ASSESSING SEASONAL DIETS OF WATERBUCK (*KOBUS ELLIPSIPRYMNUS*) IN CENTRAL TEXAS

by

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

ABSTRACT

I investigated the seasonal diets of waterbuck (*Kobus ellipsiprymnus*) located on the Mason Mountain Wildlife Management Area from June 2016 to March 2017. I used microhistology and DNA analysis techniques on freshly collected fecal material (n = 80, 20 per season). To determine if waterbuck were selectivity feeding, I conducted vegetation surveys simultaneously with fecal sample collection. I used the Daubenmire method to quantify available herbaceous vegetation and the line-intercept method to quantify available woody vegetation. I used microhistological analysis to quantify 47 unique plant species in the diet of waterbuck. Important species included Texas wintergrass (*Nassella leucotricha*), green sprangletop (*Leptochloa dubia*), eastern gamagrass (*Tripsacum dactyloides*), Canada wildrye (*Elymus canadensis*), American barnyardgrass (*Echinochloa muricata*), yellow indiangrass (*Sorghastrum nutans*), vine mesquite (*Panicum obtusum*), and Johnsongrass (*Sorghum halepense*). DNA analysis targeted the c to h region of the chloroplast trnL (UAA) intron. No samples were successfully amplified and sequenced. The bulk of the diet consisted of grasses, most of which occurred in wetlands. Resource competition between waterbuck and upland grazers such as gemsbok, sable antelope, and scimitar-horned oryx appears to be minimal. However, competition needs to be considered when stocking waterbuck with cattle or other grazers that regularly utilize riparian species.

1. INTRODUCTION

Waterbuck (*Kobus ellipsiprymnus*) are members of the subfamily Reduncinae within the family Bovidae (Djagoun et al. 2013a). There are currently 13 recognized subspecies (Wilson and Reeder 2005) originally found throughout much of sub-Saharan Africa. The species has been extirpated from most of its historical range (IUCN 2016) and occurs mainly in protected regions or areas of low human density. Currently, waterbuck are not considered to be threatened (East 1999; IUCN 2016). In their native range, waterbuck are classified as grazers and are found in savanna woodlands near bodies of water (IUCN 2016, Djagoun et al. 2013a). Their diet consists mainly of grasses, although browse and forbs are also consumed (Gagnon and Chew 2000, Gutbrodt 2006, Kassa et al. 2008). Kassa et al. (2008) found waterbuck diet to be less diverse during the dry season and much more varied during the rainy season, thus highlighting seasonal differences in diet. Multiple food habit studies have been conducted for waterbuck in their native range using various techniques. Kiley (1966) and Kassa et al. (2008) determined diet by examining and identifying plant fragments in fecal matter. Similarly, Field (1972) determined diet of waterbuck by examining and identifying the stomach contents. Stable isotope analysis has also proven successful in determining the diets of waterbuck as was demonstrated by Cerling et al. (2003), Codron et al. (2007), and Djagoun et al. (2013b).

Understanding the ecological relationships involved in the use of food resources among different species is essential for developing viable wildlife management strategies. As such, food habit studies are an important tool for wildlife managers in determining what species can or cannot be sustained in a specific area.

Ungulate species in particular are greatly affected by the type and quality of food resources available to them (Kassa et al. 2008). Interspecific competition for food must also be considered because competition between comparable species feeding at the same trophic level is likely to occur (Djagoun et al. 2013a). Furthermore, the intensity of interspecific competition can be expected to fluctuate seasonally, with competition increasing during periods of decreased vegetative growth (Djagoun et al 2013a). For these reasons, it is important to understand dietary requirements when attempting to maintain an exotic species outside of its native geographic range.

This is particularly relevant in Texas where various exotic species, domesticated livestock, and native wildlife frequently coexist on private ranches. In the 1930s, nilgai antelope were the first exotic ungulates to be introduced into Texas (Sheffield 1983). The number of exotic species in Texas has since surged due to the rise in popularity of exotic game hunting and its standing as a major industry (Traweek and Welch 1992, Nelle 1992). Male waterbuck are prized trophy animals for their large, decorative horns, and hunts can cost as much as $8,000 (Montgomery Properties Ranch, http://www.mprhunts.com/texas-exotic-hunts/texas-waterbuck-hunt). Waterbuck are just one of the many exotic ungulates found on Texas ranches, many of which are grazers and thus potential food competitors. On Mason Mountain Wildlife Management Area (Mason Mountain WMA), scimitar-horned oryx, gemsbok, sable antelope, greater kudu, and Thomson's gazelle are present in addition to waterbuck. Sable antelope (Hargrave 2015), gemsbok (Winters 2002), and Thomson's gazelle (Hansen et al. 1985) are known grazers and thus are the greatest potential food competitors to waterbuck on the Mason Mountain WMA property.

Scimitar-horned oryx are also primarily grazers (Robinson and Weckerly 2010), however they are restricted to a separate pasture on the property and cannot compete with waterbuck for forage. Gray et al. (2006) found that greater kudu are primarily browsers and therefore unlikely food competitors with waterbuck.

Microhistology is commonly used in dietary analyses to detect and identify plant species in the fecal material of herbivores (Storr 1961, Wallage-Drees et al. 1986, Baamrane et al. 2012). This method involves examining the epidermal cells and structures of plants which retain diagnostic structures even after fragmentation and passing through the digestive tract (Baumgartner and Martin 1939). Diagnostic structures include trichomes, stomata, the presence of silica or cork cells, and the size, shape, and arrangement of the epidermal cells (Sparks and Malechek 1968, Soininen et al. 2009). Fecal samples used in this technique are typically crushed and washed to remove excess debris before being mounted on slides and examined under a microscope (Holechek and Valdez 1985, Gray et al. 2006, Hargrave 2015). Plant fragments in the samples are then examined under 10-200X magnification and identified to the lowest taxon possible (Sparks and Malechek 1968, Gray et el. 2006, Hargrave 2015). Though extensively used, the microhistological method is time and training intensive and prone to researcher bias and error (Baamrane et al. 2012). Furthermore, differential digestion can confound results as some plant materials degrade differently than others as they pass through the digestive tract (Wallage-Drees et al. 1986, Baamrane et al. 2012). Some plants, such as forbs, may be fully digested in the gut, leaving behind no observable fragments in the feces while other

plant fragments may simply be too transparent to easily discern structures within the cell (Baamrane et al. 2012).

More recently, DNA sequencing has emerged as an alternate method for analyzing diets. The use of the trnL (UAA) intron in plant chloroplasts has been successfully used in the identification of plant fragments isolated from both the stomach contents and the fecal material of herbivores (Taberlet et al. 2007, Soininen et al. 2009). The region used in molecular analyses is approximately 700 – 800 base pairs in length and sits between the c and d loops. The advantages of this region for plant identification are highlighted in Taberlet et al. (2007). First, there is more interspecific variation in base pairs than intraspecific variation. Second, the trnL intron is ubiquitous, meaning they occur in chloroplasts across all plant taxa. Third, primer sites are highly conserved between plant groups, an important advantage in PCR when amplifying multiple species in a single sample. Lastly, the short length of the trnL region lends itself well to the degraded DNA found in fecal material. Previous studies using this intron have targeted the P6 loop region for analysis, a smaller section approximately 100 base pairs in length that sits between the g and h primer sites (Taberlet et al. 2007, Soininen et al. 2009). In this study, the region between the c and h primer sites, a section around 250 – 300 base pairs long, was targeted. This region was chosen over the P6 loop region because it contains more base pairs, and thus more genetic information, decreasing the likelihood of getting ambiguous results in the analysis (Hargrave 2015). At the same time, this region is still short enough to be useful in the analysis of degraded DNA (Hargrave 2015).

Objectives

There are no studies published on the diet and dietary preferences of waterbuck in the United States. The objectives of my research are to a) determine the seasonal diets of waterbuck in the Llano Uplift sub-region in central Texas using microhistological analysis to identify and quantify plant fragments found in fecal material, b) determine if waterbuck forage selectively, and if so, which foods are used more or less than available, c) use DNA analysis to identify plant DNA extracted from fecal material, and d) compare the results from both diet analysis techniques.

After determining the diet and foraging selectivity of waterbuck in the Llano Uplift sub-region, this information can be used to compare the diet of waterbuck with other exotic and native ungulates. This will provide insight into possible dietary overlap and potential food competition, help ranchers determine the feasibility of stocking waterbuck on their property, assist ranchers in maintaining already stocked populations of waterbuck, and assess the efficacy of microhistological analysis and DNA analysis for determining diet from fecal material.

2. MATERIALS AND METHODS

Study Site

I studied the dietary habits of waterbuck at Mason Mountain WMA, located in Mason County roughly 8 km due north of Mason, Texas. The management area sits within the Llano Uplift, a sub-region of the Edwards Plateau Ecoregion characterized by granitic outcroppings interspersed throughout gently rolling terrain (Griffith 2007; Singhurst et al. 2007). Annual precipitation ranges between 680 – 810 mm and mean temperatures vary from 0 – 15.5°C in January to 21 – 35°C in July (Griffith 2007). The major soil orders found in this region are Inceptisols, which are found over granitic areas, and Alfisols which are found in low lying valleys (Griffith 2007). Woody vegetation is comprised of blackjack oak (*Quercus marilandica*) and post oak (*Quercus stellata*) with black hickory (*Carya texana*), plateau live oak (*Quercus fusiformis*), and cedar elm (*Ulmus crassifolia*) occurring in some areas along with mesquite savannas (Griffith 2007). Major grasses include little bluestem (*Schizachyrium scoparium*) and sideoats grama (*Bouteloua curtipendula*) in minimally disturbed areas, and purple threeawn (*Aristida purpurea*), silver beardgrass (*Bothriochloa laguroides*), sand lovegrass (*Eragrostis trichodes*), and Texas wintergrass (*Nassella leucotricha*) in areas with higher grazing disturbance (Griffith 2007). Mason Mountain WMA has highly diverse vegetation communities, including several endemic species and numerous plant community associations (Singhurst et al. 2007).

The property is approximately 2,147 ha (5,304 ac) in size and is partitioned into four pastures enclosed by 2.4-meter-high fencing (Singhurst et al. 2007). Prior to

its acquisition by Texas Parks and Wildlife in 1997, Mason Mountain WMA was a working exotic game ranch with several species of exotic hoofstock. Waterbuck occupied a pasture approximately 1,000 ha (2,475 acres) in size (Figure 1) that was shared with six other exotic ungulates, sable antelope (*Hippotragus niger*), gemsbok (*Oryx gazella*), greater kudu (*Tragelaphus strepsiceros*), Thompson's gazelle (*Eudorcas thomsonii*), and axis deer (*Cervus axis*). White-tailed deer (*Odocoileus virginiana*), collared peccaries (*Tayassu tajacu*), and feral pigs (*Sus scrofa*) also occur on the Mason Mountain WMA.

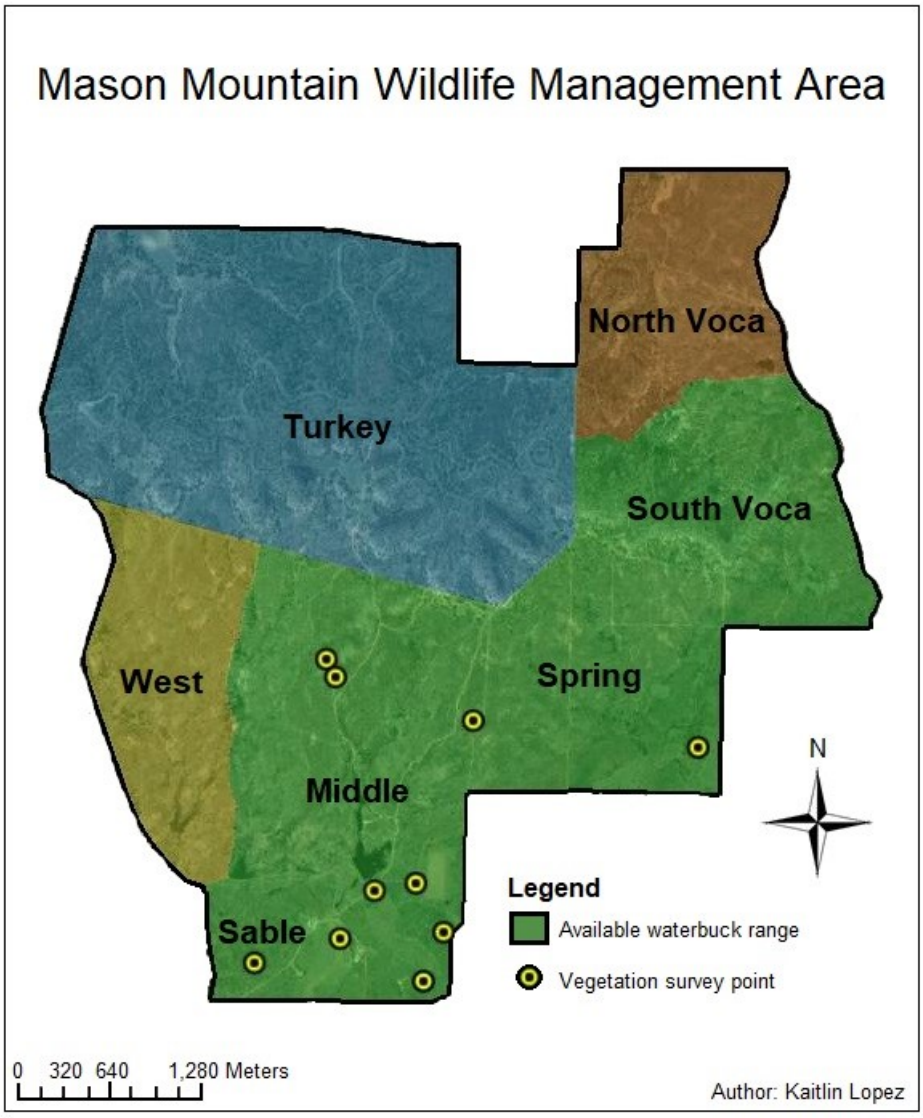

Figure 1. Pastures, available waterbuck range, and seasonal vegetation survey points on the Mason Mountain WMA property located in Mason County, Texas. Waterbuck primarily occupied Middle and Sable pastures during the 2016-2017 study.

