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Population characteristics of a white-tailed deer herd in a bottomland hardwood forest of south-central Louisiana

Justin W. Thayer

Louisiana State University and Agricultural and Mechanical College

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**POPULATION CHARACTERISTICS OF A WHITE-TAILED DEER HERD IN A
BOTTOMLAND HARDWOOD FOREST OF SOUTH-CENTRAL LOUISIANA**

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The School of Renewable Natural Resources

by
Justin W. Thayer
B.S., Louisiana State University, 2006
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“...If a man brings up his sons to be hunters, they will never grow away from him. Rather the passing years will only bring them closer, with a thousand happy memories of the woods and fields.....And it is my fixed conviction that if a parent can give his children a passionate and wholesome devotion to the outdoors, the fact that he cannot leave each of them a fortune does not really matter so much. They will always enjoy life in its nobler aspects without money and without price. They will worship the Creator in his mighty works. And because they know and love the natural world, they will always feel at home in the wide, sweet habitations of the Ancient Mother.”

-- Archibald Rutledge in “Why I taught my boys to be hunters.”

Finally, thank you, God. Somehow, I’ve survived the past 3 years without major injury. I’ve avoided poisonous snakes, malaria, and lethal levels of West-Nile. I’ve evaded escaped convicts, drunk drivers, and close calls with deer on the highway in the truck. I’ve even lived to tell about hitting a deer while on the ATV, rolling an ATV, and losing a tire on a trailer in rush-hour traffic on I-10. Thank You, again. Thank You also for watching over my loved ones while I was away. Thank You for speckled trout, redfish, ducks, turkeys, deer, thermacell, DEET, crawfish etouffee, and the undying loyalty and love of Man’s best friend.

TABLE OF CONTENTS

| | |
|--|------|
| ACKNOWLEDGEMENTS..... | ii |
| LIST OF TABLES..... | vi |
| LIST OF FIGURES..... | vii |
| ABSTRACT..... | viii |
| CHAPTER 1. INTRODUCTION..... | 1 |
| STUDY AREA..... | 4 |
| METHODS..... | 8 |
| CHAPTER 2. SEASONAL SPACE USE..... | 12 |
| INTRODUCTION..... | 12 |
| METHODS..... | 13 |
| RESULTS..... | 14 |
| MALE..... | 14 |
| FEMALE..... | 16 |
| DISCUSSION..... | 16 |
| CHAPTER 3. SURVIVAL AND CAUSE-SPECIFIC MORTALITY..... | 21 |
| INTRODUCTION..... | 21 |
| METHODS..... | 22 |
| RESULTS..... | 24 |
| DISCUSSION..... | 27 |
| CHAPER 4. CONCLUSIONS AND MANAGEMENT IMPLICATIONS..... | 32 |
| LITERATURE CITED..... | 34 |
| VITA..... | 41 |

LIST OF TABLES

| | |
|--|----|
| Table 1. Mean seasonal home range (HR) and core area (CA) size (ha) of adult and juvenile radio-marked male white-tailed deer on the Choctaw Quality Deer Management Cooperative, West Baton Rouge and Iberville Parishes, Louisiana from 2007-2008..... | 15 |
| Table 2. Mean seasonal home range (HR) and core area (CA) size (ha) radio-marked female white-tailed deer on the Choctaw Quality Deer Management Cooperative, West Baton Rouge and Iberville Parishes, Louisiana from 2007-2008..... | 16 |
| Table 3. Output from 2 a priori candidate models used to estimate survival rates for white-tailed deer males from radio-telemetry data obtained on the Choctaw Quality Deer Management Cooperative, West Baton Rouge and Iberville Parishes, Louisiana from 2007-2008..... | 25 |
| Table 4. Mean survival and cause-specific mortality rates among age classes of adult male white-tailed deer on the Choctaw Quality Deer Management Cooperative, West Baton Rouge and Iberville Parishes, Louisiana from 2007-2008..... | 26 |

LIST OF FIGURES

- Figure 1. Location of the study site in Iberville and West-Baton Rouge Parishes, Louisiana. Figure shows initial trap sites used in capture, relative location of radio-collared deer during the study, and a minimum convex polygon that depicts the extent of the study area (19,715 ha) based on deer movements..... 7
- Figure 2. Aerial photograph of a common 16 ha clearcutting pattern used to manage forests in a bottomland forest of West Baton Rouge Parish..... 20

ABSTRACT

White-tailed deer are an important economic and recreational resource in Louisiana. A basic understanding of population dynamics is essential to ensure sound management, but baseline information in Louisiana is lacking. Likewise, the notion of Quality Deer Management (QDM) continues to gain momentum in Louisiana. Our objectives were to evaluate space use, survival, and mortality for a deer herd managed under a QDM regime in south Louisiana.

We captured 65 deer in West Baton Rouge and Iberville Parishes during 2007 and 2008, radio-marked 37 males and 11 females, and ear-marked an additional 10 males and 7 females. Home ranges (95%) for adult males during spring, summer, and fall were 153.9, 70.4, and 118.0 ha, respectively and were 119% and 68% larger during spring and fall than summer. Female home ranges were 67.3, 53.9, and 25.2 ha during spring, summer, and fall, respectively. Juvenile (1.5 yr-old) males increased space use 169% in spring (231.6 ha) relative to summer (86.1 ha), and maintained 50% larger home ranges than adults in spring.

Survival estimates for adult males during spring, summer, and fall were 100, 95, and 55%, respectively. Mean annual survival for adult males was 53%. No mortalities were observed in spring or summer for 1.5 yr-old males, but ear-tag returns and harvest records indicated 1.5 yr-old males were being harvested at a rate approaching 20%. Mean annual mortality rates from harvest (40%) were greater than for non-harvest sources of mortality (16%). Non-hunting mortality included both natural causes (9%) and deer-vehicle-collisions (9%).

We observed smaller home ranges than anticipated or seen previously, suggesting that landowners managing small (<300 ha) tracts of property may be able to practice QDM at scales thought to be ineffective at improving herd dynamics. Due to low non-hunting mortality, young males (≤ 2.5 -yr) are likely to survive to the next age class if protected from harvest, but ultimately

have a small chance of reaching maturity (5.5+) because males are generally harvested as they approach the antler restriction in place. Managers should seek to increase fall survival for males if management objectives include increasing the frequency of harvesting males ≥ 3.5 yrs-old.

CHAPTER 1. INTRODUCTION

Prior to the colonization of Louisiana's forested lands, white-tailed deer were relatively abundant throughout much of the state. Records prior to 1800 suggest that between 250,000 and 400,000 white-tails inhabited the state's virgin forest (St. Amant and Perkins 1953), but similar to most other big game animals in the path of an expanding human population at the time, white-tails took the brunt of market hunting operations during the early 1900's. Concurrently, extensive logging operations cleared most of Louisiana's forested landscape, leaving deer little protection from market hunters. With an estimated 20,000 animals in 1925 (St. Amant and Perkins 1953), the white-tail deer population decline only slowed as remaining animals sought refuge in remote swamps and back-woods areas of Louisiana (Moore 1979).

Natural regeneration in the years following the clearing of Louisiana's forests provided good habitat for deer remaining in the state. With the help of wildlife laws enacted to protect species such as deer, white-tails in Louisiana began a slow recovery. To encourage deer population increases, the Louisiana Wildlife Commission initiated a deer management program in the early 1940's in hopes of restoring white-tails to all parts of the state (Barick 1951, Newsom 1969). Through funding provided by the Pittman-Robertson Act of 1937, over 3,000 deer were restocked across Louisiana between 1949 and 1969 (St. Amant and Perkins 1953, Blackard 1971). As a result of the success of the intensive restocking program, a 1970 survey estimated 300,000 deer were residing within Louisiana (US Department of the Interior). That season, Louisiana hunters were able to harvest an estimated 50,000 deer (US Department of the Interior 1970).

