THE DIFFERENCES BETWEEN WHITE-TAILED AND MULE DEER FAWNING HABITAT, AND THE EFFECTIVENESS OF THERMAL IMAGERY FOR CAPTURING DEER FAWNS

by

DAVID ALEXANDER BUTLER, B.S.

A THESIS

IN

WILDLIFE SCIENCE

Submitted to the Graduate Faculty
of Texas Tech University in
Partial Fulfillment of
the Requirements for
the Degree of

MASTER OF SCIENCE

Approved

Warren B. Ballard
Chairperson of the Committee

Mark C. Wallace

Carlton M. Britton

Accepted

John Borrelli
Dean of the Graduate School

December, 2006

ACKNOWLEDGMENTS

I would like to thank the faculty and staff of Texas Tech University for providing the opportunity to pursue higher education. I am grateful to those within the Department of Range, Wildlife, and Fisheries Management where I have made my academic home for the last 8 years. The professors and staff of the department truly make a student feel welcome and important, which makes for an incredible learning experience; thank you.

I would like to extend my greatest appreciation to my research advisors Drs. Warren Ballard and Mark Wallace for their insight, guidance, and patience. Thank you, guys for taking me under your wing and providing me with opportunities throughout my undergraduate and graduate careers at Texas Tech. I would also like to thank Dr. Carlton Britton for serving on my committee. I also thank Shawn Haskell, Richard Phillips, Matthew Butler and any other graduate student who provided stimulating conversation and debate concerning my research.

This project could not have happened without the hard work and cooperation of many people. First I would like to thank Mary Humphrey of Texas Parks and Wildlife Department for help with funding and use of equipment. I also owe a debt of gratitude to everyone involved in field work. Alicia Haskell, Andrew Sanders, Doug Larson, and Janet Reed labored long and hard in the West Texas heat to collect the data needed for this project. Additionally, I would like to thank the landowners and land managers who gave us access to their property, without their support the project would not have flown.

Last but most important, I would like to thank my mom and dad, Betty and Mickey Butler, for emotional and sometimes financial support which allowed me to pursue my dreams. Additionally I would like to thank my brother and sister-in-law, Jonathan and Kristal Butler for emotional support. Love, you guys.

TABLE OF CONTENTS

ABSTRACT

There are 2 species in the genus *Odocoileus* found in North America. White-tailed deer (*O. virginianus*) are distributed across much of North America, while mule deer (*O. hemionus*) are restricted to the western third. The two species do occur sympatrically in 12 states including Texas. Previous research in Crockett County, Texas revealed that adults of each species partition habitat based on percent shrub cover, slope, elevation, and vegetation type, and that adults of both species have high survival rates.

We focused on differences between mule deer and white-tailed deer fawn parturition dates, parturition sites, bed sites, and how bed site characteristics may affect survival. In order to increase our fawn sample we attempted to use thermal infrared imagery to detect and capture fawns. We discuss the limitations of thermal imagery on our study area.

We used univariate tests (i.e., Mann-Whitney U test and chi square goodness of fit test) to identify whether differences in birth site characteristics and parturition timing between mule deer and white-tailed deer were measurably different. We compared 7 models from parameters chosen *a priori* using AIC_C parameters estimates, SEs, and p-values to differentiate between fawn bed sites used by mule deer and white-tailed deer. We found a 33 day difference in median parturition date with white-tailed deer birthing before mule deer. Birth sites differed between species with white-tailed deer birthing at lower elevations on less steep slopes. White-tails also birthed in vegetation types associated with more mesquite and less juniper, while mule deer used more juniper

vegetation types. Our best model based on AIC_C values ($w_i = 0.7061$) contained 5 parameters: elevation, height of horizontal hiding cover, vegetation type, canopy plant species, and an interaction between canopy plant species and vegetation type to describe the differences between mule deer and white-tailed deer fawn bed sites. Additionally, we found that white-tailed deer fawns bedded farther from shrubs and on steeper slopes had better survival. There were no differences in bed site characteristics for mule deer fawns that survived or died.

We used thermal infrared imagery with little success in an attempt to capture a greater number of fawns. After 59.5 person hours of mobile searching, we observed only one fawn, and captured none. We logged 24 hours of stationary observation and observed no fawns. The lack of a forest canopy may allow vegetation, mineral, and rock to heat excessively during the afternoon causing numerous "nonfawn hot spots" making detection of neonates difficult. Furthermore, the herbaceous vegetation on our site may have prevented the unit from detecting fawns. We recommend biologists assess on site characteristics and alternative uses for thermal imagery before purchasing this expensive equipment.

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Two species in the genus *Odocoileus* are found in North America. The white-tailed deer (*O. virginianus*) is the oldest extant deer species with an evolutionary history dating back to the Pleistocene era (Cronin 1992, Geist 1998); while mule deer (*O. hemionus*) have a much shorter evolutionary history of only 12,500 to 7,000 years (Geist and Francis 1990, and Geist 1998). It is thought that mule deer evolved from black-tailed bucks and white-tailed dams (Geist 1998, Heffelfinger 2000). White-tailed deer are distributed across much of North America, while mule deer are restricted to the western third. The two species do occur sympatrically in 12 states including Texas (Brunjes 2004). Generally the species are quite similar; therefore biologists need a clear understanding of the mechanism allowing coexistence in order to properly manage both species.

In Texas the two species are sympatric in two areas, a northern one and a southern one. The Rolling Plains and High Plains ecoregions of the Texas panhandle make up the northern area, which may have historically had Rocky Mountain mule deer (*O. h. hemionus*; Cowan 1956, Wallmo 1981). The Trans Pecos ecoregion and the western edge of the Edward's Plateau ecoregion have desert mule deer (*O. h. crooki*) and define the southern area (Wallmo 1981). Crockett County, Texas lies just east of the Pecos River in the transitional ecotone between the arid deserts of the Trans Pecos and the more mesic environment of the Edward's Plateau in the southern area of sympatry. Texas

Parks and Wildlife Department (TPWD) and Texas Tech University (TTU) have conducted prior research on this site to determine important habitat parameters for each species.

In 1998 TTU began phase one of research by focusing on habitat parameters that adults of each species used for feeding, moving, and bedding behaviors. Five parameters were examined: slope, elevation, aspect, density of woody cover, and composition of woody cover (Avey et al. 2003). Avey et al. (2003) found that percent slope and presence of shrubs explained the most variation in sites use by deer when all behaviors are pooled. Avey (2001) used Thermatic Mapper satellite imagery to delineate white-tailed deer habitat from mule deer habitat, but concluded that imagery with a higher resolution would be better suited for habitat delineation.

Phase two research began in 2000. Phase two employed radio telemetry to determine cause-specific mortality for adults and to investigate landscape use differences by species and gender. Brunjes (2004) found that deer exhibit both gender and species specific preferences when selecting habitat. Mule deer typically used rougher areas with greater topographic relief and overall less vegetative cover. White-tailed deer avoided higher elevations and preferred greater vegetative cover. Males avoided areas with greater vegetative cover, while females used them often, especially during the fawning season. Brunjes (2004) also found high adult survival for both species and genders. Phase two research ended amidst a severe drought with high adult survival and low recruitment which lead to a shift in research.

Phase three of the research focuses on fawning habitat and fawn movement and survival. We began in spring 2004 and continued through 2006. The research presented in this thesis was collected during the fawning seasons of 2004 and 2005. The study was designed to describe and evaluate the differences in habitat used for fawn bed sites and adult parturition sites. We also examined parturition timing between the two deer species, and examined differences in bed site parameters for fawns that died ≤ 21 days postpartum compared to those that survived. Chapters II and III are intended for publication in a scientific journal, and are formatted for the appropriate journal; chapter IV provides a brief conclusion and overview of my studies.

Chapter II details differences in parturition timing, describes and compares habitat used by adults as birth sites, describes and compares habitat used by fawns, and lastly evaluates bed site quality as it relates to fawn survival. The chapter is intended to be submitted to the *Southwest Naturalist* as a peer-reviewed original article. The authors for the manuscript are David A. Butler, Shawn P. Haskell, Warren B. Ballard, Mark C. Wallace, Carlton M. Britton, and Mary H. Humphrey.

Lastly, Chapter III explains limitations, some of which were caused by vegetation, of thermal infrared technology to find neonates in the southwestern landscape. The manuscript has been submitted and accepted in *The Wildlife Society Bulletin*. The authors on the manuscript are David A. Butler, Warren B. Ballard, Shawn P. Haskell, and Mark C. Wallace.

Literature Cited

Avey, J. T. 2001. Habitat relationships between a sympatric mule and white-tailed deer population in south-central Texas. Thesis, Texas Tech University, Lubbock, Texas, USA.

Avey, J. T., W. B. Ballard, M. C. Wallace, M. H. Humphrey, P. R. Krausman, F. Harwell, and E. B. Fish. 2003. Habitat relationships between sympatric mule deer and white-tailed deer in Texas. The Southwestern Naturalist 48: 644–563.

Brunjes, K. J. 2004. Ecology of sympatric mule deer and white-tailed deer in west central Texas. Dissertation, Texas Tech University, Lubbock, Texas, USA.

Cowan, I. McT. 1956. What and where are the mule and black-tailed deer? *in* W. P. Taylor, ed. The deer of North America. Stackpole, Harrisburg, Pennsylvania, USA.

Cronin, M. A. 1992. Intraspecific variation in mitochondrial DNA of North America cervids. Journal of Mammalogy 73: 70–82.

Geist, V. 1998. Deer of the World: Their Evolution, Behaviour and Ecology. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Geist, B. and M. Francis. 1990. Mule deer country. North Word Press, Minocqua, Wisconsin, USA.

Heffelfinger, J. R. 2000. Hybridization in large mammals. *in* S. Demarais and P. R. Krausman, eds. Ecology and Management of large mammals in North America. Prentice-Hall, Upper Saddle River, New Jersey, USA.

Wallmo, O. C. 1981. Mule and black-tailed deer distribution and habitats *in* O. C. Wallmo, ed. Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln, Nebraska, USA.

CHAPTER II

MICROHABITAT DIFFERENCES IN BIRTH AND FAWN BED SITES OF MULE AND WHITE-TAILED DEER

Abstract

Mule deer (*Odocoileus hemionus*) have been declining throughout the west and white-tailed deer (*O. virginianus*) have remained stable or increased. In areas where the two species overlap it is important to understand the dynamics between the two species. Crockett County, Texas provides an area where the two species occur sympatrically at relatively high densities. In the summers of 2004 and 2005 we captured adult deer and fitted them with radiocollars and vaginal implant transmitters (VIT). We monitored VITs to locate parturition sites and captured 101 neonates (68 mule deer and 33 white-tailed deer). We observed 45 parturition sites and 249 day-time fawn bed sites. We used Mann-Whitney U tests, chi square goodness of fit tests, and descriptive statistics to evaluate differences in parturition timing, habitat used as parturition sites, and to evaluate how bed site quality may affect survival. We employed corrected Akaike's information criteria (AIC_C) to select the best model to describe and differentiate between mule deer fawn and white-tailed deer fawn bed sites. White-tailed deer gave birth approximately 1 month before mule deer. Mule deer birth sites were at higher elevations and on steeper slopes than white-tailed deer birth sites. Mule deer gave birth under juniper more often than did white-tailed deer. Our best model used the variables: elevation, height of

horizontal hiding cover, vegetation type, and canopy shrub species, and an interaction between vegetation type and canopy species to differentiate between mule deer and white-tailed deer fawn bed sites. Mule deer fawns bed at higher elevations in shorter hiding cover and commonly under juniper (*Juniperus spp.*). White-tailed deer fawns commonly bed under honey mesquite (*Prosopis glandulosa*) or in herbaceous vegetation. Lastly we searched for microhabitat differences between fawns that died ≤ 18 days postpartum and those that did not. We found no differences for mule deer fawns. White-tailed fawns that died ≤ 18 days postpartum bedded closer to shrubs and on flatter slopes than those that survived, however these results may be an artifact of small sample sizes. Our data show that fawns of the two species partition habitat in a similar manner as do adults in this area.

Introduction

Mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*) are sympatric along a general north-south zone from Alberta, Canada through west Texas (Kramer 1973, Hanley and Hanley 1982, Stubblefield et al. 1986, Derr 1991) despite the fact that there are apparent differences in habitat preferences (Krausman and Ables 1981, Geist 1998). Mule deer have been in decline throughout most of the west (Denney 1976, Ballard et al. 2001), while white-tailed deer have remained stable or even increased in some places (Harwell and Gore 1981, Wiggers and Beasom 1986). Some biologists believe that predation is the primary cause for mule deer decline and there are studies that support the notion that predation is an additive source of mortality (Cook et al. 1971, Smith and LeCount 1979, Whitlaw et al. 1998, and Ballard et al. 1999), but as Ballard et al. (2001) pointed out the decline may be caused by a multitude of interacting factors, specifically the population's relationship to carrying capacity, which can vary from place to place.

Crockett County, Texas is on the ecotone between the arid Trans Pecos region of Texas and the more mesic Edward's Plateau; and has sympatric populations of mule deer and white-tailed deer. Landowners in the area have practiced extensive predator control to reduce predation on their livestock which is often goats, sheep, or cattle (Cook 1984). Crockett County provides a unique situation where white-tailed deer and mule deer occur sympatrically with relatively few predators. Previous studies in this area indicated that these species partitioned habitat based on topography and vegetation with adult mule deer using steeper slopes with less vegetative cover while white-tailed adults preferred flat areas with thicker cover (Avey 2001, Avey et al. 2003, Brunjes 2004).

Because deer may choose specific sites for parturition (Huegel et al. 1985, Schwede et al. 1993, Ciuti et al. 2005) we wanted to determine if fawns of each deer species continued to partition habitat during this time period as do adults. Consequently, we measured microhabitat parameters of fawn birth sites and day beds ≤ 21 days postpartum. We also sought to determine if perhaps temporal partitioning of the same habitats might be occurring, and examined characteristics of bed sites in relation to survival to determine if differences in characteristics affected fawn survival.

Study site

We monitored white-tailed deer and mule deer does and fawns on private ranches in west-central, Texas during the summers of 2004 and 2005. The four ranches comprised 26,066 ha of contiguous land in northwest Crockett County, Texas. Crockett County lies on the eastern edge of the Edward's Plateau as it descends into the Trans Pecos deserts. Precipitation varied greatly from year to year, but averaged 49 cm at the nearest (approximately 48 km away) National Oceanic Atmospheric Administration (NOAA) weather station in Big Lake, Texas (NOAA 2003). Elevations ranged from 730–880 m above sea level. Topography and vegetation varied across the site with the southern portions being flatter than the western and northern portions which contained steep sloped mesas with flat elevated tops.

The bottom lands consisted of three primary vegetation types. Intermittent creeks had a mixed shrub community accompanied by taller more abundant herbaceous growth. On xeric soils outside the intermittent creeks, a creosote (*Larrea tridentata*) and tarbush (*Flourensia cernua*) community existed with little herbaceous growth. Honey mesquite (*Prosopis glandulosa*) with varying amounts of herbaceous growth occurred on the mesic soil types of the bottomlands. The slopes and tops of mesas contained a juniper (*Juniperus pinchotii*) community with varying amounts of herbaceous growth. Lechugia (*Agave lechugia*), sotol (*Dasylirion texana*), and other yucca (*Yucca spp.*) occurred on the upper slope and rim-rock of mesas. Prickly pear (*Opuntia spp.*), tasajillo (*Opuntia leptocaulis*), and Cholla (*Opuntia imbricata*) cacti occurred across the study area, but were more abundant in the bottomlands.

Land use on the ranches was varied, but domestic livestock (i.e., cattle, horses, and sheep) and oil production were major sources of income (Avey 2001). Lease hunting was also a source of income. Most hunting focused on deer; and the supplemental feeding of corn during the fall and winter was common.

Methods

Adult Capture

We captured adult does in early April 2004 and 2005 using a net-gun fired from a helicopter (Krausman et al. 1985). Personnel from Holt Helicopter (Uvalde, TX USA 78801) captured 50 adult female deer (25 white-tailed deer and 25 mule deer) each year. Once netted, deer were tied, blindfolded, and transported via the helicopter to a temporary processing center. At the processing center, we performed a sonogram to confirm pregnancy with ultrasound equipment (Aloka SSD-500V, Aloka, Inc, Tokyo, Japan; Smith and Lindzey 1982). Pregnant does were then fitted with a VHF radiocollar (Telonics, Mesa, AZ; Advanced Telemetry Systems, Inc., Isanti, MN), and implanted with a vaginal implant transmitter (VIT; Advanced Telemetry Systems, Inc., Isanti, MN).

Birth Sites and Neonate Capture

After release we monitored deer using radiotelemetry from a truck mounted null–peak system. We triangulated deer with the system from fixed stations to acquire location data. We monitored VIT signals to collect data for parturition timing and parturition site location, and to aid in neonate capture.

Once a VIT was expelled, we used a hand-held yagi antenna to locate the site. We identified birth sites by the presence of a large bed site with small amounts of blood, placental fluids, or odor. Additional potential cues included feces that had been smashed during labor, insect activity in the area of where placental fluids might have been, and the presence of many doe hoof prints. We marked parturition sites with flagging tape and a waypoint was taken with a Global Positioning System unit (GPS; Garmin model 76, Garmin Ltd., George Town, Cayman Islands) for subsequent vegetation analysis. We began searching for neonates immediately after classifying a VIT site as a birth site.

Ground crews of 2–7 people searched for neonates by walking transects in between the doe's current location and the birth site. We usually located fawns in the general direction of the doe (Carstensen et al. 2003). We hand-captured fawns and fitted them with an expandable radiocollar (model M4200 series, Advanced Telemetry Systems, Inc., Isanti, MN). To obtain bed site location, we observed fawns about every other day for the first 3 weeks of life, or until they repeatedly flushed from their bed sites. Bed sites were marked in the same manner as parturition sites. We returned later to conduct vegetation analysis, so as not to disturb the resting fawn.

Vegetation Analysis

We returned to fawn birth and bed sites and recorded vegetation type, horizontal cover (i.e., hiding cover), canopy cover, shrub use, canopy shrub height and radius, shading potential, slope, aspect, and elevation. We used a 2-meter tall cover board with 20 cm stripes to assess horizontal hiding cover (Nudds 1977, Griffith and Youtie 1988). We recorded the lowest strip which was ≥ 50% hidden by vegetation in the four cardinal directions at distances of 5 m. Next, we recorded percent canopy cover by laying our head in the bed site and looking up through an ocular tube with a 5X5 grid. We classified any grid cell that contained ≥ 50% vegetation as covered. In order to investigate shrub selection, we measured the distance from the center of the bed site to the base of the nearest shrub, then the distance from that shrub to next nearest shrub that had a distinctly separate canopy. We used this approach because many shrubs in the area were "sprouters" (e.g., honey mesquite and red-berry juniper) with many stems coming from one root base. We recorded the height, radius, and species of canopy shrubs. Lastly, we recorded slope and aspect with a compass-clinometer (Ranger15, Silva, Sollentuna, Sweden) and elevation to the nearest meter with GPS.

