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WHITE-TAILED DEER ANTLER POINT RESTRICTIONS, HARVEST AND SURVIVAL RATES, AND DEER HUNTER SUPPORT: PERCEPTION VERSUS REALITY

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by

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ABSTRACT

Pennsylvania regulations for the harvest of white-tailed deer (*Odocoileus virginianus*) were designed for exploitation of antlered deer and regulating harvest of antlerless deer. The regulation defining a legal antlered deer for harvest remained unchanged from 1953 to 2002, when the Pennsylvania Game Commission re-defined the minimum antler size. The new antler point restrictions (APRs) were a ≥3- or ≥4-points on one antler depending on the wildlife management unit (WMU). New APRs were designed to protect 50 – 75% of subadult antlered deer (≤1.5 years of age), whereas remaining subadults and most adult males (≥2.5 years of age) were legal for harvest. The purpose of the APRs was to allow more subadults to advance into the adult age class, thus increasing the proportion of older males and antlered deer in the population. Although APRs have been applied to management of other ungulate species to increase the male age structure and the proportion of antlered males to females, they have been controversial with some wildlife biologists and hunters. Little research has been done to document the effects of APRs on deer survival, hunter harvest, and hunter support. I designed a research study using radio-collared subadult and adult male white-tailed deer to measure harvest and survival rates when hunting occurs with APRs. Simultaneously, I used pre- and post-hunting season surveys to evaluate hunter perception and support for APRs.

I established study areas in Centre and Armstrong counties. During 2002 – 2005, I captured, radio-marked, and monitored 453 subadult and 103 adult males to estimate hunting and non-hunting season survival parameters and cause-specific mortality. To

assess hunter support and attitudes toward APRs, I conducted 7 deer hunter surveys. The first 6 surveys were pre- and post-hunting season surveys for the 12-day firearms deer season during the 2002, 2003, and 2004 hunting seasons. The first survey was conducted before APRs began, and served as a baseline measure of hunter support for APRs. I surveyed 2 different groups of hunters: a random sample, and a longitudinal panel consisting of hunters who filled out the first 6 surveys. If a panel member failed to return a survey, they were dropped from the panel, but were surveyed at the end of the study. The final survey from panel members and the final survey to dropped panel members were used to determine directional support (increasing or decreasing) for APRs after 3 years. I used harvest and survival rate data from radio-collared deer and mail survey data to conduct a comprehensive evaluation of APRs.

I found no difference in survival rates between study areas and years of the study, but survival rates differed by age (adult, subadult) and month. Monthly survival rates for subadults ranged between 0.64 (95% CI = 0.58 – 0.69) and 0.99 (95% CI = 0.97 – 1.0), with an annual survival rate of 0.46 (95% CI = 0.41 – 0.52). For adults, monthly survival rates varied between 0.36 (95% CI = 0.29 – 0.45) and 1.00, with an annual survival rate of 0.28 (95% CI = 0.22 – 0.35). Harvest rate for subadults was 0.31 (95% CI = 0.23 – 0.38), and for adults was 0.59 (95% CI = 0.40 – 0.72). After surviving their second hunting season, adult survival was 0.92 to the start of their third season. Most out-of-season losses for subadults and adults were from vehicle accidents. Other than legal harvest, sub-legal kills accounted for most mortalities during the hunting season. The statewide legal harvest declined because of the reduction in subadult harvest, while the adult harvest increased despite declining deer populations in most WMUs.

From the random sample surveys, I found hunter support for a statewide APR regulation varied between 0.61 (95% CI = 0.59 – 0.64) and 0.70 (95% CI = 0.66 – 0.73). Between 0.60 (95% CI = 0.57 – 0.62) and 0.67 (95% CI = 0.64 – 0.71) of all hunters supported APR regulations in the unit they principally hunted for deer. There was little change in the proportion of hunters supporting APRs from before the regulations were implemented to 3 years afterward. With regard to APRs as a statewide regulation, 0.23 were more supportive, 0.29 were less supportive, and 0.48 were unchanged in their level of agreement. Similar results were found for support of APRs in the unit the respondent hunted for deer (0.23 more supportive, 0.30 less supportive, and 0.47 unchanged).

Antler point restrictions were successful from a biological perspective. During my study, APRs reduced harvest rates of subadults, and after surviving their first season with antlers, adult survival was 92% to the following hunting season. In addition, harvests exhibited an increasing number of adult males, despite declining deer abundance during the study years. Socially, a majority of hunters (62%) remained supportive (28% were unsupportive) with the use of APRs after 3 years of use.

Empirical data from my research indicated reduced subadult harvest rates, high survival rates outside of the hunting season, and an increased number of adults in the harvest. Hunters should have observed more antlered deer during their hunting experience. However, there was little change in directional support for APRs after 3 years. I believe hunters had an initial impression of what the effects of APRs would be, and then ignored any additional information once APRs were implemented.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

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Chapter 1

Study Background

History of white-tailed deer management in Pennsylvania

Unlike 100 years ago, the white-tailed deer (*Odocoileus virginianus*) occurs and is hunted in every wildlife management unit (WMU) in Pennsylvania. They are adapted to every environment in the state, including urban areas, agricultural environments, and the contiguous forest land of northcentral Pennsylvania. In the history of North American wildlife management, there are few success stories as great as the white-tailed deer (McCabe and McCabe 1984). In Pennsylvania, reported harvests in 1915 were 1,267 antlered deer from 19 counties. In 2000, the reported harvest of antlered deer was 85,291 antlered deer, and 134,461 antlerless deer in 67 counties (PGC unpublished data). By the end of the 19th century, deer hunting in Pennsylvania was coming to an end because of scarcity, primarily due to the lack of protection from unregulated killing and market hunting (Kosack 1995). Protection and management, coupled with regenerating habitat following forest clearcutting (Kosack 1995) allowed deer populations to recover to today's abundance. In fact, in many parts of Pennsylvania, there were too many deer even in the 1930's (Diefenbach et al. 1997).

In eastern North America, including Pennsylvania, deer were often considered overabundant (McShea et al. 1997). Their abundance, widespread distribution, and ability to adapt to a broad variety of landscapes have also brought conflicts with forest,

agriculture, automobile travel, and other land use interests (Bashore et al. 1985, Witmer and deCalesta 1992, Conover et al. 1995, Conover 1997, Mower et al. 1997, Stromeyer and Warren 1997, Yahner 2000, Tzilkowski et al. 2002, Horsley et al. 2003). Deer populations have caused browsing in some regions of Pennsylvania that adversely affect plant and animal communities (Casey and Hein 1983, deCalesta 1997).

The Pennsylvania Game Commission (PGC) historically established regulations for white-tailed deer in which there were separate firearms seasons for antlered and antlerless deer. To be legal for harvest, an antlered deer had to possess antlers of a described minimum length or number of points. During 1953 – 2001, the same antler restriction was used, in which for legal harvest, an antlered deer had to possess at least 1 antler ≥7.6 cm (3.0 in) in length or 1 antler with ≥2 points (Kosack 1995).

With the exception of 2 years when antlered deer season was closed (1928 and 1938), no limitation has ever been placed on the number of hunters who could harvest antlered deer or which management unit they could hunt. In contrast, the number of hunters licensed to harvest antlerless deer has always been strictly regulated with antlerless license allocations with management unit designations. This style of management began in the early part of the 20th century when deer populations in Pennsylvania were at an all time low to increase deer populations.

In 1907, Pennsylvania held the first hunting season exclusively for antlered deer, and antlerless deer were protected (Kosack 1995). The first statewide antlerless deer season did not occur until 1928 (Diefenbach and Palmer 1997). But statewide antlerless deer seasons have been held every year since 1957 (Kosack 1995). Under the management philosophy in 1907, exploitation of the male proportion of the resource was

allowed, while protecting female deer for reproduction and population expansion (density and geographical). The management approach was successful because of the polygynous breeding behavior of white-tailed deer, which allowed high harvest rates of male deer.

Deer hunters lobbied successfully to prevent regulations designed to reduce deer populations (Diefenbach et al. 1997, Diefenbach and Palmer 1997). In response, antlerless allocations were often reduced to satisfy hunter desires for higher deer populations. Reduced antlerless allocations were directly linked to reduced antlerless deer harvests. In contrast, antlered deer hunting regulations remained unchanged, with no limits on the number of hunters pursuing antlered deer, similar antler restrictions to define a legal antlered deer, and a traditional 12-day firearms season beginning on the Monday after the Thanksgiving holiday.

In 2001, the PGC Board of Commissioners (BOC) approved a concurrent firearms deer season for antlered and antlerless deer. In conjunction with new concurrent seasons, antlerless allocations also were designed to reduce populations in most WMUs. Antlered deer regulations for archery, muzzleloader, and firearms seasons remained as in previous years.

A major change in a 49-year-old deer management regulation took place in 2002, when the definition of an antlered deer for legal harvest was revised. The pre-2002 definition of an antlered deer was designed to make almost all subadult (males 1.5 years old) and older males eligible for harvest during the deer hunting season. Wildlife biologists in the PGC sought an antler regulation defining an antlered deer for legal harvest that protected a proportion of subadult males, but most adults were legal to harvest. The purpose of the new antler restriction was to manipulate the sex ratio (to

increase the proportion of males in the population) and male survival rates (increase the number of adult males in the harvest).

Several antler measurements could be used as the basis for regulations to protect varying proportions of the antlered deer population. The measurements include antler points, antler beam diameters (ABD) measured 2.5 cm (1.0 in) above the antler burr, main beam length, and spread of main beams. Antler measurements (points on each antler, ABDs, and spread of main beams) were collected during the 2000 and 2001 deer hunting seasons when the antler restriction protected very few antlered deer. A representative cross section of the antlered deer population was sampled by PGC personnel during biological examinations at deer processors (Kelly et al. 2001, Wallingford and Rosenberry 2002).

Wildlife biologists in the PGC developed the criteria for an antler restriction that would best meet management objectives for antlered deer. The criteria had to: (1) allow all hunters to hunt antlered deer; (2) be easy to apply for most hunters in the field; (3) result in hunter compliance; and (4) meet the management objective of protecting 50 – 75% of subadult males. If 50 – 75% of subadults were protected, PGC wildlife biologists believed hunters would notice a difference in the number of older males in the population, thus increasing hunter support for the deer management program over time. After evaluating the advantages and disadvantages of each measurement, the simplest and most effective regulation that best fit the outlined criteria was a point count on 1 antler. The percentage of subadult and adult antlered deer protected by different point restrictions was estimated using 2000 and 2001 antler point data from harvested deer.

In April 2002, the PGC BOC passed new antler point restrictions (APRs) in all counties except Philadelphia County and surrounding counties in southeastern Pennsylvania and Allegheny County in southwestern Pennsylvania. Wildlife management units in 2002 were based on county boundaries. Hunter support for new APRs was 57% (Luloff et al. 2002). Antler point development varied by management unit, so different point restrictions were needed to protect 50 – 75% of subadult males from harvest. A 4-points per side minimum was established in 10 western counties (Armstrong, Beaver, Butler, Crawford, Erie, Indiana, Lawrence, Mercer, Washington, and Westmoreland.) The remainder of the state had a 3-points per side minimum.

In 2003, the PGC adopted new WMUs to replace the county-based system. The modified boundaries for the 4-points per side minimum were WMUs 1A, 1B, 2A, 2B, and 2D in western Pennsylvania. Wildlife Management Unit 2B includes Allegheny County, which was a special regulations county. Regulations requiring 3-points per side minimum were passed for all other WMUs, including WMUs containing special regulations counties.

History of antler restrictions in Pennsylvania

Pennsylvania has had some type of antler restriction to define a legal antlered deer for harvest for over a century. The definition has changed multiple times over the decades. The early antler restrictions were "…passed more to protect human life than to protect deer" (Anonymous 1928). The first antler restriction, considered drastic at the time, was in 1907 when the "Buck Law" was enacted to protect all deer except males

with visible antlers (Anonymous 1928). However, conservationists of the time probably realized protection of breeding-aged females would mean re-establishment of the deer herd (Anonymous 1928). In 1909, the definition of a legal deer was slightly modified to "one which possessed horns visible above the hair." (Anonymous 1928). In 1913, a legal antlered deer had to have antlers at least 5.1 cm (2.0 in) above the hairline (Kosack 1995). In 1921 and 1922, the regulation was changed to a 10.2 cm (4.0 in) minimum (Kosack 1995). For the 1923 and 1924 deer seasons, the regulation was changed again to a spike 15.2 cm (6.0 in) or ≥2 points on 1 antler (J. Kosack personal communication). From 1925 to 1952, a legal antlered deer for the harvest had to possess ≥2 points on 1 antler regardless of length, thus protecting all spike-antlered deer (Anonymous 1975). In 1953, antlered deer with spike antlers ≥7.6 cm (3.0 in) or ≥2 points to 1 antler became legal for harvest (Kosack 1995). The same definition remained in effect until 2002, when the Pennsylvania BOC adopted the ≥3- and ≥4-points per 1 side antler regulations used for this study. The definition of an antler point changed between 2002 and 2003. In 2002, PGC regulations stated, "A point is defined as an antler projection of at least 1 inch [2.5cm] in length from base to tip. The brow tine and main beam tip shall be counted as points, regardless of length" (Anonymous 2002:35). In 2003 and subsequent years of this study, a point was defined as "any antler projection (including the brow tine) at least 1 inch [2.5 cm] in length from base to tip. The main beam tip shall be counted as a point regardless of length" (Anonymous 2003:58). In addition, in 2002, 6 urbanized counties (Bucks, Chester, Montgomery, Delaware, and Philadelphia in southeastern Pennsylvania and Allegheny in southwestern Pennsylvania) with special, liberal hunting seasons for antlerless deer designed to reduce deer populations were under the previous antler

restriction (1953 – 2002) of 1 antler ≥7.6 cm (3.0 in) in length, or 1 antler with ≥2 points. In 2003, these 6 counties were included in the ≥3-point (southeastern Pennsylvania) and ≥4-point (southwestern Pennsylvania) areas. From 2003 through the end of this study, Pennsylvania APRs were statewide, and the definition of a point remained consistent. However, junior hunters (12 – 16 years of age), disabled permit holders, and residents currently serving active military duty were permitted to harvest any antlered deer with an antler ≥7.6 cm (3.0 in) or with ≥2 points on 1 antler.

Research justification

The concept of protecting subadult males from harvest is not new to deer management. The management strategy termed quality deer management (QDM) began in 1975 with the publication of Producing Quality Whitetails (Brothers and Ray 1998). Since beginning in Texas, the concepts of QDM are recognized in most states with white-tailed deer. Quality deer management involves reduced harvest of young antlered deer and the appropriate antlerless harvest to achieve management objectives (Hamilton et al. 1995). Typically, the goal is to harvest only antlered deer >2.5-years-old (Bowman et al. 2007). Harvest of only mature antlered deer can be accomplished on a voluntary basis, but application on a broad management scale (i.e. statewide) with regulated enforcement is difficult. Consequently, applications of QDM have occurred on relatively small land areas <13,000 ha (Bowman et al. 2007).

Antler point restrictions in Pennsylvania were a less subjective, but also less restrictive variation of QDM because they do not protect all subadults and a greater

proportion of the subadult male population would be harvested. In theory, restricting the harvest with APRs should reduce the harvest of younger antlered deer, and allow more to survive into older age classes. Monitoring to test whether APRs work in field applications has been lacking, and a criticism of wildlife biologists (Carpenter and Gill 1987).

Carpenter and Gill (1987) stated 3 elements should accompany the implementation of antler restrictions: (1) an assessment of hunter support; (2) experimentation to determine whether antler restrictions achieve biological objectives; and (3) educating hunters of the possible consequences of the harvest strategy. I do not address the concern of Carpenter and Gill (1987) about educating hunters, but my research was designed to address hunter support and biological outcomes. Knowledge gained from my research could be used as a foundation for addressing hunter education.

The change to APR regulations in Pennsylvania provided an opportunity to study the effects of new antler restrictions from social and biological aspects of wildlife management. Chapter 2 explores the biological aspect of APRs to estimate survival and harvest rates, and to use them as a basis to measure success or failure of APRs to achieve management goals. Antler restrictions have been used previously with white-tailed deer (Bullock et al. 1995, Strickland et al. 2001, Bowman et al. 2007), as well as other ungulates including moose (Young and Boertje 2008), mule deer (Carpenter and Gill 1987), and elk (Bender and Miller 1999, Boyd and Lipscomb 1976). Some applications have been considered management successes, whereas others have been considered failures. Although various forms of antler restrictions in white-tailed deer have been

implemented in other states, no research has documented their effects on harvest rates of 1.5-year-old males, which comprised ≥80% of the antlered deer harvest each year in Pennsylvania prior to 2002. Some managers believe in the "shoot and sort" theory (Carpenter and Gill 1987), in which significant proportions of protected antlered deer will be shot and left in the field during the hunting season. However, there were no data to support their claim. Carpenter and Gill (1987) stated the "ugly" part of antler restrictions was they were likely to be quite costly in wasted animals and discouraged hunters.

Chapter 3 explores the social component of APRs. Hunter attitudes are an essential component of any evaluation of antler restrictions and attitudes toward APRs could likely change as the sex and age structure of the deer population changed. Fifty-seven percent of hunters supported antler restrictions in January 2002 (Luloff et al. 2002), but hunter satisfaction could decline after the first year of new restrictions if hunters do not believe APRs protect subadult males. However, satisfaction increased to 86% in Arkansas after the first year of antler restrictions (Duda et al. 1999). The APRs in my research were a major change to the management paradigm for white-tailed deer in Pennsylvania. Data from antler measurements prior to APRs indicated 50 – 75% of subadult males could be protected from harvest (PGC unpublished data), and allowing them to be harvested as legal antlered deer with larger antlers. Although antler restrictions designed to protect the younger age classes from legal harvest have been used with several ungulate species, most antler restrictions were on smaller scales, i.e., restricted to certain management units. Furthermore, I found no research with white-tailed deer to simultaneously evaluate the biological effects of APRs on the resource and the social effects on the users of the resource. The research I designed allowed me to use

mailed questionnaires to measure hunter perception of biological effects of APRs on a statewide level, which could then be compared to data collected from radio-marked males in the field.

The research results I reported have broad application to deer managers across the geographic range of the white-tailed deer when an older age structure is desirable. In addition, some information could be useful in hunter management and biological management of other ungulates where APRs are applied.

Finally, in Chapter 4, I used the results of Chapters 2 and 3 to provide a comprehensive evaluation of APRs. Antlered deer harvest rates, out-of-season survival rates, and measures of the adult antlered deer harvest were the criteria I used to evaluate the biological effects of APRs. On the social side, I used survey questions from Chapter 3 to determine whether or not hunters were supportive of APRs. In addition, I measured changes in perceptions about APRs before hunters experienced them and after 3 years of experience. I used the information to explore fundamental hunter perceptions regarding APRs with respect to the biological effects of APRs on antlered deer. This information provides insights about Pennsylvania deer hunters, and where additional attention is needed in deer management.

Chapter 2

Male white-tailed deer survival and harvest rates with antler point restrictions in Pennsylvania

Introduction

Presence of antlers is a simple characteristic for hunters to use to distinguish between breeding-age male and female deer. Historically in Pennsylvania, antlered deer legal for harvest were defined as deer with antlers ≥7.6 cm (3.0 in) in length or with 1 antler having ≥2 points. Males with smaller antlers were defined as antlerless deer, but most males in Pennsylvania ≥1.5 years of age were legally classified as antlered deer (Kelly et al. 2001, Wallingford and Rosenberry 2002). Because nearly all antlered deer were legal for harvest, and the number of hunters licensed to harvest antlered deer was not restricted, the antlered deer population in Pennsylvania experienced annual harvest rates of approximately 0.80.

A relatively unrestricted harvest of the male population is sustainable because care of offspring is provided solely by females and the species' polygynous mating system is not adversely affected by a skewed sex ratio. As long as relatively few antlered deer are harvested prior to the breeding season, high harvest rates will have little effect on population growth. Consequently, throughout North America, harvests of male white-tailed deer generally have been less regulated than harvests of females.

High harvest rates of males result in populations with a younger male age structure and fewer males reaching maturity (>3 years old). Antler development (number

of points, beam length and width) increases with age (Sauer 1984, Strickland and Demarias 2007, Koerth and Kroll 2008), potentially allowing selective harvest of older males while protecting younger males based on antler development. Harvest regulations that attempt to protect younger males require more complicated, and potentially subjective, criteria to define a deer legal for harvest.

Requiring larger antlers, or more antler points, or both (e.g., APR regulations) before a deer is legal to harvest has been used by managers to increase the proportion of males in the population and the number of males in the adult age class. However, the specific effect of APRs on the populations they were applied to remains largely unknown because limited research has been conducted for any cervid species to assess whether they accomplished management goals. For example, although APRs have been used to increase bull to cow ratios in moose (Schwartz et al. 1992, Young and Boertje 2008) and elk (Boyd and Lipscomb 1976, Bender and Miller 1999), no accompanying research was conducted to document how much male survival increased in these populations. Bullock et al. (1995) reported on a selective harvest for white-tailed deer in which hunters must have ascertained antlered deer met 2 of 3 criteria before harvested: a 40.6 cm (16 in) minimum outside spread, a 40.6 cm (16 in) minimum main beam length, and a combined point count $\geq$ 8 points . The harvest criteria of Bullock et al. (1995) resulted in fewer 1.5-year-olds, and more $\geq$2.5-year-olds in the harvest, but they did not monitor harvest or survival rates, and changes in the harvest simply may have reflected changes in harvest regulations rather than changes in the sex-age structure of the population.

Bowman et al. (2007) monitored survival and cause-specific mortality of adult male white-tailed deer under QDM, but no males <1.5 years-old were studied.

Furthermore, the results of this study are of limited application to my research because important differences exist between the QDM areas in the southern United States used by Bowman et al. (2007) and APRs used by the PGC in my research. First, QDM was designed to protect all subadult males (Hamilton et al. 1995). Second, the spatial scale at which the harvest regulations were applied differed: APRs in Pennsylvania were applied statewide whereas the QDM areas studied by Bowman et al. (2007) were <13,000 ha.

Pennsylvania's deer management program has used an antler restriction since 1907 (Kosack 1995), and the same definition from 1953 – 2001. Based on antler measurement collected by the PGC in 2000 and 2001 (Kelly et al. 2001, Wallingford and Rosenberry 2002), a ≥3- or ≥4-points per 1 antler, depending on the unit, were proposed with the intent of protecting 50 – 75% of 1.5-year-old males during the hunting season. In 2002, the PGC BOC enacted the ≥3- or ≥4-points per 1 antler APRs to define a legal antlered deer for harvest, but no previous research had been done to evaluate the effects of the antler restriction on male survival rates, harvest rates, and harvest numbers. I conducted research to document survival of subadult and adult males in conjunction with new APRs for the 2002 – 2005 hunting seasons.

My objectives were to estimate cause-specific mortality, monthly survival rates and hunting season harvest rates of subadult and adult males, and the number of adult antlered deer in the harvest as measures of the biological effects of APRs. I predicted harvest rates of subadult deer (1.5- year-olds) would decline from a pre-APR rate of 0.80 to 0.25 – 0.50. Also, I predicted harvest rates of adults would not change from the pre-2002 rate of 0.80 because most would be legal for harvest; APRs would not protect adults. Last, I predicted subsequent adult harvest of males would increase after the first

year because the lower harvest rate of subadults would move additional males into the adult age class.

