University of Tennessee, Knoxville
Trace: Tennessee Research and Creative Exchange

Masters Theses | Graduate School

12-2011

Influence of Timing of Prescribed Burn on Native-Warm Season Grass Forage Quality in Tennessee

Amanda L. Mathenia
amatheni@tennessee.edu

Recommended Citation
Mathenia, Amanda L., "Influence of Timing of Prescribed Burn on Native-Warm Season Grass Forage Quality in Tennessee. " Master's Thesis, University of Tennessee, 2011.
http://trace.tennessee.edu/utk_gradthes/1082

This Thesis is brought to you for free and open access by the Graduate School at Trace: Tennessee Research and Creative Exchange. It has been accepted for inclusion in Masters Theses by an authorized administrator of Trace: Tennessee Research and Creative Exchange. For more information, please contact trace@utk.edu.

To the Graduate Council:

I am submitting herewith a thesis written by Amanda L. Mathenia entitled "Influence of Timing of Prescribed Burn on Native-Warm Season Grass Forage Quality in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agriculture and Extension Education.

Carrie A. Stephens, Major Professor

We have read this thesis and recommend its acceptance:

Bryan Q. Patterson, Patrick D. Keyser

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Influence of Timing of Prescribed Burn on Native-Warm Season Grass Forage Quality in Tennessee

A Thesis Presented for

The Master of Science

Degree

The University of Tennessee, Knoxville

Amanda L. Mathenia

December 2011

Copyright © by Amanda L. Mathenia

All rights reserved

Dedication

I would like to dedicate this thesis to my family, friends, and co-workers who have been there of me throughout the entire process. Thank you for all of your support during these past two years of my life.

Acknowledgements

I would like to express my deep gratitude to the following individuals for their support and guidance during my time in graduate school. To my major professor, Dr. Carrie Stephens, for her encouragement to pursue higher education. I would like to thank Dr. Pat Keyser for his patience, advice, and guidance shared with me throughout the project.

I would like to express my appreciation to the managers of Ames Plantation, West Tennessee Research and Education Center, Bridgestone/Firestone Wildlife Management Area, and Yuchi Wildlife Management Area for allowing me to collect nwsg forage samples at their locations. I would like to thank Dr. Elizabeth Doxon for her assistance with running the statistics.

Abstract

Native warm-season grass stands have the prospective to provide nutritious summer forage in grazing systems. The study examined the influence of timing of prescribed burn on native warm-season grass stands in Tennessee. The purpose of the study was to determine the nutritional quality of forage as it relates to the timing of prescribed burns on native warm-season grass stands in Tennessee. The prescribed burns were conducted in March, April, May, and September. Forage samples were collected at Ames Plantation, West Tennessee Research and Education Center, Bridgestone/Firestone Wildlife Management Area, and Yuchi Wildlife Management Area. These samples were then analyzed for content of moisture, dry matter (DM), crude protein (CP), fat, acid detergent fiber (ADF), neutral detergent fiber (NDF), calcium, phosphorous, magnesium, potassium, total digestible nutrients (TDN), net energy calculations for lactation (NeL), net energy calculations for maintenance (NeM), net energy calculations for gain (NeG), and relative feed value (RFV). The study found no significant difference in location values, thus the study focused on month of burn and effect on nutritional quality. TDN, NeL, NeM, and NeG were found to have significant statistical differences. For each of the characteristics the timing of prescribed burns returned the same order of months (April, September, Control group, March, and May) from highest to lowest mean of forage quality. Results showed that burning in April returned the most concentrations of total digestible nutrients and net energy. With appropriate management such as timing of burning and grazing, native warm-season grasses could be a valuable forage option for extending summer forages in livestock.

Table of Contents

Chapter 1 1

INTRODUCTION 1

Significance of Problem 2

Statement of Problem 3

Hypothesis of Study 3

Chapter 2 4

REVIEW OF LITERATURE 4

History of North American Grasslands 4

Studies of Prescribed Fire in the Past 5

Nwsg for Livestock Practices 8

Practices of Prescribed Burns 9

Chapter 3 11

METHODS 11

Site Selection 11

Site Preparation 12

Treatment Application 12

Data Collection 13

Analysis 16

Chapter 4 18

FINDINGS 18

Chapter 5 21

CONCLUSION 21

IMPLICATIONS AND RECOMMENDATIONS 23

REFERENCES 25

Appendix A 29

Tukey's Studentized Range (HSD) Tests 29

Appendix B 36

Nwsg Forage Sample Quality Values Related to Timing of Prescribed Burn. 36

VITA 52

List of Tables

Table 3.1	Nwsg burn timing study plot map	12
Table 3.2	UT Soil, Plant, and Pest Center Nwsg forage sample results	15
Table 3.3	The F- and P-values from the ANOVA for the burn time analysis. [a]Degrees of freedom are 4, 19	17

List of Figures

Figure A-1 Nwsg Forage Sample Quality TDN Values Related to Timing of Prescribed Burn. 37

Figure A-2 Nwsg Forage Sample Quality NeL Values Related to Timing of Prescribed Burn. 38

Figure A-3 Nwsg Forage Sample Quality NeM Values Related to Timing of Prescribed Burn. 39

Figure A-4 Nwsg Forage Sample Quality NeG Values Related to Timing of Prescribed Burn. 40

Figure A-5 Nwsg Forage Sample Quality Moisture Values Related to Timing of Prescribed Burn. 41

Figure A-6 Nwsg Forage Sample Quality Dry Matter Values Related to Timing of Prescribed Burn. 42

Figure A-7 Nwsg Forage Sample Quality Crude Protein Values Related to Timing of Prescribed Burn. 43

Figure A-8 Nwsg Forage Sample Quality Fat Values Related to Timing of Prescribed Burn. 44

Figure A-9 Nwsg Forage Sample Quality ADF Values Related to Timing of Prescribed Burn. 45

Figure A-10 Nwsg Forage Sample Quality NDF Values Related to Timing of Prescribed Burn. 46

Figure A-11 Nwsg Forage Sample Quality Calcium Values Related to Timing of Prescribed Burn. 47

Figure A-12 Nwsg Forage Sample Quality Phosphorus Values Related to Timing of Prescribed Burn. 48

Figure A-13 Nwsg Forage Sample Quality Magnesium Values Related to Timing of Prescribed Burn. 49

Figure A-14 Nwsg Forage Sample Quality Potassium Values Related to Timing of Prescribed Burn. 50

Figure A-15 Nwsg Forage Sample Quality RFV Values Related to Timing of Prescribed Burn. 51

Chapter 1

INTRODUCTION

Native grasslands are the most endangered ecosystem in the Mid-South. Historically, the region contained vast acreages of native grassland and savannas with scattered trees and shrub cover, which was maintained by fire (Harper et al., 2004). Native Americans managed these grasslands primarily with the use of fire. That fire prevented woody encroachment, improved forage quality, and facilitated hunting (Keyser, 2007). Today, that acreage has been replaced with non-native grasses, agricultural crops, forest cover, and suburban development. As a result, several wildlife species dependent upon quality early successional habitat have experienced significant declines in population (Harper et al., 2004).

Native warm-season grasses (nwsg) have received a tremendous amount of attention since the early 1990's, especially among wildlife managers trying to enhance habitat for northern bobwhites, grassland songbirds, and other early-successional species. During this time, much work has been devoted to improving methods for establishment, identifying sound management practices, and documenting the response of wildlife to habitat restoration efforts. Also noteworthy during this period is the interest nwsg have generated among forage and livestock producers. Research continues to show various nwsg are viable forage for hay production and grazing for several livestock species (Harper et al., 2007).

There are many warm-season grasses native to the Mid-South region; however, seven species are most commonly promoted as cover for wildlife and/or forage for livestock. These are big bluestem (*Andropogon gerardii* Vitman), little bluestem (*Schizachyrium scoparium* (Michx.) Nash), broom sedge bluestem (*Andropogon virginicus* L. var. *virginicus)*, indiangrass (,*Sorghastrum nutans* (L.) Nash), switchgrass (*Panicum virgatum* L. var. *virgatum)*, sideoats

grama (*Bouteloua curtipendula* (Michx.) Torr. var. *curtipendula)*, and eastern gamagrass (*Tripsacum dactyloides* (L.) L.). Not all of these, however, have the same quality for wildlife habitat or livestock forage (Harper et al., 2004). Grasses are classified as warm or cool-season based on their chemical pathways for photosynthesis. Warm-season grasses fix energy into 4-carbon units and are referred to as C4 grasses. As a result, their photosynthetic potential is much higher than that of cool-season grasses. They make most of their active growth when minimum daily temperatures reach approximately 60°F and soil temperatures reach 55°F. The optimum temperature for warm-season grass production is 85-95°F. Nwsg are dormant during autumn and winter (Harper et al., 2007).

A field of nwsg is no better than the technique used to manage it. If not managed correctly, nwsg can become rank and unattractive. Management is needed to set back succession and create the vegetative composition and structure desired. An open structure at ground level within a nwsg field is determined largely by the density of grass bunches and stand management (Harper et al., 2004). In fact, optimum conditions for most species occur with only about 50 % grass coverage. Therefore, at least half the vegetative cover is forbs and scattered shrubs. The only way desirable vegetation composition and an open structure at ground level can be maintained is by periodic burning and/or disking (Harper et al., 2007).

Significance of Problem

Timing of prescribed burns may have important implications for stand dynamics and quality of forage within nwsg. Preliminary studies in Tennessee suggest that late growing season burns (September) produce more desirable results, at least for controlling encroachment, than dormant season burns (March). However, effects of burns in late spring and early summer

(April/ May) have not been tested. No prior studies have been conducted in Tennessee to determine the effect of the timing of burn as it relates to the forage quality in nwsg.

Statement of Problem

The purpose of this study was to investigate the influence of the timing of burn on nwsg stands in TN as it impacts quality of forage. The study looked at the relationship between timing of burn (March 1, April 15, May 15, and September 1) as it related to forage quality of nwsg stands in Tennessee.

Objective of Study

The specific objective was as follows:

1. To determine the nutritional quality of forage as it relates to the timing of prescribed burns on nwsg stands in TN.

Hypothesis of Study

The specific hypothesis was as follows:

1. Prescribed burning in early summer (May) will have a higher nutritional quality than nwsg stands burned in early season (March/ April) and late season (September) in TN.

Chapter 2

REVIEW OF LITERATURE

History of North American Grasslands

Historically, fire, grazing by American bison, and extremes in temperature and precipitation regulated vegetation dynamics in North American prairies and grasslands (Parton & Risser, 1980; Risser & Parton, 1982; Diamond & Smeins, 1985; Gibson & Hulbert, 1987; Leach & Givnish, 1996; Collins et al., 1998; Knapp et al., 1999; Radeloff et al., 2000; Steinauer & Collins, 2001; Collins & Smith, 2006). Due to suppression of fire by humans, fire has been all but eliminated from most systems, and the brief but intense grazing by American bison has been replaced primarily by year-round grazing by domestic cattle. Studies have shown that elimination of periodic fires can lead to an annual loss of 0.45- 1.03% of the original species of plants (Leach & Givnish, 1996).

Before the region was occupied by the American Indians, fires were caused by lightning and were largely restricted to the growing season. Fires were usually small and less intense as they consumed the relatively wet growing plant material, along with the dead organic matter from the previous year (Stubbendieck & Masters, 2000). In the South west, the main historical fire season was toward the end of the dry season (late spring/ early summer), in association with the first thunderstorms, which ignited the fires but also provided moisture for plants to initiate growth. In the South east, historical fires were once common throughout the summer and peaked in May at the transition from the dry spring period to the wet summer period, when lightning incidence was at its highest, vegetation was growing, and animals were active (Knapp et al., 2009). Alteration of historical disturbance factors has reduced ecological integrity of prairie ecosystems, with loss of herbaceous species and a general encroachment of woody species of

plants. In attempts to reverse these changes, disturbance by fire frequently is reintroduced to sites under highly prescribed conditions (Collins, 1992; Collins & Smith, 2006).

Studies of Prescribed Fire in the Past

Prescribed fire has long been used as a tool for the management and restoration of grasslands and savannas; enhancing production of grass, controlling growth, and spread of woody species, and modifying composition of herbaceous species (Collins, 1992; Collins & Smith, 2006). Prescribed fire is the controlled application of fire under specified environmental conditions that allows the fire to be managed at a desired intensity within a confined area to meet predetermined vegetation management objectives. Simply put, prescribed fire is not considered a wildfire. When used properly, it is very safe and achieves specific objectives (Harper et al., 2007). Prescribed fire reduces litter buildup, sets back succession, increases nutrient availability, and stimulates herbaceous growth (Harper et al., 2004). Ehrenreich and Aikman (1963) found that increases in flower production may persist for several years following fire.

The tallgrass prairie is the only grassland that has been repeatedly burned as a management practice. Indeed, the area survives as a prairie largely because of periodic to regular burning. Research indicates that warm-season perennial grasses- big bluestem, indiangrass, and switchgrass- are favored by fire, and cool-season grasses- Kentucky bluegrass, sedges, and annual bromes- are reduced in abundance by burning (Owensby, n.d.).

