WHITE-TAILED DEER OVERABUNDANCE: A THREAT TO REGENERATION OF GOLDEN-CHEEKED WARBLER HABITAT

THESIS

Presented to the Graduate Council of
Southwest Texas State University
in Partial Fulfillment of
the Requirements

For the Degree

Master of SCIENCE

By

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San Marcos, Texas
August 2003

ACKNOWLEDGMENTS

I would like to thank Dr. John Baccus for the acquisition of the Orion grant, which enabled funding for this study, and for his support, guidance, and patience, throughout this study.

I want to thank Dr. John Cornelius and Dr. John Morrill for the financial support through the Orion grant that supported me in a portion of my project.

I am also indebted to the Nurani Hogue and the staff of the Barton Creek Habitat Preserve for the use of their equipment and facilities as well as the Kerr Wildlife Management Area for housing.

I would also like to thank Dr. Simpson and Dr. Weckerly for their review and comments on the manuscript.

I thank my fellow students: Kyle Burke, Shane Kiefer, Jennifer Mittlehauser; Charles Pekins and other staff members from Fort Hood who donated their time and effort in assisting me in data collection; as well as Bob Stafford for his help and advice using Geographic Information Systems.

I would like to give special recognition to my parents, along with Dr. Willoughby for his guidance and support.

I would especially like to thank Jennifer Wendel for her help on this project. Day after day she helped me carry heavy equipment and set up stations in some of the worst vegetation imaginable on some of the steepest terrain in the Hill Country, in the summer months of June through August without one complaint.

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ABSTRACT

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August 2001

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Texas oak (*Quercus buckleyi*), found throughout the Hill Country is a preferred browse species of white-tailed deer (*Odocoileus virginianus*) and an important component of golden-cheeked warbler (*Dendroica chrysoparia*) habitat. Degradation of Texas oak populations by overabundance of white-tailed deer will most likely affect the structure of Hill Country forests by curtailing recruitment of Texas oak, thus reducing the replacement of older trees and ultimately altering golden-cheeked warbler habitat. Objectives of my study were to develop a baseline vegetative analysis of golden-cheeked warbler habitat at Barton Creek Habitat Preserve, an area with a high density of deer, and to compare Texas oak seedling recruitment in areas with low and moderate densities of deer to seedling recruitment at Barton Creek Habitat Preserve. A baseline vegetational survey included: counting Texas oak seedlings in 50 stations in areas of golden-cheeked warbler habitat. Stations consisted of 21 1 m^2 rectangular quadrats placed at 5 m intervals along 4 transects each 25 m long that radiated in the 4 cardinal directions from a center point. To ascertain Texas oak recruitment, at other sites with low and moderate deer densities, Texas oak seedlings were counted at 50 stations on Training Area 13B at Fort Hood, Texas and Spring Pasture at Kerr Wildlife Management Area using the same methodology.

The fewest number of seedlings occurred at Barton Creek Habitat Preserve, the site with the highest white-tailed deer density (1 deer/2.67 ha). The mean number of seedlings was 1.56 per m^2. Many stations did not have any seedling recruitment. The majority of stations contained 1 –7 Texas oak seedlings per m^2 with 1 station having a quadrat containing13. Spring Pasture on the Kerr WMA had a moderate amount of Texas oak seedlings (9.04 seedlings per m^2) and a moderate deer density (1 deer/4.59 ha).

All stations contained seedling recruitment. Texas oak seedling recruitment at stations ranged from 1 –27 per m^2. Fort Hood had the most Texas oak seedling per station (33.7) and the lowest deer density (1 deer/24.28 ha). All stations contained seedling recruitment. Texas oak seedling recruitment at stations ranged from 3 –91. At Barton Creek Habitat Preserve understory vegetative density and canopy cover were measured.

INTRODUCTION

The Edwards Plateau Ecological Region, commonly referred to as the Texas Hill Country, contains about 1.6 million white-tailed deer (*Odocoileus virginianus*) (Beechnoir 1986). This constitutes not only the highest density of deer in all the ecological regions of Texas, but also in the nation (Beechnoir 1986). Reduction of white-tailed deer abundance in the Hill Country generally has been unsuccessful, especially outside of high-fenced areas. Objectives in the majority of wildlife management plans do not generally address problems at the ecosystem level. Typically, ecologists and wildlife biologists recommend deer densities of about 1 deer/4 ha. This density should enhance the health of deer and provide more diverse plant communities (Russel 1999). However, much of the Hill Country contains high deer densities of about 1 deer/1.62 ha.

The general public, especially those individuals with anti-hunting sentiments, lacks an understanding of habitat and ecosystem problems created by an overabundance of deer. This is a major impediment in implementation of sound management practices. The encroaching housing developments and resulting urban sprawl by human populations compresses already overabundant deer populations into smaller areas of available habitat. This results in a more concentrated use on plant communities. Although the white-tailed deer is the most popular game species in Texas, bag limits available to hunters and the actual harvest have not significantly reduced the abundance of white-tailed deer in the Edwards Plateau.

White-tailed deer are primarily browsers (Putman 1988). The effect of deer herbivory on plant communities is a function of the carrying capacity of the habitat and the abundance of deer. Overabundance of white-tailed deer may create serious adverse effects on ecosystems by altering plant community composition and structure. Foraging selectivity and nutrient requirements of white-tailed deer demonstrate certain trends in plant herbivory (Russell 1999). Healy (1997) reported a deer density of 10–17 deer/km^2 in central Massachusetts significantly changed the composition and structure of oak forests by preventing regeneration of oak seedlings, a preferred forage plant of white-tailed deer. Eastern white pine (*Pinus strobus*), red maple (*Acer rubrum*), and sweet birch (*Betua lenta*) became more prominent as abundance of mature oaks decreased. A deer density of 3–6 deer/km^2 allowed the physiognomy, species composition, and diversity of the forest to remain unchanged. Similar effects of vegetational decimation by white-tailed deer predation are likely occurring in the Hill Country.

