Evaluation of alternative forage species to reduce risk for cow-calf production systems in the Appalachian region

Christina Louise Newman

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Science in Crop and Soil Environmental Sciences

Dr. A. Ozzie Abaye (Chair)

Dr. William M. Clapham

Dr. Benjamin F. Tracy

Dr. William S. Swecker Jr.

Dr. Rory O. Maguire

November 30, 2010

Blacksburg, Virginia

Keywords: risk management, resampling, cow-calf, forage

Evaluation of alternative forage species to reduce risk for cow-calf production systems in the Appalachian region

Christina L. Newman

Abstract

Optimizing forage productivity is essential to reduce pasture seasonality and ensure available forage to meet the nutritional needs of livestock. This study explores the risk-buffering ability of warm-season forages to fill the summer slump gap in production of cool-season grasses. Small plot experiments were initiated in summer of 2008 in Kentland Farm, Northern Piedmont AREC and Shenandoah AREC, Virginia. Treatments included endophyte-infected tall fescue (KY31 E+), endophyte free tall fescue (KY31 E-), novel endophyte tall fescue (MaxQ), Crabgrass in combination with endophyte-infected tall fescue, Teff, Bermudagrass (BG), and Caucasian bluestem (CB). Plots were harvested May through October of 2009 and 2010 at the late boot stage at a cutting height of 10cm. Subsamples were analyzed for dry matter and nutritive value. To assess risk, bootstrap distributions of biomass and quality data were generated by Monte Carlo simulation and compared against an objective function defined as 59 kg ha^{-1} d^{-1} forage yield; 10% CP; 60% TDN. Regardless of variability, warm-season grasses produced biomass yields and nutritional values adequate to fill the summer slump from cool-season forages and demonstrated a higher probability of meeting the minimum requirements in July, August and September. Teff was most consistent in meeting the minimum requirements in mid-summer. However, with good conditions for establishment, both BG and CB can help to fill the gap in summer months when compared to cool-season tall fescue. Bootstrap distributions provide producers with a tool that links their production goals with a measurable value of production risk.

DEDICATION

To Emmanuel Estanis, whose passion for education and persistence to a better future is my inspiration.

Also to my parents, Larry and Darlene Newman and my siblings Kevin, Jenny and Steve for their constant support and encouragement.

And to Jean,
when he doesn't understand why I'm so upset that someone cut my grass,
but listens anyway.

ACKNOWLEDGEMENTS

I wish to thank all who aided in the success of this project. Below are only a few names out of the many that made it happen.

Thank you.

Dr. Ozzie Abaye

Dr. Bill Clapham

Dr. Ben Tracy

Dr. Terry Swecker

Dr. Rory Maguire

Katie Hurder

David Fiske and the crew at McCormick Farm

Jon Wooge and the crew at Kentland Farm

Dave Starner and the crew at NPAREC

Dr. Chris Teutsch and Mac Tilson

Agronomy Farm crew

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER III:

CHAPTER IV:

LIST OF FIGURES

CHAPTER III:

CHAPTER IV:

APPENDIX

CHAPTER I

INTRODUCTION

Tall fescue (*Festuca arundinacea* Schreb.) is the main cool-season forage across the Appalachian region. It is adapted to the "transition zone", defined as the area between the successful zone of cultivation for cool- and warm-season grasses. Tall fescue is the most important forage species worldwide of the *Festuca* genus and the principal cool-season perennial grass in humid areas of the USA (Moser et al., 1996). Classified as a cool-season perennial grass, peak production of tall fescue occurs in the spring months with a secondary peak of vegetative growth in early fall (Barnes et al., 2003). If stockpiled starting late summer, the accumulated growth is often used as a feed source throughout the winter in the southeastern and mid-Atlantic United States. Tall fescue is especially advantageous over other cool-season grasses because of its persistence under low management input of part-time operations and those favoring low economic risk over high return (Moser et al., 1996). Unfortunately, as with most cool-season plants, tall fescue experiences a "summer slump" or mid-summer dormancy in July and August when temperatures rise above the optimum 20-25^{o} C and is only able to withstand relatively short periods of drought (Moser et al., 1996). For this reason, when considering a year-round grazing system, tall fescue must be supplemented with alternative forages that have the ability to offer greater yield in mid-summer months, thus reducing the risk of shortages in forage.

In any grazing system, optimizing forage productivity is essential to reduce pasture seasonality and ensure available forage to meet the nutritional needs of grazing livestock. In many circumstances, alternative forages are used to complement or replace existing species in an effort to reduce the risk of yields falling below minimum requirements of the grazers (Griffith, 1978). Some strategies to extend grazing seasons include stockpiling along with complementary annual or perennial warm-season forages (Griffith, 1978). Additionally, in many production systems, grazing seasons can be optimized by controlling the stocking density of livestock and rotation among paddocks or pastures (Vallentine, 2001). In forage production and grazing systems, the greatest "risk" is that of a limited supply of feed and ability of this feed to meet animal nutrient requirements. This risk can be managed by taking specific precautions in grazing operations and making informed decisions regarding forage types and forage yield. A priority objective of any pasture management is to match forages with animal's nutritional needs, without which the pasture is of little use to the livestock producer (Vallentine, 2001).

Agriculture carries inherent risks undertaken by the producer (Fleisher, 1990). Risk may include fluctuations in income due to price variation or market values as well as uncertainty of production levels as a result of unpredictable performance from fluctuating environmental factors (Hardaker et al., 2004). In any business enterprise, production must obtain a certain minimum level in order to be sustainable in the long run. Many agricultural systems often make management decisions based on maximizing profit without accounting for the highly variable outcomes that could result (Fleisher and Robinson, 1985). Unfortunately, systems that offer the highest profit often do so because of the high risks involved. In other words, profit is the reward for bearing risk (Hardaker et al., 2004). Producers that minimize risks are left with a more stable but less profitable and efficient production (Bastian and Held, 1999). Generally, lower farm incomes tend to be associated with higher levels of risk aversion (Escalante and Barry, 2001). The task is to manage risk effectively within the capacity of the individual as to optimize the efficiency of production (Hardaker et al., 2004).

The overall objective of this study is to assess the buffer capacity (risk lowering ability) of various cool-season and warm-season annuals and perennials to complement tall fescue based pastures. More specifically, the objectives are:

1. To develop yield probability functions for tall fescue vs. warm-season species.
2. To analyze the nutrient content of various alternative forages and assess the capability of these alternative forage species to lower the risk of nutrient and yield deficiencies in the summer months of limited growth from cool-season tall fescue.

References

Barnes, R. F., C. J. Nelson, M. Collins, and K. J. More. 2003. Forages volume 1: An introduction to grassland agriculture (6th Edition). Iowa State University Press, IA.

Bastian, C., and L. Held. 1999. Enterprise diversification: Will it reduce your risk? Article #2.4, Risk and resilience in agriculture, risk management handbook. Joint Publication Coop. Ext. Serv., of Colo State Univ., Mont. State Univ., and the Univ of Wyo., pp. 1-6.

Escalante, C. L., and P. J. Barry. 2001. Risk balancing in an integrated farm risk management plan. J. of Agri. and Applied Econ., 33, 3:413-429.

Fleisher, B. 1990. Agricultural risk management. Lynne Rienner Publishers, Boulder, CO.

Fleisher, B. and L. J. Robinson. 1985. Applications of decision theory and the measurement of attitudes towards risk in farm management research in industrialized and third world settings. Department of Agri. Econ., Michigan State University.

Griffith, C. A. 1978. Summer grass conference: Management of warm-season grasses for utilization with beef cattle. Noble Foundation. Ardmore, OK.

Hardaker, J. B., R. B. M. Huirne, J.R. Anderson, and G. Lien. 2004. Coping with risk in agriculture. CABI Publ., Cambridge, MA.

Moser, L.E., D. R. Buxton and M.D.Casler. 1996. Cool-season forage grasses. Agronomy: A series of monographs #34. ASA, CSSA and SSSA, Inc. Madison, WI.

Vallentine, J. F. 2001. Grazing management. Academic Press, San Diego, CA.

CHAPTER II

LITERATURE REVIEW

Farming operations in general; and in particular grazing livestock enterprises, are risky business endeavors. Many livestock producers minimize their input costs by relying on cool-season grasses, particularly tall fescue pasture. At the same time, they expose themselves to risks associated with forage yields that fluctuate in response to variable environmental conditions. For the Appalachian region, the primary forage in cow-calf production systems is endophyte-infected Kentucky 31 tall fescue

About Tall Fescue

Tall fescue sets the standard against which agronomic performance of other grasses is measured. However, the decreased production of biomass from this cool-season forage during hot and dry conditions of the summer slump pose a risk in failing to meet minimal animal requirements of cow-calf operations. In addition, decreased animal performance and disorders caused by presence of the fungal endophyte (*Neotyphodium coenophialum)* in tall fescue reduces its suitability for many forage-livestock producers. Because of this complication, there are several varieties of endophyte free and novel endophyte tall fescue that do not cause toxicosis as an alternative to the more common forage. However, most tall fescue plants are infected with the endophytic fungus *Neotyphodium coenophialum*. A survey conducted by Ball et al., 1987 found over 90% of fescue fields in the United States to be endophyte-infected. The endophytic fungus produces ergot alkaloids that are toxic to livestock (Ball et al., 2002). A broad range of other alkaloids are also produced by the endophyte, but ergopeptine alkaloids are most closely associated with animal toxicosis (Hill et al., 1991). Since alkaloids are produced by the endophytic fungus itself, endophyte-free tall fescue does not contain the toxic alkaloids that are produced in endophyte-infected fescue, and therefore does not negatively affect animals consuming the grass.

Researchers in New Zealand have discovered endophytes that are not toxic to animals because the most harmful alkaloids, ergot alkaloids, are not produced. These endophytes are commonly referred to as non-toxic or "novel". It consists of inserting non-toxic strains of the fungus into E- tall fescue. A combination of characteristics between the two fescues (E+ and E-) has been found in novel endophyte-infected fescue. Ball et al. (2002) explained that the novel endophyte-infected fescue will have the persistence and hardiness of the E+, but without the toxic effects.

Max Q fescue was introduced as a "novel endophyte" tall fescue. This grass has an endophytic fungus that helps express positive agronomic characteristics commonly associated with varieties such as Kentucky31 tall fescue. However, the novel endophyte does not appear to cause the production of toxins found in other endophyte-infected tall fescue varieties. Moreover, research has shown that animal performance is not compromised by the presence of the novel endophyte (Nihsen et al., 2004).

Alternative Forages

During the summer of 2007, many livestock producers in the southeastern US suffered through a terrible drought and most producers ran out of forage in early summer. Many were forced to buy supplemental feed or sell expendable stock early, which greatly diminished any hope of profitability. The drought revealed a glaring need to diversify forage production to help cope with such extreme climate variation.

As a cool-season grass, tall fescue can only provide feed during early spring and early fall, resulting in a production gap in mid-summer and winter. Due to this inconsistency in meeting minimal animal requirements, this forage must often be supplemented in Virginia and the Appalachian region during the warmer summer months. A variety of alternative forages; specifically warm-season grasses, are often used to offset the lack of adequate summer growth of tall fescue (Moser et al. 1996). In an effort to manage production effectively, mixtures of alternative forage species within a system reduce risk in pasture- based livestock production.

Warm-Season Annuals

Crabgrass *(Digitaria* spp.*)*

Although often thought of as a common weed (Beal, 1896), this well-adaptive plant is utilized for forage and sometimes cut for hay (Alderson and Sharp, 1995). Crabgrass is native to Europe but has adjusted to temperate and tropical conditions around the world; most commonly in the East and Southern states of the USA (Alderson and Sharp, 1995). As a warm-season grass, this forage thrives in warm weather and reaches peak growth in late summer (Alderson and Sharp, 1995). This characteristic combined with strong roots makes it a fair compliment to tall fescue as alternative forage in year-round pasture systems. Crabgrass is classified as an annual grass but can be treated as a reseeding summer annual for summer production without having to replant each year (Barnes et al., 2003). Although little research has been conducted to utilize this species as managed summer forage, crabgrass is already a component of many cool- and warm-season pastures in the upper south of the USA (Burns et al., 2004). Dairy farmers in the southern USA use crabgrass pasture and as silage successfully with high-producing herds (Moser et al., 2004).

The biomass yield of crabgrass can be improved with appropriate management including cutting height (a minimal stubble height of 7.5-15cm), rotational stocking, and nitrogen fertilization (Moser et al., 2004). Teutsch et al (2005) conducted an experiment to examine the yield, digestibility, and nutritive value of crabgrass. The research showed a high yield from crabgrass, especially during years with intermittent drought, and digestibility greater than that of commonly used warm-season perennial grasses (Teutsch et al., 2005). The researchers concluded that crabgrass has the potential to be a high-energy forage for the livestock industry in the mid-Atlantic region (Teutsch et al., 2005).

Teff (*Eragrostis tef* Zucc. Trotter)

Teff is a warm season annual grass native to Ethiopia. Teff is a relatively new crop in the United States used for both human consumption and as animal feed (Gressel, 2008). Adapted to a wide range of climatic conditions, Teff is capable of surviving on marginal soils from water logged to drought conditions, providing a crop in a relatively short growing season (Gressel, 2008). Teff; often termed an "emergency crop", has the ability for quick establishment, relatively high yields and high quality characteristics (Ketema, 1997). Although not wide spread, Teff hay is used for livestock and horse feed in Virginia and the Appalachian region. The initial growth of Teff is not ideal for grazing due to its shallow rooting. The re-growth of Teff; however, can be grazed rotationally with minimum impact on stand vitality. In South Dakota, it was found that Teff offers flexibility because if its growth pattern and allows producers to plant the grass anytime from May through July (Twidwell, 2002).

Warm-Season Perennials

Bermudagrass *(Cynodon dactylon* (L.)(Pers.))

Bermudagrass (BG) is a warm-season perennial grass that is used to supplement cool-season pastures in the southeastern United States (Moser et al. 1996). Originating from South East Africa, BG is now distributed worldwide and in 1917 was arguably referred to as the most common and most valuable pasture plant in the southern states (Barnes et al., 1995).

Bermudagrass produces peak growth under mean daily temperatures above 24^{o}C and is found to be both drought resistant and relatively tolerant to flooding (Barnes et al., 1995).

To maximize carrying capacity in a grazing system, BG should be grazed close (2.5cm height) but light enough to allow rapid regrowth and biomass accumulation for best average daily gain (Barnes et al., 1995). When cut for hay, the grass should be harvested at about 40 cm tall and every 4-6 weeks thereafter for best nutritive value (Barnes et al., 1995). Near the end of the growing season, eight weeks of growth should be allowed until first killing frost in fall to enable BG to build up reserves and give more vigorous growth and better stands the following spring (Barnes et al., 1995). With these characteristics, BG can be a viable alternative forage to supplement tall fescue pastures in the Appalachian region.

Caucasian Bluestem (*Bothriochloa bladhii* (Retz) S.T. Blake)

Native to Africa, the Middle East and Southern Asia, Caucasian bluestem (CB) is slightly more winter hardy than most other warm-season grasses and is often used as ground cover for erodible lands (Barnes et al. 1995). Caucasian bluestem is relatively hard to establish. Once established, however, the stand can remain indefinitely if managed properly. The management of CB is totally different from common cool-season grasses such as tall fescue and orchardgrass. First green up does not occur until 8 weeks after green up of the cool-season grasses. Caucasian bluestem is ready for pasture by late May in the Piedmont and early June in southwest Virginia (Wolf et al, 2009). This warm-season grass is capable of growing on low pH soils (as low as 5.2), medium phosphorus and potash soil, and with less nitrogen than is required for cool-season grasses or BG (Wolfe et al., 2009). Caucasian bluestem is frequently used in grazing systems to provide summer pasture in areas where perennial cool-season grasses are low during summer months (Barnes et al. 1995).

Risk and Risk Management

Managing risk is an adaptive process that needs to be integrated into all aspects of decision-making procedures for an organization to avoid losses and to maximize opportunities (Hardaker et al., 2004). Complete elimination of loss and maximization of profit is not mentioned because such management would be nearly impossible. Instead, management decisions are based on individual attitudes towards risk and production or income variability in exchange for maximum returns. In most cases, the balance is found somewhere in the middle where a minimum requirement of production is more or less consistently obtained.

This optimum between production goals and a reasonable level of risk can be compared by using net income variability or downside target risk. Net income variability evaluates the production levels and income obtained from specific crops over a several year term (Held and Bastian, 1999). Differences in income over these years can demonstrate risks associated with management practices. An operation involving two highly correlated crops may produce high returns one year, and the next season, suffer from unfavorable environmental conditions that cause a yield below the level required to be sustainable. A less variable income represented over the same period may reveal a more stable production cycle but lower maximum returns demonstrated by mean-variance analysis (Collender, 1989). Decisions regarding production depend on individual techniques in risk management and attitudes towards risk aversion.

Downside target risk, as an alternative to income variability, considers risk in terms of the "chance or amount" of loss (Held and Bastian, 1999). Instead of looking at the variability between profit for a given time period, yearly profits are compared to a threshold level of target income. This level represents the minimum amount obtained under conditions of disaster.

Yearly profits are assessed by this threshold and evaluated by how frequently profits fall below the minimum, thus showing greater risk in income yields (Held and Bastian, 1999).

As a form of risk management in farming systems, diversification of products and enterprises is an important tool that can be adjusted to individual operation needs and goals. As a management technique, diversification of activities has been used as a form of managing the ups and downs in the income flow of a property (Zen et al., 2003). A new model is proposed with the purpose of determining the efficient frontier between expected income and income variance; that is, a way to show the trade-off between profit and risk faced by the farmer. This form of management allows the decision maker to choose the alternative that presents minimum variance for a given expected income (Zen et al., 2003).

Managing Risk in Agriculture

In managing risk, a number of different strategies attempt to extend the grazing season and buffer the impacts of environmental stress on forage-based systems. Allen et al. (1992) studied a number of fescue-based forage systems that varied in botanical makeup for stocker and finishing operations. One of the objectives of the research was to develop grazing systems for stocker cattle from the months of October to April and compare these systems with dry-lot cattle fed forages grown with varied nitrogen sources. Allen et al. (1992) concluded that nitrogen-fertilized, stockpiled tall fescue minimizes the need for stored forage from November to April. However, there must also be alternative forage available during warmer months to reduce the need for supplemental feeding and ease the risk of low production yield. The environment in which a producer (or any business) operates is influenced directly and indirectly by environmental and market forces that cannot be controlled and as a result, risk is a function of the vagaries of the natural and market environments. (Hardaker et al. 2004)

Risk assessment is a formal attempt to identify and quantify risk factors and generate probabilities of success or failure of particular decisions (Vose, 2008). Risk models are built upon distributions that describe the probability of a given outcome. Monte Carlo simulations sample probability distributions randomly within a model to produce a large number of scenarios (iterations or trials). The distribution of the outcomes is true to the distribution of the sampled data (Vose, 2008). Risk analysis is routinely used in decision making to maximize incidence of successful outcomes in many business enterprises (Palisade Corp. Inc., personal communication, 2008). Although risk analysis is employed successfully among many disciplines, its use in agriculture is limited. Lansigan et al. (1997) employed risk analysis to formally relate the effects of weather and management practices on rice production. Their study demonstrated through an analysis of the standard deviation of rice yield that soil type had a major effect on risk. Specifically, the variation in rice yield during periods of drought were 8 times less likely in heavy clay soil types than sandy soils because of greater holding capacity and water availability.

Many forage-based beef production operations still rely on some supplementation during the growing season when forage production limits animal performance. The least risky and most profitable approach to intensive forage-based beef production is to plan for relatively poor weather conditions and low forage production (Pope and Shumway, 1984). In the Appalachian region, where cool-season species are the main source of forage for livestock, a period of erratic and low forage production is expected in summer. In an effort to minimize seasonal forage production variability and as a result minimize risk, alternative forages can be used to buffer the low productivity of commonly used cool-season based forage systems.

Risk Evaluation

Most people have an aversion to risk and seek to optimize the mean value of the objective function or goal such as maximum yield or profit (Anderson, 2000). In a recent study involving risk analysis, the buffer capacity of triticale was evaluated as an alternative in forage-based livestock production systems (Clapham et al., 2008). Using resampling and bootstrap curves, yield probability functions were developed to assess the ability of spring, summer and fall-planted triticale to complement perennial pasture in forage production systems. In several cases, forage availability of the mixed pasture decreased in peak summer months but was ‘buffered’ by higher triticale forage yields where lower variability and less risks were shown (Clapham et al., 2008). Clapham et al. (2008) define a buffered forage system as a term used to describe a combination of a base of mixed perennial pasture and complementary available forage paddocks (one crop or mixed) that function together to reduce variability in forage production due to seasonal dynamics, extreme environmental conditions, and forage distribution patterns, and that meet the nutritional needs of grazing livestock.

In the study conducted by Clapham et al. (2008), a technique called bootstrapping was used to model yields to fully populate distribution curves for each harvest month and treatment combination. Clapham et al. (2008) confirms the explanation by Davison and Hinkley (1997) of the non-parametric bootstrap procedure as a process of resampling with replacement from an existing set of experimental observations. Resampling with replacement is the method of randomly selecting a value obtained from field observation, recording the number and replacing it to the dataset for equal probability of being chosen again. Using @Risk software (version 4.5; Palisade Corp., Newfield, NY) as an add-in with Microsoft Excel (Microsoft Corp., Redmond, WA), the bootstrap procedure used the results from the 5000 resampled simulations to define the overall mean, standard deviation, and shape of the data distribution (Clapham et al., 2008). Data obtained from this method showed that overall mean values of the simulated populations were virtually identical to the mean values of the actual data sets (Clapham et al., 2008). After extensive analysis, the results of this study suggested a high probability that triticale yield could exceed mixed pasture yields at specific times during the year and that triticale may be useful in buffering mixed pasture production in the Appalachian region (Clapham et al., 2008). It was also concluded that, in terms of risk management, producers should evaluate forage production in relation to expected yield variation, and not just on mean production values. Once risk is estimated, land and resources can be allocated such that a producer's objective function(s) are optimized while risk is minimized. This same analysis can be applied to forage yields and quality, and provide estimates of sensitivity for system components (Clapham et al., 2008).

Pasture Beef Production

Beef cattle production in the South consists primarily of commercial and purebred cow-calf operations (Ball et al., 2007). The Appalachian region has mostly small family farms, on which calves are raised on pasture. Because the cow/calf enterprise requires extensive amounts of low to medium energy level feed to maintain the cows, most operations are forage based (McKinnon and Snodgrass, 2009). On a global scale, most beef production enterprise is based o grasslands and rangelands; however, beef in the US is primarily produced from dry lot cattle receiving grain-based diets (Martin and Rogers, 2004). Recently, increased grain costs and decreased cattle prices are renewing interest in finishing cattle on forage diets (Martin and Rogers, 2004). In addition, an emerging interest in sustainable beef production is driving the demand for grass-finished beef with focus on the long-term health of the environment while maintaining the economic viability of the farm (Martin and Rogers, 2004). Production challenges such as forage supply, quality and availability emerge when considering grass-fed beef production (Martin and Rogers, 2004). Seasonal variation in rainfall and temperature, forage availability and management, and the type of forage used are variables that affect the system in general (Martin and Rogers, 2004). However, when proper forage management is used to ensure adequate supply of high quality forage, beef of acceptable quality can be produced on only grass (Martin and Rogers, 2004).

Animal Nutritional Requirements

To meet the primary needs of an efficient cow-calf production system, it is necessary to produce forage in pastures and hay fields at low cost and of sufficient quality to meet the needs of the animals with little supplemental feeding (Ball et al., 2007). Dry, mature cows can be maintained on relatively low quality forage having 7 to 8 percent CP and 50 percent digestible dry matter while lactating cows require a diet containing about 10 to 12 percent CP and 60 percent digestibility (Ball et al., 2007). Although it is a common practice to provide protein supplement with hay feeding, such supplementation is not needed if the hay was harvested at early maturity or if it contains legumes (Ball et al., 2007). It is important to determine seasonal distribution of pastures on a farm and adjust calving to match cow and calf needs to forage quality (Ball et al., 2007).

Cattle performance and carrying capacity are related to and affected by forage production and quality (Zobell et al., 1999). Growing beef cattle will consume approximately 2.5 percent of their body weight each day depending on forage quality and palatability (Zobell et al., 1999). Cow/calf herds operate at 2 to 2 1/2 acres of pasture per cow/calf unit with an additional 1/2 to 3/4 of an acre for hay production (McKinnon and Snodgrass, 2009). The summer decline in forage availability and the nutritive value of cool-season pastures coincide with increased nutritional requirements of spring-calving cow-calf pairs (NRC, 1996). At this time, calves are more dependent on the available forage to meet their requirements as cows start to decline in milk production (Scaglia et al., 2008). After evaluating several different forage systems incorporating cool-season grasses and legumes in the Appalachian region, Scaglia et al. (2008) did not see a major effect on cow productivity in forage-based cow-calf production systems. However, it was suggested that an improvement in nutritive value and quantity of the forage base available for calves will increase calf gains, and hence increase the total kilograms of beef produced at weaning (Scaglia et al., 2008). Successful management of pastures must balance animal feed requirements with seasonal and annual fluctuations in pasture production (Sheath et al., 1987).

References

Alderson, J. and W. C. Sharp, USDA. 1995. Grass varieties in the United States. CRC Press, Inc. Boca Raton, FL.

Anderson, J.R. 2000. Response and risk in rural ecosystems: From models and plots to defined universes. Agric. Ecosyst. Environ. 82:261–271.

Allen, V. G., J. P. Fontenot and D. R. Notter. 1992. Forage systems for beef production from conception to slaughter. II. Stocker systems. Journal of Animal Science 70: 588-596.

Ball, D. M., C. S. Hoveland and G. Lacefield. 2007. Southern forages (4th edition). International Plant Nutrition Institute, Norcross, Georgia.

Ball, D. M., C. S. Hoveland and G. Lacefield. 2002. Southern forages (3rd edition). Potash and Phosphate Institute, Foundation for Agronomic Research, Norcross, Georgia.

Ball, D.M., G.D. Lacefield, and C.S. Hoveland. 1987. The fescue endophyte story. Special Publication. Salem, Oregon: Oregon Tall Fescue Commission.

Barnes, R. F., C. J. Nelson, M. Collins, and K. J. More. 2003. Forages volume 1: An introduction to grassland agriculture (6th Edition). Iowa State University Press, IA.

Barnes, R. F., D.A. Miller and C.J. Nelson. 1995. Forages volume 1: An introduction to grassland agriculture (5th Edition). Iowa State University Press. Ames, Iowa.

Beal, W.J. 1896. Grasses of North America (Volume II). Henry Holt and Company, New York.

Burns, J.C., J.G. McIvor, L. Villalobos M., R.R. Vera, and D.I. Bransby. 2004. Grazing systems for C_4 grasslands: A global perspective. P. 309-354. In L.E. Moser et al. (ed.) Warm-season (C_4) grasses. Agron. Mongr. 45. ASA, CSSA, and SSSA, Madison, WI.

Clapham, W. M., J.M. Fedders, A.O. Abaye, and E.B. Rayburn. 2008. Forage pasture production, risk analysis, and the buffering capacity of triticale. Agron. J. 100:128-135.

Collender, R.N. 1989. Estimation risk in farm planning under uncertainty. American J. of Agri. Econ., Vol. 71, No. 4: 996-1002.