In addition to preventing the encroachment of trees, fire has profound effects on other components of grassland plant communities, and it can alter nutrient cycles (Collins & Wallace, 1990; Briggs & Knapp, 1995; Blair, 1997). For instance, in the tallgrass prairies of central North America, frequent fire tends to increase the dominance of C4 grasses at the expense of C3 grasses and forbs (Collins et al., 1998; Knapp et al., 1999). However, the timing of fire can

cause substantial variation in this response. In North American tallgrass prairies, fire in the spring, the traditional season of burning by cattle producers, tends to reduce forbs and promote the growth of grasses (Gibson & Hulbert, 1987; Svejcar & Browning, 1988; Biondini, Steuter, & Grygiel, 1989), whereas summer fires tend to do the opposite, increasing the abundance of forbs at the expense of grasses (Pfeiffer & Steuter, 1994).

Sparks et al. (1998) studied the effects of fire season in western Arkansas grassland. Species diversity and stand species richness were greater in burned stands than in unburned control stands. Although they set out to determine the effects of fire season on plant communities, no overall community attributes differed between late growing-season and late dormant-season burns. However, late growing-season fires decreased density of warm-season C4 plant species.

Howe (1994) stated fire maintains tallgrass prairies, but fire season is virtually unexplored as a formative influence of prairie floristics. Replicated mid-July burns, simulating the peak of lightning-caused fire in natural grasslands, strongly influenced species composition and cover in experimental restorations in southern Wisconsin. Perennials that flowered before mid-July showed only 17% cover in unburned plots and 6% in plots burned in March, but 46% cover in plots burned in mid-July. Late-flowering species dominating the remnants managed with dormant-season burns accounted for 80% cover in unburned plots and 92% cover in plots burned in March, but only 47% cover in plots burned in July.

Ideally, burning should be conducted when nwsg have produced approximately one inch of new growth. Burning in March/early April reduces winter cover for only a short time before spring green-up and does not disrupt the wildlife nesting seasons. When nwsg are burned in late March/early April, the heat of the fire often stimulates rapid new growth, which is usually

apparent within 5- 7 days after burning. Depending on conditions, increased nitrogen and other nutrients may be available the growing season after burning. If burning coincides with warm daily temperatures (60- 70°F) and adequate precipitation, accelerated plant growth is possible (Harper et al., 2007). Continued burning in late summer or early fall (August- September) may reduce grass dominance and increase forb cover (Harper et al., 2007).

Lovell, Henderson, and Howell (1981) stated it appears that the timing of prairie fire may influence the vigor and reproductive response of forb species. Early-blooming species appear to be damaged by late spring fires, and to experience enhanced flowering and fruit production following fall and early spring fires. This pattern is fairly strongly supported by statistically significant results.

Midsummer-blooming species appear to exhibit positive or neutral responses to all burn treatments possibly, in some cases, responding to ameliorated growing conditions. Since these species begin growing late in the spring, they probably suffer little direct damage from even the late spring fires.

The late-blooming species are the most variable in their responses to fire. In some cases, they are similar to the early-blooming species. Since many late-blooming species have periods of active growth in the spring as well as the fall, these species may be damaged by late spring fires but favored by fall and early spring fires.

Nwsg for Wildlife Habitat

Succession will take over an old-field or a field of planted nwsg if it is not managed. Management is especially critical in the Mid-South, where average annual precipitation exceeds 40 inches and growing seasons are relatively long. Management is needed not just to set back succession, but also to create the vegetative composition and structure desired. Prescribed fire

and disking are strongly recommended for managing fields of nwsg and associated early-succession vegetation. When used correctly (with respect to timing, frequency and intensity) fire and disking not only set back succession, but also determine plant species composition and structure, which directly influence habitat quality and forage quality (Harper et al., 2007).

McCoy et al. (2001) studied vegetation changes on 154 Conservation Reserve Program (CRP) grasslands in northern Missouri and reported that during the first two years following establishment, fields are characterized by annual weed communities with abundant bare ground and litter accumulation. Within 3-4 years, CRP fields became dominated by perennial grasses with substantial litter accumulation and little bare ground. They suggested that vegetation conditions 3-4 years after establishment might limit the value of enrolled lands for many wildlife species and some form of disturbance, such as prescribed fire or disking, might be required to maintain the wildlife habitat value of CRP grasslands.

Dykes (2005) characterized vegetation structure on 45 CP2 fields in Tennessee and reported that litter cover and depth were greater on fields that had been mowed than those that had been burned. Litter cover and depth were intermediate on unmanaged fields. Conversely, forb coverage was greatest on burned fields, followed by unmanaged and mowed fields.

Nwsg for Livestock Practices

The use of native grasses is not limited to wildlife cover and food. The forage produced from these grasses can be used as a feed source for livestock (Bates, 2007). Nwsg can provide excellent forage for livestock and, when properly managed, can still provide quality nesting and brood-rearing habitat. Nwsg are attractive as forage crop because nwsg produce the majority of their growth during the summer, when cool-season grasses produce relatively little. Midsummer is also a period when cool-season grasses undergo a “summer slump,” which is a drop in cool-

season productivity or even temporary dormancy. This slump can pose a challenge in a solely cool-season grazing system where producers may need to rely on stored hay or else purchase additional feed until grasses resume higher productivity rates (Riesterer et al., 2000). Yields of two to five tons per acre of nwsg forage can be expected, depending on rainfall, soil type and other conditions. Crude protein can be as high as 16- 17 percent, but normally is 8- 12 percent at optimum harvest. Just as with any forage species, nutrient content of nwsg is influenced by plant maturity. As plants mature, percent protein and digestible energy decrease, while fiber content increases. Maximum tonnage and high forage quality do not occur at the same time. From a practical standpoint, all grass hay should be cut just before seed heads begin to emerge, whether warm- or cool-season (Harper et al., 2004).

Practices of Prescribed Burns

Fields are normally burned with a drip torch. Burning a field is always initiated with a backing fire, lit on the downwind side of the field adjacent to and along the firebreak. A backline is created by allowing the fire to back into the field, creating a safe zone should the wind shift or if a heading fire is used later (Harper et al., 2007). A backing fire consumes material on the field very effectively and has relatively low flame heights (Harper et al., 2007).

A backing fire is started along a baseline (anchor point) such as a road, plow line, stream or other barrier, and allowed to back into the wind. Variations in wind speed have little effect on the rate of spread of a fire burning into the wind. Such fires proceed at a speed of one to three chains per hour. Backing fire is the easiest and safest type of prescribed fire to use, provided wind speed and direction are steady. It produces minimum scorch and lends itself to us in heavy fuels and young pine stands (USDA & Forest Service Southern Region, 1989).

If the process can be safely and effectively quickened, a strip-heading fire may be used. This involves lighting a series of lines of fire progressively upwind of the initial backing fire. Strips should be narrow enough so the fire does not reach a high energy level before it reaches a backing fire or a backline. Initially, strips might only be 20- 50 feet wide until it is obvious how the fire will behave (Harper et al., 2007). Fire consumes dead vegetation, stimulates fresh growth, and creates open space at ground level. Burning also stimulates the seed bank and recycles nutrients, increasing forage quality for rabbits, deer, and groundhogs (Bates, 2007).

In strip-heading fire, a series of lines of fire are set progressively upwind of a firebreak in such a manner that no individual line of fire can develop to a high energy level before it reaches either a firebreak or another line of fire. A backing fire is generally used to secure the base line and the remainder of the area then treated with strip-heading fires. Strips are often set one to three chains apart. The distance between ignition lines is determined by the desired flame length (United States Department of Agriculture & Forest Service Southern Region, 1989).

Chapter 3

METHODS

Site Selection

The sites selected for the study were at four various locations throughout Tennessee.

The West Tennessee Research and Education Center (WTREC) is located in Jackson. The plots consisted of various vegetation which included indiangrass, little bluestem, burnweed (*Erechtites hieraciifolia* (L.) Raf. ex DC.), big bluestem, partridge pea (*Chamaecrista fasciculata* (Michx.) Greene), switchgrass, goldenrod (*Oligoneuron rigidum* (L.) Small), horsenettle (*Solanum carolinense* L.), pigweed (*Amaranthus* L.), horseweed (*Conyza* Less.), and broom sedge (*Carex scoparia* Schkuhr ex Willd.).

Ames Plantation is located in Grand Junction. The plots consisted of various vegetation which included goldenrod, wild garlic (*Allium vineale* L.), big bluestem, ironweed (*Vernonia)*, broom sedge, blackberry (*Rubus* L.), sericea lespedeza (*Lespedeza cuneata* (Dum. Cours.) G. Don), ragweed (*Ambrosia* L.), Japanese honeysuckle (*Lonicera japonica* Thunb.), and American sycamore (*Platanus occidentalis* L.).

The Bridgestone/Firestone Wildlife Management Area (BFWMA) is located in Sparta. The plots consisted of various vegetation which included goldenrod, big bluestem, horseweed, switchgrass, orchardgrass (*Dactylis glomerata* L. ssp. *Glomerata)*, fescue (*Festuca paradoxa* Desv.), blackberry, johnsongrass (*Sorghum halepense* (L.) Pers.), pigweed, timothy (*Phleum pratense* L.), Queen Anne's lace (*Daucus carota* L.), daisy fleabane (*Erigeron annuus* (L.) Pers.), crabgrass (*Digitaria ischaemum* (Schreb.) Schreb. ex Muhl.), ragweed, Indian strawberry (*Duchesnea indica* (Andrews) Focke), horsenettle, winged sumac (*Rhus copallinum* L. var. *latifolia* Engl.), red clover (*Trifolium pratense* L.), and smooth sumac (*Rhus glabra* L.).

The Yuchi Wildlife Management Area (WMA) is located in Decatur. The plots consisted of various vegetation which included blackberry, switchgrass, big bluestem, goldenrod, johnsongrass, horseweed, poison ivy (*Toxicodendron radicans* (L.) Kuntze), sericea lespedeza, winged sumac, wild garlic, trumpet creeper (*Campsis radicans* (L.) Seem. ex Bureau), sweet gum (*Liquidambar* L.), daisy fleabane, fescue, and orchardgrass.

At each of the four locations, five treatments were replicated four times in a randomized complete block design with blocking based on soil variations. The study areas at each site are 60' x 185' plots and 20' firebreaks between plots.

Site Preparation

Establish plots prior to March by bush hogging. Disc to mineral soil prior to implementing burn treatments.

Treatment Application

Treatments included 5 burn dates. Refer to Table 3.1 to view the nwsg burn timing study plot map.

Table 3.1 Nwsg burn timing study plot map

	Rep I	Rep II	Rep III	Rep IV
Plot 1	1	1	5	4
Plot 2	2	3	4	1
Plot 3	5	5	1	5
Plot 4	4	4	2	3
Plot 5	3	2	3	2

Unburned control= 1 March 1 burn= 2 April 15 burn= 3 May 15 burn= 4
September 1 burn= 5

Burns were conducted on the designated date or within one week of the designated date to capture opportunities with acceptable burning conditions. If poor weather conditions precluded burning on target dates, burns were at least three weeks apart. The burns were initiated in 2007 at WTREC, BFWMA, and Yuchi and at Ames in 2008. All prescribed burning ended in September of 2011 applying the same treatments annually on one half of each plot and semi-annually on the other half.

Prescribed fires were set using backing fire followed by strip heading fire. At the date of each burn, data was collected on the current weather conditions (temperature, wind speed direction, and relative humidity), flame height, and rate of speed.

Burns were conducted by local management personnel at each location to facilitate consistent burning dates across the widely scattered locations throughout TN.

Data Collection

All data collection was done by the investigator except for on-sight burning data collected on the day of the burn.

Biomass sample collection for forage analysis was conducted at WTREC and Ames Plantation on June 1, 2011 and at BFWMA and Yuchi on June 6, 2011. The biomass forage samples were taken when the grasses were in the elongation stage just prior to boot stage. Within each plot, the investigator took random biomass samples of nwsg from each replication. For each location, biomass samples were aggregated according to month of prescribed burn. These forage samples were then sent to the Soil, Plant, and Pest Center in Nashville. University of Tennessee forage specialists then analyzed the forage samples for content of moisture, dry matter (DM), crude protein (CP), fat, acid detergent fiber (ADF), neutral detergent fiber (NDF),

calcium, phosphorous, magnesium, potassium, total digestible nutrients (TDN), net energy calculations for lactation (NeL), net energy calculations for maintenance (NeM), net energy calculations for gain (NeG), and relative feed value (RFV). Refer to Table 3.2 to see the nwsg forage sample results.