During the following 20 years, deer herds across the state met or began to exceed carrying capacity due to harvest regimes biased toward antlered deer. With habitats and herd health becoming stressed as numbers increased, the acceptance of formal deer management, including antlerless harvest, began to grow in the 1980's (Moreland 1996). During this same period, management agencies and the public became aware of the economic importance of deer and deer hunting to Louisiana. In 2006, 204,000 Louisiana big game hunters generated an estimated \$286,233,000 through big game hunting expenditures (US Department of Interior et al. 2006). In light of the importance of white-tailed deer to Louisiana, specifically their recreational and economic value, it has become imperative to fully understand not only their ecology within the state, but also the effects of various management programs on deer population productivity, stability, and health.

Although numerous studies have detailed basic population characteristics of white-tailed deer herds throughout the U.S., basic population parameters such as home range and survival are lacking for Louisiana herds. Furthermore, little research has addressed these population parameters in bottomland forests, which comprises 25% of Louisiana's forested land and holds some of the state's highest deer densities (Scott Durham, Louisiana Department of Wildlife and Fisheries, personal communication). Though much of Louisiana's bottomland forests were lost through intensive logging or conversion into agriculture (Stanturf et al. 2001), conservation and reforestation programs such as the Wetlands Reserve Program (WRP) have effectively restored functionality to thousands of hectares of these bottomland forests. For example, WRP was responsible for more than 52,000 ha of reforested bottomlands within Louisiana, Arkansas, and Mississippi in 1999 alone (King and Keeland 1999). As additional bottomland forests are

restored or replanted, these habitats will become available for white-tailed deer, providing additional areas for deer population development.

Likewise, the notion of Quality Deer Management (QDM) continues to gain momentum in Louisiana with increasing interest from private landowners throughout the state. QDM is a philosophy that focuses management efforts towards sustaining a biologically and socially balanced deer herd. Balancing a herd with its environment involves an adequate harvest of both sexes to relieve pressure on the environment and allow the available deer to maximize their potential growth in a quality habitat. Although both sexes are harvested, a liberal antlerless harvest is often used to help control deer density while younger males (≤ 1.5) are often protected from harvest. By protecting young males from harvest, those males can be recruited into older, more desirable age classes. While each participant may have varying objectives and goals when implementing QDM, its foundation is the same: protect young males, harvest adequate antlerless deer, and maintain a healthy population in balance with existing habitat conditions and landowner desires (Hamilton et al. 1995).

As interest on both private and public lands moves further toward data-intensive management regimes like QDM, so will the desire and need for regional population demographic data, such as home range, survival, and cause-specific mortality. Based on this premise, this study was implemented in 2006 by the Louisiana Department of Wildlife and Fisheries (LDWF) and the Louisiana State University Agricultural Center, with the objective of evaluating space use and survival of male and female white-tailed deer within a bottomland hardwood forest in south-central Louisiana.

Study Area

This project was conducted within a 16,000 ha bottomland hardwood forest located west of Baton Rouge and east of the Atchafalaya Basin. The eastern end of the study site (West Baton Rouge Parish) was approximately 10 miles from the Mississippi River Bridge at Baton Rouge, with the western end (Iberville Parish) bordered by Bayou Grosse Tete. The area was composed primarily of semi-contiguous bottomland hardwood forest with active logging occurring annually. The most common forest management practice occurring within the study area was clear-cutting (20 ha each) fashioned in a checker-board pattern. The overstory of forest stands contained various species, including American sycamore (*Platanus occidentalis*), water oak (*Q. nigra*), overcup oak (*Q. lyrata*), Nuttall oak (*Q. texana*), elm (*Ulmus americana*), sweetgum (*Liquidambar styraciflua*), sugarberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanicus*), black willow (*Salix nigra*), baldcypress (*Taxodium distichum*), water hickory (*Carya aquatica*), water tupelo (*Nyssa aquatica*), and honey locust (*Gleditsia triacanthos*). Midstory species included boxelder (*Acer negundo*), Drummond red maple (*A. rubra* var. *drummondii*), persimmon (*Diospyros virginiana*), tallowtree (*Triadica sebifera*) and swamp dogwood (*Cornus drummondii*). Common understory species included yellowtop (*Senecio glabellus*), rattan vine (*Berchemia scandens*), greenbrier (*Smilax* spp.), blackberry (*Rubus* spp.), horsetail (*Equisetum hyemale*), trumpet creeper (*Campsis radicans*), Virginia creeper (*Parthenocissus quinquefolia*), poison ivy (*Toxicodendron radicans*), climbing dogbane (*Trachelospermum difforme*), muscadine (*Vitis* spp.), elderberry (*Sambucus Canadensis*), Japanese honey-suckle (*Lonicera japonica*), red-berried moonseed (*Cocculus Carolinus*), deciduous holly (*Illex decidua*), peppervine (*Ampelopsis* spp.), crossvine (*Bignonia capreolata*), and ladies'-eardops (*Brunnichia ovata*). Forest openings (e.g., rights-of-way, logging roads) were dominated by food plots

comprised primarily of wheat (*Triticum* spp.), oats (*Avena* spp.), or clover (*Trifolium* spp.). Openings that were not planted such as camp yards, maintained trails, and recently used logging decks were commonly dominated by Johnsongrass (*Sorghum halepense*), ragweed (*Ambrosia* spp.), black-eyed susan (*Rudbeckia* spp.), goldenrod (*Solidago* spp.), beefsteak (*Perilla frutescens*), teaweed (*Sida rhombifolia*) and blackberry (*Rubus* spp.). Various supplemental feeds (corn, rice bran, soy beans; primarily available during hunting season) were also accessible to deer on the study site since baiting for white-tailed deer in Louisiana is a legal and common practice.

Most of the area was accessible through improved or unimproved roads. Interstate 10, a 4-lane interstate, ran traversed 8 miles of the northern portion of the study area, a large bayou (Bayou Choctaw) divided the east and west sides of the area, and the Intra-coastal Navigation Canal bordered the southern end of the study area. Interstate 10 was heavily traveled day and night, and the Intra-coastal Canal witnessed a high volume of commercial traffic during the day. There were 3 other primary or secondary paved roads or highways that dissected the study area (Figure 1).

The study site was privately owned by a multitude of both small (<200 ha) and large (>200 ha) landowners, with A. Wilbert's Sons, LLC (Wilbert) controlling most (>50%) of the land within the study area. Wilbert leased hunting rights on their lands to many hunting clubs, and also encouraged clubs to join the Choctaw Quality Deer Management (QDM) Cooperative (Co-op). This cooperative was initiated by Wilbert, the South Louisiana chapter of Quality Deer Management Association (QDMA), and Louisiana Department of Wildlife and Fisheries (LDWF) in 1997. Although clubs leasing lands from Wilbert were strongly encouraged to join the Co-op, privately owned hunting clubs and clubs leasing from other landowners surrounding

Wilbert land joined the Co-op voluntarily, resulting in nearly 30 hunting clubs participating in a program promoting QDM throughout the study site. The Co-op's harvest guidelines included a recommendation from LDWF for antlerless deer harvest by each participating club and an antler restriction designed to protect younger bucks. The Co-op's objective through QDM was to increase the quality of deer harvested within the Co-op (personal communication, Vic Blanchard, A. Wilbert's Sons, LLC). A liberal antlerless harvest was assigned to most participating clubs to reduce deer densities and relieve browsing pressure on the habitat. Reduced densities could allow the habitat to provide adequate resources for the available deer, resulting in increases in individual body weights, reproduction, and/or antler characteristics. Further, antler restrictions set in place were designed to protect most 1.5 and 2.5 yr-old males. After the formation of the Co-op, participants actively collected biological data on harvested deer and managers reviewed harvest recommendations yearly.