We compared 7 models from parameters chosen *a priori* using AIC_C parameters estimates, SEs, and p-values (Burnham and Anderson 2002, Stephens et al. 2005) to differentiate between fawn bed sites used by mule deer and white-tailed deer. We evaluated the goodness of fit of the most parameterized model (Burnham and Anderson 2002) using the Hosmer-Lemeshow test (Hosmer and Lemeshow 2000). Additionally we evaluated differences in bed site parameters between fawns which survived and those that died. We used univariate tests (e.g., Mann-Whitney U test and chi square goodness of fit tests) to identify whether differences in birth site characteristics and parturition timing between mule deer and white-tailed deer were measurably different.

Results

Parturition Date

We determined the birthing date for 74 does (48 mule deer and 26 white-tailed deer) with the aid of VITs and systematic grid searching for neonates. The timing of parturition differed between species ($U = 125.00$, $P \leq 0.001$); white-tailed deer birthed earlier in the summer than mule deer (Figure 2.1). Our sample included young of the year white-tailed deer, which mature late in the fall and thus birth later in the summer.

This birth timing extended the white-tail fawning period creating considerable overlap with mule deer. We found that median dates indicated that peak fawning occurs about 1 month apart (Table 2.1).

<u>Birth Sites</u>

The retention rate of VITs in 2004 was low and allowed for the location of only 13 (8 mule deer and 5 white-tailed deer) birth sites. The fawning season of 2005 had higher VIT retention. We pooled our data for the two years yielding a higher sample (n = 45; 24 mule deer and 21 white-tailed deer). When we compared deer species we found four parameters that were different (Tables 2.2 and 2.3); here we report test statistics and mean ± one standard error (see Table 2.2 for median values). Mule deer used steeper (U = 129.00, P = 0.004) slopes ($\bar{x}$ = 6° ± 1.59) and higher (U = 109.50, $P \leq 0.001$) elevations ($\bar{x}$ = 808 m ± 9.21) for birthing than white-tailed deer ($\bar{x}$ = 2° ± 0.46 and $\bar{x}$ = 763 ± 2.56, respectively). Although slope and elevation are statistically different, biologically those two parameters may provide little information because the sample medians differ by only 2° and 35.5 m, respectively. More importantly, we found mule deer used more (χ^2 = 18.04, df = 3, $P \leq 0.001$) junipers than white-tails to birth under, while white-tailed deer used more mesquite and herbaceous vegetation than mule deer (Figure 2.2). The two species also used vegetative types differently (χ^2 = 21.77, df = 7, P = 0.003). Mule deer birthed in juniper mix and yucca mix more commonly than did white-tails which commonly used mesquite mix (Figure 2.3).

Fawn Bed Sites

We collected data from (n = 249; 121 mule deer and 128 white-tailed deer) fawn bed sites to evaluate differences in bed site characteristics for each species. We considered 7 models with different combinations of 6 variables (Table 2.4). Our most parameterized model had a good fit (χ^2 = 4.772, df = 8, P = 0.782). Our best model based on AIC_C values (w_i = 0.7061) contained 5 parameters: elevation, height of horizontal hiding cover, vegetative type, canopy plant species, and an interaction between canopy plant species and vegetation type. We then tested each of these parameters with a Mann-Whitney U test to see if the 2 species differed. Here I present test statistics and sample means ± one standard error. See Table 2.5 for median values.

Mule deer fawns used higher (U = 2727.0, $P \leq 0.001$) elevations ($\bar{x}$ = 810m ± 3.74SE) than white-tailed deer fawns ($\bar{x}$ = 766m ± 1.71SE). Mule deer fawns used bed sites with shorter (U = 5524.5, $P \leq 0.001$) hiding cover ($\bar{x}$ = 41cm ± 2.87SE) than white-tailed deer fawns ($\bar{x}$ = 58cm ± 3.12SE). We also found that canopy plant (χ^2 = 39.69, df = 4, $P \leq 0.001$) chosen to bed under and vegetation type (χ^2 = 65.88, df = 7, $P \leq 0.001$) differed between mule deer and white-tailed deer fawn bed sites. Mule deer fawns bedded under juniper shrubs more often, while white-tailed deer used mesquite (Figure 2.4). Mule deer fawns were more commonly found in the juniper mix and yucca mix vegetation types than were white-tails, while white-tailed deer used mesquite flats more commonly than did mule deer (Figure 2.5). The interaction term in our model suggested there was a difference in how mule deer fawns and white-tailed deer fawns used canopy plants in relationship to the vegetation type they were in (Figure 2.6). For example, in the tarbush mix vegetative community (Figure 2.6c) mule deer did not use juniper at all, whereas in the juniper mix mule deer use a juniper shrub for canopy ≈60% of the time (Figure 2.6a). Additionally, the interaction may be used to describe the differences between the two deer species in the same vegetative community. For example, in the mesquite mix mule deer used "other" category shrubs ≈50% of the time (Figure 2.6c), while white-tails in the mesquite mix used "other" shrubs only ≈15% of the time (Figure 2.6d).

Fawn Bed Site Quality

We examined each of the microhabitat parameters to determine if bed site characteristics differed between fawns who survived beyond or died before 18 days post parturition for both white-tailed deer and mule deer fawns (n= 128 and 121 bed sites, respectively). Thirty three of 107 fawns died ≤ 18 days postpartum. We found no statistical differences between mule deer fawns that survived or died. We used data from 118 bed sites from white-tailed deer survivors and 10 bed sites from those fawns that died ≤ 18 days post parturition. White-tailed deer fawns that died during the first 3 weeks of life used flatter (U = 306.00, P = 0.009) slopes and bedded closer (U = 363.50, P = 0.047) to shrubs, than those that survived (Table 2.6).

Discussion

Parturition Date

We observed a 33 day difference between median dates of each species' birthing period. We initially thought that if a temporal difference was identified then the two species would likely use the same habitat, but that was not the case. Two potential explanations for the different parturition timing are predation avoidance and resource availability. Mule deer range across our study site, but white-tailed deer primarily use lowlands (Avey 2001, Avey et al 2003, Brunjes 2004, personal observation) and therefore the difference in parturition date may benefit white-tails and some mule deer by eliminating interspecific competition in lowlands and riparian areas. During the "hider" phase fawns' movements are minimal (Jackson et al. 1972, Geist 1981, Ozoga et al. 1982) and as they age fawns rely less on hiding (Jackson et al. 1972, Hirth 1977, Marchinton and Hirth 1984). In areas with high predator densities the parturition timing difference might allow white-tailed deer fawns to become less reliant on bed sites as interspecific competition from mule deer begins. The mule deer species, as a whole, may benefit less from temporal segregation because those ranging on steep slopes and mesa tops encounter virtually no competition from white-tails.

Whittaker and Lindzey (1999) also noted a difference in parturition date between sympatric mule deer and white-tailed deer populations in Colorado, and concluded that mule deer, which birthed 8-10 days after white-tailed deer, may exhibit increased survival do to predator swamping. Mule deer probably did not benefit on our study site in a similar matter because of our low predation rate on neonates (i.e., 10% on our site versus 38% in Colorado).

Another feasible explanation involves the synchronization of parturition in relationship to the availability of resources. Millar (1977) indicated that females often give birth when the climate is favorable and forage is readily available because the energy costs for lactation are greater than those of gestation. Previous research on desert bighorn (*Ovis canadensis*; Rubin et al. 2000), Alpine musk deer (*Moschus sifanicus*; Meng et al. 2003), white-tailed deer (McCabe and Leopold 1951), and caribou (*Rangifer tarandus*; Post et al. 2003) has found that peak birthing corresponded with plant phenology. Specific to mule deer, Robinette et al. (1977) and Bowyer (1991) suggest that the timing of parturition coincided with long term climatic patterns so that females meet nutritional requirements. According to Kie and Czech (2000) rutting behavior occurs later for desert mule deer than for other black-tailed deer, which would coincide with the later parturition date we observed. The desert mule deer's range extends from western Arizona to southwest Texas, and south into Mexico (Kie and Czech 2000) where monsoonal moisture causes forage green up in mid to late summer. Robinette et al. (1977) reports peak birthing in the Arizona chaparral occurs in July and August, which is similar to the mule deer on our study site (Table 2.1). The Texas white-tailed deer evolved in a mesic environment where green up would have occurred in spring and early summer accounting for the early birth dates (Table 2.1).

Although our research could not confirm the causal mechanism for the difference in parturition timing, the second explanation appears more reasonable. First our study site has few large predators (Avey 2001, Brunjes 2004), so interspecific competition for quality bed sites may not occur. After two summers we observed only 11 of 107 fawns die from predation ≤ 18 days postpartum. Secondly previous research on caribou has found that parturition was synchronized with plant phenology in both areas with wolves and without wolves leading investigators to conclude that the availability of forage plants is more important in the timing of parturition than predator avoidance (Post et al. 2003).

Birth Sites

Probably the most biologically significant difference between deer species birth sites was in canopy plant species used. Mule deer does used herbaceous growth only twice and never use mesquite shrubs, but juniper was used 13 times (54.2%). Mule deer range across the study site both in areas where juniper is and is not the primary vegetation; therefore we might have expected to see a uniform distribution of canopy plant use. With mesquite and herbaceous growth only accounting for 8.3% of total mule deer parturition sites, it appears that mule deer may select for juniper to birth under (Figure 2.7) White-tailed deer range primarily on the lowlands, and that may explain why herbaceous growth and mesquite were commonly used (61.9%) for parturition sites while juniper (19.0%) was not.

Although the elevation relief on our study site was slight in comparison to other areas where the two deer species occur sympatrically (Avey 2001, Krausman and Ables 1981) they did appear to separate on the basis of slope and elevation. Our study contained numerous mesas with steep slopes vegetated with juniper and these areas appeared to be used exclusively by mule deer does in which to give birth. Whereas, white-tailed does used lowlands and avoided slopes.

Fawn Bed Sites

We speculated before this study that fawns of each deer species would use similar habitats with temporal differences between them, or that parturition timing would not differ and that the two species would use habitats differently. Previous research in Crockett County indicated adults partitioned habitat based on elevation (Brunjes 2004), plant size (Avey 2001), and vegetation type (Avey 2001, Avey et al. 2003, Brunjes 2004). We considered these parameters plus visual obstruction (height of hiding cover), shading potential, and the species of plant fawns chose to bed under as key variables to differentiate habitat used for fawn beds. We reject our initial hypotheses. We found both a temporal difference and differential habitat use.

Elevation and vegetation type are broad scale, landscape variables, so we should look to adult behaviors to explain these differences. One potential explanation for the difference in elevation and vegetation type could be the predator avoidance strategies employed by the adults of each species. Geist (1998) indicated that mule deer use open landscapes to spot predators at a distance, while white-tailed deer use dense cover and quick escape as their anti-predator strategy. Mule deer fawns used the juniper mix and yucca mix vegetation types 45.5% of the time, while white-tails only used them 6.2% of the time. These two vegetation types had low shrub densities when compared to the other vegetation types. These types occur at higher elevations and on slopes, which in addition to fewer shrubs should aid in spotting potential predators. Conversely, 44.5% of white-tailed deer fawn bed sites were in the mesquite mix and even stand mix, which had a much higher shrub density.

Adults may choose broad scale landscape parameters, and their anti-predator strategies may explain differences we found for vegetation type and elevation, but fawns choose the actual bed site (Marchinton and Hirth 1984, Huegel et al. 1986, Uresk et al. 1999), and the two species use the same strategy for survival $\leq$ 18 days postpartum (Geist 1981, Marchinton and Hirth 1984, Geist 1998). If fawns are employing the same strategy for survival, then you would expect that they would use similar microhabitat. Our data support this notion because only two microhabitat parameters differed between species.

The species of canopy shrub chose to bed under and height of hiding cover differed statistically between deer species, but it may not have differed functionally. White-tailed deer used mesquite shrubs and herbaceous growth to bed under, whereas mule deer used more juniper shrubs. Deer fawns probably do not consider the species of a shrub for bedding, but rather cue on its concealment properties. However, statistically mule deer fawns used shorter hiding cover than that of white-tailed deer fawns. We argue that both mule deer and white-tailed deer fawns bed in hiding cover that is functionally the same because it is taller than a bedded fawn ($\bar{x}_{md} = 41$cm and $\bar{x}_{wtd} = 58$cm).

Another possible explanation for differences found between mule deer and white-tailed deer fawns is that predation pressure was not the driving force in bed site selection. Our study site has a low predator density (Avey 2001, Brunjes 2004) which might explain why fawns are not choosing microhabitat similarly. Three to six weeks postpartum is a critical time for fawns during which their movements are minimal and rely on hiding as their primary defense against predation (Jackson et al. 1972, Geist 1981, Ozoga et al. 1982, Marchinton and Hirth 1984). After two summers we observed only 11 of 107 fawns die from predation ≤ 18 days postpartum. With so few predations during the "hider" phase, predation pressure may not be the driving force behind bed site selection on our study site. A future study in an area of sympatry using a control and treatment (i.e., predator removal) approach could provide insight into the role of predation on habitat partitioning by fawns.

Fawn Bed Site Quality

Initially we thought fawns that died ≤ 18 days postpartum would have bed site characteristics different from those that survived. We assumed that fawns dying from predation would have poor quality bed sites (i.e., a bed site with little hiding cover) because previous studies have found that fawns selected for bed sites with greater hiding cover (Huegel et al. 1986, Hyde et al. 1987), and that ones dying from other causes may have similar characteristics (e.g., steep slopes or no canopy cover to protect from the sun). Fawns that die early in life have fewer bed sites measured, so we combined all forms of mortality. White-tails that died ≤ 18 days postpartum bedded closer to shrubs and used less slope than those who survived. Numerous studies have found that white-tailed deer select for dense vegetation (Giest 1998, Avey 2001, Brunjes 2004), so it is odd that those who survived were found farther from shrubs and used steeper slopes where vegetation was not as thick.

Further research with a larger sample of mortalities during the “hider” phase would be beneficial. Our results may be spurious for white-tailed deer, and a larger more representative sample may produce different results. Furthermore, additional data may allow us to detail the differences among mortality types (e.g., predation versus starvation). Conversely a larger sample may not be necessary for mule deer. Mule deer does are more aggressive towards smaller predators (Griffith 1988, Lingle 1989, Lingle and Pellis 2002), and since our study site had a low density of coyotes and high density of bobcats (personal observation) bed site quality may not play an important role in mule deer fawn survival.

Overall Conclusions

We found that mule deer fawns and white-tailed deer fawns used habitat differently. Fawns appear to partition habitat in the same manner as adults. Our data for adult parturition sites show similar differences between adult does as do our fawn bed sites. Both fawns and adult mule deer used higher elevations, juniper canopy shrubs, and open vegetation types (e.g., juniper mix and yucca mix). Previous studies on our study site also found that adults partitioned habitat on the basis of elevation, slope, vegetation type, and shrub cover (Avey 2001, Avey et al. 2003, Brunjes 2004). Avey (2001) found that mule deer adults used steeper slopes, less shrub cover, and greater forb cover than white-tailed deer. Brunjes (2004) focus on a broader scale to reveal that mule used vegetation types associated with juniper, steeper slopes, and higher elevations. White-tailed deer used vegetation types that had lots of mesquite and were overall denser than those of mule deer adults.

Our study seem to show that juniper and mesquite (often considered undesirable shrubs) are important to mule deer and white-tailed deer habitat. Land managers should consider this during the range management practices. Although our study does not provide an answer to the proper amount of shrubs needed (there are definitely upper and lower bounds), it is clear that complete removal of juniper and mesquite would not benefit deer populations.

Literature Cited

Avey, J. T. 2001. Habitat relationships between a sympatric mule and white-tailed deer population in south-central Texas. Thesis, Texas Tech Univeristy. Lubbock, Texas, USA.

Avey, J. T., W. B. Ballard, M. C. Wallace, M. H. Humphrey, P. R. Krausman, F. Harwell, and E. B. Fish. 2003. Habitat relationships between sympatric mule deer and white-tailed deer in Texas. The Southwestern Naturalist 48: 644–653.

Ballard, W. B., D. Lutz, T. W. Keegan, L. H. Carpenter, and J. C. deVos, Jr. 2001. Deer-predator relationships: a review of recent North American studies with emphasis on mule and black-tailed deer. Wildlife Society Bulletin 29: 99–115.

Ballard, W. B., H. A. Whitlaw, S. J. Young, R. A. Jenkins, and G. J. Forbes. 1999. Predation and survival of white-tailed deer fawns in north-central New Brunswick. Journal of Wildlife Management 63: 574–579.

Bowyer, R. T. 1991. Timing of parturition and lactation in southern mule deer. Journal of Mammalogy 72: 138-145.

Brunjes, K. J. 2004. Ecology of sympatric mule deer and white-tailed deer in west-central Texas. Dissertation, Texas Tech University, Lubbock, Texas, USA.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference. A Practical information-theoretic approach, second edition. Springer Science+Business Media, Inc. New York, New York, USA.

Carstensen, M., G. D. DelGiudice, and B. A. Sampson. 2003. Using doe behavior and vaginal-implant transmitters to capture neonate white-tailed deer in north-central Minnesota. Wildlife Society Bulletin 31:634–641.

Ciuti, S., P. Bongi, S. Vassale, and M. Apollonio. 2005. Influence of fawning on the spatial behaviour and habitat selection of female fallow deer (*Dama dama*) during late pregnancy and early lactation. Journal of Zoology 286: 97–107.

Cook, R. S. 1984. Texas. Pages 457–474 *in* L. K. Halls, editor. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Cook, R. S., M. White, D. O. Trainer, and W. C. Glazener. 1971. Mortality of young white-tailed deer fawns in south Texas. Journal of Wildlife Management 35: 47–56.

Denney, R. N. 1976. Regulations and mule deer harvest – political and biological management. Pages 87–92 *in* G. W. Workman and J. B. Low editors. Mule deer decline in the West: a symposium. Utah State University, Logan, Utah, USA.

Derr, J. N. 1991. Genetic interactions between white-tailed and mule deer in the southwestern United States. Journal of Wildlife Management 55: 228–237.

Geist, V. 1981. Behavior: adaptive strategies in mule deer *in* O. C. Wallmo ed. Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln, Nebraska, USA.

Geist, V. 1998. Deer of the world: their evolution, behavior, and ecology, first edition. Stackpole Books, Mechanicsburg, Pennsylvania.

Griffith, B. 1988. Group predator defense by mule deer in Oregon. Journal of Mammalogy 69: 627–629.

Griffith B., and B. A. Youtie. 1988. Two devices for estimating foliage density and deer hiding cover. Wildlife Society Bulletin 16: 206–210.

Hanley T. A., and K. A. Hanley. 1982. Food resource partitioning by sympatric ungulates on Great Basin rangeland. Journal of Range Management 35: 152–158.

Harwell, W. F., and H. G. Gore. 1981. White-tailed deer population trends. Job Performance Report. Federal Aid Project Number W-109-R-4. Job Number 1. Texas Parks and Wildlife Department, Austin, Texas, USA.

Hirth, D. H. 1977. Social behavior of white-tailed deer in relation to habitat. Wildlife Monographs 53. The Wildlife Society, Bethesda, Maryland, USA.

