Elemental Concentrations in Native Range Grasses from the Northern Great Plains of Montana

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Highlight: A study of elemental concentrations in five range grasses from the Northern Great Plains of Montana indicated levels of calcium, magnesium, iron, and manganese adequate for optimum performance of range cattle. Concentrations of copper and zinc were below established nutrient requirement levels. Concentrations of these two elements were usually highest in spring samples and decreased throughout the summer and fall. Year-to-year variation was small in spring grass collections for both elements, but summer and fall collections revealed wide fluctuations in elemental levels. For maximum performance of range cattle in the study area, copper and zinc supplements appear to be necessary during summer, fall, and winter grazing seasons.

The trace element requirements for cattle have been established, particularly for animals in feedlots (National Research Council 1976). However, range cattle encounter different environmental conditions than do feedlot cattle and these affect nutrient requirements as well as the intake of range plants. There are numerous reports of trace element toxicity and deficiency diseases in pasture cattle (Fontenot 1972; Miller 1970; Hartmans 1974) and trace element additives are commonly incorporated into food supplements for range animals. The extensive use of trace mineral supplements in the livestock industry points out the need for establishing the pattern of potential mineral intake based on forage plant concentrations.

The availability and consumption of trace elements by livestock on native range is influenced by a number of factors. A variety of life forms and individual plant species constitute the range resource and represent varying elemental compositions. Within single species, investigators have even shown that mineral levels are related to the stage of maturity of the plant (Smoliak and Bezeau 1967; Hamilton and Gilbert 1972). Selective grazing behavior of cattle and over- or under-grazing at different seasons, as well as soil intake, influence elemental balances on native range (Healy 1974). The availability of an element may also be influenced by concentrations of other elements in the forage. The relationships between copper, molybdenum, and sulfur illustrate this point (Lessard et al. 1970).

Miltmore et al. (1970) noted copper and zinc deficiencies in some cattle forages in British Columbia, and Hamilton and Gilbert (1972) found adequate levels of copper but marginal concentrations of zinc in Wyoming grasses. Elemental levels in pasture grasses from the Northern Great Plains of Montana have not been examined.

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The purpose of this study was twofold: to establish the levels of calcium, magnesium, iron, manganese, copper, and zinc in range forage grasses, and to determine if these elemental concentrations were high enough to meet nutrient requirements of range cattle as established by the National Research Council (NRC 1976).

Methods and Procedures

The grasses analyzed in this study were collected from sites located in Rosebud County, Mont., approximately 180 km west of North Dakota and 70 km north of Wyoming. The area constitutes a mixture of mid-grass prairie and open ponderosa pine stands. Permanent collection sites were established in vegetation representative of the local plant communities. Three perennial grasses, western wheatgrass (*Agropyron smithii*), bluebunch wheatgrass (*A. spicatum*), and needleandthread grass (*Stipa comata*), were selected for analysis, as well as a sample of mixed perennial grasses and the annual cheatgrass (*Bromus tectorum*). These plants represented the dominant range grasses within the study area. Soils were quite variable. Needleandthread and bluebunch wheatgrass were common on sandy-skeletal, mixed Borollic Camborthids, and Typic Torriorthents on flat uplands, while western wheatgrass was found primarily on the coarse and fine loamy Aridic Haploborolls and Borollic Camborthids on toeslopes and gently sloping alluvial terraces. Mixed perennial grasses and *Bromus* species were found on all soils in the study area. Chemical analyses of surficial materials from these sites indicated that the soils represented a spectrum of nutrient regimes.

Grasses were clipped approximately 5 cm above ground level during March, May, July, and October of 1973. Samples from 1974 were collected during February, May, August, and October. Cuttings were dried to a constant weight in a forced-draft oven at 70°C. Tissues were digested in a 3:2 mixture of hot nitric-perchloric acids and elemental concentrations determined by atomic absorption spectroscopy. Accuracy of analyses was assured by simultaneous analyses of National Bureau of Standards (NBS) Standard Orchard Leaves and comparison of these values to certified levels. Precision and accuracy were also determined using the NBS standard (Table 1).

Table 1. Summary of accuracy and precision studies using NBS reference material, orchard leaves (all values in mg/kg unless otherwise indicated).

Element	NBS certified value	Mean and SD of 6 analyses	Relative SD (%)*	Relative error (%)**
Ca	20100 ± 300	20700 ± 500	2.4	1.0
Cu	12 ± 1	12.3 ± 0.4	3.2	2.5
Fe	300 ± 20	291 ± 27	9.3	3.0
Mg	6200 ± 200	6000 ± 300	5.0	3.2
Mn	91 ± 4	87.9 ± 0.7	0.8	3.4
Zn	25 ± 3	25.6 ± 1.2	4.7	2.4

* $SD/\bar{x} \times 100$.