One woody plant preferred by white-tailed deer is Texas oak (*Quercus buckleyi*) (Beardmore 1994). Degradation of Texas oak populations by high densities of deer may affect the structure of Hill Country forests by curtailing recruitment of this species, thus reducing the replacement of older trees. If Texas oak recruitment does not replace dead trees, the species may decrease drastically in Hill Country forests.

Long-term results of Texas oak reduction in the Hill Country due to herbivory by white-tailed deer may effect other indigenous species. One species that may be affected by the disappearance of Texas oak is the golden-cheeked warbler (*Dendroica chrysoparia*) (GCW), an endangered species. During breeding and nesting seasons, GCW habitat is restricted to the Hill Country (Kroll 1980, Campbell 1995, Baccus and Tolle 2003). Controversy over land use practices and declining habitat of this bird centers on development (Kroll 1980, Campbell 1995,) but not overabundance of white-tailed deer. A limited breeding range (33 counties), habitat destruction and fragmentation are all limiting factors that synergistically may result in severe declines or disappearance of the GCW in portions of the Hill Country (Kroll 1980, Campbell 1995). No studies have demonstrated long-term negative impacts of any biotic factors, such as overabundance of white-tailed deer, on vegetation essential to the biology and ecology of GCWs.

DeCalesta (1997), Healy (1997), McShae et al. (1997), Underwood and Porter (1997), and William and Doster (1997) contended that potentially severe adverse effects to the ecosystem may occur in areas where white-tailed deer are overabundant in comparison to areas that have been managed for lower deer densities. They also contended that the density of white-tailed deer must be curtailed to avoid negative effects to plant and animal community composition and for an overall preservation of ecosystems. There is no information on the rate of recovery for plant communities when deer overabundance is decreased.

It may be possible to determine negative effects of white-tailed deer foraging behavior by determining Texas oak seedling recruitment in areas of high deer density and comparing that to seedling recruitment in areas of lower deer density. If areas of high deer density show little or no seedling recruitment, while areas with lower densities have increased seedling recruitment, this information may be used by biologists, land managers, and ecologists concerned with the long-term survival of GCW habitat to formulate a plan for reducing deer overabundance. This information will be part of an ongoing investigation that will take several years to complete. The objectives of my investigation were: 1) to develop a baseline vegetative analysis of GCW habitat at Barton Creek Habitat Preserve (BCHP), an area with a high density of deer, and 2) to compare Texas oak seedling recruitment in areas with low and moderate densities of deer to seedling recruitment at BCHP. The baseline analysis included: hardwood recruitment (number of seedlings), understory density of shrubs below 2 m (browsing height of white-tailed deer), and canopy cover.

MATERIALS AND METHODS

STUDY AREAS

Barton Creek Habitat Preserve

The study site with a high deer density was the BCHP, a 1620 ha habitat for golden-cheeked warblers and black-capped vireos (*Vireo articapillus*) located at the intersection of RR 2244 and Hwy 71 in Travis County, Texas. BCHP had a mean deer density of 1 deer/2.67 ha (SE = 0.792). Estimates of the white-tailed deer density on the BCHP were obtained using conventional spotlight methodology (Larkin 1998). Deer were counted at night along predetermined routes within the BCHP with a high-powered spotlight. Deer densities obtained by spotlight surveys for the past 5 years were used to determine population trends (Table 1). The BCHP was the main study area because of the preserve's large amount of GCW habitat (about 730 ha), the desire to protect GCW habitat, and high deer density. No active wildlife management, other than prescribed burning, occurred on the BCHP. However, hunters, mountain bikers, horseback riders, and hikers trespass on the land. Sampling stations at BCHP occurred primarily in Sweetwater Pasture (Fig. 1) because past bird counts demonstrated a substantial use of this area by GCWs.

BCHP consists of heavily wooded, steep slopes, deeply-incised canyons, and wooded uplands. Barton Creek, a perennial stream, enters the preserve on the northwest boundary and travels in an oblique fashion southeast along the perimeter and exits the property through the eastern boundary. The BCHP is bounded on all sides by residential neighborhoods. Vegetation on the BCHP consists of an oak-Ashe juniper woodland on steep-sloped areas leading down to drainages and an Ashe juniper savannah on upland areas.

Table 1. Five-year trend in deer abundance (ha/deer) as determined by spotlight surveys at Barton Creek Habitat Preserve (BCHP), Travis County, Texas, Kerr Wildlife Management Area (Kerr WMA), Kerr County, Texas, and Fort Hood (FH), Bell County, Texas.

	Year				
Study Area	1998	1999	2000	2001	2002
BCHP	1.53/deer	3.63/deer	2.71/deer	3.12/deer	2.38/deer
Kerr WMA	4.39/deer	4.53/deer	4.39/deer	4.37/deer	5.28/deer
FH	40.44/deer	27.69/deer	23.55/deer	13.9/deer	15.8/deer

