

Pennsylvania
2023-24 Deer Harvest Estimates



Introduction

The Pennsylvania Game Commission (PGC) uses a report card registration system for hunters to report the harvest of each white-tailed deer in combination with field-checked deer to estimate reporting rates by type of deer (antlered versus antlerless), and wildlife management unit (WMU). Reporting rates and report card counts are used to estimate harvest by WMU for antlered and antlerless deer. Traditionally, the PGC has field-checked harvested deer only during the regular rifle seasons when most deer are harvested and has used these reporting rates to estimate harvest in all other seasons (e.g., early and late archery and muzzleloader seasons). Harvests were calculated as:

$$H = \frac{N_{RC}}{r_{3\text{-year}}}; \quad (1)$$

where H is the calculated harvest, N_{RC} is the number of report cards, and r is the reporting rate based on a 3-year running average. Harvests are calculated for antlered and antlerless deer by deer management unit, but no measure of precision was determined.

A recent evaluation of this method validated the science behind the PGC's method of sampling harvested deer and estimating reporting rates (Rosenberry et al. 2004). Based on results of this evaluation, a new method of estimating deer harvests was implemented for the 2004-05 hunting seasons. The new method no longer calculates a harvest estimate based on a 3-year running average. Rather, it estimates an annual harvest based on year-specific data. In addition, the new method provides a harvest estimate (as compared to calculated) with appropriate measures of precision (e.g., variance, standard error, coefficient of variation). This additional information permits an evaluation of the reliability of deer harvest estimates that was not possible in the past.

Methods

Beginning in 2004-05, deer harvests are estimated using a mark-recapture technique that is similar to the method we use to estimate bear populations. As a result of their widespread use over a long time period, much work has been done on application of mark-recapture techniques under many different scenarios. When estimating deer harvests, a closed, two-sample Lincoln-Petersen estimator is used. Deer are considered marked when they are checked in the field by deer aging teams. The recapture occurs when marked deer are reported on report cards sent in by hunters.

Assumption of the Lincoln-Petersen estimator include:

1. The sampled population is closed.
2. All animals are equally likely to be captured in each sample
3. Data are recorded correctly.

Assumption 1. Closed Population. The sampled population is the annual deer harvest. Additions to this population occur throughout the hunting seasons; however, once deer aging activities are

completed, the marked sample will not change. Additions only occur as unmarked animals that continue to be reported throughout the deer hunting seasons. As a result, the closure assumption can be relaxed and the Lincoln-Petersen estimator remains valid for estimating the harvest once all report cards are tallied (Pollock et al. 1990).

Assumption 2. Equal catchability. This assumption is difficult to meet in most wildlife situations (Pollock et al. 1990, Thompson et al. 1998). For estimating deer harvests, the assumption that all animals are equally likely to be included in each sample refers to a harvested deer's chance being in both the marked sample and reported sample. Our marking procedures at processors and other specific locations do not provide an equal chance of being marked because some deer will not be taken to a processor. One method of relaxing this assumption is to use different methods for marking and reporting. In the case of deer harvest estimates, if the probabilities of a deer being marked and being reported are independent, Lincoln-Petersen estimates will be unbiased (Seber 1982). Available evidence indicates that our marked sample is representative of the harvest and therefore should not bias our results (Rosenberry et al. 2004).

One known problem with reporting rates is they differ by seasons (Rosenberry et al. 2004). As a result, early seasons such as archery and October muzzleloader and rifle season estimates would be biased high. This is an issue that warrants further investigation; however, the effect on the overall harvest estimate is minimal because most deer are harvested during the regular firearms season (Rosenberry et al. 2004).

Assumption 3. Data recorded correctly. This assumption is met through accurate recording and entering of data into databases. Validation programs are used to check data for accuracy.

Based on the assumptions of the Lincoln-Petersen estimator and the characteristics of our samples, the Lincoln-Petersen estimator is an appropriate method for estimating deer harvests.

Because reporting rates in Pennsylvania vary by year, antlered and antlerless deer, and WMU (Rosenberry et al. 2004), annual deer harvest estimates are calculated for antlered and antlerless deer in each WMU using Chapman's (1951) modified Lincoln-Petersen estimator;

$$\hat{H} = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1; \quad (2)$$

where \hat{H} is the harvest estimate, n_1 is the number of deer marked by deer aging teams, n_2 is the number of deer reported via report cards by hunters, and m_2 is the number of deer marked by deer aging teams and reported via report cards by hunters. This estimator is recommended (Nichols and Dickman 1996) because it has less bias than the original Lincoln-Petersen estimator (Chapman 1951).