Study areas

To estimate survival parameters of antlered white-tailed deer in Pennsylvania, I captured deer within 2 study areas in the state: Armstrong County in western Pennsylvania, and Centre County in central Pennsylvania. Deer capture began in winter 2001 – 02, continued in the following winters of 2002 – 03, and 2003 – 04. Both study areas were used simultaneously by Long (2005), who provides a detailed description of the study areas.

Armstrong County

I chose an approximately 1,200 km^2 area of eastern Armstrong County on the east side of the Allegheny River in the Appalachian Plateau region of Pennsylvania as the western study area (Figure 2.1). The Armstrong County study area was almost exclusively private land, and consisted of a mixture of forested and agricultural land. Forest lands were fragmented by agricultural land, with many forests existing as small woodlots. Armstrong County was within the PGC WMU 2D. Antlered deer legal for harvest in WMU 2D had to have at least 1 antler with ≥4 points.

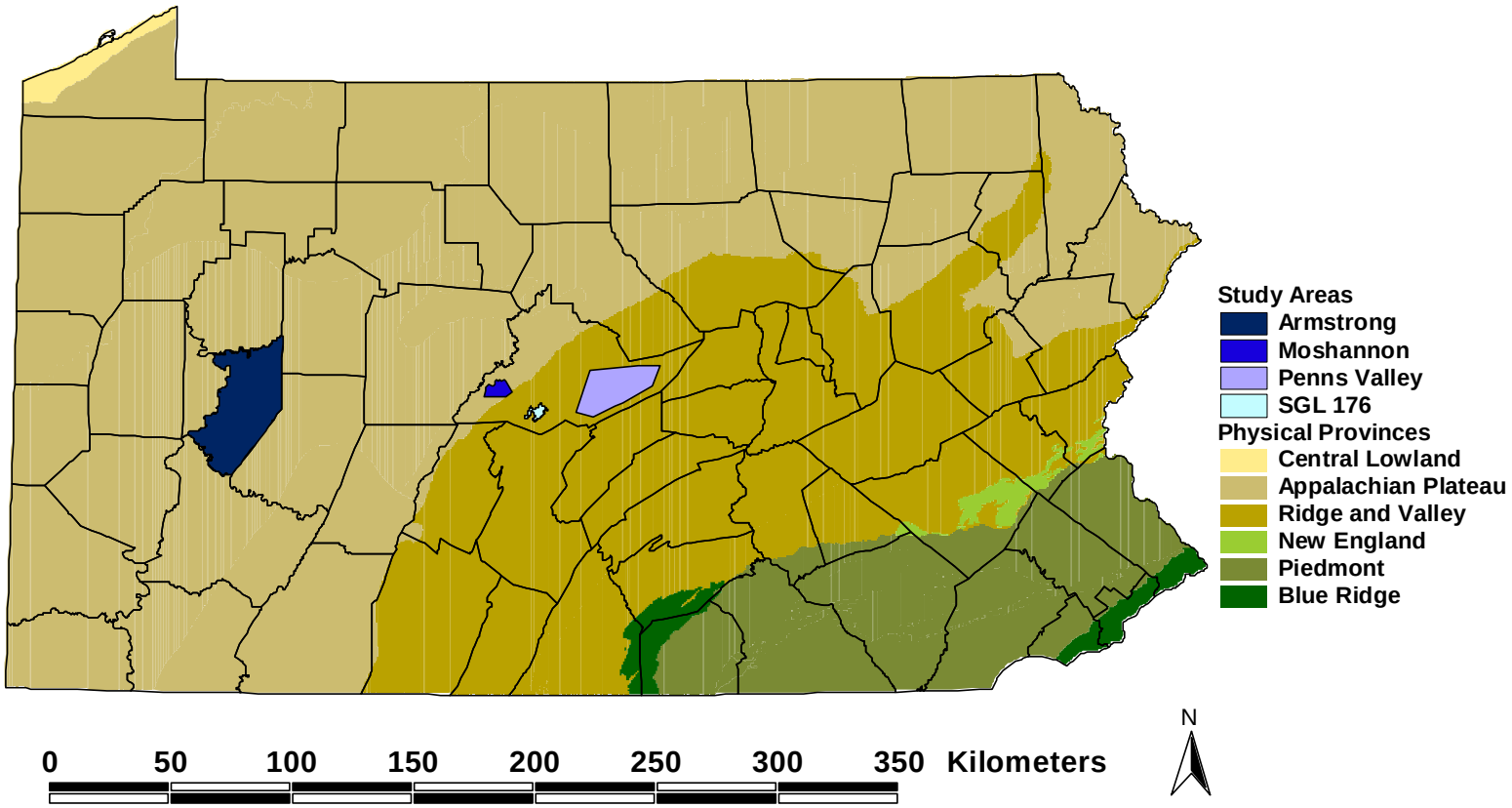

Figure 2.1: Map of 2 study areas for investigation of male white-tailed deer survival and harvest rates when managed with antler point restrictions in Pennsylvania, 2002 – 2005. Study areas included Armstrong County in western Pennsylvania with a ≥4-points per 1 antler restriction, and Centre County in central Pennsylvania with a ≥3-points per 1 antler restriction. The Centre County study area was composed of 3 smaller regions, including Moshannon, Penns Valley, and State Game Land (SGL) 176. The Armstrong County study area lies entirely within the Appalachian Plateau Province, whereas in Centre County, the Moshannon region lies within the Appalachian Plateau Province, and Penns Valley and SGL 176 lie within the Ridge and Valley Province. The 3 regions within Centre County were treated as a single study area. (Figure used by permission, Long 2005.)

Centre County

The Centre County study area was within WMU 4D in central Pennsylvania. A legal antlered deer during the hunting season in WMU 4D had to have ≥3 antler points on at least 1 antler. The Centre County study area was part of 2 physiographic provinces: the Appalachian Plateau in western Centre County; and the Ridge and Valley province in central and eastern Centre County. Public land within the study area included Moshannon State Forest (60 km^2) and adjacent State Game Lands 33 in the Appalachian Plateau region of western Centre County (60 km^2), and State Game Lands 176 (SGL 176; 25 km^2) in the Ridge and Valley province of south-central Centre County. A third component of the Centre County study area consisted of an area of parallel ridges and valleys approximately 620 km^2. George's Valley, Egg Hill, Penns Valley, Brush Mountain, Brush Valley, Nittany Mountain, and Nittany Valley comprised most of the area, with Penns Valley being where most deer capture occurred. Forests along ridges were contiguous. Valleys were primarily agricultural, with row crops farms and dairy operations. Ownership was primarily private, with deer hunting taking place throughout the land.

Methods

Deer capture, marking, and monitoring

I captured subadult and adult males for the study. Age class at the time of capture

was determined using body size and presence of antler growth on the pedicle from the previous year (Long 2005). Subadults at the time of capture were 7 – 10 months old, and would grow their first set of antlers during the following summer. Subadults were classified as adults after surviving the following hunting season. All males in my study older than subadults were classified as adults.

The first deer were captured in the Armstrong County study area December 10-12, 2001 with a contracted crew using net guns and helicopters (Hawkins and Powers Aviation, Inc., Greybull, Wyoming, USA). All others were captured from mid-January to mid-April of 2002, 2003, and 2004. I captured deer using modified Clover traps (Clover 1954, Beringer et al. 1996, Haulton et al. 2001), drop nets (Ramsey 1968, Conner et al. 1987) modified for remote-release, and rocket nets (Beringer et al. 1996, Haulton et al. 2001). I used 3 drop nets and 20 Clover traps in each area in 2002. Also, I used a dart gun (Pneu-dart, Inc., Williamsport, Pennsylvania, USA) in Centre County. In 2003 and 2004, I added 20 Clover traps to each study area, and 2 rocket nets to the Centre County study area. I checked Clover traps each day, usually before noon, with deer being handled by a crew of 2 – 4 people. I operated drop nets and rocket nets from approximately an hour before sunset to approximately 4 hours after dark. I used a crew of 3 – 6 people when operating capture nets.

Males caught with the net gun and Clover traps were not injected with immobilizing drugs because handling times were short, less than 15 minutes for pursuit and handling for helicopter capture and less than 5 minutes for Clover traps. Males caught in rocket nets and drop nets required 30 – 60 minutes to process so males were blindfolded and immobilized with intramuscular injections (IM) of xylazine

hydrochloride (100 mg/ml) at approximately 1 mg/1.8 kg (Rosenberry et al. 1999). To simplify drug application during capture, subadults received 0.2 ml, and adult males 0.4 ml of xylazine hydrochloride (Long 2005) to produce muscle relaxation and reduce stress. The drug dosages were well below the dosage recommended by Bubenik (1982) for immobilization of white-tailed deer using xylaxine hydrochloride alone. I antagonized immobilizations with IM injections of yohimbine hydrochloride (5 mg/ml; injection dose 1 mg/2.8 kg) or tolazoline hydrochloride (100 mg/ml; injection dose 1 mg/0.2 kg). During capture operations, I applied dosage volumes for yohimbine hydrochloride of 3.0 ml per subadult and 5.0 ml per adult male (Long 2005). For antagonism with tolazoline hydrochloride, I used 1.5 ml for subadults and 3.0 ml for adult males (Long 2005). Tolazoline hydrochloride was used most frequently to antagonize immobilized males because recovery is more consistent than yohimbine hydrochloride (Kreeger 1996). The capture protocol was approved by the Pennsylvania State University Institutional Animal Care and Use Committee (#01R135). Data recorded for each deer captured included date, time, location of capture, trap type, sex, and age class (subadult or adult).

I marked all captured deer with 2 uniquely numbered plastic ear tags (Original Tags™, Temple Tag Co., Temple, Texas, USA), imprinted with toll-free contact information for the PGC. Also, I marked subadult males with 19 g VHF ear tag transmitters (Advanced Telemetry Systems, Inc., Isanti, MN, USA), or 1 of 2 types of radiocollars: a 245 g expandable VHF neck collars (Advanced Telemetry Systems, Inc., Isanti, MN, USA); or a 700 g expandable, automatic release global positioning system (GPS) neck collar (Telonics, Inc., Mesa, AZ, USA). The combination of ear tag

transmitters and collars was a compromise for this research because I needed to monitor survival and dispersal (Long 2005). Ear tag transmitters were less noticeable to hunters than radiocollars and I believed would provide accurate estimates of harvest rates. Increased visibility of the collars could potentially influence a hunter's decision to harvest the animal during the hunting season, which would bias survival and harvest rate estimates. However, radio-collars contained larger batteries and transmitted a more powerful signal that could be received at a greater distance to aid in monitoring movements of dispersing males.

Ear tag transmitters often were cast by deer during the first year of the study, so in the second year, deer were fitted with 2 ear-tag transmitters and the thickness and orientation of the antenna was changed. I used a thicker antenna that was more durable, and the orientation of the antenna was made to point upward away from the deer's body to reduce aggravation (Long 2005). The transmitter modifications reduced transmitter loss in 2003 and 2004.

To assist with determining survival status, all radio transmitters contained a mortality sensor. After 4 hours of remaining motionless, the pulse rate of the signal doubled. I then walked in to confirm the status of the animal based on recovery of the transmitter. To increase the battery life, ear tag transmitters were programmed with a duty cycle to transmit only Monday – Wednesday during winter (January – April) and summer months (July – August) from 0800 – 2000 h, and transmitted a pulse rate of 40 instead of 55 pulses/min.

I programmed GPS collars on subadults to collect locations a minimum of once every 23 hours. Data collected on subadults included date, time, latitude, longitude,

altitude, degree of precision, temperature, and activity. I programmed the release mechanism of GPS collars on subadults to open on 31 January of the year following capture to recover data from the collar.

Also, I attached GPS collars (Advanced Telemetry Systems, Inc., Isanti, MN, USA) with identical VHF transmitters to adults (i.e., males ≥ 18 months of age) captured during the study. Global positioning collars for adults were larger (1100 g) than GPS units on subadults, and did not have expandable collars. Data collected on subadult and adult male GPS collars were identical for each successful location. I remotely released adult male GPS collars during January or February of the year following capture.

Also I included 12 male deer with functional radiocollars from an earlier study (Vreeland et al. 2004) conducted in the Penns Valley study area of Centre County. In May – July of 2000 and 2001, male fawns were caught at 1 – 2 weeks of age, and marked with uniquely numbered ear tags of the same manufacturer used in my study and a 97 g expandable VHF neck collars (Advanced Telemetry Systems, Inc., Isanti, MN, USA; (Diefenbach et al. 2003, Vreeland et al. 2004).

I collected survival data on radio-marked deer using ground-based and aerial telemetry a minimum of 1 time per week in 2002, 2003, and 2004. In 2005, I monitored radio-marked deer for survival a minimum of once per month through the 2005-06 deer hunting season. I used a fixed-wing aircraft fitted with telemetry antennas to locate deer when I could not locate them from the ground.

Survival and harvest rate analyses

I conducted survival analyses using known-fates models in Program MARK v. 4.2 (White and Burnham 1999), which was based on the Kaplan-Meier survival model (Kaplan and Meier 1958, Pollock et al. 1989). To estimate harvest rates, I censored all males dying from causes other than hunting. I was limited to monitoring survival once per month in 2005, so I estimated monthly survival and harvest rates. The start of archery season began on the Saturday closest to October 1, firearms season began on the Monday following Thanksgiving Day, and winter archery/flintlock season began on the day following Christmas. No legal hunting occurred on Sunday. The hunting season format caused a change in the date of opening day each year for each season. To account for slight changes in deer season dates, I defined monthly monitoring periods as the 24th day of the month to the 23rd day of the subsequent month. These starting and ending dates best encompassed the early fall archery (first 3 weeks), late fall archery (final 3 weeks), firearm, and winter archery and flintlock firearm deer hunting seasons in Pennsylvania. The monitoring periods allowed for a convenient split of the archery season, which occurred over a 6-week period.

I developed 11 candidate models to estimate survival based on 4 grouping variables (month of year, year, age (subadults vs. adults), and study site). I used Akaike's Information Criterion (AIC), corrected for small sample size (AIC_c) to select the most parsimonious model of survival (Burnham and Anderson 1998). I then used the best model to report survival rates, standard error, and 95% confidence intervals estimated by MARK. Deer not located during a monitoring period were censored from the analysis.

Cause-specific mortality

I investigated all mortalities to determine cause of death. Deer found dead were physically examined whenever possible, and if the cause of death could not be determined, I submitted the carcass for necropsy to the Pennsylvania State University Animal Diagnostic Laboratory.

The loss of antlered deer is important to the evaluation of APRs, and Carpenter and Gill (1987) cited causes related to APRs within and outside the hunting season requiring investigation. Therefore, I separated mortalities into hunting season (24 September – 23 January) and non-hunting season time periods to provide precise measurements of the loss of antlered deer in relation to APRs. Deer hunting season included archery, firearms, and muzzleloader seasons. However, there were periods of season closure. I defined 3 categories of human-caused mortality that occurred during the hunting season: sub-legal kills, illegal kills, and mistaken kills. I defined sub-legal kills as antlered deer not legal for harvest, but confirmed dead from gunshot or arrow wounds during a deer hunting season. Illegal kills occurred during an illegal time period during the deer hunting season (after hunting hours or a time period when no deer hunting season was open), or during a deer hunting season but with a sporting arm not legal for that season. Mistaken kills were sub-legal, killed during a deer season and self-reported by hunters to law enforcement. Mortalities outside the hunting season were classified as road-killed, starvation, killed for crop damage, disease, illegal, predation, and unknown. Males could be legally killed for crop damage, but any other male deer found shot outside of the hunting season were classified as illegal.

Harvest estimates of adult antlered deer

I obtained harvest estimates of antlered deer on statewide and county (Armstrong and Centre counties) levels from the PGC. I estimated the number of adult antlered deer in the harvest from harvest data and sex-age-kill data (PGC unpublished data).

Results

Capture, marking, and monitoring

I captured 544 males from December 2001 to April 2004. In Armstrong County, I captured and radio-marked 325 (260 subadults and 65 adult) male white-tailed deer (Table 2.1, Figure 2.2). In Centre County, I captured and radio-marked 219 males: 182 subadults and 37 adults (Table 2.1, Figure 2.3).

Survival and harvest rates

Of the 11 models I developed, the most parsimonious model (AIC_c weight = 70.4%) indicated survival varied by age and month of year, but did not vary between study areas or year (Table 2.2). Monthly survival rates ranged from 0.99 to 0.64 for subadults and 1.0 to 0.36 for adults (Table 2.3). The probability of surviving a year was 0.46 (SE = 0.03; 95% CI = 0.41 – 0.52) for subadults and 0.28 (SE = 0.03; 95% CI = 0.22– 0.35) for adults. As expected, the lowest survival rates were during the firearms

Table 2.1: Summary statistics for the capture of 544 unique male white-tailed deer in Armstrong and Centre counties, Pennsylvania, from 2002 – 2004. Capture methods included Clover traps, drop nets, rocket nets, dart guns, and helicopter. Subadults were 7 – 10 months old at the time of capture. Adults were ≥1.5-years-old at the time of capture. This table does not include 11 subadults and 1 adult monitored in this study but captured as neonates in a previous study (Vreeland et al. 2004).

Study Area	Year	Subadults	Adults	Total
Armstrong	2002	81	10	91
	2003	103	13	116
	2004	76	42	118
	All years	260	65	325
Centre	2002	36	2	38
	2003	74	7	81
	2004	72	28	100
	All years	182	37	219
All study areas and years		442	102	544

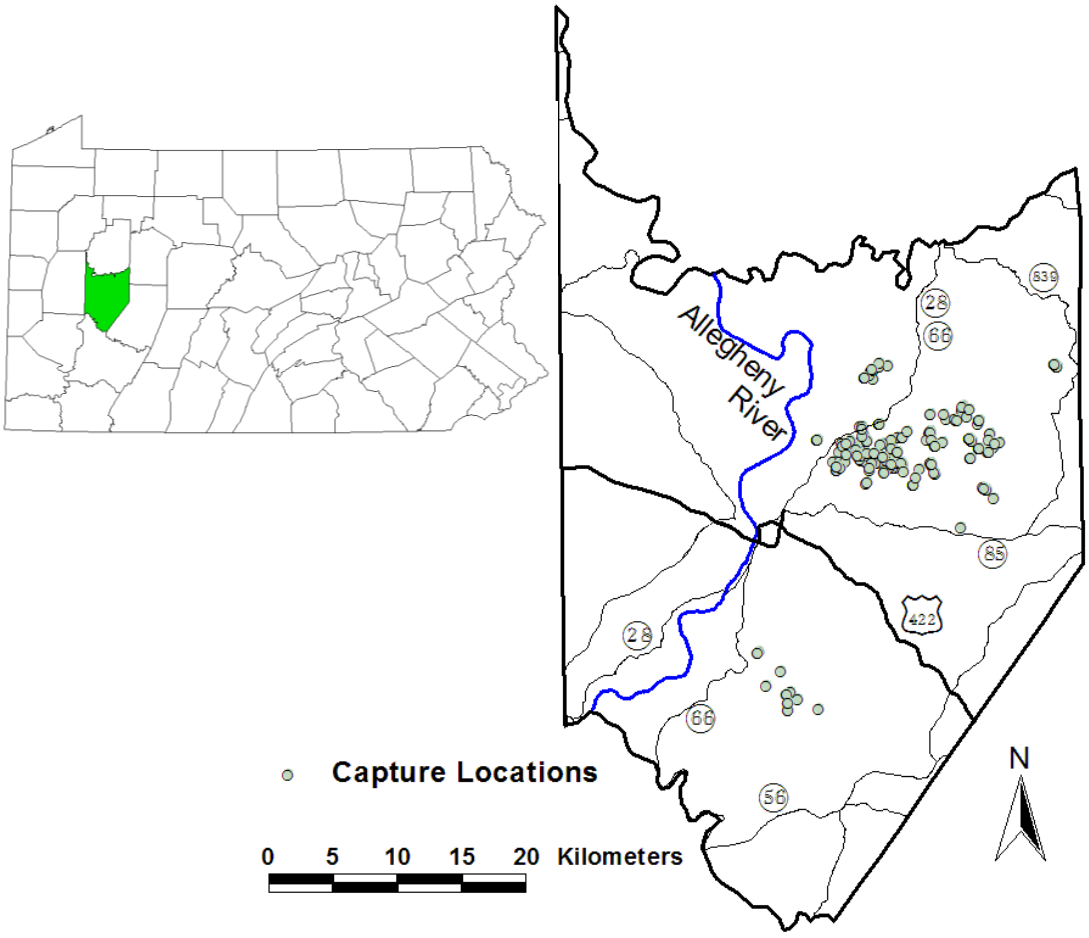

Figure 2.2: Capture locations of 325 male white-tailed deer trapped and radio-marked in Armstrong County, Pennsylvania, from 2001 – 2004. Completely overlapping capture locations were not registered separately. (Figure used by permission, Long 2005.)

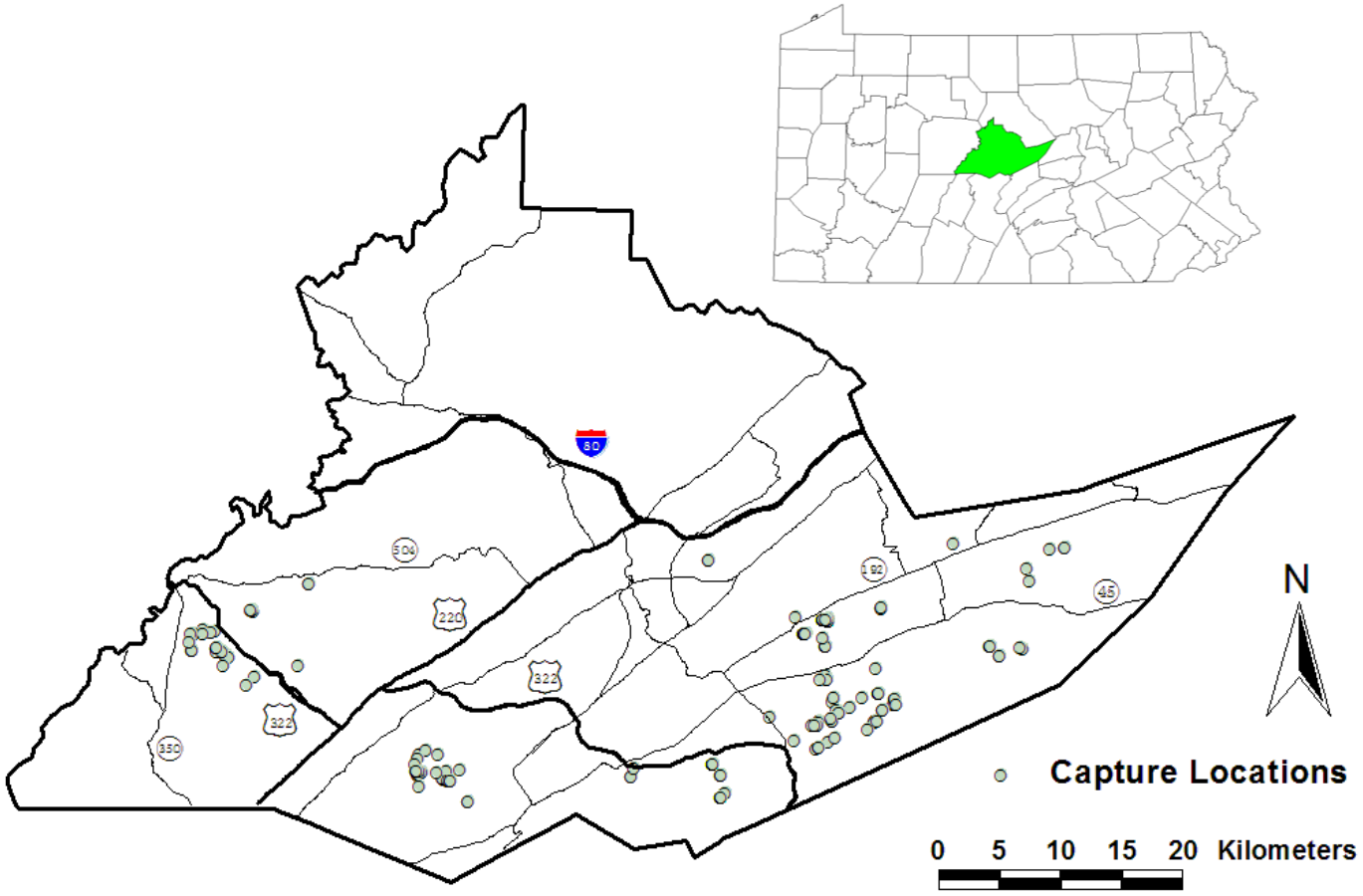

Figure 2.3: Capture locations of 219 male white-tailed deer trapped and radio-marked in Centre County, Pennsylvania, from 2002 – 2004. Completely overlapping capture locations were not registered separately. (Figure used by permission, Long 2005.)