Table 3.2 UT Soil, Plant, and Pest Center Nwsg forage sample results

				UT Soil, Plant and Pest Center-Nashville					Forage Analysis						
17-Jun-11				Dry Matter Basis											
Identification	Moisture	DM	Protein	Fat	ADF	NDF	Ca	P	Mg	K	TDN	NeL	Nem	Neg	RFV
AMES															
MARCH	59.53	40.47	14.23	1.17	40.66	67.24	0.28	0.53	0.13	1.98	56	0.57	0.53	0.25	79
APRIL	62.74	37.26	12.69	1.49	37.76	66.71	0.56	0.25	0.20	1.32	60	0.61	0.60	0.33	83
MAY	34.54	65.46	11.89	1.89	45.36	71.23	0.22	0.13	0.21	1.85	51	0.51	0.46	0.21	70
SEPTEMBER	59.21	40.79	14.28	3.23	34.60	63.29	0.62	0.45	0.27	1.92	63	0.65	0.64	0.38	91
CONTROL	58.99	41.01	11.30	1.28	39.08	66.16	0.55	0.21	0.19	1.16	58	0.59	0.56	0.31	82
WTREC															
MARCH	58.66	41.34	9.61	1.90	39.81	68.38	0.63	0.22	0.17	1.19	57	0.58	0.55	0.29	79
APRIL	66.79	33.21	14.07	2.31	37.85	71.79	0.21	0.35	0.18	2.42	60	0.61	0.60	0.33	77
MAY	52.52	47.48	18.25	1.64	41.65	61.10	0.10	0.30	0.26	2.42	55	0.56	0.52	0.26	86
SEPTEMBER	59.94	40.06	10.90	1.60	40.20	68.65	0.67	0.24	0.19	1.26	57	0.58	0.55	0.29	78
CONTROL	56.40	43.60	12.30	1.83	39.29	68.97	0.37	0.33	0.18	1.51	58	0.59	0.56	0.31	79
BRWMA															
MARCH	63.75	36.25	10.71	1.64	37.19	70.26	0.46	0.19	0.13	1.34	61	0.62	0.61	0.35	79
APRIL	63.30	36.70	14.08	1.35	39.43	72.78	0.25	0.54	0.10	1.58	58	0.59	0.56	0.31	74
MAY	66.00	34.00	12.98	1.45	35.97	67.45	0.38	0.34	0.21	1.83	61	0.63	0.61	0.35	84
SEPTEMBER	64.43	35.57	13.57	1.27	36.00	71.59	0.47	0.29	0.20	2.09	61	0.63	0.61	0.35	79
CONTROL	63.56	36.44	13.36	1.25	36.32	70.00	0.52	0.19	0.13	1.34	61	0.63	0.61	0.35	81
YUCHI															
MARCH	65.07	34.93	11.05	2.35	41.55	64.16	0.67	0.26	0.13	1.62	55	0.56	0.52	0.26	82
APRIL	64.88	35.12	10.82	1.65	34.00	66.36	0.33	0.37	0.27	2.46	64	0.66	0.65	0.39	87
MAY	62.10	37.90	8.37	1.96	73.88	67.84	0.71	0.19	0.11	1.36	52	0.53	0.47	0.22	75
SEPTEMBER	61.97	38.03	10.64	1.84	38.33	67.24	0.37	0.26	0.24	1.09	59	0.60	0.58	0.32	82
CONTROL	62.19	37.81	9.59	1.51	35.70	65.30	0.45	0.24	0.27	2.08	61	0.63	0.61	0.35	87

Analysis

The study's purpose was to determine the nutritional quality of forage as it relates to the timing of prescribed burns on nwsg stands in TN. Using analysis of variance, the investigator tested effects of location and time of burn with the following 15 characteristics moisture, DM, CP, fat, ADF, NDF, calcium, phosphorus, magnesium, potassium, TDN, NeL, NeM, NeG, and RFV. Following a significant ANOVA, the investigator conducted a means separation test using Tukey's Honestly Significant Difference (HSD). All analyses were performed in SAS 9.2 (SAS Institute, Cary, N.C.).

None of the location values were significant, so therefore the independent variable for the study was the timing of burn (March, April, May, September, Control). This in turn made the location the extraneous variable. The dependent variables of the study were moisture, DM, CP, fat, ADF, NDF, calcium, phosphorus, magnesium, potassium, TDN, NeL, NeM, NeG, and RFV. Most often, $P<0.05$ is used as a cutoff. However, there were no characteristics that were significant at that level. When $P<0.01$ was used as a cutoff level, four characteristics were significant as follows TDN, NeL, NeM, and NeG. Refer to Table 3.3 for all of the F- and P-values from the ANOVA for the burn time analysis.

Table 3.3 The F- and P-values from the ANOVA for the burn time analysis. [a]Degrees of freedom are 4, 19

Nutritional Characteristic	F-statistic[a]	P-value
Moisture	1.85	0.18
Dry matter	1.85	0.18
Crude Protein	0.41	0.79
Fat	0.52	0.71
Acid detergent fiber	1.67	0.22
Neutral detergent fiber	0.40	0.80
Calcium	0.93	0.47
Phosphorus	0.88	0.50
Magnesium	1.34	0.31
Potassium	0.62	0.65
Total digestible nutrients	2.71	0.08
Net energy calculations		
Lactation	2.40	0.10
Maintenance	2.64	0.08
Gain	2.83	0.07
Relative Feed Value	0.33	0.85

Chapter 4

FINDINGS

The objective of this study was to determine the nutritional quality of forage as it relates to the timing of prescribed burns on nwsg stands in TN.

The timing of burns for the study were conducted in March, April, May, September, and a Control group. The nutritional quality of forage characteristics tested were moisture, DM, CP, fat, ADF, NDF, calcium, phosphorus, magnesium, potassium, TDN, NeL, NeM, NeG, and RFV. NDF concentrations were the most similar across each of the prescribed burn months. Out of those 15 characteristics tested, four returned with statistical significance which included TDN, NeL, NeM, and NeG. For each of the four statistically significant different characteristics, the timing of prescribed burns returned in the same order of months from highest to lowest mean for forage quality. The concentration of total digestible nutrients and net energy for lactation, maintenance, and gain was found to be the highest in nwsg forage samples taken from the locations burned in April, followed by September, Control group, March, and finally May.

For the following nwsg forage nutritional value findings, refer to Appendix A for a list of Tukey's studentized range tests. Figures reflecting these test finds can be found in Appendix B for each nutritional quality value.

Conducting prescribed burning on nwsg plots in April was found to return 60.5% TDN in forage quality compared to the control group containing 59.5% TDN. Biomass forages samples taken from plots burned in May had 54.8% TDN. Overall plots burned in April contained 5.75% more TDN than plots burned in May (see Figure A-1).

The highest values for net energy calculations for lactation were found in nwsg plots burned in April containing 0.62 megacalories (Mcal)/lb. Burning nwsg plots in May returned the lowest concentration values of 0.56 Mcal/lb(see Figure A-2).

Biomass forage samples taken from nwsg plots burned in April had the highest calculations for net energy for maintenance with 0.60 Mcal/lb. Burning in the months of September and March along with the control group had concentrations of NeM 0.60-0.55 Mcal/lb. Concentrations were the lowest in plots burned in May with a value of 0.52 Mcal/lb (see Figure A-3).

Conducting prescribed burning on nwsg plots in April was found to return 0.34 Mcal/lb in forage quality of NeG compared to the control group containing 0.33 Mcal/lb. Biomass forages samples taken from plots burned in May had 0.26 Mcal/lb. Overall plots burned in April contained 8% more Mcal/lb than plots burned in May (see Figure A-4).

Biomass forage samples taken from nwsg plots burned in April contained the most moisture content and least amount of dry matter. These samples contained 64.4% moisture and 35.6% DM. Biomass forage samples taken from nwsg plots burned in May contained the least amount of moisture and most amount of dry matter. Moisture content of samples burned in May contained 53.8% moisture and 46.2% DM (see Figures A-5 and A-6).

Crude protein content was found in the highest percentages in forage samples taken from nwsg plots burned in April with 12.9%. Nwsg plots burned in March had the lowest percentage of crude protein with a value of 11.4% (see Figure A-7).

The highest values of fat percentage were present in nwsg samples taken from plots burned in September. These samples contained 2% fat. With a value of 1.5% fat, biomass forage samples taken from plots in the control group contained the least amount of fat (see Figure A-8).

The highest values returned for concentration of acid detergent fiber came from biomass forage samples taken from nwsg plots burned in May. The lowest values of concentration of ADF were found in nwsg samples burned in April. Burning in the month April contained 12% less ADF (see Figure A-9).

Conducting prescribed burns on nwsg plots in April was found to have 69.4% NDF compared to the lowest concentration of 66.9% NDF of biomass forage samples burned in May. There is a 2% higher concentration of NDF of nwsg samples burned in April than found in the control group (see Figure A-10).

Calcium concentrations were found to be the highest in nwsg samples taken from plots burned in September at 0.5% and the lowest in April at 0.3% (see Figure A-11). Phosphorous concentrations were found to be the highest in nwsg samples taken from plots burned in April at 0.4% and the lowest in May at 0.2% (see Figure A-12). The nutrient magnesium was found to be the highest in nwsg forage samples taken from plots burned in September at 0.2% and the lowest in March at 0.1% (see Figure A-13). Potassium concentrations were found to be the highest in nwsg forage samples taken from plots burned in April at 1.9% and the lowest value of 1.5% in the control group (see Figure A-14).

Nwsg biomass forage samples taken from plots burned in September contained the highest relative feed value of 82.5. Samples taken from the control group followed with a RFV of 82.3. Conducting burns in May returned the lowest RFV of 78.8 (see Figure A-15).

Chapter 5

CONCLUSION

Native warm-season grasses (nwsg) are being proposed for use in a range of purposes, from ecological uses such as erosion control and wildlife habitat, to agricultural uses such as a forage or bioenergy crop. Prescribed burning of nwsg is being suggested because fire consumes dead vegetation, stimulates fresh growth, and creates open space at ground level. Burning in early summer (May) is hypothesized to have a higher nutritional quality than nwsg stands burned in early season (March/April) and late season (September) in Tennessee. This research examined the nutritional quality of forage as it related to the timing of prescribed burns on nwsg stands in Tennessee.

The hypothesis stated above was not supported by the research conducted by the investigator. Overall nwsg stands burned in May did not have a higher nutritional than nwsg stands burned in March, April, or September. In contrast, prescribed burns of nwsg stands conducted in April contained the most overall nutritive qualities.

Moisture is the water present in the forage analyzed. Dry matter is the percentage of the forage that is not water (Henning et al., 1991). Results showed that nwsg stands burned in April contained the highest moisture and lowest dry matter content. Nwsg stands burned in May contained the lowest moisture and highest dry matter content.

Crude protein (CP) is the sum of true protein and non-protein nitrogen. It is a measure of a forage's ability to meet the protein needs of livestock. Although high-protein forages are also often high in energy, CP content is of little value in determining energy content. Since protein is one of the most costly supplements for livestock, high protein forages are desirable (Henning et

al., 1991). Results showed that nwsg stands burned in April contained the highest values at 12.9% CP.

Acid detergent fiber (ADF) is the percentage of highly indigestible plant material present in a forage. ADF is a useful predictor of energy and digestibility in forages. Low ADF values mean higher energy value and digestibility since lignin and silica are not digestible by ruminants. Therefore, low ADF values are desirable (Henning et al., 1991). The results of forage sampling show that nwsg stands burned in April have the lowest ADF value of 37.3% and nwsg stands burned in May have the highest ADF value of 49.2%.

Neutral detergent fiber (NDF) represents all of the structural or dell wall material in the forage. The NDF of a forage is inversely related to the amount that a cow or calf is able to consume; thus, forages with low NDF with have higher intakes than those with high NDF (Henning et al., 1991). Results of the study suggest that nwsg stands burned in May will have the highest intakes with the lowest NDF of 66.9%. Study results also suggest that nwsg stands burned in April will have the least amount of intake with 69.4% NDF.

Total digestible nutrients (TDN) reports the percentage of digestible material in a forage. TDN are calculated from ADF and express the differences in digestible material between forages. The energy term used (TDN, NeL, NeM, or NeG) depends on how the energy needs for the class of livestock are expressed. Net energy of maintenance (NeM) and lactation (NeL) are expressessions of energy value of forage that refer to the forage's ability to meet the energy requirements of dairy and beef cattle. Net energy for gain (NeG) is the amount of energy in a forage available for growth after the maintenance needs have been met (Henning et al., 1991). Conducting prescribed burns in April yielded the highest forage quality values which included 60.5% TDN, 0.62 Mcal/lb NeL, 0.60 Mcal/lb NeM, and 0.34 Mcal/lb NeG. Results showed that

nwsg stands burned in May yielded the lowest forage values of 54.8% TDN, 0.56 Mcal/lb NeL, 0.52 Mcal/lb NeM, and 0.26 Mcal/lb NeG.

IMPLICATIONS AND RECOMMENDATIONS

Presently, many southeastern forage systems are established with cool-season grasses like tall fescue which need regular nutrient inputs to stay productive. Nwsg are suggested as a possible alternative or addition to these traditional cool-season forage systems. Nwsg are able to produce high yields on marginal soils with little inputs. Nwsg have been adapted for growth during the hottest season of the year while being rather drought tolerant. With proper management practices, livestock can graze on nwsg during the summer when cool-season species productivity is low, allowing cool-season pastures time to recover from spring grazing.