Approximately unbiased variance of the harvest estimate $\text{Var}(\hat{H})$ is estimated as;

$$\text{Var}(\hat{H}) = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)}; \quad (3)$$

from Seber (1970).

Results

By using mark-recapture estimators, more information is now available on precision of harvest estimates. Prior to 2003-04, calculated harvests were provided to the public with implied precision of a single deer (e.g., 517,529). In 2003-04, precision of calculated deer harvests was reported to the nearest ten deer (e.g., 464,890). In each case, implied precision of deer harvests overestimated the actual precision, but no methods of estimating precision were utilized. This is no longer the case and measures of precision are available for each harvest estimate. Consequently, more information can now be conveyed to the public regarding deer harvest estimates.

There are a number of options for presenting deer harvest results to the public. From a statistical viewpoint, the most appropriate presentation might include point estimates plus or minus standard errors or with confidence intervals. From a public relations standpoint, the most appropriate presentation may be point estimates. A concern with the statistical presentation is that all the numbers could be confusing to the general public and a concern with point estimates is the implied precision because point estimates are calculated to the single deer. An alternative, to both of these extreme cases, is to provide point estimates rounded to an appropriate number of figures. For example, if the precision of the harvest estimate is less than 1,000 based on the standard error, the harvest estimate would be rounded to the nearest 100. If the precision of the harvests estimate is greater than 1,000 based on the standard error, the harvest estimate would be rounded to the nearest 1,000. In the wildlife management literature, standard errors are commonly presented with point estimates as a measure of precision.

Season Harvests

Overall harvests are broken down into archery, regular firearms, and muzzleloader harvests, not because these numbers are used for deer management purposes, but because the public requests them. The overall removal of deer from a population during all hunting seasons is the parameter of greatest management interest. Whether a deer was harvested with a bow, muzzleloader, or rifle has limited value for management recommendations. Based on an evaluation of Pennsylvania's harvest estimates, attempting to calculate archery and muzzleloader harvests based on report cards and reporting rates results in biased numbers (Rosenberry et al. 2004), because hunters during the October seasons (archery, early muzzleloader, and October rifle) report deer harvests at a higher rate than hunters during the regular firearms season. This is a known problem with presenting archery and muzzleloader harvests, but it has minimal effect on

total harvests (Rosenberry et al. 2004) that are used for management purposes. Since season harvest estimates are expected by the public, we modified our method of calculating season harvests in 2007-08. Prior to 2007-08, we simply divided the overall harvest into season harvests using the proportion of report cards received during each type of season. For example, if 20% of the report cards were from archery season, then 20% of the harvest was identified as archery harvest. In 2007-08, we modified this slightly. First, we estimated the total deer harvests for all seasons. Second, we estimated the firearms season harvest using the animals we checked in the field, the number of those animals reported by hunters, and the number of report cards from the firearms season. We then subtracted the firearms season harvest from the overall harvest leaving only those deer killed during the archery and muzzleloader seasons. These remaining deer were divided into archery and muzzleloader harvests using the proportion of report cards similar to previous years. The primary difference between the current method and the previous method is that it should reduce bias in archery and muzzleloader harvests because the firearms harvest is estimated based on field data and not proportion of report cards.

Literature Cited

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HARVEST ESTIMATES, 2023-24

Overall Harvest Estimates

WMU	ANTLERED	ANTLERLESS	TOTAL
1A	8,000	13,800	21,800
1B	10,300	13,600	23,900
2A	10,000	13,300	23,300
2B	7,000	16,000	23,000
2C	10,600	20,600	31,200
2D	11,800	21,400	33,200
2E	6,900	12,800	19,700
2F	9,100	13,900	23,000
2G	8,100	6,500	14,600
3A	5,200	6,000	11,200
3B	7,700	7,600	15,300
3C	8,900	10,600	19,500
3D	6,200	7,300	13,500
4A	5,700	9,300	15,000
4B	5,000	9,500	14,500
4C	8,200	6,700	14,900
4D	8,400	13,500	21,900
4E	8,100	13,700	21,800
5A	4,100	7,800	11,900
5B	9,700	14,300	24,000
5C	9,100	13,100	22,200
5D	2,900	6,700	9,600
UNK	600	410	1,010
TOTAL	171,600	258,410	430,010

Archery Harvest Estimates*(Includes harvests taken with archery methods, outside of the general firearms season)*

