

**Pennsylvania**  
**2017-18 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 deer management unit (DMU). Reporting rates and report card counts are used to estimate harvest by DMU 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:

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

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 DMU (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 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.

### **Disease Management Area Deer Management Assistance Program Permits**

In 2017-18, chronic wasting disease (CWD) management approach changed. The disease management area (DMA) permit was discontinued. In its place, deer management assistance program (DMAP) permits were approved for portions or entire DMAs. In DMA2, DMAP permits were available in 3 areas (Unit 2874, Unit 2875, and Unit 3046). Units 2874 and 2875 were large (375 mile<sup>2</sup> and 525 mile<sup>2</sup>, respectively). Unit 3046 was limited to individual landowners around a CWD infected captive facility in Franklin County. The entire area of DMA3 was another DMAP area (Unit 3045). The reported harvest of antlerless deer taken with these permits are noted in the overall harvests, but not season harvests.

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## HARVEST ESTIMATES, 2017-18 (not including DMAP)

### *Overall Harvests*

WMU	ANTLERED	WMU	CWD DMAP	Total	TOTAL
		Antlerless	Permits	Antlerless	
1A	6,300	12,600	0	12,600	18,900
1B	8,300	13,000	0	13,000	21,300
2A	6,100	10,900	0	10,900	17,000
2B	4,500	14,000	0	14,000	18,500
2C	9,800	7,700	272	7,972	17,772
2D	14,700	17,000	391	17,391	32,091
2E	6,900	6,200	469	6,669	13,569
2F	9,500	7,200	2	7,202	16,702
2G	8,200	5,500	1	5,501	13,701
2H	1,700	1,900	0	1,900	3,600
3A	5,400	5,000	0	5,000	10,400
3B	8,900	7,000	0	7,000	15,900
3C	8,700	11,900	0	11,900	20,600
3D	4,700	4,200	0	4,200	8,900
4A	4,800	6,500	1,172	7,672	12,472
4B	5,600	7,100	8	7,108	12,708
4C	6,800	6,500	0	6,500	13,300
4D	10,600	8,400	17	8,417	19,017
4E	8,200	8,700	0	8,700	16,900
5A	2,900	3,800	1	3,801	6,701
5B	9,000	12,800	0	12,800	21,800
5C	8,800	15,600	0	15,600	24,400
5D	3,300	7,500	0	7,500	10,800
UNK	50	70	6	76	126
<b>TOTAL</b>	<b>163,750</b>	<b>201,070</b>	<b>2,339</b>	<b>203,409</b>	<b>367,159</b>

*Archery Harvests*

<b>WMU</b>	<b>TOTAL</b>	<b>ANTLERED</b>	<b>ANTLERLESS</b>
<b>1A</b>	6,030	2,710	3,320
<b>1B</b>	6,100	3,370	2,730
<b>2A</b>	4,070	2,040	2,030
<b>2B</b>	9,550	3,060	6,490
<b>2C</b>	4,900	3,400	1,500
<b>2D</b>	8,520	5,720	2,800
<b>2E</b>	3,160	2,040	1,120
<b>2F</b>	4,450	3,110	1,340
<b>2G</b>	3,160	2,050	1,110
<b>2H</b>	710	390	320
<b>3A</b>	2,780	1,670	1,110
<b>3B</b>	4,590	3,030	1,560
<b>3C</b>	4,730	2,530	2,200
<b>3D</b>	2,780	1,550	1,230
<b>4A</b>	2,210	960	1,250
<b>4B</b>	3,820	2,060	1,760
<b>4C</b>	4,570	2,770	1,800
<b>4D</b>	4,940	3,020	1,920
<b>4E</b>	4,910	3,040	1,870
<b>5A</b>	1,930	870	1,060
<b>5B</b>	9,750	4,830	4,920
<b>5C</b>	12,690	5,800	6,890
<b>5D</b>	7,660	2,770	4,890
<b>UNK</b>	100	40	60
<b>STATE</b>	<b>118,110</b>	<b>62,830</b>	<b>55,280</b>

