September 20, 2024

John Newberry
Department of Environment and Conservation
Division of Water Resources
Davy Crockett Tower
500 James Robertson Parkway, 9th Floor
Nashville, Tennessee 37243-1102

RE: Rule 0400-40-05-.06 (8) on the reissuance of the Biosolids General permit for the land application of biosolids.

Dear Mr. Newberry,

The Tennessee Farm Bureau Federation (TFBF) is an organization of over 695,000 family members with the purpose to represent Tennessee's diverse group of commodity producers across the state. We are proud to be the largest general farm organization in Tennessee. Our policy is developed through a grassroots network of farmer members who identify, research, deliberate, vote on, and adopt policies on various issues related to agriculture and rural living. On behalf of our member producers, we write to support the reissuance of the Tennessee Department of Environment and Conservation (TDEC) Biosolids General permit for the land application of biosolids.

Farmers have a deep and long-standing interest in protecting the environment based on philosophical beliefs and practical self-interest. The environment is essential to all agriculture and our families. The land is typically a farmer's most significant asset and primary source of income. Farmers have every incentive to leave this natural resource in better shape for the next generation. Modern agriculture is environmentally sustainable, and farmers strive to constantly improve the environmental resources in their care while playing a significant role in climate solutions. Success in farming is dependent on the environment. Farmers continually strive to balance earning a living from the land while being stewards of the land, air, and water. Increasingly, farmers are asked to produce more using fewer resources.

According to USDA, across the country net farm income is forecast to decrease by $10.2 billion (6.8 percent) from 2023 to 2024, and net cash farm income is forecast to decrease by $16.3 billion (9.6 percent) compared to the previous year.[i] This is caused by a combination of low commodity prices and high input costs, including fertilizer. Fertilizer costs to farmers have been volatile in recent years, including record highs in 2022. Considering this, farmers need access to alternative fertilizers, such as biosolids, while maintaining healthy soils. Applying biosolids to agricultural fields is a viable alternative to

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commercial fertilizer and using biosolids is a much cheaper option than using commercial fertilizer. Also, biosolids are domestically sourced, while around half of the nitrogen and nearly 80 percent of the potash fertilizer used on its farms in the United States is imported.[ii]

Attached to this letter is a study completed by the University of Tennessee Institute of Agriculture (UTIA) which compared using biosolids, broiler litter, and commercial fertilizer. In summation, the study found that when using appropriate application rates biosolids are a viable alternative to traditional commercial fertilizer. Furthermore, soil tests indicate buildup of metals is not a concern and can provide plants with available metal micronutrients such as copper and zinc. TFBF encourages TDEC to consult with UTIA for questions, concerns, and recommendations for agronomic applications of biosolids.

However, chemical contaminants such as perchlorate and per- and polyfluoroalkyl substances (PFAS) could put farms at risk. As the U.S. Environmental Protection Agency (EPA) provides guidance for such, TFBF supports TDEC requiring wastewater management facilities to test for these chemicals on-site before giving farmers access to biosolids and other substances based on the best available science. TFBF supports the work of the TDEC initiatives surrounding PFAS. Furthermore, TFBF recommends TDEC consider the information provided by these initiatives and guidance from the EPA to be included in the Biosolids General permit as the scientific information becomes available. Farmers and landowners who use biosolids should not be liable if PFAS is detected on their farm as farmers do not manufacture or knowingly spread PFAS on their farms. It is important to note Tennessee farmers are committed to ensuring they grow healthy and affordable food for America's families and the FDA regularly tests food for PFAS.[iii]

Thank you for your consideration.

Sincerely,

Eric Mayberry
President
Tennessee Farm Bureau Federation

Enclosure: *Hay Yield and Forage Quality Following Application of EQ Biosolids, Broiler Litter, and Commercial Fertilizer in Tennessee.*

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[i] U.S. Department of Agriculture, Economic Research Service. (2024, September 5). *Farm Sector Income & Finances: Farm Sector Income Forecast*.
[ii] U.S. Department of Agriculture, Foreign Agricultural Service. (2022, June 30). *Impacts and Repercussions of Price Increases on the Global Fertilizer Market*.
[iii] U.S. Food and Drug Administration. (2024, April 18). *Testing Food for PFAS and Assessing Dietary Exposure*.

Hay Yield and Forage Quality Following Application of EQ Biosolids, Broiler Litter, and Commercial Fertilizer in Tennessee

Final Project Report

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&

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EXECUTIVE SUMMARY

A plot study was conducted at University of Tennessee Research and Education Centers (RECs) in Crossville and Greeneville from 2009 to 2011 to evaluate the yield and forage quality of tall fescue-dominated grass stands to different fertilizer treatments: two spring application rates of broiler litter (2 and 4 tons/acre), four spring application rates of Nashville Metro Exceptional Quality (EQ) biosolids (0.75, 1, 1.5, and 3 tons/acre) augmented with supplemental potassium as recommend by soil tests, chemical fertilizer applied at UT Extension recommended rates based on soil tests (60 lbs/acre of nitrogen in the spring and fall with supplemental phosphate and potassium as recommended by soil tests), and chemical fertilizer applied at a "commonly applied" producer rate (300 lbs of a 19-19-19 blended fertilizer in the spring only). All these treatments were compared with a no fertilizer control. Summary findings are as follows:

- Moderate (1.5 tons EQ biosolids/acre, 2 tons broiler litter/acre) and high (3 tons EQ biosolids/acre, 4 tons broiler litter/acre) spring applications of organic fertilizers generally increased spring hay yields and forage quality compared to the control and were equivalent to the resulted obtained with chemical fertilizers.
- Spring nitrogen availability was 44±8% and 32±7% from the litter and biosolids, respectively.
- Fall hay yield and forage quality were typically similar for all treatments; carryover and release of nitrogen from the spring applied litter and biosolids was negligible.
- Litter and biosolids provide micronutrients. The spring forage concentrations of both copper and zinc increased as the application rate of litter and biosolids increased and were often higher than in the control and/or chemically fertilized plots.

CHAPTER 1 - INTRODUCTION

A primary mission of the University of Tennessee (UT) Extension is to conduct applied research to provide agricultural producers with science-based recommendations. Many farmers are considering alternative fertilizers for pasture and hay fields because of the increasing cost of chemical fertilizers. Poultry litter has been successfully used as an alternative fertilizer for many years. However, the long-term application of litter can led to imbalances in nutrient uptake that impact forage quality and can increase the potential for water pollution from pathogens and phosphorus. Biosolids are treated residuals from municipal wastewater treatment plants (WWTPs) that can also be used as an alternative fertilizer. Biosolids are available in a range of qualities that reflect the degree of treatment to reduce vector attractiveness and lower pathogen and heavy metal concentrations. A heat-dried and pelleted biosolid originating from the Nashville Metro WWTP is marketed in Tennessee by Mannco Fertilizer, Inc. as Top Choice Organic (TCO). TCO meets the EPA's most stringent standards for pathogen and vector attraction reduction and low heavy metal concentrations, qualifying as a an "exceptional quality" (EQ) biosolids (U.S. Environmental Protection Agency 1994). EQ biosolids do not carry the undesirable 30 day grazing restriction of lower quality Class B biosolids that are more commonly available. Odor, water pollution, and forage imbalances may not be as much of a concern with long term use of EQ biosolids as compared with broiler litter. Unlike litter, TCO can likely be blended with traditional chemical fertilizers for single pass application and may eventually be distributed in bulk via Farmer Cooperatives. **The objective of this study was to compare the yield and forage quality and soil response of tall fescue dominated grass stands amended with broiler litter, TCO, and chemical fertilizer.**

CHAPTER 2 - STUDY DESIGN

This study was conducted at the University of Tennessee Greeneville and Plateau Research and Education Centers (RECs) with tall fescue-dominated grass stands. These locations are in the important hay and cattle production regions in Tennessee (**Figure 1**).The experimental design consisted of 20×6 foot plots replicated in four blocks (A-D) (**Figure 2**). Fifteen foot wide alleys were left between the blocks and mowed regularly along with the block perimeters.

Nine plot treatments were investigated (**Table 1**): two spring application rates of broiler litter (2 and 4 tons/acre), four spring application rates of Nashville Metro EQ biosolids (0.75, 1, 1.5, and 3 tons/acre) augmented with supplemental potassium as recommend by soil tests, chemical fertilizers applied at UT Extension recommended rates based on soil tests (60 lbs/acre of nitrogen in the spring and fall with supplemental phosphate and potassium as recommended by soil tests) (Savoy and Joines 2009), chemical fertilizers applied at a “commonly applied” producer rate (300 lbs of a 19-19-19 blended fertilizer in the spring only), and a control with no fertilizer application. All of the fertilizers were applied by hand.

Fertilizers were not re-applied after the first cut of hay. Instead, the plots were mowed at the end of summer to simulate summer pasture grazing, typically within two weeks of beginning the fall plot treatments. Lime was not added to the plots, although soil tests did recommend lime at the Plateau REC. This was not expected to affect yield or forage quality and allowed assessment of the treatment effects on soil pH. Weeds were controlled as-needed following practices recommended by the University of Tennessee Extension (G. Neil Rhodes and William P. Phillips 2012).

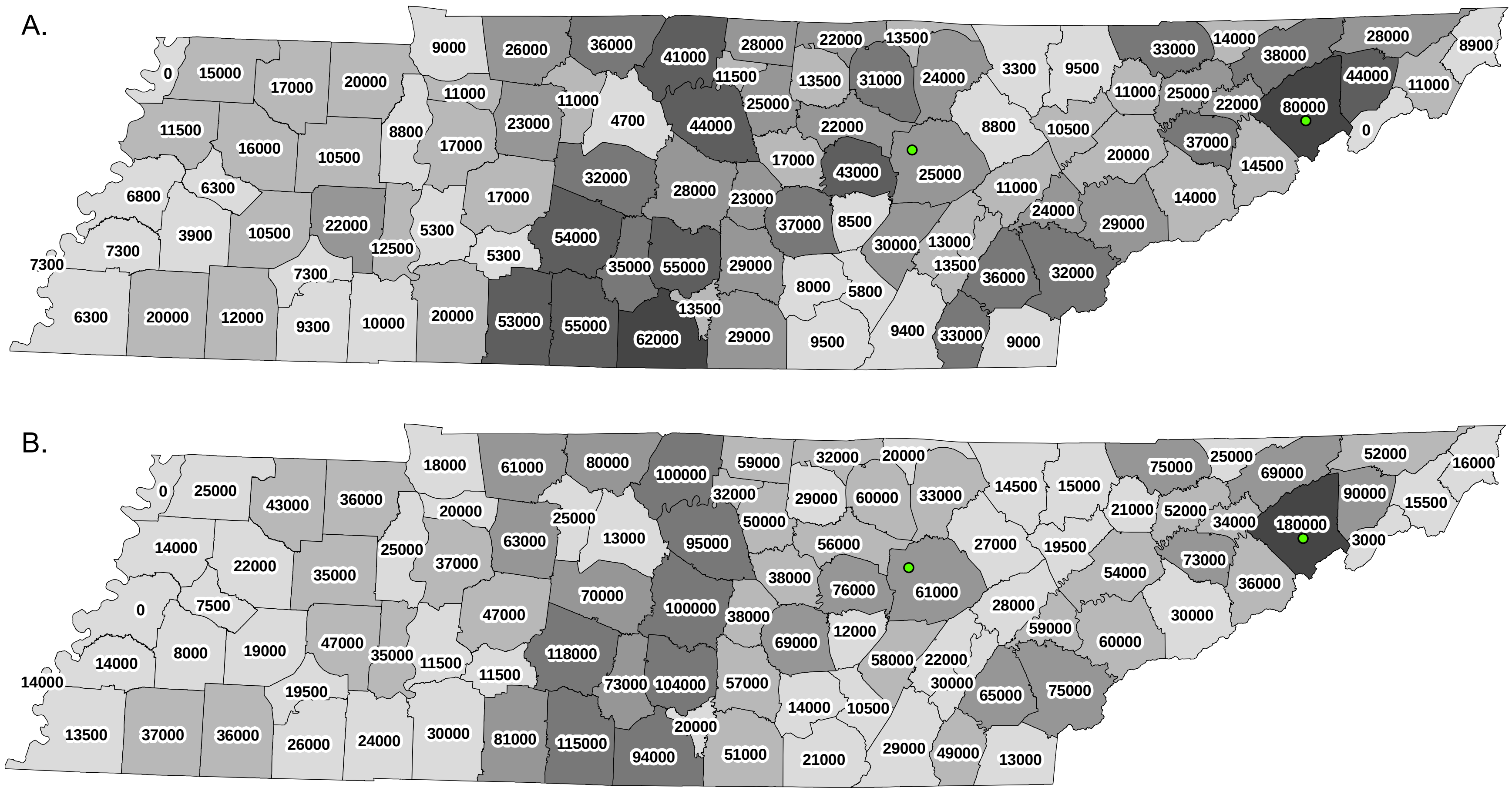

Figure 1. Location of the Greeneville and Plateaus RECs in northeast and north central Tennessee, respectively(green dots). The locations are presented in context of the state's categorical total cattle numbers (A) and hay production (tons) (B) for 2011 (USDA National Agricultural Statistics Service).

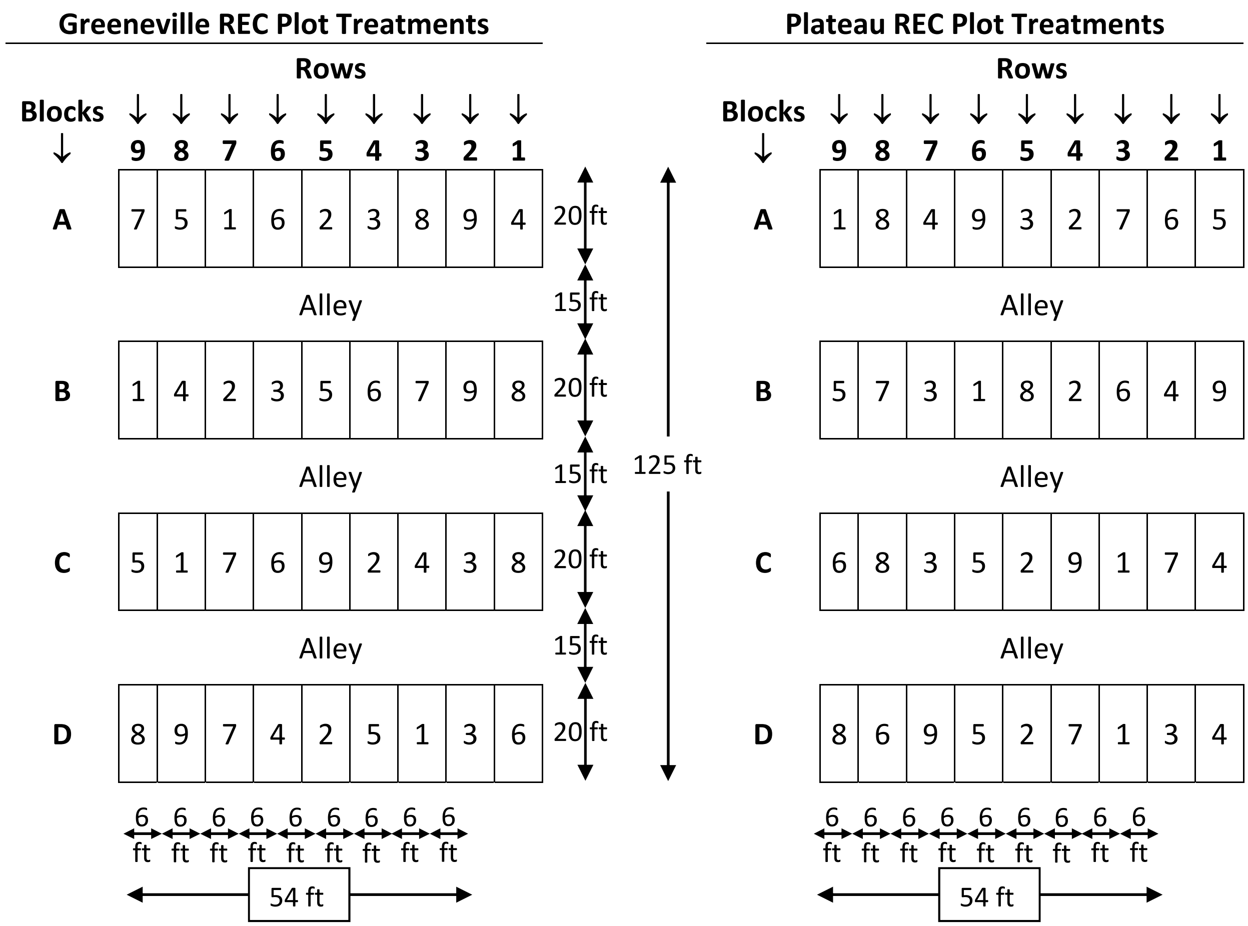

Figure 2. Plot treatment assignments and physical dimensions.

Table 1. Plot treatments and the resulting application rates of primary plant nutrients.

Number	Treatment	Spring lbs/acre			Fall Nitrogen lbs/acre
		Nitrogen	P_2O_5	K_2O	
1	2 ton/acre broiler litter[1]	95-118	95-107	93-114	-
2	4 ton/acre broiler litter[1]	189-235	190-214	185-228	-
3	0.75 ton/acre EQ biosolids + K_2O as needed[2]	62-75	38-39	0-60	-
4	1 ton/acre EQ biosolids + K_2O as needed[2]	83-101	50-52	0-60	-
5	1.5 ton/acre EQ biosolids + K_2O as needed[2]	124-151	75-78	0-60	-
6	3 ton/acre EQ biosolids + K_2O as needed[2]	248-302	150-157	0-60	-
7	Chemical fertilizers based on soil tests[3]	60	0-60	0-60	60
8	Chemical fertilizers using producer practice[4]	58	58	58	-
9	Control	-	-	-	-

1. Litter nutrient application rates were computed from the range of yearly sample analysis results.
2. Biosolids nitrogen and phosphorus application rates were computed from the range of yearly sample analysis results; potassium application rate range reflects the practice of blending muriate of potash with biosolids based on soil test results (biosolids potassium concentrations, as expected, were very low).
3. Nitrogen was applied as urea; application rates of P_2O_5 and K_2O chemical fertilizers were based on soil test results.
4. Blended fertilizer (300 lbs/acre) was composed of 7.5% ammonical nitrogen, 11.5% urea, 19% superphosphate, and 19% muriate of potash.

CHAPTER 3 - HAY YIELD AND FORAGE QUALITY TEST PARAMETERS

Each spring and fall hay was harvested from the plots when the fescue was between the boot and the early head developmental stages. The center three feet of forage was removed from the full plot length and weighed to establish the wet weight yield. Four to five subsamples of the forage were composited, immediately weighed, dried at 105°C for at least 24 hours, and weighed again to establish the dry weight yield. The dried samples were forwarded to Sure-Tech Laboratories (Indianapolis, IN) to measure the forage biochemical makeup and calculate the forage quality metrics. The forage biochemical breakdown included measurements of the crude, available, unavailable, and adjusted protein, fat, neutral and acid detergent fiber, non-fat carbohydrate, and ash. The calculated forage quality metrics included the net energy for maintenance/lactation/gain, total digestible nutrients, and relative forage quality. For reference, these biochemical parameters and quality metrics are described, and their context for beef cattle production is provided, at the beginning of **Appendix D**. Also measured were the major (calcium, phosphorus, potassium magnesium, and sulfur) and trace (copper, manganese, and zinc) minerals and nitrate concentration of the forage samples. For reference, these additional test parameters are described, and their context for beef cattle production is provided, at the beginning of **Appendix E**.

CHAPTER 4 – BIOSOLIDS ANALYSIS RESULTS

Biosolids were collected from the Nashville Metro Biosolids and Wastewater Treatment Facility in Nashville, TN during the spring of 2009-2011 for application to the study plots. EPA 503B analyses were performed on composite biosolids samples (**Appendix A**); results are summarized in **Table 2**.

Primary Plant Nutrients

Total nitrogen concentrations were 80, 85, and 101 lbs/ton in 2009, 2010, and 2011, respectively. Total phosphorus concentrations were 115, 120, and 115 lbs P_2O_5/ton in 2009, 2010, and 2011, respectively. The potassium concentration was low at 5, 4, and 4 lbs/ton as K_2O in 2009, 2010, and 2011. The EQ biosolids tested equivalent to a 5-6-0 fertilizer. If each unit of fertilizer is valued at $0.50/unit, the primary plant nutrients in the biosolids have a value of ≈$76/ton biosolids "as is" assuming the nitrogen and phosphorus are 32 and 100% available (see Chapter 7 which establishes nitrogen availability of the biosolids). In order for the full estimated value to be realized, soil tests should be used to establish a need for the phosphorus.

Metals/Trace Nutrients

The EQ biosolids metal concentrations were well below the EPA 503 pollutant concentration limits (Table 3). This is important because Tennessee agricultural producers frequently express concerns about using biosolids as a fertilizer and soil amendment because of the effect of high metal concentrations. The biosolids are a potential source of micronutrients that are deficient in Tennessee soils/or and forages: 0.7 and 1.1 lbs/ton of copper and zinc, respectively.

Table 2. Biosolids analysis results.

Component			EPA 503 Regulatory Limits (mg/kg)[1]	2009		2010		2011	
				(mg/kg)[1]	(lbs/ton)[2]	(mg/kg)[1]	(lbs/ton)[2]	(mg/kg)[1]	(lbs/ton)[2]
Nutrients	Nitrogen (as N)	Ammonia	-	-	5	-	5	-	6
		Organic	-	-	78	-	80	-	95
		Total	-	-	83	-	85	-	101
	P_2O_5-lbs/ton		-	-	120	-	115	-	120
	K_2O-lbs/ton		-	-	10	-	7	-	7
Metals	Cadmium		39	1.0	-	0.82	-	0.87	-
	Chromium		1,200	145	-	52.2	-	44.3	-
	Copper		1,500	433	0.87	344	0.69	314	0.63
	Lead		300	38	-	28.1	-	34.8	-
	Zinc		2,800	653	1.3	537	1.07	566	1.13
Physical Properties	% Moisture		-	3.8 %		6.5%		2.5%	
	pH		-	7.2		7.2		7.3	

1. Regulatory limits are the "Pollutant Concentration Limits" for EQ biosolids on a dry weight basis.
2. Wet weight basis.

CHAPTER 5 - BROILER LITTER ANALYSIS RESULTS

Broiler litter was collected from a storage building at a Greene County Tennessee farm during the spring of 2009-2011 for application to the study plots. One to three composite samples were analyzed for nutrient and metal concentrations (**Appendix B**); results are summarized in **Table 3**.

Primary Plant Nutrients

A composite sample of the litter applied in the spring 2009 contained 59 lbs N/ton, 54 lbs P_2O_5/ton, and 51 lbs K_2O/ton. Three replicate composite samples of the litter applied in the Spring 2010 contained 47 ± 7 lbs N/ton, 50 ± 1 lbs P_2O_5/ton, and 44 ± 3 lbs K_2O/ton on an "as is" basis. Three replicate composite samples of the litter applied in the Spring 2011 contained 51 ± 4 lbs N/ton, 48 ± 4 lbs P_2O_5/ton, and 46 ± 7 lbs K_2O/ton on an "as is" basis. Thus, the litter was the equivalent of a 2.5-2.5-2.5 fertilizer. If each unit of fertilizer is valued at $0.50/unit, the value of the primary plant nutrients in the litter averaged ≈$61/ton assuming the nitrogen is 44% available and the phosphorus and potassium are 100% available (see Chapter 7 which establishes nitrogen availability of the broiler litter). In order for the full estimated value to be realized, soil tests should be used to establish the need for potassium and phosphorus.

Metals/Trace Nutrients

Total concentrations of copper and zinc in litter were comparable to the EQ biosolids: 0.9 and 0.6 lbs ton, respectively (**Table 3**). As was noted for the biosolids analysis, soil and forage copper and zinc deficiencies may be improved with regular application of broiler litter. Improvements in the forage deficiencies for these micronutrients would depend on whether they are in a plant available.

Table 3. Broiler litter analysis results (lbs/ton "as is").

Component			2009	2010				2011			
				1	2	3	Mean ± SD	1	2	3	Mean ± SD
Nutrients	Nitrogen (as N)	NO_3^-	0.1	0.2	0.1	0.1	0.1 ± 0.1	0.1	0.3	0.1	0.2 ± 0.1
		Ammonia	11.8	6.3	7.3	6.7	6.8 ± 0.5	4.9	6.7	15.4	9.0 ± 5.6
		Organic	46.9	38.7	33.8	48.6	40 ± 7.5	43.2	42.6	40.3	42 ± 1.5
		Total	58.8	45.2	41.2	55.4	47 ± 7	48.2	49.6	55.8	51 ± 4.0
	P_2O_5		53.6	50.8	49.9	49.9	50 ± 1	50.4	49.0	43.1	47.5 ± 3.9
	K_20		50.6	52.3	53.7	57.1	44 ± 3	53.0	46.7	39.4	46.4 ± 6.8
Metals	Calcium		56.4	49.6	44.2	47.2	47.0 ± 2.7	46.0	46.8	36.6	43.1 ± 5.1
	Magnesium		10	11.4	11	11	11.1 ± 0.3	8.6	8.2	6.8	7.9 ± 0.9
	Sulfur		11	10.1	9.8	10.4	10.1 ± 0.2	8.4	8.8	7.0	8.1 ± 0.9
	Iron		0.6	2.6	1.3	1.0	1.6 ± 0.9	0.36	0.61	0.34	0.4 ± 0.2
	Manganese		0.9	1.3	0.9	1.0	1.1 ± 0.2	0.78	0.84	0.55	0.7 ± 0.2
	Zinc		0.6	0.6	0.6	0.7	0.6 ± 0.2	0.58	0.51	0.42	0.5 ± 0.1
	Copper		1.0	1.0	1.1	1.3	1.1 ± 0.2	0.89	0.72	0.56	0.7 ± 0.2
Physical Properties	% Moisture		35.9%	39.2%	42.3%	37.2%	40% ± 3%	41.9%	38.4%	52.7%	44% ± 8%
	pH		8.7	8.9	9.0	9.1	9.0 ± 0.1	8.9	8.7	8.2	8.6 ± 0.4

CHAPTER 6 - HAY YIELD

Statistical Analyses

Spring and fall hay yield data are summarized in **Appendix C**. For each harvest an analysis of variance (ANOVA) was conducted to test the null hypothesis that the plot treatments resulted in equivalent dry hay yields (**Table 4**). Where ANOVA rejected the null hypothesis, a Tukey Honestly Significant Differences (HSD) analysis was used to delineate significant differences (**Table 4**; **Figure 3** and **Figure 4**).

Spring Hay Yields

The study clearly indicates that dry hays yields will increase as the application rate of the EQ biosolids increases (**Figure 3**). For example, in 2009 yields were 1.0 $\pm$ 0.2, 1.3 $\pm$ 0.3, 1.6 $\pm$ 0.3, and 2.0 $\pm$ 0.1 tons/acre (Greeneville REC) and 2.3 $\pm$ 0.4, 2.4 $\pm$ 0.6, 2.6 $\pm$ 0.4, and 2.9 $\pm$ 0.3 tons/acre (Plateau REC) at 0.75, 1, 1.5 and 3 tons/acre of EQ biosolids, respectively. Mean yields for the moderate (1.5 tons/acre) EQ biosolids application rate were always numerically higher than yields for the control plots; the increased yield was statistically significantly in four out of six test years (**Figure 3**). Mean yields with the moderate EQ biosolids application rate were not significantly different from the chemical fertilizer treatments (**Figure 3**).

Dry hay yields also increased with increasing litter application rates (**Figure 3**). Mean yields for the moderate (2 tons/acre) litter application rate were always higher than the control plot yields; the increased yield was statistically significantly in four out of six test years (**Figure 3**). Mean yields with the moderate litter application rate were always similar to the yields for the two chemical fertilizer treatments (**Figure 3**).

Table 4. Hay yield statistical analyses (shaded results confirm that statistically significant differences in the yields were observed: p-value<0.05).

Season	Location	2009			2010			2011		
		ANOVA F-ratio	p-value	Tukey HSD Difference	ANOVA F-ratio	p-value	Tukey HSD Differences	ANOVA F-ratio	p-value	Tukey HSD Difference
Spring	Greeneville REC	7.55	<0.001	Yes	15.7	<0.001	Yes	9.105	<0.001	Yes
	Plateau REC	3.04	0.001	Yes	9.53	<0.001	Yes	13.88	<0.001	Yes
Fall	Greeneville REC	4.61	<0.001	Yes	4.124	0.003	Yes	0.884	0.542	-
	Plateau REC	0.59	0.78	-	1.823	0.116	-	1.223	0.324	-

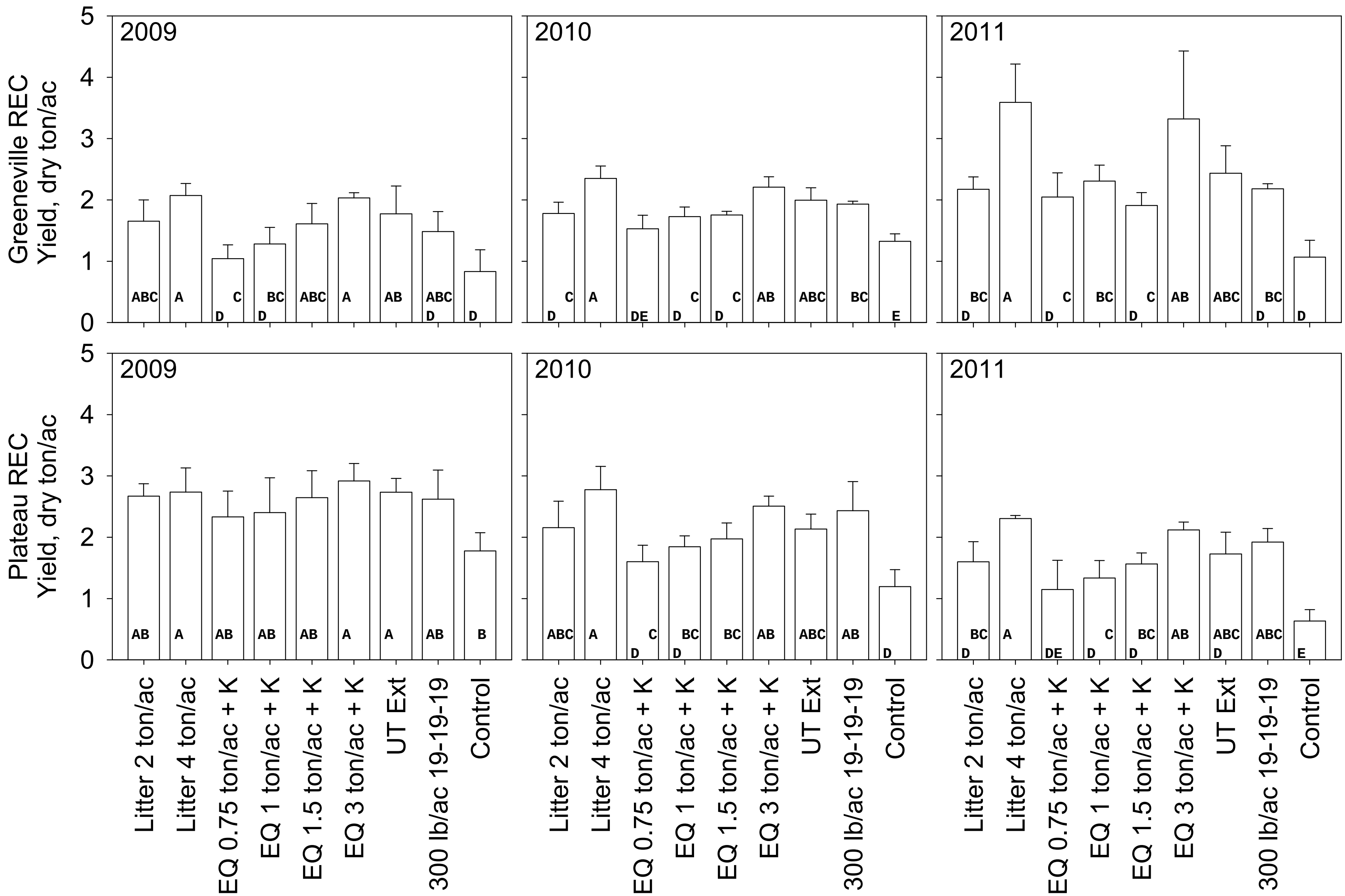

Figure 3. Spring forage yields. For each season and location, bars not sharing a common letter are significantly different.

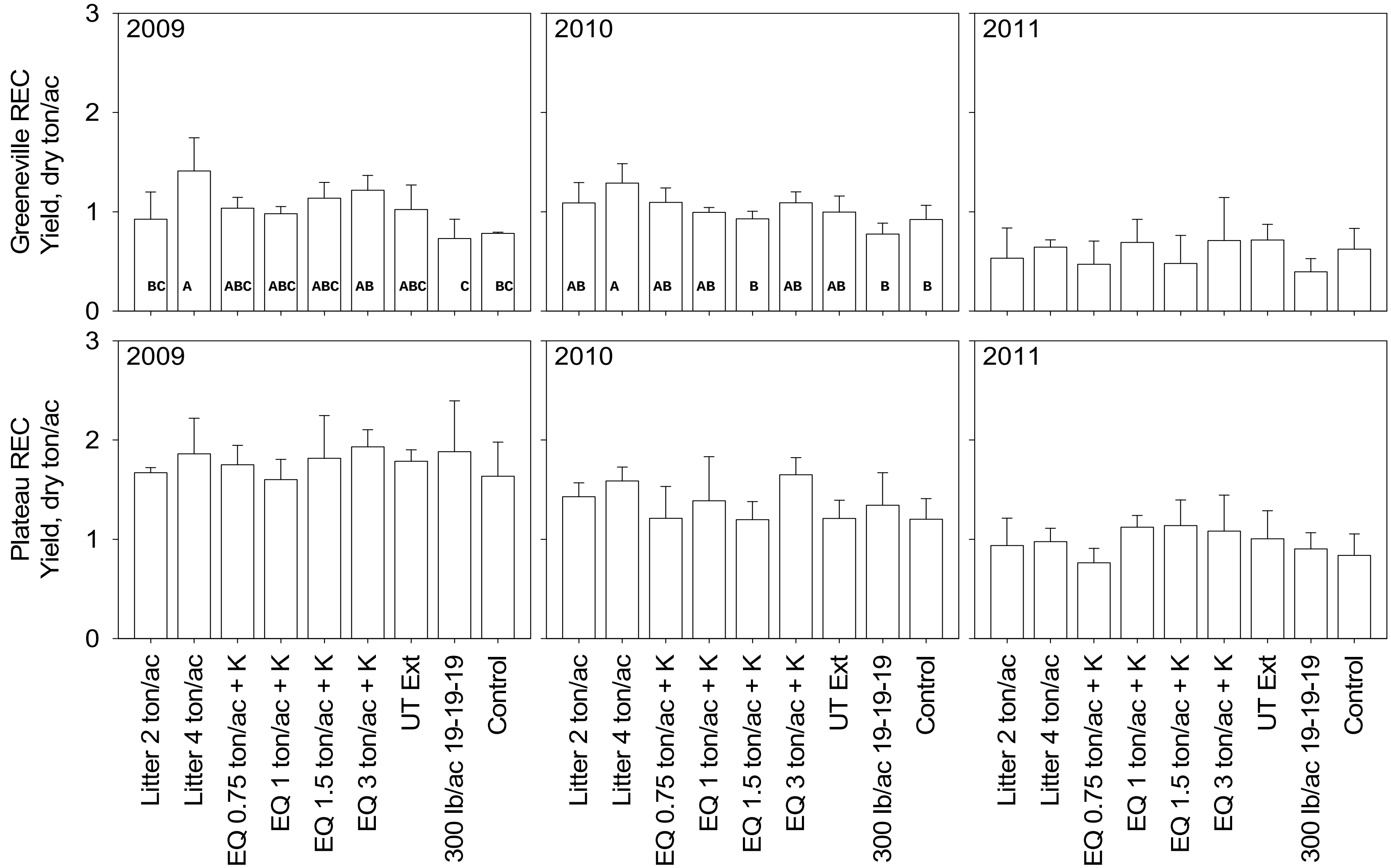

Figure 4. Fall forage yields. For each season and location, bars not sharing a common letter are significantly different.

In all six test years the mean yield with the highest application rates of biosolids and litter were statistically higher than for the control plots (**Figure 3**). In all test years the mean yield for the high application rates of EQ biosolids and litter were not significantly different from the chemical fertilizer applied at UT Extension recommended rates (**Figure 3**). Mean yields for the plots amended with the two chemical fertilizer treatments were the same (**Figure 3**). The unfertilized control always had the lowest yield and was similar to the lowest application rate of the EQ biosolids (0.75 tons/acre) (**Figure 3**).

Fall Hay Yields

The only plots that received additional fertilizer in the fall were the UT Extension chemical fertilizer treatment: 60 lbs of urea-N/acre. In four out of six test years, there were no statistically significant differences in the fall dry hay yields (**Figure 4**). The only statistically significant differences in fall yields were in 2009 and 2010 with the high litter rate (4 tons/acre) (**Figure 4**). This suggests there was a negligible yield effect due to the carryover of organic nitrogen from the spring application of the biosolids and litter.

CHAPTER 7 – SPRING NITROGEN AVAILABILITY OF ORGANIC FERTILIZERS

Spring forage yields are plotted as a function of the total nitrogen applied in **Figure 5**. Increasing yields for the increasing application rates of biosolids and litter are clearly evident, as are the virtually identical yields obtained with Treatment 7 (60 lbs of urea plus P_2O_5, and K_2O according to soil test recommendations) and Treatment 8 (300 lbs of a blended triple 19 fertilizer). A key factor in evaluating the monetary value of the biosolids and litter is nitrogen availability (phosphorus and potassium are not yield limiting in this study design). To estimate nitrogen availability of the organic fertilizers, the overall mean yield for Treatments 7 and 8 (Y_{CHEM}) were first computed for each test year and location: 1.6, 2.0, and 2.3 tons/acre in 2009, 2010, and 2011 respectively at the Greeneville REC, and 2.7, 2.3, and 1.8 tons/acre in 2009, 2010, and 2011, respectively, at the Plateau REC. The overall chemical fertilizer mean was then input into regression lines of the dry hay yield response to the control and biosolids **(Figure 6**) and litter (**Figure 7**) treatments. Nitrogen availability was then determined for the biosolids and litter by solving the following equation:

$$\text{N-availability} = \frac{\frac{Y_{CHEM} - b}{m}}{\bar{X}_{CHEM}}$$

Where:

Y_{CHEM} = mean yield obtained with chemical treatments 7 and 8

b = slope of best fit line through the control and organic fertilizer yields

m = intercept of best fit line through the control and organic fertilizer yields

X_{CHEM} = average nitrogen application rate for chemical fertlizers (58.5 lbs/acre)

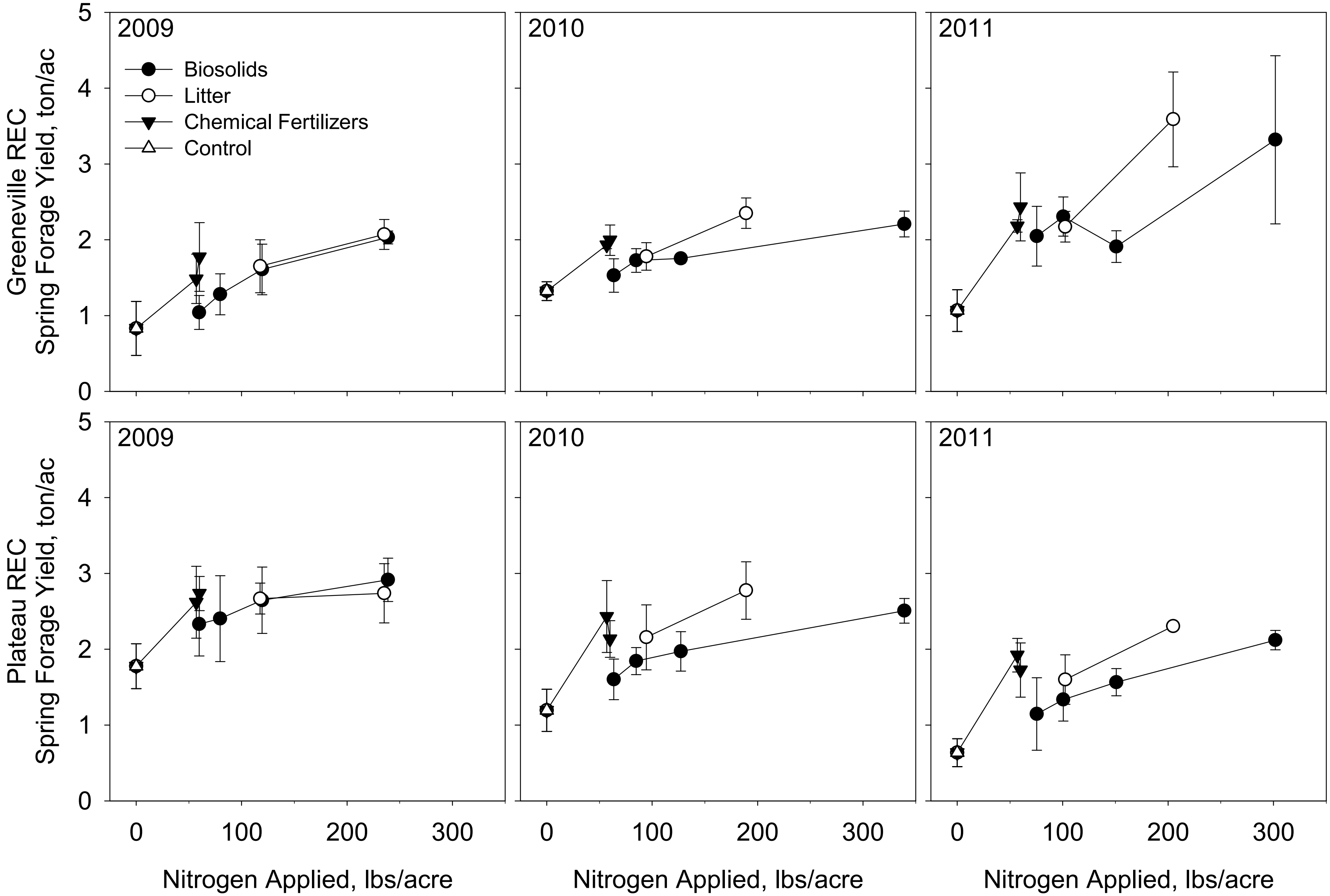

Figure 5.Spring forge yields as a function of total nitrogen applied (fit with point to point lines).

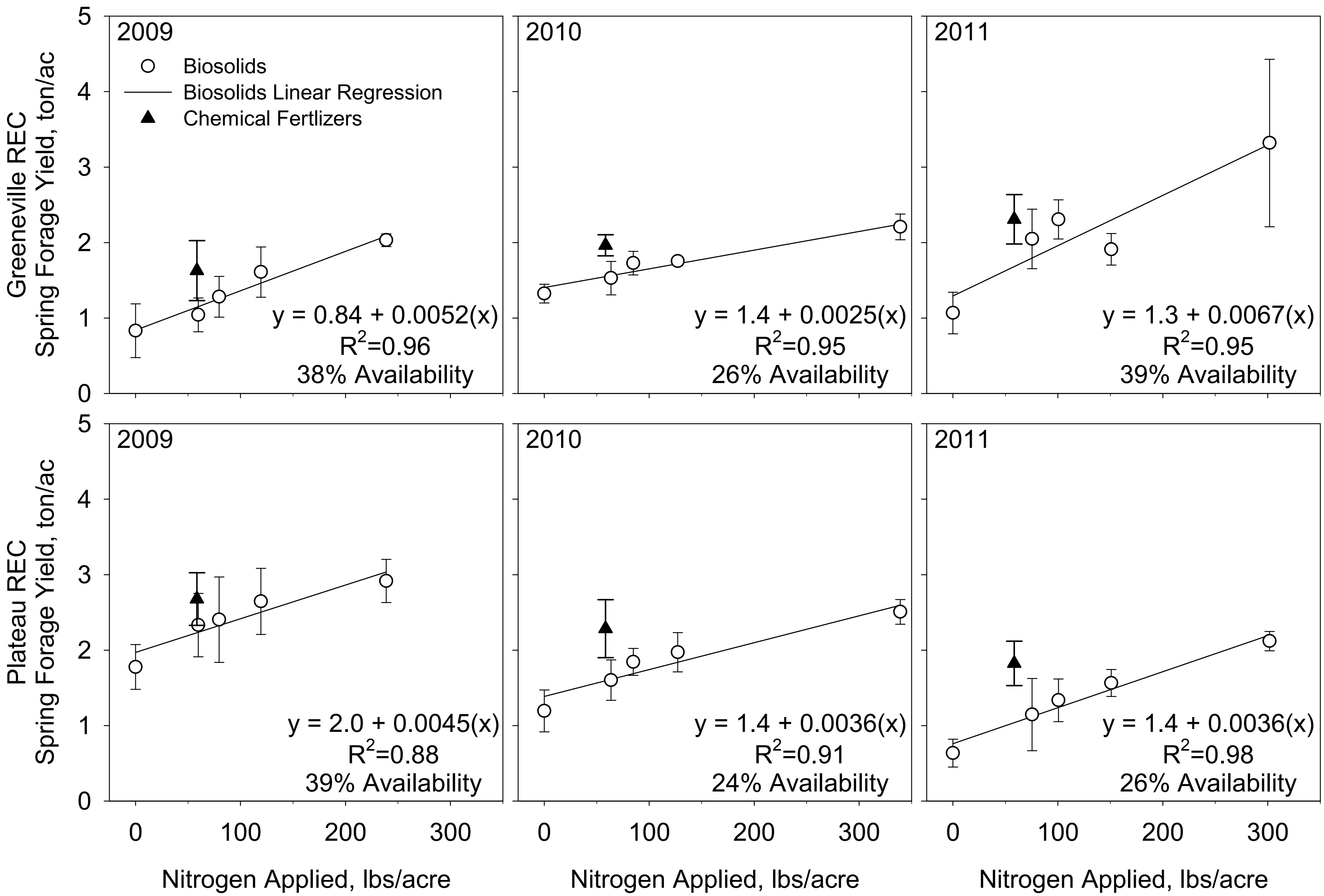

Figure 6. Linear regression of spring forage yields obtained with the control and biosolids amended plots.

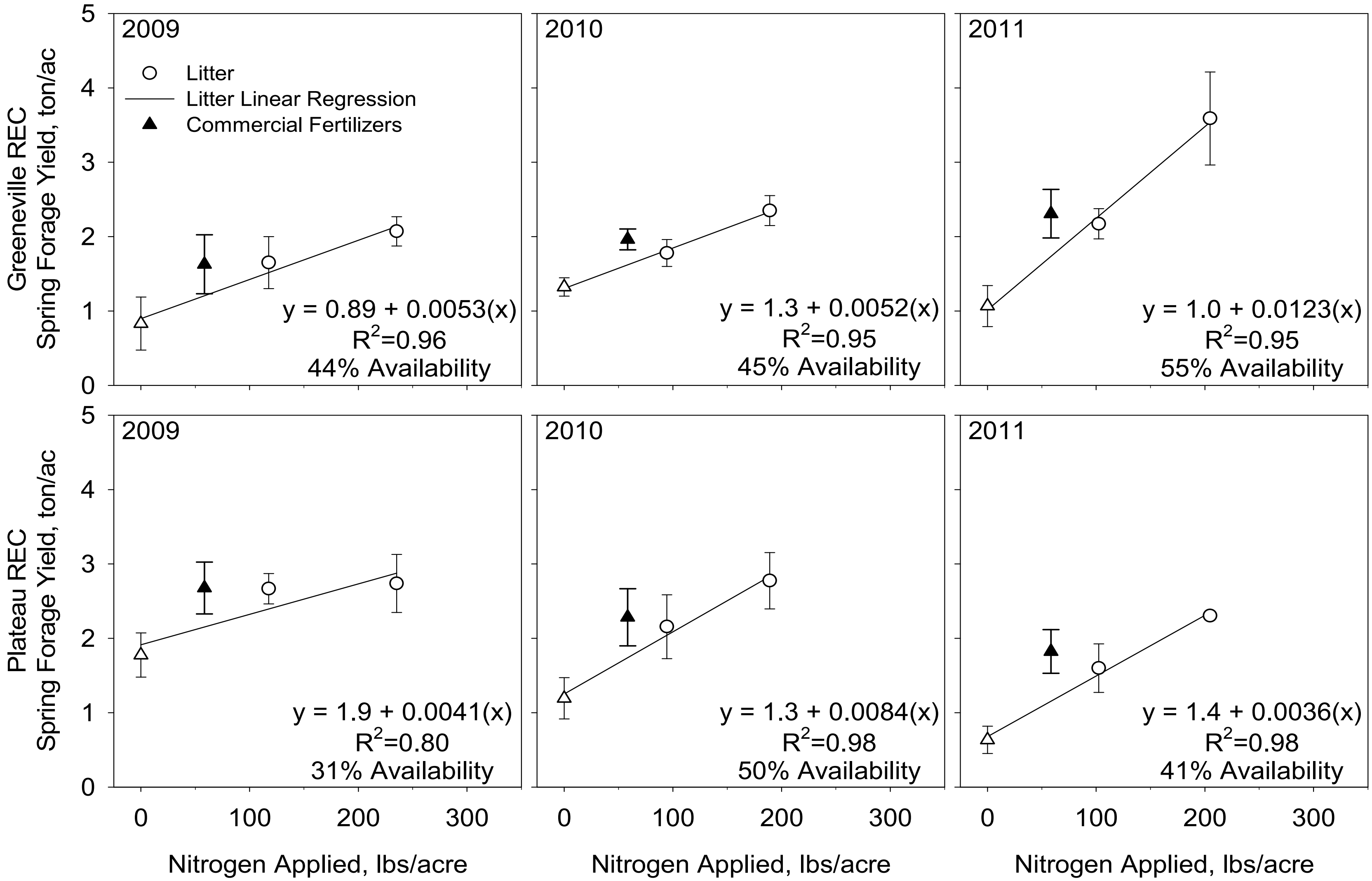

Figure 7. Linear regression of spring forage yields obtained with the control and broiler litter amended plots.

The nitrogen availability estimate for the biosolids and litter are displayed in the best fit line plots of the EQ biosolids (**Figure 6**) and broiler litter (**Figure 7**) yields. The biosolids nitrogen availability was 32±7% with a range from 24 to 39%. The litter nitrogen availability was 44±8% with a range from 31 to 55%. The litter nitrogen availability exceeded the biosolids nitrogen for all plot years except for the Spring 2009 at the Plateau REC. A Wilcoxon Signed Rank test indicated that the nitrogen availability was significantly higher with the litter versus the biosolids (p-value=0.047). The differences in the nitrogen availability are illustrated graphically in **Figure 8**.

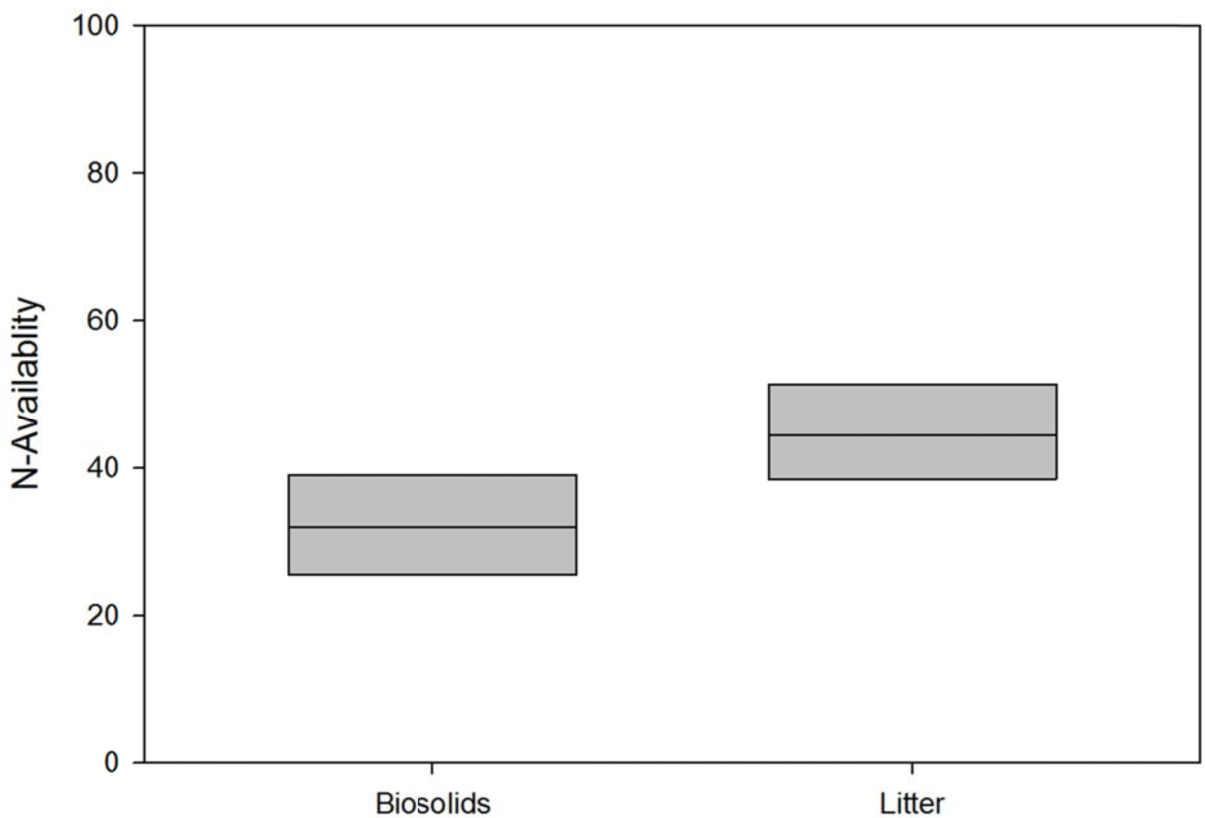

Figure 8. Box plot graph of the calculated nitrogen availability of the EQ biosolids and broiler litter nitrogen.

CHAPTER 8 – FALL NITROGEN RESIDUAL OF ORGANIC FERTILIZERS

Fall forage yields are plotted as a function of the spring organic fertilizer nitrogen applied and fall applied chemical fertilizer in **Figure 9**. The only plots that received additional nitrogen fertilizer in the fall were treatment 7 in the UT Extension recommended application of 60 lbs of urea nitrogen for a fall hay cut or fescue stockpiling (Savoy and Joines 2009). Statistically significant yield increases were o0nly observed in two out of six plot years (Figure 4).The results indicate that the spring nitrogen carryover from litter and biosolids will, for most years, be negligible.

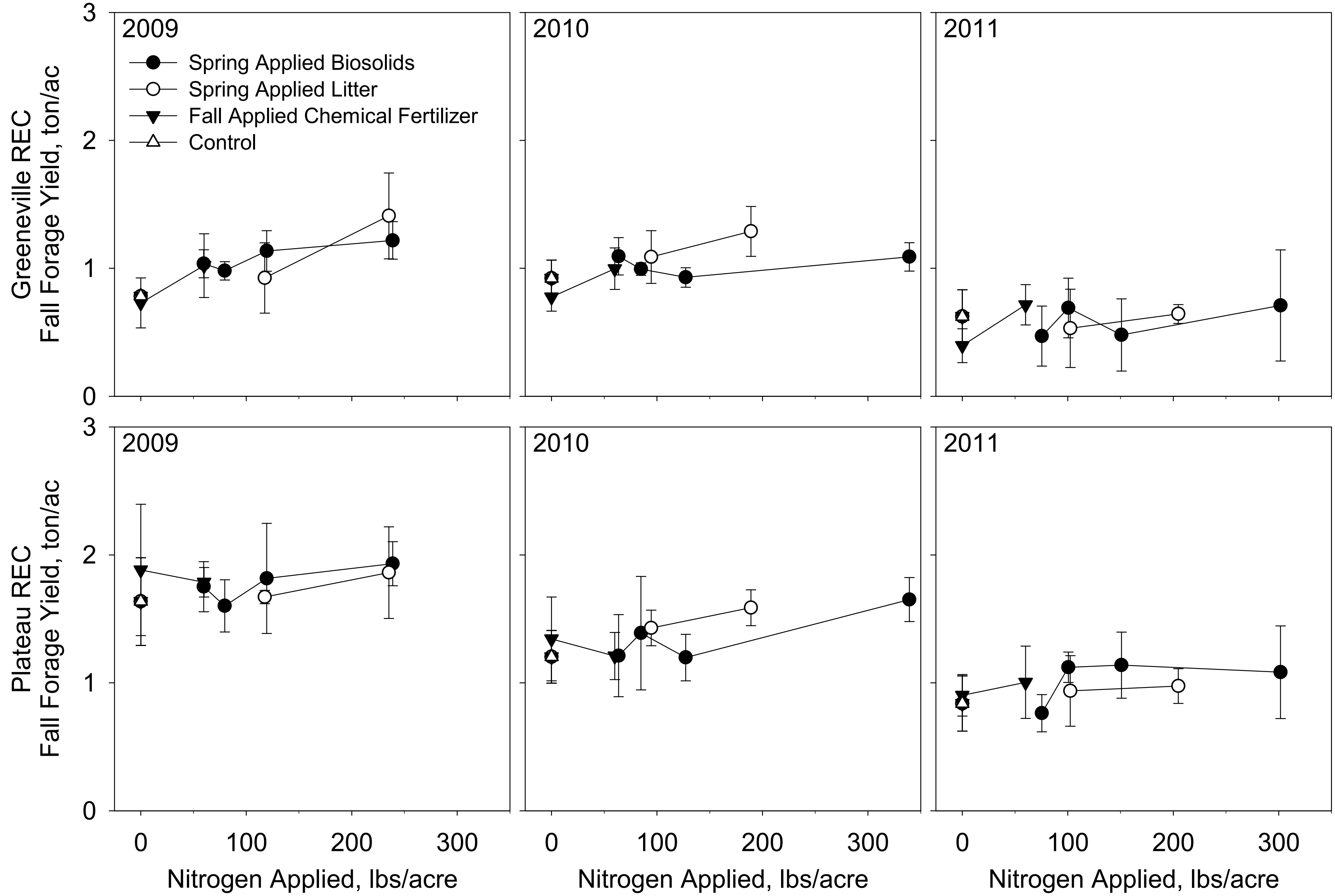

Figure 9. Fall forge yield as a function of total nitrogen applied including point to point lines.

