Pennsylvania
2019-20 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:

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

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;

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

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 Var($\hat{H}$) is estimated as;

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

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.

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HARVEST ESTIMATES, 2019-20 (not including DMAP)

Overall Harvests

WMU	ANTLERED	WMU Antlerless	CWD DMAP Permits	Total Antlerless	TOTAL
1A	6,400	13,200	0	13,200	19,600
1B	8,700	12,700	0	12,700	21,400
2A	6,900	9,900	0	9,900	16,800
2B	5,500	10,400	0	10,400	15,900
2C	9,400	12,700	1,369	14,069	23,469
2D	13,000	17,500	1,388	18,888	31,888
2E	6,400	7,600	1,873	9,473	15,873
2F	9,000	8,800	924	9,724	18,724
2G	8,100	6,100	5	6,105	14,205
2H	2,400	1,100	0	1,100	3,500
3A	5,700	5,700	0	5,700	11,400
3B	7,600	10,300	0	10,300	17,900
3C	9,400	12,800	0	12,800	22,200
3D	6,000	4,900	0	4,900	10,900
4A	6,000	5,300	2,624	7,924	13,924
4B	5,700	7,300	985	8,285	13,985
4C	7,000	8,300	0	8,300	15,300
4D	8,700	10,300	655	10,955	19,655
4E	7,300	9,500	0	9,500	16,800
5A	3,400	5,000	0	5,000	8,400
5B	10,200	14,800	545	15,345	25,545
5C	7,600	14,400	27	14,427	22,027
5D	2,500	6,700	0	6,700	9,200
UNK	340	430	66	496	836
TOTAL	**163,240**	**215,730**	**10,461**	**226,191**	**389,431**

Archery Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	7,560	3,240	4,320
1B	7,190	3,960	3,230
2A	5,680	3,140	2,540
2B	9,650	4,150	5,500
2C	8,169	4,230	3,939
2D	9,885	5,800	4,085
2E	4,484	2,540	1,944
2F	5,346	3,340	2,006
2G	3,921	2,540	1,381
2H	920	690	230
3A	3,480	2,080	1,400
3B	5,750	3,160	2,590
3C	6,230	3,370	2,860
3D	3,720	2,250	1,470
4A	3,306	1,610	1,696
4B	4,901	2,350	2,551
4C	6,510	3,550	2,960
4D	6,407	3,120	3,287
4E	6,170	3,420	2,750
5A	3,460	1,580	1,880
5B	13,820	6,420	7,400
5C	12,405	5,330	7,075
5D	6,640	2,180	4,460
UNK	304	140	164
STATE	145,908	74,190	71,718

Muzzleloader Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	1,740	60	1,680
1B	1,210	40	1,170
2A	1,020	60	960
2B	750	50	700
2C	1,924	70	1,854
2D	2,801	100	2,701
2E	1,312	60	1,252
2F	1,594	60	1,534
2G	1,381	60	1,321
2H	180	10	170
3A	820	20	800
3B	1,750	40	1,710
3C	1,770	30	1,740
3D	880	50	830
4A	1,403	90	1,313
4B	1,120	50	1,070
4C	1,290	50	1,240
4D	1,698	80	1,618
4E	1,330	80	1,250
5A	640	20	620
5B	1,518	80	1,438
5C	1,112	70	1,042
5D	260	20	240
UNK	104	10	94
STATE	29,607	1,260	28,347

ANNUAL CHANGES

Overall Harvests

WMU	2018-19	2019-20	% Change
1A	18,200	19,600	8%
1B	23,800	21,400	-10%
2A	16,900	16,800	-1%
2B	17,000	15,900	-6%
2C	21,387	23,469	10%
2D	32,758	31,888	-3%
2E	16,001	15,873	-1%
2F	15,673	18,724	19%
2G	13,702	14,205	4%
2H	4,300	3,500	-19%
3A	12,200	11,400	-7%
3B	15,400	17,900	16%
3C	19,900	22,200	12%
3D	10,900	10,900	0%
4A	13,330	13,924	4%
4B	12,216	13,985	14%
4C	13,000	15,300	18%
4D	17,381	19,655	13%
4E	16,300	16,800	3%
5A	7,700	8,400	9%
5B	23,808	25,545	7%
5C	24,015	22,027	-8%
5D	8,600	9,200	7%
UNK	219	836	282%
STATE	**374,690**	**389,431**	**4%**