Table 2.2: Performance of 11 candidate models estimating survival rates (S) of juvenile and adult male white-tailed deer in central and western Pennsylvania, 2002 – 2005. Models were tested based on monthly monitoring periods from the 24th day of each month to the 23rd day of the following month in each year and each site.

Model	Model description	k[a]	ΔAIC_c[b]	w[c]
S (age x month)	Survival varied between age and months.	24	0.00	0.70
S (study area x age x month)	Survival varied between sites, age, and months.	48	1.73	0.30
S (age x month (mont s 1-10 equal, 11 and 12 different) x study area	Survival varied between age, site, and month when months 1-10 had equal survival rates but months 11 and 12 were different.	12	19.8	0.00
S (age x month (months 1-10 equal, 11 and 12 different))	Survival varied between age and month when months 1-10 had equal survival rates but months 11 and 12 were different.	6	24.25	0.00
S (age x month (months 1-10 equal, 11 and 12 different) x year)	Survival varied between age, year, and month when months 1-10 had equal survival rate but months 11 and 12 were different.	21	43.09	0.00
S (age x year x month)	Survival varied among age, months, and years.	84	75.63	0.00
S(Age*month (months 1-11 equal, month 12 different)*site)	Survival varied between age, site, and month when months 1-11 had equal survival rates but month 12 was different.	8	89.85	0.00
S(Age*month (months 1-11 equal, month 12 different))	Survival varied between age and month when months 1-11 had equal survival rate but month 12 was different.	4	90.57	0.00
S(Age*month (months 1-11 equal, month 12 different)*year)	Survival varied between age, year, and month when months 1-11 had equal survival rates but month 12 was different.	14	101.88	0.00
S(Site*age*year*month (pool yr 1 adults))	Survival varied between sites, age, months, and years when year 1 adults from both study areas are pooled.	155	142.80	0.00
S (null)	Survival probability is constant among site, age, year, and month.	1	745.41	0.00

[a] Number of model parameters

[b] Difference between AIC_c and AIC_c of best-fit model

[c] Relative weight of AIC_c

Table 2.3: Monthly survival estimates ($\hat{S}$), standard errors (SE($\hat{S}$)), and 95% confidence intervals (CI) for subadult and adult male white-tailed deer in Armstrong and Centre counties, Pennsylvania, from 2002 – 2005. Subadults were captured at 7 – 10 months of age, and carried their first antlers during the following deer hunting season. Adults were males older than subadults. Subadults were classified as adults after surviving their first season with antlers.

	Subadult				Adult			
Time period	n[1]	$\hat{S}$	SE($\hat{S}$)	95% CI	n[1]	$\hat{S}$	SE($\hat{S}$)	95% CI
December 24 – January 23	50	0.98	0.02	0.94 – 1.00	117	0.99	0.01	0.95 – 1.00
January 24 – February 23	199	0.95	0.01	0.92 – 0.98	141	0.98	0.01	0.95 – 0.99
February 24 – March 24	373	0.96	0.01	0.93 – 0.97	166	0.97	0.01	0.94 – 0.99
March 24 – April 24	421	0.97	0.01	0.95 – 0.98	167	1.00	0.00	1.00 – 1.00
April 24 – May 24	401	0.98	0.01	0.96 – 0.99	163	0.99	0.01	0.96 – 1.00
May 24 – June 24	377	0.99	0.00	0.98 – 1.00	160	1.00	0.00	1.00 – 1.00
June 24 – July 25	355	0.99	0.00	0.98 – 1.00	155	1.00	0.00	0.97 – 1.00
July 24 – August 25	343	0.99	0.01	0.97 – 1.00	149	0.99	0.01	0.96 – 1.00
August 24 – September 25	324	0.99	0.01	0.97 – 1.00	142	0.99	0.01	0.96 – 1.00
September 24 – October 25	310	0.97	0.01	0.95 – 0.98	134	0.95	0.02	0.90 – 0.97
October 24 – November 26	290	0.91	0.02	0.87 – 0.94	115	0.89	0.03	0.83 – 0.93
November 24 – December 24	253	0.64	0.03	0.58 – 0.69	95	0.36	0.04	0.29 – 0.45
Annual survival		0.46	0.03	0.41 – 0.52		0.28	0.03	0.22 – 0.35

[1] Number of individuals at risk during time period.

hunting season. Ninety-two percent (SE = 0.02) of antlered deer surviving the hunting seasons survived to the start of the subsequent hunting seasons in October.

The cumulative harvest rates for subadult and adult antlered deer were 0.31 and 0.59, respectively (Table 2.4.) Harvest rates were highest during the 2-week firearms season and lowest during the late season archery/muzzleloader season, which was the last season of the year (Table 2.4).

Cause-specific mortality

I was not able to determine antler size of individual radio-collared deer before the hunting season, so my analyses were based on the entire marked sample of males. Legal harvest was the greatest source of mortality for subadults and adults, accounting for 20% of subadults and 63% of radio-collared adults (Table 2.5). Thirty-three of 274 (12%) subadults were illegally harvested during the hunting seasons (Table 2.5). Twenty-one of 33 were classified as sub-legal kills. Of the adults, 9 of 140 (6%) were classified as illegal harvests. During the period outside the hunting season, road-kills were the source of greatest mortality for both subadults (5%) and adults (4%) (Table 2.6). Two of 16 adult deer were illegally shot before hunting season.

Table 2.4: Harvest rates ($\hat{H}$), standard error (SE($\hat{H}$)), and 95% confidence interval (CI) of subadult and adult antlered deer under antler point restrictions regulations during the 2002 – 2005 hunting seasons in Armstrong and Centre counties, Pennsylvania. Subadults were 1.5 years old, and adults were ≥2.5 years old. Subadults were classified as adults after surviving the hunting season.

		Season $\hat{H}$			Cummulative $\hat{H}$		
Age group	Hunting season[1]	$\hat{H}$	SE($\hat{H}$)	95% CI	$\hat{H}$	SE($\hat{H}$)	95% CI
Subadults	Archery[2]	0.02	0.01	0.01 – 0.05	0.02	0.01	0.01 – 0.04
	Archery[3]	0.04	0.01	0.02 – 0.07	0.06	0.01	0.03 – 0.09
	Firearms[4]	0.26	0.03	0.21 – 0.32	0.31	0.03	0.25 – 0.36
	Archery/flintlock[5]	0.01	0.01	0.00 – 0.03	0.31	0.04	0.23 – 0.38
Adults	Archery[2]	0.04	0.01	0.02 – 0.08	0.04	0.01	0.01 – 0.07
	Archery[3]	0.08	0.02	0.04 – 0.13	0.11	0.02	0.06 – 0.16
	Firearms[4]	0.54	0.04	0.46 – 0.63	0.59	0.04	0.50 – 0.67
	Archery/flintlock[5]	0.00			0.59	0.08	0.40 – 0.72

[1] Seasons occur without overlap

[2] Early fall (first 3 weeks) archery season.

[3] Late fall (final 3 weeks) archery season.

[4] Includes 2 weeks of firearms season.

[5] Includes winter archery and flintlock firearms seasons.

Table 2.5: Cause-specific mortality and survival of subadult and adult males during the Pennsylvania hunting season under antler point restrictions, 2002 – 2005. Subadults were 1.5 years old, and adults were ≥2.5 years old. Thirty-one subadult and 34 additional adults were censored after the telemetry signal was lost. One adult mortality caused by a collar malfunction in the Centre study area was not included in the table.

	Subadult						Adult					
	Armstrong		Centre				Armstrong		Centre			
Source	*n*	%	*n*	%	Total	%	*n*	%	*n*	%	Total	%
Legal harvest	37	23	19	17	56	20	52	63	36	63	88	63
Illegal harvest												
- Sub-legal kills[1]	18	11	3	3	21	8	3	4	4	7	7	5
- Illegal kills[2]	5	3	0	0	5	2	0	0	0	0	0	0
- Mistaken kills[3]	2	1	5	4	7	3	1	1	1	2	2	1
Unknown legality[4]	12	7	12	11	24	9	5	6	1	2	6	4
Non-harvest												
- Road-killed	4	2	6	5	10	4	4	5	1	2	5	4
- Natural injury	2	1	0	0	2	<1	0	0	0	0	0	0
- Disease	2	1	0	0	2	<1	0	0	0	0	0	0
Unknown	0	0	2	2	2	<1	0	0	1	2	1	<1
Survived	79	49	66	58	145	53	18	22	13	23	31	22

[1] Sub-legal males were antlered deer not legal for harvest, but confirmed dead from gunshot or arrow wounds during a deer season.
[2] Illegal kills were males killed in an illegal time period during the deer season, or during a deer season but with an illegal weapon.
[3] Mistaken kills were sub-legal, killed during a deer season, and self-reported by hunters to law enforcement.
[4] Unknown legality were males confirmed dead during the hunting season, but the number of points could not be ascertained.

Table 2.6: Cause-specific mortality and survival of subadult and adult male white-tailed deer under antler point restrictions from time of capture to the hunting season and during other subsequent months with no hunting seasons in Pennsylvania, 2002 – 2005. Subadults were captured at 7 – 10 months of age, and carried their first set of antlers during the following deer hunting season. Adult males survived their first hunting season with antlers. Ninety-two and 67 additional subadults and adults, respectively, were censored due to loss of telemetry signal. Four males were not included: 3 subadults died near the trapsite; and 1 adult died from a collar injury.

	Subadult						Adult					
	Armstrong		Centre				Armstrong		Centre			
Source	*n*	%	*n*	%	Total	%	*n*	%	*n*	%	Total	%
Road-killed	15	7	4	3	19	5	5	5	3	4	8	4
Starvation	0	0	15	10	15	4	0	0	1	1	1	<1
Crop damage kill	4	2	0	0	4	1	1	1	0	0	1	<1
Disease	2	1	0	0	2	1	1	1	1	1	2	1
Illegally shot	2	1	0	0	2	1	2	2	0	0	2	1
Predation	0	0	1	<1	1	<1	0	0	1	1	1	<1
Unknown	4	2	6	4	10	3	1	1	0	0	1	<1
Survived	182	87	123	83	305	85	100	91	75	93	175	92

Adult antlered males in the statewide harvest

The number of adult antlered deer in the statewide harvest increased after the initiation of APRs. In 2000 and 2001 prior to APRs, adult males in the harvest averaged 41,636 (Table 2.7). In the initial year of APRs, I estimated there were almost 50,000 adult males in the statewide harvest, and from 2003 – 05, adult males in the harvest averaged 59,211 (Table 2.7). Prior to APR, the adult male harvest in Armstrong County averaged 416. From 2003 – 05, adult males in the harvest averaged 1,034 (Table 2.8). During the same years in Centre County, the adult male harvest was 976 and 1,216, respectively.

Table 2.7: Statewide estimates and standard errors (SE) for antlered white-tailed deer harvest, and estimates of antlered harvest by subadult and adult age classes, Pennsylvania, 2000 – 2005. Subadults were 1.5 years old during the deer hunting season. Adult males were ≥2.5 years old.

	Antlered harvest [1]		Estimated subadult	Estimated adult
Year	Estimate	SE	harvest	harvest
2000	240,365	2,270	198,381	41,984
2001	197,799	1,737	156,511	41,289
2002	161,949	1,987	112,077	49,875
2003	140,987	1,788	81,579	59,408
2004	124,107	1,596	62,649	61,457
2005	120,080	1,760	63,311	56,770

[1] Methods described by Rosenberry et al. (2004).

Table 2.8: County estimates and standard errors (SE) for antlered white-tailed deer harvest, and estimates of antlered harvest by subadult and adult age classes, Pennsylvania, 2000 – 2005. Subadults were 1.5 years old during the deer hunting season. Adult males were ≥2.5 years old.

		Antlered harvest [1]		Estimated subadult	Estimated adult
County	Year	Estimate	SE	harvest	harvest
Armstrong	2000	4,284	167	3,864	420
	2001	4,290	190	3,878	412
	2002	3,357	137	2,753	604
	2003	2,535	104	2,010	525
	2004	3,093	145	1,974	1,120
	2005	3,134	144	1,677	1,457
Centre	2000	5,029	137	4,089	940
	2001	4,324	117	3,312	1,012
	2002	3,479	94	2,115	1,364
	2003	2,767	86	1,353	1,414
	2004	2,128	77	900	1,228
	2005	1,814	94	809	1,005

[1] Methods described by Rosenberry et al. (2004).

Discussion

The main biological concerns about APRs center around 2 issues: (1) whether they protect the antlered deer they were designed to protect during the hunting seasons; and (2) whether the antlered deer protected from harvest survive to be hunted the following season. Despite their legal protection, mortality of protected males within the hunting season and illegal kills outside of the hunting season were additive sources of mortality because they were killed, but not available for legal harvest. The loss of protected animals due to hunting was described as the "shoot and sort" phenomenon by Carpenter and Gill (1987) where hunters would shoot deer and then determine whether

legal to harvest. Boyd and Lipscomb (1976:7) reported on the "shoot and sort" phenomenon with the loss of 22 bull elk with 3-point antlers in a 4-point area, stating they were "…probably shot because their racks appeared large enough to be legal." Boyd and Lipscomb (1976) based their conclusions on interviews with hunters, not with telemetry data from radio-collared elk. With moose, Schwartz et al. (1992) reported a decrease in the illegal harvest of cows, but an increase in the illegal bull kill with implementation of a selective harvest for bulls. The reported illegal kill of bulls averaged 7% of the legal harvest, but because a radio-marked population was not used, they acknowledged their methods accounted for a minimum proportion of the total illegal kill.

In my study, 8% (21 of 274) of subadults and 5% (7 of 140) of adults were sub-legal males shot during the hunting season and unretrieved (Table 2.5). Sub-legal males shot and unretrieved represents the consequences of the "shoot and sort" phenomenon reported by Carpenter and Gill (1987). Unretrieved sub-legal males and mistaken kills were part of the cost of APRs (Carpenter and Gill (1987). However, my estimate may be positively biased because males protected by APRs were legal deer for youth hunters, disabled hunters, and active military personnel. Some male losses could have been caused by hunters in a legal manner. Regardless, about twice as many subadults were legally harvested, and almost 5 times as many survived the hunting season compared to unretrieved harvests. Most hunters did not shoot first and ascertain legality later, but adhered to the changes in regulations.

The illegal kill of sub-legal males within the hunting season and of older males outside the hunting season were concerns to managers using APRs. There were no

documented incidents of illegal kills in the Centre County study area. Most illegal kills in Armstrong County took place with subadults during the hunting season. Illegal kills, however, were only 5 of 274 marked subadults. Only 2 of 191 adult males were illegally killed before hunting season. With so few males illegally killed, I concluded the concerns of Carpenter and Gill (1987) about losses to sub-legal kills during the hunting season and illegal kills outside the hunting season were unfounded for this study.

Pennsylvania APRs were designed to protect 50 – 75% of subadults from harvest to increase the number of adult males in the population next year. Consequently, APRs in Pennsylvania decreased the subadult harvest rate from >0.80 statewide (PGC unpublished data) prior to APRs to 0.31 during this study. Antler development is greatest between subadult and 2-year-old adult males because subadult male antlers exhibit approximately 25-30% of the maximum potential, but as a 2-year-old, antler size increases to 60% of maximum potential (Strickland and Demarias 2007). Most males attain 6 to 8 point antlers (3-4 per side) by at least the 3-year-old age class (Sauer 1984, Koerth and Kroll 2008). Adult male harvest rates (0.59) were almost double the harvest rate of subadults. Thus, Pennsylvania APRs shifted hunter pressure toward harvesting adults. Although approximately equal numbers of subadults and adults were harvested (Table 2.7), the subadult male harvest was 31% of the male cohort in my study areas.

Prior to APRs, <20% of a subadult male cohort survived to be available for harvest, and >80% of ≥2.5-year-old males were harvested. After APRs were implemented, the adult harvest rate of 0.59 allowed a greater proportion of ≥2.5-year-old males to survive the hunting seasons. I expected the adult harvest rate to be >80%.

Although simple in concept, counting points under field conditions can be difficult, and could be a reason for the lower harvest rate of adults. Consequently, an additional effect of APRs was more males survived to the 3-, 4-, and 5-year-old age classes. The PGC pooled age data from males ≥2.5 years old because accuracy of the wear and replacement ageing technique deteriorates with older deer (Gee et al. 2002). Therefore, I could not estimate the harvest of antlered deer >2.5 years old from 2002 – 2005. However, cementum annuli analysis from ≥2.5 year old males harvested during the 2006 and 2007 firearms hunting seasons estimated the proportion of 2.5-year-old males in the ≥2.5-year-old age class was 73%, suggesting 27% of adult males in the harvest were ≥3.5-years-old (PGC, unpublished data). During my study, 36% of adult males alive at the beginning of the firearms season survived all forms of mortality.

Once antlered deer survived the hunting season, they had a survival rate of 0.92 to the next deer hunting season. Bowman et al. (2007) reported a mortality rate of 0.12 for adult males due to natural causes under a QDM program in Mississippi. I documented mortality from starvation in winter, automobiles, predation, disease, and other sources were minor outside of the hunting season. Vehicle collision was the most common source of mortality and starvation was the second most common. However, most (14 of 15) of the starvation mortalities came from the forested Moshannon State Forest and State Game Lands 33 in western Centre County. Therefore, I consider starvation to be atypical because it came from a small portion of the Centre County study area. Regardless, because only 8% of the males surviving the previous hunting season died prior to the subsequent hunting season, the hunting harvest of antlered subadults was additive

mortality, and not compensatory, which was a concern expressed by Carpenter and Gill (1987).

The increased harvest of adult antlered deer and the increased proportion of adults in the antlered deer harvest under an APR harvest strategy were evidence the APRs allowed more subadults to survive to the adult age class. With elk, Unsworth et al. (1993) stated APRs must be accompanied with restrictions in hunter numbers or hunter access. Subsequent research on elk and moose by Bender and Miller (1999) and Young and Boertje (2008), respectively, reported limiting hunter density and access reduced the antlered harvest, thereby increasing the bull to cow ratio. However, no limitations on hunter numbers, access, or hunting opportunity occurred during my study. Regulations, however, can constrain hunter participation (Miller and Vaske 2003) and Pennsylvania did see a decrease in hunter effort in the initial year of APRs. Statewide hunter-days declined between 2001 and 2002 (Table 2.9) because of approximately 65,000 fewer hunters. Hunter-days remained stable from 2002 – 2005. Deer populations, and consequently, antlered deer harvests declined from 2000 – 2005 (Table 2.7 and 2.8). Despite declining trends in deer populations and antlered deer harvests, the number of adult males in the harvest increased from about 42,000 before APRs took place to over 60,000 in 2004, with an average of 59,200 during 2003 – 2005 when the definition of an antler point remained consistent (Table 2.7). In Armstrong County, the adult male harvest increased from 416 before APRs to an average of 1,034 from 2003 – 2005. During the same years in Centre County, the difference was less 976 to 1,216, but the harvest declined from >5,000 to 1,800 (Table 2.8.). Despite the harvest decline, which was associated with a declining

population (Table 2.9), the number of adult males in the harvest with APRs increased. Some of the increased harvest of adults can be attributed to the survival of 2-year-olds to the 3-year-old age class.

Carpenter and Gill (1987) stated the objective of stockpiling older males can only be met if hunter pressure was reduced (fewer and shorter seasons), hunter participation was reduced, and there were naturally low mortality rates. Two of the 3 conditions were met with Pennsylvania APRs. Antlered deer hunting regulations for season length remained the same, and all hunters could hunt antlered deer. However, hunter participation (hunter-days during the firearms season) did decline when APRs began, and remained lower than pre-APR estimates (Table 2.9). The decline in hunter-days was unexpected because no restrictions were placed on antlered deer hunter numbers. In addition to APRs, 3 other factors could have influenced hunter-days: (1) number of deer hunters; (2) concurrent deer seasons; and (3) declining deer populations. Estimates of the number of Pennsylvania deer hunters had been declining since 1986 (Rosenberry et al. 2009). Concurrent deer seasons brought additional opportunity on Saturdays when hunting interfered less with work obligations. Finally, a declining deer population means less satisfaction (Langenau et al. 1981, Hammitt 1990, Holbook and McSwain 1991). The influence of each factor on hunter effort is unclear, but combined, the effect resulted in fewer hunter-days afield during the firearms deer season. The final condition of Carpenter and Gill (1987), low mortality rates was met in my study, with monthly survival rates between 0.97 – 1.0 (Table 2.3).

Another concern of Carpenter and Gill (1987) was the stockpiling older males may

Table 2.9: Statewide estimates for white-tailed deer pre-season population abundance, and total number of days hunters participated in the firearms season, Pennsylvania, 2000 – 2005.

		Statewide hunter days [3]	
Year	Estimated pre-hunt population [1,2]	Estimate	95% CI
2000	1,487,898	3,478,022	3,420,905 – 3,535,139
2001	1,372,594	3,571,833	3,507,181 – 3,636,485
2002	1,380,479	3,259,869	3,191,897 – 3,327,841
2003	1,254,997	3,264,793	3,195,350 – 3,334,236
2004	1,174,230		
2005	1,140,321	3,188,982	3,118,930 – 3,259,034

[1] Population estimates for 2000 and 2001 from the Pennsylvania Game Commission (PGC; unpublished data).

[2] Population estimates for 2002 – 2005 from Norton (2010).

[3] From Rosenberry 2001, Rosenberry 2002, Rosenberry 2003, Rosenberry 2004, Librandi-Mumma 2006. No Game Take survey conducted by the PGC in 2004.

result in increased natural mortality of younger age classes. No increase in natural mortality was observed in my study, nor in the study reported by Bowman et al. (2007) in Mississippi. Pennsylvania's APR management strategy was only designed to increase the number of subadult males moving into the 2-year-old age class. Prior to APRs, adult harvest rates were >0.80 (PGC unpublished data). During my study, adult harvest rates were 0.59, but 28% of adult males surviving the previous hunting season as a subadult also survived through the following hunting season to enter into the 3-year-old age class. Survival rates of subadults in my study outside hunting season were between 0.95 and 0.99 (Table 2.3). Bowman et al. (2007) reported yearling male natural mortality rate to be the lowest among all age classes, and the ≥5.5-year-old age class had the highest mortality. In my Pennsylvania study, survival rates indicated more males survived into older age classes.

