

2012-13 Deer Harvest Estimates



March 2013

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:

$$H = \frac{N_{RC}}{r_{3-year}} ; \quad (1)$$

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;

$$Var(\hat{H}) = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)}; \quad (3)$$

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

- Chao, A. 1989. Estimating population size for sparse data in capture-recapture experiments. *Biometrics* 45:427-438.
- Chapman, D. G.. 1951. Some properties of the hypergeometric distribution with applications to zoological censuses. *University of California Publications on Statistics* 1:131-160.
- Nichols, J. D. and C. R. Dickman. 1996. Capture-recapture methods in Measuring and monitoring biological diversity: standard methods for mammals. D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster editors. Smithsonian Institution Press, Washington D.C.
- Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990. Statistical inference for capture-recapture experiments. *Wildlife Monographs* 107.
- Rexstad, E. A. and K. P. Burnham. 1992. User's guide for interactive Program CAPTURE. Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, Colorado.
- Rosenberry, C. S., D. R. Diefenbach, and B. D. Wallingford. 2004. Reporting rate variability and precision of white-tailed deer harvest estimates in Pennsylvania. *Journal of Wildlife Management* 68:860-869.
- Seber, G. A. F. 1982. The estimation of animal abundance and related parameters, Second edition. Charles Griffin and Company LTD. London.
- Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, New York, New York.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations. Academic Press, New York, New York.

Special Note: Adams/York CWD DMA check station deer

Deer harvests in WMUs 5A and 5B are based on estimates from all checked deer (i.e., 500A data) and deer reported via report cards, online, and phone PLUS some deer taken to the check station.

The decision to use all deer checked and/or reported via 500A and regular reporting methods is based on an analysis that showed reporting rates were not different between deer checked and/or reported from townships inside and outside the DMA.

Overall antlered and antlerless harvests do include deer taken to the check station that were not reported by regular methods (i.e., report cards, online, or phone).

For example:

WMU 5A Antlered Harvest

2,567 antlered deer (point estimate) + 228 antlered deer (taken to check station and not reported elsewhere) = 2,795; after rounding antlered harvest estimate is 2,800.

WMU 5A Antlerless Harvest

3,347 antlerless deer (point estimate) + 249 antlerless deer (taken to check station and not reported elsewhere) = 3,596; after rounding antlerless harvest estimate is 3,600.

WMU 5B Antlered Harvest

8,098 antlered deer (point estimate) + 405 antlered deer (taken to check station and not reported elsewhere) = 8,503; after rounding antlered harvest estimate is 8,500.

WMU 5B Antlerless Harvest

11,948 antlerless deer (point estimate) + 571 antlerless deer (taken to check station and not reported elsewhere) = 12,519; after rounding antlerless harvest estimate is 12,500.

Season-specific harvests (i.e., archery and muzzleloader) do not include check station deer.

HARVEST ESTIMATES, 2012-13 (not including DMAP)

Overall Harvests

WMU	ANTLERED	ANTLERLESS	TOTAL
1A	6,100	11,900	18,000
1B	7,000	11,100	18,100
2A	6,700	12,700	19,400
2B	4,800	16,000	20,800
2C	7,600	10,800	18,400
2D	13,700	20,800	34,500
2E	4,800	5,600	10,400
2F	7,100	6,100	13,200
2G	6,600	6,500	13,100
3A	4,300	6,700	11,000
3B	5,800	8,700	14,500
3C	7,900	10,500	18,400
3D	4,000	6,000	10,000
4A	4,200	6,500	10,700
4B	5,600	5,600	11,200
4C	5,300	7,800	13,100
4D	6,900	6,300	13,200
4E	5,000	6,100	11,100
5A ¹	2,800	3,600	6,400
5B ¹	8,500	12,500	21,000
5C	7,800	23,600	31,400
5D	1,300	3,800	5,100
UNK	60	50	110
STATE	133,860	209,250	343,110

¹ – These estimates include deer taken to CWD DMA check station.

Archery Harvests

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	4,520	2,300	2,220
1B	3,730	2,250	1,480
2A	4,290	1,970	2,320
2B	9,840	2,800	7,040
2C	4,380	2,220	2,160
2D	7,390	4,480	2,910
2E	1,900	1,160	740
2F	2,340	1,550	790
2G	2,340	1,250	1,090
3A	1,630	880	750
3B	2,980	1,450	1,530
3C	3,500	1,840	1,660
3D	2,250	1,080	1,170
4A	1,310	660	650
4B	2,590	1,480	1,110
4C	3,340	1,850	1,490
4D	2,640	1,450	1,190
4E	2,750	1,550	1,200
5A ¹	1,410	780	630
5B ¹	7,720	4,020	3,700
5C	13,540	4,170	9,370
5D	3,490	970	2,520
UNK	70	60	10
STATE	89,950	42,220	47,730

¹ - Deer only taken to the check station in the CWD DMA not included.

Muzzleloader Harveys

WMU	TOTAL	ANTLERED	ANTLERLESS
1A	1,480	100	1,380
1B	970	50	920
2A	2,110	30	2,080
2B	1,160	100	1,060
2C	1,720	80	1,640
2D	3,410	120	3,290
2E	1,000	40	960
2F	1,160	50	1,110
2G	1,460	50	1,410
3A	870	20	850
3B	1,720	50	1,670
3C	2,000	60	1,940
3D	750	20	730
4A	790	40	750
4B	910	20	890
4C	860	50	810
4D	1,060	50	1,010
4E	1,050	50	1,000
5A ¹	390	20	370
5B ¹	1,380	80	1,300
5C	1,560	130	1,430
5D	110	30	80
UNK	20	0	20
STATE	27,940	1,240	26,700

¹ - Deer only taken to the check station in the CWD DMA not included.

