Mineral Element Levels in Saskatchewan Moose Hair

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Abstract

Hair samples from 459 moose *(Alces alces andersoni)* in Saskatchewan were analyzed to determine concentrations of Ca, K, Na, Mg, Fe, Pb, Cu, Se, Mo, Mn, Co, and Hg. Regional seasonal and annual variations in levels of the mineral elements were documented. Peak levels for most elements were observed during the early winter period and low levels generally occurred in spring. Samples from two of the six areas investigated had significantly lower levels ($P<0.05$) of three of the four macro-elements (Ca, Na, K, and Mg). In addition, the Mn levels in all areas were well below the suggested low limit for normal cattle hair, and only one region was above the low limit suggested for iron. However, clinical symptoms associated with individual element deficiencies have not been reported.

Although the role of mineral elements in human and animal nutrition has been the subject of many research investigations in recent years (Miller and Neathery 1977), the elemental requirements of free ranging wild ungulates have not been well documented. Alaskan researchers (Franzmann et al. 1975) have established considerable baseline data on hair elemental levels for Alaskan moose *(Alces alces gigas)* and have obtained a general knowledge of regional, seasonal and annual variability in the concentrations of several mineral elements in moose hair.

In addition, Flynn et al. (1977) described hoof growth abnormalities observed among moose inhabiting an area of the Kenai Penninsula, Alaska, and reported reduced copper levels in both hair and browse samples.

Although moose *(Alces alces andersoni)* in Saskatchewan are not known or suspected to be subject to any specific elemental toxicity or deficiency, some regions of the provincial moose range are known to be superior to others in both habitat quality and moose density estimates. The purpose of this investigation was to:

1) contribute to a baseline data bank for elemental levels in moose, and to obtain information for Saskatchewan animals in particular;
2) compare elemental levels for moose from different geographical and vegetative communities within the province; and
3) screen the Saskatchewan moose population to determine whether or not any specific mineral element problems exist.

METHODS

Hair samples were obtained from 430 hunter-killed moose during the 1975 hunting season, 12 animals collected during a condition assessment study in April 1974, and 17 animals handled during a tagging operation in March 1976.

Hunters were requested to remove hair samples from the shoulder hump area of harvested animals. However, the follicle was not available in all cases as some hunters did not pluck the hair sample; those samples not plucked were cut flush with the hide so that the first 0.5 - 1.0 cm of hair was missing. It was assumed for this investigation that all sam-

ples contained 2.0 cm of the proximal 3.0 cm of hair growth and thus reflected mineral uptake of the previous two or three months (Flynn et al. 1974).

Samples were prepared and analyzed at the Department of Surgery, Cleveland Metropolitan General Hospital, Case Western Reserve University School of Medicine, Cleveland, Ohio, according to the technique (atomic adsorption spectrophotometry) described by Franzmann et al. (1976). Concentrations were determined for Ca, K, Na, Mg, Cu, Fe, Mn, Zn, Co, Mo, Hg, Se, and Pb, all recorded in parts per million (ppm).

The samples were segregated and compared by region, month, and year to determine the extent of geographical, seasonal and annual variability in mineral element concentrations. Statistical comparisons used a Student's "t" test at the 95% level (Steel and Torrie 1960).

STUDY AREA

Each moose hair sample was allotted to one of six regions within the province (Fig. 1). Each region encompassed one or more game management zones except for Region 1 which included only Moose Mountain Provincial Park. Regions 2 through 6 comprise the major portion of the mixedwood section of the Saskatchewan forest (described by Kabzems et al. 1976); Region 1, Moose Mountain Provincial Park, is a 225 km^2 island of aspen forest in the broad ecological zone designated as aspen parkland.