Chapter 3

An evaluation of hunter support for antler point restrictions

Introduction

Management of wildlife resources involves 2 major components: the biological component including populations and habitat, and the social component, comprised of people with a stake or interest in the management of the wildlife resource. Modern wildlife management has become as much a social endeavor as a biological endeavor (Duda et al. 1998). As management decisions affect increasing numbers of people, the social element becomes more essential, even critical to the overall success of any decision. There is a long list of natural resource project failures because social support was lacking (Fazio and Gilbert 1986). Successful wildlife programs require a thorough understanding of wildlife populations, habitats, and people (Duda et al. 1998).

Although there are many stakeholders in deer management, deer hunters comprise an important, consumptive user group whose support is necessary for successful deer management. Deer hunting is the primary method of managing deer populations, and in 2001, Pennsylvania had approximately 859,000 deer hunters (Rosenberry et al. 2009). Changes in hunting regulations almost always generate public comment, and major paradigm shifts in management philosophy and deer hunting traditions can be expected to generate controversy.

In Alaska, a selective harvest system (SHS) for bull moose allowed for the harvest of spike and fork horn (≤2 points on each antler) bulls, bulls with antlers >127 cm (50 in), and/or bulls with 3 or more brow points on 1 side (Schwartz et al. 1992). Although

considered biologically successful (Schwartz et al. 1992), the SHS was not without controversy among hunters. About 10% of hunters indicated they hunted elsewhere to avoid the SHS (Fulton and Hundertmark 2004) and there was a 25% decline in the number of hunters after implementation of the SHS. On the professional level within the Alaska Department of Fish and Game, Monzingo (1999) disagreed with Bartley (1999) about the SHS for moose.

In Vermont, an APR to protect spike-antlered white-tailed deer was enacted in 2005 by a hunter initiative designed to increase the number of older, antlered deer (S. Haskell, Vermont Department of Fish and Game, personal communication). Hunter support for the APR was high, with 75% favoring the regulation which decreased the subadult frequency in the harvest from 63% to 50% (S. Haskell, Vermont Department of Fish and Game, personal communication).

Revised APRs in Pennsylvania were introduced in 2002 and considerable debate ensued among the PGC BOC, who approve state hunting regulations. The implementation of any new APR designed to have a measurable population effect will by necessity change traditional regulations familiar to hunters. In 2002, the PGC BOC changed the definition of an antlered deer legal for harvest on a statewide level, breaking a longstanding tradition in Pennsylvania deer management. The change in the legal definition of an antlered deer for harvest affected all hunters statewide except junior license holders, disabled person permit holders, and residents serving active duty in the United States Armed Forces. Recognizing most hunters were quiet, and only a few were outspoken, Carpenter and Gill (1987) recommended the use of surveys to monitor hunting recreation attitudes and opinions.

Deer hunter surveys conducted before APRs began, and during their use could measure hunter support and perception of the effect of APRs on the deer herd, as well as hunters themselves. Changes in regulations not supported by hunters can lead to decreased hunter satisfaction (Fulton and Manfredo 2004). If APRs were to be successful, they would have to be supported by Pennsylvania deer hunters. Any change in APRs can bring concerns of illegal harvests, increased difficulty for hunters ascertaining whether an animal is legal to harvest, and the waste of animals killed illegally (Carpenter and Gill 1987, Monzingo 1999, Fulton and Hundertmark 2004, Kandoth et al. 2010).

My purpose for this chapter was to: (1) evaluate hunter support with APRs; and (2) assess hunter perception of the effects of APRs. I conducted pre- and post-hunting season mail surveys during the first 3 years of APRs in Pennsylvania. I used a series of questions to assess each of the following: (a) hunter support for APRs; (b) hunter perception of antlered deer survival; (c) hunter satisfaction with the antlered deer harvest; (d) perception of breeding activity shifting to older males; (e) satisfaction with observed sex ratios; (f) satisfaction with observed antler size; (g) satisfaction with the number of antlered deer seen; (h) influence of APRs on deer hunting enjoyment; and (i) acceptance of problems hunters perceived were associated with APRs. Also, I surveyed the same hunters over time to assess changes in attitudes and opinions. Finally, I evaluated how support for APRs changed by using matched responses from identical respondents before APRs began and 3 years after implementation.

Methods

Statewide deer hunter surveys were conducted by the PGC and provided by the agency for my use as secondary data. The study of human participants from secondary data was approved by the Penn State Office for Research Protection (IRB #14835) for each of the surveys. Hunter opinions concerning the effects of APRs were monitored via a pre-season and post-season mail survey for the 2002-04 deer hunting seasons.

Procedures for all surveys followed Dillman (2000). Questions measuring support for APRs were similar in wording and composition to the phone survey conducted by Luloff et al. (2002). I used the results of Luloff et al. (2002) and the fall 2002 mail survey as pre-treatment data. The firearms deer season was held between the pre- and post-hunting season surveys. The PGC conducted the initial pre-season survey in October and November 2002, with similar surveys in 2003 and 2004 conducted during the same time frame. I accepted surveys postmarked before or on the opening day of firearms season for the pre-hunting season survey. The first post-hunting season survey was mailed in April in 2003 to ensure the most current list of hunters was available for sampling. In subsequent years (2004 and 2005), the survey was conducted in January – February using the previous year's license buyers so the survey could be mailed immediately after the hunting season. Mazurkiewicz et al. (1996) found no difference in opinion-preference survey data after a 4-month period, so although there was a considerable time lag in the April 2003 survey, I considered the responses to be reliable. The series of surveys was designed to monitor changes in support for APRs as deer population sex and age structures changed because of the APRs.

I analyzed survey data using SAS version 9.1 (SAS Institute, Cary, North Carolina, USA). I used Chi-square analyses with $\alpha = 0.05$ significance level to identify differences among groups.

I received data from 2 survey groups. The first data set was from a sample of survey participants the PGC randomly selected for each survey to ensure the estimates for a given point in time were representative of all hunters (hereafter referred to as random). Minimum sample size for the random sample was to be sufficient for a return of >600 surveys, thus providing a minimum confidence interval of ±4% (Krueger 2001). The second data set was from the construction of a panel of hunters (hereafter referred to as panel) the PGC repeatedly surveyed over the 3-year period.

Random sample

I summarized responses from survey questions chosen *a priori* from the random group of deer hunters for each of the first 6 surveys mailed by the PGC. The objective of the surveys was to measure hunter perceptions and support for APRs over time.

I focused on nine topics from the deer hunter survey. First, I examined whether hunters supported APRs. The remaining topics were used to determine why hunters did or did not support APRs. The nine topics of investigation were:

A. Hunter support for APRs. (Part 3 questions 1, 2, and Part 5 question 9 of Appendix A.)
B. Hunter perception of subadult male survival. (Part 4 questions 8, 10, 11 and Part 5 question 4 of Appendix A.)

C. Hunter satisfaction with the antlered deer harvest. (Part 5 questions 6 and 8 of Appendix A.)

D. Hunter perception of breeding activity shifting to older males. (Part 4 question 9 of Appendix A.)

E. Hunter satisfaction with observed sex ratios. (Part 3 question 3, Part 4 questions 2, 4, and 7 of Appendix A.)

F. Hunter satisfaction with observed antler size. (Part 4 questions 1 and 6 of Appendix A.)

G. Hunter satisfaction with the number of antlered deer seen. (Part 4 question 3 of Appendix A.)

H. Influence of APRs on deer hunting enjoyment. (Part 5 questions 10, 11, 12, 13 of Appendix A.)

I. Hunter acceptance of perceived problems associated with APRs. (Part 5 questions 1, 2, 3, 5, and 7 of Appendix A.)

Survey questions measured attitudes using a 5-point Likert scale with the categories of strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree. For summary statistics and data analysis of survey results, I excluded survey questions without responses because the lack of a response to a question cannot be interpreted. Therefore, the percentages given were based only on hunters responding to each question, not the total number responding to the survey.

I used factor analysis (PROC FACTOR; SAS version 9.1; SAS Institute, Cary, North Carolina, USA) with a varimax rotation to analyze survey data. I hypothesized hunter responses were related to 3 major factors, each measured by multiple variables in

the survey. The major factors, or labels, were subadult survival, sex ratios, and antlered harvest. I chose 10 questions (Appendix A: Part 3 question 3, Part 4 questions 2, 4, 7, 8, 10, and 11, and Part 5 questions 4, 6, and 8) to factor analyze. The number of underlying factors was determined using a scree test (Cattell 1966) to visually identify the number of components important to the analysis. I used Cronbach's alpha coefficient of internal consistency (Cronbach 1951) to assess reliability of all multi-item factors I created.

Panel sample

The initial survey from the random sample was larger (2,906) to develop the panel sample to analyze longitudinal responses from individuals. Respondents of the initial deer hunter survey were mailed the second survey and asked if they would participate as part of a panel of hunters to be monitored repeatedly across time to evaluate changes in attitudes and opinions (LaPage 1994, Fulton and Manfredo 2004). Panel studies can provide stronger inferences than cross-sectional studies about variables influencing change within individuals (Markus 1979, Wright et al. 2001). Only respondents who continued to return completed surveys were sent subsequent surveys. Loss of participants over time (death, loss of interest, movement) is a limitation of panel studies (Fulton and Manfredo 2004). Also, if there are differences between respondents who dropped out and respondents who finished the panel surveys, then results of the panel surveys will be biased and of limited value to this study. In September 2005, the PGC mailed an abbreviated survey to panel members who dropped out during the study

(Appendix B) and posed specific questions regarding APRs. I compared the response of dropouts to panel member finalists (respondents who completed all 6 surveys).

Questions for panel surveys and random surveys were identical. I chose *a priori* 5 questions from the September 2005 survey to determine if a difference existed between panel finalists and panel dropouts. Three questions assessed attitudes regarding support for APRs, 1 on support for a regulation to increase the antlered to antlerless ratio, and 1 regarding their rating of the overall PGC deer management program (Appendix B). I used Chi-square analyses with a significance level of 0.05 to test for differences between the 2 groups. If I found differences between the random and panel groups, I would not analyze the panel data, except for the first and last surveys, which include the September 2005 follow-up survey to panel members who had dropped out during the study.

Comparison of responses before APRs and 3 years after APRs

I compared attitudes prior to APRs (survey 1) with surveys after 3 years of APRs within the same individual. Data for the comparisons came from the initial survey for everyone, and the final survey for panel members and the nonresponse survey to panel members who dropped out. The purpose of surveying these hunters was to measure direction of support (more supportive or less supportive) over the 3 year period for specific issues related to APRs (Appendix A and 2). The numerical score for each question (Likert scale of 1-5) from the initial survey was subtracted from the numerical score from their last survey. Scores could range from -4 to 4. A score of 0 would indicate no change over the 3 year period. A negative score would indicate the

respondent became less supportive over time, whereas a positive score would indicate greater support over time.

Results

I received responses from 666-1,821 surveys for the random surveys, and 728-1,821 from the panelist group (Tables 3.1 and 3.2, respectively). Response rates for the random surveys were 64 – 69% (Table 3.1), and achieved a confidence level of ±4% or less for the random group (Krueger 2001). Response rates for the panel surveys were from 64 – 94%, and were lowest with the initial 2 surveys until respondents not wanting to participate dropped out (Table 3.2).

I received responses from 576 initial panel members who failed to complete all 6 surveys. Chi-square tests for differences between panel finalists and panel dropouts were significant for 4 of 5 critical questions (Table 3.3). Therefore, I concluded the panel respondents were not representative of all hunters. I did not analyze panel survey data further except to compare initial responses to responses after 3 years of APRs.

Table 3.1: Sample sizes and response rates for 6 deer hunter surveys mailed to randomly selected hunters to determine support for white-tailed deer antler point restriction regulations in Pennsylvania, 2002 – 2005.

Survey period	Surveys mailed	Undeliverable	Surveys received	Response rate (%)
Fall 2002	2,906	135	1,819	66
Winter 2003	1,070	29	666	64
Fall 2003	1,159	55	728	66
Winter 2004	1,138	58	744	69
Fall 2004	1,166	48	736	66
Winter 2005	1,202	54	753	66

Table 3.2: Sample sizes and response rates for 6 deer hunter surveys mailed to hunters selected as panel members to analyze longitudinal responses from individuals to determine support for antler point restriction regulations in Pennsylvania, 2002 – 2005.

Survey period	Surveys sent	Undeliverable	Requested to be dropped	Surveys received	Response rate (%)
Fall 2002	2,906	135		1,819	66
Winter 2003	1,819	10	235	1,154	64
Fall 2003	1,154	3	35	989	86
Winter 2004	989	1	39	868	88
Fall 2004	868	2	18	775	90
Winter 2005	775	1	3	728	94

Table 3.3: Chi-square tests for differences between panel finalists and panel drop-outs of a series of surveys on antler point restrictions in Pennsylvania, 2002 – 2005. Panel finalists completed 6 surveys over a 3 year time period, whereas panel drop-outs completed <6 of the surveys.

	Number of respondents			%				
Survey question	Finalist	Drop-out	Survey response	Finalist	Drop-out	df	χ^2	*p*
I support a statewide antler restriction.	667	555	Agree	66	54	2	21.7	<0.001
			Neither	11	19			
			Disagree	24	27			
I support an antler restriction in the wildlife management units I principally hunt for deer.	666	553	Agree	64	52	2	21.6	<0.001
			Neither	11	19			
			Disagree	25	29			
I support a regulation that would increase the ratio of antlered bucks to antlerless deer in the statewide population.	666	552	Agree	56	49	2	10.2	0.006
			Neither	18	25			
			Disagree	25	26			
Current antler restrictions are a good change in Pennsylvania's deer management program.	666	559	Agree	53	48	2	3.7	0.161
			Neither	22	25			
			Disagree	25	27			
I would rate the PGC's deer management program as: Excellent, Good, Fair, Poor, Don't know.	646	561	Excellent	7	4	4	10.1	0.039
			Good	27	27			
			Fair	28	33			
			Poor	35	30			
			Don’t know	4	6			

Random deer hunter surveys

The proportion of hunters supportive of a statewide APR varied between 0.61 and 0.70 (Figure 3.1). A greater proportion of hunters who hunted in the 3-point area agreed with APRs than hunters from the 4-point area. In the 3-point area, the proportion of hunters supporting APRs ranged from 0.63 – 0.73 while in the 4-point area, support was 0.54 – 0.61. However, support was greater than opposition to APRs in both 3- and 4-point areas (Appendix C Tables 2 and 3). More hunters supported APRs than opposed them, and in most cases the support was by more than 2:1 in favor of APRs.

The proportion of hunters supportive of APRs in the WMU they principally hunt varied between 0.60 and 0.67, whereas 0.18 – 0.29 of hunters opposed them (Figure 3.2, Appendix C, Table 4). Of hunters principally hunting in the 3-point area, the proportion of hunters supportive was 0.62 – 0.71 for the APR in the WMU they hunted. In the 4-point area, 0.50 – 0.57 supported the APR in the WMU they hunted. The proportion of hunter support in the 4-point area started at its lowest point (0.50; with 0.36 opposing them), and increased to its highest level of 0.57 after the 2004 hunting season. Even in the 4-point area, more hunters supported APRs than opposed them.

The proportion of hunters agreeing with the statement "APRs were a good change in Pennsylvania's deer management program" varied between 0.49 – 0.59, while 0.17 – 0.32 disagreed (Figure 3.3). In the 3-point area, the proportion of hunters agreeing was 0.53 – 0.63, while 0.16 – 0.29 disagreed. Similarly, the proportion of hunters agreeing

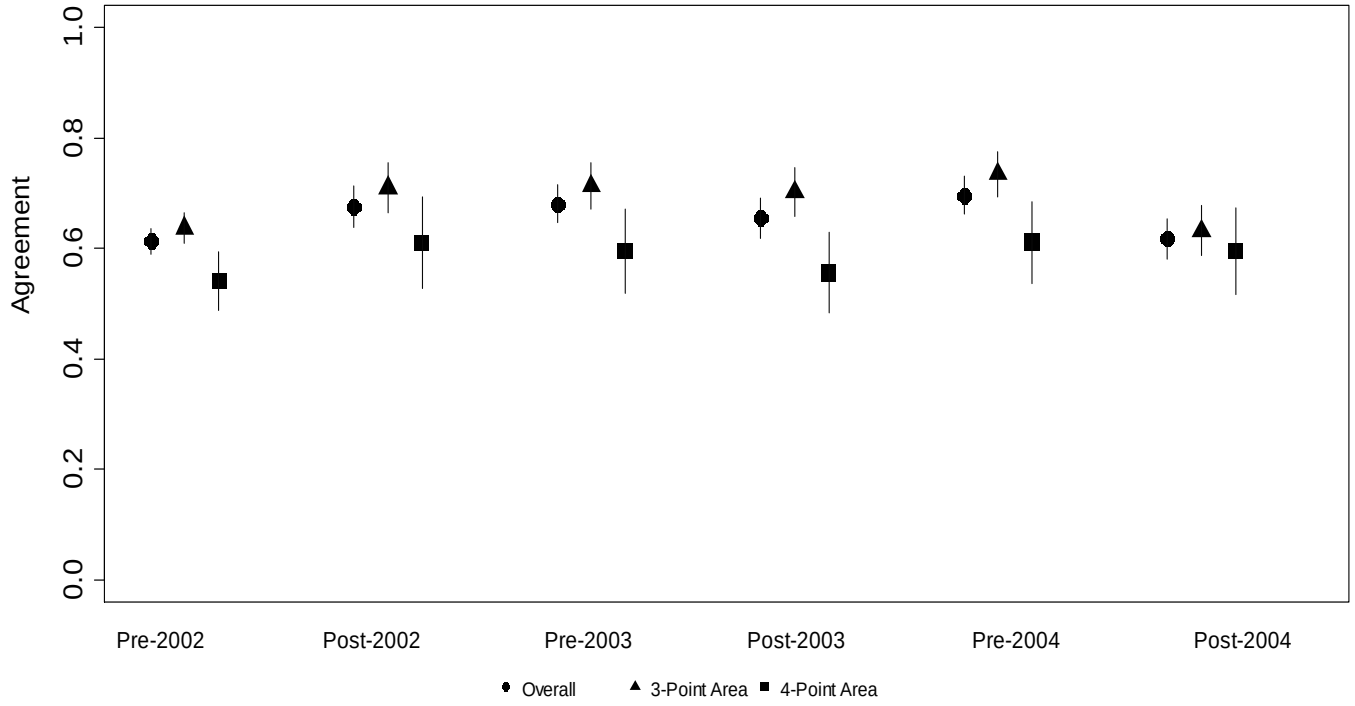

Figure 3.1: Agreement (proportion of respondents) of Pennsylvania deer hunters when asked if they support a statewide antler point restriction for white-tailed deer as described in Part 3 of Appendix A. The Pennsylvania Game Commission (PGC) conducted surveys pre- and post- hunting season in 2002, 2003, and 2004. The deer hunting season separating the surveys was the November – December 12-day firearms deer season in which most hunters participate. I was provided with secondary data from the PGC. Vertical lines represent the 95% confidence interval.

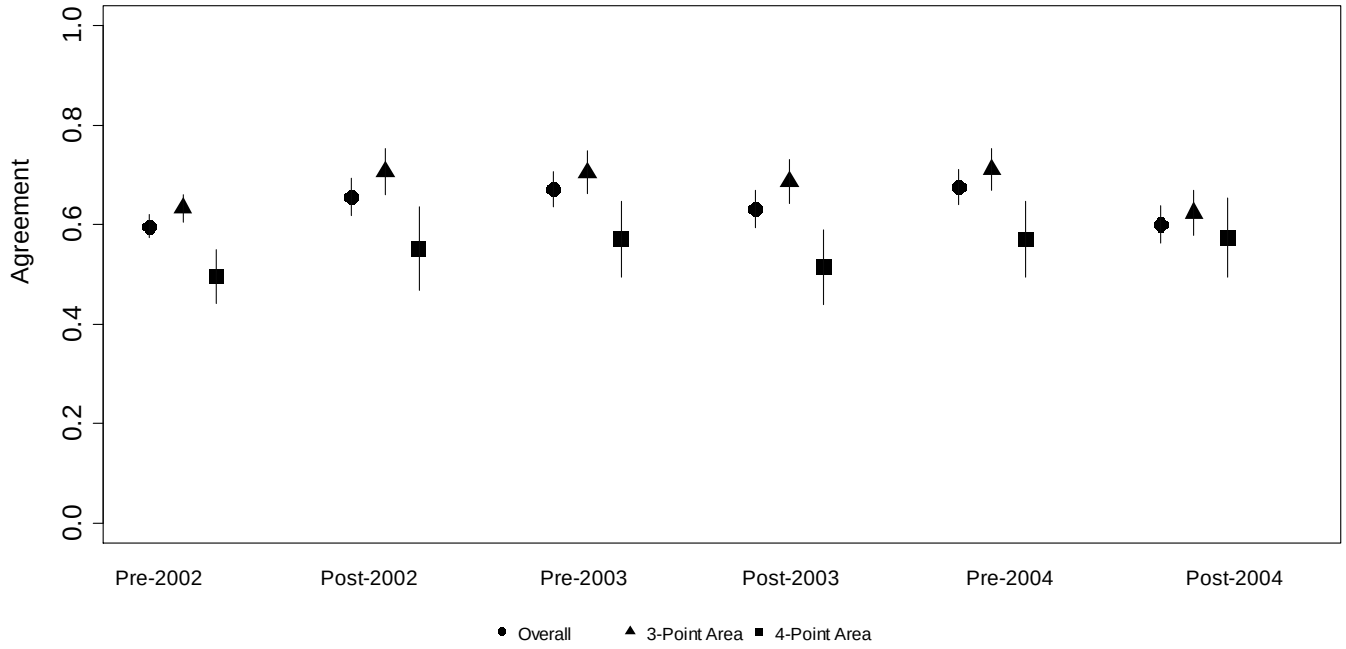

Figure 3.2: Agreement (proportion of respondents) of Pennsylvania deer hunters when asked if they support with an antler point restriction for white-tailed deer as described in Part 3 of Appendix A in the wildlife management unit they principally hunted for deer. The Pennsylvania Game Commission (PGC) conducted surveys pre- and post-hunting season in 2002, 2003, and 2004. The deer hunting season separating the surveys was the November – December 12-day firearms deer season in which most hunters participate. I was provided with secondary data from the PGC. Vertical lines represent the 95% confidence interval.

