Effect of Year and Season on Mineral Concentrations of Cool- and Warm-season Grasses from Native Range.[2]

W. W. Poland and L. L. Manske,
Dickinson Research Extension Center
North Dakota State University

Research Summary: Concentrations of minerals and animal requirements for minerals are not constant across the grazing season. Beef cow producers should place emphasis on Na (salt), S, Cu and Zn when designing supplementation programs for the Northern Great Plains. Strategic supplementation programs for P, and possibly Mg, would also seem warranted.

Introduction

At least 17 minerals are listed as dietary requirements for beef cattle (NRC, 1996). In some grazing situations, one or more minerals may be severely, or at least marginally, deficient. Even marginal dietary deficiencies can be of economic importance to beef producers through reduced growth, reproduction, or health status (Spears, 1994).

Matching animal requirements for minerals to available supply forms the basis for designing appropriate supplementation programs. Availability of minerals must be stressed because it encompasses dietary concentration, digestibility and potential antagonistic relationships with other dietary nutrients. Understanding the various factors that affect availability is essential if livestock producers are to minimize production bottlenecks due to mineral deficiencies in a cost-effective manner.

Strategic supplementation of minerals that are limiting in the diet can have positive economic return. However, current information on dietary mineral supply and availability is lacking. This lack of knowledge can lead to indiscriminate mineral supplementation practices. Excessive supplementation above requirement would not be expected to have positive return on investment.

The objective of this study was to describe seasonal changes on the mineral concentration of native range grasses in western North Dakota. Combined with other data collected throughout the region, quantifying seasonal variations in nutrient concentrations should help producers identify periods during the grazing season when nutrient supplementation may be necessary to maintain optimum performance.

Materials and Methods

Three long-term (1983 - 2000) grazing treatments were imposed on native range in southwestern North Dakota (Manske, 2001). Grazing treatments included a 6.0-month seasonlong (SL6.0), a 4.5-month seasonlong (SL4.5) and a 4.5-month twice-over rotational (Rot-X) system. Basically, SL6.0 involved a single pasture grazed from mid May until mid November; SL4.5 involved a single pasture grazed from either mid June until late October (1983 - 1994) or early June until mid October (1995 - 2000); and Rot-X involved three pastures grazed in a rotational sequence from early June until October.

Forage samples for mineral analysis were taken from a silty range site, considered to be a regionally standard site (Manske, 2001), from pastures in each of the grazing treatments. Samples were collected using a hand-clip technique and sorted into plant-type categories in the field. Major categories were cool-season grasses (CSG), warm-season grasses (WSG), sedges, forbs, standing dead and litter. Seven possible sample periods were included: mid May (15May), early June (01Jun), mid June (15Jun), late June to mid July (15Jul), late July to mid August (15Aug), late August to mid September (15Sep) and mid October to mid November (15Oct). Samples from three years (1984, 1993 and 1996) were selected for analysis. Each of these years received normal precipitation amounts for the year and during the growing season.

[2] Partial funding for this project was provided by a grant from the North Dakota State Board of Agricultural Research and Education (SBARE).

Standard techniques (UV-Vis and AA; AOAC, 1990) were used to analyze forage samples for calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), and sulfur (S), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn).

For the purposes of this report, a regression analysis (PROC GLM; SAS System for Windows, Release 8.00) was used to describe seasonal changes in mineral concentration of CSG and WSG. Data were pooled across grazing treatments and all years and sampling dates were included. An initial model included the effects of year and polynomial components to the fourth order of sampling date. In the final model, nonsignificant ($P > .1$) higher-order polynomial components in the initial model were removed and solutions generated. Average concentration each mineral are presented to described seasonal changes and were compared to a range in beef cow requirements (NRC, 1996). Approximate error bars for least squares means of mineral concentration were calculated as root error mean square divided by the square root of the average number of observations per mean ($n = 10.86$).

Results and Discussion

Year. Mineral concentration of Ca, P, Mg, K, Zn and Mo in both CSG and WSG, Cu in CSG and Fe in WSG were significantly ($P < .1$) variable among years (Tables 1 and 2). This is to say that the average annual concentration of these minerals was different in at least one of the three years. This variation was present even though the years included in this analysis were selected to represent years receiving normal (100 ± 25% of the long term average) precipitation. Concentration of Na, S and Mn and Cu/Mo ratio in both CSG and WSG, Cu in WSG and Fe in CSG were not affected ($P > .1$) by yearly variation.

