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Analysis of Cadmium, Mercury and Other Elements in Mackenzie Valley Moose Tissues Collected from 2005 to 2016

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ABSTRACT

Thirty-five elements, including cadmium (Cd) and mercury (Hg), were analyzed in kidney, liver and muscle collected from moose (*Alces americanus*) harvested in the Mackenzie River Valley in the Dehcho region of the NWT between 2005 and 2016. Most of the moose were judged to be of good or excellent body condition at the time of harvest, which was later confirmed from kidney fat and bone marrow analysis. Tissues were analyzed in two phases (2005-2007 and 2011-2016), which allowed for limited testing for changes in tissue concentrations with time. The effects of sex and age were analyzed statistically for 18 elements. Due to large differences in moisture content between 2007 and 2016, all statistical tests were conducted on a dry weight (dw) basis.

Tissue concentrations varied significantly between sexes for manganese (Mn), molybdenum (Mo) and zinc (Zn), and increased with age for Cd, Mo and Zn. Total mercury did not change with age ($p>0.05$). The mean Cd concentration for all kidney samples ($n=81$) was 20.8 mg/kg wet weight (ww)(range = 0.21 – 222 mg/kg ww) , which was lower than moose in Alaska, Yukon and in the southern Mackenzie Mountains (mean 222.5, range 8.9 - 624 mg/kg ww) (Larter and Kandola 2010). Three individuals exceeded 150 mg/kg ww. Cd concentration in kidney increased significantly with age and there was a strong correlation between kidney and liver, and kidney and muscle in matched samples collected from the same moose.

Total Hg concentration in kidney and liver remained low, and has been shown to be lower than in other large mammals in the NWT, even though there is a potential for intake of Hg in moose through aquatic macrophytes. Moose tissues are considered to be a minor source of mercury to consumers. Copper (Cu), an essential element that may be associated with a number of diseases when deficient in the diet, remained at levels consistent with other populations of moose and there is no evidence of deficiency in this population. The study

concluded that there is no immediate concern for the concentrations of elements in moose in this Dehcho moose population; however due to demonstrated accumulation of metals such as Cd, its links to wildlife disease and potential impacts on human health, the monitoring of moose tissues should continue.

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INTRODUCTION

Chemical contaminants and naturally-occurring elements have been monitored in moose in the Dehcho region of the Northwest Territories (NWT) since 2005 as part of a continuing program to evaluate moose abundance and health (Larter 2009; Larter et al. 2017). Moose are an important traditional food for residents of the Dehcho (Van Oostdam et al. 2005) and the presence of potentially toxic elements, such as cadmium and mercury, may lead to enhanced levels of exposure in the consumers of moose organs. The monitoring program was designed in part to provide Dehcho residents advice on the levels of contaminants in a major traditional food species (Larter 2009).

Cadmium (Cd) has been identified in several studies as a contaminant of concern found in moose tissues in the NWT (Larter and Kandola 2010) and Yukon (YK) (Gamberg et al. 2005a), although not in meat. Significantly elevated levels of cadmium in moose kidney in the southern Mackenzie Mountains, attributed to natural mineralization of soils and enhanced uptake by some plants in the moose diet (Reimann et al. 2015, Larter et al. 2016), has led to advisories from Government of the Northwest Territories (GNWT) Health and Social Services to limit the consumption of moose kidneys from that area (Larter and Kandola 2010). The advisory was renewed in 2017, and a consumption limit of 56 g of liver or 37 g of kidney per month of moose organs from that region was recommended (GNWT-HSS 2017). Lower Cd concentrations in moose kidney and liver in Alaska led to the conclusions that Cd intake would remain below recommended weekly intake levels, and the consumption of moose was encouraged due to its nutritional benefits (Arnold et al. 2006). Cd is a nephrotoxin and a dietary intake in excess of 30 µg/d in humans is expected to cause kidney dysfunction in about 1% of the population (Satarug et al. 2000). Contaminants with documented adverse health effects in terrestrial wildlife include Cd (Outridge et al. 1994), mercury (Hg) (Thompson 1996), and lead (Pb) (Ma 1996) and can

lead to a loss of confidence in traditional foods that provide nutritional and social benefits (McAuley and Knopper 2011).

