Pennsylvania

2015-16 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, 2015-16 (not including DMAP)

Overall Harvests

WMU	ANTLERED	Regular Antlerless	DMA Permits	ANTLERLESS	TOTAL
1A	6,000	9,100	0	9,100	15,100
1B	6,900	7,700	0	7,700	14,600
2A	6,500	10,500	0	10,500	17,000
2B	5,200	15,000	0	15,000	20,200
2C	9,100	7,300	1,190	8,490	17,590
2D	12,300	15,700	0	15,700	28,000
2E	4,700	5,300	0	5,300	10,000
2F	7,000	5,400	0	5,400	12,400
2G	6,100	4,100	0	4,100	10,200
2H	1,400	1,400	0	1,400	2,800
3A	4,300	4,000	0	4,000	8,300
3B	6,800	7,400	0	7,400	14,200
3C	7,600	10,500	0	10,500	18,100
3D	3,500	3,700	0	3,700	7,200
4A	5,100	6,400	2,270	8,670	13,770
4B	5,700	7,000	0	7,000	12,700
4C	5,400	5,000	0	5,000	10,400
4D	7,200	7,200	243	7,443	14,643
4E	6,200	6,900	0	6,900	13,100
5A	2,900	4,600	0	4,600	7,500
5B	8,000	11,500	0	11,500	19,500
5C	7,400	13,600	0	13,600	21,000
5D	2,200	5,200	0	5,200	7,400
UNK	80	30	0	30	110
TOTAL	**137,580**	**174,530**	**3,703**	**178,233**	**315,813**

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

Archery Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	5,090	2,610	2,480
1B	4,040	2,560	1,480
2A	4,270	2,160	2,110
2B	11,630	3,750	7,880
2C	4,817	3,130	1,687
2D	7,110	4,780	2,330
2E	2,260	1,460	800
2F	2,640	1,860	780
2G	2,140	1,340	800
2H	540	290	250
3A	1,940	1,180	760
3B	3,940	2,320	1,620
3C	4,000	2,060	1,940
3D	2,040	1,060	980
4A	2,361	960	1,401
4B	3,060	1,660	1,400
4C	3,530	2,150	1,380
4D	3,554	1,840	1,714
4E	3,490	2,150	1,340
5A	1,890	880	1,010
5B	8,220	4,430	3,790
5C	11,190	4,880	6,310
5D	5,210	1,770	3,440
UNK	10	0	10
STATE	98,972	51,280	47,692

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

Muzzleloader Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	1,210	90	1,120
1B	760	40	720
2A	1,430	40	1,390
2B	970	50	920
2C	1,136	70	1,066
2D	2,090	120	1,970
2E	740	40	700
2F	760	40	720
2G	760	60	700
2H	260	10	250
3A	660	20	640
3B	1,260	80	1,180
3C	1,500	40	1,460
3D	560	40	520
4A	1,325	40	1,285
4B	840	40	800
4C	670	50	620
4D	1,028	60	968
4E	810	50	760
5A	610	20	590
5B	1,080	70	1,010
5C	1,210	120	1,090
5D	190	30	160
UNK	0	0	0
STATE	21,859	1,220	20,639

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

ANNUAL CHANGES

Overall Harvests

WMU	2014-15	2015-16	% Change
1A	15,900	15,100	-5%
1B	14,600	14,600	0%
2A	14,700	17,000	16%
2B	17,300	20,200	17%
2C	16,029	17,590	10%
2D	27,800	28,000	1%
2E	10,000	10,000	0%
2F	11,900	12,400	4%
2G	9,500	10,200	7%
2H	2,800	2,800	0%
3A	7,600	8,300	9%
3B	14,100	14,200	1%
3C	16,800	18,100	8%
3D	9,400	7,200	-23%
4A	10,105	13,770	36%
4B	10,200	12,700	25%
4C	9,800	10,400	6%
4D	13,348	14,643	10%
4E	11,700	13,100	12%
5A	5,700	7,500	32%
5B	19,300	19,500	1%
5C	30,200	21,000	-30%
5D	5,100	7,400	45%
UNK	91	110	21%
STATE	303,973	315,813	4%