The five broad regions within the mixedwood forest section roughly follow the boundaries of the grey-wooded soil zone in the province (Ellis and Clayton 1970), but the dominant cover types of the areas are quite different (Fig. 2). Both Regions 2 and 3 have similar proportions of

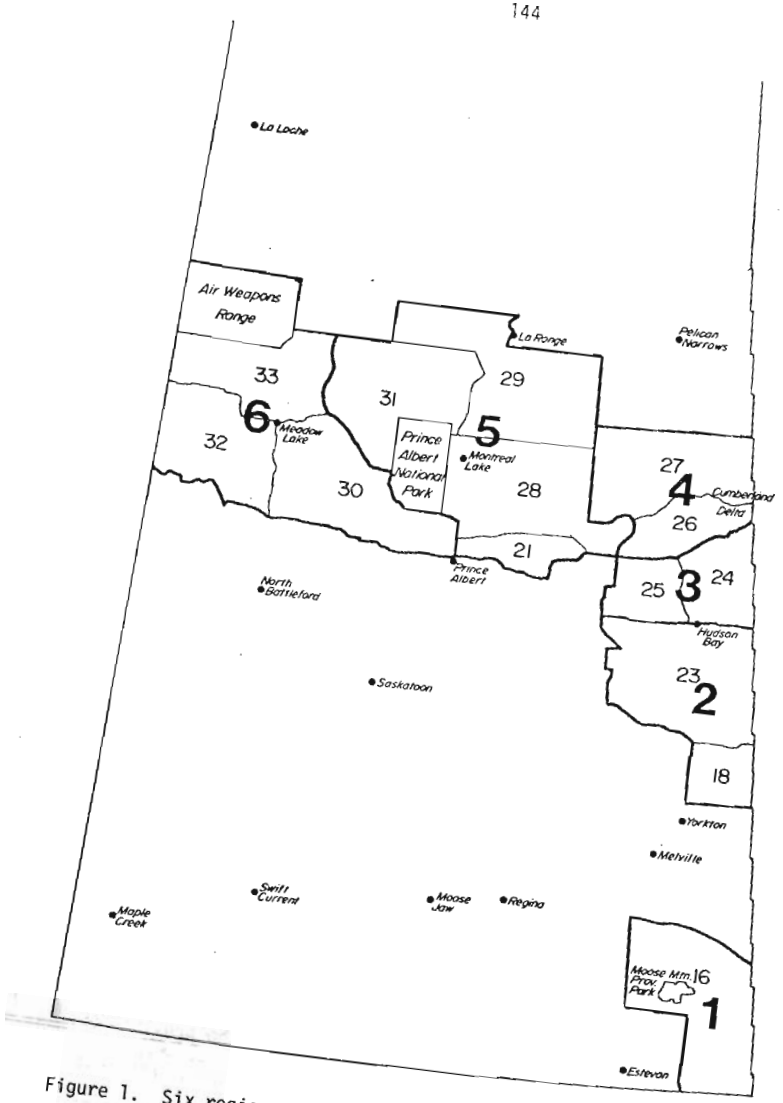

Figure 1. Six regions of Saskatchewan from which moose hair samples were taken.