In addition to the potential adverse health effects from elements like Cd, questions remain regarding the optimal nutritional requirements in moose for other elements. Seasonal changes in resource use (McLoughlin et al. 2011) and plant growth (Brekken and Steinnes 2004, Deram et al. 2006) may result in nutritional deficiencies that could affect overall health and productivity. Deficiencies in copper (Cu) and selenium (Se) were found in a declining population of moose in Minnesota although it was concluded that the deficiencies were unlikely the proximal cause of disease and mortality (Murray et al. 2006). Management of domesticated red deer has shown that diets are usually deficient in Cu, cobalt (Co), Se and iodine (I), and require supplementation for improved growth and to reduce clinical signs of deficiency (Grace and Wilson 2002).

Relatively inexpensive technology now allows organs to be analyzed for over 30 elements to allow rapid screening of potential contaminants and to establish natural levels and variability of elements in wild moose populations. The collection of body condition, sex and age at the time of harvest help to determine the influence of these factors on contaminant concentrations (Mochizuki et al. 2008). Long-term monitoring programs also allow for testing the data for temporal trends (Gamberg et al. 2005b), and changes that might occur under the influence of a changing climate.

The objective of the present study is to report the results of chemical analysis from the Dehcho moose monitoring program from 2005-2016. Tissues were analyzed for 35 elements at two separate times, 2007 and 2016, which allows for limited testing of temporal trends for individual elements. Factors, such as season of harvest, sex and age of the moose have been reported in other studies to have a significant influence on the concentrations of some elements will be tested to determine their influence in the Dehcho

moose data set. Comparison of concentrations in matched kidney-liver and kidney-muscle samples (i.e., organs collected from the same moose) help to better define and improve predictions of elemental concentrations between organs.

MATERIALS AND METHODS

Sample Collection

Tissue samples (kidney, liver and muscle) were collected opportunistically from resident and Indigenous hunters in the Dehcho region of the NWT between 2005 and 2016. Dates of collection, body condition, reproductive status and sample IDs are presented in Appendix A.

A first incisor tooth was collected from most moose and aged following standard protocols at Matson's Laboratory in Milltown, MT (Matson 1981). Aging was conducted by cementum analysis. Tissue samples were processed following Larter and Kandola (2010). Briefly, the fat and capsule was peeled from the kidney, it was cut bilaterally, rinsed with distilled water and one half was kept frozen in a ziplock bag prior to forwarding to the lab. Liver and muscle tissue samples were trimmed to ≤300g wet weight, rinsed with distilled water and kept frozen in a whirl-pac bag prior to forwarding to the lab.

Multi-element Analysis

Tissue samples were analyzed at the National Laboratory for Environmental Testing (NLET) in Burlington, ON (Environment Canada 2015) using methods similar to those reported in Larter et al. (2016). For multi-element analysis, subsampled tissues (*ca*. 0.5 g) were digested in a 120 mL TFM (a tetrafluoroalkoxy resin-based material) digestion vessel using an 8:1 ratio of nitric acid and hydrogen peroxide and analyzed for thirty-four elements by inductively coupled plasma-sector field spectrometry (NLET Method 2705). The elements analyzed in 2007 and 2015/2016 are listed in Table 1, with the respective detection limits (DLs). Boron (B), calcium (Ca) and magnesium (Mg) were not reported in the 2007 results.

Table 1. List of elements and detection limits (DLs) analyzed in moose tissues in the 2007 and 2016 analyses, reported in wet weight (ww).

Element	DL (mg/kg ww)	Element	DL (mg/kg ww)
Aluminum (Al)	0.02	**Magnesium* (Mg)**	0.1
Antimony (Sb)	0.001	**Manganese (Mn)**	0.005
Arsenic (As)	0.002	**Mercury (Hg)**	0.002
Boron* (B)	0.05	**Molybdenum (Mo)**	0.001
Barium (Ba)	0.005	**Nickel (Ni)**	0.005
Beryllium (Be)	0.0001	**Palladium (Pd)**	0.01
Bismuth (Bi)	0.0001	**Platinum (Pt)**	0.001
Cadmium (Cd)	0.0001	**Potassium (K)**	0.2
Calcium* (Ca)	0.2	**Rubidium (Rb)**	0.001
Cesium (Cs)	0.0005	**Selenium (Se)**	0.01
Chromium (Cr)	0.001	**Silver (Ag)**	0.0001
Cobalt (Co)	0.0002	**Strontium (Sr)**	0.005
Copper (Cu)	0.01	**Thallium (Tl)**	0.0001
Gallium (Ga)	0.0001	**Tin (Sn)**	0.01
Iron (Fe)	0.05	**Uranium (U)**	0.0001
Lanthanum (La)	0.0001	**Vanadium (V)**	0.001
Lead (Pb)	0.001	**Zinc (Zn)**	0.01
Lithium (Li)	0.01		