Fecal Collection

I collected 20 fecal samples in every meteorological season to determine the diets of waterbuck. During collection activities, waterbuck were located and field notes recorded of their eating habits. After they had moved away from the area all samples of recently deposited fecal material were collected. If more than 20 fresh

samples were found only 20 were collected. Freshness was determined by texture and appearance, with recently deposited material being soft to the touch and having a light sheen. After collection, the samples were frozen and stored in a freezer until lab analysis could be done. Each sample consisted of at least 12 pellets to ensure enough material was collected for analysis. For DNA analysis, 250 mg of fecal material (<1 pellet) was needed per sample. Five pellets were needed for microhistological analysis.

Reference Slides

I prepared reference slides of the vegetation present on Mason Mountain WMA to assist in identifying plant fragments in the collected fecal material. I collected leaves and stems from plants found at vegetation transect sites and in other areas of the property where waterbuck had been observed. I soaked leaf cuttings approximately 2 cm in length in a sodium hypochlorite solution to clear away pigment and scraped it with a razor blade to remove the mesophyll layer until only the epidermis remained (Soininen et al. 2009, Robinson and Weckerly 2010, Hargrave 2015). The piece of epidermis was then inverted, mounted on a slide, and examined under a microscope at 200X magnification (Robinson and Weckerly 2010, Hargrave 2015). Pictures of the epidermis were taken with a Dino-Eye Premier AM7023B digital eyepiece camera by AnMo Electronics Corporation, Taiwan for later comparison. Storr (1961), noted that the upper and lower epidermis of some species are very different in appearance. To avoid any possible confusion during comparison of reference material to fragments detected in the fecal material, both

upper and lower epidermal surfaces of the plant samples were prepared and photographed as described above.

Microhistological Analysis

Eighty samples were analyzed using microhistology. Five pellets from the collected fecal samples were thawed, washed to remove excess debris, and dried under a fume hood. After drying, I used a Wiley Mill to grind the pellets to a standard size using a size 20-mesh sieve. Approximately 1.5 g of the ground sample was soaked in sodium hypochlorite to clear pigmented plant material. I then prepared a wet mount by transferring two drops (~100 mg) of the fecal material onto a slide. I made five slides per sample and examined five fields of view per slide at 200X magnification using a compound microscope. Fields of view were spaced 5 mm apart using pre-marked distances on the stage. In each field of view, I photographed the nearest identifiable fragment to the pointer with a Dino-Eye Premier AM7023B digital eyepiece camera (AnMo Electronics Corporation, Taiwan). Fragment photographs were taken at 200X magnification. An identifiable fragment was defined as a fragment that was cleared enough to visualize the epidermal structures. To determine species, I compared the epidermal characteristics such as trichomes, stomata, cell walls, and the size, shape and arrangement of cells of fragments observed in the fecal slides to the characteristics observed in the reference plant slides.

Diet Construction

The importance of each species consumed in the diet can be determined by looking at both the number of samples in which a species was detected (frequency of

occurrence) and the percent composition of the diet. To calculate frequency of occurrence, I counted the number of samples in which each species was detected out of the total number of samples analyzed (N = 80). To construct composition of the seasonal diets, I counted the number of fragments for each species detected out of the 500 fragments looked at per season. Similarly, the annual diet was constructed by counting the number of fragments for each species detected out of the 2,000 fragments looked at annually.

Vegetation Analyses

To determine the distribution and abundance of plant species available to waterbuck on Mason Mountain WMA, I conducted vegetation surveys seasonally at 10 points within the area used by waterbuck (Figure 1). At each point, I laid out a 100-m transect line in a randomly selected azimuth. Herbaceous vegetation was quantified using the Daubenmire method (Daubenmire 1959). I used a 100 x 25-cm frame placed perpendicular and in an alternating pattern (i.e. left side or right side of the line) along the transect at 10m intervals. All non-woody vegetation, litter, bare ground, and rocks occurring within the frame were classified into one of the six Daubenmire (1959) cover classes. Available woody vegetation was measured using the line-intercept method (Gates 1949). Available woody vegetation was any vegetation considered to be within reach of an adult waterbuck and was estimated to be at a height of 2 m or less.

Diet Selectivity

Plant selectivity was measured by comparing the proportion of plants utilized (percent composition of the diet) to the estimated proportion of plants available in the

environment (quantified on the vegetation transects). Since fecal samples cannot be assigned to individuals, I used a Design I general study, which assumes all measurements are made at the population level, to measure diet selectivity (Manly et al. 1993, Krebs 1999).

Following Krebs (1999), estimated availability of herbaceous plants was calculated by comparing the number of Daubenmire frames in which a plant made up at least 5% of the cover to the total number of Daubenmire frames. Since no woody plants were detected in microhistological analysis, estimated availability of browse species was not calculated for selectivity analysis. Unidentified fragments were not included in any of the calculations.

To test the null hypothesis that there is no difference in the proportion of plants in the diet (use) and the proportion of plants in the habitat (availability), I conducted a log-likelihood chi-square test as described by Krebs (1999). The alternate hypothesis is that there is a difference between the proportion of plants in the diet (use) and the proportion of plants in the habitat (availability). To demonstrate selection for or against a specific plant in the diet, I used Manly's alpha index of selectivity (Manly et al. 1993, Krebs 1999). This is a simple measure of selection and is suitable for most situations (Krebs 1999). A Manly's alpha value greater than 1/m, where m is the number of available food items, indicates selection for that food item (Manly et al. 1993, Krebs1999). Conversely, a Manly's alpha value less than 1/m indicates selection against that food item (Manly et al. 1993, Krebs 1999). However, a Manly's alpha value without confidence intervals can be misleading. To further support the results from Manly's alpha selection index, I constructed 95% confidence

intervals around frequencies of use in the diet and compared to frequencies of estimated availability in the environment (Neu et al. 1974). If the frequency of estimated availability fell within the confidence interval for a specific plant, then that species was used in proportion to its availability. If frequency of estimated availability was above the confidence interval, then that plant species was used less than its availability, and if frequency of estimated availability was below the confidence interval, than that plant was used more than its availability.

DNA Analysis

Multiple other studies have successfully used DNA analysis to determine the diets of ungulates. Soininen et al. (2009), used the trnL method on stomach contents to determine the diets of two small herbivores (*Microtus oeconomus* and *Myodes rufocanus),* while Baamrane et al. (2012) looked at the trnL (UAA) intron on fecal fragments to determine the diets of Moroccan dorcas gazelle (*Gazella dorcas*). Hargrave (2015), also looked at the trnL (UAA) intron to determine the diets of sable antelope, a large ungulate present on the Mason Mountain WMA property, and found that DNA analysis revealed a more detailed picture of the diet than microhistology.

To identify sequences in the diet a DNA reference library was created using the plant samples collected on the property. Following Rogers and Bendich (1988), a modified CTAB extraction was used to extract DNA from the leaves of plant samples. For amplification, the c to d region on the trnL (UAA) intron was targeted by using a PCR solution containing 0.1 µM of the trnL-c primer (^{5}'CGA AAT CGG TAG ACG CTA CG) and 0.1 µM of the trnL-d primer (^{5}'GGG GAT AGA AAA ACT TGA AC), 1 µl of the extracted DNA, 0.2 µM dNTP (10 mM each), 2.5 mM

$MgCl_2$, 1 x *Taq* buffer, 1U *Taq* polymerase, and 1 µl of bovine serum albumine (BSA in water, 30.0 mg ml^{-1}) (Taberlet et al. 2007). The solution was placed in a thermocyler for 10 minutes at 95℃, followed by 40 cycles of 30 seconds at 95℃, 30 seconds at 50℃, and 45 seconds at 72℃. After the 40 cycles were done the solution ran at 72℃ for seven minutes. Next, gel electrophoresis was used to verify the presence and quantity of PCR product. Once verified the PCR product was cleaned using a Exo/SAP cleanup. Cleaned PCR products were cycle-sequenced with a BigDye™ Terminator v3.1 Cycle Sequencing Kit and cleaned up with Centri-Sep spin columns from Princeton Separations, Inc. To determine the sequences, PCR products were run on a ABI3500xl Genetic Analyzer from Applied Biosystems. The resulting sequences were compiled into a DNA reference library for later comparison to extracted fecal sequences.

To prepare the fecal samples, I extracted DNA from 250mg of stool using the PowerLyzer PowerSoil DNA Isolation Kit from MO BIO Laboratories Inc. In test runs, this kit showed better results over the E.Z.N.A.® Stool DNA kit from Omega Bio-tek and was used for all extractions. For amplification, I targeted the c to h region of the trnL (UAA) intron found in chloroplasts by using a PCR solution containing the required materials. Following Taberlet et al. (2007), this PCR solution contained 0.1 µM of the trnL-c primer (^{5}'CGA AAT CGG TAG ACG CTA CG) and 0.1 µM of the trnL-h primer (^{5}'CCA TTG AGT CTC TGC ACC TAT C). In addition, the solution contained 1 µl of the extracted DNA, 0.2 µM dNTP, 2.5 mM $MgCl_2$, 1 x *Taq* buffer, 1U *Taq* polymerase, and BSA, as described above. The solution was run through a thermocyler for 10 minutes at 95℃, followed by 40 cycles of 30 seconds at

95℃, 30 seconds at 50℃, and 45 seconds at 72℃. After the 40 cycles were done the solution ran at 72℃ for seven minutes. After PCR, I used gel electrophoresis to examine the presence of amplification products in the reaction. I found that PCR amplification had been unsuccesfful and I was unable to move forward with sequencing.

3. RESULTS

Microhistological Analysis

I analyzed 80 fecal samples (20 per season) and examined 2,000 epidermal plant fragments (500 per season) using microhistological technique. I identified 1,947 fragments to species or genus level. Forty-seven unique species were detected in the diet (Table 1). Green sprangletop (*Leptochloa dubia*) was the most frequently detected species (n = 59). Other species that occurred in at least half of the samples were eastern gamagrass (*Tripsacum dactyloides*) (n = 55), vine mesquite (*Panicum obtusum*) (n = 51), Johnsongrass (*Sorghum halepense*) (n = 49), American barnyardgrass (*Echinochloa muricata*) (n = 47), Canada wildrye (*Elymus canadensis*) (n = 43), and dallisgrass (*Paspalum dilatatum*) (n = 41).

Table 1. Frequency of occurrence for plant species identified in waterbuck fecal samples (N = 80) from Mason Mountain WMA using microhistological analysis.

Species	Scientific Name	Number of Samples Detected In	Frequency of Occurrence
Green sprangletop	*Leptochloa dubia*	59	0.7375
Eastern gamagrass	*Tripsacum dactyloides*	55	0.6875
Vine mesquite	*Panicum obtusum*	51	0.6375
Johnsongrass	*Sorghum halepense*	49	0.6125
American barnyardgrass	*Echinochloa muricata*	47	0.5875
Canada wildrye	*Elymus canadensis*	43	0.5375
Dallisgrass	*Paspalum dilatatum*	41	0.5125
Texas wintergrass	*Nassella leucotricha*	39	0.4875
Unidentified	-	37	0.4625
Yellow indiangrass	*Sorghastrum nutans*	34	0.425
Hooded windmillgrass	*Chloris cucullata*	31	0.3875
Little bluestem	*Schizachrium scoparium*	28	0.35
Vaseygrass	*Paspalum urvillei*	28	0.35
Bermudagrass	*Cynodon dactylon*	25	0.3125
Ozark grass	*Limneoda arkansana*	25	0.3125
Plains lovegrass	*Eragrostis intermedia*	25	0.3125
Silver beardgrass	*Bothriochloa laguroides*	25	0.3125
Coastal sandbur	*Cenchrus spinifex*	22	0.275
Hybrid beardgrass	*Bothriochloa hybrida*	20	0.25
Tumble lovegrass	*Eragrostis sessilispica*	19	0.2375
Whitemouth dayflower	*Commelina erecta*	19	0.2375
Hairy grama	*Bouteloua hirsuta*	18	0.225
Sixweeksgrass	*Vulpia octoflora*	16	0.2
Resuegrass	*Bromus catharticus*	15	0.1875
Fall witchgrass	*Digitaria cognata*	12	0.15
Signalgrass sp.	*Urochloa* sp.	11	0.1375
Yellow woodsorrel	*Oxalis stricta*	10	0.125
Bushy bluestem	*Andropogon glomeratus*	9	0.1125
Rabbitsfoot	*Polypogon monspeliensis*	9	0.1125
Sideoats grama	*Bouteloua curtipendula*	9	0.1125
Texas cottontop	*Digitaria patens*	9	0.1125
Sand dropseed	*Sporobolus cryptandrus*	8	0.1
Carolina canarygrass	*Phalaris caroliniana*	6	0.075
Sneezeweed	*Helenium* sp.	6	0.075
Milkvetch	*Astragalus* sp.	5	0.0625
Jungle rice	*Echinochloa colona*	5	0.0625
Cattail	*Typha* sp.	4	0.05
Kleingrass	*Panicum coloratum*	4	0.05
Prairie wedgescale	*Sphenopholis obtusata*	4	0.05
Croton	*Croton* sp.	3	0.0375
Sedge	*Cyperus* sp.	3	0.0375
Southwest bristlegrass	*Setaria scheeli*	3	0.0375
Arizona cottontop	*Digitaria californica*	2	0.025
Knotroot bristlegrass	*Setaria parviflora*	2	0.025
Wilman's lovegrass	*Eragrostis superba*	2	0.025
King Ranch bluestem	*Bothriochloa ischaemum*	1	0.0125
Silver bladderpod	*Lasquerella argyraea*	1	0.0125
Switchgrass	*Panicum virgatum*	1	0.0125

In summer, I identified 33 species of plants (29 grasses and four forbs) from 20 fecal samples. Grasses comprised 97.3% of the diet. Of these grasses, six species each made up 5% or more of the diet. Yellow Indiangrass (*Sorghastrum nutans*) was present in the greatest amount making up 17.4% of the diet. Other species detected were, dallisgrass (12.3%), plains lovegrass (*Eragrostis intermedia*) (8.1%), little bluestem (6.9%), green sprangletop (6.5%), and silver beardgrass (6.1%). The remaining 23 grasses each comprised < 5% of the diet and were combined into the category "Other" (Figure 2). Forbs made up 2.8% of the diet. Forbs consisted of milkvetch (*Astragalus* sp.) (1.2%), sedge (*Cyperus* sp.) (0.6%), croton (*Croton* sp.) (0.4%), and whitemouth dayflower (*Commelina erecta*) (0.2%). No browse species were detected in the summer diet.

