Pennsylvania
2018-19 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

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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, 2018-19 (not including DMAP)

Overall Harvests

WMU	ANTLERED	WMU Antlerless	CWD DMAP Permits	Total Antlerless	TOTAL
1A	5,800	12,400	0	12,400	18,200
1B	8,000	15,800	0	15,800	23,800
2A	6,000	10,900	0	10,900	16,900
2B	5,000	12,000	0	12,000	17,000
2C	9,600	11,100	687	11,787	21,387
2D	11,800	20,300	658	20,958	32,758
2E	6,300	8,700	1,001	9,701	16,001
2F	7,700	7,500	473	7,973	15,673
2G	6,300	7,400	2	7,402	13,702
2H	2,500	1,800	0	1,800	4,300
3A	4,800	7,400	0	7,400	12,200
3B	7,000	8,400	0	8,400	15,400
3C	7,700	12,200	0	12,200	19,900
3D	5,200	5,700	0	5,700	10,900
4A	5,100	6,400	1,830	8,230	13,330
4B	5,300	6,800	116	6,916	12,216
4C	5,800	7,200	0	7,200	13,000
4D	8,300	8,700	381	9,081	17,381
4E	7,000	9,300	0	9,300	16,300
5A	3,100	4,600	0	4,600	7,700
5B	9,200	14,200	408	14,608	23,808
5C	7,600	16,400	15	16,415	24,015
5D	2,600	6,000	0	6,000	8,600
UNK	50	150	19	169	219
TOTAL	147,750	221,350	5,590	226,940	374,690

Archery Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	5,680	2,530	3,150
1B	5,540	2,750	2,790
2A	4,090	2,050	2,040
2B	9,280	3,520	5,760
2C	5,778	3,400	2,378
2D	8,012	4,540	3,472
2E	3,551	1,950	1,601
2F	3,736	2,520	1,216
2G	2,771	1,430	1,341
2H	750	480	270
3A	2,500	1,180	1,320
3B	3,790	2,160	1,630
3C	3,760	1,940	1,820
3D	3,070	1,660	1,410
4A	2,158	820	1,338
4B	3,358	1,760	1,598
4C	4,250	2,350	1,900
4D	4,226	2,430	1,796
4E	4,440	2,550	1,890
5A	2,100	880	1,220
5B	10,041	4,640	5,401
5C	11,928	4,690	7,238
5D	5,870	2,080	3,790
UNK	40	40	0
STATE	110,719	54,350	56,369

Muzzleloader Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	1,220	70	1,150
1B	1,260	50	1,210
2A	1,010	50	960
2B	720	80	640
2C	1,415	100	1,315
2D	2,334	60	2,274
2E	1,255	50	1,205
2F	1,078	80	998
2G	1,130	70	1,060
2H	250	20	230
3A	800	20	780
3B	1,210	40	1,170
3C	1,340	60	1,280
3D	630	40	590
4A	1,071	80	991
4B	667	40	627
4C	850	50	800
4D	1,072	70	1,002
4E	1,060	50	1,010
5A	500	20	480
5B	1,425	60	1,365
5C	1,382	110	1,272
5D	230	20	210
UNK	0	0	0
STATE	23,909	1,290	22,619

ANNUAL CHANGES

Overall Harvests

WMU	2017-18	2018-19	% Change
1A	18,900	18,200	-4%
1B	21,300	23,800	12%
2A	17,000	16,900	-1%
2B	18,500	17,000	-8%
2C	17,772	21,387	20%
2D	32,091	32,758	2%
2E	13,569	16,001	18%
2F	16,702	15,673	-6%
2G	13,701	13,702	0%
2H	3,600	4,300	19%
3A	10,400	12,200	17%
3B	15,900	15,400	-3%
3C	20,600	19,900	-3%
3D	8,900	10,900	22%
4A	12,472	13,330	7%
4B	12,708	12,216	-4%
4C	13,300	13,000	-2%
4D	19,017	17,381	-9%
4E	16,900	16,300	-4%
5A	6,701	7,700	15%
5B	21,800	23,808	9%
5C	24,400	24,015	-2%
5D	10,800	8,600	-20%
UNK	126	219	74%
STATE	**367,159**	**374,690**	**2%**