* - elements not reported in the 2007 data

Analytical accuracy and recovery rates were confirmed using certified reference tissues from the National Research Council of Canada. Mean recoveries for the certified values were 89-96% for DOLT-4 (dogfish liver), 84 to 98% for DORM-2 (dogfish muscle) and 97.1-104.7% for TORT-2 (lobster hepatopancreas). Recoveries ranged from 90-105%. The NLET laboratory is certified by the Canadian Association for Laboratory Accreditation (CALA) and actively participates in inter-laboratory comparison programs through the Northern Contaminants Program at Indigenous and Northern Affairs Canada.

Data Analysis

Concentration data were analyzed using Systat 11.00.01 (Systat Software, Chicago, IL). Statistical comparisons were made on a dry weight (dw) basis, converted from wet weight

(ww) basis using sample specific moisture content, or using log transformed dw to maintain normality. Normality of data sets was checked using the Shapiro-Wilks normality test and examination of residuals. Tissue elemental concentrations are reported as arithmetic means, with standard deviation (SD), in accordance with Health Canada (2010) recommendations for human health risk assessment. For values below the detection limit (DL) we used a value of ½ the DL in order to calculate means where >50% of the samples were above the DL. Sample sets with ≥50% of the samples below the DL are summarized as <DL.

RESULTS

Harvest Dates and Ages

Elemental data are available from a total of 157 tissues collected from 81 moose harvested in the Mackenzie Valley between January 2005 and January 2016. Organs were analyzed for elemental composition from two sampling periods; 2005-2007 (termed "2007") and 2011-2016 (termed "2016"). Harvest dates for the 81 moose were distributed throughout the year but showed greater numbers in April and late September in the 2007 analysis (Figure 1). The majority of the moose in the 2016 group were harvested in the fall (September-October).

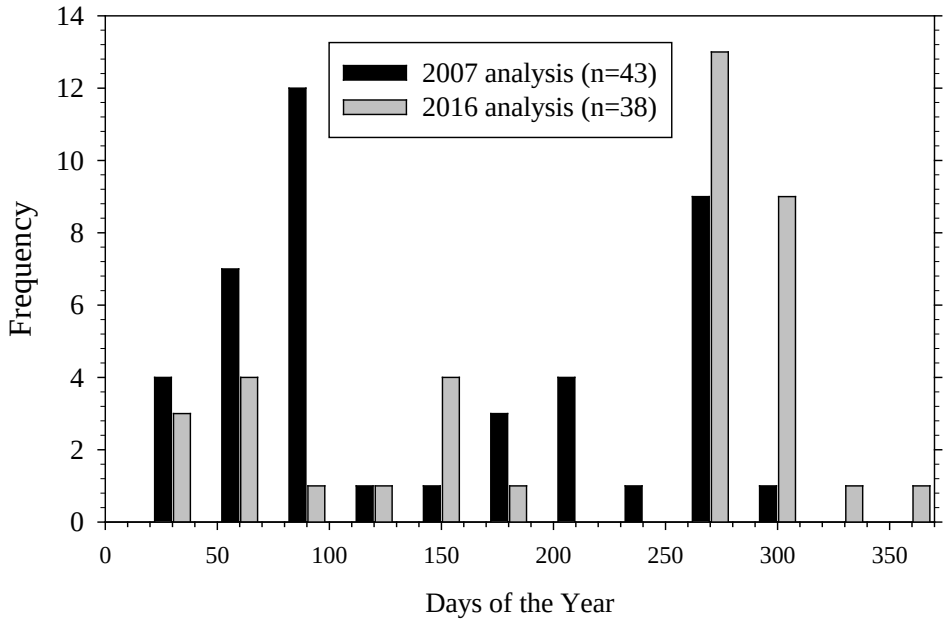

Figure 1. Distribution of dates of harvest through the year for the moose collected in 2005-2007 (2007 analysis) and 2011-2016 (2016 analysis).

Data on sex, body condition, kidney fat and reproductive status of females is summarized for the two blocks of analysis (2005-2007 and 2011-2016) in Table 2. Visual assessments by harvesters at the time of harvest in both time periods indicated good or excellent

condition in most moose and none were in poor condition. Both sample sets were dominated by males. The range of ages was greater in the 2007 samples.