In fall, I identified 29 plant species (27 grasses and two forbs.) from 20 fecal samples. Grasses made up 99.4% of the diet. Of these grasses, seven species each comprised at least 5% of the diet. The fall diet was made up of 15% green sprangletop, 14.6% American barnyardgrass, 7.1% yellow Indiangrass, 6.7% vine mesquite, 6.5% hooded windmillgrass (*Chloris cucullata*), 6.5% Johnsongrass, and 5.2% eastern gamagrass. The remaining 22 grass species, each comprising less than 5% of the diet, were combined into the category "Other" (Figure 3). Forbs made up 0.6% of the diet with yellow woodsorrel (*Oxalis stricta*) comprising 0.4% and sedge comprising 0.2%. No browse species were detected.

In the winter fecal samples, I identified 25 plant species, 20 grasses and five forbs. Grasses comprised 91.7% of the diet, with five species each contributing 5% or more to the diet. Texas wintergrass was present in the greatest amount making up

29.3% of the diet. Other species detected included, Canada wildrye (17.7%), eastern gamagrass (12.9%), vine mesquite (6.4%), and sixweeks grass (*Vulpia octoflora*) (5.2%). The remaining 15 grass species each made up less than 5% of diet and were lumped into the category "Other" (Figure 4). Forbs made up 8.3% of the diet. Forbs detected in the diet were whitemouth dayflower (5%), sneezeweed (*Helenium* sp.) (1.5%), yellow woodsorrel (1.2%), cattail (*Typha* sp.) (0.4%), and silver bladderpod (*Lesquerella argyraea*) (0.2%). No browse species were detected.

The spring diet was made up of 35 plant species, 30 grasses (96.8%) and five (3.2%) forbs. Eight grass species each contributed >5% of the diet. Vine mesquite made up 11% of the diet, vaseygrass (*Paspalum urvillei*) made up 10.8%, green sprangletop comprised 10.6%, eastern gamagrass made up 9.8%, Canada wildrye made up 9.1%, Johnsongrass made up 8.1%, Texas wintergrass made up 6.7%, and American barnyardgrass comprised 5.5% of the diet. The remaining 22 grass species each contributed < 5% to the diet and were combined into the category "Other" (Figure 5). Forbs made up 3.2% of the diet. Whitemouth dayflower comprised 1.6%, cattail and yellow woodsorrel both made up 0.6%, and croton and sneezeweed both comprised 0.2%. No browse species were detected in spring samples.

In the annual diet, I detected 47 species, 39 (93.4%) grasses and eight (5%) forbs. Grasses which made up more than 5% of the diet were Texas wintergrass (9.2%), green sprangletop (8.5%), eastern gamagrass (8%), Canada wildrye (7.1%), American barnyardgrass (6.5%), yellow Indiangrass (6.2%), vine mesquite (6.1%), and Johnsongrass (5.1%). Each of the remaining 31 grass species made up less than 5% of the annual diet and were lumped in to the category "Other" (Figure 6). The

following forbs comprised 3.8% of the annual diet: whitemouth dayflower (1.7%), yellow woodsorrel (0.6%), sneezeweed (0.4%), milkvetch (0.3%), cattail (0.3%), sedge (0.2%), croton (0.15%), and silver bladderpod (0.1%). No browse species were detected.

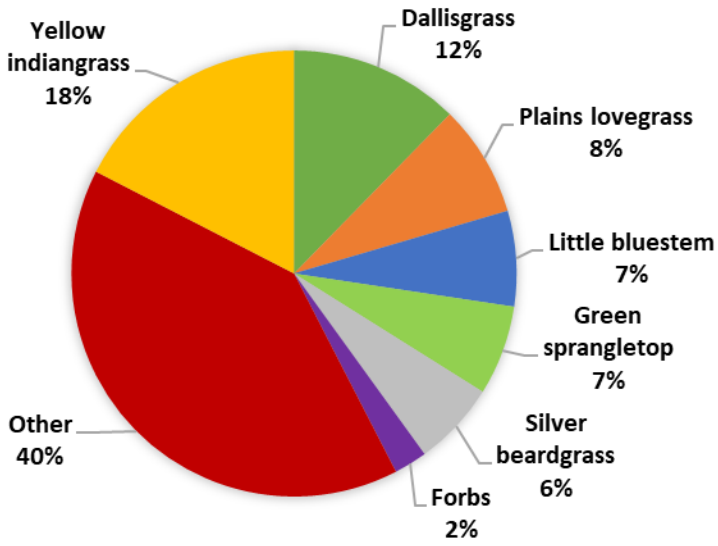

Figure 2. Percent composition of plants detected in the summer 2016 diet of waterbuck. Data obtained from microhistological analysis.

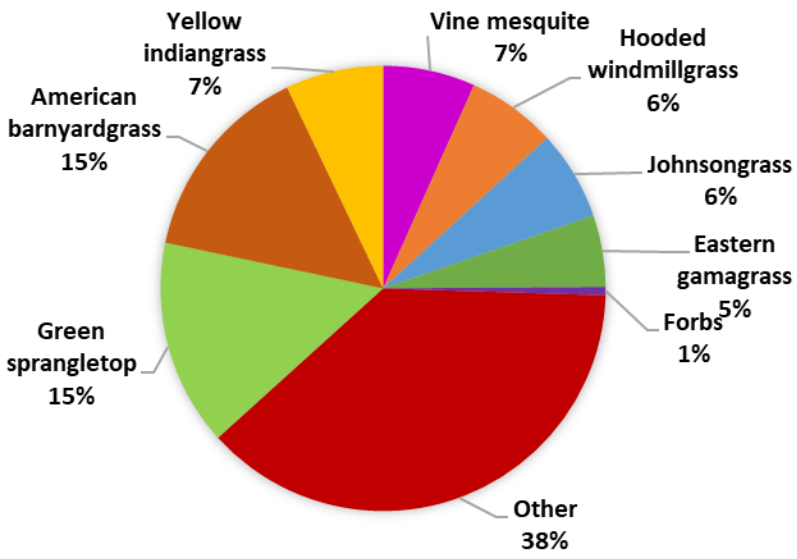

Figure 3. Percent composition of plants detected in the fall 2016 diet of waterbuck. Data obtained from microhistological analysis.

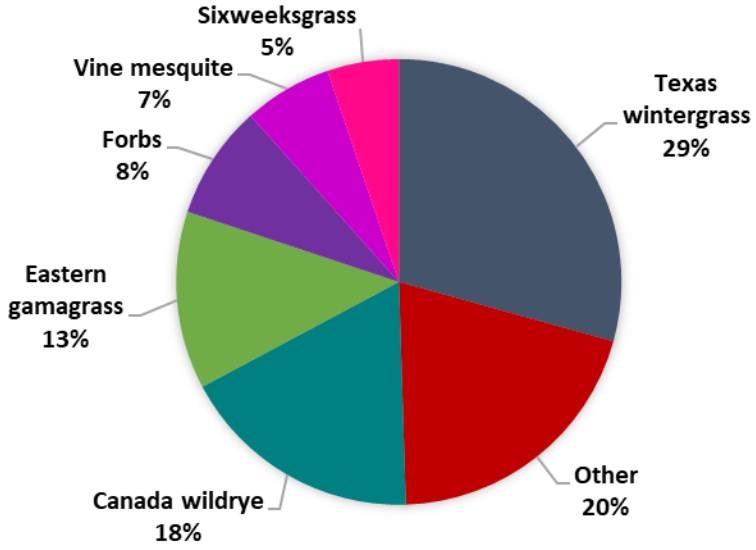

Figure 4. Percent composition of plants detected in the winter 2017 diet of waterbuck. Data obtained from microhistological analysis.

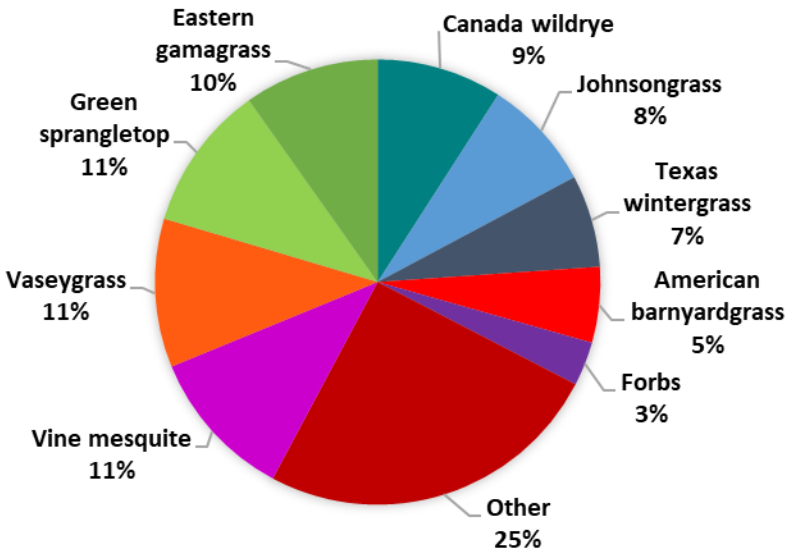

Figure 5. Percent composition of plants detected in the spring 2017 diet of waterbuck. Data obtained from microhistological analysis.

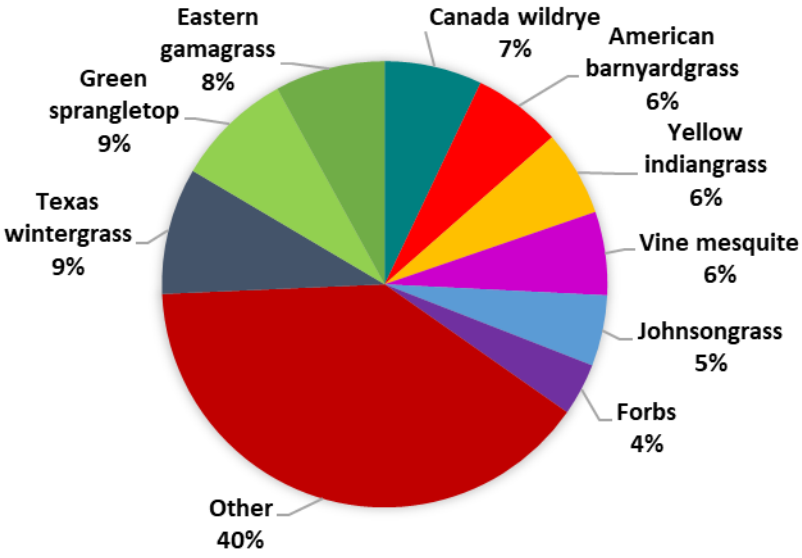

Figure 6. Percent composition of plants detected in the annual diet of waterbuck. Data obtained from microhistological analysis.

Plant Selectivity

In summer, I encountered 95 species of plants in the vegetation transects (Appendix 6). Combined, forbs had a higher percentage of availability than grasses. Texas wintergrass was the most widely available grass species. Other common species encountered in summer were western ragweed (*Achillea millefolium*), yellow woodsorrel, little bluestem, sneezeweed, and plantain.

In fall, I detected 67 species on the vegetation transects (Appendix 7). Grasses had a higher availability than forbs overall. The most commonly available species were western ragweed, Texas wintergrass, and little bluestem.

Along the winter vegetation transects I encountered 53 species (Appendix 8). Forbs were more commonly detected than grasses. Sixweeksgrass had the highest availability. Plantain and Texas wintergrass were also commonly available.

On the spring vegetation transects I detected 70 species (Appendix 9). Grasses were more prevalent than forbs. Sixweeksgrass and Texas wintergrass were the most widely available species.

Annually, I encountered 113 plant species and forbs had a higher availability than grasses (Appendix 10). Texas wintergrass had the highest availability while sixweeksgrass and western ragweed were also commonly available.

The null hypothesis that there was no difference between the proportion of plants in the diet (use) and the proportion of plants in the habitat (availability) was rejected for the summer diet ($\chi 2 = 389.64$, df = 7, P-value<0.001). In the summer, the estimated availability of yellow indiangrass, plains lovegrass, and green sprangletop fell below the 95% confidence interval of observed use in the diet indicating selection

for these species (Table 2). The Manly's alpha score was greater than 0.125 for yellow indiangrass (α=0.969), plains lovegrass (α=0.225), and green sprangletop (α=0.361) which also indicates selection for these species (Table 3). The estimated availability of little bluestem fell above the observed use confidence interval indicating that it was avoided (Table 2). The Manly's alpha scores for little bluestem also supports this conclusion (Table 3). Dallisgrass and silver beardgrass have Manly's alpha scores of α=0.098 and α=0.113 respectively suggesting avoidance (Table 3). However, their estimated availability in the environment falls within their respective observed use confidence intervals suggesting that these species were used proportional to their availability in the environment (Table 2).

The null hypothesis that there was no difference between the proportion of plants in the diet (use) and the proportion of plants in the habitat (availability) was rejected for the fall diet ($\chi 2 = 884.39$, df = 8, P-value<0.001). In the fall, the estimated availability of green sprangletop, American barnyardgrass, yellow indiangrass, Johnsongrass, and eastern gamagrass fell below the observed use confidence interval indicating selection for these species (Table 4). The Manly's alpha score was greater than 0.11 for green sprangletop (α=0.385), American barnyardgrass (α=0.375), yellow indiangrass (α=0.182), Johnsongrass (α=0.166), and eastern gamagrass (α=0.134) which also indicates selection (Table 5). The estimated availability of vine mesquite also fell below its observed use confidence interval suggestion selection (Table 4). However, its Manly's alpha score (α=0.086) suggests avoidance (Table 5). Hooded windmillgrass had an estimated availability that fell

within its observed use confidence intervals suggesting proportional use (Table 4). However, its Manly's alpha score suggests avoidance (Table 5).

