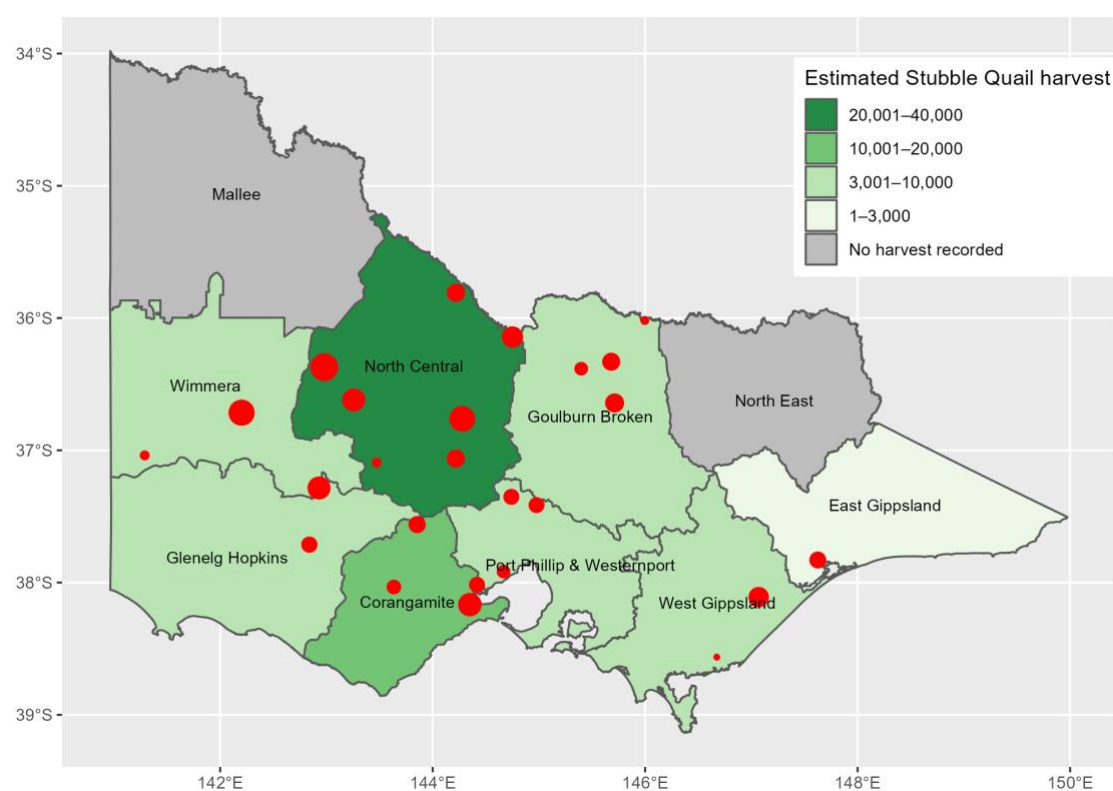
Land tenure	Days (%)			Harvest (%)		
	No dogs	Dogs	Total	No dogs	Dogs	Total
Private land only	22.3	19.6	84.8	18.5	26.1	91.3
State Game Reserves only	2.7	0.0	15.2	0.5	0.0	8.7
Both	0.0	0.0	0.0	0.0	0.0	0.0
Total	25.0	19.6	100.0	19.0	26.1	100.0

<sup>21</sup> Active Stubble Quail hunter is defined as a Game Licence holder endorsed to hunt Stubble Quail who hunted for Stubble Quail at least once during the 2022 Stubble Quail season.

**Table 3.16: Percentage of hunting days and associated Stubble Quail harvest per grassland type in 2022.**

Habitat type	Days (%)	Stubble Quail harvest (%)
Introduced grass	13.4	5.9
Native grass	2.7	4.5
Stubble	70.5	77.7
Stubble and introduced grass	4.5	4.2
NA	3.6	4.7
Stubble and native grass	5.4	3.1
<b>Total</b>	<b>100.0</b>	<b>100.0</b>

Total harvest was estimated to be greatest in the North Central CMA, followed by the Corangamite CMA and the Wimmera CMA (Figure 3.4). The top five towns for the total reported number of Stubble Quail harvested were (in descending order) Donald, Horsham, Bendigo, Geelong and Ararat. The top five towns for the total number of reported Stubble Quail hunting days were (in descending order) Ararat, Donald, Geelong, Ballarat and Bendigo.