Hosmer, D. W., and S. Lemeshow. 2000. Applied logistic regression. Second edition. John Wiley & Sons, New York, New York, USA.

Huegel, C. N., R. B. Dahlgren, and H. L. Gladfelter. 1985. Use of doe behavior to capture white-tailed deer fawns. Wildlife Society Bulletin 13: 287–289.

Huegel, C. N., R. B. Dahlgren, and H. L. Gladfelter. 1986. Bedsite selection by white-tailed deer fawns in Iowa. Journal of Wildlife Mangement 50: 474–480.

Hyde, K. J., C. A. DeYoung, and A. Garza, Jr. 1987. Bed sites of white-tailed deer fawns in south Texas. Proceedings of the Annual Conference, Southeastern Association of Fish and Wildlife Agencies 41: 288–293.

Jackson, R. M., M. White, and F. F. Knowlton. 1972. Activity patterns of young white-tailed deer fawns in south Texas. Ecology 53: 262–270.

Kie, J. G., and B. Czech. 2000. Mule and black-tailed deer *in* S. Demarais and P. R. Krausman, eds. Ecology and Management of Large Mammals in North America. Prentice Hall, Upper Saddle River, New Jersey, USA.

Kramer, A. 1973. Interspecific behavior and dispersion of 2 sympatric deer species. Journal of Wildlife Management 37: 288–300.

Krausman, P. R., and E. D. Ables. 1981. Ecology of Carment Mountains white-tailed deer. National Parks Service, Scientific Monograph Series 15.

Krausman, P. R., J. J Hervert, and L. L. Ordway. 1985. Capturing deer and mountain sheep with a net-gun. Wildlife Society Bulletin 13: 71–73.

Lingle, S. 1989. Limb coordination and body configuration in the fast gaits of white-tailed deer, mule deer, and their hybrids: Adaptive significance and management implications. Thesis, University of Calgary, Calgary, Alberta, Canada.

Lingle, S., and S. M. Pellis. 2002. Fight or flight? Antiperdator behavior and the escalation of coyote encounters with deer. Oecologia 131: 154-164.

Marchinton, R. L., and D. H. Hirth. 1984. Behavior *in* L. K. Hall ed. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

McCabe, R. A., and A. S. Leopold. 1951. Breeding season of Sonora white-tailed deer. The Journal of Wildlife Management 15: 433-434.

Meng, X., Q. Yang, Z. Feng, L. Xia, Y. Jiang, and P. Wang. 2003. Timing and synchrony of parturition in Alpine musk deer (*Moschus sifanicus*). Folia Zoology 52: 39-50.

Millar, J. S. 1977. Adaptive features of mammalian reproduction. Evolution 31: 370-386.

National Oceanic and Atmospheric Administration. 2003. National Climatic Data Center. Annual Climatological Summary: 410779/99999, BIG LAKE2, Texas. available at: http://cdo.ncdc.noaa.gov/ancsum/ACS (Accessed: 5 October 2003).

Nudds, T. D. 1977. Quantifying the vegetative structure of wildlife cover. Wildlife Society Bulletin 5: 113–117.

Ozoga, J. J., L. J. Verme, and C. S. Bienz. 1982. Parturition behavior and territoriality in white-tailed deer; impact on neonatal mortality. Journal of Wildlife Management 46: 1–11.

Post, E., P. Sporon Bøving, C. Pedersen, and M. A. MacArthur. 2003. Synchrony between caribou calving and plant phenology in depredated and non-depredated populations. Canadian Journal of Zoology 81: 1709-1714.

Robinette, W. L., N. V. Hancock, and D. A. Jones. 1977. The Oak Creek mule deer herd in Utah. Utah State Division of Wildlife Resources Publication, 77-15: 1-148.

Rubin, E. S., W. M. Boyce, and V. C. Bleich. 2000. Reproductive strategies of desert bighorn sheep. Journal of Mammalogy 81: 769-786.

Schwede, G., H. Hendrichs, and W. McShea. 1993. Social and spatial organization of female white-tailed deer, *Odocoileus virginianus*, during the fawning season. Animal Behavior 45: 1007–1017.

Smith, R. B., and F. G. Lindzey. 1982. Use of ultrasound for detecting pregnancy in mule deer. Journal of Wildlife Management 46: 1089-1092.

Smith, R. H., and A. LeCount. 1979. Some factors affecting survival of desert mule deer fawns. Journal of Wildlife Management 43: 657–665.

Stephens, P. A., S. W. Buskirk, G. D. Hayward, and C. M. del Rio. 2005. Information theory and hypothesis testing: a call for pluralism. Journal of Applied Ecology 42: 4–12.

Stubblefield, S. S., R. S. Warren, and B. R. Murphy. 1986. Hybridization of free-ranging white-tailed deer and mule deer in Texas. Journal of Wildlife Management 50: 688–690.

Uresk, D. W., T. A. Benzon, K. E. Severson, and L. Benkobi. 1999. Characteristics of white-tailed deer fawn beds, Black Hills, South Dakota. Great Basin Naturalist 59: 348–354.

Whitlaw, H. A., W. B. Ballard, D. L. Sabine, S. J. Young, R. A. Jenkins, and G. J. Forbes. 1998. Survival and cause-specific mortality rates of adult white-tailed deer in New Brunswick. Journal of Wildlife Management 62: 1335–1341.

Whittaker, D. G., and F. G. Lindzey. 1999. Effect of coyote predation on early fawn survival in sympatric deer species. Wildlife Society Bulletin 27: 256-262.

Wiggers, E. P., and S. L. Beasom. 1986. Characterization of sympatric or adjacent habitats of two deer species in west Texas. Journal of Wildlife Management 50:129–134.

Table 2.1. The sample size, range, and median date for white-tailed deer and mule deer parturition in Crockett County, Texas, May–August 2004, 2005.

Species	n	Range	Median
Mule deer	46	20 June–20 August	21 July
White-tailed deer	28	19 May–6 August	18 June

Table 2.2. Median, mean (±SE), test statistic, and significance level for continuous variables measured at adult parturition sites in Crockett County, Texas June–August 2004 and 2005. Sample sizes were 24 mule deer sites and 21 white-tailed deer sites.

Parameter	Median	Mean	*U* statistic	α
Distance from shrub (cm)				
Mule	77.50	95.38 (12.18)		
White-tailed	91.00	101.57 (14.00)	218.50	0.446
Elevation (m)				
Mule	802.50	807.83 (9.21)		
White-tailed	763.00	763.05 (2.56)	109.50	≤ 0.001
Horizontal cover (cm)				
Mule	37.50	41.77 (7.41)		
White-tailed	30.00	37.62 (9.37)	215.00	0.398
Shrub height (m)				
Mule	2.00	1.73 (0.27)		
White-tailed	3.00	2.45 (0.42)	195.00	0.190
Shrub radius (cm)				
Mule	115.50	124.67 (20.13)		
White-tailed	114.00	117.14 (20.19)	242.50	0.828
Percent canopy cover (%)				
Mule	0.00	34.67 (8.78)		
White-tailed	60.00	44.57 (8.95)	226.50	0.540

Table 2.2 continued.

Parameter	Median	Mean	*U* statistic	α
Slope (°)				
Mule	3.00	5.88 (1.59)		
White-tailed	1.00	1.52 (0.46)	129.00	0.004
Shading potential (klx)				
Mule	43.83	39.26 (5.40)		
White-tailed	37.81	37.18 (5.41)	243.00	0.838

Table 2.3. Degrees of freedom, chi-square statistic and significance for aspect, shrub species used as canopy, and vegetation type for mule deer and white-tailed deer parturition sites in Crockett County, Texas, summers 2004 and 2005.

Parameter [a]	df	Chi-square statistic	α
Aspect	4	7.28	0.122
Canopy species	3	18.04	0.001
Vegetation type	7	21.77	0.003

[a.] Sample size for both parameters is 45 (24 mule deer and 21 white-tailed deer)

Table 2.4. Candidate models for describing the differences between mule deer and white-tailed deer fawn bed sites in Crockett County, Texas, summers 2004 and 2005 (n = 249). Models are ordered by AIC_C.

Model[a]	-2 log(L)	K	AIC_C	ΔAIC_C	w_i
ELE + HC+ VT + CS + (VT*CS)	185.60	18	224.57	0.00	0.71
ELE + HC+ HT + VT + CS + (VT*CS)	185.36	19	226.68	2.11	0.25
ELE + VT + CS + (VT*CS)	193.31	17	229.96	5.39	0.05
ELE + HC+ VT + HT	213.85	13	241.39	16.82	0.00
ELE + HC+ HT	236.46	5	246.71	22.14	0.00
ELE + HC+ VT	240.14	12	265.46	40.89	0.00
Constant only	344.99	2	349.04	124.47	0.00

[a] Abbreviations are as follows: CS = canopy plant species, ELE = elevation, HC = height of hiding cover, HT = canopy shrub height, VT = vegetation type.

Table 2.5. Median, minimum and maximum values (range), mean (±SE), and significance values for variables found in our model (bases on AIC_C values) describing differences between mule deer and white-tailed deer fawn bed sites in Crockett County, Texas summers 2004 and 2005.

Parameter	Median	Range	Mean	α
Elevation (m)				
Mule	806.00	746 – 878	810.05 (3.74)	
White-tailed	759.00	739 – 828	765.57 (1.71)	≤ 0.001
Horizontal cover (cm)				
Mule	40.00	0 – 135	41.40 (2.87)	
White-tailed	57.00	5 – 165	58.05 (3.12)	≤ 0.001

Table 2.6. Median, mean (±SE), test statistic, and significance values of vegetative parameters for white-tailed deer fawns that survived or died ≤ 18 days post parturition in Crockett County, Texas during the summers of 2004 and 2005.

Parameter	Median	Mean	*U* statistic	α
Distance from shrub (cm)				
Survived	48.00	80.43 (8.27)		
Died	30.50	42.60 (11.13)	363.50	0.047
Elevation (m)				
Survived	762.00	766.30 (1.79)		
Died	753.00	756.80 (5.12)	402.00	0.089
Horizontal cover (cm)				
Survived	50.00	58.39 (3.33)		
Died	50.00	52.50 (8.07)	565.00	0.824
Percent canopy cover (%)				
Survived	32.00	36.21 (3.27)		
Died	54.00	49.20 (12.79)	435.00	0.206
Shrub height (m)				
Survived	1.50	1.77 (0.10)		
Died	1.50	1.75 (0.34)	476.50	0.885
Shrub radius (cm)				
Survived	88.50	106.53 (7.94)		
Died	96.00	120.90 (21.97)	367.50	0.395

Table 2.6 continued.

Parameter	Median	Mean	U statistic	α
Slope (°)				
Survived	2.00	2.84 (0.35)		
Died	0.00	0.50 (0.40)	306.00	0.009
Shading potential (klx)				
Survived	53.87	51.23 (2.08)		
Died	63.67	58.66 (9.00)	462.00	0.256

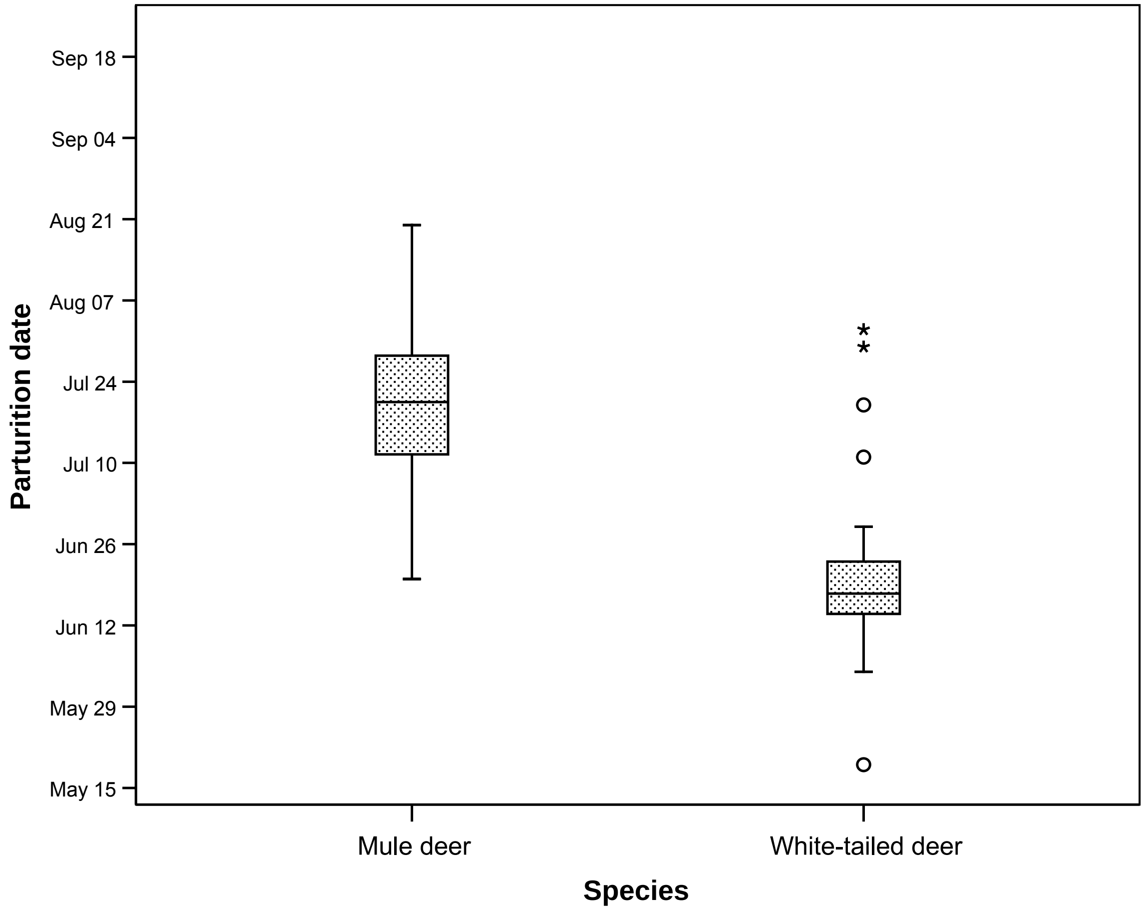

Figure 2.1 Median, quartiles, and extreme values for timing of parturition for mule deer and white-tailed deer in Crockett County, Texas, summers 2004 and 2005. The asterisks represent two white-tail yearlings.

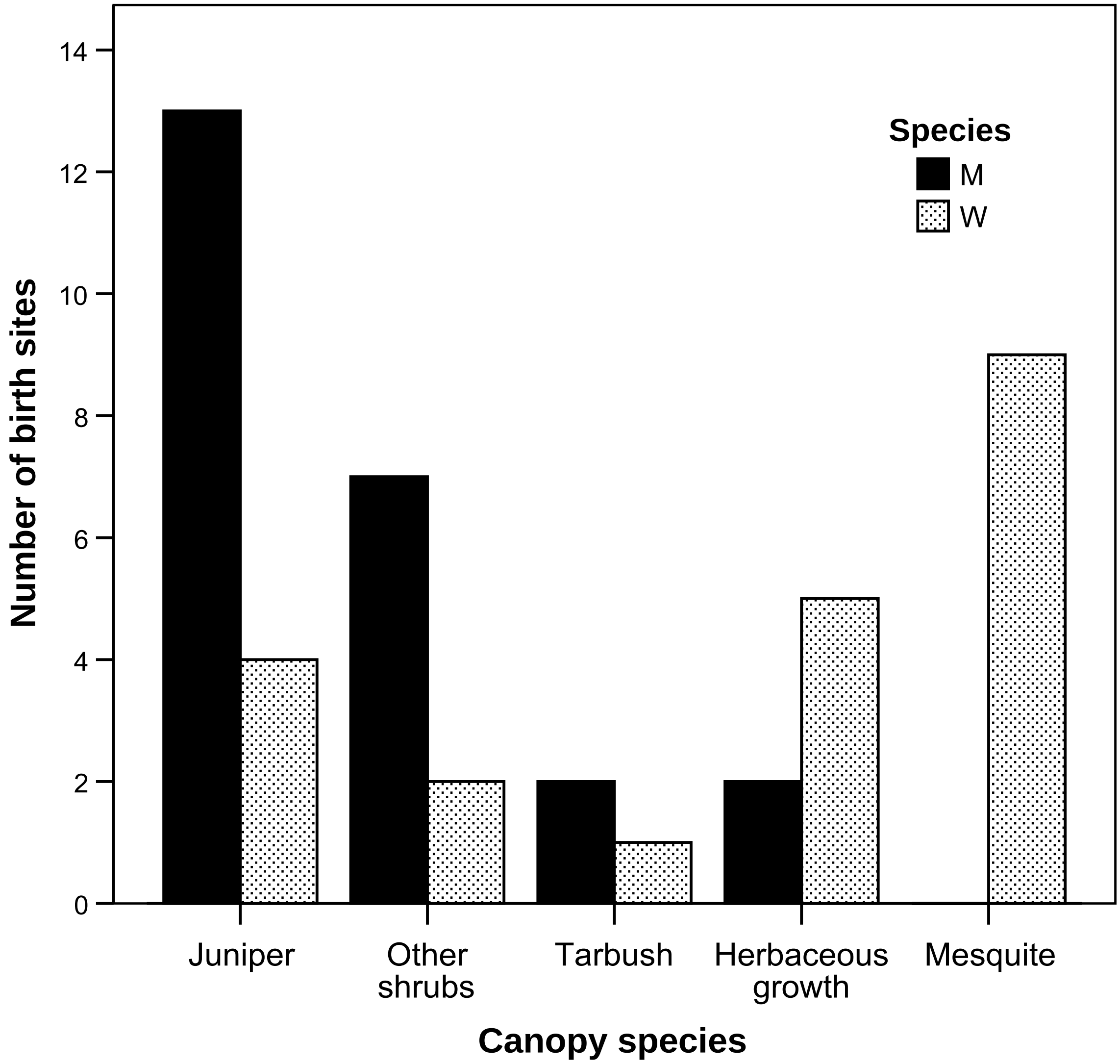

Figure 2.2 Frequency of the canopy plant used for parturition sites by mule deer and white-tailed deer, Crockett County, Texas summers 2004 and 2005.