ANNUAL CHANGES

Overall Harvests

WMU	2011-12	2012-13	% Change
1A	15,000	18,000	20%
1B	15,500	18,100	17%
2A	19,800	19,400	-2%
2B	21,500	20,800	-3%
2C	21,000	18,400	-12%
2D	30,400	34,500	13%
2E	11,200	10,400	-7%
2F	12,100	13,200	9%
2G	11,800	13,100	11%
3A	10,000	11,000	10%
3B	13,600	14,500	7%
3C	17,000	18,400	8%
3D	11,700	10,000	-15%
4A	11,300	10,700	-5%
4B	10,800	11,200	4%
4C	12,900	13,100	2%
4D	13,700	13,200	-4%
4E	11,200	11,100	-1%
5A ¹	7,200	6,400	-11%
5B ¹	20,100	21,000	4%
5C	33,100	31,400	-5%
5D	5,000	5,100	2%
UNK	300	110	-63%
STATE	336,200	343,110	2%

¹ - These estimates include deer taken to CWD DMA check station.

Antlered Harvests

WMU	2011-12	2012-13	% Change
1A	5,200	6,100	17%
1B	6,000	7,000	17%
2A	7,100	6,700	-6%
2B	4,500	4,800	7%
2C	8,200	7,600	-7%
2D	11,100	13,700	23%
2E	4,100	4,800	17%
2F	5,400	7,100	31%
2G	6,300	6,600	5%
3A	3,300	4,300	30%
3B	5,900	5,800	-2%
3C	7,100	7,900	11%
3D	4,500	4,000	-11%
4A	4,800	4,200	-13%
4B	5,300	5,600	6%
4C	5,500	5,300	-4%
4D	7,100	6,900	-3%
4E	5,100	5,000	-2%
5A ¹	3,600	2,800	-22%
5B ¹	7,200	8,500	18%
5C	8,900	7,800	-12%
5D	1,200	1,300	8%
UNK	140	60	-57%
STATE	127,540	133,860	5%

¹ - These estimates include deer taken to CWD DMA check station.

Antlerless Harvests

WMU	2011-12	2012-13	% Change
1A	9,800	11,900	21%
1B	9,500	11,100	17%
2A	12,700	12,700	0%
2B	17,000	16,000	-6%
2C	12,800	10,800	-16%
2D	19,300	20,800	8%
2E	7,100	5,600	-21%
2F	6,700	6,100	-9%
2G	5,500	6,500	18%
3A	6,700	6,700	0%
3B	7,700	8,700	13%
3C	9,900	10,500	6%
3D	7,200	6,000	-17%
4A	6,500	6,500	0%
4B	5,500	5,600	2%
4C	7,400	7,800	5%
4D	6,600	6,300	-5%
4E	6,100	6,100	0%
5A ¹	3,600	3,600	0%
5B ¹	12,900	12,500	-3%
5C	24,200	23,600	-2%
5D	3,800	3,800	0%
UNK	160	50	-69%
STATE	208,660	209,250	0%

¹ – These estimates include deer taken to CWD DMA check station.

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	343	112	1996	6,100
1B	715	205	2007	7,000
2A	321	98	2054	6,700
2B	150	50	1633	4,800
2C	591	223	2875	7,600
2D	643	196	4178	13,700
2E	356	127	1715	4,800
2F	686	218	2275	7,100
2G	613	269	2886	6,600
3A	425	152	1536	4,300
3B	525	190	2088	5,800
3C	742	263	2790	7,900
3D	454	180	1606	4,000
4A	317	115	1548	4,200
4B	461	162	1983	5,600
4C	432	178	2205	5,300
4D	563	210	2589	6,900
4E	511	221	2150	5,000
5A ³	135	57	1094	2,600
5B ³	438	153	2840	8,100
5C	499	206	3239	7,800
5D	45	17	518	1,300
UNK ²			20	60
STATE	9,965	3,602	47,825	133,260

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

³ - Deer only taken to the check station in the CWD DMA not included.

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	858	252	3492	11,900
1B	1911	505	2933	11,100
2A	789	172	2779	12,700
2B	453	95	3373	16,000
2C	882	263	3235	10,800
2D	1293	350	5652	20,800
2E	384	113	1646	5,600
2F	521	148	1731	6,100
2G	411	137	2165	6,500
3A	701	210	2005	6,700
3B	608	148	2128	8,700
3C	828	250	3181	10,500
3D	642	231	2168	6,000
4A	553	183	2146	6,500
4B	419	139	1878	5,600
4C	851	293	2699	7,800
4D	425	138	2063	6,300
4E	602	206	2086	6,100
5A ³	236	102	1454	3,300
5B ³	1123	389	4145	11,900
5C	1252	380	7190	23,600
5D	160	62	1473	3,800
UNK ²			15	50
STATE	15,902	4,766	61,637	208,350

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

³ - Deer only taken to the check station in the CWD DMA not included.

COMMENTS

- Be sure to look at footnotes regarding harvests in WMUs 5A and 5B. For overall harvest estimates, deer taken to the check station and not reported elsewhere are added to harvest estimates. For season-specific harvests, this is based only on deer reported via report card, online, or phone. Check station deer are not included in season-specific harvests.
- Reporting rates; Antlered 36% (Range: 29% to 44%), Antlerless 30% (Range: 21% to 43%)
- XX% of deer harvest reports were online, XX% were on report cards, and X% 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 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

- This year's antlered harvest is slightly above the average harvest since 2005 when efforts began to stabilize deer populations in most of the state.
- Age structure of this year's harvest was 49% 1.5 year old bucks and 51% 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 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 61% adult females, 22% button bucks, and 18% doe fawns. This is similar to long term averages.