Yearly means expressed as a percentage of the 3-year average are plotted in Figure 1. Two interesting observations can be made when comparing these plots. The general pattern of variation within a mineral appears similar between CSG and WSG. Furthermore, with the exception of perhaps S, the pattern of higher or lower than average appears to be consistent among macro minerals. For example, in 1996 all macro minerals were lower than the three-year average. In the other years, the tendency was for all macro minerals to be greater than the average. This consistency among years does not appear to be true among trace minerals. Plotting the yearly variations in CSG versus WSG (Figure 2) suggests a strong correlation between these two variables. This could imply that yearly conditions that either increase or decrease the forage concentration of a particular mineral does so in both grass types with similar degrees of magnitude. Thus, for example, annual conditions that cause a 10% increase in Mg concentration or a 25% decrease Zn concentration does so in grasses in general without respect to type (CSG or WSG).

Advancing season. All mineral concentrations, except of Na in CSG and Na and S in WSG, were influenced by advancing season ($P < .1$; Tables 1 and 2). Ca concentration increased cubically with advancing season. However, the Ca concentration in WSG was greater from July through September compared to CSG. Although CSG had a higher P concentration early in the season and lower a concentration in September, the general pattern of P concentration was to remain relatively stable until beginning to decline in July and September in CSG and WSG, respectively. Mg concentrations increased until mid season (July - August) and then declined. WSG had lower Mg concentrations in mid May and higher concentrations in July through September when compared to CSG. K concentration declined with advancing season in both grass types. K concentration in CSG was higher than WSG until late in the grazing season. The concentration of Cu and S in CSG declined with advancing season to reach a more stable level similar to that in WSG. This lower level was then maintained throughout the remaining season. The Cu and S concentration of CSG was greater than that in WSG until August and September, respectively. Fe and Mn concentrations increased quadratically with advancing season. In general, CSG had a lower concentration of Fe, and a higher concentration of Mn, when compared to WSG. Zn concentration declined, while Mo concentration increased, with advancing season. Concentrations of Zn and Mo in WSG were more variable than in CSG across the season. The Cu/Mo ratio declined with advancing season and tended to be higher in CSG until September when the ratios converged.

Forage concentrations versus beef cow requirements. The range in mineral requirements for beef cows (NRC, 1996) are compared to mineral concentrations in CSG and WSG in Figures 3 (macro minerals) and 4 (trace minerals and Cu/Mo ratio). The upper and lower bounds on a requirement represent the requirement of an early lactating cow and dry cow in mid gestation, respectively. Requirements for late gestation and mid to late lactation are intermediate to these bounds. Ca, Fe and Mo concentrations in grasses from native range exceed cow requirements throughout the grazing season. K concentrations exceed requirements until October suggesting consideration of K supplementation of cows in extended grazing scenarios may be warranted very late in the season. Although Mn concentrations might be considered marginal (particularly in WSG) for much of the grazing season, universal or even strategic supplementation would not seem warranted in the Northern Great Plains based upon these data.

On the other hand, concentrations of Na, S, Cu and Zn were below requirements across most of the grazing season. Full season or an aggressive strategic supplementation program involving these minerals deserves consideration. Since water can be a significant source of dietary consumption of certain minerals (e.g. Na, S), base mineral consumption from all sources needs to be assessed before formulating final supplementation strategies.

The low and decreasing character of the Cu/Mo ratio suggests a particular problem for Cu nutrition. This is especially true: 1) if S supplementation is excessive, 2) later in the season when Fe concentrations are increasing and 3) when long term water sources contain high levels of S or Fe. S, Fe an Mo plus S have all been shown to decrease Cu availability (Spears, 1994). The net effect would be an increase the dietary requirement for Cu to counteract these antagonists when a problem exists.

P and Mg present special problems for grazing beef cows. Forage concentrations tend to be intermediate or low relative to the range in cow requirements and responsive to yearly variation. This may help explain the lack of a consistent biological response to supplementation with these minerals to beef cows. Some level of P and Mg supplementation may be advised especially at specific times during the production cycle (early lactation and very late in the season). However, strategic supplementation of P and Mg may be viewed more as an insurance policy against marginal deficiencies with no guarantee of an economical response to supplementation..