When considering the diet for pregnant replacement heifers ranging in weight from 1,000-1,400 pounds, all months of prescribed burn including control showed that concentrations of crude protein, calcium, and phosphorus were adequate to maintain these heifers thru 9 months of pregnancy. Total digestible nutrient concentrations were adequate to support the diet of these replacement heifers through 9 months of pregnancy when nwsg were burned in March, April, September, and control group. Conducting prescribed burning in May would only provide enough total digestible nutrients through the first seven months of pregnancy for these replacement heifers.

When considering the diet for 500 pound feedlot steers or heifers with the anticipated finishing weight of 1,000 pounds, the research provides evidence that nwsg stands burned in April, May, and September contained adequate crude protein concentrations to provide for an average daily gain (ADG) of 2.5 pounds. Crude protein concentration amounts when conducting prescribed burns in April and May supported an ADG of 3 pounds for 600 pound feedlot steers

or heifers with the anticipated finishing weight of 1,000 pounds. Total digestible nutrient concentrations were adequate to support an ADG of 1.5 pounds of both 500 and 600 pound feedlot steers or heifers with the anticipated finishing weight of 1,000 pounds when nwsg stands were burned in April, September, and control group. When considering calcium and phosphorus concentrations, conducting prescribed burns on nwsg stands in April and September returned values enough for an ADG of 3 pounds for 600 pound feedlot steers or heifers with an anticipated finishing weight of 1,000 pounds.

This work suggests that using nwsg to compliment cool-season grasses provides benefits to livestock forage systems. When nutritive values among the prescribed burning months varied, conducting prescribed burns in April returned the highest nutritive values. This research also provides evidence that conducting prescribed burns in March, April, September, and control group generally returned nutritive values that were statistically the same. This work suggests discouraging a livestock producer from conducting prescribed burns in May if they wish for the highest nutritive values.

REFERENCES

Bates, G. E. (2007, January). *Native grasses for hay production*. Paper presented at the Tennessee Native Grasslands Workshop "The State of the State". Murfreesboro, Tennessee.

Biondini, M. E., Steuter, A. A., & Grygiel, C. E. (1989). Seasonal fire effects on the diversity patterns, spatial distribution and community structure of forbs in the Northern Mixed Prairie. *Vegetatio, 85,* 21-31.

Blair, J. M. (1997). Fire, N availability, and plant response in grasslands; a test of the transient maxima hypothesis. *Ecology, 78,* 2359-2368.

Briggs, J. M., & Knapp, A. K. (1995). International variability in primary production in tallgrass prairie; climate, soil, moisture, topographic position, and fire as determinants of aboveground biomass. *American Journal of Botany, 82,* 1024-1030.

Collins, S. L. (1992). Fire frequency and community heterogeneity in tallgrass prairie vegetation. *Ecology, 73,* 2001-2006.

Collins, S. L., Knapp, A. K., Briggs, J. M., Blair, J. M., & Steinauer, E. M. (1998). Modulation of diversity by grazing and mowing in native tallgrass prairie. *Science, 280,* 745-747.

Collins, S. L., Knapp, A. K., Briggs, J. M., Blair, J. M., & Steinauer, E. M. (1998). Modulation of diversity by grazing and mowing in native tallgrass prairie. *Science, 280,* 745-747.

Collins, S. L., & Smith, M. D. (2006). Scale-dependent interaction of fire and grazing on community heterogeneity in tallgrass prairie. *Ecology, 87,* 2058-2067.

Collins, S. L., & Wallace, L. L. (1990). *Fire in North American tallgrass prairie*. (p. 175). Norman, OK: University of Oklahoma Press.

Diamond, D. D., & Smeins, F. E. (1985). Composition, classification and species response patterns of remnant tallgrass prairies in Texas. *American Midland Naturalist, 113,* 294-308.

Dykes, S. (2005). *Effectiveness of native grassland restoration in restoring grassland bird communities in Tennessee*. (Master's Thesis).

Ehrenreich, J. H., & Aikman, J. M. (1963). An ecological study of the effect of certain management practices on native prairie of Iowa. *Ecol. Monogr., 33,* 113-130.

Gibson, D. J., & Hulbert, L. C. (1987). Effect of fire, topography and year-to-year climactic variation on species composition in tallgrass prairie. *Vegetatio, 72,* 175-185.

Gibson, D. J., & Hulbert, L. D. (1987). Effects of fire, topography, and year-to-year climate variation on species composition in tallgrass prairie. *Vegetatio, 72,* 175-185.

Harper, C. A., Bates, G. E., Gudlin, M. J., & Hansbrough, M. P. (2004). *A landowner's guide to native warm-season grasses in the mid-south*. Knoxville, TN: Office of Marketing and Communications Services, University of Tennessee Institute of Agriculture.

Harper, C. A., Bates, G. E., Hansbrough, M. P., Gudlin, M. J., Gruchy, J. P., & Keyser, P. D. (2007). *Native warm-season grasses identification, establishment and management for wildlife and forage production in the mid-south*. Knoxville, TN: Office of Marketing and Communications Services, University of Tennessee Institute of Agriculture.

Henning, J. C., Lacefield, G. D., & Amaral-Phillips, D. (1991, July). Interpreting forage quality reports. In *University of Kentucky*.

Howe, H. F. (1994). Response of early- and late-flowering plants to fire season in experimental prairies. *Ecological Applications, 4,* 121-133.

Keyser, P. D. (2007, January). *Foreword*. Paper presented at the Tennessee Native Grasslands Workshop "The State of the State". Murfreesboro, Tennessee.

Knapp, A. K., Blair, J. M., Briggs, J. M., Collins, S. L., Hartnett, D. C., Johnson, L. C., Towne, E. G. (1999). The keystone role of bison in North American tallgrass prairie. *Bioscience, 49,* 39-50.

Knapp, E. E., Estes, B. L., & Skinner, C. N. (2009). *Ecological effects of prescribed fire season: A literature review and synthesis for managers*. Redding, CA: USDA, Forest Service, Pacific Southwest Research Station.

Leach, M. K., & Givnish, T. J. (1996). Ecological determinants of species loss in remnant prairies. *Science, 273,* 15555-1558.

Lovell, D. L., Henderson, R. A., & Howell, E. A. (1981). The response of forb species to seasonal timing of prescribed burns in remnant Wisconsin prairies. *Proceedings of the Eighth North American Prairie Conference, 8,*

McCoy, T. D., Kurzejeski, E. W., Burger, L. W., & Ryan, M. R. (2001). Effects of conservation practice, mowing, and temporal changes on vegetation structure on Conservation Reserve Program fields in northern Missouri. *Wildlife Society Bulletin, 29,* 979-987.

Owensby, C. (1988). *Prescribed or controlled burning*. Manhattan, KS: Kansas State University Cooperative Extension Service.

Parton, W. J., & Risser, P. G. (1980). Impact of management practices on the tallgrass prairie. *Oecologia, 46,* 223-234.

Pfeiffer, K. E., & Steuter, A. A. (1994). Preliminary response of sanhills prairie to fire and bison grazing. *Journal of Range Management, 47,* 395-397.

Radeloff, V. C., Mladenoff, D. J., & Boyce, M. S. (2000). A historical perspective and future outlook on landscape scale restoration in the northwest Wisconsin pine barrens. *Restoration Ecology, 8,* 119- 126.

Riesterer, J. L., M.D. Casler, D. J. Undersander, and D. K. Combs. (2000). Seasonal yield distribution of cool-season grasses following winter defoliation. *Agronomy Journal*, *92,* 974-980

Risser, P. G., & Parton, W. J. (1982). Ecosystem analysis of the tallgrass prairie: Nitrogen cycle. *Ecology, 63,* 1342-1351.

Sparks, J. C., Masters, R. E., Engle, D. M., Palmer, M. W., & Bukenhofer, G. A. (1998). Effects of late growing-season and late dormant-season prescribed fire on herbaceous vegetation in restored pine-grassland communities. *Journal of Vegetation Science, 9,* 133-142.

Steinauer, E. M., & Collins, S. L. (2001). Feedback loops in ecological hierarchies following urine deposition in tallgrass prairie. *Ecology, 76,* 73-85.

Stubbendieck, J., & Masters, R. (2000). Use of prescribed fire in grassland management. *Center for Grassland Studies Newsletter, 6*(2), 1.

Svejcar, T. J., & Browning, J. A. (1988). Growth and gas exchange of andropogon gerardii as influenced by burning. *Journal of Range Management, 41,* 239-244.

United States Department of Agriculture, Forest Service Southern Region. (1989, February). *The Bugwood Network*. Retrieved from http://www.bugwood.org/pfire/techniques.html

Appendix A

Tukey's Studentized Range (HSD) Tests

Burn Time Study

The ANOVA Procedure

NOTE: This test controls the Type I experiment wise error rate, but it generally has a higher Type II error rate than REGWQ.

Tukey's Studentized Range (HSD) Test for Moisture

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	33.91662
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	11.419

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	Treatment (TRT)
A	64.427	4	Apr
A	61.752	4	Mar
A	61.388	4	Sep
A	60.286	4	Control
A	53.789	4	May

****

Tukey's Studentized Range (HSD) Test for Dry Matter

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	33.91662
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	11.419

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	46.211	4	May
A	39.714	4	Control
A	38.612	4	Sep
A	38.248	4	Mar
A	35.573	4	Apr

****

Tukey's Studentized Range (HSD) Test for Protein

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	4.705096
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	4.253

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	12.915	4	Apr
A	12.873	4	May
A	12.348	4	Sep
A	11.638	4	Control
A	11.400	4	Mar

****

Tukey's Studentized Range (HSD) Test for Fat

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	0.259253
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	0.9983

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	1.9850	4	Sep
A	1.7650	4	Mar
A	1.7350	4	May
A	1.7000	4	Apr
A	1.4675	4	Control

****

Tukey's Studentized Range (HSD) Test for Acid Detergent Fiber

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	62.92113
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	15.553

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	49.215	4	May
A	39.803	4	Mar
A	37.598	4	Control
A	37.283	4	Sep
A	37.260	4	Apr

****

Tukey's Studentized Range (HSD) Test for Neutral Detergent Fiber

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	8.862439
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	5.8369

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	69.410	4	Apr
A	67.693	4	Sep
A	67.608	4	Control
A	67.510	4	Mar
A	66.905	4	May

****

Tukey's Studentized Range (HSD) Test for Calcium

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	0.035033
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	0.367

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	0.5325	4	Sep
A	0.5100	4	Mar
A	0.4725	4	Control
A	0.3525	4	May
A	0.3375	4	Apr

****

Tukey's Studentized Range (HSD) Test for Phosphorous

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	0.014632
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	0.2372

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	0.37750	4	Apr
A	0.31000	4	Sep
A	0.30000	4	Mar
A	0.24250	4	Control
A	0.24000	4	May

****

Tukey's Studentized Range (HSD) Test for Magnesium

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	0.002819
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	0.1041

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	0.22500	4	Sep
A	0.19750	4	May
A	0.19250	4	Control
A	0.18750	4	Apr
A	0.14000	4	Mar

****

Tukey's Studentized Range (HSD) Test for Potassium

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	0.256758
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	0.9935

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	1.9450	4	Apr
A	1.8650	4	May
A	1.5900	4	Sep
A	1.5325	4	Mar
A	1.5225	4	Control

****

Tukey's Studentized Range (HSD) Test for Total Digestible Nutrients

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	8.425
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	5.691

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	TRT
	A	60.500	4	Apr
B	A	60.000	4	Sep
B	A	59.500	4	Control
B	A	57.250	4	Mar
B		54.750	4	May

****

Tukey's Studentized Range (HSD) Test for Net Energy calculations for Lactation

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	0.001119
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	0.0656

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	0.61750	4	Apr
A	0.61500	4	Sep
A	0.61000	4	Control
A	0.58250	4	Mar
A	0.55750	4	May

****

Tukey's Studentized Range (HSD) Test for Net Energy calculations for Maintenance

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	0.001981
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	0.0873

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	TRT
	A	0.60250	4	Apr
B	A	0.59500	4	Sep
B	A	0.58500	4	Control
B	A	0.55250	4	Mar
B		0.51500	4	May

****

Tukey's Studentized Range (HSD) Test for Net Energy calculations for Gain

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	0.00174
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	0.0818

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	0.34000	4	Apr
A	0.33500	4	Sep
A	0.33000	4	Control
A	0.28750	4	Mar
A	0.26000	4	May

****

Tukey's Studentized Range (HSD) Test for Relative Feed Value

Alpha	0.1
Error Degrees of Freedom	12
Error Mean Square	32.41667
Critical Value of Studentized Range	3.92135
Minimum Significant Difference	11.163

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TRT
A	82.500	4	Sep
A	82.250	4	Control
A	80.250	4	Apr
A	79.750	4	Mar
A	78.750	4	May

Appendix B

Nwsg Forage Sample Quality Values Related to Timing of Prescribed Burn.

