

Pennsylvania
2014-15 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 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.

Literature Cited

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HARVEST ESTIMATES, 2014-15 (not including DMAP)

Overall Harvests

WMU	ANTLERED	ANTLERLESS	TOTAL
1A	5,100	10,800	15,900
1B	5,800	8,800	14,600
2A	5,100	9,600	14,700
2B	4,300	13,000	17,300
2C	7,000	9,029	16,029
2D	11,400	16,400	27,800
2E	4,400	5,600	10,000
2F	6,000	5,900	11,900
2G	4,800	4,700	9,500
2H	1,700	1,100	2,800
3A	3,300	4,300	7,600
3B	6,000	8,100	14,100
3C	6,500	10,300	16,800
3D	4,200	5,200	9,400
4A	3,300	6,805	10,105
4B	4,600	5,600	10,200
4C	4,800	5,000	9,800
4D	6,500	6,848	13,348
4E	5,800	5,900	11,700
5A	2,400	3,300	5,700
5B	6,900	12,400	19,300
5C	8,000	22,200	30,200
5D	1,300	3,800	5,100
UNK	60	31	91
TOTAL	119,260	184,713	303,973

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

Archery Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	4,670	2,320	2,350
1B	3,610	2,270	1,340
2A	3,960	1,940	2,020
2B	9,670	3,060	6,610
2C	4,516	2,740	1,776
2D	7,160	4,510	2,650
2E	2,240	1,460	780
2F	2,690	1,730	960
2G	1,900	1,050	850
2H	520	380	140
3A	1,410	870	540
3B	3,450	1,950	1,500
3C	3,440	1,660	1,780
3D	2,310	1,350	960
4A	1,797	740	1,057
4B	2,840	1,650	1,190
4C	3,080	1,840	1,240
4D	3,276	1,920	1,356
4E	3,140	2,070	1,070
5A	1,680	960	720
5B	7,650	3,730	3,920
5C	15,000	4,790	10,210
5D	3,720	990	2,730
UNK	40	40	0
STATE	93,769	46,020	47,749

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

Muzzleloader Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	1,130	80	1,050
1B	590	30	560
2A	1,340	60	1,280
2B	930	40	890
2C	1,100	60	1,040
2D	2,240	90	2,150
2E	760	40	720
2F	910	70	840
2G	900	50	850
2H	180	20	160
3A	490	30	460
3B	1,250	50	1,200
3C	1,460	40	1,420
3D	490	50	440
4A	1,156	60	1,096
4B	760	50	710
4C	720	60	660
4D	993	80	913
4E	660	30	630
5A	420	40	380
5B	1,250	70	1,180
5C	1,600	110	1,490
5D	80	10	70
UNK	0	0	0
STATE	21,409	1,220	20,189

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

ANNUAL CHANGES

Overall Harvests

WMU	2013-14	2014-15	% Change
1A	20,300	15,900	-22%
1B	17,600	14,600	-17%
2A	20,000	14,700	-27%
2B	19,600	17,300	-12%
2C	18,200	16,029	-12%
2D	35,300	27,800	-21%
2E	12,900	10,000	-22%
2F	14,600	11,900	-18%
2G	11,900	9,500	-20%
2H	3,200	2,800	-13%
3A	9,600	7,600	-21%
3B	14,900	14,100	-5%
3C	19,700	16,800	-15%
3D	8,400	9,400	12%
4A	11,000	10,105	-8%
4B	11,100	10,200	-8%
4C	12,100	9,800	-19%
4D	15,400	13,348	-13%
4E	14,000	11,700	-16%
5A	6,900	5,700	-17%
5B	20,200	19,300	-4%
5C	29,800	30,200	1%
5D	6,100	5,100	-16%
UNK	120	91	-24%
STATE	352,920	303,973	-14%

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

Antlered Harvests

WMU	2013-14	2014-15	% Change
1A	6,400	5,100	-20%
1B	6,800	5,800	-15%
2A	6,800	5,100	-25%
2B	5,600	4,300	-23%
2C	7,200	7,000	-3%
2D	13,700	11,400	-17%
2E	4,900	4,400	-10%
2F	6,600	6,000	-9%
2G	5,000	4,800	-4%
2H	1,500	1,700	13%
3A	4,200	3,300	-21%
3B	6,200	6,000	-3%
3C	7,000	6,500	-7%
3D	3,400	4,200	24%
4A	5,000	3,300	-34%
4B	5,300	4,600	-13%
4C	5,200	4,800	-8%
4D	7,200	6,500	-10%
4E	6,300	5,800	-8%
5A	2,800	2,400	-14%
5B	7,400	6,900	-7%
5C	8,100	8,000	-1%
5D	1,600	1,300	-19%
UNK	80	60	-25%
STATE	134,280	119,260	-11%