The null hypothesis that there was no difference between the proportion of plants in the diet (use) and the proportion of plants in the habitat (availability) was rejected for the winter diet ($\chi 2 = 456.13$, df = 6, P-value<0.001). Canada wildrye and eastern gamagrass both had availabilities that fell below their observed use confidence intervals suggesting these species were selected for (Table 6). Their Manly's alpha scores also suggest selection (Table 7). The proportional availability of Texas wintergrass, vine mesquite, and sixweeksgrass fell within their observed use confidence intervals indicating these food resources were used in proportion to their availability in the environment (Table 6). However, Manly's alpha scores were less than 0.14 for Texas wintergrass (α=0.065), vine mesquite (α=0.122), and sixweeksgrass (α=0.122) indicating avoidance (Table 7).

The null hypothesis that there was no difference between the proportion of plants in the diet (use) and the proportion of plants in the habitat (availability) was rejected for the spring diet ($\chi 2 = 1066.03$, df = 9, P-value<0.001). The estimated availabilities for vine mesquite, vaseygrass, green sprangletop, eastern gamagrass, Canada wildrye, Johnsongrass, and American barnyardgrass fell below their observed used confidence intervals indicating selection (Table 8). The Manly's alpha scores were greater than 0.1 for vine mesquite (α=0.131), vaseygrass (α=0.257), eastern gamagrass (α=0.233), Johnsongrass (α=0.194), and American barnyardgrass (α=0.131) which also indicates selection (Table 9). However, the Manly's alpha scores were less than 0.1 for green sprangletop (α=0.084) and Canada wildrye

(α=0.055) suggesting avoidance (Table 9). Texas wintergrass had an availability that fell above the observed use confidence interval suggesting avoidance (Table 8). This is also supported by its Manly's alpha score of α=0.007 (Table 9).

The null hypothesis that there was no difference between the proportion of plants in the diet (use) and the proportion of plants in the habitat (availability) was rejected for the annual diet ($\chi 2 = 6723.358475$, df = 9, P-value<0.001). Annually, the availability of Texas wintergrass fell within the observed use confidence interval indicating it is used proportional to its availability in the habitat (Table 10). However, the Manly's alpha score was less than 0.1 for Texas wintergrass (α=0.015) indicating avoidance (Table 11). The availabilities of green sprangletop, eastern gamagrass, Canada wildrye, American barnyardgrass, yellow indiangrass, vine mesquite, and Johnsongrass all below their observed use confidence intervals indicating these species were selected for (Table 10). The Manly's alpha scores for green sprangletop, eastern gamagrass, American barnyardgrass, yellow indiangrass, and Johnsongrass also support selection (Table 11). However, Canada wildrye and vine mesquite both had Manly's alpha scores of α=0.066 which indicates avoidance (Table 11).

Table 2. Comparison of observed use in the diet to expected use in the diet based on estimated availability in the environment for the summer 2016 diet of waterbuck on the Mason Mountain WMA. The null hypothesis of proportional use was rejected for the summer diet ($\chi 2 = 389.64$, df = 7, P-value<0.001).

Food Item	# of Fragments Detected	Proportion of Use in the Diet (Observed)	Proportion of Estimated Availability (Expected)	95% CI Lower Bound	95% CI Upper Bound	Utilized More (M) or Less (L) Than Expected
Yellow indiangrass	86	0.1737	0.0175	0.1211	0.2264	M
Dallisgrass	61	0.1232	0.1228	0.0776	0.1669	-
Plains lovegrass	40	0.0808	0.0351	0.0430	0.1187	M
Little bluestem	34	0.0687	0.2281	0.0336	0.1038	L
Green sprangletop	32	0.0646	0.0175	0.0305	0.0988	M
Silver beardgrass	30	0.0606	0.0526	0.0275	0.0937	-

Table 3. Results from the Manly's alpha selectivity index for the summer 2016 diet of waterbuck on the Mason Mountain WMA. α-scores > 0.125 indicate preference.

Food Item	Manly's Alpha	Utilized More (M) or Less (L) Than Expected
Yellow indiangrass	0.969	M
Dallisgrass	0.098	L
Plains lovegrass	0.225	M
Little bluestem	0.029	L
Green sprangletop	0.361	M
Silver beardgrass	0.113	L

Table 4. Comparison of observed use in the diet to expected use in the diet based on estimated availability in the environment for the fall 2016 diet of waterbuck on the Mason Mountain WMA. The null hypothesis of proportional use was rejected for the fall diet ($\chi 2 = 884.39$, df = 8, P-value<0.001).

Food Item	# of Fragments Detected	Proportion of Use in the Diet (Observed)	Proportion of Estimated Availability (Expected)	95% CI Lower Bound	95% CI Upper Bound	Utilized More (M) or Less (L) Than Expected
Green sprangletop	72	0.1503	0.0108	0.0996	0.2008	M
American barnyardgrass	70	0.1461	0.0108	0.0963	0.1960	M
Yellow indiangrass	34	0.0709	0.0108	0.0347	0.1072	M
Vine mesquite	32	0.0668	0.0215	0.0316	0.1021	M
Hooded windmillgrass	31	0.0647	0.0430	0.0299	0.0995	-
Johnsongrass	31	0.0647	0.0108	0.0299	0.0995	M
Eastern gamagrass	25	0.0522	0.0108	0.0208	0.0836	M

Table 5. Results from the Manly's alpha selectivity index for the fall 2016 diet of waterbuck on the Mason Mountain WMA. α-scores > 0.11 indicate preference.

Food Item	Manly's Alpha	Utilized More (M) or Less (L) Than Expected
Green sprangletop	0.385	M
American barnyardgrass	0.375	M
Yellow indiangrass	0.182	M
Vine mesquite	0.086	L
Hooded windmillgrass	0.041	L
Johnsongrass	0.166	M
Eastern gamagrass	0.134	M

Table 6. Comparison of observed use in the diet to expected use in the diet based on estimated availability in the environment for the winter 2017 diet of waterbuck on the Mason Mountain WMA. The null hypothesis of proportional use was rejected for the winter diet ($\chi 2 = 456.13$, df = 6, P-value<0.001).

Food Item	# of Fragments Detected	Proportion of Use in the Diet (Observed)	Proportion of Estimated Availability (Expected)	95% CI Lower Bound	95% CI Upper Bound	Utilized More (M) or Less (L) Than Expected
Texas wintergrass	141	0.2931	0.2615	0.2290	0.3572	-
Canada wildrye	85	0.1767	0.0462	0.1229	0.2304	M
Eastern gamagrass	62	0.1289	0.0154	0.0817	0.1761	M
Vine mesquite	31	0.0644	0.0308	0.0299	0.0990	-
Sixweeksgrass	25	0.0519	0.3230	0.0207	0.0832	-

Table 7. Results from the Manly's alpha selectivity index for the winter 2017 diet of waterbuck on the Mason Mountain WMA. α-scores > 0.14 indicate preference.

Food Item	Manly's Alpha	Utilized More (M) or Less (L) Than Expected
Texas wintergrass	0.065	L
Canada wildrye	0.223	M
Eastern gamagrass	0.487	M
Vine mesquite	0.122	L
Sixweeksgrass	0.009	L

Table 8. Comparison of observed use in the diet to expected use in the diet based on estimated availability in the environment for the spring 2017 diet of waterbuck on the Mason Mountain WMA. The null hypothesis of proportional use was rejected for the spring diet ($\chi 2 = 1066.03$, df = 9, P-value<0.001).

Food Item	# of Fragments Detected	Proportion of Use in the Diet (Observed)	Proportion of Estimated Availability (Expected)	95% CI Lower Bound	95% CI Upper Bound	Utilized More (M) or Less (L) Than Expected
Vine mesquite	54	0.1098	0.0202	0.0662	0.1533	M
Vaseygrass	53	0.1077	0.0101	0.0645	0.1509	M
Green sprangletop	52	0.1057	0.0303	0.0629	0.1485	M
Eastern gamagrass	48	0.0976	0.0101	0.0562	0.1389	M
Canada wildrye	45	0.0915	0.0404	0.0513	0.1316	M
Johnsongrass	40	0.0813	0.0101	0.0432	0.1194	M
Texas wintergrass	33	0.0671	0.2323	0.0322	0.1019	L
American barnyardgrass	27	0.0549	0.0101	0.0232	0.0866	M

Table 9. Results from the Manly's alpha selectivity index for the spring 2017 diet of waterbuck on the Mason Mountain WMA. α-scores > 0.1 indicate preference.

Food Item	Manly's Alpha	Utilized More (M) or Less (L) Than Expected
Vine mesquite	0.131	M
Vaseygrass	0.257	M
Green sprangletop	0.084	L
Eastern gamagrass	0.233	M
Canada wildrye	0.055	L
Johnsongrass	0.194	M
Texas wintergrass	0.007	L
American barnyardgrass	0.131	M

Table 10. Comparison of observed use in the diet to expected use in the diet based on estimated availability in the environment for the annual diet of waterbuck on the Mason Mountain WMA. The null hypothesis of proportional use was rejected for the annual diet ($\chi 2 = 6723.358475$, df = 9, P-value<0.001).

Food Item	# of Fragments Detected	Proportion of Use in the Diet (Observed)	Proportion of Estimated Availability (Expected)	95% CI Lower Bound	95% CI Upper Bound	Utilized More (M) or Less (L) Than Expected
Texas wintergrass	179	0.0919	0.1070	0.0717	0.1122	-
Green sprangletop	166	0.0853	0.0134	0.0657	0.1048	M
Eastern gamagrass	156	0.0801	0.0080	0.0611	0.0991	M
Canada wildrye	138	0.0709	0.0187	0.0529	0.0888	M
American barnyardgrass	126	0.0647	0.0053	0.0475	0.0819	M
Yellow indiangrass	121	0.0621	0.0053	0.0452	0.0791	M
Vine mesquite	118	0.0606	0.0160	0.0439	0.0773	M
Johnsongrass	100	0.0514	0.0053	0.0359	0.0668	M

Table 11. Results from the Manly's alpha selectivity index for the annual diet of waterbuck on the Mason Mountain WMA. α-scores > 0.1 indicate preference.

Food Item	Manly's Alpha	Utilized More (M) or Less (L) Than Expected
Texas wintergrass	0.015	L
Green sprangletop	0.111	M
Eastern gamagrass	0.174	M
Canada wildrye	0.066	L
American barnyardgrass	0.211	M
Yellow indiangrass	0.202	M
Vine mesquite	0.066	L
Johnsongrass	0.167	M

DNA Sequencing

DNA from 72 plant species collected from the study site were successfully sequenced (Appendix 11). Using the PowerLyzer PowerSoil DNA Isolation Kit from MO BIO Laboratories Inc. I was able to extract DNA from 20 fecal samples (five per season). However, all PCR attempts failed, and I was unable to produce enough PCR product for sequencing. Various modifications to the methods were made to get successful PCR amplification. This included using all new primers and reagents, using 2 µl of the extracted DNA, using 1-2 µl of 1:10 dilutions of the extracted DNA, and using various temperature settings in the thermocycler. However, PCR results remained unsuccessful and I was unable to produce enough PCR product for sequencing.

4. DISCUSSION

Diet from Microhistological Analysis

On the Mason Mountain WMA, grasses made up most of the waterbuck diet. This agrees with results of previous food habit studies conducted on the species in their native range (Kiley 1966, Gutbrodt 2006, Kassa et al. 2008). Kiley (1966) found that species readily eaten were tanglehead (*Heteropogon contortus*), threeawns (*Aristida* sp.), windmill grasses (*Chloris* sp.), and guineagrass (*Urochloa maximum*) by waterbuck in Kenya and Uganda. Indian goosegrass (*Eleusine indica*), thatching grasses (*Hyparrhenia* sp.), and kangaroo grass (*Themeda triandra*) were also consumed when newly sprouted (Kiley 1966). Kassa et al. (2008) found 27 taxa in the diet of waterbuck from the Pendjari National Park in Benin, with *Panicum anabaptistum*, hippo grass (*Echinochloa stagnina*), and Kunth bluestem (*Andropogon gayanus*) being the most important species. In addition, Kiley (1966) described lovegrasses (*Eragrostis* sp.) as unpalatable and did not detect any in the diet of waterbuck. Similarly, Kiley (1966) described *Brachiaria* species and *Cynodon dactylon* as palatable forage, but also did not detect any in the diet. In contrast, three *Eragrostis* species, *Cynodon dactylon,* and *Urochloa* (a sister taxon to *Brachiaria*) were detected in the diets of waterbuck on Mason Mountain WMA. Several species found in the diet by previous studies, tanglehead, guineagrass, thatching grasses, kangaroo grass, and Indian goosegrass all occur in Texas (USDA 2017); however, none of these were detected during my vegetation surveys or by any previous surveys. Windmill grasses and threeawns were detected both on the property and in the fecal samples. Shared genera detected in the diets in this study and previous studies are

Echinochloa, *Panicum*, *Chloris*, *Aristida*, *Urochloa*, and *Andropogon*. Although previous studies have found several species of browse in waterbuck diets, most notably paperbark acacia (*Vachellia sieberiana*) (Kassa et al. 2008), I detected no browse species through microhistology, nor did I observe waterbuck consuming browse during this study. I was unable to identify 53 of the 2,000 plant fragments examined. Because they frequently inhabited woody areas, it is possible that some of these unidentified fragments were from browse species.

Waterbuck were most often observed in Middle Pasture, with specific locations varying with time of day. At night, waterbuck were mostly observed in or near the riparian areas on the property. Most of the plants consumed, based on microhistological analysis, have connections to riparian zones. Of the noted species in the diet, dallisgrass, American barnyardgrass, vine mesquite, eastern gamagrass, and vaseygrass are all considered to be hydrophytes typically observed in wetlands (USDA 2017). Yellow indiangrass, Johnsongrass, and Canada wildrye are classified as non-hydrophytes that can sometimes occur in wetlands (USDA 2017). In the field, these species were observed in close association with the riparian areas on the property. Green sprangletop does not have a listed USDA wetland status, but I observed this species near creek edges. During daylight hours, waterbuck were typically observed in drier upland areas of the property, often near stands of whitebrush (*Aloysia gratissima*) and oak (*Quercus* sp.). I observed them feeding during the day in areas occupied by plains lovegrass, Texas wintergrass, hooded windmillgrass, silver bluestem, little bluestem, and sixweeksgrass.

