

Pennsylvania
2020-21 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:

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

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 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.

Literature Cited

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HARVEST ESTIMATES, 2020-21

Overall Harvests

WMU	ANTLERED	ANTLERLESS	TOTAL
1A	9,000	18,000	27,000
1B	11,700	17,800	29,500
2A	8,100	11,800	19,900
2B	6,200	15,000	21,200
2C	8,400	15,700	24,100
2D	12,000	18,700	30,700
2E	6,500	11,300	17,800
2F	10,700	10,000	20,700
2G	7,500	6,800	14,300
2H	2,900	1,600	4,500
3A	7,000	6,700	13,700
3B	9,100	8,500	17,600
3C	10,800	14,500	25,300
3D	6,200	6,400	12,600
4A	5,200	10,800	16,000
4B	5,000	10,800	15,800
4C	7,000	8,100	15,100
4D	9,100	12,300	21,400
4E	8,600	11,200	19,800
5A	3,500	6,100	9,600
5B	9,600	16,400	26,000
5C	8,400	15,200	23,600
5D	2,200	6,500	8,700
UNK	80	200	280
TOTAL	174,780	260,400	435,180

Archery Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	10,900	4,720	6,180
1B	9,340	5,160	4,180
2A	6,540	3,540	3,000
2B	13,100	4,630	8,470
2C	7,490	3,860	3,630
2D	9,640	6,080	3,560
2E	4,730	2,660	2,070
2F	6,190	4,100	2,090
2G	4,250	2,470	1,780
2H	1,350	970	380
3A	4,100	2,470	1,630
3B	5,580	3,470	2,110
3C	7,050	3,570	3,480
3D	4,910	2,670	2,240
4A	3,530	1,650	1,880
4B	5,130	2,260	2,870
4C	6,150	3,260	2,890
4D	6,570	3,550	3,020
4E	7,270	3,850	3,420
5A	3,600	1,680	1,920
5B	13,570	5,840	7,730
5C	13,220	5,810	7,410
5D	6,100	1,790	4,310
UNK	40	70	100
STATE	160,350	80,130	80,350

Muzzleloader Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	2,100	80	2,020
1B	1,560	40	1,520
2A	1,260	60	1,200
2B	900	70	830
2C	1,610	40	1,570
2D	1,860	120	1,740
2E	1,170	40	1,130
2F	1,910	100	1,810
2G	1,450	30	1,420
2H	250	30	220
3A	1,010	30	980
3B	1,220	30	1,190
3C	1,850	30	1,820
3D	790	30	760
4A	1,170	50	1,120
4B	1,070	40	1,030
4C	1,050	40	1,010
4D	1,330	50	1,280
4E	1,330	50	1,280
5A	500	20	480
5B	1,530	60	1,470
5C	1,080	90	990
5D	200	10	190
UNK	60	0	60
STATE	28,260	1,140	27,120

ANNUAL CHANGES

Overall Harvests

WMU	2019-20	2020-21	% Change
1A	19,600	27,000	38%
1B	21,400	29,500	38%
2A	16,800	19,900	18%
2B	15,900	21,200	33%
2C	23,469	24,100	3%
2D	31,888	30,700	-4%
2E	15,873	17,800	12%
2F	18,724	20,700	11%
2G	14,205	14,300	1%
2H	3,500	4,500	29%
3A	11,400	13,700	20%
3B	17,900	17,600	-2%
3C	22,200	25,300	14%
3D	10,900	12,600	16%
4A	13,924	16,000	15%
4B	13,985	15,800	13%
4C	15,300	15,100	-1%
4D	19,655	21,400	9%
4E	16,800	19,800	18%
5A	8,400	9,600	14%
5B	25,545	26,000	2%
5C	22,027	23,600	7%
5D	9,200	8,700	-5%
UNK	836	280	-
STATE	389,431	435,180	12%