Unpublished data from the Louisiana Department of Wildlife and Fisheries indicate the study area contains a moderate to high density deer herd. A 7-day, 14-site camera survey during January 30 to February 6th, 2009 indicated a density of 1 deer per 3 ha, a buck-to-doe ratio of 1:1.1, and a fawn-to-doe ratio of 0.59:1. Herd health collections performed in the spring of 2007 and 2008 indicated: fetus/doe ratios of 1.3 and 1.9, average weights 106 lbs and 112 lbs, and kidney fate percentages of 54% and 55%, respectively. Lastly, a browse survey performed during late spring (4/28/2007) indicated moderate browse pressure with several indicator species (deciduous holly, water oak, and Smilax sp.) being browsed to moderate-high levels.

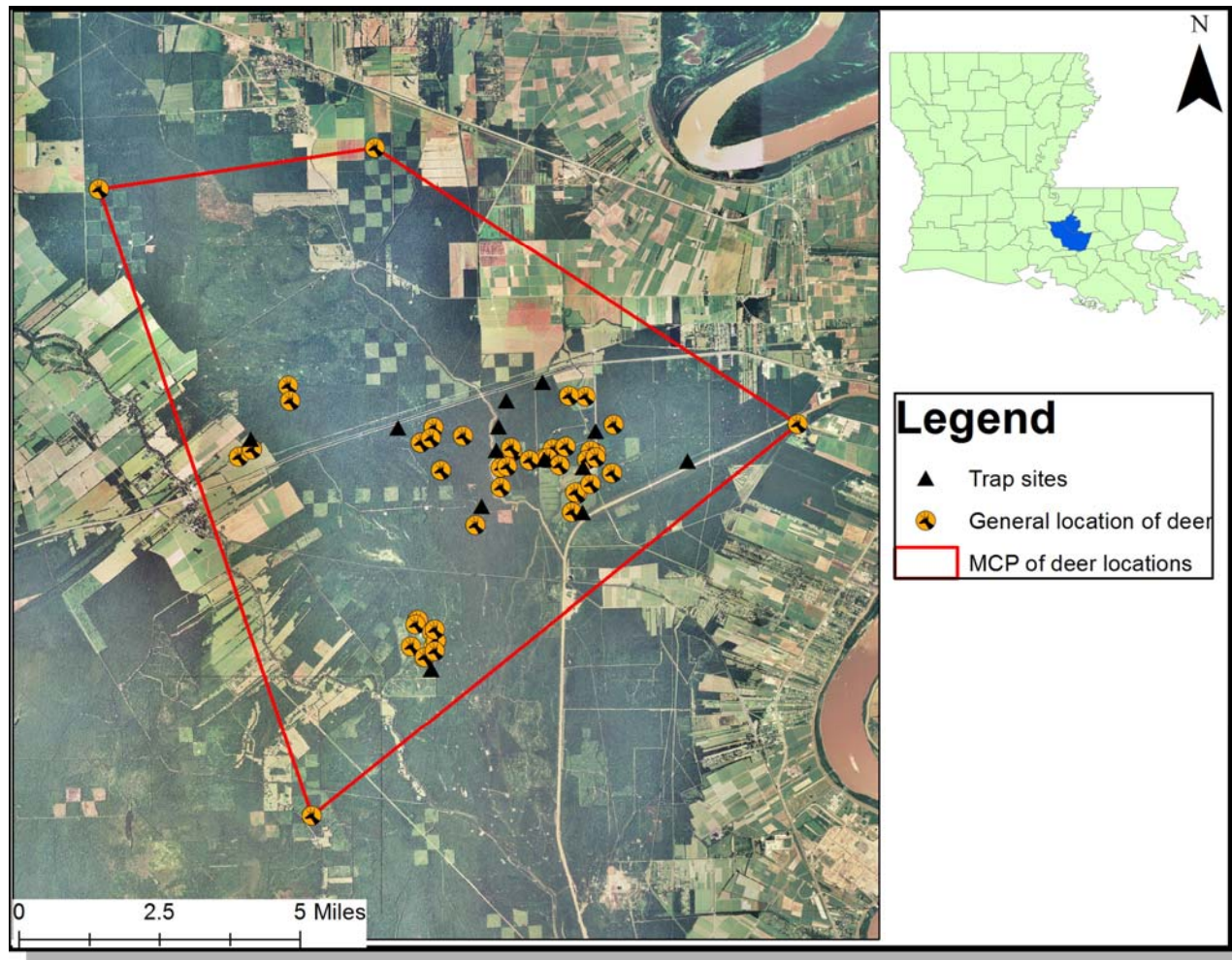


Figure 1. Location of the study site in Iberville and West-Baton Rouge Parishes, Louisiana. Figure shows initial trap sites used in capture, relative location of radio-collared deer during the study, and a minimum convex polygon that depicts the extent of the study area (19,715 ha) based on deer movements.

Methods

Deer were captured during spring (Feb-April) 2007-2008 with drop nets and dart projectors at permanent bait sites (whole kernel corn and rice bran; $n=13$). Locations for drop nets were chosen based on available space for setup (30m×30m) and were placed in rights-of-way such as power lines, unused fields, or within established food plots. Priority was given to areas near Interstate 10, Bayou Choctaw, and the Intra-coastal Canal as significant interest in these areas as possible barriers to deer movement existed. We used drop nets near both Bayou Choctaw and the Intra-Coastal Canal, and dart sites near Interstate 10 because there was not an area large enough to set up the drop net. Other drop nets were placed throughout the study site according to available space.

Deer captured with drop nets were chemically immobilized with an intramuscular injection by hand or a pole syringe of 5 mg/kg Telazol (Fort Dodge Animal Health, Fort Dodge, Iowa) and 2.49 mg/kg Xylazine (Phoenix Scientific, St. Joseph, Missouri) at the dosage of 1 ml per 38.5 kg (Amass and Drew 2006). Deer captured with the dart gun (Pneu-Dart Incorporated, Williamsport, Pennsylvania) were immobilized with the same combination of Telazol and Xylazine. Darts were equipped with a VHF transmitter (Pneu-Dart Incorporated, Williamsport, Pennsylvania) to allow us to track the animal after it was darted. We used a VHF receiver (Advanced Telemetry Systems, Isanti, Minnesota) and hand-held 3-element Yagi antenna to locate darted animals, and for all immobilized deer, we monitored heart rate, respiratory rate, and rectal temperature every 10 minutes after capture until release. After processing, deer were intravenously injected with the Xylazine antagonist Tolazoline (100 mg/ml, Tolazine[®]; Lloyd Laboratories, Shenandoah, Iowa, USA) at 3.0 mg/kg and released on-site.

While immobilized, fawns and adult deer were marked with numbered Monel ear-tags in both ears (National Brand and Tag Company; Newport, Kentucky), and sex, age, estimated weight, and antler measurements were recorded. Adults were collared with a 400-gram VHF radio-collar (Mod M2510B; Advanced Telemetry Systems, Isanti, Minnesota) equipped with an 8-hour time-delayed motion sensor to detect mortalities. At 400-grams, radio collars were <1% of body weight in adult deer. Yearling 1.5 yr old male deer were collared with an expandable VHF radio-collar (Mod M4230B; Advanced Telemetry Systems, Isanti, Minnesota) to allow growth. Captured deer were aged with tooth replacement and wear techniques (Severinghaus 1949) and categorized as fawns, 1.5, or ≥ 2.5 years of age. Hereafter, 1.5 yr-olds will be referred to as juveniles and ≥ 2.5 as adults.

