COMPARING NATURAL VEGETATION AND FOOD PLOT PREFERENCE IN CAPTIVE WHITE-TAILED DEER

A Thesis

Presented to

The Faculty of the Department of Agricultural Sciences

Sam Houston State University

In Partial Fulfillment

of the Requirements for the Degree of

Master of Science

---

by

Robert W. McQueen

May 2020

COMPARING NATURAL VEGETATION AND FOOD PLOT PREFERENCE IN CAPTIVE WHITE-TAILED DEER

by

Robert W. McQueen

APPROVED:

Marcy M. Beverly, PhD
Committee Director

Stanley F. Kelley, PhD
Committee Member

Mark J. Anderson, PhD
Committee Member

John B. Pascarella, PhD
Dean, College of Science and Engineering Technology

DEDICATION

I dedicate this work to my wife, Michelle, who has supported me in all of the adventures I have pursued and will continue to pursue. To my Mother-in-Law, Donice, for helping maintain the home front while I spent many hours away to perform the research and complete this document. Lastly, to my daughter, Daegan Marie, surround yourself with the correct people that are like-minded, goal oriented, and as equally driven, and you will be able to achieve anything you set your mind too.

ABSTRACT

Mcqueen, Robert W., Comparing Natural Vegetation and Food Plot Preference in Captive White-tailed Deer. Master of Science (Agricultural Sciences), May 2020, Sam Houston State University, Huntsville, Texas.

Supplemental feed is the most expensive input in the captive white-tailed deer and exotic wildlife industries. This is due to operations utilizing high energy/high protein pellets as supplemental feed. To combat this, low fence operations often plant food plots with high quality vegetation to minimize cost and increase forage availability for wildlife. The objective of this study was to determine forage preference of wildlife species in captivity. Seven food plots comprising of twenty-five acres were planted with one of three forage blends. The treatments were, a commercial blend of soybeans, a commercial blend of soybeans, sunflowers, and milo, and an unplanted, natural vegetation. Utilization cages were distributed in all treatment plots to prevent wildlife access to areas and serve as ungrazed control sample. Vegetative samples, inside and outside of the utilization cages, were collected on days 30, 60, and 90 after planting. Vegetative weights on days 60 and 90 supporting consumption of the commercial blends, ($P < 0.05$), over the unplanted, natural vegetation treatment. This data illustrates that the preferred forage for white-tailed deer and exotics were the commercial blends of forages. Decreased consumption of feed pellets suggests a cost savings and implies food plots were preferred.

Keywords: Forage preference, White-tailed deer, Food plots, Supplemental feed, Forage Selection
Author List: McQueen, Robert W., M.M. Beverly, S.F. Kelley, M.J. Anderson

ACKNOWLEDGEMENTS

The forage blends, labor, and land were donated by Colony Shore LP, DBA 50x Ranch. This work could not have been completed without the assistance of numerous faculty members, graduate, and undergraduate students at Sam Houston State University.

PREFACE

Wildlife is found in captivity around the world in zoos, rehabilitation centers, and breeding and hunting operations. The costliest input to manage these animals is feed; by supplementing natural diets with high-energy protein pellets. What if we could reduce these feed costs by allowing these species to utilize their natural foraging behaviors, while allowing for optimal nutritional intake? This research will determine if food plots promote the natural foraging tendencies of white-tailed deer and determine if there is a preference of forages selected.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

CHAPTER I

Introduction

Texas ranchers, hunting operations, and breeding facilities collectively have millions of white-tailed deer (*Odocoileus virginianus*) and exotic species held within high fence systems. The growth of the herd and the health of individuals are the driving factors for these operations, to produce a viable population of game to hunt, sell, and reintroduce into the wild. There has been limited research on forage preference of these animals in a captive setting; to offset limited vegetative resources, feed pellets are typically provided. White-tailed deer are browsers and are more specific in the forage they choose. They prefer tender, new growth vegetation; whereas, exotic species are highly adaptable to various forage types. Research observations have demonstrated the ability of exotics to turn Texas' native vegetation into growth.

Cost of feed is the largest cost uncured by these operations, especially in the smaller operations, that have not built the clientele to offset these costs. Focusing on the hunting industry, specifically pasture animals will be priority, but it is also worth mentioning that the breeding side of these businesses, for example, feed costs outweigh all other costs per head on an annual basis. Understanding the vegetation preference of white-tailed deer and various exotic species in captive settings, will allow for providing a food source that they will readily forage upon, potentially lead to a decrease in competition when resources are limited, and a decrease in feed cost for these operations.

Objectives

The objectives of this research were to:

I. determine forage preferences of white-tailed deer and various exotic species in a captive setting.

II. analyze nutritional qualities of two commercial blends of forages and natural vegetation and compare them to a commercially provided supplemental-pelleted food source.

Literature Review

Habitat Selection. Male and female white-tailed deer (*Odocoileus virginianus)*, even though segregated at different periods of year, exhibit overlap in their habitat selection. A study conducted by Champagne et al. (2018), found that during wintering months in Canada, white-tailed deer browsed less on pines when available forage species diversity is increased. The increased diversity in forages, gave the deer an alternate source of browse, thus, minimizing the impact on one single food source. Different germination periods and growth rates of each individual plant species directly affect the availability and duration of preference. Planting a variety of selected seeds with different germination periods, allow for a more palatable, tender, higher quality forage for the deer to select. This is beneficial in both natural and captive settings, the forages with higher nutritive value will always be sought and accommodate both sexes of deer with different nutritional needs at any given time. It was found that during the summer months bucks at the age of 3.5 years old , and 4.5 years old, were 3.3 and 11.1 times; respectively more likely to utilize pelleted feed than does of the same age (Bartoskewitz et al. 2003). Bartoskewitz et al. (2003) also found that 29-56% of the bucks harvested had consumed the protein pellet feed; whereas only 13-30% of the females appeared to have spent any amount of time at the feeders.

Soils. Soils are directly related to the quality of forages available to our herds, regardless of management regime. With highly productive soils, production of quality forages in food plots can be an alternative form of supplementation when compared to protein pellets. Lashley et al. (2015) found that soils are extremely important in producing quality forages, with the capability to exceed the minimal requirements necessary for the maintenance of animals. They thought that plant species would mature at a much faster rate during drought, requiring additional nutrient intake, and a decreased period of preference.

Forages and Food Plots. Food plots are an integral part of wildlife management and have been utilized during stressful times of the year to offset environmental factors that limit available browse. In addition, game managers and hunters alike, capitalize on providing additional forage sources during these times of marginal forage availability, to increase the likelihood of having an encounter with wildlife. According to Ed Spinazzola (2006) there are two types of food plots, hunting plots and destination plots. Hunting plots consist of planted forages to attract deer to an area away from their destination plot, which is planted with higher quality forages. Some of the forages found in hunting plots are grains such as wheat, oats, rye, chicory, and clovers. These food plots are small in dimension and allow hunters, game managers, and wildlife enthusiasts, to have high forage production in a smaller area and the opportunity to get closer to animals for an ethical harvest or higher quality photgraph.

The destination plots are larger, final feeding sites for deer and exotic species prior to going to their bedding areas. Similar to hunting plots, a variety of forages are planted that are beneficial to wildlife. In these plots, the mixtures of forages should have different germination periods, which allow plants to be at different stages of growth and maintain a level of quality and palatability as each plant develops. These feed plots are planted during periods of adequate rainfall, to ensure early germination of the first seeds that will produce forage for the wildlife and act as a cover crop for the next forages to germinate. Spring and early fall are the best seasons to plant the selected forages, to allow plants to provide nutrients to the herd when the native browse is lacking. Lashley and Harper (2012) documented the effects drought has on native forages and forage selection by white-tailed deer. They recognized that drought directly effects the quality of forages and the selection by white-tailed deer. With a decrease in overall crude protein, white-tailed deer were not as selective during drought years, consuming more parts of the plant and less specific of selected plant species. Spring food plots should be planted with forages such as alfalfa, clover, sorghum (milo), sunflowers, soybeans, and cowpeas. Fall food plots, which will carry into the over-wintering period, can consist of brassicas such as kale, rape, turnips, or other cool season forages. In any scenario, the forage provided should be the highest quality available to meet the nutritional requirements of the herd.