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

Antlered Harvests

WMU	2014-15	2015-16	% Change
1A	5,100	6,000	18%
1B	5,800	6,900	19%
2A	5,100	6,500	27%
2B	4,300	5,200	21%
2C	7,000	9,100	30%
2D	11,400	12,300	8%
2E	4,400	4,700	7%
2F	6,000	7,000	17%
2G	4,800	6,100	27%
2H	1,700	1,400	-18%
3A	3,300	4,300	30%
3B	6,000	6,800	13%
3C	6,500	7,600	17%
3D	4,200	3,500	-17%
4A	3,300	5,100	55%
4B	4,600	5,700	24%
4C	4,800	5,400	13%
4D	6,500	7,200	11%
4E	5,800	6,200	7%
5A	2,400	2,900	21%
5B	6,900	8,000	16%
5C	8,000	7,400	-8%
5D	1,300	2,200	69%
UNK	60	80	33%
STATE	119,260	137,580	15%

Antlerless Harvests

WMU	2014-15	2015-16	% Change
1A	10,800	9,100	-16%
1B	8,800	7,700	-13%
2A	9,600	10,500	9%
2B	13,000	15,000	15%
2C	9,029	8,490	-6%
2D	16,400	15,700	-4%
2E	5,600	5,300	-5%
2F	5,900	5,400	-8%
2G	4,700	4,100	-13%
2H	1,100	1,400	27%
3A	4,300	4,000	-7%
3B	8,100	7,400	-9%
3C	10,300	10,500	2%
3D	5,200	3,700	-29%
4A	6,805	8,670	27%
4B	5,600	7,000	25%
4C	5,000	5,000	0%
4D	6,848	7,443	9%
4E	5,900	6,900	17%
5A	3,300	4,600	39%
5B	12,400	11,500	-7%
5C	22,200	13,600	-39%
5D	3,800	5,200	37%
UNK	31	30	-3%
STATE	184,713	178,233	-4%

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

DATA SETS USED TO ESTIMATE DEER HARVESTS

Antlered

WMU	Deer checked by PGC deer aging personnel	Deer checked by PGC and reported by hunters	Deer reported by hunters	Harvest Estimates[1]
1A	253	86	2,065	6,000
1B	687	216	2,174	6,900
2A	434	133	2,005	6,500
2B	124	40	1,702	5,200
2C	722	256	3,246	9,100
2D	655	198	3,728	12,300
2E	407	148	1,731	4,700
2F	679	242	2,497	7,000
2G	444	159	2,183	6,100
2H	89	42	681	1,400
3A	316	110	1,510	4,300
3B	601	191	2,181	6,800
3C	652	235	2,751	7,600
3D	289	123	1,496	3,500
4A	374	128	1,752	5,100
4B	422	145	1,967	5,700
4C	437	180	2,223	5,400
4D	730	275	2,733	7,200
4E	592	231	2,426	6,200
5A	134	57	1,229	2,900
5B	368	125	2,734	8,000
5C	286	107	2,790	7,400
5D	67	29	966	2,200
UNK[2]			30	80
STATE	**9,762**	**3,456**	**48,800**	**137,580**

[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

Antlerless

WMU	Deer checked by PGC deer aging personnel	Deer checked by PGC and reported by hunters	Deer reported by hunters	Harvest Estimates[1]
1A	533	177	3,040	9,100
1B	1,312	368	2,155	7,700
2A	656	170	2,734	10,500
2B	567	116	3,167	15,000
2C	875	283	2,356	7,300
2D	1,418	448	4,976	15,700
2E	469	144	1,623	5,300
2F	680	212	1,699	5,400
2G	266	93	1,458	4,100
2H	73	26	517	1,400
3A	317	98	1,246	4,000
3B	686	194	2,088	7,400
3C	991	307	3,247	10,500
3D	306	97	1,166	3,700
4A	345	93	1,727	6,400
4B	571	162	1,983	7,000
4C	535	199	1,856	5,000
4D	620	192	2,236	7,200
4E	791	256	2,243	6,900
5A	302	110	1,696	4,600
5B	1,208	446	4,233	11,500
5C	791	278	4,773	13,600
5D	239	100	2,176	5,200
UNK[2]			9	30
STATE	**14,551**	**4,569**	**54,404**	**174,530**

[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, 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 35% (Range: 30% to 47%), Antlerless 31% (Range: 21% to 42%)

- Majority of deer were reported online. 60% of deer harvest reports were online, 35% 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 15% from 2014-15.

- Age structure of this year's harvest was 41% 1.5 year old bucks and 59% 2.5 year old and older bucks. This is the highest percentage of adult bucks in the harvest in decades.

- 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

- Antlerless hunting opportunities were reduced for 2015-16 (i.e., shorter concurrent firearms seasons, fewer antlerless licenses) and the harvest decreased.

- Age structure of this year's harvest was 63% adult females, 20% 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.