Table 2. Summary of ages, pregnancy rates and indicators of body condition for moose with tissues analyzed in 2007 and 2016: n is sample size, value is age range in years, and body condition based upon visual assessment by harvester.

Measurement	2005-2007				2011-2016			
	Females		Males		Females		Males	
	n	Value	n	Value	n	Value	n	Value
Age Range (y)	**15**	**0-12**	**28**	**0-12.5**	**10**	**1-10**	**26**	**1-6**
Pregnancy	14	5–not pregnant 9–pregnant	-	-	8	5–not pregnant 3–pregnant	-	-
Lactating	14	14–not lactating	-	-	8	7–not lactating 1–lactating	-	-
Harvest Month (1-12)	15	1-9	28	1-10	10	1-10	28	1-10
Body Condition	15	5–excellent 8–good 2–fair	28	7–excellent 7–good 4–fair	9	6–excellent 3–good	26	18–excellent 5–good 3-fair
Kidney Fat Index*	11	Mean=52.1 (SD=36.8)	25	Mean=50.0 (SD=41.1)		-		-
Marrow (% fat)	13	Mean=72.6 (SD=13.5)	25	Mean=68.8 (SD=23.1)	10	Mean=88.6 (SD=5.7)	24	Mean=73.3 (SD=21.9)

Kidney Fat Index = Kidney fat/Kidney weight x 100 (Larter 2009).

Tissues collected in 2007 include roughly the same number of kidney samples from males as in the 2016 analysis. A larger number of liver and kidney samples were collected in 2007 than 2016 (Table 3). The 2016 data set also includes muscle samples from 11 males and three females, while matched kidney and muscle samples from two moose were available in the 2007 collection.

Table 3. Number of aged individuals and tissues available for multi-element analysis in the two sampling periods, 2007 and 2016.

Year	Male				Female			
	Aged	Muscle	Liver	Kidney	Aged	Muscle	Liver	Kidney
2007	28	-	26	28	15	-	14	15
2016	26	12	15	28	10	4	5	10

Ages were available from a total of 79 individual moose (Table 3). The range of ages was 0 to 12 years for the 2005-2007 set of moose samples, with a mean age of 4.3 (SD=3.5, n=43) years. The range of ages was 0 to 10 years for the 2011-2016 set of moose samples, with mean age of 2.9 (SD=2.3, n=36) years. Distribution of ages within the two harvest times indicates that the 2005-2007 collection contained several older animals, including those of six year, and three exceeding ten years (Figure 2). In contrast, the 2011-2016 collection was dominated by one and two- year old animals. ANOVA reported that the age of females was greater than males ($p<0.01$) and the mean age of the 2011-2016 collection was significantly lower ($p<0.01$) than the 2005-2007 collection.

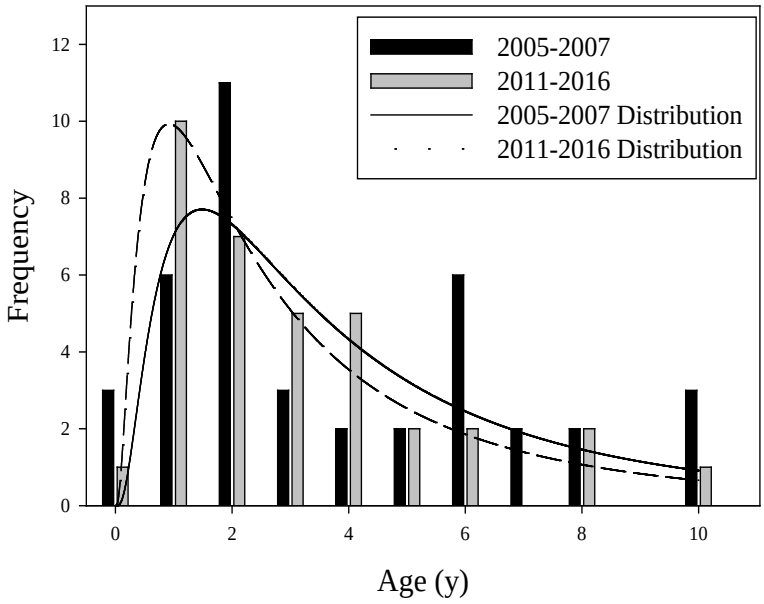

Figure 2. Distribution of ages for the moose harvested from 2005-2007 and 2011-2016. Distributions are fit with a logarithmic distribution.

