POPULATION CHARACTERISTICS OF A WHITE-TAILED DEER HERD IN AN INDUSTRIAL PINE FOREST OF NORTH-CENTRAL LOUISIANA

A Thesis

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ABSTRACT

White-tailed deer are the most important game species in Louisiana, and throughout the southeastern United States. Likewise, the forest products industry represents the most important agricultural commodity in Louisiana, and industrial landowners frequently lease their properties to sportsmen specifically for white-tailed deer hunting. I conducted research assessing survival, space use, and habitat selection of white-tailed deer on a 3885 ha industrial forest owned by Plum Creek Timber Company. I captured 61 deer in Union Parish, Louisiana in 2009-2010, radio-marked 24 females and 23 males, and ear-tagged 7 females and 6 males. Season and sex interacted to affect home range and core area sizes. Males home range sizes varied seasonally and were 232 ha, 70 ha, and 129 ha for spring, summer and fall respectively. Female home range sizes did not differ seasonally and were 104 ha, 90 ha, and 62 ha for spring, summer, and fall respectively. Forest openings were important to both sexes when establishing home ranges. Core area selection exhibited a season and sex interaction as both sexes shifted selection in the fall to 0-4 year old pine and 13-19 year old pine stands. Use of habitats within home ranges did not vary by sex, season, or an interaction between them. Males and females chose 5-12 year old pine stands consistently across all seasons. Survival differed by season, but not by sex. Survival rates for adult males in spring, summer, and fall were 0.95, 0.97, and 0.54 respectively. Survival rates for females were 0.95, 0.97, and 0.56 for spring, summer, and fall respectively. All fall mortality was hunting-related, whereas mortalities during unknown spring and summer resulted from unknown causes. The extensive use of bait, primarily corn and rice bran, was thought to influence space use and survival, and further research is needed to determine effects of baiting on susceptibility of harvest of different age classes and sexes.

Introduction

White-tailed deer are the most sought after big game species in the southeastern United States. Market hunting in the early 1900s reduced deer densities throughout the South, but restocking efforts allowed populations to dramatically rebound. Nationally, big game hunters numbered 10.7 million in 2006 and spent $11.8 billion on their expeditions (U.S. Fish and Wildlife Service 2006). In Louisiana, $286,233,000 was spent by 204,000 big game hunters representing 195,200 harvested deer (U.S. Fish and Wildlife Service 2006) in 2006. More recently, deer harvest in Louisiana has declined 17% with only 147,300 animals being harvested in the 2009-2010 season (personal communication, Scott Durham, Louisiana Department of Wildlife and Fisheries).

Forestry represents Louisiana's top cash crop and a $3.1 billion dollar industry in 2010 (Louisiana Forestry Association 2011). Much of the forest industry of the southeast and Louisiana is industrial pine forest being propagated in loblolly pine (*Pinus taeda*). Plantations are often intensively managed even-aged stands with short stand rotation lengths (Gresham 2002). Chemical site treatments of fertilizer and herbicides are often used to maximize stand productivity and timber value. However, repeated herbicide applications can lead to floristic diversity being suppressed up to 15 years when both woody and herbaceous plants are controlled for a 3-5 year establishment period (Miller et al. 2003).

Many timber companies, such as Plum Creek Timber Company, lease out expansive tracts of property to recreational clubs for hunting purposes. Leasers in conjunction with state and private wildlife biologist are often allowed to manage wildlife populations to a varying degree. Many clubs enroll in a Deer Management Assistance Program (DMAP) which allows for additional harvest of females and provides assistance from a state biologist to reach management goals. As the idea of Quality Deer Management (QDM) continues to gain popularity so does the increase in lease prices and expectations for harvesting mature deer.

Ecology of white-tailed deer has been studied throughout its geographic range. In northern latitudes deer are considered migratory, experience severe winter weather and face predation from large carnivores (Verne 1973, Zagata and Haugen 1974). In southern ranges deer are more sedentary, experience less severe winter weather and fewer if any larger predators (Marchinton and Jeter 1966, Byford 1969). These factors influence space use, habitat selection and annual survival.