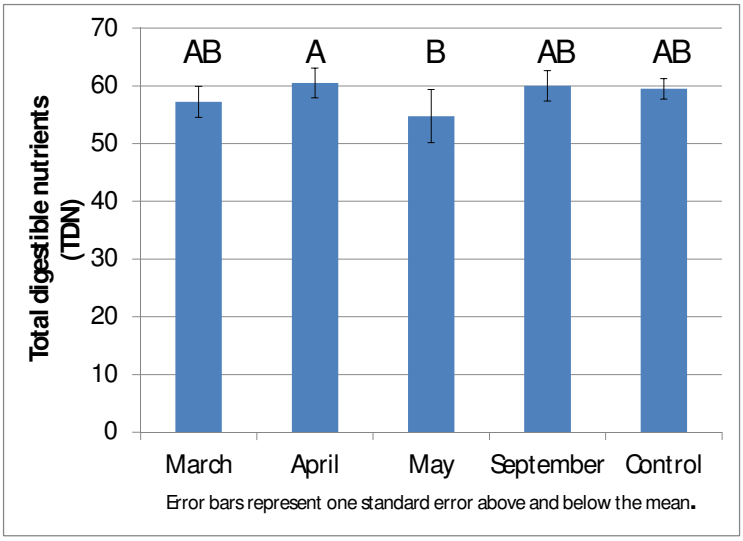

Figure A-1 Nwsg Forage Sample Quality TDN Values Related to Timing of Prescribed Burn.

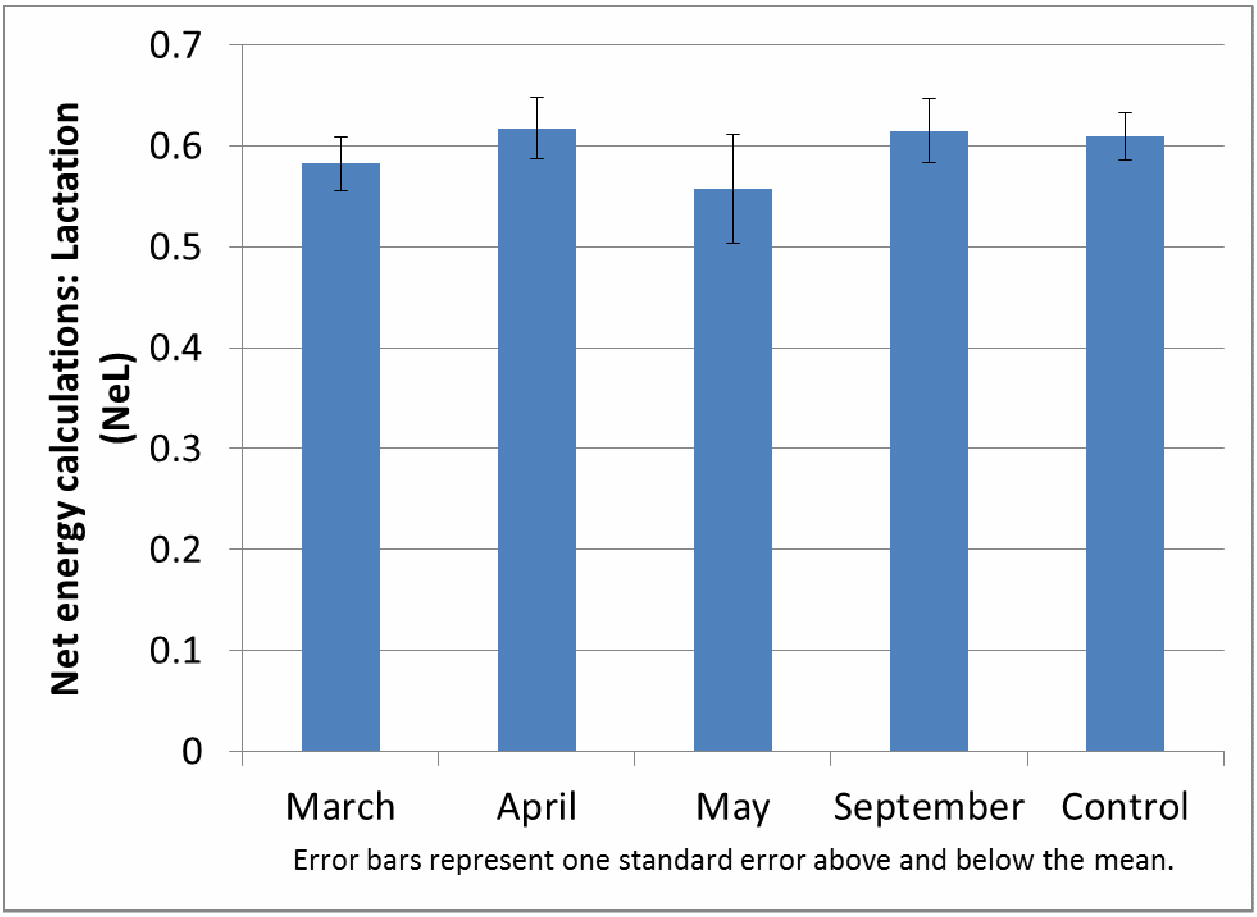

Figure A-2 Nwsg Forage Sample Quality NeL Values Related to Timing of Prescribed Burn.

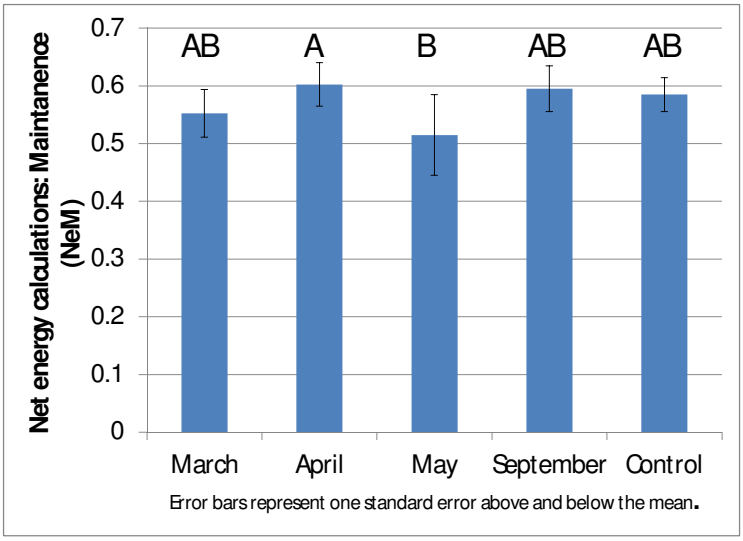

Figure A-3 Nwsg Forage Sample Quality NeM Values Related to Timing of Prescribed Burn.

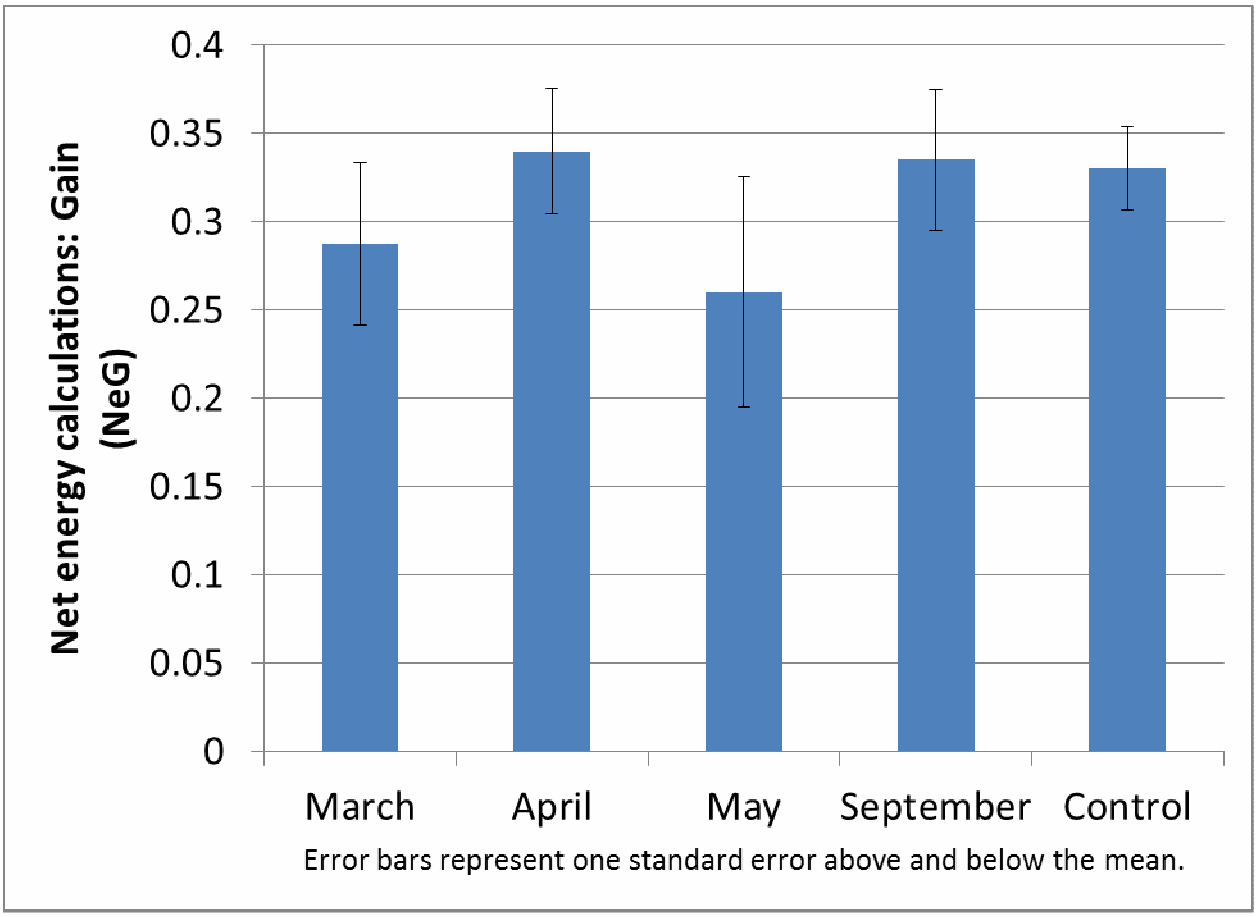

Figure A-4 Nwsg Forage Sample Quality NeG Values Related to Timing of Prescribed Burn.

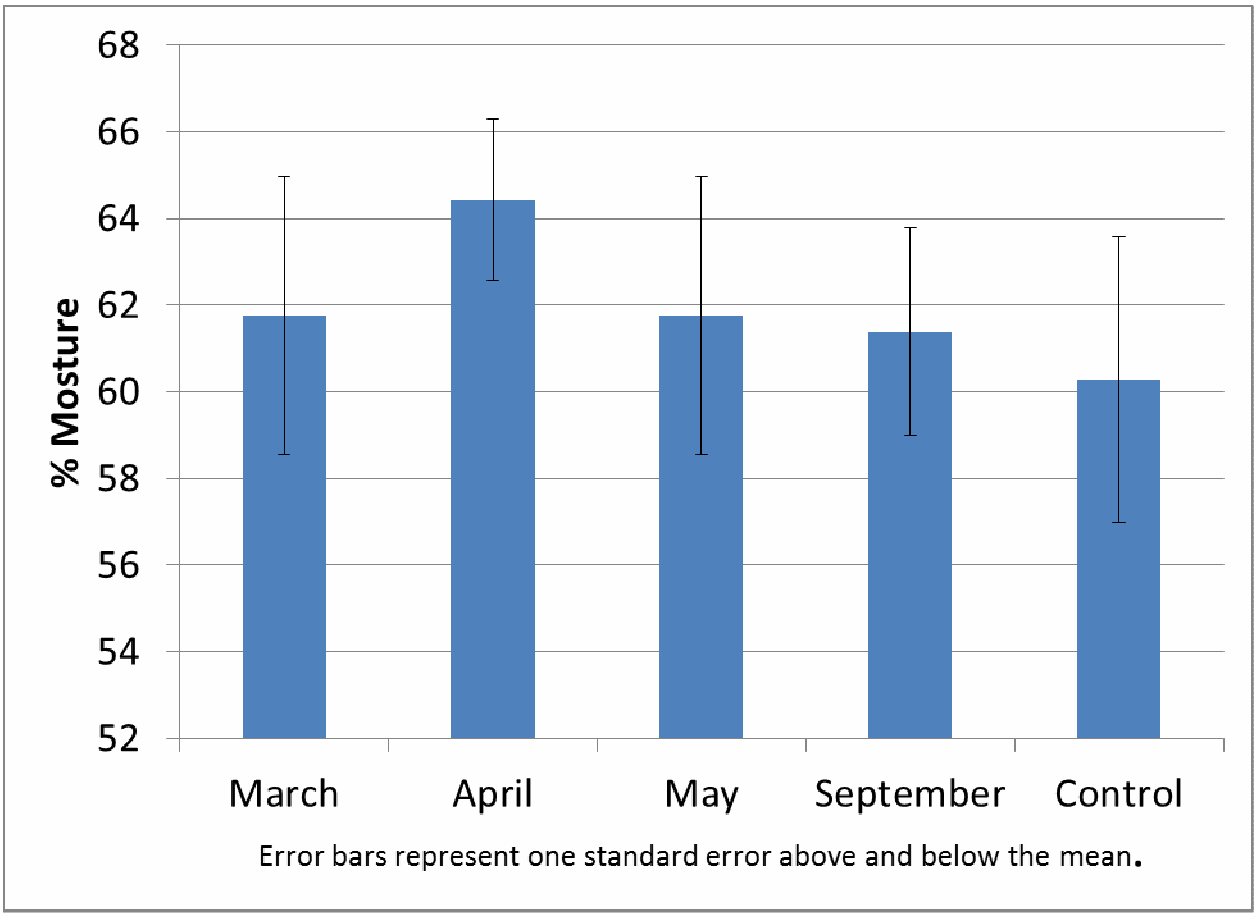

Figure A-5 Nwsg Forage Sample Quality Moisture Values Related to Timing of Prescribed Burn.