Browsing Behavior, Forage Selection, and Competition. White-tailed deer are a native species of ungulate, found across the United States, with the major limiting factor for survival being forage quantity and quality. They are dietary specialist, preferring browse (leaves, young or soft parts of plants, and fruits produced from these forages) and forbs (herbaceous flowering plants that are not grasses, such as clovers and sunflowers) rather than grasses. Lastly, white-tailed deer will eat grasses, only when there is no browse, nor forbs available. Grasses are of low quality and are deficient of most nutrients white-tailed deer need for maintenance. The tender, younger growth of their preferred browsing habits are abundant in some environments, and a limiting factor in others, thus, resulting in lower densities and smaller sized animals. White-tailed deer can adapt and thrive as long as there are sufficient resources in the form of cover, forage, browse, and dry matter (hay or woody plant parts) for rumen turnover. During the harsh times of the year, summer and winter months, supplemental feed may be required to assist in the survivability of the herds.

Once exotic species (non-native wildlife) are introduced into the natural habitat of white-tailed deer, there becomes an increase in competition for the available forage resources. Evaluating supplemental feeding in all forms, minimizing the competition and providing an alternate source of high-quality forage for native wildlife species, is paramount for their survival and presence. In the Texas breeding and hunting industry, white-tailed deer is one of the top sources of income, resulting in $1.6 billion of economic activity and providing over 16,800 jobs (Outlaw et al. 2017). This activity includes hunting, direct sales of the animals themselves, semen sales of desired sires, hotels, travel, veterinarians, and technicians that provide breeding services. Likewise, the exotic industry, which is similar to the white-tailed industry, generates approximately of $1.3 billion in economic activity and supports over 14,000 employment opportunities (Anderson et al. 2007). With the economic impact of industries, white-tailed deer and exotics, decreased vegetative competition can minimize the negative impact of species overlap, decrease costs of supplemental energy/protein feeds, increase profits, provide a natural forage for all wildlife, and optimize health and growth of the herds.

White-tailed deer are dietary specialists (browsers) with a very narrow spectrum of forage preference. Consuming up to 1.36 metric tons of forage annually (Spinazzola 2006), the need for high quality forage is apparent and necessary for the maintenance of individuals that share habitat with exotic species. Most exotic species are dietary generalists (grazers or have great adaptability) and have a having a much wider foraging spectrum with the ability to adjust their forage preference based on availability and seasonality. There becomes an immense amount of pressure and competition for resources necessary for maintenance and survival. With the introduction of exotic species in Texas, direct interaction and forage competition has been created between these species and the native wildlife. It is inevitable that one species will thrive, while the competing species will have to relocate to a habitat of lesser quality, or have difficulty maintaining a viable population at the current densities. In all ecosystems, there are species that have their niche, if the introduced or exotic species are generalist, and the native species a specialist, the intensity of these interactions may lead to a decrease in one species and an increase in the other (Baccus et al. 1985). Altering the habitat through supplemental feeding, preferably through the addition of forage crops in the form of food plots, could increase the available resources in which multiple species are competing. This would allow native species to compete with the introduced species, and at a minimum, maintain their current populations. With the right circumstances, this could allow for additional population growth, increase in the health of the herd and individuals, and allow for increased body and antler growth.

There are approximately 135 exotic species in breeding and hunting operations in Texas, not all are browsers but grazers, such as red deer, elk, and many species of rams. With these species able to utilize grasses that are readily available, they are not necessarily foraging on high quality browse of which white-tailed deer are seeking on a regular basis. At times, exotic species consume the preferred browse of white-tailed deer, even without specifically seeking these specific forages. By providing supplemental forage in food plots, this can increase the transition zones between two different plant successional zones (ecotone/edge), this would be more beneficial to the native white-tailed deer populations by providing an area which some exotic species would not be comfortable foraging or grazing. This could ultimately minimize the impact grazers have on browsers, segregating or creating different areas for multiple species to feed, with minimal overlap. As mentioned by Faas and Weckerly (2010) axis deer are superior when compared to white-tailed deer, easily interrupting their normal routines and spatial selection of white-tailed deer.

In Texas, exotic species are game species, but regulated, as livestock such as cattle or sheep, with this categorization there is no data recommending how to manage the populations. Faas and Weckerly (2010) tested how habitat selections of white-tailed deer were affected by the presence of axis deer. Out of 29 observations, 19 surveys recorded white-tailed deer or axis present, during 17 of 29 surveys, axis completely displaced white-tailed deer from the observed habitat, but white-tailed deer never displaced the exotic axis deer.

Baccus et al. (1985) conducted a study at the Kerr Wildlife Management Area, in Kerr County, Texas comparing the effects of direct competition of forage sources between white-tailed deer and three exotic deer species (axis, fallow, and sika). White-tailed deer compete directly with axis for the vegetation in the early stages of successional growth, specifically the browse, forbs, and higher quality grasses, (Baccus et al. 1985). Axis can utilize these grasses at a higher level of efficiency for maintenance and reproduction, than white-tailed deer. Whereas, white-tailed deer populations decline when grasses become their primary forage resource. As the availability of the browse and forb community decrease, axis deer are able to transition their diet selection and capitalize on the available grasses to continue their yearly production cycles.

When browse is available, sika deer will show preference to browse, along with white-tailed deer; yet, if there is increased competition and limited availability of the browse, sika shift their foraging habits to the available grasses. Thus, again confirming the generality of forage selection of exotics and the ability to capitalize on the lower nutritional levels of grasses (Baccus et al. 1985).

Fallow deer consume more browse than both axis and sika when they have a choice, making them the most concerning competitor to white-tailed deer for available forage. As with the other exotics previously mentioned, when browse is limited, fallow will shift their diets to forbs and grasses more readily.

Some exotic species can coexist with white-tailed deer within the same habitat and cause no competitive threat for forages, whereas other species will directly influence white-tailed deer. Feldhamer and Armstrong (1993) noted rare incidences where the habitat provides the necessities for both exotic and native wildlife to coexist, yet, the habitat quality and forage availability rapidly deteriorate and are never sustained for long periods. This further suggests that in a captive setting, where habitat, forage resources, and segregation of different species are managed, a balance between different species and available forage resources is critical for all species to thrive. Managers should make every effort to optimize the opportunity for all species to inhabit the same areas, while minimizing the impact on each other through forage, cover, and other potential limiting factors. In areas where animals cannot be divided, increased forage resources could be a solution to minimize the negative effects of grazing competition.

Hypothesis: Forage-Selection Hypothesis stems from finding sexually dimorphic species, such as white-tailed deer, to be segregated at different times of the year. The hypothesis does not necessarily state why the sexes should come together or separate, just simply says they forage differently. There are two hypotheses that contribute to the forage selection differences amongst the sexes, the Bell-Jarmon, and the Gastroenteric Hypothesis. As mentioned, there is nothing that says bucks and does should or should not forage together at these certain times, but both hypotheses are capable of predicting forage quality and quantity, not just the different habitats in which they temporarily use.

In a natural setting, the Optimal Foraging Theory is the basis of wildlife survival. This theory states that animals strive to intake the maximum number of calories, while expending the least amount of energy. The energy expended can include, searching, procuring, and digesting of food resources. The quality of habitat in this case, directly affects the fecundity, reproductive rates, biological carrying capacity, and individual growth, as well as, the health of the individuals and the herd. As briefly mentioned, there are a few hypotheses describing why white-tailed deer segregate for much of the year. The Gastroenteric Hypothesis is based on metabolic requirements, nutritional values of forages, and the ability to retain forages in the rumen. In sexually dimorphic species, there are differences in body characteristics, (appearance and body size) which explain the need for separation and habitat selection between the sexes. With a larger body to maintain and developing antlers annually, it is evident that male deer need to consume larger quantities of forages regardless of quality yet predicted to be higher in fiber. The slower digestion rate due to the higher levels of fiber, assists in higher nutrient uptake for the males, and this is ideal for segregation into an area of low forage quality (Stewart et al. 2011).