Antlered Harvests

WMU	2017-18	2018-19	% Change
1A	6,300	5,800	-8%
1B	8,300	8,000	-4%
2A	6,100	6,000	-2%
2B	4,500	5,000	11%
2C	9,800	9,600	-2%
2D	14,700	11,800	-20%
2E	6,900	6,300	-9%
2F	9,500	7,700	-19%
2G	8,200	6,300	-23%
2H	1,700	2,500	47%
3A	5,400	4,800	-11%
3B	8,900	7,000	-21%
3C	8,700	7,700	-11%
3D	4,700	5,200	11%
4A	4,800	5,100	6%
4B	5,600	5,300	-5%
4C	6,800	5,800	-15%
4D	10,600	8,300	-22%
4E	8,200	7,000	-15%
5A	2,900	3,100	7%
5B	9,000	9,200	2%
5C	8,800	7,600	-14%
5D	3,300	2,600	-21%
UNK	50	50	0%
STATE	**163,750**	**147,750**	**-10%**

Antlerless Harvests

WMU	2017-18	2018-19	% Change
1A	12,600	12,400	-2%
1B	13,000	15,800	22%
2A	10,900	10,900	0%
2B	14,000	12,000	-14%
2C	7,972	11,787	48%
2D	17,391	20,958	21%
2E	6,669	9,701	45%
2F	7,202	7,973	11%
2G	5,501	7,402	35%
2H	1,900	1,800	-5%
3A	5,000	7,400	48%
3B	7,000	8,400	20%
3C	11,900	12,200	3%
3D	4,200	5,700	36%
4A	7,672	8,230	7%
4B	7,108	6,916	-3%
4C	6,500	7,200	11%
4D	8,417	9,081	8%
4E	8,700	9,300	7%
5A	3,801	4,600	21%
5B	12,800	14,608	14%
5C	15,600	16,415	5%
5D	7,500	6,000	-20%
UNK	76	169	122%
STATE	**203,409**	**226,940**	**12%**

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DATA USED TO ESTIMATE DEER HARVESTS

Antlered

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates
1A	187	66	2,067	5,800
1B	479	147	2,457	8,000
2A	345	95	1,674	6,000
2B	119	37	1,594	5,000
2C	481	171	3,415	9,600
2D	451	145	3,826	11,800
2E	321	114	2,240	6,300
2F	566	203	2,757	7,700
2G	447	195	2,754	6,300
2H	88	32	918	2,500
3A	381	141	1,793	4,800
3B	536	191	2,494	7,000
3C	583	220	2,928	7,700
3D	441	154	1,819	5,200
4A	286	113	2,042	5,100
4B	370	133	1,904	5,300
4C	442	190	2,492	5,800
4D	693	244	2,929	8,300
4E	543	197	2,540	7,000
5A	97	44	1,419	3,100
5B	404	143	3,258	9,200
5C	270	101	2,854	7,600
5D	97	42	1,154	2,600
UNK			19	50
STATE	8,627	3,118	53,347	147,750

Antlerless

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates
1A	593	171	3,602	12,400
1B	1,475	379	4,058	15,800
2A	722	163	2,483	10,900
2B	488	103	2,619	12,000
2C	740	259	3,906	11,787
2D	1,408	431	6,237	20,958
2E	465	142	2,667	9,701
2F	758	244	2,431	7,973
2G	460	159	2,558	7,402
2H	87	32	679	1,800
3A	451	135	2,235	7,400
3B	774	241	2,608	8,400
3C	1,007	326	3,948	12,200
3D	436	129	1,692	5,700
4A	413	137	2,131	8,230
4B	525	157	2,029	6,916
4C	740	264	2,558	7,200
4D	751	239	2,777	9,081
4E	981	324	3,092	9,300
5A	196	75	1,793	4,600
5B	1,017	355	4,962	14,608
5C	728	226	5,106	16,415
5D	268	121	2,721	6,000
UNK[2]			55	169
STATE	15,483	4,812	68,947	226,940

[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 36% (Range: 28% to 45%), Antlerless 31% (Range: 21% to 45%)

- Majority of deer were reported online. 71% of deer harvest reports were online, 24% were on report cards, and 6% were by phone.

- Harvest estimates are based on more than 24,000 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 decreased 10% from 2017-18.

- 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 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 |
    | 2018-19[1] | 21% 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 66% adult females, 17% 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.