The diets of waterbuck on Mason Mountain WMA were quite varied. The annual diet was comprised of 47 plants (Appendix 1). Sixteen species made up approximately 80% of the diet. The summer diet consisted of 33 species (Appendix 2). Nearly 80% of the diet was comprised of 11 species. Likewise, the fall diet consisted of 31 species, 11 of which made up nearly 80% of the diet (Appendix 3). In winter, the diet was comprised of 25 species (Appendix 4). Seven species made up just over 80% of the diet. Thirty-five species comprised the spring diet, 11 of those made up nearly 80% (Appendix 5). In comparison, waterbuck diet detected in other studies typically consisted of fewer species, with the bulk of the diet being composed of one or two species. This discrepancy could be attributed to a couple of factors. First, the waterbuck in this study were located in central Texas with limited riparian areas. With limited quantities of wetland plants to consume, waterbuck may have been forced to consume non-riparian plants they might otherwise avoid, leading to an increase in diet diversity. Secondly, species determination from microhistology is time consuming and requires a lot of training. It is likely that some human error occurred during the fragment identification process in this study.

Annually, green sprangletop, eastern gamagrass, vine mesquite, Johnsongrass, American barnyardgrass, Canada wildrye, and dallisgrass had high frequencies of occurrence (≥0.5) suggesting that these were at least somewhat important species regardless of their composition in the diet (Table 1). Green sprangletop was selected for and comprised large portions of the diet in fall (Table 4), spring (Table 8), and annually (Table 10) indicating that it is a very important species to waterbuck in those seasons. Green sprangletop was also selected for in summer but only comprised a

small portion of the diet (Table 2) which suggests it may not be as important in that season. Eastern gamagrass was selected for and made up large percentages of the diet in fall (Table 4), winter (Table 6), spring (Table 8), and annually (Table 10) suggesting it is a highly important food item. Vine mesquite is a very important plant in spring where it was selected for and comprised nearly 11% of the diet (Table 8). Vine mesquite was also selected for in fall (Table 4), winter (Table 6), and annually (Table 10) but was not as important to waterbuck in those seasons. Johnsongrass was selected for in spring and made up ~8% of the diet suggesting it is an important species in that season (Table 8). Johnsongrass was also selected for in the fall (Table 6) and annually (Table 10) but is likely only somewhat important based on percent composition in those seasons. American barnyardgrass was selected for and comprised large proportion of the diet in fall (Table 6) suggesting it is a very important species. American barnyardgrass was also selected for in the spring (Table 8) and annually (Table 10) but constituted smaller percentages of the diet indicating it is less important in these seasons. Canada wildrye was most important in winter where it was selected for and made up ~17% of the diet (Table 6). Canada wildrye is less important in the spring (Table 8) and annually (Table 10) where its percent composition of the diet is lower. Dallisgrass is a very important plant in summer where is was selected for and accounts for ~12% of the diet (Table 2). Yellow indiangrass had a frequency of occurrence less than 0.5 (Table 1) but was selected for and comprised ~17% of the diet in summer making in an important species in that season (Table 2). Yellow indiangrass was also selected for in the fall (Table 6) and annual (Table 10) diets but was less important in these seasons. Plains lovegrass

(*Eragrostis intermedia*) also had a low frequency of occurrence (Table 1) but was selected for and is somewhat important in the summer diet based on percent composition (Table 2). Texas wintergrass was not selected for in any season but accounted for most of the winter (Table 6) and annual (Table 10) diets making it an important species to waterbuck.

Comparison to Other Ungulates on the Property

Waterbuck shared habitat with six other ungulate species, gemsbok, greater kudu, Thomson's gazelle, sable antelope, axis deer, and white-tailed deer. Scimitar-horned oryx were also located on the property but were segregated from waterbuck in a separate pasture. Gemsbok (Winters 2002), sable antelope (Hargrave 2015), and Thomson's gazelle (Cerling et al. 2003) are known grazers. Sable antelope are large antelope whose diet on the Mason Mountain property consisted largely of little bluestem, oaks, and Texas wintergrass (Hargrave 2015). Dietary overlap between waterbuck and sable antelope is minimal as each feeds primarily in different areas. While I observed no interaction between the species in the field, the greatest potential for competition would occur in winter as Texas wintergrass is the primary grass utilized by both species in this season (Hargrave 2015). Additionally, in seasonally drier conditions, when riparian species are less abundant, waterbuck may utilize non-riparian species, such as little bluestem, more often, creating the potential for food competition.

Gemsbok were the most abundant of the large, exotic ungulates stocked with waterbuck on the Mason Mountain WMA and were often observed foraging in the same areas that waterbuck occupied during the day. However, I observed no direct

interactions between the species in the field. Gemsbok are classified as grazers and their diet on the property consists largely of little bluestem, plains lovegrass, and sideoats grama (Winters 2002). Texas wintergrass is also an important species in the gemsbok winter diet (Winters 2002). Dietary overlap between waterbuck and gemsbok is most significant during winter as Texas wintergrass is a highly important food item for both species. Little bluestem, plains lovegrass, and sideoats grama were also detected in the diets of waterbuck but were not important components. If riparian plants are present in high enough quantities, food competition between the species should not be significant during spring, summer, and fall.

Scimitar-horned oryx were segregated from waterbuck and the other exotic ungulates in Turkey Pasture, an area of limestone uplift in the northern part of the property. Scimitar-horned oryx are grazers whose diet on the Mason Mountain WMA consists primarily of lovegrasses (*Eragrostis* sp.), dropseed grasses (*Sporobolus* sp.), and forbs (Robinson and Weckerly, 2010). Little bluestem was also frequently detected in the diet, as was Texas wintergrass during the winter season (Robinson and Weckerly, 2010). Texas wintergrass and forbs are important components of the winter diets of both scimitar-horned oryx and waterbuck. Thus, any resource competition between the two species would likely occur in winter if they were stocked together.

Thomson's gazelles are grazers of dry grasslands in their native range (Cerling 2003, IUCN 2008). The population on Mason Mountain WMA consisted of only 3-5 individuals. No diet studies have been done on Thomson's gazelle in the United States. In the field, the gazelles were never observed feeding near a body of

water and spent most of their time in the open fields located in southernmost part of Middle Pasture. Based on these observations, I do not believe Thomson's gazelle would compete with waterbuck for food.

Axis deer are another exotic ungulate found on the property and are an invasive species occurring throughout the Texas hill country. Butts et al. (1982) determined that browse was the forage class primarily consumed by axis deer. However, Armstrong and Harmel (1981) found that the percent composition of browse, forbs, and grass in the diet shifts seasonally. While browse and forbs usually comprise most of the diet, axis deer can switch to grass when browse and forbs became unavailable (Armstrong and Harmel 1981). On the Mason Mountain WMA, I observed axis deer throughout the property including the riparian areas used by waterbuck. Given their ability to utilize grasses, competition with waterbuck for food, particularly in winter when availability of browse is low, is possible.

Greater kudu (Gray et al. 2007), and white-tailed deer (Armstrong and Harmel 1981, Henke et al. 1988) are browsers also occurring on the Mason Mountain WMA and are not likely to compete with waterbuck for food.

Diet from DNA Analysis

I was unable to sequence DNA from any of the fecal samples. It is possible that the reagents and primers used in the master PCR mix were not working as intended. All new reagents and primers were ordered after PCR failed using older materials. While the positive control was consistently amplified, all subsequent PCR trials for waterbuck fecal samples continued to be unsuccessful. Therefore, I do not believe the materials are the cause for PCR failure in this study. Another explanation

could be that DNA in the fecal material is simply too degraded after passing through the digestive system for the successful amplification of the c to h region of the trnL (UAA) intron. Amplification of this region might prove more successful if carried out on the stomach contents of waterbuck before food has fully passed through the digestive tract. However, as with all prized exotic game animals, it is preferable to conduct diet studies that do not require the sacrifice of the animal. The P6 loop region sits between the c and g primers on the trnL (UAA) intron and is only about 100 base pairs long. If DNA is too degraded in the fecal material for amplification of the c to h region (250 – 300bp long), then targeting a smaller region could prove more successful.

Implications for Management

Annually, dietary overlap and food competition between waterbuck and other exotic grazers appears to be minimal. Sable antelope and gemsbok more frequently utilized upland plant species while waterbuck mostly utilized riparian plants. Scimitar-horned oryx did not have access to the same foraging areas as waterbuck on the Mason Mountain WMA; therefore, the potential for competition between the two species is speculative. However, the diet of scimitar-horned oryx more closely resembles the diets of gemsbok and sable antelope than of waterbuck. Additionally, scimitar-horned oryx are native to desert regions in Africa where riparian plants are lacking (Robinson and Weckerly 2010). Therefore, provided there is adequate wetland cover and reasonable stocking rates, maintaining waterbuck with sable antelope, gemsbok, or scimitar-horned oryx should not generate significant competition over food resources. Winter is the one season where dietary overlap and

competition is most likely to occur because Texas wintergrass is a major staple of the winter diet for all the large exotic grazers stocked on the Mason Mountain WMA.

It was suggested that cattle often compete with African grazers in their native range for food (Dunham et al. 2003, Hibert et al. 2010). Additionally, nearly all the important plants used by waterbuck, including yellow indiangrass, dallisgrass, green sprangletop, American barnyardgrass, vine mesquite, Johnsongrass, eastern gamagrass, Canada wildrye, plains lovegrass, Texas wintergrass, and little bluestem are considered good forage for livestock (Shaw 2011). Therefore, careful consideration should be taken when stocking cattle with waterbuck.

Stocking waterbuck with greater kudu, white-tailed deer, and axis deer should not be problematic, but potential competition with axis deer during periods of low browse and forb growth should be considered.

Future Studies

Further statistical analyses are needed to determine the extent, or lack thereof, of resource competition between waterbuck and other grazing ungulates on the property. Future studies could also look at the percentage of riparian species occurring in the diet as a factor of the amount of available riparian area. I believe that as available wetland area increases the number of upland species utilized by waterbuck would decrease. Similarly, future studies could look at how the diet changes across multiple years as a factor of precipitation and subsequent plant growth. Further research could also compare diets determined from stomach contents to diets determined from fecal material to determine the effects of differential

digestion. Future studies are also still needed to determine the diets of waterbuck via DNA analysis.

APPENDIX

Appendix 1. Percent composition of the summer 2016 diet of waterbuck on the Mason Mountain Wildlife Management Area. Data obtained from microhistological analysis.

Scientific name	Common name	# of Fragments Detected	% Composition of the Diet
Sorghastrum nutans	Yellow indiangrass	86	17.4
Paspalum dilatatum	Dallisgrass	61	12.3
Eragrostis intermedia	Plains lovegrass	40	8.1
Schizachrium scoparium	Little bluestem	34	6.9
Leptochloa dubia	Green sprangletop	32	6.5
Bothriochloa laguroides	Silver beardgrass	30	6.1
Sorghum halepense	Johnsongrass	24	4.8
Eragrostis sessilispica	Tumble lovegrass	24	4.8
Cynodon dactylon	Bermudagrass	22	4.4
Tripsacum dactyloides	Eastern gamagrass	21	4.2
Echinochloa muricata	American barnyardgrass	20	4.0
Cenchrus spinifex	Coastal sandbur	18	3.6
Bouteloua hirsuta	Hairy grama	10	2.0
Chloris cucullata	Hooded windmillgrass	8	1.6
Elymus canadensis	Canada wildrye	7	1.4
Sporobolus cryptandrus	Sand dropseed	7	1.4
Digitaria patens	Texas cottontop	7	1.4
Digitaria cognata	Fall witchgrass	6	1.2
Paspalum urvillei	Vaseygrass	6	1.2
Astragalus sp	Milkvetch	6	1.2
Andropogon glomeratus	Bushy bluestem	5	1.0
-	Unidentified	5	1.0
Echinochloa colona	Jungle rice	3	0.6
Polypogon monspeliensis	Rabbitsfoot	3	0.6
Cyperus sp.	Sedge	3	0.6
Panicum coloratum	Kleingrass	2	0.4
Eragrostis superba	Wilman's lovegrass	2	0.4
Croton sp.	Croton	2	0.4
Bothriochloa ischaemum	King Ranch bluestem	1	0.2
Setaria parviflora	Knotroot bristlegrass	1	0.2
Urochloa sp.	Signalgrass	1	0.2
Panicum virgatum	Switchgrass	1	0.2
Commelina erecta	Whitemouth dayflower	1	0.2
Panicum obtusum	Vine mesquite	1	0.2

Appendix 2. Percent composition of the fall 2016 diet of waterbuck on the Mason Mountain Wildlife Management Area. Data obtained from microhistological analysis.

Scientific name	Common name	# of Fragments Detected	% Composition of the Diet
Leptochloa dubia	Green sprangletop	72	15.0
Echinochloa muricata	American barnyardgrass	70	14.6
Sorghastrum nutans	Yellow indiangrass	34	7.1
Panicum obtusum	Vine mesquite	32	6.7
Chloris cucullata	Hooded windmillgrass	31	6.5
Sorghum halepense	Johnsongrass	31	6.5
Tripsacum dactyloides	Eastern gamagrass	25	5.2
Bothriochloa hybrida	Hybrid beardgrass	23	4.8
Cynodon dactylon	Bermudagrass	21	4.4
-	Unidentified	21	4.4
Paspalum dilatatum	Dallisgrass	19	4.0
Schizachrium scoparium	Little bluestem	16	3.3
Cenchrus spinifex	Coastal sandbur	14	2.9
Eragrostis sessilispica	Tumble lovegrass	12	2.5
Bouteloua hirsuta	Hairy grama	10	2.1
Digitaria cognate	Fall witchgrass	9	1.9
Limnodea arkansana	Ozark grass	7	1.5
Paspalum urvillei	Vaseygrass	7	1.5
Eragrostis intermedia	Plains lovegrass	6	1.3
Urochloa sp.	Signalgrass	6	1.3
Digitaria patens	Texas cottontop	6	1.3
Polypogon monspeliensis	Rabbitsfoot	5	1.0
Bothriochloa laguroides	Silver beardgrass	5	1.0
Nassella leucotricha	Texas wintergrass	5	1.0
Setaria scheelei	Southwest bristlegrass	3	0.6
Andropogon glomeratus	Bushy bluestem	2	0.4
Oxalis stricta	Woodsorrel	2	0.4
Sporobolus cryptandrus	Sand dropseed	2	0.4
Elymus canadensis	Canada wildrye	1	0.2
Panicum coloratum	Kleingrass	1	0.2
Setaria parviflora	Knotroot bristlegrass	1	0.2
Cyperus sp.	Sedge	1	0.2

Appendix 3. Percent composition of the winter 2017 diet of waterbuck on the Mason Mountain Wildlife Management Area. Data obtained from microhistological analysis.