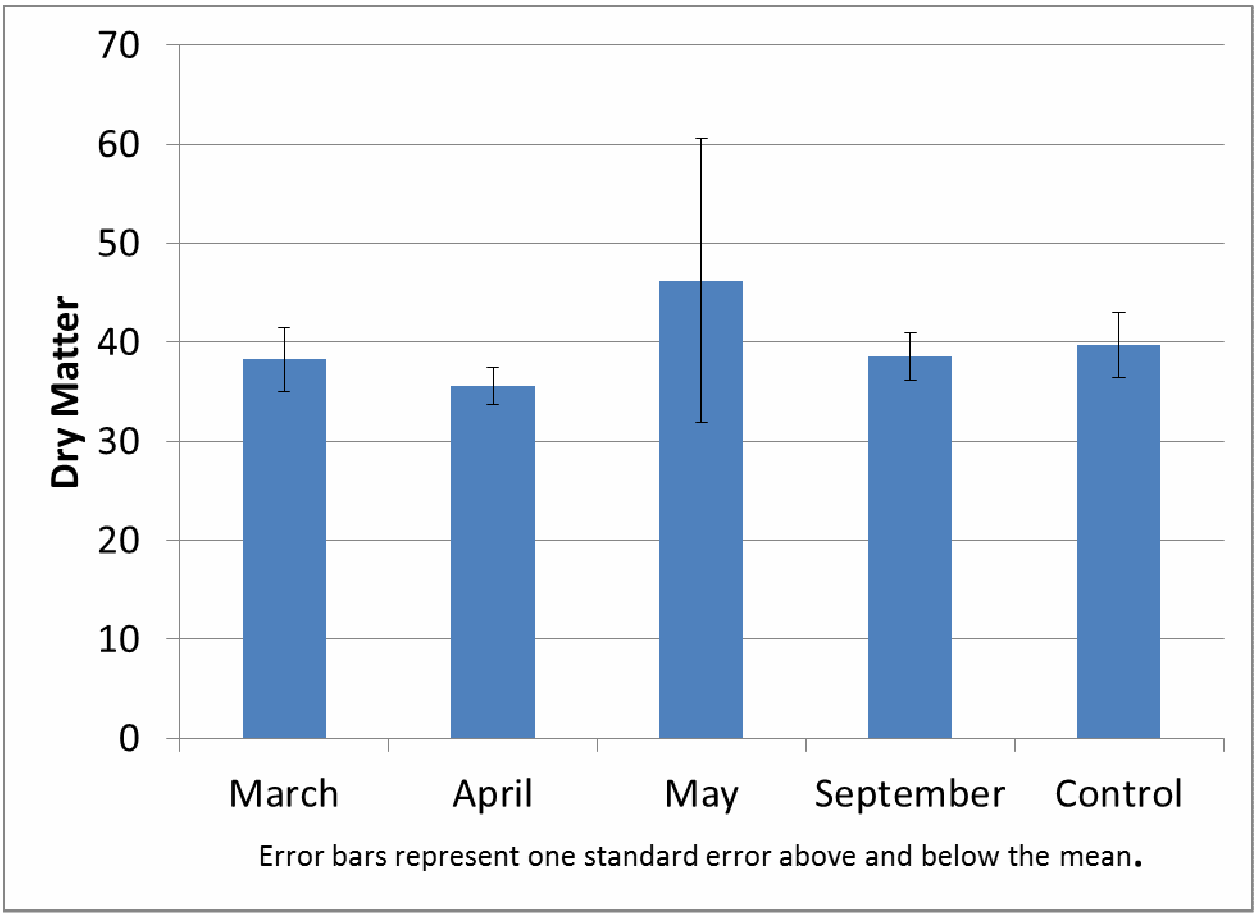

Figure A-6 Nwsg Forage Sample Quality Dry Matter Values Related to Timing of Prescribed Burn.

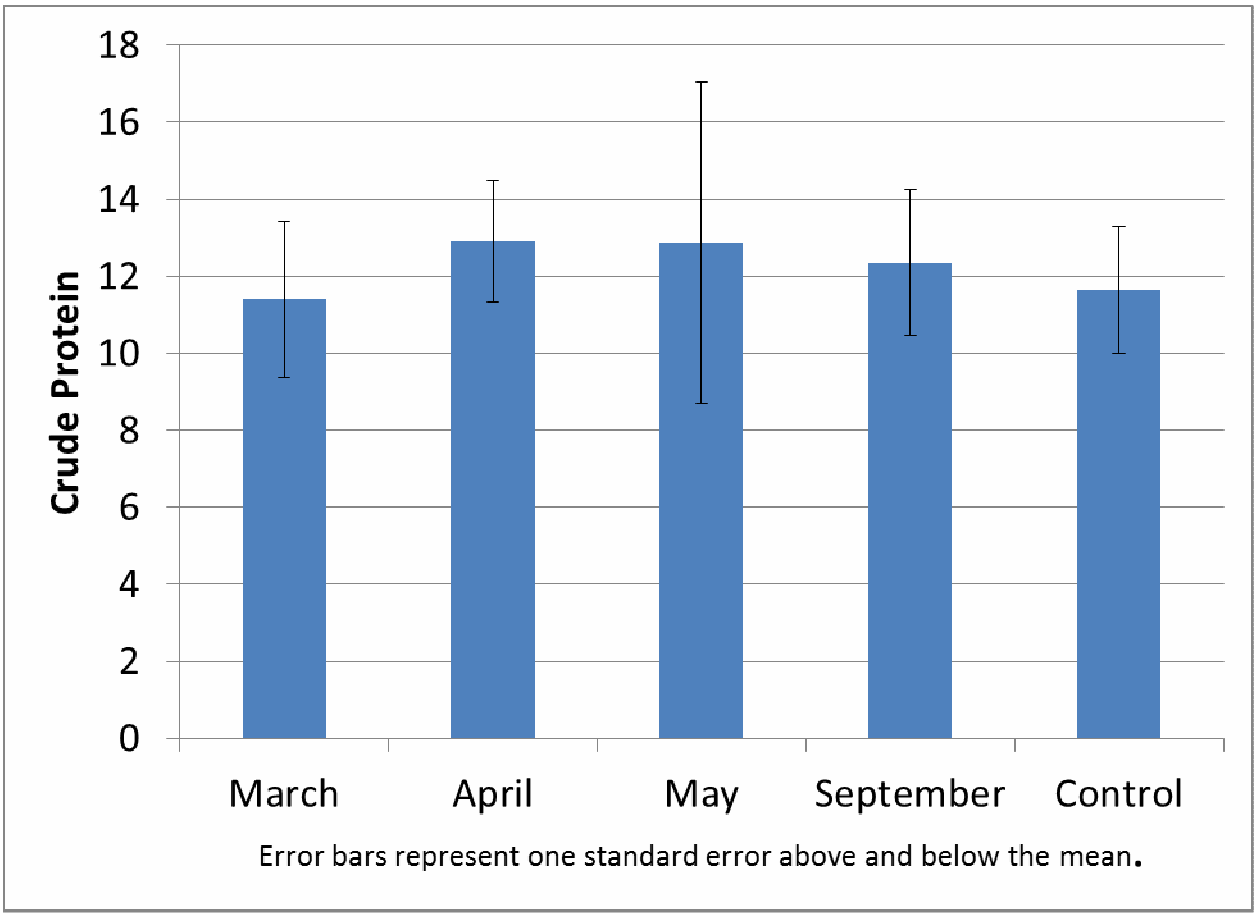

Figure A-7 Nwsg Forage Sample Quality Crude Protein Values Related to Timing of Prescribed Burn.

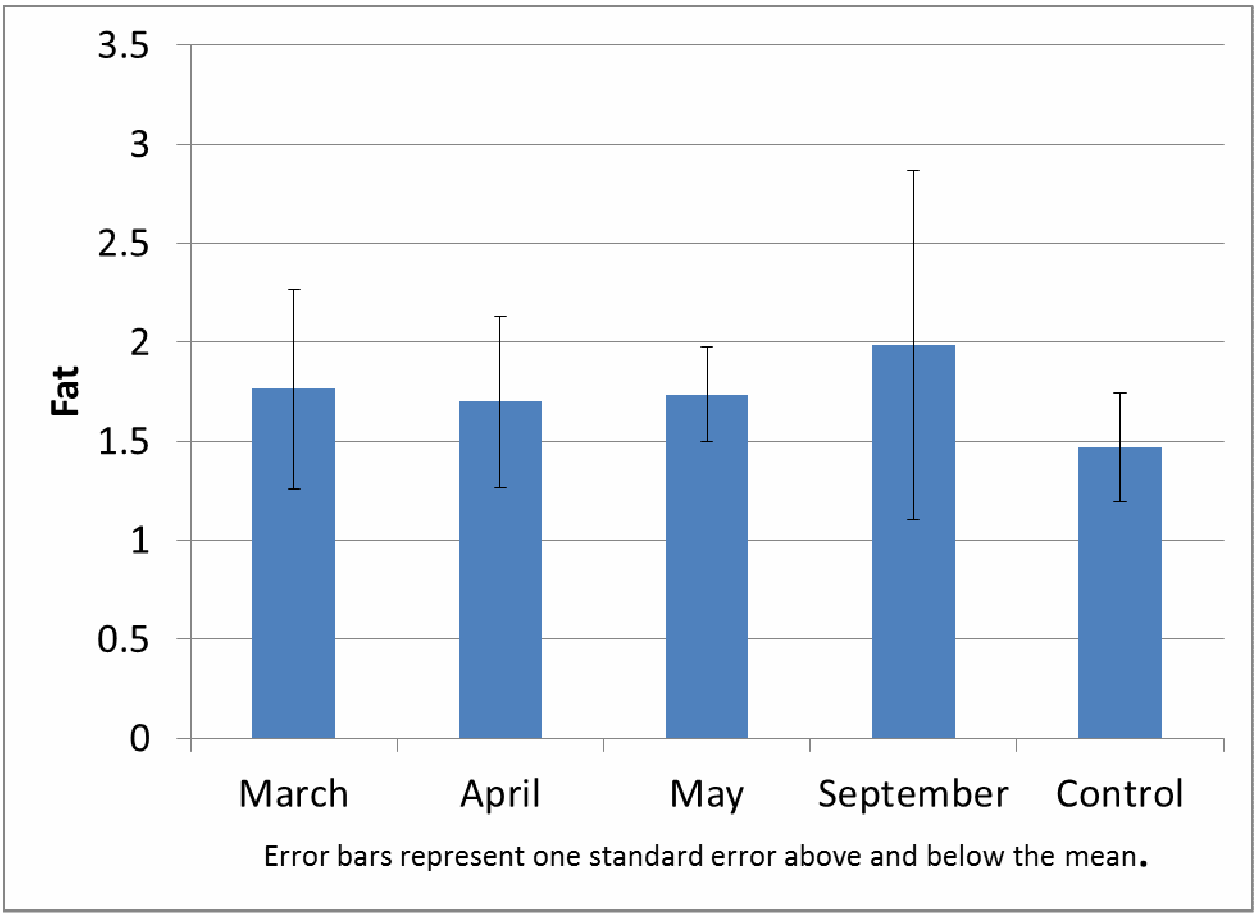

Figure A-8 Nwsg Forage Sample Quality Fat Values Related to Timing of Prescribed Burn.