Conclusions

The concentration of most minerals were variable from year to year. Only Na, S and Mn were not significantly affected by year in this study. When annual effects were present, the response to a particular mineral seemed to be consistent in direction and magnitude within both grass types. Most minerals had variable concentrations in grasses across the grazing season. Ca, Fe, Mn and Mo tended to increase, while K, Cu and Zn tended to decrease, with advancing season. P and Mg tended to either increase or maintain a level until mid season when concentrations then declined with further season advancement. Na and S concentrations did not change dramatically across the majority of the grazing season. Supplementation programs need to account for all intake sources of minerals and potential antagonistic relationships. However, based upon these data, producers with grazing beef cows should strongly consider Na (salt), S, Cu and Zn when designing supplementation regimens in the Northern Great Plains. Strategic supplementation programs for P, and possibly Mg, would also seem warranted.

Literature Cited

AOAC. 1990. Official methods of analysis (15th ed.). Assoc. of Official Anal. Chem., Arlington, VA.

Manske, L.L. 2001. Mineral content of native range herbage on four management treatments. NDSU Dickinson Research Extension Center. Range Research Project Report, DREC 01-5001. Dickinson, ND. 105p.

NRC. 1996. Nutrient requirements of beef cattle (7th rev. ed.). National Research Council, National Academy of Sciences. National Academy Press, Washington, DC.

Spears, J.W. 1994. Minerals in forages. In: G.C. Fahey, Jr. (ed.). Forage quality, evaluation and utilization. ASA, CSSA and SSSA, Madison, WI. USA.

Table 1. Effect of year and season on concentration of macro (%) and trace (ppm) minerals and copper- to- molybdenum (Cu/Mo) ratio in cool-season grasses from native range.

	Year				Polynomial coefficients[a]						
Mineral	1984	1993	1996	SE	Intercept	date	$date^2$	$date^3$	$date^4$	R^2	REMS
Macro-minerals											
Calcium[†††]	.379[y]	.377[y]	.291[x]	.0146	(***)	***	(***)	***	=	0.36	.069
Phosphorus[†]	.147[y]	.145[y]	.125[x]	.0074	-	**	(***)	=	=	0.49	.035
Magnesium[†††]	.139[y]	.130[y]	.098[x]	.0046	-	**	(**)	=	=	0.44	.022
Potassium[†††]	1.18[xy]	1.36[y]	1.00[x]	.0617	-	-	(***)	=	=	0.75	.293
Sodium	.024	.028	.013	.0048	=	=	=	=	=	0.08	.018
Sulfur	0.091	0.090	--	.0041	***	(***)	***	(***)	***	0.61	0.018
Trace minerals											
Copper[†]	1.60[x]	2.29[y]	2.08[xy]	.194	(*)	*	(*)	*	(*)	0.47	.912
Iron	262	208	230	23.5	**	(**)	**	(**)	**	0.46	108
Manganese	50.2	49.1	52.0	2.57	***	(***)	***	=	=	0.30	12.3
Zinc[†††]	23.3[y]	21.8[y]	14.6[x]	.970	***	(***)	=	=	=	0.45	4.63
Molybdenum[†††]	.93[x]	1.52[y]	.88[x]	.140	-	**	=	=	=	0.25	.651
Cu/Mo	2.22	2.52	3.53	.582	***	(***)	=	=	=	0.15	2.69

[a] Information regarding polynomial coefficients describing changes in component across season. *,**,*** indicate coefficients differ from zero ($P \leq .1$, .05 and .01, respectively). Parenthesis indicate a negative coefficient. - indicates a coefficient not different from zero ($P > .1$). = indicate higher order terms that were not included in the regression (coefficient not different from zero; $P > .1$).

[†,†††] Indicates a significant effect of year (P<.1 and .01, respectively).

[x,y,z] Means with in a row with differing superscripts differ ($P < .05$).

Table 2. Effect of year and season on concentration of macro (%) and trace (ppm) minerals and copper- to- molybdenum (Cu/Mo) ratio in warm-season grasses from native range.