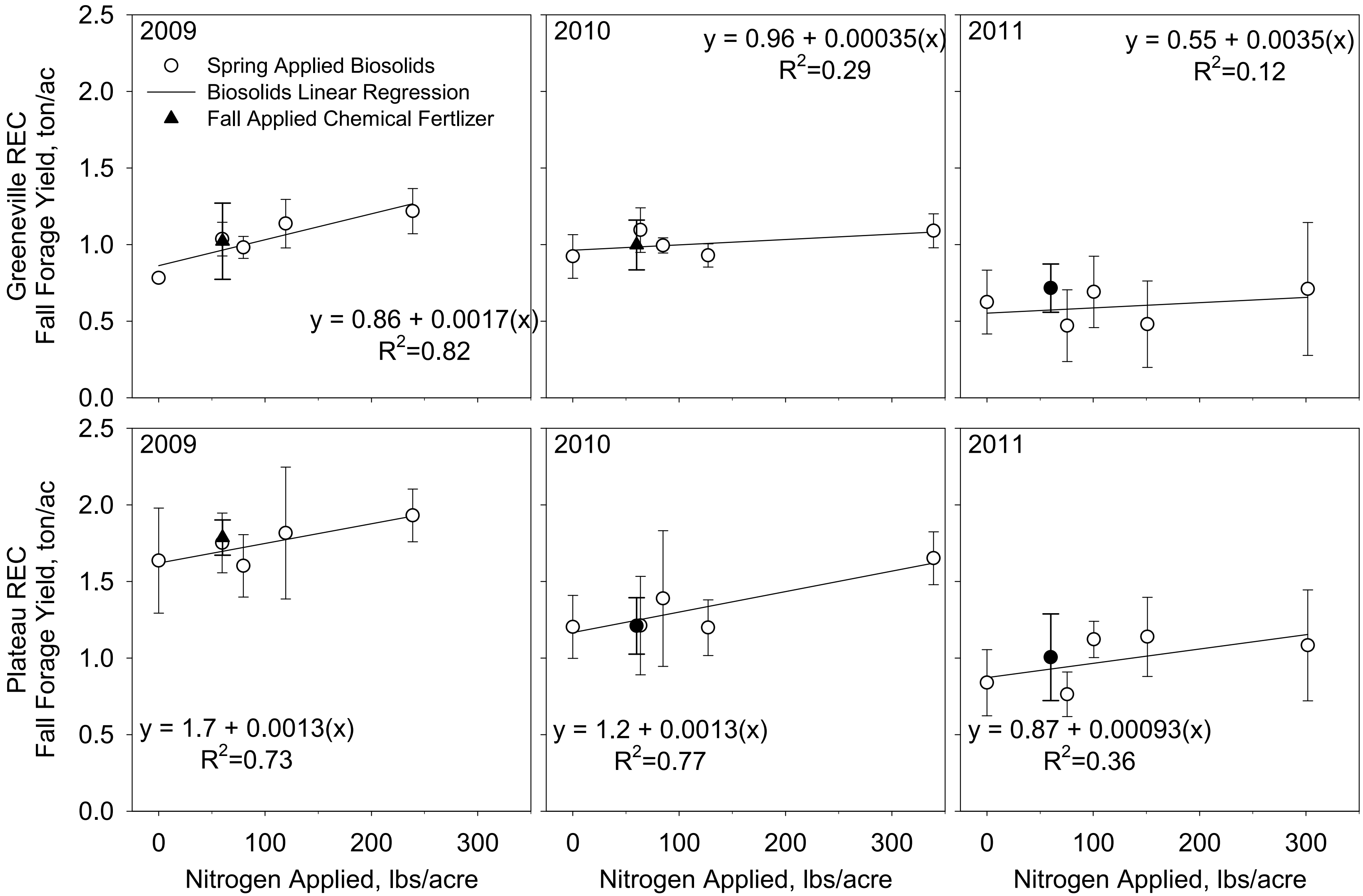

Figure 10. Linear regression of fall forage yields obtained with the control, chemical fertilizer and biosolids amended plots.

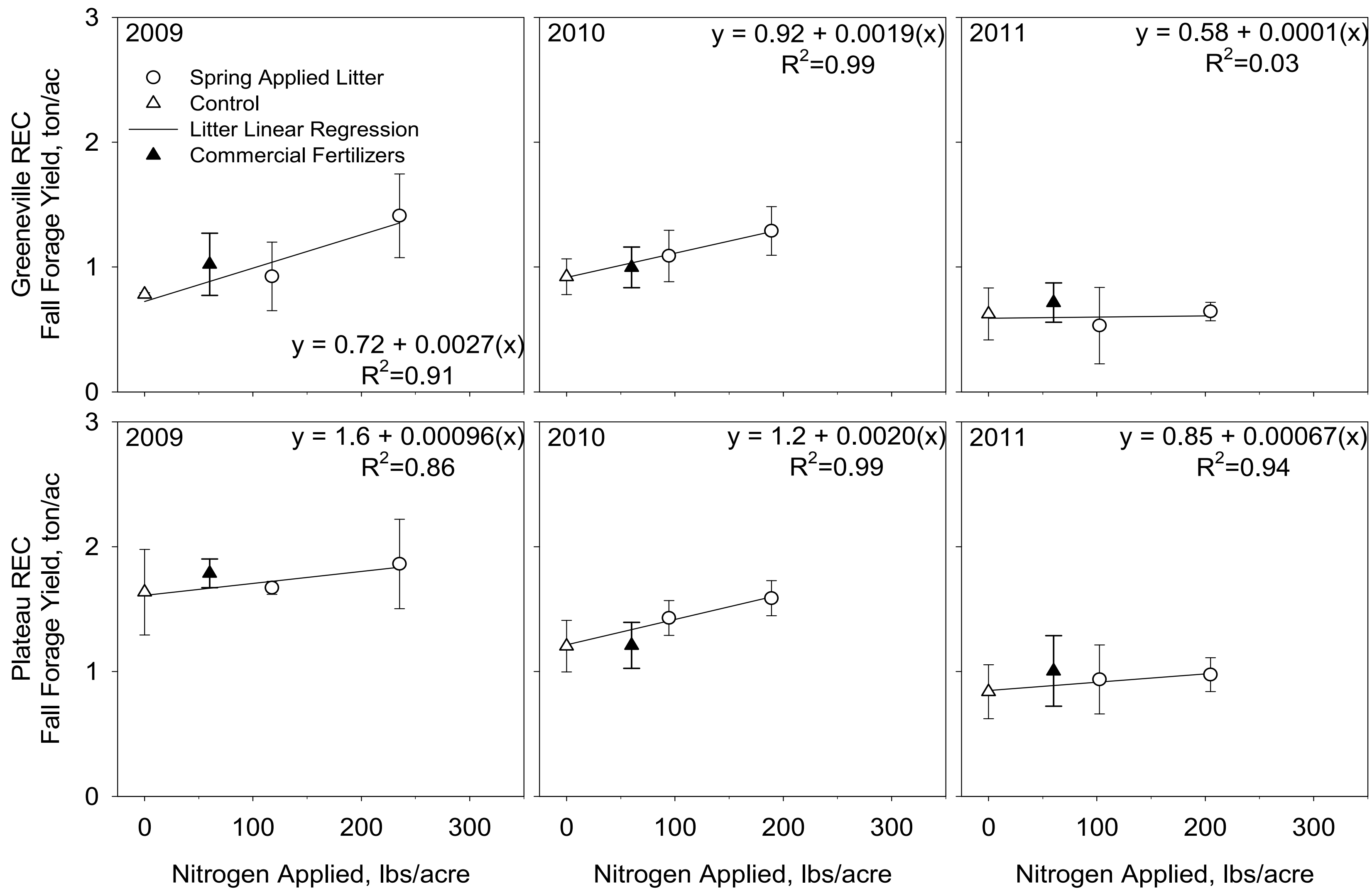

Figure 11. Linear regression of fall forage yields obtained with the control, chemical fertilizer and litter amended plots.

CHAPTER 9 – FORAGE ORGANIC BREAKDOWN AND QUALITY METRICS

Forage organic breakdown measurements and calculated quality metrics are summarized (**Table 11-Table 22**) and plotted (**Figure 18-Figure 45**) in **Appendix D**. Spring and fall statistical analyses are provided in **Table 5** and **Table 6**, respectively.

Forage Organic Breakdown-Protein. Significant differences were observed for the crude, available, and adjusted crude protein concentrations in four out of the six spring plots years and three out of six fall plot years (**Table 5**). Where significant differences were observed in the spring data, the highest application rates of biosolids and litter tended to produce forages with crude protein concentrations that were higher than for the control plots and in two instances were higher than for the chemical fertilizer treatments. In the fall, the forage protein concentrations tended to be significantly higher in the plots receiving a fall application of urea-N versus the remainder of the treatments. However, all of the forages generally had crude protein concentrations that were at least 13%, which is adequate to provide a 1.7 lb/day weight gain in growing beef steers (Ball, Hoveland et al. 2002). Forage unavailable protein concentrations were different in only one of six fall test years: the control plots yielded forages with unavailable protein concentrations that were higher than for several other treatments.

Forage Organic Breakdown-Fat. Plots are provided in **Appendix D** for the spring and fall forage fat concentrations (**Figure 26** and **Figure 27**, respectively). Forage fat concentrations were significantly different in only one plot year, that being the spring of 2011 at the Greeneville REC (**Table 5-Figure 26**). In this one plot year, the plots that received 1.5 tons EQ biosolids/acre had a fat content (3.0 ± 0.4%) that was statistically greater than for the plots that received 4 tons broiler litter/acre (2.5 ± 0.2%).

Table 5. Spring statistical analysis of forage organic breakdown and quality metrics data.

Location	Biochemical Parameter	2009			2010			2011		
		ANOVA F-ratio	p-value	Tukey HSD Difference	ANOVA F-ratio	p-value	Tukey HSD Differences	ANOVA F-ratio	p-value	Tukey HSD Difference
Greeneville REC	**ORGANIC BREAKDOWN**									
	Crude Protein	28.85	<0.01	Yes	1.195	0.339	-	1.426	0.231	-
	Available Protein	31.98	<0.01	Yes	1.449	0.222	-	1.424	0.232	-
	Adjusted Crude Protein	28.85	<0.01	Yes	1.195	0.339	-	1.426	0.231	-
	Unavailable Protein	0.28	0.96	-	0.980	0.472	-	1.070	0.412	-
	Fat	1.60	0.17	-	0.339	0.917	-	2.588	0.031	Yes
	Acid Detergent Fiber	2.74	0.02	Yes	1.014	0.449	-	0.808	0.602	-
	Neutral Detergent Fiber	2.42	0.04	No	1.357	0.259	-	1.116	0.384	-
	Non-Fiber Carbohydrates	1.72	0.14	-	4.359	0.002	Yes	0.952	0.492	-
	Ash	0.21	0.99	-	0.520	0.831	-	1.828	0.115	-
	QUALITY METRICS									
	Net Energy Lactation	3.199	0.011	Yes	1.086	0.402	-	7.623	0.638	-
	Net Energy Maintenance	3.053	0.014	Yes	1.233	0.318	-	0.716	0.675	-
	Net Energy for Gain	2.813	0.021	Yes	1.232	0.319	-	0.624	0.750	-
	Total Digestible Nutrients	3.082	0.013	Yes	1.183	0.345	-	0.703	0.687	-
	Relative Forage Value	2.683	0.026	Yes	1.132	0.374	-	0.857	0.563	-
Plateau REC	**ORGANIC BREAKDOWN**									
	Crude Protein	3.94	<0.01	Yes	15.61	<0.001	Yes	8.543	<0.001	Yes
	Available Protein	4.11	<0.01	Yes	15.27	<0.001	Yes	7.781	<0.001	Yes
	Adjusted Crude Protein	3.94	<0.01	Yes	15.61	<0.001	Yes	8.543	<0.001	Yes
	Unavailable Protein	0.61	0.76	-	1.106	0.390	-	0.661	0.721	-
	Fat	0.80	0.61	-	1.795	0.122	-	1.396	0.243	-
	Acid Detergent Fiber	1.38	0.25	-	1.356	0.260	-	2.400	0.042	Yes
	Neutral Detergent Fiber	1.05	0.43	-	0.369	0.928	-	0.230	0.982	-
	Non-Fiber Carbohydrates	4.09	<0.01	Yes	7.283	<0.001	Yes	1.923	0.098	-
	Ash	1.86	0.11		3.436	0.008	-	0.847	0.571	-
	QUALITY METRICS									
	Net Energy Lactation	1.14	0.37	-	1.551	0.186	-	1.898	0.102	-
	Net Energy Maintenance	1.04	0.43	-	1.614	0.167	-	1.693	0.146	
	Net Energy Gain	0.96	0.49	-	1.457	0.219	-	1.955	0.092	-
	Total Digestible Nutrients	1.02	0.45	-	1.551	0.186	-	1.898	0.102	-
	Relative Forage Value	1.17	0.35	-	0.519	0.832	-	0.706	0.684	-

Table 6. Fall statistical analysis of forage organic breakdown and quality metrics data.

Location	Biochemical Parameter	2009			2010			2011		
		ANOVA F-ratio	p-value	Tukey HSD Difference	ANOVA F-ratio	p-value	Tukey HSD Differences	ANOVA F-ratio	p-value	Tukey HSD Difference
Greeneville REC	**ORGANIC BREAKDOWN**									
	Crude Protein	1.05	0.42	-	14.75	<0.001	Yes	6.430	<0.001	Yes
	Available Protein	1.246	0.312	-	11.77	<0.001	Yes	7.159	<0.001	Yes
	Adjusted Crude Protein	1.137	0.371	-	13.28	<0.001	Yes	6.430	<0.001	Yes
	Unavailable Protein	1.123	0.380	-	0.545	0.0812	-	4.524	<0.001	Yes
	Fat	1.053	0.423	-	1.819	0.117	-	0.363	0.931	-
	Acid Detergent Fiber	1.04	0.43	-	4.969	<0.001	Yes	4.122	0.003	Yes
	Neutral Detergent Fiber	1.03	0.44	-	1.013	0.450	-	3.364	0.008	Yes
	Non-Fiber Carbohydrates	0.715	0.677	-	0.226	0.982	-	1.792	0.123	-
	Ash	1.136	0.372	-	0.798	0.610	-	3.392	0.008	Yes
	QUALITY METRICS									
	Net Energy Lactation	1.02	0.39	-	5.044	<0.001	Yes	4.040	0.003	Yes
	Net Energy Maintenance	0.85	0.57	-	5.483	<0.001	Yes	4.474	0.002	Yes
	Net Energy Gain	0.99	0.47	-	5.236	<0.001	Yes	4.461	0.002	Yes
	Total Digestible Nutrients	0.94	0.50	-	5.575	<0.001	Yes	4.568	0.001	Yes
	Relative Forage Value	1.17	0.35	-	1.939	0.095	-	4.182	0.002	Yes
Plateau REC	**ORGANIC BREAKDOWN**									
	Crude Protein	1.91	0.10	-	1.811	0.119	-	6.288	<0.001	Yes
	Available Protein	1.976	0.089	-	1.685	0.148	-	5.858	<0.001	Yes
	Adjusted Crude Protein	1.934	0.096	-	1.850	0.111	-	5.932	<0.001	Yes
	Unavailable Protein	2.039	0.080	-	0.378	0.923	-	1.298	0.286	-
	Fat	0.579	0.786	-	1.023	0.443	-	0.648	0.731	-
	Acid Detergent Fiber	0.94	0.50	-	1.286	0.291	-	0.753	0.645	-
	Neutral Detergent Fiber	0.62	0.76	-	1.539	0.190	-	2.241	0.056	-
	Non-Fiber Carbohydrates	0.699	0.689	-	1.935	0.096	-	0.832	0.583	-
	Ash	0.669	0.714	-	0.263	0.973	-	3.885	0.004	Yes
	QUALITY METRICS									
	Net Energy Lactation	0.86	0.56	-	1.129	0.376	-	0.915	0.519	-
	Net Energy Maintenance	1.06	0.42	-	1.213	0.328	-	0.770	0.632	-
	Net Energy Gain	1.08	0.41	-	1.189	0.342	-	0.894	0.535	-
	Total Digestible Nutrients	1.09	0.40	-	1.417	0.235	-	0.872	0.552	-
	Relative Forage Value	0.62	0.75	-	0.843	0.574	-	2.009	0.084	-

Forage Organic Breakdown-Fiber. Plots are provided in **Appendix D** for the spring and fall acid detergent fiber (ADF) concentrations (**Figure 28** and **Figure 29**, respectively) and spring and fall neutral detergent fiber (NDF) concentrations (**Figure 30** and **Figure 31**, respectively). ADF concentrations were significantly different in two of six spring plots years and two of six fall plot years (**Table 5**). In the spring, the only significant differences were between the plots that received 3 tons EQ biosolids/acre and the control plots. However, the results were small in terms of the absolute difference observed and the findings were inconsistent (**Figure 28**). In the fall, the differences that were observed were clear: the plots receiving a fall application of urea-N displayed lower ADF concentrations (contributing the higher forage quality) than many or all of the remaining treatments (**Figure 29**). Neutral detergent fiber concentrations were significantly different in only one plot year (fall of 2011, Greeneville, REC) (**Table 5**). This difference observed was again clear, with the plots that received a fall application of urea-N displaying lower NDF concentrations than all of the other treatments except for the two highest application rates of EQ biosolids (**Figure 31**).

Forage Organic Breakdown-Non-Fiber Carbohydrates. Plots are provided in **Appendix D** for the spring and fall non-fiber carbohydrate concentrations (**Figure 32** and **Figure 33**, respectively). NFC concentrations were significantly different in three of six spring plots years but none of the fall plot years (**Table 5**). Where differences were observed in the spring, the control plots tended to display higher NFC concentrations that the plots fertilized with the highest rates of litter and EQ biosolids.

Forage Organic Breakdown-Ash. Plots are provided in **Appendix D** for the spring and fall forage ash concentrations (**Figure 34** and **Figure 35**, respectively). Ash concentrations were significantly different in only one of six spring plots years and one of six fall plot years (**Table 5**). However, in all cases the average ash concentration was well below 10% as expected.

Forage Quality Metrics-Net Energy Values. Plots are provided in **Appendix D** for the spring and fall forage Net Energy Lactation (NEL - **Figure 36** and **Figure 37**), Net Energy Maintenance (NEM - **Figure 38** and **Figure 39**), and Net Energy Gain (**Figure 40** and **Figure 41**). These calculated forage quality metrics measure the energy content of forages after removing the energy lost in manure, urine, gas production, and heat during metabolism and digestion (National Research Council 2000). NEM, NEL, and NEG were significantly different in one of six spring plots years (**Table 5**) and two of six fall plot years (**Table 6**). Where the differences were significant in the Spring (2009, Greeneville REC), the plots that received the highest rates of litter (2 tons/acre) and biosolids (3 tons/acre) tended to have higher NEL, NEM, and NEG, than the control plots, but were statistically similar to the plots that received chemical fertilizer (**Figure 36**, **Figure 38**, and **Figure 40**, respectively). The clear trend in the statistically significant fall differences (2010 and 2011, Greeneville REC) was for the plots that received a fall application of urea to display higher NEL, NEM, and NEG concentrations than the remainder of the treatments (**Figure 37, Figure 39** and **Figure 41**).

Forage Quality Metrics-Total Digestible Nutrients. Plots of TDN results are provided in **Appendix D** for the spring and fall results (**Figure 42** and **Figure 43**, respectively). As for the Net Energy forage metrics, only one of six spring plots years (**Table 5**) and two of six fall plot years (**Table 6**) displayed differences. The same trends were present: where spring differences were observed, values were higher in the plots receiving the highest rates of litter and biosolids versus the control, and in the fall the plots that received urea were generally higher than the remaining treatments. However, all of the treatments tended to yield forage TDN values within a range expected for vegetative-boot stage tall fescue (61-66%)(Ball, Hoveland et al. 2002). The observed values for all treatments were also consistently over the recommended value for lactating beef cattle (60%) and at or near the recommended value for growing (1.5 lbs/day) beef steers (65%)(Ball, Hoveland et al. 2002).

Forage Quality Metrics-Relative Forage Value. Plots of the RFV results are provided in **Appendix D** for the spring and fall (**Figure 44** and **Figure 45**, respectively). Only one each of the six spring and six fall plots years displayed significant differences(**Table 5 and Table 6, respectively**). In the spring (2009, Greeneville, REC), the plots receiving the highest rate of litter (4 tons/acre) displayed higher RFV than the control plots, but were similar to all other treatments (**Figure 44**). In the fall, the plots receiving additional fall applied urea displayed much higher RFVs (**Figure 45**). Generally, all of the plots yielded RFVs within the range (84-101) expected for boot-head stage tall fescue (Ball, Hoveland et al. 2002).

CHAPTER 10 - FORAGE MINERAL AND NITRATE CONCENTRATIONS

Forage mineral and nitrate concentration data are provided in **Appendix E** (**Table 25**-**Table 36**).Statistical analyses of the data are summarized in **Table 7**. Bar chart plots of the mineral and nitrate data (with statistical differences noted) are provided in **Appendix E** (**Figure 46**-**Figure 63**).

Major Mineral – Calcium. No significant differences were observed for the spring or fall forage calcium concentrations (**Table 7**). All of the treatments yielded adequate forage calcium concentrations (0.31%) (**Figure 46** and **Figure 47**).

Major Mineral – Magnesium. No significant differences were observed for the spring forage magnesium concentrations (**Table 7**). However, the fall forages collected from the Greeneville REC displayed consistent, significant differences (**Table 7**). Generally, higher fall magnesium concentrations were observed for the plots receiving the chemical fertilizer at UT Extension rates. However, all of the spring and fall treatments yielded forage with at or near sufficient magnesium (0.7%) (**Figure 48** and **Figure 49**).

Major Mineral – Potassium. In two of six spring plot years and two of six fall plot years forages displayed significant potassium concentration differences (**Table 7**). Where differences were observed, the controls plots were lower than for several of the other treatments (**Figure 50** and **Figure 51**)**.** Although high forage potassium concentrations are associated with long-term and over-application of broiler litter (and the potential ensuing development of grass tetany in beef cattle) (Fisher, Gill et al. 2003), this tendency was not observed in this short study. All of the measured concentrations were below the maximum tolerable level of 3% and above the minimally sufficient potassium concentrations of 0.7%.

Table 7. Statistical analysis of forage mineral and nitrate statistical analysis results.

Season	Location	Parameter	2009 ANOVA F-ratio	2009 p-value	2009 Tukey HSD Difference	2010 ANOVA F-ratio	2010 p-value	2010 Tukey HSD Differences	2011 ANOVA F-ratio	2011 p-value	2011 Tukey HSD Difference
Spring	Greeneville REC	Calcium	0.86	0.57	-	0.937	0.503	-	1.820	0.117	-
		Magnesium	1.71	0.14	-	2.176	0.063	-	1.246	0.312	-
		Potassium	5.16	<0.01	Yes	3.139	0.012	-	1.286	0.292	-
		Phosphorus	7.52	<0.01	Yes	1.197	0.337	-	2.621	0.029	Yes
		Manganese	0.80	0.60	-	1.735	0.136	-	1.815	0.118	-
		Copper	9.62	<0.01	Yes	8.264	<0.001	Yes	7.552	<0.001	Yes
		Zinc	4.64	<0.01	Yes	5.292	0.001	Yes	1.841	0.113	-
		Sulfur	11.90	<0.01	Yes	14.14	<0.001	Yes	7.336	<0.001	Yes
		Nitrate	1.73	0.14	-	1.169	0.355	-	0.572	0.791	-
	Plateau REC	Calcium	0.74	0.65	-	0.538	0.818	-	0.902	0.529	-
		Magnesium	1.98	0.09	-	1.593	0.172	-	1.056	0.421	-
		Potassium	2.04	0.08	-	3.718	0.005	Yes	0.790	0.616	-
		Phosphorus	2.21	0.06	-	1.909	0.100	-	1.750	0.132	-
		Manganese	0.59	0.78	-	1.459	0.218	-	5.115	<0.001	Yes
		Copper	4.363	<0.001	Yes	8.200	<0.001	Yes	10.48	<0.001	Yes
		Zinc	0.71	0.68	-	2.948	0.017	Yes	2.431	0.040	Yes
		Sulfur	4.55	<0.01	Yes	30.86	<0.001	Yes	24.92	<0.001	Yes
		Nitrate	2.357	0.046	Yes	10.69	<0.001	Yes	3.080	0.013	Yes
Fall	Greeneville REC	Calcium	0.974	0.477	-	0.866	0.557	-	2.046	0.079	-
		Magnesium	2.638	0.028	Yes	2.804	0.021	Yes	4.026	0.003	Yes
		Potassium	0.772	0.630	-	0.548	0.810	-	3.593	0.006	Yes
		Phosphorus	1.089	0.119	-	0.661	0.720	-	3.741	0.005	Yes
		Manganese	1.076	0.409	-	2.340	0.047	Yes	2.094	0.072	-
		Copper	0.886	0.541	-	0.745	0.652	-	1.976	0.089	-
		Zinc	1.031	0.438	-	0.640	0.738	-	1.446	0.223	-
		Sulfur	1.059	0.419	-	2.997	0.015	Yes	5.321	<0.001	Yes
		Nitrate	1.749	0.133	-	5.279	<0.001	Yes	0.381	0.921	-
	Plateau REC	Calcium	2.082	0.074	-	1.043	0.430	-	1.444	0.224	-
		Magnesium	2.267	0.054	-	1.900	0.102	-	2.434	0.040	Yes
		Potassium	0.744	0.623	-	0.177	0.992	-	2.409	0.042	Yes
		Phosphorus	1.084	0.403	-	1.566	0.182	-	0.529	0.824	-
		Manganese	1.017	0.447	-	1.460	0.218	-	1.661	0.154	-
		Copper	1.418	0.234	-	0.813	0.597	-	1.100	0.393	-
		Zinc	1.369	0.254	-	0.179	0.992	-	1.865	0.108	-
		Sulfur	0.512	0.837	-	1.006	0.454	-	1.149	0.365	-
		Nitrate	1.597	0.172	-	3.322	0.009	Yes	5.527	<0.001	Yes

Major Mineral – Phosphorus. Only two of the six spring and one of fall plot years yielded forages with significant phosphorus concentration differences (**Table 7**). Where differences were observed in the spring, the concentrations measured in the plots receiving the highest amendments rate of litter were higher than in the control plots (**Figure 52** and **Figure 53**). However, all of treatments yielded forages with sufficient phosphorus concentrations of 0.21%.

Trace Mineral - Manganese. One spring and one fall plot years yielded forages with significant manganese concentration differences (**Table 7**)**.**However, all of the treatments yielded forages with manganese concentrations well above the minimum requirement for lactating beef cattle of 40 mg/kg(**Figure 54** and **Figure 55**).

Trace Mineral - Copper. Significant forage copper concentration differences were observed for all of the spring forage test years but none of the fall forage test years (**Table 7**). Forage harvested from the litter and biosolids amended plots generally displayed increased copper concentrations as the application rate increased (**Figure 56** and **Figure 57**); the highest amendments rates of litter and biosolids tended to produce forages with significantly higher copper concentrations than in the control and chemically fertilized plots. The fact that both the litter and biosolids appear to provide plant available copper is important because at both the Greenville and Plateau RECs the plots yielded forage moderately deficient in the trace mineral (<10 mg/kg).This is commonly seen deficiency in Tennessee forages (Gill, Fisher et al. 2005).

Trace Minerals - Zinc. Half of the spring test years yielded forages with significant zinc concentration differences; none of the fall harvests yielded forage with significantly different zinc concentration (**Table 7**). In the spring plot years where differences were observed, forage zinc concentration tended to increase as the application rate of litter and biosolids increased (**Figure 58** and **Figure 59**).The fact that both the litter and biosolids appear to provide plant available zinc is important because at both the Greenville and Plateau RECs the plots mostly yielded forages moderately deficient (<30 mg/kg) in this trace mineral.

Major Mineral – Sulfur. All six spring and two fall plot years yielded forages with significant sulfur concentration differences (**Table 7**). The spring forage sulfur concentrations in particular tended to increase as the biosolids and litter application rates increased (**Figure 60** and **Figure 61**). However, all of the forages, including those from the chemically fertilized and control plots, were near or exceeded the upper optimal range for sulfur (0.2 mg/kg) at which point the sulfur becomes marginally antagonistic in terms of forage copper availability (Gill, Fisher et al. 2005).

Nitrate. Statistical significant differences were observed for the spring forage nitrate concentrations at the Plateau REC, but not at the Greeneville, REC; significant differences were observed for three out of the six fall harvests (**Table 7**). Forage nitrate concentrations were highly variable from season to season, with the plots receiving the highest amendment rate of biosolids tending to display significantly higher concentrations than the control plots in the spring season, and the plots receiving a fall application of urea tending to yield forage with relatively higher nitrate concentrations (**Figure 62** and **Figure 63**). However, all of the treatments resulted in mean forage nitrate concentrations well 2,500 mg/kg, which is a safe level for all types of animals; in all cases the results were well below the maximum tolerate level of 10,000 mg/kg.

CHAPTER 11 - SOIL TESTS

Initial Composite Soil Test Results

Four to five soil samples, composed of eight to 10 randomly collected subsamples, were collected from within the plot study areas and analyzed for phosphorus, potassium, soil water and buffer pH, and trace elements (**Appendix F-Table 37** and **Table 38**). The results were used to set the 2009 application rates for P_2O_5 for treatment 7 (chemical fertilizers at UT Extension recommended rates based on crop and soil test results) and K_2O for treatment 7 and treatments 3-6 (EQ biosolids at 0.75, 1, 1.5 and 3 tons/acre, respectively) using **Table 8** below.

Table 8. Recommended P_2O_5 and K_2O application rates for tall fescue pasture and hay fields in Tennessee based on soil test results (Savoy and Joines 2009).

Test Parameter	Test Result		Recommended Application Rate (lbs/acre)
	Category	Concentration (lbs/ac)	
Phosphorus	Low	0-90	60
	Medium	91-160	30
	High	161-320	-
	Very High	>320	-
Potassium	Low	0-18	60
	Medium	19-30	30
	High	31-120	-
	Very High	>120	-

Greeneville REC samples were collected March 13, 2009:

- Phosphorus ranged from 44 to 79 lbs/acre and averaged 58 ± 15 lbs/acre. Because all of the results were in the high range no phosphors fertilizer was applied for the treatment 7 plots in 2009.
- Potassium ranged from 88 to 142 lbs/acre and averaged 104 ± 15 lbs/acre. Two results (88 lbs/acre) were just inside the “low” range which extends from 0 to 90

lbs/acre. The other two results, 97 and 142 lbs/acre, were within the “medium” range of values which extends from 91 to 160 lbs/acre. Because the average result was well within the “medium” range, 30 lbs K_2O/acre was applied to the treatments 3-6 and 7 plots in 2009.

- The soil water pH ranged from 6.8 to 7.1 and averaged 7.0 ± 0.1. Limestone was not recommended.
- Calcium, copper, iron, magnesium, manganese, and zinc, all were reported to be “sufficient.”

Plateau REC samples were collected March 12, 2009:

- Phosphorus ranged from 18 to 29and averaged 22 lbs/acre. One of the five replicate composite samples was at the top of the “low” range which extends from 0 to 18 lbs/acre. All of the remaining samples were within the “medium” range which extends from 19 to 30 lbs/acre. Because the average result was well within the “medium” range, 30 lbs P_2O_5/acre was applied to the treatment 7 plots in 2009.
- Potassium ranged from 130 to 229 lbs/acre and averaged 179 ± 76 lbs/acre. Two samples tested within the “medium” range which extends from 90 to 160 lbs/acre and the remaining three samples tested within the “high” range which extends from 160 to 320 lbs/acre. Because two of the five results were within the medium range 30 lbs K_2O/acre was applied to the treatment 3-6 and 7 plots in 2009.
- The soil water pH ranged from 5.6 to 6.0 and averaged 5.7 ± 0.2. Limestone was recommended at 2 to 3 tons/acre but was not applied so that the amendment effect on soil pH could be analyzed.

- Calcium, magnesium, zinc, copper, iron, and manganese all were reported to be "sufficient."

2010-2011 Plot Soil Results

In the spring 2010, spring 2011, and fall 2011 (after final fall forage samples were collected) the soil in each treatment plot (rather than the entire plot area) was sub-sampled eight to ten times and analyzed for potassium, phosphorus, pH, and metals (**Appendix F**). This intensive soil sampling was used to set the 2010 and 2011 individual plot application rates for P_2O_5 for treatment 7 and K_2O for treatment 7 and treatments 3-6. The data was statistically analyzed to address these concerns:

- Soil potassium buildup can lead to forage luxury uptake producing cattle metal deficiencies resulting in rough hair coats, decreased breeding efficiency, and disease associated with compromised immune system (Gill, Fisher et al. 2005).
- Soil phosphorus buildup can be caused by repeated over application of broiler litter and biosolids and increase the potential for surface water degradation.
- Soil metal concentration buildup, or lack there of, may indicate whether the alternative organic fertilizers tested provide needed micronutrients or produce high concentrations of soil metals that represent a long term human/animal health risk.

A summary of the soil test statistical analyses are provided in **Table 9**; plots of each test parameter tested are provided in **Appendix F** (**Figure 64** -**Figure 75**).

Table 9. Soil test statistical analyses for the Greeneville and Plateau RECs ($\alpha = 0.05$); statistically significant difference are highlighted with shading.

Location	Parameter	2010			2011			2012		
		ANOVA F-ratio	p-value	Tukey HSD Difference	ANOVA F-ratio	p-value	Tukey HSD Differences	ANOVA F-ratio	p-value	Tukey HSD Difference
Greeneville REC	pH	0.586	0.780	-	1.041	0.431	-	1.332	0.270	-
	Buffer pH	-	-	-	-	-	-	-	-	-
	Boron	0.662	0.720	-	1.229	0.320	-	0.636	0.741	-
	Calcium	0.347	0.939	-	0.437	0.888	-	0.695	0.693	-
	Copper	0.798	0.610	-	0.994	0.463	-	0.949	0.494	-
	Iron	0.764	0.637	-	0.144	0.996	-	1.797	0.122	-
	Potassium	1.724	0.138	-	1.584	0.176	-	1.748	0.133	-
	Magnesium	0.446	0.882	-	0.689	0.698	-	0.325	0.949	-
	Manganese	1.054	0.422	-	0.711	0.680	-	0.457	0.875	-
	Sodium	4.990	<0.001	Yes	4.006	0.003	Yes	7.254	<0.001	Yes
	Phosphorus	5.569	<0.001	Yes	4.239	0.002	Yes	9.138	<0.001	Yes
	Zinc	1.771	0.127	-	0.671	0.712	-	0.885	0.542	-
Plateau REC	pH	1.121	0.381	-	2.346	0.047	Yes	0.981	0.472	-
	Buffer pH	0.135	0.997	-	0.841	0.576	-	0.520	0.831	-
	Boron	0.829	0.585	-	0.779	0.625	-	0.871	0.552	-
	Calcium	0.900	0.530	-	1.457	0.219	-	2.966	0.16	Yes
	Copper	0.663	0.781	-	0.947	0.496	-	1.025	0.442	-
	Iron	0.226	0.983	-	0.404	0.908	-	0.223	0.984	-
	Potassium	2.132	0.068	-	1.797	0.122	-	1.251	0.309	-
	Magnesium	0.908	0.525	-	1.068	0.413	-	0.504	0.843	-
	Manganese	1.161	0.358	-	1.095	0.397	-	1.003	0.456	-
	Sodium	0.443	0.884	-	1.200	0.336	-	1.541	0.190	-
	Phosphorus	0.970	0.479	-	7.522	<0.001	Yes	3.825	0.004	Yes
	Zinc	1.208	0.333	-	0.725	0.668	-	0.960	0.487	-

Soil and Soil Water pH. A statistically significant difference was observed for soil water pH in 2011 at the Plateau REC (**Figure 64**). The soil water pH was higher in the plots that litter at 2 tons/ac (5.7 ± 0.2) than the plots receiving UT Extension recommended chemical fertilizer rates (5.5 ± 0.1). This can be explained by the known liming effect of poultry litter. However, the water pH difference observed was negligible.

Soil Potassium Concentrations. No statistically significant differences in soil test potassium concentrations were observed for any of the test plots (**Table 9**).

Soil Phosphorus Concentrations. Statistically significant differences in soil test phosphorus concentrations were observed at both the Greeneville and Plateau RECs (Table 9; **Figure 70**). The plots that received the highest application rate of litter (4 tons/ac-treatment 2) displayed elevated concentrations of soil phosphorus in the 2011 and 2012 at the Greeneville REC. The observed results were significantly higher than the results measured in the treatment 9 (control) and treatment 7 (chemical fertilizer at UT Extension recommended rates) plots. The plots that received the highest application rate of EQ biosolids (3 tons/ac) showed elevated soil phosphorus concentrations in all test years at both locations except for 2010 at the Plateau REC. The observed results were significantly higher than measured in the treatment 9 (control) and treatment 7 (chemical fertilizer at UT Extension recommended rates)plots. The data clearly show that high application rates of broiler litter and biosolids, in excess of the expected crop removal rate (≈ 8 lbs P_2O_5/ton fescue hay), will quickly result in soil buildup of phosphorus that has the potential to degrade surface water quality.

Soil Metal Concentrations. Statistically significant differences in soil test sodium concentrations were observed at the Greeneville REC. The plots that received the highest application rate of litter (4 tons/ac) displayed sodium concentrations significantly higher than the control plots, and the total sodium concentration increase steadily over time (Figure 73). Increased sodium concentrations can produce soil crusting that increases rainfall runoff rates and erosion of fine textured-soils. However, increases were small and litter provides organic matter which will ameliorate soil crusting.

A statistically significant difference was observed for the soil calcium concentration in 2012 at the Plateau REC (**Figure 67**). The soil calcium concentration was higher in the plots that received EQ biosolids at the 1.5 ton/ac rate (1,238 ± 246 lbs/ac) compared to the control plot (833 ± 101 lbs/ac). The difference was not significantly different from the soil calcium concentration measured in 2009 at the beginning of the study (1,303 ± 274 lbs/ac).

CHAPTER 12 – STUDY SUMMARY

The past experience of agricultural producers who have fertilized pasture and hay fields with low quality biosolids hampers beneficial reuse of the TCO product in Tennessee. Most utilities have and continue to produce Class B biosolids that introduce an undesirable 30 day grazing restriction. Often these products are lime amended and have a low yield impact and the potential to impair forage quality by significantly lowering soil pH. Many beef and hay producers now assume all biosolids possess little nutrient value and place forage quality at risk.

This study was conducted to address these concerns and illustrates that the TCO product can be used successfully as an alternative organic fertilizer on pasture and hay fields. **Hay yield and forage quality, when using an appropriate application rate based on a nitrogen availability factor of 32%, are no different with the TCO product than with chemical fertilizers.** The soil tests that were conducted now confirm that buildup of metals is not a concern (a common perceptional barrier to beneficial reuse in Tennessee). In fact, the TCO product will likely can improve Tennessee forages by providing plant available metal micronutrients (copper and zinc).

One concern in using the TCO product could be that long-term application, because of the high phosphorus content, may result in an undesirable buildup of soil phosphorus that could cause water pollution. One method that could be used to control this issue would be to apply the TCO product only when soil tests indicate phosphorus is needed, or the product could be applied at phosphorus removal rates along with supplemental nitrogen from blended chemical fertilizer.

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Appendix A

Nashville Metro EQ Biosolids Analyses

A&L Analytical Laboratories, Inc.

2790 Whitten Rd. Memphis, TN 38133 (901) 213-2400 Fax (901) 213-2440

www.allabs.com

22229
Biosystems Engineering Soil Science
Shawn Hawkins
2506 E.J. Chapman Drive
KNOXVILLE , TN 37996-4531

Project ID :
Description : Manco #1

Report Date : 4/1/2009

Report Number : **09-082-0279**

REPORT OF ANALYSIS

Received : 3/23/2009

Lab No : **58886**

Matrix: **Solids**

Sample ID : **Mannco 3-09-1**

Sampled: **3/18/2009 11:30**

Test	Results	Units	MQL	Date / Time Analyzed	By	Analytical Method
% Moisture	**3.78**	%	0.010	03/24/09 17:15	NFP	SM-2540G
Ammonia Nitrogen	**2370**	mg/Kg - dry	26.0	03/26/09 10:16	DRG	SM-4500-NH3C
Organic N	**37400**	mg/Kg - dry	26.0	04/01/09 10:39	GD	CALCULATION
pH	**7.2**	s.u.		03/25/09 10:05	LF	SW-9045D
Total Cadmium	**0.976**	mg/Kg - dry	0.097	03/27/09 03:39	JTR	SW-6010B
Total Chromium	**140**	mg/Kg - dry	0.244	03/27/09 03:39	JTR	SW-6010B
Total Copper	**417**	mg/Kg - dry	0.244	03/27/09 03:39	JTR	SW-6010B
Total Lead	**36.6**	mg/Kg - dry	0.293	03/27/09 03:39	JTR	SW-6010B
Total Nitrogen	**39800**	mg/Kg - dry	26.0	04/01/09 10:38	GD	CALCULATION
Total Phosphorus	**8.30**	mg/Kg - dry	0.103	04/01/09 01:21	JTR	SW-6010B
Total Potassium	**2020**	mg/Kg - dry	24.4	03/27/09 03:46	JTR	SW-6010B
Total Solids	**100**	% - dry	0.010	03/24/09 17:15	NFP	SM-2540G
Total Volatile Solids	**62.9**	% - dry	0.010	03/24/09 17:15	NFP	SM-2540G
Total Zinc	**629**	mg/Kg - dry	2.44	03/27/09 03:46	JTR	SW-6010B
Nitrate+Nitrite-N	<6.24	mg/Kg - dry	6.24	03/27/09 10:00	DJS	SM-4500-NO3E
Total Kjeldahl Nitrogen	**39800**	mg/Kg - dry	26.0	03/26/09 09:53	DRG	SM-4500-NH3D-TKN

Qualifiers/ Definitions MQL Method Quantitation Limit

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The One Source

Send To: Biosystems Engineering Soil Science
Shawn Hawkins

KNOXVILLE , TN 37996-4531

Project : Analytical Testing

Purchase Order :
Report Date : 04/23/2009
Date Received : 04/09/2009

REPORT OF ANALYSIS

Date Sampled : 03/18/2009

Lab Number: 60749
Sample Id : Mabbco 3-09-1

Analysis	Result	Quantitation Limit	Method	Date and Time Test Started	Analyst
Digestion ,	Digested		SW-3050B	04/13/2009 16:49	JTR
Total Phosphorus , mg/Kg	25200	49.9	SW-6010B	04/22/2009 20:22	JTR

Method Reference:
USEPA, SW-846, Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, 3rd Ed. Current Revision
Comments:

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Project : Analytical Testing

Purchase Order :
Report Date : 04/23/2009
Date Received : 04/09/2009

REPORT OF ANALYSIS

Date Sampled :

Lab Number: 60750
Sample Id : Mabbco 3-09-1

Analysis	Result	Quantitation Limit	Method	Date and Time Test Started	Analyst
Total Phosphorus , mg/Kg	23000	1240	SM-4500-PE	04/21/2009 09:10	TB

Method Reference:
Standard Methods for the Analysis of Water and Wastewater, 20th Ed. 1998
Comments:

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Figure 12. Spring 2009 biosolids EPA 503 monitoring analysis.

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10-084-0240 **Page:** 1 of 2
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2506 E.J. Chapman Dr.
Knoxville , TN 37996-4531

Project : Mannco

Purchase Order : R12-4310-060
Report Date : 04/08/2010
Date Received : 03/25/2010

REPORT OF ANALYSIS

Date Sampled : 03/12/2010

Lab Number: 59134
Sample Id : Mannco-SP2010

Analysis	Result	Quantitation Limit	Method	Date and Time Test Started	Analyst
Digestion ,	Digested		SW-3050B	03/31/2010 15:41	
% Moisture , %	6.54	0.010	SM-2540G	04/02/2010 13:00	TSM
Ammonia Nitrogen , mg/Kg	2530	25.0	SM-4500-NH3C	03/29/2010 11:24	DRG
Organic N , mg/Kg	39900	25.0	CALCULATION	03/29/2010 11:24	
pH , s.u.	7.2		SW-9045D	04/08/2010 16:00	LF
Total Cadmium , mg/Kg	0.821	0.099	SW-6010B	04/06/2010 04:40	JTR
Total Chromium , mg/Kg	52.2	0.249	SW-6010B	04/06/2010 04:40	JTR
Total Copper , mg/Kg	344	0.249	SW-6010B	04/06/2010 04:40	JTR
Total Lead , mg/Kg	28.1	0.299	SW-6010B	04/06/2010 04:40	JTR
Total Nitrogen , mg/Kg	42400	0.100	CALCULATION	03/29/2010 08:43	
Total Phosphorus , mg/Kg	26100	99.9	SW-6010B	04/03/2010 13:33	JTR
Total Potassium , mg/Kg	1540	5.00	SW-6010B	04/06/2010 04:40	JTR
Total Solids , %	93.5	0.010	SM-2540G	04/02/2010 13:00	TSM
Total Volatile Solids , %	49.6	0.010	SM-2540G	04/02/2010 13:00	TSM

Sample results are reported 'as received' and are not moisture corrected unless noted.

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10-084-0240 **Page:** 2 of 2
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Knoxville , TN 37996-4531

Project : Mannco

Purchase Order : R12-4310-060
Report Date : 04/08/2010
Date Received : 03/25/2010

REPORT OF ANALYSIS

Date Sampled : 03/12/2010

Lab Number: 59134
Sample Id : Mannco-SP2010

Analysis	Result	Quantitation Limit	Method	Date and Time Test Started	Analyst
Total Zinc , mg/Kg	537	0.499	SW-6010B	04/06/2010 04:40	JTR
Nitrate+Nitrite-N , mg/Kg	0.586	0.100	EPA-300.0	03/29/2010 08:43	KS
Total Kjeldahl Nitrogen , mg/Kg	42400	25.0	SM-4500-NH3D-TKN	04/01/2010 07:38	DRG

Method Reference:
Calculation from lab derived data.
Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600/R-93/100)
Standard Methods for the Analysis of Water and Wastewater, 20th Ed. 1998
USEPA, SW-846, Test Methods for Evaluating Sdid Wastes, Physical/Chemical Methods, 3rd Ed. Current Revision
Comments:

Sample results are reported 'as received' and are not moisture corrected unless noted.

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Figure 13. Spring 2010biosolids EPA 503 monitoring analysis.

Report Number
11-089-0279 Page: 1 of 2

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Mr. Shawn Hawkins
2506 E.J. Chapman Dr.
Knoxville , TN 37996-4531

Project : Mannco

Purchase Order : R12-4310-060
Report Date : 04/05/2011
Date Received : 03/30/2011

REPORT OF ANALYSIS

Date Sampled : 03/27/2011

Lab Number: 92163
Sample Id : Mannso-SP2011-1

Analysis	Result	Quantitation Limit	Method	Date and Time Test Started	Analyst
0.45 Micron Filtration (Prep) ,	Filtered		SW-9056 (PREP)	04/04/2011 16:52	
Digestion ,	Digested		3050B	04/01/2011 10:29	
Ammonia Nitrogen , mg/Kg	3040	25.0	4500-NH3C	04/04/2011 10:40	DRG
Organic N , mg/Kg	47300	107	CALCULATION	04/01/2011 08:19	
pH , s.u.	7.3		SW-9045D	03/31/2011 12:42	LGF
Total Cadmium , mg/Kg	0.973	0.100	6010B	04/01/2011 05:22	JTR
Total Chromium , mg/Kg	44.3	0.250	6010B	04/01/2011 05:22	JTR
Total Copper , mg/Kg	314	0.250	6010B	04/01/2011 05:22	JTR
Total Lead , mg/Kg	34.8	0.300	6010B	04/01/2011 05:22	JTR
Total Nitrogen , mg/Kg	50300	1.00	CALCULATION	04/01/2011 08:19	
Total Phosphorus , mg/Kg	25000	125	6010B	04/05/2011 13:40	JTR
Total Potassium , mg/Kg	1430	5.00	6010B	04/01/2011 05:22	JTR
Total Solids , %	97.5	0.010	2540G	04/01/2011 16:05	GHD
Total Volatile Solids , %	56.5	0.010	2540G	04/01/2011 16:05	GHD

Sample results are reported 'as received' and are not moisture corrected unless noted.

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Project : Mannco

Purchase Order : R12-4310-060
Report Date : 04/05/2011
Date Received : 03/30/2011

REPORT OF ANALYSIS

Date Sampled : 03/27/2011

Lab Number: 92163
Sample Id : Mannso-SP2011-1

Analysis	Result	Quantitation Limit	Method	Date and Time Test Started	Analyst
Total Zinc , mg/Kg	566	0.500	6010B	04/01/2011 05:22	JTR
Nitrite (NO2-N) , mg/Kg	1.36	1.00	SW-9056	04/04/2011 16:12	KYS
Nitrate (NO3-N) , mg/Kg	4.35	1.00	SW-9056	04/04/2011 16:12	KYS
Nitrate+Nitrite-N , mg/Kg	5.71	1.00	SW-9056	04/04/2011 16:12	
Total Kjeldahl Nitrogen , mg/Kg	50300	107	4500-NH3D-TKN	04/01/2011 08:19	DRG

Method Reference:

Calculation from lab derived data.
Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600/R-93/100)
Standard Methods for the Analysis of Water and Wastewater, 20th Ed. 1998
USEPA, SW-846, Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, 3rd Ed. Current Revision

Comments:

Sample results are reported 'as received' and are not moisture corrected unless noted.

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Figure 14. Spring 2011 biosolids EPA 503 monitoring analysis.

Appendix B

Broiler Litter Analysis

***MANURE FOR FERTILIZER ANALYSIS (report for AGRI-429)

Name:	SHAWN HAWKINS	**Received in lab:**	**4/23/2009**
Address:	2506 E.J. CHAPMAN DR.	**Mailed:**	**5/01/2009**
City:	KNOXVILLE	State,Zip:	TN 37996
County:		CK#:	

Lab. No.	M90690	M90690
Sample No.	McNABB	McNABB
Animal type	broilers	
-age/lbs	none given	
Bedding type	shavings/sawdust	
Manure type	deep stack/ca	
Sample date	4/09/2009	
Age of manure	5 mo	
pH	8.7	
Ec(umhos)	9850	
% H20	35.9	

'Total on Dry Basis

Total %N	4.59	Total %Mg	0.78
		Total %S	0.86
Total %P	1.83	Fe,mg/kg	481
		Mn,mg/kg	698
Total %K	3.26	Zn,mg/kg	473
Total %Ca	4.40	Cu,mg/kg	791
Total %Carbon	38.20	Na, mg/kg	
NO3-N, mg/kg	62.6	B, mg/kg	
NH4-N, mg/kg	9202	Al, mg/kg	

Total on "as-is" basis

Total %N	2.94	Total %Mg	0.50
		Total %S	0.55
Total %P	1.17	Fe,mg/kg	308
		Mn,mg/kg	447
Total %K	2.09	Zn,mg/kg	303
Total %Ca	2.82	Cu,mg/kg	507
Total %Carbon	24.47	Na, mg/kg	
NO3-N, mg/kg	40.1	B, mg/kg	
NH4-N, mg/kg	5895	Al, mg/kg	

lbs/ton on "as-is" basis

N	58.8	Mg	10.0
P2O5	53.6	S	11.0
K2O	50.6	Fe	0.62
Ca	56.4	Mn	0.89
Total Carbon	489.4	Zn	0.61
NO3-N	0.08	Cu	1.01
NH4-N	11.8	Na	
		B	
		Al	

***All analyses performed on as-is basis. Dry basis values calculated from moisture content.

*lbs/ton P2O5 = %Total P on "as-s" basis multiplied by 20*2.29

*lbs/ton K2O - %Total K on "as-is" basis multiplied by 20*1.2

Figure 15. Spring 2009 litter analysis results.

AGRICULTURAL DIAGNOSTIC LABORATORY
UNIVERSITY OF ARKANSAS - FAYETTEVILLE
***MANURE FOR FERTILIZER ANALYSIS (report for AGRI-429)

Name:	SHAWN HAWKINS	Received in lab:	5/14/2010
Address:	2506 E.J. CHAPMAN DR.	Mailed:	5/21/2010
City:	KNOXVILLE	State,Zip:	TN 37996
County:		CK#:	INVOICE DIRECTLY

Lab. No.	M100737			M100737
Sample No.	SAMPLE 1			SAMPLE 1
Animal type	broilers			
-age/lbs	none given			
Bedding type	shavings/sawdust			
Manure type	deep stack/ca			
Sample date	4/01/2010			
Age of manure	1-3 mo			
pH	8.9			
Ec(umhos)	9400			
% H20	39.2			

'Total on Dry Basis

Total %N	3.72	Total %Mg	0.94
		Total %S	0.83
Total %P	1.83	Fe,mg/kg	2102
		Mn,mg/kg	1087
Total %K	3.55	Zn,mg/kg	495
Total %Ca	4.08	Cu,mg/kg	823
Total %Carbon	36.76	Na, mg/kg	
NO3-N, mg/kg	187.5	B, mg/kg	
NH4-N, mg/kg	5157	Al, mg/kg	

Total on "as-is" basis

Total %N	2.26	Total %Mg	0.57
		Total %S	0.50
Total %P	1.11	Fe,mg/kg	1278
		Mn,mg/kg	661
Total %K	2.16	Zn,mg/kg	301
Total %Ca	2.48	Cu,mg/kg	500
Total %Carbon	22.35	Na, mg/kg	
NO3-N, mg/kg	114.0	B, mg/kg	
NH4-N, mg/kg	3135	Al, mg/kg	

lbs/ton on "as-is" basis

N	45.2	Mg	11.4
P2O5	50.8	S	10.1
K2O	52.3	Fe	2.6
Ca	49.6	Mn	1.3
Total Carbon	447.0	Zn	0.6
NO3-N	0.23	Cu	1.0
NH4-N	6.3	Na	
		B	
		Al	

***All analyses performed on as-is basis. Dry basis values calculated from moisture content.
*lbs/ton P2O5 = %Total P on "as-s" basis multiplied by 20*2.29
*lbs/ton K2O - %Total K on "as-is" basis multiplied by 20*1.2

Figure 16. Spring 2010 litter analysis results.

AGRICULTURAL DIAGNOSTIC LABORATORY
UNIVERSITY OF ARKANSAS - FAYETTEVILLE
***MANURE FOR FERTILIZER ANALYSIS (report for AGRI-429)

Name:	SHAWN HAWKINS	Received in lab:	5/14/2010
Address:	2506 E.J. CHAPMAN DR.	Mailed:	5/21/2010
City:	KNOXVILLE	State,Zip:	TN 37996
County:		CK#:	INVOICE DIRECTLY

Lab. No.	M100738		M100738		
Sample No.	SAMPLE 2		SAMPLE 2		
Animal type	broilers				
-age/lbs	none given				
Bedding type	shavings/sawdust				
Manure type	deep stack/ca				
Sample date	4/01/2010				
Age of manure	1-3 mo				
pH	9.0				
Ec(umhos)	9280				
% H20	42.3				

'Total on Dry Basis

Total %N	3.57		Total %Mg	0.95		
			Total %S	0.85		
Total %P	1.89		Fe,mg/kg	1110		
			Mn,mg/kg	783		
Total %K	3.84		Zn,mg/kg	553		
Total %Ca	3.83		Cu,mg/kg	994		
Total %Carbon	35.42		Na, mg/kg			
NO3-N, mg/kg	41.0		B, mg/kg			
NH4-N, mg/kg	6316		Al, mg/kg			

Total on "as-is" basis

Total %N	2.06		Total %Mg	0.55		
			Total %S	0.49		
Total %P	1.09		Fe,mg/kg	641		
			Mn,mg/kg	452		
Total %K	2.22		Zn,mg/kg	319		
Total %Ca	2.21		Cu,mg/kg	574		
Total %Carbon	20.45		Na, mg/kg			
NO3-N, mg/kg	23.7		B, mg/kg			
NH4-N, mg/kg	3647		Al, mg/kg			

lbs/ton on "as-is" basis

N	41.2		Mg	11.0		
P2O5	49.9		S	9.8		
K2O	53.7		Fe	1.3		
Ca	44.2		Mn	0.9		
Total Carbon	409.0		Zn	0.6		
NO3-N	0.05		Cu	1.1		
NH4-N	7.3		Na			
			B			
			Al			

***All analyses performed on as-is basis. Dry basis values calculated from moisture content.
*lbs/ton P2O5 = %Total P on "as-s" basis multiplied by 20*2.29
*lbs/ton K2O - %Total K on "as-is" basis multipied by 20*1.2

Figure 16. Cont.

AGRICULTURAL DIAGNOSTIC LABORATORY

UNIVERSITY OF ARKANSAS - FAYETTEVILLE

***MANURE FOR FERTILIZER ANALYSIS (report for AGRI-429)

Name:	SHAWN HAWKINS	Received in lab:	5/14/2010
Address:	2506 E.J. CHAPMAN DR.	Mailed:	5/21/2010
City:	KNOXVILLE	State,Zip:	TN 37996
County:		CK#:	INVOICE DIRECTLY

Lab. No.	M100739		M100739		
Sample No.	SAMPLE 3		SAMPLE 3		
Animal type	broilers				
-age/lbs	none given				
Bedding type	shavings/sawdust				
Manure type	deep stack/ca				
Sample date	4/01/2010				
Age of manure	1-3 mo				
pH	9.1				
Ec(umhos)	9850				
% H20	37.2				

'Total on Dry Basis

Total %N	4.41		Total %Mg	0.88		
			Total %S	0.83		
Total %P	1.74		Fe,mg/kg	823		
			Mn,mg/kg	787		
Total %K	3.76		Zn,mg/kg	527		
Total %Ca	3.76		Cu,mg/kg	1049		
Total %Carbon	37.34		Na, mg/kg			
NO3-N, mg/kg	74.0		B, mg/kg			
NH4-N, mg/kg	5329		Al, mg/kg			

Total on "as-is" basis

Total %N	2.77		Total %Mg	0.55		
			Total %S	0.52		
Total %P	1.09		Fe,mg/kg	517		
			Mn,mg/kg	494		
Total %K	2.36		Zn,mg/kg	331		
Total %Ca	2.36		Cu,mg/kg	659		
Total %Carbon	23.45		Na, mg/kg			
NO3-N, mg/kg	46.5		B, mg/kg			
NH4-N, mg/kg	3347		Al, mg/kg			

lbs/ton on "as-is" basis

N	55.4		Mg	11.0		
P2O5	49.9		S	10.4		
K2O	57.1		Fe	1.0		
Ca	47.2		Mn	1.0		
Total Carbon	469.0		Zn	0.7		
NO3-N	0.09		Cu	1.3		
NH4-N	6.7		Na			
			B			
			Al			

***All analyses performed on as-is basis. Dry basis values calculated from moisture content.

*lbs/ton P2O5 = %Total P on "as-s" basis multiplied by 20*2.29

*lbs/ton K2O - %Total K on "as-is" basis multiplied by 20*1.2

Figure 16. Cont.

AGRICULTURAL DIAGNOSTIC LABORATORY

UNIVERSITY OF ARKANSAS - FAYETTEVILLE

***MANURE FOR FERTILIZER ANALYSIS (report for AGRI-429)

Name:	SHAWN HAWKINS	Received in lab:	3/30/2011
Address:	2506 E.J. CHAPMAN DR.	Mailed:	4/06/2011
City:	KNOXVILLE	State,Zip:	TN 37996
County:	GREENE (TN)	CK#:	

Lab. No.	M10541		M10541		
Sample No.	Mannco Litter 5p2011-1		Mannco Litter 5p2011-1		
Animal type	broilers				
-age/lbs	1-42				
Bedding type	shavings/sawdust				
Manure type	cake				
Sample date	3/27/2011				
Age of manure	1-3 months				
pH	8.9				
Ec(umhos)	8040				
% H20	41.9				

-on dry basis-

Total %N	4.15		Total %Mg	0.74		
			Total %S	0.72		
Total %P	1.89		Fe,mg/kg	307		
			Mn,mg/kg	668		
Total %K	3.77		Zn,mg/kg	503		
Total %Ca	3.96		Cu,mg/kg	770		
			Na, mg/kg			
NO3-N, mg/kg	98.0		B, mg/kg			
NH4-N, mg/kg	4211		Al, mg/kg			

-on as-is basis-

Total %N	2.41		Total %Mg	0.43		
			Total %S	0.42		
Total %P	1.10		Fe,mg/kg	178		
			Mn,mg/kg	388		
Total %K	2.19		Zn,mg/kg	292		
Total %Ca	2.30		Cu,mg/kg	447		
			Na, mg/kg			
NO3-N, mg/kg	56.9		B, mg/kg			
NH4-N, mg/kg	2445		Al, mg/kg			

-lbs/ton on as-is basis-

N	48.2		Mg	8.6		
P2O5	50.4		S	8.4		
K2O	53.0		Fe	0.36		
Ca	46.0		Mn	0.78		
			Zn	0.58		
NO3-N	0.11		Cu	0.89		
NH4-N	4.9		Na			
			B			
			Al			

***All analyses performed on as-is basis. Dry basis values calculated from moisture content.

*lbs/ton P2O5 = %Total P on "as-s" basis multiplied by 20*2.29

*lbs/ton K2O - %Total K on "as-is" basis multiplied by 20*1.2

Figure 17. Spring 2011 litter analysis results.