Davison, A.C., and D.V. Hinkley. 1997. Bootstrap methods and their applications. Cambridge Univ. Press, New York.

Gressel, J. 2008. Genetic glass ceilings: Transgenics for crop biodiversity. Johns Hopkins University Press. Baltimore, MD.

Hardaker, J. B., R. B. M. Huirne, J.R. Anderson, and G. Lien. 2004. Coping with risk in agriculture. CABI Publ., Cambridge, MA.

Held, L., and C. Bastian. 1999. Choosing the right enterprise mix to reduce your risk: a case example in Wyoming's big horn basin. Article #2.5, Risk and resilience in agriculture, risk management handbook. Joint Publication of Coop. Ext. Serv., of Colo State Univ., Mont. State Univ., and the Univ of Wyo., pp.1-11.

Hill N. S., D. P. Belesky, and W. C. Stringer. 1991. Competitiveness of tall fescue as influenced by *Acremonium coenophialum.* Crop Sci. 31:185-190.

Ketema, S. 1997. Tef *Eragrostis tef* (Zucc.) Trotter. Promoting the conservation and use of underutilized and neglected crops. Institute of Plant Genetics and Crop Plant Research, Gatersleben. International Plant Genetic Resources Institute, Rome, Italy.

Lansigan, F. P., S. Pandey, and B.A.M. Bouman. 1997. "Combining crop modeling with economic risk-analysis for the evaluation of crop management strategies." Field Crops Res. 51: 133-145.

Martin, J.M., and R.W. Rogers. 2004. Review: Forage-produced beef: Challenges and potential. Mississippi State University. The Professional Animal Scientist 20:205-210.

McKinnon, B.R. and H.S. Snodgrass. 2009. Getting started in the cattle business in Virginia. Virginia Cooperative Extension, Virginia Polytechnic Institute and State University, Blacksburg, VA. Publication 400-790.

Moser, L.E., B.L. Burson and L.E. Sollenberger. 2004. Warm-season (C4) grasses. ASA, CSSA, and SSSA, Inc. Madison, WI.

Moser, L.E., D. R. Buxton and M.D.Casler. 1996. Cool-season forage grasses. Agronomy: A series of monographs #34". ASA, CSSA and SSSA, Inc. Madison, WI.

Nihsen, M.E., E.L. Piper, C.P. West, R.J. Crawford, Jr., T.M. Denard, Z.B. Johnson, C.A. Roberts, D.A. Spiers, and C.F. Rosenkrans, Jr. 2004. Growth rate and physiology of steers grazing tall fescue inoculated with novel endophytes. J. Anim. Sci. 82:878-883.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7th ed. Natl. Acad. Press, Washington, DC.

Pope, C.A., and C.R. Shumway. 1984. Management of intensive forage-beef production under yield uncertainty. Southern Journal of Agri. Econ. Dec: 37-44

Scaglia, G., W.S. Swecker Jr., J.P. Fontenot, D. Fiske, J.H. Fike, A.O. Abaye, P.R. Peterson, W. Clapham, and J.B. Hall. 2008. Forage systems for cow-calf production in the Appalachian region. J. Anim. Sci. 86:2032-2042.

Sheath, G.W., R.J.M. Hay and K.H. Giles. 1987. Managing pastures for grazing animals. Chapter 5 *in* Livestock feeding on pasture. New Zealand Society of Animal Production, Hamilton, NZ. p.145.

Teutsch, C.D., J.H. Fike and W. M.Tilson. 2005. Yield, digestibility, and nutritive value of crabgrass as impacted by nitrogen fertilization rate and source. Agron. J. 97:1640-46.

Twidwell, E., A. Boe and D. Casper. 2002. Teff: A new annual forage grass for South Dakota. South Dakota State University.

Vose, D. 2008. Risk analysis: A quantitative guide. John Wiley & Sons Ltd, Chichester, West Sussex, UK.

Wolf, D. D., R.S. White, and S.E. Tinsley. 2009. Establishing and managing Caucasian bluestem. VCE pub. 418-01.

Zen, S.D., F.C. Peres, G. Sant'Ana de Camargo Barros. 2003. Diversification as a form of risk management in agriculture. International Farm Management Congress.

Zobell, D.R., C. Burrell and C. Bagley. 1999. Raising beef cattle on a few acres. Utah State University Extension, Logan, Utah. September 1999: AG-505.

CHAPTER III

EVALUATION OF ALTERNATIVE FORAGE SPECIES TO REDUCE RISK FOR COW-CALF PRODUCTION SYSTEMS

Abstract

Tall fescue is the main cool-season forage in cow-calf production systems across the Appalachian region. However, cool-season species suffer a slump in biomass production during the hot, dry summer months. An experiment was initiated in summer 2008 at three research stations in Virginia at Kentland Farm in Blacksburg, the Northern Piedmont AREC in Orange and Shenandoah AREC in Steeles Tavern. Seven forage species were established as small plots (3m x 9m) arranged in a randomized complete block design with 4 replications at each location. The treatments included endophyte-infected tall fescue (KY31 E+) (*Festuca arundinacea* Schreb.), endophyte-free tall fescue (KY31 E-), novel-endophyte tall fescue (MaxQ), Caucasian bluestem (CB) (*Bothriochloa bladhii* (Retz) S.T. Blake), Teff (var. Tiffany) (*Eragrostis tef* Zucc. Trotter), Bermudagrass (BG; var. Wrangler) *(Cynodon dactylon* (L.)(Pers.)), and Crabgrass (var. Red River) *(Digitaria* spp.*)* in combination with endophyte-infected tall fescue. Samples were taken throughout the production seasons of 2009 and 2010 (April 15-Nov 1) at the late-boot stage for forage biomass and quality. Forage production and quality values followed the typical seasonal distribution for cool- and warm-season species. Specifically, all cool-season grasses produced adequate amounts of biomass in spring but declined in production for the remainder of the season. Similarly, high levels of crude protein (CP) were observed in spring and early fall from cool-season grasses. On the contrary, biomass yield of warm-season grasses was highest in mid-summer. While the CP values of cool-season grasses ranged from 8-9% mid-summer, warm-season grasses held a CP value between 9 and 15%. Despite these values, the yield

potential of perennial warm-season grasses was substantially reduced due to problems associated with establishment. Depending on location, unseasonably wet or dry spring contributed to poor establishment and sparse stand. However, regardless of variability in biomass yields, warm-season grasses; both annual and perennial, produced biomass yields and nutritional values adequate to fill the summer slump from cool-season forages.

Introduction

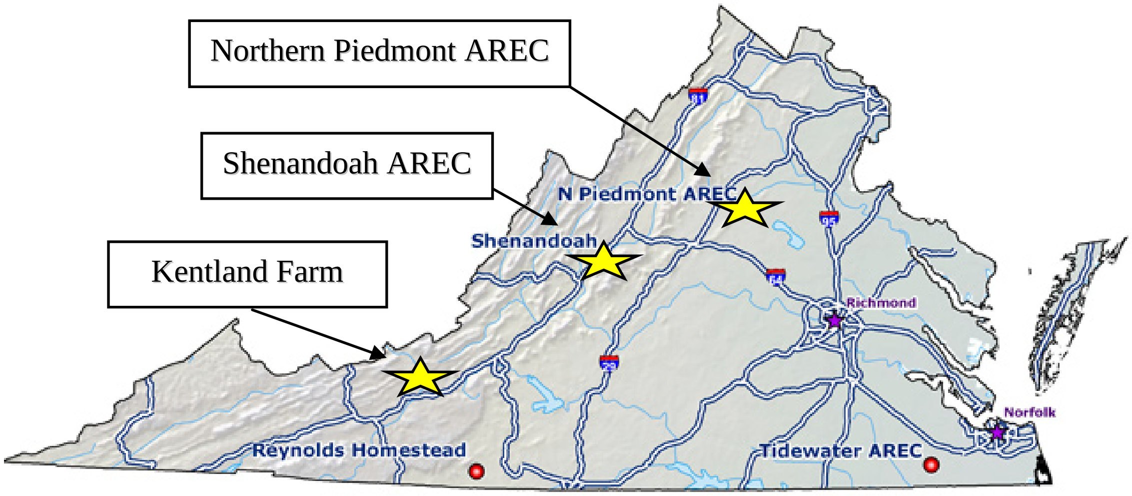
In the Appalachian region of the Southeastern United States, cool-season perennial forages can potentially be integrated with warm-season species in order to extend the growing season. Tall fescue (*Festuca arundinacea* Schreb.) is the main cool-season forage across the Appalachian region. It is adapted to the "transition zone", defined as the area between the successful zone of cultivation for cool and warm-season grasses. Tall fescue is the most important forage species worldwide of the *Festuca* genus and the principal cool-season perennial grass in the humid areas of the USA (Moser et al., 1996). Classified as a cool-season perennial grass, peak production of tall fescue occurs in the spring months with a secondary peak of vegetative growth in early fall (Barnes et al., 2003). If stockpiled starting late summer, the accumulated growth is often used as a feed source throughout the winter in the southeastern and mid-Atlantic United States. Tall fescue is especially advantageous over other cool-season grasses because of its persistence under low management input of part-time operations and those favoring low economic risk over high return (Moser et al., 1996). Unfortunately, as with most cool-season plants, tall fescue experiences a "summer slump" or lack of production in July and August when temperatures rise above the optimum 20-25^{o}C and is only able to withstand relatively short periods of drought (Moser et al., 1996). When considering a year-round grazing system, tall fescue must be supplemented with alternative forages that have the ability to offer greater yield in mid-summer months, thus reducing the risk of shortages in forage. In any grazing system, optimizing forage productivity is essential to reduce pasture seasonality and ensure available forage to meet the nutritional needs of grazing livestock. In many circumstances, alternative forages are used to complement or replace existing species in an effort to reduce the risk of yields falling below minimum requirements of the grazers (Griffith, 1978).

This study examined seven different cool- and warm-season forage species. Tall fescue varieties were compared with warm-season annuals and perennials to evaluate performance based on production yields and nutrient content during the summer slump. As a burgeoning field in agriculture, year-round grazing systems are becoming increasingly important in a growing world economy. With proper techniques using alternative forages and risk management strategies, producers will have confidence that they can reach optimal production and satisfy livestock needs in a forage-based operation.

Methods and Materials

Small plot experiments were conducted in 2009 and 2010 at three Virginia geographical locations: Kentland, Northern Piedmont AREC and Shenandoah AREC (Fig 3- 1). A randomized complete block design was utilized with seven forage species as the main plot. The seven forage treatments included endophyte-infected tall fescue (KY31 E+), endophyte free tall fescue (KY31 E-), novel endophyte tall fescue (MaxQ), Crabgrass (var. Red River) in combination with endophyte-infected tall fescue (KY31 E+), Teff (var. Tiffany), Bermudagrass (BG; var. Wrangler), and Caucasian bluestem (CB). Each plot measured 3 x 9 meters with 3 meter alleyways between treatments and 4.5 meters between replications.

Fig. 3-1. Experimental locations at Kentland, Northern Piedmont AREC and Shenandoah AREC in 2009 and 2010.



Perennial forage species were established at all three locations in the summer of 2008. First attempts for seeding were made in mid-June 2008 but were unsuccessful. The species were established after a second attempt in the Shenandoah and Kentland and on a third attempt in the Northern Piedmont (Table 3-1). In 2009, Teff was planted with a no-till drill and established at the first attempt. In 2010, however, at all locations, multiple attempts were made before Teff established successfully. The establishment failure might have been attributed to the fact that seeds were placed into a soft seedbed which might have caused the seed to be placed too deep, resulting in poor emergence and meager stands. Lack of rainfall at the beginning of the season in 2010 also contributed to poor conditions for establishment. To avoid a stand establishment failure at the second attempt, the seed was broadcast and lightly packed to ensure seed-soil contact. This was done at both the Shenandoah and Northern Piedmont AREC locations. In 2009 and 2010, as one of the treatments, crabgrass was inter-seeded into one of the tall fescue (KY31 E+) treatments late spring. Immediately after first harvest of the cool-season forages, when forage regrowth was minimal, crabgrass was seeded using a no-till drill over the existing stand of tall fescue. Table 3-2 shows the seeding rates used to establish perennial stands in 2008 and annual species in 2009 and 2010.

Table 3-1. Dates of species establishment in Kentland, Northern Piedmont AREC (NPAREC) and Shenandoah AREC. ǂ Indicates failed establishment.

	Kentland	**NPAREC**	**Shenandoah AREC**
Perennials	July17, 2008	August 15, 2008	July 8, 2008
Annuals	June 2, 2010	June, 4, 2009	June, 2, 2010
	June 1, 2010 ǂ June 10, 2010	June 2, 2010 ǂ June 28, 2010	June 1, 2010 ǂ June 28, 2010

Table 3-2. Seeding rate (kg/ha) of grass species used on a pure-live seed (PLS) basis.

Species	**Seeding Rate (kg/ha)**
KY31 Tall Fescue (E+)	35
KY31 Tall Fescue (E-)	33
Max Q	34
Caucasian bluestem (CB)	11
Teff (Tiffany)	6.7
Bermudagrass (Wrangler) (BG)	2.2
Crabgrass (Red River)	4.6

Early spring, before first harvest, all plots were treated with 2,4-D to control broad leaf weeds. In 2009 and 2010, early to late spring (Table 3-3), nitrogen (N) in the form of urea was applied to all cool season species. The N rate varied by species recommendations (Table 3-3). The warm-season grasses were fertilized early June, at the time of establishment. BG was fertilized initially and following each harvest while CB was fertilized after every other harvest based on best management practices of these species.

Table 3-3. Nitrogen application dates by species and location.

	Kentland	NPAREC	Shenandoah AREC
KY31 E+	June 4, 2009 March 18, 2010	June 4, 2009 March 19, 2010	June 4, 2009 March 19, 2010
KY31 E-	June 4, 2009 March 18, 2010	June 4, 2009 March 19, 2010	June 4, 2009 March 19, 2010
MaxQ	June 4, 2009 March 18, 2010	June 4, 2009 March 19, 2010	June 4, 2009 March 19, 2010
Caucasian Bluestem (CB)	June 4, 2009 August, 11, 2009 June 1, 2010 August 3, 2010	June 4, 2009 August 10, 2009 June 2, 2010 August 12, 2010	June 4, 2009 August 10, 2009 June 2, 2010 August 12, 2010
Teff	June 4, 2009 June 1, 2010	June 4, 2009 June 2, 2010	June 4, 2009 June 2, 2010
Bermudagrass (BG)	June 4, 2009 June 25, 2009 August, 11, 2009 June 1, 2010 June 29, 2010 August 3, 2010	June 4, 2009 July 8, 2009 August 10, 2009 June 2, 2010 June 28, 2010 August 12, 2010	June 4, 2009 June 26, 2009 August 10, 2009 June 2, 2010 June 28, 2010 August 12, 2010
Crabgrass/KY31 E+	June 4, 2009 March 18, 2010	June 4, 2009 March 19, 2010	June 4, 2009 March 19, 2010

* Nitrogen applied at 67.2kg/ha

Forage Assessment

During the growing season, plots were harvested starting April 15 through October. The decision regarding harvest dates (Table 3-4, 3-5) was based on the growth stages of individual species (treatment). Generally, harvest was done when the grasses reached the late boot stage. In most cases, cool-season treatments (E+, E-, MaxQ, Crabgrass/E+) were harvested twice in late spring and early summer and once or twice in late summer and fall, depending on weather conditions. Warm-season perennial grasses were harvested on average three times.

Table 3-4. Harvest dates by treatment in Kentland, Northern Piedmont AREC (NPAREC), and Shenandoah AREC in 2009.

	Kentland	**NPAREC**	**Shenandoah AREC**
Cool-Season Treatments: E+; E- MaxQ; Crabgrass/E+	May 30 July 9 September 23 November 1	May 29 July 8 September 8 October 27	June 1 July 8 September 3 October 27
Warm-Season Perennials: Caucasian Bluestem; Bermudagrass (BG)	June 25 August 11 September 23	July 8 August 10 September 22	June 26 August 10 September 22
Warm-Season Annuals: Teff	July 14 August 11 September 23	July 15 August 10 September 8	July 15 August 10 September 8 October 6

Table 3-5. Harvest dates by treatment in Kentland, Northern Piedmont AREC (NPAREC), and Shenandoah AREC in 2010. ǂ Indicates unsuccessful establishment.

	Kentland	**NPAREC**	**Shenandoah AREC**
Cool-Season Treatments: E+; E- MaxQ; Crabgrass/E+	May 12 June 29 October 19	May 10 June 28 October 19	May 10 June 28 October 18
Warm-Season Perennials: Caucasian Bluestem; Bermudagrass (BG)	June 29 August 3 September 6	June 28 August 12	June 28 August 12 September 9
Warm-Season Annuals: Teff	August 3 September 6	n/a ǂ	August 12 September 9 October 18

Prior to harvesting, all forage treatments were visually evaluated for botanical composition using the double DAFOR scale (Brodie, 1985 and Abaye et al., 1997). Species establishment was determined by the percentage of desired species within the treatment plots.

Using a flail-type mechanical forage harvester, each treatment plot was harvested by clipping a swath (3m x 0.8m) through the center of the plot. Forage was harvested at a stubble height of 10 cm. A subsample of fresh forage was collected from each plot for dry matter and nutritive value analysis. Samples were dried in a forced air-oven 60º C for at least 48 hours and ground to pass through a 1-mm screen using a Wiley sample mill (Thomas Scientific, Swedesboro, NJ).

To compensate for differences in harvest dates and number of growing days, treatments are compared on a kg/ha/day basis. Harvest seasons in 2009 and 2010 were broken into five sampling periods described as late May, June/July, August, September and October. Seasonal distribution of forage growth and quality was observed over the sampling periods.

Neutral detergent fiber (NDF) (Van Soest and Wine, 1967), acid detergent fiber (ADF) (Van Soest, 1963; Goering and Van Soest, 1970), in vitro true digestibility (IVTD) and crude protein (CP) were estimated using near infrared spectroscopy (NIRS) for each subsample. WINISI II software was used to select a calibration data set for wet chemistry determination (Infrasoft International, Port Matilda, PA). One equation was used for all forage species. Total digestible nutrient (TDN) values were determined with the following calculation for grass hay samples: TDN=100.32-1.1180*ADF. Data were analyzed for all single effects and interactions using PROC GLM (v. 9.2, SAS Institute, Gary, NC). Effect of treatment, location, harvest, and year were tested. All two, three and four way interactions between variables were also tested. Significance was tested at the 5% level unless noted different.

Rainfall and temperature data were collected at each location to evaluate the influence on forage growth and nutritive value throughout the season and between years. The 2009 and 2010 rainfall data were compared against a 55 year average to determine the typical weather patterns expected as compared to historical averages.

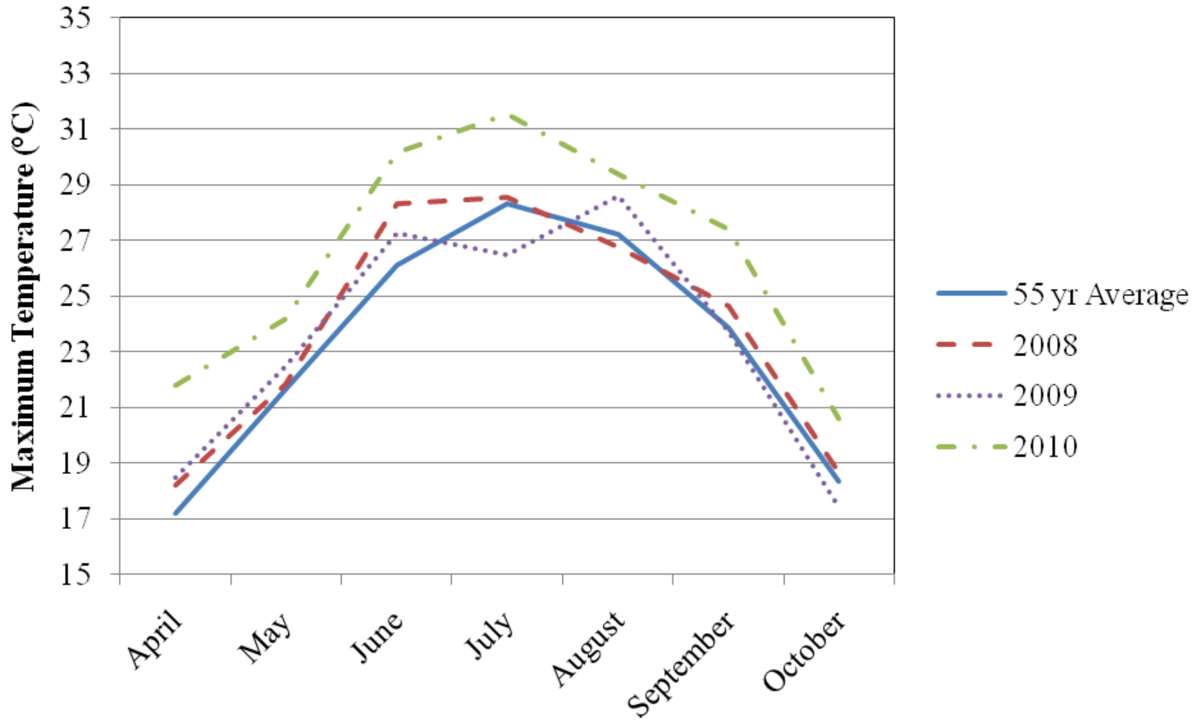
Results and Discussion

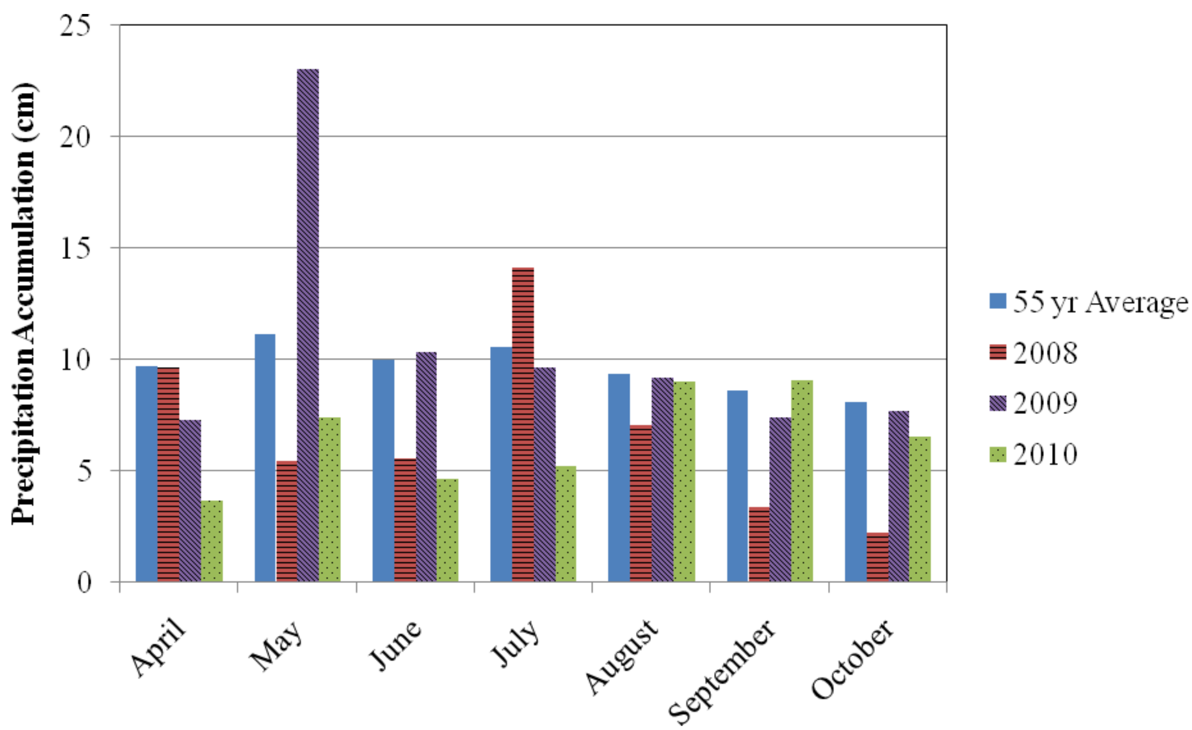
Environmental Conditions

Kentland

During the establishment year 2008, monthly temperatures were consistent with the historical average. However, precipitation was below average throughout the season with the exception of April and July. Monthly maximum temperatures in 2009 were also comparable to the 55 year average but exceeded the historical average in 2010. Early spring precipitation in 2009 exceeded the 55 year average for May and followed a pattern similar or slightly below average for the remainder of the season. Monthly rainfall during the 2010 growing season was below average for April, May, June and July (Fig. 3-2).

Fig. 3-2. Temperature and accumulated precipitation by month in 2008, 2009, 2010 and the 55 year average for Kentland.





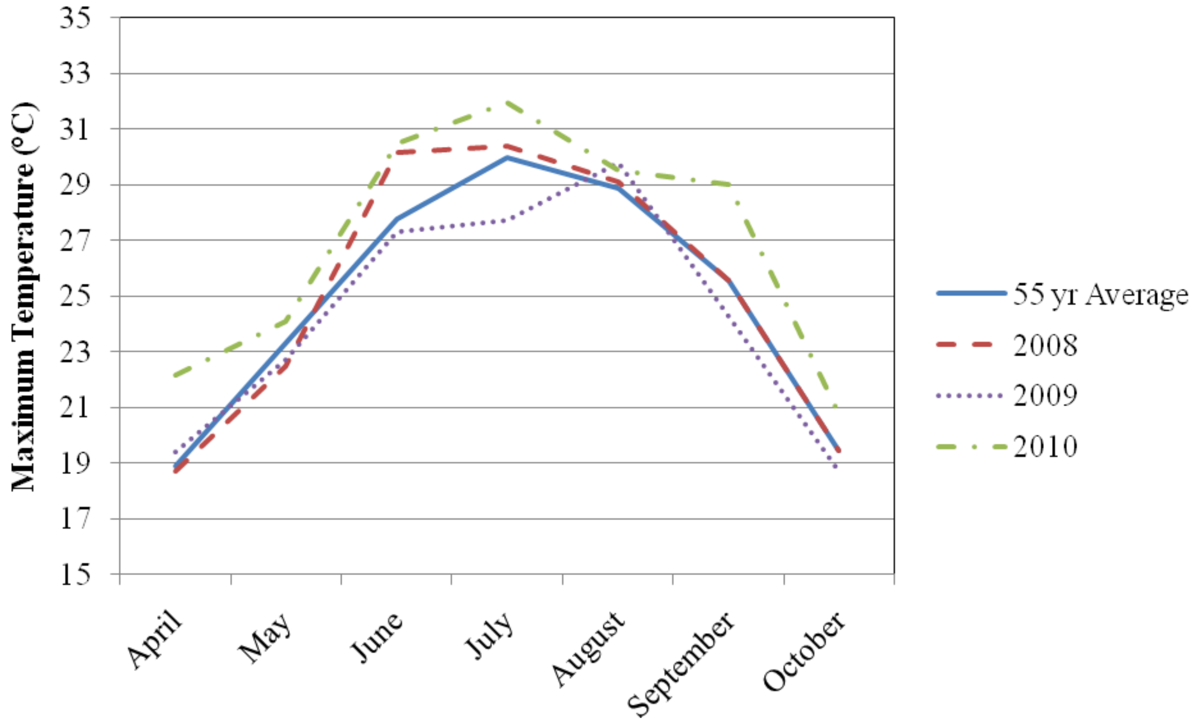
Northern Piedmont

In 2008, maximum temperatures were similar to the 55yr average for all months except June. Precipitation exceeded the historical average for most months except July and October of 2008. Monthly maximum temperatures in 2009 were comparable to the 55 year average but higher than historical observations in 2010. Early spring precipitation in 2009 exceeded the 55 year average for May and June in the Northern Piedmont after which, values were similar or slightly below average for the remainder of the growing season. Monthly rainfall in the 2010 growing season was below average for April through August, but was close to average for September and October (Fig 3-3).