	Year				Polynomial coefficients[a]						
Mineral	1984	1993	1996	SE	Intercept	date	date^2	date^3	date^4	R^2	REMS
Macro-minerals											
Calcium[†††]	.394[xy]	.407[y]	.356[x]	.0135	(*)	**	(*)	*	=	0.34	.064
Phosphorus[†]	.137[xy]	.142[y]	.120[x]	.0079	(**)	**	(**)	***	(***)	0.42	.037
Magnesium[†††]	.143[y]	.149[y]	.105[x]	.0047	(***)	***	(***)	=	=	0.58	.022
Potassium[†††]	.860[xy]	.922[y]	.709[x]	.0547	(-)	***	(***)	=	=	0.48	.260
Sodium	.024	.028	.011	.0053	=	=	=	=	=	0.08	.019
Sulfur	.075	.071	-	.0038	=	=	=	=	=	0.01	.017
Trace minerals											
Copper	1.26	1.80	1.76	.184	(**)	**	(**)	**	(**)	0.21	.84
Iron[†]	411[y]	298[x]	346[xy]	31.3	***	(***)	***	=	=	0.17	142
Manganese	44.9	41.2	44.9	2.43	(-)	-	(-)	(*)	=	0.44	11.6
Zinc[†††]	25.2[z]	22.0[y]	14.2[x]	.949	(*)	*	(**)	**	(**)	0.53	4.49
Molybdenum[†††]	1.07[x]	1.82[y]	1.04[x]	.159	*	(*)	*	(*)	*	0.28	.72
Cu/Mo	1.46	1.45	2.46	.468	(**)	**	(**)	**	(**)	0.23	2.08

[a] Information regarding polynomial coefficients describing changes in component across season. *,**,*** indicate coefficients differ from zero ($P \leq .1$, .05 and .01, respectively). Parenthesis indicate a negative coefficient. - indicates a coefficient not different from zero ($P > .1$). = indicate higher order terms that were not included in the regression (coefficient not different from zero; $P > .1$).
[†,†††] Indicates a significant effect of year (P<.1 and .01, respectively).
[x,y,z] Means with in a row with differing superscripts differ ($P < .05$).