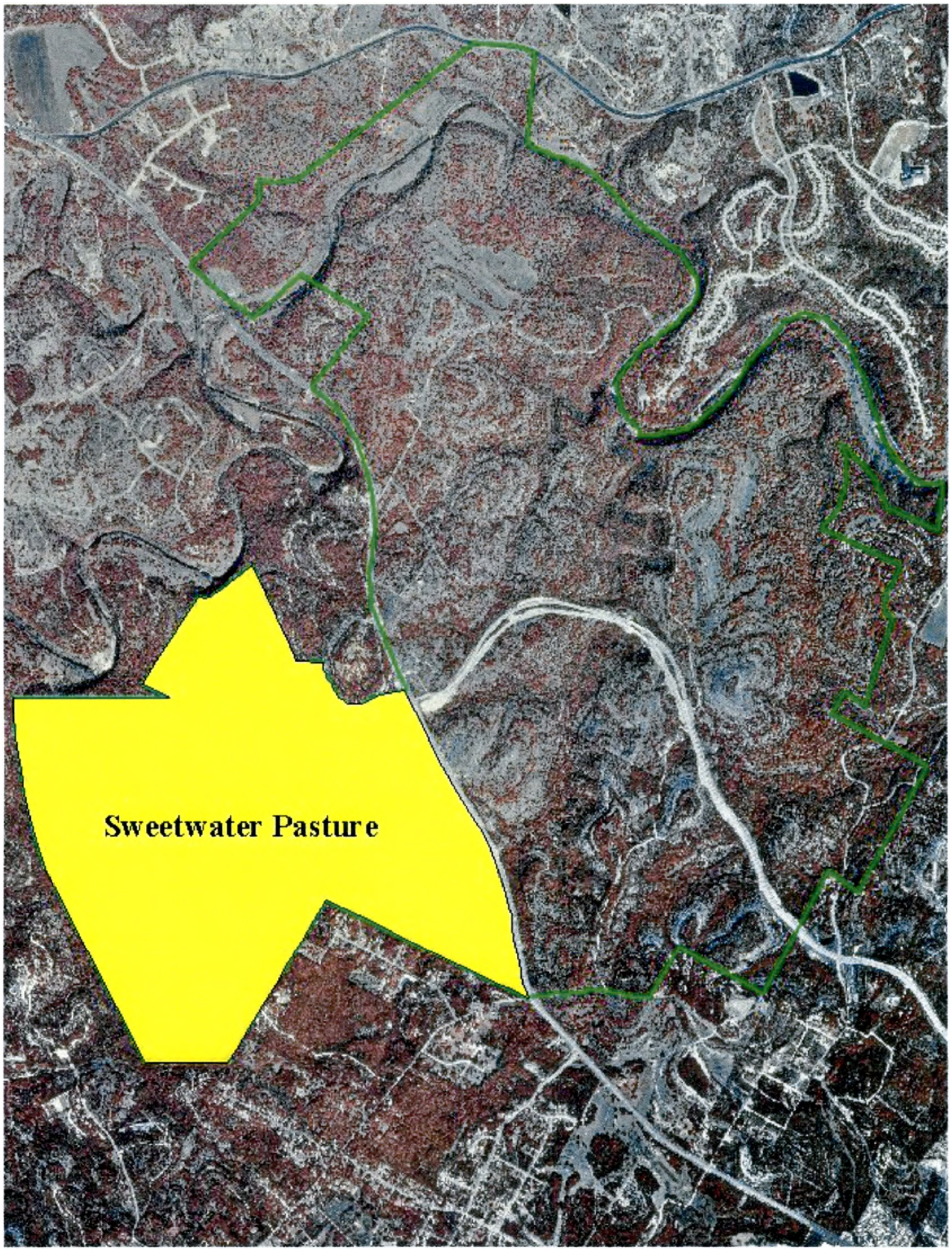

Figure 1. Map showing the primary vegetational study site in the Sweetwater Pasture at the Barton Creek Habitat Preserve (BCHP), Travis County, Texas. The boundaries of the preserve are shown in green.

The dominant trees on slopes are Ashe juniper, Texas oak, netleaf hackberry (*Celtis reticulata*), post oak (*Quercus stellata*), and plateau live oak (*Quercus fusiformis*). Riparian areas consist of a mixture of bald cypress (*Taxodium distichum*), American sycamore (*Platanus occidentalis*), sugarberry hackberry (*Celtis laevigata*), and elm (*Ulmus spp.*), with scattered pecan (*Carya illinoensis*), Arizona walnut (*Juglans nigra*), and escarpment cherry (*Prunus serotina*).

Fort Hood

The low deer density site was located on Training Area 13B (TA 13B) within East Pasture at Fort Hood, an Army installation located in Killeen, Bell County, Texas, (Fig. 2). The East Pasture had a mean deer density of 1 deer/24.28 ha (SE = 10.64) (J. Cornelius, personal communication). Estimates of the white-tailed deer density on the study areas were obtained using conventional spotlight methodology (Larkin 1998). Deer were counted at night along predetermined routes within the East Pasture with a high-powered spotlight. Deer densities obtained by spotlight surveys for the past 5 years were used in this study to determine population trends (Table 1).

TA 13B was designated in 1992 as an area for GCW demographic studies. It was chosen because it is the highest quality GCW habitat on Fort Hood (Pekins 2002). TA 13B is located on the southern edge of the large, contiguous patch of "core" habitat for GCWs on the east side of the installation. TA 13B consists of heavily wooded, steep slopes, deeply-incised canyons, and wooded uplands. The vegetational communities on TA 13B are an Ashe juniper-Texas oak mixed forest with Carolina buckthorn (*Frangula caroliniana*) on slopes and an Ashe juniper-live oak forest with scattered grasslands, prickly pear (*Opuntia engelmannii lindheimeri*), sugar hackberry, and cedar elm (*Ulmus

Figure 2. Map showing the primary vegetational study site in the Training Area 13B (TA 13B) at Fort Hood Military Installation, Bell County, Texas.

crassifolia) on uplands. Some shin oak (*Quercus sinuata breviloba*) may be found on uplands, but it is mainly confined to the mesa-upland interface. Both mesas and slopes have scattered Texas ash (*Fraxinus texensis*) and Texas redbud (*Cercis canadensis*). During the breeding season, military activities are restricted on TA 13B; however, non-military activities such as hunting, cattle grazing, and horseback riding occur. TA 13B is 126-ha in size (Pekins 2002).

Kerr Wildlife Management Area

The moderate deer density site was located in Spring Pasture within Kerr Wildlife Management Area (Kerr WMA), a 2,630-ha facility owned by Texas Parks and Wildlife Department, located near Hunt, Texas (Fig. 3). The Kerr WMA has a mean deer density of 1 deer/4.59 ha (SE = 0.389), (Bill Armstrong, personal communication). Estimates of the white-tailed deer density were obtained using conventional spotlight methodology (Larkin 1998). Deer were counting at night along predetermined routes for the entire Kerr WMA with a high-powered spotlight. Deer densities obtained by spot light surveys for the past 5 years were used to determine population trends (Table 1). A 2.3-m high fence surrounds the Kerr WMA. Spring Pasture has been dedicated to support GCW demographic studies. It was chosen as a study site because it represents the best GCW habitat on Kerr WMA.