Antlered Harvests

WMU	2018-19	2019-20	% Change
1A	5,800	6,400	10%
1B	8,000	8,700	9%
2A	6,000	6,900	15%
2B	5,000	5,500	10%
2C	9,600	9,400	-2%
2D	11,800	13,000	10%
2E	6,300	6,400	2%
2F	7,700	9,000	17%
2G	6,300	8,100	29%
2H	2,500	2,400	-4%
3A	4,800	5,700	19%
3B	7,000	7,600	9%
3C	7,700	9,400	22%
3D	5,200	6,000	15%
4A	5,100	6,000	18%
4B	5,300	5,700	8%
4C	5,800	7,000	21%
4D	8,300	8,700	5%
4E	7,000	7,300	4%
5A	3,100	3,400	10%
5B	9,200	10,200	11%
5C	7,600	7,600	0%
5D	2,600	2,500	-4%
UNK	50	340	580%
STATE	**147,750**	**163,240**	**10%**

Antlerless Harvests

WMU	2018-19	2019-20	% Change
1A	12,400	13,200	6%
1B	15,800	12,700	-20%
2A	10,900	9,900	-9%
2B	12,000	10,400	-13%
2C	11,787	14,069	19%
2D	20,958	18,888	-10%
2E	9,701	9,473	-2%
2F	7,973	9,724	22%
2G	7,402	6,105	-18%
2H	1,800	1,100	-39%
3A	7,400	5,700	-23%
3B	8,400	10,300	23%
3C	12,200	12,800	5%
3D	5,700	4,900	-14%
4A	8,230	7,924	-4%
4B	6,916	8,285	20%
4C	7,200	8,300	15%
4D	9,081	10,955	21%
4E	9,300	9,500	2%
5A	4,600	5,000	9%
5B	14,608	15,345	5%
5C	16,415	14,427	-12%
5D	6,000	6,700	12%
UNK	169	496	193%
STATE	**226,940**	**226,191**	**0%**

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DATA USED TO ESTIMATE DEER HARVESTS

Antlered

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates
1A	189	61	2,093	6,400
1B	462	147	2,767	8,700
2A	236	61	1,812	6,900
2B	97	30	1,740	5,500
2C	408	161	3,733	9,400
2D	406	133	4,270	13,000
2E	257	103	2,567	6,400
2F	611	237	3,505	9,000
2G	453	166	2,965	8,100
2H	96	38	966	2,400
3A	346	117	1,939	5,700
3B	472	165	2,652	7,600
3C	509	157	2,906	9,400
3D	352	107	1,840	6,000
4A	237	82	2,085	6,000
4B	219	80	2,106	5,700
4C	455	177	2,722	7,000
4D	561	214	3,343	8,700
4E	514	185	2,641	7,300
5A	83	33	1,378	3,400
5B	307	100	3,328	10,200
5C	241	91	2,906	7,600
5D	46	22	1,217	2,500
UNK			120	340
STATE	**7,557**	**2,667**	**57,601**	**163,240**

Antlerless

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates
1A	592	143	3,195	13,200
1B	1,162	303	3,329	12,700
2A	890	188	2,103	9,900
2B	464	108	2,431	10,400
2C	827	252	3,893	14,069
2D	965	305	5,534	18,888
2E	411	150	2,800	9,473
2F	744	230	2,733	9,724
2G	366	111	1,868	6,105
2H	48	22	509	1,100
3A	399	130	1,854	5,700
3B	831	230	2,849	10,300
3C	1,055	322	3,917	12,800
3D	440	138	1,554	4,900
4A	267	95	1,880	7,924
4B	322	104	2,374	8,285
4C	608	194	2,666	8,300
4D	588	194	3,398	10,955
4E	960	280	2,781	9,500
5A	124	41	1,663	5,000
5B	838	270	4,794	15,345
5C	718	241	4,834	14,427
5D	263	107	2,749	6,700
UNK[2]			152	496
STATE	13,882	4,158	65,860	226,191

[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 35% (Range: 26% to 48%), Antlerless 30% (Range: 21% to 46%)

- Majority of deer were reported online. 73% of deer harvest reports were online, 22% were on report cards, and 5% were by phone.

- Harvest estimates are based on more than 21,000 deer checked by Game Commission personnel and more than 120,000 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 10% from 2018-19.

- Age structure of this year's harvest was 34% 1.5 year old bucks and 66% 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 660,000 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.

  o 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[1]   24% of deer hunters harvested an antlered deer

    [1] 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 69% adult females, 16% button bucks, and 15% 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.