Steadman (1996) conducted a trial of food plots using lablab and white milo to see if the benefits of planting food plots would cause differences in antler growth of randomly selected white-tailed bucks. A 5.4% and an 11.96% growth increase in bucks 5.5 years old and 4.5 years old, respectively; was reported for those that had access to the food plots. As early as the first year of testing, additional antler growth within the two age groups was recorded. McBryde (1995) stated that in most circumstances' food plots are more cost effective, but the yield of the food plots must meet or exceed 3,169 kg/ha, or approximately 3.2 metric tons/acre planted.

Exotic Cervids. Red deer stag (*Cervus elaphus*) have been raised in a production setting in New Zealand, Hungary, and Poland for many years, with the difference being the acreage in which these red deer were "confined". The herds usually have vast areas to roam with native vegetation available for most of the year, and only needing to be relocated from their mountainous and meadow home ranges during the harsh winter months for supplemental feeding.

Energy requirements change seasonally based on the annual production cycle of red deer, depending on seasonal changes, and forage availability and quality. In a New Zealand study, comparing three test groups, one group was monitored in a pasture setting, and the other two groups were monitored while confined in a housing unit and provided with a higher quality diet, consisting of: Lucerne hay, nuts, pelleted feed (46% barley, 35% Lucerne, 15% linseed meal, and 4% minerals and vitamins), (Fennessy et al. 1981). Live weight gain (LWG) and metabolizable energy intake (MEI) were collected and compared. Further estimations were made based off winter maintenance requirements (MR) of all groups. "The estimates of maintenance requirement (MR) calculated from regression relationships (housing unit n=85, pasture n=11) were 0.57 and 0.85 MJ ME/kg$^{0.75}$/d for stags raised in the confined housing units and in the pasture respectively" (Fennessy et al. 1981). Estimates of the energy requirements of the stag in the pasture with the four seasons of the year were broken down into the number of days per season: Autumn-65 days, MR=0.74; Winter-100 days, MR=0.85; Spring-100 days, MR=0.68; Summer-100 days, MR=0.63, for the stags in the pasture and was established by adding 30%, 50%, 20%, and 10% above the requirements for the housed stags. In addition, the ME required for velvet antler growth was 0.33 assuming the stags were able to utilize the available nutrients daily, to produce velvet for antlers weighing 2.4kg. LWG was 15.2±0.87, 27.55±2.26, for outdoor and indoor stag body weight, respectively.

Red deer are large animals with a relatively high MEI requirement; thus, for them to acquire this daily requirement, they need high quality forage. Selecting forages with high protein and low fiber, allows for shorter digestion period with potential increase in nutrient uptake and allows them to utilize secondary metabolites available for performance, (Zweifel-Schielly et al. 2012).

In the same study, Zweifel-Schielly et al. (2012) examined feces throughout the year of 15 radio-collared red deer, to gain a better understanding of the diet of red deer in harsh mountain habitats. The fecal samples were analyzed for protein, energy, fiber, cellulose, and lignin. Forty-one percent of the fecal samples had portions of grass species, Orchardgrass (*Dactylis glomerata*), Kentucky Bluegrass (*Poa pratensis*), and Perennial Ryegrass (*Lolium perenne*) dominating other forages consumed by the red deer. These grass-like floras are the basis of growth for red deer in native habitats, without having the benefit of higher quality natural forage. As a ruminant animal, red deer stags are great at partitioning nutrients from grasses to growth with the microbes in the rumen changing with the seasonality of vegetation for improved digestibility.

Antler Growth. In the hunting and breeding industry the larger the animal's antlers, the more scorable inches, that individual has a higher value. Antler growth gets a vast amount of attention in the *Cervidae* family; current research correlates antler growth with superior quality of forage resources, genetics, and health of the individual. Crude protein (CP), nitrogen (N), calcium (Ca), and phosphorus (P) are the major classes of nutrients for antler growth and composition. During antler growth, there is a mobilization of minerals from the skeletal system of male cervids, primarily from the ribs and shoulder blades, to the antlers. It is not until after the velvet is stripped, that lost nutrients from the bones are replenished. The daily requirements of CP, Ca, and P have been studied in a variety of trials, yet all consisted of a small number of individuals, and most studies were not conducted on specific species, but rather multiple species per study. White-tailed deer, though numbers are small per trial, are the most studied with findings indicating that antler growth of males that have access to a high energy, high protein pellet supplemental feed during the summer months do tend to have larger antler sizes, than those without access to pelleted feed, or high-quality diets (Bartoskewitz et al. 2003).

During antler growth, high quantities of proteins are required. These proteins make up nearly 80% of the antler weight while in velvet. Asleson, Hellgren and Varner (1996) reported for optimum antler growth in male, white-tailed deer under the age of 1.5 years require 13-16% CP due to the rapid growth rate within the first two-years of life. Whereas, protein requirements for male white-tailed deer 2.5 years old and older are relatively unknown, this limited study found that N levels at 0.46g N/kg$^{0.75}$/d, or a 5.1%

CP diet was enough for basic survival and minimal growth. For moderate antler growth in the same deer, the requirements increased to 0.88g N/kg$^{0.75}$/d, or 9.8% CP diet. Wright et al. (2002) reported a recommendation of 16% for adult male white-tailed deer to achieve optimal antler growth. With the requirements of CP and N determined for moderate growth, the daily intake of CP, to maximize the genetic potential of our animals will need to be higher.

Calcium makes up approximately 19% of the mature, hard antler by weight (Murphy 2017). Throughout the year, deer will feed on Ca rich vegetation, with the surplus being deposited in the skeletal system for future use, specifically antler growth. This routine minimizes the possibility of insufficient minerals in the available forage at the time antlers begin to develop. Muir et al. (1987), recorded that a 3kg antler would contain 537g of Ca. The maximum rate of Ca deposition (33% of total antler Ca), would occur between 91 and 112 days of antler growth, at 8.4g Ca/day.

Though phosphorus only makes up 10% of hard antler composition, many researchers believe it is one of the most limited nutrients in antler growth. Yet, studies show most white-tailed deer get enough P from their daily diet, to meet their minimum requirements (Murphy 2017). Using an estimation on one species may be helpful to have a starting point for other, larger species. Grasman and Hellgren (1993) estimated the annual P requirements for a male, white-tailed deer with an average antler weight of 621g (ranging between 326-1195g), and body weight of 70kg, to be 638g representing 0.07-0.12% dietary P. When P exceeds minimal requirements, excess will be deposited in the skeletal system and stored for use when P is deficient in the diet. For optimal antler mass, the P intake is a direct function of DMI, and should with higher levels needed in younger white-tailed deer, (Grasman and Hellgren 1993). As animals mature, their nutritional requirements change, and so do the antler characteristics and size. Like body weight, antler growth is impacted by environmental conditions, such as population density. An increase of 50% in female population, from 100 to 150 red deer hinds, decreases antler mass. Phosphorus is found to impact antler mass, but does not influence main beam length, or number of tines, in red deer stags by 154g (Kruuk et al. 2007). In addition, Kruuk et al. (2007) found that antler mass in red deer stags varies with age, not reaching a maximum weight until age 10.

Female Cervids: Reproduction and Performance. Considering the needs of female, white-tailed deer during different physiological periods of their annual life cycle (pregnancy, parturition, and lactation) show a greater need to capitalize on available forages. In order meet the higher nutritional requirements during these times, quality of forages within the habitat can cause segregation (Gastroenteric Hypothesis). With a rumen of lesser capacity, female white-tailed deer need the higher quality forage, to meet requirements for reproduction and lactation.