Spring Pasture consists of a heavily wooded gently rolling topography dissected by moderately deeply-incised drainage and wooded uplands. The vegetational community within the Kerr WMA consists of an oak-Ashe juniper woodland. The dominant hardwood species found on the area include Texas oak, live oak, post oak, blackjack oak (*Quercus marilandica*), shin oak, Texas redbud, honey mesquite (*Prosopis glandulosa*),

Figure 3. Map showing the primary vegetational study site in Spring Pasture at the Kerr Wildlife Management Area (Kerr WMA), Kerr County, Texas. The boundaries of the management area are shown in green.

flameleaf sumac (*Rhus lanceolata*), and netleaf hackberry. Dominant understory shrubs consist of saw greenbrier (*Smilax bona-nox*), agarito (*Berberis trifoliolata*), and Texas persimmon (*Diospyros texana*) (Hunter 1983, Beechnoir 1986). Cattle are excluded from grazing in Spring Pasture; hunting is the only activity.

VEGETATIVE ANALYSIS

This study will establish a sampling protocol at BCHP to document expected changes in vegetation after implementation of a reduction in deer density. Fifty sampling points (stations) were randomly selected in areas with GCW habitat (Fig 4) using occurrence maps from previous bird survey data. I placed stations in areas with hardwoods (primarily Texas oak) and recorded the location with a global positioning system (GPS) (Appendix 1). Stations were permanently marked with T-posts and surveying tape.

I counted hardwood seedlings in 21 1 m^2 rectangular quadrats (Bonham 1989) placed at 5 m intervals along 4 transects each 25 m long that radiated in the 4 cardinal directions from a center point. I documented the understory density of shrubs using a vegetative profile board (VPB) (Nudds 1977). Readings were taken in each of the 4 cardinal directions 15 m from the center point at each station. The amount of horizontal cover is most likely a suitable indicator of the degree of use and herbivory of habitat by deer (Bookhout 1996). Little or no vegetative obstruction below the 2 m line is indicative of an overabundance of deer (Lemmon 1957). Point ocular estimates of canopy cover were conducted with a spherical densiometer to measure overstory structure (Lemmon 1957, Bookhout 1996). One densiometer reading was taken at the center point of the station and 1 at each end of the north, east, and west transects. The average of all 4 readings represented the percentage of canopy cover for the station.

The results of this survey will establish baseline data on the number of seedlings, the density of shrubs below the 2 m line, and canopy cover. Data collected at these sites in subsequent studies will be used to track changes in the floral community as the density of deer is decreased. The expected long-term effects of deer density reduction will be an

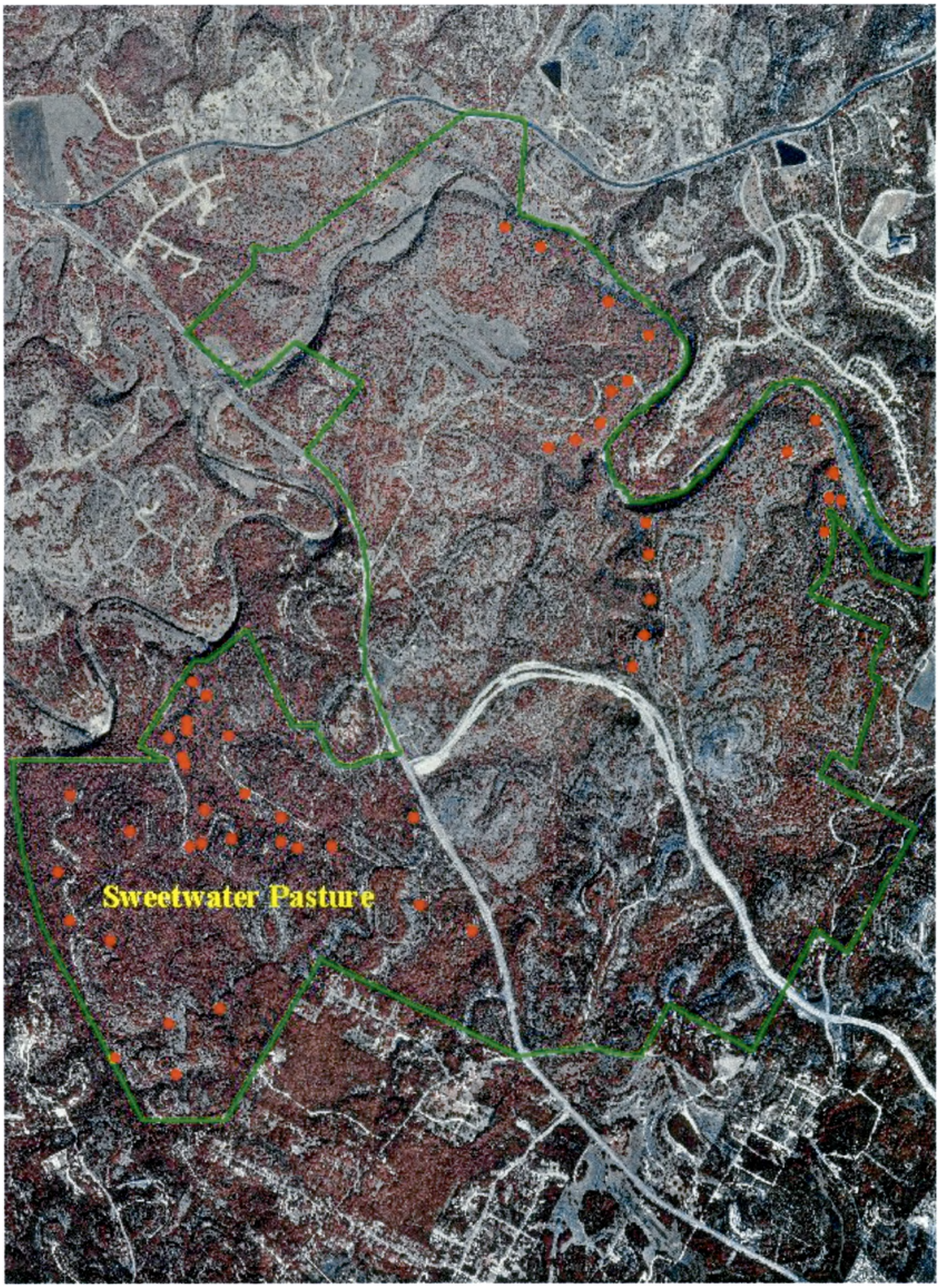

Figure 4. Map showing sampling station locations in the Barton Creek Habitat Preserve (BCHP), Travis County, Texas. The boundaries of the preserve are shown in green.