AGRICULTURAL DIAGNOSTIC LABORATORY
UNIVERSITY OF ARKANSAS - FAYETTEVILLE
***MANURE FOR FERTILIZER ANALYSIS (report for AGRI-429)

Name:	SHAWN HAWKINS	Received in lab:	3/30/2011
Address:	2506 E.J. CHAPMAN DR.	Mailed:	4/06/2011
City:	KNOXVILLE	State,Zip:	TN 37996
County:	GREENE (TN)	CK#:	

Lab. No.	M10542		M10542		
Sample No.	Mannco Litter 5p2011-2		Mannco Litter 5p2011-2		
Animal type	broilers				
-age/lbs	1-42				
Bedding type	shavings/sawdust				
Manure type	cake				
Sample date	3/27/2011				
Age of manure	1-3 months				
pH	8.7				
Ec(umhos)	8120				
% H20	38.4				

-on dry basis-

Total %N	4.03		Total %Mg	0.67		
			Total %S	0.71		
Total %P	1.74		Fe,mg/kg	494		
			Mn,mg/kg	681		
Total %K	3.13		Zn,mg/kg	413		
Total %Ca	3.80		Cu,mg/kg	586		
			Na, mg/kg			
NO3-N, mg/kg	259.9		B, mg/kg			
NH4-N, mg/kg	5459		Al, mg/kg			

-on as-is basis-

Total %N	2.48		Total %Mg	0.41		
			Total %S	0.44		
Total %P	1.07		Fe,mg/kg	304		
			Mn,mg/kg	419		
Total %K	1.93		Zn,mg/kg	254		
Total %Ca	2.34		Cu,mg/kg	361		
			Na, mg/kg			
NO3-N, mg/kg	160.0		B, mg/kg			
NH4-N, mg/kg	3361		Al, mg/kg			

-lbs/ton on as-is basis-

N	49.6		Mg	8.2		
P2O5	49.0		S	8.8		
K2O	46.7		Fe	0.61		
Ca	46.8		Mn	0.84		
			Zn	0.51		
NO3-N	0.32		Cu	0.72		
NH4-N	6.7		Na			
			B			
			Al			

***All analyses performed on as-is basis. Dry basis values calculated from moisture content.

*lbs/ton P2O5 = %Total P on "as-s" basis multiplied by 20*2.29

*lbs/ton K2O - %Total K on "as-is" basis multiplied by 20*1.2

Figure 17. Cont.

AGRICULTURAL DIAGNOSTIC LABORATORY
UNIVERSITY OF ARKANSAS - FAYETTEVILLE
***MANURE FOR FERTILIZER ANALYSIS (report for AGRI-429)

Name:	SHAWN HAWKINS	Received in lab:	3/30/2011
Address:	2506 E.J. CHAPMAN DR.	Mailed:	4/06/2011
City:	KNOXVILLE	State,Zip:	TN 37996
County:	GREENE (TN)	CK#:	

Lab. No.	M10543	M10543
Sample No.	Mannco Litter 5p2011-3	Mannco Litter 5p2011-3
Animal type	broilers	
-age/lbs	1-42	
Bedding type	shavings/sawdust	
Manure type	cake	
Sample date	3/27/2011	
Age of manure	1-3 months	
pH	8.2	
Ec(umhos)	11940	
% H20	52.7	

-on dry basis-

Total %N	5.90	Total %Mg	0.72
		Total %S	0.74
Total %P	1.99	Fe,mg/kg	355
		Mn,mg/kg	577
Total %K	3.45	Zn,mg/kg	440
Total %Ca	3.87	Cu,mg/kg	588
		Na, mg/kg	
NO3-N, mg/kg	116.5	B, mg/kg	
NH4-N, mg/kg	16324	Al, mg/kg	

-on as-is basis-

Total %N	2.79	Total %Mg	0.34
		Total %S	0.35
Total %P	0.94	Fe,mg/kg	168
		Mn,mg/kg	273
Total %K	1.63	Zn,mg/kg	208
Total %Ca	1.83	Cu,mg/kg	278
		Na, mg/kg	
NO3-N, mg/kg	55.1	B, mg/kg	
NH4-N, mg/kg	7722	Al, mg/kg	

-lbs/ton on as-is basis-

N	55.8	Mg	6.8
P2O5	43.1	S	7.0
K2O	39.4	Fe	0.34
Ca	36.6	Mn	0.55
		Zn	0.42
NO3-N	0.11	Cu	0.56
NH4-N	15.4	Na	
		B	
		Al	

***All analyses performed on as-is basis. Dry basis values calculated from moisture content.
*lbs/ton P2O5 = %Total P on "as-s" basis multiplied by 20*2.29
*lbs/ton K2O - %Total K on "as-is" basis multiplied by 20*1.2

Figure 17. Cont.

Appendix C

Hay Yield

Table 10. Yield data for the Greeneville and Plateau RECs.

Plot	Greeneville REC						Plateau REC					
	2009		2010		2011		2009		2010		2011	
	Sprin	Fall	Sprin	Fall	Sprin	Fall	Sprin	Fall	Sprin	Fall	Sprin	Fall
A1	1.9	1.3	1.7	1.1	2.1	0.6	2.6	1.6	2.1	1.3	1.6	1.2
A2	1.6	1.1	1.7	0.9	2.1	0.8	3.1	2.6	3.0	1.7	1.9	1.0
A3	1.4	1.0	1.6	1.2	2.2	0.7	1.9	1.4	1.9	0.8	1.1	1.2
A4	2.0	1.2	2.0	1.2	5.0	1.0	1.7	2.0	1.0	1.3	0.4	1.1
A5	1.8	1.4	2.3	1.1	3.4	0.6	2.1	1.9	1.5	0.9	0.9	0.6
A6	1.2	1.2	1.8	1.1	1.8	0.7	2.8	2.1	2.7	1.7	2.3	0.9
A7	1.3	1.0	1.9	0.9	2.3	0.6	2.6	1.8	2.0	1.0	1.4	0.6
A8	0.7	0.8	1.3	1.0	1.3	0.3	3.3	2.1	2.4	1.8	2.1	1.2
A9	1.2	1.0	1.6	1.0	2.0	0.4	2.7	2.0	2.0	1.2	1.3	1.0
B1	1.9	0.7	1.8	1.3	2.3	0.1	2.5	1.6	2.1	1.0	1.5	0.9
B2	1.4	0.9	1.9	1.1	2.5	1.0	2.6	1.9	2.1	1.1	1.5	1.0
B3	2.2	0.9	2.4	1.5	4.0	0.6	1.9	1.6	1.4	1.0	0.8	0.7
B4	1.2	1.1	1.6	1.3	2.4	0.2	2.4	1.7	1.6	1.3	1.2	1.1
B5	1.4	1.2	1.7	0.9	2.0	0.4	2.3	1.5	2.4	0.9	1.9	0.7
B6	2.0	1.4	2.1	1.0	2.5	0.8	2.7	2.1	3.2	1.4	2.3	0.9
B7	1.1	0.9	2.1	0.8	2.0	0.5	2.7	2.0	2.7	1.4	2.1	0.6
B8	0.7	0.8	1.1	0.9	1.2	0.6	2.7	1.9	1.8	1.3	1.1	1.1
B9	1.3	0.6	2.0	0.7	2.2	0.3	1.7	1.8	1.0	0.9	0.6	0.9
C1	2.1	1.3	1.8	1.0	1.8	0.2	2.7	2.0	2.5	1.8	2.0	1.4
C2	2.0	1.3	1.8	1.0	1.9	0.6	2.9	1.6	2.4	1.3	1.7	0.9
C3	2.0	1.1	2.0	1.1	2.6	0.9	2.5	1.9	1.5	1.3	1.1	0.8
C4	2.2	1.1	2.3	1.2	2.9	0.9	3.2	2.3	2.1	1.2	1.7	1.4
C5	0.6	0.8	1.4	1.1	0.7	0.8	3.2	1.9	2.9	1.6	2.2	0.9
C6	2.1	1.7	2.1	1.3	2.8	0.6	2.2	1.5	1.6	1.3	0.7	0.7
C7	0.9	0.9	1.7	0.9	2.2	0.7	2.8	1.7	2.4	1.6	1.6	0.7
C8	1.1	1.0	1.5	1.0	2.4	0.4	3.1	1.7	2.5	1.5	1.8	1.3
C9	1.4	0.8	1.9	0.8	2.1	0.3	1.9	1.6	1.6	1.6	1.6	1.2
D1	2.0	0.5	1.9	0.7	2.2	0.4	2.2	1.8	1.9	1.3	2.2	1.0
D2	1.4	0.8	1.4	0.7	1.1	0.8	3.0	1.7	2.4	1.6	2.3	1.1
D3	2.1	0.7	2.1	1.0	3.0	0.8	1.5	1.2	1.2	1.3	0.8	0.6
D4	1.5	1.0	1.6	1.0	2.6	0.7	2.2	1.3	1.6	1.4	1.7	1.3
D5	2.1	1.6	2.6	1.2	4.2	0.7	2.2	1.3	2.3	1.7	2.4	1.2
D6	1.3	0.9	1.8	0.8	1.7	0.6	2.7	1.7	1.9	1.2	2.2	1.2
D7	1.3	0.8	2.0	0.9	2.3	0.7	2.9	1.7	2.5	1.5	2.0	0.7
D8	0.7	0.9	1.2	0.9	1.6	0.6	2.9	1.6	2.0	1.6	1.8	1.0
D9	2.0	1.2	2.4	1.0	2.9	0.1	3.0	1.5	2.0	1.9	1.6	0.9

Appendix D

Forage Organic Breakdown and Quality Metrics

Protein- Crude, Available, Unavailable, Adjusted Crude. Crude protein (CP) is the total measureable protein concentration. Available protein is the protein that can be digested by cattle; unavailable protein is bound or has been heat damaged and cannot be digested. Unavailable protein should not exceed 10% of CP; if it does the adjusted crude protein (ACP) is the amount of protein after the unavailable protein has been subtracted. Generally, the CP and ACP are equal in the absence of heat damage. Forage quality is often evaluated based on the CP concentration: a growing beef steer requires 10-11% and 11-13% CP to obtain 1.5 and 1.7 lbs/day weight gains, respectively, while dry and lactating beef cows requires 7-8%and 10-12% CP, respectively (Ball, Hoveland et al. 2002).

Fat. Fats are easily digestible sources of energy for livestock.

Neutral Detergent and Acid Detergent Digestible Fiber. Forage fibers that are more or less digestible by livestock are measured with neutral and acid detergents. Acid digestible fiber is used to determine the energy yield of specific forages for different livestock species (results herein are for fescue grass grazed by cattle). Higher acid fiber content lowers the energy yield of the forages for livestock. Forages with lower fiber content are higher generally higher quality.

Non-Fiber Carbohydrates. An estimate of the starch and sugar content of forages.

Ash. The total forage mineral content should be less than 10% for grasses.

Net Energy for Maintenance (NEM), Lactation (NEL), Gain, (NEG). These are estimates of forage energy content for maintenance (NEM), maintenance plus lactation (NEL), and maintenance plus weight gain (NEG).

Total Digestible Nutrients. The sum of the crude protein, fat, and non-fiber carbohydrates that is a gross measure of forage quality and energy content. A growing beef steer requires forages with TDN of 65% and 68% to obtain 1.5 and 1.7 lb/day weight gains, respectively. Dry and lactating beef cows require forages with TDN of 50% and 60%, respectively.

Relative Feed Value (RFV). RFV is a gross measure of forage for cool season grasses indexed to full bloom alfalfa. Higher values generally indicate higher quality forage. Fescue typically hasa RFV between 101 and 122 and 84 and 101 at the between the vegetative and boot states (Ball, Hoveland et al. 2002).

Table 11. Spring 2009 forage nutritional analysis, Greenville, REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	13.2	12.2	13.2	1.0	2.3	35.5	61.7	13.8	9.0	62	0.64	0.63	0.36	92
A2	13.4	12.6	13.4	0.8	3.3	34.7	60.3	17.1	5.9	63	0.65	0.64	0.38	95
A3	13.0	12.1	13.0	0.9	3.4	34.6	60.3	17.4	5.9	63	0.65	0.64	0.38	95
A4	15.6	14.9	15.6	0.7	3.0	33.1	59.2	17.0	5.3	65	0.67	0.67	0.40	99
A5	16.9	16.2	16.9	0.7	3.3	33.9	59.2	14.7	5.9	64	0.66	0.65	0.39	98
A6	11.4	10.7	11.4	0.7	2.4	38.9	66.6	13.9	5.7	58	0.59	0.56	0.31	82
A7	12.1	11.4	12.1	0.7	2.7	35.3	63.5	15.7	6.0	62	0.64	0.63	0.36	90
A8	10.2	9.5	10.2	0.7	2.7	38.1	63.9	17.5	5.7	59	0.60	0.58	0.32	86
A9	12.5	11.8	12.5	0.8	3.1	34.9	63.7	15.0	5.7	62	0.64	0.63	0.36	90
B1	13.6	12.7	13.6	0.9	3.4	35.0	60.4	16.5	6.1	62	0.64	0.63	0.36	95
B2	12.0	11.2	12.0	0.9	2.9	35.6	63.9	16.7	4.5	62	0.64	0.63	0.36	89
B3	15.7	14.8	15.7	0.9	3.2	35.4	62.7	12.8	5.6	62	0.64	0.63	0.36	91
B4	13.1	12.2	13.1	0.9	3.6	34.2	61.9	16.0	5.4	63	0.65	0.64	0.38	94
B5	14.9	14.1	14.9	0.9	3.6	33.9	61.8	13.8	5.9	64	0.66	0.65	0.39	94
B6	15.8	15.0	15.8	0.8	3.0	35.6	64.0	11.5	5.6	62	0.64	0.63	0.36	89
B7	12.9	12.1	12.9	0.8	3.1	35.1	63.3	16.0	4.8	62	0.64	0.63	0.36	90
B8	11.8	10.9	11.8	0.9	2.9	37.1	60.7	18.0	6.6	61	0.62	0.61	0.35	92
B9	11.3	10.5	11.3	0.8	2.6	37.8	65.3	14.9	5.9	60	0.61	0.60	0.33	85
C1	12.7	11.9	12.7	0.8	3.0	38.2	63.4	14.5	6.4	59	0.60	0.58	0.32	87
C2	12.8	12.0	12.8	0.8	2.7	37.1	62.9	15.6	6.1	61	0.62	0.61	0.35	89
C3	13.0	12.1	13.0	0.8	2.9	35.5	64.9	13.6	5.6	62	0.64	0.63	0.36	88
C4	16.1	14.9	16.1	1.2	3.3	33.1	61.3	12.7	6.5	65	0.67	0.67	0.40	96
C5	11.2	10.3	11.2	1.0	2.0	36.6	65.6	14.7	6.5	61	0.62	0.61	0.35	86
C6	15.3	14.4	15.3	0.9	2.6	35.6	61.2	13.9	6.9	62	0.64	0.63	0.36	93
C7	13.1	12.3	13.1	0.8	2.2	36.6	63.5	13.7	7.6	61	0.62	0.61	0.35	89
C8	12.3	11.4	12.3	0.9	2.1	36.2	63.8	13.7	8.1	61	0.63	0.61	0.35	89
C9	12.8	11.7	12.8	1.1	2.5	37.8	64.6	12.6	7.5	60	0.61	0.60	0.33	86
D1	11.9	11.0	11.9	1.0	2.2	36.6	63.2	14.5	8.2	61	0.62	0.61	0.35	89
D2	10.2	9.1	10.2	1.2	2.4	39.2	66.8	13.7	6.9	58	0.59	0.56	0.31	81
D3	12.3	11.4	12.3	1.0	2.2	37.9	63.5	16.6	5.4	60	0.61	0.60	0.33	87
D4	12.8	11.8	12.8	1.0	2.7	34.9	61.2	16.9	6.4	62	0.64	0.63	0.36	94
D5	16.1	15.4	16.1	0.7	2.6	32.7	57.6	16.9	6.8	65	0.67	0.67	0.40	103
D6	14.1	12.8	14.1	1.3	3.2	34.0	60.9	14.9	6.9	64	0.66	0.65	0.39	95
D7	12.5	11.8	12.5	0.7	2.8	34.5	58.8	19.6	6.3	63	0.65	0.64	0.38	98
D8	12.3	11.3	12.3	0.9	3.0	34.9	60.4	18.0	6.3	62	0.64	0.63	0.36	95
D9	17.2	16.0	17.2	1.1	2.6	33.9	63.0	9.1	8.2	64	0.66	0.65	0.39	92

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 12. Spring 2009 forage nutritional analysis, Plateau, REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	15.6	14.9	15.6	0.7	2.6	36.7	63.0	11.5	7.3	61	0.62	0.61	0.35	89
A2	14.2	13.4	14.2	0.8	3.5	34.2	62.4	14.2	5.8	63	0.65	0.64	0.38	93
A3	14.5	13.5	14.5	1.0	3.1	35.8	62.3	14.2	6.0	61	0.63	0.61	0.35	91
A4	13.1	12.1	13.1	0.9	3.0	34.6	61.8	16.0	6.1	63	0.65	0.64	0.38	93
A5	14.6	13.4	14.6	1.2	3.4	35.3	62.8	12.0	7.2	62	0.64	0.63	0.36	91
A6	17.1	16.1	17.1	1.0	3.5	35.6	63.3	8.2	7.9	62	0.64	0.63	0.36	90
A7	15.1	14.2	15.1	0.9	3.3	36.4	64.2	11.1	6.3	61	0.63	0.61	0.35	88
A8	14.5	13.4	14.5	1.1	2.9	36.7	64.6	11.4	6.6	61	0.62	0.61	0.35	87
A9	10.9	10.2	10.9	0.7	1.6	41.6	69.1	13.5	4.9	55	0.56	0.52	0.26	76
B1	14.7	13.6	14.7	1.1	3.2	37.0	66.7	10.0	5.5	61	0.62	0.61	0.35	84
B2	13.9	12.9	13.9	1.1	2.9	37.4	65.8	11.2	6.2	60	0.61	0.6	0.33	85
B3	14.4	13.5	14.4	0.9	3.0	37.1	64.6	12.1	5.9	61	0.62	0.61	0.35	86
B4	14.9	13.8	14.9	1.1	3.1	36.7	65.3	10.0	6.8	61	0.62	0.61	0.35	86
B5	14.9	13.8	14.9	1.1	3.5	35.3	63.9	11.6	6.1	62	0.64	0.63	0.36	89
B6	15.5	14.6	15.5	1.0	2.8	37.4	66.4	8.1	7.2	60	0.61	0.6	0.33	84
B7	17.7	16.7	17.7	1.0	3.0	34.5	62.0	11.4	5.9	63	0.65	0.64	0.38	93
B8	17.2	16.1	17.2	1.1	3.1	33.4	62.0	7.2	10.5	64	0.66	0.65	0.39	94
B9	13.0	12.1	13.0	1.0	2.9	34.4	62.6	16.7	4.7	63	0.65	0.64	0.38	92
C1	17.3	16.5	17.3	0.8	3.0	34.5	61.5	10.5	7.7	63	0.65	0.64	0.38	94
C2	13.4	12.6	13.4	0.8	2.8	36.6	65.3	12.1	6.5	61	0.62	0.61	0.35	86
C3	14.3	13.5	14.3	0.8	3.2	34.6	63.0	13.4	6.2	63	0.65	0.64	0.38	91
C4	14.1	13.3	14.1	0.8	2.7	37.2	63.3	12.4	7.6	61	0.62	0.61	0.35	88
C5	14.9	13.9	14.9	1.0	3.1	35.6	64.6	10.2	7.2	62	0.64	0.63	0.36	88
C6	10.4	9.7	10.4	0.7	1.9	41.0	67.6	15.6	4.4	56	0.57	0.53	0.28	78
C7	13.0	12.3	13.0	0.7	2.6	38.5	65.3	13.1	6.0	59	0.6	0.58	0.32	84
C8	13.2	12.6	13.2	0.6	2.6	37.4	65.7	13.4	5.1	60	0.61	0.6	0.33	85
C9	14.6	13.8	14.6	0.8	3.5	33.5	60.8	14.7	6.4	64	0.66	0.65	0.39	96
D1	13.3	12.5	13.3	0.7	2.8	36.7	62.5	15.0	6.5	61	0.62	0.61	0.35	90
D2	16.2	15.4	16.2	0.8	2.6	36.5	64.5	9.2	7.5	61	0.62	0.61	0.35	87
D3	12.2	11.4	12.2	0.8	2.9	37.9	65.4	14.2	5.3	60	0.61	0.6	0.33	85
D4	14.5	13.5	14.5	1.0	3.3	34.3	61.3	13.0	7.9	63	0.65	0.64	0.38	94
D5	13.9	13.1	13.9	0.8	3.0	36.4	64.7	10.8	7.7	61	0.63	0.61	0.35	87
D6	12.5	11.8	12.5	0.7	3.0	37.5	63.1	15.0	6.5	60	0.61	0.6	0.33	88
D7	13.9	12.8	13.9	1.1	3.2	36.6	62.5	13.8	6.6	61	0.62	0.61	0.35	90
D8	13.5	12.8	13.5	0.8	2.6	36.8	66.5	9.9	7.6	61	0.62	0.61	0.35	84
D9	14.3	13.4	14.3	1.0	3.0	34.9	63.2	13.0	6.5	62	0.64	0.63	0.36	91

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 13. Fall 2009 forage nutritional analysis, Greeneville REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	13.7	12.1	13.7	1.5	1.8	36.8	62.2	16.2	6.1	61	0.62	0.61	0.35	90
A2	13.9	12.3	13.9	1.5	2.2	37.4	63.9	15.4	4.7	60	0.61	0.60	0.33	87
A3	13.1	11.5	13.0	1.7	2.5	38.6	64.9	14.6	4.8	59	0.60	0.58	0.32	84
A4	14.4	12.9	14.4	1.5	2.2	35.7	62.0	16.8	4.6	61	0.63	0.61	0.35	92
A5	14.4	12.6	14.3	1.7	2.1	38.3	66.5	12.2	4.9	59	0.60	0.58	0.32	83
A6	14.4	12.8	14.4	1.6	2.5	38.5	66.5	11.8	4.8	59	0.60	0.58	0.32	82
A7	11.7	10.3	11.7	1.5	2.3	40.2	66.6	14.8	4.6	57	0.58	0.55	0.29	80
A8	13.3	11.7	13.3	1.6	1.8	38.7	64.0	15.9	5.0	59	0.60	0.58	0.32	85
A9	13.0	11.3	12.9	1.7	2.3	40.5	66.4	13.6	4.6	56	0.57	0.53	0.28	80
B1	13.5	11.8	13.4	1.7	1.9	36.4	64.7	15.0	4.9	61	0.63	0.61	0.35	87
B2	13.1	11.3	12.9	1.7	2.3	38.2	64.2	16.0	4.5	59	0.60	0.58	0.32	86
B3	14.1	12.4	14.1	1.8	2.3	36.4	61.6	16.5	5.5	61	0.63	0.61	0.35	91
B4	13.0	11.3	12.8	1.8	1.9	39.6	65.9	14.4	4.7	58	0.59	0.56	0.31	82
B5	15.3	14.0	15.3	1.3	2.4	37.0	64.5	14.2	3.7	61	0.62	0.61	0.35	87
B6	14.1	12.4	14.1	1.7	1.7	36.8	63.4	15.3	5.5	61	0.62	0.61	0.35	88
B7	12.7	11.1	12.7	1.5	1.9	37.3	62.1	16.7	6.6	60	0.61	0.60	0.33	90
B8	13.0	11.5	13.0	1.5	2.1	35.1	60.7	19.0	5.3	62	0.64	0.63	0.36	94
B9	14.6	12.8	14.5	1.8	2.5	38.9	66.1	12.5	4.3	58	0.59	0.56	0.31	82
C1	12.5	10.8	12.3	1.7	2.2	41.5	67.9	13.0	4.3	55	0.56	0.52	0.26	77
C2	13.9	12.5	13.9	1.4	2.3	36.2	62.1	16.4	5.3	61	0.63	0.61	0.35	91
C3	14.6	13.0	14.6	1.6	1.7	36.4	63.9	14.5	5.3	61	0.63	0.61	0.35	88
C4	14.2	12.5	14.2	1.6	2.3	40.8	70.0	9.9	3.7	56	0.57	0.53	0.28	76
C5	14.3	13.0	14.3	1.3	1.9	35.6	62.1	15.9	5.8	61	0.63	0.61	0.35	92
C6	14.2	12.6	14.2	1.6	1.9	36.1	62.0	16.4	5.5	61	0.63	0.61	0.35	91
C7	13.7	12.1	13.7	1.6	1.8	36.3	62.1	16.8	5.7	61	0.63	0.61	0.35	91
C8	16.2	14.8	16.2	1.5	2.2	36.3	62.1	14.1	5.3	61	0.63	0.61	0.35	91
C9	12.7	11.2	12.7	1.5	1.8	36.2	62.5	16.9	6.0	61	0.63	0.61	0.35	90
D1	16.1	14.8	16.1	1.3	2.3	32.2	57.4	16.8	7.5	66	0.68	0.68	0.42	104
D2	12.7	10.8	12.4	1.8	2.0	40.9	67.4	14.1	3.8	56	0.57	0.53	0.28	79
D3	13.4	12.0	13.4	1.4	2.3	34.8	59.3	19.1	5.9	63	0.65	0.64	0.38	97
D4	12.8	11.2	12.8	1.6	2.2	36.5	65.2	14.6	5.2	61	0.62	0.61	0.35	86
D5	14.1	12.6	14.1	1.5	2.2	36.2	61.4	17.7	4.6	61	0.63	0.61	0.35	92
D6	12.7	11.0	12.6	1.7	2.1	39.0	66.9	13.9	4.5	58	0.59	0.56	0.31	81
D7	13.6	12.0	13.6	1.6	2.1	36.6	61.3	17.9	5.1	61	0.62	0.61	0.35	92
D8	13.6	11.7	13.4	1.9	2.0	39.3	65.5	13.6	5.4	58	0.59	0.56	0.31	83
D9	13.2	11.7	13.2	1.5	1.7	37.0	64.0	16.5	4.7	61	0.62	0.61	0.35	87

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 14. Fall 2009 forage nutritional analysis, Plateau REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	16.2	14.7	16.2	1.5	1.9	32.0	60.7	14.4	6.8	66	0.68	0.68	0.42	98
A2	14.6	12.7	14.5	1.9	2.3	37.7	67.8	10.0	5.5	60	0.61	0.60	0.33	82
A3	13.4	11.8	13.4	1.6	1.6	36.5	66.0	12.7	6.4	61	0.62	0.61	0.35	85
A4	14.8	13.2	14.8	1.5	2.3	35.5	62.6	14.1	6.3	62	0.64	0.63	0.36	91
A5	16.4	14.6	16.4	1.8	2.0	36.4	65.5	10.3	5.8	61	0.63	0.61	0.35	86
A6	15.0	13.4	15.0	1.5	2.0	36.3	66.1	11.3	5.7	61	0.63	0.61	0.35	85
A7	13.6	12.0	13.6	1.6	1.6	36.9	65.2	13.4	6.3	61	0.62	0.61	0.35	86
A8	16.4	14.8	16.4	1.6	2.5	35.7	63.9	11.2	6.0	61	0.63	0.61	0.35	89
A9	13.3	11.3	12.9	2.0	2.0	39.8	66.8	13.2	4.8	57	0.58	0.55	0.29	81
B1	14.3	12.6	14.3	1.7	2.3	38.6	67.0	11.4	5.0	59	0.60	0.58	0.32	82
B2	12.8	11.3	12.8	1.5	1.8	38.0	67.5	12.1	5.8	60	0.61	0.60	0.33	82
B3	15.2	13.6	15.2	1.7	2.6	35.3	60.7	15.6	5.9	62	0.64	0.63	0.36	94
B4	15.5	13.7	15.5	1.9	2.7	36.6	64.0	12.1	5.7	61	0.62	0.61	0.35	88
B5	13.6	11.7	13.3	1.9	2.2	37.7	67.0	12.3	5.0	60	0.61	0.60	0.33	83
B6	14.2	12.5	14.2	1.7	1.9	36.9	64.6	13.5	5.8	61	0.62	0.61	0.35	87
B7	15.1	13.3	15.1	1.8	2.1	34.4	57.9	17.5	7.4	63	0.65	0.64	0.38	100
B8	15.0	13.4	15.0	1.7	1.7	36.1	65.4	12.9	5.0	61	0.63	0.61	0.35	87
B9	16.4	14.8	16.4	1.6	2.8	35.5	63.9	11.4	5.5	62	0.64	0.63	0.36	89
C1	13.0	11.4	12.9	1.6	1.8	37.8	66.1	13.2	5.9	60	0.61	0.60	0.33	84
C2	14.8	13.4	14.8	1.4	2.3	34.6	63.2	13.2	6.4	63	0.65	0.64	0.38	91
C3	14.6	13.2	14.6	1.5	1.8	37.1	64.7	12.0	6.9	61	0.62	0.61	0.35	86
C4	15.9	14.3	15.9	1.6	2.2	37.5	66.7	9.8	5.4	60	0.61	0.60	0.33	83
C5	15.8	14.3	15.8	1.5	2.3	34.8	62.8	13.8	5.3	63	0.65	0.64	0.38	92
C6	14.4	12.8	14.4	1.5	1.7	38.0	66.2	11.5	6.3	59	0.60	0.58	0.32	83
C7	17.0	15.2	17.0	1.8	1.8	36.8	65.1	10.1	6.1	61	0.62	0.61	0.35	86
C8	15.7	14.0	15.7	1.7	2.6	36.5	62.5	13.6	5.7	61	0.62	0.61	0.35	90
C9	16.2	14.6	16.2	1.6	2.5	34.8	62.2	13.0	6.2	63	0.65	0.64	0.38	92
D1	17.0	15.4	17.0	1.6	2.6	33.8	60.5	13.5	6.4	64	0.66	0.65	0.39	96
D2	15.4	13.7	15.4	1.8	2.1	35.2	62.6	14.2	5.7	62	0.64	0.63	0.36	91
D3	14.5	13.0	14.5	1.5	2.1	36.5	65.8	11.7	6.0	61	0.62	0.61	0.35	86
D4	12.9	11.6	12.9	1.3	1.6	37.8	67.3	11.0	7.1	60	0.61	0.60	0.33	82
D5	14.4	13.0	14.4	1.4	2.1	36.5	65.2	12.8	5.5	61	0.62	0.61	0.35	86
D6	14.3	12.7	14.3	1.7	2.3	37.3	65.5	12.4	5.5	60	0.61	0.60	0.33	85
D7	13.8	12.2	13.8	1.6	1.8	38.7	67.9	11.9	4.6	59	0.60	0.58	0.32	81
D8	15.4	13.7	15.4	1.7	2.6	36.3	63.8	12.7	5.5	61	0.63	0.61	0.35	88
D9	15.7	14.2	15.7	1.5	2.2	34.5	61.8	13.6	6.7	63	0.65	0.64	0.38	93

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 15. Spring 2010 forage nutritional analysis, Greeneville REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	16.1	15.4	16.1	0.8	2.8	30.6	54.2	19.5	7.3	68	0.70	0.71	0.44	112
A2	14.9	14.0	14.9	0.9	2.9	33.4	59.7	15.6	6.9	64	0.66	0.65	0.39	98
A3	14.9	14.0	14.9	0.9	2.8	31.8	54.6	20.8	6.9	66	0.68	0.68	0.42	109
A4	18.0	17.1	18.0	0.8	2.5	32.1	58.0	15.0	6.6	66	0.68	0.68	0.42	102
A5	16.2	15.2	16.2	1.0	2.9	34.0	58.1	15.8	7.1	64	0.66	0.65	0.39	100
A6	18.0	17.0	18.0	1.1	2.3	32.6	54.4	18.3	7.0	65	0.67	0.67	0.40	109
A7	16.8	15.8	16.8	1.0	2.6	32.6	53.5	19.8	7.3	65	0.67	0.67	0.40	110
A8	18.9	17.9	18.9	1.0	2.7	28.5	47.8	22.7	7.8	70	0.73	0.74	0.47	130
A9	18.7	17.8	18.7	1.0	3.0	30.0	49.6	21.6	7.2	69	0.71	0.73	0.45	123
B1	16.8	15.6	16.8	1.2	2.6	32.7	56.5	17.5	6.7	65	0.67	0.67	0.40	104
B2	15.8	14.9	15.8	0.9	2.4	34.2	60.9	15.1	5.8	63	0.65	0.64	0.38	95
B3	15.8	14.9	15.8	0.9	2.6	34.2	59.7	15.0	7.0	63	0.65	0.64	0.38	97
B4	16.1	15.2	16.1	0.9	2.6	31.7	56.5	18.2	6.6	67	0.69	0.70	0.43	106
B5	15.5	14.6	15.5	0.9	3.1	33.4	58.3	16.6	6.5	64	0.66	0.65	0.39	100
B6	18.3	17.5	18.3	0.8	2.8	31.9	56.9	15.5	6.5	66	0.68	0.68	0.42	105
B7	15.9	14.9	15.9	1.0	2.3	33.1	57.0	18.0	6.8	65	0.67	0.67	0.40	103
B8	13.3	12.3	13.3	1.0	2.3	33.7	56.2	21.7	6.6	64	0.66	0.65	0.39	104
B9	15.6	14.7	15.6	0.9	2.7	32.7	55.9	18.6	7.3	65	0.67	0.67	0.40	105
C1	18.7	17.7	18.7	1.0	2.5	30.4	54.4	17.9	6.6	68	0.70	0.71	0.44	111
C2	13.5	12.7	13.5	0.8	2.2	34.9	59.7	18.0	6.6	63	0.65	0.64	0.38	96
C3	17.8	16.9	17.8	0.9	2.7	30.9	54.8	17.6	7.2	68	0.70	0.71	0.44	110
C4	19.3	18.1	19.3	1.1	2.7	30.8	56.6	14.2	7.1	68	0.70	0.71	0.44	107
C5	16.0	15.0	16.0	1.0	2.6	30.7	54.6	20.0	6.7	68	0.70	0.71	0.44	111
C6	14.6	13.7	14.6	0.9	2.4	33.4	59.9	15.9	7.3	64	0.66	0.65	0.39	98
C7	18.4	17.5	18.4	0.9	2.6	31.5	54.6	17.4	7.1	67	0.69	0.70	0.43	110
C8	18.8	18.0	18.8	0.8	2.6	30.7	51.3	20.4	6.9	68	0.70	0.71	0.44	118
C9	15.6	14.6	15.6	1.0	2.7	32.6	56.3	18.6	6.8	65	0.67	0.67	0.40	105
D1	15.0	14.2	15.0	0.9	2.7	34.0	57.9	17.7	6.7	64	0.66	0.65	0.39	100
D2	14.9	13.9	14.9	1.0	2.5	33.2	56.2	20.5	6.0	65	0.67	0.67	0.40	104
D3	17.5	16.6	17.5	0.9	2.8	31.4	55.5	17.5	6.9	67	0.69	0.70	0.43	108
D4	14.5	13.6	14.5	0.9	3.0	34.0	57.9	17.5	7.1	64	0.66	0.65	0.39	100
D5	15.4	14.5	15.4	0.9	2.3	33.8	59.4	15.8	7.1	64	0.66	0.65	0.39	98
D6	17.8	16.8	17.8	0.9	2.4	30.3	51.8	21.1	7.0	68	0.70	0.71	0.44	117
D7	19.7	17.9	19.7	1.8	2.7	28.3	50.9	18.6	8.2	70	0.73	0.74	0.47	122
D8	17.1	16.1	17.1	1.0	2.7	30.9	50.5	22.2	7.5	67	0.69	0.70	0.43	119
D9	17.4	16.7	17.4	0.7	2.6	31.8	55.0	18.5	6.5	66	0.68	0.68	0.42	109

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 16. Spring 2010 forage nutritional analysis, Plateau REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	17.0	16.1	17.0	0.9	2.8	32.9	60.0	12.5	7.7	65	0.67	0.67	0.40	98
A2	17.4	16.6	17.4	0.8	3.2	32.7	59.5	12.0	7.9	65	0.67	0.67	0.40	99
A3	15.7	14.9	15.7	0.8	3.6	33.5	61.7	12.2	7.0	64	0.66	0.65	0.39	95
A4	13.7	12.9	13.7	0.9	2.9	34.1	61.1	15.3	6.9	63	0.65	0.64	0.38	95
A5	14.5	13.7	14.5	0.8	3.5	33.7	61.3	13.4	7.3	64	0.66	0.65	0.39	95
A6	16.1	15.3	16.1	0.7	3.7	32.8	61.7	11.2	7.4	65	0.67	0.67	0.40	96
A7	16.6	16.0	16.6	0.6	3.4	33.4	62.5	10.5	7.0	64	0.66	0.65	0.39	94
A8	18.6	17.7	18.6	1.0	2.7	32.9	62.3	9.1	7.3	65	0.67	0.67	0.40	95
A9	17.5	16.6	17.5	0.9	3.0	32.7	61.4	11.1	6.9	65	0.67	0.67	0.40	96
B1	15.9	15.1	15.9	0.8	2.8	35.2	62.5	11.3	7.5	62	0.64	0.63	0.36	91
B2	15.2	14.3	15.2	0.9	3.4	33.8	61.7	12.9	6.8	64	0.66	0.65	0.39	94
B3	15.7	14.1	15.7	1.6	2.5	35.0	64.2	9.6	8.1	62	0.64	0.63	0.36	89
B4	14.0	13.3	14.0	0.8	2.6	35.9	64.5	11.5	7.4	61	0.63	0.61	0.35	88
B5	15.7	14.9	15.7	0.7	3.0	34.0	62.8	11.2	7.3	64	0.66	0.65	0.39	92
B6	15.8	14.9	15.8	0.8	2.9	35.1	63.0	11.5	6.9	62	0.64	0.63	0.36	91
B7	20.0	18.3	20.0	1.7	2.4	32.9	64.0	5.1	8.5	65	0.67	0.67	0.40	92
B8	16.6	15.7	16.6	0.9	2.8	33.2	63.5	10.4	6.7	65	0.67	0.67	0.40	92
B9	13.6	12.8	13.6	0.8	3.0	34.4	62.5	14.5	6.5	63	0.65	0.64	0.38	92
C1	20.0	19.2	20.0	0.8	3.0	31.6	59.1	10.0	8.0	67	0.69	0.70	0.43	101
C2	16.6	15.8	16.6	0.9	3.1	33.6	61.5	11.9	6.9	64	0.66	0.65	0.39	95
C3	15.7	14.9	15.7	0.8	3.3	33.7	60.5	13.6	7.0	64	0.66	0.65	0.39	96
C4	16.6	15.9	16.6	0.7	3.3	33.1	61.5	11.3	7.4	65	0.67	0.67	0.40	95
C5	16.4	15.5	16.4	0.9	2.8	34.2	61.5	11.4	7.9	63	0.65	0.64	0.38	94
C6	14.0	13.1	14.0	0.9	3.5	33.0	59.4	16.6	6.5	65	0.67	0.67	0.40	99
C7	14.6	13.9	14.6	0.8	2.7	34.2	63.5	12.1	7.1	63	0.65	0.64	0.38	91
C8	17.5	16.7	17.5	0.8	3.2	32.1	61.0	11.3	7.0	66	0.68	0.68	0.42	97
C9	16.5	15.7	16.5	0.8	2.9	32.5	59.6	14.0	7.0	65	0.67	0.67	0.40	99
D1	17.5	16.8	17.5	0.8	3.4	31.6	59.7	11.9	7.5	67	0.69	0.70	0.43	100
D2	19.9	18.9	19.9	1.0	2.7	33.0	60.5	9.7	7.3	65	0.67	0.67	0.40	97
D3	14.4	13.3	14.4	1.1	2.7	33.3	61.0	15.3	6.5	65	0.67	0.67	0.40	96
D4	16.1	15.2	16.1	0.9	3.1	32.6	60.1	13.9	6.8	65	0.67	0.67	0.40	98
D5	16.2	15.4	16.2	0.9	2.9	33.7	61.6	12.0	7.3	64	0.66	0.65	0.39	95
D6	16.1	15.1	16.1	1.1	3.1	32.6	60.8	12.6	7.4	65	0.67	0.67	0.40	97
D7	16.1	15.2	16.1	0.9	2.8	33.4	61.5	12.4	7.3	64	0.66	0.65	0.39	95
D8	16.1	15.1	16.1	1.0	3.0	33.4	60.9	12.8	7.3	64	0.66	0.65	0.39	96
D9	16.3	15.2	16.3	1.1	2.8	33.4	60.8	12.9	7.3	64	0.66	0.65	0.39	96

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 17. Fall 2010 forage nutritional analysis, Greeneville REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	17.0	15.7	17.0	1.3	3.3	32.2	56.2	17.5	6.7	66	0.68	0.68	0.42	106
A2	13.5	11.9	13.5	1.5	3.2	34.1	55.6	21.4	7.0	63	0.65	0.64	0.38	104
A3	13.0	11.5	13.0	1.4	3.4	36.9	62.0	17.6	4.9	61	0.62	0.61	0.35	90
A4	15.7	14.3	15.7	1.4	3.3	34.0	57.3	19.2	5.2	64	0.66	0.65	0.39	101
A5	15.7	14.4	15.7	1.3	3.3	33.3	54.6	21.3	5.9	64	0.66	0.65	0.39	107
A6	12.5	11.1	12.5	1.3	4.1	36.1	55.2	23.1	6.7	61	0.63	0.61	0.35	103
A7	13.7	12.2	13.7	1.5	4.0	36.3	56.9	20.6	6.3	61	0.63	0.61	0.35	99
A8	12.1	10.5	12.0	1.6	2.8	37.9	63.6	16.3	5.3	60	0.61	0.60	0.33	87
A9	12.4	10.9	12.4	1.5	3.1	38.0	63.2	17.8	4.0	60	0.61	0.60	0.33	87
B1	12.9	11.4	12.9	1.5	4.2	33.2	52.4	26.7	5.4	65	0.67	0.67	0.40	112
B2	13.5	12.2	13.5	1.3	4.3	34.3	53.1	23.9	7.0	63	0.65	0.64	0.38	109
B3	15.6	14.2	15.6	1.4	3.5	33.7	57.8	17.4	6.7	64	0.66	0.65	0.39	101
B4	12.7	11.0	12.5	1.7	3.0	36.7	62.6	16.3	5.8	61	0.62	0.61	0.35	90
B5	14.6	13.1	14.6	1.4	3.8	34.6	57.3	19.4	6.2	63	0.65	0.64	0.38	101
B6	13.9	12.8	13.9	1.1	3.6	33.0	52.4	24.5	6.6	65	0.67	0.67	0.40	112
B7	16.3	15.3	16.3	1.1	4.0	29.8	49.7	24.2	7.2	69	0.71	0.73	0.45	123
B8	13.4	12.4	13.4	1.1	3.7	33.2	52.0	24.2	7.8	65	0.67	0.67	0.40	113
B9	13.3	11.9	13.3	1.4	4.3	33.9	52.6	24.3	7.2	64	0.66	0.65	0.39	110
C1	13.7	12.6	13.7	1.1	3.1	35.6	62.1	16.4	5.2	62	0.64	0.63	0.36	92
C2	14.8	13.6	14.8	1.3	4.2	34.4	57.1	19.6	5.9	63	0.65	0.64	0.38	101
C3	17.5	16.3	17.5	1.2	4.0	30.4	55.6	17.2	7.1	68	0.70	0.71	0.44	109
C4	14.7	12.1	13.9	2.6	3.2	31.0	55.7	19.8	7.2	67	0.69	0.70	0.43	108
C5	13.6	12.2	13.6	1.3	3.5	33.3	57.4	19.1	7.4	65	0.67	0.67	0.40	102
C6	13.7	11.9	13.5	1.8	2.8	36.8	60.3	18.8	4.6	61	0.62	0.61	0.35	93
C7	13.0	11.6	13.0	1.4	3.0	36.1	59.6	18.1	6.7	61	0.63	0.61	0.35	95
C8	12.9	11.7	12.9	1.3	3.1	36.8	60.0	18.5	5.9	61	0.62	0.61	0.35	93
C9	14.5	13.2	14.5	1.4	4.1	32.4	55.2	21.2	6.5	66	0.68	0.68	0.42	107
D1	13.9	12.6	13.9	1.3	3.3	35.7	60.6	16.9	6.0	61	0.63	0.61	0.35	94
D2	13.5	12.2	13.5	1.3	3.2	35.2	59.7	18.6	5.6	62	0.64	0.63	0.36	96
D3	17.4	16.2	17.4	1.3	3.9	28.5	53.1	20.1	6.9	70	0.73	0.74	0.47	117
D4	13.4	11.8	13.4	1.6	3.2	34.9	59.8	17.7	6.6	62	0.64	0.63	0.36	96
D5	14.5	13.2	14.5	1.2	3.7	31.4	56.7	19.6	6.8	67	0.69	0.70	0.43	106
D6	14.0	12.5	14.0	1.5	3.4	32.3	54.1	22.5	6.8	66	0.68	0.68	0.42	110
D7	14.3	13.0	14.3	1.3	4.1	33.6	56.6	20.2	6.3	64	0.66	0.65	0.39	103
D8	13.4	12.1	13.4	1.4	3.2	36.1	59.7	18.3	6.1	61	0.63	0.61	0.35	95
D9	14.4	13.1	14.4	1.3	3.4	32.1	57.0	19.0	7.1	66	0.68	0.68	0.42	104

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 18. Fall 2010 forage nutritional analysis, Plateau REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	13.6	12.1	13.6	1.5	2.4	37.9	64.7	14.0	5.2	60	0.61	0.60	0.33	85
A2	12.8	11.0	12.6	1.7	2.7	38.7	65.6	14.4	4.6	59	0.60	0.58	0.32	83
A3	12.5	11.0	12.5	1.5	2.7	39.2	66.3	13.7	5.0	58	0.59	0.56	0.31	82
A4	11.6	10.0	11.4	1.6	2.3	42.2	70.6	11.1	4.1	54	0.55	0.50	0.25	74
A5	10.9	9.4	10.7	1.5	2.3	43.4	71.1	11.1	4.3	53	0.54	0.49	0.24	72
A6	12.8	11.4	12.8	1.5	2.4	40.8	69.3	10.8	4.5	56	0.57	0.53	0.28	77
A7	11.6	10.0	11.4	1.6	2.2	42.3	71.2	10.7	3.9	54	0.55	0.50	0.25	73
A8	12.0	10.6	12.0	1.4	2.4	39.9	67.3	13.0	5.1	57	0.58	0.55	0.29	80
A9	13.6	12.0	13.6	1.6	2.5	38.0	65.0	14.8	4.0	59	0.60	0.58	0.32	85
B1	13.3	11.8	13.3	1.6	2.9	37.7	65.6	13.3	5.2	60	0.61	0.60	0.33	84
B2	10.8	9.2	10.5	1.6	2.0	42.3	69.4	12.4	4.8	54	0.55	0.50	0.25	75
B3	10.4	9.0	10.3	1.4	1.8	41.8	70.3	11.8	4.9	55	0.56	0.52	0.26	75
B4	11.2	9.9	11.2	1.3	1.8	40.8	70.6	10.7	5.0	56	0.57	0.53	0.28	75
B5	14.5	13.1	14.5	1.4	2.4	35.6	64.0	12.6	6.3	61	0.63	0.61	0.35	89
B6	13.1	11.8	13.1	1.3	2.4	38.3	67.4	11.0	5.9	59	0.60	0.58	0.32	81
B7	13.9	12.4	13.9	1.5	2.2	39.2	66.8	12.1	4.7	58	0.59	0.56	0.31	81
B8	12.4	11.0	12.4	1.4	2.3	40.1	68.2	11.5	5.2	57	0.58	0.55	0.29	79
B9	12.0	10.6	12.0	1.5	2.0	41.1	70.0	10.5	5.0	56	0.57	0.53	0.28	76
C1	13.8	12.4	13.8	1.3	2.4	37.2	65.1	12.6	6.0	60	0.61	0.60	0.33	86
C2	13.9	12.7	13.9	1.2	2.4	36.4	65.7	11.7	6.1	61	0.63	0.61	0.35	86
C3	11.2	9.7	11.1	1.5	1.8	41.5	70.1	11.0	5.1	55	0.56	0.52	0.26	75
C4	11.7	10.3	11.7	1.3	2.0	39.0	66.8	12.4	6.5	58	0.59	0.56	0.31	81
C5	13.0	11.6	13.0	1.5	2.3	38.7	67.9	10.5	6.0	59	0.60	0.58	0.32	80
C6	11.9	10.3	11.7	1.6	2.6	39.4	68.3	12.6	4.6	58	0.59	0.56	0.31	79
C7	12.3	10.9	12.3	1.3	2.2	39.0	67.1	12.5	5.5	58	0.59	0.56	0.31	81
C8	13.1	11.8	13.1	1.3	2.7	37.6	66.6	11.9	5.9	60	0.61	0.60	0.33	83
C9	13.6	12.0	13.6	1.6	2.7	38.8	66.6	12.4	4.8	58	0.59	0.56	0.31	82
D1	15.8	14.3	15.8	1.6	3.4	34.5	61.1	14.2	6.3	63	0.65	0.64	0.38	95
D2	14.2	12.9	14.2	1.4	2.5	36.2	64.5	12.2	6.5	61	0.63	0.61	0.35	88
D3	13.5	12.3	13.5	1.2	2.4	37.2	66.4	11.1	6.4	61	0.62	0.61	0.35	84
D4	15.0	13.8	15.0	1.2	3.3	34.8	62.0	14.1	6.3	63	0.65	0.64	0.38	93
D5	15.4	14.1	15.4	1.3	2.9	35.6	62.9	13.0	6.1	62	0.64	0.63	0.36	90
D6	14.5	13.2	14.5	1.3	3.1	34.4	62.5	13.3	7.1	63	0.65	0.64	0.38	92
D7	14.6	13.2	14.6	1.3	2.5	35.9	63.7	12.6	6.6	61	0.63	0.61	0.35	89
D8	13.3	11.9	13.3	1.4	2.7	36.6	63.7	14.1	6.3	61	0.62	0.61	0.35	88
D9	13.9	12.6	13.9	1.4	2.7	36.1	64.9	11.6	7.0	61	0.63	0.61	0.35	87

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 19. Spring 2011 forage quality indicators for the Greenville, REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	13.1	12.4	13.1	0.8	2.6	34.1	61.4	16.5	6.5	63	0.65	0.64	0.38	94
A2	14.4	13.4	14.4	1.0	3.4	34.3	60.6	14.6	7.0	63	0.65	0.64	0.38	95
A3	14.1	13.3	14.1	0.8	3.0	34.6	61.0	14.5	7.5	63	0.65	0.64	0.38	94
A4	15.9	15.0	15.9	0.9	2.5	34.9	51.9	23.2	6.6	62	0.64	0.63	0.36	111
A5	16.8	16.0	16.8	0.8	2.5	35.9	58.2	14.9	7.7	61	0.63	0.61	0.35	97
A6	13.2	12.4	13.2	0.7	2.6	34.7	62.2	14.5	7.5	63	0.65	0.64	0.38	93
A7	18.7	17.6	18.7	1.1	2.5	34.7	54.7	16.4	7.7	63	0.65	0.64	0.38	105
A8	18.9	17.9	18.9	1.0	2.9	30.7	49.7	21.0	7.6	68	0.7	0.71	0.44	122
A9	13.7	12.9	13.7	0.8	2.6	35.9	64.2	12.8	6.7	61	0.63	0.61	0.35	88
B1	14.5	13.7	14.5	0.8	2.5	37.2	63.8	12.2	7.0	60	0.61	0.6	0.33	87
B2	13.4	12.5	13.4	0.9	3.1	36.3	64.7	12.9	6.0	61	0.63	0.61	0.35	87
B3	16.0	14.9	16.0	1.1	2.3	36.5	60.6	14.9	6.3	61	0.62	0.61	0.35	93
B4	14.9	13.9	14.9	1.1	2.7	35.5	60.6	15.1	6.8	62	0.64	0.63	0.36	94
B5	13.7	13.0	13.7	0.7	3.0	32.9	59.9	16.9	6.7	65	0.67	0.67	0.4	98
B6	17.0	16.0	17.0	1.0	2.7	36.8	60.7	12.0	7.6	61	0.62	0.61	0.35	92
B7	13.0	12.1	13.0	0.9	2.8	34.8	63.2	14.4	6.6	63	0.65	0.64	0.38	91
B8	14.5	13.7	14.5	0.8	2.8	34.5	58.7	17.1	6.9	63	0.65	0.64	0.38	98
B9	15.1	14.2	15.1	0.9	2.5	35.1	60.1	15.1	7.2	62	0.64	0.63	0.36	95
C1	13.2	12.4	13.2	0.8	2.6	35.3	64.4	12.9	7.0	62	0.64	0.63	0.36	89
C2	13.5	12.6	13.5	0.9	2.7	34.8	63.8	12.7	7.3	63	0.65	0.64	0.38	90
C3	12.8	11.9	12.8	0.9	2.3	37.2	65.2	13.7	6.0	61	0.62	0.61	0.35	85
C4	16.1	15.3	16.1	0.9	2.7	34.4	50.1	23.6	7.6	63	0.65	0.64	0.38	115
C5	14.3	13.3	14.3	1.0	2.7	32.7	57.1	18.9	7.0	65	0.67	0.67	0.4	103
C6	16.6	15.7	16.6	0.9	2.7	37.6	62.0	10.7	8.0	60	0.61	0.6	0.33	89
C7	17.8	16.5	17.8	1.3	2.9	35.5	55.7	16.4	7.3	62	0.64	0.63	0.36	102
C8	15.9	14.8	15.9	1.1	2.6	36.4	58.5	15.3	7.7	61	0.63	0.61	0.35	96
C9	14.4	13.5	14.4	0.9	2.5	34.8	60.0	15.7	7.4	63	0.65	0.64	0.38	96
D1	13.2	12.1	13.2	1.1	3.0	35.9	63.5	14.1	6.4	61	0.63	0.61	0.35	89
D2	11.7	11.0	11.7	0.7	2.8	35.2	62.7	16.2	6.6	62	0.64	0.63	0.36	91
D3	16.9	15.9	16.9	1.0	2.9	37.6	58.1	15.3	6.8	60	0.61	0.6	0.33	95
D4	15.5	14.8	15.5	0.7	3.2	33.0	54.5	20.4	6.4	65	0.67	0.67	0.4	108
D5	21.2	20.0	21.2	1.2	2.4	29.8	50.8	22.5	6.7	69	0.71	0.73	0.45	120
D6	13.6	12.9	13.6	0.7	3.1	33.3	62.1	13.8	7.4	64	0.66	0.65	0.39	94
D7	14.6	13.8	14.6	0.8	2.9	34.4	60.7	14.5	7.4	63	0.65	0.64	0.38	95
D8	21.4	20.0	21.4	1.4	2.5	31.9	46.1	22.2	7.7	66	0.68	0.68	0.42	129
D9	15.7	14.9	15.7	0.8	2.8	36.1	60.0	14.0	7.6	61	0.63	0.61	0.35	94

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 20. Spring 2011 forage quality indicators for the Plateau, REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	13.6	12.9	13.6	0.7	2.7	34.2	59.2	18.0	6.6	63	0.65	0.64	0.38	98
A2	16.1	15.1	16.1	1.0	2.9	34.0	64.3	10.3	6.5	64	0.66	0.65	0.39	90
A3	16.0	15.1	16.0	0.9	3.5	33.7	63.9	10.8	5.8	64	0.66	0.65	0.39	91
A4	15.0	14.1	15.0	0.9	2.9	32.1	61.6	14.5	6.1	66	0.68	0.68	0.42	97
A5	14.9	14.3	14.9	0.7	2.7	34.6	63.4	12.0	7.0	63	0.65	0.64	0.38	91
A6	18.1	17.5	18.1	0.6	3.2	33.0	61.1	9.8	7.8	65	0.67	0.67	0.40	96
A7	16.7	16.0	16.7	0.7	2.8	33.8	64.5	9.2	6.9	64	0.66	0.65	0.39	90
A8	17.0	15.8	17.0	1.2	2.9	35.1	64.1	9.3	6.8	62	0.64	0.63	0.36	89
A9	17.8	17.1	17.8	0.7	2.4	36.1	62.7	10.1	7.0	61	0.63	0.61	0.35	90
B1	15.6	15.0	15.6	0.6	3.1	33.4	64.3	10.3	6.8	64	0.66	0.65	0.39	91
B2	17.1	16.4	17.1	0.7	2.8	33.7	60.8	12.9	6.6	64	0.66	0.65	0.39	96
B3	15.8	15.0	15.8	0.7	2.7	33.3	61.8	13.3	6.5	64	0.66	0.65	0.39	95
B4	16.4	15.7	16.4	0.7	2.9	33.8	62.2	11.8	6.7	64	0.66	0.65	0.39	94
B5	16.7	16.0	16.7	0.7	2.6	34.8	63.1	10.9	6.7	63	0.65	0.64	0.38	91
B6	18.5	17.9	18.5	0.6	3.1	35.6	62.0	9.5	7.0	61	0.63	0.61	0.35	92
B7	20.6	19.9	20.6	0.7	3.1	34.6	59.3	10.4	6.6	63	0.65	0.64	0.38	97
B8	15.7	15.1	15.7	0.6	2.9	33.4	62.9	11.6	6.9	64	0.66	0.65	0.39	93
B9	14.6	13.9	14.6	0.7	2.9	34.2	63.9	12.1	6.6	63	0.65	0.64	0.38	91
C1	19.4	18.8	19.4	0.7	3.0	35.6	61.4	8.4	7.8	61	0.63	0.61	0.35	93
C2	16.3	15.7	16.3	0.6	2.8	34.6	60.7	13.1	7.2	63	0.65	0.64	0.38	95
C3	15.0	14.3	15.0	0.7	3.0	34.3	61.6	13.9	6.5	63	0.65	0.64	0.38	94
C4	16.6	15.9	16.6	0.7	3.5	34.6	61.1	12.0	6.8	63	0.65	0.64	0.38	94
C5	16.7	16.0	16.7	0.7	2.6	33.9	62.9	10.6	7.2	64	0.66	0.65	0.39	92
C6	14.9	14.1	14.9	0.8	2.6	33.4	61.0	14.8	6.7	64	0.66	0.65	0.39	96
C7	15.8	15.1	15.8	0.7	3.2	34.5	62.1	11.8	7.2	63	0.65	0.64	0.38	93
C8	15.6	14.9	15.6	0.7	2.4	35.6	60.8	14.2	7.0	61	0.63	0.61	0.35	93
C9	15.7	15.1	15.7	0.6	3.2	33.4	58.5	16.0	6.6	64	0.66	0.65	0.39	100
D1	17.4	16.7	17.4	0.7	2.6	35.1	61.8	11.5	6.7	62	0.64	0.63	0.36	93
D2	19.0	18.4	19.0	0.6	3.0	35.8	61.0	10.1	6.9	61	0.63	0.61	0.35	93
D3	14.1	13.5	14.1	0.7	3.2	33.8	63.2	12.1	7.4	64	0.66	0.65	0.39	92
D4	15.5	14.9	15.5	0.7	3.1	35.6	60.1	14.3	7.1	62	0.64	0.63	0.36	95
D5	17.1	16.5	17.1	0.7	2.8	34.7	60.1	12.3	7.7	63	0.65	0.64	0.38	96
D6	17.4	16.8	17.4	0.6	2.7	34.9	60.6	11.2	8.1	62	0.64	0.63	0.36	95
D7	16.4	15.8	16.4	0.7	2.9	34.9	62.6	10.4	7.7	62	0.64	0.63	0.36	92
D8	15.2	14.3	15.2	0.9	2.7	33.8	60.8	13.8	7.6	64	0.66	0.65	0.39	96
D9	16.1	15.4	16.1	0.7	2.8	34.0	60.3	13.3	7.5	64	0.66	0.65	0.39	96

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value

Table 21. Fall 2011 forage biochemical analysis, Greenville, REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	16.0	15.0	16.0	1.0	2.6	32.2	55.5	18.8	7.2	66	0.68	0.68	0.42	107
A2	14.9	13.5	14.9	1.4	2.6	34.0	60.9	14.0	7.7	64	0.66	0.65	0.39	95
A3	11.9	10.7	11.9	1.3	2.0	37.4	63.6	16.8	5.8	60	0.61	0.60	0.33	88
A4	12.8	11.5	12.8	1.3	2.5	34.9	63.0	15.5	6.3	62	0.64	0.63	0.36	91
A5	13.6	12.6	13.6	1.0	3.3	35.6	59.0	17.2	7.0	62	0.64	0.63	0.36	97
A6	11.7	10.4	11.7	1.3	2.5	36.5	61.2	18.2	6.4	61	0.62	0.61	0.35	92
A7	13.0	11.8	13.0	1.1	2.5	34.7	60.3	18.1	6.1	63	0.65	0.64	0.38	95
A8	16.6	15.1	16.6	1.5	2.4	33.5	53.1	21.2	6.8	64	0.66	0.65	0.39	110
A9	13.7	12.4	13.7	1.3	2.9	36.7	60.5	16.5	6.4	61	0.62	0.61	0.35	93
B1	13.6	12.3	13.6	1.3	2.4	37.1	63.6	14.6	5.8	61	0.62	0.61	0.35	88
B2	15.7	14.2	15.7	1.5	2.1	37.2	62.5	14.6	5.2	61	0.62	0.61	0.35	89
B3	13.3	12.4	13.3	1.0	2.9	35.4	60.3	16.6	6.8	62	0.64	0.63	0.36	95
B4	13.4	12.2	13.4	1.2	2.2	35.6	62.3	16.7	5.4	62	0.64	0.63	0.36	91
B5	13.0	12.2	13.0	0.9	2.8	34.0	57.3	20.2	6.7	64	0.66	0.65	0.39	101
B6	13.6	12.6	13.6	1.0	3.5	36.2	55.8	19.8	7.4	61	0.63	0.61	0.35	101
B7	17.6	16.8	17.6	0.8	2.9	27.0	43.3	27.4	8.7	72	0.75	0.77	0.49	146
B8	14.2	12.8	14.2	1.5	2.8	36.0	61.5	15.1	6.4	61	0.63	0.61	0.35	92
B9	13.5	12.6	13.5	0.9	3.0	30.0	53.7	22.3	7.4	69	0.71	0.73	0.45	113
C1	14.7	13.4	14.7	1.3	3.0	37.9	63.9	12.5	6.0	60	0.61	0.60	0.33	87
C2	14.5	13.2	14.5	1.3	2.6	37.9	63.4	13.1	6.5	60	0.61	0.60	0.33	87
C3	17.0	16.2	17.0	0.9	2.8	29.7	48.9	23.8	7.5	69	0.71	0.73	0.45	125
C4	14.7	13.7	14.7	1.0	2.7	31.9	54.5	19.8	8.2	66	0.68	0.68	0.42	109
C5	14.8	13.4	14.8	1.4	2.8	37.5	67.3	9.6	5.5	60	0.61	0.60	0.33	82
C6	13.3	12.3	13.3	1.0	3.1	36.1	61.8	14.4	7.4	61	0.63	0.61	0.35	91
C7	13.1	11.9	13.1	1.2	2.8	36.9	65.4	13.2	5.5	61	0.62	0.61	0.35	86
C8	12.7	11.5	12.7	1.3	2.0	37.8	65.9	13.7	5.6	60	0.61	0.60	0.33	84
C9	12.0	10.7	12.0	1.3	2.3	37.5	65.4	14.6	5.7	60	0.61	0.60	0.33	85
D1	14.0	12.8	14.0	1.3	3.2	38.2	63.0	13.5	6.4	59	0.60	0.58	0.32	87
D2	14.8	13.4	14.8	1.4	3.3	37.0	64.5	12.0	5.5	61	0.62	0.61	0.35	87
D3	16.3	15.1	16.3	1.2	2.7	31.4	54.0	19.8	7.2	67	0.69	0.70	0.43	111
D4	13.1	11.9	13.1	1.2	2.9	34.5	58.5	18.2	7.3	63	0.65	0.64	0.38	99
D5	11.3	10.5	11.3	0.7	1.7	38.3	63.2	17.5	6.3	59	0.60	0.58	0.32	87
D6	13.0	12.2	13.0	0.8	2.9	34.1	56.9	19.5	7.7	63	0.65	0.64	0.38	102
D7	11.5	10.2	11.5	1.2	2.7	35.3	59.1	20.8	6.0	62	0.64	0.63	0.36	97
D8	12.0	10.6	12.0	1.4	3.4	35.3	61.1	18.0	5.6	62	0.64	0.63	0.36	94
D9	11.8	10.8	11.8	1.0	2.1	37.1	63.8	15.9	6.5	61	0.62	0.61	0.35	87

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

Table 22. Fall 2011 forage biochemical analysis, Plateau, REC.