Deer captured with the drop nets were usually immobilized within 3-5 minutes of capture, whereas darted deer were usually recovered 5-15 minutes after darting. Total time from capture until release averaged 2 hours. Capture stress on the animals was minimized through swift immobilization, application of eye ointment (Paralube, Pharaderm, Melville, New York) to prevent corneal drying, blindfolding, positioning sternally or on the right side, and assuring a quiet working environment during processing (Beringer et al. 1996). To ensure proper animal handling, the primary researcher attended a Safe Capture class in Dallas, Texas on proper and safe chemical immobilization of deer and large ungulates (Amass and Drew 2006). All capture and handling methods were reviewed and accepted by the Louisiana State University Agricultural Center Animal Care and Use Committee (Protocol No. A06-07).

Radio-marked deer locations were calculated via triangulation (Cochran and Lord 1963) from 3-6 fixed telemetry stations ($n=178$) with a hand-held 3 element Yagi antenna and an ATS R2000 receiver (Advanced Telemetry Systems, Inc., Isanti, Minnesota). Fixed telemetry stations

were geographically referenced with a Garmin Map60cx global positioning unit (GPS, Garmin International Inc, Olathe, Kansas) to obtain Universal Transverse Mercator (UTM) coordinates in the map datum NAD83. Radio-marked animals were located 1-5 times a week throughout the study with ≥ 3 sequential bearings taken along roads. If radio-marked deer could not be located from the ground, fixed-wing aircraft were used to locate the animal. While triangulating locations, a 15-minute time interval was used to minimize error associated with movement of the marked animal. The program Location of a Signal (LOAS, Version 4.0.2.2 beta, Ecological Software Solutions 1999) with the maximum likelihood estimator method (Lenth 1981), was used to estimate UTM coordinates and error ellipse areas of animal locations from the raw bearings. Estimated locations were accepted with error ellipses not exceeding 4 ha to maximize accuracy and 8 hours between attempts to ensure independence of observations (Swihart and Slade 1985). Although we allowed 8 hours to elapse between successive locations, we understand an animals' previous location likely influences future locations.

Telemetry error was calculated during both the leaf-on (spring and summer) and leaf-off (winter) periods (Withey et al. 2001) with >50 bearings per observer, per season taken on dummy radios ($n=10$). Dummy radios were placed at deer neck height with observers unaware of the true location of the dummy radio. Average angle error was $\pm 7.8^\circ$.

If a mortality signal from the radio-collar was detected or suspected from lack of movement, homing was used to locate the animal or collar. Upon locating the collar or deceased animal, we obtained UTM coordinates of the location and attempted to document the cause of death (if apparent), or transported the carcass to the Louisiana State University Veterinary School for necropsy. If radio-marked animals were sighted during routine telemetry, a GPS unit was used to obtain UTM coordinates of the animals' exact location.

Monitoring periods were divided into 3 seasons: spring (February 15-May 31), summer (June 1-September 31), and fall/winter (October 1-Feb 15). These periods were delineated based on deer biology (pre-fawning, fawning, and breeding seasons, respectively) and hunting seasons within the study area (Oct1-Feb15). Peak of breeding and range of conception/parturition were determined through the collection of parturient females during March and April of 2007 (n=13) and 2008 (n=10). After counting and sexing fetuses, forehead-rump length measurements were used to determine fetus age in days and used to back-date to conception date (Hamilton et al. 1985). Based on the conception date, 200 days were added to determine approximate parturition date (Cheatum and Morton 1942, Haugen and Davenport 1950, Golley 1957, Haugen 1959, and Verme 1965).

CHAPTER 2. SEASONAL SPACE USE

Introduction

Home range is the area an animal traverses during the course of its daily activities (Burt 1943). Within home ranges, core areas are regions of concentrated use and presumably contain resources of most importance to animals (Ewer 1968, Samuel et al. 1985). Therefore, core area use may relate to biologically significant features such as dependable food sources, protective and/or bedding cover, or areas of accessibility to mates for breeding.

Studies detailing home range and core area sizes for white-tailed deer are numerous, but have predominantly focused on white-tails in northern parts of their range. Unlike white-tails in northern latitudes, southern white-tails are generally assumed to be sedentary (Marchinton and Jeter 1966, Byford 1969, and Tucker 1981), and they do not display migratory movements often seen in colder climates (Heezen and Tester 1967, Rongstad and Tester 1969, Verme 1973, and Zagata and Haugen 1974). The lack of migratory movements or large seasonal shifts may be a response to the homogeneity of both the climate and habitat found in the southern reaches of the white-tail range (Jeter and Marchinton 1964).

Home range and core area sizes have been reported for white-tails in various habitat and forest types, but little information is available for white-tails inhabiting bottomland hardwood forests of the southeast. The highly fertile soils of the Mississippi Alluvial Valley (MAV) produce diverse and nutritious vegetation that support some of the highest carrying capacities of white-tails in the southeast (Murphy and Noble 1972), and the MAV is considered to be the best deer habitat within the region (Stransky 1969). Studies detailing home range sizes for deer in Louisiana and the Gulf coast (LA, MS, AL) are limited to a few dated works. Historical home

range data for Louisiana deer include a 1968 study in an upland pine/hardwood landscape in which 3 female deer were used to calculate home ranges of 506, 555, and 762ha (Lewis 1968). Mott (1981) reported that the estimated average annual home ranges for 5 male deer (1511 ha) were about twice that of 4 females (737ha) that were tracked in a bottomland forest of east-central Mississippi. Additionally, a pair of studies in the bottomland forest of Davis Island, Mississippi, indicated that annual home ranges of 5-13 deer varied from 200 to 3614 ha (Herriman 1983, Morrison 1985). All of these studies noted that annual home ranges for males were larger than for females.

Although the 3 Mississippi studies did provide estimates of white-tailed deer home range within bottomland forests, sample sizes and weather events (e.g., Mississippi River stage rose from 23 to 42ft in December 1982, flooding half of the available deer habitat) may account for the large variation of size in home range estimates reported in the studies. Improving our understanding of space use within bottomland systems is important for developing management regimes and may have implications for the scale at which programs such as QDM are implemented and are most effective. Therefore, my objective was to quantify home range and core area sizes of male and female white-tailed deer in a bottomland forest of south-central Louisiana.

Methods

Locations of radio-collared deer were obtained by radio-telemetry as described in Chapter 1, and triangulated locations were imported into ArcView 3.2 (ESRI, Redlands, California) and converted to point themes. Area observation curves were constructed based on 9-14 males per season to determine the minimum number of locations necessary to appropriately estimate home range. Only radio-marked deer with ≥ 15 locations per season were included in

the home range analysis. Prior to analysis, the program Animal Space Use 1.1 Beta (Horne 2005) was used to estimate the smoothing parameter (h) based on the likelihood cross-validation method (CVh; Silverman 1986). Once h was identified for an individual deer within a season, both home range (95%) and core area (50%) were calculated with the fixed-kernel analysis method (Worton 1989) within the Animal Movement Extension application (Hooge and Eichenlaub 2000) in ArcView. Composite home range and core areas were also derived for radio-marked males having ≥ 3 complete seasons of data. For both juvenile and adult males, composite ranges included spring, summer, and fall seasons. Further, to describe average length of radio-monitoring, we calculated the average number of seasons individuals were monitored.

A factorial analysis of variance (ANOVA) was used to test for season by age interactions in home range and core area sizes with SAS V9 (SAS Institute, Inc. 1996). A one-way ANOVA was used to test for effects of season and age on home range and core area size when no significant difference was found in the factorial analysis. Additionally, a one-way ANOVA was used to test for effects of year on home range and core area. Due to small sample size and social behavior of females, ages were pooled in all analyses and statistical tests. Statistical tests were considered significant at $P < 0.05$.