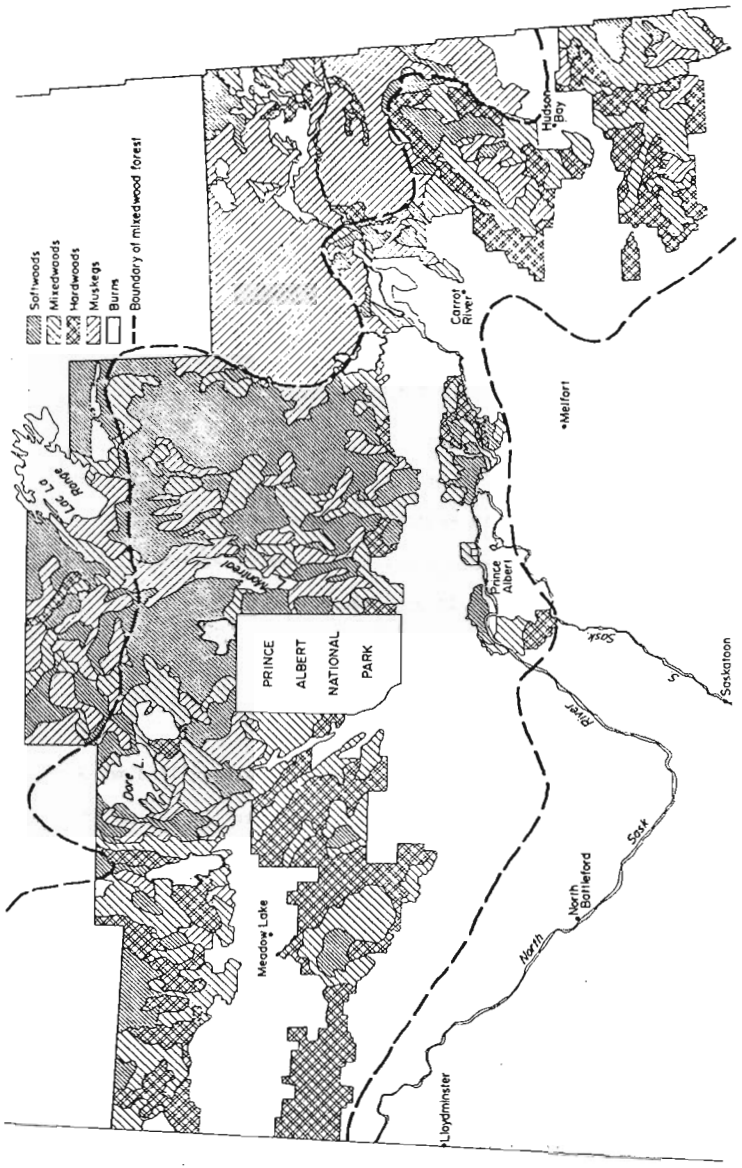

Figure 2. Forest cover types of the mixedwood section of the Saskatchewan provincial forest.

hardwood, softwood, and mixedwood stands in the forested portions, but the Pasquia Hills section (Region 3) has a large component of organic bog as well. The fourth region, the Cumberland Delta, is dominated by bogs and water bodies relative to large stands of forest. The central portion of the mixedwood forest (Region 5) has a large softwood and mixedwood component with few, small, isolated hardwood stands. Conversely, the forests on the west side of the province (Region 6) are characterized by large hardwood stands and infrequent areas of softwood.

MOOSE POPULATION DENSITIES

The long term average density estimates for each of the six regions vary from 0.21 moose/km^2 in Region 5 to 0.68 moose/km^2 in the Cumberland Delta. The respective estimates for each of Regions 1, 2, 4, and 6 were 0.27, 0.45, 0.40 and 0.40 moose/km^2.

RESULTS AND DISCUSSION

Hair mineral element levels determined for hunter-killed moose collected in the September 22 - October 11 and November 10 - December 6, 1975 hunting season are presented in Tables 1 and 2 respectively. The results for samples collected from animals handled April 8-9, 1974 and March 10-12, 1976 are presented in Table 3.

Franzmann et al. (1976) reviewed the literature pertaining to the low limits of several mineral elements for normal cattle hair. In the data for Saskatchewan moose, peak elemental levels were not observed below the low limits for normal cattle hair of Ca (300 ppm), Mg (100 ppm),

Table 1. Moose hair elemental levels ($\bar{X}$ ppm ± 1S.D.) for three regions in Saskatchewan, September-October, 1975.

Region (n)	Zn	Cu	Ca	Mg	K	Na	Co	Fe	Pb	Mn	Se	Mo	Hg
3(44)	121.18 ±44.29	10.55 ±4.35	1399.77 ±577.86	181.71 ±71.27	2052.27 ±1355.17	1709.32 ±1417.70	0.148 ±0.102	33.80 ±30.49	13.16 ±10.84	0.834 ±0.581	1.739 ±0.581	0.761 ±0.345	0.070 ±0.029
4(22)	108.46 ±10.64	11.77 ±4.18	1256.36 ±463.33	152.73 ±55.80	2256.81 ± 1303.93	1780.00 ±1209.36	0.067 ±0.073	25.73 ±21.78	2.41 ±4.94	0.663 ±0.331	1.614 ±0.677	0.650 ±0.215	0.075 ±0.031
5(128)	105.86 ±18.39	12.76 ±6.92	955.55 ±406.68	115.66 ±50.66	1852.73 ±1009.55	1403.05 ±852.41	0.167 ±0.095	28.95 ±22.50	11.46 ±12.28	0.822 ±0.433	1.830 ±0.616	0.684 ±0.318	0.071 ±0.026

Table 2. Moose hair elemental levels ($\bar{X}$ ppm ± 1S.D.) for six regions in Saskatchewan, November-December, 1975.