Plot	Protein[1]				Fat (%)	Fiber[2]		NFC[3] (%)	Ash (%)	TDN[4] (%)	Net Energy[5]			RFV[6]
	CP (%)	ACP (%)	AP (%)	ADP (%)		ADF (%)	NDF (%)				NEL	NEM	NEG	
A1	14.8	13.2	14.8	1.7	2.5	36.4	62.4	13.3	7.0	61	0.63	0.61	0.35	90
A2	13.9	12.0	13.7	1.9	2.6	35.9	66.7	12.9	3.9	61	0.63	0.61	0.35	85
A3	16.1	14.6	16.1	1.5	3.0	34.9	63.6	12.4	5.0	62	0.64	0.63	0.36	90
A4	11.4	9.8	11.2	1.6	2.6	37.1	66.0	15.9	4.1	61	0.62	0.61	0.35	85
A5	13.0	11.2	12.8	1.8	2.9	34.9	64.8	15.1	4.2	62	0.64	0.63	0.36	89
A6	14.7	13.1	14.7	1.6	3.1	35.0	62.0	15.3	4.9	62	0.64	0.63	0.36	93
A7	20.1	18.8	20.1	1.4	3.0	31.6	54.1	15.4	7.4	67	0.69	0.70	0.43	111
A8	17.2	15.6	17.2	1.6	2.3	35.5	58.3	15.9	6.2	62	0.64	0.63	0.36	98
A9	14.4	12.7	14.4	1.7	2.7	34.4	61.0	16.4	5.6	63	0.65	0.64	0.38	95
B1	14.6	13.1	14.6	1.6	3.4	35.1	61.6	14.2	6.1	62	0.64	0.63	0.36	93
B2	17.5	15.9	17.5	1.6	2.5	34.0	59.3	14.1	6.5	64	0.66	0.65	0.39	98
B3	14.6	13.0	14.6	1.6	2.5	35.2	65.4	12.6	4.9	62	0.64	0.63	0.36	87
B4	12.7	11.0	12.5	1.7	3.0	34.7	68.9	11.5	3.9	63	0.65	0.64	0.38	84
B5	13.7	12.1	13.7	1.7	3.0	33.2	62.5	15.5	5.2	65	0.67	0.67	0.40	94
B6	15.7	14.0	15.7	1.7	2.6	34.7	60.7	15.6	5.4	63	0.65	0.64	0.38	95
B7	15.3	13.8	15.3	1.5	1.9	34.1	59.4	17.2	6.1	63	0.65	0.64	0.38	98
B8	12.7	11.0	12.6	1.7	3.2	34.7	67.2	11.9	5.1	63	0.65	0.64	0.38	86
B9	14.8	13.4	14.8	1.4	3.0	34.2	58.8	18.0	5.5	63	0.65	0.64	0.38	98
C1	12.6	10.8	12.3	1.7	3.0	34.4	67.7	12.0	4.8	63	0.65	0.64	0.38	85
C2	13.7	12.1	13.7	1.6	2.9	34.6	67.1	12.0	4.4	63	0.65	0.64	0.38	86
C3	14.1	12.6	14.1	1.5	2.3	33.0	62.4	15.5	5.7	65	0.67	0.67	0.40	94
C4	13.4	11.8	13.4	1.6	2.8	33.2	62.7	15.4	5.6	65	0.67	0.67	0.40	94
C5	14.6	13.1	14.6	1.5	2.5	34.1	64.8	12.4	5.6	63	0.65	0.64	0.38	90
C6	13.3	11.9	13.3	1.5	3.3	33.7	64.4	13.5	5.6	64	0.66	0.65	0.39	90
C7	14.5	13.0	14.5	1.5	2.9	38.5	65.0	12.7	5.0	59	0.60	0.58	0.32	84
C8	18.0	16.5	18.0	1.6	3.0	34.8	60.1	12.3	6.6	63	0.65	0.64	0.38	96
C9	13.5	11.9	13.5	1.6	2.3	37.4	69.6	10.0	4.6	60	0.61	0.60	0.33	80
D1	13.7	12.2	13.7	1.5	2.4	34.1	66.5	12.7	4.7	63	0.65	0.64	0.38	87
D2	14.1	12.7	14.1	1.4	2.7	37.7	63.4	14.3	5.4	60	0.61	0.60	0.33	87
D3	15.0	13.6	15.0	1.4	2.5	37.8	66.0	11.1	5.4	60	0.61	0.60	0.33	84
D4	13.3	11.7	13.3	1.6	2.7	35.8	63.7	14.6	5.7	61	0.63	0.61	0.35	89
D5	15.8	14.1	15.8	1.7	3.4	34.4	60.1	13.8	6.9	63	0.65	0.64	0.38	96
D6	19.6	18.3	19.6	1.3	2.8	33.7	59.2	11.0	7.5	64	0.66	0.65	0.39	98
D7	17.1	15.9	17.1	1.2	3.6	31.0	57.3	16.3	5.7	67	0.69	0.70	0.43	105
D8	14.2	12.8	14.2	1.4	3.1	35.4	60.8	16.0	5.9	62	0.64	0.63	0.36	94
D9	13.9	12.0	13.7	1.9	2.6	35.8	63.3	16.1	4.1	61	0.63	0.61	0.35	90

1.Protein: CP = Crude Protein, ACP = Adjusted Crude Protein,Available Protein, and ADP = Acid Detergent Protein.
2. Fiber: ADF = Acid Detergent Fiber and NDF = Neutral Detergent Fiber.
3. NFC: Non-Fiber Carbohydrates.
4 TDN: Total Digestible Nutrients.
5. Net Energy (MCal/lb): NEL = Net Energy for Lactation, NEM = Net Energy for Maintenance, and NEG = Net Energy for Gain.
6. RFV (unitless) = Relative Forage Value.

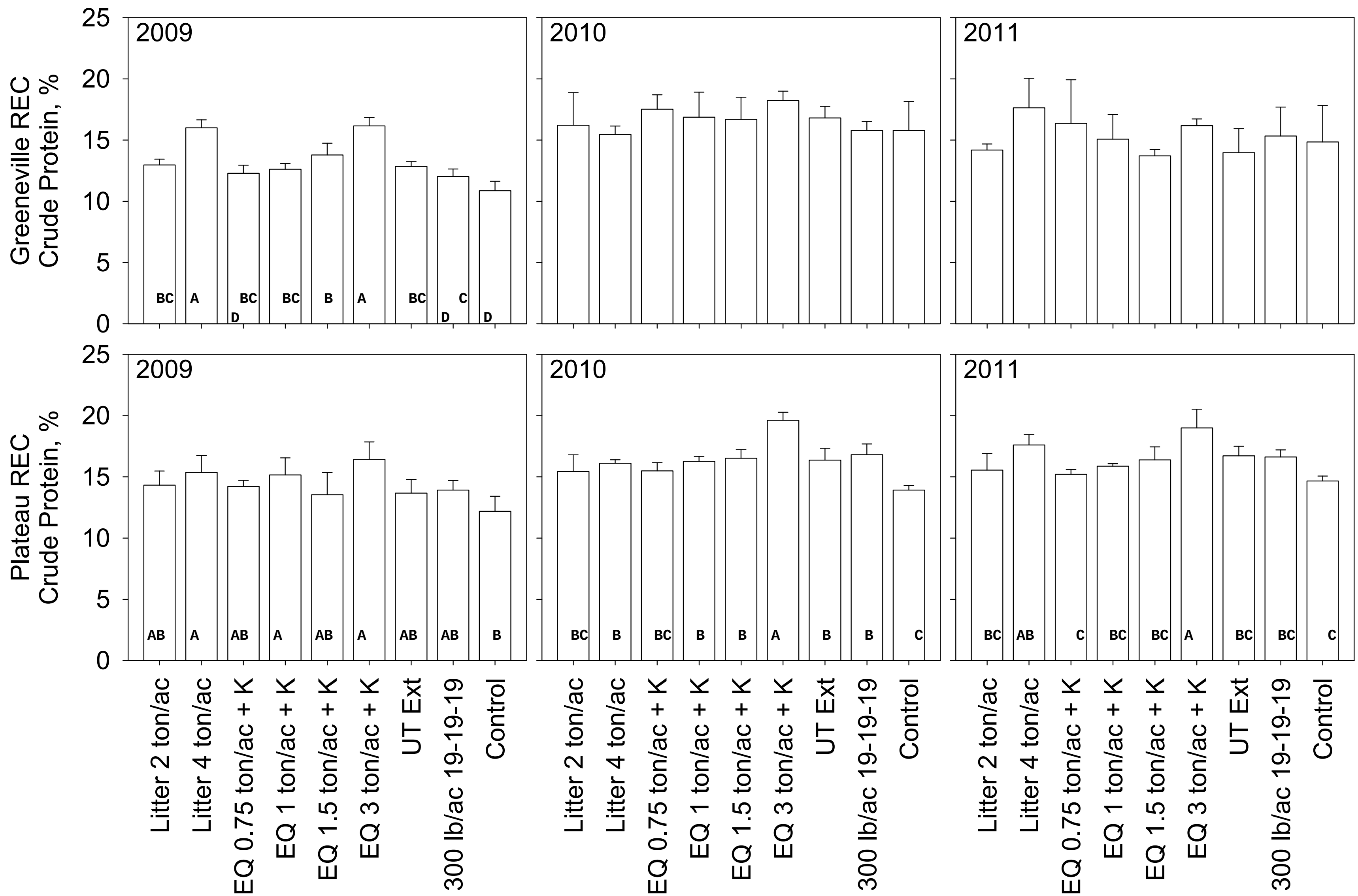

Figure 18. Spring forage crude protein concentrations (bars not sharing a common letter are significantly different).

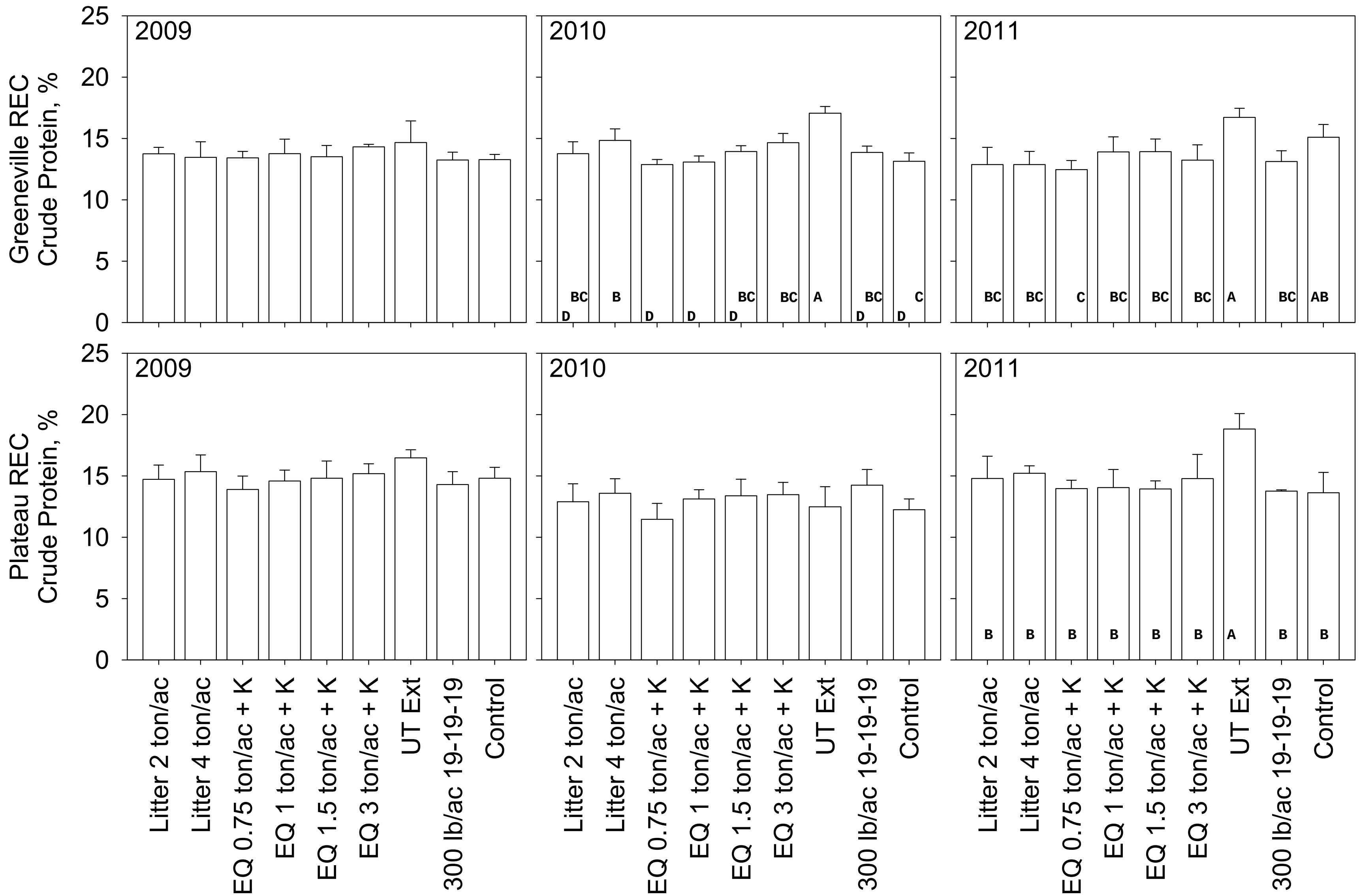

Figure 19. Fall forage crude protein concentrations (bars not sharing a common letter are significantly different).

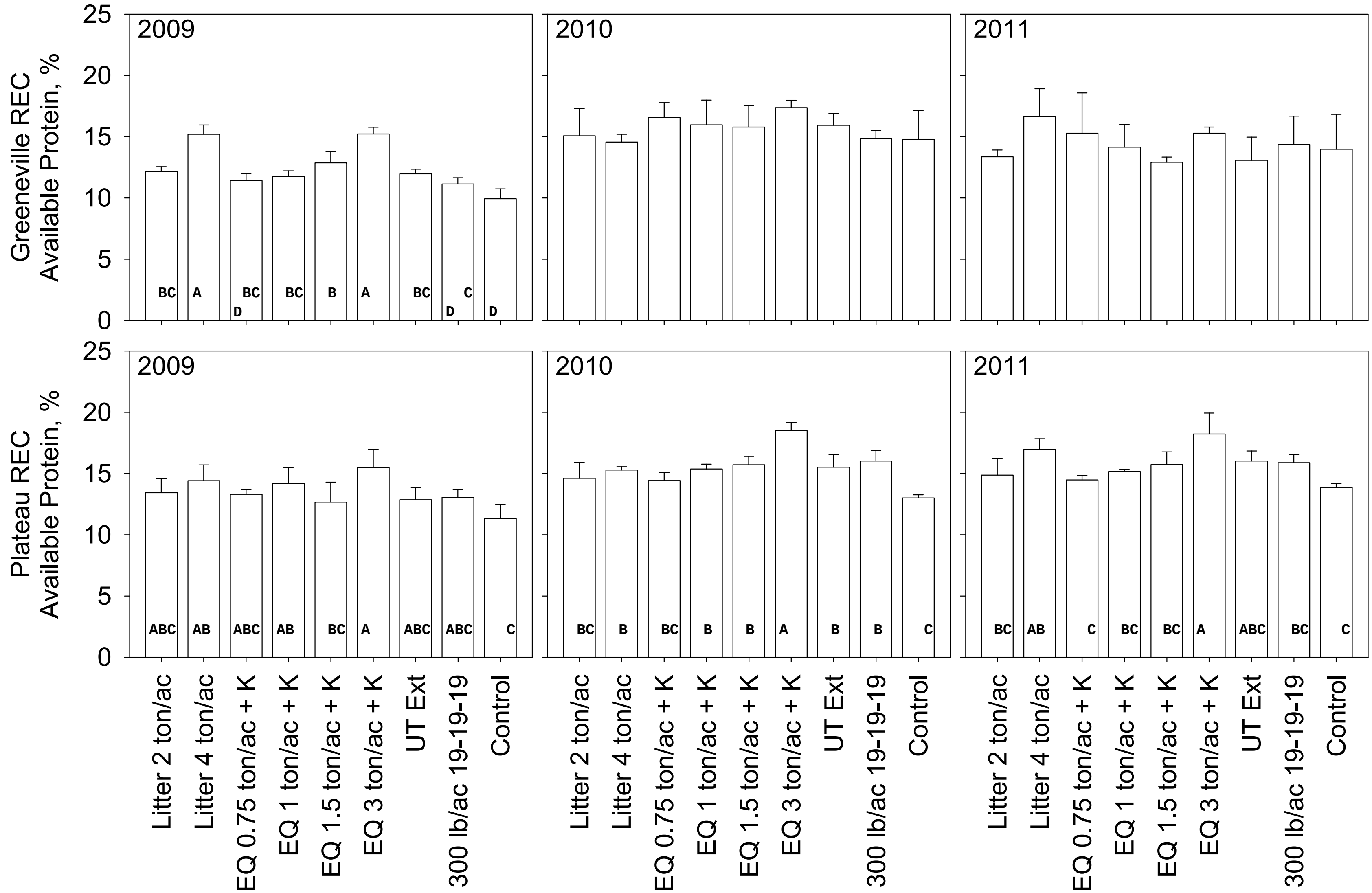

Figure 20. Spring forage available protein concentrations (bars not sharing a common letter are significantly different).

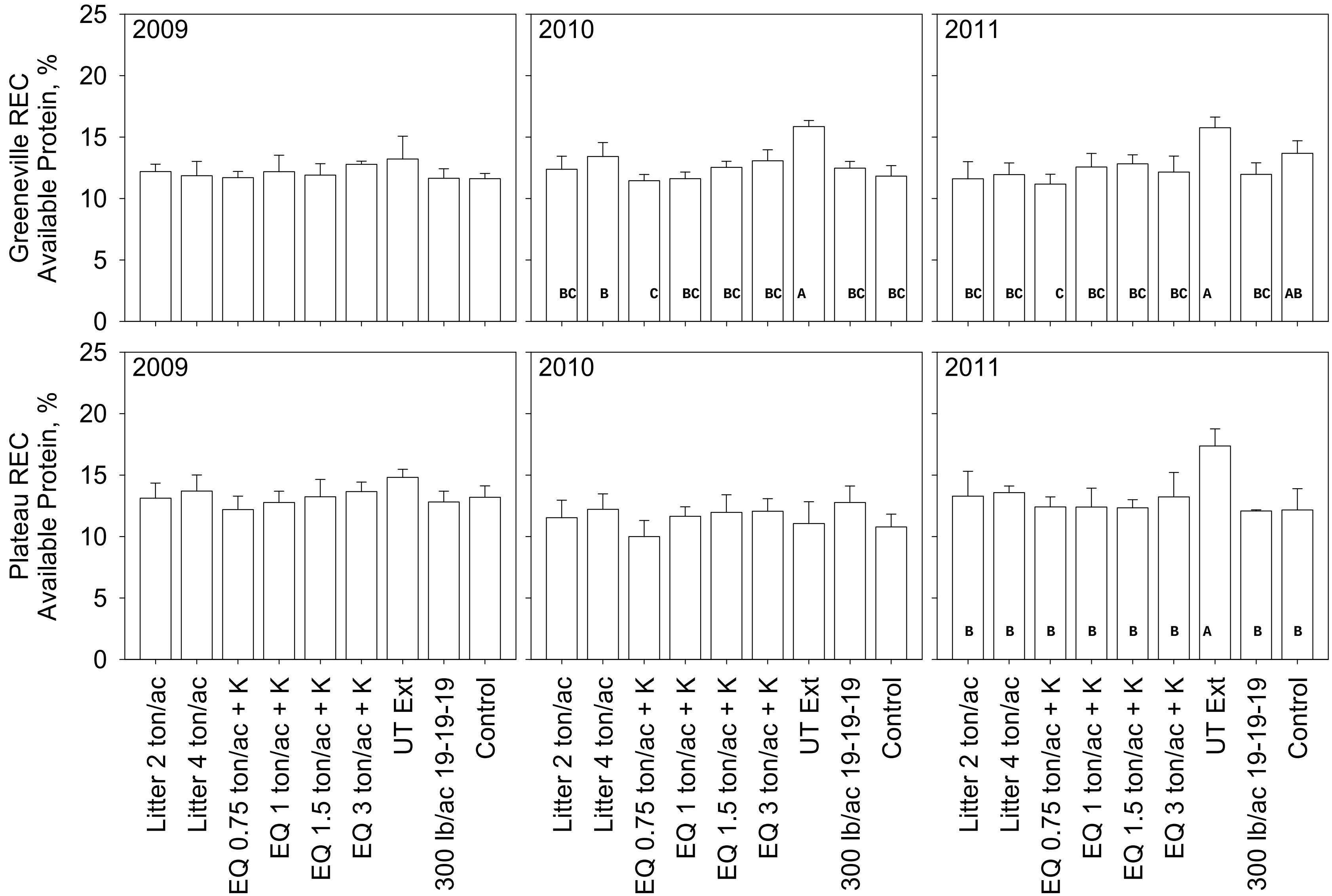

Figure 21. Fall forage available protein concentrations (bars not sharing a common letter are significantly different).

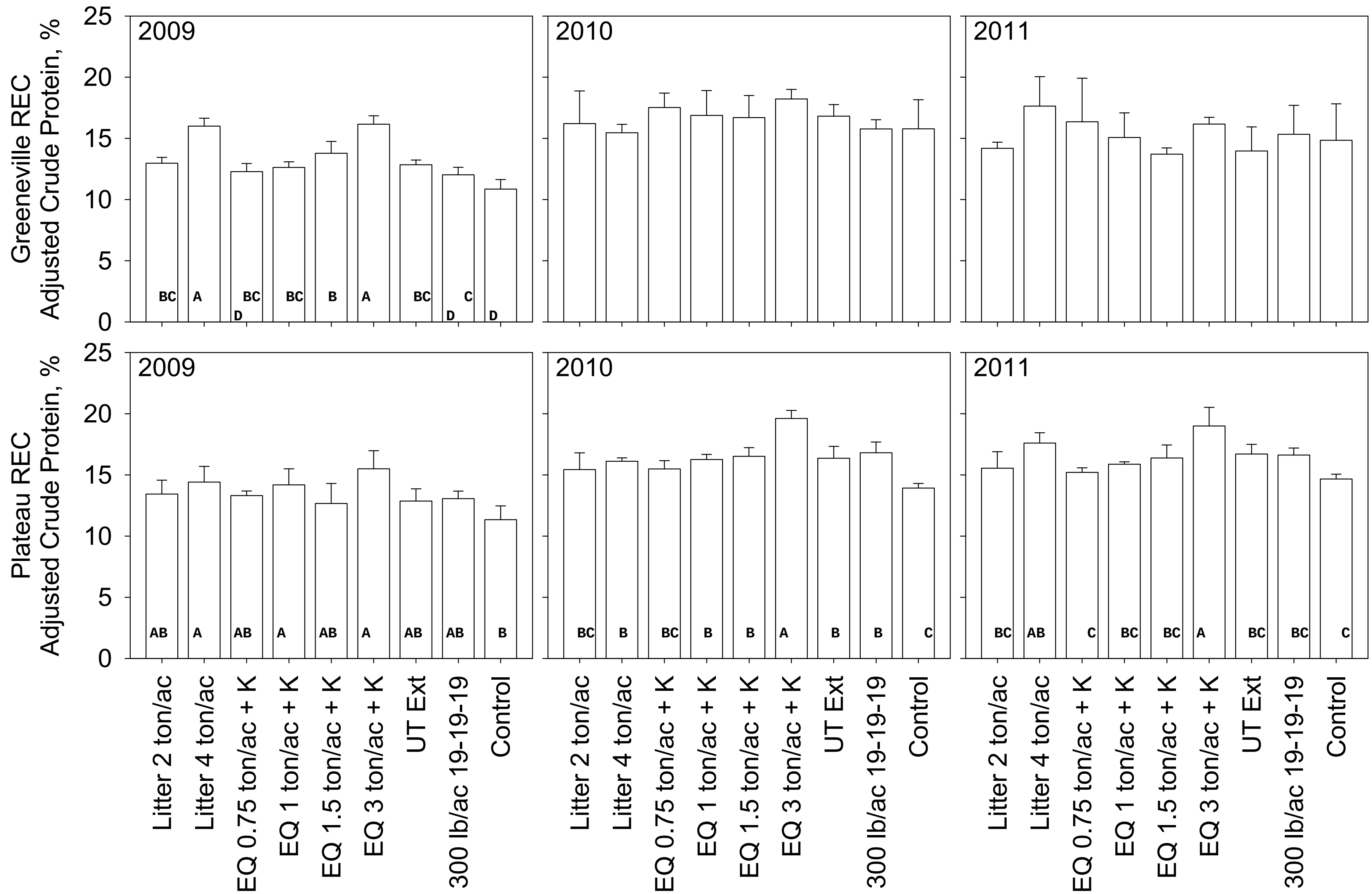

Figure 22. Spring adjusted crude protein concentrations (bars that do not share a common letter are significantly different).

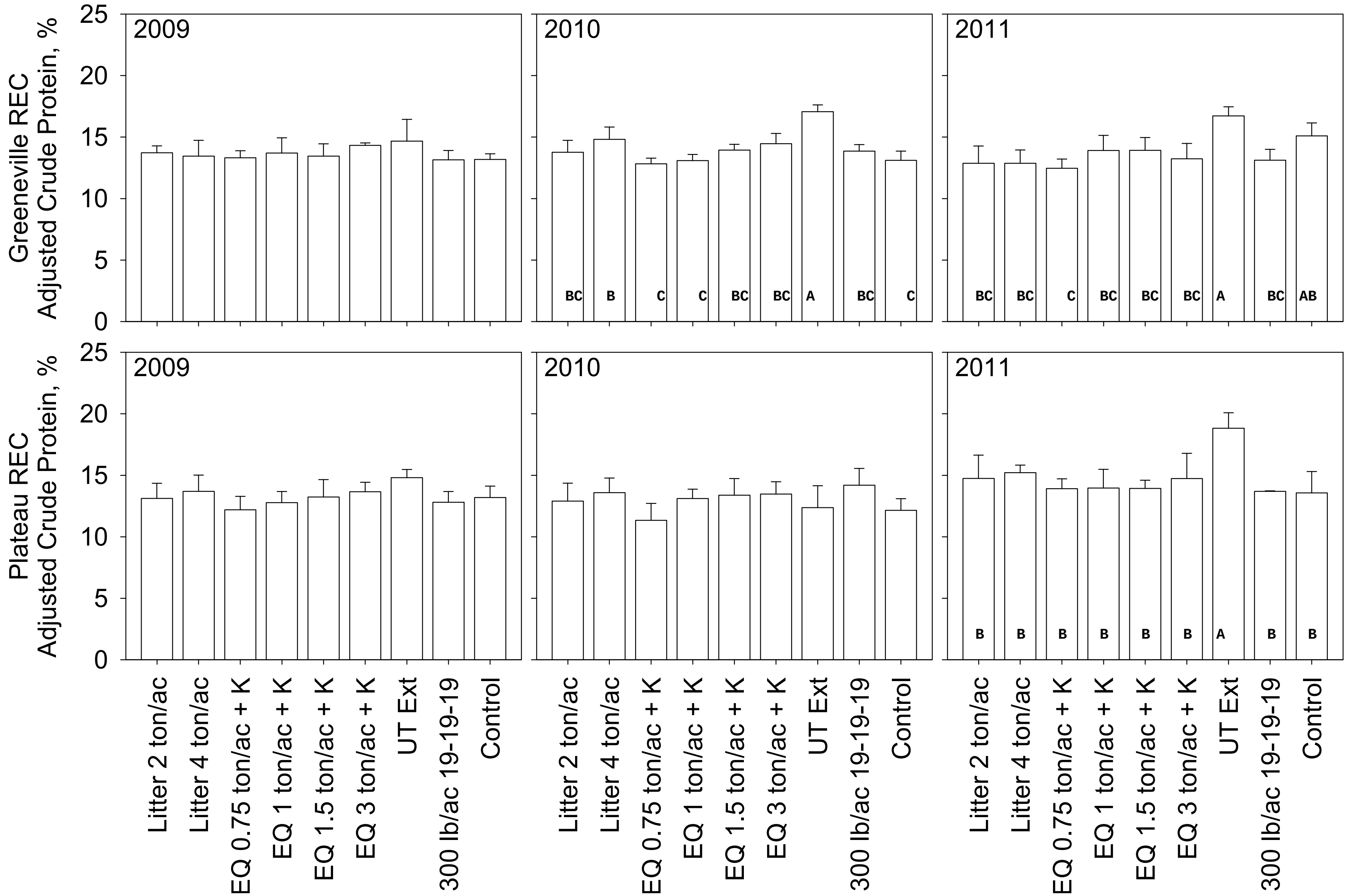

Figure 23. Fall adjusted crude protein concentrations (bars that do not share a common letter are significantly different).

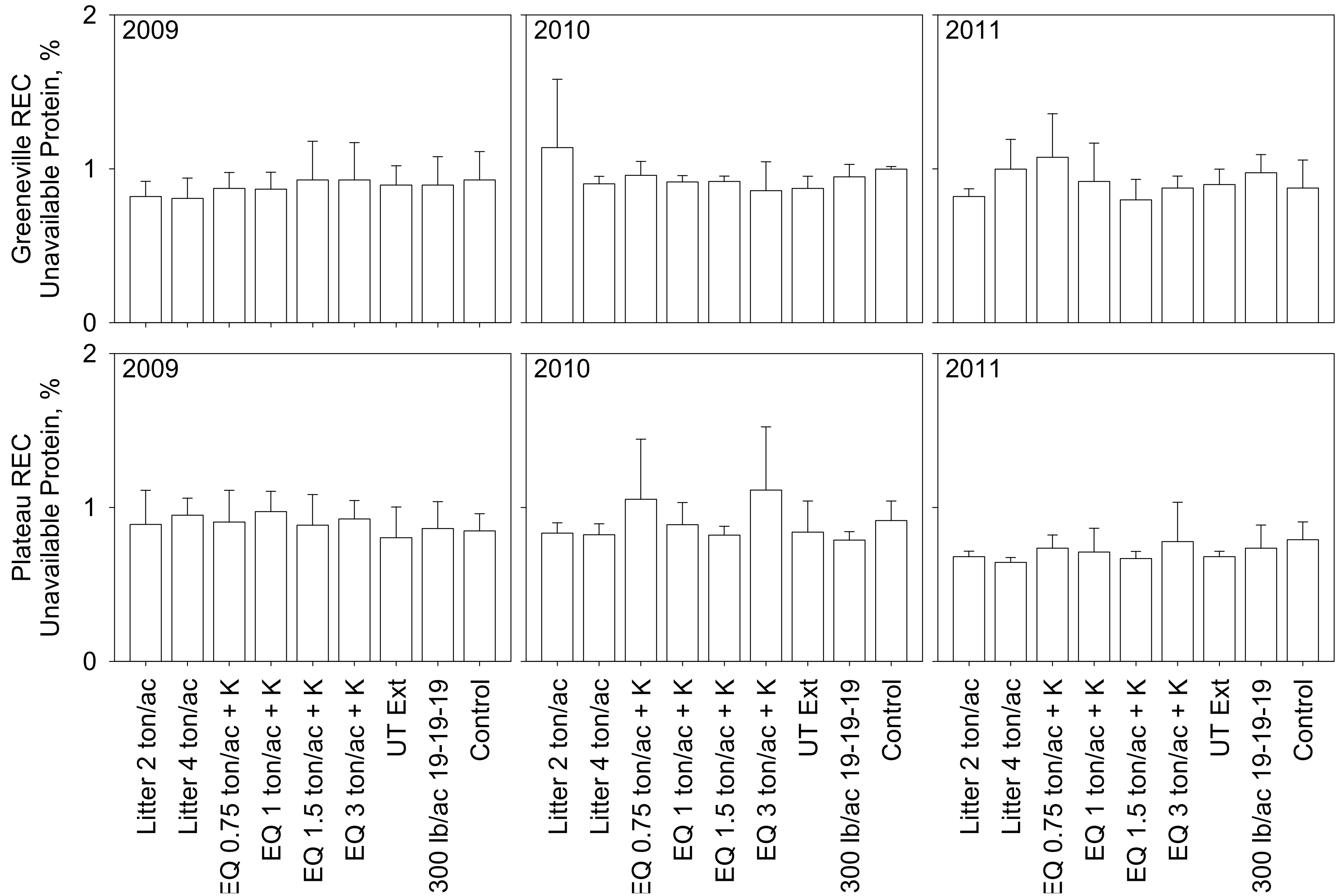

Figure 24. Spring forage unavailable protein concentrations.

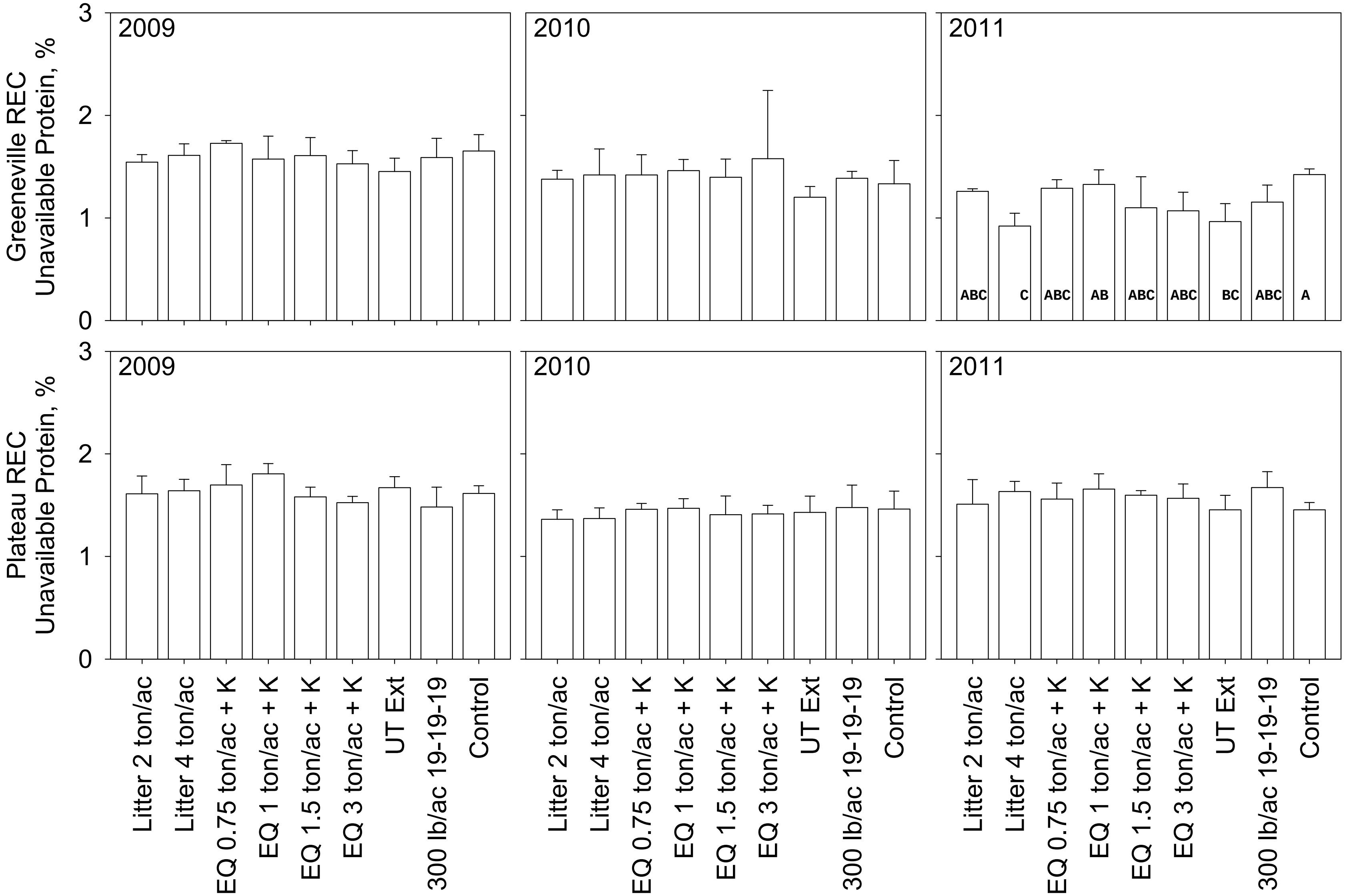

Figure 25. Fall forage unavailable protein concentrations.

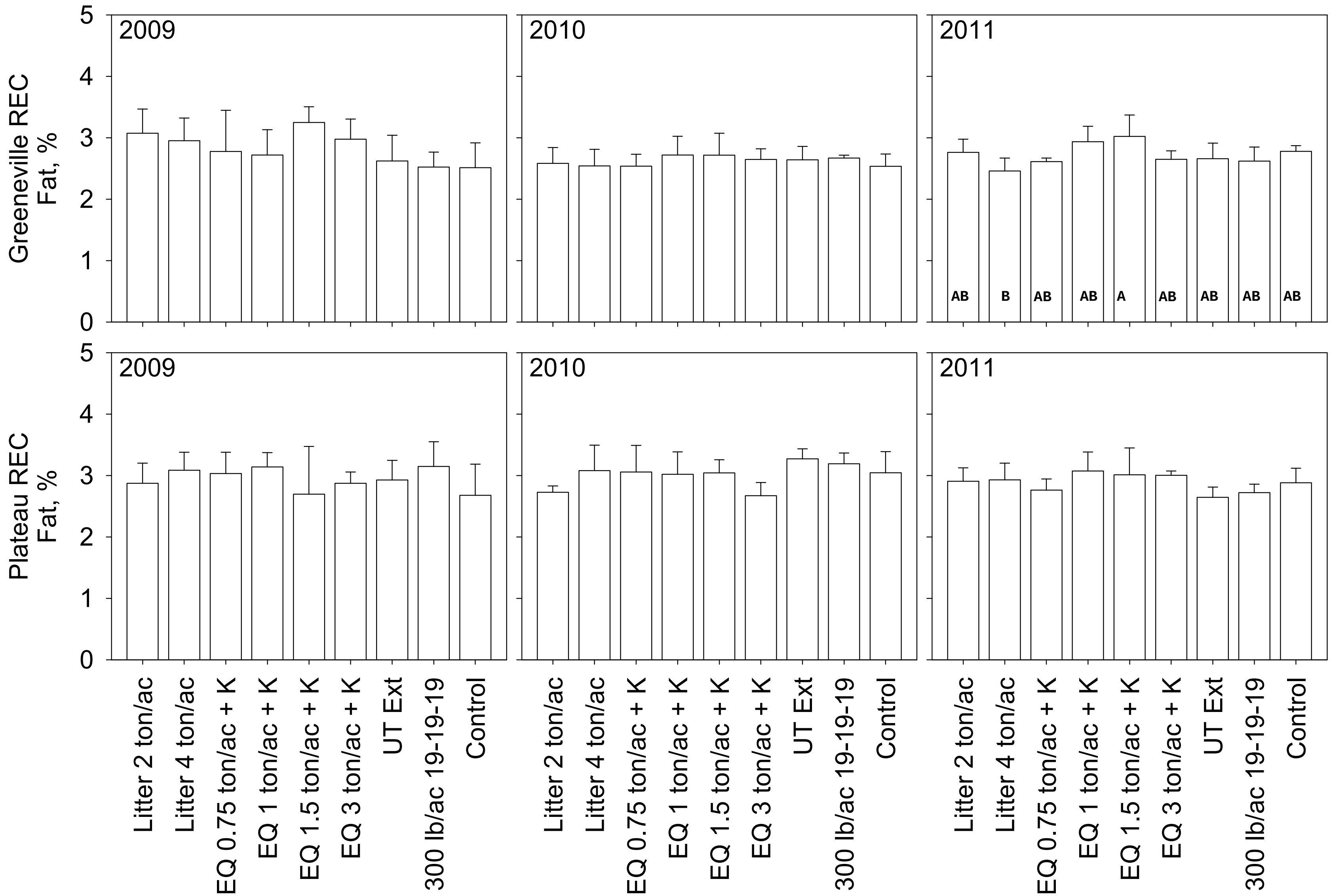

Figure 26. Spring forage fat concentrations (bars that do not share a common letter are significantly different).

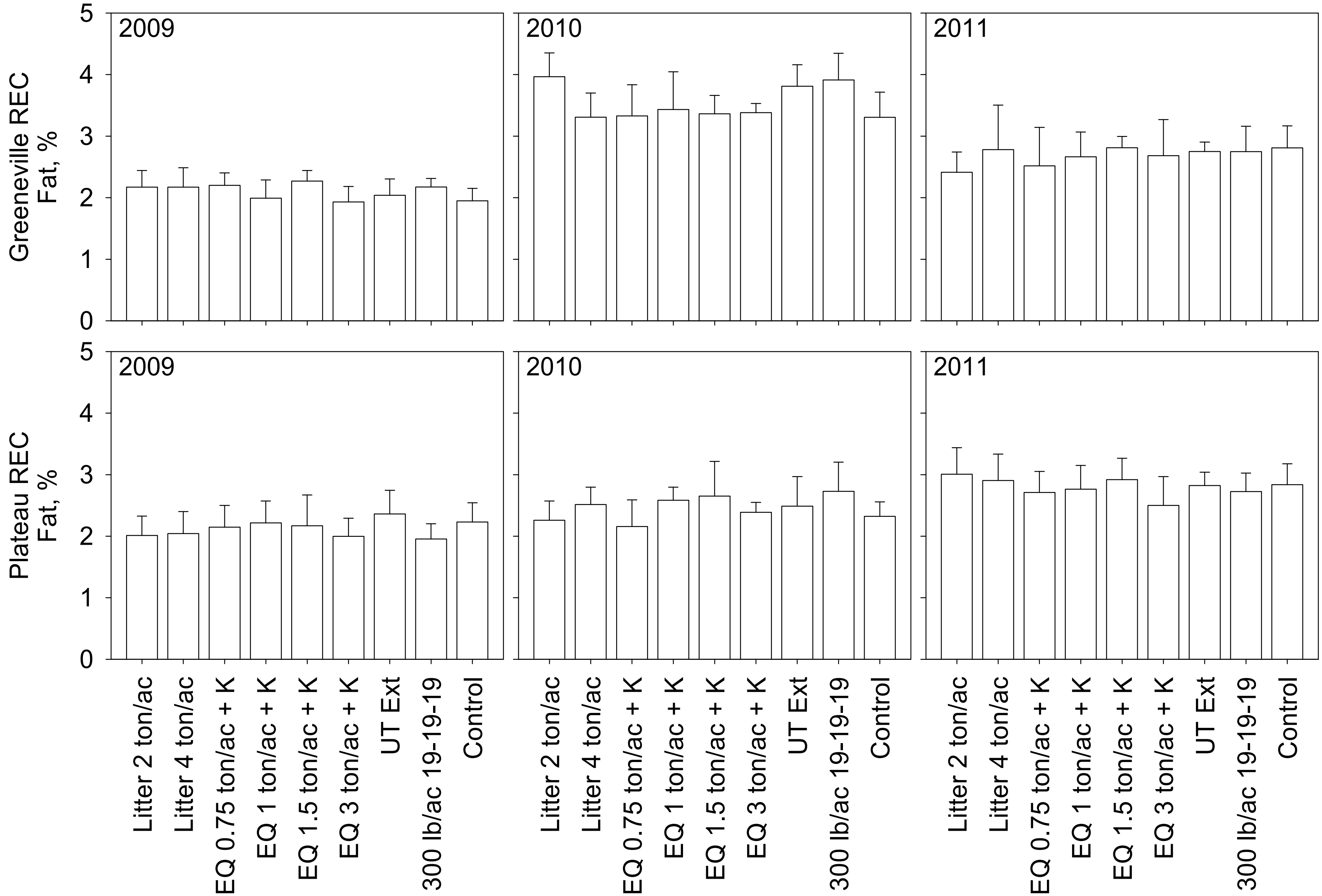

Figure 27. Fall forage fat concentrations.

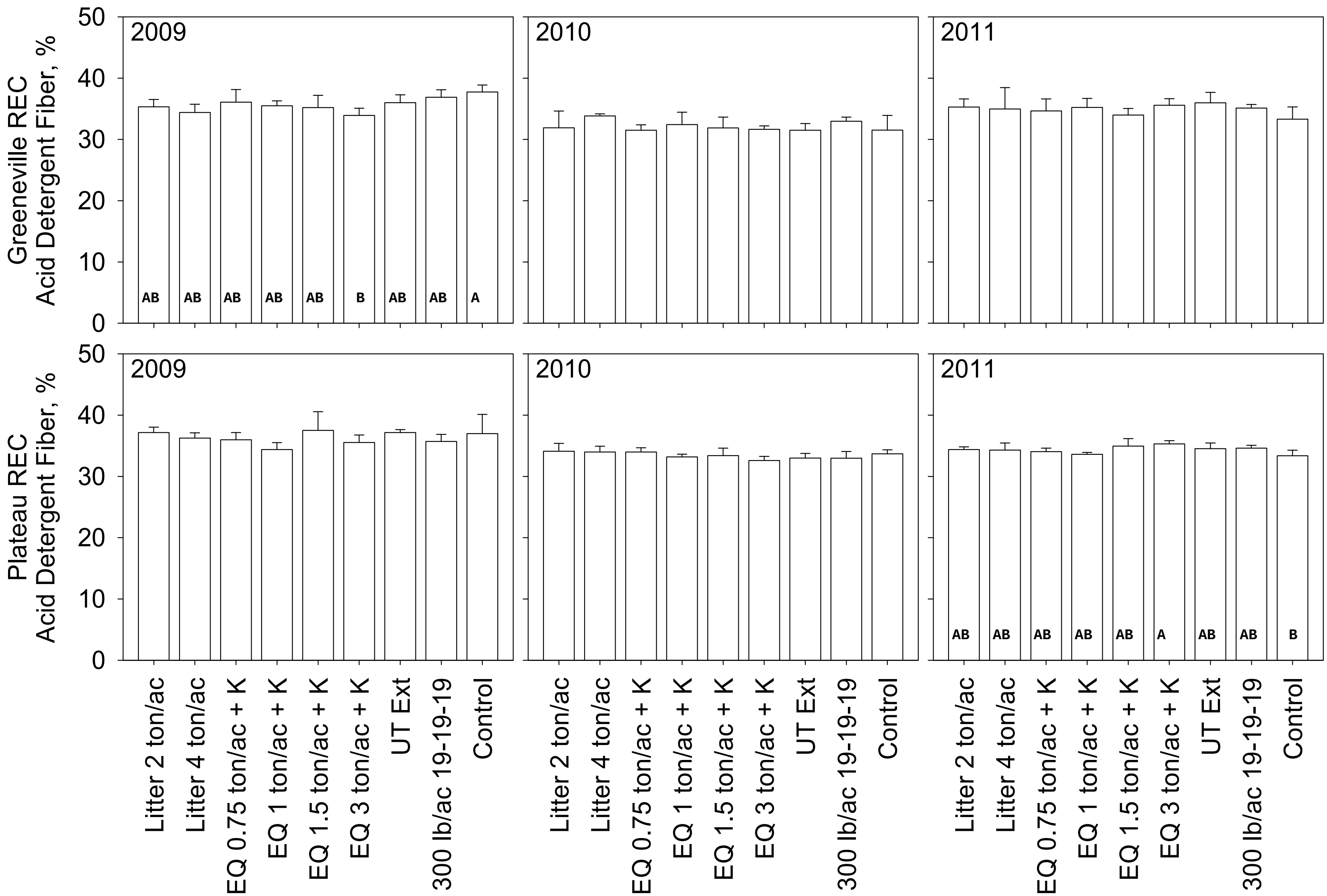

Figure 28. Spring forage acid detergent fiber concentrations(bars that do not share a common letter are significantly different).

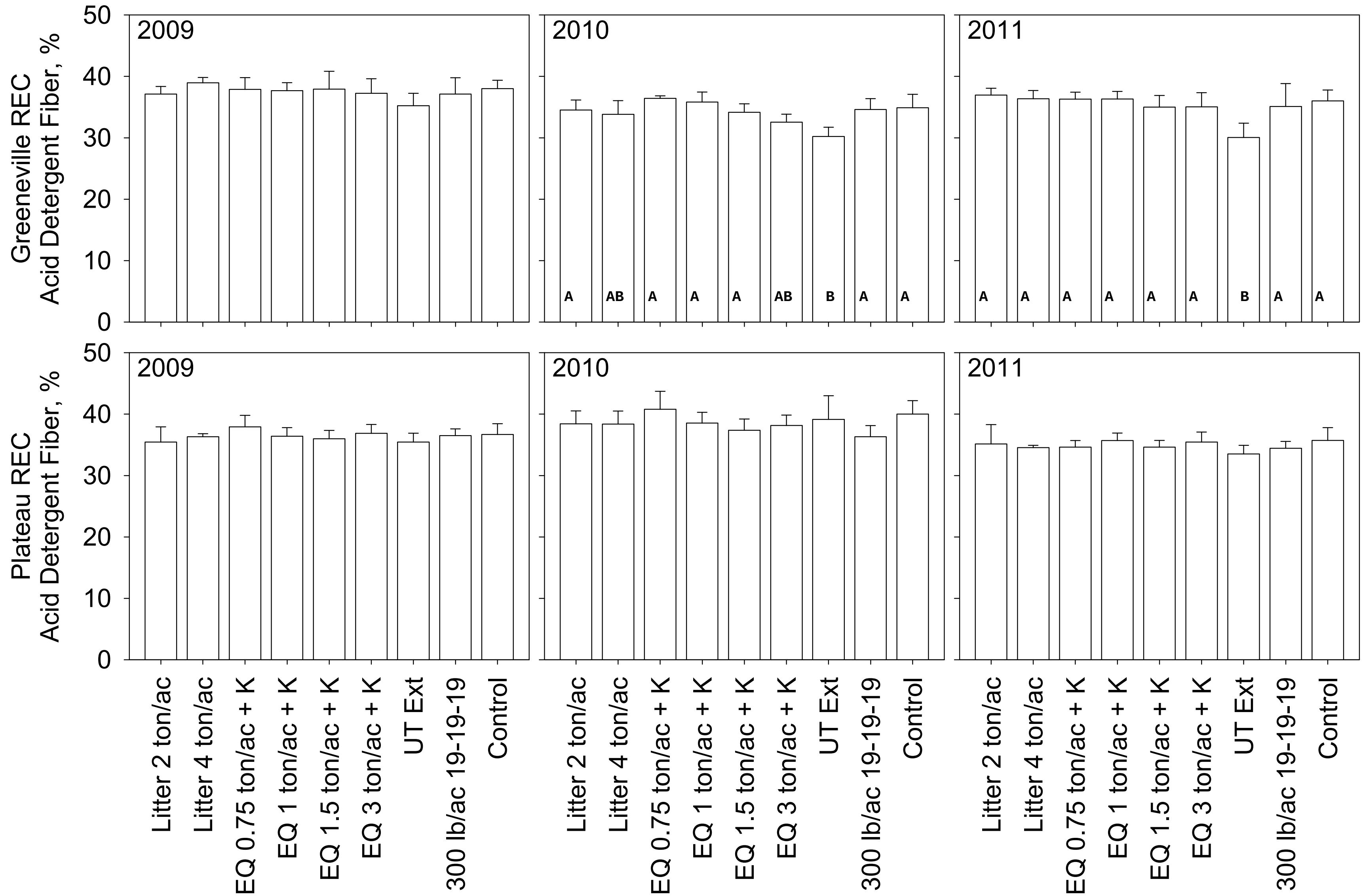

Figure 29. Fall forage acid detergent fiber concentrations (bars that do not share a common letter are significantly different).

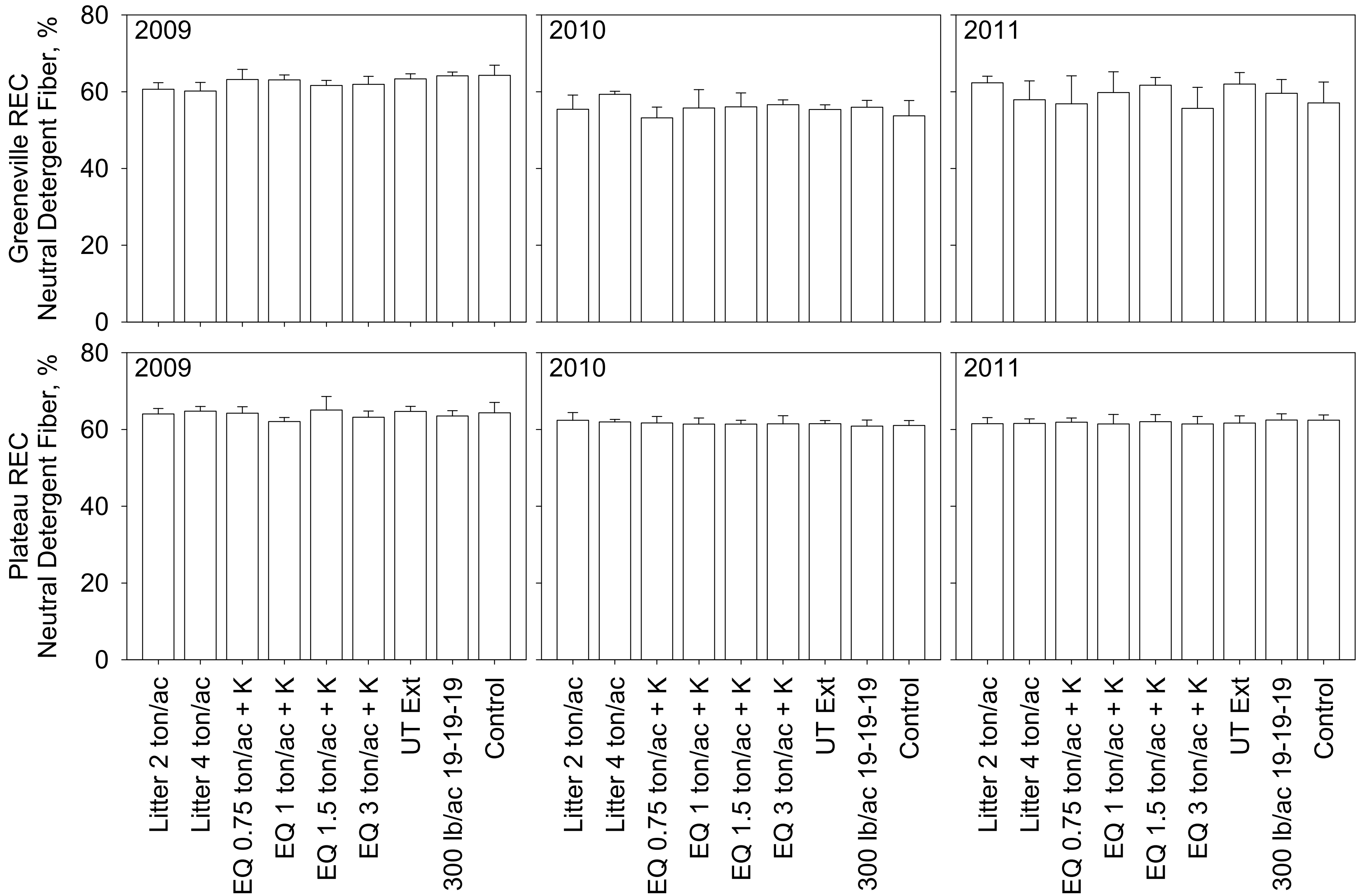

Figure 30. Spring forage neutral detergent fiber concentrations.