Scientific name	Common name	# of Fragments Detected	% Composition of the Diet
Nassella leucotricha	Texas wintergrass	141	29.3
Elymus canadensis	Canada wildrye	85	17.7
Tripsacum dactyloides	Eastern gamagrass	62	12.9
Panicum obtusum	Vine mesquite	31	6.4
Vulpia octoflora	Sixweeksgrass	25	5.2
Commelina erecta	Whitemouth dayflower	24	5.0
Paspalum urvillei	Vaseygrass	23	4.8
Limnodea arkansana	Ozark grass	21	4.4
-	Unidentified	19	4.0
Leptochloa dubia	Green sprangletop	10	2.1
Echinochloa muricata	American barnyardgrass	9	1.9
Helenium sp.	Sneezeweed	7	1.5
Sphenopholis obtusata	Prairie wedgescale	6	1.2
Oxalis stricta	Woodsorrel	6	1.2
Paspalum dilatatum	Dallisgrass	5	1.0
Sorghum halepense	Johnsongrass	5	1.0
Bromus catharticus	Rescuegrass	5	1.0
Bothriochloa hybrida	Hybrid beardgrass	3	0.6
Phalaris caroliniana	Carolina canarygrass	2	0.4
Schizachrium scoparium	Little bluestem	2	0.4
Sporobolus cryptandrus	Sand dropseed	2	0.4
Bouteloua curtipendula	Sideoats grama	2	0.4
Typha sp.	Cattail	2	0.4
Digitaria californica	Arizona cottontop	1	0.2
Andropogon glomeratus	Bushy bluestem	1	0.2
Lesquerella argyraea	Bladderpod	1	0.2

Appendix 4. Percent composition of the spring 2017 diet of waterbuck on the Mason Mountain Wildlife Management Area. Data obtained from microhistological analysis.

Scientific name	Common name	# of Fragments Detected	% Composition of the Diet
Panicum obtusum	Vine mesquite	54	11.0
Paspalum urvillei	Vaseygrass	53	10.8
Leptochloa dubia	Green sprangletop	52	10.6
Tripsacum dactyloides	Eastern gamagrass	48	9.8
Elymus canadensis	Canada wildrye	45	9.1
Sorghum halepense	Johnsongrass	40	8.1
Nassella leucotricha	Texas wintergrass	33	6.7
Echinochloa muricata	American barnyardgrass	27	5.5
Bromus catharticus	Resuegrass	18	3.7
Chloris cucullata	Hooded windmillgrass	11	2.2
Eragrostis intermedia	Plains lovegrass	11	2.2
Bouteloua hirsuta	Hairy grama	10	2.0
Limnodea arkansana	Ozark grass	10	2.0
Bouteloua curtipendula	Sideoats grama	9	1.8
Vulpia octoflora	Sixweeksgrass	9	1.8
Paspalum dilatatum	Dallisgrass	8	1.6
Commelina erecta	Whitemouth dayflower	8	1.6
-	Unidentified	8	1.6
Phalaris caroliniana	Carolina canarygrass	6	1.2
Bothriochloa laguroides	Silver beardgrass	6	1.2
Andropogon glomeratus	Bushy bluestem	5	1.0
Bothriochloa hybrida	Hybrid beardgrass	4	0.8
Urochloa sp.	Signalgrass	4	0.8
Typhya sp.	Cattail	3	0.6
Polypogon monspeliensis	Rabbitsfoot	3	0.6
Oxalis stricta	Yellow woodsorrel	3	0.6
Cynodon dactylon	Bermudagrass	2	0.4
Schizachrium scoparium	Little bluestem	2	0.4
Digitaria californica	Arizona cottontop	1	0.2
Echinochloa colona	Jungle rice	1	0.2
Panicum coloratum	Kleingrass	1	0.2
Sporobolus cryptandrus	Sand dropseed	1	0.2
Eragrostis sessilispica	Tumble lovegrass	1	0.2
Croton sp.	Croton sp	1	0.2
Helenium sp.	Sneezeweed	1	0.2
Sorghastrum nutans	Yellow indiangrass	1	0.2

Appendix 5. Percent composition of the annual (2016 – 2017) diet of waterbuck on the Mason Mountain WMA. Data obtained from microhistological analysis.

Scientific name	Common name	# of Fragments Detected	% Composition of the Diet
Nassella leucotricha	Texas wintergrass	179	9.19
Leptochloa dubia	Green sprangletop	166	8.53
Tripsacum dactyloides	Eastern gamagrass	156	8.01
Elymus canadensis	Canada wildrye	138	7.09
Echinochloa muricata	American barnyardgrass	126	6.47
Sorghastrum nutans	Yellow indiangrass	121	6.21
Panicum obtusum	Vine mesquite	118	6.06
Sorghum halepense	Johnsongrass	100	5.14
Paspalum dilatatum	Dallisgrass	93	4.78
Paspalum urvillei	Vaseygrass	89	4.57
Eragrostis intermedia	Plains lovegrass	57	2.93
Schizachrium scoparium	Little bluestem	54	2.77
-	Unidentified	53	2.72
Chloris cucullata	Hooded windmillgrass	50	2.57
Cynodon dactylon	Bermudagrass	45	2.31
Bothriochloa laguroides	Silver beardgrass	41	2.11
Limnodea arkansana	Ozark grass	38	1.95
Eragrostis sessilispica	Tumble lovegrass	37	1.90
Vulpia octoflora	Sixweeksgrass	34	1.75
Cenchrus spinifex	Coastal sandbur	32	1.64
Bouteloua hirsuta	Hairy grama	30	1.54
Bothriochloa hybrida	Hybrid beardgrass	30	1.54
Commelina erecta	Whitemouth dayflower	33	1.69
Bromus catharticus	Resuegrass	23	1.18
Digitaria cognata	Fall witchgrass	15	0.77
Andropogon glomeratus	Bushy bluestem	13	0.67
Digitaria patens	Texas cottontop	13	0.67
Sporobolus cryptandrus	Sand dropseed	12	0.62
Polypogon monspeliensis	Rabbitsfoot	11	0.56
Bouteloua curtipendula	Sideoats grama	11	0.56
Urochloa sp.	Signalgrass	11	0.56
Oxalis stricta	Woodsorrel	11	0.56
Helenium sp.	Sneezeweed	8	0.41
Phalaris caroliniana	Carolina canarygrass	8	0.41
Astragalus sp.	Milkvetch	6	0.31
Sphenopholis obtusata	Prairie wedgescale	6	0.31
Typha sp.	Cattail	5	0.26
Echinochloa colona	Jungle rice	4	0.21
Panicum coloratum	Kleingrass	4	0.21
Cyperus sp.	Sedge	4	0.21
Croton sp.	Croton	3	0.15
Setaria scheelei	Southwest bristlegrass	3	0.15
Digitaria californica	Arizona cottontop	2	0.10
Setaria parviflora	Knotroot bristlegrass	2	0.10
Eragrostis superba	Wilman's lovegrass	2	0.10
Lesquerella argyraea	Bladderpod	1	0.05
Bothriochloa ischaemum	King Ranch bluestem	1	0.05
Panicum virgatum	Switchgrass	1	0.05

Appendix 6. Daubenmire (1959) coverages of herbaceous vegetation during the 2016 summer season at Mason Mountain WMA.

Scientific Name	Common Name	Sum of Midpoints	% Cover
Litter	Litter	257.5	2.34
Bare ground	Bare ground	3410.0	31.00
Rock	Rock	292.5	2.66
Echinochloa muricata	American barnyardgrass	5.0	0.05
Daucus pusillus	American wild carrot	177.5	1.61
Digitaria californica	Arizona cottontop	17.5	0.16
Helenium amarum	Basin sneezeweed	412.5	3.75
Cynodon dactylon	Bermuda grass	15.0	0.14
Amphiachyris drcunculoides	Broomweed	20.0	0.18
Desmanthus illinoensis	Bundleflower	25.0	0.23
Helenium subaxillaris	Camphorweed	45.0	0.41
Elymus canadensis	Canada wildrye	5.0	0.05
Cenchrus spinifex	Coastal sandbur	100.0	0.91
Cocculus carolinus	Common moonseed	2.5	0.02
Hilaria belangeri	Curly mesquite	15.0	0.14
Paspalum dilatatum	Dallisgrass	85.0	0.77
Vicia ludviciana	Deer pea vetch	32.5	0.30
Scutellaria drummondii	Drummond's skullcap	12.5	0.11
Dalea nana	Dwarf prairie clover	5.0	0.05
Tripsacum dactyloides	Eastern gamagrass	17.5	0.16
Digitaria cognata	Fall witchgrass	57.5	0.52
Ambrosia confertiflora	Field ragweed	52.5	0.48
Talinum auranticum	Flameflower	2.5	0.02
Mirabilis sp.	Four o'clock	2.5	0.02
Leptochloa dubia	Green sprangletop	5.0	0.05
Smilax bona-nox	Greenbriar	5.0	0.05
Thelesperma sp.	Greenthread	15.0	0.14
Bouteloua hirsuta	Hairy grama	67.5	0.61
Physalis sp.	Heartleaf ground cherry	30.0	0.27
Chloris cucullata	Hooded windmillgrass	5.0	0.05
Monarda sp.	Horse mint	30.0	0.27
Conyza canadensis	Horseweed	150.0	1.36
Bothriochloa hybrida	Hybrid beardgrass	62.5	0.57
Gaillardia pulchella	Indian blanket	127.5	1.16
Sorghum halepense	Johnsongrass	7.5	0.07
Bothriochloa ischaemum	King Ranch bluestem	130.0	1.18
Phyllanthus sp.	Knotweed leafflower	5.0	0.05
Aphanostephus ramosissimus	Lazy daisy	35.0	0.32
Chaetopappa sp.	Least daisy	17.5	0.16
Dicanthelium acuminatum	Lindheimer's panicgrass	162.5	1.48
Schizachrium scoparium	Little bluestem	427.5	3.89
Menodora heterophylla	Low menodora	2.5	0.02
Ratibida columnifera	Mexican hat	197.5	1.80
Artemisia ludoviciana	Mexican sagebrush	7.5	0.07
Evolvulus sp.	Morning glory	2.5	0.02
Tragia ramosa	Noseburn	5.0	0.05
Sedum nuttallianum	Nuttall’s stonecrop	2.5	0.02
Dichondra recurvata	Oakwoods ponysfoot	5.0	0.05
Wedelia texana	Orange zexmenia	2.5	0.02
Opuntia leptocaulis	Pencil cactus	2.5	0.02
Parietaria pensylvanica	Pennsylvania pellitory	25.0	0.23

Coreopsis tinctoria	Plains coreopsis	135.0	1.23
Eragrostis intermedia	Plains lovegrass	57.5	0.52
Plantago sp.	Plantain	392.5	3.57
Opuntia engelmannii	Prickly pear	107.5	0.98
Oenothera sp.	Primrose spp.	2.5	0.02
Aristida purpurea	Purple threeawn	240.0	2.18
Eragrostis secundiflora	Red lovegrass	2.5	0.02
Cistus ladanifer	Rockrose	2.5	0.02
Sabatia formosa	Rose gentian	2.5	0.02
Sporobolus cryptandrus	Sand dropseed	112.5	1.02
Lechea san-sabeana	San-saba pinweed	350.0	3.18
Dichanthelium oligosanthes	Scribner's rosettegrass	12.5	0.11
Cyperus sp.	Sedge	12.5	0.11
Mimosa nuttallii	Sensitive briar	5.0	0.05
Bouteloua curtipendula	Sideoats grama	30.0	0.27
Urochloa texana	Signalgrass spp.	20.0	0.18
Bothriochloa laguroides	Silver beardgrass	72.5	0.66
Lasquerella argyraea	Silver bladderpod	25.0	0.23
Solanum elaegnifolium	Silverleaf nightshade	12.5	0.11
Xanthisma texanum	Sleepy daisy	90.0	0.82
Froelichia sp.	Snake cotton	25.0	0.23
Selaginella sp.	Spikemoss	105.0	0.95
Sida abutifolia	Spreading sida	57.5	0.52
Galium texense	Texas bedstraw	277.5	2.52
Convolvulus equitans	Texas bindweed	2.5	0.02
Digitaria patens	Texas cottontop	17.5	0.16
Croton texensis	Texas croton	25.0	0.23
Geranium texanum	Texas geranium	2.5	0.02
Bouteloua rigidseta	Texas grama	52.5	0.48
Rhynchosia senna	Texas snoutbean	105.0	0.95
Verbena halei	Texas vervain	72.5	0.66
Nassella leucotricha	Texas wintergrass	1157.5	10.52
Paspalum setaceum	Thin paspalum	20.0	0.18
Krameria lanceolata	Trailing krameria	2.5	0.02
Eragrostis sessilispica	Tumble lovegrass	5.0	0.05
Chloris verticillata	Tumble windmillgrass	20.0	0.18
Paspalum urvillei	Vaseygrass	5.0	0.05
Triodanis sp.	Venus's looking glass	15.0	0.14
Panicum obtusum	Vine mesquite	15.0	0.14
Lepidium virginicum	Virginia pepperweed	2.5	0.02
Solanum dimidiatum	Western horsenettle	165.0	1.50
Ambrosia psilostachya	Western ragweed	675.0	6.14
Achillea millefolium	Western yarrow	90.0	0.82
Evolvulus sericeus	White evolvulus	55.0	0.50
Commelina erecta	Whitemouth dayflower	42.5	0.39
Sorghastrum nutans	Yellow indiangrass	5.0	0.05
Oxalis stricta	Yellow woodsorrel	622.5	5.66

Appendix 7. Daubenmire (1959) coverages of herbaceous vegetation during the 2016 fall season at Mason Mountain WMA.