Results

Males

Seasonal home ranges and core areas for 7 males were excluded from the analyses due to insufficient number of locations during an individual season as a result of censoring (failure to transmit, dropped collar, death of animal). Consequently, analyses included 116 home ranges and core areas for 36 males. For the seasonal analysis, juvenile males were only included in spring and summer analyses of their capture year due to recruitment into the adult age class at

the onset of the fall season. The average number of seasons that males were radio-monitored was 3.14 (n=37).

Home range ($F_{1/114} = 0.8$, $P = 0.374$) and core area ($F_{1/114} = 0.99$, $P = 0.322$) size did not differ among years, thus data were pooled for further analysis to investigate seasonal differences. Season and age interacted to affect both home range ($F_{4/111} = 7.41$, $P < 0.001$) and core area ($F_{4/111} = 4.47$, $P = 0.002$; Table 1) sizes.

Table 1. Mean seasonal home range (HR) and core area (CA) size (ha) of adult and juvenile radio-marked male white-tailed deer on the Choctaw Quality Deer Management Cooperative, West Baton Rouge and Iberville Parishes, Louisiana from 2007-2008.

| <i>Season</i> | <i>Age</i> | <i>HR Size</i> | <i>HR Standard Error</i> | <i>CA Size</i> | <i>CA Standard Error</i> |
|---------------|------------|----------------|------------------------------|----------------|------------------------------|
| Spring | Juvenile | 231.6 | 28.3 | 39.4 | 5.8 |
| | Adult | 153.9 | 16.6 | 25.5 | 3.4 |
| Summer | Juvenile | 86.1 | 28.3 | 15.9 | 5.8 |
| | Adult | 70.4 | 16.8 | 13.4 | 3.4 |
| Fall | Juvenile | n/a | n/a | n/a | n/a |
| | Adult | 118 | 16.9 | 19.8 | 3.4 |
| Composite | Juvenile | 108.7 | 14.4 | 16.7 | 2.4 |
| | Adult | 147.5 | 32.8 | 23.7 | 5.8 |

Adult maintained larger home range sizes in fall ($t_{111} = 1.99$, $P = 0.049$) and spring ($t_{111} = 3.52$, $P < 0.001$) than summer, and larger core areas in spring than summer ($t_{111} = 2.53$, $P = 0.013$). Juveniles also had larger home range ($t_{111} = 3.63$, $P < 0.001$) and core area ($t_{111} = 2.89$, $P = 0.005$) sizes in the spring than summer, both of which were larger for juveniles than adults (home ranges, $t_{111} = -2.37$, $P = 0.020$; and core areas, $t_{111} = -2.08$, $P = 0.040$) in spring.

Females

The seasonal home range and core area for 1 female was excluded from analyses because she died prior to a sufficient number of locations being collected during a particular season. As a consequence, analyses of female deer movements included 34 home ranges and core areas for 10 females. The average number of seasons that females were radio-monitored was 3.18 (n=11). Home range ($F_{1/32} = 3.96$, $P = 0.551$) and core area ($F_{1/32} = 2.12$, $P = 0.155$) size did not differ among years, thus data were pooled for further analysis to investigate seasonal differences. Mean home range and core area sizes were 42.2 ha and 8.8 ha, respectively in 2007, and 71.7 ha and 15.3 ha, respectively in 2008. Home range ($F_{2/31} = 2.33$, $P = 0.114$) and core area sizes ($F_{2/31} = 1.03$, $P = 0.370$; Table 2) were similar across seasons.

Table 2. Mean seasonal home range (HR) and core area (CA) size (ha) radio-marked female while-tailed deer on the Choctaw Quality Deer Management Cooperative, West Baton Rouge and Iberville Parishes, Louisiana from 2007-2008.

| <i>Season</i> | <i>HR Size</i> | <i>HR</i> | <i>CA Size</i> | <i>CA</i> |
|---------------|----------------|-----------------------|----------------|-----------------------|
| | | <i>Standard Error</i> | | <i>Standard Error</i> |
| Spring | 67.3 | 11.2 | 14.0 | 4.8 |
| Summer | 53.9 | 11.7 | 11.4 | 3.5 |
| Fall | 25.2 | 15.9 | 5.6 | 4.8 |

Discussion

Our estimates of home range and core area sizes were less than previous studies for both sexes. We recognize that comparing precise estimates of space use among studies is tenuous and should be done with caution due to variation in estimation methods (kernel, minimum convex polygons, smoothing parameter options, etc.), sample sizes, and monitoring intensities among studies. Nevertheless, deer in this study exhibited less variability among individuals and maintained smaller ranges than has been reported in previous studies. We suggest that reduced

space use observed in this study was a synergistic function of climate, deer density, habitat characteristics, and forest management practices.

Although previous studies within bottomland hardwood forests of Mississippi reported larger home ranges (200-3614 ha) and extensive variability among animals, both severe flooding from the Mississippi River (Herriman 1983, Morrison 1985) and small sample sizes (Mott 1981) likely influenced these findings. Long-term inundation like that observed by Herriman (1983) and Morrison (1985) can often occur in areas subject to the annual flood pulses of the Mississippi River (<http://waterdata.usgs.gov>). Although our study site was not subjected to these flood pulses due to its location behind river levees, the site was directly affected by Hurricane Gustav in September 2008. Although the storm was a drastic event with damaging winds (20% red oak lost, temporary flooding; personal communication, Vic Blanchard, A. Wilbert's Sons, LLC) and rainfall resulting in wide-spread flooding, inundation was short term (<2 weeks).

Overall, our findings suggest that juveniles used 22-50% more space than adults seasonally. During spring, increased space use of juveniles is likely associated with dispersal movements. Similar to juvenile males, adult males also increased space use during spring relative to other seasons, which has been linked to breeding activity (Welch 1960, Kammermeyer and Marchinton 1977, Nelson and Mech 1981, Beier and McCullough 1990). Although the local breeding season occurred primarily during fall, we suggest that increased spring ranges for adults may be partially related to late breeding activity. Seasons were delineated based on reproductive chronology (Dec. 20th – Feb. 12th) and hunting seasons (Oct. 1st -Feb 15th). Although the fall season effectively captured the range and peak of breeding activity in both years (Jan14-18 in 2007/2008, respectively), reduced female ranges in fall may have contributed to increased movements by males searching for breeding opportunities during the

final stages of estrous. Given the decreasing frequency of females in estrous during this time, some males may have altered movement patterns during the transition of the fall to spring seasons to increase the odds of finding a receptive female. Alternatively, early spring also coincides with a time of depleted resource availability, removal of bait by hunters, and the need for males to recover depleted body reserves lost during breeding. A combination of these factors may force deer, especially males, to increase movements to secure necessary resources.

Males and females tended to reduce space use during summer. Decreases in female home ranges are common during summer because of the reduction in mobility associated with fawning (Summer; Pledger 1975, Ozoga et al. 1982, Bertrand et al. 1996, D'Angelo et al 2004). Males may decrease their summer ranges as a response to seasonal increases in forage (Harestad and Bunnell 1979, Beier and McCullough 1990), a reduction in conspecific aggression (Thomas et al 1965), increased aggregation among males (Hirth 1977), and as a response to extreme weather conditions (Michael 1970). High heat loads increase heart rate in domestic livestock (Brosh 2007), effectively decreasing the efficiency in the ratio of oxygen consumption to heart rate. Research on cattle and lambs has even prompted recommendations as drastic as night feedings for some geographic areas to mitigate effects of high heat loads on production efficiency (Brosh et al. 2001, Aharoni et al. 2005). The reduction in home ranges observed in this study during summer could partially be a result of strategies designed to conserve energy and mitigate thermoregulatory stress. Furthermore, reduced space use during summer may indicate that deer on the study site are able to meet physiological and nutritional needs in a reduced area (Hellickson et al. 2008), with forage availability that may have exceeded metabolic demand (Harestad and Bunnell 1979). On our study site, we suspect that abundant early successional habitat (created through clearcutting) juxtaposed with mature forest stands provided

deer with a mosaic of forage and thermal cover throughout the summer, resulting in reduced space use.