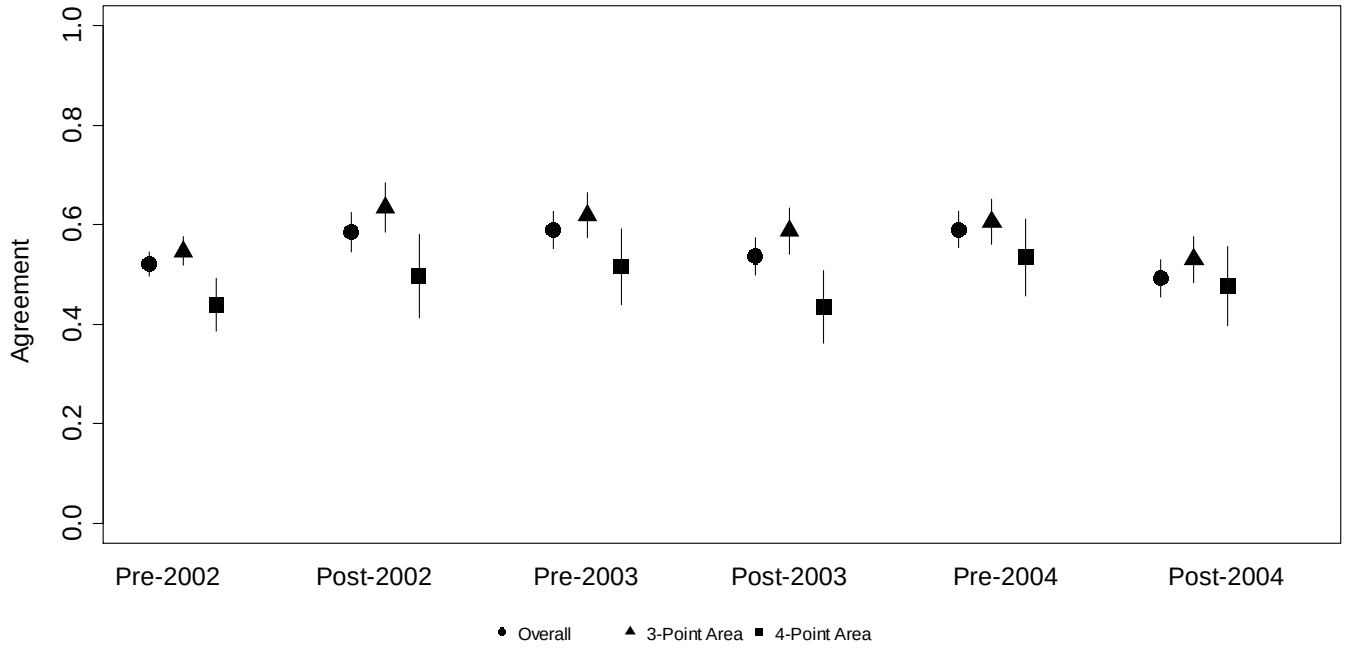

Figure 3.3: Agreement (proportion of respondents) of Pennsylvania deer hunters when asked if antler point restrictions for white-tailed deer as described in Part 3 of Appendix A were a "good" change in Pennsylvania's deer management program. The Pennsylvania Game Commission (PGC) conducted surveys pre- and post- hunting season in 2002, 2003, and 2004. The deer hunting season separating the surveys was the November – December 12-day firearms deer season in which most hunters participate. I was provided with secondary data from the PGC. Vertical lines represent the 95% confidence interval.

in the 4-point area was 0.44 – 0.53, while 0.21 – 0.33 disagreed.

For the purpose of my research, I did not believe there was a need to separate survey responses from hunters in 3- and 4-point areas because at least one-half of 3- and 4-point area hunters supported APRs in all surveys (Appendix C Tables 3 and 6). Also, even though hunter support for APRs in the 4-point area was less than support in the 3-point area, I detected no differences between 3- and 4-point area hunters in the final post-hunting season survey when asked if they supported APRs, and if APRs were a good change to Pennsylvania's deer management program.

Most hunters believed APRs would increase subadult survival. A majority of hunters believed APRs would result in more older aged bucks, but about one-fourth (0.19 – 0.27) believed there would be no increase because of pre-season poaching (Table 3.4). The proportion of hunters that believed the shooting of sub-legal bucks in hunting season would negate any increase in large bucks due to APRs varied between 0.23 – 0.33. About a one-third of respondents believed hunters would shoot any antlered deer and leave them lay if they were not legal (Table 3.4).

The proportion of hunters that believed current APRs would cause a dramatic decrease in the number of bucks harvested in the area they hunt was between 0.43 – 0.60 (Table 3.5). The proportion of hunters that believed there would be very few legal bucks harvested (Table 3.5) was between 0.38 – 0.66. About one-half (0.42 – 0.54) of deer hunters believed current APRs would result in more older bucks doing most of the breeding (Appendix A, Table 16).

Table 3.4: Agreement (proportion of respondents and SE) from Pennsylvania deer hunters to survey statements regarding antler point restrictions and hunter perception of subadult survival. Agreement was the proportion of respondents who selected strongly agree or agree from the Likert scale (1-5) for each statement. Surveys were conducted pre- and post-firearms hunting season in 2002, 2003, and 2004.

	Pre-season 2002		Post-season 2002		Pre-season 2003		Post-season 2003		Pre-season 2004		Post-season 2004	
Statement	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE
1. Current regulations will result in older aged bucks.	0.70	0.01	0.69	0.02	0.73	0.02	0.67	0.02	0.70	0.02	0.59	0.02
2. Current regulations will result in no older aged bucks because large bucks will be poached before season.	0.24	0.01	0.21	0.02	0.19	0.02	0.22	0.02	0.22	0.02	0.27	0.02
3. Current regulations will result in no increase in large bucks because hunters will still shoot sublegal bucks.	0.33	0.01	0.27	0.02	0.23	0.02	0.25	0.02	0.24	0.02	0.31	0.02
4. Hunters will shoot any antlered deer and leave them in the woods if they are not legal.	0.45	0.01	0.32	0.02	0.34	0.02	0.29	0.02	0.36	0.02	0.34	0.02

Table 3.5: Agreement (proportion of respondents and SE) from Pennsylvania deer hunters to survey statements regarding hunter perceptions of antler point restrictions and antlered deer harvest. Agreement was the proportion of respondents who selected strongly agree or agree from the Likert scale for each statement. Surveys were conducted pre- and post-firearms hunting season in 2002, 2003, and 2004.

	Pre-season 2002		Post-season 2002		Pre-season 2003		Post-season 2003		Pre-season 2004		Post-season 2004	
Question	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE
1. Current regulations will result in cause a dramatic decrease in the number of bucks harvested where I hunt.	0.60	0.01	0.46	0.02	0.47	0.02	0.53	0.02	0.43	0.02	0.54	0.02
2. In the area I hunt, there will be very few legal bucks harvested.	0.49	0.01	0.48	0.02	0.38	0.02	0.59	0.02	0.39	0.02	0.66	0.02

Most hunters (0.52 – 0.73) supported a regulation to increase the ratio of antlered to antlerless deer (Table 3.6). The lowest support occurred in winter 2005, but support was greater than the proportion of hunters (0.29) who opposed a regulation to increase antlered to antlerless deer (Appendix C, Table 3.17). The proportion of hunters that believed the area they hunted had an acceptable ratio of antlered to antlerless deer was <0.27 (0.19 – 0.27), but they also did not agree they saw too many antlerless deer (0.13 – 0.34). Less than one-half of hunters (0.29 – 0.42) agreed the new harvest regulations for bucks will result in a buck to doe ratio closer to 1:1 (Table 3.6).

The proportion of hunters that agreed bucks in their hunting area had adequate antler size was between 0.29 – 0.41. However, most (0.57 – 0.72) agreed current harvest regulations would result in more bucks with larger antlers (Table 3.7). The proportion of hunters that agreed they saw an adequate number of bucks varied between 0.20 – 0.30 (Appendix C, Table 23).

The proportion of hunters that agreed APRs would reduce their enjoyment of deer hunting varied between 0.22 – 0.37 (Table 3.8). Of these hunters, 0.62 – 0.74 agreed deer hunting enjoyment would be less because they could not shoot a spike buck or buck with 2 or more points on 1 side. Of hunters that agreed APRs would reduce their enjoyment of deer hunting, the proportion that also believed the APRs were too complex was between 0.44 – 0.63. But the strongest reason I found for APRs reducing deer hunting enjoyment was a concern about shooting an illegal buck. About three-fourths (0.69 – 0.84) of hunters who indicated APRs decreased their deer hunting enjoyment agreed they were concerned about shooting an illegal buck (Table 3.8).

Table 3.6: Agreement (proportion of respondents and SE) from Pennsylvania deer hunters to survey statements regarding hunter perception of antler point restrictions and deer sex ratios. Agreement was the proportion of respondents who selected strongly agree or agree from the Likert scale for each statement. Surveys were conducted pre- and post-firearms hunting season in 2002, 2003, and 2004.

	Pre-season 2002		Post-season 2002		Pre-season 2003		Post-season 2003		Pre-season 2004		Post-season 2004	
Statement	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE
1. I support a regulation that would increase the ratio of antlered bucks to antlerless deer in the statewide deer population.	0.68	0.01	0.72	0.02	0.73	0.02	0.63	0.02	0.69	0.02	0.52	0.02
2. In the area I hunted most often last year, the deer population has an acceptable ratio of antlered to antlerless deer.	0.27	0.01	0.23	0.02	0.23	0.02	0.20	0.02	0.22	0.02	0.19	0.02
3. In the area I hunted most often last year, I saw too many antlerless deer.	0.34	0.01	0.29	0.02	0.31	0.02	0.24	0.02	0.25	0.02	0.13	0.01
4. The current harvest regulations for bucks will result in a buck to doe ratio closer to 1:1.	0.41	0.01	0.39	0.02	0.42	0.02	0.36	0.02	0.36	0.02	0.29	0.02

Table 3.7: Agreement (proportion of respondents and SE) from Pennsylvania deer hunters to survey statements regarding hunter perception of antler point restrictions and observed antler size of bucks. Agreement was the proportion of respondents who selected strongly agree or agree from the Likert scale for each statement. Surveys were conducted pre- and post-firearms hunting season in 2002, 2003, and 2004.

	Pre-season 2002		Post-season 2002		Pre-season 2003		Post-season 2003		Pre-season 2004		Post-season 2004	
Statement	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE
1. In the area I hunted most often last year, the bucks I saw had adequate antler size.	0.41	0.01	0.34	0.02	0.31	0.02	0.29	0.02	0.34	0.02	0.29	0.02
2. The current harvest regulations for bucks will result in more bucks with larger antlers.	0.68	0.01	0.69	0.02	0.72	0.02	0.64	0.02	0.67	0.02	0.57	0.02

Table 3.8: Agreement (proportion of respondents and SE) from Pennsylvania deer hunters to survey statements regarding influence of antler point restrictions on deer hunting enjoyment. Agreement was the proportion of respondents who selected strongly agree or agree from the Likert scale for each statement. Surveys were conducted pre- and post-firearms hunting season in 2002, 2003, and 2004.

	Pre-season 2002		Post-season 2002		Pre-season 2003		Post-season 2003		Pre-season 2004		Post-season 2004	
Statement	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE
1. Current antler restriction regulations will reduce my enjoyment of deer hunting.	0.30	0.01	0.28	0.02	0.22	0.02	0.31	0.02	0.24	0.02	0.37	0.02
2. For those agreeing to statement 1 above: My enjoyment of deer hunting in [year] will change because I cannot shoot any buck with 3 inches or more on one antler.	0.72	0.02	0.70	0.04	0.72	0.04	0.66	0.03	0.75	0.03	0.64	0.03
3. For those agreeing to statement 1 above: My enjoyment of deer hunting in [year] will change because current regulations are too complex.	0.47	0.02	0.47	0.04	0.63	0.04	0.49	0.04	0.51	0.04	0.44	0.03
4. For those agreeing to statement 1 above: My enjoyment of deer hunting in [year] will change because I will be too concerned about shooting an illegal buck.	0.81	0.02	0.81	0.03	0.82	0.03	0.80	0.03	0.84	0.03	0.69	0.03

Most hunters (0.51 – 0.66) agreed it would be difficult to identify legal bucks with the new APRs (Table 3.9). Prior to the first season of APRs, about one-half (0.55) of hunters agreed it would be too easy to accidentally kill a sub-legal buck in season, but after the initial season, the proportion of hunters agreeing declined to 0.38 – 0.46 (Table 3.9). About 7 of 10 hunters (0.67 – 0.75) agreed current APRs were clear and easy to understand (Table 3.9). In 5 of 6 surveys, ≥0.50 (0.50 – 0.63) agreed deer herd quality would increase with the current APR (Table 3.9). The lowest level of agreement, 0.40, occurred after the third year of APRs. However, over one-half of hunters (0.53 – 0.65) agreed the new regulations would improve their opportunity to harvest a larger buck in the future (Table 3.9).

In the final question, hunters were asked to rank the overall PGC deer program. Prior to the first year of APRs, the proportion of respondents that rated the PGC's deer management program as excellent or good was 0.39. In subsequent surveys pre- and post-hunting season, the proportion of hunters rating the PGC deer program as excellent or good increased and ranged from 0.47 – 0.57 (Appendix C, Table 33). However, after the hunting season of the third year, the proportion of hunters ranking the deer management program as excellent or good declined to 0.29.

Factor analysis of 10 survey questions revealed 3 major factors to explain hunter opinion of subadult survival, sex ratios, and antlered harvest (Table 3.10). Three variables ((1) no increase in quality because of poaching; (2) no increase in quality because hunters will shoot sublegal bucks; and (3) hunters will shoot deer and let them lay) loaded on the major factor labeled subadult survival. Four variables loaded on the

Table 3.9: Agreement (proportion of respondents and SE) from Pennsylvania deer hunters to survey statements regarding perceived problems associated with antler point restrictions. Agreement was the proportion of respondents who selected strongly agree or agree from the Likert scale for each statement. Surveys were conducted pre- and post-firearms hunting season in 2002, 2003, and 2004.

	Pre-season 2002		Post-season 2002		Pre-season 2003		Post-season 2003		Pre-season 2004		Post-season 2004	
Statement	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE	Agree	SE
1. It will be difficult to identify legal bucks with current antler restrictions.	0.66	0.01	0.58	0.02	0.53	0.02	0.59	0.02	0.51	0.02	0.59	0.02
2. It will be too easy to accidentally kill an illegal buck in the [current year] season.	0.55	0.01	0.46	0.02	0.41	0.02	0.42	0.02	0.38	0.02	0.39	0.02
3. Current antler restriction regulations are clear and easy to understand.	0.71	0.01	0.67	0.02	0.70	0.02	0.72	0.02	0.75	0.02	0.74	0.02
4. Deer herd quality will improve with current antler restrictions.	0.54	0.01	0.59	0.02	0.63	0.02	0.50	0.02	0.58	0.02	0.40	0.02
5. Current antler restriction regulations will improve my opportunity to harvest a larger buck in the future.	0.62	0.01	0.65	0.02	0.71	0.02	0.63	0.02	0.68	0.02	0.53	0.02

Table 3.10: Mean, standard deviation, and factor loadings using a varimax rotation for 10 survey statements measuring deer hunter perceptions of the effects of antler point restrictions in Pennsylvania, 2002 – 05. The strongest factor loading for each variable appears in bold.

			Factor loading		
Statement	Mean	SD	Subadult survival	Sex ratio	Antlered harvest
The current harvest regulations for bucks will result in no increase in quality of bucks because the large bucks will be poached before season.	3.26	1.07	**65**	-13	10
The current harvest regulations for bucks will result in no increase in older bucks because hunters will still shoot sub-legal bucks.	3.16	1.05	**87**	-11	5
Hunters will shoot any antlered deer and leave them in the woods if they are not legal.	2.92	1.10	**52**	-13	11
The current harvest regulations for bucks will result in more older aged bucks.	2.34	1.04	-25	**68**	-2
I support a regulation that would increase the ratio of antlered bucks to antlerless deer in the statewide deer population.	2.28	1.19	-15	**64**	-5
In the area I hunted most often last year, I saw too many antlerless deer.	3.34	1.25	2	**38**	-3
The current harvest regulations for bucks will result in a buck to doe ratio closer to 1:1.	2.92	1.09	-16	**69**	-1
In the area I hunted most often last year, the deer population has had an acceptable ratio of antlered to antlerless deer.	3.46	1.11	0	-2	**-21**
Current antler restrictions will cause a dramatic decrease in the number of bucks harvested in the area I hunt.	2.58	1.06	8	-1	**44**
In the area I hunt, there will be very few legal bucks harvested.	2.61	1.03	16	-20	**86**

second major factor, labeled sex ratios. The variables were with regard to: (1) regulations resulting in older aged bucks; (2) support for a regulation to increase the antlered: antlerless ratio; (3) harvest regulations will result in a buck:doe ratio closer to 1:1; and (4) hunters seeing too many antlerless deer. Three variables loaded on the third factor, labeled antlered harvest. Two variables loaded heavily on the label antlered harvest: (1) hunter agreement APRs will cause a dramatic decrease in the number of bucks harvested where they hunt; and (2) hunter agreement that very few legal bucks will be harvested where I hunt. The remaining variable measuring agreement the deer population had an acceptable ratio of antlered:antlerless deer had a weak loading on the factor labeled antlered harvest (-0.21), but was retained because it had almost no relationship to either of the remaining 2 factors, with loadings of 0 and -2 for subadult survival and sex ratio, respectively. This weak relationship was the probable cause of the low measure of consistency (Cronbach's alpha = 0.11). Deletion of the variable had no effect on the analysis results, but deletion did increase Cronbach's alpha to 0.56.

Comparison of responses before APRs and 3 years after APRs

A comparison of responses before APRs took place and after they had been in place 3 years indicated little change in hunter attitudes regarding a statewide APR (Table 3.11). I found similar results when asked if they supported an APR in the WMU they principally hunted, and when asked if current APRs were a good change in Pennsylvania's deer management program. About half of respondents were unchanged

Table 3.11: Proportion of respondents and direction of support (less, same, more) after 3 years of antler point restrictions (APRs) to 5 survey statements chosen *a priori* and presented to a sample of Pennsylvania deer hunters. The initial response was received in 2002 before the first firearms season with APRs. The after response was obtained from a panel of hunters who completed a series of 6 surveys ending in 2005, and from a follow-up survey to panel members who did not complete all 6 surveys. For questions 1 – 4, responses were on a Likert scale ranging from strongly agree, agree, neither agree or disagree, disagree, and strongly disagree. Question 5 was on a Likert scale of excellent, good, fair, poor, or don't know. Proportions may not sum to 100 due to rounding.

		Before-after response comparison		
Survey statement	*n*	Less supportive	Same	More supportive
1. I support a statewide antler restriction.	1,136	0.29	0.48	0.23
2. I support an antler restriction in the wildlife management units I principally hunt for deer.	1,125	0.30	0.47	0.23
3. I support a regulation that would increase the ratio of antlered bucks to antlerless deer in the statewide deer population.	1,119	0.42	0.42	0.17
4. Current antler restrictions are a good change in Pennsylvania's deer management program.	1,141	0.31	0.49	0.21
5. I would rate the PGC's deer management program as: Excellent, Good, Fair, Poor, or Don't know.	984	0.41	0.38	0.21

in their support for each question. However, after 3 years, more hunters were less supportive of a regulation to increase the ratio of antlered bucks to antlerless deer (Table 3.11). Hunters were less supportive of the PGC's deer management program after 3 years of APRs (Table 3.11).

Discussion

The survey period between 2002 and 2005 contained multiple deer hunting regulation changes in Pennsylvania. In addition to APRs, other regulation changes included a 2-week concurrent antlered/antlerless firearms season for youth and senior hunters and a 3-day fall flintlock season for antlerless deer (2000), a 3-day October firearms season for antlerless deer for youth and senior hunters, an expansion of the fall flintlock season to 7 days, and statewide firearms concurrent antlered and antlerless seasons for all hunters (2001), APRs (2002), liberalizing of the week of fall muzzleloader season for antlerless deer to allow for any muzzleloading firearm (2003), and the initiation of the deer management assistance program (DMAP; 2003). The DMAP was a landowner-specific program designed to increase antlerless harvests of deer to meet a specific landowner goal. While APRs were designed to increase the antlered population, all other regulations were designed to increase antlerless deer season length, increase antlerless harvests, and lower the overall deer population. Regulation changes were effective in reducing overall deer abundance (Table 2.9 of Chapter 2).

The effects of declining deer abundance on hunter attitudes were apparent in the results of the random surveys. Seeing game and the possibility of harvesting game were

more important than the actual killing of game to most hunters (Duda et al. 1996). Gigliotti (2000) reported seeing deer was more strongly correlated with satisfaction than harvest success. Heberlein and Kuentzel (2002) found harvesting a deer had the largest direct effect on satisfaction, whereas seeing deer had the second largest effect. Langenau et al. (1981), Hammitt et al. (1990), and Holbook and McSwain (1991) reported deer seen and deer harvested were important factors to hunter satisfaction. In Pennsylvania deer hunters, Miller and Graefe (2001) reported successful harvest predicted satisfaction among archery, rifle, and muzzleloader user groups. Clearly, seeing deer and harvesting deer are important components of hunter satisfaction, so the reduction of deer populations during the initial years of APRs could have influenced hunter attitudes toward APRs.

During the hunting season, seeing deer and harvesting deer were related, because the latter cannot be done without the former. The relationship between population density and harvest was profound, yet McCullough and Carmen (1981) found no relationship between hunter estimates of the deer population and the number of deer seen. Holsworth (1973) reported a 4-fold reduction in hunter kill per hour when deer density went from 259 to 78 deer/km^2 (100 to 30 deer/mi^2). If expressed as effort (hours/deer killed) the same curvilinear relationship was reported by Van Deelen and Etter (2003). The relative effort to harvest a deer (hours/deer killed) increases exponentially when deer density was lowered to 15 deer/km^2 (40 deer/mi^2) and beyond (Van Deelen and Etter 2003). As effort required to see and harvest deer increased, hunter satisfaction with associated regulations was expected to decrease. In my surveys, the decline in satisfaction was expressed in the sharp decline in overall rating of the PGC deer management program after the third year of APRs (Appendix C, Table 33). Similar

results were seen when hunters were asked if APRs were a good change in Pennsylvania's deer management program. Again, support declined to its lowest level (49% supportive with 32% opposed) after the third hunting season with APRs. Because support for APRs did not decline during the survey period, the decline in the overall rating of the deer management program seems to be related more to population reduction, or some other factor, rather than APRs.

Wildlife management is based on human values (Decker et al. 2001) so the social side of ungulate management is important to the success of any management program. For example, with APRs for moose in Alaska, a thorough evaluation of the social component was needed in addition to the biological component (Schwartz et al. 1992). Carpenter and Gill (1987) cautioned against the use of APRs without hunter support for them. A fair and unbiased measure of support for APRs could only be made if populations were held constant. If the population was to remain constant, the antlerless proportion of the population would need to be reduced to allow for the increase in adult males. But during this study, deer populations exceeded management goals in all units, and in some units, by more than 2-fold (Wallingford and Grund 2003). White-tailed deer can have adverse effects on vegetation (Tilghman 1989, Hough 1965) and wildlife (Casey and Hein 1983, deCalesta 1994). Therefore, additional herd reduction was necessary. Lowering population abundance by increasing the harvest of antlerless deer was a part of the PGC deer management program designed to address sustainability (Diefenbach et al. 1997). However, reducing deer abundance was not popular with hunters.

Despite the management program changes during this study to reduce the deer population, the proportion of hunters supporting APRs remained ≥0.60 as a statewide regulation (Figure 3.1, Appendix C, Table 1). I found similar results when hunters were asked if they supported APRs in their specific hunting area (Figure 3.2, Appendix C, Table 4). Support for APRs after 3 years of their implementation and aggressive population reductions was equal to support at the beginning of the study. Surveys in other states with APRs also indicated strong support for them (e.g. Kandoth et al. 2010, S. Haskell Vermont Department of Fish and Game personal communications).