Scientific Name	Common Name	Sum of Midpoints	% Cover
Litter	Litter	52.5	0.48
Bare ground	Bare ground	3755.0	34.14
Rock	Rock	292.5	2.66
Echinochloa muricata	American barnyardgrass	5.0	0.05
Digitaria californica	Arizona cottontop	60.0	0.55
Amphiachyris drcunculoides	Broomweed	172.5	1.57
Desmanthus illinoensis	Bundleflower	15.0	0.14
Helenium subaxillaris	Camphorweed	20.0	0.18
Cenchrus spinifex	Coastal sandbur	215.0	1.95
Nothoscordum bivalve	Crow-poison	12.5	0.11
Hilaria belangeri	Curly mesquite	92.5	0.84
Dalea nana	Dwarf prairie clover	5.0	0.05
Tripsacum dactyloides	Eastern gamagrass	17.5	0.16
Digitaria cognata	Fall witchgrass	135.0	1.23
Ambrosia confertiflora	Field ragweed	85.0	0.77
Leptochloa dubia	Green sprangletop	5.0	0.05
Eragrostis curtipedicellata	Gummy lovegrass	30.0	0.27
Bouteloua hirsuta	Hairy grama	162.5	1.48
Physalis sp.	Heartleaf ground cherry	2.5	0.02
Chloris cucullata	Hooded windmillgrass	62.5	0.57
Conyza canadensis	Horseweed	7.5	0.07
Bothriochloa hybrida	Hybrid beardgrass	40.0	0.36
Sorghum halepense	Johnsongrass	10.0	0.09
Bothriochloa ischaemum	King Ranch bluestem	120.0	1.09
Dicanthelium acuminatum	Lindheimer's panicgrass	25.0	0.23
Schizachrium scoparium	Little bluestem	402.5	3.66
Chamaesyce serpens	Mat spurge	5.0	0.05
Ratibida columnifera	Mexican hat	30.0	0.27
Eragrostis lugens	Mourning lovegrass	47.5	0.43
Tragia ramosa	Noseburn	17.5	0.16
Dichondra recurvata	Oakwoods ponysfoot	17.5	0.16
Coreopsis tinctoria	Plains coreopsis	2.5	0.02
Eragrostis intermedia	Plains lovegrass	160.0	1.45
Plantago sp.	Plantain	12.5	0.11
Opuntia engelmannii	Prickly pear	207.5	1.89
Aristida purpurea	Purple threeawn	310.0	2.82
Cooperia drummondii	Rain lily	5.0	0.05
Eragrostis secundiflora	Red lovegrass	70.0	0.64
Sporobolus cryptandrus	Sand dropseed	157.5	1.43
Dichanthelium oligosanthes	Scribner's rosettegrass	17.5	0.16
Cyperus sp.	Sedge	42.5	0.39
Bouteloua curtipendula	Sideoats grama	117.5	1.07
Urochloa sp.	Signalgrass sp.	15.0	0.14
Bothriochloa laguroides	Silver beardgrass	30.0	0.27
Solanum elaegnifolium	Silverleaf nightshade	10.0	0.09
Xanthisma texanum	Sleepy daisy	25.0	0.23
Froelichia sp.	Snake cotton	120.0	1.09
Setaria scheeli	Southwest bristlegrass	15.0	0.14
Selaginella sp.	Spikemoss	127.5	1.16
Sida abutifolia	Spreading sida	202.5	1.84
Galium texense	Texas bedstraw	47.5	0.43

Digitaria patens	Texas cottontop	15.0	0.14
Croton texensis	Texas croton	2.5	0.02
Geranium texanum	Texas geranium	12.5	0.11
Bouteloua rigidseta	Texas grama	32.5	0.30
Rhynchosia senna	Texas snoutbean	25.0	0.23
Verbena halei	Texas vervain	37.5	0.34
Nassella leucotricha	Texas wintergrass	592.5	5.39
Paspalum setaceum	Thin paspalum	170.0	1.55
Eragrostis sessilispica	Tumble lovegrass	15.0	0.14
Chloris verticillata	Tumble windmillgrass	32.5	0.3
Paspalum urvillei	Vaseygrass	2.5	0.02
Panicum obtusum	Vine mesquite	15.0	0.14
Solanum dimidiatum	Western horsenettle	110.0	1.00
Ambrosia psilostachya	Western ragweed	632.5	5.75
Achillea millefolium	Western yarrow	35.0	0.32
Evolvulus sericeus	White evolvulus	107.5	0.98
Commelina erecta	Whitemouth dayflower	20.0	0.18
Sorghastrum nutans	Yellow indiangrass	5.0	0.05
Oxalis stricta	Yellow woodsorrel	205.0	1.86

Appendix 8. Daubenmire (1959) coverages of herbaceous vegetation during the 2017 winter season at Mason Mountain WMA.

Scientific Name	Common Name	Sum of Midpoints	% Cover
Litter	Litter	3585.0	32.59
Bare ground	Bare ground	1080.0	9.82
Rock	Rock	315.0	2.86
Echinochloa muricata	American barnyardgrass	7.5	0.07
Daucus pusillus	American wild carrot	147.5	1.34
Anemone sp.	Anemone	2.5	0.02
Lupinus texensis	Bluebonnet	40.0	0.36
Elymus canadensis	Canada wildrye	17.5	0.16
Cenchrus spinifex	Coastal sandbur	22.5	0.20
Nothoscordum bivalve	Crow-poison	25.0	0.23
Hilaria belangeri	Curly mesquite	52.5	0.48
Vicia ludviciana	Deer pea vetch	145.0	1.32
Tripsacum dactyloides	Eastern gamagrass	17.5	0.16
Engelmannia peristenia	Engelmann's daisy	15.0	0.14
Digitaria cognata	Fall witchgrass	5.0	0.05
Ambrosia confertiflora	Field ragweed	60.0	0.55
Leptochloa dubia	Green sprangletop	5.0	0.05
Eragrostis curtipedicellata	Gummy lovegrass	2.5	0.02
Bouteloua hirsuta	Hairy grama	5.0	0.12
Bothriochloa hybrida	Hybrid beardgrass	15.0	0.10
Sorghum halepense	Johnsongrass	7.5	0.09
Schizachrium scoparium	Little bluestem	47.5	0.43
Chamaesyce serpens	Mat spurge	97.5	0.89
Ratibida columnifera	Mexican hat	117.5	1.07
Dichondra recurvata	Oakwoods ponysfoot	17.5	0.16
Eragrostis intermedia	Plains lovegrass	32.5	0.30
Plantago sp.	Plantain	400.0	3.64
Opuntia engelmannii	Prickly pear	152.5	1.39
Aristida purpurea	Purple threeawn	52.5	0.48
Bromus catharticus	Rescuegrass	72.5	0.66
Sporobolus cryptandrus	Sand dropseed	17.5	0.16
Lechea san-sabeana	San-saba pinweed	47.5	0.43
Sporobolus cryptandrus	Sideoats grama	22.5	0.20
Urochloa sp.	Signalgrass sp.	15.0	0.14
Bothriochloa laguroides	Silver beardgrass	40.0	0.36
Lasquerella argyraea	Silver bladderpod	15.0	0.14
Vulpia octoflora	Sixweeksgrass	647.5	5.89
Xanthisma texanum	Sleepy daisy	135.0	1.23
Corydalis micrantha	Smallflower fumewort	152.5	1.39
Astragalus nuttallianus	Smallflowered milkvetch	102.5	0.93
Froelichia sp.	Snake cotton	15.0	0.14
Selaginella sp	Spikemoss	212.5	1.93
Galium texense	Texas bedstraw	47.5	0.43
Geranium texanum	Texas geranium	92.5	0.84
Erodium texanum	Texas stork's bill	80.0	0.73
Verbena halei	Texas vervain	30.0	0.27
Nassella leucotricha	Texas wintergrass	367.5	3.34
Paspalum urvillei	Vaseygrass	2.5	0.02
Panicum obtusum	Vine mesquite	17.5	0.16
Lepidium virginicum	Virginia pepperweed	305.0	2.77
Achillea millefolium	Western yarrow	80.0	0.73

Evolvulus sericeus	White evolvulus	2.5	0.02
Commelina erecta	Whitemouth dayflower	35.0	0.39
Callirhoe involucrata	Winecup	12.5	0.11
Sorghastrum nutans	Yellow indiangrass	10.0	0.09
Oxalis stricta	Yellow woodsorrel	202.5	1.84

Appendix 9. Daubenmire (1959) coverages of herbaceous vegetation during the spring 2017 season at Mason Mountain WMA.

Scientific Name	Common Name	Sum of Midpoints	% Cover
Litter	Litter	2347.5	21.34
Bare ground	Bare ground	802.5	7.30
Rock	Rock	292.5	2.66
Echinochloa muricata	American barnyardgrass	7.5	0.07
Daucus pusillus	American wild carrot	75.0	0.68
Lupinus texensis	Bluebonnet	15.0	0.14
Desmanthus illinoensis	Bundleflower	2.5	0.02
Elymus canadensis	Canada wildrye	32.5	0.30
Cenchrus spinifex	Coastal sandbur	15.0	0.14
Nothoscordum bivalve	Crow-poison	20.0	0.18
Hilaria belangeri	Curly mesquite	5.0	0.05
Tripsacum dactyloides	Eastern gamagrass	17.5	0.16
Engelmannia peristenia	Engelmann's daisy	5.0	0.05
Ambrosia confertiflora	Field ragweed	72.5	0.66
Leptochloa dubia	Green sprangletop	15.0	0.14
Eragrostis curtipedicellata	Gummy lovegrass	15.0	0.14
Bouteloua hirsuta	Hairy grama	25.0	0.23
Physalis sp.	Heartleaf ground cherry	7.5	0.07
Castilleja sp.	Indian paintbrush	2.5	0.02
Sorghum halepense	Johnsongrass	10.0	0.09
Chaetopappa sp.	Least daisy	15.0	0.14
Schizachrium scoparium	Little bluestem	77.5	0.70
Conyza canadensis	Horseweed	17.5	0.16
Chamaesyce serpens	Mat spurge	27.5	0.25
Allium canadense	Meadow garlic	5.0	0.05
Artemisia ludoviciana	Mexican sagebrush	2.5	0.02
Ratibida columnifera	Mexican hat	145.0	1.32
Achillea millefolium	Western yarrow	90.0	0.82
Tragia ramosa	Noseburn	2.5	0.02
Dichondra recurvata	Oakwoods ponysfoot	2.5	0.02
Opuntia leptocaulis	Pencil cactus	2.5	0.02
Eragrostis intermedia	Plains lovegrass	250.0	2.27
Opuntia engelmannii	Prickly pear	107.5	0.98
Aristida purpurea	Purple threeawn	150.0	1.36
Vicia ludviciana	Deer pea vetch	257.5	2.34
Cooperia drummondii	Rain lily	5.0	0.05
Plantago sp.	Plantain	322.5	2.93
Bromus catharticus	Rescuegrass	255.0	2.32
Sporobolus cryptandrus	Sand dropseed	30.0	0.27
Lechea san-sabeana	San-saba pinweed	55.0	0.50
Dichanthelium oligosanthes	Scribner's rosettegrass	20.0	0.18
Cyperus sp.	Sedge	12.5	0.11
Mimosa nuttallii	Sensitive briar	2.5	0.02
Bouteloua curtipendula	Sideoats grama	32.5	0.30
Urochloa sp.	Signalgrass spp.	2.5	0.02
Bothriochloa laguroides	Silver beardgrass	135.0	1.23
Lasquerella argyraea	Silver bladderpod	15.0	0.14
Solanum elaegnifolium	Silverleaf nightshade	10.0	0.09
Vulpia octoflora	Sixweeksgrass	820.0	7.45
Xanthisma texanum	Sleepy daisy	97.5	0.89
Corydalis micrantha	Smallflower fumewort	40.0	0.36

Astragalus nuttallianus	Smallflowered milkvetch	70.0	0.64
Froelichia sp.	Snake cotton	15.0	0.14
Selaginella sp.	Spikemoss	132.5	1.20
Sida abutifolia	Spreading sida	65.0	0.59
Galium texense	Texas bedstraw	77.5	0.70
Geranium texanum	Texas geranium	37.5	0.34
Bouteloua rigidseta	Texas grama	17.5	0.16
Rhynchosia senna	Texas snoutbean	5.0	0.05
Erodium texanum	Texas stork's bill	20.0	0.18
Verbena halei	Texas vervain	77.5	0.70
Nassella leucotricha	Texas wintergrass	542.5	4.93
Nuttallanthus texanus	Toad flax	80.0	0.73
Paspalum urvillei	Vaseygrass	10.0	0.09
Panicum obtusum	Vine mesquite	17.5	0.16
Lepidium virginicum	Virginina pepperweed	92.5	0.84
Solanum dimidiatum	Western horsenettle	2.5	0.02
Ambrosia psilostachya	Western ragweed	47.5	0.43
Evolvulus sericeus	White evolvulus	47.5	0.43
Commelina erecta	Whitemouth dayflower	22.5	0.20
Callirhoe involucrata	Winecup	27.5	0.25
Sorghastrum nutans	Yellow indiangrass	32.5	0.30
Oxalis stricta	Yellow woodsorrel	170.0	1.55

Appendix 10. Annual Daubenmire (1959) coverages of herbaceous vegetation during 2016 – 2017 at Mason Mountain WMA.