Shenandoah

In 2008, both temperature and precipitation were similar to or higher than historical averages in all months except July and October. In 2009, monthly maximum temperature was slightly below average in the Shenandoah but was similar to that of 2010. Precipitation in May 2009 exceeded the 55 year average but settled to slightly below average values for the continuing months. In 2010, monthly accumulated rainfall was slightly below the 55yr average through July but exceeded averages for the remainder of the season (Fig 3-4).

Fig. 3-3. Temperature and accumulated precipitation by month in 2008, 2009, 2010 and the 55 year average for Northern Piedmont AREC.



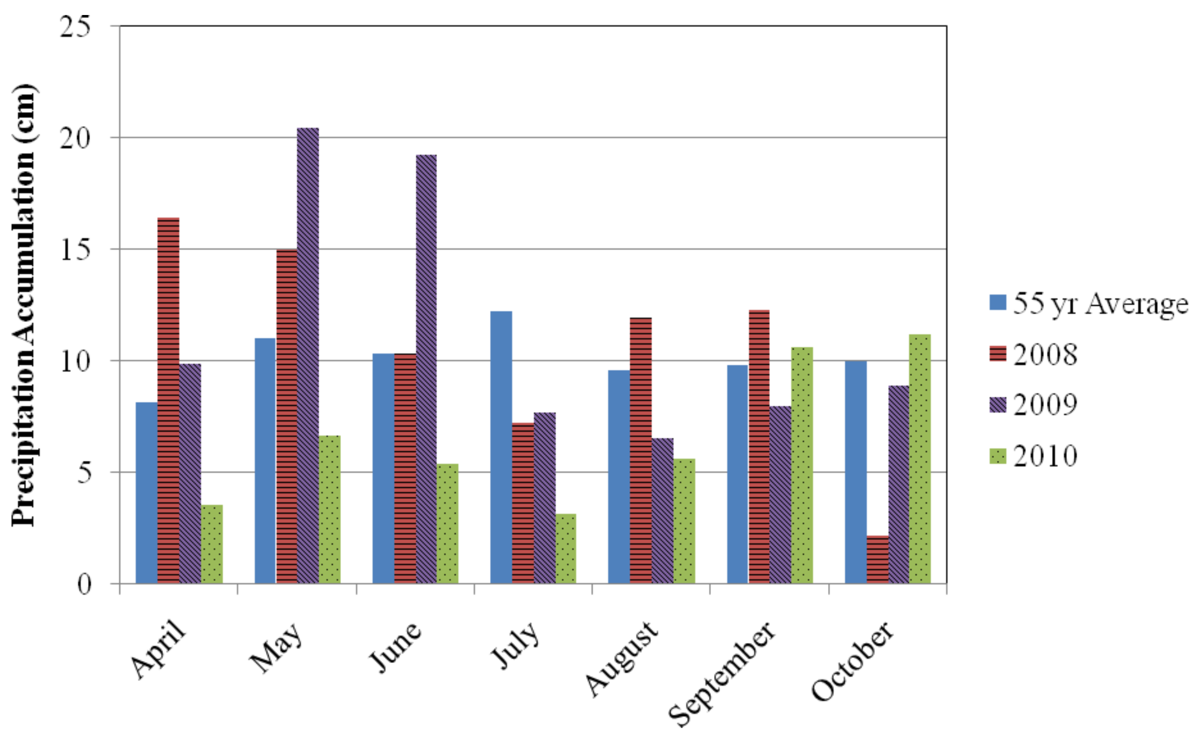
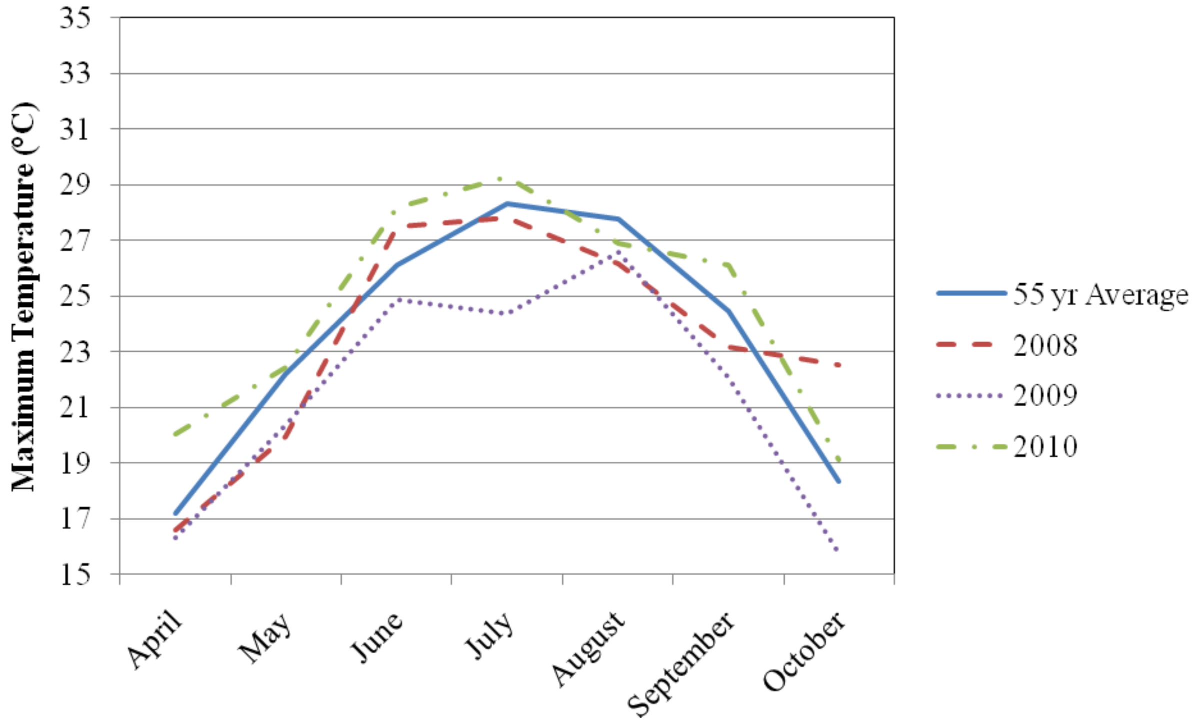
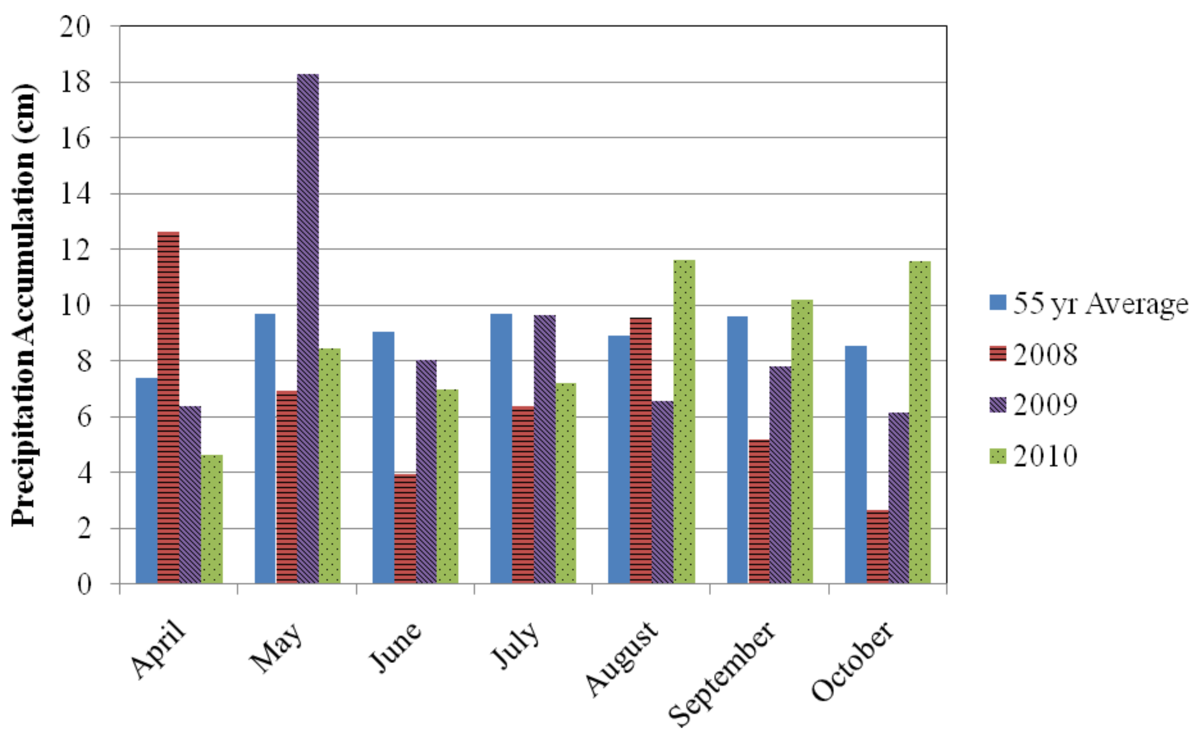


Fig. 3-4. Temperature and accumulated precipitation by month in 2008, 2009, 2010 and the 55 year average for Shenandoah AREC





Forage Establishment

Establishment of forage species varied across treatments and locations. In all locations, fescue types were successfully established in 2008 and maintained similar botanical composition of 80-100 percent, throughout the experimental years (Appendix I). The establishment of BG and CB however, varied across locations and years (Appendix I). This was contrary to Roberts (1996) who stated that CB is easier to establish than native warm-season grasses and will make grazeable pasture in a shorter period of time. Depending on location, the difficulty in establishing CB for this study can be attributed to lack of or too much moisture during establishment in combination with poor seed bed preparation and seeding depth. According to Wolf et al. (2009), a shallow seeding depth on firm, dry soil is the ideal establishment condition for CB. When established in August of 2008, the Northern Piedmont and Shenandoah reported above average rainfall, lending to wet soils (Fig 3-3 and Fig 3-4). This is in contrast to August 2008 in Kentland where the amount of rainfall received was lower than average and thus the condition might have been more suitable for the establishment of CB. Teff on the other hand, as an annual forage was established each year. The establishment of Teff, like CB, was highly dependent on moisture status of the soil at planting, or immediately after planting, and seed bed preparation. The inter-seeded crabgrass did not establish; however, the presence of volunteer crabgrass was evident. Failure in establishment of crabgrass could be due to issues in seed-soil contact. Proper technique for establishing a stand of crabgrass as a forage crop is to use a clean, firm seedbed and cultipacked after seeding (Blount et al., 2010). However, for this study, because crabgrass was inter-seeded into an existing stand of cool-season forage, these techniques were not utilized as crabgrass is often observed as a volunteer forage in mid-summer pastures of the Appalachia. For this reason, the seventh treatment was maintained as a cool-season fescue (E+) stand.

Forage Biomass Total Yield

Total forage yield varied between treatment, year and location. Additionally, there was year by location and location by treatment interactions. Differences in total forage yield are expected as weather conditions fluctuate between years and experimental sites. Additionally, the target species biomass yield was strongly related to establishment and persistence. As previously indicated, on average, the cool-season grasses were successfully established and maintained 80-100% pure stand throughout experimental years while the establishment and stand density of the warm-season perennials were poor across locations and years. Due to location and year interactions, data is presented by location and year (Appendix II).

Kentland

There was no significant difference in total biomass between treatments and year with the exception of BG (Fig. 3-5). In terms of botanical composition, percent pure stand of BG increased from 40% in 2009 to 70% in 2010. However, regardless of this percent increase in pure stand, total biomass of BG was higher in 2009 than 2010. This can be attributed to the morphological characteristics of BG, which is low growing, thus the cutting height of 10 cm might not have removed all the observed biomass. Contrary to the suggested cutting height of 2.5 cm for BG (Barnes et al., 1995) we decided to harvest at 10 cm cutting height to avoid further loss of the sparsely established stand. However, an argument can be made that the 2.5 cm cutting height might have stimulated more tiller growth and subsequently higher yield. On the other hand, CB being a more erect grass that requires height cutting height for persistence, might not have been affected may even be benefited from the 10 cm cutting height (Fig 3-5). Wolf et al. (2009) stated the importance of cutting height on long term persistence of CB.

Fig. 3-5. Total forage biomass (kg/ha) for growing seasons 2009 and 2010 by treatment in Kentland.✦ Indicates significant difference between year (p=0.05).

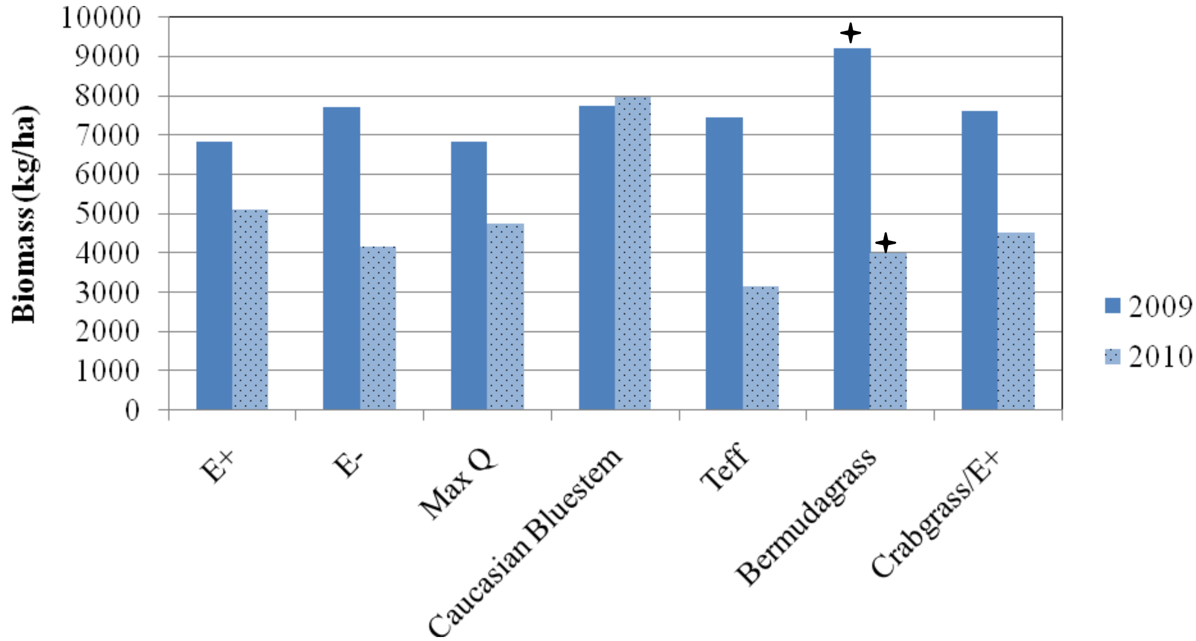
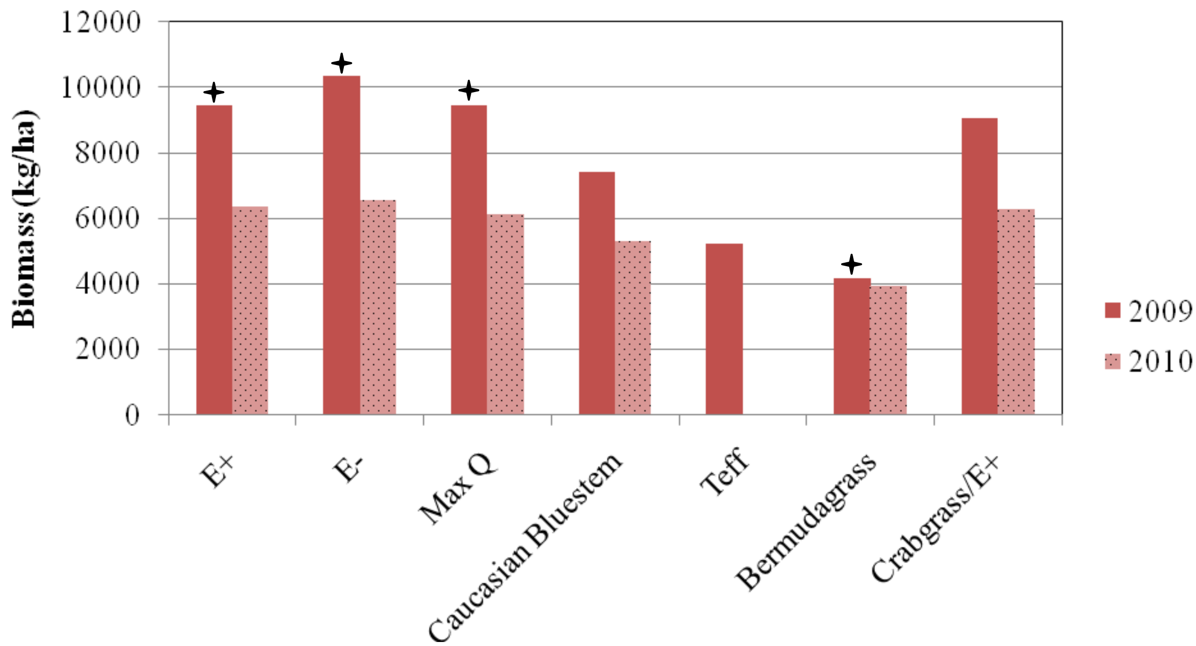


Fig. 3-6. Total forage biomass (kg/ha) for growing seasons 2009 and 2010 by treatment in Northern Piedmont AREC. ✦Indicates significant difference between treatment (p=0.05).



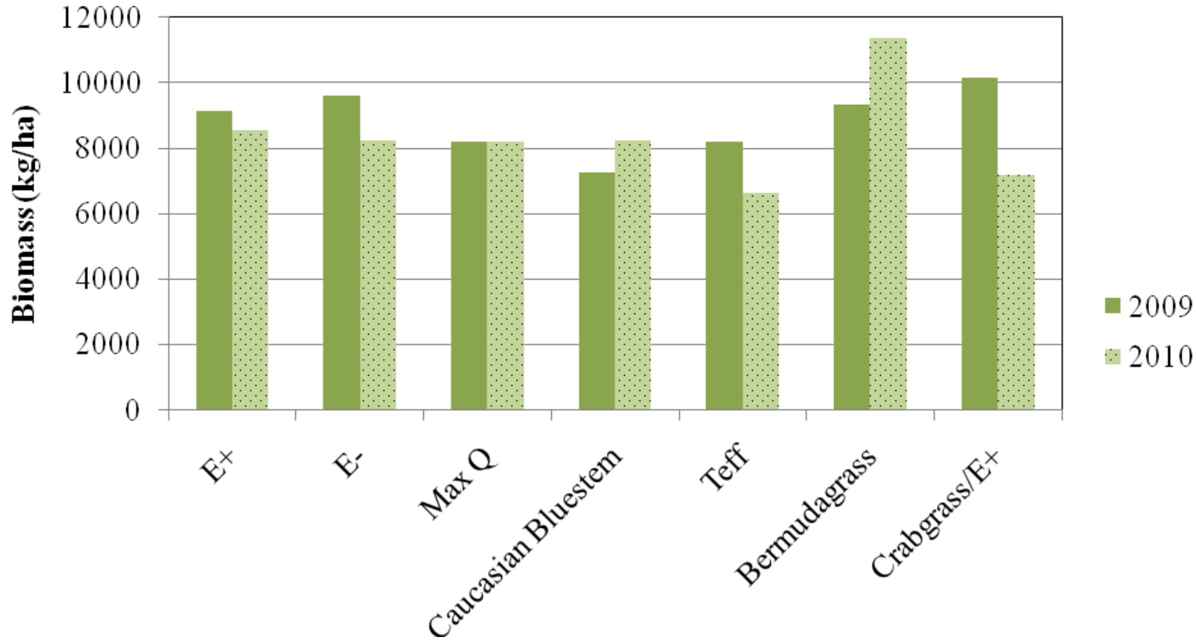
Northern Piedmont

Similar to Kentland, there was no difference in total biomass between experimental years (Fig 3-6). However, in 2009, yields from BG were significantly lower than KY31 E+, KY31 E-, and Max Q. This could be attributed to poor establishment and therefore sparse stand of the plant (Appendix I-B). Teff did not establish at Northern Piedmont AREC in 2010. In addition to lack of moisture experienced in 2010 across locations, the establishment of Teff at the Northern Piedmont location might have been hindered by pests. After the second attempt, Teff seedlings were reported to emerge, but soon after emergence quickly disappeared.

Shenandoah

Total biomass was relatively constant between treatments for both experimental years (Fig 3-7). Also, no significant differences between treatments or years were observed at this location. However, total yield of BG was higher in the Shenandoah than yields from the same species at Kentland in 2010 and at Northern Piedmont in both 2009 and 2010. In 2009 at the Shenandoah, the average percentage BG in the stand was 61% compared to 41% at Kentland and 2% at the Northern Piedmont. Even with a substantial 50% increase in BG stand at the Northern Piedmont in 2010, total yields were still lower than those measured at the Shenandoah. The less than desired establishment, persistance, and biomass yield of warm-season grasses at the Northern Piedmont can be attributed to soil type and lack of mosture during and after seeding. According to Ball et al. (2007), BG is not well adapted to poorly drained, heavy soils. In the Northern Piedmont region, soils contain a high percentage of clay, exhibiting properties of high water holding capacity but not nessarlily avalable water . This is in contrast to soil type at the Shenandoah, where soil properties resemble that of a loam, more suitable to draining water and conditions favorable for BG production.

Fig. 3-7. Total forage biomass (kg/ha) for growing seasons 2009 and 2010 by treatment in Shenandoah AREC.



Forage Yield Distributions

Differences in daily available forage were observed between years, locations, harvest months, and treatments (Appendix II). Additionally, differences in year by location, year by harvest period, year by treatment, location by treatment, location by harvest period, year by location by treatment, year by location by harvest group and location by treatment by harvest group interactions were observed.

In both 2009 and 2010, Fig. 3-11 through 3-16 (Appendix II), showed a typical forage distribution curve for cool- and warm-season grasses. However, forage distribution varied across the two experimental years. In 2009, forage biomass distribution at each harvest month of the cool-season perennials (KY31 E+, KY31 E-, MaxQ, and Crabgrass/KY31 E+) showed a typical cool-season distribution curve that is high in early spring, followed by a rapid decline in mid-summer (Blaser et al., 1986). In 2010, a much drier year, the peak spring growth in May was followed by a rapid decline in forage production for the remainder of the summer months. Although typical with bulk of forage production in mid-summer months (Ball et al., 2007), the seasonal distribution of warm-season grasses also varied across location and years attributing to climate variability across locations during the experimental years (Appendix II).

Forage Nutritive Value

Variation in crude protein (CP), vitro true digestibility (IVTD), and total digestible nutrient (TDN) were found across year, location, treatment, and harvest month. Year by treatment, year by harvest month, location by treatment, location by harvest month, treatment by harvest month and year by location by harvest month interactions were also found. Therefore, data is presented by year, month, and treatment.

Crude Protein (CP)

In general, at the Kentland location, the minimum requirement of CP was met by all treatments with the exception of August in 2009 (7.2%). Most of the CP values ranged from 8.2 to 15 percent. The 2009 CP values of E+, E-, Max Q and Crabgrass/E+ were much higher than that of 2010 for May and June/July harvests (Fig. 3-6). The opposite result was found in October where CP values were higher in 2010 than 2009 (Fig. 3-6). This higher CP value in June/July of 2009 can be explained by timing of N application (Table 3-3). In 2010, N was applied to cool-season forages in March while in 2009, N was applied after the first harvest in May, lending to higher protein levels in the second harvest of June/July. Although lower in most cases, the same trend was found in CP values of the Northern Piedmont and Shenandoah. At the Northern Piedmont and Shenandoah locations, CP values for June/July were higher than May in 2009. Again, the higher CP value in June/July can be explained by the fact that N was applied to cool-season grasses after the first harvest in May 2009, lending to higher protein levels in the second harvest of June/July. Vona et al., (1984) stated that N fertilization will increase forage yield and crude protein up to a certain maximum for all non-legume forage species. Generally, the CP values of both cool- and warm-season grasses were adequate to provide the minimum requirements of 8% for a beef cattle enterprise.

Table 3-6. Crude protein values (%CP) by treatment and harvest month for Kentland in 2009 and 2010 experimental years.

	MAY		**JUNE/JULY**		**AUGUST**		**SEPTEMBER**		**OCTOBER**	
Trt	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
E+	12.4[α]	9.5[Ӽα]	13.7	8.9[Ӽ]	[†]	[†]	10.6	[†]	13.6	15.0[Ӽ]
E-	13.8[Ӽα]	10.6[α]	14.6[Ӽ]	8.5[Ӽж]	[†]	[†]	7.8 [Ӽ]	[†]	13.1[Ӽ]	14.1[Ӽ]
MaxQ	12.2[α]	9.9[Ӽα]	13.9	9.1[Ӽ]	[†]	[†]	9.4	[†]	13.8	14.6[Ӽ]
CB	[†]	[†]	12.7[Ӽ]	8.2[ж]	7.2[Ӽα]	12.1[αж]	10.1	9.5	[†]	[†]
Teff	[†]	[†]	14.3	[†]	11.1[α]	16.8[Ӽαж]	9.1	11.9[Ӽ]	[†]	[†]
BG	[†]	[†]	14.6	13.2[ж]	10.9	14.9	13.0	12.8	[†]	[†]
Crab/E+	11.1[α]	10.1[Ӽα]	13.6	8.7[Ӽ]	[†]	[†]	10.2	[†]	13.0	14.7[Ӽ]

[Ӽ] Indicates significant difference between harvest month (p=0.05).
[ж] Indicates significant difference between treatments (p=0.05).
[α] Indicates significant difference between experimental year (p=0.05).
[†] Data not available due to inactive growth period.

Table 3-7. Crude protein values (%CP) by treatment and harvest month for Northern Piedmont AREC in 2009 and 2010 experimental years.

	MAY		JUNE/JULY		AUGUST		SEPTEMBER		OCTOBER	
Trt	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
E+	10.5	9.1	12.6	8.7	†	†	8.9	†	9.6	11.1
E-	11.5	9.3	14.4[Ϫ]	9.2	†	†	9.8[Ϫ]	†	11.1	11.9
MaxQ	9.9	9.4	13.1	8.7	†	†	9.1	†	9.7	9.7
CB	†	†	13.1[α]	8.2[α]	12.0	9.1	†	†	†	†
Teff	†	†	13.8	†	13.1	†	11.2	†	†	†
BG	†	†	15.1	12.2	12.7	13.3	†	†	†	†
Crab/E+	9.9	8.9	12.9	8.8	†	†	8.9	†	10.7	13.2

[Ϫ] Indicates significant difference between harvest month (p=0.05).
[α] Indicates significant difference between experimental year (p=0.05).
[†] Data not available due to inactive growth period.