**Figure 3.4: Estimates of total Stubble Quail harvest in 2022 by CMA region.**

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



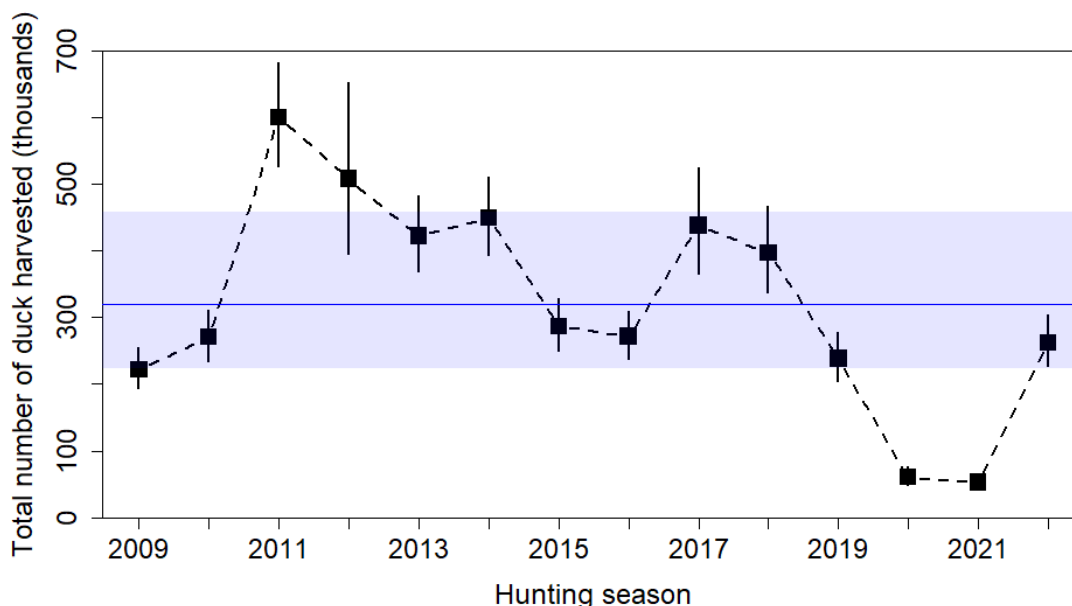
## 3 Discussion

### 3.1 Duck

A total of 262,567 ducks were estimated to have been harvested in Victoria during the 2022 season (95% CI = 227,075 – 303,606), which was within the average harvest from 2009 to 2022, over the period of the telephone surveys (Table 4.1 and Figure 4.1). The estimated harvest of duck in 2022 was 4.7 times larger than the averaged estimated harvests in 2020 and 2021, when COVID-19 restrictions negatively affected the duck harvest totals.

The estimated number of total hunting days (96,100: 95% CI = 81,000 – 114,000) and hunting days per licence holder (4.2: 95% CI = 1.7 – 4.9) were higher than historical levels. The average duck harvest per licence holder (11.6: 95% CI = 10.0 – 13.4) was below average, possibly reflecting the reduced daily bag limit (4 ducks per day compared to a maximum allowable bag limit of 10 ducks per day). This shows the potential to manipulate duck harvest using adaptive harvest management strategies. Hunter efficiency (ducks per hunting day) was 27% below the average from 2009 to 2022 (Table 4.1). This is to be expected given the bag limit in 2022 was 4 ducks per day, down from the maximum prescribed daily bag limit of 10 ducks per day. The long-term average harvest is 3.7 ducks per hunting day.

It was estimated that 50% (95% CI = 45 – 55%) of Game Licence holders hunted for ducks during the 2022 duck season. That equates to an estimate of 11,282 (95% CI = 10,224 – 12,449) active duck hunters in the 2022 duck season. The average seasonal duck harvest per active duck hunter was estimated to be 23.3 (95% CI = 19.5 – 27.7) over 8.5 days (95% CI = 7 – 10.4). These estimates are similar to the 2017 to 2019 estimates, but greater than the 2020 and 2021 estimates, which had been the lowest at that point, reflecting the unusual duck seasons in 2020 and 2021.



**Figure 4.1: Estimates of total duck harvests (in thousands) from 2009 to 2022.**

The squares are the estimated total harvests for each season; the solid vertical lines indicate the 95% confidence intervals; the blue line is the average duck harvest from 2009 to 2022; the shaded area is the 95% confidence interval for the average duck harvest from 2009 to 2022.

