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BUREAU OF WILDLIFE MANAGEMENT
RESEARCH DIVISION
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TITLE: White-tailed Deer Research/Management

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TITLE: Deer Health, Forest Habitat Health, Deer Harvests, and Deer Population Trends by Wildlife Management Unit (WMU)

PERIOD COVERED: 1 July 2005 through 30 June 2006

COOPERATING AGENCIES: Pennsylvania Cooperative Fish and Wildlife Research Unit (PCFWRU), Pennsylvania Department of Conservation and Natural Resources (DCNR), Pennsylvania State University (PSU), and U.S. Forest Service (USFS)

WORK LOCATION(S): Statewide

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Abstract: When adopted in June 2003, the Game Commission's deer management plan changed the way deer management goals were defined. Instead of management goals defined as density of deer in an area, management goals were defined based on deer health, habitat health, and deer-human conflicts. In 2005-06, we identified deer reproduction (i.e., embryo counts per doe and fawn pregnancy rates) as a measure for deer health, and we identified regeneration of canopy replacement tree species including species capable of achieving high canopy status as a measure for forest habitat health. New methods of monitoring deer population trends were also developed. We monitored Wildlife Management Unit (WMU) deer health, forest habitat health, and deer population trends using reproductive parameters from road-killed does, advanced tree seedling and sapling regeneration (ATSSR) from the Pennsylvania Regeneration Study, deer harvest estimates and compositions, and field studies. Deer health was judged to be good in 7 WMUs, satisfactory in 8 WMUs, poor in 5 WMUs, and uncertain in 2 WMUs. Forest habitat health was judged to be good in 1 WMU, satisfactory in 13 WMUs, and poor in 7 WMUs. Hunters harvested 354,390 deer (120,500 antlered and 233,890 antlerless) in the 2005-06 deer seasons. Deer populations in most WMUs declined from January 2001 to January 2006, but remained stable between October 2004 and October 2005. Antlerless allocations were designed to reduce the population in 3 urban/suburban WMUs, increase the population in 1 WMU, and keep the population steady in all remaining WMUs. We recommend the continuation of current regulations to monitor the deer population, and modification of antlerless allocations to change the antlerless deer harvest.

OBJECTIVE

To monitor deer health, forest habitat health, deer harvests, and deer population trends by WMU.

METHODS

Deer Health

To obtain data on deer health, Wildlife Conservation Officers examined female deer killed by various causes from 1 February through 31 May 2005. 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 Region Wildlife Management Supervisors, who along with the Deer Management Section, made the age assignments in July 2005. Personnel in the Bureau of Automated Technology Services (BATS) processed the reproductive data and provided summary reports for the state and each WMU.

Based on results from published studies (Cheatum and Severinghaus 1950, Verme 1965, Verme 1967, Verme 1969, Hesselton and Sauer 1973, Hesselton and Jackson 1974, McCullough 1979, Stoll and Parker 1986, Folk and Klinstra 1991, Osborne et al 1992, Taylor 1996, Swihart et al 1998), we defined good, satisfactory, and poor deer health as follows. For 3-year-old and older females, at least 1.7 embryos per doe was considered good, less than 1.5 embryos per doe was considered poor. For 2-year-old females, at least 1.5 embryos per doe was considered good and less than 1.1 embryos was considered poor. For 1-year-old females, if at least 30% were pregnant, deer health was considered good. If 10% or fewer were pregnant, deer health was considered poor. For all values, satisfactory falls between cutoffs for good and poor.

Due to uncertainty associated with sampling and use of generalized cutoffs based on published results, we did not expect complete agreement in reproductive assessments across age classes within a WMU. As a result, we considered reproductive measures of 3-year-old and older females as most important in assessing WMU level deer health, because this age class produces the greatest number of offspring and has the greatest effect on the population. Pregnancy rates of 1-year-old females followed 3-year-old and older embryo counts in importance because female fawn breeding stops at high population sizes (McCullough 1979). In New York, Hesselton and Jackson (1974) demonstrated that female fawns, or 1-year-old females, are most sensitive to range conditions.