Estimates of space use vary widely throughout the southeast (42 - 3614 ha; Lewis 1968, Mott 1981, Herriman 1983, Morrison 1985, Hellickson et al. 2008, Karns 2008, Thayer 2009). These studies have occurred in many habitat types, but in Louisiana and adjacent states with similar habitats (e.g. Mississippi), work has been confined to bottomlands. Bottomlands are considered high quality habitat for deer (Stransky 1969), but the distribution of these forests is limited and industrial forests comprise a large percentage of available habitat for deer. Deer inhabit many kinds of habitats including mesquite dominated forest in central Texas (Brunjes et al. 2006), tamarack swamps in south-central Wisconsin (Larson et al. 1978), various coniferous forests in northern Idaho (Pauley et al. 1993), and cedar swamps in Minnesota (Rongstad and Tester 1969) but there is a lack of information detailing habitat selection within industrial forests

Many recent studies reporting survival rates have been conducted on areas where harvest management is focused on producing mature males (Ditchkoff, et al. 2001, Bowman et al. 2007, Thayer et al. 2009). Yearling males are normally protected under this regime using antler restrictions whereas hunters are asked to focus efforts on harvesting adult females.

Predation (DeYoung 1989, Nelson and Mech 1986), vehicle collisions (Miller et al. 2003, Thayer 2009), disease (Miller et al. 2003), male aggression (Thomas et al. 1965) and hunting (Fuller 1990, Nelson and Mech 1986) are sources of mortality of white-tailed deer across their range. Variability in survival rates reported in the southeast (44%-91%; DeYoung 1989, Ditchkoff et al. 2001, Bowman et al. 2007, Thayer et al. 2009) are dependent upon sex, age, season and density (Gavin et al. 1984, Whitlaw et al. 1998, DelGiudice et al. 2002).

An earlier study in bottomland forests of south-central Louisiana (Thayer et al. 2009) indicated that estimates of space use were among the least reported in the deer literature. Likewise, survival rates of males were approximately 50% annually, despite antler restrictions designed to increase survival of males. The Louisiana Department of Wildlife and Fisheries (LDWF) recognized the immense variability in habitats across physiographic regions of Louisiana, and the relevance of collecting science-based information to improve management of deer throughout the state. Specifically, industrial pine forests comprise substantial portions of north-central and southeast Louisiana, and the highest annual deer harvest occurs in Union Parish, which is dominated by upland pine forests managed for wood fiber production. Therefore, my research was initiated to collect baseline information on ecological characteristics of deer populations in an industrial forest. Specifically, my objectives were to evaluate space use, habitat usage and survival of adult male and female white-tailed deer within an industrial pine forest in north-central Louisiana.

Study Area

This project was conducted on 3885 ha of upland pine forest owned by Plum Creek Timber Company in Union Parish, Louisiana, USA (Figure 1). The area was composed primarily of loblolly pine plantations harvested on an approximately 25 year rotation. First thinning of plantations occurred between ages 13-15 with a second thinning between 17-20 years. Fertilization through aerial application commonly occurred after each thinning. Most stands were 24-29 ha in size and average size of stands did not exceed 49 ha. Site preparation included rowing site debris into raised beds before planting and an herbicide application to reduce competition from woody plants.

Figure 1. . Location of study site chosen to investigate space use, survival and habitat selection of white-tailed deer in industrial pine plantations in Union Parish, Louisiana, USA, 2009-2011.

Dominant overstory species consisted of loblolly pine, bald cypress (*Taxodium distichum*), white oak (*Quercus alba*), willow oak (*Quercus phellos*), water oak (*Q. nigra*), sweetgum (*Liquidambar styraciflua*) and black gum (*Nyssa sylvatica*). Midstory species consisted of red maple (*Acer rubrum*), hickory (*Carya* spp.), American holly (*Illex opaca*), sweetgum, and oaks (*Quercus* spp.). Common understory species included beggars lice (*Desmodium* sp), switchgrass (*Panicum* sp.), goldenrod (*Solidago* spp.), blackberry (*Rubus* spp.), rattan vine (*Berchemia scandens*), greenbrier (*Smilax* spp.) Japanese honey-suckle (*Lonicera* *japonica*), muscadine (*Vitis* spp.), French mulberry (*Callicarpa americana*), Carolina buckthorn (*Rhamnus caroliniana*), blueberry (*Vaccinium* spp.), and Virginia creeper (*Parthenocissus quinquefolia*). Forest openings (e.g. gas pipelines, gas well sites, recent logging decks, forest roads) were usually planted as food plots consisting of ryegrass (Lolium spp.), clover (*Trifolium* spp.) or wheat (*Triticum* spp.).