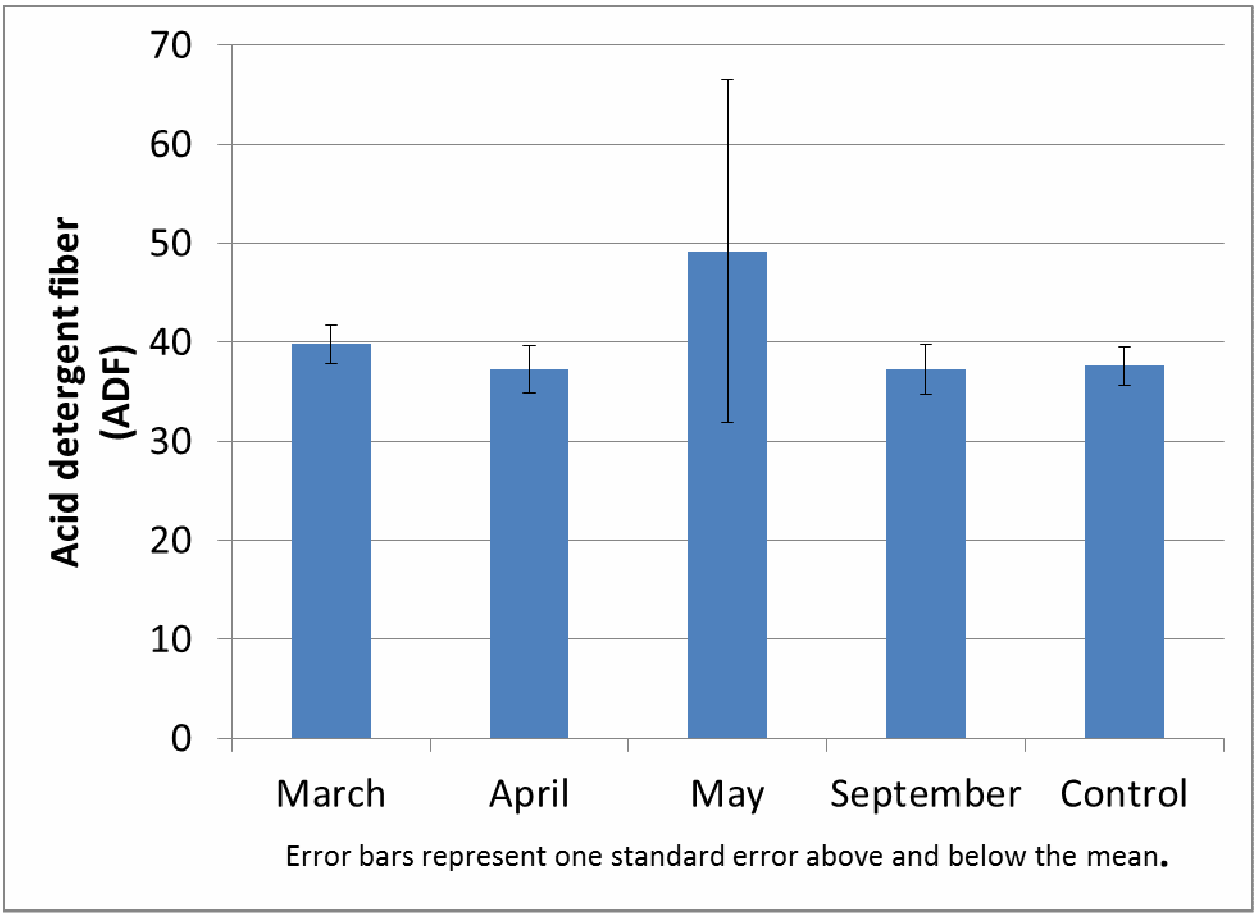

Figure A-9 Nwsg Forage Sample Quality ADF Values Related to Timing of Prescribed Burn.

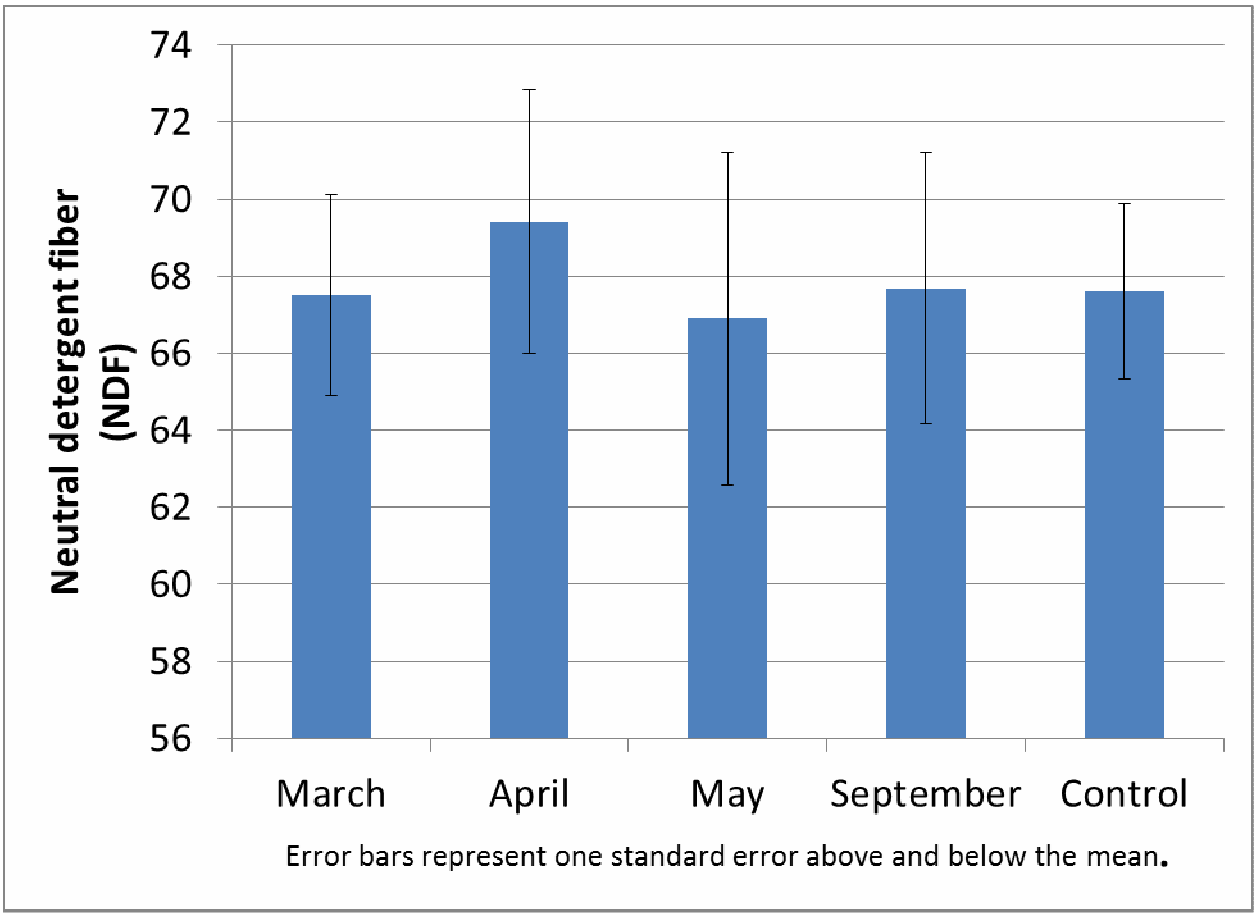

Figure A-10 Nwsg Forage Sample Quality NDF Values Related to Timing of Prescribed Burn.

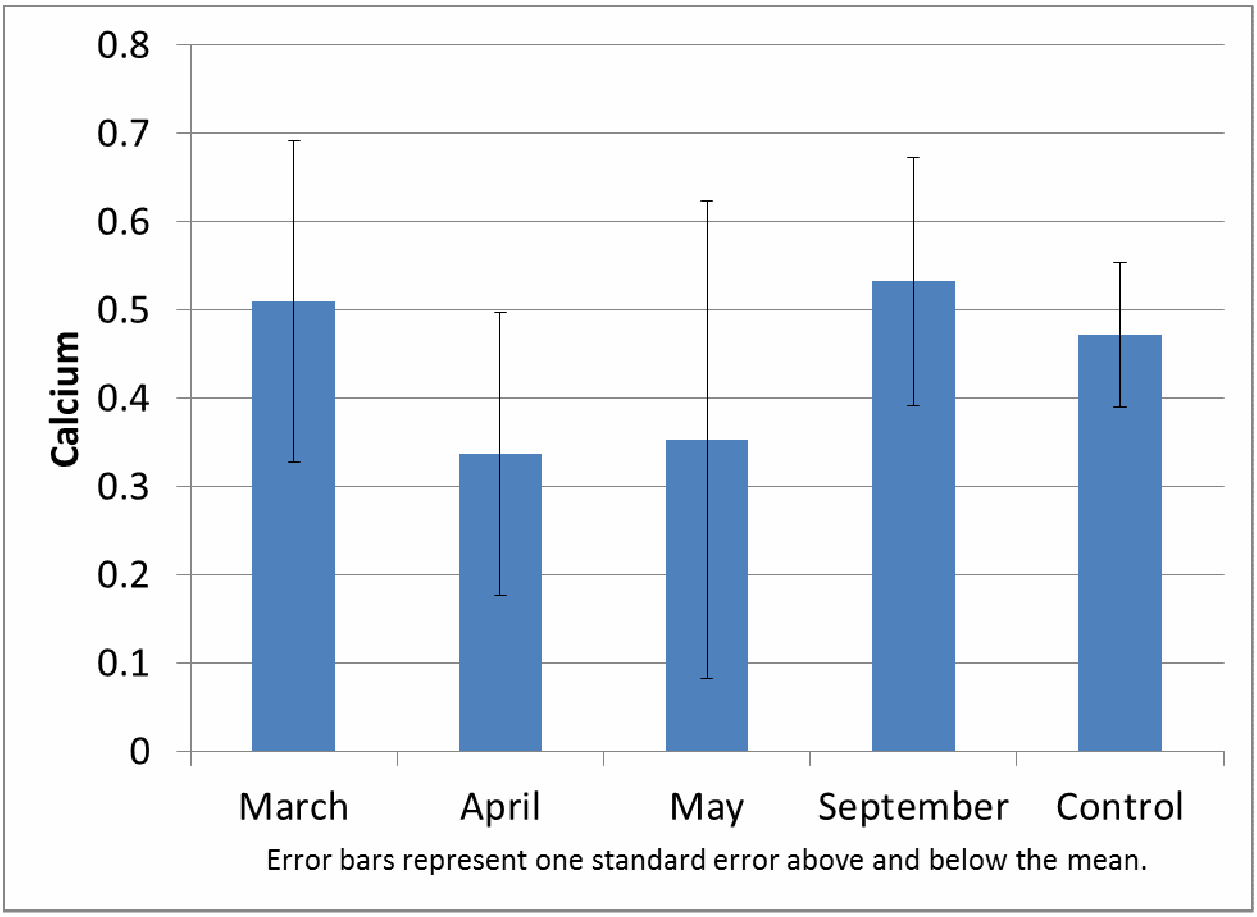

Figure A-11 Nwsg Forage Sample Quality Calcium Values Related to Timing of Prescribed Burn.

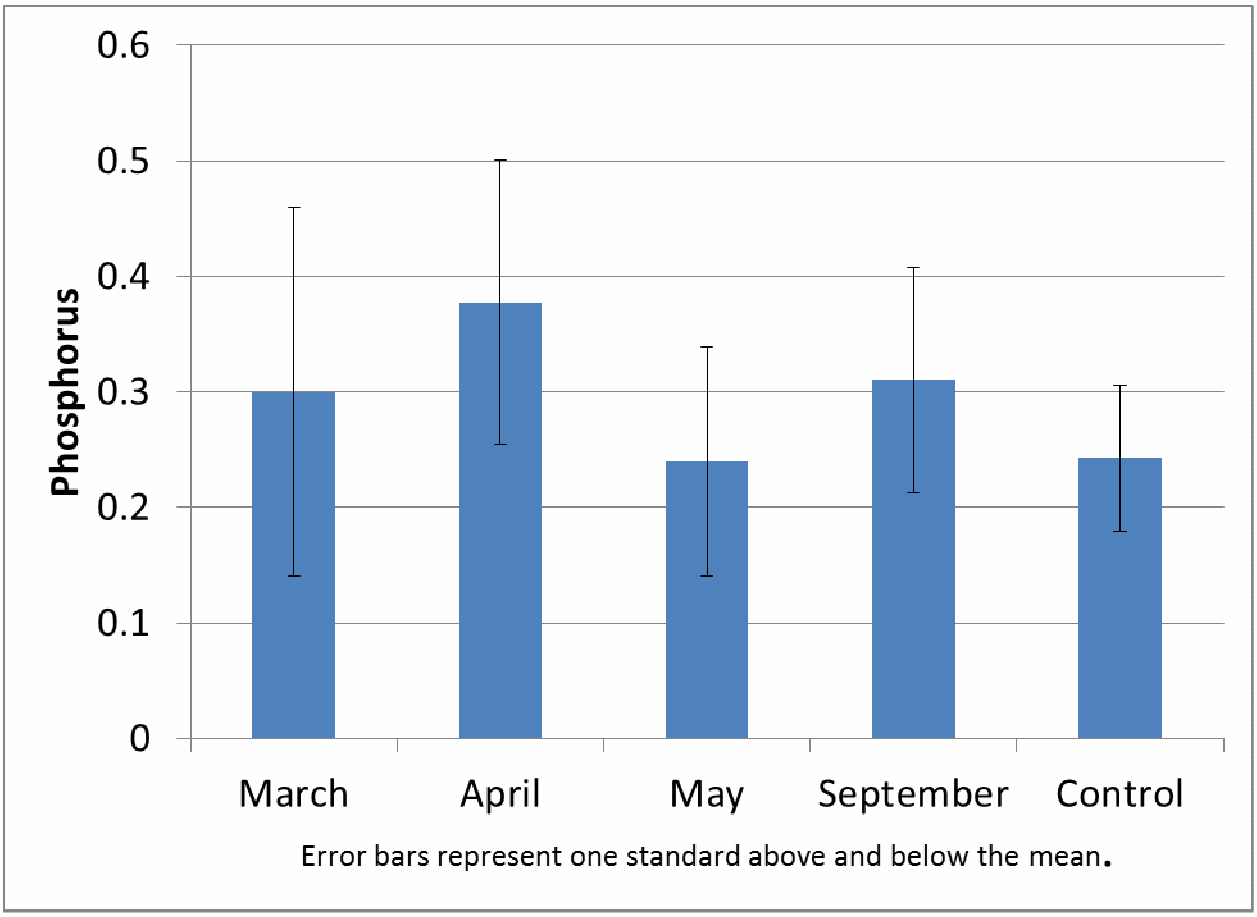

Figure A-12 Nwsg Forage Sample Quality Phosphorus Values Related to Timing of Prescribed Burn.