increase in floral and faunal diversity and improvement of the hardwood component of the ecosystem, which may improve or stabilize the GCW habitat.

To ascertain Texas oak recruitment, at other sites with low and moderate deer densities, I counted hardwood seedlings at 50 stations on TA 13B (Fig. 5) at Fort Hood and Spring Pasture (Fig. 6) at Kerr WMA using the same methodology employed at BCHP. I recorded the stations on both areas with a GPS (Appendix 2 and 3). Hunting controlled the deer density on Fort Hood and Kerr WMA. Therefore, deer densities will not be reduced on TA 13B or Kerr WMA for subsequent investigations to observe potential changes in vegetation initiated by this study. Horizontal visual obscurity using the VPB and canopy cover using the densiometer were not surveyed.

I determined the mean and standard error for the amount of seedlings observed at each site. Due to the large amount of data (n = 1050 m^2 quadrats per site) the results of the hardwood seedling survey will be statistically analyzed using a single factor analysis of variance (Ramsey and Schafer 2002) to determine differences in amounts of seedlings observed in areas of high, medium, and low deer densities. I used linear contrast (Ramsey and Schafer 2002) to demonstrate the correlation of deer density and number of seedlings at each site.

Figure 5. Map showing sampling station locations in Training Area 13B at Fort Hood, Bell County, Texas. The boundaries of TA 13B are shown in green.

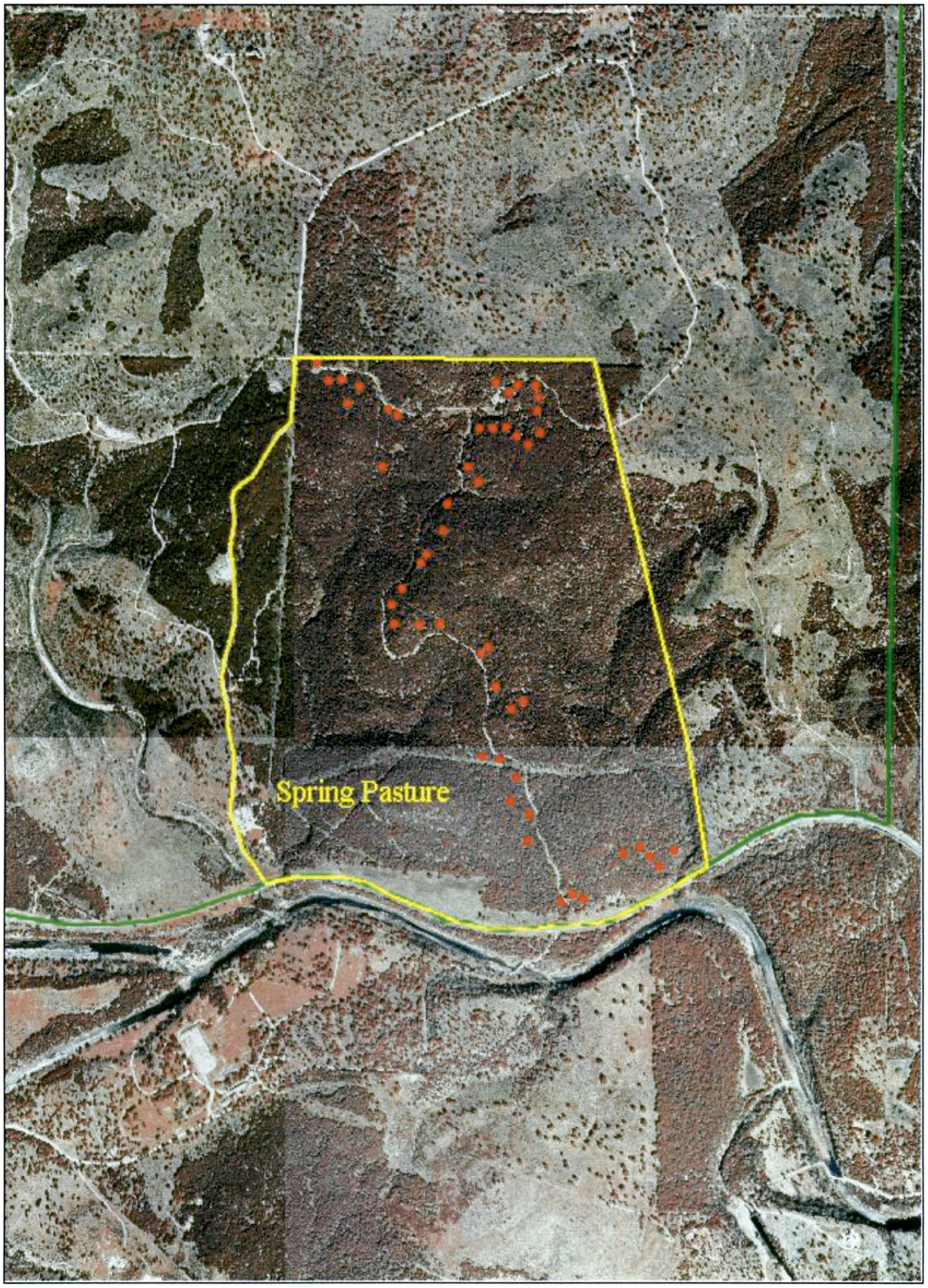

Figure 6. Map showing sampling station locations in Spring Pasture at Kerr Wildlife Management Area (Kerr WMA), Kerr County, Texas. The boundary of the management area is shown in green.