*Muzzleloader Harvests*

<b>WMU</b>	<b>TOTAL</b>	<b>ANTLERED</b>	<b>ANTLERLESS</b>
<b>1A</b>	1,570	90	1,480
<b>1B</b>	1,000	30	970
<b>2A</b>	1,230	60	1,170
<b>2B</b>	1,050	40	1,010
<b>2C</b>	1,100	100	1,000
<b>2D</b>	2,180	80	2,100
<b>2E</b>	940	60	880
<b>2F</b>	1,150	90	1,060
<b>2G</b>	1,040	50	990
<b>2H</b>	290	10	280
<b>3A</b>	720	30	690
<b>3B</b>	1,110	70	1,040
<b>3C</b>	1,470	70	1,400
<b>3D</b>	620	50	570
<b>4A</b>	990	40	950
<b>4B</b>	780	40	740
<b>4C</b>	730	30	700
<b>4D</b>	1,160	80	1,080
<b>4E</b>	1,090	60	1,030
<b>5A</b>	470	30	440
<b>5B</b>	1,250	70	1,180
<b>5C</b>	1,310	100	1,210
<b>5D</b>	240	30	210
<b>UNK</b>	0	0	0
<b>STATE</b>	<b>23,490</b>	<b>1,310</b>	<b>22,180</b>



## ANNUAL CHANGES

### *Overall Harvests*

<b>WMU</b>	<b>2016-17</b>	<b>2017-18</b>	<b>% Change</b>
1A	16,900	18,900	12%
1B	16,100	21,300	32%
2A	16,200	17,000	5%
2B	19,800	18,500	-7%
2C	16,635	17,772	7%
2D	29,200	32,091	10%
2E	10,541	13,569	29%
2F	14,400	16,702	16%
2G	10,200	13,701	34%
2H	3,800	3,600	-5%
3A	9,200	10,400	13%
3B	14,800	15,900	7%
3C	19,600	20,600	5%
3D	8,500	8,900	5%
4A	12,313	12,472	1%
4B	11,400	12,708	11%
4C	11,700	13,300	14%
4D	15,433	19,017	23%
4E	14,800	16,900	14%
5A	7,000	6,701	-4%
5B	21,300	21,800	2%
5C	23,900	24,400	2%
5D	9,400	10,800	15%
UNK	132	126	-5%
<b>STATE</b>	<b>333,254</b>	<b>367,159</b>	<b>10%</b>

*Antlered Harvests*

<b>WMU</b>	<b>2016-17</b>	<b>2017-18</b>	<b>% Change</b>
1A	6,500	6,300	-3%
1B	7,900	8,300	5%
2A	7,000	6,100	-13%
2B	5,800	4,500	-22%
2C	8,300	9,800	18%
2D	12,800	14,700	15%
2E	5,200	6,900	33%
2F	7,700	9,500	23%
2G	6,200	8,200	32%
2H	1,900	1,700	-11%
3A	5,400	5,400	0%
3B	7,500	8,900	19%
3C	8,600	8,700	1%
3D	4,300	4,700	9%
4A	4,400	4,800	9%
4B	5,200	5,600	8%
4C	6,400	6,800	6%
4D	7,900	10,600	34%
4E	7,300	8,200	12%
5A	3,000	2,900	-3%
5B	8,900	9,000	1%
5C	8,300	8,800	6%
5D	2,900	3,300	14%
UNK	60	50	-17%
<b>STATE</b>	<b>149,460</b>	<b>163,750</b>	<b>10%</b>

*Antlerless Harvests*

<b>WMU</b>	<b>2016-17</b>	<b>2017-18</b>	<b>% Change</b>
1A	10,400	12,600	21%
1B	8,200	13,000	59%
2A	9,200	10,900	18%
2B	14,000	14,000	0%
2C	8,335	7,972	-4%
2D	16,400	17,391	6%
2E	5,341	6,669	25%
2F	6,700	7,202	7%
2G	4,000	5,501	38%
2H	1,900	1,900	0%
3A	3,800	5,000	32%
3B	7,300	7,000	-4%
3C	11,000	11,900	8%
3D	4,200	4,200	0%
4A	7,913	7,672	-3%
4B	6,200	7,108	15%
4C	5,300	6,500	23%
4D	7,533	8,417	12%
4E	7,500	8,700	16%
5A	4,000	3,801	-5%
5B	12,400	12,800	3%
5C	15,600	15,600	0%
5D	6,500	7,500	15%
UNK	72	76	6%
<b>STATE</b>	<b>183,794</b>	<b>203,409</b>	<b>11%</b>