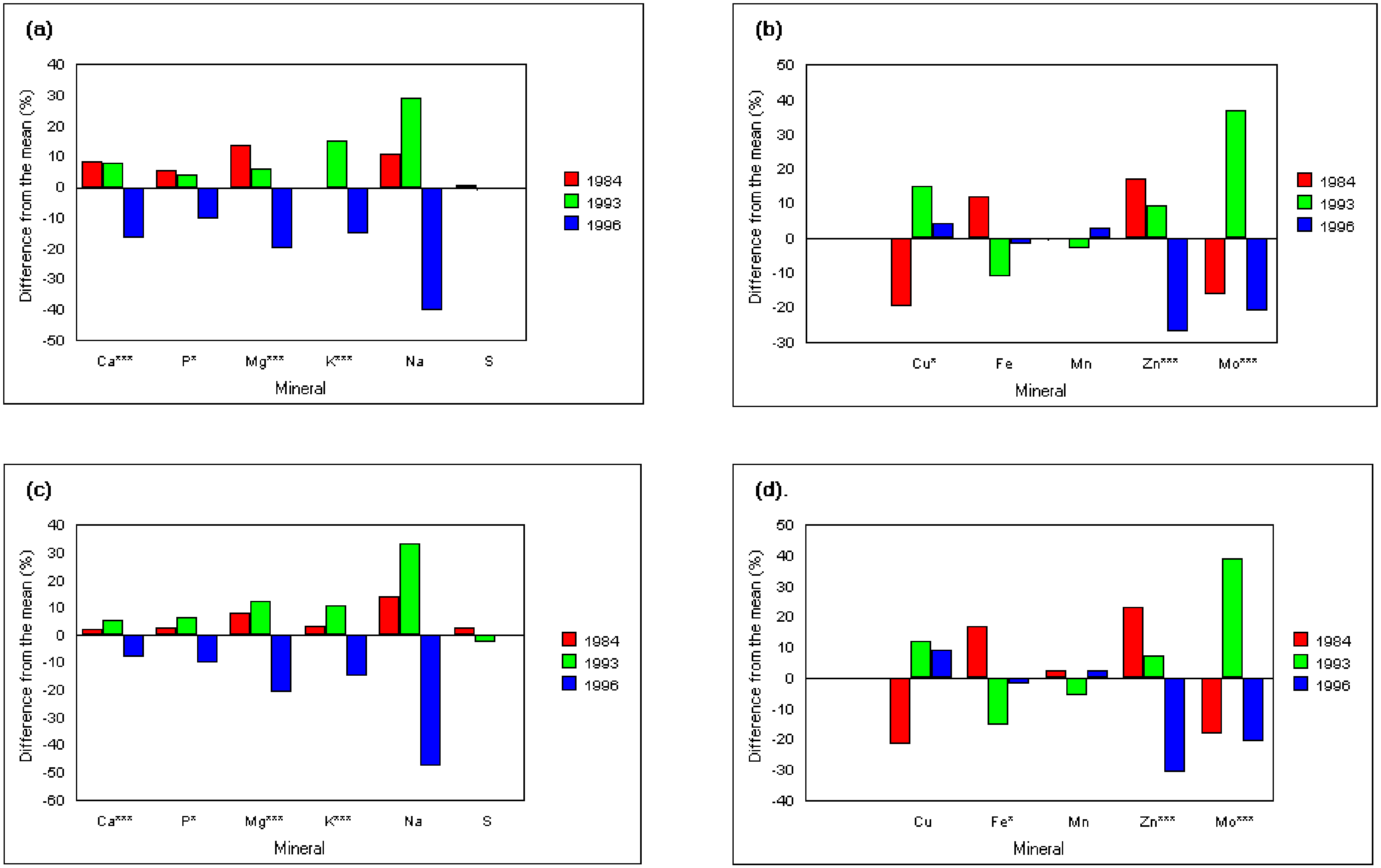

Figure 1. Variation (% of mean) among years for macro- (a and c) and trace (b and d) mineral concentrations in cool (a and b) and warm (c and d) season grasses from native range. *,**,*** indicate significant variation among years within a mineral ($P < .1$, .05 and .01, respectively).

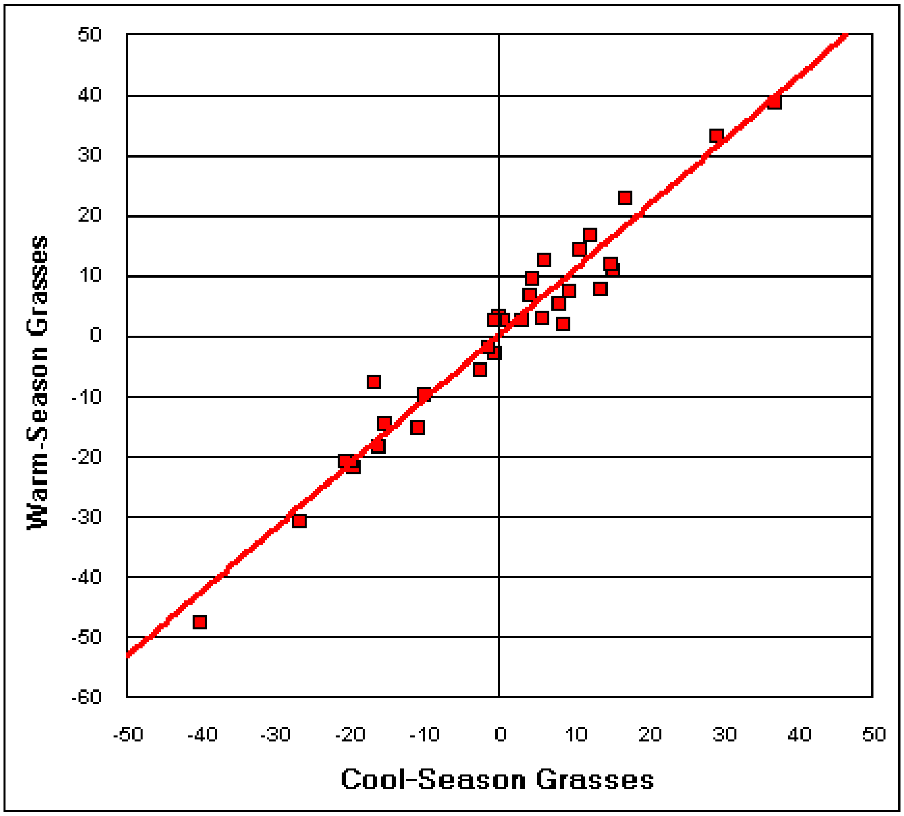

Figure 2. Relationship of variation (% of mean) among years for mineral concentrations in cool- and warm-season grasses from native range (R^2 = .953; slope = 1.07 ± .043; and intercept = 0.0 ± 3.94).