Antlered Harvests

WMU	2019-20	2020-21	% Change
1A	6,400	9,000	41%
1B	8,700	11,700	34%
2A	6,900	8,100	17%
2B	5,500	6,200	13%
2C	9,400	8,400	-11%
2D	13,000	12,000	-8%
2E	6,400	6,500	2%
2F	9,000	10,700	19%
2G	8,100	7,500	-7%
2H	2,400	2,900	21%
3A	5,700	7,000	23%
3B	7,600	9,100	20%
3C	9,400	10,800	15%
3D	6,000	6,200	3%
4A	6,000	5,200	-13%
4B	5,700	5,000	-12%
4C	7,000	7,000	0%
4D	8,700	9,100	5%
4E	7,300	8,600	18%
5A	3,400	3,500	3%
5B	10,200	9,600	-6%
5C	7,600	8,400	11%
5D	2,500	2,200	-12%
UNK	340	80	-
STATE	163,240	174,780	7%

Antlerless Harvests

WMU	2019-20	2020-21	% Change
1A	13,200	18,000	36%
1B	12,700	17,800	40%
2A	9,900	11,800	19%
2B	10,400	15,000	44%
2C	14,069	15,700	12%
2D	18,888	18,700	-1%
2E	9,473	11,300	19%
2F	9,724	10,000	3%
2G	6,105	6,800	11%
2H	1,100	1,600	45%
3A	5,700	6,700	18%
3B	10,300	8,500	-17%
3C	12,800	14,500	13%
3D	4,900	6,400	31%
4A	7,924	10,800	36%
4B	8,285	10,800	30%
4C	8,300	8,100	-2%
4D	10,955	12,300	12%
4E	9,500	11,200	18%
5A	5,000	6,100	22%
5B	15,345	16,400	7%
5C	14,427	15,200	5%
5D	6,700	6,500	-3%
UNK	496	200	-
STATE	226,191	260,400	15%

DATA USED TO ESTIMATE DEER HARVESTS

Antlered

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates
1A	119	28	2,225	9,000
1B	398	102	3,012	11,700
2A	184	50	2,240	8,100
2B	87	28	2,043	6,200
2C	331	139	3,559	8,400
2D	303	95	3,827	12,000
2E	256	87	2,230	6,500
2F	573	188	3,518	10,700
2G	346	129	2,811	7,500
2H	65	21	951	2,900
3A	333	103	2,169	7,000
3B	459	143	2,845	9,100
3C	431	127	3,212	10,800
3D	332	115	2,152	6,200
4A	196	66	1,762	5,200
4B	180	64	1,807	5,000
4C	424	178	2,947	7,000
4D	438	147	3,081	9,100
4E	487	160	2,845	8,600
5A	81	29	1,288	3,500
5B	305	103	3,247	9,600
5C	244	85	2,931	8,400
5D	59	37	1,370	2,200
UNK			27	80
STATE	6,631	2,224	58,099	174,780

Antlerless

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates¹
1A	422	85	3,559	18,000
1B	1,466	369	4,478	17,800
2A	514	120	2,780	11,800
2B	503	111	3,276	15,000
2C	1,070	380	5,600	15,700
2D	1,208	393	6,102	18,700
2E	658	215	3,719	11,300
2F	834	279	3,337	10,000
2G	310	89	1,969	6,800
2H	69	25	580	1,600
3A	313	92	1,982	6,700
3B	651	201	2,635	8,500
3C	1,037	284	3,991	14,500
3D	510	177	2,217	6,400
4A	571	158	3,015	10,800
4B	691	185	2,894	10,800
4C	692	231	2,696	8,100
4D	1,062	338	3,908	12,300
4E	1,015	295	3,265	11,200
5A	271	96	2,170	6,100
5B	897	268	4,914	16,400
5C	865	301	5,298	15,200
5D	283	124	2,851	6,500
UNK²			67	200
STATE	15,912	4,816	77,303	260,400

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

COMMENTS

- Reporting rates remain low. Antlered 34% (Range: 24% to 63%), Antlerless 30% (Range: 20% to 44%)
- Majority of deer were reported online. 66% of deer harvest reports were online, 30% were on report cards, and 4% were by phone.
- Harvest estimates are based on more than 22,000 deer checked by Game Commission personnel and more than 135,000 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, click on “Popular Hunting Pages” at bottom of home page, then “White-tailed deer”.

Antlered Harvests

- Antlered harvest increased 7% from 2019-20.
- 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. 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 higher today than in 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
2018-19	22% of deer hunters harvested an antlered deer
2019-20	25% of deer hunters harvested an antlered deer
2020-21 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 68% adult females, 17% button bucks, and 15% doe fawns, consistent with 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.