The area was accessible through improved and unimproved roads including state highway 143 which bordered the eastern edge of the site. Bayou DeLoutre comprised the western boundary and Ford Road served as the northern boundary, whereas Phillips Ferry Road was the southern boundary. Buffalo Hole Road traversed the site as well as 5 other secondary roads. Traffic on all roads was light and localized.

The study area was leased by 2 individual clubs (Buffalo Hole and Ten Mile Creek). These clubs leased approximately 1536 ha and 2347 ha respectively with 97 members total. Harvest guidelines were similar in each club; members were allowed to harvest 3 antlerless and 3 antlered deer corresponding with state regulations. Buffalo Hole was a member of the Louisiana Deer Management Assistance Program (DMAP) since 1981, whereas Ten Mile Creek chose to only keep club harvest records. Average annual deer harvest over the last 10 years for the study site was 95 females and 106 males. Union Parish reported the highest total harvest for the state on private lands in 2009 with 6668 animals harvested (Louisiana Department of Wildlife and Fisheries, unpublished data).

Herd health data collected from hunter harvested adult females in 2009-2011 indicated a fetus/doe ratio of 1.2, average weight of 110lbs and a kidney fat index of 71.9%. Browse surveys conducted in June 2010 indicated low browse pressure on most desirable stems (black gum, rattan vine, Smilax spp.) and an overall low browsing index (Louisiana Department of

Wildlife and Fisheries, unpublished data). A week long camera survey performed in early fall 2007 consisting of 24 camera sites indicated a deer density of 1 deer per 7 ha with a buck:doe ratio of 0.96 (Louisiana Department of Wildlife and Fisheries, unpublished data).

Methods

Deer were captured using drop nets during the winter/spring (January-March) and summer (July-September) in 2009-2010 at permanent bait sites (*n*=14) using whole kernel corn and rice bran. Trapping sites were constructed in previously used logging decks and planted with rye grass during fall. Sites were distributed throughout the study site in multiple age class forest stands, along pipe lines, and were separated by at least 0.4 miles.

Captured deer were chemically immobilized using an intramuscular injection 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). Vital signs including heart rate, rectal temperature and respiratory rate were monitored on immobilized deer every 5-10 minutes from capture until release. After processing was complete, deer were injected intravenously with Tolazoline (100 mg/ml, Tolazine®; Lloyd Laboratories, Shenandoah, Iowa, USA) at 3.0 mg/kg and released at the capture site.

While deer where immobilized, all were marked in both ears with numbered Monel ear-tags (National Brand and Tag Company; Newport, Kentucky) and sex, weight, estimated age, and antler characteristics were recorded. Age was estimated from tooth replacement and wear techniques (Severinghaus 1949) and deer were categorized as fawns, 1.5 or ≥2.5 years of age. Expandable VHF radio-collars (Mod M4230B; Advanced Telemetry Systems, Isanti, Minnesota) were placed on yearling 1.5 yr old deer in an attempt to allow for growth of the animal. We placed 400-gram VHF radio-collars (Mod M2510B; Advanced Telemetry Systems, Isanti, Minnesota) which constituted <1% of body weight on adult deer. All radio-collars were equipped with an 8-hour time-delayed motion sensor to detect mortalities.

Immobilization of captured deer occurred within 2-5 minutes of capture with a total duration time of 120 minutes. Stress was reduced with rapid immobilization, use of eye ointment and blindfolds, and sternal or right side placement of the animal. The primary researchers attended a Safe Capture class in Baton Rouge, Louisiana to ensure proper chemical immobilizations of deer (Amass and Drew 2006). Capture and handling procedures occurred under Louisiana State University Agricultural Center Institutional Animal Care and Use Protocol (AE2009-18).

Locations of radio-marked deer were calculated using triangulation (Cochran and Lord 1963) from 3-5 fixed telemetry stations (*n*= 138) with an ATS R2000 receiver (Advanced Telemetry Systems Inc., Isanti, Minnesota) and a hand-held 3 element Yagi antenna. Locations were obtained 1-5 times per week using 3 bearings taken within a 20 minute interval to minimize error associated with deer movement. Telemetry error was calculated with >50 bearings per observer, per season on dummy radio collars that were placed at neck height of deer. Locations of radios were withheld from observers to simulate actual telemetry. The average angle of error was ±7.1°

If a mortality signal from the radio-collar was detected, homing was used to locate the radio-collar or perished animal. When the animal or radio-collar was located a hand-held GPS unit was used to record the coordinates. If the animal had perished every attempt was made to determine cause of death. Hunters were asked to view radio-collared animals just like all other animals in an attempt to limit bias and to report harvest of all radio-collared and ear-tagged animals. When radio-collared animals were observed visually during telemetry or by chance, exact locations were recorded.