**Table 4.1: Comparison of duck harvest statistics of 2009 to 2022.**

**NAs represent years before the end-of-season survey was conducted and where the statistic relied on the end-of-season survey estimate of proportion of active hunters.**

Year	Total harvest	Hunting days	Ducks per licence holder	Hunting days per licence holder	Ducks per hunting day	Proportion of active hunters	Ducks per active hunter	Season length	Daily bag limit
2009	222,302	76,659	11.10	3.98	2.79	NA	NA	7	5
2010	270,574	85,801	12.54	3.98	3.15	NA	NA	10	8
2011	600,739	103,450	26.02	4.48	5.81	NA	NA	13	10
2012	508,256	109,718	21.19	4.60	4.61	NA	NA	13	10
2013	422,294	91,748	17.24	3.75	4.60	NA	NA	13	10
2014	449,320	118,800	17.29	4.57	3.78	NA	NA	12	10
2015	286,729	90,634	11.35	3.59	3.16	NA	NA	12	5
2016	271,576	100,749	10.73	3.98	2.70	NA	NA	12	4
2017	438,353	96,508	17.36	3.83	4.53	0.66	25.4	12	10
2018	396,708	91,570	15.65	3.62	4.32	0.55	28.1	12	10
2019	238,666	81,023	9.62	3.27	2.94	0.55	17.6	9	5
2020	60,403	29,501	2.58	1.26	2.05	0.32	8.1	5	3
2021	52,456	19,720	2.16	0.81	2.67	0.32	6.9	3	5
2022	262,567	96,102	11.57	4.24	2.73	0.50	23.3	12	4
<b>Average</b>	<b>320,067</b>	<b>85,142</b>	<b>13.31</b>	<b>3.57</b>	<b>3.73</b>	<b>0.48</b>	<b>18.2</b>	<b>10.4</b>	<b>7.1</b>

**Table 4.2: Comparison of duck harvests by species from 2009 to 2022.**

**NAs represent years where the hunting of that species was prohibited, while 0 was used if they could be harvested, but there were none reported.**

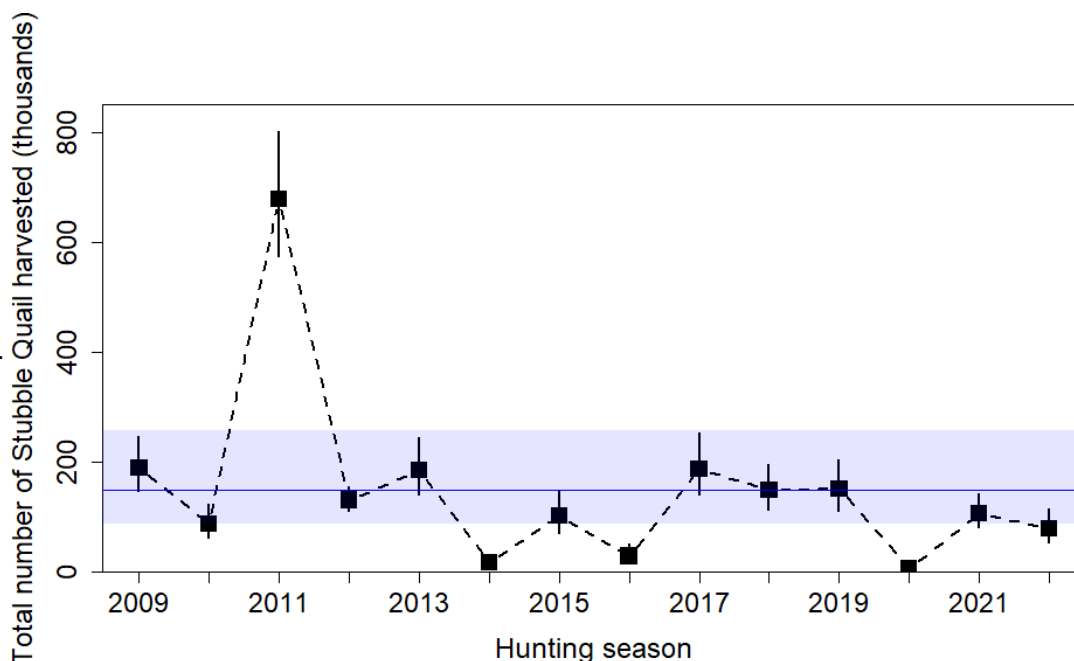
Year	Australian Wood Duck	Blue-winged Shoveler	Chestnut Teal	Grey Teal	Hardhead	Mountain Duck	Pacific Black Duck	Pink-eared Duck
2009	131,084	NA	13,176	20,919	NA	2,173	55,150	NA
2010	112,390	216	14,354	26,011	324	5,936	96,487	0
2011	132,908	4,854	49,812	211,034	25,657	8,090	156,484	12,597
2012	150,150	1,319	23,506	110,574	30,222	9,234	160,704	21,587
2013	106,553	7,104	39,804	135,947	7,349	2,694	92,714	30,129
2014	131,282	4,155	29,866	127,126	6,363	8,440	127,646	14,154
2015	80,194	1,497	19,456	79,945	998	6,860	81,940	15,839
2016	77,955	NA	18,097	77,069	506	6,454	89,850	1,645
2017	90,929	NA	13,639	175,038	8,083	12,124	118,460	20,080
2018	89,354	NA	27,123	122,941	4,816	6,971	132,827	12,674
2019	57,588	NA	13,528	63,421	621	8,688	83,031	3,103
2020	18,204	NA	4,374	6,028	0	3,783	27,778	236
2021	14,301	NA	5,233	11,197	61	1,643	19,534	304
2022	68,632	NA	26,044	47,506	NA	20,567	98,700	1,118
<b>Average</b>	<b>90,109</b>	<b>3,191</b>	<b>21,287</b>	<b>86,768</b>	<b>7,083</b>	<b>7,404</b>	<b>95,808</b>	<b>10,267</b>