A mineral consumption study conducted by Ayotte et al. (2006), noted female white-tailed deer visited mineral licks more frequently with high concentrations of, magnesium (Mg), calcium (Ca), and phosphorus (P), than sites that were primarily high in sodium (Na). This can be associated with rumen bacteria turnover with springtime forages becoming available. Although providing a forage source that meets or exceeds all nutritional necessities of female white-tailed deer during this period in their life cycle, Cooper et al. (2006), mentions that changing one limiting factor will not change the habitat selection of these females. In a natural setting, regardless of foraging preference and availability, ensuring the surrounding habitat is adequate for survival for these females and the offspring is paramount for the continuation of a viable population. According to the Rose Petal Theory, a matriarchically defined family structure, females and fawns will have an overlapping home range, provided there is suitable habitat available. With adequate forage, cover, and water, the separation of these family units will occur naturally, maintaining the population densities within a certain area. Thus, increasing the need to establish a food source that is high in quality in all areas that are within the home range of these females and their offspring.

In addition, Verme (1969) reviewed nutrition in relation to reproductive success in female white-tailed deer and found that yearling does having access to high quality feed and forage, had a fawning rate 2.5 times higher than yearling females on a low-quality diet. Likewise, females in their prime reproductive years produced twins in 20 out of 25 fawn crops, and it can be viewed that higher quality diets, whether it be through planted food plots or pelleted feed. This study defined the quality of each habitat by class. Class I was of optimal nutrition and availability with limited to no competition, forages found year-round, and most of the offspring came in the form of twins. Class II was an area of intense management; the densities were kept in balance through hunting, and very little hardships or pressure on the habitat or available forage. If the environmental factors were favorable, the reproduction would remain consistent. Class III in the northern range with harsh winters, forage availability was seasonally limited, resulting in numerous instances of malnutrition. They found that in the later stages of fetal development there was not enough forages available and stillborn, or extremely malnourished fawns were produced. Finally, Class IV, this habitat was not adequate for a viable population of white-tailed deer due to increased competition and over browsing, advanced plant and forest succession resulting in very limited availability of preferred forages being present. With the quality of habitat being minimal at best, the reproduction of the female white-tailed deer was extremely low. Supplementation of available forages through food plots would increase the available tonnage of forage available, increase the quality of the habitat, and allow for proper growth of the local population.

CHAPTER II

Materials and Methods

Seven food plots (Figure 1) covering a total of 25 acres were planted on a privately owned, game ranch (50x Ranch, Cameron, Texas) with one of three vegetative treatments. The seven food plot locations were selected with knowledge of deer patterns and usage of the food plots, proximity of food plots to protein feeders, and even distribution throughout the ranch. Treatment A was a commercial blend of soybeans created by Eagle Seed in Weiner, Arkansas, named Game Keeper®, this blend contains Big Fellow®, Large Lad®, and Whitetail Thicket RR ®. This proprietary blend of soybeans was designed to increase tonnage per acre, quality of nutrients available, and have a higher level of drought tolerance than most soybeans. Treatment B was a blend of Sorghum (Milo), Peredovik Sunflower, and Big Buck 6 soybean (Eagle Seed, Weiner, Arkansas). Treatment C were areas left untreated to allow for natural vegetation and the prior seed bank to germinate providing a native forage option. Prior to planting, soil samples were collected and sent to Producers Cooperative (Bryan, Texas) for analysis. Based on the analysis, lime and fertilizer were applied according to the recommendations for the planted forage crops. The lime and fertilizer were blended together in pelleted form to have a prolonged infiltration into the soil to assist in nutrient uptake by the crops.

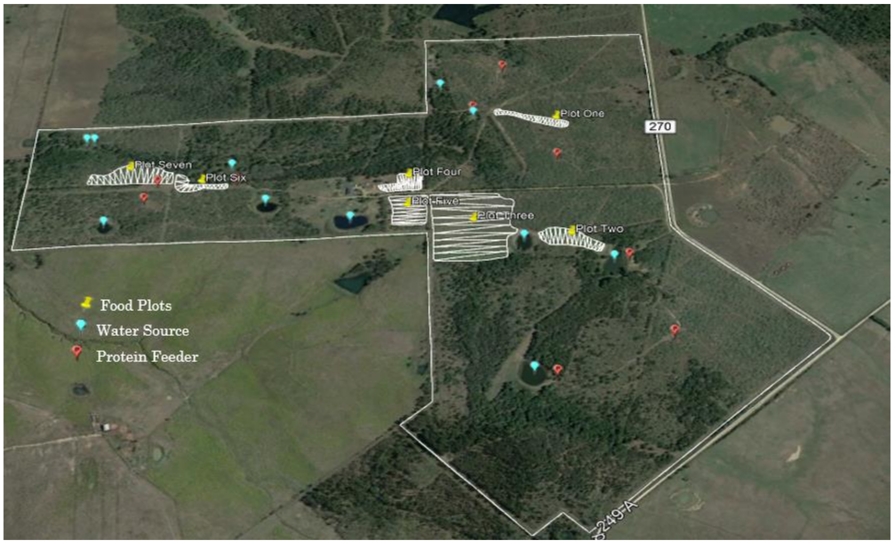

Figure 1. Food plot location, in relation to water sources and protein feeders

The food plots were divided into 9 equal sections (Figure 2), on an individual field basis, the size of each food plot varied from .71 to 12.5 acres, therefore, each field had different dimensions planted. Each section, within each field, was randomly assigned one treatment to be planted; utilizing a Latin Square design; three sections of each treatment were planted per field. Each of the three treatments had a 3’ x 3’ utilization cage within one section to protect that area from consumption.

Figure 2. Placement of each treatment within food plots.

Vegetative samples from inside and outside of the utilization cages were collected on days 30, 60, and 90 following the planting date. Inside the utilization cages, forage samples were collected by placing an 18” x 18” frame within an area of current growth. Within the 18” x 18” frame, heights of vegetation were measured and recorded, followed by removal of all vegetation within the frame to ground level. On the outside of the cages, the frame was randomly placed in one of the other two sections of the corresponding treatment areas. The vegetative heights were measured and recorded, followed by removal of all vegetation within the frame, to ground level. This was performed on three randomly selected fields at each of the 30, 60, and 90-day samplings. The selection of three fields per month were chosen in order to avoid depleting the samples within the utilization cages.

All forage sample data were analyzed using mixed procedures in SAS version 9.4, with repeated measures to account for multiple sampling dates. The samples were separated into two categories, leaf and stem, and stalk. The samples were then dried at 48.89 degrees Celsius (120 degrees Fahrenheit), for thirty-six hours. Once dried, a dry weight was taken to estimate a tonnage produced per acre, if the vegetation were to be untouched. After weights were taken, all samples were sent to Texas A&M AgriLife Extension Service Soil, Forage and Water Testing Laboratory (College Station, Texas) for nutrient analysis (CP, N, P, Ca, K, Mg, Na, Fe, Cu, Zn, Mn, S and ADF).

To determine approximate preference of forages within the treatment areas, population density was estimated by conducting three spotlight surveys with a minimum of three personnel, and no separation of species. After the three surveys were concluded, an average wildlife density was determined. The following formula was used to determine the animal density per acre: $\widehat{\mathrm{N}} = \frac{\widehat{\mathrm{N}}_1}{\alpha}$. $\widehat{\mathrm{N}}$ represents the estimated number of animals, $\widehat{N}_1$ is the number of animals surveyed, and α is the proportion of the total area measured (Lancia et al 2005), the estimated population was 217 animals during the period of this trial.

CHAPTER III

Results and Discussion

Results

Food Plots. Within the food plots, Treatment A (soybean blend) had the lowest weight of 195 g in the treatment areas accessible by the white-tailed deer, similarly to the weight of Treatment B (soybean, milo, peredovik sunflower), 200.6 g ($P = 0.5775$). This signified a foraging preference over Treatment C (native forbs), which was dominated by One-seed Croton, (*Croton monanthogynus)*, with a weight of 245.3 g ($P < 0.05$).

