PENNSYLVANIA GAME COMMISSION
BUREAU OF WILDLIFE MANAGEMENT
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TITLE: White-tailed Deer Research/Management

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TITLE: Estimating Management Unit Deer Population Sizes & Growth Rates

PERIOD COVERED: 1 July 2004 through 30 June 2005

COOPERATING AGENCIES: None

WORK LOCATION(S): Statewide

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Abstract: We estimated reproductive parameters using road-killed does, and deer harvests by management unit using sex and age of harvested deer, license numbers of successful hunters, and reported harvests. Deer Management Assistance Program (DMAP) harvests were based on report cards from participants. Wildlife Conservation Officers (WCOs) also conducted winter deer mortality surveys along predetermined routes in their respective districts. Three hundred fifty-four does examined between 1 February and 31 May 2004, were used to determine conception and fawning dates. The average reproductive rate was 0.98 embryos/doe with the median conception date of 15 November. The median projected birth date was 31 May. In the past year, 2 evaluations of population and harvest estimation procedures were completed. Population estimates for 2004 were not included in this report due to weaknesses discovered in the modeling procedures during evaluation. In the absence of population estimates, an index to population abundance was used to assess deer population trends. Population indices indicated population declines in most Wildlife Management Units (WMUs). The internal evaluation of harvest estimation procedures was submitted for an independent, scientific review to the *Journal of Wildlife Management*. Based on this review, harvest estimation procedures were revised to provide important measures of precision of harvest estimates. Hunters harvested 409,320 deer (124,410 antlered and 284,910 antlerless) in the 2004-05 deer seasons. Statewide, WCOs found 0.16 dead deer/mile on winter survey routes in 2005. Approximately 2,691 square miles of land were enrolled in the expanded Deer Management Assistance Program. The PGC issued 47,807 DMAP coupons, of which 34,310 were redeemed for DMAP licenses. About 81% of DMAP permit holders submitted their mandatory report card. Hunters using DMAP reported harvesting 7,932 antlerless deer. We recommend developing a new procedure for estimating deer populations, continuing the regular, concurrent antlered and antlerless firearms season, continuing antler restrictions to allow a rigorous evaluation of their effects on deer populations and hunter support, and allowing hunters to purchase and use the entire antlerless allocation without regard to individual limits.

OBJECTIVE

To determine deer population sizes and harvest recommendations by management unit.

METHODS

To obtain data on reproduction by age class, WCOs examined female deer killed by various causes from 1 February through 31 May 2004. They recorded location (county, township, and WMU), date killed, cause of death, and number and sex of embryos for each doe on a form attached to a deer jaw envelope. They measured embryos so that we could determine conception and projected birth dates and removed 1 side of the lower jaw from each deer for age determination. Jaws were forwarded to wildlife biologists who made the age assignments in July 2004. Personnel in the Bureau of Automated Technology Services (BATS) processed the reproductive data and provided summary reports for the state and each WMU. During the 2004 rifle seasons for deer, 32 data collection teams examined deer in assigned areas. Each team collected data for 3 days during the first week of the regular firearms season, 2 days during the second week of the season, and 2 days after the close of the season. Data collected included age, sex, location of harvest (e.g., WMU, county, and township), and hunting license number from ear tags. Deer teams determined deer age as fawn (6 months old), yearling (18 months old) or adult (at least 30 months old) using tooth wear and replacement (Severinghaus 1949). Data collection teams also recorded points of antlers to determine antler characteristics by age class.

BATS personnel entered and processed data from these biological collections and from 2004-2005 deer harvest report cards submitted by hunters. BATS also provided a PC download for population analysis. For each WMU the download included: the number of antlered and antlerless deer checked by aging teams, the number of antlered and antlerless deer checked by deer aging teams and reported by hunters, the total number of antlered and antlerless deer reported by hunters, reporting rates, age and sex breakdowns of the harvest, reproductive data, and reported regular firearms, muzzleloader, and archery harvests.