### 3.2 Stubble Quail

The total of 77,590 Stubble Quail estimated to have been harvested in Victoria during the 2022 season (95% CI = 52,862 – 113,884) is below the average harvest since the telephone surveys started in 2009 (Figure 4.2 and Table 4.2).

The estimated numbers of total hunting days (10,214) and Stubble Quail harvested per licence holder (2.84) were lower than historical levels (19,479 and 5.57, respectively). Hunter efficiency (7.60 Stubble Quail per hunting day) was similar to the average from 2009 to 2022 (7.55).

It was estimated that 9% (95% CI = 7 – 12%) of Game Licence holders actually hunted for Stubble Quail during the 2022 Stubble Quail season. That equates to an estimate of 2549 (95% CI = 1979 – 3283) active Stubble Quail hunters in the 2022 Stubble Quail season. The average Stubble Quail harvest per active Stubble Quail hunter was estimated to be 30.4 (95% CI = 19.3 – 48.1). This estimate is similar to that for 2017 (34.7), smaller than those for 2019 (69.4) and 2021 (59.4), and larger than those for 2018 (13.7) and 2020 (5.1). The large variation between years could be reflecting the unusually small active hunter estimates and the limited number of respondents who hunt quail as well as fluctuations in the species.



**Figure 4.2: Estimates of total Stubble Quail harvests (in thousands) from 2009 to 2022.**

The squares are the estimated total harvests for each season; the solid vertical lines indicate the 95% confidence intervals; the blue line is the average Stubble Quail harvest from 2009 to 2022; the shaded area is the 95% confidence interval for the average Stubble Quail harvest from 2009 to 2022.

**Table 4.2: Comparison of Stubble Quail harvests of 2009 to 2022.**

Year	Total harvest	Hunting days	Quail per licence holder	Hunting days per licence holder	Quail per hunting day	Proportion of active hunters	Quail per active hunter
2009	189,155	24,648	7.89	1.03	7.97	NA	NA
2010	86,302	24,739	3.59	1.03	3.48	NA	NA
2011	678,431	46,719	26.17	1.80	14.52	NA	NA
2012	129,711	22,262	4.80	0.82	5.81	NA	NA
2013	184,123	21,958	6.69	0.98	8.39	NA	NA
2014	16,243	10,852	0.56	0.38	1.47	NA	NA
2015	101,244	22,432	3.58	0.79	4.51	NA	NA
2016 <sup>22</sup>	28,043	6,559	1.00	0.23	4.29	NA	NA
2017	186,691	22,052	6.51	0.77	8.45	0.15	43.7
2018	148,500	17,772	5.19	0.62	8.36	0.18	28.5
2019	188,015	25,358	6.68	0.90	7.43	0.08	87.2
2020	4,848	3,771	0.18	0.14	1.29	0.04	5.1
2021	105,968	16,381	3.70	0.57	6.49	0.06	59.4
2022	77,590	10,214	2.84	0.37	7.60	0.09	30.4
<b>Average</b>	<b>149,042</b>	<b>19,479</b>	<b>5.57</b>	<b>0.74</b>	<b>7.55</b>	<b>0.10</b>	<b>42.4</b>

Due to the structure of Game Licences in Victoria, not every holder of a Game Licence endorsed for hunting Stubble Quail will hunt Stubble 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 Stubble 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 Stubble Quail, even though they may not intend to do so. In 2022, it was estimated that 34% (95% CI = 25 – 47%) of Game Licence holders endorsed for Stubble Quail<sup>23</sup> self-identified as a ‘Stubble Quail hunter’. That includes those who did not actively hunt Stubble Quail in 2022. This equates to an estimate of 8854 (95% CI = 6479 – 12,100) ‘Stubble Quail hunters’ in the 2022 Stubble Quail hunting season. This does not affect the estimates of Stubble Quail harvest, because the calculations explicitly account for the proportion of Stubble Quail Game Licence holders who did not actually hunt Stubble Quail.

It should be noted that the number of hunting days was only an approximate estimate of total effort: someone who hunted for 2 hours and someone else who hunted for 12 hours were both recorded as having hunted for 1 day.

<sup>22</sup> The 2016 Stubble Quail surveys were conducted after the season rather than each month of the season. It is assumed that the change in methodology that year would only have produced minor differences.