WMU	ANTLERED	ANTLERLESS	TOTAL
1A	4,400	3,800	8,200
1B	5,040	2,610	7,650
2A	4,530	2,600	7,130
2B	5,320	8,750	14,070
2C	5,100	5,040	10,140
2D	5,610	4,130	9,740
2E	3,040	2,530	5,570
2F	3,400	2,090	5,490
2G	2,670	1,170	3,840
3A	1,830	970	2,800
3B	3,090	1,530	4,620
3C	3,220	2,020	5,240
3D	2,630	2,020	4,650
4A	1,820	1,750	3,570
4B	2,470	2,530	5,000
4C	4,220	1,770	5,990
4D	3,400	3,380	6,780
4E	3,930	3,310	7,240
5A	1,970	2,480	4,450
5B	6,490	6,100	12,590
5C	6,470	6,200	12,670
5D	2,480	4,560	7,040
UNK	240	140	380
TOTAL	83,370	71,480	154,850

Regular Firearms Season Harvest Estimates*(Includes all harvests taken during the general firearms season, regardless of hunting implement)*

WMU	ANTLERED	ANTLERLESS	TOTAL
1A	3,500	9,000	12,500
1B	5,100	10,200	15,300
2A	5,400	9,500	14,900
2B	1,600	6,600	8,200
2C	5,400	13,900	19,300
2D	6,000	15,500	21,500
2E	3,800	9,200	13,000
2F	5,600	10,500	16,100
2G	5,300	4,700	10,000
3A	3,300	4,500	7,800
3B	4,500	5,300	9,800
3C	5,600	7,800	13,400
3D	3,500	4,800	8,300
4A	3,800	6,800	10,600
4B	2,500	6,400	8,900
4C	3,900	4,500	8,400
4D	4,900	9,100	14,000
4E	4,100	9,400	13,500
5A	2,100	4,800	6,900
5B	3,100	7,400	10,500
5C	2,500	6,300	8,800
5D	400	2,000	2,400
UNK	360	250	610
TOTAL	86,260	168,450	254,710

Muzzleloader Harvest Estimates*(Includes harvests taken with a muzzleloader, outside of the general firearms season)*

WMU	ANTLERED	ANTLERLESS	TOTAL
1A	100	1,000	1,100
1B	160	790	950
2A	70	1,200	1,270
2B	80	650	730
2C	100	1,660	1,760
2D	190	1,770	1,960
2E	60	1,070	1,130
2F	100	1,310	1,410
2G	130	630	760
3A	70	530	600
3B	110	770	880
3C	80	780	860
3D	70	480	550
4A	80	750	830
4B	30	570	600
4C	80	430	510
4D	100	1,020	1,120
4E	70	990	1,060
5A	30	520	550
5B	110	800	910
5C	130	600	730
5D	20	140	160
UNK	0	20	20
TOTAL	1,970	18,480	20,450

ANNUAL CHANGES

Overall Harvest Estimates

WMU	Total Harvest Estimate				Percent Change	
	2020-21	2021-22	2022-23	2023-24	Previous Year	Previous 3-Year Average
1A	27,000	19,200	22,800	21,800	-4%	-5%
1B	29,500	21,900	24,400	23,900	-2%	-5%
2A	19,900	17,400	19,700	23,300	18%	23%
2B	21,200	17,300	21,600	23,000	6%	15%
2C	24,100	24,700	26,600	31,200	17%	24%
2D	30,700	31,400	37,000	33,200	-10%	1%
2E	17,800	15,400	17,300	19,700	14%	17%
2F	20,700	19,100	20,600	23,000	12%	14%
2G	18,700	15,500	15,500	14,600	-6%	-12%
3A	13,700	10,800	11,300	11,200	-1%	-6%
3B	17,600	14,300	16,200	15,300	-6%	-5%
3C	25,300	17,000	20,000	19,500	-3%	-6%
3D	12,600	11,000	12,900	13,500	5%	11%
4A	16,000	15,200	14,900	15,000	1%	-2%
4B	15,800	11,900	13,200	14,500	10%	6%
4C	15,100	12,100	15,100	14,900	-1%	6%
4D	21,400	17,500	20,100	21,900	9%	11%
4E	19,800	19,700	20,400	21,800	7%	9%
5A	9,600	10,300	10,500	11,900	13%	17%
5B	26,000	24,900	27,200	24,000	-12%	-8%
5C	23,600	21,300	23,900	22,200	-7%	-3%
5D	8,700	8,900	9,200	9,600	4%	7%
UNK	280	110	2,560	1,010		
TOTAL	435,080	376,910	422,960	430,010	2%	4%