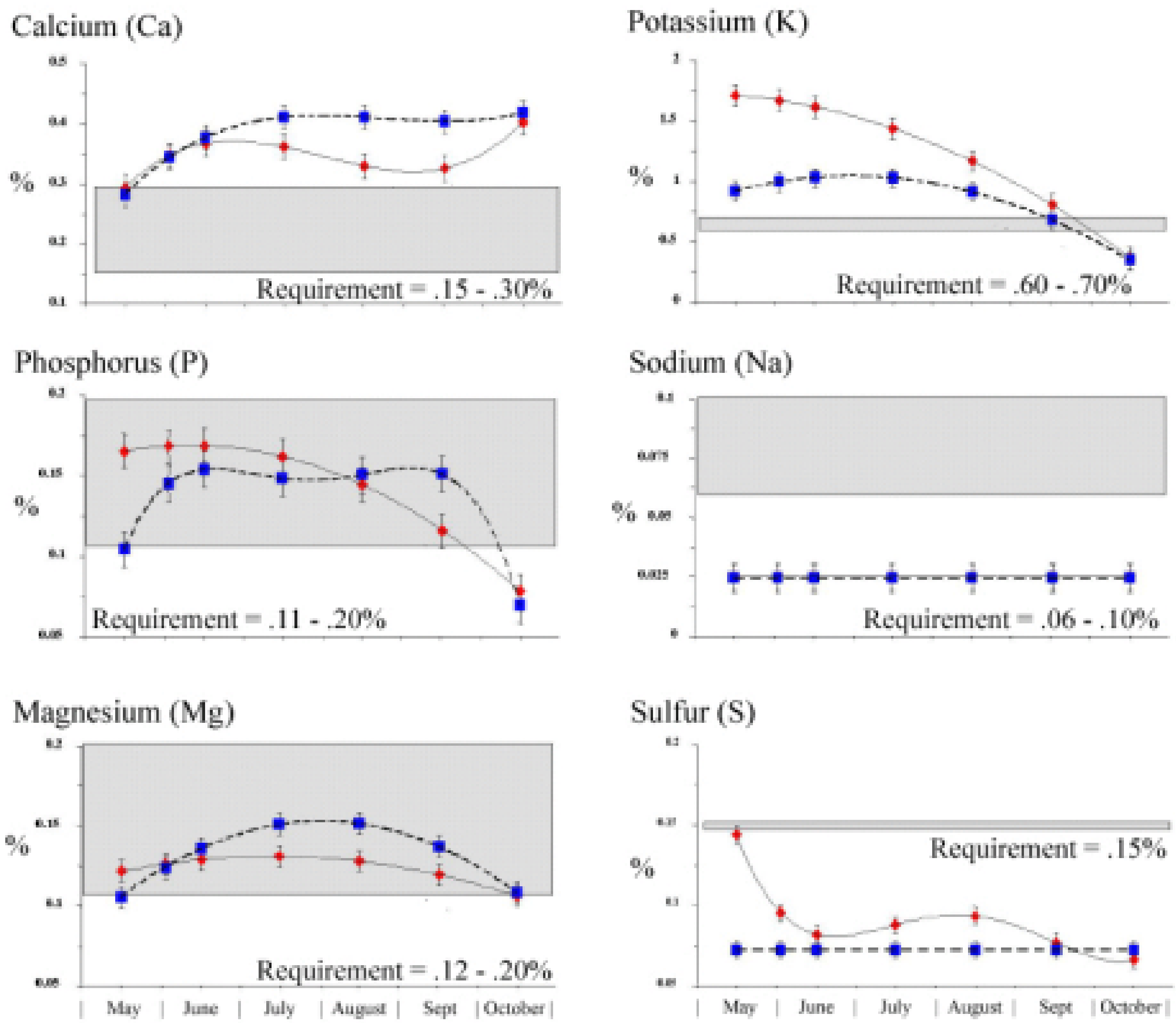

Figure 3. Effect of season on concentration of macro minerals in cool (solid line) and warm (dashed line) season grasses from native range. Range in beef cow requirements (NRC, 1996) are shown by shaded areas.