Monitoring periods of telemetry were divided into 3 seasons: spring (February 1-May 30) summer (June 1 – September 30) and fall (October 1 – January 31). Seasons were determined based on biological cues of deer (fawning, breeding) and the hunting season in the study area (October 1 – January 31).

Seasonal Space Use

Telemetry bearings were input into Location of a Signal (LOAS, Version 4.0 Ecological Software Solutions 1999) and the maximum likelihood estimator method was used to estimate Universal Transverse Mercator (UTM) coordinates and error eclipse areas. Locations on individual deer were separated by a minimum of 8 hrs to provide some measure of independence and only locations with an error eclipse areas <1 ha were used in analyses. Only animals with ≥18 locations per season were included in the home range analysis based on observation curves constructed on 16 animals (8 M, 8F). Locations were then imported into ArcMap 9.2 (ESRI, Redlands, California) where they were converted to point themes. Using the Home Range Tool application, estimates of home range (95%) and core area (50%) were calculated using an adaptive-kernel analysis (Worton 1989) in conjunction with the likelihood cross-validation method (Silverman 1986).

A factorial analysis of variance (ANOVA) using Proc Mixed was used to test for season by sex interactions in home range and core area sizes with SAS V9.2 (SAS Institute, Inc. 1996). A one-way ANOVA was used to test for effects of year on home range and core areas. Additionally, LSMeans was used to test for effects of season and sex on home range and core area size when no significant difference occurred in the factorial analysis. All age classes were collapsed for analysis because of 1) relatively low sample sizes within older age classes of males and 2) a skewed age ratio in females towards older individuals. Statistical differences were considered significant at $P < 0.05$.

<u>Habitat Selection</u>

Plum Creek provided land cover maps containing stand size, age, species planted and habitat type (commercial pines, gas lines, gas wells, bottomland hardwoods, roads etc) for the study area. Commercial pine stands were further separated based on age, stand structure and commercial management activities (thinning, herbicide application, harvest). Habitats were classified as 0-4 year old pine, 5-12 year old pine, 13-19 year old pine, ≥20 year old pine, hardwoods, and forest openings (roads, pipelines, natural gas well sites, forest paths). Habitats classified as 0-4 year old pine included stands recently harvested, newly planted, and whose overstory was still open. The 5-12 year old pine stands included those ranging from closed canopy stands to the age of average first thinning. Pine stands old enough to receive a first and second thinning were classified 13-19 year old pine. The ≥ 20 year old pine included the most mature pine stands on the study area, which were eligible for harvest under normal harvest conditions.

Home ranges, core areas, and point themes were intersected with land cover maps using ArcView to quantify seasonal use of habitats. Compositional analysis was used to determine habitat selection at 3 scales: home ranges vs. habitats available in the study area (1^{st} order), core area vs. habitats available in the home range (2^{nd} order; Aebischer et al. 1993), and locations vs. habitats available in the home range (3^{rd} order; Chamberlain and Leopold 2000). When a habitat was not available at a given scale the value of 0.7 was inserted to minimize Type I error (Bingham and Brennan 2004). Differences of log-ratios of habitat use and availability percentages were examined using a multivariate analysis of variance (MANOVA) with sex, season, and sex and season interaction as the main effects (Aebischer et al 1993). When significant differences between habitat availability and selection were found, a ranking matrix of t-tests were constructed to determine order of habitat selection.

Survival

Program MARK was used to model survival rates of adult radio-collared deer seasonally using a known fate model. Encounter histories for all adults were constructed for the 24 month period between February 2009 and January 2011. Deer that were monitored during both years of the study were considered 2 separate samples in the analysis.