Multi-element Analysis

Summarized concentration data for moose samples collected in 2005-2007 and 2011-2016 are presented in Tables 4-9. Raw data for individual samples are presented in Appendix B.

Data above DLs were available for 29 out of the 35 elements reported for each sample. Calcium (Ca), boron (B) and magnesium (Mg) were not reported in the analyses conducted in 2007. Beryllium (Be), bismuth (Bi), lead (Pd), platinum (Pt), Tin (Sn) and uranium (U) were below detection in a large proportion of samples (>90%) and no further statistical analysis was conducted with these elements.

Analysis of covariance (ANCOVA) using time of analysis (2007 vs. 2016), sex and tissue (kidney and liver) as factors, and age as a covariate, was conducted on the remaining 18 elements (Table 10). No difference ($p>0.05$) was observed between sexes for all elements, with the exception of manganese (Mn) and molybdenum (Mo). For both those elements, concentrations were higher in females than males. Similarly, elements generally did not increase with age ($p>0.05$), except for Ca ($P<0.001$), Mo ($P<0.05$) and Zn ($P<0.001$).

There was no significant difference in tissue moisture between males and females, although there were large differences between tissues and years of analysis. Liver moisture was relatively constant 66.4% and 66.3% respectively in 2007 and 2016, however kidney moisture was significantly lower in 2007 (70.5%) than in 2016 (78.7%). Due to the large differences in tissue moisture, all concentrations were compared on a dw basis, usually following a log transformation.

Table 4. Mean, SD, minimum and maximum values summarized for moose kidney harvested in 2005-2007. Concentration is in mg/kg ww, n/a is not analyzed.

Element	Sampling Year 2005, 2006 and 2007							
	Kidney							
	Female (n=15)				Male (n=28)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Age (y)	5.6	3.87	0	12	3.64	3.13	0	12.5
Moisture (%)	71.0	7.0	59.7	82.9	70.3	7.00	57.6	80.0
Aluminum	0.041	0.042	0.01	0.130	0.07	0.12	<0.02	0.61
Antimony	<0.001	-	<0.001	0.008	<0.001	-	<0.001	5.84
Arsenic	0.007	0.017	<0.002	0.069	0.011	0.019	<0.001	0.072
Barium	0.302	0.174	0.108	0.841	0.240	0.117	0.068	0.601
Beryllium	<0.0001	-	<0.0001	0.0001	<0.0001	-	<0.0001	0.0004
Bismuth	<0.0001	-	<0.0001	<0.0001	<0.0001	-	<0.0001	0.0451
Cadmium	17.1	13.5	0.2130	48.7	32.0	57.4	0.737	222
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.012	0.011	0.001	0.046	0.018	0.023	0.001	0.085
Chromium	0.096	0.301	<0.001	1.140	0.011	0.012	<0.001	0.048
Cobalt	0.052	0.031	0.016	0.133	0.051	0.020	0.026	0.096
Copper	3.72	0.626	2.45	5.18	3.73	0.60	2.47	4.87
Gallium	0.001	0.003	<0.0001	0.007	<0.0001	-	<0.0001	0.0074
Iron	44.9	11.5	30.7	64.4	43.5	11.7	24.1	66.7
Lanthanum	<0.0001	-	<0.0001	0.0001	<0.0001	-	<0.0001	0.0007
Lead	0.019	0.050	0.001	0.196	15.6	82.0	0.0005	434 [1]
Lithium	0.026	0.028	<0.01	0.110	0.032	0.050	<0.01	0.24
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	2.97	0.858	0.748	4.370	2.63	0.85	0.80	4.1
Mercury	0.028	0.018	0.010	0.058	0.034	0.028	0.007	0.157
Molybdenum	0.351	0.109	0.168	0.492	0.350	0.092	0.162	0.507
Nickel	0.129	0.184	<0.005	0.583	0.087	0.100	<0.005	0.511
Palladium	<0.01	-	<0.01	0.090	<0.01	-	<0.01	0.040
Platinum	<0.001	-	<0.001	0.001	<0.001	-	<0.001	0.002
Potassium	2337	285	1800	2760	2388	228	1880	2910
Rubidium	4.618	2.02	1.65	9.46	6.29	4.29	1.04	18.5
Selenium	0.739	0.303	0.330	1.440	0.892	0.173	0.57	1.35
Silver	<0.0001	-	<0.0001	0.0011	<0.0001	-	<0.0001	0.017
Strontium	0.110	0.038	0.048	0.178	0.114	0.052	0.051	0.283
Thallium	0.003	0.003	0.001	0.014	0.004	0.005	0.000	0.026
Tin	<0.01	-	<0.01	0.090	<0.01	-	<0.01	1.040
Uranium	<0.0001	-	<0.0001	<0.0001	<0.0001	-	<0.0001	0.0001
Vanadium	<0.001	-	<0.001	0.0070	<0.001	-	<0.001	0.0020
Zinc	27.9	5.88	18.5	38.6	27.9	7.64	18.7	51.6