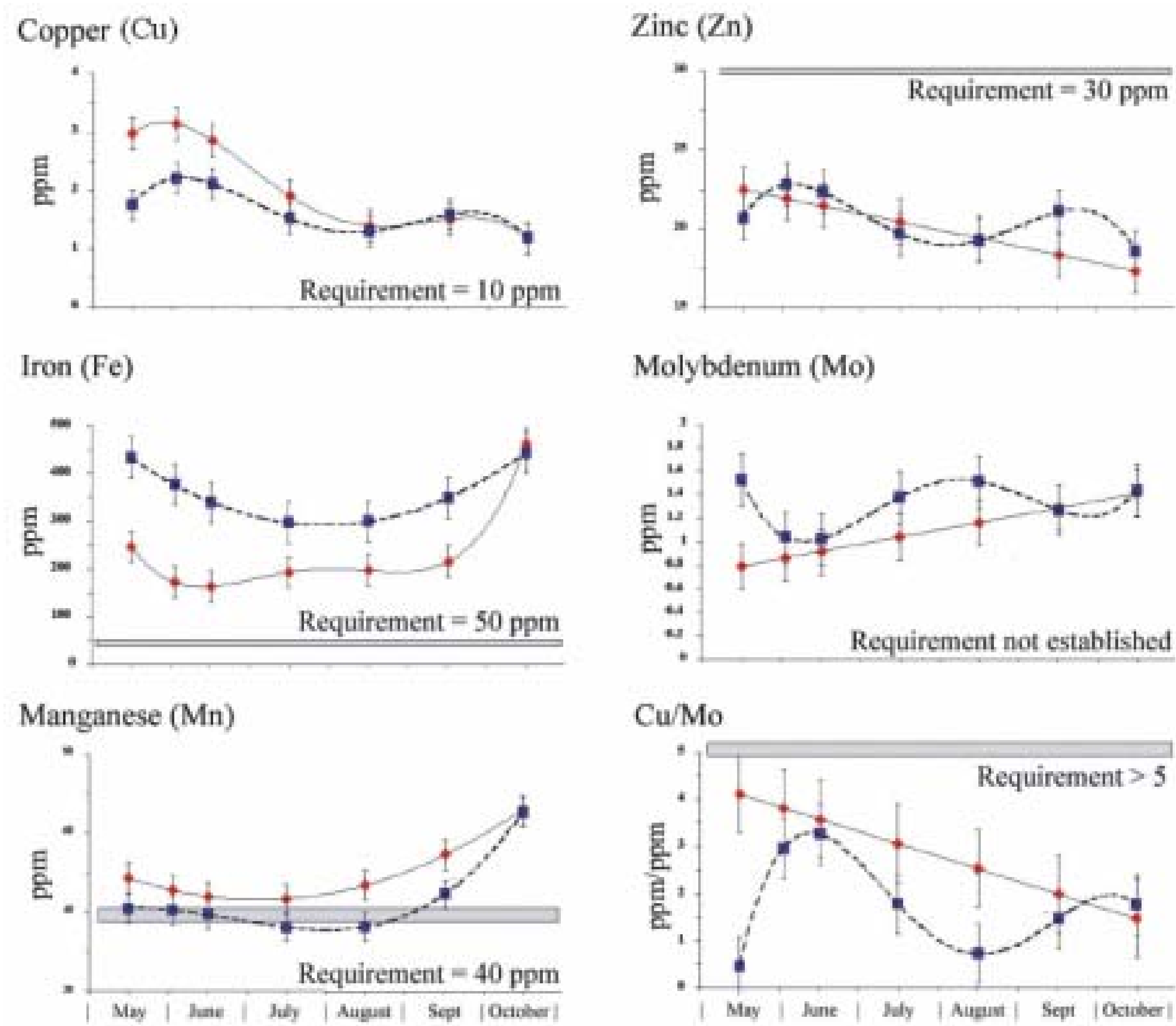

Figure 4. Effect of season on concentration of trace minerals in cool (solid line) and warm (dashed line) season grasses from native range. Range in beef cow requirements (NRC, 1996) are shown by shaded areas.