During fall, males increased space use and females reduced space use relative to other seasons. As noted previously, males are known to increase movement during the breeding season (Welch 1960, Kammermeyer and Marchinton 1977, Nelson and Mech 1981, Beier and McCullough 1990), whereas females may decrease space use during breeding periods (Ozoga and Verme 1975, Holzenbein and Schwede 1989, Labisky and Fritzen 1998). Other studies have suggested that relative male density may influence fall movements in that females may restrict their within-range movements to make their locations more predictable to prospective males (Downing and McGeinnes 1976, Ivey and Causey 1981, Holzenbein and Schwede 1989, Beier and McCullough 1990).

Although movement is expected to vary among individuals and be influenced by numerous environmental, ecological, and behavioral variables (Wiens et al. 1995, Phillips et al. 2004), forest management strategies on our study area likely play a key role in influencing space use. Jeter and Marchinton (1964) suggested that the lack of migratory movements or large seasonal location shifts for deer in southern latitudes was partially a response to the homogeneity of habitat conditions found in southern reaches of the whitetail range. Wilbert has implemented timber management plans that continually stagger stand ages through periodic timber harvests and natural or artificial regenerations, specifically using a rotational system selecting different timber management units to harvest within each year. This rotation results in each management unit being selected every 6 years, during which time several 16 ha blocks are cut, each staggered to create a checker-board pattern of clearcuts and residual mature forest on the landscape (Figure 2). This forest management regime results in a forest with abundant early and late successional

plant communities. The close juxtaposition of mature forest providing mast during fall and winter with early successional habitats replete with high quality browse and cover likely allows deer to maintain smaller home ranges than one would expect based on an examination of literature detailing space use of deer in southern latitudes.

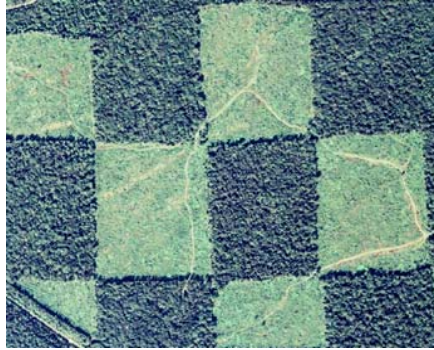


Figure 2. Aerial photograph of a common 16 ha clearcutting pattern used to manage forests in a bottomland forest of West Baton Rouge Parish.

CHAPTER 3. SURVIVAL AND CAUSE-SPECIFIC MORTALITY

Introduction

Understanding survival and mortality patterns within a population is paramount to successful management. Management programs such as Quality Deer Management (QDM) rely on protection of young males (<2.5-yr old) for recruitment into older age classes (Hamilton et al. 1995). Although young males are protected from harvest-related mortality through the use of age or antler restrictions, other sources of mortality may have serious impacts on management goals if survival of young males is being compromised. Although hunting is the most common source of mortality for white-tailed deer (Fuller 1990, Nelson and Mech 1986), other factors such as predation (DeYoung 1989, Nelson and Mech 1986, Bartush and Lewis 1981, Litvaitis and Shaw 1980), disease (Samuel 1994, Miller et al. 2003, Davidson and Doster 1997), deer-vehicle collisions (Miller et al. 2003, Allen and McCullough 1976), weather, and malnutrition (Teer 1984) can be significant deer mortality sources depending on various biological, spatial, and temporal variables such as sex, age, season, and deer density (Gavin et al. 1984, Dusek et al. 1992, Whitlaw et al. 1998, DelGiudice et al. 2002).

Previous studies have revealed substantial variability in estimated survival and cause-specific mortality in white-tailed deer. Annual survival rates of adult males in Texas have been reported to vary from 50-91% (DeYoung 1989, Heffelfinger et al. 1990, Ditchkoff et al. 2001, Webb et al. 2007), with annual non-hunting mortality ranging from 7 to 18%. Bowman et al. (2007) reported annual survival rates for male deer in Mississippi to vary from 44-82%, with natural mortality rates of 2-14% depending on age (1.5-5.5+ yr). Similar to this study, landowners in the Bowman et al. (2007) study subscribed to QDM and had a vested interest in

the fate of the younger males. Interestingly, despite antler restrictions in place to protect males <2.5-yrs old, Bowman et al. (2007) found young males were still being harvested at rates higher than expected.

As deer hunting interests on private and public lands move farther towards data-intensive management regimes like QDM, knowledge of regional population demographics such as survival and cause-specific mortality rates will become increasingly important. These data are unavailable in Louisiana, and my objective was to estimate seasonal and annual survival rates and to quantify cause-specific mortality of white-tailed deer in a bottomland hardwood forest of south-central Louisiana.

Methods

Adult and juvenile (1.5 yr-old) white-tailed deer were captured with methods previously described in chapter one. Adults and 1.5 yr-old deer > 80 lbs were radio-collared, whereas fawns and 1.5 yr-old deer <80lbs were ear-tagged only. Low sample size (n=17) of ear-tagged fawns and radio-tagged females (n=11; these data were also complicated by their habitual matriarchal social grouping) prevented statistical analyses of these data sets. Radio-marked animals were monitored as described in the telemetry protocol 1-5 times per week throughout the duration of the study until censoring (radio failure, dropped collar, death of the animal, or end of the study). Hunting seasons spanned the period from 1 October through 15 February, with the modern firearm season generally ranging from the second week in November through the middle of January. One week in December, as well as the remainder of the season, was either archery, primitive weapon, or both. Hunting clubs within the Choctaw Quality Deer Management Cooperative (Co-op) used antler restrictions (38.1 cm main beam length and 33.0 cm inside spread) to protect young males. The Co-op antler restrictions were formulated by deriving

average antler characteristics (e.g., number of points, inside spread, and main beam length) for each male age class from local harvest data. Thus, setting the restriction above the average antler characteristics of a certain age class affords some protection from harvest to those males falling under the restriction. Additionally on the Co-op, antlerless deer were harvested at 1 doe per 20.5 ha, which can be considered a moderate antlerless deer harvest (liberal = 1 doe/8-12 ha, personal communication, Scott Durham, Louisiana Department of Wildlife and Fisheries) to balance the deer herd with the habitat (QDM; Hamilton et al. 1995). Clubs hunting within the Co-Op were informed about the radio-collared deer and asked to treat the animals like any other in hopes of reducing possible bias in regards to estimating harvest rates. Hunters also were asked to report the harvest of any collared or ear-tagged deer. Season of death or censoring was recorded as well as cause of death; either harvest, natural, or deer-vehicle-collision (DVC).

Program MARK (White & Burnham 1999) was used to calculate survival estimates and cause-specific mortality rates in adult males (>1.5-yrs). Because survival data was derived from radio-telemetry, a known fate model was used with season (spring, summer, and fall) as the interval. Some animals were tracked in both years of the study and were subsequently considered separate samples in the analysis. To estimate cause-specific non-hunting mortality rates, survival rates considering either natural or DVC mortalities were determined while censoring all hunting-related mortalities. Conversely, hunting-related mortality was estimated by censoring all non-hunting mortalities when estimating survival. Mortality rates were then calculated by $1 - \text{survival}$.

We applied 2 candidate models to determine effects of season on survival:

1. S (.)

Where survival (S) was constant across seasons and;

2. $S(t)$

Where survival (S) was not constant through seasons

We used Akaike's information criterion (AICc), changes in AICc and Δ AICc values, and Akaike weights (AICw) to evaluate model performance and chose the best-fitting model (Anderson et al. 2000). Multiple models were developed because survival rates of male white-tailed deer may vary through time due to fall hunting seasons (Gavin et al. 1984, Hewitt et al. 1999, Ditchkoff et al. 2001, Fuller 1990, Nelson and Mech 1986).