[1] – Outlier probably caused by lead shot

Table 5. Mean, SD, minimum, and maximum values summarized for moose liver harvested in 2005-2007. Concentration is in mg/kg ww, n/a is not analyzed.

Element	Sampling Year 2005, 2006 and 2007							
	Liver							
	Female (n=14)				Male (n=26)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Age (y)	5.93	3.79	0	12	3.85	3.16	0	12.5
Moisture (%)	66.7	5.78	50.8	74.2	66.6	3.02	59.3	72.2
Aluminum	0.094	0.059	0.030	0.200	0.30	0.58	0.01	2.62
Antimony	0.009	0.018	<0.001	0.054	0.01	0.01	<0.001	0.065
Arsenic	0.015	0.031	<0.002	0.122	0.028	0.060	<0.002	0.283
Barium	0.123	0.052	0.038	0.187	9.46	31.2	0.015	118
Beryllium	<0.0004	-	<0.0001	0.0015	0.0006	0.0005	<0.0001	0.0019
Bismuth	<0.0001	-	<0.0001	0.0005	<0.0001	-	<0.0001	0.0001
Cadmium	2.85	2.58	0.0493	9.39	2.65	2.20	0.344	7.58
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.007	0.006	0.001	0.025	0.011	0.017	0.0006	0.065
Chromium	0.044	0.070	0.003	0.264	0.083	0.098	0.01	0.34
Cobalt	0.077	0.027	0.032	0.114	0.081	0.020	0.05	0.14
Copper	33.7	26.4	3.13	78.8	33.9	37.9	3.07	161
Gallium	0.003	0.005	<0.0001	0.012	0.0010	0.0029	<0.0001	0.012
Iron	239	236	77	1030	219	183	89.6	1050
Lanthanum	0.0007	0.0006	<0.0001	0.0026	0.0008	0.0011	0.0001	0.0056
Lead	0.312	1.136	0.002	4.260	0.011	0.012	0.001	0.057
Lithium	0.011	0.010	<0.01	0.040	0.011	0.011	<0.01	0.06
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	2.95	0.887	1.08	4.17	2.96	1.04	1.33	4.88
Mercury	0.010	0.011	<0.002	0.035	0.017	0.021	<0.002	0.096
Molybdenum	1.58	0.652	0.607	2.98	1.198	0.234	0.678	1.61
Nickel	<0.005	-	<0.005	0.175	0.056	0.072	<0.005	0.243
Palladium	<0.01	-	<0.01	<0.01	<0.01	-	<0.01	0.01
Platinum	<0.001	-	<0.001	0.0020	<0.001	-	<0.001	0.002
Potassium	2777	233	2400	3260	2911	401	2270	3710
Rubidium	6.06	2.21	1.99	8.31	8.45	5.77	1.6	24
Selenium	0.894	0.966	0.05	3.6	1.36	1.55	0.2	7.85
Silver	0.079	0.047	0.018	0.158	0.057	0.085	0.0014	0.424
Strontium	0.063	0.029	0.029	0.108	0.063	0.057	0.02	0.32
Thallium	0.0004	0.0003	0.0002	0.0011	0.000	0.000	0.0001	0.0012
Tin	<0.01	-	<0.01	0.030	<0.01	-	<0.01	0.16
Uranium	<0.0001	-	<0.0001	0.0001	<0.0001	-	<0.0001	0.0005
Vanadium	<0.0001	-	<0.001	0.001	0.0012	0.0015	<0.001	0.008
Zinc	24.6	5.86	17.5	39.9	27.8	11.1	15.2	62.6

Table 6. Elemental concentrations in moose kidney and muscle harvested in 2011. Concentration is in mg/kg ww, n/a is not analyzed.