Scientific Name	Common Name	Sum of Midpoints	% Cover
Litter	Litter	6242.5	14.19
Bare ground	Bare ground	9047.5	20.56
Rock	Rock	1192.5	2.71
Echinochloa muricata	American barnyardgrass	25.0	0.06
Daucus pusillus	American wild carrot	400.0	0.91
Anemone sp.	Anemone	2.5	0.01
Digitaria californica	Arizona cottontop	77.5	0.18
Helenium amarum	Basin sneezeweed	412.5	0.94
Cynodon dactylon	Bermuda grass	15.0	0.03
Lupinus texensis	Bluebonnet	55.0	0.13
Amphiachyris drcunculoides	Broomweed	192.5	0.44
Desmanthus illinoensis	Bundleflower	40.0	0.09
Helenium subaxillaris	Camphorweed	65.0	0.15
Elymus canadensis	Canada wildrye	55.0	0.13
Cenchrus spinifex	Coastal sandbur	330.0	0.75
Cocculus carolinus	Common moonseed	2.5	0.01
Nothoscordum bivalve	Crow-poison	25.0	0.06
Hilaria belangeri	Curly mesquite	165.0	0.38
Paspalum dilatatum	Dallisgrass	85.0	0.19
Vicia ludviciana	Deer pea vetch	435.0	0.99
Scutellaria drummondii	Drummond's skullcap	12.5	0.03
Dalea nana	Dwarf prairie clover	10.0	0.02
Tripsacum dactyloides	Eastern gamagrass	70.0	0.16
Engelmannia peristenia	Engelmann's daisy	20.0	0.05
Digitaria cognata	Fall witchgrass	197.5	0.45
Ambrosia confertiflora	Field ragweed	270.0	0.61
Talinum auranticum	Flame-flower	2.5	0.01
Mirabilis sp.	Four o'clock	2.5	0.01
Leptochloa dubia	Green sprangletop	30.0	0.07
Smilax bona-nox	Greenbriar	5.0	0.01
Thelesperma sp.	Greenthread	15.0	0.03
Eragrostis curtipedicellata	Gummy lovegrass	47.5	0.11
Bouteloua hirsuta	Hairy grama	260.0	0.59
Physalis sp.	Heartleaf ground cherry	40.0	0.09
Chloris cucullata	Hooded windmillgrass	67.5	0.15
Monarda sp.	Horse mint	30.0	0.07
Conyza canadensis	Horseweed	175.0	0.40
Bothriochloa hybrida	Hybrid beardgrass	117.5	0.27
Gaillardia pulchella	Indian blanket	127.5	0.29
Castilleja sp.	Indian paintbrush	2.5	0.01
Sorghum halepense	Johnsongrass	35.0	0.08
Bothriochloa ischaemum	King Ranch bluestem	250.0	0.57
Phyllanthus sp.	Knotweed leafflower	5.0	0.01
Aphanostephus ramosissimus	Lazy daisy	35.0	0.08
Chaetopappa sp.	Least daisy	32.5	0.07
Dicanthelium acuminatum	Lindheimer's panicgrass	187.5	0.43
Schizachrium scoparium	Little bluestem	955.0	2.17
Menodora heterophylla	Low menodora	2.5	0.01
Chamaesyce serpens	Mat spurge	130.0	0.30
Allium canadense	Meadow garlic	10.0	0.02
Ratibida columnifera	Mexican hat	490.0	1.11

Artemisia ludoviciana	Mexican sagebrush	10.0	0.02
Evolvulus sp.	Morning glory	2.5	0.01
Eragrostis lugens	Mourning lovegrass	47.5	0.11
Tragia ramosa	Noseburn	25.0	0.06
Sedum nuttallianum	Nuttall's stonecrop	2.5	0.01
Dichondra recurvata	Oakwoods ponysfoot	42.5	0.1
Wedelia texana	Orange zexmenia	2.5	0.01
Opuntia leptocaulis	Pencil cactus	5.0	0.01
Parietaria pensylvanica	Pennsylvania pellitory	25.0	0.06
Coreopsis tinctoria	Plains coreopsis	137.5	0.31
Eragrostis intermedia	Plains lovegrass	500.0	1.14
Plantago sp.	Plantain	1127.5	2.56
Opuntia engelmannii	Prickly pear	575.0	1.31
Oenothera sp.	Primrose spp.	2.5	0.01
Aristida purpurea	Purple threeawn	752.5	1.71
Cooperia drummondii	Rain lily	5.0	0.01
Eragrostis secundiflora	Red lovegrass	72.5	0.16
Bromus catharticus	Rescuegrass	327.5	0.74
Cistus ladanifer	Rockrose	2.5	0.01
Sabatia formosa	Rose gentian	2.5	0.01
Sporobolus cryptandrus	Sand dropseed	317.5	0.72
Lechea san-sabeana	San-saba pinweed	452.5	1.03
Dichanthelium oligosanthes	Scribner's rosettegrass	50.0	0.11
Cyperus sp.	Sedge	67.5	0.15
Mimosa nuttallii	Sensitive briar	7.5	0.02
Bouteloua curtipendula	Sideoats grama	202.5	0.46
Urochloa sp.	Signalgrass sp.	80.0	0.18
Bothriochloa laguroides	Silver beardgrass	277.5	0.63
Lasquerella argyraea	Silver bladderpod	40.0	0.09
Solanum elaegnifolium	Silverleaf nightshade	32.5	0.07
Vulpia octoflora	Sixweeksgrass	1467.5	3.34
Xanthisma texanum	Sleepy daisy	347.5	0.79
Corydalis micrantha	Smallflower fumewort	192.5	0.44
Astragalus nuttallianus	Smallflowered milkvetch	172.5	0.39
Froelichia sp.	Snake cotton	175.0	0.4
Setaria scheeli	Southwest bristlegrass	15.0	0.03
Selaginella sp.	Spikemoss	577.5	1.31
Sida abutifolia	Spreading sida	325.0	0.74
Galium texense	Texas bedstraw	450.0	1.02
Convolvulus equitans	Texas bindweed	2.5	0.01
Digitaria patens	Texas cottontop	15.0	0.03
Croton texensis	Texas croton	27.5	0.06
Geranium texanum	Texas geranium	145.0	0.33
Bouteloua rigidseta	Texas grama	102.5	0.23
Rhynchosia senna	Texas snoutbean	135.0	0.31
Erodium texanum	Texas stork's bill	100.0	0.23
Verbena halei	Texas vervain	217.5	0.49
Nassella leucotricha	Texas wintergrass	2660.0	6.05
Paspalum setaceum	Thin paspalum	190.0	0.43
Nuttallanthus texanus	Toad flax	80.0	0.18
Krameria lanceolata	Trailing krameria	2.5	0.01
Eragrostis sessilispica	Tumble lovegrass	20.0	0.05
Chloris verticillata	Tumble windmillgrass	52.5	0.12
Paspalum urvillei	Vaseygrass	20.0	0.05
Triodanis sp.	Venus's looking glass	15.0	0.03
Panicum obtusum	Vine mesquite	65.0	0.15

Lepidium virginicum	Virginia pepperweed	400.0	0.91
Solanum dimidiatum	Western horsenettle	177.5	0.40
Ambrosia psilostachya	Western ragweed	1355.0	3.08
Achillea millefolium	Western yarrow	295.0	0.67
Evolvulus sericeus	White evolvulus	212.5	0.48
Commelina erecta	Whitemouth dayflower	85.0	0.19
Callirhoe involucrata	Winecup	40.0	0.09
Sorghastrum nutans	Yellow indiangrass	52.5	0.12
Oxalis stricta	Yellow woodsorrel	1200.0	2.73

Appendix 11. Plant species sequenced and their BLAST results including percent pairwise identity and percent query coverage.

GeneBank Acc #	Study Site Species (Scientific Name)	BLAST Results (Scientific Name)	% Pairwise Identity	% Query Coverage
MG709390	*Phalaris caroliniana*	*Phalaris platensis*	99.8	100.00
MG709391	*Sphenopholis obtusata*	*Sphenopholis obtusata*	100.0	86.83
MG709392	*Limnodea arkensana*	*Sphenopholis obtusata*	100.0	86.83
MG709393	*Lepidium virginicum*	*Capsella bursa-pastoris*	99.8	100.00
MG709394	*Leptochloa dubia*	*Leptochloa dubia*	99.8	95.95
MG709395	*Tridens albescens*	*Tridens flavus var. flavus*	100.0	100.00
MG709396	*Urochloa texana*	*Paspalum dilatatum*	99.5	100.00
MG709397	*Northoscordum bivalve*	*Nothoscordum montevidense*	100.0	84.08
MG709398	*Eragrostis lugens*	*Eragrostis tef*	99.4	100.00
MG709399	*Digitaria californica*	*Digitaria ciliaris*	99.5	93.93
MG709400	*Eragrostis secundiflora*	*Eragrostis minor*	99.8	100.00
MG709401	*Hilaria belangeri*	*Hilaria cenchroides*	99.5	100.00
MG709402	*Yucca constricta*	*Yucca filamentosa*	99.8	100.00
MG709403	*Paspalum urvilleri*	*Paspalum dilatatum*	100.0	100.00
MG709404	*Celtis reticulata*	*Celtis sellowiana*	100.0	89.02
MG709405	*Quercus stellata*	*Quercus serrata*	99.6	100.00
MG709406	*Opuntia engelmannii*	*Cylindropuntia tunicata*	99.7	100.00
MG709407	*Setaria scheelei*	*Setaria viridis*	99.0	100.00
MG709408	*Cyperus retroflexus*	*Cyperus clandestinus*	99.7	87.15
MG709409	*Bouteloua rigidiseta*	*Bouteloua rigidiseta*	100.0	100.00
MG709410	*Typha latifolia*	*Typha latifolia*	99.5	100.00
MG709411	*Verbena halei*	*Verbena halei*	99.1	100.00
MG709412	*Rhynchosia senna*	*Rhynchosia himalensis var. craibiana*	96.5	91.57
MG709413	*Aphanostephus skirrhobasis*	*Aphanostephus ramosissimus*	99.6	94.93
MG709414	*Xanthisma texanum*	*Sida* sp.	96.8	93.91
MG709415	*Ambrosia artemisiifolia*	*Euphorbia maculata*	99.8	90.34
MG709416	*Panicum coloratum*	*Pityopsis falcata*	100.0	94.79
MG709417	*Muhlenbergia lindheimeri*	*Conyza bonariensis*	99.8	100.00
MG709418	*Muhlenbergia reverchonii*	*Echinochloa colona*	100.0	100.00
MG709419	*Digitaria patens*	*Paspalidium geminatum*	99.2	100.00
MG709420	*Chloris cucullata*	*Chloris cucullata*	100.0	96.02
MG709421	*Galium texense*	*Lampranthus spectabilis*	87.3	100.00
MG709422	*Sida abutifolia*	*Pityopsis falcata*	99.4	100.00
MG709423	*Chamaesyce serpens*	*Ambrosia artemisiifolia*	99.6	100.00
MG709424	*Heterotheca latifolia*	*Heterotheca villosa*	100.0	100.00
MG709425	*Conyza canadensis*	*Muhlenbergia reverchonii*	100.0	100.00
MG709426	*Echinochloa colona*	*Muhlenbergia reverchonii*	100.0	96.13
MG709427	*Setaria parviflora*	*Digitaria ciliaris*	98.6	93.98
MG709428	*Panicum vigatum*	*Chloris truncata*	99.2	100.00
MG709429	*Dalea hana*	*Myrocarpus venezuelensis*	92.3	100.00
MG709430	*Wedelia texana*	*Wedelia biflora*	99.4	100.00
MG709431	*Croton texensis*	*Croton lindheimerianus*	100.0	97.40
MG709432	*Gaillardia pulchella*	*Gaillardia aristata*	99.8	92.08
MG709433	*Bouteloua curtipendula*	*Bouteloua curtipendula*	100.0	100.00
MG709434	*Polypogon monspeliensis*	*Polypogon elongatus*	99.8	100.00
MG709435	*Sporobolus cryptandras*	*Sporobolus wrightii*	99.5	96.02
MG709436	*Quercus marilandica*	*Quercus rubra*	100.0	97.67
MG709437	*Coreopsis tinctoria*	*Praxelis clematidea*	98.8	100.00
MG709438	*Nassella leucotricha*	*Nassella hyalina*	100.0	100.00

MG709439	*Cenchrus spinifex*	*Cenchrus americanus*	98.7	100.00
MG709440	*Bromus catharticus*	*Bromus catharticus*	100.0	96.89
MG709441	*Paspalum setaceum*	*Paspalum dilatatum*	99.7	100.00
MG709442	*Dichanthelium oligosanthes*	*Dichanthelium acuminatum*	99.8	100.00
MG709443	*Bromus japonicus*	*Bromus japonicus*	98.5	92.50
MG709444	*Eragrostis superba*	*Eragrostis superba*	100.0	93.52
MG709445	*Eragrostis sessilispica*	*Eragrostis tenella*	98.6	92.20
MG709446	*Aloysia grattisima*	*Aloysia gratissima*	100.0	96.45
MG709447	*Ambrosia psilostachya*	*Ambrosia psilostachya*	99.8	96.08
MG709448	*Helenium amarum*	*Helenium autumnale*	99.8	100.0
MG709449	*Ratibida columnifera*	*Ratibida columnaris*	100.0	95.10
MG709450	*Tripsacum dactyloides*	*Zea luxurians*	98.3	99.81
MG709451	*Echinochloa muricata var. microstachya*	*Steinchisma laxum*	100.0	100.00
MG709452	*Cynodon dactylon*	*Cynodon dactylon*	100.0	100.00
MG709453	*Vulpia octoflora*	*Festuca rubra*	99.5	100.00
MG709454	*Panicum obtusum*	*Paspalum dilatatum*	99.5	100.00
MG709455	*Bothriochloa hybrida*	*Bothriochloa alta*	100.0	100.00
MG709456	*Bothriochloa lagunides*	*Bothriochloa alta*	100.0	100.00
MG709457	*Sorghastrum nutans*	*Sorghastrum nutans*	100.0	100.00
MG709458	*Dicathelium acuminatum*	*Dichanthelium acuminatum*	97.4	100.00
MG709459	*Schizachyrium scoparium*	*Schizachyrium scoparium*	100.0	100.00
MG709460	*Eragrostis curtipedicellata*	*Tridens flavus var. flavus*	100.0	96.13
MG709461	*Sorghum halepense*	*Sorghusm bicolor*	100.0	100.00

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