Forest Habitat Health

To obtain data on forest regeneration, advanced tree seedling and sapling regeneration (ATSSR) data are collected as part of a systematic sampling scheme from public and private lands in WMUs from the Pennsylvania Regeneration Study being conducted as part of the Forest Inventory Analysis (FIA) by Pennsylvania Department of Conservation and Natural Resources (DCNR), Pennsylvania State University (PSU), and U.S. Forest Service (USFS). Subsets of all plots are collected each year, with a complete sampling of plots occurring every 5 years. ATSSR from 2 groupings of tree species are available from the Pennsylvania Regeneration Study. The measure selected for use in deer management is the grouping of dominant canopy species and species capable of achieving high canopy status. "The composition of the ATSSR has a direct impact on the future composition of the forest overstory (Marquis and others 1994). To cover the range of future forest character and client needs 2 composition groupings are used. The first groups tree species by preference for timber management. The second composition grouping represents the forest's ability to regenerate the existing dominant canopy. Dominant species include those that contribute at least 2 % of the State's total-tree biomass and are able to grow into the existing canopy; Other High Canopy species include all others that are capable of attaining canopy dominance" (McWilliams et al. 2004:13-14).

We requested ATSSR data for dominant canopy species and species capable of achieving high canopy status by WMU from the USFS and DCNR. Because of the sampling scheme used in the Pennsylvania Regeneration Study, it takes 5 years to

visit all sample plots. Based on input from cooperating agencies that designed and conduct the Pennsylvania Regeneration Study, we defined forest habitat as good if 70% or more of the sampled plots contained adequate regeneration. If less than 50% of the plots contained adequate regeneration, forest habitat health was considered poor. Satisfactory falls between cutoffs for good and poor.

Deer Harvest Estimates and Composition

To estimate deer harvests and collect data for monitoring deer population trends, 33 data collection teams examined deer in assigned areas across the state. 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 (WMU, county, and township), and hunting license number from ear tags. Deer teams determined deer age as 6 months (fawn), 18 months (yearling), or at least 30 months (adult) using tooth wear and replacement (Severinghaus 1949). Data collection teams also recorded points of antlers to determine antler characteristics by age class.

A data entry company is contracted to enter deer aging and harvest report card data. Bureau of Automated Technology Services (B.A.T.S.) validated and processed harvest data and ran harvest data analysis programs. For each WMU the analyses 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, age and sex composition of the harvest, reproductive data, and reported regular firearms, muzzleloader, and archery harvests.

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

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. This estimator is recommended (Nichols and Dickman 1996) because it has less bias than the original Lincoln-Petersen estimator (Chapman 1951).

Deer Population Trends

This year represents the first year using a modified Sex-Age-Kill (SAK) deer population monitoring procedure developed in collaboration with the PCFWRU. As we accumulate more years of data and results from on-going evaluations, refinements to this procedure will occur.

Although no longer the primary measure of deer population trends, we continue to use the antlerless hunter success index (i.e., estimated antlerless harvest divided by the number of antlerless licenses) from 2004-05 to supplement SAK population trends. In addition, an antlered harvest index (i.e., estimated antlered harvest for a WMU) is also used to supplement population trends.

We used the SAK method of population reconstruction (Eberhardt 1960, Creed et al. 1984, Skalski and Millspaugh 2002) with modifications for Pennsylvania's antler restrictions to monitor deer population trends. Modifications involve estimation of 1.5-year-old and 2.5-year-old and older male populations. Population trend monitoring relies on research data from Pennsylvania (e.g., Long et al. 2005), harvest estimates, and deer aging data. Population monitoring began

with adult males (males 1.5 years of age and older) and progressed to females and fawns.

The modified SAK procedure began by estimating males 2.5 years of age and older from harvest estimates and adult male harvest rates. Once the population of males 2.5 years of age and older were estimated, we determined the 1.5-year-old male population. Because protection levels of 1.5-year-old males varied among WMUs and harvest rates could also vary, we worked back in time to generate harvest rates for 1.5-year-old males. First, we determined the pre-hunt population of 1.5-year-old males in the preceding year using current year population estimate of 2.5-year-old males, survival rate from 1.5 to 2.5 years of age, and estimated harvest of 1.5-year-old males in the preceding year. Harvest rate of 1.5-year-old males from the preceding year was then calculated using the pre-hunt population and estimated harvest of 1.5-year-old males. Current year population of 1.5-year-old males was determined using a 3-year running average of harvest rates of 1.5-year-old males from the 3 previous years. Following determination of the 1.5-year-old males and males 2.5 years of age and older, calculation of female, fawn, and the total populations followed procedures similar to Skalski and Millspaugh (2002).