Table 3-8. Crude protein values (%CP) by treatment and harvest month for Shenandoah AREC in 2009 and 2010 experimental years.

	MAY		JUNE/JULY		AUGUST		SEPTEMBER		OCTOBER	
Trt	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
E+	8.7[Ϫ]	11.6	14.5[Ϫα]	8.9[α]	†	†	9.9	†	9.7[Ϫ]	9.2[ж]
E-	10.1[Ϫ]	11.2	16.3[Ϫα]	9.7[α]	†	†	10.9[Ϫ]	†	11.2[Ϫ]	8.8[ж]
MaxQ	9.4[Ϫ]	10.5	14.5[Ϫα]	8.4[α]	†	†	9.9	†	10.7	8.3[ж]
CB	†	†	17.2[Ϫα]	10.3[α]	10.9[Ϫ]	11.2	†	13.8	†	†
Teff	†	†	16.3[Ϫ]	†	14.3[Ϫα]	19.6[α]	10.6[Ϫα]	15.8[α]	11.6	16.2[ж]
BG	†	†	14.6	12.2	10.9	13.4	13.0	16.3	†	†
Crab/E+	10.0[Ϫ]	10.9	14.8[Ϫα]	8.9[α]	†	†	9.5[Ϫ]	†	10.0[Ϫ]	9.5[ж]

[Ϫ] Indicates significant difference between harvest month (p=0.05).
[ж] Indicates significant difference between treatments (p=0.05).
[α] Indicates significant difference between experimental year (p=0.05).
[†] Data not available due to inactive growth period.

In Vitro True Digestibility (IVTD)

At the Shenandoah, IVTD values in May of 2009 were lower than the Northern Piedmont and Kentland while the IVTD values in October of 2009 at Kentland exceeded the other locations (Table 3-9, 3-10, and 3-11). Lower IVTD observed in 2009 at the Northern Piedmont and Shenandoah can be attributed to plant maturity. In May of 2009, harvest was delayed due to excessive rainfall. Ball et al. (2007) states that plant maturity has the greatest effect on nutritive value. In general, IVTD values of warm-season grasses were not different from those of cool-season forages (Table 3-9, 3-10 and 3-11). Regardless of location, year, month or treatments, IVTD values indicated that all plant species were within the range of values acceptable to meet maintenance level nutritional needs (Table 3-9, 3-10 and 3-11).

Table 3-9. In vitro true digestibility values (%IVTD) by treatment and harvest month for Kentland in 2009 and 2010 experimental years.

	MAY		**JUNE/JULY**		**AUGUST**		**SEPTEMBER**		**OCTOBER**	
Trt	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
E+	67.8[Ӽ]	71.0	78.4[Ӽ]	76.6[ж]	†	†	75.9	†	81.6[Ӽ]	72.8
E-	70.6[Ӽ]	70.9	75.2	72.5	†	†	70.7	†	80[Ӽα]	69.8[α]
MaxQ	71.5[Ӽ]	70.7	76.8	76.1[ж]	†	†	73.4	†	81.9[Ӽ]	73.0
CB	†	†	75.2[Ӽ]	66.5[ж]	65.9	69.5	67.7[Ӽ]	73.7	†	†
Teff	†	†	70.9	†	68.6	68.5	69.5	74.4	†	†
BG	†	†	72.5	65.9[ж]	65.1	66.9	67.9	70.4	†	†
Crab/E+	68.8	72.0	75.9	75.5	†	†	73.7	†	77.4	72.3

[Ӽ] Indicates significant difference between harvest month (p=0.05).
[ж] Indicates significant difference between treatments (p=0.05).
[α] Indicates significant difference between experimental year (p=0.05).
[†] Data not available due to inactive growth period.

Table 3-10. In vitro true digestibility values (%IVTD) by treatment and harvest month for Northern Piedmont AREC in 2009 and 2010 experimental years.

	MAY		JUNE/JULY		AUGUST		SEPTEMBER		OCTOBER	
Trt	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
E+	61.6[α]	71.1[α]	70.2[ж]	73.8[ж]	†	†	69.5	†	69.6	78.7
E-	60.4[Ӽα]	71.3[α]	70.3[Ӽж]	73.7[ж]	†	†	68.9	†	73.3[Ӽ]	70.6
MaxQ	60.9[α]	72.0[α]	70.0	73.7[ж]	†	†	67.2	†	69.1	76.8
CB	†	†	63.4[жα]	52.1[Ӽжα]	71.2	70.2[Ӽ]	†	†	†	†
Teff	†	†	78.5[Ӽж]	†	74.8	†	68.7[Ӽ]	†	†	†
BG	†	†	71.7[α]	60.4[жα]	72.9	67.8	†	†	†	†
Crab/E+	57.9[Ӽα]	71.6[Ӽα]	71.9[Ӽ]	74.5[ж]	†	†	68.9	†	72.6[Ӽα]	82.8[Ӽα]

[Ӽ] Indicates significant difference between harvest month (p=0.05).
[ж] Indicates significant difference between treatments (p=0.05).
[α] Indicates significant difference between experimental year (p=0.05).
[†] Data not available due to inactive growth period.

Table 3-11. In vitro true digestibility values (%IVTD) by treatment and harvest month for Shenandoah AREC in 2009 and 2010 experimental years.

	MAY		JUNE/JULY		AUGUST		SEPTEMBER		OCTOBER	
Trt	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
E+	54.8[Ӽα]	74.5[α]	71.5[Ӽ]	66.6	†	†	71.7[Ӽ]	†	71.7[Ӽ]	73.4
E-	59.1[Ӽα]	73.7[α]	71.5[Ӽ]	67.8	†	†	72.4[Ӽ]	†	74.7[Ӽ]	69.9
MaxQ	55.3[Ӽα]	72.6[α]	73.6[Ӽ]	64.9	†	†	71.1[Ӽ]	†	73.1[Ӽ]	70.9
CB	†	†	75.6[α]	62.0[Ӽα]	66.9	71.3[Ӽ]	†	72.8[Ӽ]	†	†
Teff	†	†	74.6	†	72.3	72.9	73.2	72.1	68.5	72.8
BG	†	†	68.8	61.8[Ӽ]	67.4	65.6	†	71.5[Ӽ]	†	†
Crab/E+	57.0[Ӽα]	74.5[α]	70.8[Ӽ]	69.9	†	†	71.5[Ӽ]	†	72.8[Ӽ]	73.9

[Ӽ] Indicates significant difference between harvest month (p=0.05).
[α] Indicates significant difference between experimental year (p=0.05).
[†] Data not available due to inactive growth period.

Total Digestible Nutrients (TDN)

Overall, TDN values for warm-season grasses were comparable or slightly lower than those of cool-season species (Table 3-12, 3-13, 3-14). These results are consistent with reports that warm-season grasses are generally lower in forage quality than cool-season grasses (Anderson, 2000). Additionally, Moore et al. (1980) observed that many warm-season grasses utilizing the C_4 pathway exhibit relatively low digestibilities because of higher accumulation of cell wall components. Generally, warm-season forages were able to meet the minimum requirement of beef cattle of 50% (Ball et al., 2007) in most cases (Table 3-12, 3-13 and 3-14). Many of the differences in TDN between location and treatments can be attributed plant species, season, and poor stand establishment. As stated earlier, forage species such as CB and BG established poorly at several experimental sites. As a consequence, most of these poorly established plots were filled with low quality grass and broadleaf weeds.

Table 3-12. Total digestible nutrient values (%TDN) by treatment and harvest month for Kentland in 2009 and 2010 experimental years.

	MAY		JUNE/JULY		AUGUST		SEPTEMBER		OCTOBER	
Trt	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
E+	58.2ⁱ	63.0	64.9	59.6	ⁱ	ⁱ	61.8	ⁱ	70.8ⁱ	66.8
E-	61.3	63.8	65.9ⁱ	57.6	ⁱ	ⁱ	55.3ⁱ	ⁱ	67.6ⁱ	62.9
MaxQ	61.3ⁱ	63.5	64.8	60.9	ⁱ	ⁱ	58.5ⁱ	ⁱ	70.6ⁱ	65.9
CB	ⁱ	ⁱ	59.0ⁱ	53.7	46.2ⁱα	58.3α	52.9	58.3	ⁱ	ⁱ
Teff	ⁱ	ⁱ	60.2	ⁱ	52.3α	63.1α	54.8	62.6	ⁱ	ⁱ
BG	ⁱ	ⁱ	63.2	61.5	50.1α	62.3α	57.7	63.5	ⁱ	ⁱ
Crab/E+	58.5ⁱ	64.6	64.1	59.5	ⁱ	ⁱ	59.2	ⁱ	68.7ⁱ	65.2

ᵡ Indicates significant difference between harvest month (p=0.05).
ж Indicates significant difference between treatments (p=0.05).
α Indicates significant difference between experimental year (p=0.05).
ⁱ Data not available due to inactive growth period.

Table 3-13. Total digestible nutrient (%TDN) values by treatment and harvest month for Northern Piedmont AREC in 2009 and 2010 experimental years.

	MAY		JUNE/JULY		AUGUST		SEPTEMBER		OCTOBER	
Trt	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
E+	54.4[χα]	62.5[α]	56.3	60.4[ж]	[†]	[†]	57.4	[†]	60.6[χ]	66.0
E-	53.6[α]	61.5[α]	57.5	60.1[ж]	[†]	[†]	57.4	[†]	62.4	65.2
MaxQ	52.8[α]	63.4[α]	56.7	60.1[ж]	[†]	[†]	55.8	[†]	60.9	63.4
CB	[†]	[†]	55.5	48.9[χж]	58.8	58.9[χ]	[†]	[†]	[†]	[†]
Teff	[†]	[†]	62.2	[†]	58.6	[†]	54.5	[†]	[†]	[†]
BG	[†]	[†]	56.7	56.8	59.9	63.4	[†]	[†]	[†]	[†]
Crab/E+	49.9[χα]	62.8[α]	58.1	60.8[χж]	56.9	[†]	[†]	[†]	62.5[χ]	71.0[χ]

[χ] Indicates significant difference between harvest month (p=0.05).
[ж] Indicates significant difference between treatments (p=0.05).
[α] Indicates significant difference between experimental year (p=0.05).
[†] Data not available due to inactive growth period.

Table 3-14. Total digestible nutrient values (%TDN) by treatment and harvest month for Shenandoah AREC in 2009 and 2010 experimental years.

	MAY		JUNE/JULY		AUGUST		SEPTEMBER		OCTOBER	
Trt	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
E+	48.9[χα]	69.8[χα]	63.9	57.5[χ]	[†]	[†]	61.7[χ]	[†]	63.1[χ]	62.7
E-	52.7[χα]	67.9[χα]	65.3[χα]	56.4[χα]	[†]	[†]	61.3[χ]	[†]	66.9[χж]	60.6
MaxQ	50.4[χα]	67.5[χα]	65.8[χ]	55.1[χ]	[†]	[†]	61.1[χ]	[†]	66.7[χж]	61.3
CB	[†]	[†]	64.8[χα]	51.9[χα]	53.1[χ]	59.5	[†]	63.0[χ]	[†]	[†]
Teff	[†]	[†]	59.1	[†]	57.7[α]	67.2[α]	56.9	65.2	56.6[жα]	66.6[α]
BG	[†]	[†]	61.7	56.0[χ]	60.0	62.2	[†]	68.1[χ]	[†]	[†]
Crab/E+	50.6[χα]	69.1[α]	63.2[χ]	58.8[χ]	[†]	[†]	61.1[χ]	[†]	63.8[χ]	61.6[χ]

[χ] Indicates significant difference between harvest month (p=0.05).
[ж] Indicates significant difference between treatments (p=0.05).
[α] Indicates significant difference between experimental year (p=0.05).
[†] Data not available due to inactive growth period.

Summary and Conclusions

Biomass yield as well as quality of cool-season grasses fell below that of warm-season species during the summer slump period of 2009 and 2010 (July-September). All cool-season grasses produced adequate amounts of biomass for spring harvests but lacked production for the remainder of the season. When nutrient values of cool-season grasses decreased mid-summer, warm-season species provided CP at values between 8 and 15 percent dependant on location. Where forage biomass and nutritive values of warm-season forages fell below the minimum required, in most cases, it was attributed to establishment failure. Throughout experimental years, the botanical composition of KY31 E+, KY31 E-, Max Q E++ and Crabgrass in combination with KY31 E+ were 93%, 87%, 95% and 88%, respectively. Unlike the cool season grasses however; overall, perennial warm-season grasses established poorly, with 27% and 46% stand for CB and BG, respectively. Teff, on the other hand, an annual warm-season grass, established well and maintained over 77% Teff in the stand.

From our results, it is apparent that alternative warm-season forages, despite poor establishment, can help buffer the summer slump period of cool-season grasses in July and August. However, successful establishment and the maintenance of high botanical composition of the desired species could have a major impact on both biomass yield and quality of each forage species. The amount and onset of rainfall also played a major role in the production of both cool- and warm-season grasses.

References

Abaye, A.O., V.G. Allen, and J.P. Fontenot. 1997. The double DAFOR scale: A visual technique to describe botanical composition of pastures. *In*: Proc. American Forage and Grassland Council, Georgetown, TX. 6:96-100.

Anderson, B.E. 2000. Use of warm-season grasses by grazing livestock. *In*: Native warm-season grasses: Research trends and issues. CSSA and ASA, Madison, WI. Special pub. No. 30.

Ball, D. M., C. S. Hoveland and G. Lacefield. 2007. Southern forages (4th edition). International Plant Nutrition Institute, Norcross, Georgia.

Barnes, R.F., C.J. Nelson, M. Collins, and K.J. More. 2003. Forages volume 1: An introduction to grassland agriculture (6th Edition). Iowa State University Press, Ames, Iowa.

Barnes, R.F., D.A. Miller and C.J. Nelson. 1995. Forages volume 1: An introduction to grassland agriculture (5th Edition). Iowa State University Press. Ames, Iowa.

Blaser, R.E., W.C. Hammes, J.P. Fontenot, H.T. Bryant, C.E. Polan, D.D. Wolf, E.S. McClaugherty, R.G. Kline, and J.S. Moore. 1986. Forage-animal management system. Pages 86-87 in Virginia Agric. Exp. Sta. Bull. Virginia Polytech. Inst. And State Univ., Blacksburg.

Brodie, J. 1985. Vegetation analysis. *In*: Grassland studies. p. 7-9. George Allen & Unwin, Boston.

Goering, H.K and P.J. Van Soest. 1970. Forage fiver analysis (apparatus, reagents, procedures and some applications). In: Agriculture handbook No. 379. ARS, USDA, Washington, USA.

Griffith, C.A. "Summer Grass Conference: Management of Warm Season Grasses for Utilization with Beef Cattle." Ardmore, Oklahoma: Noble Foundation, 1978

Moore, J.E., J.C. Burns, A.C. Linnerod and R.J. Moore. 1980. Relationships between the properties of southern forages and animal response. Proc. 37th Southern Pasture and Forage Crop Improvement Conf., Nashville, TN.

Moser, L.E., D. R. Buxton and M.D.Casler. 1996. Cool-season forage grasses agronomy: A series of monographs #34. ASA, CSSA, and SSSA Inc. Madison, WI.

Roberts. G. 1996. Caucasian bluestem. University Extension No. G4674

SAS. 1982. SAS User's Guide: Statistics. SAS Inst., Inc. Cary, NC.

Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Assoc. Off. Anal. Chem. 46:829.

Van Soest, P. J., and R. H. Wine. 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell wall constituents. J. Assoc. Off. Anal. Chem. 50:50.

Vona, L.C., G.A. Jung, R.L. Reid and W.C. Sharp. 1984. Nutritive value of warm-season grass hays for beef cattle and sheep; digestibility, intake and mineral utilization. J. Anim. Sci. 1984.59:1582-1593.

Wolf, D. D., R.S. White, and S.E. Tinsley. 2009. Establishing and managing Caucasian bluestem. VCE pub. 418-01.

CHAPTER IV

RESPAMPLING AND THE BOOTSTRAP DISTRIBUTION FOR RISK MANAGEMENT IN COW-CALF PRODUCTION SYSTEMS OF THE APPLACHIA

Abstract

In managing risk, a number of different strategies attempt to extend the grazing season and buffer the impacts of environmental stress on forage-based systems. An experiment was initiated in 2008 at three Virginia locations: Kentland Farm in Blacksburg, Northern Piedmont AREC, and Shenandoah AREC to determine the production risks associated with alternative forage species during the summer slump. The treatments included endophyte-infected tall fescue (KY31 E+) (*Festuca arundinacea* Schreb.), endophyte-free tall fescue (KY31 E-), novel-endophyte tall fescue (MaxQ), Caucasian bluestem (CB) (*Bothriochloa bladhii* (Retz) S.T. Blake), Teff (var. Tiffany) (*Eragrostis tef* Zucc. Trotter), Bermudagrass (BG; var. Wrangler) *(Cynodon dactylon* (L.)(Pers.)), and Crabgrass (var. Red River) *(Digitaria* spp.*)* in combination with endophyte-infected tall fescue. Samples were taken at the late-boot stage for forage biomass and quality from May through October in 2009 and 2010. To assess the risk associated with each species, bootstrap distributions of biomass and quality data were generated by Monte Carlo simulation and compared against an objective function to estimate the probability of each species failing to meet the minimum animal requirement. The objective function was defined for this study at 59 kg ha^{-1} d^{-1} forage yield, 10% CP, and 60% TDN. Warm-season grasses demonstrated a higher probability of meeting the minimum requirements in mid-summer months of July, August and September. Among the warm-season forages, Teff was most consistent in meeting the minimum requirements in mid-summer for forage biomass, CP and TDN as compared to BG and CB. However, with proper management and good conditions for

establishment, both BG and CB can help to fill the gap in summer months when compared to cool-season tall fescue. Yield and quality distributions provide producers with a tool that links their production goals with a measurable value of production risk associated with their risk tolerance.

Introduction

Beef cattle production in the South consists primarily of commercial and purebred cow-calf operations (Ball et al., 2007). Because the cow/calf enterprise requires extensive amounts of low to medium energy level feed to maintain the cows, the operation is a forage based enterprise (McKinnon and Snodgrass, 2009). Production challenges such as forage supply, quality and availability emerge when considering grass-fed beef production (Martin and Rogers, 2004). Seasonal climate variation, forage management practices, and forage availability are all variables that affect the operation (Martin and Rogers, 2004). Cattle performance and carrying capacity are related to and affected by forage production and quality (Zobell et al., 1999). Summer decline in forage availability and the nutritive value of cool-season pastures coincide with increased nutritional requirements of spring-calving cow-calf pairs (NRC, 1996). At this time, calves are more dependent on available forage to meet their requirements as cows start to decline in milk production (Scaglia et al., 2008). Successful pasture management must balance animal feed requirements with seasonal and annual fluctuations in pasture production (Sheath et al., 1987).

When considering risks within livestock production systems, there are many factors that cannot be controlled by the producer, particularly climate (temperature, and the onset of precipitation) (Fleisher, 1990). Forages that can adapt and hold constant growth and quality above minimum animal requirements through variable conditions help minimize production risk.

Many producers make management decisions based on maximizing profit without accounting for the highly variable outcomes that could result (Fleisher and Robinson, 1985). Unfortunately, systems that offer the highest profit often do so because of the high risks involved. Risk needs to be managed effectively within the capacity of the individual as to optimize the efficiency of production (Hardaker et al., 2004). To determine the minimum accepted level of forage biomass and quality, individual producer goals and risk tolerance must be evaluated (Clapham et al., 2009). This minimum requirement is termed the objective function, against which all values are compared to reduce management risks within the operation. Values obtained from field experiments are compared against the objective function to determine the most risk efficient alternative to limited cool-season forage production. This study is not only focused on where production yields will be highest, but where alternative forages work with existing species in order to produce an optimum amount of pasture at a reasonable level of risk. Taking into consideration that producers have a variety of production goals and levels of risk aversion, the objective function can also change depending on individual.

With limited knowledge of forage species growth, development and reaction to stressful conditions, producers find it difficult to make good management decisions to fill the summer slump. Monte Carlo simulation offers a powerful method of generating data similar to what could be found in numerous years of field studies. This resampled dataset is then plotted and fit to a distribution curve using the bootstrap method, offering an outcome true to the distribution of the sampled data (Vose, 2008). This distribution gives the producer a probability of success or failure as compared to the objective function; or the operation goals, greatly increasing the chances of making a well-informed risk management decision. Management decisions must be made individually by a producer based on his/her goals and level of risk aversion. Bootstrap distributions allow the producer to make more informed decisions based on the probability of success or failure in meeting a minimum requirement.

Methods and Materials

Small plot experiments were conducted in 2009 and 2010 at three Virginia geographical locations: Kentland, the Northern Piedmont AREC and the Shenandoah AREC (Fig 3- 1). A randomized complete block design was utilized with seven forage species as the main plot. The seven forage treatments included endophyte-infected tall fescue (KY31 E+), endophyte free tall fescue (KY31 E-), novel endophyte tall fescue (MaxQ), Crabgrass in combination with endophyte-infected tall fescue (KY31 E+), Teff, Bermudagrass (BG), and Caucasian bluestem (CB). Each plot measured 3 x 9 meters with 3 meter alleyways between treatments and 4.5 meters between replications.

Perennial forage species were established at all three locations in the summer of 2008. First attempts for seeding were made in mid-June 2008 but were unsuccessful. Establishment of these species was documented after a second attempt in the Shenandoah and Kentland and on a third attempt in the Northern Piedmont (Table 3-1). In 2009, Teff was planted with a no-till drill and established at the first attempt. At all locations in 2010, multiple attempts were made before Teff established successfully. Seed was drilled into a soft seedbed (not firm) which might have caused the seed to be placed too deep, resulting in poor emergence and weak stands. Lack of rainfall at the beginning of the season in 2010 also contributed to poor conditions for establishment. To avoid a stand establishment failure at the second attempt, the seed was broadcast and lightly packed to ensure seed-soil contact. This was done at both the Shenandoah and Northern Piedmont AREC locations. In 2009 and 2010, as one of the treatments, crabgrass was inter-seeded into one of the tall fescue (KY31 E+) treatments after the first harvest of the season, late spring. Table 3-2 shows the seeding rates used to establish perennial stands in 2008 and annual species in 2009 and 2010. Crabgrass treatments did not establish when inter-seeded into one of the tall fescue(E+) treatments. For this reason, the seventh treatment was maintained as a cool-season tall fescue (E+) stand.

Before first harvest, all plots were treated with 2,4-D to control broad leaf weeds. In 2009 and 2010, early to late spring, nitrogen (N) in the form of urea was applied to all cool season species. The N rate varied by species recommendations (Table 3-3). The warm-season grasses were fertilized early June, at the time of establishment. BG was fertilized initially and following each harvest while CB was fertilized after every other harvest based on best management practices of these species.

Forage Biomass Yield, Quality and Distribution

During the growing season, plots were harvested starting April 15 through October in 2009 and 2010. The decision regarding harvest dates (Table 3-4, 3-5) was based on the growth stages of individual species (treatment). Generally, harvest was done when the grasses reached the late boot stage. In most cases, cool-season grasses (E+, E-, MaxQ, Crabgrass/E+) were harvested twice in late spring and early summer and once or twice in late summer and fall, depending on weather conditions. Warm-season perennial grasses were harvested on average three times.

Prior to harvesting, all forage treatments were visually evaluated for botanical composition using the double DAFOR scale (Brodie, 1985 and Abaye et al., 1997). Species establishment was determined by the percentage of desired species within the treatment plots. Using a flail-type mechanical forage harvester, each treatment plot was harvested by clipping a swath (3m x 0.8m) through the center of the plot. Forage was harvested at a stubble height of 10 cm. A subsample of fresh forage was collected from each plot for dry matter and nutritive value analysis. Samples were dried in a forced air-oven 60º C for at least 48 hours and ground to pass through a 1-mm screen using a Wiley sample mill (Thomas Scientific, Swedesboro, NJ).

To compensate for differences in harvest dates and number of growing days, treatments are compared on a kg/ha/day basis. Harvest seasons in 2009 and 2010 were broken into five sampling periods described as late May, June/July, August, September and October. Seasonal distribution of forage growth and quality was observed over the sampling periods.

Neutral detergent fiber (NDF) (Van Soest and Wine, 1967), acid detergent fiber (ADF) (Van Soest, 1963; Goering and Van Soest, 1970), in vitro true digestibility (IVTD) and crude protein (CP) were estimated using near infrared spectroscopy (NIRS). WINISI II software was used to select a calibration data set for wet chemistry determination (Infrasoft International, Port Matilda, PA). Total digestible nutrient (TDN) values were determined with the following calculation for grass hay samples: TDN=100.32-1.1180*ADF. Data were analyzed for all single effects and interactions using PROC GLM (SAS Institute, Gary, NC). Effects of treatment, location, harvest, and year were tested and interactions among variables were tested.

Rainfall and temperature data were collected at each location to evaluate the influence on forage growth and nutritive value throughout the season and among years and sites. The 2009 and 2010 rainfall data were compared against a 55 year average to determine the typical weather patterns expected as compared to historical averages.

Resampling, Bootstrap Distributions and the Objective Function

The dataset compiled of observations from 2009 and 2010 was not large enough to define monthly yield distributions of a given treatment accurately. Monte Carlo simulation, specifically resampling with replacement (Davison and Hinkley, 1997; Clapham et al. 2008) was used to generate bootstrap distributions of monthly yields for each species. Bootstrap distributions are for the most part (except in cases with extreme outliers) normally distributed as a result many resampling iterations and the Central Limit Theorem (Efron and Tibshirani, 1998). Simon et al. (1992) confirmed that this method used real-world results from short-term research to simulate the outcome if research was conducted over the long-term. The bootstrap procedure used @Risk software (version 5.5; Palisade Corp., Newfield, NY) running as an add-in with Microsoft Excel 2007 (Microsoft Corp., Redmond, WA).

Production for a given treatment and harvest month was simulated by selecting twelve random observations from the appropriate dataset (four replications sampled at three locations, yielding twelve observations per year of a given treatment and harvest month). The twelve selected observations were then averaged to simulate a mean yield representative of one year. This process was repeated for 5000 iterations and results were used to generate a bootstrap distribution, bootstrap mean and standard deviation. The entire procedure was repeated for each treatment and harvest month combination for biomass yield, CP and TDN values. These figures were then compared to the minimum nutritional requirement determined by the study, the objective function. The baseline requirement for this study was set for cow-calf operations at 59 kg ha^{-1} d^{-1} forage yield. This minimum was calculated based on a 590kg animal consuming 2.5% body weight per day on a dry matter basis (Zobell et al., 1999) and a stocking rate of 4 cow-calf units per hectare (McKinnon and Snodgrass, 2009). An objective function was also defined for nutritive values of crude protein (CP) and total digestible nutrients (TDN). Based on requirements of a lactating cow, these minimum values were set at a level of 10% CP and 60% TDN (Ball et al., 2007). The seven forage treatments were compared against one another and the objective function in an effort to assess the least risky and most effective forage alternative.