Based on evaluations of population modeling and harvest estimating procedures, a number of changes occurred in 2004-05. First, a review of the population model developed in 2002 uncovered areas that could have been improved to provide more accurate population estimates. As a result, population estimates are not included in this report nor were they used in management decisions. In the absence of population estimates, catch-per-unit-effort (CPUE) methods (Roseberry and Wolff 1991) were used to monitor WMU population trends. This analysis used antlerless hunter success (i.e., antlerless harvest divided by antlerless licenses). These data were the most reliable data available because antlerless licenses were known from license sales and antlerless harvests had high precision (CVs <8%). Only 2 years of WMU data were available for trends because WMUs were first established for the 2003-04 hunting season. We did not attempt to convert pre-2003 county allocations to WMUs due to known potential for errors in these conversions.

Second, a recent evaluation validated the science behind the PGC's method of estimating deer harvests using report cards and reporting rates (Rosenberry et al. 2004). Based on results of this evaluation, we refined the method of estimating deer harvests for the 2004-05 hunting seasons. The new method no longer calculates a harvest estimate based on reporting rates from 3-year running averages. Rather, it estimates an annual harvest based on year-specific data. In addition, the new method provides a harvest estimate with appropriate measures of precision (e.g., variance, standard error, coefficient of variation). This additional information permits an evaluation of the precision of deer harvest estimates that was not possible in the past.

Harvests were estimated using mark-recapture methods. When estimating deer harvests, a closed, 2-sample Lincoln-Petersen estimator was used. Deer were

considered marked when they were checked in the field by deer aging teams. Recapture occurred when marked deer were reported on report cards sent in by hunters.

Assumption of the Lincoln-Petersen Estimator

Assumption 1. The sampled population is closed.-- The sampled population was the annual deer harvest. Additions to this population occur throughout the hunting seasons; however, once the marked sample is completed, the marked sample will not change. Additions only occur as unmarked animals continued to be reported throughout the deer hunting seasons. As a result, the closure assumption was relaxed and the Lincoln-Petersen estimator remains valid for estimating the harvest once all report cards were tallied (Pollock et al. 1990).

Assumption 2. All animals are equally likely to be captured in each sample.-- 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 were equally likely to be included in each sample referred to a harvested deer's chance of being in both the marked sample and reported sample. Our marking procedures at processors and other specific locations did 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 was representative of the harvest and therefore should not bias our results (Rosenberry et al. 2004).

One known problem with reporting rates was 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, effect on the overall harvest estimate was minimal because most deer were harvested during the regular firearms season (Rosenberry et al. 2004).

Assumption 3. Marks are neither lost nor incorrectly recorded.-- This assumption was met because once an animal is marked, it cannot lose its mark because its has been recorded and entered into a database.

Based on the assumptions of the Lincoln-Petersen estimator and the characteristics of our samples, the Lincoln-Petersen estimator was an appropriate method for estimating deer harvests.

Because reporting rates in Pennsylvania vary by year, antlered and antlerless deer, and management unit (Rosenberry et al. 2004), deer harvest estimates were calculated for antlered and antlerless deer in each WMU using Chapman's (1951) modified Lincoln-Petersen estimator;

$$\hat{H} = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1;$$ (1)

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).

In late March and early April, WCOs conducted winter deer mortality surveys in their assigned districts. Each WCO walked 3 1.5-mile routes along stream

bottoms to locate possible winter losses. They recorded the sex and age of all dead deer found and submitted the data to their respective region biologists. Region biologists converted data to a deer/mile index and forwarded the information to us to compare with previous winter loss indices.

In 2004, the Deer Management Assistance Program (DMAP) was expanded to public landowners, private landowners who do not charge a fee to hunt, and hunting clubs of 1,000 or more acres that were established prior to 1 January 2000. This program provides landowners with a tool to increase antlerless deer harvests to meet individual landowner land management goals. Applications were received by 1 July 2004, and reviewed by Wildlife Management staff in early July.

RESULTS

WCOs examined 601 females during the 2004 pre-fawning season. Three hundred and fifty-four were pregnant and 342 were usable for determining conception dates. Fourteen percent of the fawns, and 89 percent of the adults were pregnant. Pregnant fawns averaged 1.15 embryos/doe. Pregnant adults averaged 1.72 embryos/doe. The average reproductive rates for pregnant and barren fawns and adults were 0.16 and 1.53 embryos/doe, respectively. The average reproductive rate for all females was 0.98 embryos/doe. The median conception date for all does was 15 November. Ninety percent of all breeding occurred between 16 October and 16 December (Fig. 1), with the median date fawns bred as 14 December, 1 month later than adult does. The median projected birth date for all fetuses examined was 31 May. Over the last 5 years, conception timing has changed little (Table 1).