When interpreting results from the modified SAK procedure, it is important to know that due to the nature of population reconstruction methods, such as those used in the SAK procedure, the most accurate population estimate for a particular year occurs at some point in the future when data for each cohort of deer is complete (Skalski et al. 2005). Consequently, for the most recent years, population numbers should be viewed as indices rather than estimates (Skalski et al. 2005). Second, due to necessary assumptions of this population monitoring procedure, population numbers used to assess trends should be viewed as relative (i.e., whether trends are increasing, decreasing, or remaining stable), not absolute numbers.

Winter Mortality Survey

The winter mortality survey was not completed this year. Efforts are underway to develop a new protocol for conducting this survey.

RESULTS

Deer Health

WCOs examined 883 females during the 2005 pre-fawning season. Five hundred thirty-nine were pregnant and 521 were usable for determining conception dates. Twenty-four percent of the fawns, and 87% of the adults were pregnant. Pregnant fawns averaged 1.19 embryos/doe. Pregnant adults averaged 1.73 embryos/doe. The average reproductive rates for pregnant and barren fawns and adults were 0.28 and 1.51 embryos/doe, respectively. The average reproductive rate for all females was 1.00 embryos/doe. The median conception date for all does was 14 November. Ninety percent of all breeding occurred between 16 October and 16 December, with the median date fawns bred as 1 December, 2 weeks 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).

WMU deer health assessments were based on reproduction from 3 consecutive years, 2003 to 2005. We pooled these 3 years because annual sample sizes for each age class are too small to make reliable inferences. In WMUs 2E and 5A, health assessments are uncertain and this may be due to small sample sizes (Table 2). Using criteria described in the methods, we identified 7 WMUs with good deer health, 8 with satisfactory deer health, 5 with poor deer health, and 2 with uncertain deer health (Table 2).

Forest Habitat Health

WMU forest habitat health assessments were based on the first 4 years of the Pennsylvania Regeneration Study, 2001 to 2004. Results from the 2005 growing season were not available in time to be included in this year's assessment. Using criteria described in the methods, we identified 1 WMU with good forest habitat health, 13 with satisfactory forest habitat health, and 7 with poor forest habitat health (Table 3).

Deer Harvest Estimates and Composition

PGC personnel checked an average of 382 (range: 44 to 703) antlered deer and 875 (range: 197 to 1,678) antlerless deer per WMU during the 2005 firearms season (Table 4). Based on deer checked and report cards sent in by successful hunters, hunters harvested an estimated 354,390 deer in the 2005-06 deer seasons (Table 4). The antlered harvest was 120,500, similar to the 2004-05 harvest of 124,410. The antlerless harvest was 233,890, down 18% from 284,910 in 2004-05. Due to reduced deer populations, antlerless license allocations for the 2005-06 hunting seasons were reduced by 15% from the 2003-04 hunting seasons (Table 5). The reduction in antlerless licenses explained much of the change in antlerless harvests. Similarly, the antlered harvest was down 3%, accompanied by a 5% reduction in license sales.

For the 2006-07 hunting seasons, antlerless allocations were increased in 5 WMUs, decreased in 8 WMUs, and remained the same in 9 WMUs (Table 5).

Antlered harvests were nearly evenly split between 1.5-year-old males and 2.5-year-old and older males (Table 6). Since the implementation of antler restrictions during the 2002-03 hunting seasons, the age structure of the antlered harvest has increased, as has the number of 2.5-year old and older bucks being harvested (Table 6). Antlerless harvest composition has changed little since 2001-02 hunting seasons (Table 7).

Deer Population Trends

Most WMUs exhibited declining deer population trends from January 2001 to January 2006 (Figure 1). From October 2004 to October 2005, estimated deer population trends remained relatively stable in most WMUs (Table 8).

Deer Management Recommendations

All deer hunting seasons and regulations will remain in place for the 2006-07 hunting seasons. These regulations include 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 2006-07 antlerless deer license allocation (Table 5). Allocations were intended to hold most WMU population trends steady with 4 exceptions. Reducing deer populations in WMUs 2B, 5C, and 5D remained the goal. In WMU 4B, a population increase was recommended based upon an evaluation of deer and forest habitat health, deer population trends, and recommendation from a pilot Citizen's Advisory Committee (see Project Job No. 21012).