Because of small sample sizes in 1.5 yr-old males, females (pooled ages), and the ear-tagged only sample, survival estimates and mortality rates were not analyzed in program MARK for these groups. Based on the season of capture, 1.5 yr-old males caught in spring moved into the adult cohort at the onset of the subsequent fall (Oct. 1), therefore these animals were considered 2.5-years old during the first fall after their capture. The ear-tagged only sample consisted of animals that were too small to support the weight of a radio-collar. These animals, mostly current-year fawns or late drop previous-year 1-yr olds were not likely to be eligible for harvest due to antler restrictions. Thus, survival of 1.5 yr-old males, females, and the ear-tagged only sample are reported as the percentage surviving throughout the duration of the study by dividing the number of individuals alive at the end of the study by the number of individuals alive at the beginning of the study.

Results

Our estimates of survival rates were based on 34 adult (≥ 2.5 yr-old) male deer. During fall hunting seasons, 14 males (41% of radio-marked sample) were harvested by hunters. Thirteen of 14 radio-marked deer were reported after they were harvested, and one hunter removed the radio-collar and discarded it off of a bridge into Bayou Grosse Tete. The hunter

was later identified and questioned by enforcement personnel, and ultimately admitted to taking the deer during a legal hunting season.

Aside from harvest, causes of death for adult males included natural ($n=3$; one from a bacterial infection, and 2 from unknown causes) and DVC ($n=2$). One male was shot, wounded, and later recovered by field staff. The best approximating model showed survival varying across seasons (Table 3). Survival was lower in fall (0.55, SE = 0.08) than summer (0.95, SE = 0.03) and spring (1.00, SE = 0.00). Mean annual survival was 0.53 (SE = 0.08) during 2007-2009. Mean annual mortality rates from harvest (0.40) were greater than non-harvest (0.16). Cause-specific non-hunting mortality rates included both natural causes (0.09) and DVC's (0.09).

Table 3. Output from 2 a priori candidate models used to estimate survival rates for white-tailed deer males from radio-telemetry data obtained on the Choctaw Quality Deer Management Cooperative, West Baton Rouge and Iberville Parishes, Louisiana from 2007-2008.

| <i>MODEL</i> | <i>AICc</i> | $\Delta AICc$ | <i>AICw</i> | <i>K</i> | <i>DEVIANCE</i> |
|--------------|-------------|---------------|-------------|----------|-----------------|
| S(.) | 109.2265 | 34.5022 | 0 | 1 | 38.6653 |
| S(t) | 74.7243 | 0 | 1 | 3 | 0 |

Eleven 1.5 yr-old males were captured during the springs of 2007-2008. No deaths were observed for any 1.5 year old male prior to the fall hunting season when they were recruited into the 2.5 year old age class.

Adult ($n=10$) and 1.5 yr-old ($n=1$) females were pooled for analyses. Three females were harvested (27% of radio-marked sample) and one died from unknown natural causes. Two of 3 harvested females were wounded, not recovered by the hunter, and then later recovered by field staff. Seven females (64%) survived until the end of the study.

Table 4. Mean survival and cause-specific mortality rates among age classes of adult male white-tailed deer on the Choctaw Quality Deer Management Cooperative, West Baton Rouge and Iberville Parishes, Louisiana from 2007-2008.

| Age class | Interval | n | Survival | | Cause-specific mortality rate | | | | | | | |
|-----------|----------|----|----------|------|-------------------------------|------|-------------|------|----------------------|------|-----------|------|
| | | | Rate | SE | Hunting ^a | SE | Non-Hunting | SE | Natural ^b | SE | Vehicular | SE |
| 1.5 | Spring | 11 | 1.00 | Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Summer | 11 | 1.00 | Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ≥ 2.5 | Spring | 34 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Summer | 34 | 0.95 | 0.03 | 0.00 | 0.00 | 0.05 | 0.03 | 0.05 | 0.03 | 0.00 | 0.00 |
| | Fall | 34 | 0.55 | 0.08 | 0.40 | 0.08 | 0.13 | 0.07 | 0.05 | 0.04 | 0.09 | 0.06 |
| | Annual | 34 | 0.53 | 0.08 | 0.40 | 0.08 | 0.16 | 0.07 | 0.09 | 0.05 | 0.09 | 0.06 |

a. Hunting = legal harvest and wounding loss

b. Natural = known or unknown natural

Seventeen (10 males, 7 females) deer were ear-tagged only and only 4 (2 males, 2 females) were known to have been harvested and reported (24%). One male was captured as a 1.5 yr-old and harvested the subsequent fall as a 2.5 yr-old. The second male harvested was captured as a fawn and later harvested as a 2.5 yr-old. Both females harvested were fawns at capture, then harvested at 1.5 and 2.5 years of age, respectively. Assuming complete reporting rates, 80% of males and 71% of females tagged as fawns or 1.5 yr-old bucks (<80lbs at capture) survived to the end of the study. These may be considered maximum estimates as we have no way of monitoring the ear-tagged animals for mortalities other than when ear-tags were reported.

Discussion

Not surprisingly, survival rates found in this study most closely resemble those reported by Bowman et al. (2007) in Mississippi. When considering only males ≥ 2.5 -yrs old, Bowman et al. (2007) reported annual survival rates ranging from 44-63%. Although deer populations in Texas are in close proximity geographically, survival rates of adult males in several Texas studies (50-91%; DeYoung 1989, Heffelfinger et al. 1990, Ditchkoff et al. 2001, Webb et al. 2007) may be inflated because males are often protected from harvest until they reach 4.5 or 5.5+ yrs-old throughout much of south Texas, e.g., Webb et al. (2007) reported that deer were not harvested or culled until they reached at least 6.5 years of age.

Similar to other studies, survival was considerably higher outside hunting seasons. Elevated survival during spring (100%) and summer (95%) were likely related to the lack of hunting, abundant forage and a decrease in interaction-related injuries between individuals (e.g., fighting among males during the breeding season; Thomas et al. 1965) and were similar to spring and summer survival rates reported by Bowman et al. (2007). Survival rates were lowest during fall hunting seasons, which also coincided with breeding periods for deer on our study site. As

described in Chapter 2, peak breeding occurred in mid-January and the hunting season extended through February 15th. Aside from harvest, the loss of nutritional reserves from breeding activity is known to be stressful for males and can lead to increased susceptibility to natural mortality (Warren et al. 1981, Gavin et al. 1984, Hewitt et al. 1999, Ditchkoff et al. 2001). Ditchkoff et al. (2001) reported that 72% of mortalities occurred during or after the breeding season in Oklahoma, and similar results were found for deer during the period from January-March in Texas (Hewitt et al. 1999) and November-January in Washington (Gavin et al. 1984). In this study, the breeding season extended through the end of hunting season; hence one would expect some natural mortality in either the fall or spring season (Miller and Ozoga 1997). Although the breeding season on our study area was considered late and rather lengthy, we did not observe any natural mortalities during fall or spring.

Although female survival was not calculated using Program MARK, 64% of radio-marked females survived through the study period. Although LDWF suggested a liberal antlerless harvest (1 doe/12 ha; personal communication, Scott Durham, Louisiana Department of Wildlife and Fisheries) for most participating clubs within the Co-op, the average annual doe harvest was 1 doe/20.5 ha. Further, and as described in Chapter 1, habitat and reproductive evaluations performed on the study site indicate moderate to high deer densities. A combination of data from LDWF and the observed survival estimate reported here are reflective of the average annual antlerless harvest within the Co-op.