RESULTS

Seedling Recruitment by Site

BCHP

BCHP had the lowest mean density (1.56, SE = 0.3454, range 0-13) for Texas oak seedlings. Twenty-three of 50 stations did not have Texas oak seedling recruitment. The majority of stations (26) containing Texas oak seedlings had from 1–7 with only 1 station having 13 (Table 2). These seedlings were root sprouts found in 1 quadrat that was randomly placed at the base of a Texas oak tree. Texas oak trees at BCHP generally consisted of only 2 age classes: mature trees or seedlings. Mature trees were 6-13 m in height with a diameter at breast height (dbh) ranging from 20.32-50.8 cm. Seedling height ranged from 2.54-12.7 cm. Little understory growth of plant species preferred by white-tailed deer was observed at stations; however, the Ashe juniper component was extremely dense at most stations. There were no observations of any other herbivorous species, such as lagomorphs, rodents, or insects that could significantly affect the lack of recruitment of Texas oak seedlings. Incidental observations of some seedlings did, however, demonstrate cropping of stems and leaves characteristic of white-tailed feeding behavior.

Kerr WMA

All stations in Spring Pasture at the Kerr WMA had Texas oak seedlings (Table 2). The mean number of seedlings per station was 9.04 (SE = 0.8186, range 1-27). More age classes were represented than at BCHP. Structure consisted of many seedlings that ranged from 2.54-45.72 cm in height to few immature trees that ranged from 45.72-1.8 m in height with dbh ranging from 2.54-7.62 cm. Many mature trees about 6-12 m in height

Table 2. Number of stations that contained different ranges of Texas oak seedlings observed in 50 stations located at the Barton Creek Habitat Preserve (BCHP), Travis County, Texas, Kerr Wildlife Management Area (Kerr WMA), Kerr County, Texas, and Fort Hood (FH), Bell County, Texas.

	Number of seedlings						
Location	0	1-3	4-7	8-10	11-13	14-19	>20
BCHP	23	19	7	0	1	0	0
Kerr WMA	0	10	12	13	4	7	4
Fort Hood	0	0	1	1	0	5	43

with a dbh ranging from 20.32-50.8 cm were observed. There were no observations of other herbivorous species, such as lagomorphs, rodents, or insects having any effects on recruitment of Texas oak seedlings. Incidental observations of some seedlings did, however demonstrate cropping of stems and leaves characteristic of white-tailed feeding behavior.

Fort Hood

All stations in TA 13B on Fort Hood had Texas oak seedling recruitment (Table 2). The mean number of seedlings per station was 33.7 (SE = 2.27345, range 3-91). The structure of the Texas oak population was comparable to the population at Spring Pasture at the Kerr WMA, however a more diverse age class existed on TA 13B. A larger number of Texas oak seedlings ranged from 2.54-60.96 cm in height. A larger number of immature trees were present ranging from 60.96-3.65 m in height and a dbh ranging from 2.54-7.62 cm. More mature trees was present that contained similar dimensions to Spring Pasture and BCHP. The understory on TA 13B was extremely dense with a 4-layer architecture. There were no observations of any other predator species such as lagomorphs, rodents, or insects having any affects on recruitment of Texas oak seedlings. Incidental observations of some seedlings did, however demonstrate cropping of stems and leaves characteristic of white-tailed deer foraging behavior.

The abundance of Texas oak seedlings at the 3 study sites was significantly different ($F_{2,147}$ = 109.04, P = < 0.001). The orthogonal contrast demonstrated that about 91% of the variation in the abundance of Texas oak seedlings among sites was explained by a linear trend ($F_{1,147}$ = 195.248, P = < 0.001). The highest deer density at BCHP had the lowest amount of Texas oak seedlings, the moderate deer density had the moderate seedling density, and the lowest deer density had the highest seedling density.

Overstory vegetation on BCHP

The dominant vegetative communities on the BCHP have dense overstory architecture classified as a forested community (Table 3). Texas woody vegetative communities are divided up into 3 classes: forest, woodland, shrub/scrubland (Diamond et al. 1987). The amount of canopy cover is one of the main determinants used to classify these vegetative community types. A forest is a vegetative community dominated by trees that are greater than 3 m in height and has a canopy cover greater than 61%. A woodland is a vegetative community that is dominated by trees that are greater than 3 m in height and has a canopy cover that ranges from 26%-60%. A shrub/scrubland is a vegetative community that is dominated by woody plants that range from 0.5 m-3 m in height and has a canopy cover of less than 26%. No stations were located in a shrub/scrubland community.

Understory vegetation on BCHP

VPB readings were high because of the extremely dense understory component of Ashe juniper (Table 4). Many stations contained Ashe juniper with no vegetation present on the branches, however the density was still so great that the bare branches created high horizontal cover readings. The high horizontal cover readings, because of the Ashe juniper, do not portray the expected indication of an overabundance of deer (little horizontal structure below 2 m). However, this survey did demonstrate a subtle change in horizontal cover directly proportionate to height. Horizontal cover readings increased as survey height increased. Small horizontal cover was caused by Texas persimmon

Table 3. Number of stations with indicated percent canopy cover as determined by ocular estimates with a spherical densiometer at 50 stations on the Barton Creek Habitat Preserve (BCHP), Travis County, Texas

	Percent Canopy Cover					
Location	0-26%	26-60%	61-70%	71-80%	80-90%	>90%
BCHP	0	3	4	12	26	5

Table 4. Number of stations with percent visual obstruction by understory density of shrubs as determined by using a horizontal vegetational profile board at 50 stations on the Barton Creek Habitat Preserve (BCHP), Travis County, Texas.