RECOMMENDATIONS

1. Increase annual, WMU sample sizes of females collected for monitoring deer health.
2. Identify and develop additional analyses and measurements to improve utility of forest habitat health measure where needed (e.g., a direct measure of deer browsing).
3. Maintain deer aging sampling effort. Current numbers of deer checked in the field provide reasonably precise harvest estimates in most WMUs. Harvest estimates are least precise in smaller WMUs where it is more difficult to collect sufficient data.
4. Identify and develop a method to more accurately estimate reporting rates for early archery and October muzzleloader and rifle seasons deer harvests. A previous evaluation suggested use of firearms season reporting rates results in over-estimates of early season deer harvests. Fortunately, the effect on the overall harvest estimate was minimal because most deer were harvested during the regular firearms season.
5. Identify and develop a method of estimating adult male populations that is less dependent on current regulations.
6. Continue to evaluate validity of assumptions and population monitoring procedures through internal and external peer-review. Prioritize research needs based on internal and external reviews.
7. Develop a new protocol for conducting the winter mortality survey. The new protocol should provide estimates of winter-killed deer across the landscape.
8. Continue concurrent antlered and antlerless firearms seasons for all hunters. This provides more hunting opportunities to hunters and maintains consistency in hunting seasons that is important to monitoring population trends. In addition, the antlerless allocation can control the antlerless harvest without changing season length (see RESULTS section).
9. Continue antler restriction regulations to allow rigorous evaluation of their effects on the deer population and changes in hunter support over time.
10. Continue to allow hunters to purchase and use the entire antlerless allocation.

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Table 1. Number of does examined, median conception date, percent of does bred between 16 October and 16 December, mean embryos per adult doe (≥ 2 years of age), and adult doe pregnancy rates from 2000 to 2005, 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
2005	883	14 November	90	1.51	87

Table 2. Number of does examined and assessment of deer health by WMU and age class. Data are based on samples collected from 2003 to 2005, Pennsylvania.

WMU	1-year-olds			2-year-olds			3-year-olds and older			WMU Health
	n	% Preg.	Health	n	Embryos per doe	Health	n	Embryos per doe	Health	
1A	49	45	Good	19	1.63	Good	32	1.53	Satis.	Satis.
1B	61	21	Satis.	31	1.29	Satis.	37	1.92	Good	Good
2A	38	8	Poor	24	1.54	Good	30	1.53	Satis.	Satis.
2B	94	27	Satis.	46	1.41	Satis.	54	1.61	Satis.	Satis.
2C	44	25	Satis.	34	1.21	Satis.	39	1.46	Poor	Poor
2D	44	30	Good	13	1.31	Satis.	22	1.73	Good	Good
2E	6	33	Good	5	1.40	Satis.	10	1.40	Poor	Uncertain
2F	36	17	Satis.	26	1.23	Satis.	33	1.58	Satis.	Satis.
2G	30	3	Poor	18	1.22	Satis.	64	1.55	Satis.	Satis.
3A	19	0	Poor	8	1.13	Satis.	40	1.48	Poor	Poor
3B	38	3	Poor	26	1.38	Satis.	49	1.78	Good	Good
3C	40	0	Poor	14	1.43	Satis.	43	1.42	Poor	Poor
3D	44	14	Satis.	22	1.00	Poor	63	1.41	Poor	Poor
4A	45	13	Satis.	26	1.54	Good	47	1.70	Good	Good
4B	34	21	Satis.	18	1.56	Good	17	2.00	Good	Good
4C	20	10	Poor	4	1.25	Satis.	15	1.67	Satis.	Satis.
4D	31	16	Satis.	30	1.27	Satis.	41	1.39	Poor	Poor
4E	34	18	Satis.	17	1.59	Good	18	1.67	Satis.	Satis.
5A	19	42	Good	4	1.75	Good	14	1.21	Poor	Uncertain
5B	36	42	Good	20	1.50	Good	25	1.80	Good	Good
5C	66	41	Good	41	1.85	Good	98	1.66	Satis.	Satis.
5D	15	33	Good	11	1.64	Good	20	1.80	Good	Good

Table 3. Number of plots sampled and assessment of forest habitat health by WMU. Data are based on samples collected from 2001 to 2004, Pennsylvania.

WMU	<i>n</i>	% with adequate regeneration	Health
1A	60	62	Satis.
1B	73	47	Poor
2A	62	58	Satis.
2B	35	69	Satis.
2C	138	49	Poor
2D	78	68	Satis.
2E	53	60	Satis.
2F	93	24	Poor
2G	229	42	Poor
3A	44	59	Satis.
3B	125	47	Poor
3C	66	55	Satis.
3D	103	51	Satis.
4A	60	60	Satis.
4B	68	66	Satis.
4C	57	51	Satis.
4D	75	49	Poor
4E	48	75	Good
5A	25	64	Satis.
5B	39	69	Satis.
5C	42	31	Poor
5D	4	0	

Table 4. Number of deer checked by PGC personnel, number of report cards sent in by successful hunters, and estimated harvests for antlered and antlerless deer by WMU, Pennsylvania 2005-06.