<sup>23</sup> This includes all people endorsed to hunt Stubble Quail regardless if they can hunt deer or duck as well.

### 3.3 Locations with the most hunting days

The top five towns for the total number of reported duck hunting days in 2022 were (in descending order) Sale, Bairnsdale, Shepparton, Kerang and Geelong, while for Stubble Quail the top five towns were (in descending order) Ararat, Donald, Geelong, Ballarat and Bendigo.

Combining duck and Stubble Quail, Sale had the most hunting days during the 2022 hunting seasons, followed by Bairnsdale, Shepparton, Kerang and Geelong. This assumed that all hunting days were equal in length, even though the time spent hunting on any particular day could vary considerably for each respondent, and for game species.

### 3.4 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 the reasons for non-response [exceeding bag limit, or (conversely) not harvesting anything], memory recall (respondents not remembering their harvest), and deliberate over- or under-reporting (numbers knowingly being reported incorrectly). Any bias due to non-response is likely to have been negligible, because the response rate for all surveys was generally above 95% (i.e. very high). Memory bias can inflate estimates of total harvest, in some cases by as much as 40% (Wright 1978; Barker 1991). It is likely, however, that the sampling strategy of the telephone interviews (after each 2-week period in the case of ducks) would have ensured that both memory bias and non-response bias were kept low (compared with postal surveys and 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 caution.

It needs to be noted that, due to a clerical error, the 2016 telephone Stubble Quail survey did not follow the standard methodology, as all surveys happened at the end of the season. That means the results of the 2016 telephone Stubble Quail survey may have increased memory bias and may not be strictly comparable with those of other years.

It is important to note that the methodology explicitly accounts for the reality that not every Game Licence holder hunts in every survey period (see Gormley and Turnbull 2010). Therefore, the estimate of total season bag per Game Licence holder is the sum of the 'harvest per Game Licence holder', not the sum of the 'harvest per hunter'.

The uncertainty in the estimates of total harvest (as indicated by the confidence intervals) was due to two factors. First, there was variation in the reported numbers of animals harvested between respondents who had hunted (see Figure 3.1 and Figure 3.3). For example, within a given survey period for duck hunting, some respondents indicated that they hunted unsuccessfully, whereas others had undertaken multiple trips and reported a total harvest of more than 50 ducks during the same period. The second source of uncertainty was due to sampling the hunters, rather than taking a complete census. However, the degree of sampling uncertainty was reduced by having sample sizes of 200 respondents per survey for ducks and 300 respondents per survey for Stubble Quail. Statistically, these sample sizes were considered adequate for providing reasonable estimates.

The spatial distributions of the duck and Stubble Quail harvests should also be interpreted with caution. Grouping the harvest for a relatively large region (CMA) provides a broad-scale view of the distribution of the harvest. Grouping by smaller regions would provide a finer-scale representation, but this would come at the cost of increased bias in many regions. Because the data are from a sample of Game Licence holders rather than a complete census, it is likely that some areas that were actually hunted are shown as having a zero harvest if no respondents who hunted 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.

### 3.5 Recommendation

The number of Game Licence holders endorsed to hunt Stubble Quail who do hunt Stubble Quail is very low and is thus affecting the accuracy of the activity indices. Adding a question asking respondents in the end-of-season survey if they identify as a Stubble Quail hunter could help increase the accuracy. If that does not give the required improvement, then a greater number of Game Licence holders will need to be surveyed.



## 4 References

- Barker, R.J. (1991). Nonresponse bias in New Zealand waterfowl harvest surveys. *Journal of Wildlife Management* **55** (1), 126 – 131. <https://doi.org/10.2307/3809249>
- Barker, R.J. (2006). *Survey of waterfowl hunting in Victoria by Victorian licence holders 2006*. Report for the Game Management Unit, Department of Sustainability and Environment, Heidelberg, Victoria.
- Barker, R.J., Geissler, P.H. and Hoover, B.A. (1992). Sources of nonresponse to the federal waterfowl hunter questionnaire survey. *Journal of Wildlife Management* **56**, 337 – 343. doi: [10.2307/3808832](https://doi.org/10.2307/3808832)
- Game Management Authority. (2022). Hunting. <https://www.gma.vic.gov.au/hunting> (accessed October 2022).
- Gormley, A.M. (2009). *Survey of quail hunting in Victoria by Victorian Licence holders 2008*. Report for the Game Management Unit, DSE. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria.
- Gormley, A.M. and Turnbull, J.D. (2009). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2009*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 196. Department of Sustainability and Environment, Heidelberg, Victoria.
- Gormley, A.M. and Turnbull, J.D. (2010). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2010*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 210. Department of Sustainability and Environment, Heidelberg, Victoria.
- Gormley, A.M. and Turnbull, J.D. (2011). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2011*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 224. Department of Sustainability and Environment, Heidelberg, Victoria.
- Moloney, P.D. and Flesch, J.S. (2021). *Estimates of duck and stubble quail harvest in Victoria for 2021: results from surveys of Victorian game licence holders in 2021*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Moloney, P.D. and Hampton, J.O. (2020). *Estimates of duck and Stubble Quail harvest in Victoria for 2020: results from surveys of Victorian Game Licence holders in 2020*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Moloney, P.D. and Powell, Z. (2019). *Estimates of duck and Stubble Quail harvest in Victoria for 2019: results from surveys of Victorian Game Licence holders in 2019*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2012). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2012*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 239. Department of Sustainability and Environment, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2013). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2013*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 251. Department of Environment and Primary Industries, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2014). *Estimates of harvest for deer, duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2014*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