In Pennsylvania, subadult males required protection during the hunting season between 1 and 2 years of age, which is an important time for white-tailed deer antler development. During this year of protection, there is a noticeable increase in antler development. Yearlings typically display 25-30% of their antler potential, while 2-year-olds display about 60% (Strickland and Demarias 2007). Manfredo et al. (2004) considered the time for protection as a cost. For hunters, this is an opportunity cost, but the cost is only 1 year. A majority of Pennsylvania hunters accepted the cost of protecting a proportion of subadult males to allow them another year of antler development by supporting APRs. I wanted to examine why hunters did or did not support APRs by exploring hunter support and perceptions of APRs during the first 3 years in Pennsylvania.

Hunters were optimistic that APRs would increase subadult survival. But simultaneously, there were concerns about illegally shot adults before season and losses to hunters shooting sub-legal males. I found the proportion of hunters concerned about pre-hunting season poaching and the perceived loss of sub-legal bucks in season

remained stable and did not change with increased experience with APRs (Table 3.4). In each survey, the proportion of respondents that perceived hunters would shoot any antlered deer and leave them in the woods if they were not legal was ≥0.29 (Table 3.4). Because my research included monitoring the fates of adult and subadult males, I was able to compare hunter perceptions about the biological effects of APRs on the antlered deer population to empirical data from the collared population. APRs increased subadult survival rates by lowering the harvest rate from >0.80 to 0.31 (Chapter 2).

Pennsylvania hunters were concerned with the same issues Carpenter and Gill (1987) used to develop the shoot and sort theory. Initially, the proportion of respondents that believed hunters would shoot any antlered deer and leave the deer lay in the woods if not legal was 0.45 (Table 3.4). My results were similar to the findings of Monzingo (1999), who reported 70% of moose hunters believed APRs would increase the number of illegal moose kills, and 75% of moose hunters believed APRs increased their chances of making a mistake. However, empirical data from a radio-marked population to corroborate this hunter belief were lacking. Schwartz et al. (1992) reported an illegal kill of 7% of the legal moose harvest, with most illegal bulls mistakenly identified as larger bulls with ≥3 tines on 1 brow palm. If hunters have difficulty counting tines on moose, counting points on antlers of eastern white-tailed deer in vegetation is probably more difficult. In addition, during hunting season, deer often are moving because of cooperative hunting (deer drives) or inadvertently from the activities of independent hunters. New Jersey hunters agreed identifying legal antlered deer in APR zones would be difficult while driving deer (Kandoth et al. 2010). In Pennsylvania, driving deer is a common form of hunting, especially during the firearms season. Despite the difficulty of

seeing and counting points to identify a legal antlered deer, the proportion of hunters in Pennsylvania that supported APRs was >0.60.

My estimates of mortality of radio-collared males (Chapter 2) were not in congruence with the apprehension hunters had for the illegal killing of sub-legal males during season. During the hunting season, I found only 8% and 5% of radio-marked subadult and adult males, respectively, were killed as sub-legal deer during the hunting season (Chapter 2, Table 2.5). My results indicated sub-legal kills were not a major source of mortality in either age class. In addition, the estimates of sub-legal kills in my study likely were overestimated because junior, active duty military, and persons with disabilities license holders could have legally killed the sub-legal males I classified as sub-legal harvests.

Hunters perceived APRs would not increase the number of older males in the population because hunters would continue to shoot sub-legal males (Table 3.4). However, only 3% and 1% of radio-collared subadult and adult males, respectively, were shot and reported as mistaken kills (Chapter 2, Table 2.5). Additionally, hunters perceived there would be losses of large-antlered bucks prior to the hunting season, thereby negating the increase in the quality of bucks and the intent of APRs to result in more older males in the population (Table 3.4). Although males died because of a variety of reasons, I found only 1% each for subadult and adults were illegally shot outside the hunting season (Chapter 2; Table 2.6). Few losses from illegal shooting and high survival rates indicated most males were available as adults the following hunting season. Because most dispersal takes place prior to the firearms season (Long et al. 2008), subadults tend to be established in their adult range when they were protected with APRs.

Lower subadult harvest rate, low illegal kill, and high out-of-season survival rates were factors leading to increased numbers of adults available for harvest the following year. The number of adult males in the harvest increased in the years following APRs, despite the reduction of the overall deer population (Table 2.9).

Hunters expected APRs would have a negative effect on the number of bucks harvested where they hunt (Table 3.5), but most (0.53 – 0.71) agreed that APRs would improve their opportunity to harvest a larger buck in the future (Table 3.9). The antlered deer harvest in 2001 was ≥197,000 (Chapter 2, Table 2.7). During the first year of APRs, the antlered harvest declined to approximately 162,000. In 2003, the antlered harvest declined to 141,000 (Chapter 2 Table 2.7). At least part of the greater number of antlered deer killed in 2002 could be attributed to the ambiguous definition of the brow point (see Chapter 1). In 2004, the antlered deer harvest declined to 124,000, then stabilized at an average of approximately 120,000. A confounding factor is the population decline from 2001 – 2005. Empirical data from radio-tracked males in my study indicated the decline in harvest was linked to lower harvest rates (Chapter 2, Table 2.4). The survival rate to the following hunting season was 0.92, so most antlered deer that survived the hunting season were hunted the following year as ≥2-year-old males. Thus, APRs should have improved hunter opportunity to harvest a larger buck in the future. The time delay associated with protection of subadult males (Manfredo et al. 2004) and lower harvest opportunity were costs directly linked to APRs, but they did not affect hunter support for APRs.

Antler point restrictions were designed to increase the proportion of antlered deer in the population by increasing the number of older bucks. My empirical data indicated

APRs had a direct effect on the sex ratio. Hunters were supportive of a regulation designed to increase the antlered to antlerless ratio (Table 3.6), and they were optimistic APRs would result in more bucks with larger antlers (Table 3.7). Although they were consistent with responses about the effects of APRs (Table 3.4), the proportion of hunters that believed the APRs would result in an increase in the buck to doe ratio was only 0.29 – 0.42 (Table 3.6). The implementation of APRs during the survey period increased the proportion of antlered deer in the population. The APRs provided protection to antlered deer during the hunting season, survival rate was >0.90 to the next hunting season, and female harvests increased. Consequently, the antlered to antlerless ratio increased, but the increase was not apparent to deer hunters.

Pennsylvania hunters were not satisfied with antlered to antlerless ratios before APRs, and satisfaction did not increase after APRs improved the ratio. In management, increases in the proportion of males in the population could occur by increasing the number of antlered deer, decreasing the number of does, or a combination of both. In the case of APRs in my study, hunter preference would likely have been for an increase in antlered deer because seeing deer was a factor necessary for deer hunter satisfaction (Langenau et al. 1981, Hammit et al. 1990, Holbrook and McSwain 1991, Duda et al. 1996, Gigliotti 2000, Heberlein and Kuentzel 2002). The option used by the PGC was to increase antlered deer by protecting subadult males and reduce antlerless deer. Hunters were not prepared or willing to accept lower deer populations, regardless of the effects of APRs. Most hunters disagreed when asked if they saw too many antlerless deer (Table 3.6). Because deer populations were being reduced, fewer deer would have been seen compared to the period before APRs and deer sightings of either sex-age group would

have been encouraging. I believe hunter observations of deer during the hunting seasons were insufficient to detect real changes in the antlered to antlerless ratio because the ratio cannot change greatly among different management programs with antlered harvest rates >0.50. In Wisconsin, where all licensed hunters could hunt antlered deer, but not antlerless unless they obtained an antlerless license, the antlered male to adult doe ratio was about 1:1.7 – 2.2. Under a trophy management program with intensive management to increase males in the older age classes, the adult sex ratio became 1 antlered male to 1.15 adult females (Kubisiak et al. 2001). The results from Kubisiak et al. (2001), however, were from a 37.0 km^2 (14.3 mi^2) enclosed study area. Managers can see the difference in data at the WMU level, but in my study, hunters did not see the difference at the local level where they hunted. Based on my survey responses, hunter support for APRs was not due to the actual or observed increase in the proportion of antlered deer in the population. Satisfaction with the number of antlered deer seen did not increase and satisfaction with overall deer sightings declined (Appendix C, Tables 19 and 23), but APRs during my study were accompanied with reductions in the antlerless proportion of the deer herd.

Antler point restrictions in conjunction with population reduction did not produce the quantity or quality of antlered deer hunters expected. Despite more adult males in the population and the harvest, more hunters agreed bucks had adequate antler size before APRs began (Table 3.7). Similarly, fewer hunters agreed buck sightings were adequate after 3 years of APRs than before they began (Appendix C, Table 21). Antlered deer abundance, however, is linked to population abundance as well as APRs, and I could not separate the effects of APRs and population size. Decreasing populations during the

survey period reduced the number of males, especially subadults that could be observed multiple times during the hunting season even if they could not be harvested. However, additional adults in the population and protected subadults were directly due to APRs, and additional antlered deer in the population should have been noticeable.

Some hunters wanted to remain with the traditional definition of an antlered deer for the hunting season. Most Pennsylvania deer hunters have experience with only the old antler restriction. With no prior experience with new APRs, hunters could only perceive how APRs would affect their deer hunting. However, increased experience with APRs did not clarify them to hunters (Table 3.9). Pennsylvania's new APRs were a considerable change in deer management, breaking a long-standing tradition defining an antlered deer legal for harvest dating back to 1953 (Kosack 1995). Given the previous definition of an antlered deer for the harvest existed for multiple generations, finding about one- third of hunters believed APRs would reduce their enjoyment of deer hunting was not unexpected (Table 3.8). Even after experience with APRs over 3 years, their enjoyment of deer hunting did not increase. For hunters agreeing that APRs would decrease their enjoyment of deer hunting, most agreed with 3 reasons offered on the survey to account for their reduced enjoyment: they preferred the former antler restriction, APRs were too complex, and they were afraid of killing a sub-legal buck (Table 3.8). Possible reasons to explain their responses include familiarization with former regulations, additional antlered deer available for harvest, or simple resistance to change. The basic concept of APRs is not complex, requiring hunters to count antler points. Counting points does not require the antler assessment needed to determine

minimum antler spread or length. However, vegetation and running deer can make counting points difficult in hunting conditions.

Concern over shooting a sub-legal male was also reported from hunters in a SHS for moose (Fulton and Hundertmark 2004), a much larger and slower animal than white-tailed deer. I expected Pennsylvania hunters would be concerned with shooting sub-legal males. Antler point restrictions created a protected group of antlered deer not existing before. Prior to Pennsylvania's new APRs, a hunter with an antlered and antlerless tag in concurrent seasons could harvest any deer, regardless of sex, antler size, or body size and remain completely legal. An antlered deer with sub-legal antlers could be tagged as an antlerless deer. Antler point restrictions completely protected antlered deer with less than the minimum number of points on 1 antler, unless both antlers were <7.6 cm (3 in) in length. Seeing antlers <7.6 cm (3 in) in length can be difficult under field conditions because they can be obscured by the ears. Hunters perceived problems identifying legal bucks and the ease of accidentally killing an illegal buck (Table 3.9). Identifying legal bucks could be an even more difficult issue for hunters using deer drives (Kandoth et al. 2010). Experience with APRs did not ease the perception (Table 3.9). Hunter perception agreed with field data from radio-collared adult deer because the adult harvest rate was lower with APRs than under the previous management paradigm. Lowered harvest rates on adults could have been because of the need to see the last point on 1 antler.

Conceptually, most hunters agreed APRs were clear and easy to understand (Table 3.9). Initially, hunters also believed APRs would make it too easy to accidentally kill an illegal buck during the hunting season. However, over the surveyed time period,

there was a decreasing trend in agreement it would be too easy to accidentally kill an illegal buck, indicating hunters were adjusting to APRs.

While hunters supported APRs, in most cases, a majority of hunters were not concerned with problems associated with APRs in the field (Table 3.8). Carpenter and Gill (1987) were concerned with APRs decreasing interest and support for hunting as regulations became more complex and hunter success declined. In Pennsylvania, their concerns did not emerge as problems because there was not an unexpected drop in license sales or a long-term decline in success rates. Hunter success rates did not decrease when compared to success rates a decade previous. Antlered deer hunter success rates, however, were more a function of fewer hunters pursuing deer (Rosenberry et al. 2009). Fewer antlered deer were being harvested with APRs, but an increased number of adult antlered deer comprised the harvest, despite a decreasing population during the time of this study.

Based on my data, hunters perceived their beliefs about APRs prior to experiencing them, and they held their belief through the survey period. My research illustrated the disconnect between hunter perceptions and the biological reality of APRs. Pennsylvania deer hunter support for APRs did not change from their initial perceptions before experiencing them to 3 years afterwards. For hunters who answered the initial survey and a survey 3 years after APRs began, about one-half had neither stronger or weaker support for them, with about one-half the remainder moving in the direction of stronger support, and one-half moving in the direction of weaker support. Perceptions did not change. This is referred to as biased processing.

Biased processing occurs when new information is processed in a way that confirms and protects an existing belief, i.e., it maintains consistency with a preconceived notion by accepting information that is consistent with our belief, and discounting contradictory information (Teel et al. 2006). McCaffrey et al. (2008) described biased processing as viewing new information through the lens of existing knowledge, attitudes, or values. The human mind can construct its own reality, and social perception may be impervious to social reality (Jussim 1991).

I believe hunters had perceptions about the effects of APRs before they experienced them, but then did not utilize their experience to modify their opinion. New information from their experience would have the greatest impact if hunters did not already have a well-formed attitude (Wilson and Bruskotter 2009). However, in my study, hunter perception of APRs could not be penetrated by the biological reality of APRs. Although changes in the sex ratio were difficult to detect via observations by individual hunters, there were other population characteristics that hunters should have perceived that could have modified their support for APRs. Empirical data indicated APRs reduced subadult harvest rates and once surviving their first season as an antlered deer, males had a 92% chance of surviving to the following season. The adult proportion of the harvest increased from about 20% prior to APRs to about 50% during the survey period. In addition, success rates of antlered deer hunters in the second (2003) and fourth year (2005; the first 2 years with consistent brow point definitions and deer hunter estimates from the PGC Game Take Survey) remained similar to the success rates of 1992-1993 at 16-18% and 16-17%, respectively (Rosenberry et al. 2009). Hunters experienced the changes caused by APRs, so they either ignored their observations or

they did not recall enough information to change their opinion. In either case, hunters seem to have discounted the facts and experiences of APRs when they did not meet their expectations.

Chapter 4

A comprehensive evaluation of antler point restrictions in Pennsylvania

Introduction

Without experimentation and measures of the biological and social elements of wildlife management, accurate assessment of the success of any new deer management paradigm is difficult. The statewide change in APRs in 2002 affected both elements, and monitoring hunter acceptance and biological effects should be part of an APR program (Carpenter and Gill 1987).

Developing and implementing a research program to monitor social and biological elements of APRs in Pennsylvania presented a number of challenges, but also a unique opportunity. From the biological element, the challenge was initiating research fieldwork to capture, radio-collar, and monitor male deer to measure the effects of APRs on survival and harvest rates, mortality causes, and harvest composition. From the social element, the challenge was monitoring support for APRs from Pennsylvania's hunting constituency in 2002 of >793,000 deer hunters (Rosenberry et al. 2009). Monitoring of social and biological elements needed to be sufficient in size to provide a thorough evaluation of APRs and permit inferences across all management units. This research is unique because simultaneous monitoring of social and biological elements of a statewide APR program for white-tailed deer has not been done before. Combining both elements allows a comprehensive evaluation of new APRs. Although expensive in personnel and dollars, a rigorous evaluation of APRs was needed (Carpenter and Gill 1987).

Any paradigm change in deer management needs to be acceptable from both biological and social perspectives. Biologically, the change should not adversely affect the resource and should accomplish management goals. Socially, hunters need to accept the change in management so they continue to be a willing participant in achieving population management objectives. The original design of APRs in Pennsylvania was to protect 50 – 75% of subadult antlered males from harvest. To be successful, however, antlered males protected from harvest as subadults would have to survive to be hunted the following year. Socially, hunters need to be aware of the expectations and costs of APRs (illegal and mistaken kills, reduced harvest) to their deer hunting experience and the deer population (Carpenter and Gill 1987).

I designed my research to answer crucial biological and social questions about APRs as they were applied in Pennsylvania. For antlered deer, I measured the biological effects of APRs on survival using telemetry and a known fates analysis to estimate harvest rates during the hunting season, and subsequent survival from post-hunting season to the following hunting season. Simultaneously, I received secondary data from the PGC as they conducted deer hunter surveys before and after the firearms deer season to monitor hunter support and perceptions for the effects of APRs. In this chapter, I combined biological and social data sets to assess the overall success of management objectives for APRs as implemented in Pennsylvania. Also, I explored whether hunters believed APRs were successful because their experience informed their opinion or because their initial beliefs persisted despite the biological effects of APRs.

Appraising success of APRs

Before the research began, I hypothesized the biological (Chapter 2) and social elements (Chapter 3) each had 2 possible outcomes with respect to statewide APRs. Biologically, regulations protected subadult antlered deer and resulted in more adult males in the population, or they did not protect subadult antlered deer. Socially, hunters either supported the APR regulations, or they did not support them (Table 4.1).

I used 2 criteria to evaluate biological effects of APRs. First, APRs must protect subadult males from harvest. Second, harvest of adults needed to be greater compared to harvests prior to APR regulations. I considered APRs successful if the harvest rate of subadults was lower than before APRs began, and if the number of 2-year-olds harvested was greater after 3 years of APRs. Measurements came from a known fates survival analysis during the hunting season, and by comparing statewide harvest estimates.

From the social aspect, I considered hunter support for APRs as positive if >50% of hunters supported their use for managing Pennsylvania's deer population after the fall 2004 deer season (Appendix A part 3, question 1). I measured support from the random sample of surveyed hunters using the 2004 post-hunting season survey.

Harvest rates of subadult males declined from about 0.80 prior to current APRs to 0.31 during the 3 years of this study (Table 2.4). The survival rate during the non-hunting season was 0.92. Only 1% of adults were illegally shot before the hunting season, while 4% were killed in deer-vehicle collisions (Table 2.6). Despite a decreasing trend in deer population abundance, more adult antlered deer were harvested after APRs began compared to pre-APR estimates (Tables 2.7 and 2.8). The antlered deer harvest in

Table 4.1: Possible management outcomes with respect to antler point restrictions (APRs) protecting subadult antlered white-tailed deer and hunter support for the regulations in Pennsylvania, 2002 – 2005. Survival rates from radio-collared subadults and subsequent survival to the following hunting seasons were used to assess whether APRs protected subadult antlered white-tailed deer. A subadult male carried his first antlers during the hunting season. I used a deer hunter survey to randomly selected hunters after 3 years of APRs to determine hunter support for APRs.

	Regulations protect subadult antlered deer	Regulations do not protect subadult antlered deer
Hunters support regulations	Deer management success Hunter management success (Outcome I)	Deer management failure Hunter management success (Outcome II)
Hunters do not support regulations	Deer management success Hunter management failure (Outcome III)	Complete management failure (Outcome IV)

the initial year of APRs was about 162,000, but declined to an average of 122,000 in the third and fourth years. Adult harvests prior to current APRs averaged 41,600 males. In the third and fourth years, they averaged 59,100 (Table 2.7).

The proportion of hunters agreeing with current APRs on the statewide level was 0.62 after the third year (Figure 3.1, Appendix C, Table 1), while 0.28 disagreed with their use. The proportion of hunters in the 3-point area that supported APRs was 0.63, while support from hunters in the 4-point area was 0.59. The proportion of hunters opposing APRs was 0.26 in the 3-point area and 0.34 in the 4-point area (Appendix C, Tables 2 and 3).

The biological objectives of lowered harvest rates (Table 2.4), and an increased number of adults in the harvest (Table 2.7) were met. There were 4 reasons contributing to the difference in antlered deer harvest from the initial year to the second year of APRs. First, there was a change in the definition of an antler point (Chapter 1), specifically the definition of a brow point. Second, there was a good acorn crop in the fall prior to the first trapping season. Mast production could have allowed fawns to survive their first winter in better health condition, leading to better antler development as subadults. Third, a mild winter during the first trapping season, which could have contributed to better health and subsequent antler development as subadult deer; and fourth, counties in special regulations and under the pre-2002 APR were now included in the 3- and 4-point restriction WMUs (depending on their location). These 4 factors affected primarily the subadult harvest rates, but the other important measure was the number of adults in the harvest. Despite declining deer populations, more adult males were harvested with APRs than during the time period with the previous antler restriction and greater deer abundance (Tables 2.7 and 2.8).

Antler point restrictions are a social issue (Kandoth et al. 2010). I considered APRs to be a success from the social perspective because the proportion of hunters that supported APRs was 0.62, and 0.28 opposed them. This criterion of ≥50% support was exceeded in both 3- and 4-point areas.

Simultaneous success in protecting subadult males and ≥50% hunter support for APRs results in Outcome I of Table 4.1. Based on the criteria I outlined, APRs in Pennsylvania were a deer management success.

Testing hunter perception of APRs

Hunter support for APRs remained stable throughout the study. I assumed because a majority of deer hunters supported APRs, collectively their measure of support for them would increase because of the population effect of APRs on antlered deer. Assuming that APRs were biologically successful, I made several predictions to test whether hunters perceived the biological effects of APRs through their hunting experience. My predictions were: (1) support for statewide APRs would increase; (2) support for APRs in the WMU they principally hunt for deer would increase; (3) hunter's support for a regulation to increase the ratio of bucks to does would increase; (4) hunter's opinion that new APRs were a good change to Pennsylvania's deer management program would increase; and (5) overall rating of the Pennsylvania deer management program would increase.

The highest proportion of hunters (0.48) showed no change in support for a statewide APR 3 years after they began (Table 3.11). Of the remainder, about one-half (0.29) were less supportive, and 0.23 were more supportive. Similar results were found when respondents were asked if they supported an APR in the WMU they principally hunted for deer: 0.47 were unchanged, 0.30 were less supportive, and 0.23 were more supportive. The proportion of hunters supportive of a regulation to increase the ratio of antlered deer to adult females did decline, with about 0.42 less supportive, 0.42 were neither more or less supportive, and 0.17 more supportive. Similarly, the proportion of hunters unchanged in their opinion the new APRs were a good change to Pennsylvania's deer management program was 0.49. About 0.31 were less inclined, while 0.21 were

more inclined to believe they were a good change. In their rating of the overall deer program, the proportion of hunters with identical ratings after 3 years of APRs was 0.38, while 0.41 gave lower ratings and 0.21 gave higher ratings.

Antler point restrictions were the primary experimental change in my research. But simultaneously, deer populations were declining (Table 2.9). A declining deer population could have affected survey results because hunters need to see and harvest deer for satisfaction (Langenau et al. 1981, Hammitt 1990, Holbook and McSwain 1991). Hunters should have seen a greater proportion of antlered deer in the second and third year of APRs compared to observations before APRs. However, because of lower deer populations, they would have observed fewer deer, especially antlerless deer, during the hunting season. If populations were held constant, I would hypothesize support for APRs would have increased.