Antlerless Harvests

WMU	2013-14	2014-15	% Change
1A	13,900	10,800	-22%
1B	10,800	8,800	-19%
2A	13,200	9,600	-27%
2B	14,000	13,000	-7%
2C	11,000	9,029	-18%
2D	21,600	16,400	-24%
2E	8,000	5,600	-30%
2F	8,000	5,900	-26%
2G	6,900	4,700	-32%
2H	1,700	1,100	-35%
3A	5,400	4,300	-20%
3B	8,700	8,100	-7%
3C	12,700	10,300	-19%
3D	5,000	5,200	4%
4A	6,000	6,805	13%
4B	5,800	5,600	-3%
4C	6,900	5,000	-28%
4D	8,200	6,848	-16%
4E	7,700	5,900	-23%
5A	4,100	3,300	-20%
5B	12,800	12,400	-3%
5C	21,700	22,200	2%
5D	4,500	3,800	-16%
UNK	40	31	-23%
STATE	218,640	184,713	-16%

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	251	84	1,730	5,100
1B	571	180	1,824	5,800
2A	378	125	1,705	5,100
2B	102	38	1,615	4,300
2C	498	190	2,685	7,000
2D	593	192	3,709	11,400
2E	363	124	1,524	4,400
2F	599	214	2,142	6,000
2G	416	172	2,007	4,800
2H	72	25	594	1,700
3A	265	99	1,243	3,300
3B	533	179	2,035	6,000
3C	660	261	2,586	6,500
3D	354	136	1,603	4,200
4A	284	119	1,396	3,300
4B	354	138	1,805	4,600
4C	423	189	2,164	4,800
4D	462	162	2,274	6,500
4E	516	201	2,284	5,800
5A	86	35	983	2,400
5B	348	127	2,533	6,900
5C	355	135	3,069	8,000
5D	37	15	554	1,300
UNK ²			23	60
STATE	8,520	3,140	44,087	119,260

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	746	231	3,351	10,800
1B	1,563	435	2,449	8,800
2A	842	226	2,579	9,600
2B	543	123	3,000	13,000
2C	915	303	2,839	8,600
2D	1,491	492	5,432	16,400
2E	548	162	1,660	5,600
2F	662	209	1,873	5,900
2G	305	96	1,480	4,700
2H	56	21	410	1,100
3A	501	178	1,516	4,300
3B	676	198	2,367	8,100
3C	680	207	3,146	10,300
3D	539	206	1,994	5,200
4A	288	84	1,469	5,000
4B	492	172	1,975	5,600
4C	514	197	1,920	5,000
4D	498	162	2,150	6,600
4E	641	212	1,963	5,900
5A	263	118	1,479	3,300
5B	1,088	365	4,156	12,400
5C	1,209	391	7,176	22,200
5D	149	60	1,540	3,800
UNK ²			9	30
STATE	15,209	4,848	57,933	182,230

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 increased slightly.** Antlered 37% (Range: 32% to 45%), Antlerless 32% (Range: 23% to 45%)
- **Majority of deer were reported online and this increase by 2%.** 59% 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 nearly 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. These count data are then plugged into the 'mark-recapture' equation to estimate the harvest.
- 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 decreased 11% from 2013-14. Antlered harvest during the 3 days with highest participation during the firearms season dropped by nearly 12,000. The remainder of the rifle season was similar to 2013-14.
- Age structure of this year's harvest was 43% 1.5 year old bucks and 57% 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 2014-15 (i.e., shorter concurrent firearms seasons, fewer antlerless licenses) and the harvest decreased. Based on these changes, a decrease of about 12% was expected in the antlerless harvest. Actual decrease was 16%.

- Similar to the antlered harvest, the antlerless harvest was about 21,000 fewer on the 1st Saturday of the firearms season.
- Age structure of this year's harvest was 61% adult females, 20% button bucks, and 18% 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.