** Absolute value of (certified value $- \bar{x}$)/certified value $\times$ 100.

Results

The elemental concentrations of the native grasses and the established nutrient requirements are summarized in Table 2. The averages, standard deviations, and numbers for all plants analyzed during the 2-year collection period are shown in this table.

Calcium

The National Research Council report (1976) indicated a calcium concentration in the dry diet from 1,800 to 4,400 mg/kg as sufficient for most range cattle. All of the grasses studied in each of the eight seasons exhibited calcium levels within this range (Table 2). Minimum calcium values were recorded in western wheatgrass in spring samples (3,000 mg/kg). Summer and fall concentrations were higher than those in winter and spring in all samples except needleandthread grass.

Table 2. Summary of elemental concentrations in cattle feeds calculated on dry weight basis (all values in mg/kg).

Element	Dietary requirement*	Dietary requirement**	This study
Ca	1800 to 4400		3500 ± 700 (N=261)
Mg	400 to 1000		1200 ± 200 (N=252)
Fe	10	30	167 ± 99 (N=274)
Mn	1.0 to 10.0	40	39 ± 14 (N=969)
Cu	4	10	3.6 ± 0.8 (N=1181)
Zn	20 to 30	50	17 ± 4 (N=1181)

* National Research Council (NRC), 1976.

** Agricultural Research Council (ARC), 1963.

Magnesium

The average magnesium level for all grasses from all seasons (Table 2) was above the nutrient requirement range of 400 to 1,000 mg/kg. The mixed perennial grasses collected in the fall of 1974 showed the highest concentration of magnesium—1,700 mg/kg. The lowest concentration was found in cheatgrass samples from the summer of 1974 with an average magnesium level of 800 mg/kg. These values indicated that cattle grazing on these five grasses were consuming sufficient quantities of magnesium.

Iron

Although a minimum requirement for iron has not been established, a level of 10 mg/kg in the dry diet was indicated by the NRC (1976) as sufficient for most cattle. The grasses in this study exhibited a large range in iron content. The maximum and minimum averages were 499 and 70 mg/kg in cheatgrass, fall 1973, and western wheatgrass, spring 1974, respectively. The samples collected in the spring contained lower levels (< 100 mg/kg) of iron, while those collected in the fall exhibited much higher concentrations (> 200 mg/kg). Compared to the NRC (1976) recommended level, these data indicated adequate levels of dietary iron in the grasses of the study area.

Manganese

The manganese requirement of beef cattle is usually 1 to 10 mg/kg in the dry diet (NRC 1976). The requirement for reproduction appears to be higher, with an intake of 20 mg/kg adequate for normal pregnancy. All of the grasses in this study exceeded these manganese levels. Bluebunch wheatgrass exhibited the lowest level (21 mg/kg) in the summer of 1973. Manganese did not appear to pose a dietary problem in the study area.

Zinc

Dietary requirements for zinc in cattle forage are reported to be 20 to 30 mg/kg (NRC 1976). Determination of levels of this element in cattle forages consistently showed marginal or below minimum dietary concentrations in the rangeland grasses of the study area. Figure 1 shows the zinc concentration for each of the five grasses throughout the 2-year study.

Of the grasses, cheatgrass (Fig. 1) exhibited the highest consistent zinc content throughout the seasons. This grass probably does not form a significant food source on these ranges during summer, fall, or winter, however, because it matures very early and is less palatable thereafter than perennial grasses (Cook and Harris 1952). Needleandthread grass yielded low zinc levels, with all seasons below the nutrient requirement range. The zinc content of the other grasses showed levels below or in the lower part of the dietary range.