Deer population indices in most WMUs declined from 2003 to 2004 (Table 2). However, an index may not be related to population abundance in a 1:1 ratio. In other words, if the index declines 20%, population abundance likely declined, but may not have declined exactly 20%.

Hunters harvested 409,320 deer in the 2004-05 deer seasons (Table 3). The antlered harvest was 124,410, a decrease compared to the 2003-04 harvest of 142,270. The antlerless harvest was 284,910, down from 322,620 in 2003-04. Reduced deer populations in many WMUs likely lead to declines in antlered and antlerless harvests. The 2004-05 deer season was the fourth year of concurrent deer season in Pennsylvania. With increasing experience under antler restrictions and concurrent seasons, we expect hunter behavior in harvest selection to become more consistent in future years.

Statewide, WCOs found 0.16 dead deer/mile on winter survey routes in 2005. This is a decrease over previous years, and indicates low winter loss. Index values were well below the high losses recorded in 1978 (Table 4).

Approximately 2,692 square miles of Pennsylvania land were enrolled into the PGC's DMAP in 2004-05 compared to 1,086 square miles in 2003-2004. The PGC provided 47,812 DMAP coupons to landowners of which 34,135 (72%) were redeemed for DMAP licenses. Mandatory reporting regardless of hunter success was required during the 2003-04 season and approximately 81% of DMAP hunters submitted report cards to the PGC. Hunters reported harvesting 7,946 antlerless deer with these licenses, which translates into a 23% success rate. Overall, antlerless deer harvested per square mile declined from 5.7 in 2003-04 seasons to 3.0 in 2004-05.

Several recommendations were proposed and accepted by the Commissioners at the January meeting and approved in April. Most regulations regarding seasons and bag limits for deer remained unchanged. The Deer Management Assistance Program (DMAP) was expanded to include additional landowners and issuance of 2 DMAP permits per hunter per DMAP area. Eligible lands for DMAP are: publicly-owned lands; private land owners or lessees where no fee is charged for hunting;

and private land hunting clubs established prior to 1 January 2000. Private land hunting clubs no longer need to own 1,000 or more acres.

The Board also expanded the firearms season in WMU 5C. In addition to the regular 2-week concurrent deer season, hunters in WMU 5C can use firearms for an additional 7 weeks.

Other important regulations that remain in place are a 12-day concurrent antlered and antlerless firearms season for all hunters; a 7-day antlerless muzzleloader season in October; a 3-day antlerless rifle season in October for junior, senior, disabled, and military license holders; sale of unsold antlerless licenses, up to 2 per hunter, that remain after all hunters have had an opportunity to purchase one; and field possession regulations that allow a hunter to harvest another deer after tagging the first deer harvested.

The Board also approved the 2005-2006 antlerless deer license allocation of 879,000 (Table 3). Last year, hunters purchased 1,020,974 antlerless deer licenses, which resulted in a harvest of 284,910 antlerless deer. Due to declines in population indices and uncertainty regarding how low deer population abundance had declined, we designed antlerless license allocation recommendations with the intent of stabilizing most WMU deer populations until new procedures for estimating deer populations are developed.

RECOMMENDATIONS

1.   Develop a new method for estimating management unit deer populations.

2.   Continue concurrent antlered and antlerless firearms seasons for all hunters. This provides more hunting opportunities to hunters and maintains consistency in hunting seasons that are important to monitoring population trends.

3.   Continue antler restriction regulations to allow rigorous evaluation of their effects on the deer population and changes in hunter support over time.

4.   Allow hunters to purchase and use the entire antlerless allocation without regard to individual limits.

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Table 1. Number of does examined, median conception date, percent of does bred between October 16th and December 16th, mean embryos per adult doe ($\geq$ 2 years of age), and adult doe pregnancy rates from 2000 to 2004, Pennsylvania.

Year	n	Median Conception Date	Percent (%) bred 16 October to 16 December	Mean embryos per adult doe	Adult doe pregnancy rates (%)
2000	1,075	14 November	90	1.60	90
2001	942	17 November	91	1.58	92
2002	502	14 November	86	1.64	91
2003	618	14 November	93	1.60	92
2004	601	15 November	90	1.53	89

Table 2. Changes in deer population indices in each WMU from 2003 to 2004, Pennsylvania. Index used was catch-per-unit-effort using antlerless deer harvest and antlerless allocation sold. Population index may not be related to population abundance in a 1:1 ratio (i.e. a 20% decline in index may not equal a 20% drop in population abundance.