Nutrients. Table 1 illustrates the average nutrient levels across Treatments A, B and C. Average protein of treatments showed an upward movement over the course of the study, but they showed a difference based on the day in which the samples were taken. Treatment A and Treatment C showed no difference from each other with an average protein content of 22.3% and 22.7%; respectively, whereas, Treatment B had a lower protein content than all other treatments at 19.0% ($P < 0.01$). Treatment A also had the highest protein content, numerically, with a 28.0% maximum protein content at day 90.

Table 1. Average Nutritional Values (% or ppm) of leaf and stem parts

	*Trt A			*Trt B			*Trt C			*P*-value		
Trait	30	60	90	30	60	90	30	60	90	Trt	Day	Trt x Day
Protein	18.5^{ab}	20.4^{ac}	28^{e}	19.6^{ad}	21.7^{bcd}	15.7^{a}	21.6^{bcd}	22.8^{bcd}	23.8^{bcd}	0.0122	0.2512	0.0008
Acid Detergent Fiber (%)	30.0	27.5	24.8	30.6	28.0	31.6	29.9	22.6	22.3	0.0272	0.2404	0.3086
Minerals												
Nitrogen (N) (%)	2.9^{ab}	3.3^{ad}	4.5^{e}	3.1^{ac}	3.5^{bcd}	2.5^{a}	3.4^{bcd}	3.6^{bcde}	3.8^{cde}	0.0121	0.2117	0.0006
Phosphorus (P)(ppm)	4578.9	3473.8	3559.7	5181.4	3992.8	4093.3	5889.4	3863.1	4319.4	0.0275	0.006	0.7122
Potassium (K) (ppm	19775.0	22026.0	22464.0	21531.0	28096.0	31588.0	25312.0	27950.0	33445.0	0.0152	0.0742	0.7684
Calcium (Ca) (ppm)	10393^{a}	14130^{a}	13523^{a}	8469.2^{a}	15019^{ab}	11403^{a}	10177^{a}	26625^{c}	23975^{bc}	0.0001	0.0186	0.0379
Magnesium (Mg) (ppm)	2983.8	4406.5	4684.7	2656.0	4452.5	4016.3	2903.3	5288.7	4514.9	0.3711	0.0049	0.7901
Sodium (Na) (ppm)	1807.0	289.9	458.0	1527.6	327.2	409.9	1813.8	2343.9	1022.7	0.0700	0.1394	0.3437
Zinc (Zn) (ppm)	63.1	71.3	66.0	57.0	71.1	73.0	58.2	65.0	54.3	0.4842	0.804	0.8549
Iron (Fe) (ppm)	421.6	291.0	159.7	359.5	144.2	94.4	354.6	183.7	49.4	0.2909	0.005	0.9749
Copper (Cu) (ppm)	12.5	5.9	12.2	12.3	12.2	15.3	12.3	6.5	11.8	0.0771	0.193	0.4416
Manganese (Mn) (ppm)	116.4^{ad}	101.6^{a}	139.6^{af}	105.9^{ac}	175.3^{g}	129.6^{ae}	144^{ag}	69.6^{a}	100.8^{ab}	0.2117	0.9693	0.0249
Sulfur (S) (ppm)	3404.6^{a}	2178.9^{a}	2945^{a}	2409.8^{a}	4299^{a}	2755.2^{a}	4815^{a}	10200^{b}	8801.1^{b}	0.0001	0.3685	0.0084

*Treatment A was a soybean blend, Treatment B was a blend of soybean, milo, and peredovik sunflower, and Treatment C was natural vegetation

^{abc} within row, means with different superscripts differ at $P < 0.05$

Acid Detergent Fiber (ADF) is a numerical value that indicates the digestibility of the plant material by ruminants. The lower the value, the more digestible; thus, requiring less energy to breakdown, and potential for an increased uptake of nutrients. The leaves and stems of Treatments A and C were more digestible; whereas Treatment B had a higher ADF; therefore, more difficult for the wildlife to digest and suggests less available nutrients available for absorption (*P* = 0.0272; Table 1).

Nitrogen (N), associated with crude protein, is a necessity for maintenance and antler growth. Over the course of the study Treatments A and C had greater N content (*P* < 0.01) as compared to Treatment B. Treatments A and C had the highest N content at the 60- and 90-day sampling intervals (Figure 3).

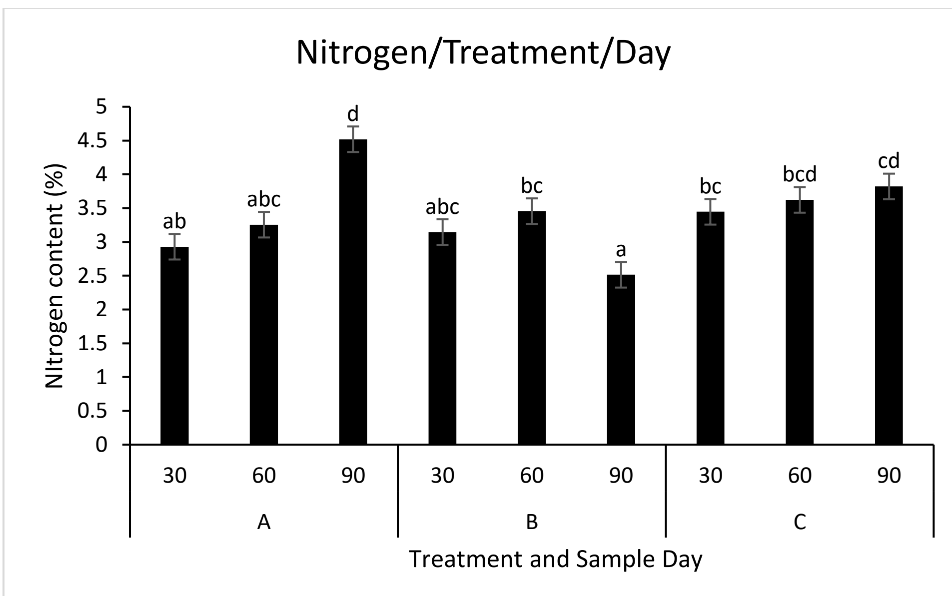

Figure 3. Nitrogen content at each sampling interval

[abc] within row, means with different superscripts differ at $P < 0.05$

Treatment C had higher levels ($P < 0.0379$) of calcium (Ca) (Figure 4) compared to all other treatments. The native vegetation, appeared to take up more Ca as the plant matured, with the highest level being at day 60.

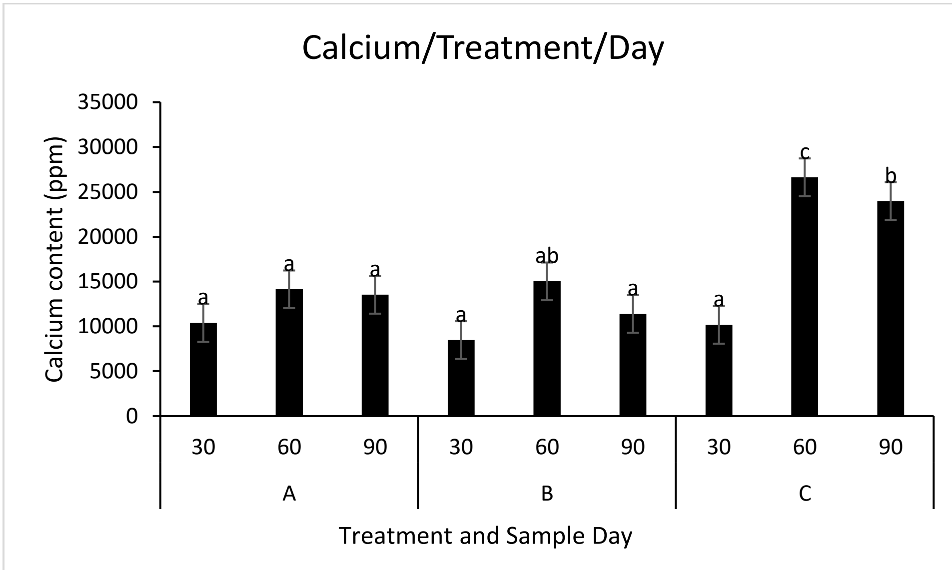

Figure 4. Calcium content at each sampling interval

[abc] within row, means with different superscripts differ at $P < 0.05$

The interaction in manganese (Mn), between treatment and days showed Treatment B on day 60 had the highest content of manganese at 175.3 ppm compared to all other treatments and sample dates (P = 0.0249) (Figure 5).