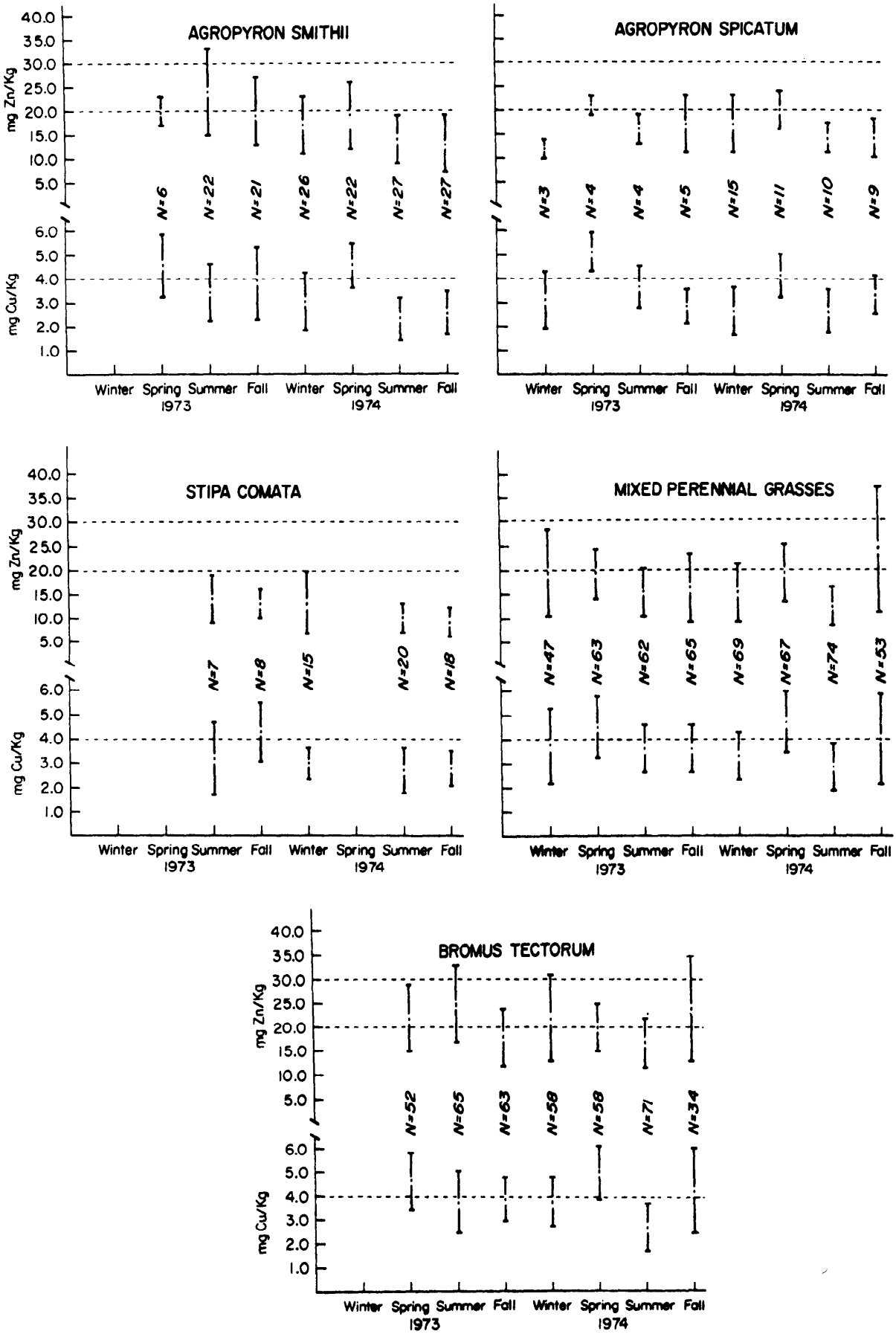

Fig. 1. *Zinc and copper concentration of five range grasses. Dashed lines represent minimum dietary level on range. Vertical lines represent* ± 1 S.D., means indicated by mid point.

When seasons were combined, that is both spring zinc levels versus all summer and all fall zinc levels, elemental concentrations in spring collections of bluebunch wheatgrass were significantly higher ($P=0.01$) than summer, fall, and winter levels. The zinc content of the mixed perennial grasses showed highest levels in both spring and fall samples while the other grasses showed no significant seasonal changes.

When these data were viewed on the basis of individual seasons for each species, there is a marked consistency in spring-to-spring zinc levels. Summer, fall, and winter averages, on the other hand, exhibited wide fluctuations. For example, western wheatgrass showed spring zinc concentrations of 20 and 19 mg/kg but summer concentrations of 24 and 14 mg/kg and fall levels of 20 and 13 mg/kg.

Copper

The National Research Council has established a nutrient requirement of 4 mg/kg of copper in the dry diet for beef cattle. The average copper value for all grasses in this study (Table 2) was 3.6 ± 0.8 mg/kg. Average, seasonal copper concentrations in the grasses analyzed in this study were below the NRC minimum level in 24 out of 35 collections. Needleandthread grass (Fig. 1) yielded the lowest copper concentrations with only samples collected in the fall of 1973 having an average above the minimum dietary requirement. When seasons were combined, spring grasses exhibited maximum copper values with a general trend of decreasing content as the plants matured. This is clearly shown in bluebunch wheatgrass and the mixed perennial grasses. Both grasses have significantly higher ($P=0.01$) copper levels in spring samples.

When the data were analyzed by species on a seasonal basis, copper concentrations were most consistent in spring samples. Elemental levels in summer and fall showed wide variations, similar to those found in zinc concentrations. Copper levels in spring collections of western wheatgrass were 4.5 mg/kg for both years of the study. Summer levels in this species were 3.5 and 2.3 while fall samples showed concentrations of 3.9 and 2.5 mg/kg.

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