Antlered Harvests

WMU	Antlered Harvest Estimate				Percent Change	
	2020-21	2021-22	2022-23	2023-24	Previous Year	Previous 3-Year Average
1A	9,000	6,000	9,000	8,000	-11%	0%
1B	11,700	9,300	9,100	10,300	13%	3%
2A	8,100	6,800	8,700	10,000	15%	27%
2B	6,200	5,200	6,600	7,000	6%	17%
2C	8,400	9,300	10,000	10,600	6%	15%
2D	12,000	11,500	14,000	11,800	-16%	-6%
2E	6,500	5,900	6,700	6,900	3%	8%
2F	10,700	8,900	8,800	9,100	3%	-4%
2G	10,300	8,700	8,600	8,100	-6%	-12%
3A	7,000	5,400	5,700	5,200	-9%	-14%
3B	9,100	6,700	7,300	7,700	5%	0%
3C	10,800	7,600	8,000	8,900	11%	1%
3D	6,200	4,700	5,500	6,200	13%	13%
4A	5,200	4,900	3,800	5,700	50%	23%
4B	5,000	3,500	4,800	5,000	4%	13%
4C	7,000	5,700	6,900	8,200	19%	26%
4D	9,100	7,200	7,900	8,400	6%	4%
4E	8,600	7,900	8,000	8,100	1%	-1%
5A	3,500	3,100	3,100	4,100	32%	27%
5B	9,600	7,800	10,900	9,700	-11%	3%
5C	8,400	6,600	7,200	9,100	26%	23%
5D	2,200	2,600	2,500	2,900	16%	19%
UNK	80	20	1,090	600		
TOTAL	174,680	145,320	164,190	171,600	5%	6%

Antlerless Harvests

WMU	Antlerless Harvest Estimate				Percent Change	
	2020-21	2021-22	2022-23	2023-24	Previous Year	Previous 3-Year Average
1A	18,000	13,200	13,800	13,800	0%	-8%
1B	17,800	12,600	15,300	13,600	-11%	-11%
2A	11,800	10,600	11,000	13,300	21%	19%
2B	15,000	12,100	15,000	16,000	7%	14%
2C	15,700	15,400	16,600	20,600	24%	30%
2D	18,700	19,900	23,000	21,400	-7%	4%
2E	11,300	9,500	10,600	12,800	21%	22%
2F	10,000	10,200	11,800	13,900	18%	30%
2G	8,400	6,800	6,900	6,500	-6%	-12%
3A	6,700	5,400	5,600	6,000	7%	2%
3B	8,500	7,600	8,900	7,600	-15%	-9%
3C	14,500	9,400	12,000	10,600	-12%	-11%
3D	6,400	6,300	7,400	7,300	-1%	9%
4A	10,800	10,300	11,100	9,300	-16%	-13%
4B	10,800	8,400	8,400	9,500	13%	3%
4C	8,100	6,400	8,200	6,700	-18%	-11%
4D	12,300	10,300	12,200	13,500	11%	16%
4E	11,200	11,800	12,400	13,700	10%	16%
5A	6,100	7,200	7,400	7,800	5%	13%
5B	16,400	17,100	16,300	14,300	-12%	-14%
5C	15,200	14,700	16,700	13,100	-22%	-16%
5D	6,500	6,300	6,700	6,700	0%	3%
UNK	200	90	1,470	410		
TOTAL	260,400	231,590	258,770	258,410	0%	3%

DATA USED TO ESTIMATE DEER HARVESTS

Antlered

WMU	No. Checked in Field	Checked & Reported	Total Reported	Reporting Rate	Published Harvest Estimates ¹
1A	203	63	2,524	0.31	8,000
1B	333	96	2,981	0.29	10,300
2A	198	53	2,734	0.27	10,000
2B	91	29	2,229	0.32	7,000
2C	318	107	3,598	0.34	10,600
2D	372	136	4,322	0.37	11,800
2E	240	77	2,224	0.32	6,900
2F	441	161	3,337	0.37	9,100
2G	393	143	2,954	0.36	8,100
3A	340	124	1,909	0.36	5,200
3B	401	128	2,464	0.32	7,700
3C	505	158	2,807	0.31	8,900
3D	328	114	2,152	0.35	6,200
4A	189	48	1,462	0.25	5,700
4B	172	59	1,747	0.34	5,000
4C	348	126	2,991	0.36	8,200
4D	403	127	2,660	0.32	8,400
4E	371	120	2,619	0.32	8,100
5A	81	29	1,507	0.36	4,100
5B	359	130	3,534	0.36	9,700
5C	255	83	2,989	0.33	9,100
5D	90	40	1,323	0.44	2,900
UNK ²			201		600
TOTAL	6,431	2,151	57,268	0.33	171,600

¹ - Published harvest estimates are estimated using a Mark-Recapture estimator and are rounded to the nearest 100 or 1,000 depending on precision of the estimate.