WMU	Change (%) in Population Index
1A	−15
1B	−23
2A	− 7
2B	−23
2C	−31
2D	−12
2E	−18
2F	−23
2G	−31
3A	−17
3B	−14
3C	−10
3D	−24
4A	−22
4B	−24
4C	− 7
4D	−27
4E	− 8
5A	−12
5B	−18
5C	−17
5D	12

Table 3. 2004-05 deer harvests and 2005 antlerless licenses in each
Wildlife Management Unit (WMU), Pennsylvania.

| WMU | 2004-05 Harvest | | 2005 Antlerless |
	Antlered	Antlerless	License Allocation
1A	5,100	15,600	40,000
1B	5,400	12,000	27,000
2A	7,800	18,500	55,000
2B	4,200	16,000	68,000
2C	8,600	19,500	53,000
2D	10,500	22,100	56,000
2E	4,400	8,100	21,000
2F	6,400	13,100	30,000
2G	6,600	10,600	29,000
3A	4,200	11,600	27,000
3B	6,400	13,400	41,000
3C	6,900	13,500	32,000
3D	4,500	9,800	38,000
4A	4,100	11,000	35,000
4B	4,900	11,000	35,000
4C	5,400	12,100	39,000
4D	6,300	12,700	40,000
4E	4,100	11,000	38,000
5A	2,400	7,300	28,000
5B	7,400	14,800	56,000
5C	7,100	16,900	71,000
5D	1,300	4,200	20,000
Unknown	410	110	
Total	124,410	284,910	879,000

Table 4. Dead deer found on winter survey routes in 2005 and dead deer found/mile surveyed in 2005 and 1978 in Pennsylvania.

County	2005		Dead deer/mile	
	Miles	Dead deer	2005	1978
Adams	5.00	0	0.00	0.33
Allegheny	10.25	15	1.46	0.15
Armstrong	10.70	1	0.09	0.11
Beaver	7.00	0	0.00	0.00
Bedford	14.00	2	0.14	1.35
Berks	15.10	2	0.13	0.00
Blair	15.50	5	0.32	4.00
Bradford	17.50	3	0.17	0.81
Bucks	9.50	3	0.32	
Butler	10.20	1	0.10	0.09
Cambria	10.10	0	0.00	2.18
Cameron	5.00	2	0.40	13.60
Carbon	15.00	0	0.00	0.13
Centre	17.50	1	0.06	3.35
Chester	19.00	0	0.00	0.00
Clarion	9.00	9	1.00	1.88
Clearfield	14.50	6	0.41	5.17
Clinton	12.00	0	0.00	0.87
Columbia	11.50	4	0.35	0.83
Crawford	15.00	2	0.13	0.33
Cumberland	9.00	2	0.22	0.55
Dauphin	12.25	0	0.00	1.67
Delaware	1.50	0	0.00	
Elk	9.15	6	0.66	1.86
Erie	8.00	0	0.00	0.08
Fayette	12.00	2	0.17	0.00
Forest	12.00	1	0.08	0.42
Franklin	11.10	1	0.09	0.29
Fulton	4.50	0	0.00	0.75
Greene	9.00	6	0.67	0.83
Huntingdon	16.10	4	0.25	0.95
Indiana	11.00	1	0.09	2.16
Jefferson	11.10	4	0.36	1.00
Juniata	5.80	0	0.00	2.67
Lackawanna	9.60	1	0.10	2.24
Lancaster	13.30	0	0.00	0.00
Lawrence	4.50	0	0.00	0.33
Lebanon	6.00	0	0.00	
Lehigh	5.00	0	0.00	0.00
Luzerne	14.50	0	0.00	0.78
Lycoming	21.20	2	0.09	0.70
McKean	16.10	1	0.06	1.23
Mercer	9.50	0	0.00	0.00
Mifflin	6.25	0	0.00	0.77
Monroe	9.50	3	0.32	4.10
Montgomery	10.00	1	0.10	0.14
Montour	4.50	0	0.00	0.00
Northampton	5.90	3	0.51	
Northhumberland	4.50	0	0.00	1.67
Perry	9.00	1	0.11	1.01
Philadelphia	4.50	3	0.67	
Pike	10.00	0	0.00	4.33
Potter	20.50	3	0.15	3.69
Schuylkill	9.00	1	0.11	0.74
Snyder	5.55	0	0.00	0.63
Somerset	19.00	4	0.21	3.93
Sullivan	4.50	1	0.22	0.75
Susquehanna	10.20	1	0.10	3.97
Tioga	23.50	2	0.09	4.17
Union	6.00	0	0.00	1.09
Venango	11.90	0	0.00	0.38
Warren	20.00	2	0.10	2.10
Washington	10.25	1	0.10	0.29
Wayne	12.50	0	0.00	16.42