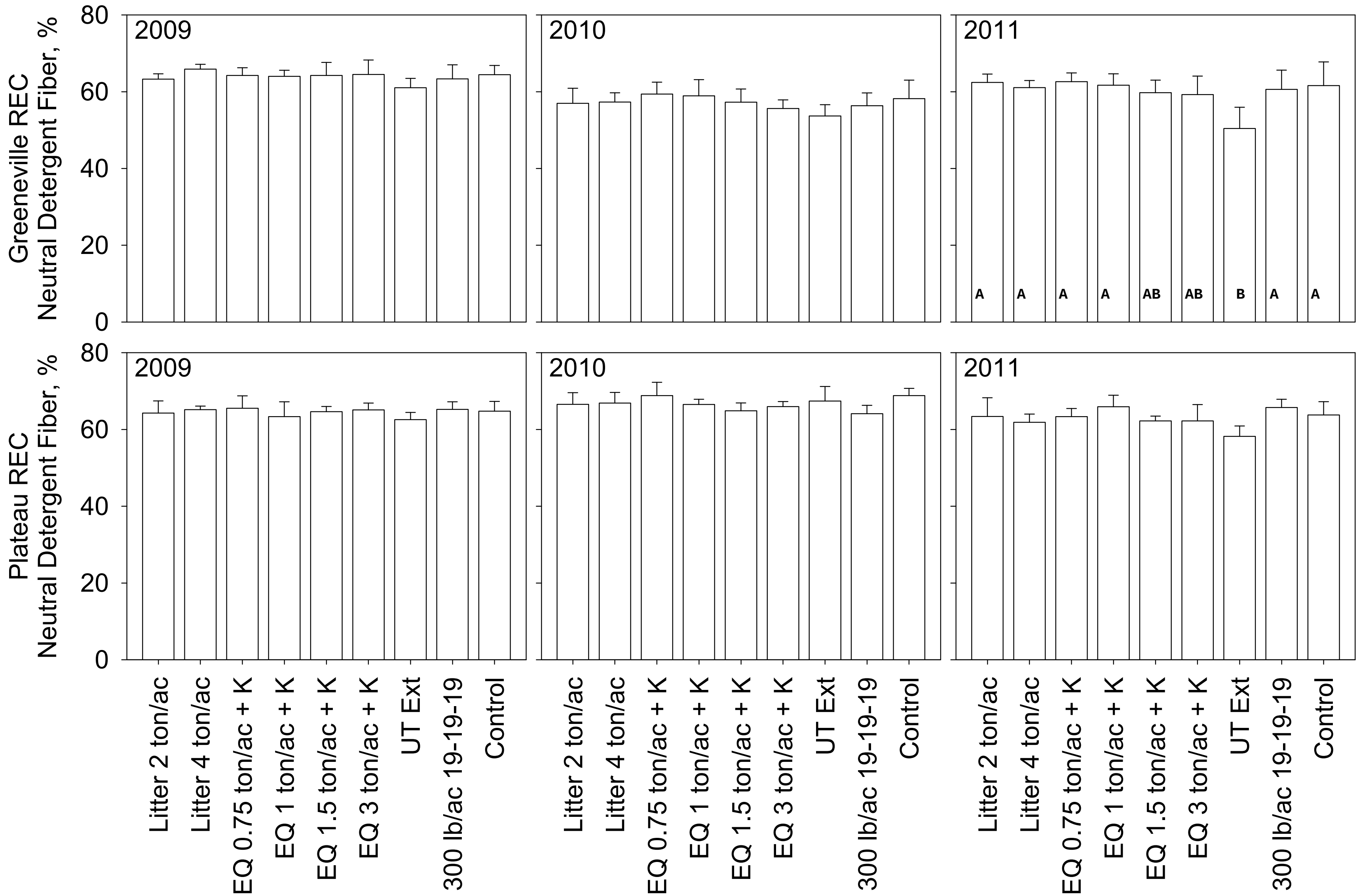

Figure 31. Fall forage neutral detergent fiber concentrations (bars that do not share a common letter are significantly different).

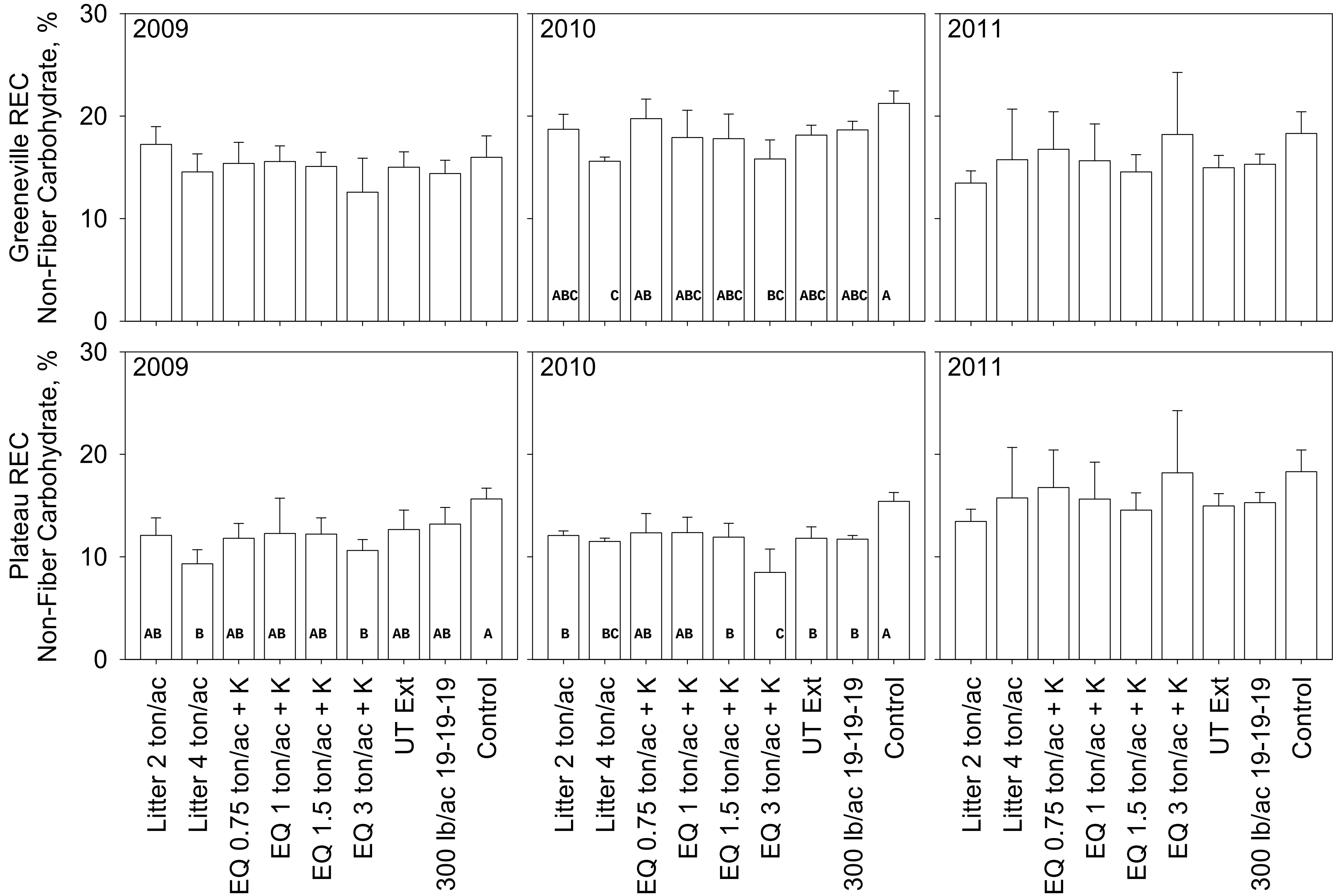

Figure 32. Spring forage non-fiber carbohydrate concentrations (bars that do not share a common letter are significantly different).

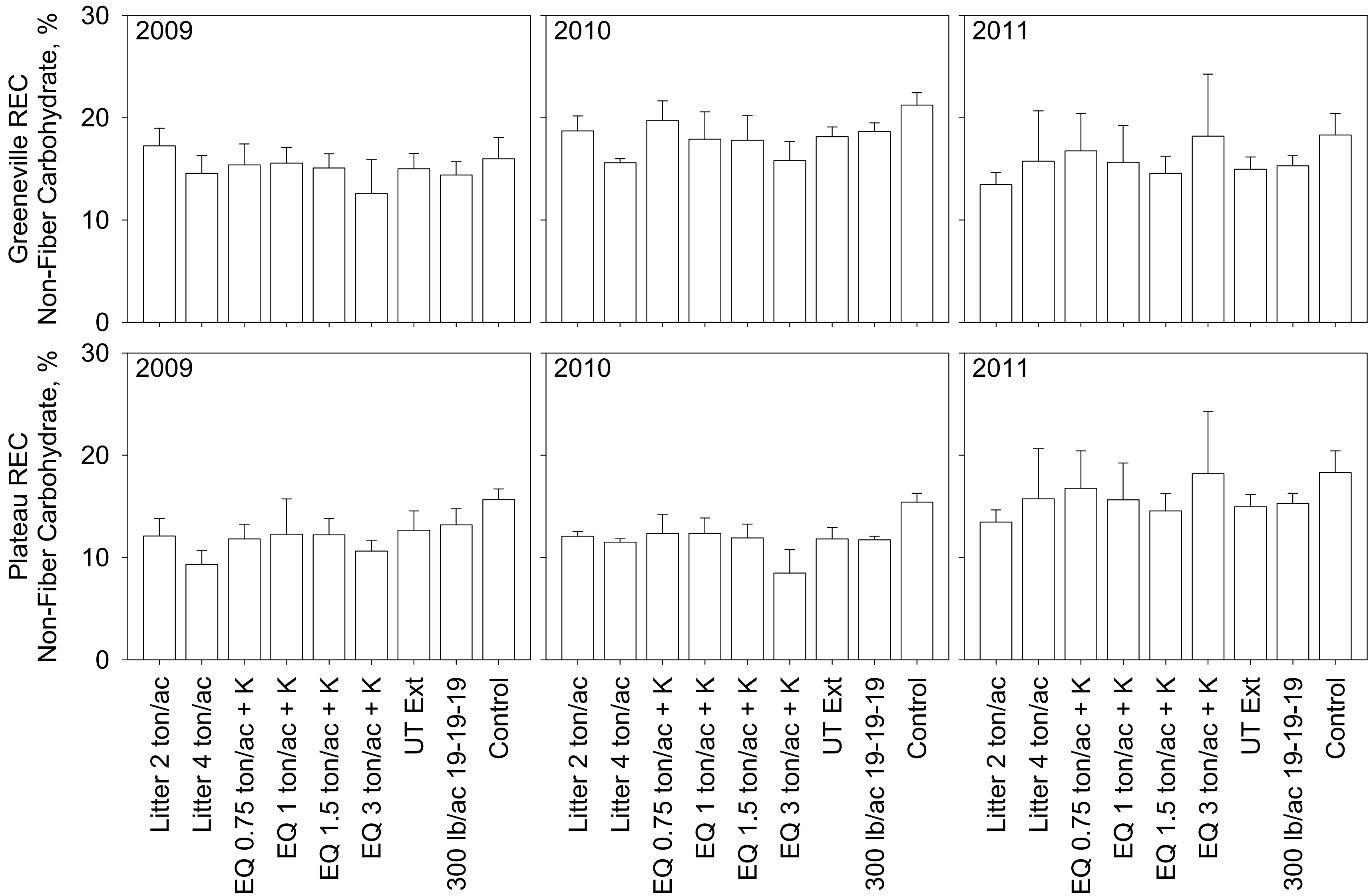

Figure 33. Fall forage non-fiber carbohydrate concentrations (bars that do not share a common letter are significantly different).

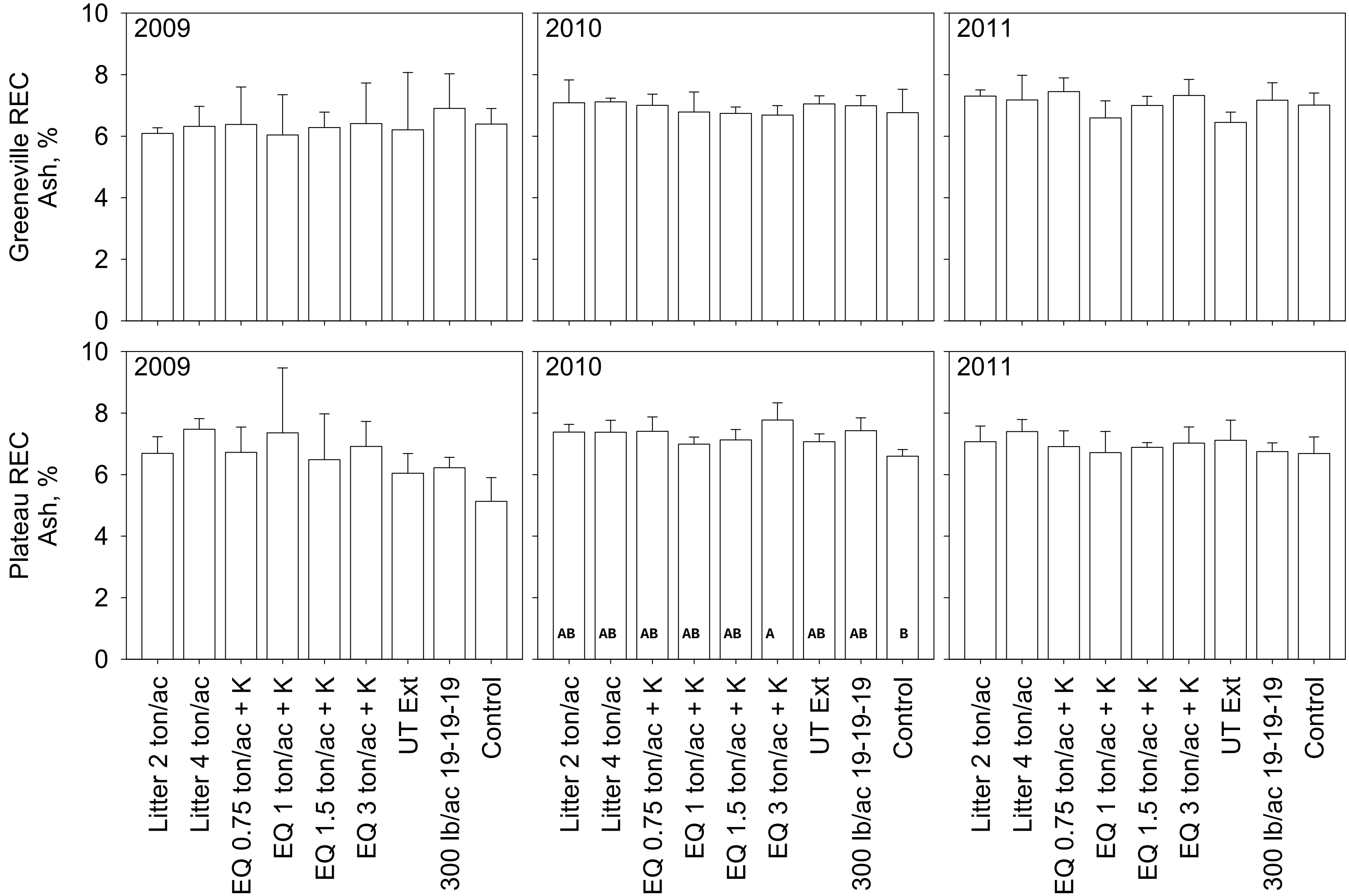

Figure 34. Spring forage ash concentrations(bars that do not share a common letter are significantly different).

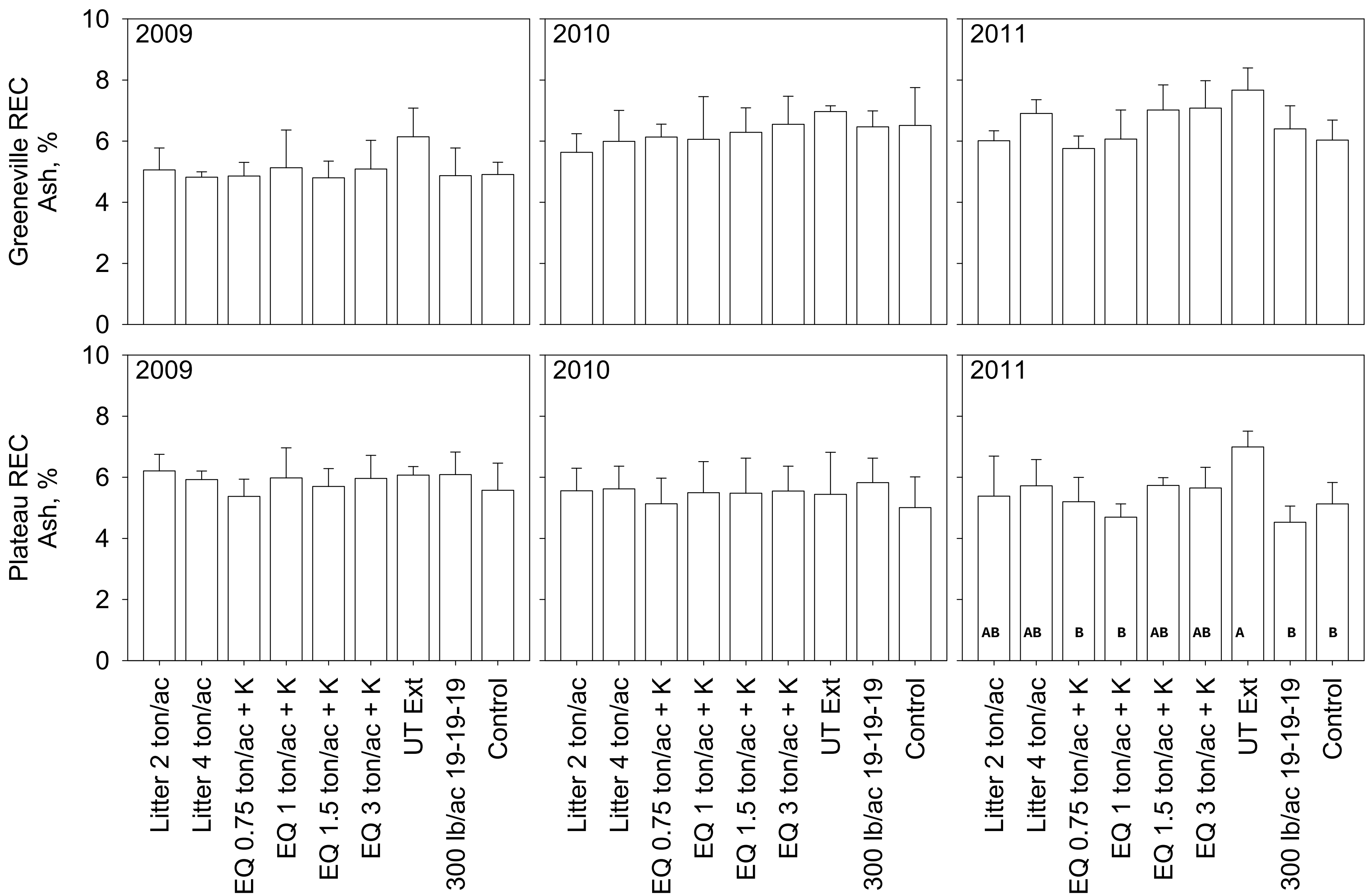

Figure 35. Fall forage ash concentrations (bars that do not share a common letter are significantly different).

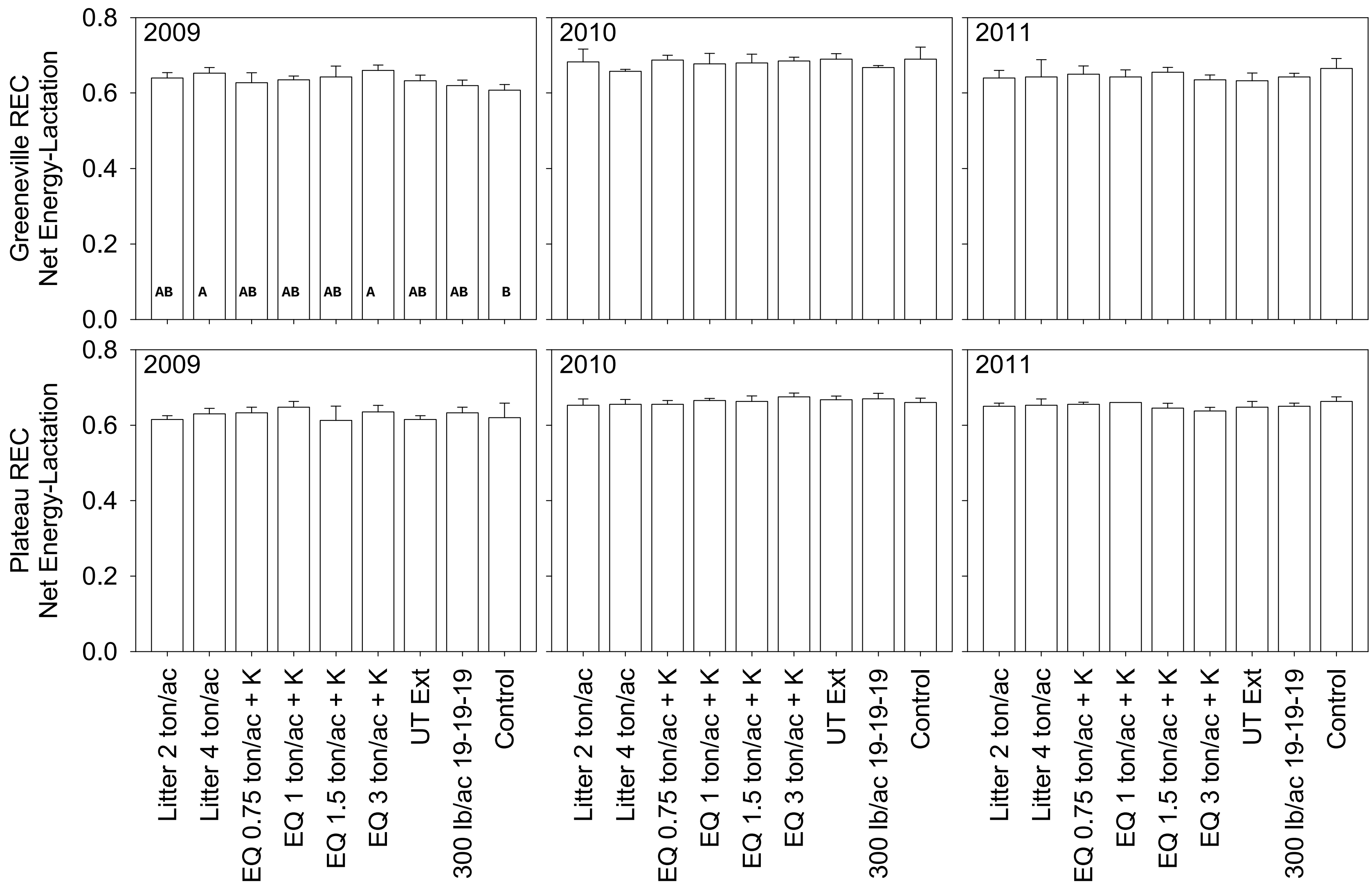

Figure 36. Spring forage Net Energy-Lactation values (bars that do not share a common letter are significantly different).

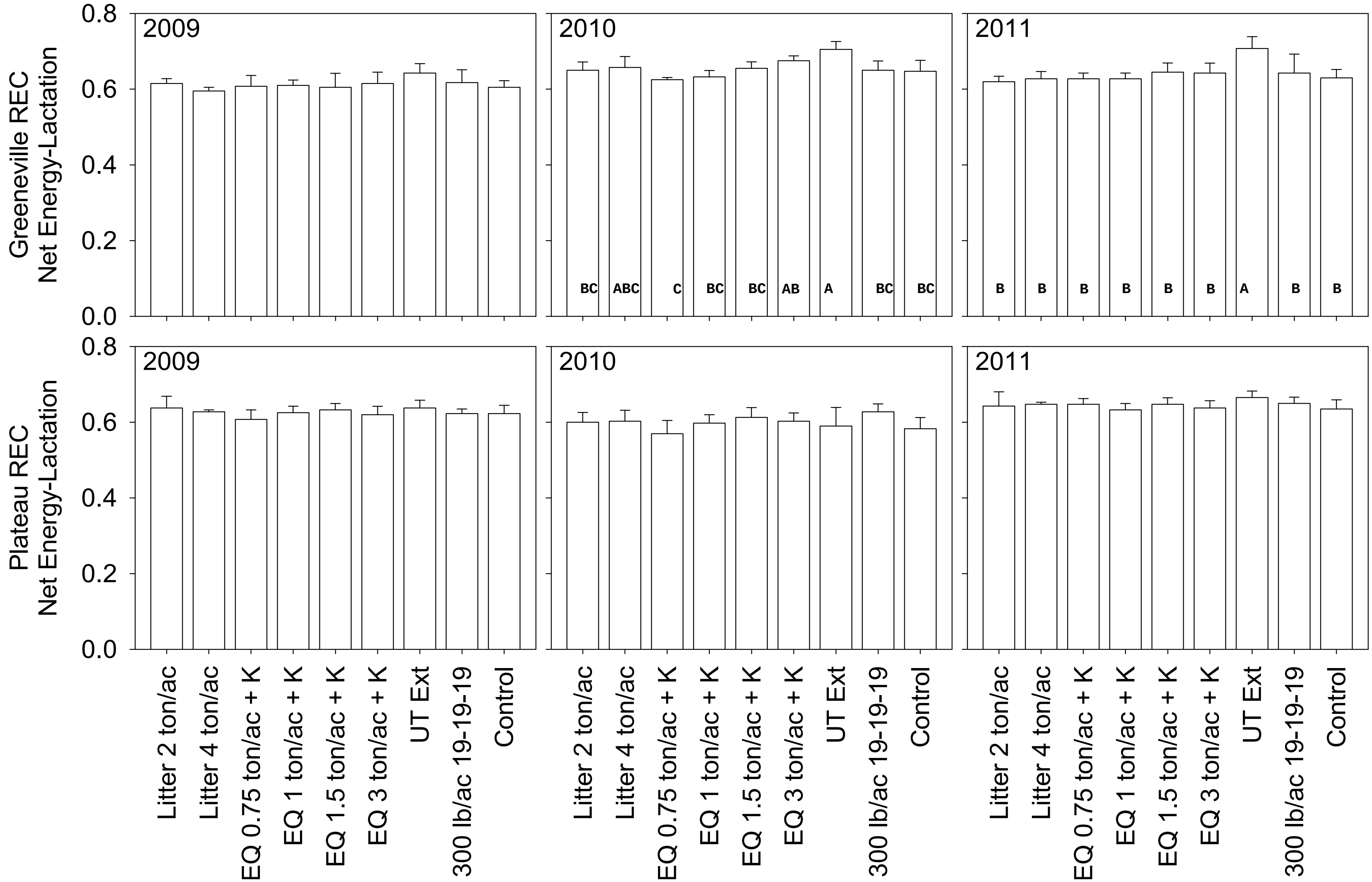

Figure 37. Fall forage Net Energy-Lactation values (bars that do not share a common letter are significantly different).

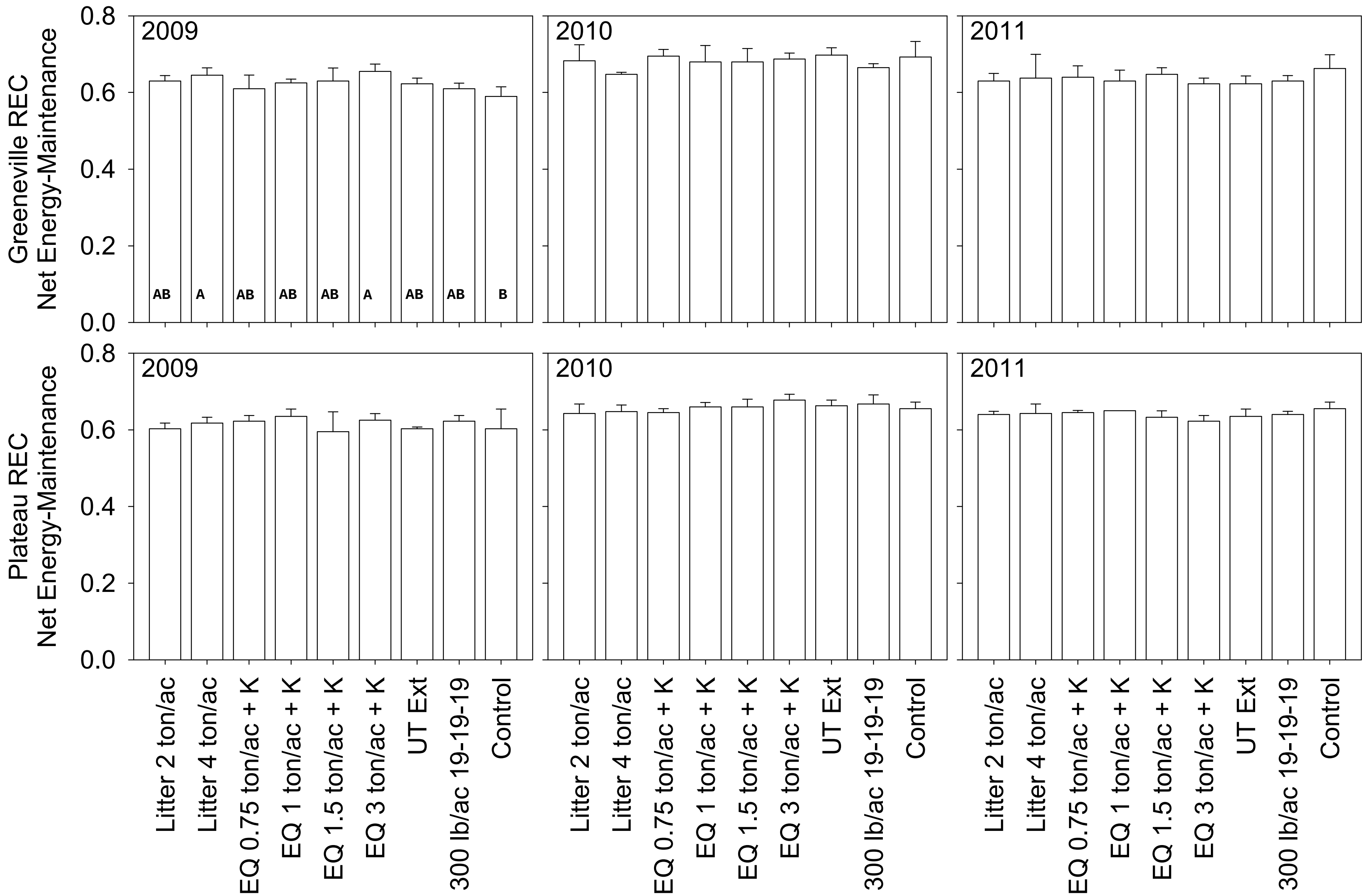

Figure 38. Spring forage Net Energy-Maintenance values (bars that do not share a common letter are significantly different).

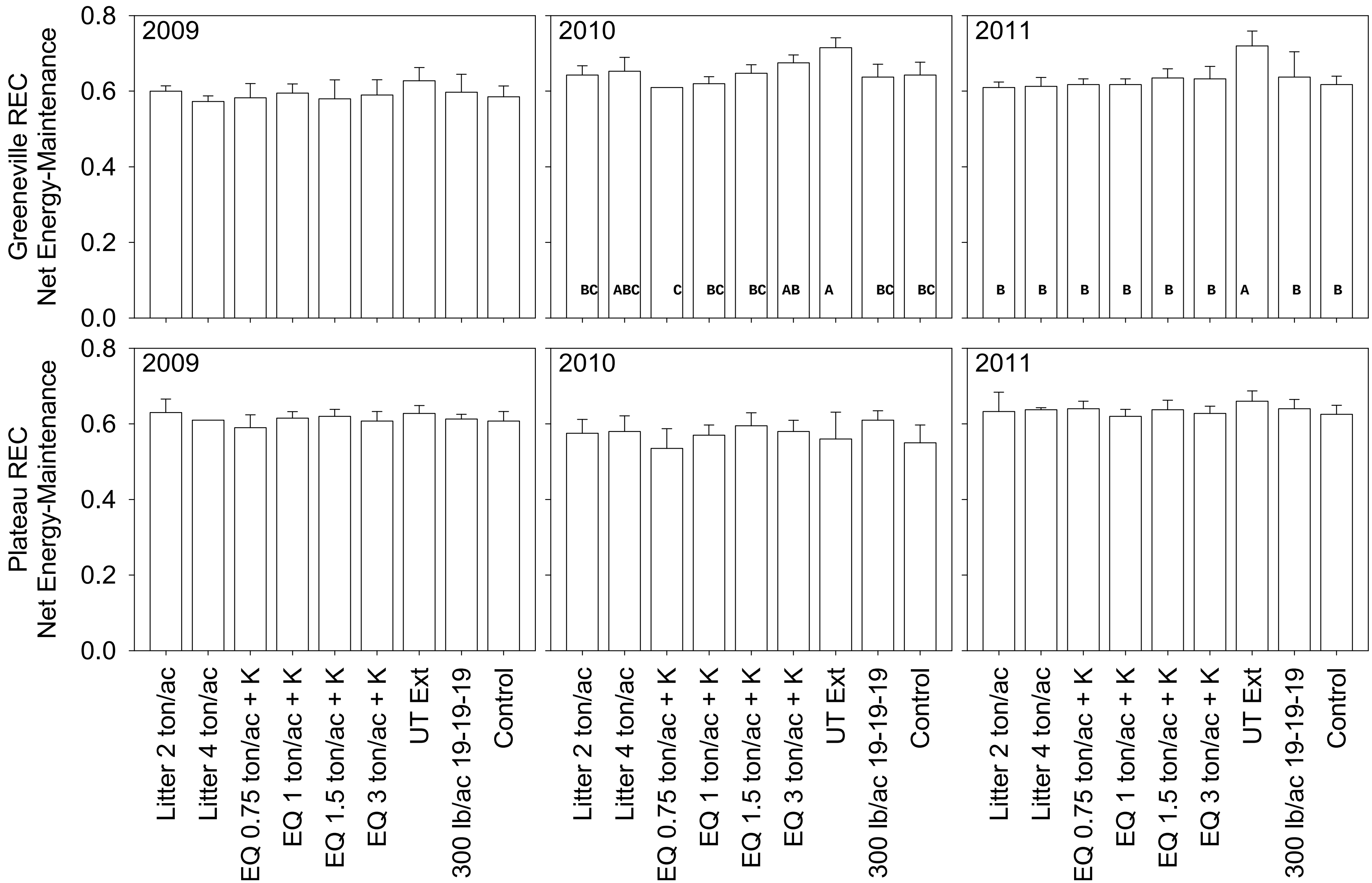

Figure 39. Fall forage Net Energy-Maintenance values (bars that do not share a common letter are significantly different).

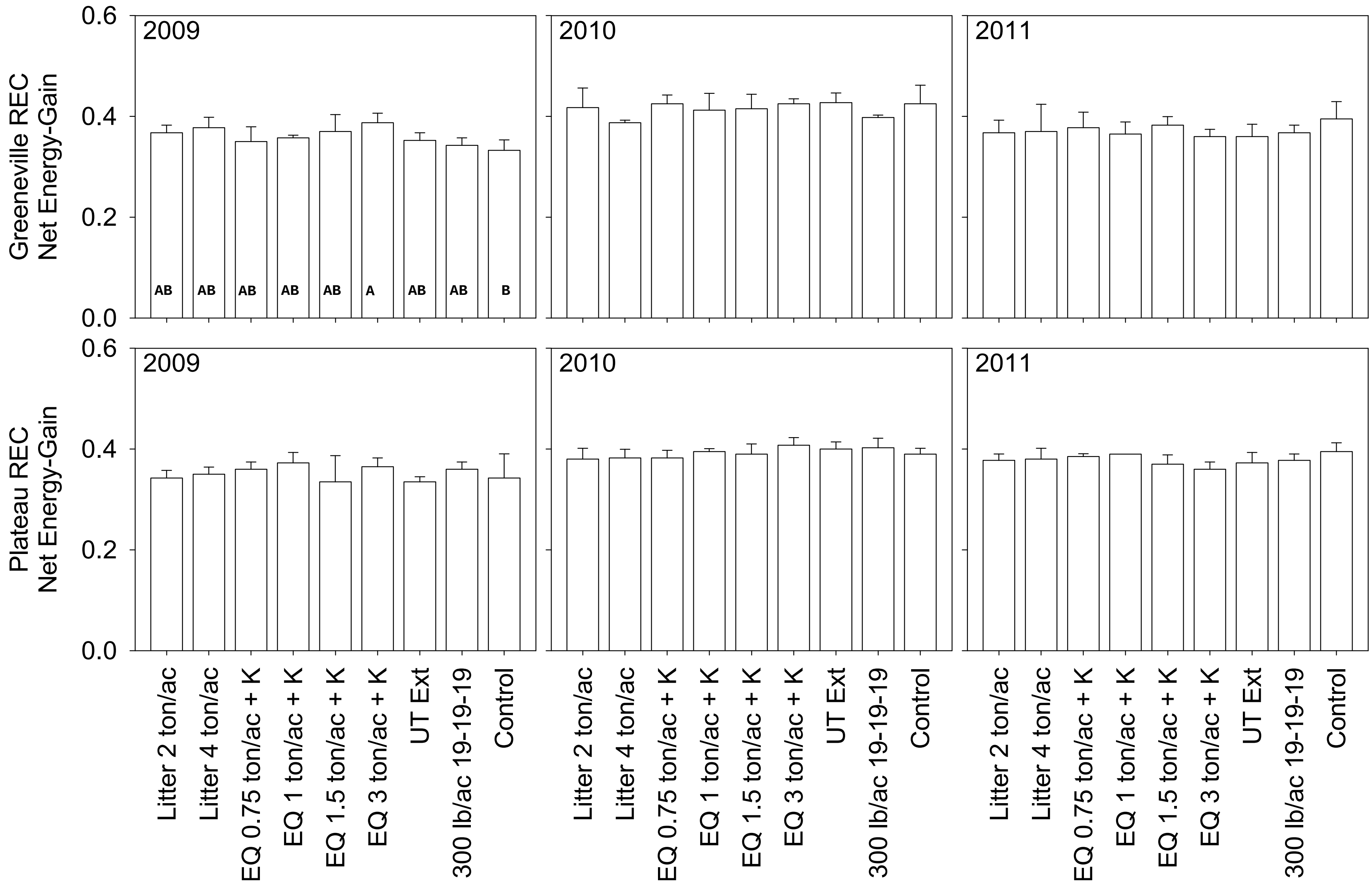

Figure 40. Spring forage Net Energy-Gain values (bars that do not share a common letter are significantly different).

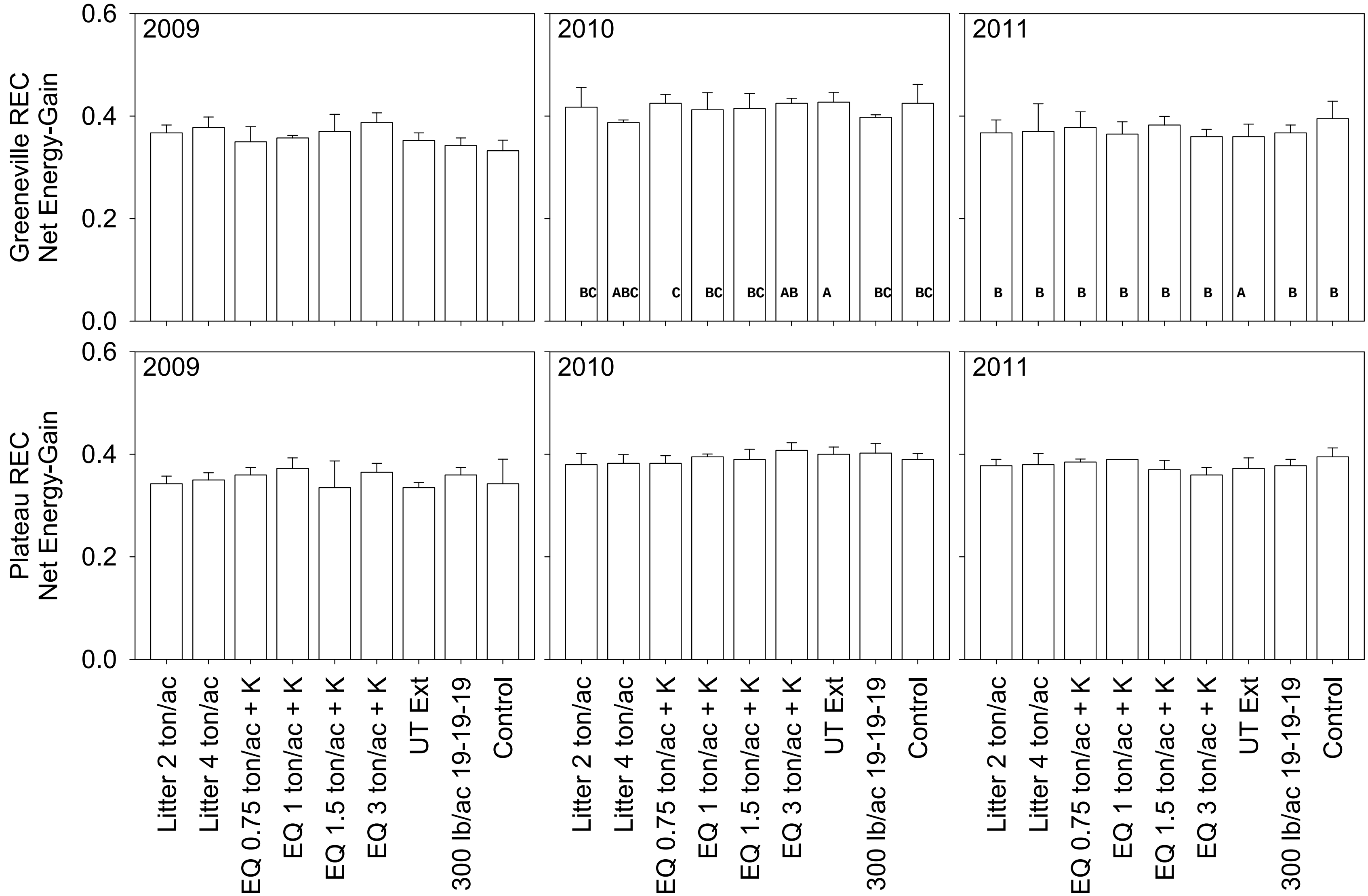

Figure 41. Fall forage Net Energy-Gain values (bars that do not share a common letter are significantly different).

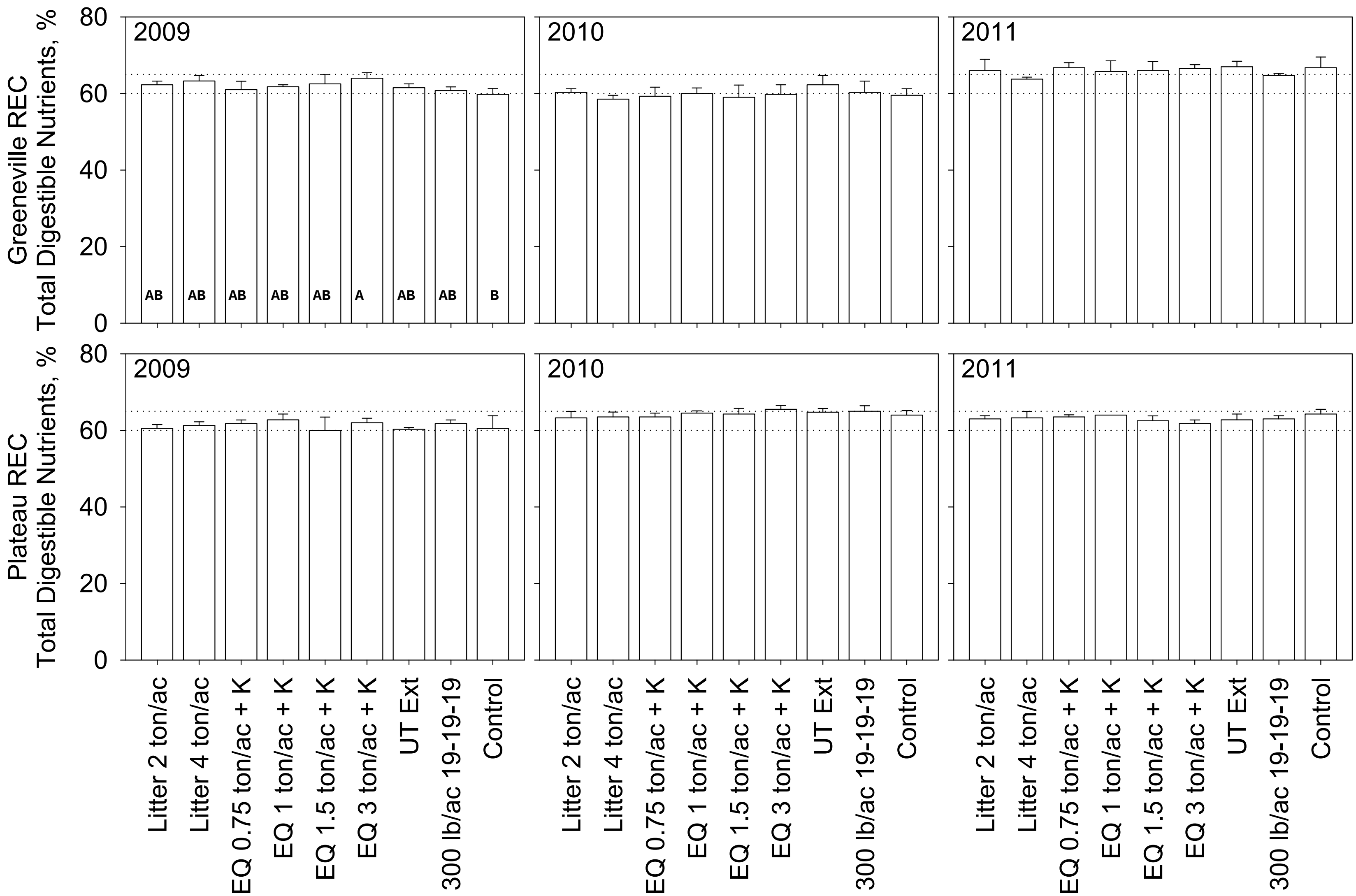

Figure 42. Spring forage Total Digestible Nutrients (bars that do not share a common letter are significantly different). Recommended values for lactating (60%) and growing (1.5 lbs/day-65%) beef cattle are illustrated.

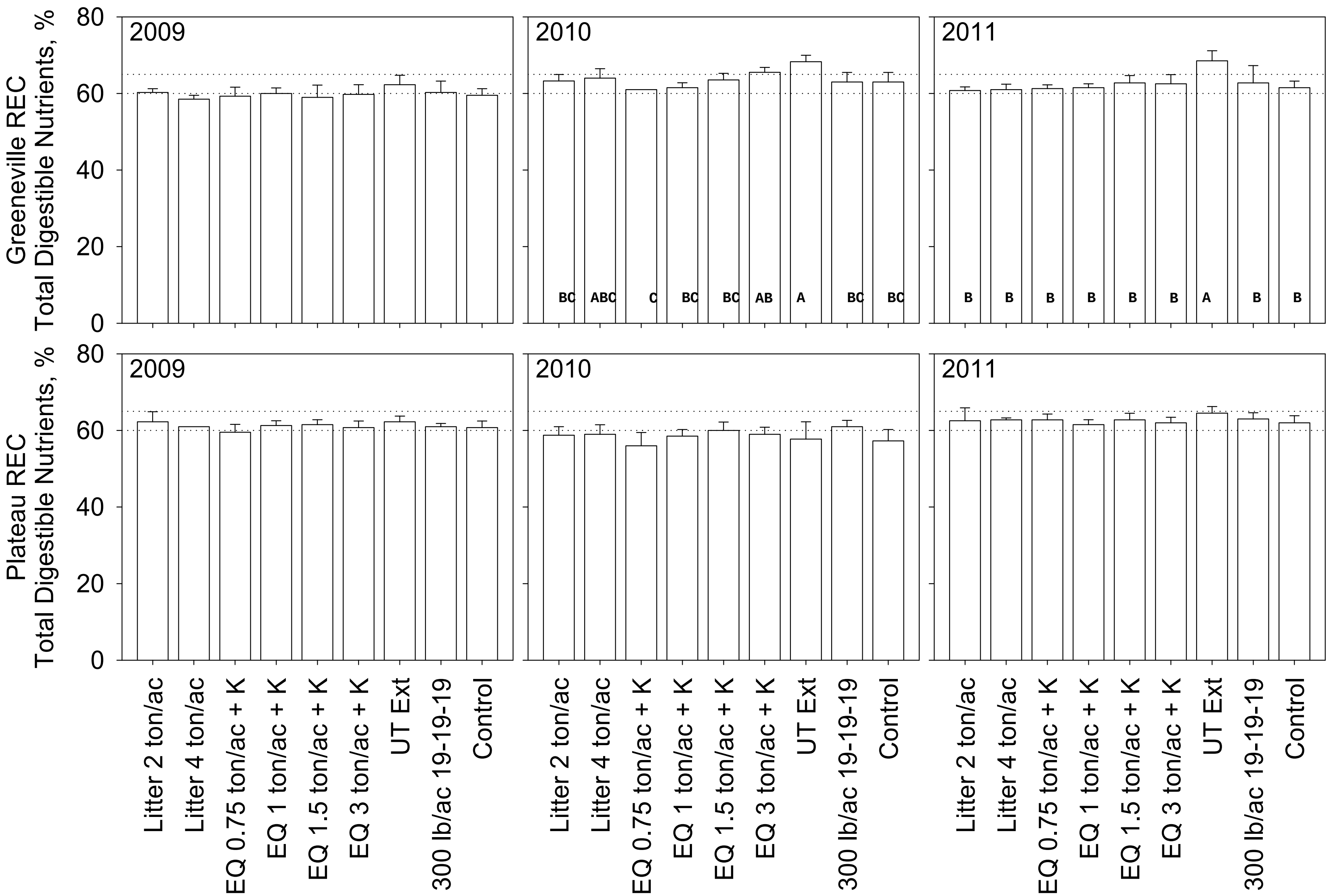

Figure 43. Fall forage Total Digestible Nutrients (bars that do not share a common letter are significantly different).Recommended values for lactating (60%) and growing (1.5 lbs/day-65%) beef cattle are illustrated.

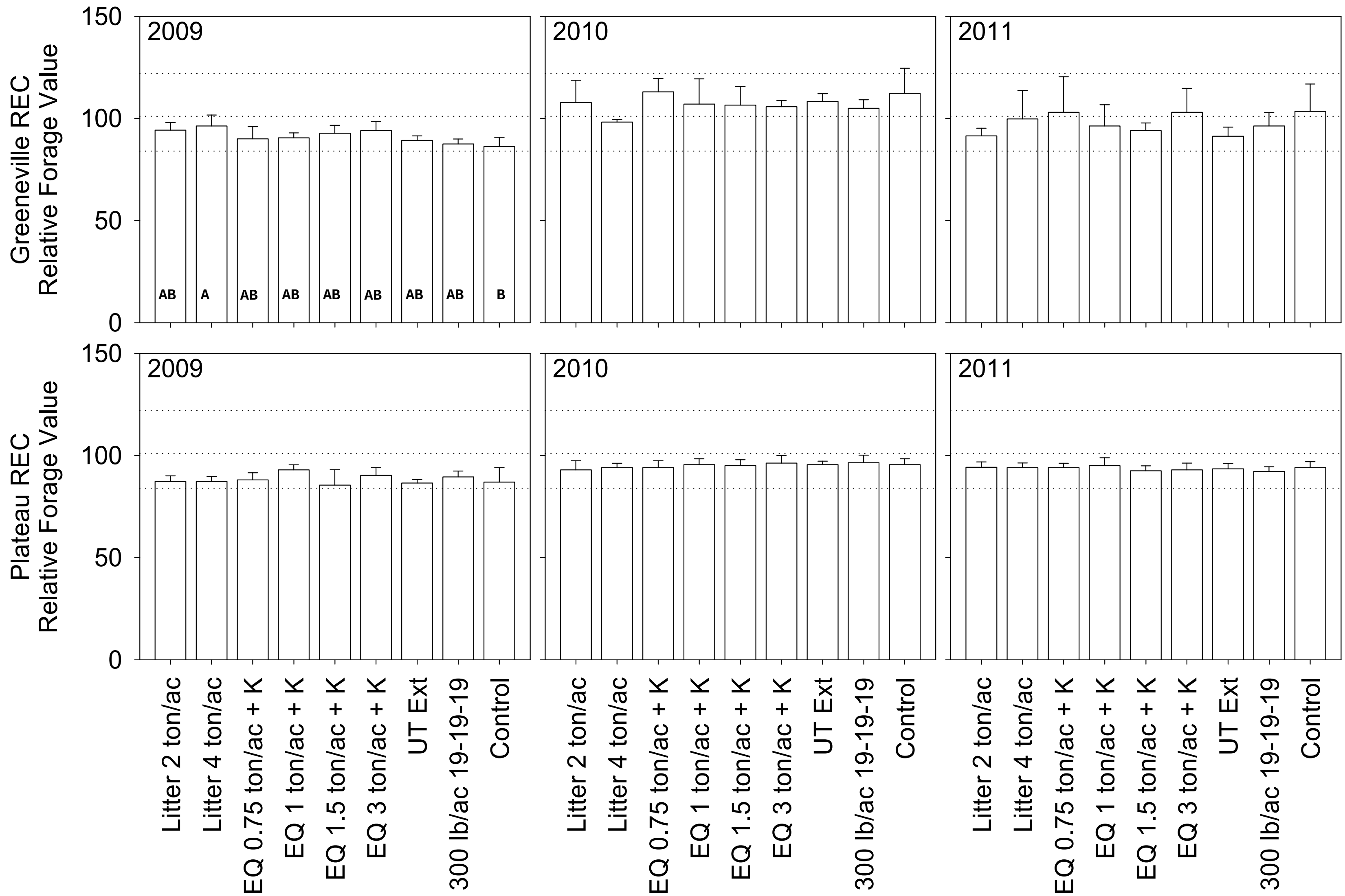

Figure 44. Spring forage Relative Forage Values (bars that do not share a common letter are significantly different). Expected values for the boot-head (84-101) and vegetative-boot (101-122 are illustrated (Ball, Hoveland et al. 2002).

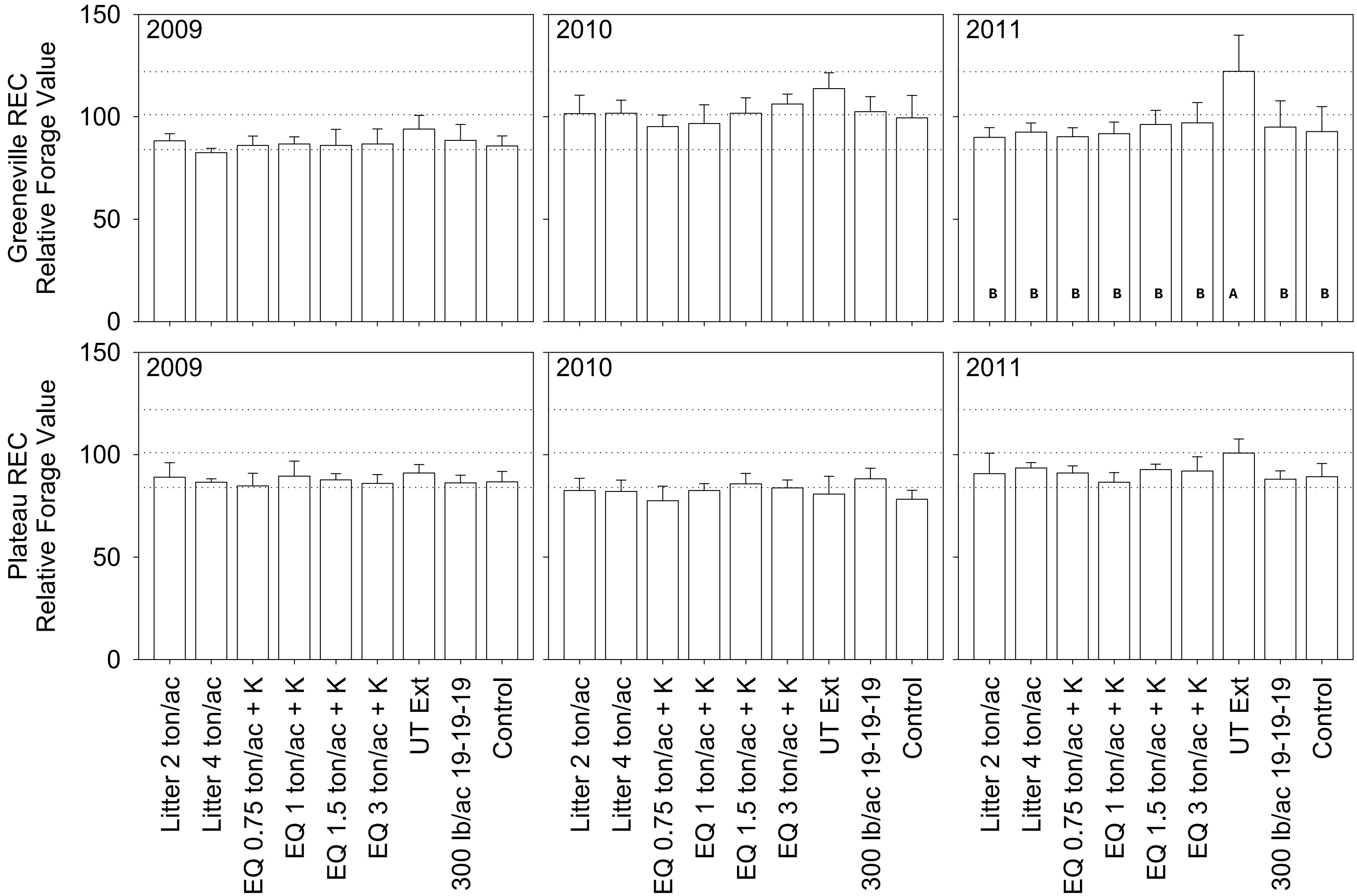

Figure 45. Fall forage Relative Forage Values (bars that do not share a common letter are significantly different).Expected values for the boot-head (84-101) and vegetative-boot (101-122 are illustrated (Ball, Hoveland et al. 2002).