Element	Sampling Year 2011			
	Female		Male	
	Kidney (n=1)	Muscle (n=1)	Kidney (n=1)	Muscle (n=1)
Age (y)	2	2	3	3
Moisture (%)	79.5	73.6	78.8	72.1
Aluminum	<0.02	6.34	0.59	6.08
Antimony	<0.002	0.014	<0.002	0.003
Arsenic	<0.004	0.006	<0.004	0.004
Barium	0.10	0.16	0.076	0.364
Beryllium	<0.0002	0.0002	<0.0002	0.0001
Bismuth	<0.0002	<0.0001	<0.0002	<0.0001
Cadmium	6.49	0.017	2.68	0.026
Calcium	93.8	109	86.5	106
Boron	n/a	n/a	n/a	n/a
Cesium	0.005	0.003	0.004	0.004
Chromium	0.005	0.286	0.008	0.36
Cobalt	0.08	0.013	0.039	0.01
Copper	3.88	1.06	3.13	2.24
Gallium	0.0004	0.0027	0.0002	0.0032
Iron	23.1	30	59.5	55.8
Lanthanum	<0.0002	0.004	<0.0001	0.006
Lead	0.004	0.01	0.006	0.009
Lithium	0.06	0.03	0.02	0.01
Magnesium	140	144	129	186
Manganese	2.87	0.34	2.57	0.497
Mercury	0.005	0.005	0.022	0.005
Molybdenum	0.208	0.007	0.176	0.009
Nickel	0.062	0.028	0.022	0.039
Palladium	<0.02	<0.01	<0.02	<0.01
Platinum	<0.002	<0.0001	<0.002	<0.001
Potassium	2060	1890	1930	2680
Rubidium	4.62	2.44	2.31	2.46
Selenium	0.7	0.13	0.49	0.09
Silver	0.0002	<0.0001	<0.0002	<0.0001
Strontium	0.107	0.202	0.089	0.13
Thallium	0.0014	<0.0001	0.002	0.0002
Tin	<0.01	0.03	<0.02	0.02
Uranium	<0.0002	0.0004	<0.0002	0.0004
Vanadium	<0.002	0.016	<0.002	0.041
Zinc	24.3	85	18.3	51.6

Table 7. Mean, SD, minimum, and maximum values summarized for moose kidney harvested in 2012-2016. Concentration is in mg/kg ww.

Element	Sampling Year 2012 - 2016							
	Kidney							
	Female				Male			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Age (y)	3.78	3.19	1.00	10.0	2.68	1.91	0	7.5
Moisture (%)	78.4	1.62	76.2	81.3	79.0	2.39	72.6	82.4
Aluminum	0.28	0.30	0.05	1.04	0.351	0.273	0.040	1.030
Antimony	0.005	0.003	0.002	0.011	0.007	0.023	<0.001	0.121
Arsenic	<0.002	-	<0.002	0.301	0.005	0.009	<0.002	0.045
Barium	0.38	0.49	0.13	1.68	0.185	0.065	0.087	0.324
Beryllium	<0.0001	-	<0.0001	<0.0001	<0.0001	-	<0.0001	0.0001
Bismuth	<0.0001	-	<0.0001	0.0001	<0.0001	-	<0.0001	0.0004
Cadmium	16.9	9.84	7.47	34.3	13.8	13.0	1.350	57.9
Calcium	143	79.9	89.3	350	90.2	16.3	59.7	128
Boron	0.24	0.09	0.14	0.45	0.19	0.11	<0.05	0.43
Cesium	0.14	0.37	0.00	1.12	0.029	0.030	0.002	0.125
Chromium	0.03	0.02	0.01	0.06	0.059	0.079	0.004	0.300
Cobalt	0.06	0.03	0.02	0.09	0.057	0.027	0.020	0.150
Copper	3.71	0.25	3.45	4.08	3.50	0.80	2.12	4.79
Gallium	0.004	0.000	0.003	0.005	0.004	0.001	0.003	0.005
Iron	46.7	9.49	25.2	55.7	53.3	18.8	24.1	121
Lanthanum	0.0002	0.0002	<0.0001	0.0005	0.0002	0.0003	<0.0001	0.002
Lead	0.004	0.006	<0.001	0.020	0.004	0.003	<0.001	0.012
Lithium	0.018	0.013	<0.01	0.040	0.022	0.016	<0.01	0.060
Magnesium[1]	162	8.81	153	179	157	17.6	125	189
Manganese	3.15	0.37	2.60	3.74	2.10	1.10	0.65	3.82
Mercury	0.03	0.02	0.01	0.08	0.019	0.009	0.006	0.04
Molybdenum	0.41	0.07	0.29	0.51	0.37	0.17	0.090	0.86
Nickel	0.21	0.34	0.06	1.11	0.29	0.39	0.016	1.54
Palladium	<0.01	-	<0.01	0.02	0.008	0.007	<0.01	0.030
Platinum	<0.001	-	<0.001	<0.001	<0.001	-	<0.001	<0.001
Potassium	2671	177	2430	2920	2423	322	1790	3110
Rubidium	8.47	8.10	2.38	29.2	7.25	4.50	2.44	20.7
Selenium	1.01	0.35	0.74	1.78	0.80	0.23	0.48	1.50
Silver	0.0003	0.001	<0.0001	0.002	<0.0001	-	<0.0001	0.002
Strontium	0.13	0.08	0.05	0.32	0.077	0.028	0.035	0.156
Thallium	0.012	0.025	0.001	0.079	0.003	0.002	0.001	0.009
Tin	<0.01	-	<0.01	0.01	<0.01	-	<0.01	0.860
Uranium	<0.0001	-	<0.0001	<0.0001	<0.0001	-	<0.0001	<0.0001
Vanadium	0.007	0.006	0.002	0.019	0.008	0.009	<0.001	0.049
Zinc	30.9	5.84	24.5	43.4	29.0	8.55	17.4	53.7