Table 4 (cont'd). Dead deer found on winter survey routes in 2005 and dead deer found/mile surveyed in 2005 and 1978 in Pennsylvania.

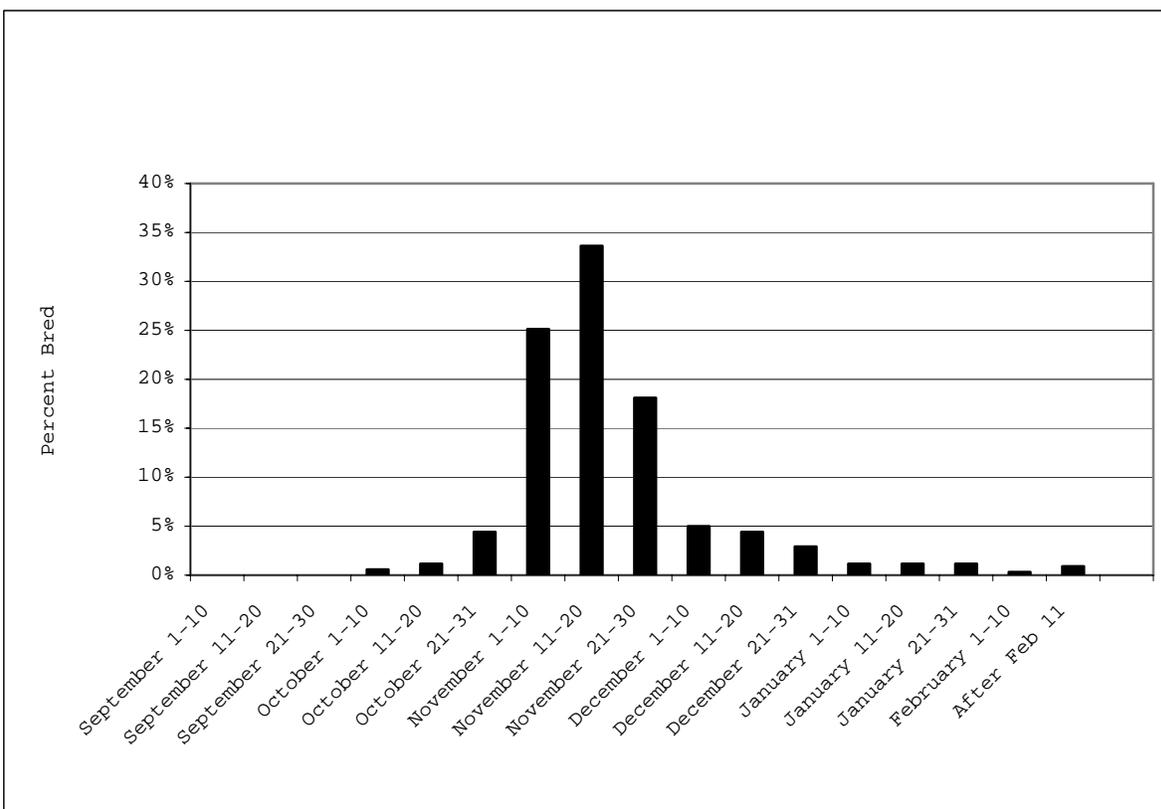|	2005		Dead deer/mile	
County	Miles	Dead deer	2005	1978
Westmoreland	14.30	1	0.07	3.03
Wyoming	4.50	0	0.00	0.00
York	21.50	1	0.05	
2005 Totals	732.90	115	0.16	
1978 Totals	686.05	1,330		1.94

Fig. 1. Conception time periods based on 342 roadkilled does, Pennsylvania, 2003.