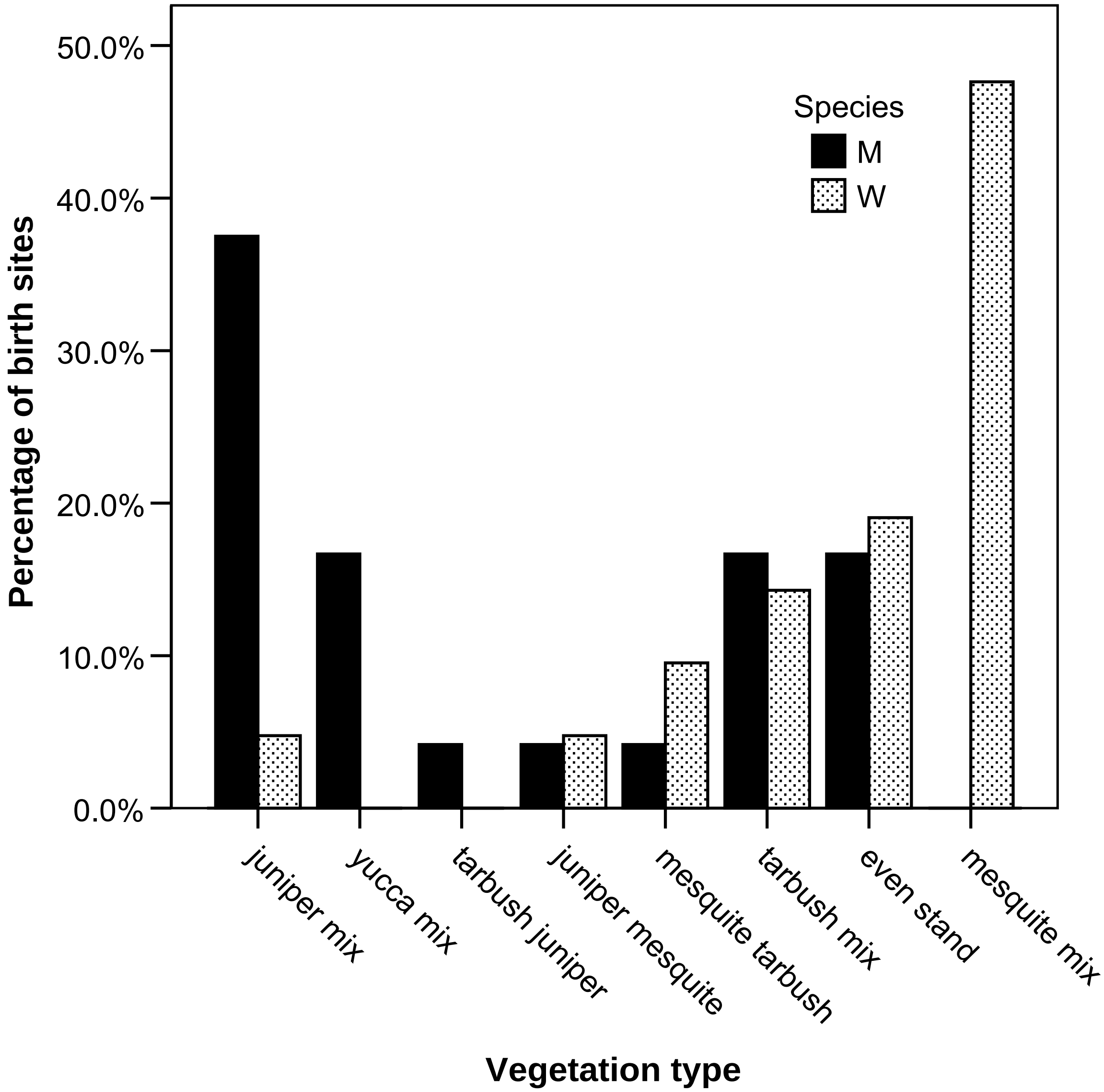

Figure 2.3. Percent frequency of vegetation type used by mule deer and white-tailed deer for birthing in Crockett County, Texas, summers 2004 and 2005.

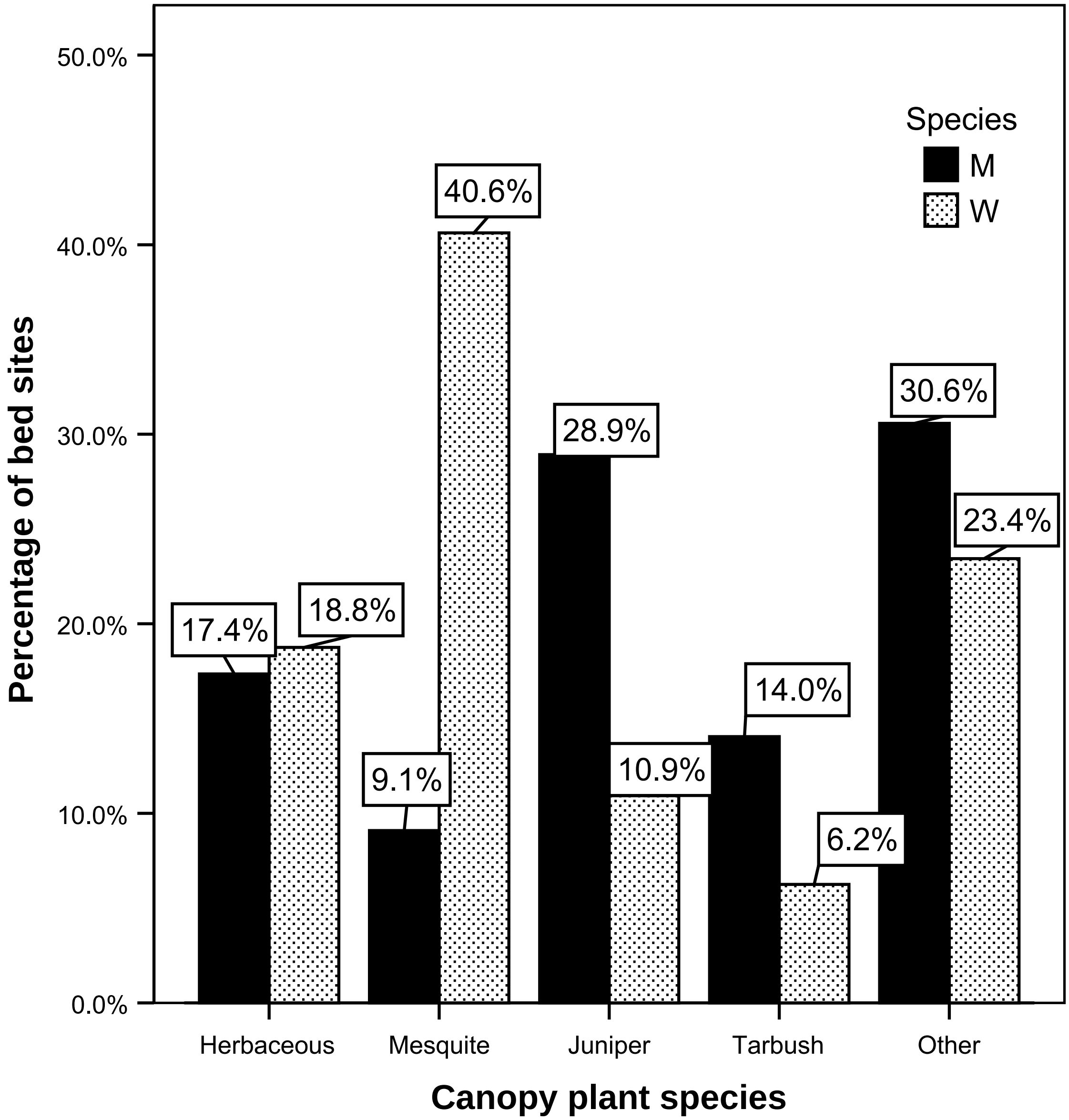

Figure 2.4. Percent frequency of canopy plants used by mule deer and white-tailed deer fawns to bed under in Crockett County, Texas summers 2004 and 2005.

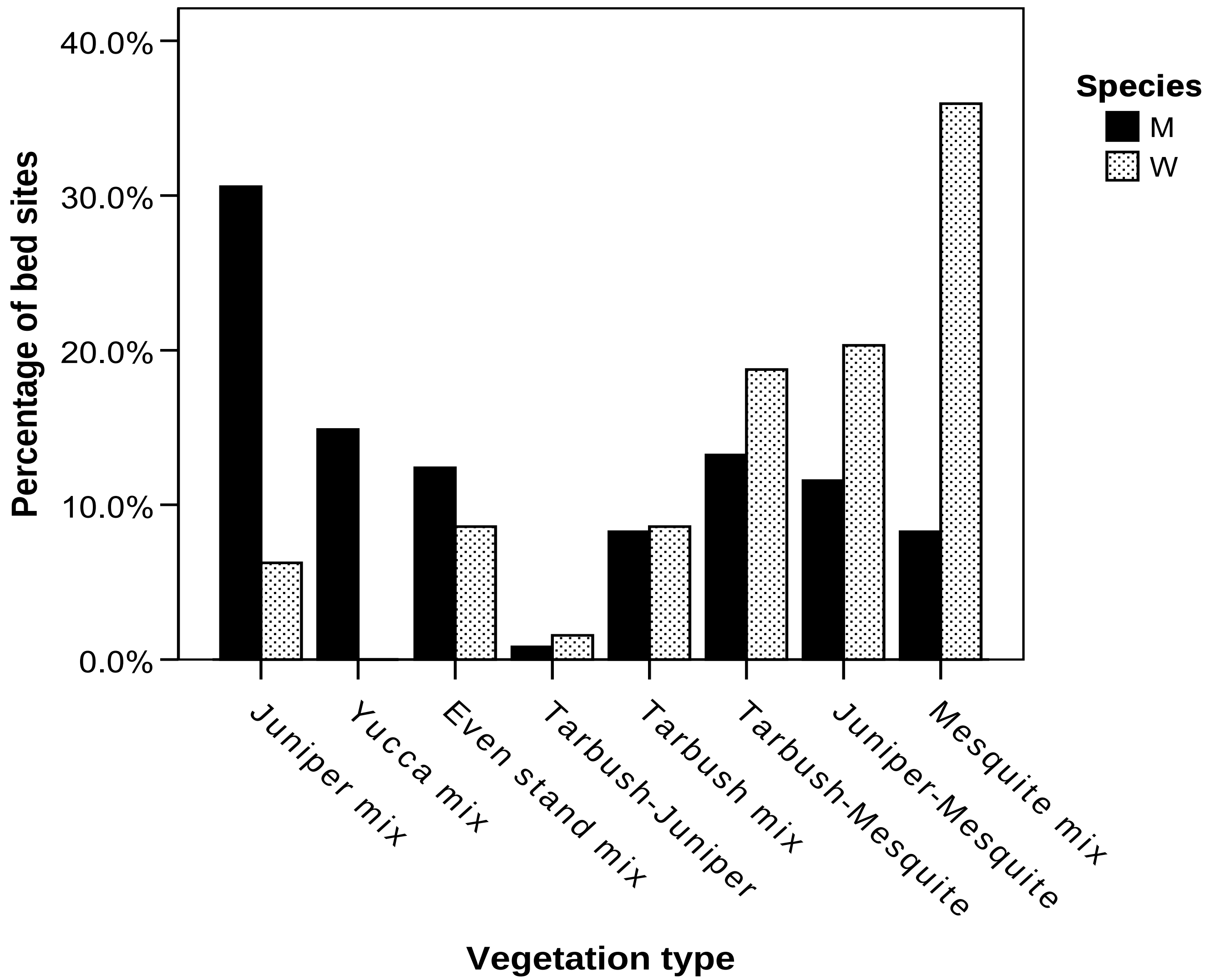

Figure 2.5. Percent fawn bed sites by vegetation type for deer in Crockett County, Texas, summers 2004 and 2005.

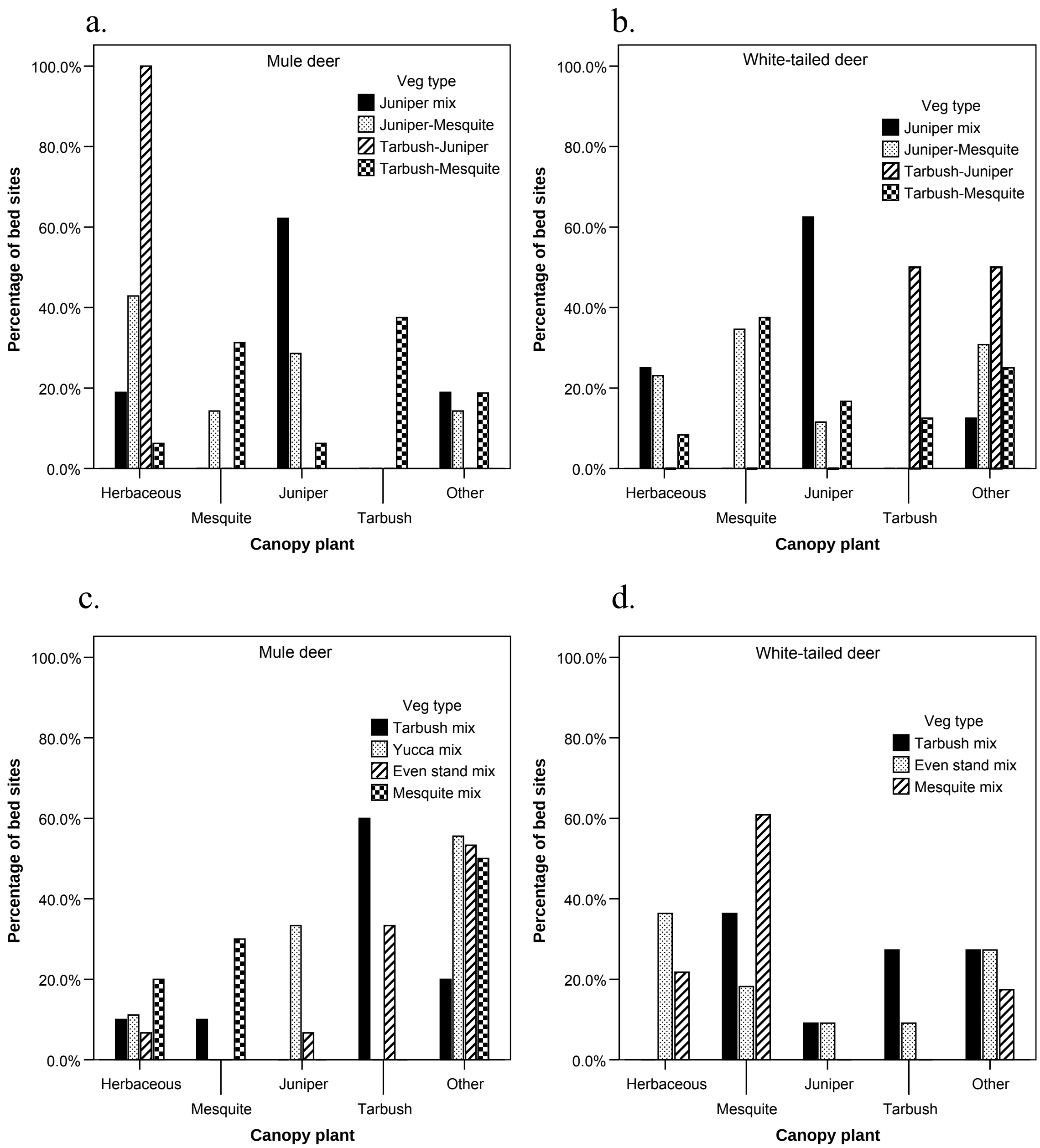

Figure 2.6. Interactions between vegetative type and canopy plant chosen for mule deer and white-tailed deer fawns in Crockett County, Texas, summers 2004 and 2005. Comparing bars within a graph and between graphs vertically (within species) shows an interaction is present. Comparing graphs horizontally and diagonally (between species) shows how the interaction can be useful in describing bed site differences.

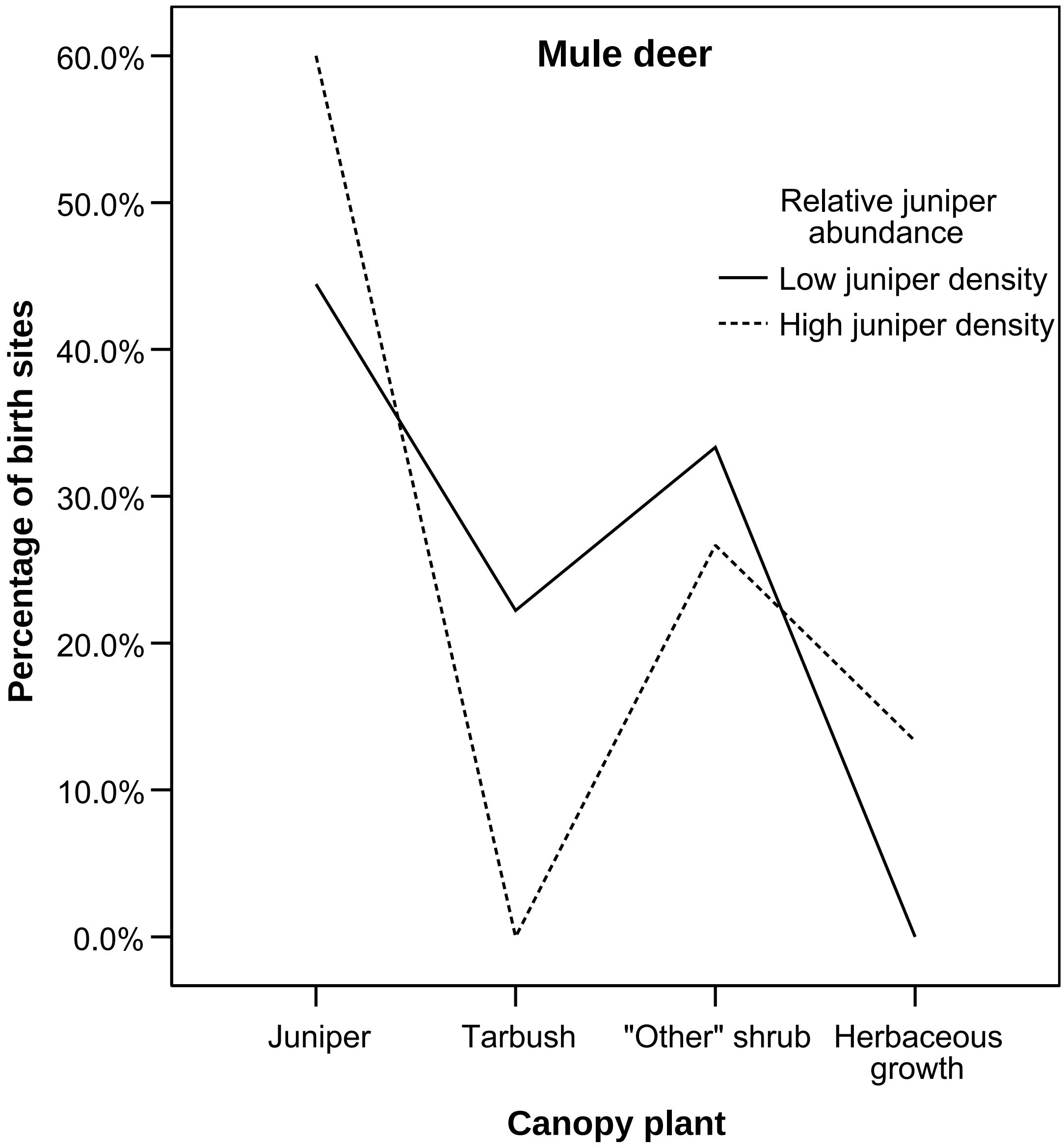

Figure 2.7. Percent frequency of mule deer parturition sites by canopy species in areas of high and low juniper density in Crockett County, Texas, summers 2004 and 2005.