I agree with Miller and Vaske (2003) and Cornucelli (2009) that regulations should not constrain hunter participation, nor be difficult to understand. Both factors would further exacerbate declining deer hunter numbers (Rosenberry et al. 2009), and result in lower hunter satisfaction. Pennsylvania's APRs did not limit the number of hunters legally pursuing antlered deer through regulations, and antlerless opportunities were expanded. The APRs in Pennsylvania were a statewide regulation change. Of all possible regulations to reduce antlered harvest of subadults, the APR was easiest to apply for all hunters in the field. Other methods (beam length, antler spread) of reducing subadult harvest often were voluntary and applied on small management areas (Kroll 1991, Bullock et al. 1995). About 15% of hunters disagreed that current APRs were clear and easy to understand (Chapter 3, Table 3.9). Therefore, deer management objectives

(Rosenberry et al. 2009) can be achieved with current APRs and antlerless deer hunting. Although there was an opportunity cost for producing older-age class animals (Manfredo et al. 2004), Pennsylvania hunters accepted the cost and were supportive of APRs. For most antlered deer, the opportunity cost was only 1 year (Sauer 1984, Jacobson 1995, Koerth and Kroll 2008). For reaching their full potential antler growth, Strickland and Demarais (2007) reported subadults exhibited 25-30% of the full potential, while 2.5-year-olds exhibited 60% of their potential.

During this study, hunters had experience with 3 years of APRs, so they were familiar with field difficulties of identifying legal and sub-legal antlered deer, and they perceived fewer antlered deer would be harvested. The concern of shooting an illegal buck was identified as the strongest reason APRs would reduce deer hunting enjoyment (Appendix C, Table 3.27). Despite the concern, about half of the respondents had the same level of support for a statewide APR before experiencing them as they did after experiencing them for 3 years (Table 3.11). Similar results were obtained when hunters were asked if they support the APR in the WMU they hunt. Only 17% were more supportive of a regulation to increase the ratio of antlered to antlerless deer. I expected support to be higher because hunters supported APRs.

Hunters had perceptions of APRs and their effect on deer populations before ever experiencing them, and retained their opinions through the first 3 seasons. Social scientist refer to this phenomenon as biased processing, which occurs when new information is processed to confirm and protect existing beliefs (Teel et al. 2006). The impact of new information is greater when there is not already a well-formed belief (Wilson and Bruskotter 2009). However, hunters in my surveys appeared to have well-

established beliefs about the effects of APRs, despite the biological evidence I found with radio-collared deer.

My pre-hunting season measure of support for APRs in 2002 was similar to the results of Luloff et al. (2002). The level of support from hunters for APRs after experiencing hunting seasons with the new regulations showed little change from their perceptions before APRs began (Figure 3.1). The level of support in the first year of APRs was based on perceptions of population effects. In the post-season measure of support, hunters would have had the benefit of experience, and observations of sub-legal antlered deer. But the measure of support would be based on hunter perception of being able to see the same sub-legal antlered deer a year later as a legal, adult antlered deer. I expected an increase in support for APRs in the second and third years, after there was sufficient time to produce adult males with larger antlers, and legal for harvest. In addition, sub-legal males could be observed by multiple hunters, increasing satisfaction with APRs. From empirical data, there was ample evidence of reduced subadult harvest rates, increased male survival, and the increased number of adults taken in the harvest. Hunters should have noticed a difference in the field. Age and antler size of harvested bucks and the number of antlered deer observed in the field (legal and sub-legal) all increased after the first year. Yet hunter responses did not reflect the increases in the survey. I believe hunters formed a belief perseverance, where the initial impressions and experience persisted despite later conflicting information (Bordens and Horowitz 2002). After the initial impression, additional information was often reinterpreted in light of the first impression (Bordens and Horowitz 2002), creating a perception that was impervious to reality (Jussim 1991).

Management implications

My research indicated biological and social acceptance was not an issue with APRs in Pennsylvania. However, from a management perspective, my concern was the lack of directional change toward increasing support after 3 years of APRs. Hunters were not aware of the population effects of APRs, especially when combined with population reduction to balance deer with habitat. The lack of hunter awareness illustrates the need for the third and final reservation Carpenter and Gill (1987) reported: education. My research explores the interactions of male survival, harvest strategy, and the resource users. The results need to be used to educate deer hunters across the state about the biological effects of APRs. Ajzen and Fishbein (1977) theorized behavioral intentions result from an individual's attitude and his/her evaluation of the judgments of significant others. Every hunter forms their opinion about APRs based on their observations and/or perceptions. Use of outside expertise for marketing (Diefenbach and Palmer 1997) and hunter spokespersons or groups to deliver the message to other hunters may be an effective way to communicate the effects of APRs to other hunters (Holsman 2000).

The hunter observations of antlered deer under APR management did not meet hunter expectations. My results showed antlered to antlerless sex ratios increased. Protection of almost 7 of 10 subadults and a survival rate of >0.90 for adult males from the end of one season to the start of the following season should be observed in the field, but apparently the increase was not as much as hunters expected. Antler point restrictions and their effects on the deer population may not be able to deliver what hunters want and expect from them. Hunters perceived antlered deer population effects

would occur, yet 3 years later, were less supportive of a regulation to increase the proportion of antlered deer in the population. Although they do not seem to be able to see the results in the field, education from research could help hunters to understand what effect APRs have on deer populations and bridge the difference between population effects and what hunters expect to see from APRs. A base of knowledge from research about APRs in Pennsylvania now exists, and there is a need to advise the BOC and deer management stakeholders about the consequences of management strategies (Carpenter and Gill 1987).

Although my research focused on a regulation to increase the age and abundance of antlered deer, the primary focus of deer management needs to be on antlerless deer. There is a constant need to harvest antlerless deer for population control (Diefenbach et al. 1997) because they can affect forest tree species composition (Tilghman 1989), herbaceous understories (Hough 1965), and other forest wildlife (Casey and Hein 1983, deCalesta 1994). The lack of forest regeneration has to be a concern in Pennsylvania's deer management program. Antler point restrictions do not interfere with population management. Limiting the antlered harvest with APRs does not reduce the opportunity for hunters to hunt antlered or antlerless deer.

Future social research should continue to monitor hunter support for APRs, and any changes made to them. In addition, surveys should measure social acceptance of the costs of APRs in relation to other management strategies. More important is the need to determine whether hunters are willing to harvest deer to levels at which deer populations and their habitat are sustainable. If they are not, then deer hunting is more of a

recreational than management activity, and alternative forms of management will need to be explored.

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Appendix A:

Survey instrument used by the Pennsylvania Game Commission to evaluate deer hunter support for antler point restrictions. One pre-hunting season and 1 post-hunting season survey was sent bracketed around the 2002, 2003, and 2004 firearms deer season. Instruments for other surveys were identical with the exception of grammatical corrections for pre- or post-hunting season, and year.

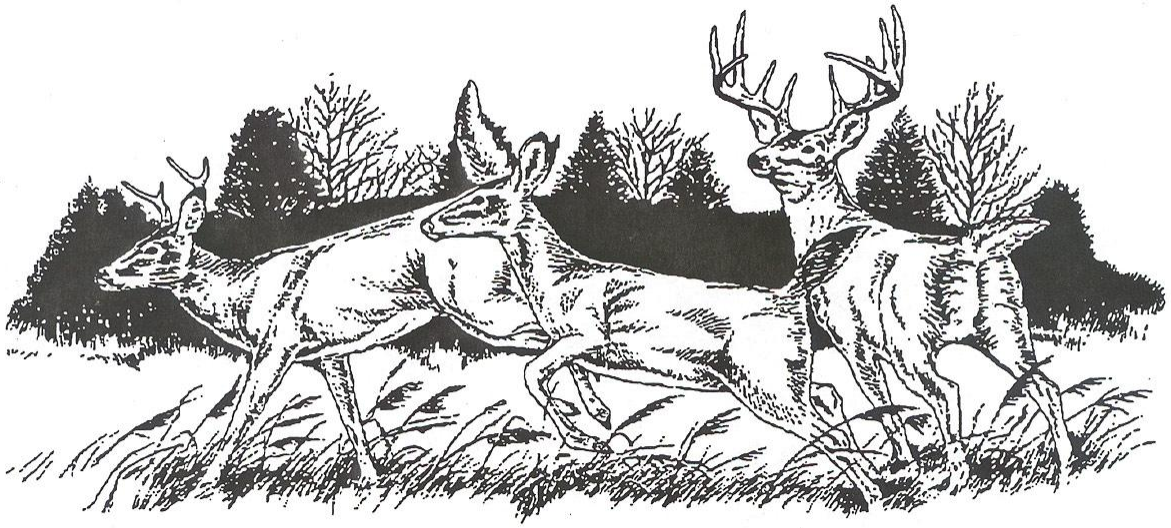
Pennsylvania Deer Hunter Survey
Fall 2004

The purpose of this survey is to measure hunter opinion about deer and recent changes made to deer management. Receiving your completed survey is important to us for evaluating hunter attitudes and preferences. **It is important that the hunter to whom this was sent complete the survey.**

ALL YOUR ANSWERS WILL REMAIN CONFIDENTIAL.

This survey should be filled out as soon as possible. A prompt response is greatly appreciated. It will take about 20 minutes to complete.

Thank you for your participation!!



Bureau of Wildlife Management
Pennsylvania Game Commission
2001 Elmerton Avenue
Harrisburg, PA 17110-9797

Part 1. This section is designed to tell us about you, the Pennsylvania hunter, and your interest level in hunting deer.

INSTRUCTIONS: Please circle the number beside your answer(s). Some questions have only one answer; others may have more than one. Follow the directions provide by each question.

1. What is your gender? (Circle the number of your answer.)

    1. Male 2. Female

2. Year of birth? 19____

3. In 2003-04 **(last year)**, was your hunting license a junior license (ages 12-16), or senior license (age 65 or older), or a regular adult license? (Circle the number of your answer.)

    1. Junior
2. Senior
3. Regular adult

4. In addition to the general hunting license, what other licenses or stamps did you purchase for the 2003-04 **(last year)** deer hunting seasons in Pennsylvania? (Circle **ALL** numbers that apply.)

    1. None
    2. Combination (archery and muzzleloader licenses for junior and senior hunters only)
    3. Archery license
    4. Flintlock (muzzleloader) license
    5. Antlerless license

5. Have you seen a program on deer management in Pennsylvania by Dr. Gary Alt over the last 4 years? (Circle **ALL** numbers that apply.)

    1. Yes; Public meeting
    2. Yes; TV program
    3. Yes; Deer management video "Creating new traditions"
    4. No

6. Have you seen any other programs on deer management in Pennsylvania over the last 4 years? (Circle the number of all you have seen.)

    1. Yes; Presentation by PA Game Commission (PGC) personnel other than Dr. Gary Alt
    2. Yes; Presentation by Penn State Extension
    3. Yes; Presentation by Quality Deer Management Association (QDMA)
    4. Yes; Other, please specify 1. _____
        2. _____
    5. No

7. Do you intend to hunt deer in the 2004-05 season **(this year)**? (Circle the number of your answer.)

1. Yes
2. No

If you answered "Yes" to question 7, go to question 9.

If you answered "No" to question 7, please answer question 8.

8. I do not intend to hunt deer in the 2004-05 season because: (Circle **ALL** numbers that apply.)

1. I hunt species other than deer
2. Too many family obligations
3. My work schedule will not allow me to hunt deer
4. I have health-related problems
5. Other (please list): _____
   _____

You do not need to answer any more questions. Please place the survey in the postage paid envelope and place in the mail. Thank you for your participation.

9. In the wildlife management unit where you plan to do most of your hunting **during the 2004 gun season**, a legal buck (according to PGC regulations) is: (Circle the number of your answer.)

1. A deer with a spike at least 3 inches in length or one antler with 2 or more points
2. A deer with at least 2 points on each antler
3. A deer with at least 3 points to one antler
4. A deer with at least 4 points to one antler
5. I do not plan to hunt deer during the gun season

Part 2. This section is designed to tell us about your style of deer hunting and your past level of harvest success.

INSTRUCTIONS: Please answer each of the questions below regarding your past deer hunting experience in Pennsylvania.

Please tell us where you hunted during the **2003** (last year) hunting season by placing a check mark (✓) in each appropriate box. **CHECK ALL BOXES THAT APPLY. You may check more than one box for each season**. **Public lands** are owned by a local, state, or federal branch of government (like state game lands and state forest lands). **Private lands** are owned by private citizens and business corporations (like large power companies and timber companies) with no direct link to local, state, or federal government. Note: **If you did not hunt in one of the deer seasons**, please check the "Didn't Hunt" column.

		PUBLIC LANDS				**PRIVATE LANDS**		
SEASONS	Didn't Hunt	State Forest/ State Park	State Game Lands	Allegheny National Forest	Other Public Land	Not Posted	Posted Leased	Posted Not Leased
1. Archery	☐	☐	☐	☐	☐	☐	☐	☐
2. Flintlock/ Muzzleloader	☐	☐	☐	☐	☐	☐	☐	☐
3. Regular Firearms	☐	☐	☐	☐	☐	☐	☐	☐

How many people did you hunt deer with during the different deer hunting seasons **in 2003**? Place a check mark (✓) in each appropriate box. **CHECK ALL BOXES THAT APPLY. You may check more than one box for each season**. Group hunting is cooperatively hunting together to move deer to each other. Note: **If you did not hunt in one of the deer seasons**, please mark the "Didn't Hunt" column.

SEASONS	Didn't Hunt	By Myself	Small Group (5 hunters or less)	In a group with 6 or more hunters
4. Archery	☐	☐	☐	☐
5. Flintlock/ Muzzleloader	☐	☐	☐	☐
6. Regular Firearms	☐	☐	☐	☐

7. During the 12-day gun season, do you plan to hunt deer with the same number of hunters in 2004 as you did in 2003? (Circle the number of your answer.)

1. Yes
2. No; I will hunt with fewer hunters
3. No; I will hunt with more hunters

What hunting method(s) did you use when hunting deer in the different seasons **in 2003**? Place a check mark (✓) in each appropriate box. **CHECK ALL BOXES THAT APPLY. You may check more than one box for each season**. Drive hunting is defined as moving deer to other hunters in your party. Note: **If you did not hunt in one of the deer seasons**, please mark the "Didn't Hunt" column.

SEASONS	Didn't Hunt	Elevated Stand	Ground Stand	Stalk/Still Hunting	Silent Drives	Noisy Drives
8. Archery	☐	☐	☐	☐	☐	☐
9. Flintlock/ Muzzleloader	☐	☐	☐	☐	☐	☐
10. Regular Firearms	☐	☐	☐	☐	☐	☐

Focusing on the 12-day **gun season following Thanksgiving**, how did you hunt deer on each of the days listed below **in 2003**? Place a check mark (✓) in each appropriate box. **CHECK ALL BOXES THAT APPLY. You may check more than one box for each season**. Note: **If you did not hunt in the gun season**, please mark the "Didn't Hunt" column.

DAY	Didn't Hunt	Elevated Stand	Ground Stand	Stalk/Still Hunting	Silent Drives	Noisy Drives
11. Monday (opening day)	☐	☐	☐	☐	☐	☐
12. Tuesday of first week	☐	☐	☐	☐	☐	☐
13. Wednesday of first week	☐	☐	☐	☐	☐	☐
14. First Saturday	☐	☐	☐	☐	☐	☐
15. Second Saturday	☐	☐	☐	☐	☐	☐

16. In which of the following years did you harvest a buck? (Circle all that apply.)
    1. 2001-2002
    2. 2002-2003
    3. 2003-2004
    4. I did not harvest a buck in any of the years listed above.

For each of the following years, please tell us if you purchased an antlerless hunting license (including DMAP permits for the deer management assistance program), whether or not you actually hunted for antlerless deer, and if you harvested an antlerless deer. Place a check mark in the box next to the answer for each question for each year.

YEAR	17. Did you purchased an antlerless license?		18. Did you hunt antlerless deer?		19. Did you harvest an antlerless deer?	
2001-2002	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
2002-2003	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
2003-2004	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No

20. The wildlife management unit (WMU) where you plan to do **most** of your hunting **during the 2004 gun season** is _____ (write in the unit you hunt in.)

Part 3. This section is **very** important for the Game Commission to understand hunter opinion about antler restrictions. In 2002, Pennsylvania deer hunters had their first year of deer hunting with new antler restriction regulations that were designed to protect about 50-75% of yearling bucks (with their first set of antlers) in the fall population.

Brief background: One goal of the Pennsylvania Game Commission's deer management program is to decrease the harvest rate of yearling bucks allowing them to move into older age classes and develop larger antlers. In addition, this would increase the buck to doe ratio in the deer population and allow for a more natural breeding ecology (increased breeding competition, stronger bucks do most breeding). To accomplish this, the Game Commission passed regulations for new antler restrictions to protect some of the younger bucks. Most of these protected bucks are yearlings with their first set of antlers. In the following year, most of these bucks would no longer be protected by the antler restriction. Under the current antler restriction, a legal buck would have to have at least 3 points or 4 points on one antler, depending on the management unit.

The wildlife management units with a 4-point restriction are 1A, 1B, 2A, 2B, and 2D. All other wildlife management units are under a 3-point restriction. Junior hunters, disabled permit holders, and Pennsylvania residents serving on active duty in the U.S. Armed Forces can harvest antlered deer with two or more points to one antler, or one antler three-inches or more in length.

INSTRUCTIONS: Please circle the number that indicates your level of agreement with each statement about current antler restrictions in Pennsylvania.

	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE
1. I support a **statewide** antler restriction, as described above.	1	2	3	4	5
2. I support an antler restriction, as described above, **in the wildlife management units** I principally hunt for deer.	1	2	3	4	5
3. I support a regulation that would increase the ratio of antlered bucks to antlerless deer in the statewide deer population.	1	2	3	4	5

Part 4. The following questions are designed to help us understand your past experience, opinions, and preferences concerning Pennsylvania deer hunting and hunting regulations.

INSTRUCTIONS: Please circle the number that indicates your level of agreement with the following statements.

	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE
1. In the area I hunted most often last year, the bucks I saw had adequate antler size.	1	2	3	4	5
2. In the area I hunted most often last year, the deer population has had an acceptable ratio of antlered to antlerless deer.	1	2	3	4	5
3. In the area I hunted most often last year, the number of bucks I saw was adequate.	1	2	3	4	5
4. In the area I hunted most often last year, I saw too many antlerless deer.	1	2	3	4	5
5. In the area I hunted most often last year, I saw too many deer.	1	2	3	4	5

Please circle the number that indicates your level of agreement with the following statements.
The current harvest regulations for bucks will result in…

	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE
6. more bucks with larger antlers.	1	2	3	4	5
7. a buck to doe ratio closer to 1:1.	1	2	3	4	5
8. more older-aged bucks.	1	2	3	4	5
9. older bucks doing most of the breeding.	1	2	3	4	5
10. no increase in quality of bucks because the large bucks will be poached before season.	1	2	3	4	5
11. no increase in older bucks because hunters will still shoot sub-legal bucks.	1	2	3	4	5

Part 5. This section will help us understand your thoughts about how current antler restrictions will affect your hunting.

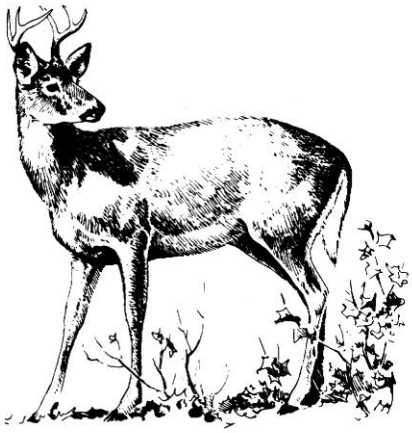
INSTRUCTIONS: Please circle the number that indicates your level of agreement with the following statements.

	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE
1. It will be difficult to identify legal bucks with current antler restrictions.	1	2	3	4	5
2. It will be too easy to accidentally kill an illegal buck in the 2004 deer season.	1	2	3	4	5
3. Current antler restriction regulations are clear and easy to understand.	1	2	3	4	5
4. Hunters will shoot any antlered deer and leave them in the woods if they are not legal.	1	2	3	4	5
5. Deer herd quality will improve with current antler restrictions.	1	2	3	4	5
6. Current antler restrictions will cause a dramatic decrease in the number of bucks harvested in the area I hunt.	1	2	3	4	5
7. Current antler restriction regulations will improve my opportunity to harvest a larger buck in the future.	1	2	3	4	5
8. In the area I hunt, there will be very few legal bucks harvested.	1	2	3	4	5
9. Current antler restrictions are a good change in Pennsylvania's deer management program.	1	2	3	4	5
10. Current antler restriction regulations will reduce my enjoyment of deer hunting in 2004.	1	2	3	4	5

Please answer questions 11, 12, 13, and 14 ONLY if you circled 1 ("STRONGLY AGREE") or 2 ("AGREE") in question 10. All others, please go to Part 6.

	STRONGLY AGREE	AGREE	NEITHER AGREE OR DISAGREE	DISAGREE	STRONGLY DISAGREE
11. My enjoyment of deer hunting in 2004 will change because I cannot shoot any buck with 3 inches or more to one antler.	1	2	3	4	5
12. My enjoyment of deer hunting in 2004 will change because current regulations are too complex.	1	2	3	4	5
13. My enjoyment of deer hunting in 2004 will change because I will be too concerned about shooting an illegal buck.	1	2	3	4	5

14. Please list any other reason you feel your enjoyment of deer hunting in 2004 will change.
    1. _____
    2. _____
    3. _____
    4. _____

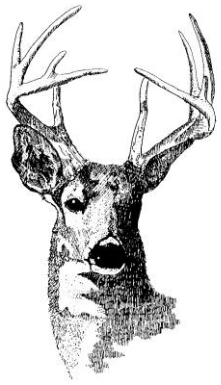


Part 6. The next two questions are to provide an overall measure of Pennsylvania's deer management program, and for you to provide any comments you want to share with us.
INSTRUCTIONS: Please circle the number that indicates your level of agreement with the following statements.

1. I would rate the PGC's deer management program as (Circle the number of your answer):

    1. Excellent 2. Good 3. Fair 4. Poor 5. Don't know

2. Do you have any comments or opinions about the survey and/or deer management in Pennsylvania? Write them in the space below.



That's the end of the survey. Please make sure you have answered all the appropriate questions.

Instructions for returning the survey: Please place the survey in the postage-paid envelope and place in the mail. If you misplaced the postage-paid envelope, the address to return the survey to is:

Bureau of Wildlife Management
Pennsylvania Game Commission
2001 Elmerton Avenue
Harrisburg, PA 17110-9797

Thank you for your participation.

ALL YOUR ANSWERS WILL REMAIN CONFIDENTIAL.

Thank you very much for your time and cooperation. Your responses will be important to assess the Pennsylvania Game Commission's deer management program.

PGC use only:

Appendix B:

Survey instrument used by the Pennsylvania Game Commission in 2005 to determine bias of deer hunter survey panel members and members who dropped out of the panel. Panel members were chosen randomly, and asked to participate in 6 deer hunter surveys across a 3 year time period to evaluate antler point restriction regulations using longitudinal data from individuals. As panel members failed to return a survey, they were dropped from the panel.