	Percent obscurity					
Height	1-20%	21-40%	41-60%	61-80%	81-100%	100%
0.0-0.5	7	17	14	11	3	0
0.5-1.0	2	12	17	10	9	0
1.0-1.5	2	9	16	17	6	0
1.5-2.0	1	1	12	18	17	1

(*Diospyros mexicana*), mountain laurel (*Sophora secundiflora*), branches of small or immature plateau live oak trees, shin oak trees, cedar elm or Texas oak, the herbaceous component, terrain, and brush piles from clearing. Most likely the high percent canopy cover did not allow enough light to create sufficient conditions for herbaceous growth. The amount of horizontal cover increases at higher intervals on the VPB.

DISCUSSION

Caughley (1981) designated 4 categories of overabundance in animal populations. These 4 categories were: (1) when animals threaten human life or livelihood, (2) when animals depress densities of favored species, (3) when animals are too numerous for their own good, and (4) when their numbers cause ecosystem dysfunction. The focus of this investigation was based on overabundance categories 2 and 4 and provided evidence that overabundance of white-tailed deer could change a finite population of Texas oaks ultimately affecting the long-term physiognomy, composition, and diversity of the Hill Country forest. Reliance of GCW populations on a diminishing Texas oak component of forests will most likely cause a depression in GCW densities (Category 2). A decrease in biodiversity ultimately indicates ecosystem dysfunction (Category 4).

The results of my study predict potential long-term changes in the physiognomy, compostition, and diversity of forests because of the effect of an overabundance of deer on Texas oak regeneration. Since deer intensively select plants, such as Texas oak, the amount of this plant population remaining in the forest community will depend upon its fitness, which is a function of survival and fecundity (Russell 1999). White-tailed deer herbivory most likely reduces recruitment of Texas oak by altering plant morphology and decreasing growth rate (Russell 1999). For example, this study focused on the survival of Texas oak seedlings. All above ground biomass of seedlings is susceptible to herbivore predation. Depending on the intensity, frequency, and season of plant use, mortality may occur (Russell 1999), decreasing the abundance of seedlings present. This study demonstrates that deer density is directly proportional to the intensity and frequency of plant use. Texas oak seedling abundance on high deer density areas such as the BCHP is extremely small compared to Kerr WMA and Fort Hood, areas with lower deer densities. The size structure of Texas oak plants on the different study areas indicates the effect of different deer densities have on the growth rates of Texas oak populations. The population of Texas oak at BCHP lack diversity of different age classes. This indicates the frequency and intensity of browsing on the survival or growth of Texas oaks seedlings. No seedlings grow to sapling size, and no saplings or young adult trees have survived or matured to a stage that is not affected by the browsing pressure. The failure to recruit mature trees into the Texas oak population will significantly affect the rate of succession. The expected results of this change in succession will most likely be a community structure with a smaller percentage of Texas oak trees in the mid and upper canopy layers. The change in the structure and composition of the forest will most likely affect the density of GCWs. GCWs inhabit areas in the Hill Country that contain large contiguous oak–Ashe juniper forests and woodlands. Typically GCWs demonstrate a preference for older stands of Ashe juniper along with a certain percentage of mature deciduous, hardwood species (Campbell 1995, Baccus and Tolle 2003). They use the bark of mature Ashe juniper trees for nesting material. Generally, the percentage of oak to Ashe juniper trees in GCW habitat ranges from 10–40% oak and 60-90% Ashe juniper. Beardmore (1994) reported that the GCW relied upon mature Texas oak trees for foraging habitat. Although deer densities at the Kerr WMA and Fort Hood are substantially different, both have more diverse age classes of Texas oak, therefore, recruitment is most likely sufficient to sustain the composition of Texas oak in the forest. Based on my results, Fort Hood should have a higher percent composition of Texas oak trees in the future forest than the Kerr WMA.

Russell (1999) argued that the effect of an overabundance of deer on vegetation is probably the cause of reduction in hardwood recruitment, which is not a recurring pattern that fluctuates dynamically but will be lasting unless deer densities are reduced. One important objective initiated by this study was the production of a vegetative baseline for subsequent investigations of vegetative parameters after a reduction of deer density on BCHP. Deer will be removed by hunting under special permits that will allow the take of animals in a different fashion than conventional hunting. This will speed up the process of deer removal. Generally, management objectives that require the removal of deer for the majority of the Hill Country rely on conventional hunting that follows state hunting regulations. Hunting at best does not remove the number of deer that will significantly change abundance trends of white-tailed deer in the Hill Country. This is mainly a function of game regulations set by the Texas Parks and Wildlife Department. Other issues such as demography and the socioeconomic status of Texans create a very small percentage of hunters that are motivated and able to hunt deer. This is compounded by the fact that a large percentage of legal deer hunters in Texas do not harvest the number of deer allotted by state tags. I consider the number of tags issued to hunters per number of deer actually harvested to be the most important factor dealing with the issue of removing deer. This research shows that objectives for deer management within the Hill Country were always, or has recently become unsuccessful. Increasing the number of deer that the individual hunter may harvest may be a strategy that would enhance the ecosystem and increase the quality of deer. I assume that the present bag limit reflects the primary and most visible responsibility of biologists, which is conservation of species and habitat. This most likely may account for the conservative issuance of tags. I have experienced that the general public in Texas for the most part are responsible hunters and harvest only what is needed. Increasing the number of tags available, may compensate for those hunters who do not use their tags to their full potential. Hunters that have the means and desire will harvest more deer.

The goal of deer removal is to promote stability in the ecosystem (Russell 1999), however, DeCalesta (1997), Healy (1997), Knox (1997), McCabe and McCabe (1997), McCullough (1997), and White (1997), argue that deer populations never existed under stable conditions or that the predatory component had an insignificant role in stability. Scientists and the general public must consider that the situation today is different than the past. In the past, before the inundation of people, one acceptable management implication would be to let Mother Nature run its course when occurrences of instability in the ecosystem demonstrated adverse effects to floral and faunal diversity. Historically this is the way ecosystems have functioned and altering this course to appease the concerns of few preservationists may not be in the best interest of the ecosystem. Today the constant bombardment of development and fragmentation, which slashes away at the little remaining habitat for white-tailed deer and GCWs in the Hill Country, requires a more forthright effort to control white-tailed deer overabundance to stimulate the regeneration of GCW habitat. Fortunately, we have the knowledge, equipment, and technology that may alter the course for GCW habitat that was put in jeopardy. But, do we have the will?