CHAPTER III

LIMITATIONS OF THERMAL INFRARED IMAGING FOR LOCATING NEONATAL DEER IN SEMI-ARID SHRUB COMMUNITIES

Abstract

Neonate capture can be an important part of ungulate research. Systematic grid searching has been the most common method, but it is time consuming and usually requires a large number of people. A variety of methods have been used by wildlife professionals to capture ungulate neonates. We used a Raytheon PalmIR 250 Digital (Raytheon Commercial Infrared, Dallas, TX 75423, USA) thermal infrared camera during the coolest time of night to search for deer (*Odocoileus* spp.) neonates in west-central Texas. Using 2 methods: stationary observation and mobile searching, we detected one fawn and captured none. Efficiency of this technology at our study site may have been limited by the lack of a forest canopy and density of shrubs and herbaceous cover on our study site. Ground cover can obscure a bedded fawn, and direct sunlight on bed site habitat can result in false-signals. We suggest wildlife professionals consider vegetation parameters, ungulate density, and road quality before purchasing expensive thermal imaging equipment.

Introduction

First year recruitment is often the most variable demographic parameter affecting population dynamics in ungulates (Gaillard et al. 2000). In cases where recruitment is low, it may be beneficial to capture and radio collar neonates to determine cause-specific mortality. Grid searching is a traditional method to capture neonates (Ballard et al. 1999). Unfortunately, grid searching requires a large amount of effort (i.e., either large numbers of volunteers or long hours for smaller ground crews), so wildlife biologists constantly seek alternatives to maximize efficiency.

Bolte et al. (1970) attempted searching from horseback, which should increase visibility and speed. Others have used movement and location data from radiocollared female deer to narrow the search area (Huegel et al. 1985). White et al. (1972) observed does' behavior from a high vantage to pin point an area for neonate searching. Diem (1954) employed taped vocalizations in an attempt to cue on doe behavioral responses. More recently, researchers have used vaginal-implant transmitters ([VIT], Bowman and Jacobson 1998, Carstensen et al. 2003) to alert biologists as to when parturition occurs thereby allowing them to find the birth site as a starting point for neonate searching. All have the potential to streamline the searching process (White et al. 1972, Bowman and Jacobson 1998, Carstensen et al. 2003), but maternal behavior may be hard to interpret and VIT retention rates can be low (unpublished data, S. Haskell Texas Tech University; Seward 2003). Recently, Ditchkoff et al. (2005) described a technique using truck mounted thermal imagery to detect neonates in a South Carolina forest with great success.

We attempted to duplicate Ditchkoff et al's (2005) thermal technique to aid in capturing white-tailed deer (*Odocoileus virginianus*) and mule deer (*O. hemionus*) neonates for a survival and habitat study in west-central Texas. In addition, we tested the mobile technique with radiocollared fawns of known locations and attempted to monitor does and fawns from a fixed vantage point using thermal imagery. Here we discuss the limitations of our techniques.

Study Area

This study was conducted on 3 contiguous ranches (26,066 ha) in northwest Crockett County, Texas during the month of June. Topography was varied with southern and eastern portions being flat, while the western and northern portions had mesas with steep sides and flat tops. Elevation on the study site ranged from 730–880 m, although neonate searching primarily occurred at lower elevations off of mesa tops because of the poor quality of mesa roads. At the nearest National Oceanic and Atmospheric Administration (NOAA) weather station, the average daytime high temperature for June was 32.7°C (90.9° F), and the average night time low was 18.7°C (NOAA 2005). Average annual precipitation was 47.5 cm (NOAA 2005).

Vegetation across the study area was varied. In the intermittent riparian corridors, herbaceous vegetation was common with grasses and forbs reaching 0.5 m tall. Scattered thickets of hackberry (*Celtis laevigata* var. *reticulata*) and walnut trees (*Juglans microcarpa*) accompanied the thicker herbaceous grass. Outside of the riparian corridors, the bottomlands had 2 dominant communities; a creosote (*Larrea tridentata*) and tarbush (*Flourensia cernua*) community with low growing herbaceous vegetation was found in areas with well drained soils, while a mesquite (*Prosopis glandulosa*) community with varying herbaceous height occurred on more mesic soils. Prickly pear (*Opuntia* spp.) and other cactus species occurred across lowlands. Much of the lowlands had been heavily grazed by cattle and sheep. On the slopes and mesa tops the primary vegetation was a juniper (*Juniperus pinchotii*) community with sparse varying herbaceous vegetation. Slopes and rim rock areas often contained sotol (*Dasylirion wheeleri*) and *Yucca* spp. Algerita (*Mahonia trifoliolata*), lotebush (*Ziziphus obtusifolia*), and tasajillo (*Opuntia leptocaulis*) as well as the aforementioned shrubs made up a mixed community interspersed throughout the study site.

Land use was primarily livestock ranching, but hunting and oil and gas extraction were also common. Road quality varied from a paved county road to two-track unimproved ranch roads. There were also maintained caliche roads of intermediate quality. Deer density on the study site was $20/km^2$ (unpublished data, S. Haskell, Texas Tech University). The buck:doe ratio and parturition rate for the site was 1:2.2 and 1.88, respectively (unpublished data, S. Haskell, Texas Tech University).

Methods

We used a Raytheon PalmIR 250 Digital (Raytheon Commercial Infrared, Dallas, TX 75423, USA) thermal imaging camera to attempt to locate newborn deer fawns for capture (Texas Tech University ACUC permit # 03075-10). For further description of the camera see Ditchkoff et al. (2005). We mounted the thermal camera to an adjustable tripod and placed it on the cab of a pickup. Using an audio/video cord we routed the display to a portable digital video disc (DVD) player (Model: IS-PD101351, Insignia, Richfield, Minn.) with a 22.9 cm screen.

Mobile Searching Method

Using the equipment above, the driver cruised at 4.8–8.0 km/h (3–5 mi/h), while the observer sat on the cab next to the camera watching the screen for potential fawns. The observer conducted a 360° sweep with the thermal camera. The camera was positioned so that the bottom of the screen showed the ground approximately 10–15 m perpendicular to the truck; the idea being that any fawn closer than 15 m could be spotted by the driver as the truck idled past due to headlights, or more likely, that the thermal unit would be able to detect a fawn in this area during the 360° sweeps in front of or behind the truck. The upper bound of our view varied greatly from <50 m to as far as the horizon due to topographical relief.

Searches were conducted after 01:30 hr, to ensure the soil and vegetation had time to dissipate most of the afternoon's heat, and lasted until about 15 minutes prior to sunrise. Searches were conducted on roads with 2 main preferential criteria: smoothness of road surface and areas where large shrubs were sparse and herbaceous vegetation was short, the latter being more important because vegetation will buffer an animal's body heat. We conducted mobile searches 14–29 June 2005 during the peak of white-tailed deer fawning (unpublished data, S. Haskell, Texas Tech University). If an object was spotted on the monitor, the driver was instructed to stop and investigate. Using a walkie-talkie the observer directed the driver towards the potential fawn. The driver wore a headlamp, carried a flashlight, and was prepared to hand-capture any fawn spotted.

We used a truck mounted dual yagi, null–peak system to triangulate fawns (n = 18) fitted with VHF radio collars and with identifiers (ATS, Isanti, MN, 55040 USA) that were located near ranch roads. We assessed efficiency by recording man-hour data and searching in areas where simultaneous location data for fawns previously radio collared were available.

Stationary Observation Method

We were in a unique situation where we had radiocollared dams with vaginal implant transmitters and ultrasound data, so we knew the number of fetuses. Prior to peak fawning season (when we employed the mobile searching method), we monitored does (n = 3) with post partum fawns from a fixed position to see when they visited their uncollared neonate(s). In 2 cases we had already captured 1 neonate, but had been unable to locate its twin, and in the other case we had been unable to locate either fawn.

We conducted stationary observations from approximately 02:30 hr until daylight. Vantage points included elevated hunting stands, hill sides, and the truck cab's roof in flat areas. We used the truck's dual yagi antenna system or a hand-held yagi antenna to confirm that the deer seen on the monitor was indeed the dam of interest. The dual yagi system was also used to monitor (when applicable) the collared neonate's position.

Results

After 21 nights of using the thermal camera (both stationary and mobile), we captured no fawns and observed only 1. The fawn observed was extremely mobile, as it was observed fleeing from the truck with multiple adult deer.

Mobile Searching Method

We employed the mobile method for 14 days from 14 June until 29 June for a total of 29.8 hours (Table 3.1). This method required 1 driver and at least 1 observer, for

59.5 person-hours. The average amount of time spent per night searching was 2.1 hours (SE = 0.33). We triangulated 18 fawns near roads. After plotting triangulations we deleted 2 locations which placed fawns well beyond 200 m from the road (Table 3.2). For the remaining fawns, the mean distance from the road was 85.7 m (SE = 15.4, n = 16). Four of these fawns were <15 m of the road (Table 3.2). None of the radiocollared fawns were detected with the thermal infrared system.

Stationary Observation Method

We were unable to detect any fawns using the stationary observation method. This method was used on does with radiocollars that had given birth early in the fawning season (21 May–12 June). We logged 24 hours of monitoring on 7 different nights. On 2 nights we were not confident that we were observing the correct radiocollared doe. On the first occasion there were several deer in view but at a distance such that the hand-held yagi antenna was not precise enough to discriminate which deer was collared. Thick vegetation prohibited a clear view of the doe on the second occurrence.

Discussion

Thermal imagery has been used with relative success in many wildlife studies (Wiggers and Beckerman 1993, Focardi et al. 2001, Ditchkoff et al. 2005), but that was not the case in the current study. False positives, vegetation issues (e.g., no forest canopy and too much herbaceous growth), lower deer density, and several other minor issues all limited the thermal infrared unit's effectiveness.

The Raytheon PalmIR 250 is a sophisticated piece of equipment which displays differences in radiant heat. First, using radiant heat rather than low levels of light allows for day and night use, however in areas where ambient temperatures approach or exceed terrestrial species' body temperatures the thermal unit may be rendered useless during daylight hours (Ditchkoff et al. 2005). Such was the case for the current study; therefore, we conducted all searching, both mobile and stationary, at night to limit the effect of high ambient temperatures, thus decreasing the chances of investigating false-positives or missing actual fawns (i.e., false-negatives). The camera uses the relative heat of one body to another, as opposed to total heat emission, which may cause researchers to miss fawns. For example, it was noted that a telephone pole surrounded by cool night air appeared totally and completely white (the camera was set to display hot objects as white). In contrast, a jackrabbit (*Lepus californicus*) sitting next to a cactus was not detected because the water in the cactus retained enough heat that the heat difference between the rabbit's body and cactus was quite small in relation to that of a telephone pole to night air. One desert study showed a jackrabbits' (*L. townsendii*) body temperature to be 38.2° C (Rogowitz 1990); thus the rabbit's body temperature is greater than the telephone pole or cactus, but the camera may be unable to detect this unless they were separated from each other. This phenomenon could lead to false-negatives (i.e., missing fawns).

False positives can cause observers to question what is being observed and either waste time investigating "nonfawn hot spots" or miss a fawn because they think it is something else. The study site had no forest canopy to prevent the sun's radiant heat from building up on flat surfaces (e.g., bare ground, metal signs, large rocks, cactus, etc.) which can lead to many false positives. This phenomenon could explain the difference in success between this study and that of Ditchkoff et al. (2005) which was conducted in South Carolina under long-leaf pine (*Pinus palustris*) and hardwood forest canopies. The forest canopy may have dissipated much of the sun's radiant heat. Ditchkoff et al. (2005) reported that during the day patches of sunlight on the forest floor created false positives, but mentioned nothing about this at night. The desert landscape of the southwestern United States does not have the solar protection of a forest canopy, and therefore "hot spots" exist throughout the night.

Vegetation on the study site limited the performance of the thermal infrared camera because sparse herbaceous vegetation can buffer a neonate's body heat enough that the thermal unit cannot detect it. A lack of low-growing herbaceous vegetation would certainly be beneficial in locating bedded fawns (David Butler, personal observation, Texas Tech University). We approached our first collared fawn (captured by daytime grid searching with aid from a VIT) at night on 2 separate occasions with hand-held telemetry gear and the thermal camera. The distances where a "hot spot" was detected were 5 m and 3 m; the distances where the fawn could actually be identified as such were 2 m and <1 m, respectively. The fawn was not bedded in what would be considered dense vegetation; on both occasions it was identifiable with a flashlight at approximately 10 m (this was estimated after the fawn was found with the thermal gear by backing away until it could no longer be seen with flashlights). Ditchkoff et al. (2005: 1167) reported that only forest "tracts that had recently (e.g., 1–2 months previously) been burned with prescribed fire proved to be suitable" for searching. Our mobile searching area consisted mainly of overgrazed mesquite and tarbush flats with sparse herbaceous vegetation, exceptions being in a few patchy areas with dense juniper (*Juniper pinchotii*) and riparian corridors. The 16 radio collared “test fawns” occurred in all types of the searching area, and none could be detected with the thermal unit. Despite low herbaceous productivity the rangelands may have provided too much herbaceous growth, thereby decreasing the chances of finding bedded neonates.

Other aspects of this study site that might have decreased chances of capturing neonates included lower deer densities and poor quality roads. Ditchkoff et al. (2005) reported a deer density of $31/km^2$. The winter density of deer on the current study area in 2004 was $20/km^2$ (unpublished data). Also the quality of roads used varied greatly with some being rough which made 360° sweeps difficult, even at 4.8–8.0 km/h. The monitor could also slide or bounce further complicating accurate observations. If road condition was too severe a smoother surface was sought and the monitoring started again. Such rough roads were avoided in future monitoring. The roads used for this study were not always level. What appeared to be the smallest of pitch could send the camera looking out into the horizon, or nearly straight down. The observer was frequently adjusting the field of view on such roads. A shock absorbing mount is needed if this method is determined to be useful. An additional observer would have been beneficial, so that 1 person could concentrate on balancing and adjusting the camera while the other watched the monitor.

The variety of problems encountered during the study make the notion of using thermal infrared imagery to locate and capture neonates impractical in such terrain. It seems for infrared imagery to be effective ideal conditions must exist. Ditchkoff et al.’s

(2005) study in South Carolina may have benefited from high deer densities in an ideal setting with a forest canopy minimizing false-positives and negatives and enough tracts of recently burned forest so that the understory vegetation did not significantly affect detection rates. Given the proper conditions, infrared thermal imagery may be an excellent technique for finding and capturing neonates, but in conditions other than these it can be a costly mistake. Thermal infrared imaging equipment is expensive with prices ranging from $6,000 (U.S.) to upwards of $40,000 (Ditchkoff et al. 2005). We recommend wildlife professionals assess the conditions under which thermal imaging may be used before purchasing a thermal infrared imaging camera.

Acknowledgments

This study was supported by Texas Parks and Wildlife Department and Texas Tech University. Special thanks C. Britton for reviewing a previous draft of this manuscript. We also thank A. Sanders for help with field work. This research was approved by the Texas Tech University Animal Care and Use Committee. This is Texas Tech University College of Agricultural Science and Natural Resources publication T-9-1094.

Literature Cited

Ballard, W. B., H. A. Whitlaw, S. J. Young, R. A. Jenkins, and G. J. Forbes. 1999. Predation and survival of white-tailed deer fawns in northcentral New Brunswick. Journal of Wildlife Management 63:574–579.

Bolte, J. R., J. A. Hair, J. Fletcher. 1970. White-tailed deer mortality following tissue destruction induced by lone star ticks. Journal of Wildlife Management 34:546–552.

Bowman, J. L., and H. A. Jacobson. 1998. An improved vaginal-implant transmitter for locating white-tailed deer birth sites and fawns. Wildlife Society Bulletin 26:295–298.

Carstensen, M., G. D. DelGiudice, and B. A. Sampson. 2003. Using doe behavior and vaginal-implant transmitters to capture neonate white-tailed deer in north-central Minnesota. Wildlife Society Bulletin 31:634–641.

Diem, K. L. 1954. Use of a deer call as means of locating deer fawns. Journal of Wildlife Management 18:537–538.

Ditchkoff, S. S., J. B. Raglin, J. M. Smith, and B. A. Collier. 2005. Capture of white-tailed deer fawns using thermal imaging technology. Wildlife Society Bulletin 33:1164–1168.

Focardi, S., A. M. De Marinis, M. Rizzotto, and A. Pucci. 2001. Comparative evaluation of thermal infrared imaging and spotlighting to survey wildlife. Wildlife Society Bulletin 29:133–139.

Gaillard, J. M., M. Festa-Bianchet, N. G. Yoccoz, A. Loison, and C. Toïgo. 2000. Temporal variation in fitness components and population dynamics of large herbivores. Annual Review of Ecology and Systematics 31:367–393.

Huegel, C. N., R. B. Dahlgren, and H. L. Gladfelter. 1985. Use of doe behavior to capture white-tailed deer fawns. Wildlife Society Bulletin 13:287–289.

National Oceanic and Atmosphere Administration. 2005. Climatography of the United States No. 20 1971–2001. Available online at: [http://www5.ncdc.noaa.gov/climatenormals/clim20/tx/410779.pdf]. Accessed 8 November 2005.

Rogowitz, G. L. 1990. Seasonal energetics of the white-tailed jackrabbit (*Lepus townsendii*). Journal of Mammalogy 71:277–285.

Seward, N. W. 2003. Elk calf survival, mortality, and neonatal habitat use in eastern Kentucky. Thesis, University of Kentucky, Lexington, Kentucky, USA.

White, M., F. F. Knowlton, and W. C. Glazener. 1972. Effects of dam-newborn fawn behavior on capture and mortality. Journal of Wildlife Management 39:897–906.

Wiggers, E. P., and S. F. Beckerman. 1993. Use of thermal infrared sensing to survey white-tailed deer populations. Wildlife Society Bulletin 21:263–268.

Table 3.1. Dates and times the “mobile method” of thermal infrared imaging was used to search for white-tailed deer neonates in Crockett County, Texas, June 2005.

Date:	Start time:	End time:	Total time:
14 June	02:35	06:05	3:30
15 June	03:50	05:50	2:00
16 June	02:55	05:55	3:00
17 June	01:40	06:12	4:32
18 June	03:09	05:56	2:47
19 June	02:34	05:39	3:05
20 June	03:20	05:40	2:20
21 June	04:15	05:55	1:40
22 June	02:55	05:49	2:54
23 June	02:36	03:05	0:29
25 June	03:00	03:55	0:55
27 June	02:56	03:20	0:24
28 June	03:10	04:20	1:10
29 June	03:14	04:14	1:00
		Grand Total:	29:46

Table 3.2. Dates and distances of known radiocollared fawns that were not detected from a truck using thermal infrared imaging in Crockett County, Texas, June 2005.