Although survival in 1.5 yr-old males was 100% during spring and summer, 3 of 11 (27%) animals were killed in the subsequent fall by either harvest (n=2) or DVC (n=1). Nevertheless, recruitment of males into the 2.5 yr-old age class from the 1.5 yr-old class appears to be high, most likely a result of QDM goals and antler restrictions for deer on the study site.

Similarly, Bowman et al. (2007) reported 100% spring and summer survival for 1.5 yr-old males ($n=94$), although annual survival was 82% after the fall hunting season. In light of a low natural mortality rate for these young deer (2%), they suggested increasing education and commitment within participating hunting clubs would help achieve their management objectives. In this study, it is encouraging to report 100% survival during the spring and summer season, but we also understand that our capture and marking protocol prohibited us from monitoring 1.5 yr-old males during hunting seasons.

The harvest-rate of 1.5 yr-old males in the Bowman et al. (2007; 16%) study was surprising, because the QDM regime was similar to that used in our study, i.e., antler restrictions were in place to protect males < 2.5 yrs-old. Although we could not account for potential harvest of 1.5 yr-old males through monitoring of our radio-collared animals, tag returns from male fawns suggest that harvest rates were low (20% harvested). Harvest data from the Choctaw Co-op over the last ten years indicates 1.5 yr-old males have made up 18% of the total male harvest ($n= 3,535$). Thus, although we were not able to quantify 1.5 yr-old male survival outside of the spring and summer season during this study, we do know that 1.5 yr-old males experience low non-hunting mortality but are being harvested at rates approaching 20% of the annual male harvest. In the Bowman et al. (2007) study, hunters often reported harvesting 1.5 yr-old males mistakenly, misidentifying them as females. Whether the justification for the incidental harvest of 1.5 yr-old males is similar here or not, our suggestion parallels that of Bowman et al. (2007) in that if males <2.5-yrs old are not harvested by hunters in the fall season, they will likely be available for harvest the following season.

Further, because we know that hunting-related mortality is the primary factor driving survival in the area, we suggest that age-specific survival for males is a function of antler

restrictions in place within the Co-op. Harvest records within the Co-op indicate main beam length (MBL) and inside spread (IS) for 2.5 yr-old males ($n=1491$; 1997-2007) average 34.5 and 29.7 cm, respectively. For 3.5 yr-old males ($n=1236$; 1997-2007), the same measurements averaged 38.4 and 33.0 cm. Thus, with Co-op antler restrictions set at 38.1 and 33.0 cm for the same two measurements, the average 2.5 yr-old male falls slightly short of the restrictions and the average 3.5 yr-old males harvested within the Co-op just barely meet the minimum requirements.

According to the average antler characteristics of male deer found within the Co-op, 1.5 yr-old males and average 2.5 yr-old males should be protected from harvest. Interestingly, however, males in these age classes, which should be protected from harvest based on Co-op antler restrictions, made up 60% of the annual buck harvest, and males over 3.5 years of age, which generally exceed the restriction, made up only 35% of the annual buck harvest. Although this study did not explicitly test age-specific survival, we suggest that survival of males on our study site may also be a function of the antler-restrictions in place, with survival decreasing as bucks approach the antler restriction, regardless of age.

Mortality rates from causes other than hunting in this study were comparable to previous studies (7-15%; DeYoung 1989, Heffelfinger et al. 1990, Ditchkoff et al. 2001, Webb et al. 2007, Bowman et al. 2007). Ditchkoff et al. (2001) suggested that mature males were more likely to succumb to natural mortality factors than their younger counterparts. Our findings support this, as no mortalities were documented for 1.5 yr-old males, whereas 3 natural mortalities occurred in older males.

Outside of mortalities caused by natural factors, DVC's can be a significant source of mortality in some regions (Miller et al. 2003), with incidents usually peaking at the height of

breeding season (Allen and McCullough 1976). Both DVC's in this study occurred during fall with and involved males of 2.5 and 5.5 years of age. Although only 4 roads (3 2-lane paved roads, one Interstate) passed through the study area, vehicular-related mortalities resulted in a probability of males dying from DVCs equal to that of natural mortalities. Thus, it appears that DVC's may be an important source of mortality for mature males on the study area.

CHAPTER 4. CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Our results indicate that white-tailed deer on our study site maintain much smaller home ranges than herds in other areas of the southeast. These small home ranges have implications for private landowners who own or manage acreages less than or equal to 200 ha of intensively managed bottomland hardwood forests in Louisiana. Our results suggest that small landowners may be able to practice QDM at scales previously thought to be ineffective at improving herd dynamics. Furthermore, cooperatives can be a useful tool to increase the acreage influenced by management activities. Although large landholdings are often seen within cooperatives, the small ranges highlighted in this study suggest that a cooperative effort incorporating a network of smaller landholdings (<300 ha) can have similar effectiveness in improving herd dynamics in similar habitats.

Conversely, home ranges for mature males in south Texas frequently exceed the average acreage (78% of Texas farms/ranches, <202 ha; Wilkins et al. 2003) of most private landholders (Hellickson et al. 2008). In our study, the average cooperator ($n=28$) acreage within the Choctaw Quality Deer Management Cooperative (2006-2007: 16,150 ha) was 577 ha. Moreover, average bottomland hardwood acreages owned by cooperators registered with the Louisiana Department of Wildlife and Fisheries Deer Management Assistance Program (DMAP; $n=223$) and Landowner Antlerless Deer Tag (LADT; $n=173$) Program in 2007-2008 were 868 ha and 444 ha, respectively (Personal communication., Scott Durham, Louisiana Department of Wildlife and Fisheries). The average home range size of adult males and females we observed was well within the average acreages described for the most cooperators in the Choctaw Co-op or DMAP/LADT programs.

From a QDM standpoint, low natural mortality found in this study for 1.5 yr-old males indicates young males are likely to be recruited into older age classes if protected from harvest (Bowman et al. 2007). Although 1.5 yr-old males comprise nearly 20% of the average annual male harvest, most are moving to the 2.5 yr-old age class. This progression from 1.5 to 2.5 yrs-old can be deemed a QDM success, but participants within the same group often have differing management objectives and goals. In the case of the Choctaw Co-op, antler restrictions in place should protect the average 1.5 and 2.5 yr-old males, but these 2 classes are responsible for over half of the average annual male harvest. When considering the management objectives for the Choctaw Co-op, too many young males are being harvested if managers desire to increase the frequency of males ≥ 3.5 yrs-old in the average annual male harvest.

Survival of adult males found in this study was in the range of that reported in similar studies, however, our findings suggest that the cumulative probability of an adult male ultimately living to and beyond 4.5+ yrs old is very low. If objectives include increasing the frequency of harvesting mature males, then increasing hunting season survival of adult males is imperative. In that vein, increasing education and commitment within participating clubs could alleviate the current harvest pressure on males not meeting antler restrictions. Thus, reducing harvest of males ≤ 2.5 -yrs old (currently 60% of average annual male harvest) could significantly increase overall survival for adult males, making it more probable that males could survive to the next age class.

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VITA

Justin W. Thayer was born in New Orleans, Louisiana, in 1984. He was raised in Slidell, Louisiana, but spent most of his younger days fishing the bayous, chasing deer in Monticello, Mississippi, or hunting ducks in Pointe a la Hache, Louisiana. Justin later graduated from Slidell High School with an interest in the medical field. In 2002, Justin was accepted into Louisiana State University and began his undergraduate career as a pre-medicine major. During his first semester at Louisiana State University, Justin found out that wildlife was a legitimate course of study and changed majors shortly thereafter. In 2006, Justin graduated from Louisiana State University with a Bachelor of Science in wildlife and fisheries with a concentration in wetland science. Following his undergraduate graduation, Justin was accepted back into Louisiana State University and began working with white-tailed deer in West Baton Rouge and Iberville Parishes. Justin is currently a candidate for a Master of Science in wildlife.