- Moloney, P.D. and Turnbull, J.D. (2015). *Estimates of harvest for duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2015*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2016). *Estimates of harvest for duck and quail in Victoria: results from surveys of Victorian Game Licence holders in 2016*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2017). *Estimates of duck and Stubble Quail harvest in Victoria for 2017: results from surveys of Victorian Game Licence holders in 2017*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Moloney, P.D. and Turnbull, J.D. (2018). *Estimates of duck and Stubble Quail harvest in Victoria: results from surveys of Victorian Game Licence holders in 2018*. Arthur Rylah Institute for Environmental Research Unpublished Client Report for the Game Management Authority. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Ramsey, D.S.L. and Fanson, B. (2022). *Abundance estimates for game ducks in Victoria: results from the 2021 aerial survey*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 335. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Wright, V.L. (1978). Causes and effects of biases on waterfowl harvest estimates. *Journal of Wildlife Management* **42**, 251 – 262. doi:[10.2307/3800262](https://doi.org/10.2307/3800262)

## Appendix 1: Questionnaire for Game Licence holders endorsed to hunt duck

1. **Did you go duck hunting over period X?**

Yes ☐ No ☐

2. **Have you been duck hunting ...**

... in the last week?   since last Sunday?   between last Monday and last Sunday?

Yes ☐ No ☐

(Tick box. If 'Yes', proceed to question 4. If 'No', "Thank you for taking part in this survey.")

3. **How many duck-hunting trips have you taken over this 1-week period?**

☐

(Indicate number in box.)

(Each trip needs to be treated separately for questions 4 – 8.)

Trip number:	Trip 1		Trip 2		Trip 3		Trip 4		Trip 5		Trip 6	
4. 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"/>	
5. How many ducks did you harvest?	<input type="text"/>		<input type="text"/>		<input type="text"/>		<input type="text"/>		<input type="text"/>		<input type="text"/>	
6. What species were the ducks? <i>"Include numbers of each species."</i>	Black duck		Black duck		Black duck		Black duck		Black duck		Black duck	
	Wood duck		Wood duck		Wood duck		Wood duck		Wood duck		Wood duck	
	Mountain Duck		Mountain Duck		Mountain Duck		Mountain Duck		Mountain Duck		Mountain Duck	
	Grey Teal		Grey Teal		Grey Teal		Grey Teal		Grey Teal		Grey Teal	
	Chestnut Teal		Chestnut Teal		Chestnut Teal		Chestnut Teal		Chestnut Teal		Chestnut Teal	
	Pink Ear		Pink Ear		Pink Ear		Pink Ear		Pink Ear		Pink Ear	
	Shoveler		Shoveler		Shoveler		Shoveler		Shoveler		Shoveler	
	Hardhead		Hardhead		Hardhead		Hardhead		Hardhead		Hardhead	
7. What type of land did you hunt on? <i>"You can register more than one choice."</i>	State Game Reserve		State Game Reserve		State Game Reserve		State Game Reserve		State Game Reserve		State Game Reserve	
	Private land		Private land		Private land		Private land		Private land		Private land	
	Public land		Public land		Public land		Public land		Public land		Public land	
8. What was the closest major town to the area you hunted in?	<input type="text"/>		<input type="text"/>		<input type="text"/>		<input type="text"/>		<input type="text"/>		<input type="text"/>	

## Appendix 2: Questionnaire for Game Licence holders endorsed to hunt Stubble Quail

1. **Do you use a dog when you hunt for quail?** Yes ☐ No ☐
  
2. **Have you been Quail hunting** in the last month? (during April – since the opening weekend?)  
Yes ☐ No ☐ (tick box).  
If 'Yes', proceed to question 3.  
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 the Customer Service Centre on 136 186.
  
3. **How many Quail-hunting trips did you take last month?**   
(Indicate number in box.)  
  
(Each trip needs to be treated separately for questions 4 – 8.)
  