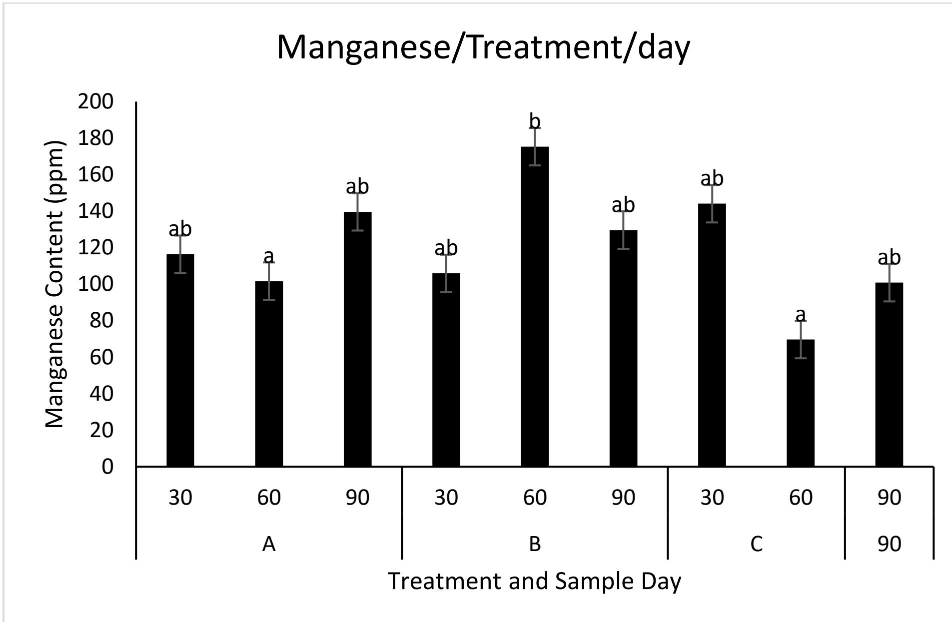

Figure 5. Manganese content (ppm) at each sampling interval

[abc] within row, means with different superscripts differ at $P < 0.05$

Sulfur (S) in Treatment C was more concentrated than other treatments ($P < 0.01$). Treatment C recorded the highest levels at day 60 and 90; this suggests that as the natural vegetation in Treatment C matured, it was able to utilize the S in the soil (Figure 6).

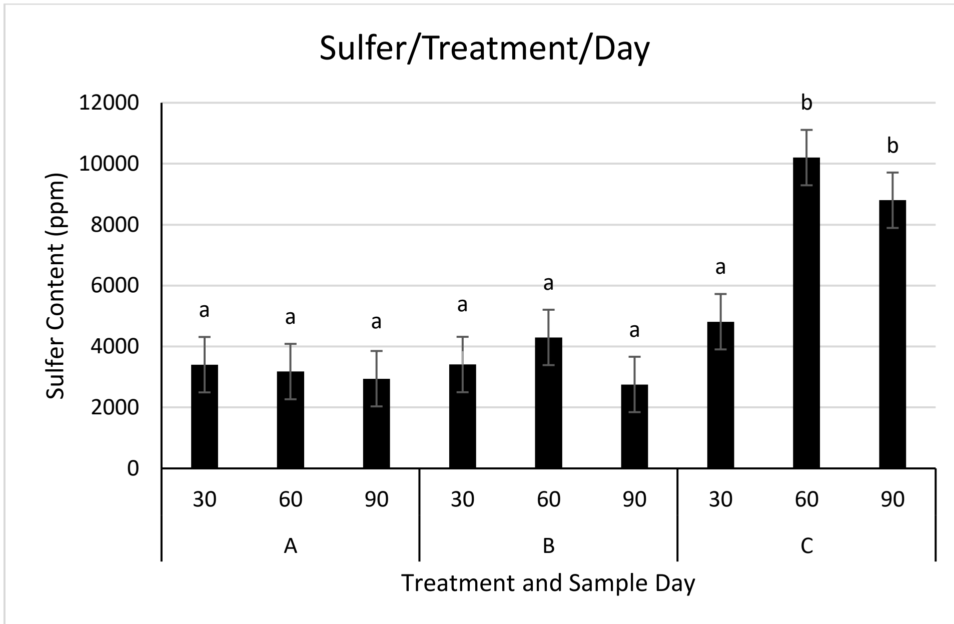

Figure 6. Sulfur content (ppm) at each sampling interval

[abc] within row, means with different superscripts differ at $P < 0.05$

Analyses showed higher levels of phosphorus (P) in Treatment C. However, there was a difference between treatments with treatments B and C being similar and Treatment A having less phosphorus ($P = 0.0275$). The day, regardless of treatment sampled, showed that the 30-day analysis had the highest phosphorus content (P = 0.006); Table 1).

Treatments B and C were not different in potassium (K) content, with averages of 27,072 ppm and 28,902 ppm; respectively, while Treatment A was lower with 21,422 ppm ($P = 0.0152$). Potassium also showed a trend to increase across all sample dates, with an average increase of approximately 3500 ppm, per 30-day sampling interval (*P* = 0.0742) (Table 1). Magnesium (Mg) was similar across all treatments for the duration of the study, with a difference in the later stages of growth (*P* = 0.0049) (Table 1).

Treatment C had higher sodium (Na) concentrations than Treatments A and B, with Treatment C having the highest concentration at 1776.8 ppm (*P* = 0.070). Overall, there was no difference in the iron (Fe) content between treatments with a difference based on day of sampling. Day 30 showed a higher Fe content present than days 60 and 90 (*P* = 0.005).Treatment B had a slightly higher copper (Cu) content, 12.9 ppm, when compared to Treatment A (9.8 ppm) and Treatment C (9.7 ppm; *P* = 0.0771; Table 1).

Zinc (Zn) was similar (*P* = 0.8549) in all plant types regardless of treatment or day samples were taken. However, between the protected sample sites and the vegetation that was accessible by wildlife, vegetation inside the protective cages recorded 71.7 ppm compared to vegetation outside the cages registering 58.2 ppm (*P* = 0.0171).

DISCUSSION

The forage blends selected for this trial was based on potential protein content, tonnage per acre, and different germination periods. Legumes are known for their nitrogen (N) fixing abilities and high protein content. Higher N values in Treatment A at the 90-day sample and Treatment C at the 60- and 90-day sample is a result of the vegetation having the ability to fix the available N in the soil. Soybeans, primarily found in Treatment A, have the ability to take up N as early as the first week of planting by forming nodules to assist in the N procurement; this process can be delayed if the soil has a high concentration of N available for plant absorption early in the growth cycle (Ruark 2009). The delayed increase of N in Treatment A indicates there could have been a surplus of available N, resulting in delaying the nodulation process, which limited the uptake of N until later in the trial.

The dominant annual broadleaf plant in Treatment C, One-seed Croton, was able to capitalize on the disturbed areas of the food plot with the existing seed bank being present. One-seed Croton has a large taproot, a single seed producing forb that is not preferred by white-tailed deer or exotic ungulates unless food resources are limited. The levels of protein were much higher than the recommended 16% in the study conducted by Wright et al. (2002) and that of the National Research Council (2007).