Results and Discussion

Forage Yield with Resampling and the Bootstrap

Biomass yield differences during 2009 and 2010 were most likely due to environmental variability. It is likely that with additional growing seasons, the variability would continue. Similar to results from Clapham et al. (2008), the bootstrap distribution of biomass values represent mean and standard deviation values for each treatment similar to recorded field values. Table 4-1 outlines the probability of a given species meeting the daily forage biomass minimum requirement of 59 kg ha^{-1} d^{-1} at each harvest month throughout the season. Due to summer slump associated with cool-season grass productivity, limited forage biomass data was available during mid-summer months. Likewise, no forage biomass was available for warm-season grasses the very beginning or end of the growing season.

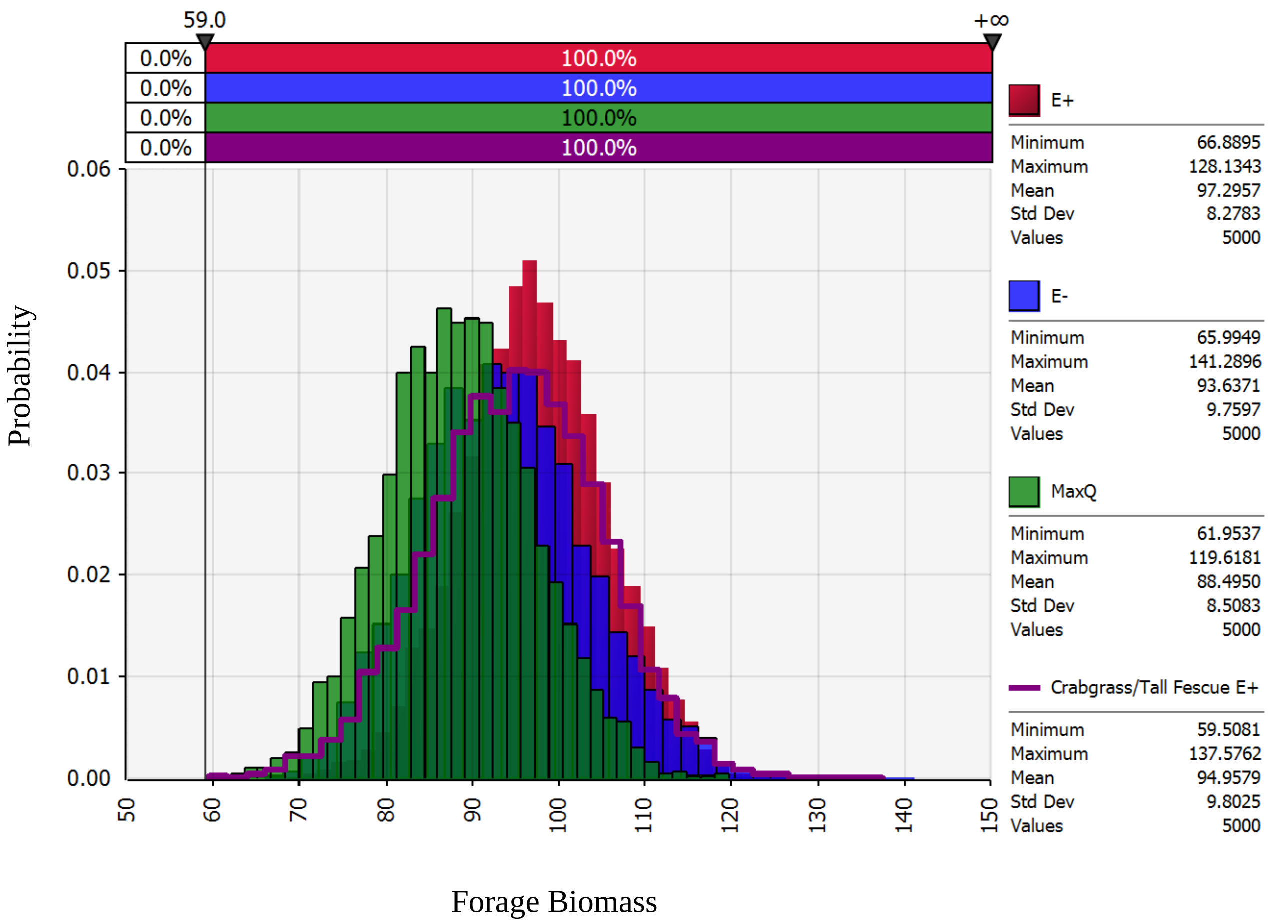
Table 4-1. Probability (%) of forage species meeting minimal animal requirements for forage biomass of 59kg/ha/day over the harvest season.

	May	**June/July**	**August**	**September**	**October**
KY31 E+	100	72.7	n/a [ƚ]	0	0
KY31 E-	100	71.2	n/a [ƚ]	0	0
Max Q	100	60.1	n/a [ƚ]	0	0
CB	n/a [ƚ]	90.5	26.9	47.1	n/a [ƚ]
Teff	n/a [ƚ]	99.9	96	35.6	0
BG	n/a [ƚ]	67.4	39.8	15.6	n/a [ƚ]
Crabgrass/KY31 E+	100	65.8	n/a [ƚ]	0.2	0

[ƚ] Unable to harvest due to lack of biomass

Probability of success means different things to different producers depending on risk tolerance. For this reason, interpretation of Table 4-1 is unique to the individual and their tolerance to risk. Clapham et al. (2009) argued that without a benchmark goal or objective function, risk cannot be quantified and optimum yield becomes a vague term. During May-June in 2008 and 2009 all the tall fescue types were able to meet the minimum requirements. However August and September cool-season forage production was poor and in extreme cases, not even harvestable. When cool-season forages did not meet the objective functions (59 kg ha^{-1} d^{-1}; 10% CP; 60% TDN) there was a greater probability for warm-season species to provide adequate biomass (Table 4-1). Normally a second peak growth from cool-season grasses is expected early fall (Barnes et al., 2003). However, in this study, no measureable forage biomass was recorded for those months. Limited production from CB and BG treatments as compared to Teff could be explained by poor establishment and stand of these perennial species (Appendix I). As an annual, Teff had the opportunity for re-establishment each season and therefore was able to meet the minimum requirement (Table 4-1). Bootstrap distributions for each treatment and harvest month are shown in Fig 4-1 to Fig4-7.

Fig. 4-1. Bootstrap distributions of biomass yield for cool-season grasses for May harvest and the probability (%) of meeting the objective function of 59kg forage/ha/day.



The cool-season forages including KY31 E+, KY31 E-, MaxQ and Crabgrass/KY 31 E+ were similar in biomass distribution for the May harvest (Fig. 4.1). Cool-season grasses typically exhibit a peak in growth during the spring months (Barnes et al., 2003). Compared to the objective function, these four cool-season grasses met

minimum requirements 100% of the time for the May harvest. Distributions of the cool-season grasses are shown in Fig. 4.2. However, unlike the May harvest, daily biomass begins to decline during the June/July period and fails to meet minimum requirements 27-40 percent of the time depending on treatment (Fig 4-2). Distributions of cool-season forage yelds demonstrate more than 75% forage biomass yield early to mid spring followed by a decline in summer (Moser et al., 1996).

Fig. 4-2. Bootstrap distributions of biomass yield for cool-season grasses for June/July harvest and the probability (%) of meeting the objective function of 59kg forage/ha/day.

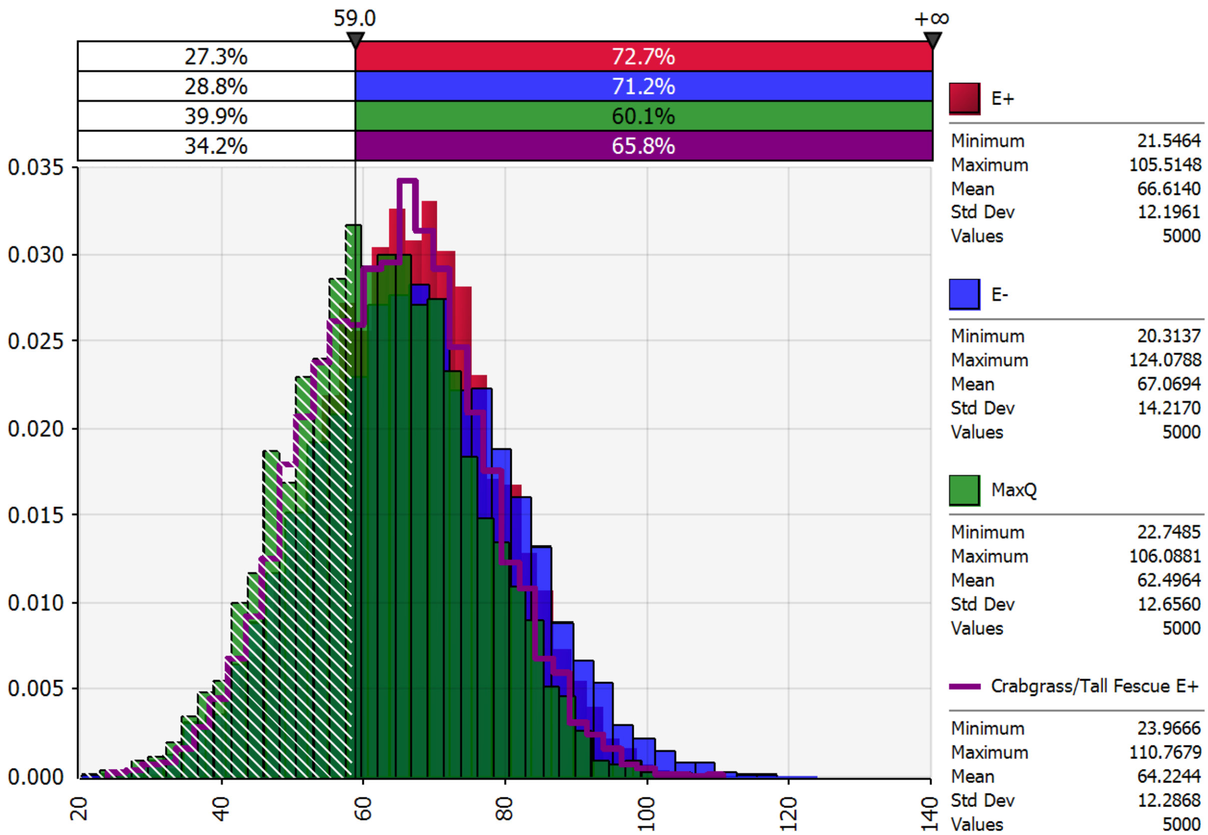


Fig. 4-3. Bootstrap distributions of biomass yield for warm-season grasses for June/July harvest and the probability (%) of meeting the objective function of 59kg forage/ha/day.

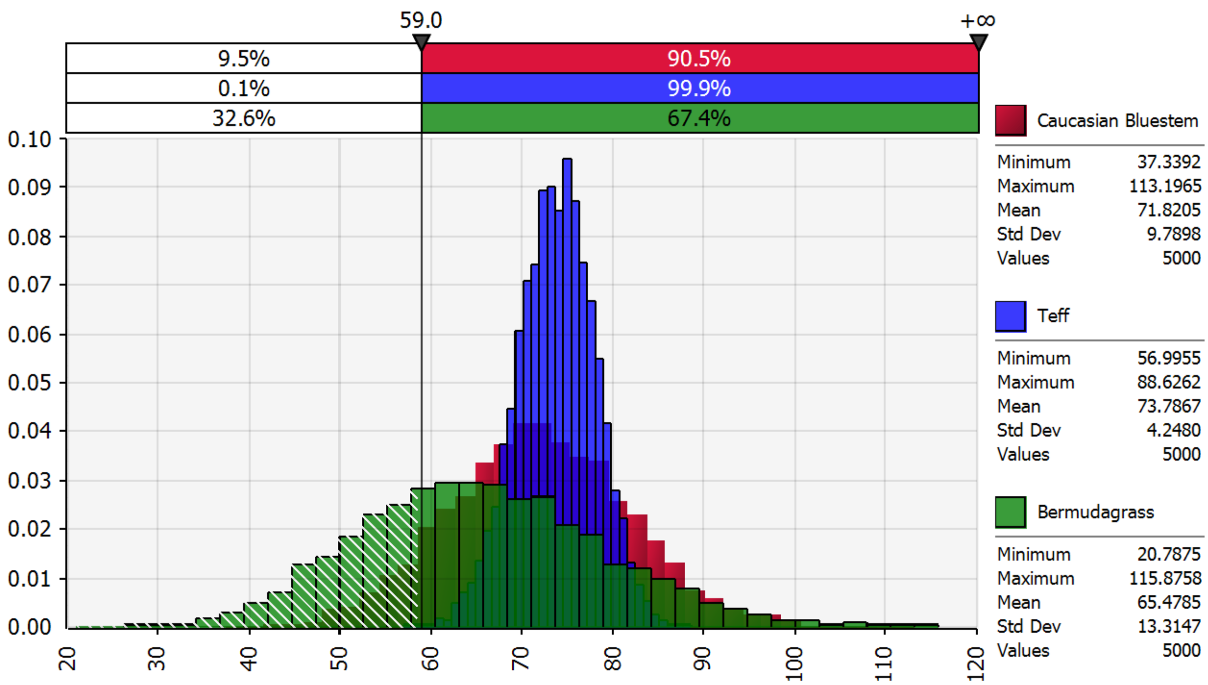


Fig. 4-4. Bootstrap distributions of biomass yield for warm-season grasses for August harvest and the probability (%) of meeting the objective function of 59kg forage/ha/day.

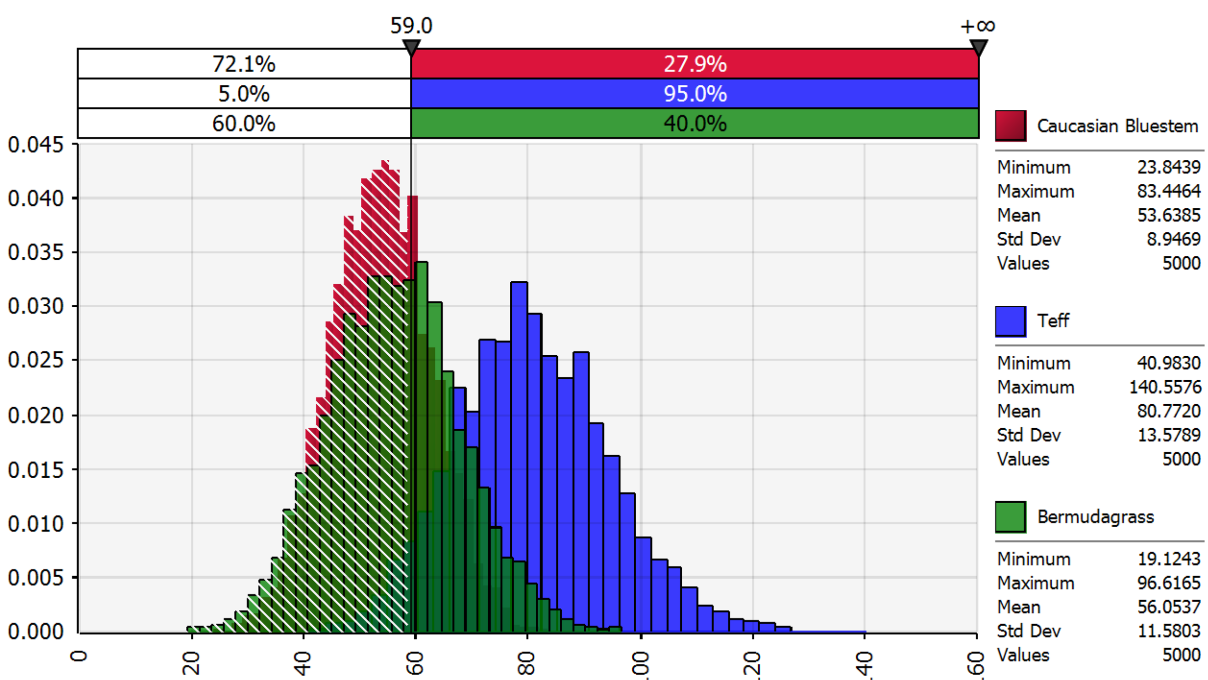
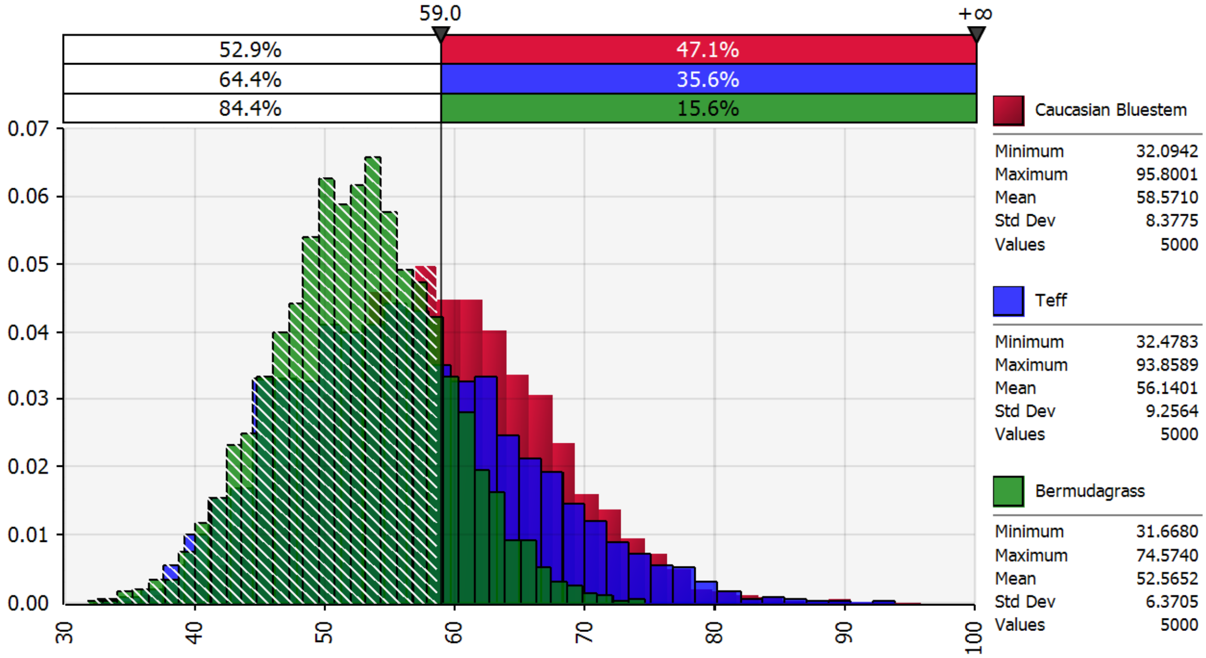


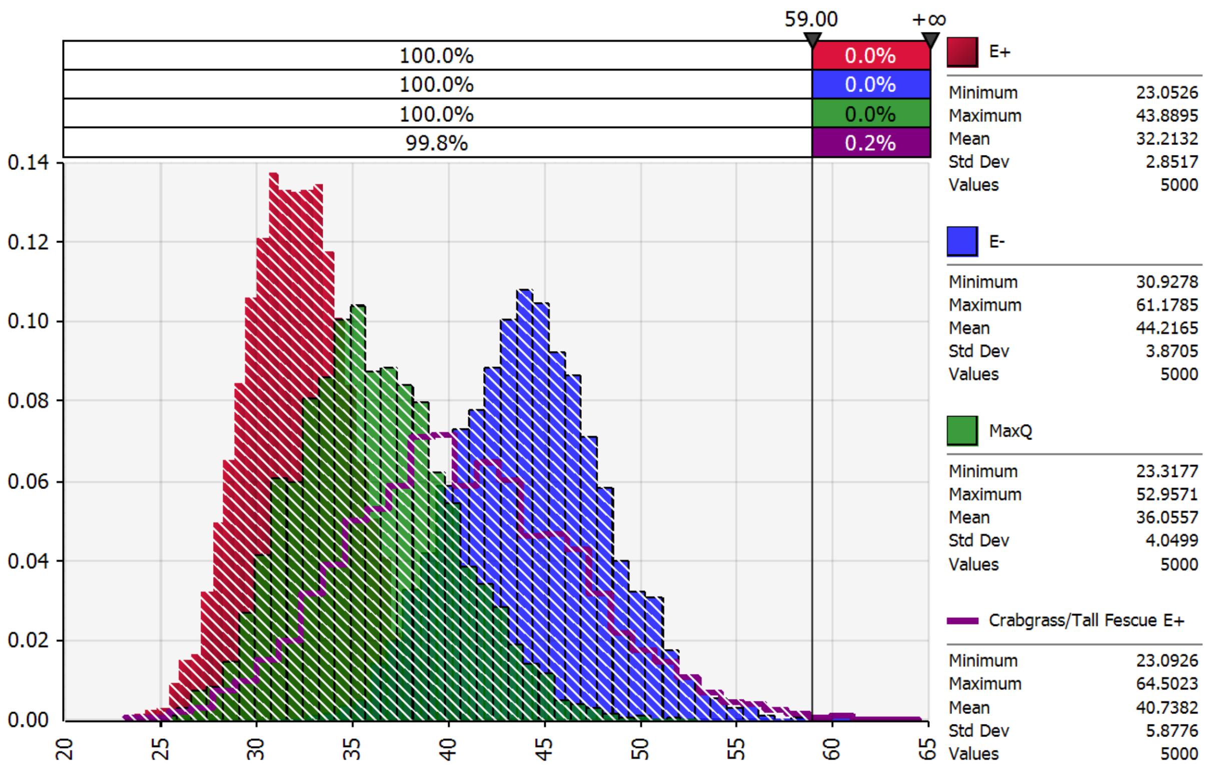
Fig. 4-5. Bootstrap distributions of biomass yield for warm-season treatments biomass in September harvest and probability (%) of meeting the objective function of 59kg forage/ha/day.



The biomass yield distributions of warm-season grasses demonstrated a higher probability of meeting the objective function than cool-season species for the June/July harvest (Fig 4-3). In a study involving similar species, Fike et al. (2005) confirms that most warm-season grasses begin their peak production as tall fescue begins to decline. For the June/July production period, the probability of Teff and CB yields exceeded BG yields and met the minimum requirement by more than 20%. This result is contrary Fike et al. (2005) conclusion that BG had relatively stable yields across weather extremes and should be superior for managing risk. This discrepency could be attribituted to poor establishment and persistance of BG and CB stands experienced in in 2008. Additionally, because of the typical prostrate growth habit of BG, less biomass may have been harvested at the 10cm cutting height (Barnes et al., 1995). In August, Teff treatments maintained a relatively high probability of meeting requirements while CB and BG treatments fell below 50 percent (Fig 4-4).

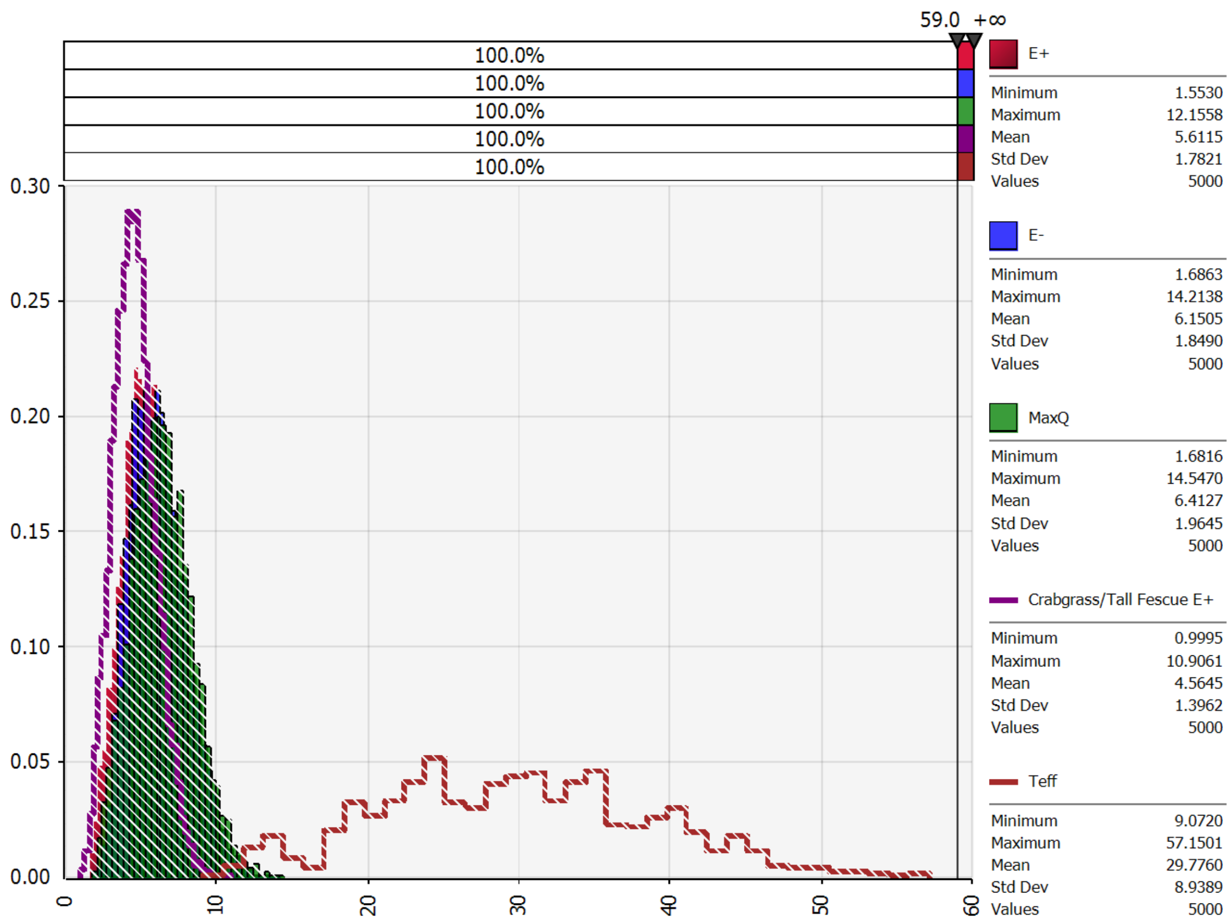
The September harvests for warm-season and cool-season grasses are demonstrated in Fig. 4-5 and Fig. 4-6, respectively. Although all treatments failed to meet the minimum requirement more than 50% of the time, warm-season species still offer a higher chance of obtaining adequate daily biomass with higher mean values than cool-season species.

Fig. 4-6. Bootstrap distributions of biomass yield for cool-season treatments biomass in September harvest and probability (%) of meeting the objective function of 59kg forage/ha/day.



The minimum requirement of biomass yield for the month of October was not met by the cool-season forages or Teff (Fig 4-7). Since Teff is a warm-season grass and is also highly dependent on day length to produce, there was no surprise that this treatment did not meet the minimum yield objective during the month of October. However, tall fesue is often expected to have substantial amount of growth during the fall months.

Fig. 4-7. Bootstrap distributions of biomass yield for cool-season and Teff grasses for October harvest and probability (%) of meeting the objective function of 59kg forage/ha/day.