Region (n)	Zn	Cu	Ca	Mg	K	Na	Co	Fe	Pb	Mn	Se	Mo	Hg
1(46)	99.76 ±24.26	28.37 ±5.97	1147.39 ±550.97	254.67 ±149.76	1677.17 ±614.04	1474.35 ±415.11	0.133 ±0.125	39.13 ±24.03	14.41 ±7.26	0.425 ±0.369	1.563 ±0.604	0.791 ±0.351	0.0[illegible] ±0.037
2(75)	106.21 ±33.65	23.06 ±7.20	1526.00 ±616.09	170.93 ±55.85	2149.07 ±1324.00	1713.20 ±852.05	0.195 ±0.167	30.68 ±21.94	19.69 ±5.96	0.769 ±0.480	1.668 ±0.634	0.761 ±0.368	0.080 ±0.033
3(18)	112.17 ±16.08	24.17 ±7.45	1793.89 ±616.86	187.33 ±56.23	2248.33 ±1287.36	1715.00 ±563.73	0.140 ±0.205	28.39 ±13.46	19.89 ±5.85	1.143 ±0.637	1.894 ±0.732	0.722 ±0.332	0.093 ±0.090
4(32)	90.84 ±22.78	26.50 ±6.62	1390.94 ±850.76	159.69 ±72.57	2303.13 ±1519.11	1770.31 ±914.34	0.329 ±0.268	31.59 ±13.36	17.16 ±5.69	0.694 ±0.693	1.603 ±0.584	0.784 ±0.378	0.080 ±0.033
5(33)	112.76 ±8.54	23.91 ±7.21	1020.30 ±334.49	131.52 ±43.99	1460.30 ±588.46	1301.21 ±464.05	0.139 ±0.111	27.76 ±15.40	18.30 ±3.89	0.928 ±0.482	2.397 ±0.855	0.815 ±0.345	0.090 ±0.049
6(32)	113.59 ±12.02	29.06 ±3.10	1267.50 ±688.87	157.50 ±87.43	1996.87 ±655.64	1731.25 ±771.75	0.117 ±0.046	24.69 ±11.59	18.03 ±5.65	0.505 ±0.369	1.728 ±0.469	0.519 ±0.233	0.100 ±0.051

Table 3. Elemental hair levels (X ppm ± 1 S.D.) for moose from Region 3 and Region 4, spring 1974 and 1976).

April 8-9, 1974	Zn	Cu	Ca	Mg	K	Na	Co	Fe	Pb	Mn	Se	Mo	Hg
Region 3 (calves & females only, n = 6)	101.05 ±6.17	14.01 ±1.27	188.37 ±67.23	75.93 ±17.92	362.47 ±72.52	423.48 ±50.91	0.450 ±0.137	39.12 ±10.97	N.A.	0.320 ±0.420	1.35 ±0.62	<0.01	0.100 ±0.020
Region 4 (calves & females only, n = 6)	98.83 ±7.63	15.06 ±1.18	211.95 ±67.44	95.61 ±26.86	506.92 ±267.22	590.07 ±91.18	0.433 ±0.216	34.70 ±11.00	N.A.	1.171 ±0.463	1.00 ±0.35	<0.01	0.135 ±0.042
March 10-12, 1976													
Region 4 (Calves & females only, n = 10)	98.10 ±13.90	13.60 ±4.14	447.50 ±475.07	101.50 ±34.24	2021.00 ±663.21	1082.00 ±556.76	0.229 ±0.027	44.88 ±18.64	15.60 ±4.22	0.400 ±0.110	1.30 ±0.22	0.870 ±0.189	0.069 ±0.021
Region 4 (all sex & age, n = 17)	105.05 ±17.58	14.29 ±3.29	497.50 ±166.90	105.58 ±36.09	2002.94 ±668.87	940.59 ±456.58	0.235 ±0.029	44.53 ±14.32	18.53 ±8.43	0.440 ±0.132	1.22 ±0.20	0.862 ±0.178	0.070 ±0.020