Appendix E

Forage Mineral and Nitrate Concentrations

The dietary major mineral requirements for beef cattle are provided in . Calcium and phosphors are rarely deficient in forages. Consumption of forages with potassium greater than 3% may inhibit magnesium uptake and result in retarded weight gain(National Research Council 2000). Sulfur interferes with copper and zinc metabolism in cattle above 0.2% (Mortimer, Dargatz et al. 1999) and is known to be elevated in soils amended with biosolids and litter. High forage sulfur concentrations occur in Tennessee forages (Fisher, Gill et al. 2003; Gill, Fisher et al. 2005). Forage copper, manganese and zinc concentrations that are deficient, marginally deficient, and adequate, and the maximum tolerable concentration are provided in . Nitrate should be below 0.25% or 2,500 mg/kg to be safe for all types of animals; the maximum tolerable concentration is approximately 10,000 mg/kg.

Table 23. Dietary major mineral requirements for beef cattle (%, dry basis) (National Research Council 1996).

Mineral	Growing & Finishing	Gestating	Lactating	Maximum Tolerable Concentration
Calcium	0.31	0.18	0.58	-
Phosphorus	0.21	0.4-0.5	0.16	-
Potassium	0.60	0.60	0.70	3.0
Magnesium	0.10	0.12	0.20	0.40
Sulfur	0.15	0.15	0.15	0.40

Table 24. Dietary minor mineral concentrations (mg/kg, dry basis) of beef cattle herds (Mortimer, Dargatz et al. 1999).

Mineral	Deficient	Marginally Deficient	Adequate	Maximum Tolerable Concentration
Copper	<4	4-10	≥ 10	100
Manganese	<20	20-40	≥ 40	1,000
Zinc	<20	20-30	≥ 30	500

Table 25. Spring 2009 forage mineral and nitrate concentrations, Greeneville REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.78	0.25	1.65	0.28	196	7.7	18.7	0.20	101
A2	0.49	0.26	1.66	0.31	154	6.3	20.0	0.26	71
A3	0.44	0.27	1.83	0.29	169	11.5	24.1	0.27	76
A4	0.58	0.30	1.44	0.31	160	7.4	22.2	0.29	67
A5	0.60	0.33	2.19	0.36	131	13.6	28.2	0.28	105
A6	0.44	0.23	1.98	0.26	209	5.2	15.7	0.22	50
A7	0.42	0.26	2.31	0.31	119	4.1	15.5	0.18	64
A8	0.45	0.23	1.85	0.23	81	4.2	15.6	0.19	53
A9	0.40	0.27	1.86	0.30	115	6.2	18.7	0.24	60
B1	0.46	0.26	1.77	0.32	178	46.3	48.4	0.23	50
B2	0.45	0.27	1.87	0.28	132	6.2	18.7	0.21	50
B3	0.52	0.28	2.29	0.33	120	21.0	34.6	0.25	139
B4	0.37	0.25	1.67	0.28	146	5.2	22.0	0.24	64
B5	0.65	0.29	1.87	0.29	169	7.3	22.0	0.27	74
B6	0.56	0.24	1.76	0.33	168	6.2	21.7	0.26	55
B7	0.47	0.25	1.73	0.29	128	6.3	19.8	0.19	62
B8	0.44	0.21	1.61	0.28	86	5.2	16.7	0.22	50
B9	0.41	0.25	2.10	0.27	111	5.2	16.6	0.20	81
C1	0.35	0.22	2.09	0.34	114	7.3	22.0	0.21	74
C2	0.40	0.21	2.18	0.32	125	15.8	24.3	0.23	74
C3	0.35	0.29	2.17	0.28	138	6.3	21.0	0.21	67
C4	0.83	0.31	1.77	0.35	142	7.5	20.3	0.30	74
C5	0.52	0.20	1.87	0.29	151	6.4	19.2	0.21	62
C6	0.64	0.22	2.52	0.34	149	24.5	35.1	0.28	116
C7	0.66	0.16	1.81	0.28	144	6.5	19.4	0.22	57
C8	0.72	0.17	1.62	0.26	78	5.4	18.4	0.22	64
C9	0.83	0.18	2.15	0.32	106	5.4	20.5	0.20	69
D1	0.73	0.17	1.88	0.28	171	6.4	22.3	0.19	74
D2	0.71	0.16	1.15	0.22	134	5.4	17.3	0.19	44
D3	0.50	0.16	2.06	0.25	132	4.3	18.1	0.18	57
D4	0.70	0.24	1.83	0.34	166	7.5	19.2	0.26	62
D5	0.42	0.26	2.76	0.36	107	15.4	28.7	0.27	93
D6	0.66	0.24	1.85	0.33	140	8.5	27.8	0.27	55
D7	0.49	0.25	2.06	0.28	181	9.4	22.0	0.23	96
D8	0.50	0.18	2.04	0.27	92	6.4	16.0	0.21	71
D9	0.81	0.25	1.76	0.35	99	7.5	26.9	0.26	249

Table 26. Spring 2009 forage mineral and nitrate concentrations, Plateau REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.33	0.20	2.79	0.34	82	9.4	21.0	0.23	258
A2	0.52	0.20	2.26	0.33	98	5.2	27.9	0.19	174
A3	0.43	0.24	2.27	0.38	121	7.2	24.8	0.23	113
A4	0.40	0.16	2.00	0.27	186	6.3	25.1	0.21	76
A5	0.69	0.22	2.44	0.36	151	6.2	19.6	0.22	86
A6	0.34	0.24	2.80	0.38	149	13.6	28.3	0.24	296
A7	0.33	0.22	2.47	0.35	149	7.3	22.9	0.20	108
A8	0.49	0.25	2.34	0.36	149	7.2	19.6	0.22	128
A9	0.34	0.15	2.11	0.21	76	5.2	16.7	0.17	118
B1	0.49	0.20	2.02	0.35	186	7.4	26.4	0.25	79
B2	0.35	0.17	2.40	0.31	150	6.3	25.2	0.19	86
B3	0.21	0.17	2.27	0.34	151	6.3	22.0	0.22	79
B4	0.35	0.18	2.36	0.36	111	12.6	25.3	0.21	108
B5	0.40	0.22	2.29	0.37	144	7.4	23.2	0.20	86
B6	0.40	0.22	2.49	0.36	134	10.4	23.9	0.23	174
B7	0.44	0.26	2.34	0.36	111	7.4	25.4	0.27	435
B8	0.62	0.27	1.97	0.36	176	8.3	30.1	0.24	299
B9	0.30	0.20	1.90	0.29	181	5.2	21.9	0.20	69
C1	0.61	0.25	2.50	0.37	105	7.3	21.9	0.27	303
C2	0.18	0.14	2.47	0.29	146	7.3	22.0	0.20	113
C3	0.32	0.17	2.24	0.31	118	7.3	25.1	0.21	126
C4	0.36	0.24	2.72	0.32	153	7.2	19.7	0.21	126
C5	0.43	0.22	2.40	0.36	112	7.4	20.0	0.21	177
C6	0.33	0.15	2.37	0.22	104	5.2	16.7	0.16	81
C7	0.29	0.21	2.54	0.37	111	7.2	19.6	0.19	123
C8	0.36	0.20	2.41	0.26	114	5.2	17.8	0.17	105
C9	0.34	0.20	2.43	0.31	176	7.3	18.9	0.23	108
D1	0.31	0.21	2.57	0.36	209	6.2	18.6	0.20	113
D2	0.33	0.23	2.67	0.33	193	11.5	28.2	0.29	131
D3	0.31	0.21	2.15	0.30	155	5.2	17.6	0.22	83
D4	0.55	0.24	2.70	0.38	141	6.2	19.7	0.24	81
D5	0.39	0.22	2.48	0.32	167	10.4	28.0	0.22	105
D6	0.35	0.23	2.45	0.35	150	6.2	19.7	0.19	83
D7	0.42	0.22	2.50	0.34	149	7.3	21.8	0.22	101
D8	0.26	0.18	2.73	0.32	145	5.2	17.8	0.19	113
D9	0.38	0.18	2.24	0.34	148	6.3	20.0	0.21	108

Table 27. Fall 2009 forage mineral and nitrate concentrations, Greeneville REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.90	0.31	0.98	0.19	115	10.9	33.8	0.22	48
A2	0.85	0.24	0.94	0.22	110	8.7	20.8	0.25	21
A3	0.78	0.26	1.38	0.20	117	9.9	28.6	0.26	30
A4	0.79	0.27	0.97	0.25	183	12	30.5	0.29	37
A5	0.76	0.21	0.89	0.18	160	9.9	29.6	0.24	23
A6	0.84	0.22	0.67	0.23	108	8.7	39.4	0.23	30
A7	0.67	0.18	0.45	0.24	146	8.8	32.9	0.22	13
A8	0.75	0.19	0.73	0.21	129	7.7	59.1	0.22	41
A9	0.69	0.21	0.85	0.20	194	8.8	49.4	0.24	8
B1	0.87	0.20	0.72	0.22	117	9.9	53.7	0.23	32
B2	0.86	0.17	0.31	0.29	75	8.7	33.8	0.25	26
B3	0.82	0.19	0.83	0.19	105	8.8	27.5	0.25	43
B4	0.70	0.21	0.92	0.26	116	8.8	25.2	0.25	21
B5	0.85	0.22	0.51	0.21	146	7.7	30.8	0.26	50
B6	0.81	0.20	0.29	0.26	137	7.7	29.8	0.24	15
B7	0.80	0.21	1.09	0.24	101	8.7	30.5	0.25	37
B8	0.90	0.19	0.96	0.25	158	7.6	28.3	0.26	60
B9	0.80	0.21	1.37	0.23	180	7.6	24.9	0.24	21
C1	0.66	0.18	0.74	0.22	112	12	36.1	0.22	28
C2	0.71	0.18	0.96	0.26	144	8.7	32.7	0.23	53
C3	0.88	0.28	1.23	0.22	173	8.8	28.5	0.23	0
C4	0.85	0.24	1.23	0.28	224	8.7	22.8	0.25	15
C5	0.76	0.25	1.04	0.25	119	12.1	30.7	0.27	28
C6	0.65	0.20	0.81	0.17	106	9.8	24.0	0.21	48
C7	0.67	0.27	1.13	0.23	167	9.9	32.9	0.25	83
C8	0.77	0.20	0.68	0.16	140	7.7	33.0	0.23	43
C9	0.88	0.19	0.99	0.18	168	8.8	34.0	0.23	34
D1	0.81	0.18	0.77	0.22	142	7.6	29.5	0.24	60
D2	0.66	0.20	0.85	0.19	150	9.9	30.7	0.24	0
D3	0.92	0.30	1.89	0.22	115	7.7	24.0	0.27	37
D4	0.85	0.26	1.58	0.23	111	7.7	23.1	0.27	37
D5	0.67	0.19	1.03	0.21	118	15.3	24.1	0.23	32
D6	0.87	0.23	0.96	0.19	90	9.9	25.2	0.26	8
D7	0.83	0.18	0.75	0.17	86	7.7	35.0	0.25	28
D8	0.89	0.22	1.06	0.18	113	8.7	29.5	0.25	13
D9	0.75	0.21	1.21	0.24	130	7.6	29.4	0.26	30

Table 28. Fall 2009 forage mineral and nitrate concentrations, Plateau REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.82	0.25	1.72	0.30	122	10.8	20.5	0.24	266
A2	0.85	0.23	1.21	0.28	210	10.8	27.0	0.23	221
A3	0.86	0.25	1.15	0.30	164	10.8	29.2	0.26	218
A4	0.79	0.23	1.14	0.26	296	9.7	35.7	0.23	143
A5	0.78	0.21	0.82	0.25	213	10.8	33.6	0.21	262
A6	0.89	0.23	1.22	0.30	192	12.9	29.1	0.25	426
A7	0.88	0.26	1.33	0.33	162	9.8	29.3	0.23	438
A8	0.75	0.29	1.72	0.24	226	10.8	29.1	0.26	364
A9	0.93	0.23	0.81	0.26	242	10.8	26.0	0.24	165
B1	0.95	0.25	0.98	0.31	192	10.9	35.9	0.27	174
B2	0.75	0.26	1.20	0.28	221	11.9	31.4	0.25	256
B3	0.75	0.21	0.97	0.26	246	9.8	26.1	0.24	165
B4	0.81	0.22	1.14	0.29	241	13.9	32.1	0.22	148
B5	0.78	0.21	1.45	0.27	229	7.6	23.8	0.25	116
B6	0.79	0.23	1.22	0.28	242	12.9	34.5	0.25	296
B7	0.80	0.26	1.04	0.32	223	11.9	61.7	0.26	227
B8	1.01	0.23	0.76	0.27	202	8.7	23.9	0.23	114
B9	0.77	0.21	0.72	0.26	257	9.7	26.0	0.25	93
C1	0.83	0.21	1.05	0.30	215	13.0	35.8	0.27	165
C2	0.76	0.21	2.03	0.26	217	9.7	25.8	0.24	99
C3	0.74	0.23	1.33	0.27	179	11.8	23.7	0.24	148
C4	0.85	0.22	1.31	0.25	260	10.7	24.7	0.22	137
C5	0.83	0.21	1.56	0.28	259	10.8	28.1	0.24	114
C6	0.85	0.20	1.17	0.28	224	12.0	26.1	0.27	124
C7	0.75	0.20	1.66	0.23	205	11.9	23.7	0.23	111
C8	0.91	0.24	1.38	0.33	250	9.8	25.0	0.25	114
C9	0.81	0.20	1.36	0.26	248	9.8	27.1	0.26	135
D1	0.74	0.19	1.25	0.23	248	14.0	23.7	0.27	98
D2	0.79	0.21	1.59	0.25	246	11.9	27.0	0.27	148
D3	0.88	0.21	1.75	0.29	216	11.9	31.4	0.3	140
D4	0.93	0.23	1.51	0.29	145	11.9	28.2	0.3	86
D5	0.84	0.23	1.36	0.30	231	12.0	27.2	0.28	162
D6	0.81	0.26	1.50	0.29	244	10.8	27.0	0.27	256
D7	0.94	0.22	1.44	0.28	297	10.9	29.3	0.27	129
D8	0.97	0.22	1.25	0.31	262	10.8	29.3	0.29	127
D9	1.09	0.24	1.86	0.30	218	9.8	30.4	0.3	119

Table 29. Spring 2010 forage metals and nitrate concentrations, Greeneville REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kb)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.84	0.29	1.90	0.25	136	7.7	25.2	0.20	8.3
A2	0.65	0.23	1.93	0.26	143	7.6	24.0	0.24	3.2
A3	0.74	0.25	1.84	0.23	140	27.3	37.1	0.24	3.4
A4	0.82	0.30	1.53	0.28	146	7.5	24.8	0.28	3.0
A5	0.74	0.23	1.96	0.25	138	22.7	37.8	0.24	3.2
A6	1.01	0.32	1.56	0.25	146	7.6	26.0	0.21	4.1
A7	0.84	0.27	1.91	0.24	124	7.5	30.2	0.18	3.7
A8	1.20	0.31	1.85	0.29	88	7.6	27.1	0.19	4.7
A9	1.06	0.29	1.67	0.27	99	7.6	29.3	0.23	4.6
B1	0.84	0.23	1.69	0.27	113	19.4	38.9	0.20	3.2
B2	0.72	0.19	1.44	0.27	181	7.5	27.8	0.23	53.8
B3	0.71	0.23	1.95	0.30	141	36.8	48.7	0.24	3.7
B4	0.82	0.27	1.58	0.23	112	7.6	23.8	0.22	3.1
B5	0.66	0.22	1.76	0.23	137	7.6	30.2	0.24	3.4
B6	0.71	0.26	1.63	0.30	197	9.7	26.9	0.28	3.8
B7	0.77	0.24	1.78	0.26	122	7.6	20.5	0.19	3.4
B8	0.74	0.21	1.77	0.26	69	9.7	22.6	0.18	3.5
B9	0.75	0.18	2.16	0.25	104	6.5	22.7	0.17	4.3
C1	0.90	0.29	1.49	0.27	105	10.9	28.4	0.24	2.7
C2	0.59	0.16	1.98	0.27	100	16.2	29.1	0.21	3.2
C3	0.86	0.32	1.74	0.23	141	7.7	23.0	0.20	3.4
C4	0.87	0.34	1.68	0.28	139	15.2	48.9	0.28	3.7
C5	0.95	0.27	1.55	0.24	124	6.5	27.1	0.20	4.0
C6	0.62	0.20	2.21	0.24	141	35.5	43.1	0.23	4.7
C7	0.97	0.27	1.71	0.24	115	7.6	28.2	0.20	4.4
C8	1.01	0.29	1.57	0.23	79	6.5	22.8	0.21	4.1
C9	0.75	0.20	1.86	0.23	99	6.5	24.9	0.18	4.2
D1	0.72	0.20	1.83	0.25	108	6.5	22.7	0.18	3.5
D2	0.76	0.23	1.39	0.25	99	6.5	24.9	0.18	2.8
D3	0.78	0.29	1.71	0.22	145	7.6	22.9	0.20	4.7
D4	0.83	0.24	1.89	0.25	119	8.6	22.7	0.22	4.0
D5	0.74	0.24	1.98	0.27	177	77.2	78.3	0.25	3.7
D6	1.05	0.32	1.50	0.26	142	11.0	27.4	0.23	3.4
D7	1.31	0.26	2.13	0.50	193	35.7	49.0	0.25	3.7
D8	0.88	0.27	1.98	0.24	89	9.8	30.4	0.20	4.9
D9	0.67	0.24	1.71	0.24	92	7.6	24.8	0.22	4.7

Table 30. Spring 2010 forage metals and nitrate concentrations, Plateau REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.63	0.22	2.41	0.32	116	11.9	33.5	0.24	4.4
A2	0.53	0.20	2.63	0.35	153	10.7	28.9	0.19	5.6
A3	0.64	0.16	2.15	0.31	210	9.7	31.2	0.24	4.4
A4	0.52	0.14	2.24	0.28	199	7.5	25.9	0.19	4.3
A5	0.45	0.15	2.45	0.28	183	7.5	24.6	0.21	5.0
A6	0.54	0.17	2.41	0.31	174	17.2	35.4	0.25	5.5
A7	0.50	0.17	2.22	0.30	182	10.7	27.9	0.21	5.0
A8	0.42	0.19	2.42	0.32	148	10.7	31.1	0.29	6.8
A9	0.55	0.19	2.13	0.30	153	9.6	26.8	0.25	5.5
B1	0.43	0.17	2.51	0.30	177	10.7	36.3	0.25	5.4
B2	0.43	0.16	2.22	0.29	184	7.5	26.7	0.20	5.7
B3	0.72	0.17	2.66	0.45	170	7.6	25.1	0.22	5.2
B4	0.29	0.13	2.65	0.26	141	13.9	29.0	0.22	5.5
B5	0.42	0.17	2.46	0.29	172	6.4	23.6	0.19	5.5
B6	0.51	0.18	2.17	0.31	162	12.9	30.0	0.24	5.6
B7	0.99	0.18	2.68	0.54	176	13.0	39.1	0.29	10.0
B8	0.65	0.22	1.88	0.28	179	7.5	26.7	0.23	3.8
B9	0.58	0.17	1.92	0.29	221	6.4	25.7	0.20	3.3
C1	0.58	0.23	2.56	0.36	120	11.7	32.0	0.30	9.4
C2	0.52	0.18	2.16	0.31	133	7.5	24.6	0.19	4.8
C3	0.49	0.17	2.22	0.30	137	9.6	33.1	0.21	4.3
C4	0.56	0.19	2.34	0.31	166	9.6	29.9	0.24	4.8
C5	0.46	0.16	2.73	0.35	106	10.6	25.4	0.23	6.5
C6	0.51	0.17	1.97	0.29	162	6.4	26.8	0.18	4.1
C7	0.60	0.17	2.24	0.31	167	10.7	26.8	0.22	4.9
C8	0.56	0.22	2.11	0.34	149	7.5	22.5	0.21	6.2
C9	0.48	0.19	2.20	0.31	164	7.4	24.5	0.25	5.3
D1	0.52	0.19	2.45	0.32	196	7.5	26.8	0.23	5.5
D2	0.57	0.20	2.30	0.36	183	10.7	33.1	0.30	7.3
D3	0.66	0.17	1.87	0.29	207	6.5	24.9	0.20	4.3
D4	0.64	0.17	2.02	0.31	179	8.6	28.9	0.24	4.4
D5	0.51	0.17	2.40	0.30	179	12.8	29.8	0.25	5.7
D6	0.74	0.22	2.18	0.30	213	7.5	23.7	0.21	5.7
D7	0.55	0.18	2.32	0.29	176	9.7	25.7	0.20	6.0
D8	0.54	0.16	2.39	0.28	174	7.5	25.7	0.23	5.5
D9	0.62	0.20	2.23	0.30	169	7.5	23.7	0.23	5.6

Table 31. Fall 2010 forage mineral and nitrate concentrations, Greeneville REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.94	0.41	1.28	0.28	202	10.8	47.4	0.21	1750
A2	1.09	0.30	1.55	0.35	113	10.7	48.1	0.22	482
A3	0.92	0.26	0.71	0.31	99	9.7	45.3	0.21	368
A4	0.96	0.30	0.75	0.29	123	10.8	42.0	0.24	259
A5	0.89	0.28	1.17	0.25	92	9.7	39.7	0.24	584
A6	0.84	0.28	1.64	0.32	117	8.6	36.5	0.23	439
A7	0.91	0.29	1.34	0.34	127	9.7	32.2	0.22	382
A8	0.78	0.31	0.89	0.31	86	8.6	40.7	0.21	467
A9	0.91	0.24	0.29	0.32	104	7.5	40.8	0.21	425
B1	1.06	0.27	0.82	0.29	96	10.9	37.0	0.20	540
B2	1.08	0.28	1.57	0.26	100	9.7	37.6	0.22	782
B3	0.96	0.31	1.48	0.36	88	10.8	40.0	0.23	689
B4	1.00	0.30	1.01	0.31	109	9.7	37.9	0.21	467
B5	0.94	0.31	1.26	0.34	134	13.0	51.9	0.24	735
B6	1.06	0.30	1.35	0.22	114	10.8	35.6	0.26	540
B7	1.14	0.29	1.60	0.24	106	11.8	32.2	0.22	735
B8	1.01	0.28	2.03	0.27	80	10.7	37.5	0.24	511
B9	1.11	0.24	1.77	0.36	106	9.7	31.3	0.22	584
C1	0.69	0.21	1.09	0.29	101	9.7	46.1	0.22	453
C2	0.81	0.25	1.31	0.38	92	10.8	45.2	0.24	511
C3	0.61	0.38	1.76	0.35	135	9.8	39.1	0.24	1090
C4	0.64	0.40	1.79	0.39	105	11.9	37.8	0.24	584
C5	0.52	0.32	2.10	0.36	105	9.7	40.8	0.25	482
C6	0.71	0.28	0.63	0.28	120	10.7	40.7	0.22	644
C7	0.79	0.25	1.72	0.25	102	9.7	43.1	0.21	482
C8	0.88	0.29	1.20	0.37	70	9.7	39.7	0.21	525
C9	0.97	0.28	1.40	0.29	113	8.7	34.6	0.22	614
D1	0.99	0.30	1.10	0.32	105	8.2	50.2	0.20	861
D2	0.89	0.29	1.00	0.30	117	8.2	39.9	0.22	599
D3	0.59	0.33	1.72	0.30	124	8.2	35.9	0.21	1260
D4	0.94	0.31	1.40	0.29	91	9.7	32.4	0.22	629
D5	0.44	0.28	1.86	0.31	81	9.3	30.7	0.23	689
D6	1.04	0.29	1.47	0.25	109	7.6	31.3	0.27	629
D7	0.97	0.28	1.34	0.32	118	8.2	34.9	0.22	674
D8	0.94	0.29	1.20	0.33	83	8.2	40.9	0.21	659
D9	0.49	0.29	1.98	0.29	96	8.3	31.0	0.26	735

Table 32. Fall 2010 forage mineral and nitrate concentrations, Plateau REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.81	0.21	1.01	0.29	102	9.2	29.6	0.22	1260
A2	0.79	0.23	0.70	0.27	193	9.2	33.6	0.17	1750
A3	0.76	0.22	0.91	0.25	170	8.2	38.7	0.21	720
A4	0.59	0.17	0.71	0.28	180	8.2	38.8	0.17	569
A5	0.64	0.19	0.72	0.28	177	8.2	40.9	0.17	584
A6	0.79	0.18	0.77	0.33	146	10.8	42.0	0.19	689
A7	0.54	0.16	0.68	0.28	184	9.7	36.5	0.18	511
A8	0.72	0.18	1.10	0.29	127	8.2	29.6	0.21	629
A9	0.54	0.17	0.68	0.26	133	8.1	30.5	0.22	584
B1	0.69	0.21	1.10	0.28	191	9.1	36.6	0.20	750
B2	0.57	0.16	1.10	0.26	182	8.1	38.7	0.17	797
B3	0.51	0.18	1.11	0.24	179	8.6	32.1	0.17	689
B4	0.52	0.18	1.16	0.29	148	9.1	35.5	0.18	614
B5	0.69	0.24	1.59	0.29	159	9.1	33.5	0.19	1010
B6	0.65	0.20	1.49	0.30	115	9.1	30.5	0.22	750
B7	0.59	0.21	0.90	0.27	144	11.2	35.5	0.23	941
B8	0.62	0.20	1.18	0.27	151	8.1	28.5	0.22	599
B9	0.59	0.19	1.10	0.31	173	9.2	35.6	0.21	584
C1	0.61	0.24	1.49	0.30	137	8.6	27.8	0.24	1020
C2	0.64	0.24	1.52	0.30	149	7.5	25.7	0.19	1160
C3	0.55	0.17	1.23	0.25	131	9.6	30.9	0.20	596
C4	0.61	0.23	1.77	0.31	172	9.6	28.9	0.22	688
C5	0.53	0.21	1.61	0.28	111	10.6	29.8	0.21	893
C6	0.59	0.18	0.91	0.27	204	7.5	33.3	0.19	566
C7	0.47	0.19	1.46	0.28	145	9.6	33.0	0.23	611
C8	0.38	0.19	1.70	0.29	162	8.1	25.3	0.21	710
C9	0.56	0.16	1.09	0.27	206	24.6	36.3	0.21	718
D1	0.76	0.22	1.61	0.33	221	9.6	29.9	0.22	1330
D2	0.69	0.23	1.71	0.33	165	8.5	26.7	0.26	844
D3	0.72	0.21	1.72	0.35	178	9.7	26.9	0.25	672
D4	0.66	0.23	1.62	0.29	193	9.6	28.9	0.28	1040
D5	0.76	0.21	1.53	0.31	184	9.6	27.8	0.26	1250
D6	0.67	0.23	2.05	0.28	248	9.6	24.6	0.25	958
D7	0.65	0.21	1.84	0.29	218	8.6	27.8	0.24	1250
D8	0.76	0.21	1.60	0.28	206	8.1	26.5	0.25	860
D9	0.69	0.22	2.00	0.31	161	9.6	24.6	0.23	1040

Table 33. Spring 2011 forage metals and nitrate concentrations, Greeneville REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kb)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.43	0.17	1.99	0.23	143	8.8	19.8	0.18	60
A2	0.54	0.23	2.08	0.31	137	8.9	24.4	0.23	49
A3	0.44	0.16	2.54	0.25	83	9.9	26.3	0.21	44
A4	1.01	0.23	1.53	0.30	113	8.8	23.1	0.23	31
A5	0.62	0.23	2.36	0.29	84	9.9	26.5	0.21	29
A6	0.37	0.17	2.58	0.24	152	8.8	19.8	0.23	31
A7	0.84	0.25	2.17	0.25	119	7.8	24.5	0.19	39
A8	0.91	0.33	1.89	0.31	70	6.7	21.1	0.18	44
A9	0.44	0.19	2.07	0.28	89	7.7	21.9	0.22	39
B1	0.54	0.20	2.14	0.25	93	8.8	26.3	0.19	42
B2	0.47	0.17	1.72	0.27	150	7.7	23.1	0.20	129
B3	0.56	0.21	1.76	0.31	93	13.2	34.2	0.23	79
B4	0.69	0.30	1.71	0.26	95	7.7	22.0	0.21	28
B5	0.40	0.20	2.06	0.27	110	8.8	23.0	0.24	19
B6	0.62	0.25	2.29	0.27	123	9.9	31.9	0.26	53
B7	0.29	0.21	2.06	0.23	122	7.6	21.8	0.15	24
B8	0.57	0.20	2.04	0.26	64	6.6	20.9	0.18	17
B9	0.56	0.22	2.20	0.26	120	6.6	20.9	0.16	27
C1	0.33	0.16	2.34	0.26	103	7.7	24.2	0.22	28
C2	0.40	0.19	2.43	0.28	80	9.9	21.9	0.21	22
C3	0.41	0.16	1.79	0.23	91	8.8	18.7	0.17	48
C4	1.26	0.28	1.76	0.31	93	7.7	18.6	0.24	18
C5	0.62	0.32	1.83	0.29	95	7.8	22.2	0.21	63
C6	0.65	0.20	2.58	0.29	75	12	27.2	0.23	72
C7	1.02	0.29	1.76	0.28	110	10	36.6	0.21	70
C8	0.93	0.26	2.10	0.23	63	8.9	24.4	0.20	60
C9	0.44	0.19	2.40	0.23	114	6.6	22.1	0.17	63
D1	0.46	0.24	1.79	0.28	119	8.8	21.9	0.19	46
D2	0.34	0.19	2.09	0.23	82	6.6	18.6	0.20	39
D3	0.74	0.27	1.73	0.27	122	9.9	25.2	0.19	63
D4	0.63	0.23	1.73	0.29	98	7.7	23.1	0.23	32
D5	0.82	0.35	1.52	0.43	128	12.3	31.3	0.27	30
D6	0.40	0.18	2.46	0.24	149	8.7	23.0	0.29	45
D7	0.52	0.21	2.31	0.29	128	8.8	22.0	0.22	70
D8	1.12	0.37	1.74	0.29	85	11.1	33.2	0.20	84
D9	0.58	0.20	2.39	0.27	149	8.8	27.4	0.32	68

Table 34. Spring 2011 forage metals and nitrate concentrations, Plateau REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.68	0.16	1.96	0.33	80	9.7	24.9	0.23	50
A2	0.54	0.15	2.00	0.35	195	10.7	33.2	0.22	78
A3	0.62	0.15	1.63	0.39	150	9.7	29.1	0.27	64
A4	0.47	0.12	1.90	0.33	166	7.6	29.2	0.24	60
A5	0.51	0.12	2.37	0.36	173	9.7	29.1	0.25	78
A6	0.77	0.17	2.45	0.38	107	11.9	31.4	0.25	108
A7	0.53	0.13	2.26	0.33	137	9.7	33.5	0.22	58
A8	0.77	0.23	1.83	0.41	141	13	31.5	0.29	82
A9	0.72	0.19	2.03	0.36	128	9.8	25.0	0.28	80
B1	0.56	0.18	2.06	0.33	203	9.8	28.2	0.27	74
B2	0.26	0.17	2.18	0.32	167	7.6	22.9	0.19	79
B3	0.38	0.23	1.94	0.32	164	9.8	24.0	0.26	53
B4	0.35	0.19	2.15	0.32	121	9.8	26.1	0.25	60
B5	0.38	0.19	2.11	0.32	193	9.8	24.0	0.23	55
B6	0.30	0.18	2.35	0.36	82	12.9	29.1	0.25	141
B7	0.66	0.21	1.87	0.39	114	13	34.8	0.30	402
B8	0.24	0.17	2.38	0.30	153	9.8	26.1	0.26	66
B9	0.40	0.16	2.12	0.33	185	8.7	19.6	0.23	49
C1	0.44	0.22	2.58	0.35	132	14.1	30.4	0.32	152
C2	0.28	0.18	2.44	0.30	193	8.7	23.9	0.21	67
C3	0.30	0.19	2.08	0.28	165	8.7	27.3	0.26	55
C4	0.44	0.20	2.10	0.33	144	9.8	25.0	0.28	58
C5	0.33	0.16	2.46	0.29	132	10.9	29.4	0.24	57
C6	0.40	0.21	2.07	0.29	166	8.7	22.8	0.22	38
C7	0.29	0.18	2.47	0.31	138	9.8	26.0	0.23	46
C8	0.39	0.22	2.18	0.31	147	8.7	20.7	0.20	49
C9	0.35	0.19	2.10	0.29	181	8.7	23.9	0.25	57
D1	0.37	0.17	2.18	0.33	200	8.8	25.2	0.22	67
D2	0.40	0.18	2.26	0.36	144	10.9	30.4	0.33	126
D3	0.26	0.17	2.59	0.29	205	8.7	21.9	0.24	47
D4	0.49	0.18	2.26	0.31	156	9.8	26.1	0.27	59
D5	0.32	0.18	2.69	0.29	163	10.8	29.3	0.27	100
D6	0.44	0.18	2.79	0.30	187	9.8	22.8	0.23	74
D7	0.33	0.17	2.73	0.35	157	10.9	28.3	0.25	71
D8	0.42	0.22	2.48	0.31	174	7.6	21.7	0.24	61
D9	0.41	0.17	2.54	0.30	158	8.7	24.9	0.26	47

Table 35. Fall 2011 forage metals and nitrate for the Greeneville REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kb)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.87	0.33	1.74	0.31	115	9.8	138.9	0.21	-
A2	1.00	0.33	1.89	0.33	113	8.8	28.5	0.30	353
A3	0.71	0.20	1.41	0.28	96	6.5	40.3	0.23	278
A4	0.67	0.25	1.57	0.29	134	8.7	33.9	0.26	216
A5	0.81	0.25	1.85	0.28	86	8.7	37.1	0.27	213
A6	0.66	0.31	1.45	0.36	185	8.8	29.7	0.28	184
A7	0.67	0.20	1.61	0.30	155	9.9	35.1	0.24	215
A8	1.05	0.39	1.29	0.39	103	8.8	39.7	0.24	253
A9	0.90	0.33	1.30	0.32	109	7.7	43.9	0.25	213
B1	0.64	0.20	1.49	0.32	91	8.8	36.2	0.23	210
B2	0.94	0.28	0.77	0.31	134	11.0	39.6	0.22	384
B3	0.85	0.26	1.72	0.29	82	9.9	41.6	0.25	252
B4	0.69	0.20	1.25	0.30	98	8.8	37.2	0.23	225
B5	0.66	0.20	1.89	0.28	101	7.7	35.0	0.28	230
B6	0.96	0.31	1.80	0.32	91	9.8	37.9	0.29	217
B7	1.11	0.43	2.14	0.34	113	7.6	34.8	0.23	242
B8	0.76	0.28	1.53	0.35	81	7.7	29.7	0.23	234
B9	0.94	0.24	1.99	0.26	129	7.6	24.0	0.23	230
C1	0.97	0.27	1.21	0.33	88	8.7	39.2	0.23	253
C2	0.81	0.24	1.62	0.33	80	7.7	44.8	0.25	247
C3	0.95	0.35	1.80	0.28	91	8.6	32.4	0.20	348
C4	1.05	0.36	2.06	0.27	105	9.8	25.0	0.31	247
C5	0.67	0.24	1.20	0.36	102	7.6	32.8	0.24	217
C6	0.86	0.24	2.04	0.27	79	9.8	36.9	0.25	288
C7	0.71	0.22	1.22	0.29	115	8.7	39.3	0.26	263
C8	0.65	0.23	1.32	0.32	84	7.6	41.3	0.22	251
C9	0.61	0.23	1.34	0.26	142	7.7	38.3	0.21	241
D1	0.87	0.32	1.35	0.30	123	7.7	39.4	0.24	277
D2	0.84	0.30	0.99	0.36	98	7.7	39.5	0.25	264
D3	1.10	0.41	1.42	0.34	103	8.7	59.8	0.20	349
D4	0.98	0.31	1.74	0.30	104	9.9	38.4	0.29	293
D5	0.50	0.14	1.94	0.21	92	8.8	32.9	0.26	226
D6	0.86	0.24	2.19	0.25	123	8.7	34.9	0.29	258
D7	0.57	0.17	1.64	0.24	116	7.6	31.7	0.23	238
D8	0.61	0.24	1.30	0.31	84	7.6	44.6	0.25	265
D9	0.51	0.22	1.83	0.21	111	8.6	30.2	0.28	221

Table 36. Fall 2011 forage metals and nitrate for the Plateau REC.

Plot	Ca (%)	Mg (%)	K (%)	P (%)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	S (%)	Nitrate (mg/kg)
A1	0.57	0.25	1.91	0.24	152	12.1	28.6	0.23	485
A2	0.62	0.25	0.44	0.37	215	9.8	28.3	0.21	235
A3	0.92	0.23	0.82	0.38	184	12.0	44.8	0.27	229
A4	0.60	0.20	0.63	0.29	280	11.0	54.1	0.18	272
A5	0.53	0.22	0.68	0.26	224	11.1	53.3	0.22	323
A6	0.77	0.26	0.81	0.32	129	11.0	36.2	0.22	247
A7	0.99	0.40	1.65	0.41	180	12.2	31.2	0.24	840
A8	1.18	0.32	1.08	0.40	131	12.1	33.0	0.26	455
A9	1.00	0.29	0.92	0.38	154	13.2	46.3	0.24	282
B1	0.93	0.32	1.19	0.39	217	9.9	40.7	0.26	369
B2	0.62	0.28	1.60	0.27	241	12.2	33.2	0.21	855
B3	0.55	0.24	1.02	0.34	190	11.0	35.0	0.25	255
B4	0.73	0.22	0.40	0.39	160	11.0	34.0	0.21	213
B5	0.72	0.31	0.87	0.38	210	9.9	31.8	0.21	255
B6	1.00	0.27	0.89	0.37	133	14.3	36.3	0.27	335
B7	1.02	0.31	1.16	0.37	116	12.0	28.5	0.23	343
B8	0.81	0.26	0.87	0.37	170	13.2	35.1	0.22	269
B9	1.06	0.31	0.80	0.40	139	12.0	36.1	0.24	297
C1	0.78	0.27	0.73	0.35	271	9.9	30.7	0.23	245
C2	0.70	0.23	0.63	0.30	207	9.9	27.4	0.21	253
C3	0.65	0.29	1.25	0.38	175	12.0	29.5	0.25	341
C4	0.79	0.29	1.10	0.38	190	12.1	32.9	0.22	264
C5	0.66	0.25	1.28	0.39	142	8.8	31.9	0.23	268
C6	0.64	0.24	1.27	0.32	204	8.7	31.7	0.23	248
C7	0.88	0.22	0.86	0.36	148	8.8	29.6	0.25	270
C8	1.05	0.31	1.37	0.42	177	9.9	28.6	0.21	2051
C9	0.55	0.21	0.90	0.29	234	10.9	36.0	0.21	303
D1	0.81	0.28	0.64	0.35	311	8.8	26.3	0.22	230
D2	0.59	0.18	1.37	0.34	172	10.8	38.8	0.26	255
D3	0.81	0.24	1.07	0.35	220	8.7	30.6	0.26	270
D4	0.65	0.20	1.40	0.35	229	10.8	43.1	0.24	272
D5	0.59	0.22	2.03	0.29	172	13.3	34.3	0.26	367
D6	0.91	0.34	1.85	0.43	209	11.0	26.5	0.23	3581
D7	0.53	0.19	1.55	0.38	211	12.0	35.9	0.27	377
D8	0.58	0.22	1.55	0.35	232	9.7	30.2	0.26	304
D9	0.79	0.25	0.41	0.31	282	10.8	39.0	0.23	305

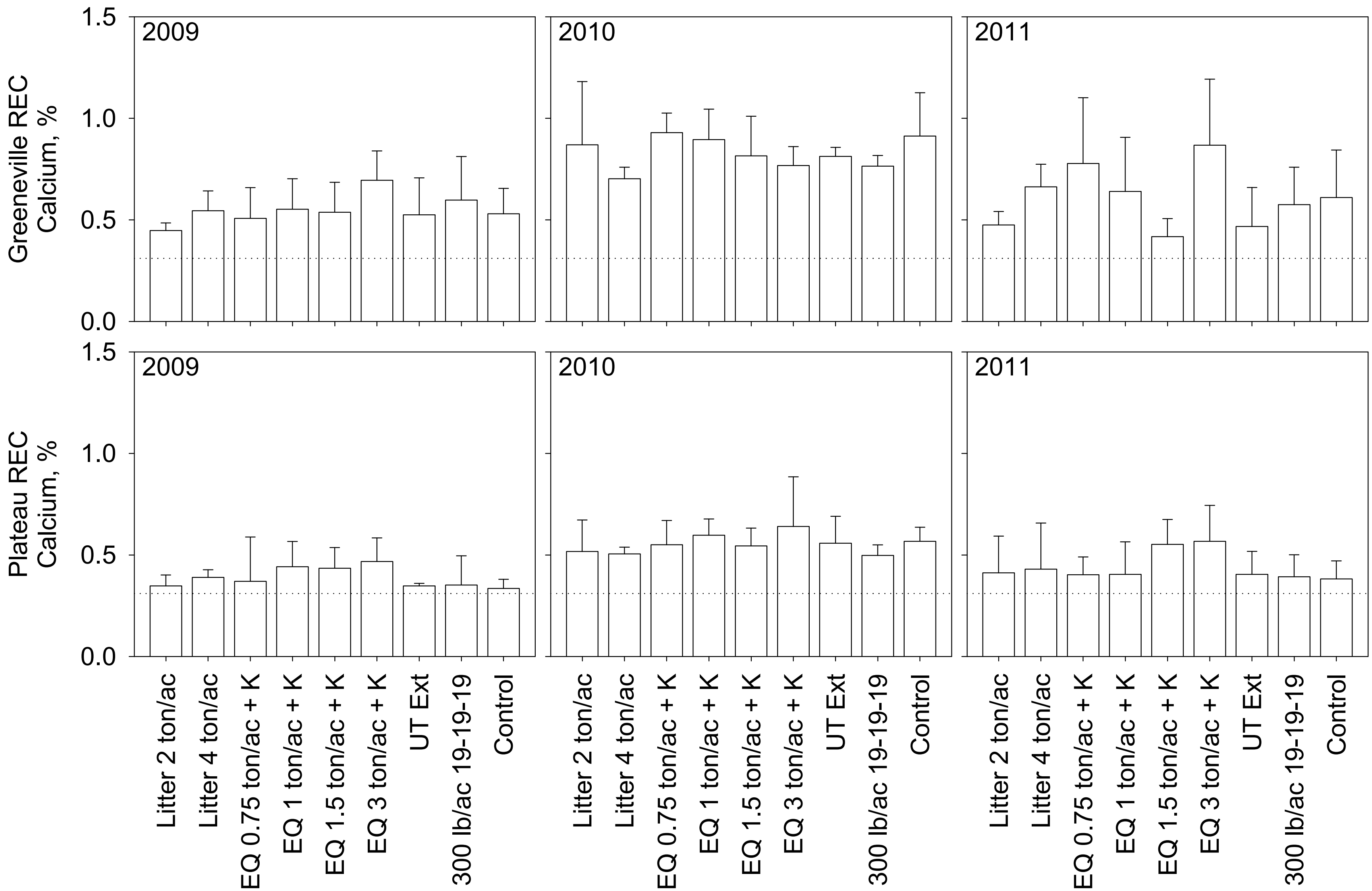

Figure 46. Spring forage calcium concentrations. An approximate lower threshold requirement for lactating cattle is indicated at 0.31%.

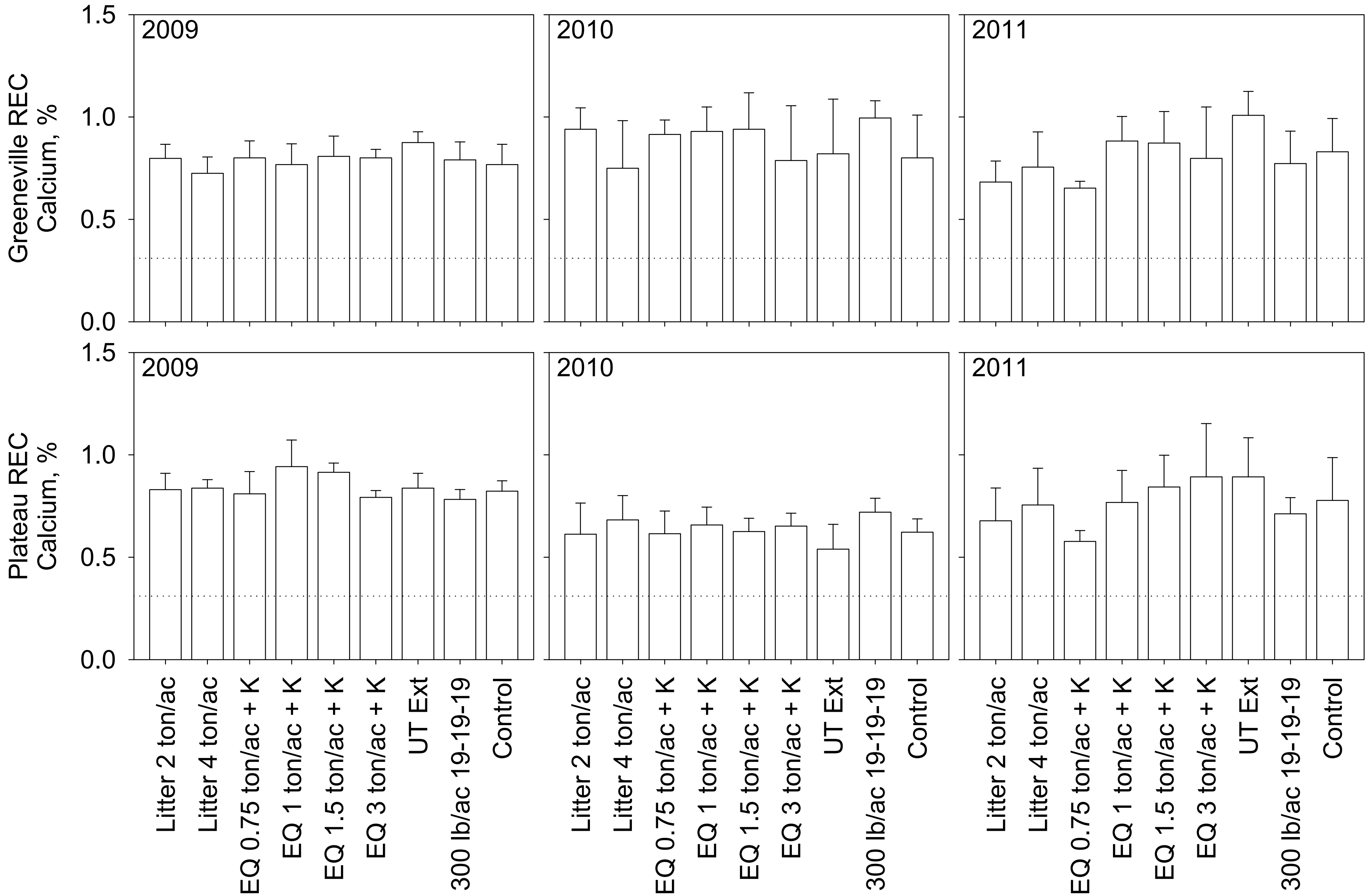

Figure 47. Fall forage calcium concentrations. An approximate lower threshold requirement for lactating cattle is indicated at 0.31%.

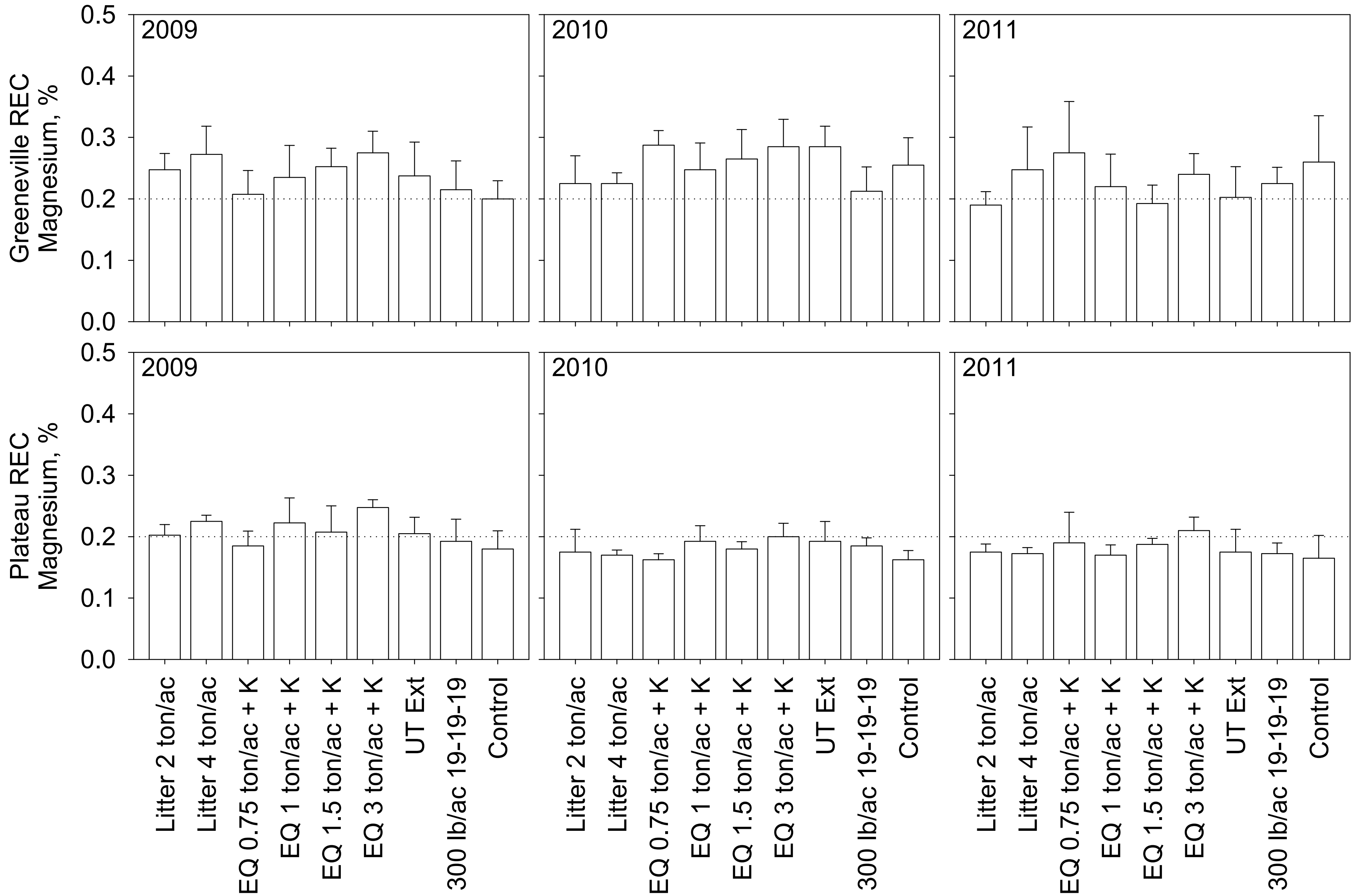

Figure 48. Spring forage magnesium concentrations. An approximate lower threshold requirement for lactating cattle is indicated at 0.2%.

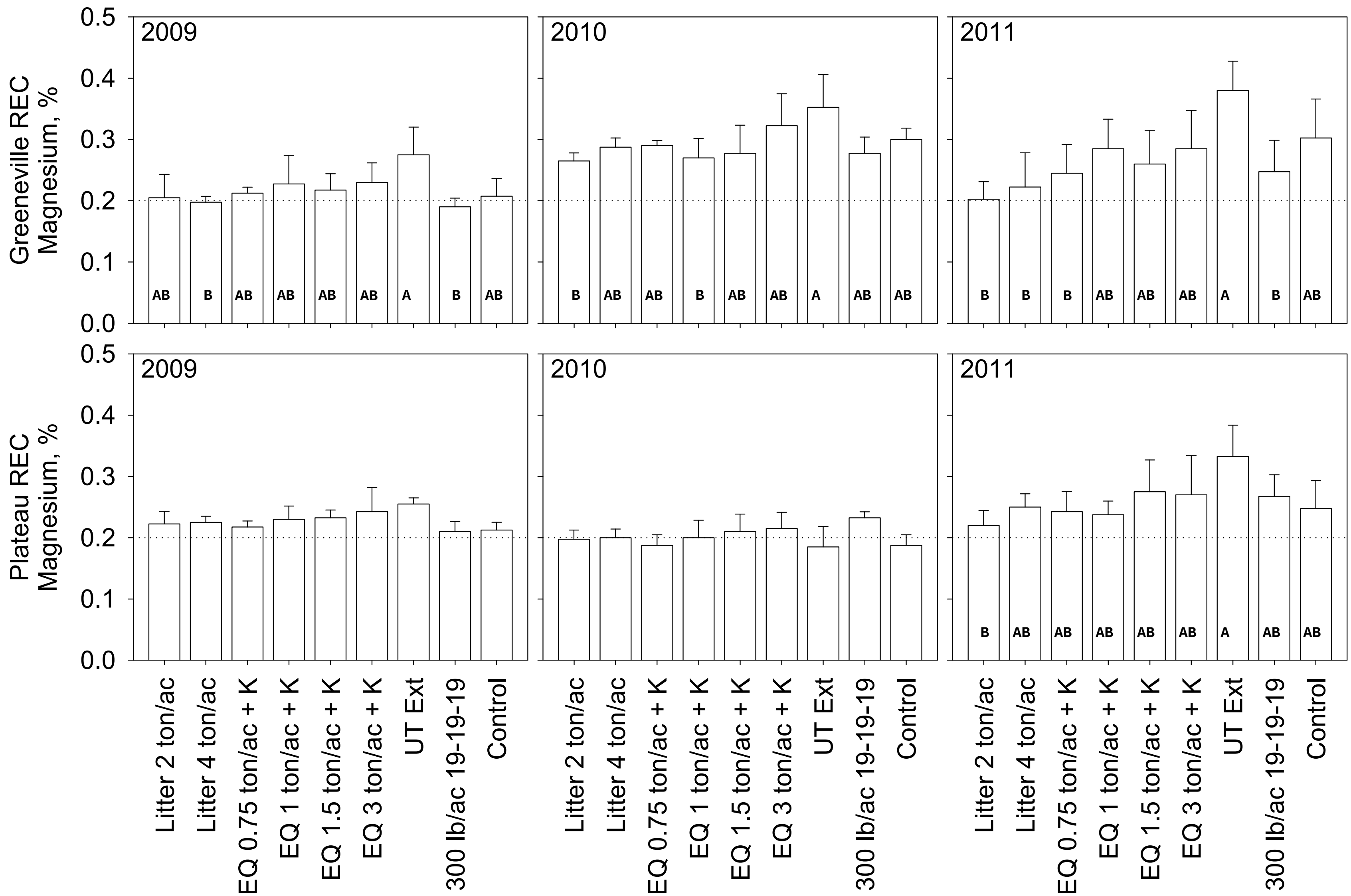

Figure 49. Fall forage magnesium concentrations (bars that do not share a common letter are significantly different). An approximate lower threshold requirement for lactating cattle is indicated at 0.2%.

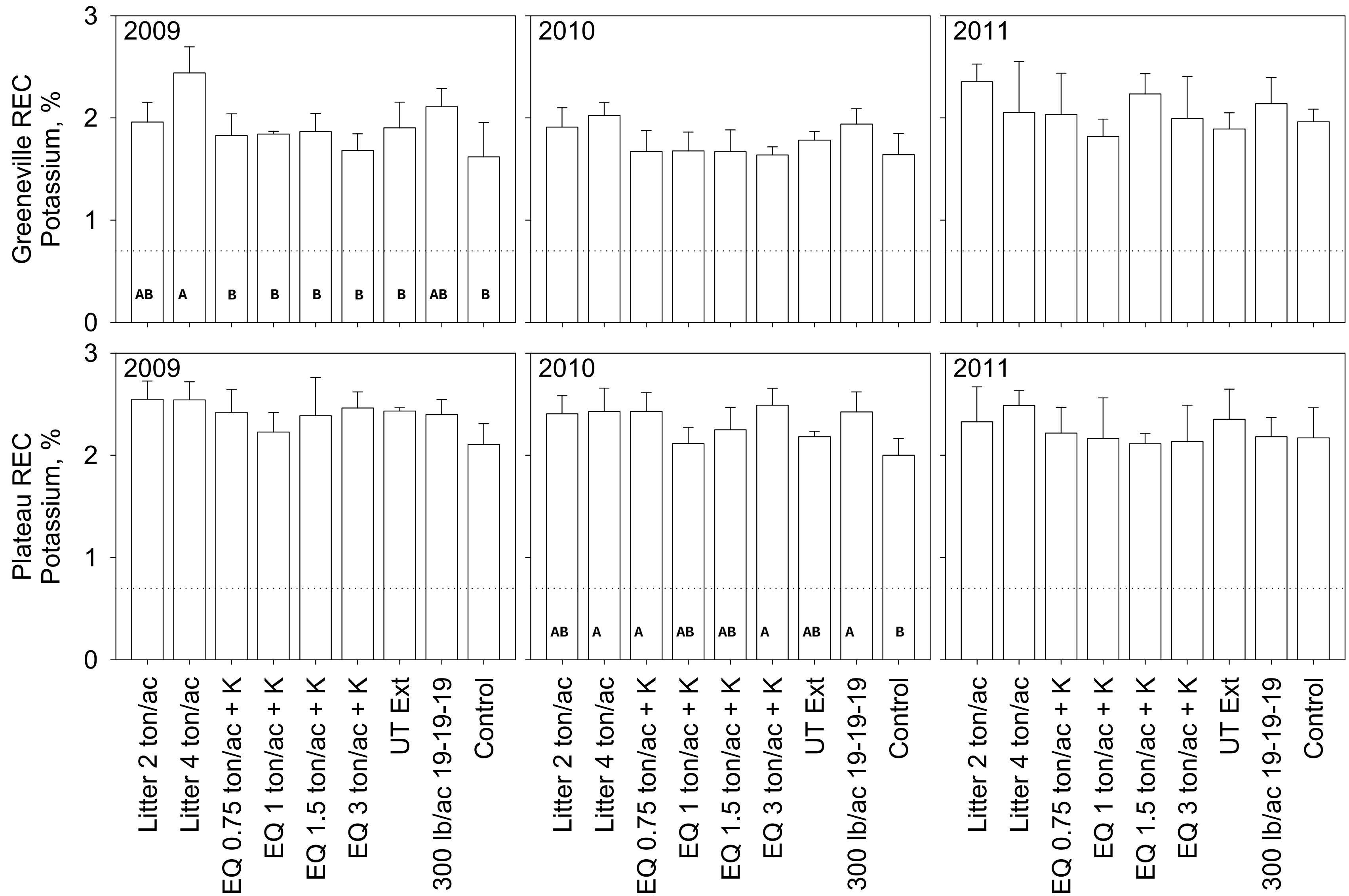

Figure 50. Spring forage potassium concentrations (bars that do not share a common letter are significantly different). An approximate lower threshold requirement for lactating cattle is indicated at 0.7%.