Phosphorus (P) is typically higher in the early stages of plant growth due to rapid cell division, growth of new tissue, development of root system, and to ensure the plant reaches maturity with enough time to produce fruits or seeds during the growing season. It was expected throughout the trial that as plants matured, there would be a difference in P. Treatment A had the lowest levels of P at 3870.7 ppm Yet at these lower levels white-tailed deer are still achieving the estimated requirements of 0.07-0.12% of daily dry matter intake (Kroll 2016).

Potassium (K) is one of the most necessary nutrients for proper plant growth and affects characteristics from shape to taste. It is responsible for mobilizing enzymes that are essential for adenosine triphosphate (ATP) production, enzymes that contribute to growth mechanisms, and assists in processes necessary for reproduction. A spike in K levels in Treatments B and C was noted due to the variation of plant size within the two treatment areas. The foliage of the milo, sunflower, and One-seed Croton alone would convey the need for increased uptake of K. According to Kroll (2016), “Potassium should be present in daily intake at 0.6-0.7 percent”; therefore, consumption of the vegetation in each of the treatment food plots would satisfy this requirement for white-tailed deer and similar ungulates.

Calcium (Ca) is utilized for cell wall formation, new growth is pliable and as the vegetation matures, the cell walls become more rigid in order to support a larger, heavier plant. One-seed Croton in Treatment C is a perennial and needs a much stronger structural base (root system) early in growth, as the plant matures it reallocates Ca to the stalk and stem for support. The thick-walled stalks of the croton would signify a need for increased uptake as it prepares for less than favorable conditions as the growing season ended. Treatments A and B were planted with annual vegetation, meaning it had to spend more energy producing roots, stalk, stems, leaves, flowers and seeds within a finite period of time. This takes away the ability or time to develop thicker cell walls, in turn requiring less Ca throughout the growing season. Even with Treatment C outperforming both Treatment A and B, the daily need of white-tailed deer weighing approximately

45.45 kg is approximately 0.3 ounces (Kroll 2016), which was met or exceeded in all treatments.

As plants matured there was a downward trend throughout the trial, to utilize less sodium across all vegetation types in the treatment groups. The natural vegetation appeared to take up sodium more easily. The minimal presence of sodium in all vegetation suggest that the soil quality was adequate for growth. The plants within the treatments did not exceed the maximum allowable Na, and would not be detrimental to growth of the available forages. With the low uptake, the vegetation in all treatments fell short of the requirements needed for cervids, 109 mg/kg per day (Hellgren and Pitts 1997). Regardless of treatment, these finding suggests the need for mineral supplementation, especially during lactation, antler growing, and post rut recovery for bucks.

All of the treatments fell short of the recommended copper (Cu) requirement of 24-40 ppm (Kroll 2016), even if higher consumption were attained, the animals could have a Cu deficiency from the treatments provided. Magnesium is the major nutrient required for photosynthesis, with a lack of Mg, chlorophyll will lose the ability to absorb sunlight, causing a degradation of energy supplies, resulting in inferior forage and minimal production. The higher concentration, within all samples, could be a result of increased root expansion. Magnesium has been correlated to lactation in the cervid family, although there has been minimal research to determine the exact requirement. In goats, which is one of the most recommended species to compare to cervid nutrient requirements, it is suggested to not to exceed 1.5 g/d for maintenance (National Research Council 2007). Higher levels can have a negative impact in goats and can become toxic.

The vegetation in all treatments exceed this exponentially, with a potential consumption of 90-138 g/d BW for white-tailed deer. Since no signs of Mg toxicity were detected in the herd for this trial, which may suggest that requirements for white-tailed deer and cervids may be higher than what the National Research Council (2007) recommends for goats.

Early in the plants' life cycle, it is necessary to utilize higher quantities of iron (Fe) for the establishment of root systems and supporting the stalk as it begins to germinate and push through the soil. Approximately 30 mg/kg day of Fe is sufficient for females that have nursing fawns (Kroll 2016). Based on this, there is a deficiency across all vegetation treatments. However, iron deficiencies were not seen within the herd, which suggests the recommendation by Kroll (2016) may be on the higher end or they were meeting their needs elsewhere. Levels below 30 mg/kg BW may provide sufficient levels of Fe to support lactating does with single or twin offspring.

Zinc (Zn) levels in the treatments fell short of the recommended levels of 115-200 ppm (Kroll 2016). The protected forage had higher levels than unprotected forage, but at no time during the study did Zn ever meet or exceed the recommended ppm. Even though the vegetation in all treatments did not meet the recommended levels, the annual fawn crop appeared to not be affected by the dietary Zn deficiencies.

Manganese (Mn) surpassed the noted requirements of 40 mg/kg (Kroll 2016). Sheep and goats have been fed diets up to 60 mg/kg BW of Mn and have been well within their daily need without reaching toxic levels (National Research Council 2007). The range of 104 - 136 mg/kg, in the current trial, may suggest that cervids can tolerate a higher level.

Although there was not a direct comparison on total forage consumed compared to consumption of supplemental protein, the addition of the spring food plot, there was a decrease in pellet purchases, from $44,930.12 in 2018, to $37,309.50 in 2019. After deducting the cost ($3,323.00) of total materials and man-hours to plant the food plots with the commercial blends, there was a savings of $4,297.62.

Implications. Supplemental feeding regimes need to be utilized for optimal health and performance of the local wild game herd. Regarding the foraging preference, nutrition, and cost, all the treatments fell within the minimum and maximum nutritional requirement thresholds for white-tailed deer and exotic herds. The commercial blend of soybeans (Treatment A), appeared to be the preferred choice by the cervids over the other treatments with a higher consumption rate than the native vegetation treatment. When selecting to plant food plots, soil type, soil quality, rainfall, and population densities need to be evaluated to determine the blend of forages that would be beneficial in the area and for species of interest. In Central Texas, this study recommends a spring food plot consisting of soybeans or an equivalent such as iron clay cowpeas. Selection would be dependent upon rainfall or the ability to irrigate the food plots. It is recommended to minimize access for the first 30-45 days when planting the commercial blends to allow the vegetation to mature and withstand high levels of foraging pressure. Incorporating commercial blends in food plots can possibly decrease the cost of supplemental feed costs.

CONCLUSION: Commercial blends of forages planted in food plots can be effective management strategies to reduce feed supplementation costs in captive white-tailed deer and exotic enterprises. The commercial plots appeared to be consumed at a higher rate by deer than the native vegetation. It can be economically beneficial to utilize food plots as a substitute for supplemental feed. Future studies evaluating different seasonal blends to determine which forage combination will provide or meet nutrient requirements and achieve optimal production with maximum cost savings. Additional research is needed to determine nutritional requirements of white-tailed deer and exotics and those species reared in a captive environment.

REFERENCES

Anderson, D. P., B. J. Frosch, and J. L. Outlaw. *Economic Impact of the Exotic Wildlife Industry*. no. 979, 2007, p. 4.

Asleson,M. A., E. C. Hellgren and L. W. Varner. *Nitrogen Requirements for Antler Growth and Maintenance in White-Tailed Deer: Published by : Wiley on Behalf of the Wildlife Society*. Vol. 60, no. 4, 1996, pp. 744–52.

Ayotte, J. B., K. L. Parker, J. M. Arocena, and M. P. Gillingham. “Chemical Composition of Lick Soils: Functions of Soil Ingestion by Four Ungulate Species.” *Journal of Mammalogy*, vol. 87, no. 5, 2006, pp. 878–88, doi:10.1644/06-mamm-a-055r1.1.

Baccus, J. T., D. E. Harmel, and W. E. Armstrong “Management of Exotic Deer in Conjunction with White-Tailed Deer.” *Game Harvest Management.* 1985, pp. 213-226.

Bartoskewitz, M. L., D. G. Hewitt, J. S. Pitts and F. C. Bryant. “*Supplemental Feed Use by Free-Ranging White-Tailed Deer in Southern Texas*.” Vol. 31, no. 4, 2003, pp. 1218–28.