WMU	Antlered			Antlerless		
	Deer Checked	Report Cards	Harvest ¹	Deer Checked	Report Cards	Harvest ¹
1A	367	1,916	5,500	1,256	5,447	13,400
1B	570	1,944	6,400	1,678	3,902	10,700
2A	408	2,517	8,500	1,166	6,970	19,600
2B	175	1,766	5,200	740	5,385	14,500
2C	544	2,842	7,400	1,253	5,346	13,700
2D	549	3,391	10,000	1,590	7,970	22,100
2E	296	1,336	4,100	478	2,292	7,500
2F	703	2,237	6,000	1,044	3,153	8,300
2G	418	2,053	5,000	454	2,407	6,200
3A	348	1,311	4,000	890	3,361	8,700
3B	505	2,044	6,000	1,145	3,974	10,900
3C	455	2,080	5,800	814	4,135	11,200
3D	321	1,584	3,900	620	3,200	7,300
4A	218	1,356	3,700	493	3,175	7,600
4B	328	1,454	3,600	642	2,593	6,600
4C	378	2,393	5,900	946	4,172	9,800
4D	433	2,138	5,600	753	3,146	8,400
4E	286	1,646	4,500	717	3,776	9,100
5A	112	805	2,400	221	2,133	4,700
5B	448	2,909	7,400	1,225	6,078	11,700
5C	489	3,190	7,700	924	8,480	17,600
5D	44	551	1,500	197	1,872	4,200
Unk.		146	400		37	90

¹ Estimated harvests are rounded to the nearest 100 or 1,000 based on precision of harvest estimate. Unknown WMU harvests are rounded to the nearest 10 due to the small number.

Table 5. Antlerless license allocations by WMU, 2003 to 2006, Pennsylvania.

WMU	2003-04	2004-05	2005-06	2006-07
1A	44,000	48,000	40,000	42,000
1B	37,000	33,000	27,000	30,000
2A	45,000	55,000	55,000	55,000
2B	45,000	68,000	68,000	68,000
2C	65,000	75,000	53,000	49,000
2D	58,000	58,000	56,000	56,000
2E	29,000	23,000	21,000	21,000
2F	44,000	44,000	30,000	28,000
2G	52,000	52,000	29,000	19,000
3A	28,000	32,000	27,000	29,000
3B	45,000	48,000	41,000	43,000
3C	40,000	37,000	32,000	27,000
3D	50,000	50,000	38,000	38,000
4A	37,000	43,000	35,000	29,000
4B	38,000	49,000	35,000	31,000
4C	46,000	44,000	39,000	39,000
4D	58,000	55,000	40,000	40,000
4E	38,000	38,000	38,000	38,000
5A	28,000	32,000	28,000	25,000
5B	60,000	64,000	56,000	53,000
5C	66,000	71,000	71,000	79,000

5D 20,000 20,000 20,000 20,000

Table 6. Number of antlered deer aged, age composition of harvests, and approximate number of 2.5-year-old and older males harvested in Pennsylvania, 2001-02 to 2005-06. Percentages may not add up to 100 percent due to rounding.

Year	n	% 1.5-year-old males	% 2.5-year-old and older males	No. of 2.5-year-old and older males
2001-02	18,893	78	22	44,700
2002-03	11,688	68	32	52,900
2003-04	11,367	56	44	62,600
2004-05	10,555	50	50	62,000
2005-06	9,062	52	48	57,800

Table 7. Number of antlerless deer aged and age composition of harvests in Pennsylvania, 2001-02 to 2005-06. Percentages may not add up to 100 percent due to rounding.

Year	n	% 0.5-year-old males	% 0.5-year-old females	% 1.5-year-old and older females
2001-02	25,450	22	18	60
2002-03	30,077	22	18	60
2003-04	28,236	21	18	61
2004-05	24,640	22	18	61
2005-06	19,459	23	19	58

Table 8. Pre-hunt deer density (deer per square mile) by WMU, 2004 to 2005 Pennsylvania. NOTE: Deer densities are used for monitoring population trends and are not used for setting management goals.