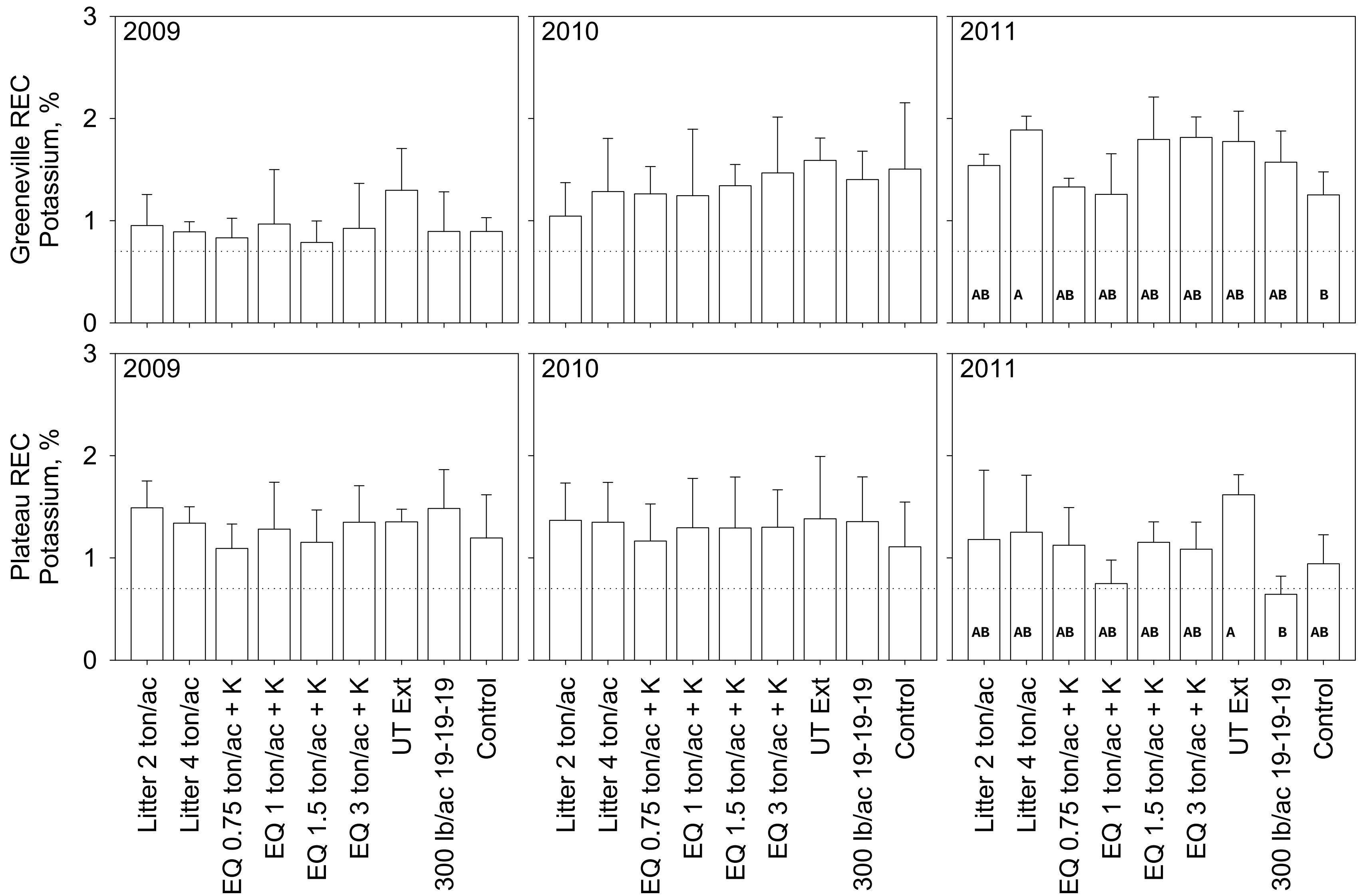

Figure 51. Fall forage potassium concentrations (bars that do not share a common letter are significantly different). An approximate lower threshold requirement for lactating cattle is indicated at 0.7%.

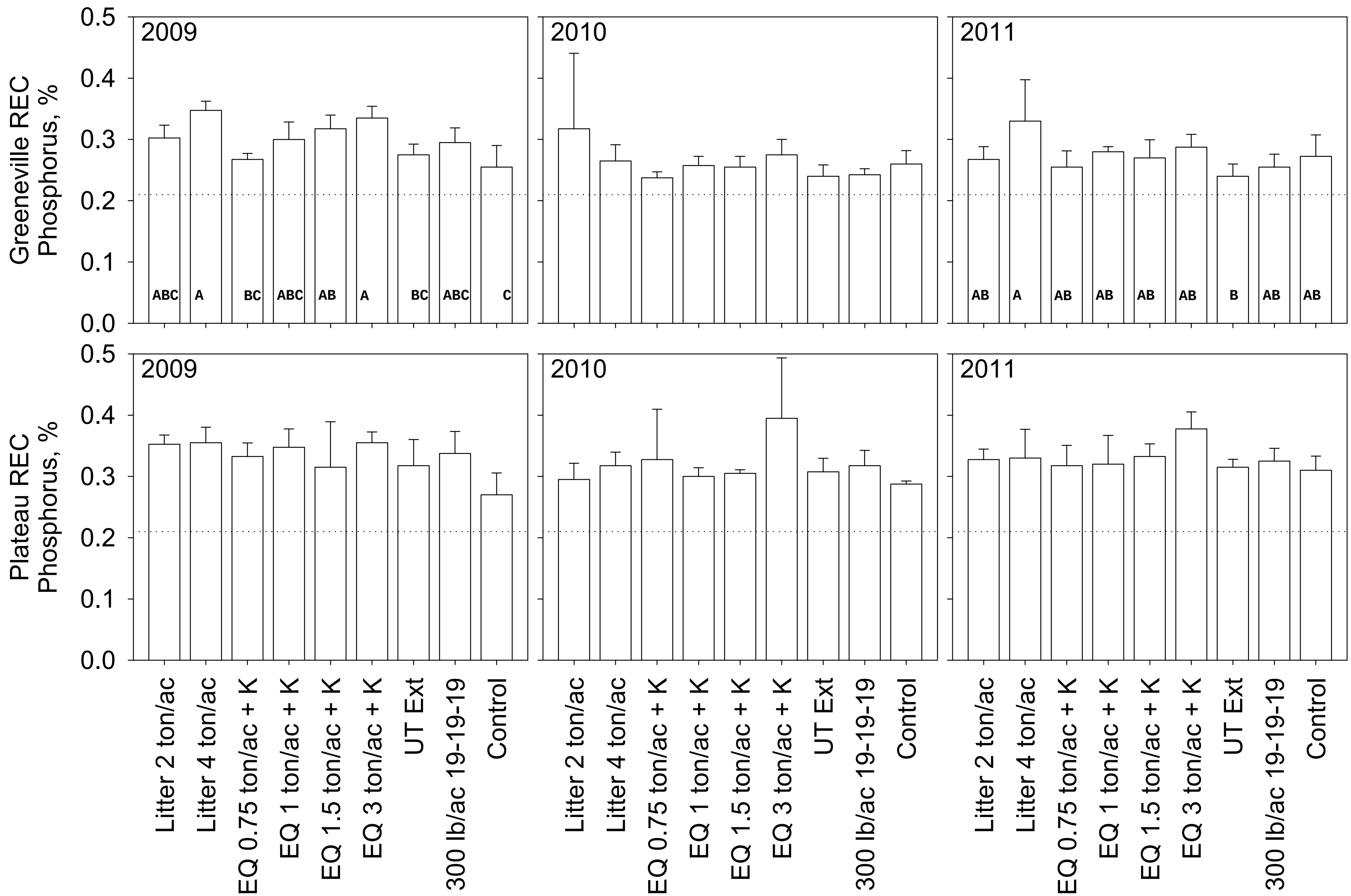

Figure 52. Spring forage phosphorus concentrations (bars that do not share a common letter are significantly different). An approximate lower threshold requirement for lactating cattle is indicated at 0.21%.

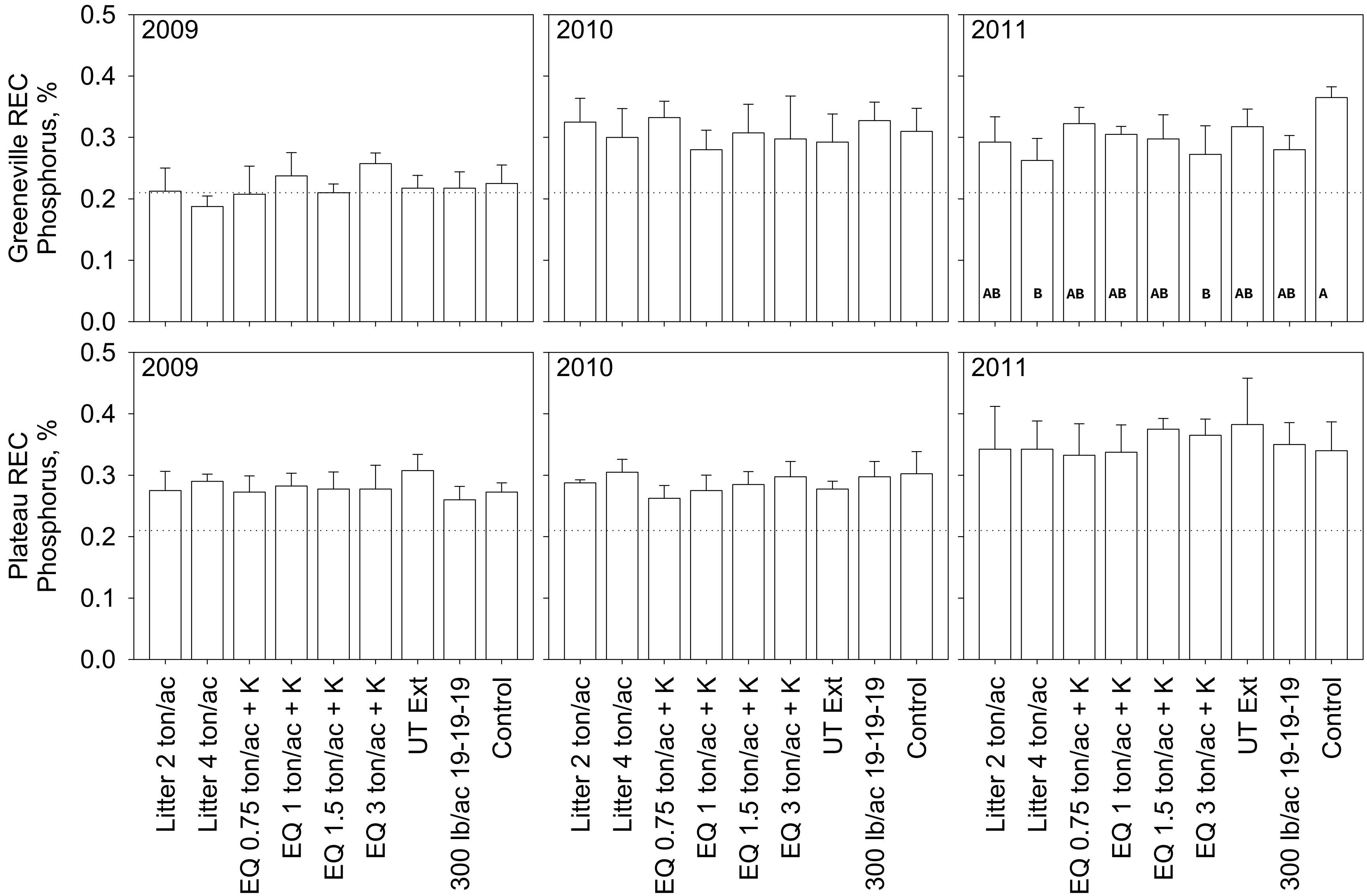

Figure 53. Fall forage phosphorus concentrations. An approximate lower threshold requirement for lactating cattle is indicated at 0.21%.

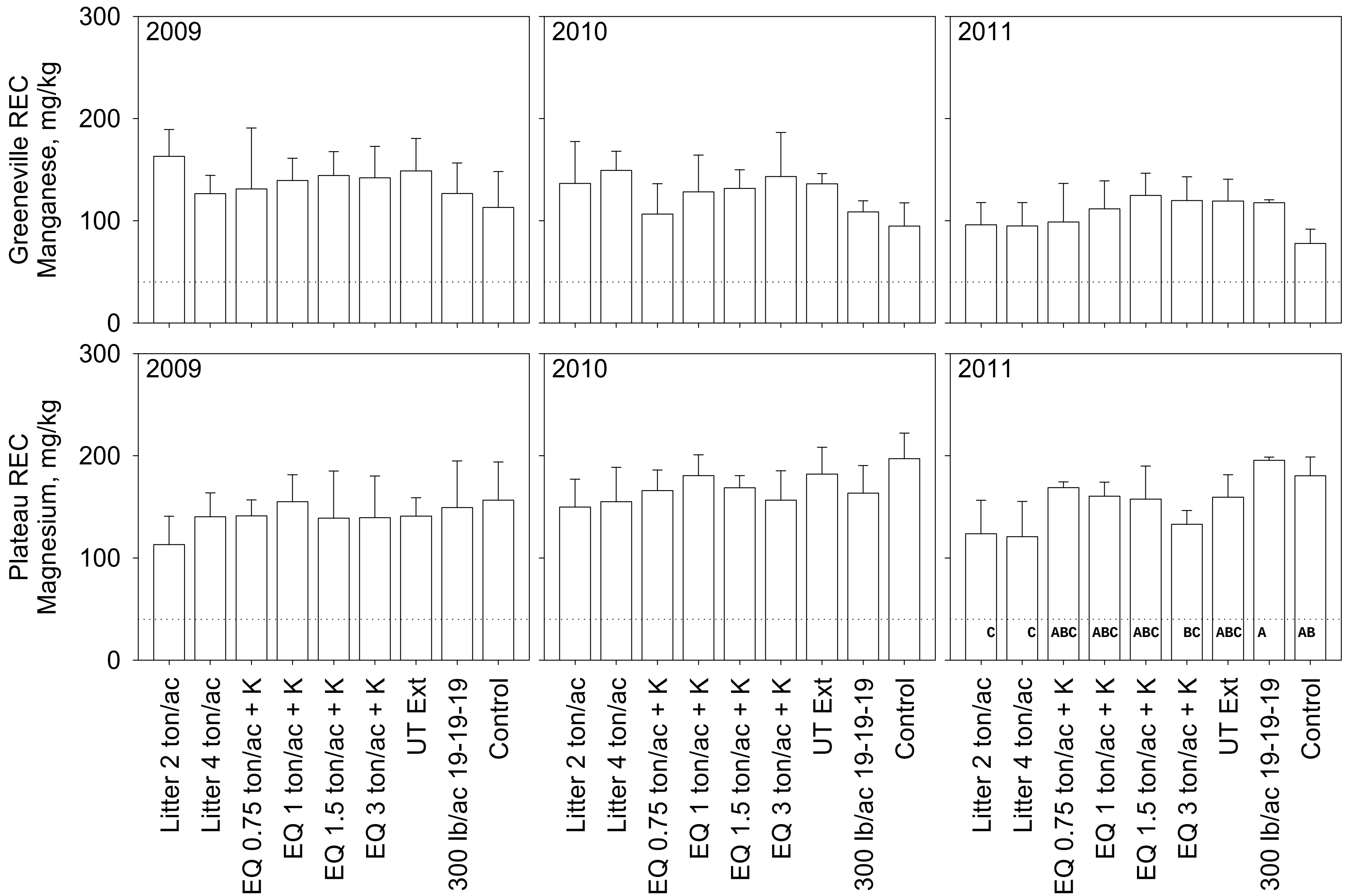

Figure 54. Spring forage manganese concentrations (bars that do not share a common letter are significantly different). An approximate adequate threshold requirement for lactating cattle is indicated at 40 mg/kg.

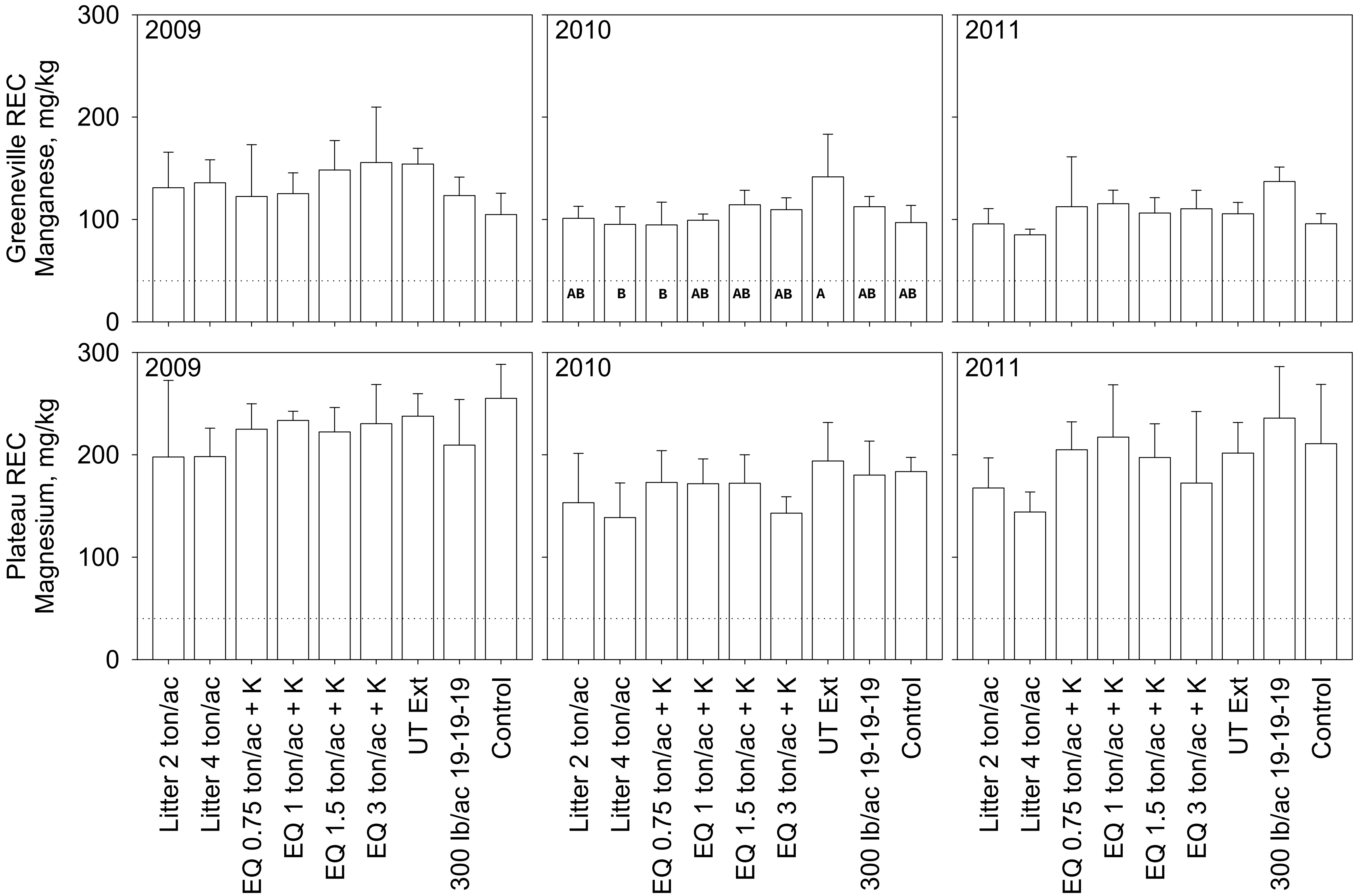

Figure 55. Fall forage manganese concentrations (bars that do not share a common letter are significantly different). An approximate adequate threshold requirement for lactating cattle is indicated at 40 mg/kg.

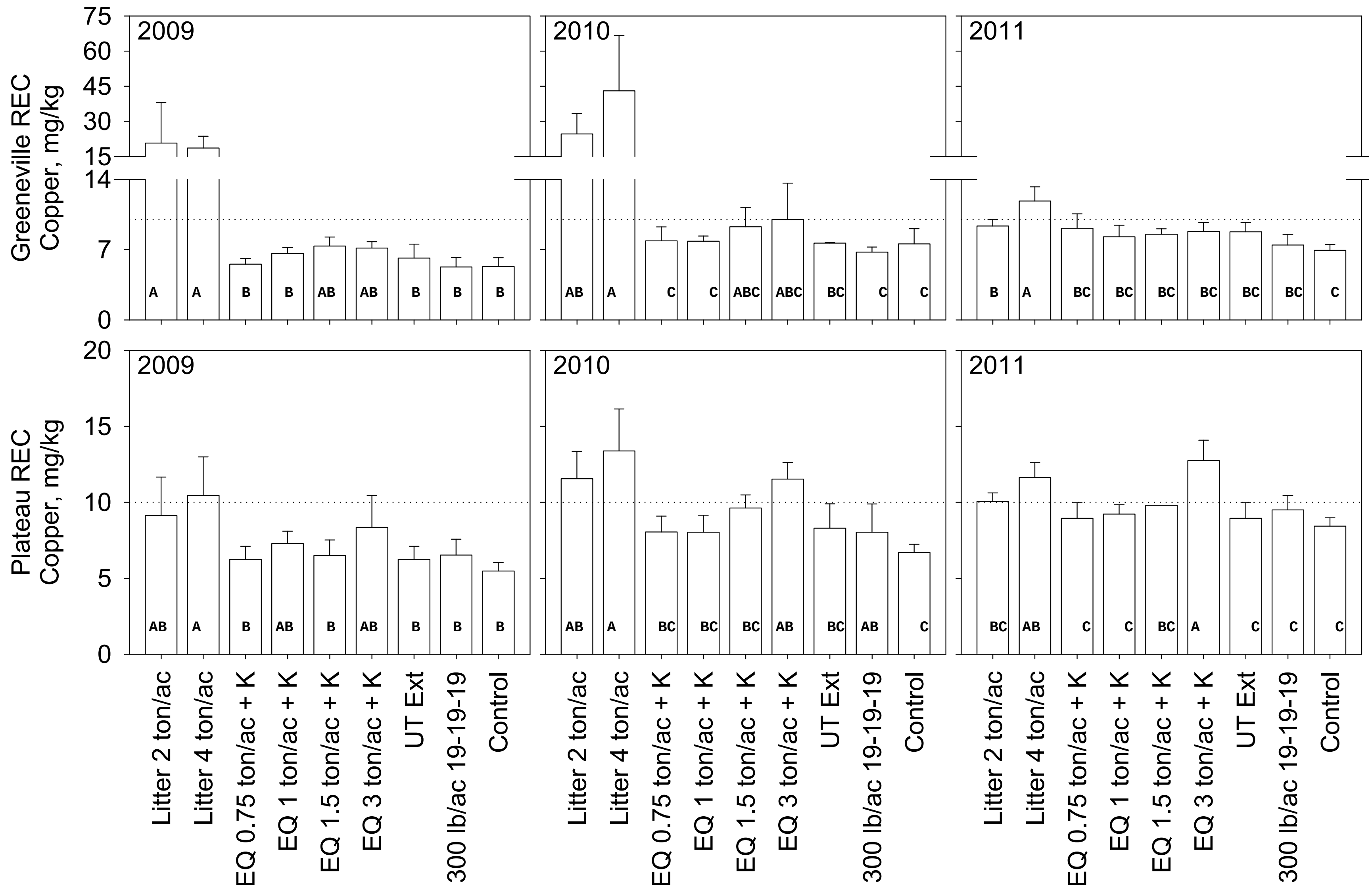

Figure 56. Spring forage copper concentrations (bars that do not share a common letter are significantly different). An approximate adequate threshold requirement is indicated at 10 mg/kg.

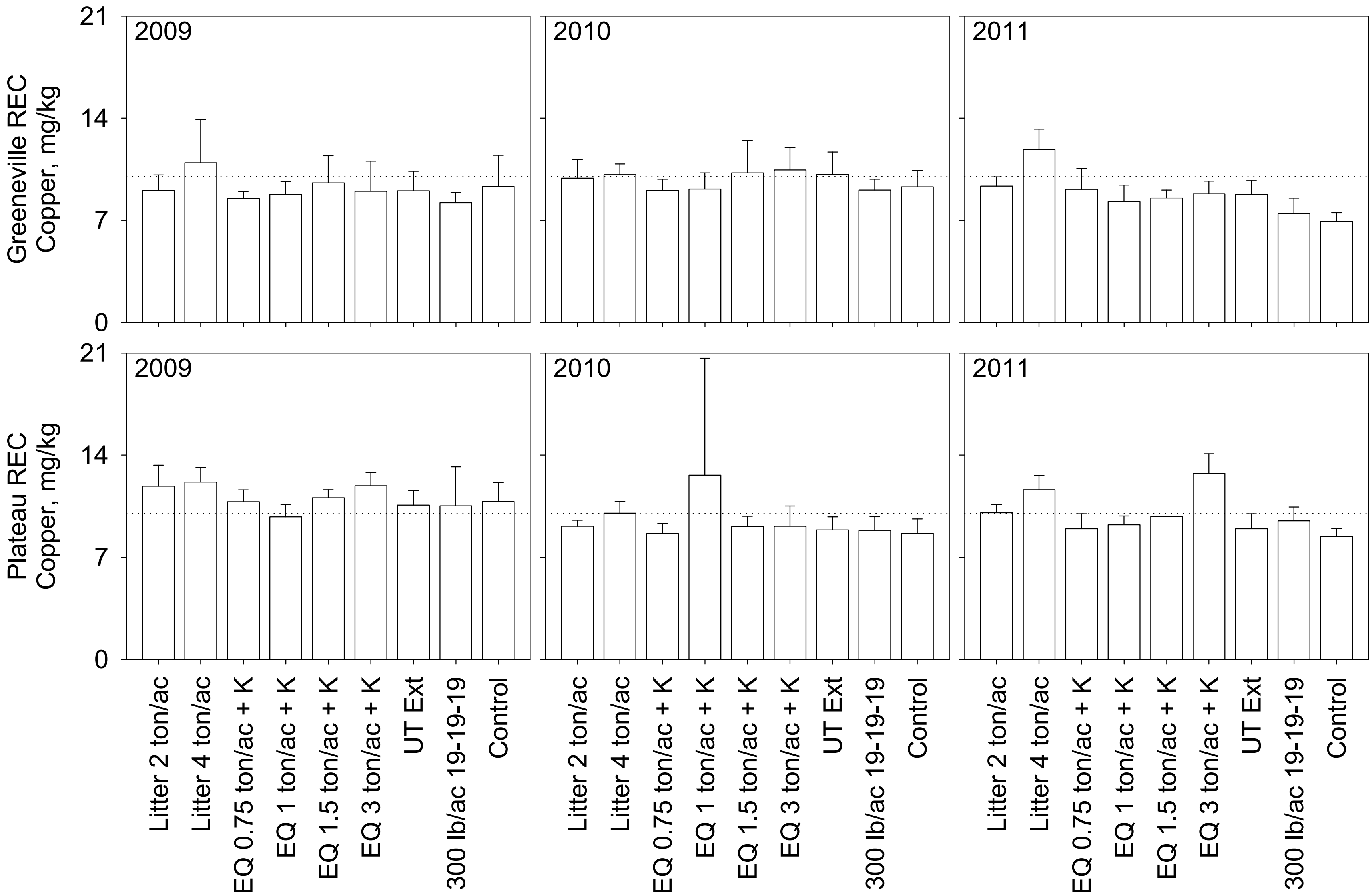

Figure 57. Fall forage copper concentrations (bars that do not share a common letter are significantly different). An approximate adequate threshold requirement is indicated at 10 mg/kg.

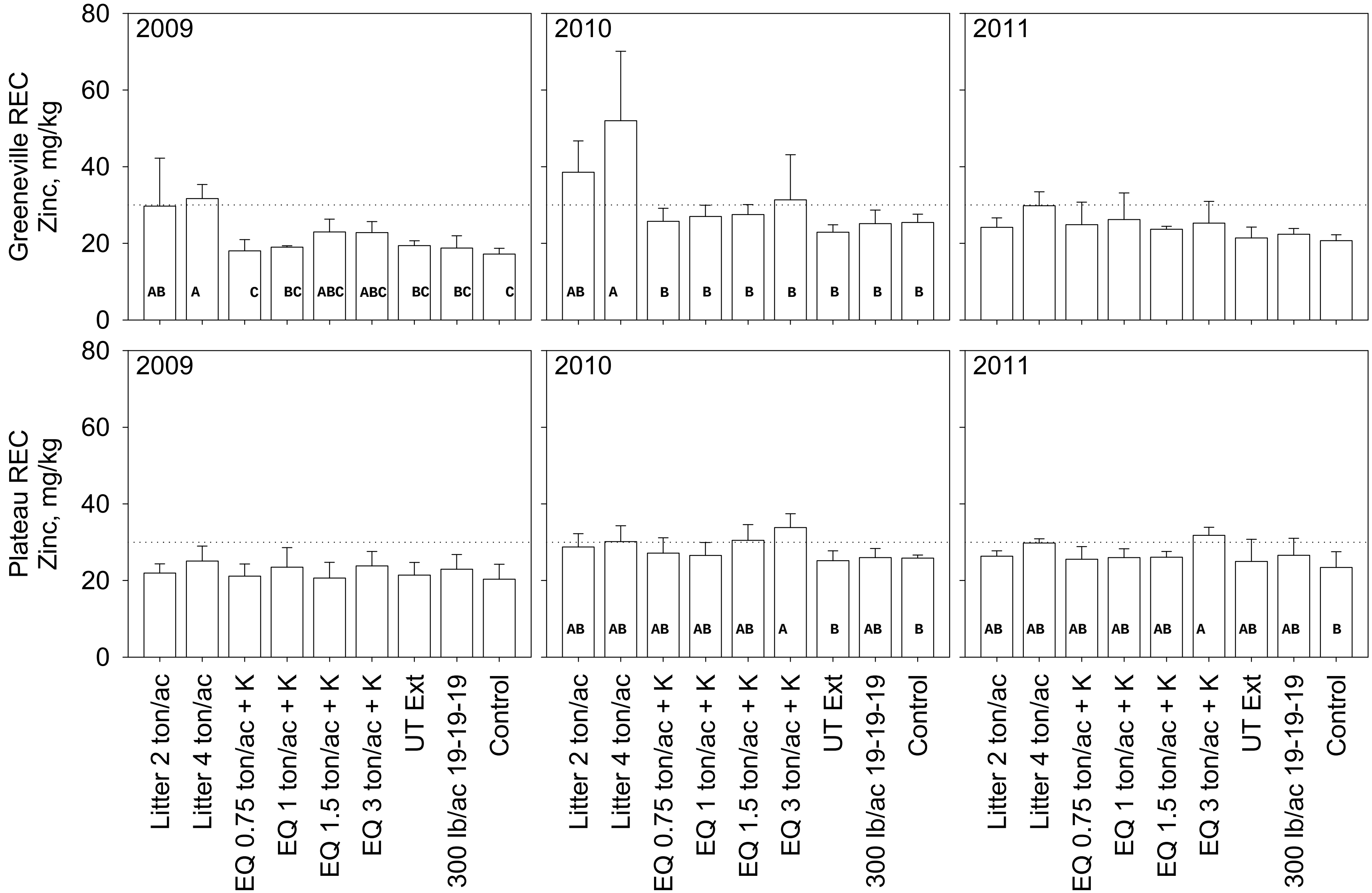

Figure 58. Spring forage zinc concentrations (bars that do not share a common letter are significantly different). An approximate adequate threshold requirement for lactating cattle is indicated at 30 mg/kg.

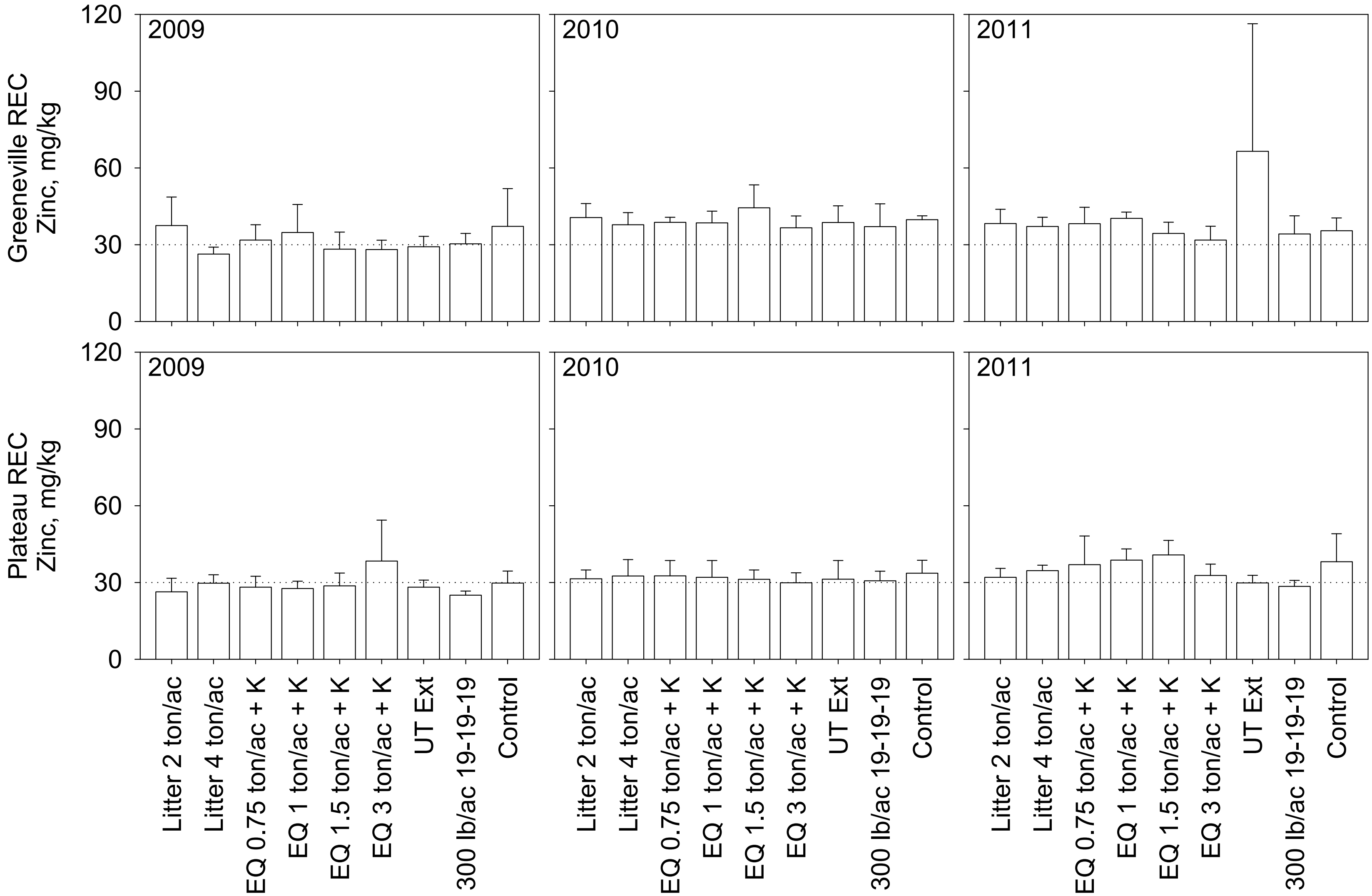

Figure 59. Fall forage zinc concentrations (bars that do not share a common letter are significantly different). An approximate adequate threshold requirement for lactating cattle is indicated at 30 mg/kg.

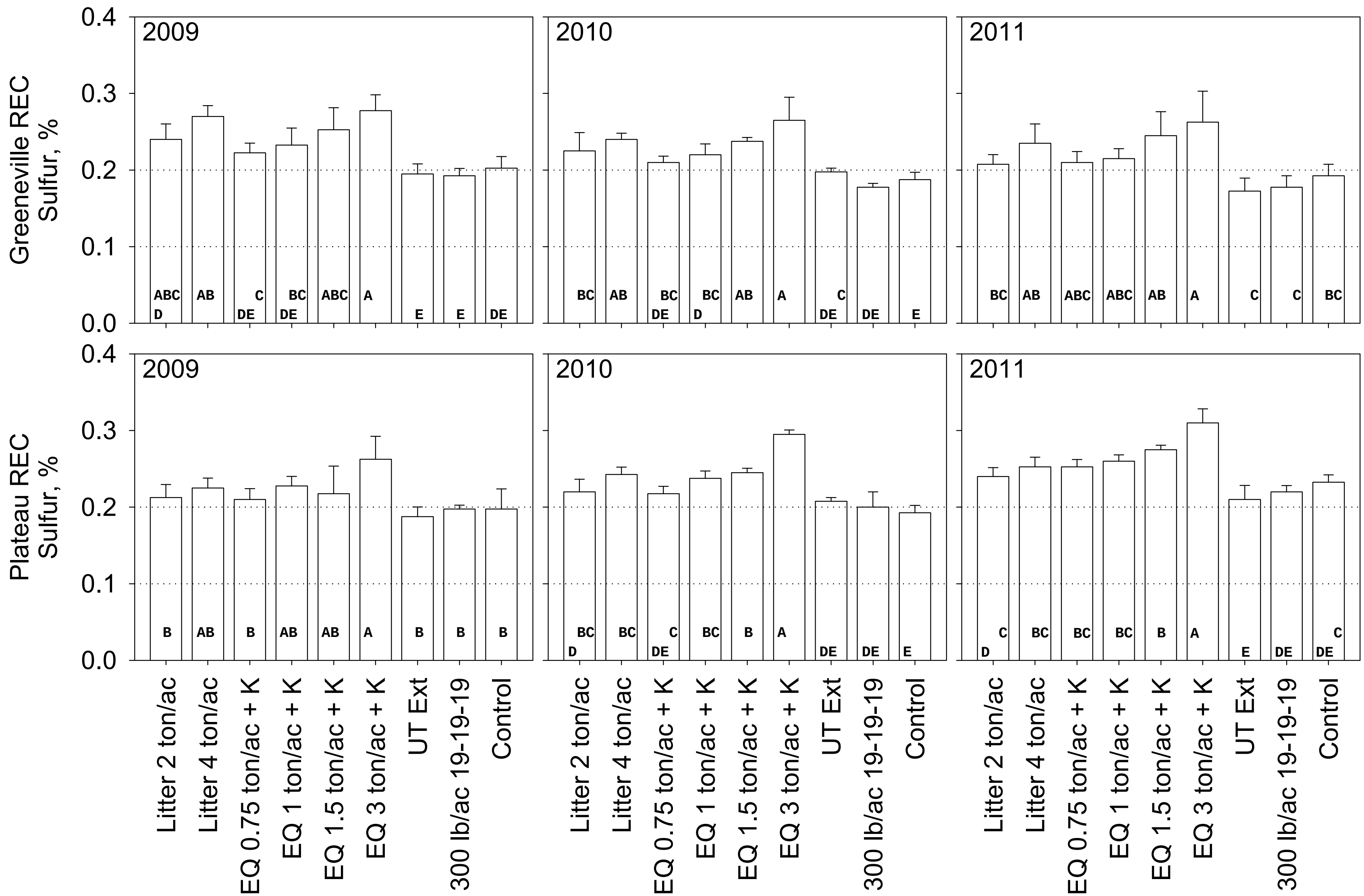

Figure 60. Spring forage sulfurconcentrations (bars that do not share a common letter are significantly different). An ideal forage concentration range between 0.1 and 0.2 mg/kg is indicated.

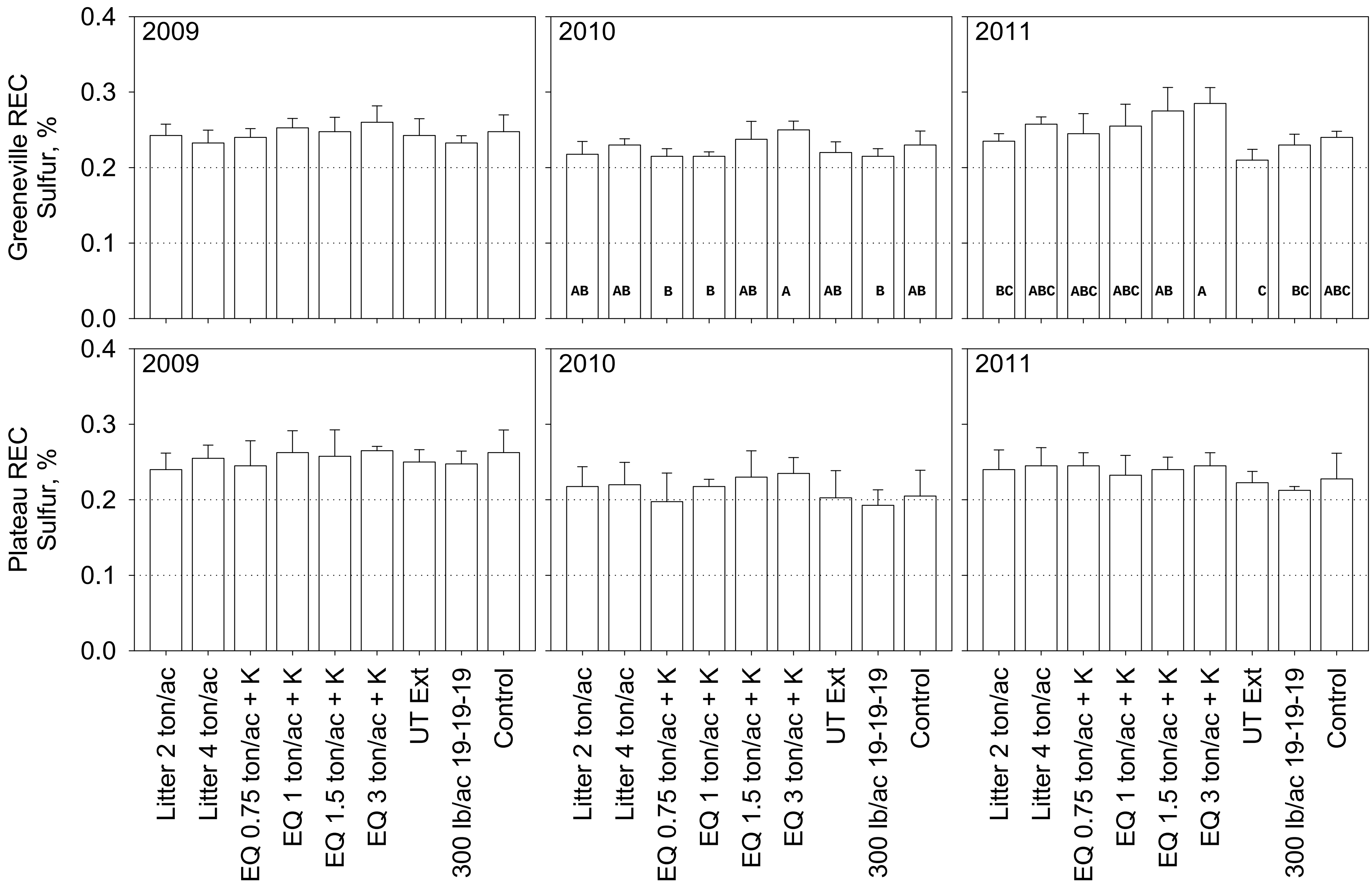

Figure 61. Fallforage sulfur concentrations (bars that do not share a common letter are significantly different). An ideal forage concentration range between 0.1 and 0.2 mg/kg is indicated.

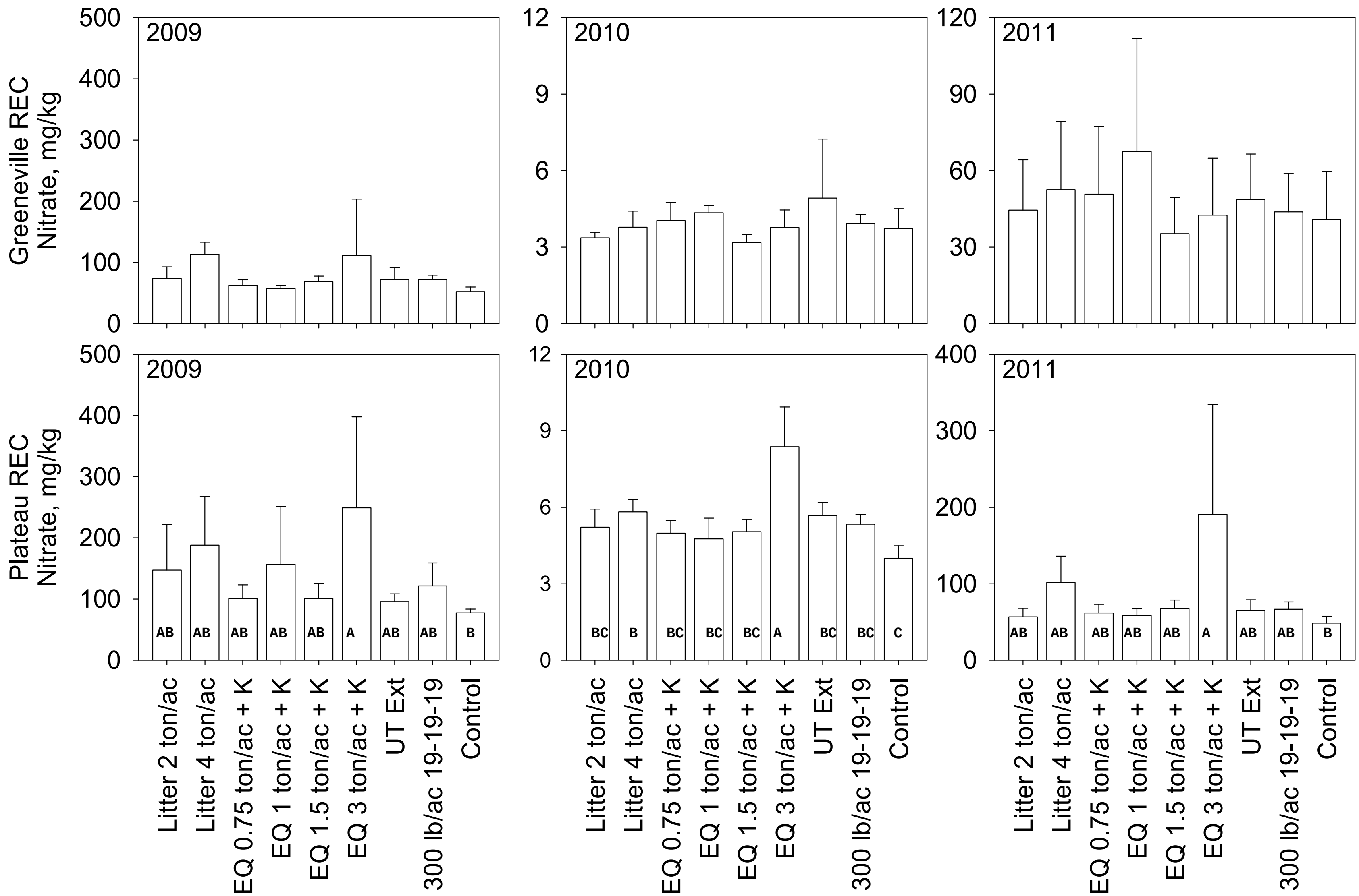

Figure 62. Spring forage nitrate concentrations (bars that do not share a common letter are significantly different).

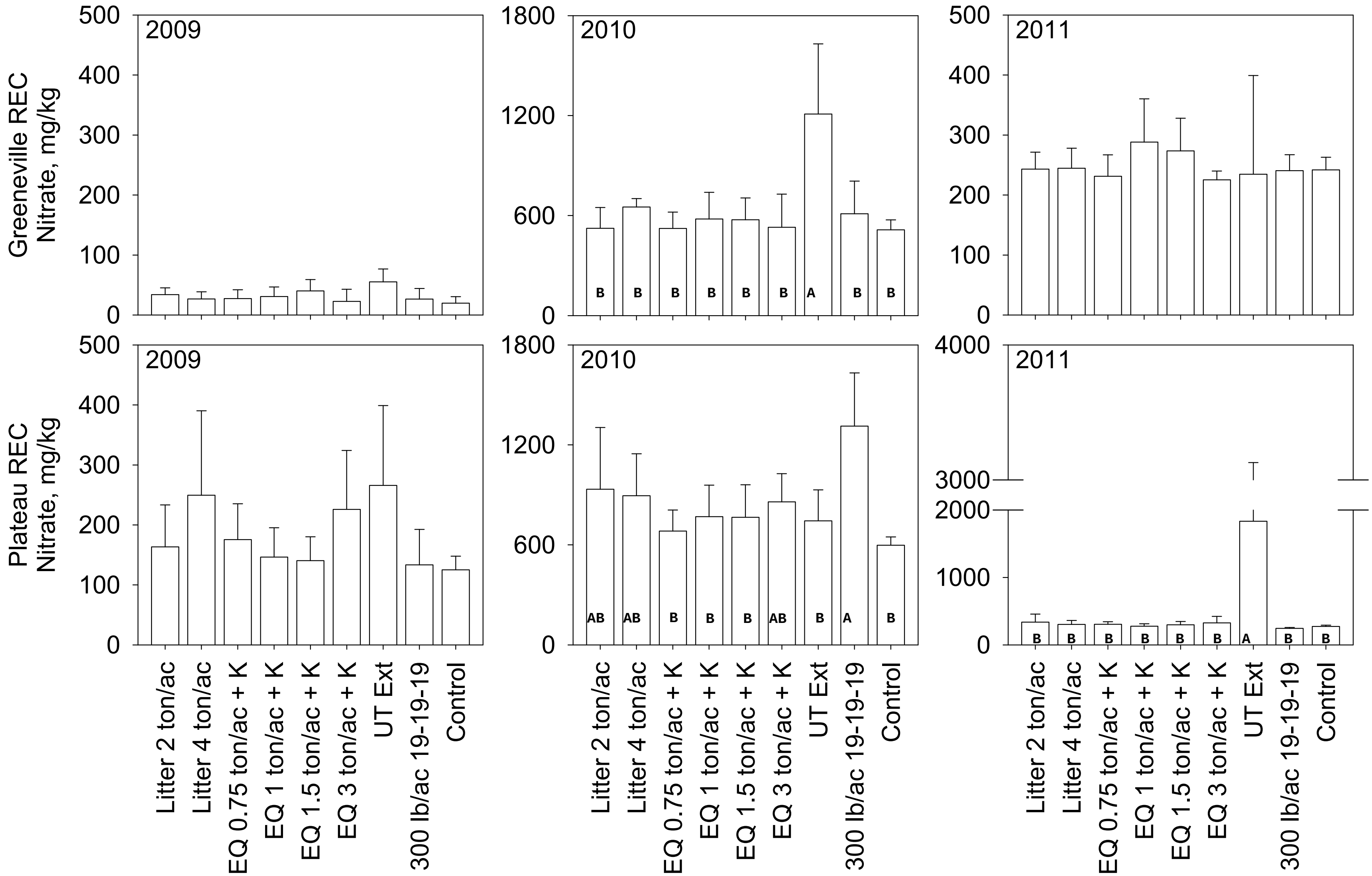

Figure 63. Fall forage nitrate concentrations (bars that do not share a common letter are significantly different).

Appendix F

Soil Test Results

Table 37. Soil test results for 2009, Greenville REC.

ID	pH	Buf pH	B (lbs/ac)	Ca (lbs/ac)	Cu (lbs/ac)	Fe (lbs/ac)	K (lbs/ac)	Mg (lbs/ac)	Mn (lbs/ac)	Na (lbs/ac)	P (lbs/ac)	Zn (lbs/ac)
A	6.8	7.5	1.2	2662	BDL*	6	97	537	93	14	79	9.6
B	7.0	7.5	1.2	2312	BDL*	7	88	622	86	8	44	8.4
C	7.0	7.6	1.1	2205	BDL*	6	88	605	91	10	53	8.8
D	7.1	7.6	1.2	2338	BDL*	7	142	624	97	17	55	10.1

* Values Below Detection Limit - assigned detection limit value of 0.1.

Table 38. Soil test results for 2009, Plateau REC The boron result obtained for sample ID A was considered an outlier and removed from the dataset during analysis of the results.

ID	pH	Buf pH	B (lbs/ac)	Ca (lbs/ac)	Cu (lbs/ac)	Fe (lbs/ac)	K (lbs/ac)	Mg (lbs/ac)	Mn (lbs/ac)	Na (lbs/ac)	P (lbs/ac)	Zn (lbs/ac)
A	6.0	7.2	**20.4**	1608	BDL*	31	180	147	34	10	18	3.9
B	5.6	7.2	0.3	1101	0.9	34	136	124	36	9	24	4.5
C	5.6	7.3	0.3	1260	BDL*	31	229	141	26	8	29	2.3
D	5.6	7.3	0.2	987	0.3	32	130	112	25	8	19	1.6
E	5.7	7.3	0.3	1559	BDL*	25	220	99	27	7	21	1.4

* Values Below Detection Limit - assigned detection limit value of 0.1.

Table 39. Soil test results 2010, Greenville REC.

Plot	pH	Buf pH	B (lbs/ac)	Ca (lbs/ac)	Cu (lbs/ac)	Fe (lbs/ac)	K (lbs/ac)	Mg (lbs/ac)	Mn (lbs/ac)	Na (lbs/ac)	P (lbs/ac)	Zn (lbs/ac)
A1	6.1	-	2.7	2124	0.7	11	87	540	116	30	38	8.1
A2	6.5	-	2.0	2415	0.7	9	70	629	110	33	60	9.5
A3	6.6	-	1.7	2397	0.9	7	77	609	105	28	45	7.5
A4	6.5	-	1.8	2299	0.7	11	73	564	154	25	119	9.2
A5	6.7	-	1.5	2343	3.4	8	103	619	116	37	84	9.9
A6	6.7	-	1.4	2138	0.6	8	76	515	108	19	39	6.5
A7	6.8	-	1.4	2014	0.5	8	195	507	115	18	32	6.3
A8	7.0	-	1.6	2270	0.5	6	163	662	98	14	21	7.3
A9	6.8	-	1.6	2247	0.5	7	93	583	96	22	26	6.8
B1	6.9	-	1.5	2345	0.6	8	98	632	122	21	31	9.0
B2	7.0	-	1.5	2392	0.5	7	73	667	100	15	41	7.8
B3	7.0	-	1.5	2495	0.6	7	75	717	96	30	42	7.6
B4	7.1	-	1.5	2963	0.5	7	58	905	84	16	36	9.6
B5	6.9	-	1.4	2359	0.7	9	76	585	152	22	70	10.9
B6	6.8	-	1.2	1966	4.4	9	58	492	97	10	58	9.1
B7	6.8	-	1.3	1921	3.1	7	70	480	95	15	22	8.9
B8	7.1	-	1.6	2667	0.5	6	113	780	90	15	34	7.9
B9	6.6	-	1.4	2131	0.4	7	167	552	84	14	27	6.8
C1	7.0	-	1.8	2475	6.5	8	123	708	97	13	42	13.8
C2	7.1	-	1.7	2556	6.0	7	83	738	97	24	40	13.5
C3	6.9	-	1.6	2571	0.5	6	68	686	100	16	29	7.6
C4	6.9	-	1.5	2415	0.6	7	61	662	93	14	53	9.1
C5	6.8	-	1.3	2095	0.6	9	91	550	97	15	41	7.6
C6	6.7	-	1.3	1790	2.5	8	94	435	96	29	35	9.0
C7	6.6	-	1.2	1823	0.7	10	108	455	89	15	25	5.9
C8	6.9	-	1.5	2147	0.6	8	161	622	79	14	26	6.2
C9	6.5	-	1.3	1924	0.6	10	157	500	82	13	23	5.3
D1	6.9	-	1.6	2449	0.5	6	67	692	112	15	26	8.7
D2	7.0	-	1.6	2525	0.4	6	83	685	103	17	36	8.4
D3	7.1	-	1.5	2164	0.5	8	57	593	88	15	31	8.8
D4	7.2	-	1.6	2750	0.4	6	64	771	98	17	42	9.8
D5	7.1	-	1.6	2579	0.7	7	99	704	104	33	52	9.7
D6	7.1	-	1.5	2222	0.6	7	77	578	108	20	42	7.5
D7	6.5	-	1.1	1770	0.7	9	121	412	127	18	34	6.1
D8	7.1	-	1.4	2333	0.5	7	96	671	90	19	27	6.7
D9	7.0	-	1.7	2626	0.8	9	150	715	87	15	91	8.9

Table 40. Soil test results for 2010, Plateau REC.

Plot	pH	Buf pH	B (lbs/ac)	Ca (lbs/ac)	Cu (lbs/ac)	Fe (lbs/ac)	K (lbs/ac)	Mg (lbs/ac)	Mn (lbs/ac)	Na (lbs/ac)	P (lbs/ac)	Zn (lbs/ac)
A1	5.8	7.5	0.5	1544	0.6	28	262	171	24	18	28	2.0
A2	5.5	7.4	0.4	1166	0.9	36	125	130	24	12	35	2.9
A3	5.4	7.3	0.6	883	1.1	32	75	80	22	19	19	3.8
A4	5.2	7.2	0.8	904	1.2	29	84	95	25	14	23	7.8
A5	5.3	7.3	0.4	1032	1.3	29	91	110	21	12	24	2.5
A6	5.4	7.3	0.9	1233	1.6	28	99	133	26	17	23	2.4
A7	5.4	7.3	0.5	1185	1.6	25	82	132	22	18	18	1.8
A8	5.3	7.3	1.1	1254	1.7	29	99	138	26	15	44	3.1
A9	5.4	7.3	0.5	1296	1.6	30	104	126	23	17	29	2.3
B1	5.3	7.3	0.4	890	1.6	34	65	84	24	10	21	2.6
B2	5.4	7.3	0.4	879	1.6	32	83	87	20	11	15	2.4
B3	5.4	7.3	0.5	1052	2.2	31	102	106	24	12	22	2.8
B4	5.4	7.3	0.4	1151	2.1	27	129	135	21	19	26	1.9
B5	5.6	7.4	0.4	1102	2.0	31	91	126	20	26	21	1.7
B6	5.4	7.3	0.5	1283	1.7	27	162	157	21	19	28	2.5
B7	5.4	7.4	0.4	966	1.5	32	71	112	18	10	23	1.9
B8	5.4	7.4	0.4	981	2.3	36	103	122	16	19	36	3.3
B9	5.4	7.4	0.3	1085	2.0	40	88	111	16	11	28	2.3
C1	5.5	7.3	0.5	1421	3.0	29	78	88	24	16	13	1.5
C2	5.5	7.3	0.4	1305	1.9	27	121	86	21	8	15	2.2
C3	5.5	7.4	0.4	1304	1.4	27	109	95	22	13	15	1.6
C4	5.5	7.4	0.4	1416	1.9	27	127	123	23	11	31	2.9
C5	5.5	7.4	0.4	1046	1.8	33	102	101	20	12	13	1.5
C6	5.4	7.4	0.4	1184	1.4	34	69	74	19	18	12	1.2
C7	5.4	7.3	0.4	1437	1.6	31	98	95	18	11	17	2.1
C8	5.4	7.4	0.3	1148	1.5	38	93	73	14	18	14	1.3
C9	5.3	7.3	0.4	1384	4.6	37	108	100	19	13	31	11.3
D1	5.4	7.4	0.4	1219	1.5	41	123	107	22	14	19	1.8
D2	5.4	7.4	0.4	1348	1.9	38	104	111	20	13	31	2.6
D3	5.4	7.4	0.4	1234	1.7	50	93	93	18	21	15	2.1
D4	5.5	7.4	0.3	1162	1.7	54	88	76	18	13	17	1.7
D5	5.4	7.3	0.4	1301	1.6	49	118	84	19	19	20	2.2
D6	5.4	7.4	0.3	1213	1.4	48	77	81	15	21	14	1.7
D7	5.4	7.3	0.3	1462	1.5	49	117	98	17	14	16	2.6
D8	5.4	7.4	0.4	1487	1.5	55	114	91	20	20	23	1.9
D9	5.4	7.4	0.4	1417	1.2	52	102	84	17	12	19	1.6

Table 41. Soil test results for 2011, Greenville REC.