I applied 5 candidate models to determine effects of season, sex, and their interaction on survival rates. Models included:

1. S (.) – Survival is constant across seasons and sex
2. S (t) – Survival is not constant across seasons
3. S (g) – Survival is not constant by sex
4. S (t*g) – Survival is not constant across seasons by sex
5. S (t+g) – Survival is not constant across seasons and sex

Akaike's information criterion (AIC_c), change in AIC_c, Δ AIC_c values, and Akaike weights (AIC_w) were used to determine which candidate model was the best fit (Anderson et al 2000). Age was not included as an effect in the models because most males in the dataset were in younger age classes, whereas most females were in older age classes. Because of small sample sizes of ear-tagged, these individuals (fawns) were not included in the program MARK analysis. Rather, the proportion of these individuals recovered and/or assumed to be alive at the end of the are reported, and should be viewed as a maximum number due to lack of monitoring capabilities except for hunter reported harvests.

Results

Seasonal Space Use

A total of 61 deer (29 M, 32 F) were captured with 47 (23 M, 24 F) receiving radio-collars and 13 juveniles (6 M, 7 F) receiving only ear-tags. Locations of radio-collared animals resulted in 146 seasonal home ranges (69 M, 77 F). Home range ($F_{1/138}$ = 0.37, P= 0.545) and core area ($F_{1/138}$=0.66, P=0.418) sizes did not differ by years, therefore data were pooled to examine potential differences by season and sex. Season and sex interacted to influence home range ($F_{2/139}$ = 7.03, P= 0.001) and core area ($F_{2/139}$ = 8.55, $P \leq$ 0.001; Table 1) sizes.

Home range ($F_{2/73}$=8.57, $P \leq 0.001$) and core area ($F_{2/65}$=10.25, $P \leq 0.001$) size varied seasonally for males. Males maintained 230% and 80% larger home ranges in spring than in summer (t_{139}=-2.98, $P \leq 0.003$) and fall (t_{139}=5.10, $P<0.001$), respectively. Core area size during fall was greater than during summer (366%; t_{139}=5.65, $P<0.001$) and spring (113%; t_{139}=-3.53, $P<0.001$). Fall home range (83%; t_{139}=2.41, $P \leq 0.017$) and core area (67%; t_{139}=2.40, $P<0.018$) size in males was also larger than in summer. Female home range ($F_{2/73}$=1.26, P=0.2891) and core area ($F_{2/73}$=0.89, P=0.4153) sizes did not differ across seasons.

Table 1. Mean seasonal home range (HR) and core area (CA) size (ha) with associated standard errors (SE) of adult radio-marked white-tailed deer in Union Parish, Louisiana USA, 2009-2011.

Season	Sex	HR ± SE	CA ± SE
Spring	M	231.8 ± 145.8	39.2 ± 25.2
	F	104 ± 76.4	15.9 ± 15.1
Summer	M	70.2 ± 55.6	8.4 ± 6.6
	F	89.7 ± 84.9	13.6 ± 13.8
Fall	M	128.7 ± 147.3	18.4 ± 27.2

	F	62.2 ± 69.5	9.6 ± 9.8
Yearly	M	169.8 ± 76.6	14.9 ± 14.5
	F	111.8 ± 119.7	13.4 ± 13

Habitat Selection

All 123 home ranges and core areas were used to assess seasonal habitat selection in males and females. Habitats selected when establishing a home range relative to habitats available in the study area varied by sex ($F_{5/115}$=8.99, $P\leq 0.001$; Table 2) but not season ($F_{10/226}$=0.98, P=0.464) and season and sex did not interact to influence habitat selection ($F_{10/222}$=0.82, P=0.609). Forest openings were selected by both sexes when establishing home ranges, whereas 13-19 year old pine stands were least important to deer at this scale. Sex and season interacted ($F_{10/222}$=2.51, P=0.007) to influence the composition of core areas in relation to habitats available within home ranges. Males selected hardwoods in the summer, and females selected 13-19 year old pine stands. Both males and females shifted selection in the fall to 0-4 year old pine and 13-19 year old pine stands. Use of habitats within home ranges did not vary by sex ($F_{5/111}$=0.38, P=0.859), season ($F_{10/222}$=0.35, P=0.965) or their interaction ($F_{10/222}$=0.61, P=0.802). Both males and females consistently used 5-12 year old pine habitat across all seasons. Habitat composition of the study area consisted of 8.6% 0-4 year old pine (334 ha), 41.6% 5-12 year old pine (1616 ha), 2.3% 13-19 year old pine (89 ha), 24% ≥20 year old pine (932 ha), 17.8% hardwoods (692 ha), and 5.1% openings (198 ha).