Champagne, E., A. Dumont, J. Tremblay, and S. D. Cote. “Forage Diversity, Type and Abundance influence Winter Resource Selection by White-tailed Deer.” *Journal of Vegetation Science*, 2018. No.29 pp. 619-628

Cooper, S. M., M. K. Owens, R. M. Cooper, and T. F. Ginnett. “Effect of supplemental feeding on spatial distribution and browse utilization by white-tailed deer in semi-arid rangeland.” Journal of Arid Environments, 2006, vol. 66, pp. 716-726.

Faas, C. J., and Floyd W. Weckerly. “Habitat Interference by Axis Deer on White-Tailed Deer.” The Journal of Wildlife Management, 2010, vol 74, no.4, pp. 698-706.

Feldhamer, G. A., and W. E. Armstrong. “Interspecific Competition Between Four Exotic Species and Native Artiodactyls in the United States.” Trans. 58th N.A. Wildlife and Natural Resource Conference, 1993, pp. 469-478.

Fennessy, P.F., G.H. Moore, and I.D. Corson. “Energy Requirements of Red Deer.” *Proceedings of the N.Z. Society of Animal Production*, 1981, no. 41, pp. 167-173.

Grasman, B. T., and E. C. Hellgren. *Phosophorus Nutrition in White-Tailed Deer: Nutrient Balance , Physiological Responses , and Antler Growth.* Wiley on Behalf of the Ecological Society of America Vol. 74, no. 8, 1993, pp. 2279–2296.

Hellgren, E. C., and W. J. Pitts. 1997. Sodium economy in white-tailed deer (Odocoileus virginianus). Physiological Zoology 70:547–555

Kroll, J.C. 2016. Minerals, What Do Whitetail Need? - Part 1. https://www.northamericanwhitetail.com/editorial/minerals-what-do-whitetail-need-part-1/262336. Accessed 1/22/2020

Kroll, J.C. 2016. Understanding What Whitetail Need, Pt. 2. https://www.northamericanwhitetail.com/editorial/deermanagement_naw_understand_0209/263897. Accessed 1/22/2020

Kruuk, Loeske, J. Pemberton, S. Brotherstone, T. Clutton-Brock, and N. Aug. *Antler Size in Red Deer: Heritability and Selection but No Evolution ANTLER SIZE IN RED DEER : HERITABILITY AND SELECTION BUT NO EVOLUTION*. Vol. 56, no. 8, 2007, pp. 1683–95.

Lancia, R.A., W. L. Kendall, H. K. Pollock, and J. D. Nichols. 2005. Estimating the Number of Animals in Wildlife Populations. Pages 106-153 in C.E. Braun, Editor. Techniques for wildlife investigations and management. Sixth edition. The wildlife Society, Bethesda, Maryland, USA.

Lashley, M. A., and C. A. Harper. "The Effects of Extreme Drought on Native Forage Nutritional Quality and White-Tailed Deer Diet Selection." *Southeastern Naturalist*, vol. 11, no. 4, 2012, pp. 699–710, doi:10.1656/058.011.0409.

Lashley, M. A., M. C. Chitwood, C. A. Harper, C. E. Moorman, and C. S. DePerno. "Poor Soils and density-mediated body weight in deer: forage quality or quantity?" Wildlife Biology, vol. 21, no.4, 2015, pp.213-219.

McBryde, G. L. "Economics of Supplemental Feeding and Food Plots for White-Tailed Deer." Wildlife Society Bulletin, vol. 23, no. 3, 1995, pp 497-501

Muir, P. D., A.R. Sykes, and G.K. Barrell. "Growth and Mineralisation of Antlers in Red Deer (Cervus Elaphus)." *New Zealand Journal of Agricultural Research*, vol. 30, no. 3, 1987, pp. 305–15, doi:10.1080/00288233.1987.10421889.

Murphy, B. "Minerals for Whitetails." Quality Whitetails, 2017, p. 1, http://www.qdma.com/articles/minerals-for-whitetails.

National Research Council (U.S.). Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids. Washington, D.C.: National Academies Press, 2007.

Outlaw, J. L., D. P. Anderson, M. L, Earle, and J. W. Rishardson. *Economic Impact of the Texas Deer Breeding Industry*. Texas A&M University, Agricultural and Food Policy Center Research Report 17-3. May 2017. Pp. 1-20

Ruark, M. 2009. Nitrogen and Soybeans. Area Soil, Water, and Nutrient Management Meetings. https://extension.soils.wisc.edu/wp-content/uploads/sites/68/2014/02/ Nitrogen _ And _ Soybeans_Ruark.pdf. Accessed 1/22/2020.

Spinazzola, E. 2006. Ultimate Deer Food Plots. Mid-Michigan Branch of Quality Deer Management Association.

Steadman, S. W. "*Food Plots at The Faith Ranch: The Impact on Antler growth in our First Year of Food Plots".* Supplemental Feeding for Deer: Beyond Dogma. Proceedings of a Symposium. Texas A & M University. 1996. Pp 87-89

Stewart, K. M., R.T. Boyer, and P.J. Weisberg. 2011. Spatial Use of Landscapes. Pages 181-215 in D.G.Hewitt, editor. Biology and Management of White-tailed Deer. CRC Press. Taylor & Francis Group, Boca Raton, USA.

Verme, L. J. "Reproductive Patterns of White-tailed Deer Related to Nutritional Plane." The Journal of Wildlife Management, vol. 33, no. 4, 1969, pp 881-887

Wright, B. D., R. K. Lyons, J. C. Cathey, and S. Cooper. "White-tailed Deer Browse Preferences for South Texas and the Edwards Plateau." Texas Cooperative Extension the Texas A&M University System. 2002.

Zweifel-Schielly, B., Y. Leuenberger, M. Kreuzer, and W. Suter. "A Herbivore's Food Landscape: Seasonal Dynamics and Nutritional Implications of Diet Selection by a Red Deer Population in Contrasting Alpine Habitats." *Journal Of Zoology*, vol. 286, no. 1, 2012, pp. 68–80, doi:10.1111/j.1469-7998.2011.00853.

VITA

Robert W. McQueen

Education

Master of Science, Agriculture

Sam Houston State University, Huntsville, Texas **2020**

Emphasis: Wildlife Behavior and Nutrition

Bachelors of Science, Wildlife Management **2013**

Eastern Kentucky University, Richmond, Kentucky

Employment History

SHSU- Department of Agricultural Sciences **2019-present**

Teaching Assistant

50X Ranch **2016-present**

Ranch Manager and Wildlife Biologist

Resource and Land Management **2018**

Land Management Internship

USDA/APHIS/WILDLIFE SERVICES **2016**

Wildlife Biologist

Loomacres, Inc. **2015-2016**

Wildlife Biologist

Kentucky Department of Fish and Wildlife **2015**

Wildlife Technician Internship

Artemis Outdoors **2013**
Wildlife Consultant Internship- Deer Industry

United States Navy **2004-2009**

Combat Coxswain, Navigator/Engineer, Command Training Officer, Command Fitness Leader, Communications Watch Officer

Teaching

WMGT 2301- Principles of Wildlife Management

Military- Small Boat Tactics, Small Arms, Crew Served Weapons, Tactical Casualty Combat Care

Leadership and Accomplishments

Graduate Advisor- SHSU Student Chapter of the Wildlife Society

Host of the 2018-2019 Department of Agricultural Sciences Banquet

Expeditionary Warfare Specialist

Professional Organizations

The Wildlife Society

Rocky Mountain Elk Foundation

Ducks Unlimited

Publications

McQueen, Robert W., M.M. Beverly, S.F. Kelley, M.J. Anderson Forage preference of white-tailed deer and exotic species in captive Settings Exotic species presence effecting habitat selection of white-tailed deer

Krause, Ethan, B. Conn, **R. McQueen**, S.F. Kelley, M.M. Beverly, M. J. Anderson. Palatability of Olive Pomace in Mozambique Tilapia (*Oreochromis mossambicus*)