Pennsylvania Deer Hunter Survey
Follow-up and Final Survey Fall 2005

The purpose of this survey is to measure hunter opinion about deer and recent changes made to deer management. Receiving your completed survey is important to us for evaluating hunter attitudes and preferences. **It is important that the hunter to whom this was addressed complete the survey.**

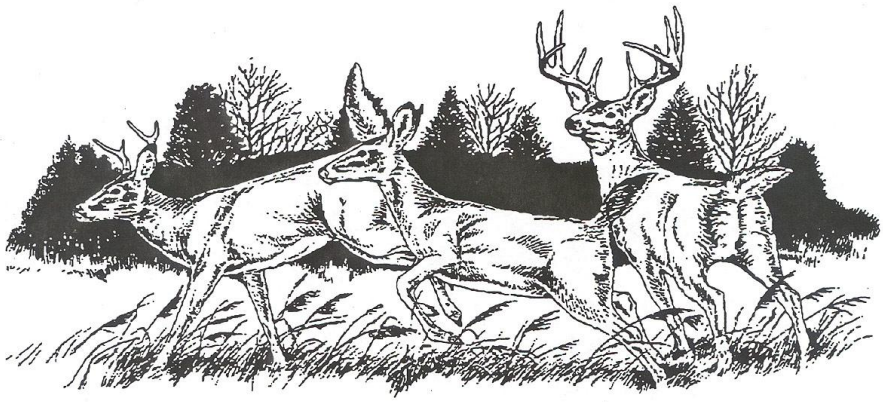
If the hunter to whom this survey was sent has passed away, we apologize for the inconvenience, and express our sympathy to you and your family. Simply check the box below, and return the survey in the postage-paid envelope.

☐ **Hunter is deceased**

ALL YOUR ANSWERS WILL REMAIN CONFIDENTIAL.

This survey should be filled out as soon as possible. A prompt response is greatly appreciated. It will take about 10 minutes to complete.

Thank you for your participation!!



Instructions for returning the survey: Please place the survey in the postage-paid envelope and place in the mail. If you misplaced the postage-paid envelope, the address to return the survey to is:

Bureau of Wildlife Management
Pennsylvania Game Commission
2001 Elmerton Avenue
Harrisburg, PA 17110-9797

Part 1. This section is designed to tell us about you, the Pennsylvania hunter.
INSTRUCTIONS: Please circle the number beside your answer(s). Some questions have only one answer; others may have more than one. Follow the directions provide by each question.

1. What is your gender? (Circle the number of your answer.)

1. Male
2. Female

2. Year of birth? 19____

3. The most important reason I stopped filling out the deer hunter surveys was because: **(Circle the ONE best answer.)**

1. I stopped hunting deer
2. I do not like filling out surveys
3. I do not like antler point restrictions
4. I did not intend to stop filling out the surveys
5. I don't trust the Game Commission
6. I don't think my responses will be used
7. I don't like the increased antlerless allocations
8. Other:_____

4. In which of the following years did you harvest a buck? (Circle all that apply.)

1. 2002-2003
2. 2003-2004
3. 2004-2005
4. I did not harvest a buck in any of the years listed above.

For each of the following years, please tell us if you purchased an antlerless hunting license (**including DMAP permits** for the deer management assistance program), whether or not you actually hunted for antlerless deer, and if you harvested an antlerless deer. Place a check mark in the box next to the answer for each question for each year.

YEAR	5. Did you purchase an antlerless license?		6. Did you hunt antlerless deer?		7. Did you harvest an antlerless deer?	
2002-2003	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
2003-2004	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
2004-2005	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No

8. The wildlife management unit (WMU) where you hunted **most during the 2004 gun season** was _____ (write in the unit you hunted in.)

Part 2. This section is **very** important for the Game Commission to understand hunter opinion about antler restrictions. In 2002, Pennsylvania deer hunters had their first year of deer hunting with new antler restriction regulations that were designed to protect about 50-75% of yearling bucks (with their first set of antlers) in the fall population.

Brief background: One goal of the Pennsylvania Game Commission's deer management program is to decrease the harvest rate of yearling bucks allowing them to move into older age classes and develop larger antlers. In addition, this would increase the buck to doe ratio in the deer population and allow for a more natural breeding ecology (increased breeding competition, stronger bucks do most breeding). To accomplish this, the Game Commission passed regulations for new antler restrictions to protect some of the younger bucks. Most of these protected bucks are yearlings with their first set of antlers. In the following year, most of these bucks would no longer be protected by the antler restriction. Under the current antler restriction, a legal buck would have to have at least 3 points or 4 points on one antler, depending on the management unit.

The wildlife management units with a 4-point restriction are 1A, 1B, 2A, 2B, and 2D. All other wildlife management units are under a 3-point restriction. Junior hunters, disabled permit holders, and Pennsylvania residents serving on active duty in the U.S. Armed Forces can harvest antlered deer with two or more points to one antler, or one antler three-inches or more in length.

INSTRUCTIONS: Please circle the number that indicates your level of agreement with each statement about current antler restrictions in Pennsylvania.

	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE
1. I support a **statewide** antler restriction, as described above.	1	2	3	4	5
2. I support an antler restriction, as described above, **in the wildlife management units** I principally hunt for deer.	1	2	3	4	5
3. I support a regulation that would increase the ratio of antlered bucks to antlerless deer in the statewide deer population.	1	2	3	4	5

Part 3. The following questions are designed to help us understand your past experience, opinions, and preferences concerning Pennsylvania deer hunting and hunting regulations.

Please circle the number that indicates your level of agreement with the following statements.
The current harvest regulations for bucks will result in…

	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE
1. more bucks with larger antlers.	1	2	3	4	5
2. a buck to doe ratio closer to 1:1.	1	2	3	4	5
3. more older-aged bucks.	1	2	3	4	5
4. no increase in quality of bucks because the large bucks will be poached before season.	1	2	3	4	5
5. no increase in older bucks because hunters will still shoot sub-legal bucks.	1	2	3	4	5

Please circle the number that indicates your level of agreement with the following statements.

	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE
6. It will be difficult to identify legal bucks with current antler restrictions.	1	2	3	4	5
7. Current antler restriction regulations are clear and easy to understand.	1	2	3	4	5
8. Hunters will shoot any antlered deer and leave them in the woods if they are not legal.	1	2	3	4	5
9. Current antler restrictions are a good change in Pennsylvania's deer management program.	1	2	3	4	5

10. I would rate the PGC's deer management program as (Circle the number of your answer):

1. Excellent 2. Good 3. Fair 4. Poor 5. Don't know

That's the end of the survey. Please make sure you have answered all the appropriate questions. Instructions for returning the survey are on the front cover. Thank you.

PGC use only:

Appendix C:

Summary results of selected questions of 6 surveys conducted by the Pennsylvania Game Commission to evaluate antler point restrictions. Surveys were sent to a randomly selected group of hunters. One pre-hunting season and 1 post-hunting season survey was sent bracketed around the 2002, 2003, and 2004 firearms deer season. Instruments for all surveys were identical with the exception of grammatical corrections for pre- or post-hunting season, and year.

Table 1. Survey responses when given the statement: I support a statewide antler restriction.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	119	7	1,700	1,042	61	233	14	425	25
2	63	9	603	407	67	72	12	124	21
3	48	7	680	463	68	106	16	111	16
4	78	10	666	436	65	81	12	149	22
5	47	6	688	479	70	91	13	118	17
6	71	9	682	421	62	67	10	194	28
	426		5,019	3,248		650		1121	

Table 2. Survey responses when given the statement: I support a statewide antler restriction; 3-pt area hunters.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	16	1	1,154	735	64	159	14	260	23
2	3	1	372	264	71	38	10	70	19
3	4	1	448	319	71	62	14	67	15
4	7	2	422	296	70	55	13	71	17
5	12	3	456	335	73	56	12	65	14
6	5	1	440	278	63	48	11	114	26
	47		3,292	2,227		418		647	

Table 3. Survey responses when given the statement: I support a statewide antler restriction; 4-pt area hunters.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	8	2	338	183	54	44	13	111	33
2	0	0	136	83	61	20	15	33	24
3	2	1	163	97	60	30	18	36	22
4	2	1	176	98	56	21	12	57	32
5	2	1	167	102	61	24	14	41	25
6	1	1	148	88	59	9	6	51	34
	15		1,128	651		148		329	

Table 4. Survey responses when given the statement: I support an antler restriction in the wildlife management units I principally hunt for deer.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	132	7	1,687	1,006	60	247	15	434	26
2	67	10	599	393	66	84	14	122	20
3	53	7	675	453	67	103	15	119	18
4	82	11	662	418	63	84	13	160	24
5	56	8	679	458	67	97	14	124	18
6	70	9	683	410	60	76	11	197	29
	460		4,985	3,138		691		1,156	

Table 5. Survey responses when given the statement: I support an antler restriction in the wildlife management units I principally hunt for deer; 3-point area hunters.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	26	2	1,144	724	63	163	14	257	22
2	7	2	368	260	71	41	11	67	18
3	8	2	444	313	70	61	14	70	16
4	10	2	419	288	69	54	13	77	18
5	17	4	451	321	71	62	14	68	15
6	4	1	441	275	62	55	12	111	25
	72		3,267	2,181		436		650	

Table 6. Survey responses when given the statement: I support an antler restriction in the wildlife management units I principally hunt for deer; 4-point area hunters.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	9	3	337	167	50	47	14	123	36
2	0	0	136	75	55	22	16	39	29
3	4	2	161	92	57	28	17	41	25
4	3	2	175	90	51	22	13	63	36
5	6	4	163	93	57	26	16	44	27
6	1	1	148	85	57	9	6	54	36
	23		1,120	602		154		364	

Table 7. Survey responses when given the statement: Current antler restrictions area good change in Pennsylvania's deer management program.

	No response			Agree		Neither		Disagree	
Survey	n	%	Total responses	n	%	n	%	n	%
1	118	6	1,701	886	52	418	25	397	23
2	59	9	607	355	58	133	22	119	20
3	49	7	679	400	59	163	24	116	17
4	68	9	676	363	54	153	23	160	24
5	47	6	688	406	59	156	23	126	18
6	78	10	675	332	49	130	19	213	32
	419		5,026	2,742		1,153		1,131	

Table 8. Survey responses when given the statement: Current antler restrictions area good change in Pennsylvania's deer management program; 3-point area hunters.

	No response			Agree		Neither		Disagree	
Survey	n	%	Total responses	n	%	n	%	n	%
1	16	1	1,154	631	55	284	25	239	21
2	6	2	369	234	63	67	18	68	18
3	6	1	446	276	62	100	22	70	16
4	0	0	429	252	59	92	21	85	20
5	6	1	462	280	61	102	22	80	17
6	11	2	434	230	53	78	18	126	29
	45		3,294	1,903		723		668	

Table 9. Survey responses when given the statement: Current antler restrictions area good change in Pennsylvania's deer management program; 4-point area hunters.

	No response			Agree		Neither		Disagree	
Survey	n	%	Total responses	n	%	n	%	n	%
1	5	1	341	150	44	88	26	103	30
2	1	1	135	67	50	39	29	29	21
3	2	1	163	84	52	41	25	38	23
4	1	1	177	77	44	42	24	58	33
5	8	5	161	86	53	37	23	38	24
6	0	0	149	71	48	30	20	48	32
	17		1,126	535		277		314	

Table 10. Survey responses when given the statement: The current harvest regulations for bucks will result in older aged bucks.

	No response			Agree		Neither		Disagree	
Survey	n	%	Total responses	n	%	n	%	n	%
1	113	6	1,706	1,193	70	267	16	246	14
2	60	9	606	420	69	95	16	91	15
3	50	7	678	493	73	106	16	79	12
4	77	10	667	446	67	99	15	122	18
5	42	6	693	487	70	97	14	109	16
6	75	10	678	402	59	115	17	161	24
	417		5,028	3,441		779		808	

Table 11. Survey responses when given the statement: The current harvest regulations for bucks will result in no increase in quality of bucks because the large bucks will be poached before season.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	111	6	1,708	411	24	512	30	785	46
2	60	9	606	125	21	186	31	295	49
3	47	6	681	130	19	221	32	330	48
4	72	10	672	149	22	214	32	309	46
5	40	5	695	155	22	193	28	347	50
6	71	9	682	187	27	208	30	287	42
	401		5,044	1,157		1,534		2,353	

Table 12. Survey responses when given the statement: The current harvest regulations for bucks will result in no increase in older bucks because hunters will still shoot sub-legal bucks.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	110	6	1,709	558	33	491	29	660	39
2	60	9	606	163	27	178	29	265	44
3	49	7	679	154	23	213	31	312	46
4	70	9	674	167	25	201	30	306	45
5	42	6	693	164	24	186	27	343	49
6	74	10	679	209	31	190	28	280	41
	405		5,040	1415		1459		2166	

Table 13. Survey responses when given the statement: Hunters will shoot any antlered deer and leave them in the woods if they are not legal.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	118	6	1701	763	45	458	27	480	28
2	61	9	605	191	32	218	36	196	32
3	48	7	680	230	34	184	27	266	39
4	72	10	672	194	29	258	38	220	33
5	48	7	687	244	36	181	26	262	38
6	78	10	675	231	34	215	32	229	34
	425		5020	1853		1514		1653	

Table 14. Survey responses when given the statement: Current antler restrictions will cause a dramatic decrease in the number of bucks harvested in the area I hunt.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	120	7	1699	1012	60	377	22	310	18
2	61	9	605	278	46	197	33	130	21
3	48	7	680	318	47	191	28	171	25
4	69	9	675	360	53	175	26	140	21
5	47	6	688	297	43	209	30	182	26
6	77	10	676	364	54	165	24	147	22
	422		5023	2629		1314		1080	

Table 15. Survey responses when given the statement: In the area I hunt, there will be very few legal bucks harvested.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	121	7	1698	839	49	474	28	385	23
2	60	9	606	291	48	193	32	122	20
3	47	6	681	257	38	227	33	197	29
4	68	9	676	402	59	154	23	120	18
5	48	7	687	271	39	215	31	201	29
6	77	10	676	449	66	145	21	82	12
	421		5024	2509		1408		1107	

Table 16. Survey responses when given the statement: The current harvest regulations for bucks will result in older bucks doing most of the breeding.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	114	6	1705	900	53	505	30	300	18
2	62	9	604	322	53	180	30	102	17
3	49	7	679	367	54	228	34	84	12
4	74	10	670	318	47	213	32	139	21
5	44	6	691	376	54	204	30	111	16
6	73	10	680	287	42	222	33	171	25
	416		5029	2570		1552		907	

Table 17. Survey responses when given the statement: I support a regulation that would increase the ratio of antlered bucks to antlerless deer in the statewide deer population.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	138	8	1681	1139	68	274	16	268	16
2	63	9	603	434	72	86	14	83	14
3	49	7	679	496	73	115	17	68	10
4	78	10	666	417	63	116	17	133	20
5	55	7	680	469	69	117	17	94	14
6	75	10	678	352	52	129	19	197	29
	458		4987	3307		837		843	

Table 18. Survey responses when given the statement: In the area I hunted most often last year, the deer population has had an acceptable ratio of antlered to antlerless deer.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	113	6	1706	466	27	269	16	971	57
2	59	9	607	142	23	135	22	330	54
3	57	8	671	152	23	140	21	379	56
4	74	10	670	137	20	120	18	413	62
5	40	5	695	151	22	172	25	372	54
6	79	10	674	130	19	133	20	411	61
	422		5023	1178		969		2876	

Table 19. Survey responses when given the statement: In the area I hunted most often last year, I saw too many antlerless deer.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	111	6	1708	577	34	366	21	765	45
2	61	9	605	177	29	146	24	282	47
3	54	7	674	212	31	160	24	302	45
4	72	10	672	163	24	114	17	395	59
5	41	6	694	175	25	149	21	370	53
6	77	10	676	90	13	95	14	491	73
	416		5029	1394		1030		2605	

Table 20. Survey responses when given the statement: The current harvest regulations for bucks will result in a buck to doe ratio closer to 1:1.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	125	7	1694	701	41	532	31	461	27
2	63	9	603	238	39	206	34	159	26
3	47	6	681	286	42	208	31	187	27
4	74	10	670	242	36	182	27	246	37
5	46	6	689	250	36	220	32	219	32
6	72	10	681	196	29	189	28	296	43
	427		5018	1913		1537		1568	

Table 21. Survey responses when given the statement: In the area I hunted most often last year, the bucks I saw had adequate antler size.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	112	6	1707	701	41	298	17	708	41
2	65	10	601	204	34	137	23	260	43
3	55	8	673	206	31	159	24	308	46
4	78	10	666	193	29	133	20	340	51
5	41	6	694	235	34	152	22	307	44
6	84	11	669	196	29	132	20	341	51
	435		5010	1735		1011		2264	

Table 22. Survey responses when given the statement: The current harvest regulations for bucks will result in more bucks with larger antlers.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	110	6	1709	1165	68	287	17	257	15
2	59	9	607	419	69	98	16	90	15
3	47	6	681	489	72	114	17	78	11
4	73	10	671	432	64	109	16	130	19
5	43	6	692	466	67	121	17	105	15
6	74	10	679	390	57	104	15	185	27
	406		5039	3361		833		845	

Table 23. Survey responses when given the statement: In the area I hunted most often last year, the number of bucks I saw was adequate.

	No response			Agree		Neither		Disagree	
Survey	n	%	Total responses	n	%	n	%	n	%
1	113	6	1706	509	30	272	16	925	54
2	63	9	603	154	26	118	20	331	55
3	54	7	674	153	23	137	20	384	57
4	75	10	669	151	23	104	16	414	62
5	42	6	693	152	22	118	17	423	61
6	77	10	676	137	20	92	14	447	66
	424		5021	1256		841		2924	

Table 24. Survey responses when given the statement: Current antler restriction regulations will reduce my enjoyment of deer hunting.

	No response			Agree		Neither		Disagree	
Survey	n	%	Total responses	n	%	n	%	n	%
1	121	7	1698	501	30	322	19	875	52
2	60	9	606	168	28	126	21	312	51
3	46	6	682	152	22	127	19	403	59
4	68	9	676	209	31	147	22	320	47
5	47	6	688	162	24	136	20	390	57
6	78	10	675	249	37	131	19	295	44
	420		5025	1441		989		2595	

Table 25. Survey responses for respondents agreeing that current antler restriction regulations will reduce their enjoyment of hunting, when given the statement: My enjoyment of deer hunting in [year] will change because I cannot shoot any buck with 3 inches or more on one antler.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	17	3	484	349	72	78	16	57	12
2	4	2	164	115	70	23	14	26	16
3	3	2	149	108	72	26	17	15	10
4	6	3	203	134	66	40	20	29	14
5	5	3	157	117	75	22	14	18	11
6	10	4	239	153	64	42	18	44	18
	45		1396	976		231		189	

Table 26. Survey responses for respondents agreeing that current antler restriction regulations will reduce their enjoyment of hunting, when given the statement: My enjoyment of deer hunting in [year] will change because current regulations are too complex.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	18	4	483	228	47	117	24	138	29
2	4	2	164	77	47	42	26	45	27
3	6	4	146	92	63	31	21	23	16
4	7	3	202	99	49	43	21	60	30
5	4	2	158	80	51	51	32	27	17
6	12	5	237	105	44	60	25	72	30
	51		1390	681		344		365	

Table 27. Survey responses for respondents agreeing that current antler restriction regulations will reduce their enjoyment of hunting, when given the statement: My enjoyment of deer hunting in [year] will change because I will be too concerned about shooting an illegal buck.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	12	2	489	394	81	40	8	55	11
2	3	2	165	134	81	15	9	16	10
3	6	4	146	119	82	11	8	16	11
4	5	2	204	163	80	16	8	25	12
5	4	2	158	133	84	10	6	15	9
6	11	4	238	165	69	32	13	41	17
	41		1400	1108		124		168	

Table 28. Survey responses when given the statement: It will be difficult to identify legal bucks with current antler restrictions.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	116	6	1703	1130	66	192	11	381	22
2	59	9	607	355	58	98	16	154	25
3	48	7	680	358	53	110	16	212	31
4	70	9	674	398	59	103	15	173	26
5	49	7	686	352	51	96	14	238	35
6	77	10	676	397	59	100	15	179	26
	419		5026	2990		699		1337	

Table 29. Survey responses when given the statement: It will be too easy to accidentally kill an illegal buck in the [current year] season.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	121	7	1698	935	55	297	17	466	27
2	60	9	606	278	46	131	22	197	33
3	48	7	680	280	41	146	21	254	37
4	70	9	674	282	42	135	20	257	38
5	50	7	685	261	38	143	21	281	41
6	78	10	675	264	39	150	22	261	39
	427		5018	2300		1002		1716	

Table 30. Survey responses when given the statement: Current antler restriction regulations are clear and easy to understand.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	116	6	1703	1203	71	266	16	234	14
2	62	9	604	404	67	90	15	110	18
3	46	6	682	479	70	122	18	81	12
4	69	9	675	486	72	93	14	96	14
5	47	6	688	519	75	83	12	86	13
6	76	10	677	499	74	79	12	99	15
	416		5029	3590		733		706	

Table 31. Survey responses when given the statement: Deer herd quality will improve with current antler restrictions.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	116	6	1703	922	54	478	28	303	18
2	58	9	608	360	59	157	26	91	15
3	49	7	679	431	63	174	26	74	11
4	68	9	676	341	50	172	25	163	24
5	48	7	687	401	58	168	24	118	17
6	76	10	677	273	40	171	25	233	34
	415		5030	2728		1320		982	

Table 32. Survey responses when given the statement: Current antler restriction regulations will improve my opportunity to harvest a larger buck in the future.

	No response		Total responses	Agree		Neither		Disagree	
Survey	n	%		n	%	n	%	n	%
1	119	7	1700	1057	62	392	23	251	15
2	60	9	606	391	65	128	21	87	14
3	46	6	682	481	71	131	19	70	10
4	69	9	675	426	63	135	20	114	17
5	48	7	687	468	68	132	19	87	13
6	75	10	678	362	53	146	22	170	25
	417		5028	3185		1064		779	

Table 33. Survey responses when given the statement: I would rate the PGC's deer management program as...

	No response		Total responses	Excellent		Good		Fair		Poor		Don't know	
Survey	n	%		n	%	n	%	n	%	n	%	n	%
1	150	10	1323	92	6	558	33	673	40	213	13	133	8
2	69	12	485	70	12	267	45	148	25	75	13	37	6
3	63	10	546	79	12	275	41	192	29	61	9	58	9
4	83	15	485	60	9	249	38	176	27	132	20	44	7
5	63	10	540	75	11	281	42	184	27	94	14	38	6
6	97	21	358	40	6	153	23	165	25	267	41	31	5
	525		3737	416		1783		1538		842			

Vita: Bret D. Wallingford

Education

- **Ph.D. Candidate, School of Forest Resources,** The Pennsylvania State University, May 2012
  Dissertation: White-tailed deer antler point restrictions, harvest and survival rates, and deer hunter support: perception versus reality
- **M.S., Wildlife Biology,** North Carolina State University, December 1990
  Thesis: Use of radio-telemetry to determine observability of female white-tailed deer on Remington Farms
- **B.S., Environmental Resource Management, School of Forest Resources,** The Pennsylvania State University, May 1985
- **Certified Wildlife Biologist, The Wildlife Society,** 1996

Employment

- **Deer population and research biologist,** Pennsylvania Game Commission, July 1995-present
- **Pheasant research biologist**, Pennsylvania Game Commission, July 1990-June 1995

Peer-Reviewed Publications:

Wallingford, B.D., R.A. Lancia, and E.C. Soutiere. 1996. Antagonism of xylazine in white-tailed deer with intramuscular injection of yohimbine. Journal of Wildlife Diseases 32:399-402.

Wallingford, B.D. and R.A. Lancia. 1991. Telemetry accuracy and a model for predicting telemetry accuracy. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 45:178-188.

Wallingford, B.D. 1990. Use of radio-telemetry to determine observability of female white-tailed deer on Remington Farms. M.S. Thesis, N.C. State University, Raleigh, NC. 74pp.

Personal interests

Hunting, fishing, trapping, camping, bird-watching, leathercraft, guns, archery, photography, carpentry, masonry, woodworking, farming, literature, history of WWII, cooking.