4. **How many days did you go hunting?**
  
5. **How many Quail did you harvest?**
  
6. **What type of land did you hunt on?** State Game Reserve / Private land / Public land  
*"You can register more than one choice."*
  
7. **What type of grasslands was the hunt on?** Stubble / Native Grass / Introduced grass  
*"You can register more than one choice."*
  
8. **What was the closest major town to the area you hunted?**

Estimate of duck and Stubble Quail harvest in Victoria for 2022

## Appendix 3: Calculation of statistics

### Common definitions used.

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

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

CV = coefficient of variation; it is calculated as:  $CV = SD \div \text{mean}$ . This provides an indication as to how much variation there is in the estimate relative to the mean.

$$p_j = \frac{h_j}{n_j}$$

### Calculations

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

e.g. for Deer Survey 4 in 2015, we obtained:

$$H_j = p_j L$$

The total number of hunters for each survey  $\frac{70}{200} = 0.350$  period ( $H_j$ ) was estimated by multiplying the total number of Licence holders ( $L$ ) by the proportion of respondents who reported having hunted during that survey period ( $p_j$ ), as found previously:

$$w_j = \frac{y_j}{h_j}$$

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

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

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

$$W_j = w_j H_j$$

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 ( $H_j$ ):

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

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

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

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

$$SE(p_j) = \sqrt{\frac{p_j(1-p_j)}{n_j}} \quad \text{e.g. for Deer Survey 4 in 2015, we obtained: } \sqrt{\frac{0.35 \times .65}{200}} = 0.034.$$

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

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

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

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

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

$$SE(W_j) = \frac{CV(W_j) \times W_j}{\sqrt{h_j}}$$

The standard error of the total harvest was calculated by:

$$SE(W_{TOT}) = \sqrt{(SE(W_1))^2 + (SE(W_2))^2 + \dots + (SE(W_6))^2}$$

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

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

$$\text{lower limit (LL)} = \hat{X} \div r, \text{ where:}$$

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

e.g. for the total deer harvest in 2015 we have

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

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

Therefore, upper and lower confidence limits are given by:

$$UL = 71,142 \times 1.26 = 89,471$$

$$LL = 71,142 \div 1.26 = 56,567.$$



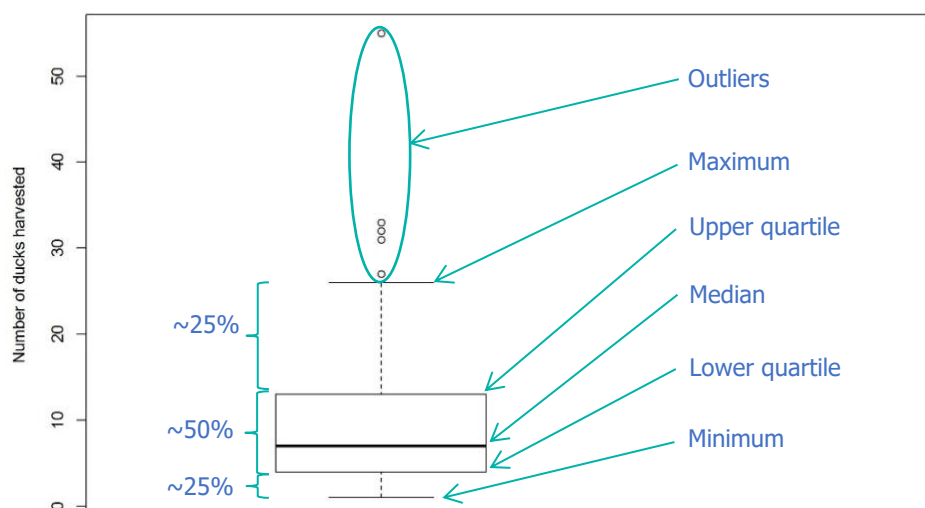
## Appendix 4: Explanation of what goes into a boxplot

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

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

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

The boxplot indicates the spread of the data. The data is broken into quarters: approximately 25% of the data are in the range between a whisker and the nearest edge of the box, and approximately 25% of the data are in the range between an edge of the box and the median line. Thus, approximately half the data are contained within the box. Any unusual data are highlighted as outliers. As an example, Figure A4.1 shows a boxplot indicating that most hunters harvested between 5 and 13 ducks, and a quarter harvested between 13 and 27 ducks. A number of outliers harvested more than 27 ducks, including one who harvested over 50 ducks. Sometimes there are no whiskers because the minimum (or maximum) is the same as the lower (or upper) quartile.