Forage Quality with Resampling and the Bootstrap

In most cases, the Crude protein (CP) and total digestible nutrients (TDN) were similar to expected values across seasonal distribution (Ball et al., 2007). Nutritive values are highly correlated with stage of maturity, type of plant species, and fertilization. Cool-season species, CP values were higher in spring and early fall harvest periods and more likely to meet the CP objective function (Table 4-2). Nutritive value results for cool-season grasses are consistent with reports by Blaser et al. (1986), that is increasing in early fall after declining rapidly mid-to late summer. This improvement in quality late in the season demonstrates that cool-season forages can meet nutritional needs early fall if managed to increase biomass production. For September, Teff was the only treatment that met the minimum requirement of 10% for CP (Table 4-2). The CB and BG CP values, however were lower than the CP objective, possibly due to incursion by grass weeds. However, presence of weeds in a target forage stand do not always lower nutritive values if the weeds are not over mature (Ball et al., 2001; Bosworth et al., 1985; Bosworth et al, 1980, Vengris et al., 1953).

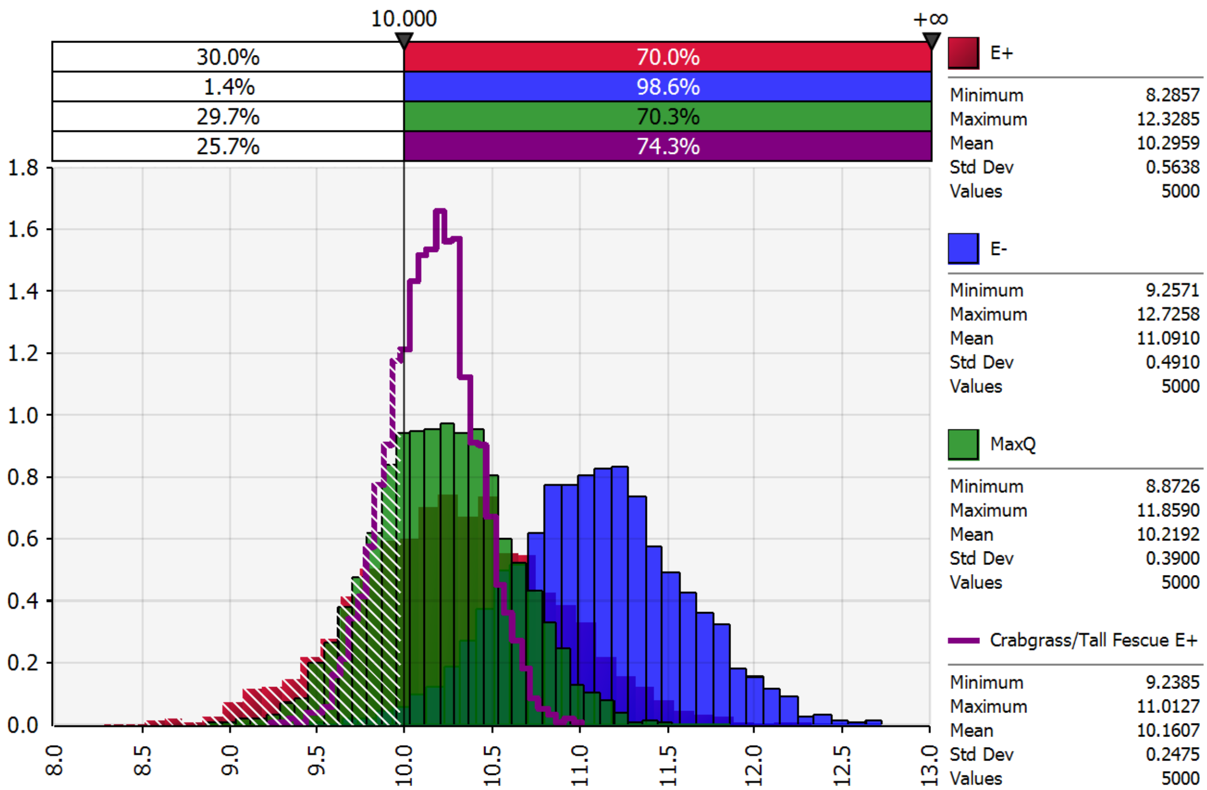
Table 4-2. Probability (%) of forage species meeting minimal animal requirements for CP of 10% over the harvest season.

	May	**June/July**	**August**	**September**	**October**
KY31 E+	70	95.8	n/a ŧ	7.5	97.8
KY31 E-	98.6	98.8	n/a ŧ	10.3	99.8
Max Q	70.3	95.8	n/a ŧ	0.3	94.4
CB	n/a ŧ	94.5	73.5	5	n/a ŧ
Teff	n/a ŧ	100	100	92.5	100
BG	n/a ŧ	100	100	18.8	n/a ŧ
Crabgrass/KY31 E+	74.3	95.5	n/a ŧ	0	99.9

ŧ Unable to harvest due to lack of biomass

Bootstrap distributions in Fig. 4-8 show a high CP value for KY31E- and slightly lower values for KY31 E+, MaxQ, and Crabgrass/KY31E+. These values are expected to be higher for cool-season grasses early in the growing season. In 2009, because of above normal wet conditions early in the season, first harvest of cool-season treatments were pushed to a later date, past optimal maturity of the forage and decreasing in nutritional quality (Table 3-4).

Fig. 4-8. Bootstrap CP distributions from cool-season grasses for May harvest and probability (%) of meeting the objective function of 10%.



The CP values of cool-season grasses for the June/July harvest, were higher than those of May. Thus, the probability of meeting the minimum requirement from cool-season grasses was greater than expected at the beginning of the summer season (Fig 4-9). Based on the normal growth pattern of cool-season species, producers would normally expect the CP level to decline starting in July. However, higher CP vaues for the June/July period could partially be explained by time of N application in 2009 (Table 3-3). In 2009 after the first harvest cool-season species were fertilized with N and resulted in increased second harvest CP levels. Additionally, the increased rainfall of spring 2009 may have enhanced cool-season forage production extending into the summer season.

Fig. 4-9. Bootstrap CP distributions from cool-season grasses for June/July harvest and probability (%) of meeting the objective function of 10%.

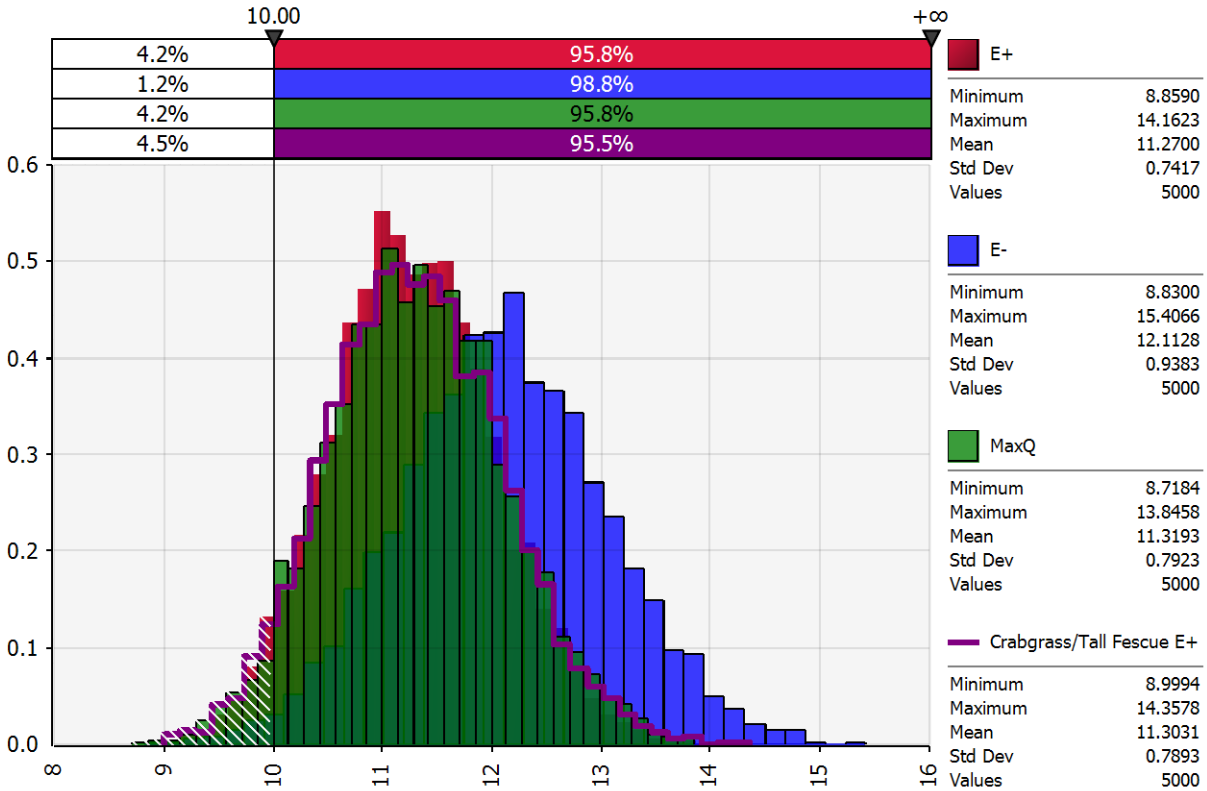


Fig. 4-10. Bootstrap CP distributions from warm-season grasses for June/July harvest and probability (%) of meeting the objective function of 10%.

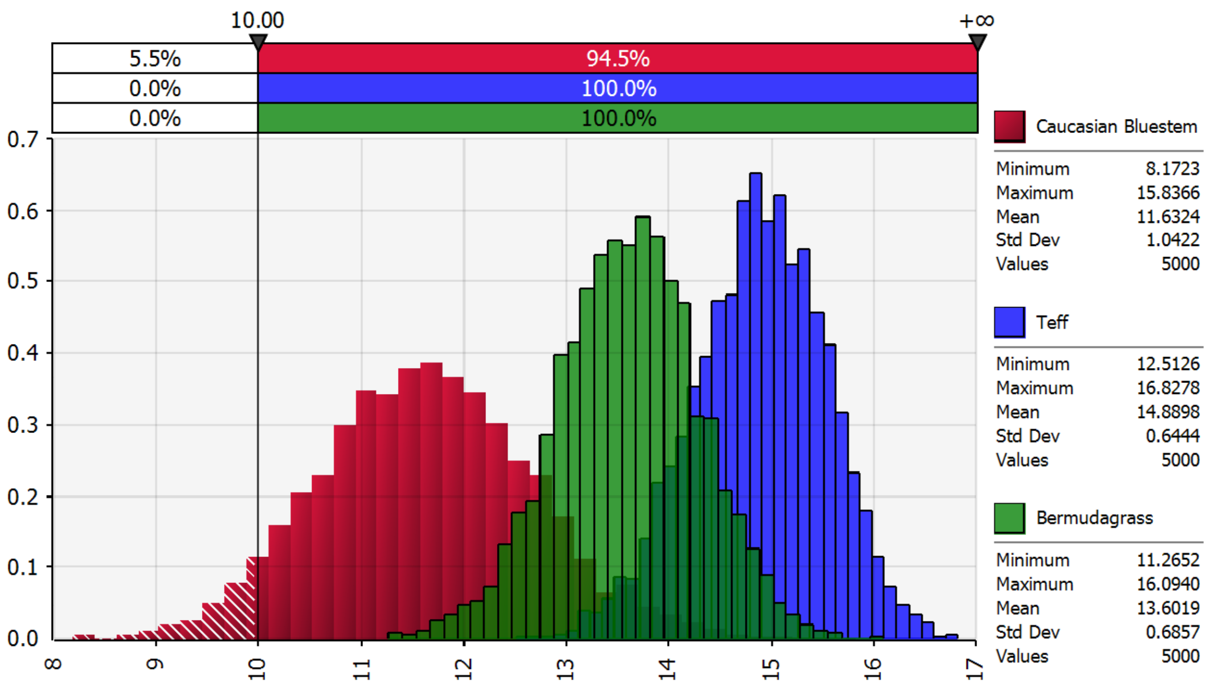
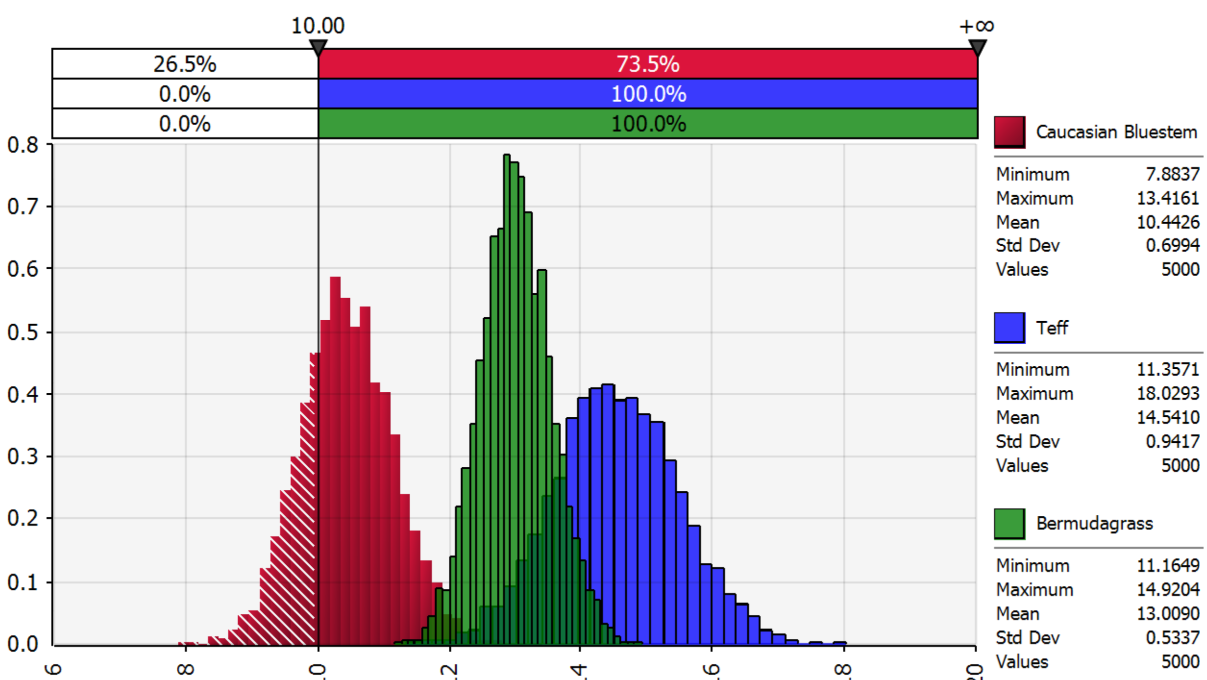


Fig. 4-11. Bootstrap CP distributions from warm-season grasses for August harvest and probability (%) of meeting the objective function of 10%.



The CP values of Teff were consistantly 9-20% and above the other warm-season grasses across the season and met the minimum requirement 77% of the time in September. The CP values obtained for Teff were similar to those reported by Roseberg et al. (2005). The mean CP value of BG was higher than CB in June/July and August harvest periods but drastically declined below minimum requirements in September. On the other hand, the CP values of CB declined throughout the season, barely meeting the objective function less than 2% of the time in September compared to 8% for BG.

Fig. 4-12. Bootstrap CP distributions from warm-season grasses for September harvest and probability (%) of meeting the objective function of 10%.

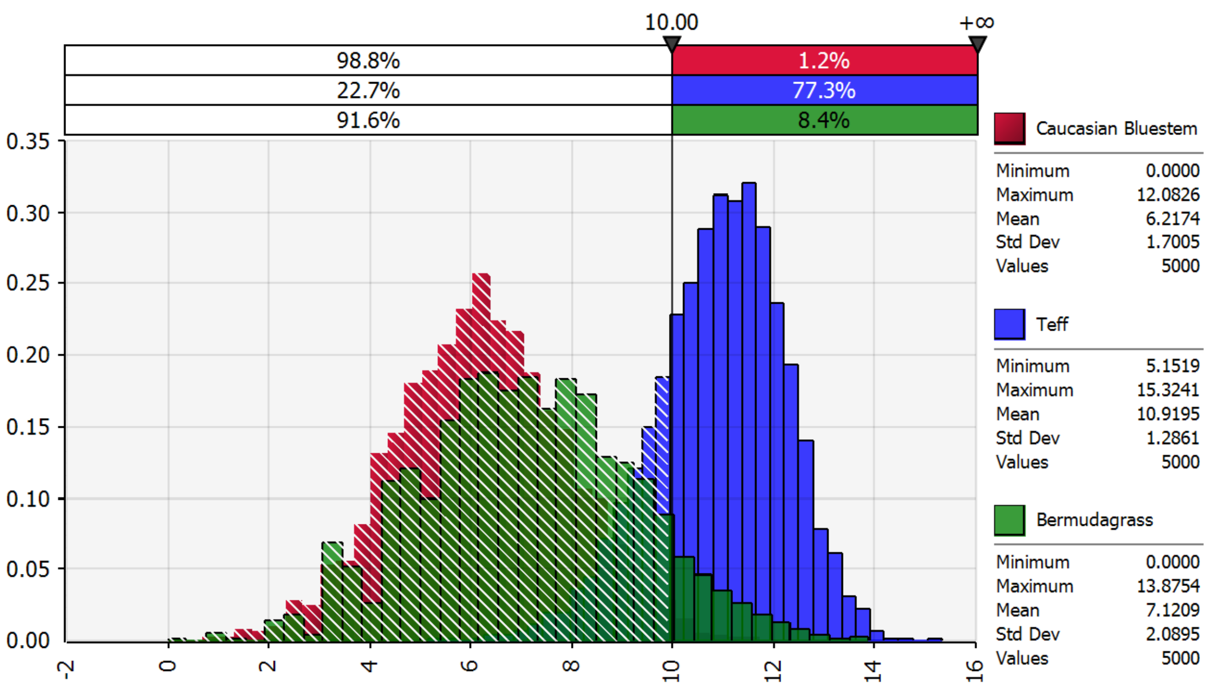
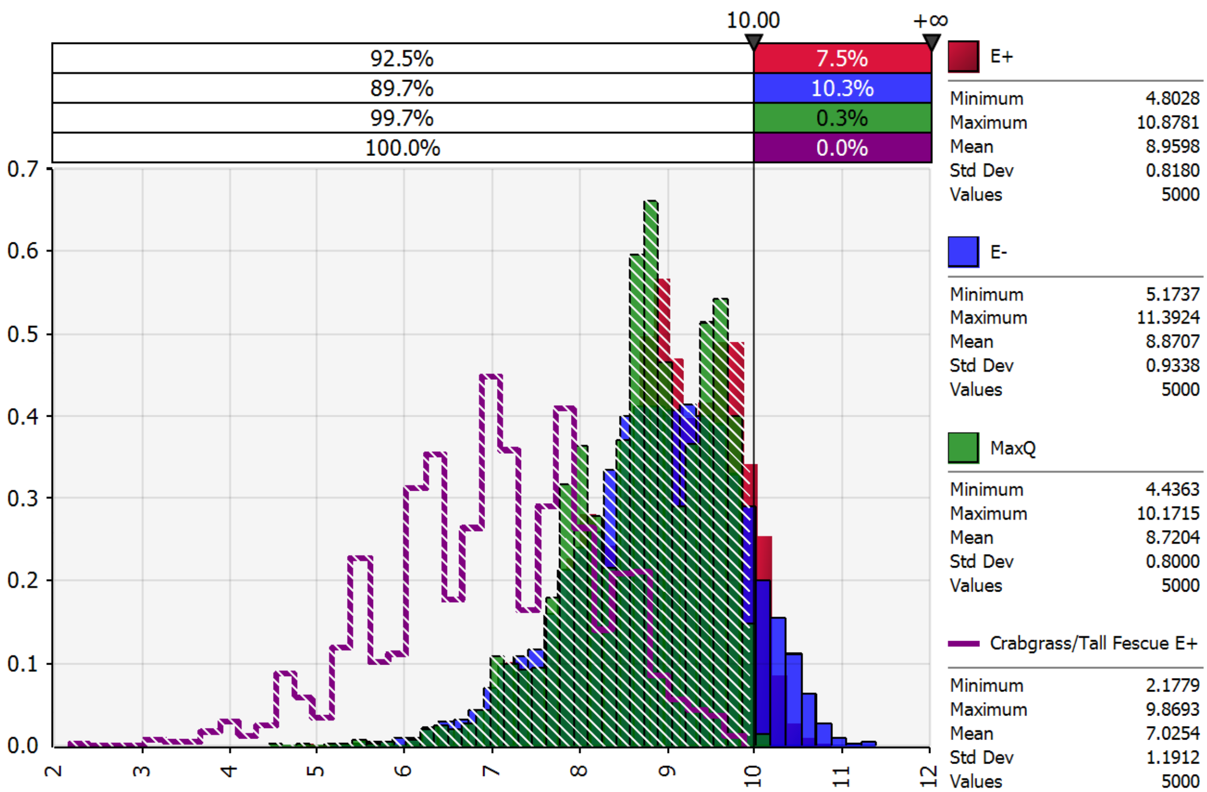
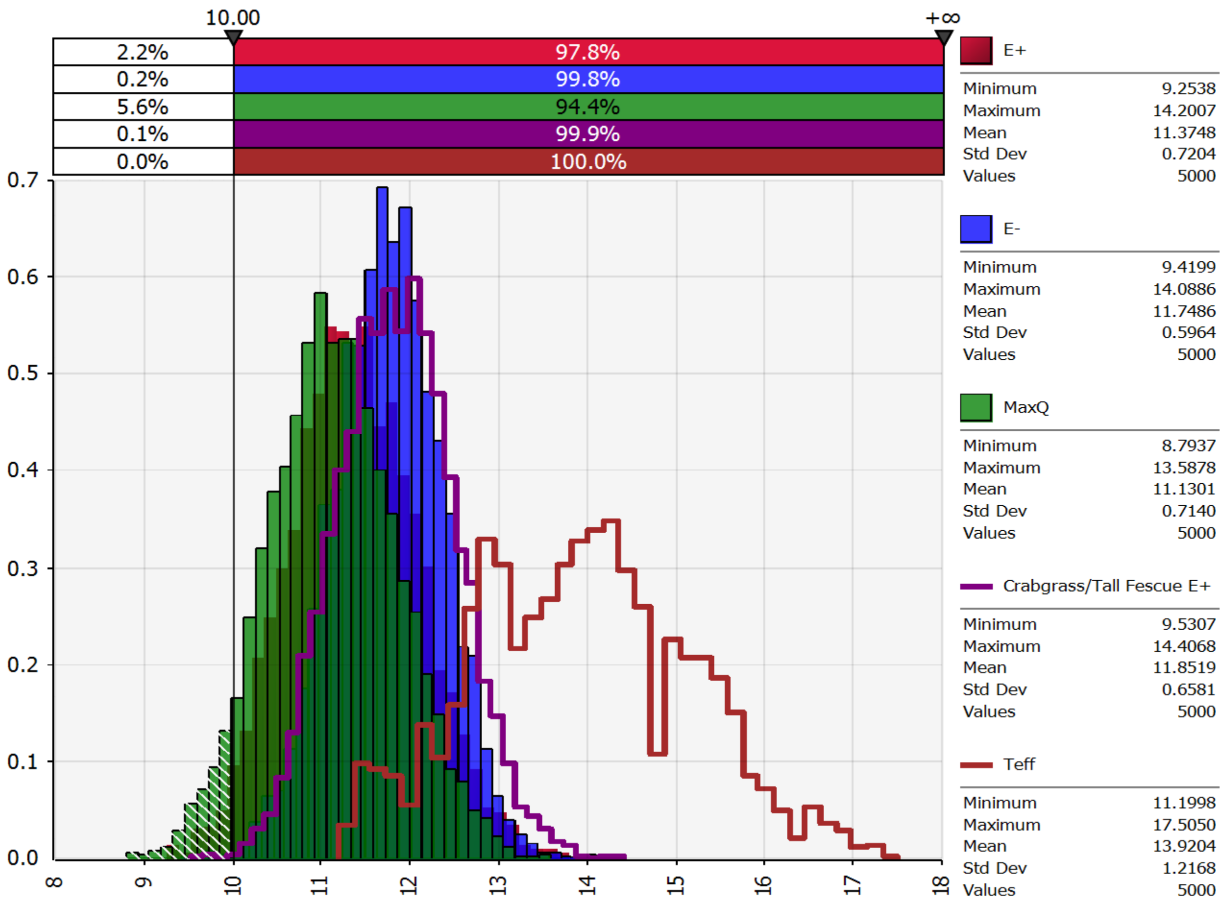


Fig. 4-13. Bootstrap CP distribution of CP from cool-season grasses for September harvest and probability (%) of meeting the objective function of 10%.



Cool-season species CP levels fell below the 10% CP objective function in most instances at the September harvest (Fig 4-13). However, mean values for KY31 E+, KY31 E- and MaxQ treatments hovered just below the minimum requirement of 10%. For the October harvest period, CP values of cool-season treatments greatly increased, meeting minimum requirements in nearly 100% of circumstances (Fig 4-14). The nutrient value of cool-season grasses in the fall was expected to be higher than that of summer, mainly due to the vegetative growth of the grass (Blaser et al., 1986). Although slightly variable, Teff also exceeded the objective function 100% of the time for October.

Fig. 4-14. Bootstrap CP distributions from cool-season grasses and Teff for October harvest and probability (%) of meeting 10%.



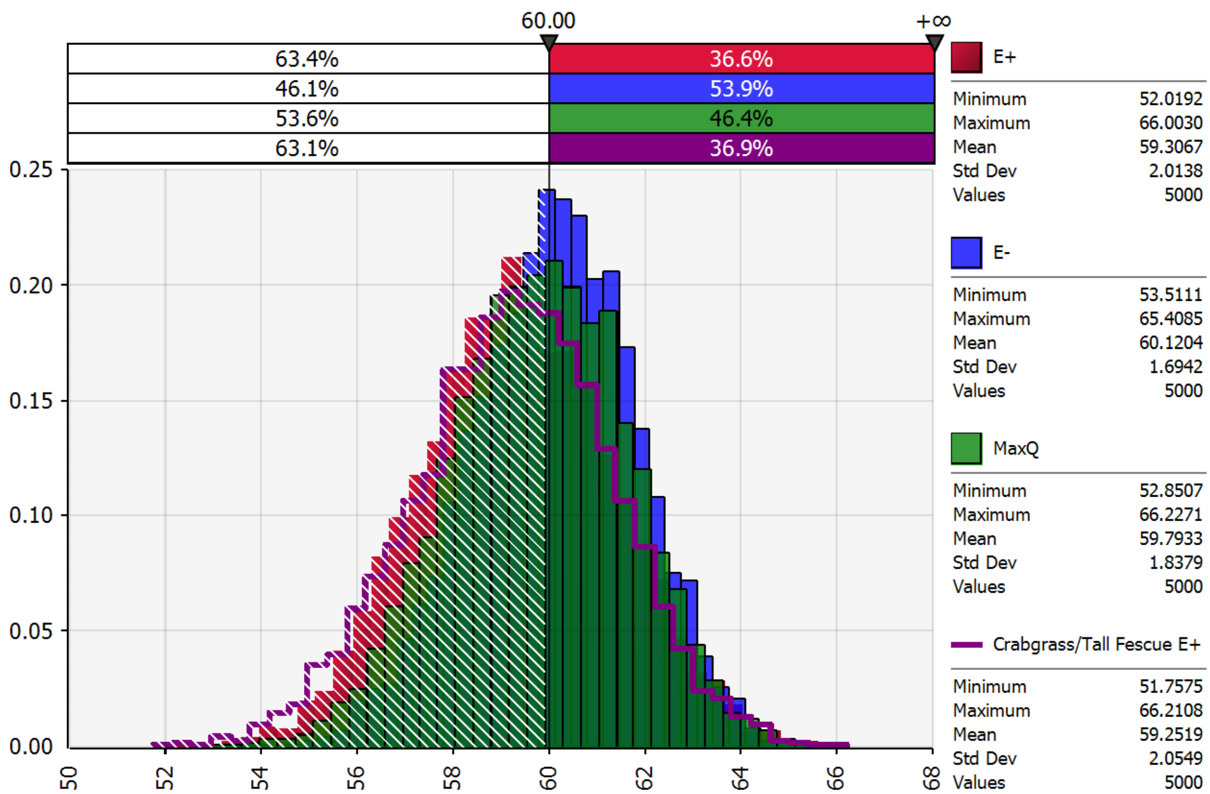
Total digestible nutrients (TDN) values followed a seasonal distribution but were lower when compared to CP for all treatments and failed to meet the objective function at higher probabilities (Table 4-3). With the exception of October for cool-season grasses, TDN values had a lower probability of meeting the objective function of 60% (Fig 4-9 to Fig 4-15).