Plot	pH	Buf pH	B (lbs/ac)	Ca (lbs/ac)	Cu (lbs/ac)	Fe (lbs/ac)	K (lbs/ac)	Mg (lbs/ac)	Mn (lbs/ac)	Na (lbs/ac)	P (lbs/ac)	Zn (lbs/ac)
A1	6.6	-	1.0	1822	0	4	39	459	68	17	12	4.1
A2	6.9	-	1.4	2125	0	5	46	557	60	18	23	5.4
A3	7.2	-	1.4	2147	0	5	69	545	84	35	27	6.0
A4	7.1	-	1.7	2199	0	2	51	573	82	19	67	7.2
A5	7.0	-	1.3	2006	0.3	7	60	492	71	15	43	6.5
A6	7.0	-	1.3	2095	0	8	46	620	72	15	24	6.6
A7	7.0	-	1.2	1807	0	7	75	449	62	15	27	4.4
A8	7.4	-	1.6	2294	0	7	115	675	76	13	22	6.2
A9	7.0	-	1.5	1758	0	7	81	473	54	12	29	4.7
B1	7.1	-	1.5	1894	0	6	61	493	74	22	21	5.6
B2	7.2	-	1.4	2630	0	5	56	863	83	15	30	9.5
B3	7.1	-	1.3	2123	1	7	80	523	89	48	57	7.0
B4	7.3	-	1.3	2029	0	7	45	527	47	15	43	6.7
B5	7.2	-	1.3	1879	0.2	7	71	477	37	46	33	5.1
B6	7.1	-	1.4	1999	0	6	43	495	38	16	37	5.5
B7	6.8	-	1.1	1615	0	7	47	380	44	15	23	4.5
B8	7.4	-	1.4	1899	0	6	67	570	39	13	28	6.4
B9	6.7	-	1.3	1517	0	7	110	400	49	13	20	3.5
C1	7.2	-	1.6	2256	0	7	72	630	41	18	40	6.9
C2	7.4	-	1.7	2347	0	5	74	666	55	28	36	6.7
C3	7.1	-	1.3	1881	0	7	48	482	58	18	29	6.1
C4	7.7	-	1.6	2689	0.2	7	50	765	82	20	51	8.8
C5	7.3	-	1.3	2410	0	2	50	692	43	15	29	7.4
C6	6.9	-	1.2	1882	0.2	3	128	435	35	33	57	6.9
C7	6.6	-	1.1	1740	0	3	48	406	32	17	14	3.9
C8	7.5	-	1.3	2202	0	3	96	638	39	13	35	6.0
C9	6.6	-	1.2	1784	81.3	7	102	466	60	11	41	32.1
D1	7.3	-	1.6	2807	0	1	69	785	54	20	39	8.3
D2	6.9	-	1.2	2210	0	1	50	577	52	17	32	6.7
D3	7.0	-	1.2	2569	0	2	57	672	59	17	49	9.5
D4	7.4	-	1.4	2857	0	2	70	819	63	14	53	8.1
D5	7.3	-	1.5	2454	0.2	3	142	671	84	39	59	8.5
D6	7.2	-	1.3	2159	0	2	67	584	59	15	30	7.1
D7	6.5	-	0.9	1577	0	3	97	363	57	27	22	4.6
D8	7.3	-	1.3	2309	0	2	85	659	40	11	27	5.6
D9	6.9	-	1.4	2297	0	4	124	601	40	15	66	6.5

Table 42. Soil test results for 2011, Plateau REC.

Plot	pH	Buf pH	B (lbs/ac)	Ca (lbs/ac)	Cu (lbs/ac)	Fe (lbs/ac)	K (lbs/ac)	Mg (lbs/ac)	Mn (lbs/ac)	Na (lbs/ac)	P (lbs/ac)	Zn (lbs/ac)
A1	6.0	7.7	1.2	1650	0	15	289	175	20	9	36	3.1
A2	5.5	7.6	0.7	1047	0	22	92	96	16	14	28	2.5
A3	5.5	7.5	0.5	1089	0.3	23	80	114	18	15	41	3.9
A4	5.5	7.6	0.4	956	0	17	94	104	15	15	20	2.9
A5	5.6	7.5	0.4	1048	0.1	18	86	119	16	11	26	2.5
A6	5.5	7.5	0.4	1083	1.1	17	106	125	19	13	23	2.3
A7	5.5	7.5	0.4	1041	0.4	16	67	110	18	29	15	1.3
A8	5.6	7.5	0.4	1332	0.8	19	68	127	20	12	61	3.2
A9	5.6	7.5	0.4	1213	0.7	23	80	111	22	12	40	2.6
B1	5.5	7.5	0.6	955	0.5	22	58	88	15	13	32	3.4
B2	5.4	7.5	0.4	840	0.6	21	64	92	12	14	15	2.7
B3	5.5	7.5	0.4	1003	0.7	17	98	109	12	14	23	1.7
B4	5.7	7.5	0.4	1005	1.2	16	93	122	12	16	23	2.1
B5	5.5	7.5	0.3	803	0.6	20	61	94	9	9	19	1.7
B6	5.8	7.6	0.4	1313	1.3	16	173	164	14	26	31	2.4
B7	5.5	7.5	0.4	1204	0.6	21	55	128	14	13	56	3.2
B8	5.6	7.6	0.3	1236	0.5	21	98	141	14	12	38	2.5
B9	5.5	7.5	0.3	1093	0.4	22	74	98	13	12	22	1.5
C1	5.7	7.5	0.5	1724	1.9	20	77	98	23	16	29	2.5
C2	5.6	7.6	0.4	1433	47.6	17	91	78	18	11	27	57.2
C3	5.6	7.5	0.4	1156	0.5	16	110	82	12	10	21	1.5
C4	5.6	7.6	0.4	1085	0.6	18	64	77	10	10	26	1.8
C5	5.7	7.6	0.4	1286	1.1	16	85	92	10	16	15	3.0
C6	5.6	7.6	0.3	1157	0.5	20	63	73	12	10	9	3.9
C7	5.7	7.6	0.4	1323	0.9	19	97	95	14	12	19	38.6
C8	5.5	7.6	0.3	1232	0.6	21	43	65	9	13	10	16.0
C9	5.5	7.5	0.3	1221	0.6	25	61	69	12	11	18	6.1
D1	5.5	7.5	0.3	1057	0.4	25	71	91	15	13	19	1.8
D2	5.5	7.5	0.4	1353	2	30	80	107	19	16	73	5.7
D3	5.6	7.5	0.3	1081	0.4	30	88	90	14	10	22	2.2
D4	5.6	7.6	0.4	1288	0.9	36	74	92	15	15	44	3.2
D5	5.6	7.5	0.4	1151	1.4	28	106	81	13	16	23	2.3
D6	5.5	7.5	0.3	1208	0.2	27	65	81	11	12	14	1.4
D7	5.5	7.5	0.3	1297	0.7	33	77	85	13	21	17	2.0
D8	5.5	7.5	0.4	1438	0.2	36	70	81	16	13	24	2.2
D9	5.5	7.5	0.4	1604	0.4	35	92	97	16	15	31	3.0

Table 43. Soil test results for 2012, Greenville REC.

Plot	pH	Buf pH	B (lbs/ac)	Ca (lbs/ac)	Cu (lbs/ac)	Fe (lbs/ac)	K (lbs/ac)	Mg (lbs/ac)	Mn (lbs/ac)	Na (lbs/ac)	P (lbs/ac)	Zn (lbs/ac)
A1	6.4	-	1.0	1311	0.0	8	52	323	57	26	18	4.4
A2	6.9	-	1.1	1389	0.1	7	40	328	44	22	39	4.2
A3	7.0	-	1.2	1521	0.3	5	51	401	50	35	28	4.8
A4	6.8	-	1.2	1612	0.1	12	38	349	70	16	140	6.2
A5	7.1	-	1.3	1666	1.2	5	114	403	57	52	80	7.3
A6	6.7	-	0.9	1219	0.0	6	42	270	50	18	31	4.0
A7	6.9	-	1.0	1370	0.0	6	63	326	50	19	22	4.3
A8	7.4	-	1.2	1633	0.0	6	89	471	58	7	22	4.8
A9	6.9	-	1.2	1608	0.0	6	55	441	62	16	26	5.2
B1	7.1	-	1.2	1552	0.4	4	59	397	38	31	31	5.3
B2	6.9	-	1.1	1528	0.0	6	47	382	39	21	59	5.6
B3	7.2	-	1.2	1698	1.2	7	72	441	45	47	75	6.6
B4	7.3	-	1.1	1873	0.0	7	37	559	40	15	37	6.4
B5	7.0	-	1.0	1445	0.5	8	40	352	38	40	52	5.1
B6	6.8	-	1.0	1383	0.1	7	28	306	37	17	50	5.4
B7	6.8	-	1.0	1324	0.0	5	36	327	38	18	19	4.5
B8	7.4	-	1.2	1554	0.0	5	50	448	33	9	25	4.3
B9	6.7	-	1.1	1393	0.0	6	84	356	37	17	22	3.6
C1	7.1	-	1.5	2063	0.1	6	71	530	68	23	72	8.1
C2	7.1	-	1.4	1802	0.5	5	77	481	55	29	51	7.4
C3	7.2	-	1.1	1674	0.0	5	41	467	46	20	30	5.8
C4	7.2	-	1.3	1878	0.3	7	44	500	53	18	105	9.1
C5	7.2	-	1.0	1355	0.0	5	49	348	36	22	26	4.2
C6	6.9	-	1.1	1492	1.4	5	149	342	44	35	74	7.1
C7	6.8	-	1.0	1215	0.2	6	64	286	38	18	28	4.3
C8	7.2	-	1.1	1498	0.0	7	79	412	36	22	28	4.8
C9	6.6	-	1.0	1310	0.0	6	106	325	33	15	24	3.7
D1	7.2	-	1.3	1700	0.0	5	52	468	54	28	30	6.0
D2	7.1	-	1.2	1765	0.0	5	45	479	64	23	30	6.3
D3	7.0	-	1.3	1822	15.8	6	67	447	104	27	45	52.6
D4	7.5	-	1.3	2064	0.0	6	51	606	78	22	58	8.0
D5	7.1	-	1.3	1701	0.9	5	83	441	72	45	61	7.6
D6	7.1	-	1.2	1704	0.0	6	56	408	76	13	51	6.9
D7	6.7	-	0.9	1278	0.8	6	94	297	69	38	39	5.2
D8	7.4	-	1.3	1905	0.2	6	84	551	56	36	39	6.2
D9	7.0	-	1.8	2803	0.2	5	134	672	59	21	88	9.7

Table 44. Soil test results for 2012, Plateau REC.

Plot	pH	Buf pH	B (lbs/ac)	Ca (lbs/ac)	Cu (lbs/ac)	Fe (lbs/ac)	K (lbs/ac)	Mg (lbs/ac)	Mn (lbs/ac)	Na (lbs/ac)	P (lbs/ac)	Zn (lbs/ac)
A1	6.3	-	0.5	1269	0.3	18	200	143	12	14	23	2.0
A2	5.7	7.2	0.4	952	0.2	23	77	98	14	22	31	2.0
A3	5.7	7.3	0.7	1584	0.7	15	92	143	30	32	28	4.7
A4	5.7	7.4	3.1	735	0.2	18	42	76	9	16	15	1.5
A5	5.8	7.3	0.4	777	0.5	17	48	72	8	19	12	1.2
A6	5.8	7.5	0.4	900	1.5	15	69	102	9	21	19	1.5
A7	5.7	7.4	0.5	775	0.6	15	36	84	8	18	12	0.5
A8	5.7	7.5	0.4	972	1.1	20	47	92	9	16	44	2.3
A9	5.7	7.4	0.4	872	0.7	19	52	79	8	18	22	1.2
B1	5.5	7.4	0.4	879	0.6	17	33	83	10	21	30	2.8
B2	5.6	7.4	0.4	735	0.6	16	44	81	9	19	16	1.4
B3	5.6	7.4	0.4	723	2.6	17	75	80	10	11	17	6.0
B4	5.8	7.4	0.4	826	2.9	15	61	101	8	28	18	3.8
B5	5.7	7.5	0.3	775	0.5	21	54	85	6	9	15	0.7
B6	5.8	7.4	0.4	823	1.0	20	105	100	6	24	17	1.1
B7	5.7	7.5	0.4	919	0.8	20	40	88	7	11	57	2.5
B8	5.8	7.4	0.4	1168	1.9	22	49	65	9	17	33	3.6
B9	5.6	7.5	0.3	758	0.7	15	46	80	6	11	24	1.2
C1	5.6	7.4	0.3	749	0.6	16	38	67	6	18	14	0.9
C2	5.7	7.5	0.4	1009	0.5	17	38	53	7	8	9	0.5
C3	5.7	7.4	0.4	952	0.5	15	53	60	7	16	15	0.8
C4	5.7	7.5	0.4	946	0.9	17	60	68	8	19	21	1.5
C5	5.9	7.5	0.5	1126	1.7	17	73	83	8	22	18	1.9
C6	5.7	7.5	0.4	934	0.5	18	47	56	6	10	8	0.5
C7	5.7	7.4	0.4	942	0.9	22	41	63	6	21	11	0.9
C8	5.7	7.5	0.4	990	0.6	21	35	60	6	17	11	0.8
C9	5.6	7.4	0.4	1004	18.0	26	53	58	8	9	24	26.9
D1	5.6	7.5	0.4	826	0.7	24	38	65	8	16	13	1.2
D2	5.6	7.4	0.4	919	1.0	27	31	66	7	22	35	1.9
D3	5.6	7.5	0.4	903	0.7	26	39	65	7	18	11	1.0
D4	5.7	7.5	0.4	992	0.7	27	51	69	7	13	30	1.6
D5	5.5	7.5	0.4	913	45.7	26	45	60	9	27	24	124.6
D6	5.6	7.4	0.4	928	0.6	27	43	66	7	21	12	1.0
D7	5.6	7.5	0.4	911	0.8	27	46	55	7	19	14	0.9
D8	5.6	7.5	0.4	1008	0.7	30	45	58	7	20	18	1.1
D9	5.7	7.5	0.4	1196	0.8	30	57	75	8	27	18	1.6

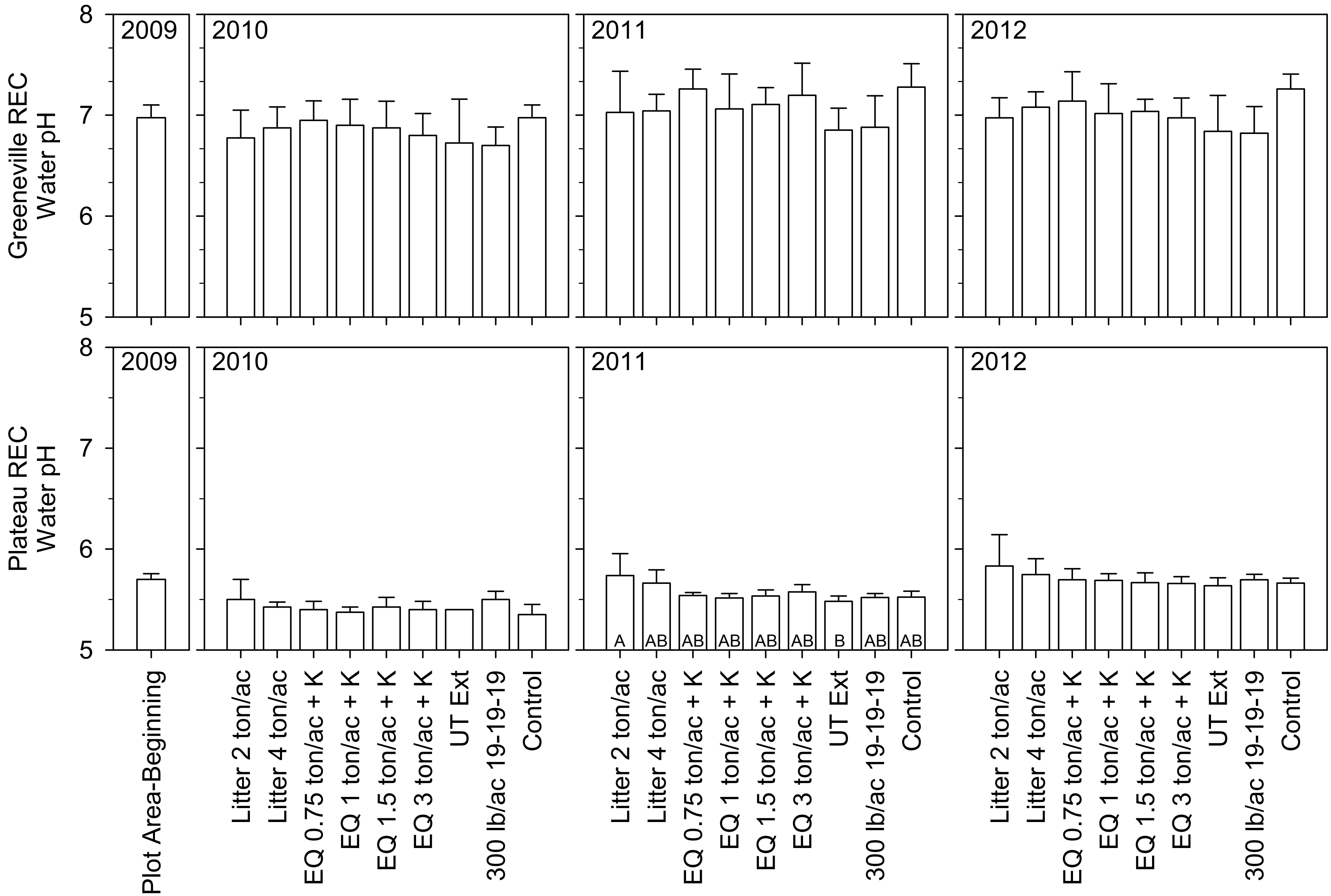

Figure 64. Soil water pH (bars that do not share a common letter are significantly different).

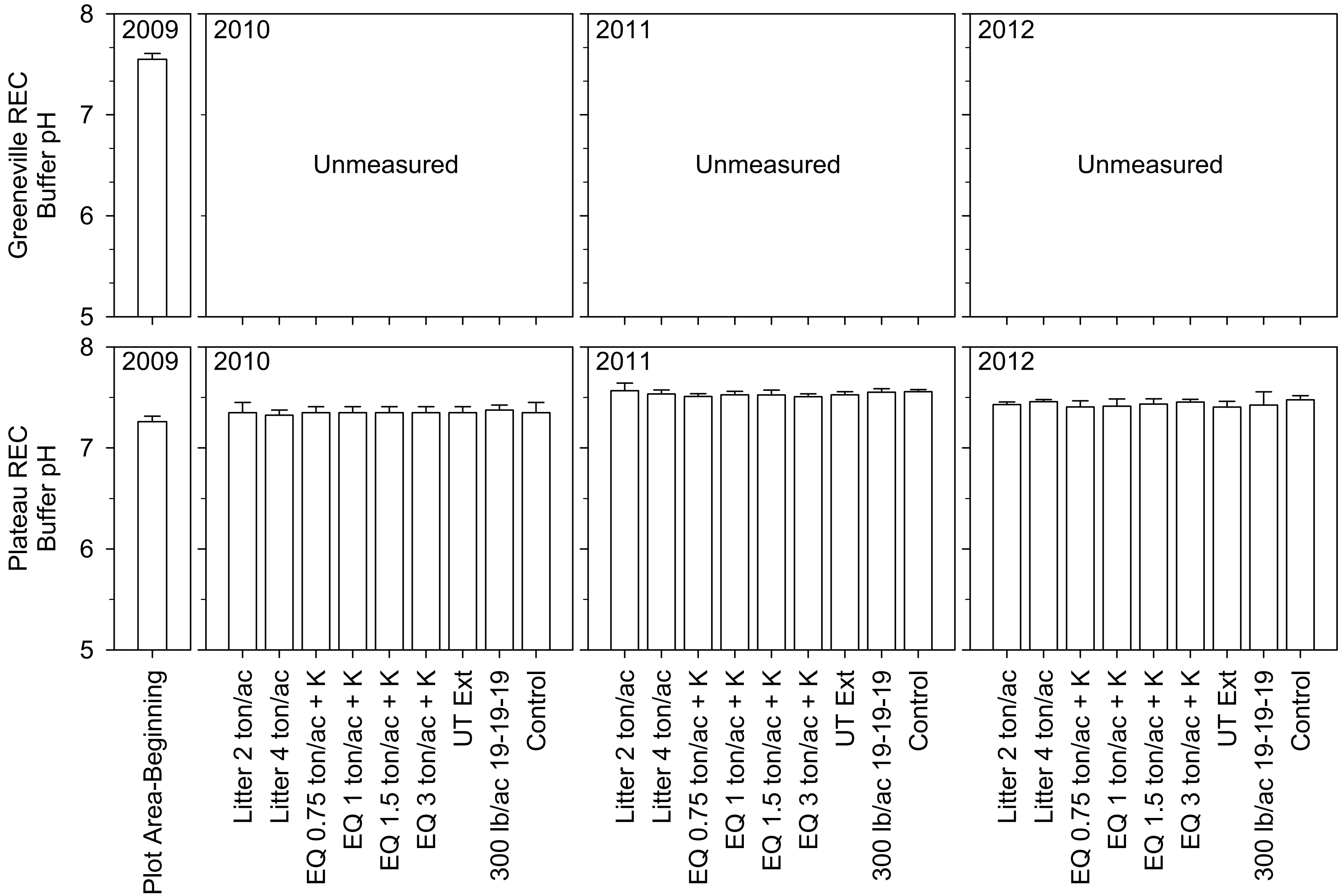

Figure 65. Soil buffer pH.

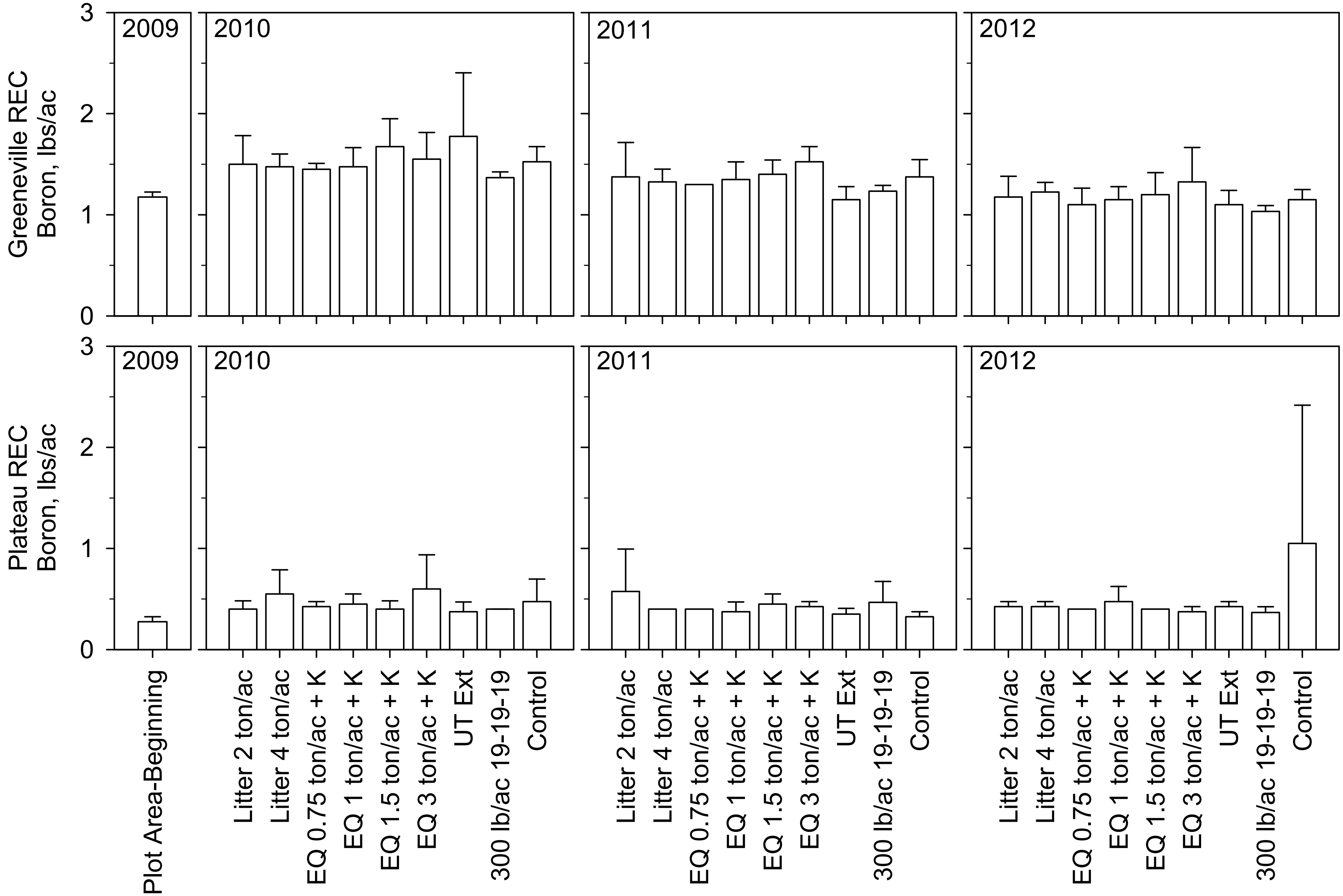

Figure 66. Soil boron concentrations.

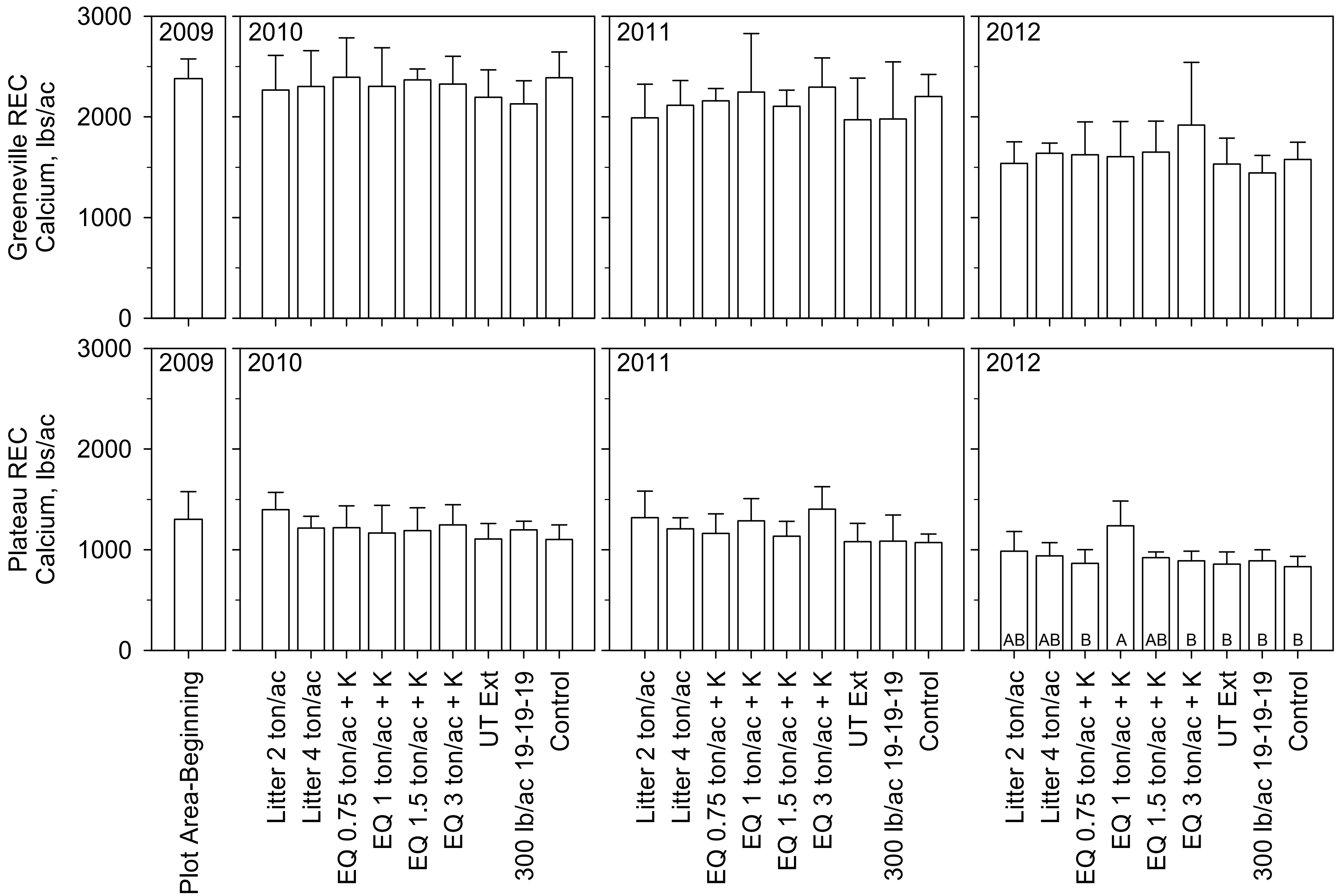

Figure 67. Soil calcium concentrations.

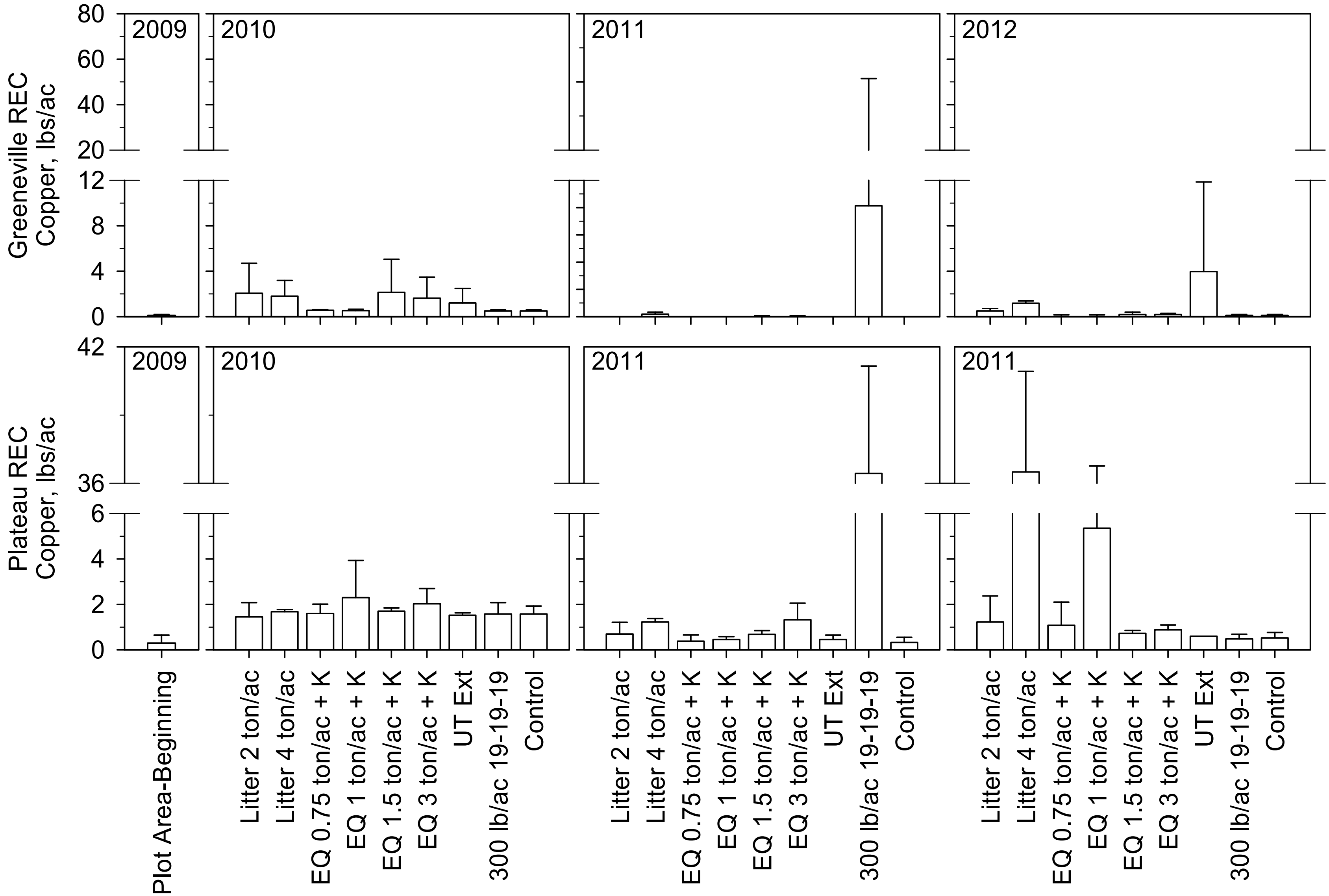

Figure 68. Soil copper concentrations.

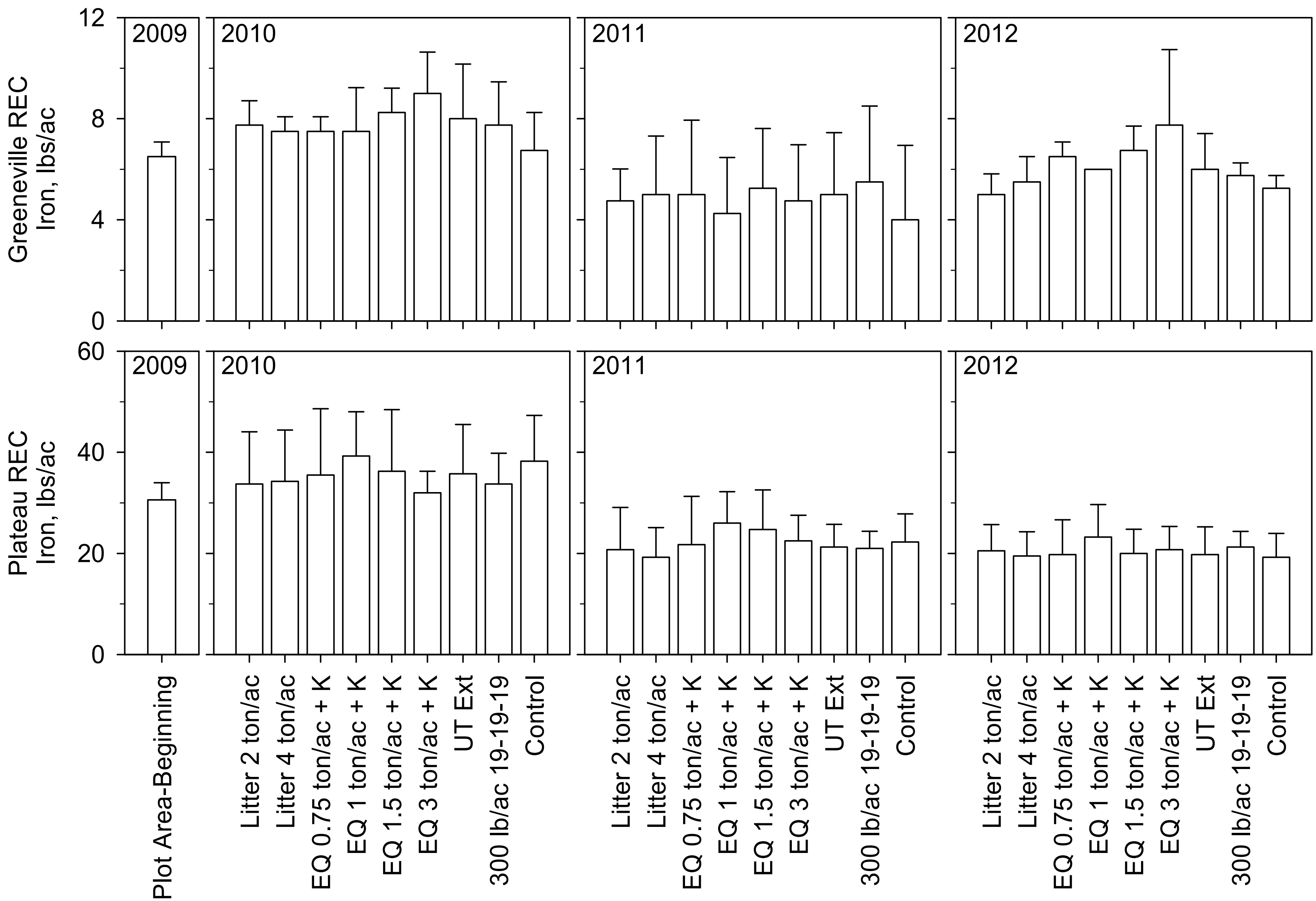

Figure 69. Soil iron concentrations.

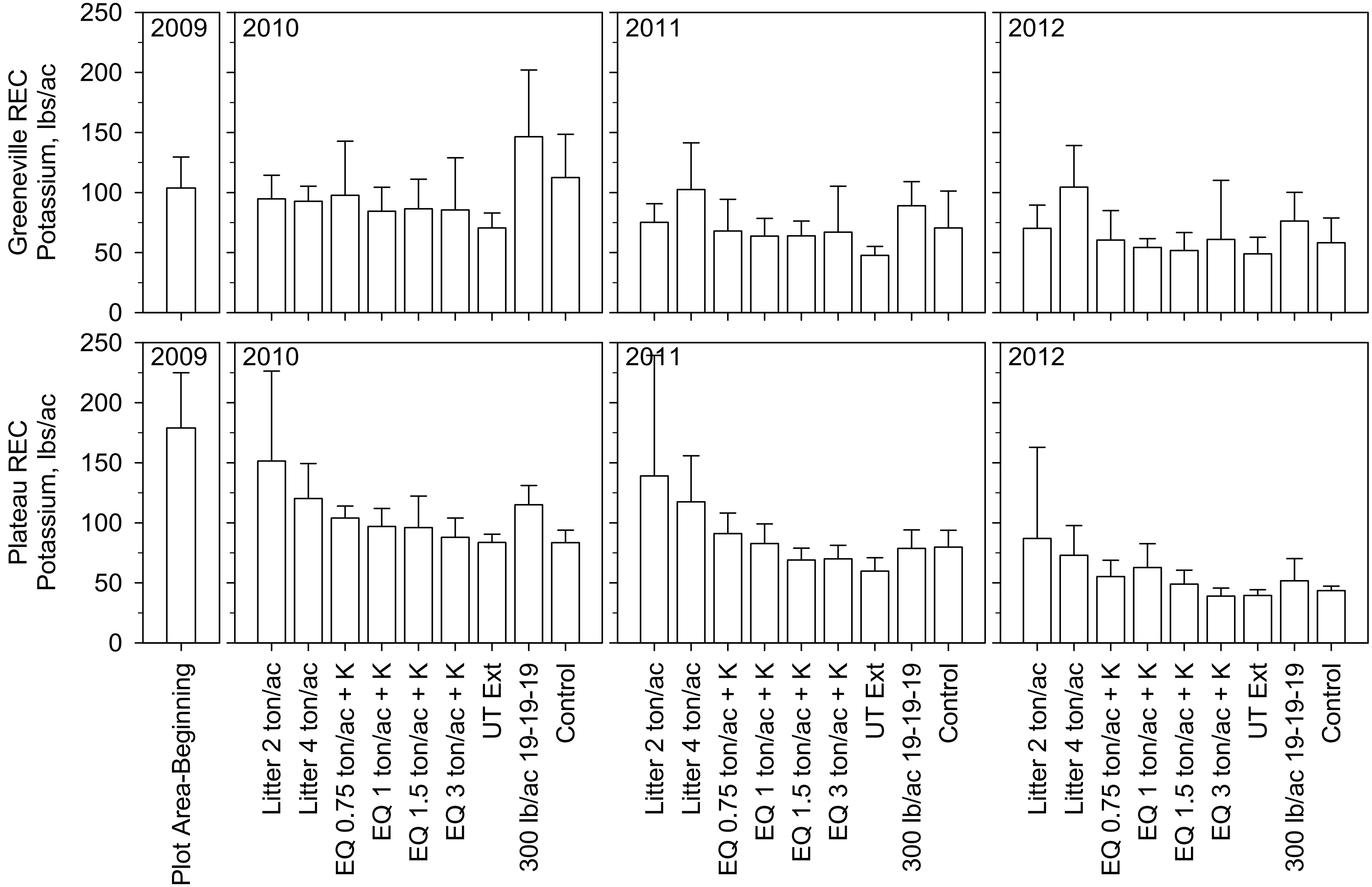

Figure 70. Soil potassium concentrations.

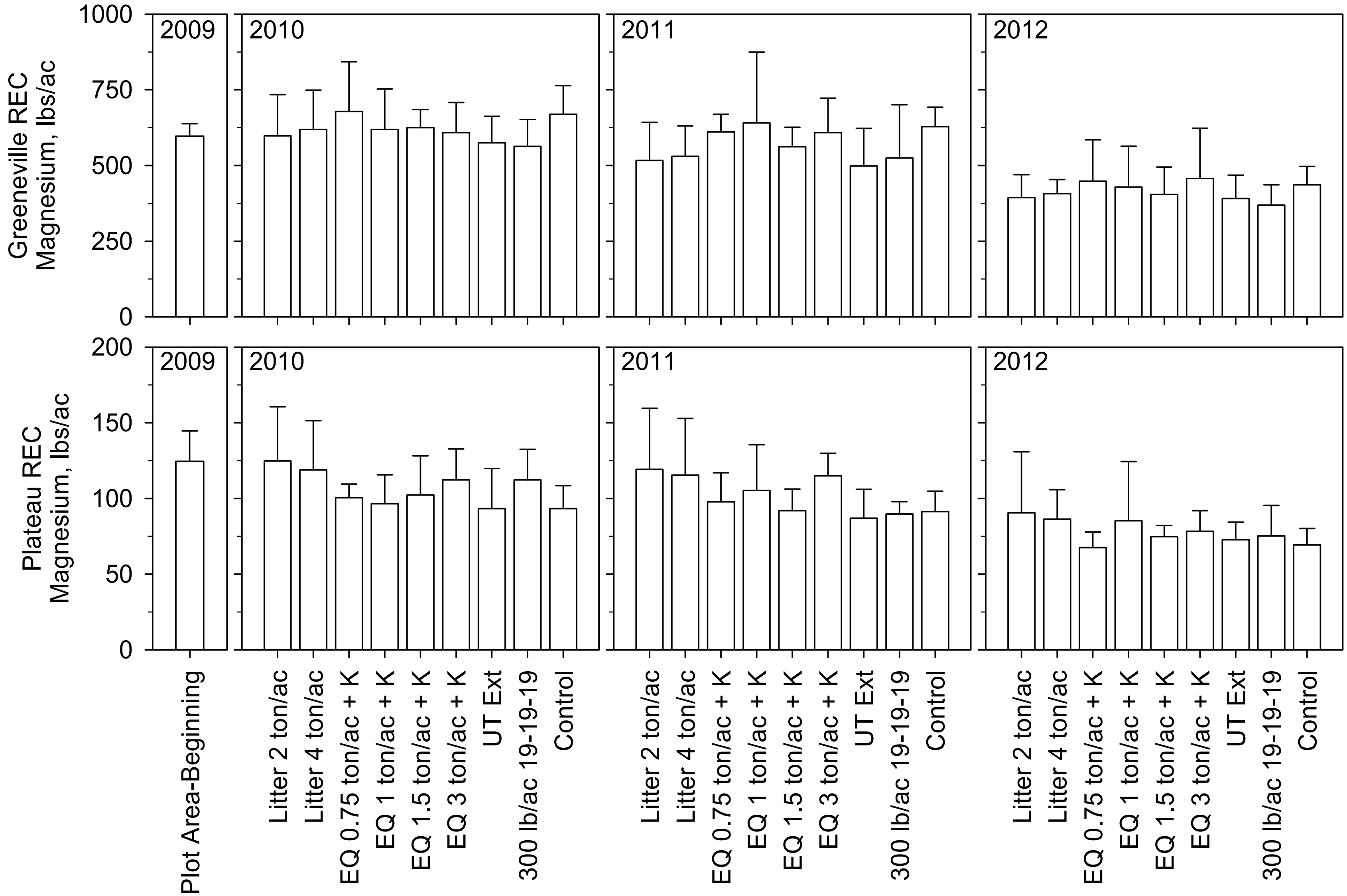

Figure 71. Soil magnesium concentrations.

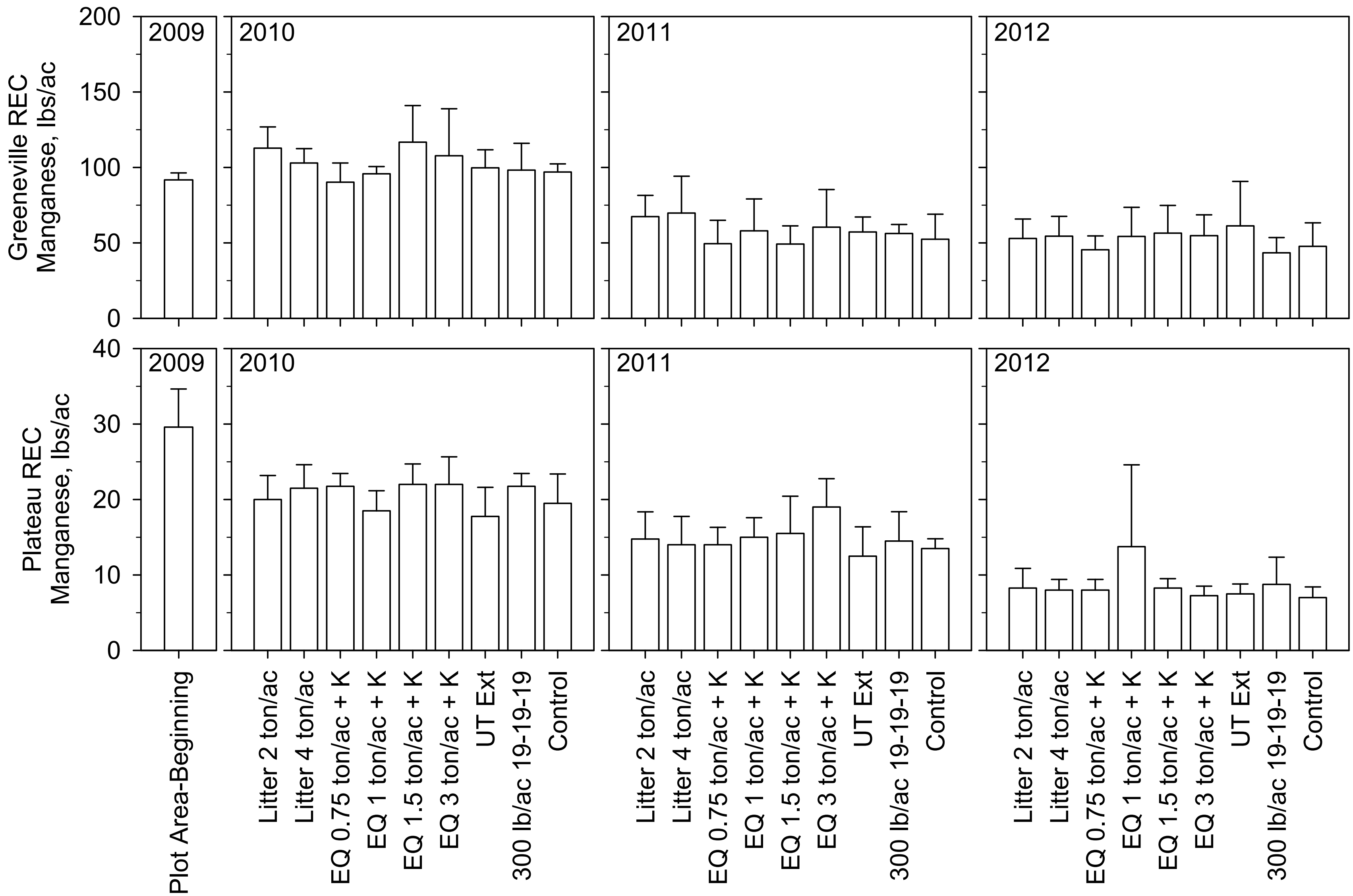

Figure 72. Soil manganese concentrations.

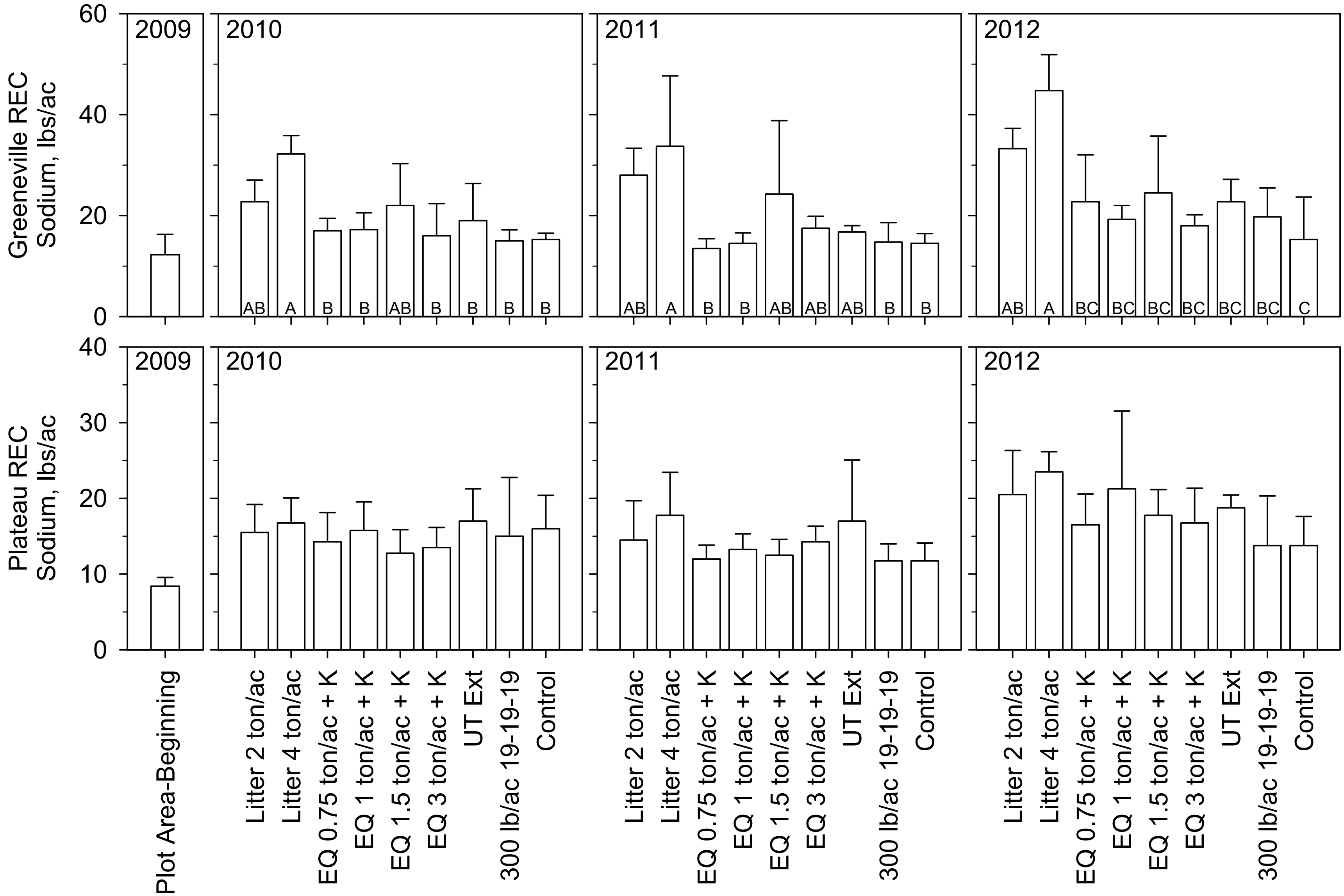

Figure 73. Soil sodium concentrations (bars that do not share a common letter are significantly different).

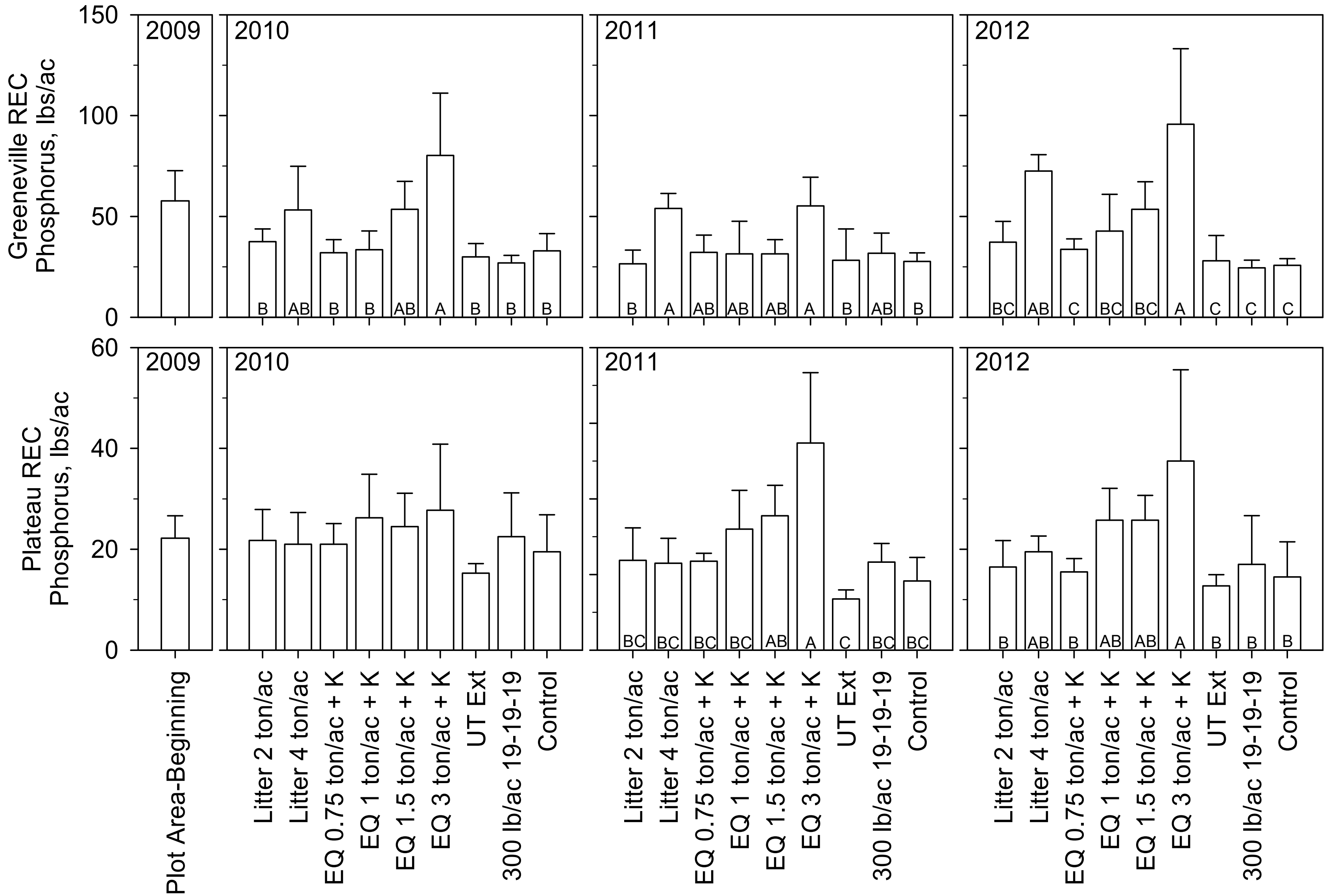

Figure 74. Soil phosphorus concentrations (bars that do not share a common letter are significantly different).

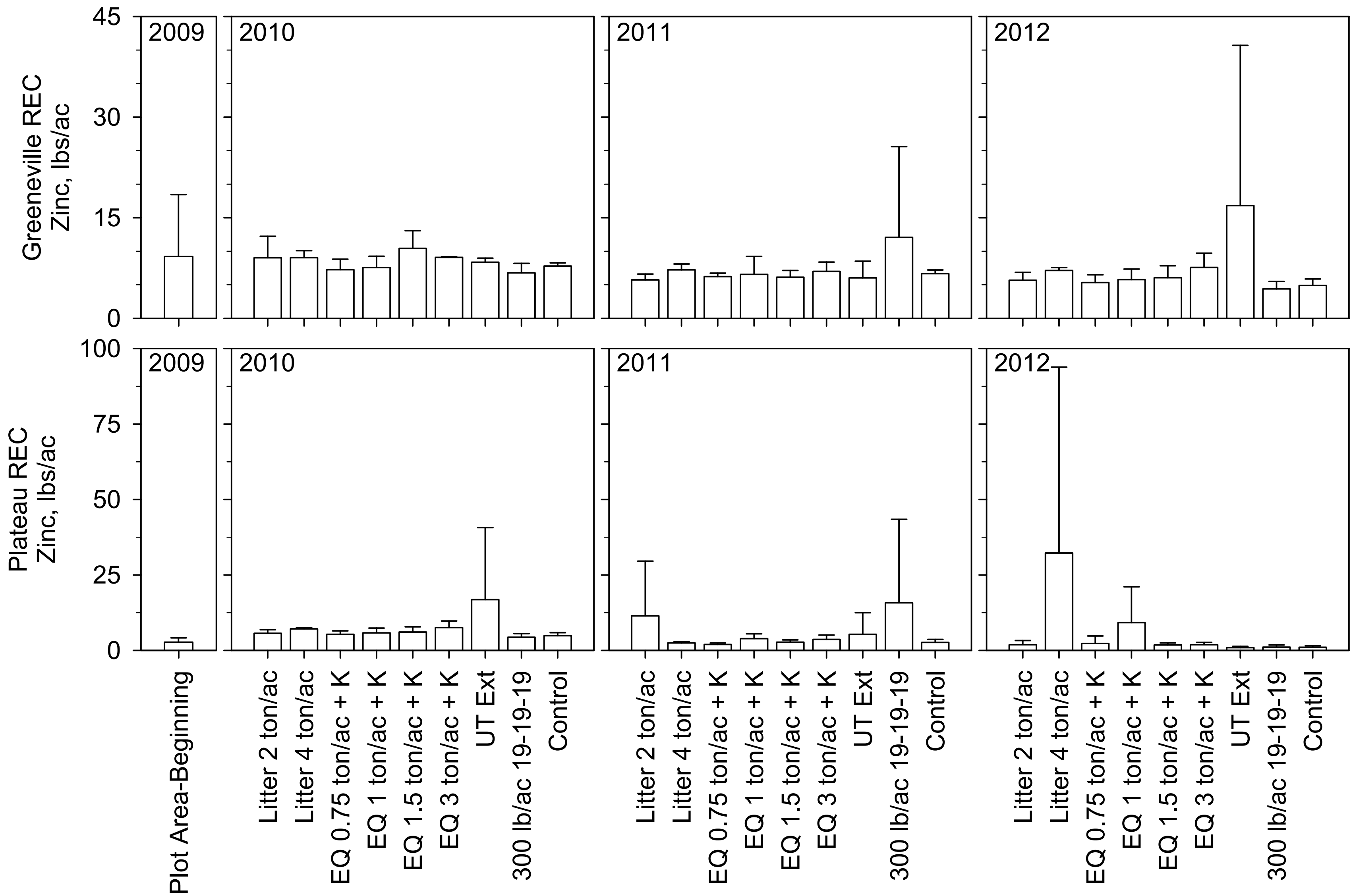

Figure 75. Soil zinc concentrations.