

Pennsylvania
2013-14 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.

Literature Cited

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HARVEST ESTIMATES, 2013-14 (not including DMAP)

Overall Harvests

WMU	ANTLERED	ANTLERLESS	TOTAL
1A	6,400	13,900	20,300
1B	6,800	10,800	17,600
2A	6,800	13,200	20,000
2B	5,600	14,000	19,600
2C	7,200	11,000	18,200
2D	13,700	21,600	35,300
2E	4,900	8,000	12,900
2F	6,600	8,000	14,600
2G	5,000	6,900	11,900
2H	1,500	1,700	3,200
3A	4,200	5,400	9,600
3B	6,200	8,700	14,900
3C	7,000	12,700	19,700
3D	3,400	5,000	8,400
4A	5,000	6,000	11,000
4B	5,300	5,800	11,100
4C	5,200	6,900	12,100
4D	7,200	8,200	15,400
4E	6,300	7,700	14,000
5A	2,800	4,100	6,900
5B	7,400	12,800	20,200
5C	8,100	21,700	29,800
5D	1,600	4,500	6,100
UNK	80	40	120
STATE	134,280	218,640	352,920

Archery Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	5,180	2,730	2,450
1B	3,910	2,380	1,530
2A	4,220	2,160	2,060
2B	9,750	3,740	6,010
2C	4,880	2,730	2,150
2D	7,900	4,960	2,940
2E	2,580	1,570	1,010
2F	2,730	1,660	1,070
2G	2,350	1,180	1,170
2H	580	290	290
3A	1,700	1,080	620
3B	3,860	2,040	1,820
3C	4,180	1,950	2,230
3D	2,300	1,170	1,130
4A	1,500	900	600
4B	2,730	1,650	1,080
4C	3,790	2,250	1,540
4D	3,610	1,950	1,660
4E	3,890	2,240	1,650
5A	1,820	970	850
5B	7,760	4,030	3,730
5C	14,950	5,110	9,840
5D	4,440	1,300	3,140
UNK	90	80	10
STATE	100,700	50,120	50,580

Muzzleloader Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	1,320	70	1,250
1B	690	20	670
2A	1,680	40	1,640
2B	1,050	60	990
2C	1,620	70	1,550
2D	2,800	140	2,660
2E	1,220	30	1,190
2F	1,270	40	1,230
2G	1,450	20	1,430
2H	320	10	310
3A	700	20	680
3B	1,550	60	1,490
3C	2,020	50	1,970
3D	700	30	670
4A	900	100	800
4B	870	50	820
4C	910	50	860
4D	1,190	50	1,140
4E	1,110	60	1,050
5A	580	30	550
5B	1,340	70	1,270
5C	1,850	90	1,760
5D	160	0	160
UNK	0	0	0
STATE	27,300	1,160	26,140

ANNUAL CHANGES

Overall Harvests

WMU	2012-13	2013-14	% Change
1A	18,000	20,300	13%
1B	18,100	17,600	-3%
2A	19,400	20,000	3%
2B	20,800	19,600	-6%
2C	18,400	18,200	-1%
2D	34,500	35,300	2%
2E	10,400	12,900	24%
2F	13,200	14,600	11%
2G	10,000	11,900	19%
2H	3,100	3,200	3%
3A	11,000	9,600	-13%
3B	14,500	14,900	3%
3C	18,400	19,700	7%
3D	10,000	8,400	-16%
4A	10,700	11,000	3%
4B	11,200	11,100	-1%
4C	13,100	12,100	-8%
4D	13,200	15,400	17%
4E	11,100	14,000	26%
5A	6,400	6,900	8%
5B	21,000	20,200	-4%
5C	31,400	29,800	-5%
5D	5,100	6,100	20%
UNK	110	120	9%
STATE	343,110	352,920	3%

Antlered Harvests

WMU	2012-13	2013-14	% Change
1A	6,100	6,400	5%
1B	7,000	6,800	-3%
2A	6,700	6,800	1%
2B	4,800	5,600	17%
2C	7,600	7,200	-5%
2D	13,700	13,700	0%
2E	4,800	4,900	7%
2F	7,100	6,600	-7%
2G	5,000	5,000	0%
2H	1,700	1,500	-12%
3A	4,300	4,200	0%
3B	5,800	6,200	7%
3C	7,900	7,000	-11%
3D	4,000	3,400	-15%
4A	4,200	5,000	19%
4B	5,600	5,300	-5%
4C	5,300	5,200	-2%
4D	6,900	7,200	3%
4E	5,000	6,300	26%
5A	2,800	2,800	0%
5B	8,500	7,400	-13%
5C	7,800	8,100	4%
5D	1,300	1,600	23%
UNK	60	80	60%
STATE¹	133,860	134,280	0%

¹ – WMU estimates do not sum to state estimate from 2012-13 due to rounding and the splitting of WMU 2G into 2G and 2H.