K (350 ppm), Na (175 ppm), Zn (75 ppm) and Cu (8.5 ppm). Manganese levels from moose in Saskatchewan were, in all cases observed, below the low limit suggested for cattle (7 ppm). The highest Mn level recorded in the province was only 1.143 ppm. In the Alaskan studies, Mn concentrations appeared to peak during the October-December period, and in some cases were below 7 ppm (Franzmann and Bailey 1977); the average October level was 5.92 ppm. Franzmann et al. (1975) reviewed Underwood's (1971) work on symptoms associated with mineral element deficiencies in domestic animals. Impaired estrus and conception, weakness and impaired growth, and ataxia of new-born are three indicators of an Mn deficiency. The suggested low limit for Fe in cattle hair is 40 ppm and low Fe is associated with anemia, weight loss, listlessness and gastritis in domestic animals. The March 10-12, 1976 Cumberland Delta moose hair sample was the only Fe level to exceed this value.

Clinical symptoms of either deficiency have not been reported for moose in Saskatchewan, and the lower levels reported for moose may simply represent a species difference with domestic cattle.

Regional variation was evident when samples from the same month and year were compared (Tables 4-5). For the September-October 1975 collection, levels of the four macro-elements were found to be significantly lower in the hair of moose from Region 5. The concentration of lead was low in the early season sample from the Cumberland Delta, but few significant differences were evident for Pb between regions during the November-December period. Extreme fluctuation between months for levels of lead was observed in Alaska as well (Franzmann et al. 1976).

For the November-December 1975 period, Region 5 moose had the lowest observed levels of each of the macro-elements (Ca, Na, Mg, K);

Table 4. Significance table (P<0.05) of elemental levels for moose hair collected September - October, 1975.

Region	3	4	5
3	-	Ca, Mg, K, Pb	Ca, Mg, K, Na,
4	-	-	Ca, Mg, K, Na, Pb

Table 5. Significance table (P<0.05) of elemental levels for moose hair collected November-December 1975.

Region	1	2	3	4	5	6
1	-	Ca, Mg, K, Na, Cu, Co, Pb, Mn, Hg	Ca, Mg, Cu, Pb, Mn, Zn	Mg, K, Co	Mg, Cu, Pb, Mn, Se, Zn	Mg, K, Pb, Mo, Zn
2	-	-	Mn	Cu, Co, Pb, Zn	Ca, Mg, K, Na, Co, Se	Mn, Mo, Hg, Cu, Co
3	-	-	-	Mn, Zn	Ca, Mn, K, Na, Se	Ca, Cu, Mn, Pb
4	-	-	-	-	Ca, K, Na, Co, Se, Zn	Cu, Co, Fe, Ni, Zn
5	-	-	-	-	-	Ca, K, Na, Cu, Mn, Se, Mo

Ca, Na, and K levels were statistically different from all other populations except those from Moose Mountain Provincial Park. The levels of Mg from moose in the Park, Co from animals inhabiting the Cumberland Delta, and Se from Region 5 animals were each significantly higher than levels recorded for the other Regions in the province. Low levels of Mo on the west side of the province and Pb in Region 1 were observed. Significant differences were recorded for Na, Mn, and Hg between animals collected from the Porcupine Forest (Region 3) and those from the Cumberland Delta (Region 4) in April 1974.

A general trend of broad seasonal cycling of mineral elements was plotted for hair samples originating from the Cumberland Delta (Fig. 3). Peak values for Mg, K, Na, Ca, Cu, Pb, Se, and Co were observed in early winter. Copper, Ca, Mg, Na and Se were significantly higher ($P<0.05$) in November-December 1975 than they were in March 1976. The extent of the annual cycling does not, however, appear to be static. The winter of 1973-74 was one of the most severe reported in Saskatchewan while the winter of 1975-76 was extremely mild (Stewart et al. 1977). Levels of three macro-elements, Ca, K, and Na were significantly higher following the mild winter, while Hg and Mn were lower ($P<0.05$). The collections from the two years were from April in 1974 and March in 1976. Franzmann and Bailey (1977) reported levels of Co, Mo, Se and Hg to be most susceptible to changes between March and April; the macro-elements appeared to be stable. The severe 1973-74 winter may, therefore, have contributed to the significant declines in the three macro-elements and may be indicative of lowered animal intake of these elements.