Date	Fawn Id.	Distance from road (m)
19 June	F18 E	161
19 June	F48 D	82
20 June	F48 D	41
20 June	F48 E	171
21 June	F18 D	9
21 June	F18 E	80
21 June	F48 D	7
21 June	F48 E	125
22 June	F18 D	71
22 June	F18 E	153
22 June	F48 D	89
22 June	F48 E	12
23 June	F18 D	193
23 June	F18 E	101
23 June	F48 D	66
23 June	F48 E	10

CHAPTER IV

CONCLUSION

In Crockett County, Texas white-tailed deer and mule deer fawns had parturition dates that differed with white-tails giving birth before mule deer. Whether this phenomenon is a residual behavior originating from different evolutionary histories with different climates and forage schemes, or if it relates to interspecific competition and anti-predator strategies remains unclear. There is scientific literature which evaluates the timing and synchronization of parturition in ungulates (McCabe and Leopold 1951, Rubin et al. 2000, Post et al. 2003), but there is little published research pertaining to areas where mule deer and white-tailed deer occur sympatrically to evaluate why they may differ.

Despite the difference in parturition timing, the deer use habitat differently. Fawns appear to partition habitat the same as adults based on vegetative communities and elevation. Previous studies have noted that elevation (Krausman and Ables 1981), slope (Avey 2001, Avey et al. 2003), and vegetation type (Brunjes 2004) are important parameters in delineating mule deer habitat from white-tailed deer habitat in areas with sympatric populations in Texas. Our data from fawn parturition sites and day bed sites showed mule deer generally used vegetative communities with lots of juniper, which dominate the slopes and higher elevations of our study site. White-tailed deer occupied areas with more mesquite and taller hiding cover. These areas are generally found on the lowlands of our study site.

The attributes of fawn bed sites did not appear to affect mule deer fawn survival, although white-tailed deer fawns that died ≤ 18 days postpartum used bed sites closer to shrubs and on flatter slopes than those that survived. Both deer species go through a neonatal "hider" phase to prevent death from predation or exposure (Geist 1981, Marchinton and Hirth 1984, Geist 1998). We might have expected to see the same parameters affecting survival since both species use the same survival strategy. A larger sample size of fawns may have aided us in this part of the study because fawns that die early will have a smaller sample of bed sites to compare to those that survived. In an effort to improve our sample size we use thermal infrared imaging to capture fawns at night.

We employed a thermal infrared imager in the cool hours of night and early morning in an attempt to capture fawns. We had no successful captures, and only one sighting. Others have used thermal imagery with success (Wiggers and Beckerman 1993, Galligan et al. 2003, Ditchkoff et al. 2005); the limitations we encountered dealt with imager's inability to detect heat through vegetation and residual heat on bare surfaces from the previous afternoon. Perhaps a thick overhead forest canopy could have provided enough shade to diminish "nonfawn hotspots," and less understory vegetation would allow detection. Unfortunately our study site, and much of the southwestern United States, is dominated by shrubs without a forest canopy. Due to the expensive nature of thermal imaging equipment we do not advocate purchasing such a unit without careful consideration.

Literature Cited

Avey, J. T. 2001. Habitat relationships between a sympatric mule and white-tailed deer population in south-central Texas. Thesis, Texas Tech University, Lubbock, Texas, USA.

Avey, J. T., W. B. Ballard, M. C. Wallace, M. H. Humphrey, P. R. Krausman, F. Harwell, and E. B. Fish. Habitat relationships between sympatric mule deer and white-tailed deer in Texas. The Southwestern Naturalist 48: 644-653.

Brunjes, K. J. 2004. Ecology of sympatric mule deer and white-tailed deer in west-central Texas. Dissertation, Texas Tech University, Lubbock, Texas, USA.

Ditchkoff, S. S., J. B. Raglin, J. M. Smith, and B. A. Collier. 2005. Capture of white-tailed deer fawns using thermal imaging technology. Wildlife Society Bulletin 33:1164–1168.

Galligan, E. W., G. S. Bakken, and S. L. Lima. 2003. Using a thermographic imager to find nests of grassland birds. Wildlife Society Bulletin 31: 865-869.

Geist, V. 1981. Behavior: adaptive strategies in mule deer *in* O. C. Wallmo ed. Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln, Nebraska, USA.

Geist, V. 1998. Deer of the world: their evolution, behavior, and ecology, first edition. Stackpole Books, Mechanicsburg, Pennsylvania.

Krausman, P. R., and E. D. Ables. 1981. Ecology of Carmen Mountains white-tailed deer. National Parks Service, Scientific Monograph Series 15.

Marchinton, R. L., and D. H. Hirth. 1984. Behavior *in* L. K. Hall ed. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

McCabe, R. A., and A. S. Leopold. 1951. Breeding season of Sonora white-tailed deer. The Journal of Wildlife Management 15: 433-434.

Post, E., P. Sporon Bøving, C. Pedersen, and M. A. MacArthur. 2003. Synchrony between caribou calving and plant phenology in depredated and non-depredated populations. Canadian Journal of Zoology 81: 1709-1714.

Rubin, E. S., W. M. Boyce, and V. C. Bleich. 2000. Reproductive strategies of desert bighorn sheep. Journal of Mammalogy 81: 769-786.

Wiggers, E. P., and S. F. Beckerman. 1993. Use of thermal infrared sensing to survey white-tailed deer populations. Wildlife Society Bulletin 21:263–268.

APPENDIX A

ADDITIONAL COMMENTS CONCERNING VEGETATION DATA COLLECTION

Nearly all studies involving the measurement of vegetation lack the power to separate means because of the large of amount of variation seen in plant communities. Additionally, traditional F-testing may not be possible because assumptions of normality and homogeneity between group variance may not be met. It is crucial for investigators to practice and refine field techniques to reduce sampling error, as well as, to go to the field and conduct presampling. Analyzing data collected during presampling will allow investigators to identify variables with lots of variation and calculate an estimated sample size needed to achieve a certain degree of confidence. It may be necessary to adjust field techniques in order to reduce variance.

Unfortunately for my study, the only presampling conducted was to evaluate the amount time a vegetation plot took. Below, I list each parameter I measured while studying fawn parturition sites and day time bed sites, describe the technique I used to measure the parameter, and make suggestions as to whether the technique should be employed in future studies.

- **Elevation:** I simply recorded this information from a Garmen Model 76 GPS unit. I found this to be reliable. I took a waypoint, which records elevation, when I visited the fawn initially, and checked it again when I returned to conduct my vegetation plot. The unit was very precise, within two meters of its original reading. This is probably the easiest way for researchers to record elevation.
- **Percent canopy cover:** I laid on my back and placed my head in the bed site. Looking straight up and using an ocular made from PVC pipe (6” long, 2”

diameter) with 5×5 grid (quarter-inch hail screen) placed in the end, I counted the number of grid cells that where ≥ 50% covered by vegetation. I did this because I concerned with what was directly above the fawn. Although I was able to detect differences between species, I do not recommend using this method in future studies. It is problematic because it is difficult to know if you are looking directly up, wind greatly affects your ability to count grid cells because leaves and limbs move, and lying on your back several times a day under and around thorny shrubs and cacti with ants and chiggers is not desirable.

- **Horizontal cover:** I used a cover board (200cm×30cm) with ten, 20-cm strips to estimate the height of hiding cover. I recorded the percent of each strip visible and the lowest strip at which the board was no longer 50% covered from 5 meters in each of the 4 cardinal directions. I averaged the 4 heights at which the board was no longer 50% hidden to determine height of hiding cover for each bed site. This technique has been used by many studies before and I would recommend it to describe hiding cover.
- **Distance from shrub:** I used a 50m tape to measure from the center of the bed site to the base of the nearest shrub. Shrubs were considered any woody vegetation greater than 0.5 m tall. This technique is accurate and easy. I was unable to identify differences between mule deer and white-tailed deer fawns because of a high degree of variance, but this is probably because the to species bed similar distances from shrubs, not because my method could not detect the difference. I believe this method could be used in future studies, but the

information gained may be hard to extrapolate to management goals. Shrub density may be more informative.

- **Shrub height:** My study site had many sprouting shrubs, so I considered any shrub touching the nearest shrub (as described above) as part of a “shrub complex” which from the fawn’s point of view acted as one large shrub. I used the tape measure for short shrubs and the cover board for taller ones to determine height of the shrub complex. This technique worked well for me, but my study area has short shrubs and fawns rarely bedded under shrubs or trees taller than 4 meters. This information may be beneficial for describing a fawn’s actual bed site, but may be hard to write into management plans.
- **Shrub radius:** As described above, sprouting shrubs were considered as a complex. My technician held the tape measure in the center of the bed site, while I measured to the center of the shrub complex. This method is somewhat subjective because the complex is not perfectly round, which may add to the data’s variance. There is also a lot of variation associated with the parameter itself. A large sample size may be required to separate means. My birth site samples of 24 and 21 were not large enough detect differences between species. I was also unable to detect differences for bed sites (samples of 121 and 128), although I did not consider this parameter for my modeling. If the objective of any future study is to describe bed sites, then these data will provide you with that opportunity. Information of this nature may be beneficial in management plans, explaining which shrubs of what size should be removed.

- **Slope:** I measured slope with the clinometer inside my compass. This was the general slope of the area. If the area was flat and I could not visibly detect a slope, then I placed the compass on the ground in the bed site to take a reading. If there was noticeable slope then I would hold the compass out and align the bottom with the slope of the landscape to take a reading. I was able to detect statistical differences between species, but the average for each species is only 4° different therefore one must wonder if it is truly biologically significant. Slope is easily measured and in certain landscapes it may be very important. I would recommend taking this reading in future studies, but carefully consider if your findings are really biologically meaningful.
- **Shading potential:** I took this reading with an incident light meter. I took readings in the shade of the bed site and again out in the open sunlight. Subtracting the full sun value from the shade value gives you the amount of light blocked by the bush. I thought this parameter might be of interest given the intensity of Texas summers. I thought it might be able to be used as an index for thermal cover of a bed site. This parameter revealed no differences and provided little information. Furthermore, it relies on too many assumptions; temperature on observation day must be similar to the vegetation plot day (otherwise a shade index is worthless), cloud cover needs to be similar, time of day needs to be similar, and it assumes fawns place themselves in the best possible shade within a bed site. It should not be used in future studies.

- **Aspect:** I also recorded data on aspect. If a bed site had slope as defined by the clinometer, then I recorded the aspect to nearest cardinal direction using my compass. North would be considered 315° to 45°, east 46° to 135°, and so on. Aspect is easily recorded, but in areas with little topographical relief, it will provide you with little biologically significant data.
- **Canopy species:** I recorded what type of shrub a fawn bedded under (as seen through the ocular tube during percent canopy cover collection), or if it did not bed under a shrub I recorded it as "herbaceous." For analyses, I used groups: herbaceous, mesquite, juniper, tarbush, and other. If a species of shrub appeared 10% of the time in bed sites I gave it its own class, otherwise it was considered "other." This is meaningful information and should be recorded in future studies. I found that mule deer used a lot of juniper for birth sites and never once used mesquite, while white-tailed deer used more mesquite and fewer junipers.
- **Vegetation type:** I categorized my study site into 8 broad vegetation classes based on their dominate shrubs. Every study area will be different with a different number and type of vegetation classes, but good broad scale information can be obtained by recording this data. Data about vegetation type are easily used in management plans. The use of aerial photos and GIS may help generate use versus availability information. Furthermore, if data are recorded for shrub density then vegetation types can be delineated not only from what shrubs are present, but also by how thick they are providing much more insight.

- **Additional comments:** All habitat studies would benefit from doing random vegetation plots to assess what is the availability of the parameters of interest compared to what the organisms are using. Logistically I was unable to perform the random plots and, therefore, can only report want was used, not what was selected or avoided.

APPENDIX B

DATA TABLES

Table B.1 Data collected at fawn bed sites in Crockett County, Texas, summer 2004.

	Fawn Id	Site	Deer Species	Shrub Ht.	Shrub Radius	Hiding Cover Ht.	Dist. to shrub	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
1	F03 A	B-F03 2	M	1.50	190.00	70.00	110.00	875.00	.92	89324.24	0	na	Juniper mix	Juniper
2	F03 A	B-F03 3	M	1.00	24.00	35.00	43.00	868.00	.16	61075.50	4	E	Juniper mix	Juniper
3	F03 B	B-F03B	M	1.50	164.00	95.00	115.00	864.00	.64	82312.20	12	W	Juniper-Mesquite	Juniper
4	F03 B	B-F03B 2	M	1.50	214.00	90.00	89.00	873.00	.00	83022.55	7	W	Juniper mix	Juniper
5	F03 B	B-F03B 3	M	1.50	181.00	30.00	77.00	864.00	.72	67438.45	4	E	Juniper mix	Juniper
6	F08 A	B-F08 2	W	1.00	26.00	50.00	26.00	759.00	.56	68673.59	3	S	Tarbush-Juniper	Catclaw acacia
7	F08 A	B-F08 3	W	.00	.00	35.00	384.00	754.00	.00	45392.19	0	na	Mesquite mix	Herb
8	F10 A	B-F10 2	W	5.00	166.00	5.00	166.00	745.00	.00	5118.56	0	na	Tarbush-Mesquite	Bare Ground
9	F10 A	B-F10 3	W	1.50	75.00	45.00	30.00	742.00	.64	62998.04	0	na	Mesquite mix	Mesquite
10	F10 A	B-F10 4	W	.50	66.00	20.00	53.00	755.00	.00	44124.22	11	N	Juniper-Mesquite	Catclaw acacia
11	F10 A	B-F10 5	W	2.50	146.00	75.00	71.00	744.00	.84	68374.83	4	E	Mesquite mix	Mesquite
12	F10 A	B-F10 6	W	.00	.00	20.00	209.00	751.00	.00	57626.53	0	na	Mesquite mix	Herb
13	F10 A	B-F10 7	W	2.00	104.00	10.00	32.00	748.00	.88	18571.98	4	W	Mesquite mix	Mesquite
14	F10 A	B-F10 8	W	1.00	69.00	30.00	56.00	752.00	.00	62082.50	0	na	Mesquite mix	mesquite
15	F12 A	B-F12 11	W	3.00	166.00	150.00	68.00	756.00	.08	3370.80	4	E	Even stand mix	Algarita
16	F12 A	B-F12 2	W	.50	105.00	70.00	66.00	758.00	.12	73056.12	0	na	Juniper-Mesquite	Juniper
17	F12 A	B-F12 4	W	.00	.00	65.00	102.00	751.00	.24	40960.00	4	E	Mesquite mix	Herb
18	F12 A	B-F12 5	W	1.00	29.00	45.00	62.00	750.00	.00	52438.71	2	N	Mesquite mix	Ephedra
19	F12 A	B-F12 6	W	1.50	69.00	35.00	28.00	749.00	.20	66879.80	0	na	Tarbush-Mesquite	Mesquite
20	F12 A	B-F12 7	W	.00	.00	40.00	142.00	752.00	.12	62585.84	1	E	Mesquite mix	Herb
21	F12 A	B-F12 8	W	1.50	52.00	75.00	51.00	754.00	.44	59783.84	0	na	Tarbush-Mesquite	Tarbush
22	F12 A	B-F12 9	W	2.00	108.00	105.00	34.00	759.00	.20	80558.91	2	N	Mesquite mix	Mesquite
23	F13 A	B-F13 2	M	.00	.00	30.00	108.00	785.00	.00	66399.06	0	na	Tarbush-Mesquite	Herb
24	F13 A	B-F13 3	M	1.00	56.00	40.00	56.00	798.00	.04	54305.80	8	S	Juniper mix	Juniper
25	F13 B	B-F13B 2	M	.50	36.00	20.00	35.00	784.00	.00	80558.91	4	E	Tarbush-Mesquite	Tarbush

Table B.1 continued.

	Fawn Id	Site	Deer Species	Shrub Ht.	Shrub Radius	Hiding Cover Ht.	Dist. to shrub	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
26	F13 B	B-F13B 3	M	2.00	158.00	85.00	158.00	789.00	.88	47867.68	10	E	Juniper mix	Juniper
27	F24 A	B-F24 2	M	1.00	38.00	40.00	38.00	761.00	.16	52141.93	0	na	Tarbush-Mesquite	mesquite
28	F24 B	B-F24B 2	M	1.00	17.00	80.00	17.00	753.00	.00	89092.68	4	S	Tarbush-Mesquite	lotebush
29	F25 A	B-F25 2	M	2.00	147.00	50.00	147.00	835.00	.08	8231.22	8	S	Yucca Mix	Juniper
30	F25 A	B-F25 3	M	.50	57.00	10.00	57.00	840.00	.00	4437.23	2	E	Yucca Mix	P Broomweed
31	F27 A	B-F27 2	M	2.00	156.00	115.00	31.00	820.00	.56	21296.73	26	N	Even stand mix	TX persimmon
32	F27 A	B-F27 3	M	1.00	40.00	15.00	97.00	848.00	.00	46839.68	5	N	Yucca Mix	Sotol
33	F28 A	B-F28 2	W	1.00	132.00	70.00	61.00	768.00	.04	69313.08	0	na	9	Creosote
34	F28 A	B-F28 3	W	1.00	137.00	10.00	28.00	763.00	.56	78885.24	7	S	Tarbush mix	Juniper
35	F28 A	B-F28 4	W	1.00	96.00	80.00	42.00	758.00	.92	69313.08	5	N	Tarbush mix	Tarbush
36	F28 A	B-F28 5	W	2.00	155.00	110.00	33.00	769.00	.68	75164.12	0	na	Juniper mix	Juniper
37	F28 A	B-F28 6	W	.50	78.00	35.00	22.00	777.00	.00	75616.54	5	E	Tarbush-Juniper	Tarbush
38	F28 A	B-F28 7	W	1.00	47.00	60.00	15.00	758.00	.08	66195.50	2	W	Mesquite mix	P Broomweed
39	F28 A	B-F28 8	W	.50	109.00	45.00	43.00	780.00	.04	58222.25	4	W	Tarbush-Mesquite	P Broomweed
40	F32 A	B-F32 2	W	.50	31.00	45.00	38.00	755.00	.00	48650.14	4	W	Juniper mix	Choilla
41	F32 A	B-F32 3	W	3.00	140.00	85.00	22.00	761.00	.96	78768.27	0	na	Tarbush mix	mesquite
42	F32 A	B-F32 4	W	2.00	162.00	90.00	67.00	752.00	.68	29101.76	8	W	Juniper-Mesquite	mesquite
43	F32 A	B-F32 5	W	2.00	108.00	90.00	108.00	775.00	.56	66399.06	4	S	Juniper mix	Juniper
44	F32 A	B-F32 6	W	1.50	130.00	85.00	106.00	752.00	.92	30071.82	10	W	Juniper-Mesquite	Algarita
45	F32 A	B-F32 7	W	.00	.00	15.00	194.00	770.00	.00	11365.62	0	na	Juniper mix	Herb
46	F32 A	B-F32 8	W	2.00	85.00	55.00	26.00	757.00	.32	71680.00	4	W	Juniper-Mesquite	lotebush
47	F33 A	B-F33S 2	M	1.00	25.00	65.00	25.00	777.00	.36	28813.27	3	S	Tarbush-Mesquite	Castela texana
48	F33 B	B-F33S 2	M	1.00	25.00	65.00	25.00	777.00	.36	28813.27	3	S	Tarbush-Mesquite	Castela texana
49	F35 A	B-F35 2	M	1.50	85.00	85.00	25.00	819.00	.84	49589.83	32	W	Even stand mix	TX persimmon
50	F35 B	B-F35B 2	M	2.00	323.00	100.00	63.00	789.00	.88	1297.29	6	E	Juniper mix	Juniper
51	F37 A	B-F37 2	M	.00	.00	5.00	126.00	846.00	.00	12541.98	0	na	Yucca Mix	Herb
52	F37 B	B-F37B 2	M	.50	18.00	5.00	366.00	846.00	.00	8274.62	0	na	Yucca Mix	Bare Ground

Table B.1 continued.