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Appendix 1. Global Positioning System (GPS) Northing and Easting coordinates for station locations on Barton Creek Habitat Preserve (BCHP), Travis County, Texas.

	BCHP				
Station	Northing	Easting	Station	Northing	Easting
1	605531	3352189	26	603025	3349974
2	605211	3352837	27	603378	3349981
3	605005	3352950	28	603102	3349858
4	605611	3352522	29	603118	3349816
5	605851	3352332	30	603142	3349338
6	605724	3352061	31	603213	3349357
7	05628	3352004	32	603232	3349553
8	605566	3351814	33	603388	3349389
9	605416	3351723	34	603469	3349646
10	605263	3351679	35	603678	3349513
11	605830	3351240	36	603686	3349372
12	605846	3351048	37	603783	3349333
13	605857	3350790	38	603984	3349342
14	605821	3350576	39	604497	3348995
15	605753	3350392	40	602794	3349428
16	606662	3351654	41	602674	3348795
17	606825	3351831	42	602437	3349642
18	606932	3351527	43	602373	3349196
19	606980	3351367	44	602440	3348914
20	606907	3351385	45	603022	3348306
21	606878	3351179	46	602702	3348095
22	603159	3350300	47	603061	3348000
23	603245	3350220	48	603323	3348394
24	603126	3350076	49	604807	3348847
25	603126	335024	50	604470	3349506

Appendix 2. Global Positioning System (GPS) Northing and Easting coordinates for station locations on Spring Pasture, Kerr Wildlife Management Area (Kerr WMA), Kerr County, Texas.

	Kerr WMA				
Station	Northing	Easting	Station	Northing	Easting
1	451550	3327406	26	451972	3326849
2	451591	3327348	27	451987	3326940
3	451635	3327353	28	452093	3327015
4	451694	3327327	29	452057	3327062
5	451651	3327275	30	452097	3327191
6	451772	3327062	31	452142	3327192
7	451821	3327237	32	452184	3327196
8	452261	3325822	33	452218	3327166
9	452267	3325907	34	452260	3327138
10	452199	3325955	35	452300	3327177
11	452220	3326033	36	452288	3327252
12	452168	3326093	37	452293	3327295
13	452108	3326100	38	452282	3327336
14	452245	3326283	39	452224	3327335
15	452206	3326257	40	452197	3327311
16	452150	3326335	41	452153	3327343
17	452125	3326462	42	451790	3327253
18	452101	3326443	43	452748	3325792
19	451965	3326541	44	452697	3325735
20	451896	3326533	45	452667	3325773
21	451813	3326538	46	452634	3325800
22	451803	3326603	47	452582	3325783
23	451838	3326657	48	452446	3325630
24	451901	3326741	49	452411	3325644
25	451921	3326773	50	452372	3325618

Appendix 3. Global Positioning System (GPS) Northing and Easting coordinates for station locations on Training Area 13B (TA 13B), Fort Hood Military Installation, Bell County, Texas.

	TA 13B				
Station	Northing	Easting	Station	Northing	Easting
1	634105	3449041	26	634541	3448102
2	634178	3449047	27	634487	3448081
3	634163	3449078	28	634456	3448075
4	634134	3449076	29	634396	3448065
5	634103	3449062	30	634346	3448069
6	634124	3449039	31	634317	3448062
7	634169	3449063	32	634258	3448108
8	634176	3449111	33	634209	3448088
9	634239	3449118	34	634655	3448428
10	634296	3449106	35	634620	3448438
11	634339	3449146	36	634593	3448478
12	634322	3449087	37	634556	3448505
13	634363	3449085	38	634543	3448527
14	634424	3449075	39	634514	3448536
15	634469	3449101	40	634492	3448552
16	634477	3449142	41	634469	3448548
17	634503	3449098	42	634423	3448561
18	634526	3449130	43	634404	3448589
19	634519	3449060	44	634369	3448594
20	634580	3449077	45	634341	3448579
21	634708	3448309	46	634301	3448576
22	634643	3448283	47	634264	3448579
23	634642	3448243	48	634236	3448567
24	634593	3448208	49	634197	3448554
25	634592	3448131	50	634165	3448535

VITA

Chris Mostyn was born in 1971 in San Marcos, Texas. He obtained his elementary and secondary education in San Marcos public schools, and graduated from San Marcos High School in 1990. During high school, Chris was accepted at Texas A&M University in College Station, Texas. He attended the university from 1990 to 1997, and was awarded a Bachelor of Science degree with a major in Wildlife and Fisheries Science. The semester prior to his college graduation, Chris accepted an internship at The Sanctuary, a white-tailed deer management area near the City of Big Rapids, Michigan. He began his post-graduation career as an assistant wildlife biologist at the Faith Ranch, a private ranch intensively managed for wildlife and located in Carrizo Springs, Texas. Chris then served as ranch manager at Bryarwood Ranch in Wimberly, Texas. This ranch specializes in fallow deer and is also managed for native white-tailed deer. Chris then accepted a position as a biologist with SWCA, Environmental Consultants, a consulting firm providing cultural and natural resources expertise to public and private clients throughout the southwestern United States. He worked out of the SWCA Austin, Texas, office on a diverse range of projects related to complex issues including wildlife management plans developed for 1-d-1w agricultural exemption, jurisdictional waters and wetlands delineation, wildlife and habitat assessment, geological assessment, and endangered species. Chris left SWCA in 2002 to pursue a Master of Science degree at Southwest Texas State University (SWTSU) where he taught undergraduate Human Anatomy and Physiology laboratories, and served as president of the SWTSU student chapter-The Wildlife Society.

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