Pennsylvania

2016-17 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 2 Antlerless Permit (DMA2 permit)

In 2014-15, a permit was developed to increase antlerless deer harvests within disease management areas where Chronic Wasting Disease (CWD) has been detected in free ranging deer. Use of this permit was limited to DMA2. Because of the large area of this DMA, antlerless harvests reported on DMA2 permits are included in overall harvest estimates.

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HARVEST ESTIMATES, 2016-17 (not including DMAP)

Overall Harvests

WMU	ANTLERED	Regular Antlerless	DMA Permits	Total Antlerless	TOTAL
1A	6,500	10,400	0	10,400	16,900
1B	7,900	8,200	0	8,200	16,100
2A	7,000	9,200	0	9,200	16,200
2B	5,800	14,000	0	14,000	19,800
2C	8,300	6,900	1,435	8,335	16,635
2D	12,800	16,400	0	16,400	29,200
2E	5,200	5,200	141	5,341	10,541
2F	7,700	6,700	0	6,700	14,400
2G	6,200	4,000	0	4,000	10,200
2H	1,900	1,900	0	1,900	3,800
3A	5,400	3,800	0	3,800	9,200
3B	7,500	7,300	0	7,300	14,800
3C	8,600	11,000	0	11,000	19,600
3D	4,300	4,200	0	4,200	8,500
4A	4,400	5,700	2,213	7,913	12,313
4B	5,200	6,200	0	6,200	11,400
4C	6,400	5,300	0	5,300	11,700
4D	7,900	7,200	333	7,533	15,433
4E	7,300	7,500	0	7,500	14,800
5A	3,000	4,000	0	4,000	7,000
5B	8,900	12,400	0	12,400	21,300
5C	8,300	15,600	0	15,600	23,900
5D	2,900	6,500	0	6,500	9,400
UNK	60	70	2	72	132
TOTAL	**149,460**	**179,670**	**4,124**	**183,794**	**333,254**

NOTE: WMUs 2C, 2E, 4A, and 4D include reported harvests from DMA2 permits.

Archery Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	5,980	3,030	2,950
1B	5,050	3,230	1,820
2A	4,340	2,440	1,900
2B	11,010	4,260	6,750
2C	5,109	3,320	1,789
2D	7,940	5,350	2,590
2E	2,668	1,760	908
2F	3,630	2,530	1,100
2G	2,450	1,620	830
2H	790	480	310
3A	2,170	1,470	700
3B	3,820	2,440	1,380
3C	4,220	2,340	1,880
3D	2,530	1,470	1,060
4A	2,314	940	1,374
4B	3,250	1,850	1,400
4C	3,950	2,570	1,380
4D	4,049	2,420	1,629
4E	4,320	2,750	1,570
5A	1,840	970	870
5B	9,060	4,730	4,330
5C	12,290	5,300	6,990
5D	6,460	2,280	4,180
UNK	10	0	10
STATE	**109,250**	**59,550**	**49,700**

NOTE: WMUs 2C, 2E, 4A, and 4D include reported harvests from DMA2 permits.

Muzzleloader Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	1,320	70	1,250
1B	1,150	70	1,080
2A	1,160	60	1,100
2B	790	40	750
2C	1,086	80	1,006
2D	2,060	150	1,910
2E	666	40	626
2F	870	70	800
2G	750	80	670
2H	310	20	290
3A	530	30	500
3B	1,080	60	1,020
3C	1,280	60	1,220
3D	470	30	440
4A	1,091	60	1,031
4B	650	50	600
4C	650	30	620
4D	956	80	876
4E	780	50	730
5A	360	30	330
5B	1,040	70	970
5C	1,110	100	1,010
5D	240	20	220
UNK	10	0	10
STATE	**20,409**	**1,350**	**19,059**

NOTE: WMUs 2C, 2E, 4A, and 4D include reported harvests from DMA2 permits.

ANNUAL CHANGES

Overall Harvests

WMU	2015-16	2016-17	% Change
1A	15,100	16,900	12%
1B	14,600	16,100	10%
2A	17,000	16,200	-5%
2B	20,200	19,800	-2%
2C	17,590	16,635	-5%
2D	28,000	29,200	4%
2E	10,000	10,541	5%
2F	12,400	14,400	16%
2G	10,200	10,200	0%
2H	2,800	3,800	36%
3A	8,300	9,200	11%
3B	14,200	14,800	4%
3C	18,100	19,600	8%
3D	7,200	8,500	18%
4A	13,770	12,313	-11%
4B	12,700	11,400	-10%
4C	10,400	11,700	13%
4D	14,643	15,433	5%
4E	13,100	14,800	13%
5A	7,500	7,000	-7%
5B	19,500	21,300	9%
5C	21,000	23,900	14%
5D	7,400	9,400	27%
UNK	110	132	20%
STATE	315,813	333,254	6%

NOTE: WMUs 2C, 2E, 4A, and 4D include reported harvests from DMA2 permits.