	Fawn Id	Site	Deer Species	Shrub Ht.	Shrub Radius	Hiding Cover Ht.	Dist. to shrub	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
53	F37 C	B-F37C 2	M	.50	31.00	20.00	282.00	846.00	.00	12177.71	0	na	Yucca Mix	Herb
54	F39 A	B-F39 2	M	1.00	85.00	40.00	85.00	803.00	.04	18507.88	4	S	Juniper mix	Sotol
55	F41 A	B-F41 2	M	.00	.00	35.00	96.00	848.00	.00	86340.90	18	E	Juniper-Mesquite	P. Broomweed
56	F41 B	B-F41B 2	M	2.00	123.00	50.00	123.00	848.00	.16	94551.89	10	N	Juniper mix	Sotol
57	F43 A	B-F43 2	M	1.00	31.00	20.00	31.00	747.00	.20	78885.24	2	S	Tarbush-Mesquite	Tarbush
58	F43 B	B-F43B 2	M	1.00	32.00	55.00	32.00	750.00	.40	83861.37	6	W	Even stand mix	Tarbush
59	F44 A	B-F44 2	M	.50	89.00	45.00	32.00	781.00	.36	69678.18	9	E	Tarbush mix	Tarbush
60	F44 A	B-F44 3	M	3.00	171.00	60.00	41.00	768.00	.96	76432.52	2	N	Tarbush-Mesquite	Juniper
61	F44 A	B-F44 4	M	2.00	88.00	120.00	61.00	784.00	.84	8868.32	0	na	Tarbush-Mesquite	Mesquite
62	F46 A	B-F46 1	W	1.00	120.00	90.00	47.00	739.00	.08	76037.01	0	na	Mesquite mix	Algarita
63	F46 A	B-F46 2	W	1.50	67.00	60.00	23.00	745.00	1.00	38018.51	0	na	Tarbush-Mesquite	Mesquite
64	F46 A	B-F46 3	W	2.00	205.00	100.00	28.00	744.00	.76	32729.55	0	na	Mesquite mix	Mesquite
65	F46 A	B-F46 4	W	.50	72.00	45.00	20.00	751.00	.20	75192.76	0	na	Tarbush mix	Tarbush
66	F46 A	B-F46 6	W	3.00	199.00	70.00	18.00	747.00	.92	82312.20	0	na	Juniper-Mesquite	Mesquite
67	F46 A	B-F46 7	W	1.50	90.00	75.00	47.00	761.00	.88	48165.71	0	na	Tarbush-Mesquite	Algarita
68	F46 B	B-F46B 2	W	2.00	35.00	45.00	76.00	742.00	.00	66194.06	2	W	Mesquite mix	Herb
69	F46 B	B-F46B 3	W	2.50	177.00	30.00	224.00	741.00	.52	40960.00	0	na	Mesquite mix	Mesquite
70	F46 B	B-F46B 4	W	2.00	263.00	70.00	33.00	755.00	.80	69086.89	0	na	Tarbush-Mesquite	Juniper
71	F46 B	B-F46B 5	W	2.00	43.00	115.00	29.00	750.00	.16	83919.45	0	na	Tarbush mix	Mesquite
72	F46 B	B-F46B 6	W	1.50	162.00	50.00	38.00	759.00	.00	85186.93	3	E	Tarbush mix	Tarbush
73	F46 B	B-F46B 7	W	3.00	229.00	100.00	39.00	754.00	.68	88981.37	6	E	Tarbush-Mesquite	Mesquite
74	F46 B	B-F46B 8	W	2.00	88.00	125.00	37.00	759.00	.88	49269.92	8	S	Tarbush mix	mesquite
75	F51 A	B-F51 10	W	.50	31.00	45.00	92.00	773.00	.00	72553.83	0	na	Tarbush-Mesquite	Juniper
76	F51 A	B-F51 11	W	1.00	31.00	50.00	35.00	781.00	.00	73005.56	0	na	Tarbush-Mesquite	Mesquite
77	F51 A	B-F51 12	W	3.50	130.00	75.00	88.00	779.00	.92	56757.81	0	na	Tarbush-Mesquite	Juniper
78	F51 A	B-F51 2	W	2.00	190.00	150.00	24.00	769.00	.96	3226.42	8	E	Mesquite mix	Mesquite
79	F51 A	B-F51 3	W	1.50	56.00	55.00	56.00	782.00	.48	83919.45	2	S	Tarbush-Mesquite	Mesquite

Table B.1 continued.

	Fawn Id	Site	Deer Species	Shrub Ht.	Shrub Radius	Hiding Cover Ht.	Dist. to shrub	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
80	F51 A	B-F51 4	W	1.00	36.00	45.00	36.00	780.00	.72	20669.92	0	na	Mesquite mix	Mesquite
81	F51 A	B-F51 5	W	3.00	137.00	90.00	137.00	771.00	.64	13580.82	4	E	Mesquite mix	Mesquite
82	F51 A	B-F51 6	W	2.50	210.00	25.00	109.00	774.00	.80	83022.55	0	na	Tarbush-Mesquite	Juniper
83	F51 A	B-F51 7	W	3.00	32.00	40.00	35.00	775.00	.80	4819.80	8	N	Mesquite mix	Mesquite
84	F51 A	B-F51 8	W	1.00	58.00	80.00	31.00	781.00	.00	91940.91	1	N	Mesquite mix	Mesquite
85	F51 A	B-F51 9	W	2.50	125.00	105.00	34.00	781.00	.60	7720.16	4	N	Mesquite mix	Mesquite
86	F52 B	B-F52B 1	M	2.50	139.00	90.00	33.00	770.00	1.00	79979.88	4	E	Mesquite mix	Mesquite
87	F52 B	B-F52B 2	M	1.00	40.00	15.00	140.00	774.00	.00	56706.16	0	na	Mesquite mix	Prickly pear
88	F52 B	B-F52B 3	M	3.00	188.00	70.00	72.00	768.00	.92	42929.78	0	na	Juniper-Mesquite	Juniper
89	F56 A	B-F56 2	M	1.00	22.00	25.00	22.00	808.00	.00	24082.85	11	N	Juniper-Mesquite	Juniper
90	UC 1	B-UC1	W	2.00	98.00	40.00	98.00	758.00	.04	64074.73	0	na	Mesquite mix	Mesquite
91	UC 2	B-UC2	W	2.50	77.00	85.00	54.00	746.00	.68	47431.20	0	na	Tarbush-Mesquite	Mesquite
92	UC 3	B-UC3	W	1.50	138.00	55.00	71.00	745.00	.76	64074.73	8	E	Tarbush-Mesquite	Catclaw acacia
93	UC 4	B-UC4	W	2.00	89.00	75.00	87.00	745.00	.48	60913.13	0	na	Mesquite mix	mesquite
94	F01 A	BC-F01S	M	1.00	47.00	65.00	47.00	861.00	.00	46101.66	17	N	Juniper mix	Juniper
95	F01 B	BC-F01S	M	1.00	47.00	65.00	47.00	861.00	.00	46101.66	17	N	Juniper mix	Juniper
96	F03 A	BC-F03	M	2.00	93.00	20.00	93.00	871.00	.88	84179.30	0	na	Juniper mix	Juniper
97	F06 A	BC-F06S	M	.00	.00	.00	64.00	828.00	.00	32017.62	4	W	Juniper-Mesquite	Herb
98	F06 B	BC-F06S	M	.00	.00	.00	64.00	828.00	.00	32017.62	4	W	Juniper-Mesquite	Herb
99	F08 A	BC-F08	W	.00	.00	95.00	78.00	755.00	.16	53932.80	0	na	Even stand mix	Herb
100	F10 A	BC-F10	W	.00	.00	25.00	265.00	745.00	.00	-5879.68	0	na	Mesquite mix	Herb
101	F12 A	BC-F12	W	2.50	53.00	130.00	36.00	759.00	.96	85239.68	8	W	Tarbush mix	Algarita
102	F13 A	BC-F13	M	1.00	69.00	.00	284.00	863.00	.00	40097.31	6	E	Juniper mix	Herb
103	F13 B	BC-F13B	M	1.00	69.00	15.00	283.00	861.00	.00	51018.78	6	E	Juniper mix	Herb
104	F14 A	BC-F14	W	1.00	111.00	15.00	53.00	755.00	.00	52141.93	0	na	Mesquite mix	mesquite
105	F19 A	BC-F19	W	3.00	69.00	60.00	31.00	758.00	1.00	10218.35	0	na	Mesquite mix	Mesquite
106	F24 A	BC-F24	M	1.00	27.00	55.00	27.00	755.00	.68	65459.10	3	S	Tarbush mix	Creosote
107	F24 B	BC-F24B	M	1.00	107.00	35.00	59.00	755.00	.72	73602.54	0	na	Tarbush mix	Mesquite

Table B.1 continued.

	Fawn Id	Site	Deer Species	Shrub Ht.	Shrub Radius	Hiding Cover Ht.	Dist. to shrub	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
108	F25 A	BC-F25	M	2.50	107.00	70.00	114.00	851.00	.52	42284.37	4	N	Yucca Mix	Juniper
109	F28 A	BC-F28	W	1.00	71.00	100.00	45.00	768.00	.00	73005.56	1	E	Mesquite mix	Catclaw acacia
110	F32 A	BC-F32	W	2.50	128.00	25.00	123.00	774.00	.80	40294.80	8	W	Juniper mix	Juniper
111	F33 A	BC-F33	M	.50	38.00	30.00	38.00	783.00	.00	7088.27	2	S	Tarbush mix	Tarbush
112	F33 B	BC-F33B	M	2.00	94.00	50.00	30.00	786.00	.48	7634.44	1	S	Tarbush-Mesquite	Mesquite
113	F35 A	BC-F35	M	1.50	160.00	135.00	154.00	862.00	.	54045.95	5	na	Juniper mix	Juniper
114	F35 B	BC-F35B	M	.50	57.00	100.00	39.00	823.00	.04	10292.34	32	W	Even stand mix	P Broomweed
115	F37 A	BC-F37	M	.50	58.00	5.00	191.00	843.00	.00	31292.92	6	W	Yucca Mix	Bare Ground
116	F37 B	BC-F37B	M	.50	37.00	20.00	89.00	848.00	.00	24285.99	1	S	Yucca Mix	sp dagger
117	F37 C	BC-F37C	M	1.00	76.00	35.00	59.00	844.00	.00	30456.56	0	S	Yucca Mix	Juniper
118	F39 A	BC-F39	M	1.00	57.00	40.00	57.00	809.00	.00	76037.01	10	W	Juniper mix	Juniper
119	F41 A	BC-F41	M	1.00	32.00	20.00	32.00	793.00	.00	70576.03	6	E	Even stand mix	Tarbush
120	F41 B	BC-F41B	M	1.00	37.00	35.00	37.00	795.00	.00	56757.81	7	S	Even stand mix	Tarbush
121	F43 A	BC-F43	M	.50	63.00	15.00	63.00	749.00	.00	85186.93	3	N	Tarbush-Mesquite	Tarbush
122	F43 B	BC-F43B	M	1.00	40.00	20.00	40.00	749.00	.28	83861.37	0	na	Tarbush-Mesquite	tarbush
123	F44 A	BC-F44	M	2.00	333.00	100.00	114.00	807.00	.84	81496.22	10	S	Juniper mix	Juniper
124	F44 B	BC-F44B	M	2.00	142.00	65.00	25.00	799.00	1.00	84179.30	12	S	Juniper mix	Juniper
125	F46 B	BC-F46B	W	1.50	133.00	20.00	17.00	742.00	.72	80589.61	6	E	Tarbush-Mesquite	Mesquite
126	F51 A	BC-F51	W	1.00	50.00	45.00	25.00	767.00	.68	15600.27	4	E	Mesquite mix	Mesquite
127	F53 A	BC-F53	M	.50	24.00	15.00	33.00	831.00	.00	444.02	6	W	Tarbush mix	Tarbush
128	F54 A	BC-F54	M	5.00	59.00	40.00	40.00	825.00	.64	913.18	0	na	Juniper-Mesquite	mesquite
129	F54 B	BC-F54B	M	5.00	59.00	40.00	40.00	825.00	.64	913.18	0	na	Juniper-Mesquite	mesquite
130	F56 A	BC-F56	M	.00	.00	.00	834.00	801.00	.00	13936.48	8	N	Juniper mix	Herb
Tot	N	130	130	130	130	130	130	130	130	129	130	130	130	130

Table B.2 Data collected at parturition sites in Crockett County, Texas, summer 2004.

	Adult Id	Deer Species	Shrub Ht (m)	Shrub radius (cm):	Hiding Cover Ht.	Dist. to shrub	Elevation:	% canopy	Shading potential	Slope:	Aspect:	Vegetation type	Canopy shrub
1	0104	M	2	116	40.00	116	859	.04	58605.19	2	E	Juniper mix	Juniper
2	0304	M	2	213	95.00	153	866	.64	83022.55	11	E	Juniper mix	Juniper
3	2404	M	3	102	65.00	57	751	1.00	67695.12	0	na	Tarbush mix	Juniper
4	2504	M	2	267	55.00	132	852	1.00	34204.12	8	W	Yucca mix	Juniper
5	2704	M	2	115	50.00	54	762	.00	28510.55	4	N	Tarbush mix	Tarbush
6	3304	M	3	266	65.00	62	787	.88	5263.78	2	S	Tarbush mix	Juniper
7	3704	M	3	197	100.00	78	843	.92	45132.61	2	E	Yucca mix	Juniper
8	4304	M	2	154	45.00	119	755	.00	5485.94	8	E	Tarbush Juniper	Mesquite
9	0804	W	4	91	20.00	91	755	.92	71314.06	2	N	Mesquite mix	Mesquite
10	2804	W	3	33	125.00	36	768	.88	43702.97	1	W	Tarbush mix	Mesquite
11	3204	W	4	69	.00	98	776	.88	76038.66	2	W	Juniper mix	Juniper
12	4604	W	1	89	30.00	65	751	.72	74159.53	0	na	Tarbush mix	Tarbush
13	4804	W	2	87	.00	87	763	.00	16167.85	0	na	Mesquite mix	Mesquite
Tot	13	13	13	13	13	13	13	13	13	13	13	13	13

Table B.3 Data collected at fawn bed sites in Crockett County, Texas, summer 2005.

	Fawn Id	Site	Deer Species	Shrub Ht. (m)	Shrub Radius (cm)	Hiding Cover Ht. (cm)	Dist. to shrub (cm)	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
1	F02 D	B-F02D 2	M	.00	.00	10.00	112.00	874.00	.00	35474.06	0	na	Tarbush-Juniper	HERB
2	F02 D	B-F02D 3	M	.50	37.00	70.00	214.00	871.00	.00	13389.31	3	N	Juniper mix	HERB
3	F03 D	B-F03D 2	M	3.00	235.00	30.00	76.00	867.00	.00	44490.68	8	W	Juniper mix	Juniper
4	F03 D	B-F03D 3	M	1.50	104.00	20.00	62.00	873.00	.00	16876.32	7	N	Juniper mix	Juniper
5	F03 E	B-F03E 2	M	.00	.00	20.00	189.00	873.00	.00	22268.44	6	N	Juniper mix	Bare ground
6	F06 D	B-F06D 2	M	2.00	151.00	30.00	87.00	870.00	.40	55697.58	5	E	Juniper-Mesquite	Juniper
7	F07 D	B-F07D 2	W	3.50	334.00	25.00	75.00	812.00	.60	60004.38	4	S	Even stand mix	Juniper
8	F07 D	B-F07D 3	W	1.00	61.00	80.00	54.00	820.00	.44	49011.75	3	S	Juniper-Mesquite	Algarita
9	F07 D	B-F07D 4	W	2.00	93.00	20.00	45.00	817.00	.00	43898.95	2	S	Juniper-Mesquite	Mes
10	F07 D	B-F07D 5	W	1.00	63.00	10.00	38.00	828.00	.48	35497.84	21	E	Juniper mix	Juniper
11	F07 E	B-F07E 2	W	2.00	81.00	65.00	53.00	803.00	.56	48039.11	6	S	Juniper-Mesquite	Mes
12	F07 E	B-F07E 3	W	2.00	73.00	30.00	94.00	811.00	.56	45448.82	3	S	Juniper-Mesquite	Mes
13	F07 E	B-F07E 4	W	4.00	208.00	20.00	46.00	817.00	.96	63795.98	4	S	Juniper-Mesquite	Mes
14	F07 E	B-F07E 5	W	2.50	22.00	100.00	71.00	811.00	.00	58779.25	3	S	Juniper-Mesquite	HERB
15	F08 E	B-F08E 2	W	3.00	191.00	25.00	156.00	757.00	.00	8822.00	4	W	Mesquite mix	Mes
16	F08 E	B-F08E 3	W	3.00	266.00	105.00	57.00	757.00	.24	13483.20	0	na	Mesquite mix	Mes
17	F11 D	B-F11D 2	W	1.00	102.00	40.00	29.00	786.00	.00	86860.60	4	N	Juniper-Mesquite	Ephedra
18	F15 D	B-F15D 2	W	1.50	66.00	10.00	33.00	792.00	.72	69678.18	2	S	Tarbush mix	Mes
19	F15 D	B-F15D 3	W	.00	.00	70.00	287.00	789.00	.00	49589.83	3	S	Juniper-Mesquite	HERB
20	F15 D	B-F15D 4	W	1.50	43.00	30.00	32.00	784.00	.80	49233.39	8	S	Mesquite mix	Mes
21	F15 D	B-F15D 5	W	3.50	406.00	10.00	54.00	795.00	.68	9822.55	2	S	Juniper-Mesquite	Juniper
22	F15 D	B-F15D 6	W	3.00	148.00	70.00	141.00	794.00	.44	71314.06	0	na	Mesquite mix	Mes
23	F17 D	B-F17D 2	M	1.00	93.00	5.00	92.00	875.00	.00	52529.49	4	N	Juniper mix	Juniper
24	F18 D	B-F18D 2	W	.50	54.00	60.00	23.00	766.00	.60	38412.36	2	E	Juniper-Mesquite	P. Broomweed
25	F18 D	B-F18D 4	W	1.50	118.00	35.00	18.00	792.00	.00	75164.12	2	E	Even stand mix	Mes
26	F18 E	B-F18E 2	W	.00	.00	15.00	134.00	763.00	.00	49608.72	2	E	Juniper-Mesquite	HERB

Table B.3 continued.