**Figure A4.1. Example boxplot, with labels.**

## Appendix 5: Harvest rates per Game Licence endorsed for hunting duck

Historically (from 2009 to 2016), the data collected only allowed for annual harvest rates to be at the level of Game Licence holder endorsed to hunt duck. Since 2017, when the end-of-year surveys have been conducted, it has been possible to estimate the annual harvest rate per active hunter. This has meant that the rate per Game Licence holder is no longer required. It has been included in this appendix, however, to allow comparison with data for the years prior to 2017.

The total average season harvest per licence holder was estimated to be 11.6 birds (95% CI = 10 – 13.4; Table A5.1). Note that, for each survey period, the average duck harvest per Game Licence holder was lower than the average duck harvest per hunter (Table 3.3), as the former includes those respondents who did not hunt during the survey period, whereas the latter includes only those who hunted.

**Table A5.1: Estimates of average harvest of ducks per Game Licence holder in each survey period in 2022.**

Period	Average harvest <sup>24</sup>	SE	95% lower CL	95% Upper CL
16 – 20 March	1.48	0.25	1.07	2.05
21 March – 3 April	1.28	0.23	0.90	1.82
4 – 17 April	1.79	0.36	1.22	2.64
18 April – 1 May	1.53	0.32	1.01	2.31
2 – 15 May	1.50	0.33	0.99	2.29
16 – 29 May	1.44	0.32	0.94	2.21
30 May – 13 June	2.54	0.43	1.84	3.52
Total	11.57	0.86	10.01	13.38

Each Game Licence holder hunted an average of 4.2 days during the 2022 duck hunting season (Table A5.2). When multiplied by the total number of Game Licence holders in each survey period, this equalled a total of 96,102 hunter days (95% CI = 81,045 – 113,957).

<sup>24</sup> Average harvest per Game Licence holder = Ducks harvested divided by Respondents (Table 3.1).

**Table A5.2: Days on which ducks were hunted per Game Licence holder for 2022.**

Period	Days hunted	SE	95% lower CL	95% Upper CL
16 – 20 March	0.60	0.08	0.46	0.78
21 March – 3 April	0.64	0.11	0.46	0.89
4 – 17 April	0.56	0.10	0.39	0.80
18 April – 1 May	0.53	0.10	0.36	0.78
2 – 15 May	0.52	0.10	0.36	0.77
16 – 29 May	0.53	0.13	0.34	0.84
30 May – 13 June	0.86	0.14	0.63	1.18
Total per licence holder	4.24	0.29	3.70	4.85
Total hunting days	96,102	8,371	81,045	113,957

## Appendix 6: Harvest rates per Game Licence endorsed for hunting Stubble Quail

Historically (from 2009 to 2016), the data collected only allowed for annual harvest rates to be at the level of Game Licence holder endorsed to hunt Stubble Quail. Since 2017, end-of-year surveys have been conducted and it has been possible to estimate the annual harvest rate per active hunter. This has meant that the rate per Game Licence holder is no longer required. It has been included in this appendix, however, to allow comparison with data for the years prior to 2017.

The total average season harvest per licence holder was estimated to be 2.8 birds (95% CI = 1.9 – 4.2; Table A6.1). However, if you limit the respondents to only those who say they hunt Stubble Quail, then the total average season harvest per self-reported Stubble Quail hunter is estimated to be 8.5 birds (95% CI = 5.9 – 12.4; Table A6.1). Note that, for each survey period, the average Stubble Quail harvest per Game Licence holder was lower than the average Stubble Quail harvest per hunter (Table 3.11), as the former includes those respondents who did not hunt during the survey period, whereas the latter includes only those who hunted.

**Table A6.1: Estimates of average harvest of Stubble Quail per Game Licence holder in each survey period in 2022.**

Period	Harvest per respondent <sup>25</sup>	SE	95% lower CL	95% Upper CL
Opening weekend	0.28	0.14	0.12	0.69
April	0.83	0.28	0.44	1.57
May	1.11	0.39	0.56	2.18
June	0.62	0.25	0.28	1.34
<b>Total</b>	<b>2.84</b>	<b>0.56</b>	<b>1.94</b>	<b>4.17</b>

Each Game Licence holder hunted an average of 0.4 days during the 2022 Stubble Quail-hunting season (Table A6.2). When multiplied by the total number of Game Licence holders in each survey period, this equalled a total of 10,214 hunter days (95% CI = 6621 – 15,755).

**Table A6.2: Days on which Stubble Quail were hunted per Game Licence holder for 2022.**

Period	Days hunted	SE	95% lower CL	95% Upper CL
Opening weekend	0.04	0.02	0.02	0.08
April	0.08	0.02	0.04	0.14
May	0.16	0.04	0.10	0.25
June	0.09	0.03	0.05	0.17
Total per licence holder	0.37	0.06	0.28	0.50
Total hunting days	10,214	2,287	6,621	15,755

<sup>25</sup> Average harvest per hunter = Ducks harvested divided by Respondents who hunted (Table 1).