Table 4-3. Probability (%) of forage species meeting minimum animal requirements for TDN of 60% over the harvest season.

	May	June/July	August	September	October
KY31 E+	36.6	26.2	n/a ǂ	19.9	100
KY31 E-	53.9	64.5	n/a ǂ	1.4	100
Max Q	46.4	67.4	n/a ǂ	0.8	100
CB	n/a ǂ	1	0.3	0	n/a ǂ
Teff	n/a ǂ	67.6	44.8	9.7	69
BG	n/a ǂ	28.9	42.1	0.1	n/a ǂ
Crabgrass/KY31 E+	36.9	84.3	n/a ǂ	0.2	100

ǂ Unable to harvest due to lack of biomass

Fig. 4-15. Bootstrap TDN distributions from cool-season grasses for May harvest and probability (%) of meeting the objective function of 60%.



Cool-season grasses for May harvest met the minimum requirement less than 50% of the time for most species (Fig 4-15). However, mean values of TDN fell just below if not equal to 60% TDN. But relying on only mean values may be a risky choice. Results from a study by Pope and Shumway (1984) conclude that the assumption of constant average forage production may result in grossly exaggerated estimates of expected net returns. This can also apply to forage quality and nutritive values as demonstrated in the distribution functions. At the June harvest, the same holds true (Fig 4-16). While most of the cool-season species increased chances of meeting the 60% minimum TDN value, there is still variation in expected values.

Fig. 4-16. Bootstrap TDN distributions from cool-season grasses for June/July harvest and probability (%) of meeting the objective function of 60%.

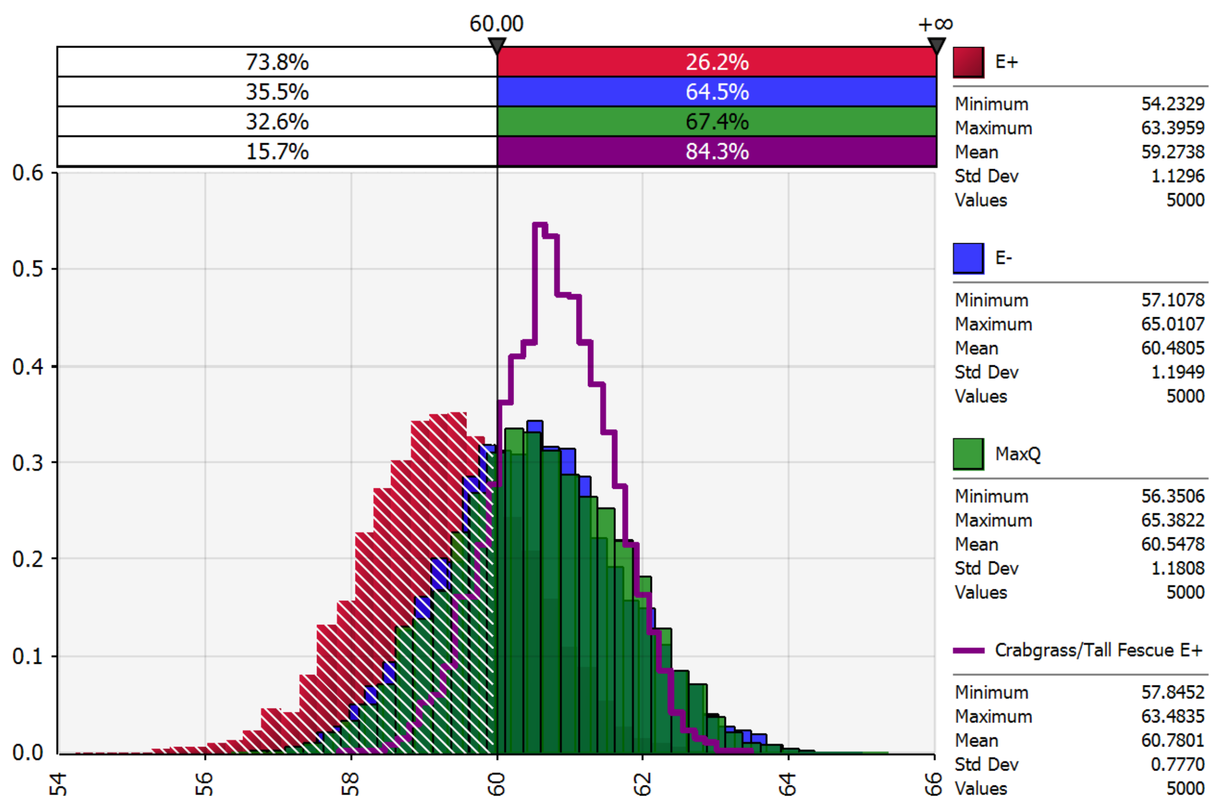


Fig. 4-17. Bootstrap TDN distributions from warm-season grasses for June/July harvest and probability (%) of meeting the objective function of 60%.

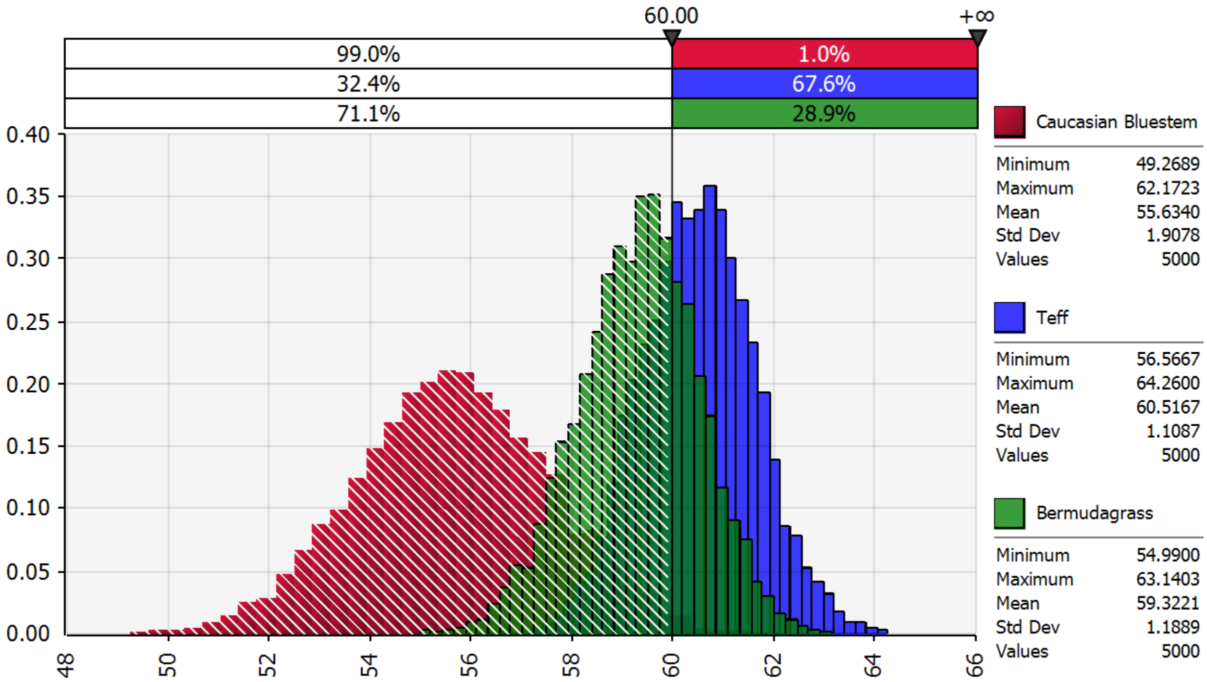
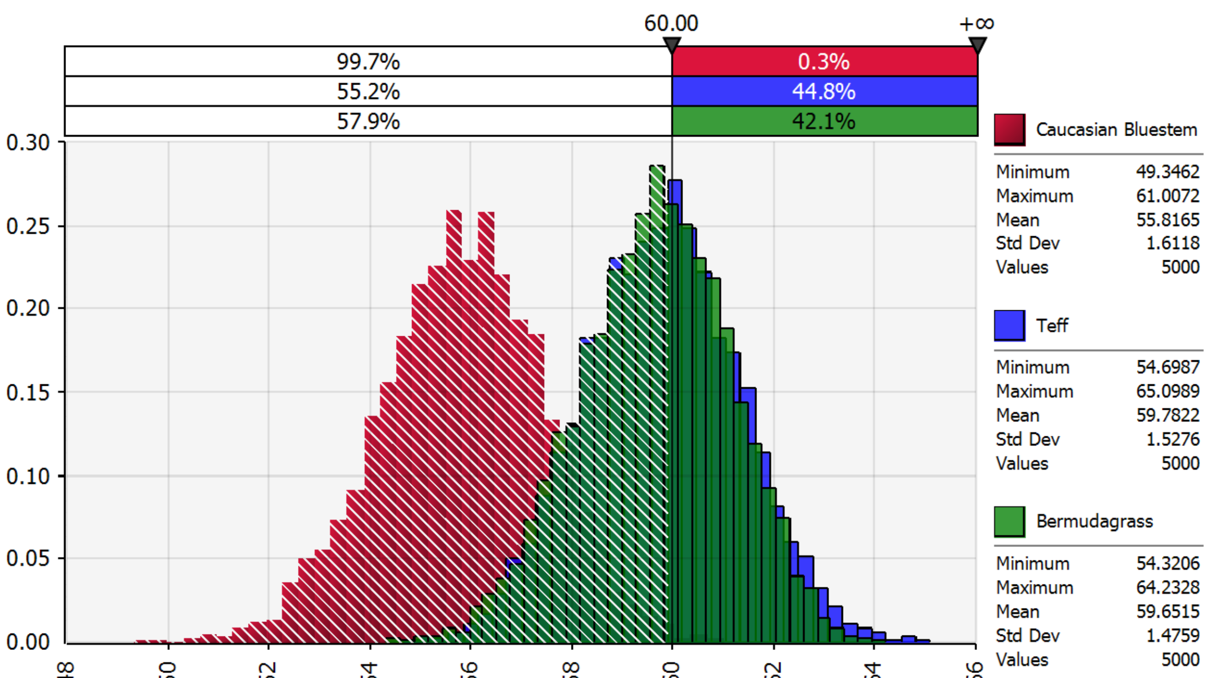


Fig. 4-18. Bootstrap TDN distributions from warm-season grasses for August harvest and probability (%) of meeting the objective function of 60%.



Values of TDN for the warm-season grasses are on average lower than cool-season species at the June/July harvest with the exception of Teff treatments (Fig 4-17). Moore et al. (1980) observed that many warm-season grasses utilizing the C_4 pathway have relatively low digestibilities. In August, values continued to be low with a slight decline of TDN values in Teff (Fig 4-18) and drastically decreased in September (Fig 4-19). However, Teff held a mean value of 53% as compared to 32% for both CB and BG. Similar to CP values, the lower than expected TDN values of BG and CB can be attributed to a high percentage of over mature weeds in the stand. In addition, the standard deviation of distribution for each species increased in September, indicating greater variability and probability of deferring from the objective function. This value is important because it takes into accound how often highs and lows occur (Bastian and Held, 1999), attributing to risk factors.

Fig. 4-19. Bootstrap TDN distributions from warm-season grasses for September harvest and probability (%) of meeting the objective function of 60%.

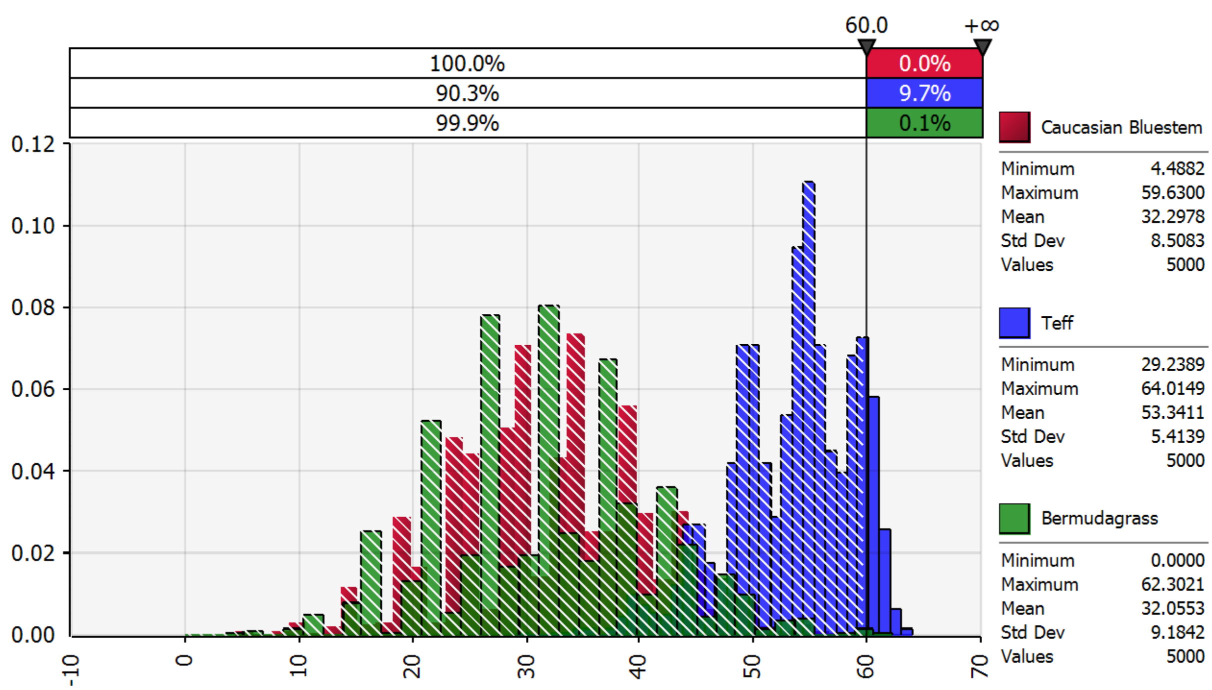
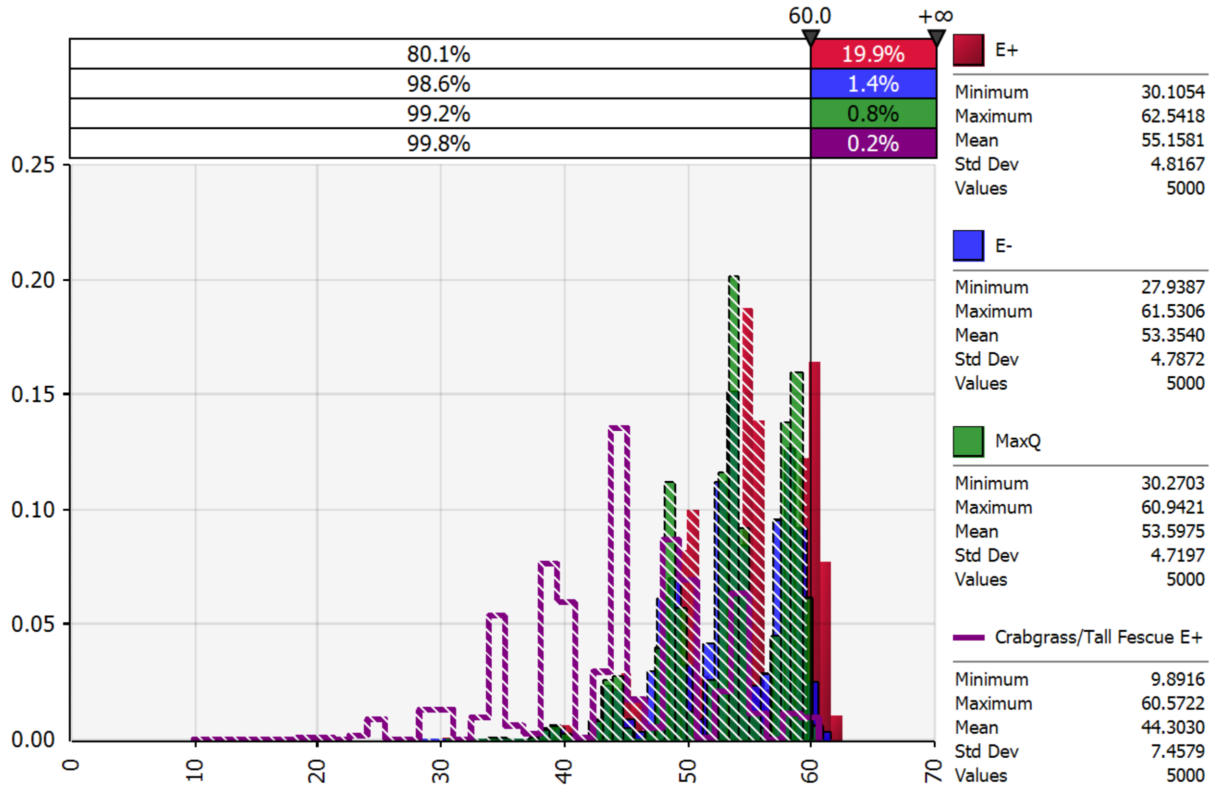
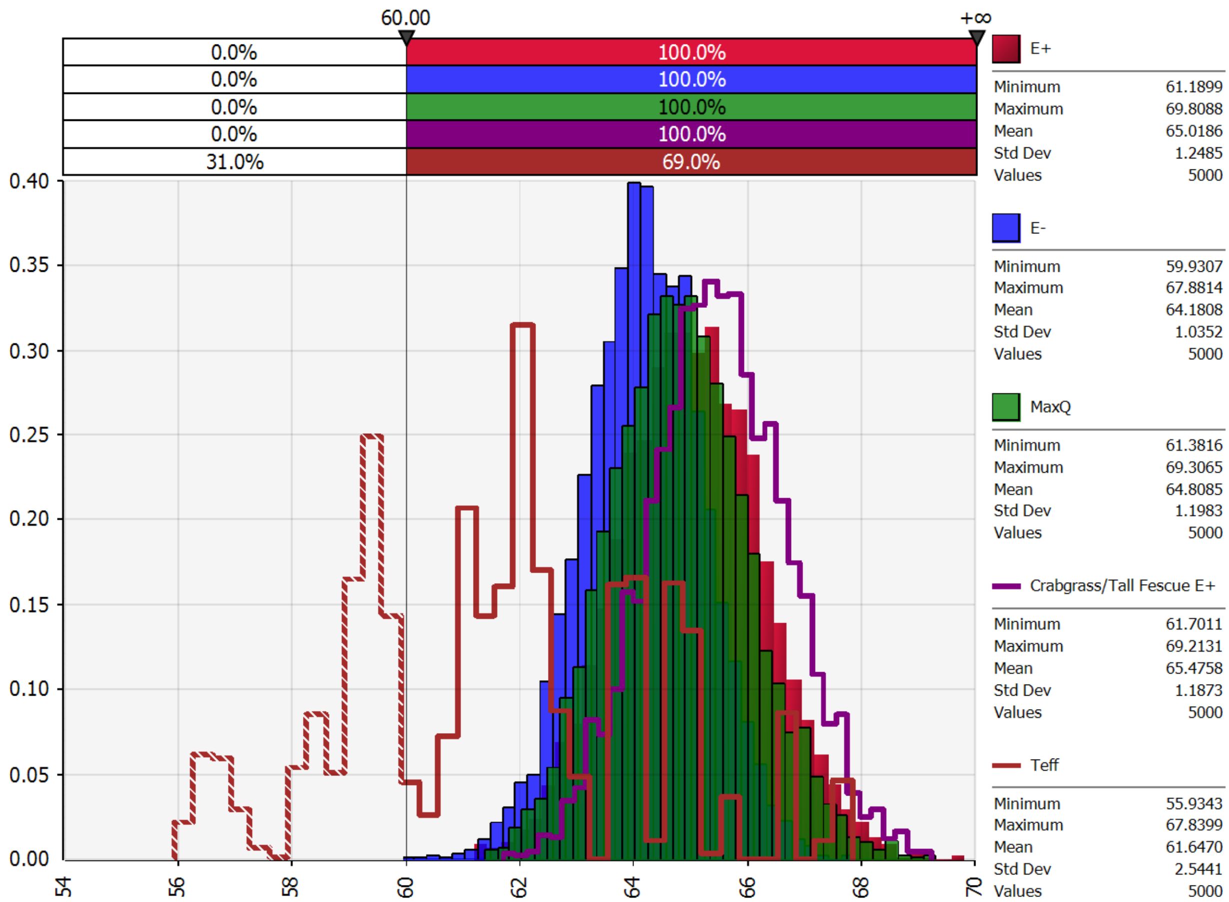


Fig. 4-20. Bootstrap TDN distributions from cool-season grasses for September harvest and probability (%) of meeting the objective function of 60%.



The TDN values for cool-season grasses also drastically decreased for September harvest (Fig. 4-20). There was greater variability within treatments and a higher probability of failing to meet minimum requirements. This distribution follows the expected seasonal pattern of nutritional values for cool-season species (Blaser et al., 1986). As expected, TDN values increased in October for all cool-season treatments and successfully met the objective function in 100% of circumstances (Fig. 4-21). Even Teff treatments obtained a second boost in TDN value near the end of the growing season.

Fig. 4-21. Bootstrap TDN distributions from cool-season and Teff grasses for October harvest and probability (%) of meeting the objective function of 60%.



Summary and Conclusions

Forage producers face the challenge of finding adequate forage to meet animal requirements and make daily decisions based on maximizing profit and production goals with little consideration for variability or risk associated with their choices. Our two year study and the data generated from the study demonstrated a very large variability in forage production. Much of the variability can be attributed to differences due to location, year, establishment and climatic conditions during the growing season. Bootstrap distributions are essential in providing probability functions that cannot be obtained from limited field datasets. Probabilities developed by this technique allow the producer to make management decisions based on likelihood of meeting a pre-determined goal. Without Monte Carlo simulation and the formation of bootstrap distributions, producers would not be able to estimate the probability of success or failure in meeting the objective function. With the objective function defined for this study based on cow-calf operations, warm-season grasses demonstrated a higher probability of meeting the minimum requirements in mid-summer months of July, August and September than cool-season forages. Among the warm-season forages, Teff was most consistent in meeting the minimum requirements for forage biomass, CP and TDN when compared to BG and CB. However, if successfully established and managed to their maximum potential, both BG and CB could help fill the production gap in summer months. Although there is no clear answer to fit every individual, the data and risk management techniques obtained from this study can be interpreted and adjusted to fit individual producer's goal.

References

Abaye, A.O., V.G. Allen, and J.P. Fontenot. 1997. The double DAFOR scale: A visual technique to describe botanical composition of pastures. *In*: Proc. American Forage and Grassland Council, Georgetown, TX. 6:96-100.

Ball, D. M., C. S. Hoveland and G. Lacefield. 2007. Southern forages 4th ed. Potash and Phosphate Institute, Foundation for Agronomic Research, Norcross, Georgia.

Ball, D. M., G. D. Lacefield, N. P. Martin, D. A. Mertens, K. E. Olson, D. H. Putnam, D.J. Undersander, and M. W. Wolf. 2001. Understanding forage quality. American Farm Bureau Federation Pub. 1-01, Park Ridge, IL.

Barnes, R.F., C.J. Nelson, M. Collins, and K.J. More. 2003. Forages Volume 1: An introduction to grassland agriculture (6th Edition). Iowa State University Press, IA.

Barnes, R.F., D.A. Miller and C.J. Nelson. 1995. Forages volume 1: An introduction to grassland agriculture (5th Edition). Iowa State University Press. Ames, Iowa.

Bastian, C., and L. Held. 1999. Enterprise diversification: Will it reduce your risk? Article #2.4, Risk and resilience in agriculture, risk management handbook. Joint Publication Coop. Ext. Serv., of Colo State Univ., Mont. State Univ., and the Univ of Wyo., pp. 1-6.

Blaser, R.E., W.C. Hammes, J.P. Fontenot, H.T. Bryant, C.E. Polan, D.D. Wolf, E.S. McClaugherty, R.G. Kline, and J.S. Moore. 1986. Forage-animal management system. Pages 86-87 in Virginia Agric. Exp. Sta. Bull. Virginia Polytech. Inst. And State Univ., Blacksburg.

Bosworth, S. C., C. S. Hoveland, and G. A. Buchanan. 1985. Forage quality of selected cool-season weed species. Weed Sci. 43:150-154.

Bosworth, S. C., C. S. Hoveland, G. A. Buchanan, and W. B. Anthony. 1980. Forage quality of selected warm-season weed species. Agron. J. 72:1050-1054.

Brodie, J. 1985. Vegetation analysis. *In*: Grassland studies. p. 7-9. George Allen & Unwin, Boston.

Clapham, W.M., J.M. Fedders and C.D. Teustch. 2009. Risk analysis, analysis of variance: Getting more from our data. Forage and Grazinglands doi:10.1094/FG-2009-0331-01-RS.

Clapham, W.M., J.M. Fedders, A.O. Abaye, and E.B. Rayburn. 2008. Forage pasture production, risk analysis, and the buffering capacity of triticale. Agron. J. 100:128-135.

Davison, A.C., and D.V. Hinkley. 1997. Bootstrap methods and their applications. Cambridge Univ. Press, New York.

Efron, B. and R.J. Tibshirani. 1998. An introduction to the bootstrap. Monographs on statistics and applied probability 57. Chapman and Hall/CRC, Boca Raton. p. 40.

Fike, J.H., C.D. Teutsch, and D.L. Ward. 2005. Warm-season grass production responses to site and defoliation frequency. Forage and Grazinglands doi:10.1094/FG-2005-0824-01-RS.

Fleisher, B. 1990. Agricultural risk management. Lynne Rienner Publishers, Boulder, CO.

Fleisher, B. and L.J. Robinson. 1985. Applications of decision theory and the measurement of attitudes towards risk in farm management research in industrialized and third world settings. Department of Agricultural Economics, Michigan State University.

Goering, H.K and P.J. Van Soest. 1970. Forage fiver analysis (apparatus, reagents, procedures and some applications). In: Agriculture handbook No. 379. ARS, USDA, Washington, USA.

Hardaker, J. B., R. B. M. Huirne, J.R. Anderson, and G. Lien. 2004. Coping with risk in agriculture. CABI Publ., Cambridge, MA

Martin, J.M., and R.W. Rogers. 2004. Review: Forage-produced beef: Challenges and potential. Mississippi State University. The Professional Animal Scientist 20:205-210.

Mckinnon, B.R. and H.S. Snodgrass. 2009. Getting started in the cattle business in Virginia. Virginia Cooperative Extension, Virginia Tech. Publication 400-790.