The fall mineral element peaks appear to be related to stages in plant phenology. Kubota (1974) observed higher levels of P, S, Ca

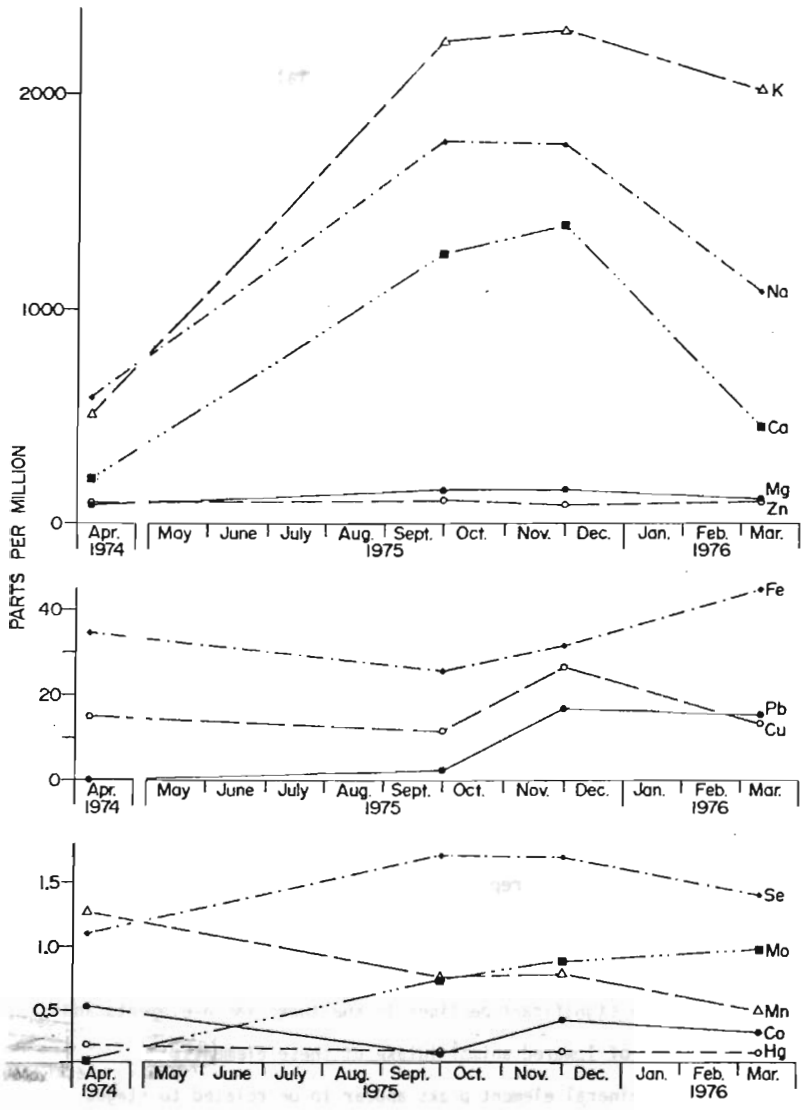

Figure 3. Seasonal changes for elemental levels in moose hair from Cumberland Delta (Region 4) animals.

and K in leaves than in current growth of twigs. He also reported on studies which demonstrated further increases in Ca concentrations as leaves matured. Higher mineral element levels recorded in early winter therefore likely reflect a higher plane of mineral nutrition in the summer and early fall.

Stewart et al. (1977), in their study of the relationship between plant phenology and moose, reported a major decline in calving success on the Cumberland Delta following the severe 1973-74 winter. The severe winter and late leaf flush (15 days later than average) recorded that spring were hypothesized as being possible limiting factors to productivity that year. Low levels of macro-element concentrations in April 1974 lead to the question of whether or not mineral metabolism significantly influenced physiological processes that spring.

CONCLUSIONS

The accumulation of data on mineral element concentrations in the hair of Saskatchewan moose has contributed to the baseline knowledge for the province. The existence of regional and seasonal variability has been established here as it was in Alaska. In addition, a general screening of moose for any potential deficiencies or toxicities was possible. The levels of Mn and Fe were both below low limits for normal cattle hair, and below the levels reported for Alaskan moose. However, clinical symptoms associated with deficiencies in other species have not been documented for moose in Saskatchewan.

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