## DATA USED TO ESTIMATE DEER HARVESTS

### *Antlered*

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates
1A	264	88	2,108	6,300
1B	628	181	2,401	8,300
2A	373	103	1,705	6,100
2B	131	44	1,519	4,500
2C	710	269	3,718	9,800
2D	721	226	4,626	14,700
2E	496	195	2,732	6,900
2F	794	269	3,222	9,500
2G	599	235	3,222	8,200
2H	91	51	975	1,700
3A	390	136	1,898	5,400
3B	660	205	2,787	8,900
3C	677	234	3,016	8,700
3D	449	168	1,748	4,700
4A	407	171	2,027	4,800
4B	428	162	2,128	5,600
4C	496	197	2,708	6,800
4D	814	265	3,457	10,600
4E	635	217	2,824	8,200
5A	108	51	1,395	2,900
5B	455	169	3,351	9,000
5C	343	119	3,085	8,800
5D	85	29	1,160	3,300
UNK			18	50
<b>STATE</b>	<b>10,754</b>	<b>3,784</b>	<b>57,830</b>	<b>163,750</b>

*Antlerless*

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates
1A	580	167	3,646	12,600
1B	1,657	405	3,194	13,000
2A	1,050	264	2,739	10,900
2B	558	114	2,865	14,000
2C	866	301	2,690	7,972
2D	1,374	447	5,549	17,391
2E	452	152	2,098	6,669
2F	705	210	2,151	7,202
2G	342	129	2,090	5,501
2H	61	20	639	1,900
3A	318	107	1,697	5,000
3B	666	223	2,340	7,000
3C	902	287	3,782	11,900
3D	336	118	1,478	4,200
4A	394	123	2,032	7,672
4B	578	157	1,926	7,108
4C	648	230	2,300	6,500
4D	717	211	2,474	8,417
4E	819	250	2,673	8,700
5A	195	79	1,555	3,801
5B	956	326	4,371	12,800
5C	916	312	5,339	15,600
5D	367	138	2,842	7,500
UNK <sup>2</sup>			24	76
<b>STATE</b>	<b>15,457</b>	<b>4,770</b>	<b>62,494</b>	<b>203,409</b>

<sup>1</sup> - 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.

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

NOTE: In WMUs with CWD DMAP permits, CWD DMAP permits not included in 'Total Reported'.

## COMMENTS

- Reporting rates remain low. Antlered 35% (Range: 28% to 56%), Antlerless 31% (Range: 20% to 41%)
- Majority of deer were reported online. 71% of deer harvest reports were online, 23% were on report cards, and 6% were by phone (Does not include DMAP harvests).
- Harvest estimates are based on more than 26,000 deer checked by Game Commission personnel and more than 150,000 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 2009-2018 deer management plan. The plan is available on the PGC’s website, [www.pgc.pa.gov](http://www.pgc.pa.gov), click on “Popular Hunting Pages” at bottom of home page, then “White-tailed deer”.

### *Antlered Harvests*

- Antlered harvest increased 10% from 2016-17.
- Age structure of this year’s harvest was 43% 1.5 year old bucks and 57% 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 700,000 deer hunters. As a result, one cannot compare antlered harvest totals to the past without including the fact that there are fewer hunters hunting deer. When corrected by the number of hunters, success rates are comparable to the past.

- Historic Antlered Deer Hunter Success Rates

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 <sup>1</sup>	23% of deer hunters harvested an antlered deer

<sup>1</sup> Current year deer hunter numbers based on last 3 years because current year deer hunter numbers will be available later this year

### *Antlerless Harvests*

- Age structure of this year's harvest was 64% adult females, 19% button bucks, and 17% doe fawns. This is similar to long term averages.
- Antlerless hunter success rates remained at approximately a quarter of all antlerless licenses used to harvest an antlerless deer. This is on average with harvest success for recent years.