	Fawn Id	Site	Deer Species	Shrub Ht. (m)	Shrub Radius (cm)	Hiding Cover Ht. (cm)	Dist. to shrub (cm)	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
27	F18 E	B-F18E 3	W	2.50	127.00	5.00	39.00	773.00	.80	68374.83	2	E	Juniper-Mesquite	Mes
28	F18 E	B-F18E 4	W	1.50	91.00	120.00	43.00	777.00	.80	80805.70	2	E	Juniper-Mesquite	Juniper
29	F18 E	B-F18E 5	W	1.00	49.00	40.00	29.00	797.00	.52	35474.06	2	E	Even stand mix	P. Broomweed
30	F19 D	B-F19D 2	W	3.50	285.00	30.00	15.00	752.00	.56	49365.58	2	S	Tarbush-Mesquite	Mes
31	F19 D	B-F19D 3	W	1.50	135.00	70.00	6.00	748.00	1.00	65167.85	0	na	Mesquite mix	Algarita
32	F19 D	B-F19D 4	W	2.50	130.00	40.00	68.00	746.00	.68	62380.98	0	na	Mesquite mix	Mes
33	F19 D	B-F19D 5	W	.00	.00	30.00	269.00	749.00	.00	65012.04	2	S	Mesquite mix	HERB
34	F20 D	B-F20D 2	W	1.50	28.00	55.00	18.00	755.00	.32	30709.86	2	W	Tarbush-Mesquite	Mes
35	F20 D	B-F20D 3	W	.50	65.00	25.00	26.00	754.00	.04	37143.96	1	W	Tarbush-Mesquite	Lycium macrodon
36	F20 D	B-F20D 4	W	1.00	68.00	20.00	48.00	751.00	.08	42273.56	1	W	Tarbush-Mesquite	Tarbush
37	F21 D	B-F21D 1	W	.00	.00	85.00	254.00	768.00	.00	54484.14	0	na	Juniper-Mesquite	HERB
38	F21 D	B-F21D 2	W	2.00	108.00	70.00	59.00	762.00	.52	45474.82	23	W	Mesquite mix	Catclaw
39	F21 D	B-F21D 4	W	3.00	223.00	165.00	32.00	765.00	.24	25342.71	13	S	Juniper mix	Juniper
40	F21 D	B-F21D 5	W	1.00	27.00	65.00	25.00	765.00	.48	30537.75	2	E	Mesquite mix	Mes
41	F22 D	B-F22D 2	M	1.50	77.00	60.00	29.00	765.00	.48	37808.27	3	E	Tarbush-Mesquite	Mes
42	F22 D	B-F22D 3	M	.50	71.00	95.00	44.00	769.00	.00	62919.33	2	E	Tarbush-Mesquite	Mes
43	F22 E	B-F22E 2	M	1.00	36.00	60.00	54.00	770.00	.56	48487.56	2	E	Tarbush mix	Catclaw
44	F25 D	B-F25D 2	M	2.00	198.00	15.00	64.00	821.00	.84	56833.96	21	N	Juniper mix	Juniper
45	F27 D	B-F27D 2	M	1.00	43.00	10.00	56.00	752.00	.00	9704.42	0	na	Mesquite mix	Tasajillo
46	F27 E	B-F27E 2	M	.50	12.00	35.00	40.00	751.00	.00	9399.10	0	na	Mesquite mix	HERB
47	F34 D	B-F34D 2	M	2.00	146.00	25.00	35.00	768.00	.60	58708.58	0	na	Even stand mix	Hackberry
48	F34 D	B-F34D 3	M	2.00	71.00	25.00	42.00	771.00	.48	73493.39	0	na	Mesquite mix	Mes
49	F34 E	B-F34E 2	M	2.50	194.00	20.00	59.00	813.00	.92	62380.98	30	S	Yucca Mix	Juniper
50	F34 E	B-F34E 3	M	1.00	71.00	.00	39.00	772.00	.00	65828.02	0	na	Even stand mix	Tasajillo
51	F34 E	B-F34E 4	M	4.50	173.00	80.00	62.00	770.00	.88	75239.78	0	na	Even stand mix	Juniper
52	F39 D	B-F39D 2	M	.00	.00	55.00	99.00	845.00	.00	39271.03	22	W	Juniper mix	HERB
53	F39 D	B-F39D 3	M	1.50	103.00	35.00	89.00	855.00	1.00	84647.95	3	S	Yucca Mix	Juniper
54	F39 E	B-F39E 2	M	.00	.00	15.00	107.00	845.00	.00	41511.28	22	W	Juniper mix	HERB

Table B.3 continued.

	Fawn Id	Site	Deer Species	Shrub Ht. (m)	Shrub Radius (cm)	Hiding Cover Ht. (cm)	Dist. to shrub (cm)	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
55	F39 E	B-F39E 3	M	2.00	134.00	40.00	50.00	855.00	.64	77462.78	3	S	Yucca Mix	Juniper
56	F43 E	B-F43E 2	M	.50	29.00	55.00	23.00	746.00	.00	1194.28	0	na	Even stand mix	Tarbush
57	F44 D	B-F44D 2	M	1.50	114.00	65.00	61.00	770.00	.00	76038.66	1	N	Mesquite mix	Algarita
58	F44 D	B-F44D 3	M	1.50	62.00	10.00	161.00	763.00	.00	58779.25	0	na	Juniper-Mesquite	HERB
59	F44 E	B-F44E 2	M	2.50	115.00	40.00	48.00	771.00	.00	69313.08	1	N	Mesquite mix	Mes
60	F44 E	B-F44E 3	M	.00	.00	70.00	677.00	764.00	.00	4455.97	0	na	Mesquite mix	Bare ground
61	F48 D	B-F48D 2	W	.50	39.00	35.00	23.00	764.00	.56	45650.55	2	E	Tarbush-Mesquite	Tarbush
62	F49 D	B-F48D 3	W	.00	.00	120.00	117.00	762.00	.00	70946.58	0	na	Tarbush-Mesquite	HERB
63	F48 E	B-F48E 2	W	1.50	171.00	30.00	71.00	766.00	.96	55537.62	2	E	Mesquite mix	Catclaw
64	F48 E	B-F48E 3	W	.00	.00	35.00	89.00	767.00	.00	35657.03	2	E	Even stand mix	P. Broomweed
65	F48 E	B-F48E 4	W	1.00	33.00	120.00	37.00	764.00	.00	65434.17	0	na	Even stand mix	Tarbush
66	F60 D	B-F60D 2	W	3.00	181.00	55.00	36.00	769.00	.84	28058.00	1	W	Juniper-Mesquite	Mes
67	F60 D	B-F60D 3	W	.50	37.00	115.00	19.00	773.00	.32	50895.31	5	W	Tarbush mix	Tasajillo
68	F60 D	B-F60D 4	W	.50	40.00	70.00	175.00	764.00	.00	42273.56	6	W	Juniper mix	HERB
69	F61 D	B-F61D 2	W	.50	26.00	40.00	17.00	749.00	.00	34869.32	0	na	Mesquite mix	Mes
70	F64 D	B-F64D 1	W	1.50	31.00	40.00	27.00	777.00	.	74992.85	2	E	Mesquite mix	Mes
71	F67 D	B-F67D 2	M	.50	32.00	30.00	25.00	793.00	.24	72275.33	2	S	Even stand mix	tarbush
72	UC 5	B-UC1 05	W	1.50	75.00	165.00	28.00	751.00	.44	53804.67	0	na	Mesquite mix	Catclaw
73	UC 6	B-UC3 05	W	.00	.00	60.00	90.00	744.00	.00	69970.81	0	na	Mesquite mix	HERB
74	F02 D	BC-F02D	M	.00	.00	50.00	402.00	878.00	.00	20887.83	4	S	Juniper mix	Bare ground
75	F03 D	BC-F03D	M	.50	60.00	100.00	65.00	874.00	.00	5118.56	0	na	Juniper mix	Bare ground
76	F03 E	BC-F03E	M	1.00	81.00	10.00	46.00	874.00	.04	66538.37	0	na	Juniper mix	Lotebush
77	F06 D	BC-F06D	M	.50	43.00	.00	46.00	857.00	.00	17539.33	8	W	Juniper mix	Juniper
78	F07 D	BC-F07D	W	1.00	19.00	45.00	31.00	807.00	.00	28813.89	6	S	Juniper-Mesquite	Tasajillo
79	F07 E	BC-F07E	W	.50	22.00	50.00	28.00	801.00	.00	51170.31	6	S	Juniper-Mesquite	Mes
80	F08 D	BC-F08D	W	4.00	243.00	55.00	136.00	756.00	.36	3652.73	0	na	Even stand mix	Mes
81	F11 D	BC-F11D	W	1.00	85.00	20.00	21.00	784.00	.72	91459.16	1	E	Mesquite mix	Mes

Table B.3 continued.

	Fawn Id	Site	Deer Species	Shrub Ht. (m)	Shrub Radius (cm)	Hiding Cover Ht. (cm)	Dist. to shrub (cm)	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
82	F13 D	BC-F13D	M	.00	.00	65.00	258.00	791.00	.00	46163.52	12	S	Juniper mix	HERB
83	F13 E	BC-F13E	M	1.50	148.00	60.00	39.00	791.00	.88	62919.33	12	S	Juniper mix	Juniper
84	F15 D	BC-F15D	W	.00	.00	65.00	517.00	802.00	.00	19836.25	0	na	Mesquite mix	HERB
85	F17 D	BC-F17D	M	1.50	151.00	.00	43.00	823.00	.44	59143.08	21	W	Juniper mix	Juniper
86	F17 E	BC-F17E	M	.50	36.00	15.00	29.00	809.00	.00	31041.88	9	W	Juniper mix	P. Broomweed
87	F18 D	BC-F18D	W	.00	.00	70.00	182.00	769.00	.00	44124.22	6	E	Juniper-Mesquite	HERB
88	F18 E	BC-F18E	W	.50	31.00	40.00	107.00	771.00	.00	38731.39	3	E	Juniper-Mesquite	HERB
89	F19 D	BC-F19D	W	3.00	198.00	80.00	33.00	750.00	.72	66538.37	0	na	Mesquite mix	Mes
90	F20 D	BC-F20D	W	.00	.00	35.00	28.00	741.00	.00	67519.62	0	na	Tarbush-Mesquite	HERB
91	F21 D	BC-F21D	W	.50	25.00	80.00	35.00	767.00	.00	71314.06	1	E	Juniper-Mesquite	Tasajillo
92	F22 D	BC-F22D	M	1.50	134.00	30.00	36.00	759.00	.92	69193.29	2	E	Even stand mix	Catclaw
93	F22 E	BC-F22E	M	1.00	25.00	15.00	48.00	763.00	.00	58708.58	2	E	Even stand mix	Goatbrush
94	F25 D	BC-F25D	M	.00	.00	95.00	16.00	843.00	.00	67585.49	3	E	Yucca Mix	Bare ground
95	F25 E	BC-F25E	M	.50	37.00	105.00	37.00	847.00	.04	43702.97	3	E	Yucca Mix	P. Broomweed
96	F27 D	BC-F27D	M	.50	21.00	30.00	26.00	759.00	.20	47743.58	0	na	Tarbush-Mesquite	Tarbush
97	F27 E	BC-F27E	M	.50	36.00	50.00	33.00	759.00	.52	60236.26	0	na	Tarbush-Mesquite	Tarbush
98	F33 D	BC-F33D	M	.50	21.00	90.00	43.00	853.00	.00	19009.67	27	E	Yucca Mix	Catclaw
99	F34 D	BC-F34D	M	.00	.00	25.00	102.00	786.00	.00	.00	7	S	Juniper-Mesquite	HERB
100	F34 E	BC-F34E	M	1.50	79.00	90.00	52.00	776.00	.00	5485.94	7	S	Juniper-Mesquite	Catclaw
101	F37 D	BC-F37D	M	.00	.00	20.00	74.00	843.00	.00	14350.31	8	N	Yucca Mix	Bare ground
102	F39 D	BC-F39D	M	1.50	126.00	10.00	102.00	806.00	.56	26883.73	6	W	Juniper mix	Juniper
103	F39 E	BC-F39E	M	1.50	156.00	50.00	117.00	806.00	.00	31777.52	6	W	Juniper mix	Juniper
104	F41 D	BC-F41D	M	.00	.00	40.00	175.00	795.00	.00	15263.06	2	S	Juniper-Mesquite	HERB
105	F41 E	BC-F41E	M	.00	.00	5.00	218.00	791.00	.00	6847.13	2	S	Juniper-Mesquite	HERB
106	F43 E	BC-F43E	M	.00	.00	.00	84.00	747.00	.00	3408.11	0	na	Even stand mix	HERB
107	F44 D	BC-F44D	M	.50	28.00	35.00	27.00	778.00	.00	68408.24	2	S	Tarbush mix	Tarbush
108	F44 E	BC-F44E	M	.50	27.00	50.00	19.00	773.00	.00	70157.33	2	S	Tarbush mix	Tarbush

Table B.3 continued.

	Fawn Id	Site	Deer Species	Shrub Ht. (m)	Shrub Radius (cm)	Hiding Cover Ht. (cm)	Dist. to shrub (cm)	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
109	F45 D	BC-F45D	M	.50	34.00	40.00	23.00	827.00	.00	67519.62	35	S	Yucca Mix	Mountain Laurel
110	F48 D	BC-F48D	W	.00	.00	30.00	91.00	757.00	.00	44546.34	0	na	Even stand mix	HERB
111	F48 E	BC-F48E	W	1.00	44.00	20.00	158.00	757.00	.00	32335.70	0	na	Even stand mix	HERB
112	F60 D	BC-F60D	W	.00	.00	5.00	84.00	754.00	.00	66538.37	1	E	Even stand mix	HERB
113	F61 D	BC-F61D	W	.00	.00	15.00	564.00	744.00	.00	24421.29	0	na	Mesquite mix	HERB
114	F63 D	BC-F63	W	.00	.00	40.00	31.00	764.00	.00	43671.79	0	na	Tarbush-Mesquite	Tasajillo
115	F65 D	BC-F65D	M	1.00	68.00	10.00	80.00	761.00	.	84179.30	1	E	Mesquite mix	Choilla
116	F68 D	BC-F68D	M	.50	52.00	.00	31.00	790.00	.40	19836.25	1	S	Tarbush mix	Tarbush
117	F68 E	BC-F68E	M	.00	.00	5.00	51.00	791.00	.00	52956.91	1	S	Tarbush mix	HERB
118	F71 D	BC-F71	M	.00	.00	15.00	76.00	770.00	.00	62811.48	0	na	Mesquite mix	HERB
119	F13 E	BM-F13E	M	1.00	126.00	10.00	27.00	852.00	.	28653.31	40	S	Even stand mix	Goatbrush
Tot	N	119	119	119	119	119	119	119	119	116	119	119	119	119

Table B.4 Data collected at parturition sites in Crockett County, Texas, summer 2005.

	Adult Id	Deer Species	Shrub Ht. (m)	Shrub Radius (cm)	Hiding Cover Ht. (cm)	Dist. to shrub	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
1	0104	M	1.5	104	70.00	115	864	.00	71656.93	17	E	juniper mix	juniper
2	0204	M	1.5	122	.00	79	873	.92	63599.05	3	SE	juniper mix	juniper
3	0304	M	2.5	225	5.00	245	874	.00	53169.31	0	NA	juniper mix	juniper
4	0604	M	2	126	75.00	213	852	.00	18091.44	16	N	juniper mix	Bare ground
5	0704	W	3	207	7.50	105	774	.68	26884.31	7	S	juniper mesquite	juniper
6	0804	W	3	211	10.00	88	758	.12	1940.12	0	NA	even stand	Little-leaf sumac
7	1104	W	3.5	238	.00	58	779	.28	70576.03	2	NE	mesquite mix	mesquite
8	1304	M	4	338	50.00	32	787	.72	42527.97	6	SE	juniper mix	juniper
9	1404	W	1.5	83	10.00	123	759	.00	6301.69	0	na	mesquite mix	buffalograss
10	1504	W	1.5	77	15.00	121	793	.00	.00	0	NA	mesquite mix	HERB
11	1604	M	1	30	65.00	93	800	.00	.00	1	N	juniper mesquite	HERB
12	1704	M	3	85	5.00	82	807	.44	47743.58	7	W	juniper mix	juniper
13	1804	W	3	171	160.00	75	774	.72	31041.25	2	E	mesquite mix	juniper
14	1904	W	3	261	65.00	345	754	.60	38217.03	0	NA	mesquite mix	mesquite
15	2004	W	1.5	47	30.00	70	748	.00	50878.12	2	SW	mesquite tarbush	HERB
16	2104	W	na	na	35.00	146	763	.00	5118.56	2	na	mesquite tarbush	buffalograss
17	2204	M	4	250	15.00	70	764	.88	66195.50	2	E	even stand	juniper
18	2304	W	3.5	170	120.00	65	755	1.00	24264.82	1	W	mesquite mix	hackberry/mes
19	2404	M	0.5	32	20.00	77	755	.00	11540.88	1	W	tarbush mix	Tarbush
20	2504	M	0.5	48	.00	56	847	.00	23866.72	3	NE	yucca mix	Bare ground
21	2704	M	0.5	18	5.00	71	759	.00	24264.82	0	NA	mesquite tarbush	Bare ground
22	2804	W	5	126	40.00	41	769	.88	50685.41	6	SW	even stand	juniper
23	3104	W	2	114	90.00	100	764	.00	52058.17	0	NA	mesquite mix	mesquite
24	3204	W	3.5	164	15.00	43	763	.84	58932.02	0	NA	tarbush mix	mesquite
25	3404	M	0.5	72	20.00	27	780	.00	46839.68	5	SW	tarbush mix	catclaw acacia
26	3904	M	1	108	70.00	219	805	.00	1978.75	6	W	juniper mix	Bare ground

Table B.4 continued.

	Adult Id	Deer Species	Shrub Ht. (m)	Shrub Radius (cm)	Hiding Cover Ht. (cm)	Dist. to shrub	Elevation	% canopy	Shading potential	Slope	Aspect	Vegetation type	Canopy shrub
27	4304	M	2	143	5.00	60	750	.00	2786.86	0	NA	even stand	Little-leaf sumac
28	4404	M	3.5	143	.00	40	767	.88	67695.12	2	SW	even stand	juniper
29	4504	M	1	24	60.00	39	829	.00	72275.33	35	S	yucca mix	Mountain Laurel
30	4804	W	0.5	23	40.00	127	761	.00	37808.27	0	NA	even stand	HERB
31	6005	W	7.5	291	.00	112	755	.84	33098.47	5	E	even stand	Hackberry
32	6105	W	2	138	.00	137	742	.00	11656.08	0	NA	mesquite mix	mesquite
Tot	32	32	32	32	32	32	32	32	32	32	32	32	32

PERMISSION TO COPY

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Texas Tech University or Texas Tech University Health Sciences Center, I agree that the Library and my major department shall make it freely available for research purposes. Permission to copy this thesis for scholarly purposes may be granted by the Director of the Library or my major professor. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my further written permission and that any user may be liable for copyright infringement.

Agree (Permission is granted.)

_David Alexander Butler___________________________ _16-Nov-06________
Student Signature Date

Disagree (Permission is not granted.)

____ ________________
Student Signature Date