Antlerless Harvests

WMU	2012-13	2013-14	% Change
1A	11,900	13,900	17%
1B	11,100	10,800	-3%
2A	12,700	13,200	4%
2B	16,000	14,000	-13%
2C	10,800	11,000	2%
2D	20,800	21,600	4%
2E	5,600	8,000	43%
2F	6,100	8,000	27%
2G	5,000	6,900	38%
2H	1,400	1,700	21%
3A	6,700	5,400	-19%
3B	8,700	8,700	0%
3C	10,500	12,700	21%
3D	6,000	5,000	-17%
4A	6,500	6,000	-8%
4B	5,600	5,800	4%
4C	7,800	6,900	-12%
4D	6,300	8,200	30%
4E	6,100	7,700	26%
5A	3,600	4,100	14%
5B	12,500	12,800	2%
5C	23,600	21,700	-8%
5D	3,800	4,500	18%
UNK	50	40	-20%
STATE	209,250	218,640	4%

[†] – WMU estimates do not sum to state estimate from 2012-13 due to rounding and the splitting of WMU 2G into 2G and 2H.

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	249	75	1,951	6,400
1B	667	192	1,974	6,800
2A	392	110	1,930	6,800
2B	139	38	1,562	5,600
2C	559	196	2,539	7,200
2D	624	179	3,946	13,700
2E	385	126	1,606	4,900
2F	745	259	2,302	6,600
2G	419	177	2,126	5,000
2H	72	31	646	1,500
3A	366	119	1,365	4,200
3B	505	166	2,030	6,200
3C	658	231	2,465	7,000
3D	271	112	1,431	3,400
4A	382	109	1,424	5,000
4B	386	136	1,880	5,300
4C	367	140	1,984	5,200
4D	635	224	2,534	7,200
4E	530	183	2,178	6,300
5A	140	50	1,021	2,800
5B	368	137	2,783	7,400
5C	379	145	3,110	8,100
5D	29	9	529	1,600
UNK ²			28	80
STATE	9,267	3,144	45,344	134,280

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	933	286	4,275	13,900
1B	1,831	482	2,836	10,800
2A	793	176	2,951	13,200
2B	553	117	3,064	14,000
2C	852	247	3,185	11,000
2D	1,171	333	6,159	21,600
2E	445	106	1,912	8,000
2F	672	199	2,379	8,000
2G	326	106	2,251	6,900
2H	63	20	543	1,700
3A	581	195	1,828	5,400
3B	692	209	2,641	8,700
3C	773	216	3,555	12,700
3D	465	180	1,936	5,000
4A	594	187	1,889	6,000
4B	508	172	1,960	5,800
4C	674	210	2,163	6,900
4D	540	166	2,538	8,200
4E	634	193	2,354	7,700
5A	267	98	1,513	4,100
5B	1,153	382	4,263	12,800
5C	1,232	390	6,884	21,700
5D	172	60	1,580	4,500
UNK ²			12	40
STATE	15,924	4,730	64,671	218,640

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

COMMENTS

- Reporting rates; Antlered 34% (Range: 27% to 43%), Antlerless 30% (Range: 21% to 39%)
- 57% of deer harvest reports were online, 39% were on report cards, and 4% were by phone (Does not include DMAP harvests).
- Harvest estimates are based on more than 25,000 deer checked by Game Commission personnel and more than 110,000 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

- Overall antlered harvest is similar to 2012-13.
- Age structure of this year's harvest was 47% 1.5 year old bucks and 53% 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

- 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.
- Age structure of this year's harvest was 62% adult females, 21% button bucks, and 18% doe fawns. This is similar to long term averages.