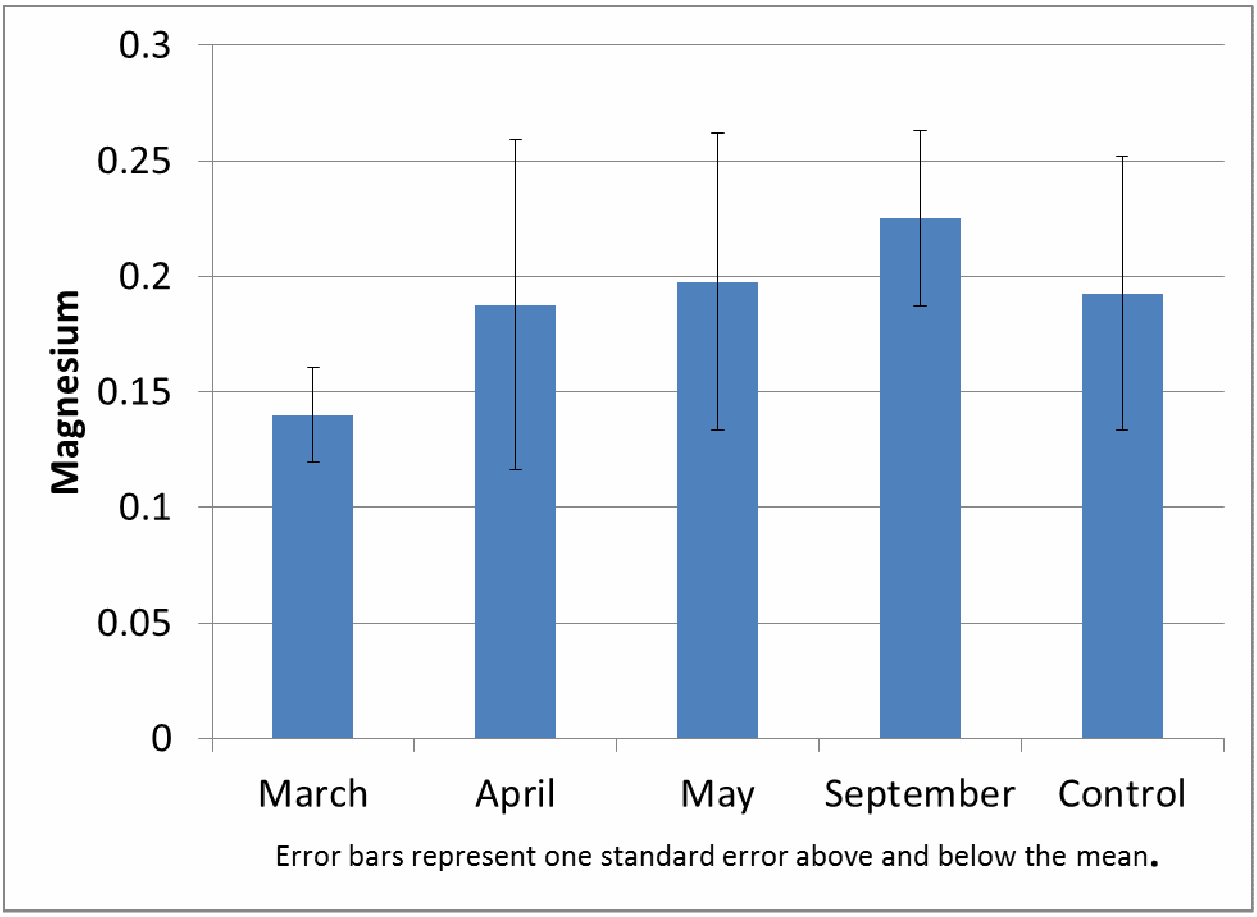

Figure A-13 Nwsg Forage Sample Quality Magnesium Values Related to Timing of Prescribed Burn.

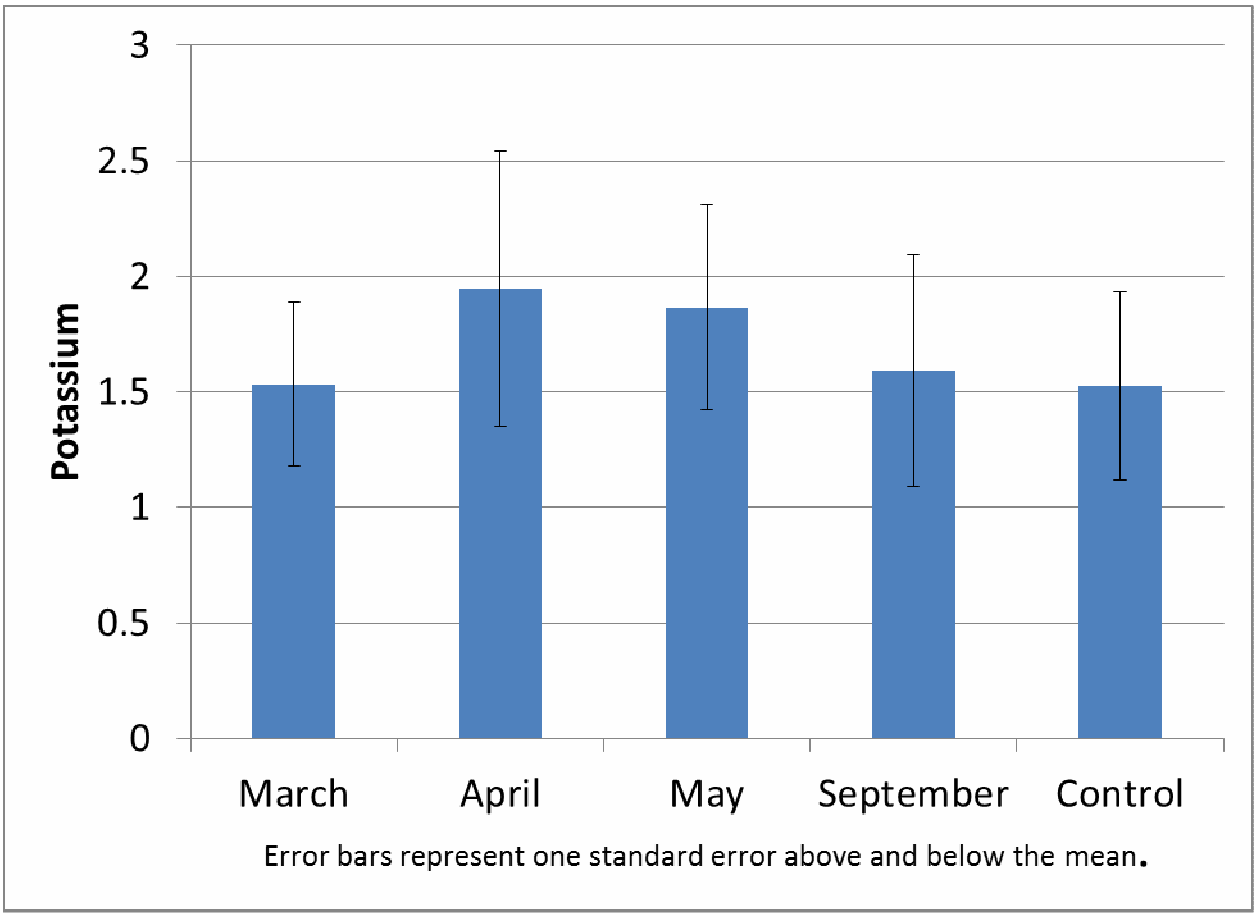

Figure A-14 Nwsg Forage Sample Quality Potassium Values Related to Timing of Prescribed Burn.

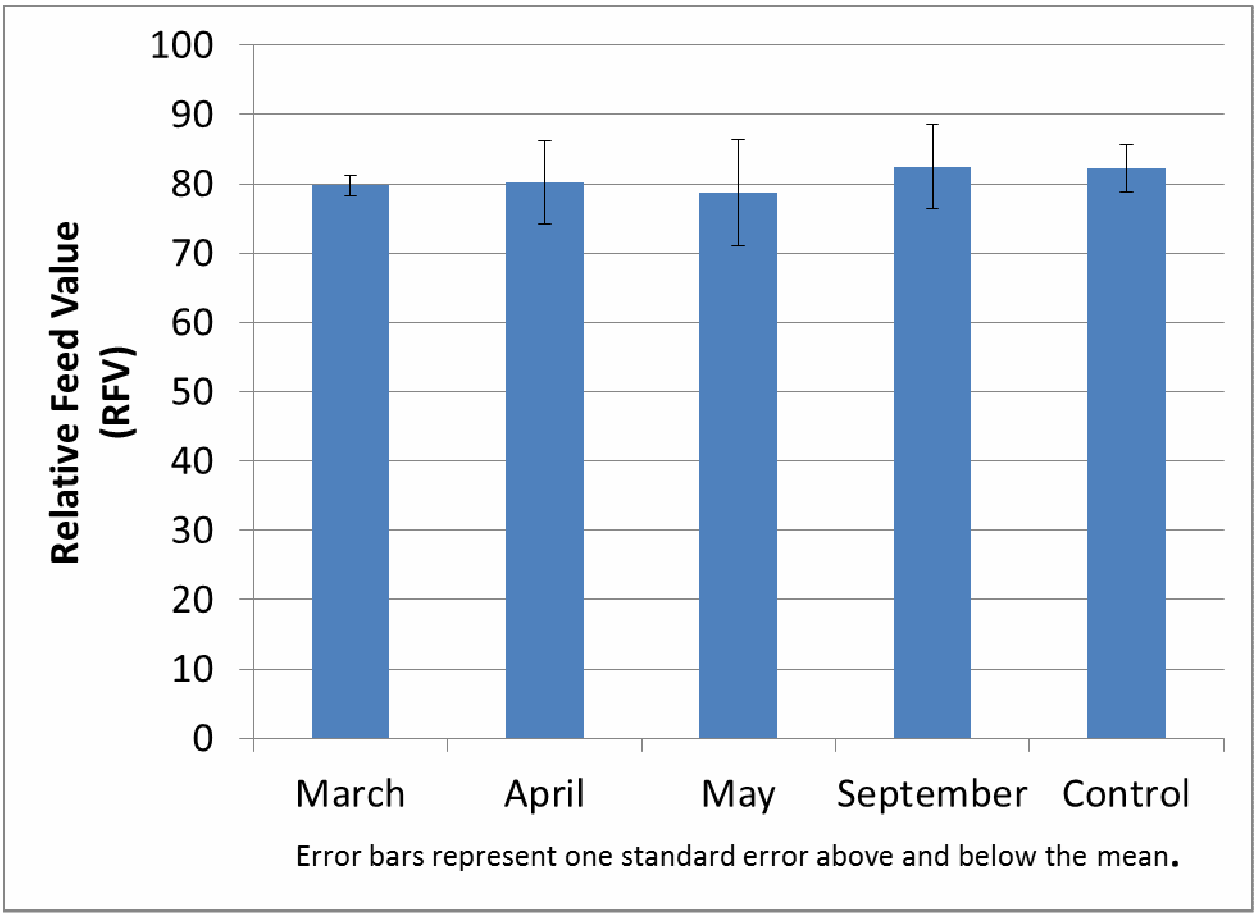

Figure A-15 Nwsg Forage Sample Quality RFV Values Related to Timing of Prescribed Burn.

VITA

Amanda Mathenia was born in Trenton, TN, to the parents of Harry and Shirley Mathenia. She is the youngest sibling to Greg, Amy, and Robbie.

Amanda was an active member in the 4-H Club throughout middle and high school where she showed registered Limousin cattle and market steers, sheep, and hogs. Amanda graduated from Peabody High School in 1999. She attended Murray State University and received her Bachelor of Science Degree in Agribusiness in 2005.

In 2008, Amanda began her career with the University of Tennessee Extension as an Agriculture and Natural Resources Extension Agent in Humphreys County. Within in year, Amanda started her Master's Degree at the University of Tennessee, Knoxville. In July 2011, Amanda transferred her position to be the ag agent for both Decatur and Perry Counties. She graduated with a Masters of Science degree with a 4.0 GPA in December 2011.