Antlered Harvests

WMU	2015-16	2016-17	% Change
1A	6,000	6,500	8%
1B	6,900	7,900	14%
2A	6,500	7,000	8%
2B	5,200	5,800	12%
2C	9,100	8,300	-9%
2D	12,300	12,800	4%
2E	4,700	5,200	11%
2F	7,000	7,700	10%
2G	6,100	6,200	2%
2H	1,400	1,900	36%
3A	4,300	5,400	26%
3B	6,800	7,500	10%
3C	7,600	8,600	13%
3D	3,500	4,300	23%
4A	5,100	4,400	-14%
4B	5,700	5,200	-9%
4C	5,400	6,400	19%
4D	7,200	7,900	10%
4E	6,200	7,300	18%
5A	2,900	3,000	3%
5B	8,000	8,900	11%
5C	7,400	8,300	12%
5D	2,200	2,900	32%
UNK	80	60	-25%
STATE	137,580	149,460	9%

Antlerless Harvests

WMU	2015-16	2016-17	% Change
1A	9,100	10,400	14%
1B	7,700	8,200	6%
2A	10,500	9,200	-12%
2B	15,000	14,000	-7%
2C	8,490	8,335	-2%
2D	15,700	16,400	4%
2E	5,300	5,341	1%
2F	5,400	6,700	24%
2G	4,100	4,000	-2%
2H	1,400	1,900	36%
3A	4,000	3,800	-5%
3B	7,400	7,300	-1%
3C	10,500	11,000	5%
3D	3,700	4,200	14%
4A	8,670	7,913	-9%
4B	7,000	6,200	-11%
4C	5,000	5,300	6%
4D	7,443	7,533	1%
4E	6,900	7,500	9%
5A	4,600	4,000	-13%
5B	11,500	12,400	8%
5C	13,600	15,600	15%
5D	5,200	6,500	25%
UNK	30	72	140%
STATE	178,233	183,794	3%

NOTE: WMUs 2C, 2E, 4A, and 4D include reported harvests from DMA2 permits.

DATA SETS USED TO ESTIMATE DEER HARVESTS

Antlered

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates
1A	274	93	2,221	6,500
1B	585	162	2,210	7,900
2A	290	79	1,931	7,000
2B	94	28	1,770	5,800
2C	535	223	3,468	8,300
2D	625	196	4,041	12,800
2E	331	117	1,855	5,200
2F	659	243	2,838	7,700
2G	394	156	2,464	6,200
2H	73	32	832	1,900
3A	287	88	1,678	5,400
3B	617	204	2,481	7,500
3C	690	236	2,959	8,600
3D	376	152	1,733	4,300
4A	297	121	1,810	4,400
4B	365	141	2,003	5,200
4C	515	211	2,621	6,400
4D	630	226	2,849	7,900
4E	633	240	2,772	7,300
5A	122	53	1,324	3,000
5B	398	138	3,095	8,900
5C	299	109	3,053	8,300
5D	78	32	1,214	2,900
UNK[2]			23	60
STATE	**9,167**	**3,280**	**53,245**	**149,460**

Antlerless

WMU	No. Checked in Field	Checked & Reported	Total Reported	Published Harvest Estimates
1A	645	200	3,228	10,400
1B	1,164	313	2,221	8,200
2A	640	170	2,463	9,200
2B	598	122	2,939	14,000
2C	762	253	2,286	8,335
2D	1,464	435	4,894	16,400
2E	443	138	1,632	5,341
2F	647	170	1,772	6,700
2G	271	100	1,483	4,000
2H	50	13	510	1,900
3A	255	80	1,194	3,800
3B	751	226	2,200	7,300
3C	901	279	3,404	11,000
3D	352	111	1,343	4,200
4A	384	112	1,680	7,913
4B	580	174	1,852	6,200
4C	653	232	1,878	5,300
4D	728	236	2,351	7,533
4E	804	254	2,367	7,500
5A	265	104	1,597	4,000
5B	1,194	419	4,345	12,400
5C	918	305	5,208	15,600
5D	350	145	2,683	6,500
UNK[2]			24	72
STATE	**14,819**	**4,591**	**55,554**	**183,794**

[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 2C, 2E, 4A, and 4D DMA2 permits were not included in harvest estimating procedures. They were added to estimated antlerless harvests.

COMMENTS

- Reporting rates remain low. Antlered 36% (Range: 27% to 44%), Antlerless 31% (Range: 26% to 41%)

- Majority of deer were reported online. 62% of deer harvest reports were online, 33% were on report cards, and 5% were by phone (Does not include DMAP harvests).

- Harvest estimates are based on more than 24,000 deer checked by Game Commission personnel and more than 100,000 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.state.pa.us, click on "White-tailed deer".

Antlered Harvests

- Antlered harvest increased 9% from 2015-16.

- Age structure of this year's harvest was 44% 1.5 year old bucks and 56% 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 740,000 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 properly corrected by the number of hunters, success rates are comparable to the past.

Antlerless Harvests

- Age structure of this year's harvest was 64% adult females, 20% button bucks, and 16% 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.