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TITLE: White-tailed Deer Research/Management

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TITLE: Survival, mortality causes, and antlered harvest rates of white-tailed deer in Pennsylvania

PERIOD COVERED: 1 July 2008 through 30 June 2009

COOPERATING AGENCIES: Pennsylvania Cooperative Fish and Wildlife Research Unit, The Pennsylvania State University, Department of Conservation and Natural Resources

WORK LOCATION(S): Wildlife Management Units 2G and 4B

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ABSTRACT Survival, mortality causes, and antlered harvest rates are vital parameters to improving reliability of deer population trends. Using radio-collared white-tailed deer, we estimated and modeled survival and antlered harvest rates for application to Pennsylvania's deer population monitoring techniques. Eighty-four deer died from July 2008 through April 2009. Leading causes of mortality were legal harvest (56) and roadkills (12). From January through April 2009, we captured 316 individual deer in Wildlife Management Units 2G (141) and 4B (175). With deer from previous years and new captures, we monitored 210 deer (121 and 89 in 2G and 4B, respectively) following the capture period. This is the third year of a multi-year study.

OBJECTIVES

1. Estimate survival and mortality causes of white-tailed deer.
2. Quantify effect of variables on survival.
3. Estimate harvest rates of antlered white-tailed deer.
4. Quantify effects of variables on harvest rates of antlered white-tailed deer.
5. Evaluate the Pennsylvania Game Commission's (PGC) sex-age-kill (SAK) model.

METHODS

Northern and southern study areas were located in Wildlife Management Units (WMUs) 2G and 4B. These WMUs represented 2 of 5 physiographic units within the WMU system in Pennsylvania. Based on deer, habitat, and human-related characteristics, the study area WMUs were selected to represent larger groups of WMUs across Pennsylvania. Field activities occurred across a broad area within each WMU to increase variability of survival and harvest covariates, thus improving biological inference of the relationship between survival and harvests and covariates (Steury et al. 2002).

We used drop nets (Conner et al. 1987), rocket nets, and modified Clover traps (Clover 1954, McCullough 1975) baited with corn to capture deer. Deer captured using drop-nets and rocket nets were sedated with a light, intramuscular (IM) dose of xylazine hydrochloride (XYL), and face-masked. XYL was delivered via hand syringe at about 0.6 mg/kg body weight, or about 20 mg for a fawn, 30 mg for a yearling, and 40 mg for an adult. These dosages were well below the dosage recommended by Bubenik (1982) for immobilization of white-tailed deer using xylazine alone; complete sedation was not required to facilitate handling deer tangled in the nets. Deer captured with Clover traps were manually restrained and face-masked.

When captured, all deer were fitted with an ear tag in each ear. All suitable male and female deer were fitted with standard VHF radio-collars that use microchip technology to indicate time of mortality, and released at the capture site. A subset of deer was fitted with GPS radio-collars that obtain detailed movement (e.g., bi-hourly locations) information. Handling protocols were approved by the Pennsylvania State University (PSU) Institutional Animal Care and Use Committee.

Deer manually restrained by personnel were immediately released after individual markers were applied. Chemical immobilizations were antagonized with IM injections of tolazoline hydrochloride (TOL; 4.0 mg/kg) because it provides a more consistent antagonism of xylazine than yohimbine hydrochloride (Kreeger 1996).

Survival and locations of radio-collared deer were monitored at varying intervals throughout the year. During capture periods, deer survival was monitored bi-weekly. Following capture periods, we collected at least 1 location per deer per week. Telemetry effort depended on availability of personnel.

Mortalities were investigated within a day or 2 of detection. Field examinations to determine cause of death were performed when possible; however, if cause of death was uncertain and the carcass was in suitable condition, animals were taken to the Animal Diagnostics Laboratory at PSU for a complete necropsy.

Radio-collared deer provide information on survival and mortality causes. Survival estimates were calculated using Kaplan-Meier staggered entry design (Pollock et al. 1989) because animals can be added as they are captured, they can be censored when contact is lost, and there is no assumption of constant survival over a time interval. Since mortality may increase due to weather events during winter (White et al. 1987), making an assumption of constant daily survival over a period of months (Heisey and Fuller 1985) during winter is unrealistic. Sample sizes of 40-50 deer are required on the air at all times to achieve good precision of survival estimates (Pollock et al. 1989). Consequently, our objective for radio-collared deer is 70 animals per study site to allow for mortalities and loss of radio contact.

We estimated antlered harvest rates using the same methods as described above for survival.