WMU	Oct. 2004	Oct. 2005
1A	24	25
1B	24	27
2A	38	40
2B	30	36
2C	22	20
2D	33	32
2E	29	32
2F	27	22
2G	16	12
3A	28	28
3B	28	28
3C	28	24
3D	20	19
4A	23	18
4B	23	19
4C	31	28
4D	22	21
4E	21	26
5A	19	15
5B	21	21
5C	33	32

5D

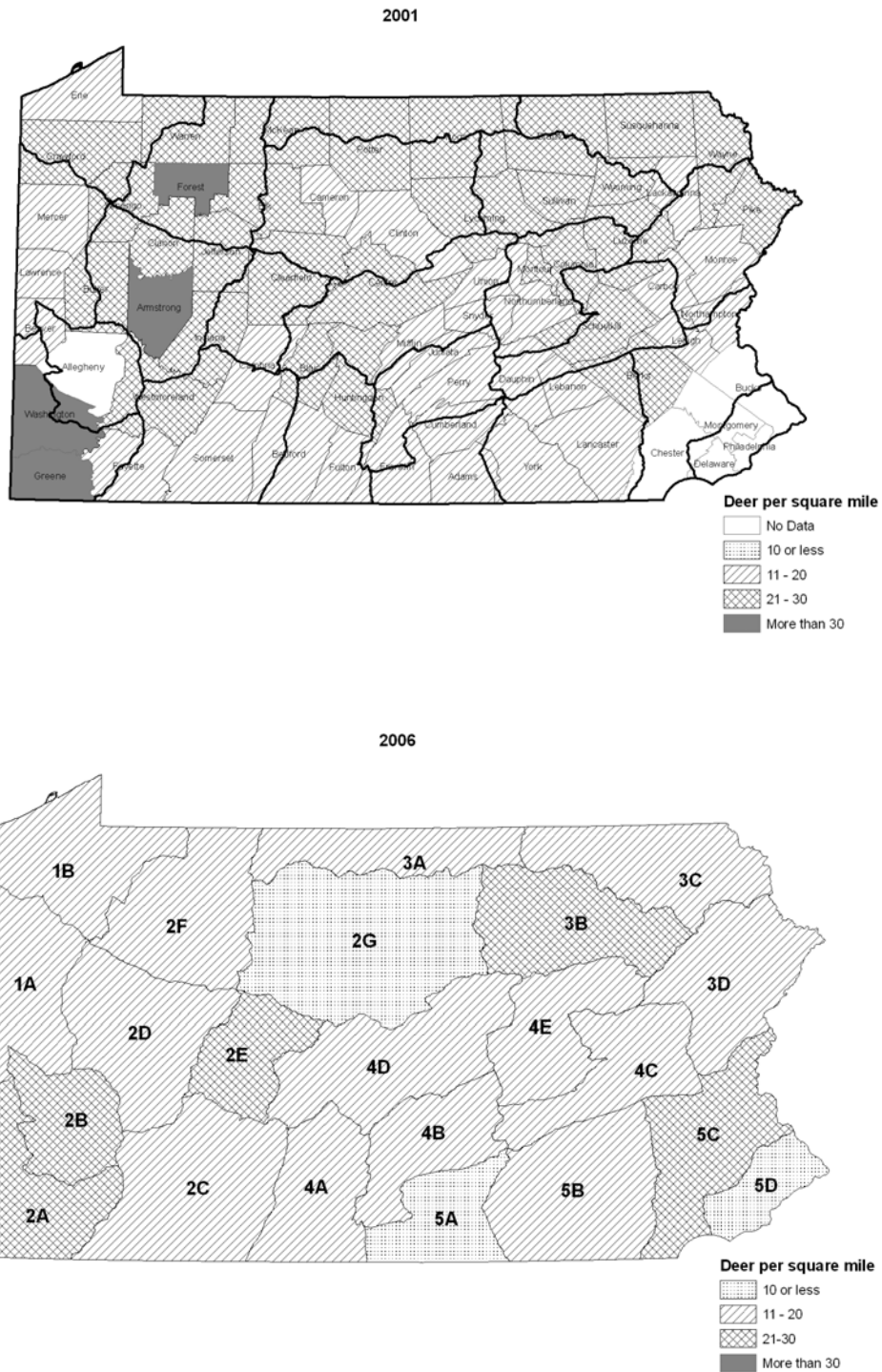


Figure 1. Post-hunt deer population densities by county in 2001 and by WMU in 2006. WMU boundaries overlay the county boundaries in the 2001 map.

Pennsylvania, 2001 and 2006. Populations were not estimated in Special Regulations counties with "No Data" in 2001.