Moore, J.E., J.C. Burns, A.C. Linnerod, and R.J. Moore. 1980. Relationships between the properties of southern forages and animal response. Proc. 37th Southern Pasture and Forage Crop Improvement Conf., Nashville, TN.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7th ed. Natl. Acad. Press, Washington, DC.

Pope, C.A., and C.R. Shumway. 1984. Management of intensive forage-beef production under yield uncertainty. Southern Journal of Agri. Econ. Dec: 37-43

Roseberg, R.J., S. Norberg, J. Smith, B. Charlton, K. Rykbost, and C. Shock. 2005. Yield and quality of teff forage as a function of varying rates of applied irrigation and nitrogen. Oregon State University, Klamath Experiment Station Annual Report 2005:119-136.

SAS. 1982. SAS User's Guide: Statistics. SAS Inst., Inc. Cary, NC.

Scaglia, G., W.S. Swecker Jr., J.P. Fontenot, D. Fiske, J.H. Fike, A.O. Abaye, P.R. Peterson, W. Clapham, and J.B. Hall. 2008. Forage systems for cow-calf production in the Appalachian region. J. Anim. Sci. 86:2032-2042.

Sheath, G.W., R.J.M. Hay, and K.H. Giles. 1987. Managing pastures for grazing animals. Chapter 5 *in* Livestock feeding on pasture. New Zealand Society of Animal Production, Hamilton, NZ. p.145.

Simon, J.L. 1992. Resampling: The new statistics. Resampling Stats, Inc., Arlington, VA

Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Assoc. Off. Anal. Chem. 46:829.

Van Soest, P. J., and R. H. Wine. 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell wall constituents. J. Assoc. Off. Anal. Chem. 50:50.

Vengris, M., M. Drake, W. G. Colby, and J. Bart. 1953. Chemical composition of weeds and accompanying crop plants. Agron. J. 45:213-218.

Vose, D. 2008. Risk analysis: A quantitative guide. John Wiley & Sons Ltd, Chichester, West Sussex, UK.

Zobell, D.R., C. Burrell, and C. Bagley. 1999. Raising beef cattle on a few acres. Utah State University Extension AG-505. EP/09-99/DF

CHAPTER V

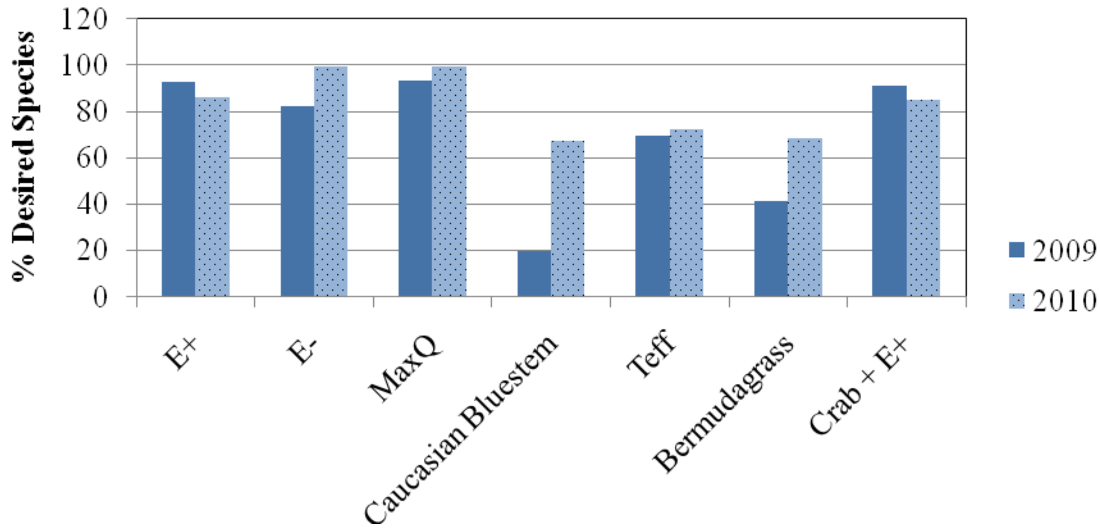
SUMMARY AND CONCLUSION

Producers make daily decisions to manage risk and uncertainty in their operations. Often, decisions are based on maximizing profit and production goals with little consideration for variability or risk associated with their choices. Forage producers often face the challenge of finding adequate forage to meet animal requirements during the summer slump period of decreased cool-season production. This study explored the risk-buffering ability of alternative warm-season forages to fill the summer slump gap in production from cool-season grasses.

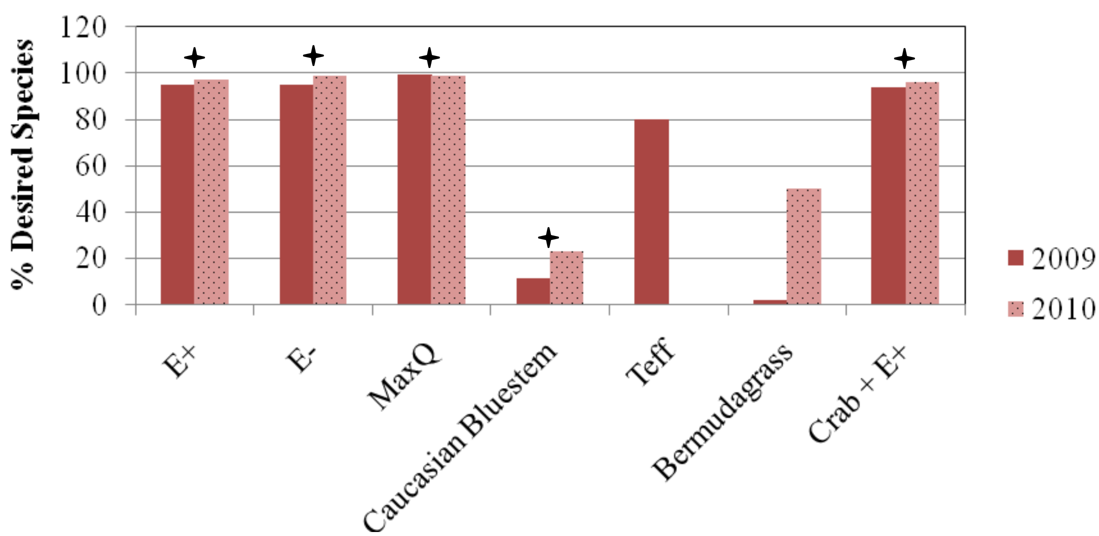
In terms of both biomass yield and nutritive values, differences were found between location, forage species, harvest time and experimental years. Much of the variation in biomass yield and nutritive values were attributed to weather conditions, establishment/management techniques and seasonal forage distribution. In the experiment, these variabilities greatly complicate the decision making process for finding alternative forages in the Appalachian region. However, such variability is common and often the source of risk and uncertainty in meeting daily requirements of livestock. The results of this study showed that both cool- and warm-season grasses, if managed to maximize potential in conjunction with favorable growing conditions, can provide adequate feed and nutritive values to livestock. Cool-season grasses produced adequate amounts of biomass for spring harvests but lacked production for the remainder of the season. Likewise, biomass yield of warm-season grasses was highest in mid-summer. When CP values of cool-season grasses decreased mid-summer, warm-season species provided a buffer at values between 8 and 15 percent dependant on location. Generally, regardless of variability in biomass yields, warm-season grasses, both annual and perennial, produced biomass yields and nutritional values adequate to fill the summer slump from cool-season forages. In most cases, the nutritive values of the forages were highly dependent upon N fertilization, moisture and stage of maturity.

Using bootstrap distributions, field observations were expanded to predict probability of success or failure in meeting a production goal (objective function) over multiple growing seasons. These methods take into consideration the variability in species, location and weather conditions of each year to give a broad scope of the surveyed region. Although recommendations cannot be made with the same confidence in each location, an overview of the region is demonstrated with all uncertainties included. In general, this study shows that with the defined objective function for cow-calf operations, warm-season grasses demonstrated a higher probability of meeting the minimum requirements in mid-summer months of July, August and September than cool-season forages. Teff was most consistent in meeting the minimum requirements for forage biomass, CP and TDN when compared to BG and CB. However, based on previous work, if successfully established and managed to their maximum potential, both BG and CB could help fill the production gap in summer months. Based on the objective function set for the study, forage biomass and quality during mid-summer cannot be met by cool-season grasses. The addition of annual and/or perennial warm-season grasses can be beneficial in providing feed during summer months, thus filling the gap created by cool-season grasses. Although this data cannot provide recommendations to all situations, the data and risk management techniques obtained from this study can be interpreted and adjusted to fit individual producer goals.

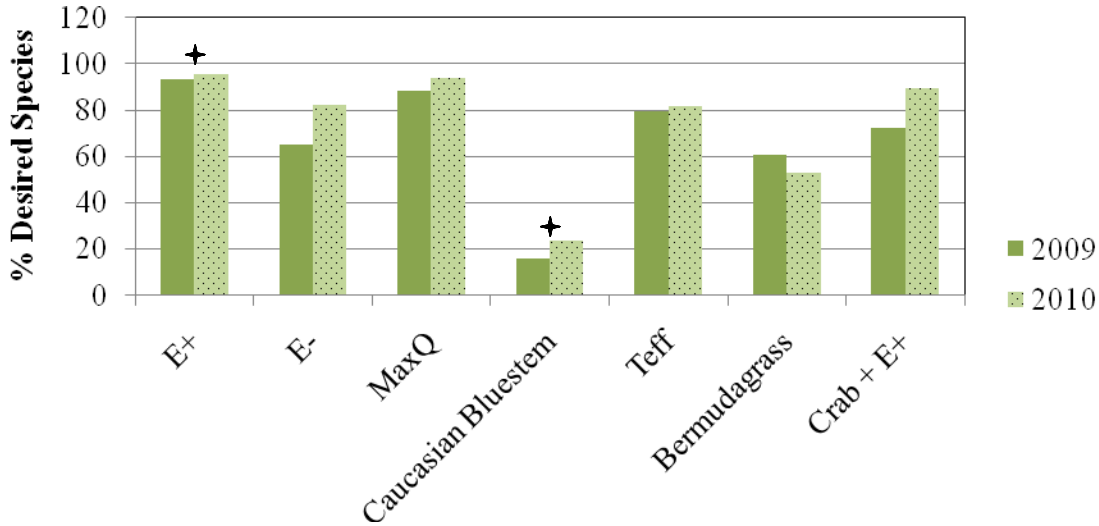
Appendix I-A. Establishment of forage treatments in Kentland for 2009 and 2010.



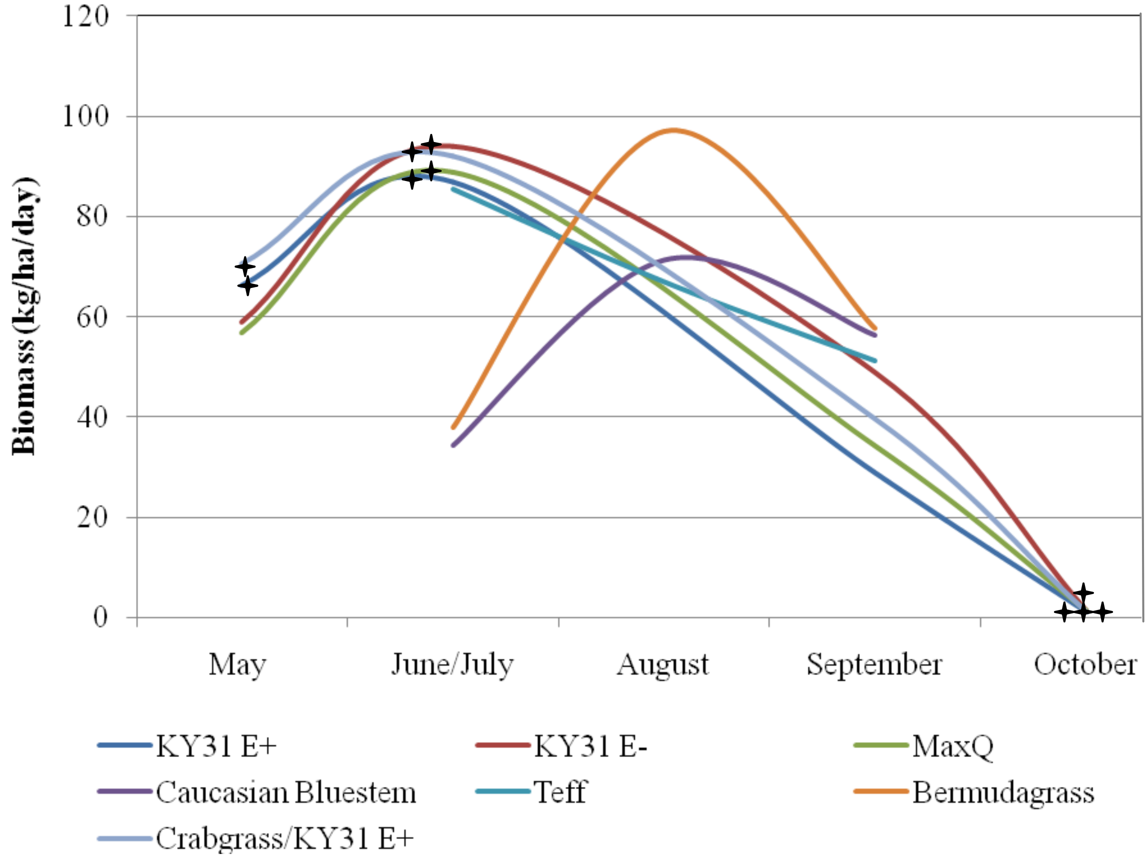
Appendix I-B. Establishment of forage treatments in Northern Piedmont AREC for 2009 and 2010.✦ Indicates significant difference between treatment (p=0.05).



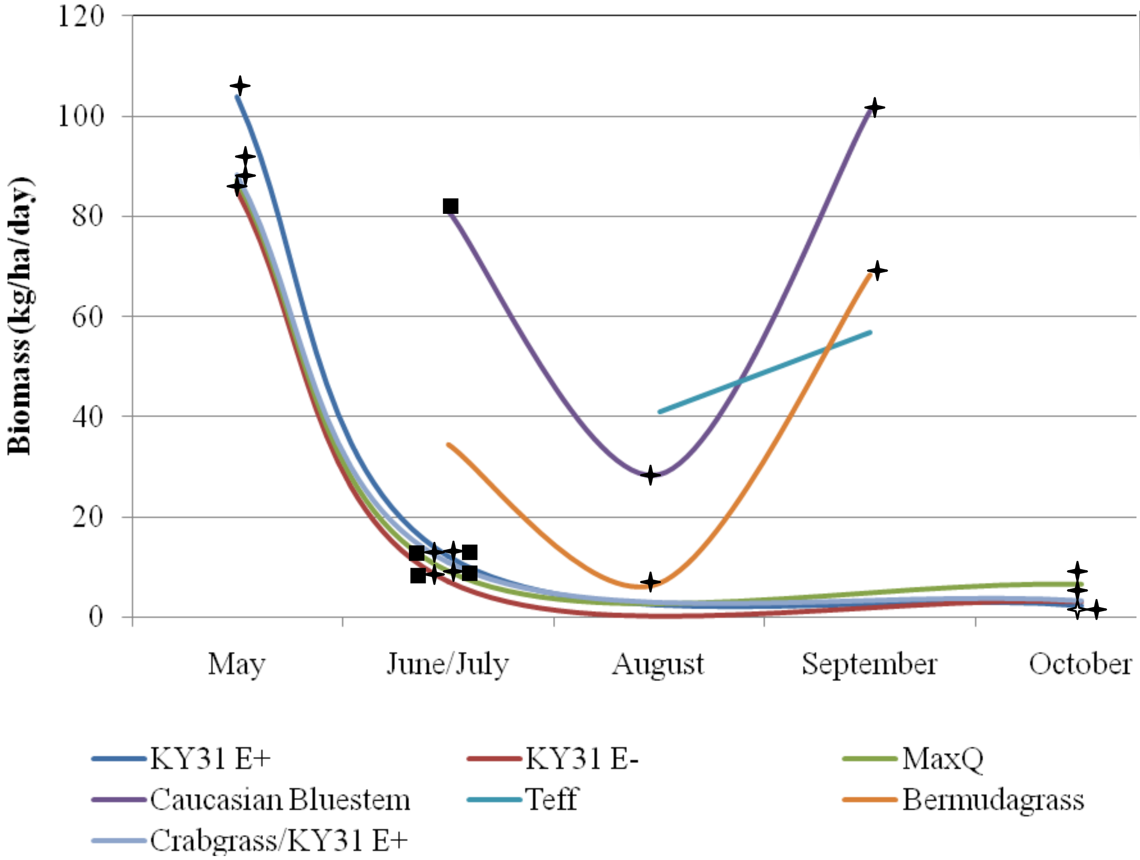
Appendix I-C. Establishment of forage treatments in Shenandoah AREC for 2009 and 2010. ✦ Indicates significant difference between treatment (p=0.05).



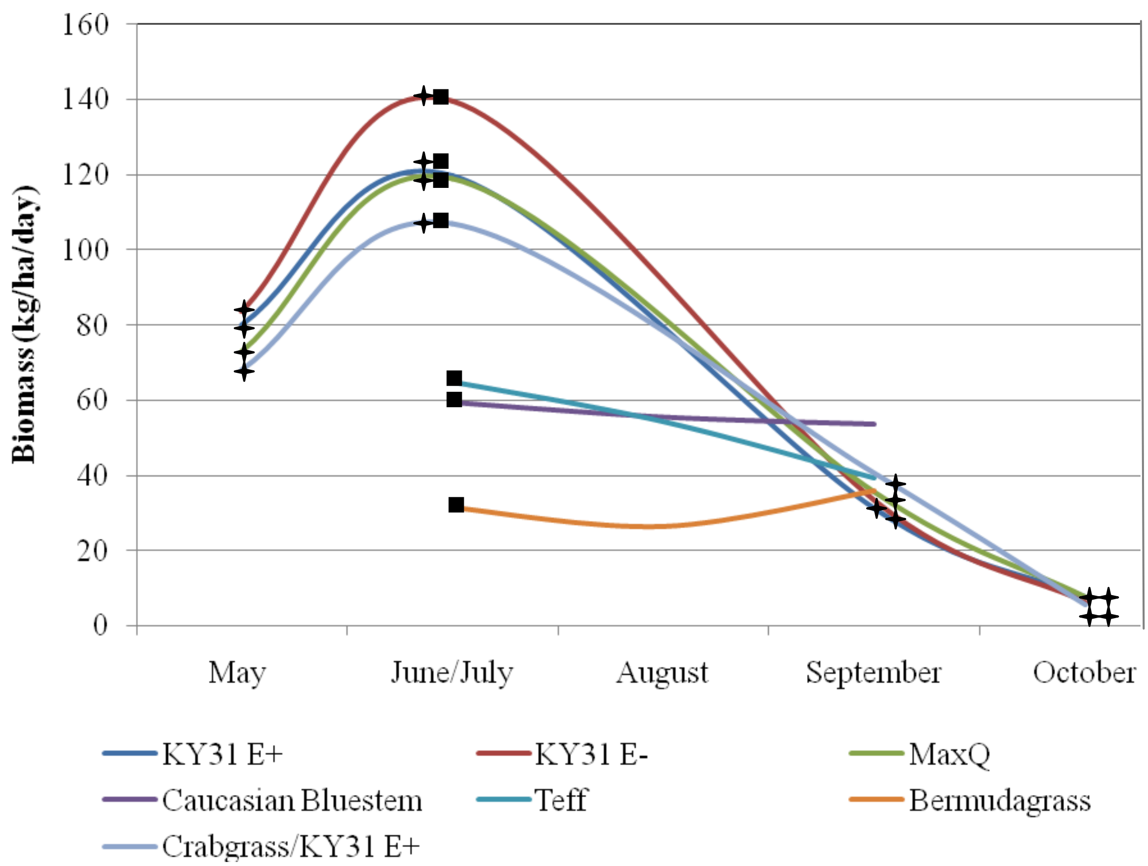
Appendix II-A. Daily biomass yield distribution by treatment across harvest season 2009 in Kentland.✦Indicates significant difference between harvest month (p=0.05).



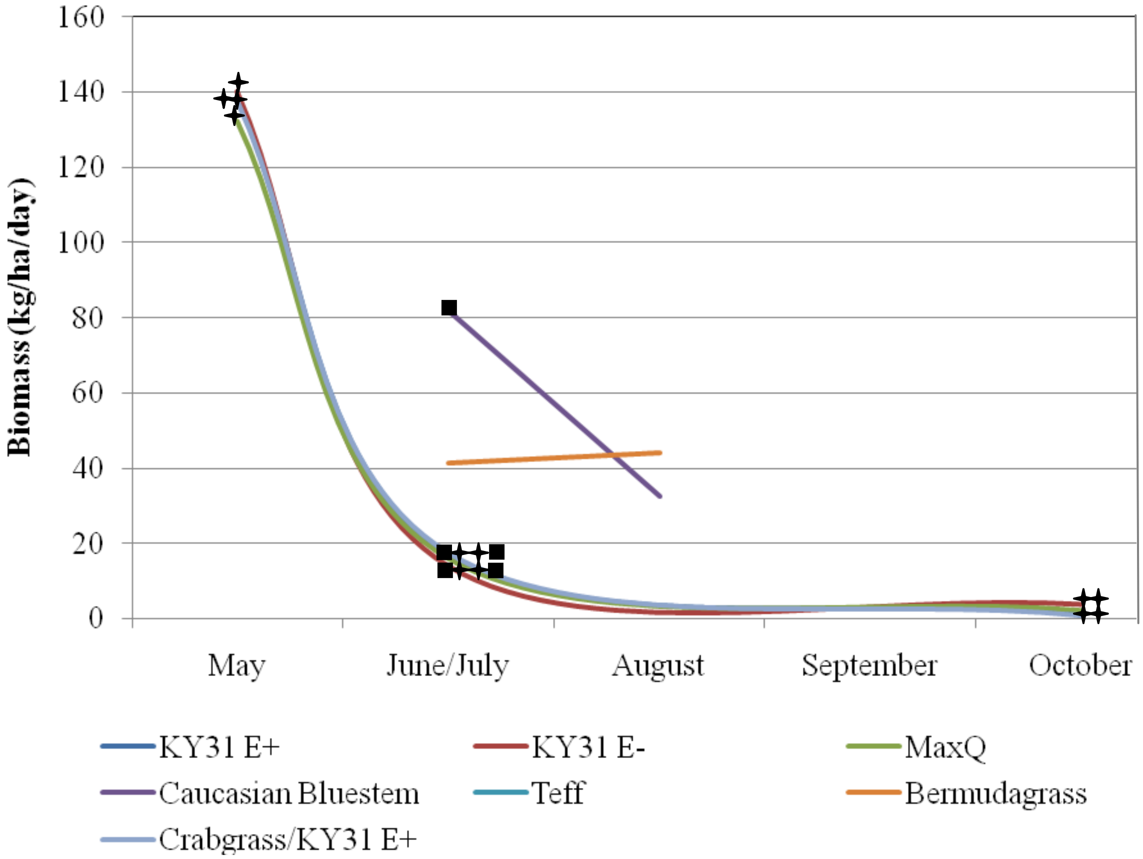
Appendix II-B. Daily biomass yield distribution by treatment across harvest season 2010 in Kentland.✦Indicates significant difference between harvest month (p=0.05).
■ Indicates significant difference between treatments (p=0.05).



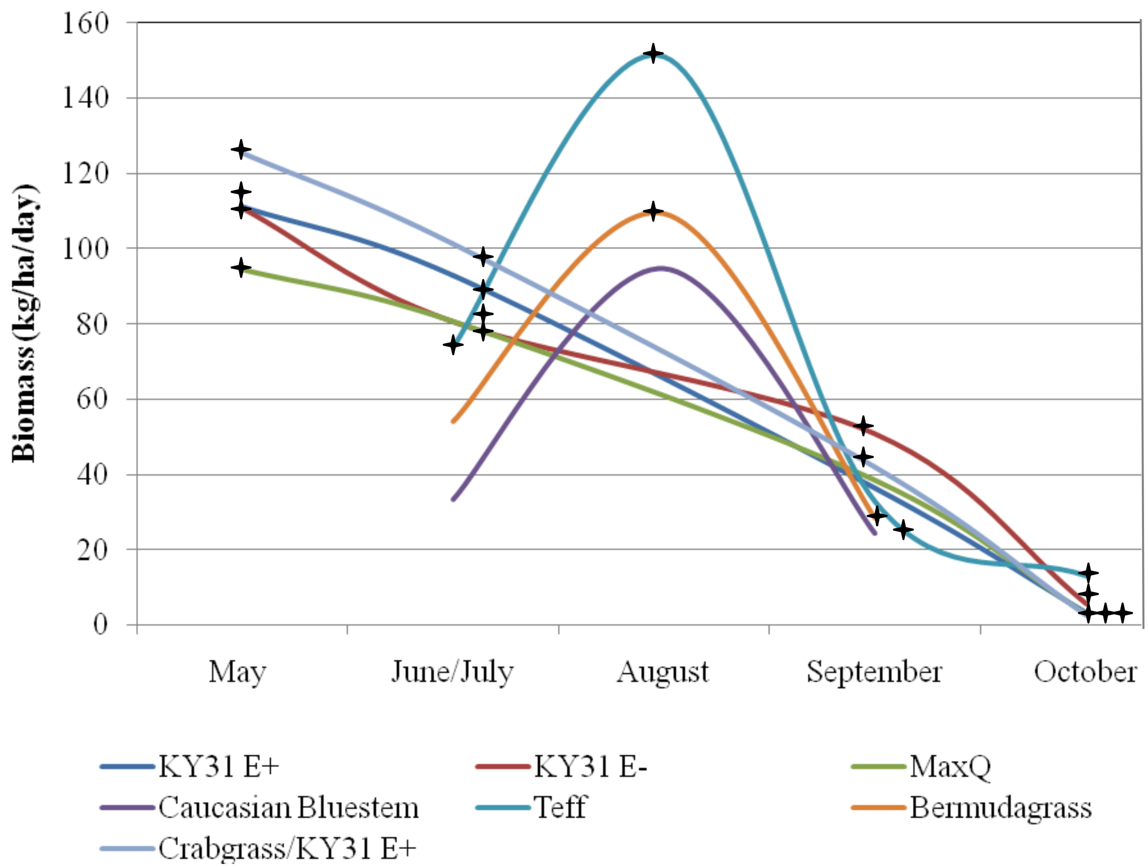
Appendix II-C. Daily biomass yield distribution by treatment across harvest season 2009 in Northern Piedmont AREC.✦Indicates significant difference between harvest month (p=0.05).■ Indicates significant difference between treatments (p=0.05).



Appendix II-D. Daily biomass yield distribution by treatment across harvest season 2010 in Northern Piedmont AREC.✦Indicates significant difference between harvest month (p=0.05).■ Indicates significant difference between treatments (p=0.05).



Appendix II-E. Daily biomass yield distribution by treatment across harvest season 2009 in Shenandoah AREC.✦Indicates significant difference between harvest months (p=0.05).



Appendix II-F. Daily biomass yield distribution by treatment across harvest season 2009 in Shenandoah AREC.✦Indicates significant difference between harvest month (p=0.05). ■ Indicates significant difference between treatments (p=0.05).