Numerous covariates such as winter severity, condition of deer, age of deer, predation, and human-related factors such as road density can influence non-hunting survival. To assess the effect of these covariates on non-hunting survival of white-tailed deer, measurements of these variables for home ranges of individual deer were modeled in relation to the deer's survival using logistic regression (Hosmer and Lemeshow 1989). Home ranges are estimated using minimum convex polygon methods. Recommended sample sizes of locations of at least 30 locations per animal (Seaman et al. 1999) was the goal but were not logistically attainable due to available personnel funding. As a result, a subset of radio-collared deer was located at least twice a week throughout the non-capture period. For radio-collared deer without sufficient home range sample sizes, including deer that died prior to accumulation of at least 30 locations, circular buffers were created within which habitat characteristic were assessed. These buffers were based on the median home range sizes of the subset of radio-collared deer for each study area (Vreeland et al. 2004). A series of candidate models containing likely combination of covariates were developed with the best model(s) chosen using Akaike's information criterion (AIC) methods (Burnham and Anderson 1998).

Effect of variables, such as forest cover and public lands, on antlered harvest rates were estimated using the same methods as described above for survival.

Survival and harvest rate models were used to evaluate important assumptions of the SAK model. Given the empirical estimates derived from these survival and harvest rate models, precision can be estimated using statistically rigorous methods, namely a parametric bootstrapping technique (Efron 1979). An evaluation of the robustness of the SAK model can then take place under hypothetical management strategies and other variation inherent in natural systems.

RESULTS

From January to April 2009, we captured 316 white-tailed deer (Table 1).

In WMU 2G, 141 deer were captured on State Forests, State Game Lands, and private lands. One hundred twenty-one deer (46 males and 75 females) were monitored following the capture period.

In WMU 4B, 175 deer were captured on State Forests, State Game Lands, and private lands. Eighty-nine deer (23 males and 66 females) were monitored following the capture period.

From July 2008 through April 2009, 84 mortalities were recorded (Table 2). Harvest related mortalities accounted for 26 and 30 radio-marked deer in WMU 2G and 4B, respectively. Two additional adult males were classified as unrecovered harvest in 4B. Non-harvest mortalities in WMU 2G were attributed to poaching (2), automobile collisions (4), natural causes (2), and unknown causes (2). Non-harvest mortalities in WMU 4B were attributed to poaching (3), automobile collisions (8), natural causes (2), and unknown causes (3).

No additional analyses were conducted on survival parameters or harvest rates of radio-marked deer at this time.

Precision of SAK model estimates was estimated for each WMU. The average coefficient of variation (standard error/sample size*100%) across WMU's was under 20% for all years' that the SAK model has been used (2002-2007). Literature has suggested that coefficient's of variation under 20% are adequate for management of game species (Robson and Regier 1964). Preliminary analysis of model robustness indicated the SAK model estimates are robust to changes in doe harvest rates, while there may be some sensitivity to model estimates when mature buck harvest rates vary.

RECOMMENDATIONS

1. Continue telemetry monitoring of survival and movements of male and female deer.

2. Continue telemetry monitoring of harvest rates of antlered deer.

3. Conduct analyses of survival, movements, and antlered harvest rates.

4. Continue evaluation of current SAK population model.

5. Incorporate results of analyses into population monitoring methods.

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Table 1. White-tailed deer captures including recaptures reported in parentheses by sex and age class from January - April 2009 in WMUs 2G and 4B, Pennsylvania. An adult is classified as an animal 1.5 years old or older.

	WMU		
Sex/age class	**2G**	**4B**	**All captures**
Male adults	31 (3)	51 (9)	82 (12)
Male fawns	23 (6)	55 (9)	78 (15)
Female adults	65 (10)	56 (5)	121 (15)
Female fawns	22 (5)	13 (0)	35 (5)
Total	141 (24)	175 (23)	316 (47)

Table 2. Mortality causes for white-tailed deer in Pennsylvania, July 2008 - April 2009.

WMU

Mortality cause	**2G**	**4B**	**Total**
Legal harvest	26	30	56
Male adults	15	18	33
Male fawns	--[a]	--[a]	--[a]
Female adults	11	12	23
Female fawns	--[a]	--[a]	--[a]
Unrecovered harvest	0	2	2
Male adults	0	2	2
Male fawns	--[a]	--[a]	--[a]
Female adults	0	0	0
Female fawns	--[a]	--[a]	--[a]
Poaching	2	3	5
Male adults	2	3	5
Male fawns	0	0	0
Female adults	0	0	0
Female fawns	0	0	0
Roadkill	4	8	12
Male adults	0	5	5
Male fawns	0	0	0
Female adults	3	2	5
Female fawns	1	1	2
Natural Causes	2	2	4
Male adults	1	0	1
Male fawns	0	0	0
Female adults	1	2	3
Female fawns	0	0	0
Unknown	2	3	5
Male adults	0	0	0
Male fawns	0	0	0
Female adults	2	3	5
Female fawns	0	0	0
Total	36	48	84
Male adults	18	28	46
Male fawns	0	0	0
Female adults	17	19	36
Female fawns	1	1	2

[a] Fawns less than 7 months-old are not marked during the hunting seasons.