² - UNK calculated as total unknown reported divided by statewide reporting rate, rounded to 10s

Antlerless

WMU	No. Checked in Field	Checked & Reported	Total Reported	Reporting Rate	Published Harvest Estimates ¹
1A	835	234	3,874	0.28	13,800
1B	1,297	339	3,561	0.26	13,600
2A	772	216	3,723	0.28	13,300
2B	501	117	3,658	0.23	16,000
2C	1,222	313	5,290	0.26	20,600
2D	1,549	500	6,923	0.32	21,400
2E	770	214	3,577	0.28	12,800
2F	1,090	331	4,224	0.30	13,900
2G	527	164	2,026	0.31	6,500
3A	559	153	1,656	0.27	6,000
3B	776	238	2,323	0.31	7,600
3C	896	279	3,297	0.31	10,600
3D	661	217	2,399	0.33	7,300
4A	611	166	2,528	0.27	9,300
4B	640	174	2,589	0.27	9,500
4C	788	295	2,512	0.37	6,700
4D	1,046	305	3,940	0.29	13,500
4E	1,326	371	3,847	0.28	13,700
5A	274	85	2,448	0.31	7,800
5B	1,135	374	4,734	0.33	14,300
5C	687	263	5,019	0.38	13,100
5D	293	112	2,559	0.38	6,700
UNK ²			137		410
TOTAL	18,255	5,460	76,844	0.30	258,410

¹ - Published harvest estimates are estimated using a Mark-Recapture estimator and are rounded to the nearest 100 or 1,000 depending on precision of the estimate.

² - UNK calculated as total unknown reported divided by statewide reporting rate, rounded to 10s

NOTE: DMAP and CWD DMAP permits not included in 'Total Reported'.

COMMENTS

- WMU 2H was combined with WMU 2G in 2023.
- Reporting rates remain low. Antlered 33% (Range: 25% to 44%), Antlerless 30% (Range: 23% to 38%), but confidence intervals on harvest estimates are still at goal levels.
- Majority of deer were reported online. 74% of deer harvest reports were online, 18% were on report cards, and 8% were by phone.
- Harvest estimates are based on more than 24,000 deer checked by Game Commission personnel and more than 134,000 harvest reports submitted by successful hunters.
- Harvest estimates are calculated using a common wildlife management technique called ‘mark-recapture’. Data used to estimate harvests includes 2 data sets; 1) data collected in the field by Game Commission deer aging teams and 2) reports from successful hunters.
- For a full explanation of harvest estimating procedures, including example calculations, see pages 55 to 59 in the [deer management plan](#). The plan is available on the PGC’s website, www.pgc.pa.gov, click on “Popular Hunting Pages” at bottom of home page, then “White-tailed deer”, then under “Deer Management”.

Antlered Harvests

- Antlered harvest increased an average of 5% from the 2022-23 season.
- Age structure of this year’s harvest was 36% 1.5-year-old bucks and 64% 2.5-year-old and older bucks.
- Comparisons between the current year’s harvest and historic antlered harvests often do not consider hunter numbers. In 1986, there were 1,000,000 deer hunters in Pennsylvania. Today, there are around 650,000 deer hunters. When corrected by the number of hunters, success rates are higher today than in the past, even with antler-point restrictions.
 - Historic Antlered Deer Hunter Success Rates versus Recent

1987-88	16% of deer hunters harvested an antlered deer
1997-98	19% of deer hunters harvested an antlered deer
2007-08	15% of deer hunters harvested an antlered deer
2017-18	23% of deer hunters harvested an antlered deer
2022-23	26% of deer hunters harvested an antlered deer
2023-24 ¹	27% of deer hunters harvested an antlered deer

¹ Current year deer hunter numbers are not available until later this year, so are based on previous year.

Antlerless Harvests

- Age structure of this year’s harvest was 69% adult females, 16% button bucks, and 14% doe fawns, consistent with long-term averages.
- Antlerless hunter success rates remained around 25% (approximately a quarter of all antlerless licenses were used to harvest an antlerless deer). This is on average with harvest success for recent years.