Table 8. Mean, SD, minimum, and maximum values summarized for moose liver harvested in 2012-2016. Concentration is in mg/kg ww.

Element	Sampling Year 2012 - 2016							
	Liver							
	Female (n=5)				Male (n=15)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Age (y)	3.40	2.79	1.0	8.0	3.03	1.76	0.000	6.000
Moisture (%)	67.8	2.83	64.0	71.9	64.5	6.711	51.9	78.1
Aluminum	0.21	0.05	0.15	0.28	0.46	0.54	0.08	2.32
Antimony	<0.001	-	<0.001	0.003	<0.001	-	<0.001	0.003
Arsenic	0.004	0.003	0.002	0.009	0.015	0.041	<0.002	0.162
Barium	0.08	0.05	0.03	0.14	0.11	0.06	0.05	0.23
Beryllium	<0.0001	-	<0.0001	0.0001	<0.0001	-	<0.0001	0.0002
Bismuth	<0.0001	-	<0.0001	0.0001	<0.0001	-	<0.0001	0.0005
Cadmium	2.97	2.53	0.84	6.48	2.68	2.01	0.90	8.85
Calcium	48.7	8.8	40.2	58.9	46.2	8.88	34.2	67.0
Boron	0.20	0.11	0.12	0.38	0.17	0.11	<0.05	0.42
Cesium	0.005	0.003	0.001	0.010	0.016	0.016	0.001	0.060
Chromium	<0.001	-	<0.001	0.011	0.03	0.06	<0.0001	0.22
Cobalt	0.09	0.03	0.06	0.13	0.08	0.03	0.04	0.14
Copper	27.7	36.7	3.530	88.7	24.4	22.3	3.16	61.5
Gallium	0.004	0.0004	0.003	0.004	0.004	0.001	0.002	0.004
Iron	515	641	181	1660	213	71.7	133	417
Lanthanum	0.0006	0.0003	<0.0004	0.001	0.0006	0.0004	0.0002	0.002
Lead	0.005	0.006	0.001	0.015	0.011	0.014	0.002	0.052
Lithium	<0.01	-	<0.01	0.030	<0.01	-	<0.01	0.02
Magnesium[1]	146	13.6	131	164	152	20.2	118	181
Manganese	2.65	0.40	2.22	3.21	2.20	0.82	0.81	3.26
Mercury	0.005	0.002	0.003	0.007	0.005	0.002	0.002	0.009
Molybdenum	1.39	0.14	1.18	1.53	1.06	0.31	0.54	1.58
Nickel	0.008	0.006	<0.005	0.018	0.027	0.054	<0.005	0.217
Palladium	<0.01	-	<0.01	<0.01	<0.01	-	<0.01	<0.01
Platinum	<0.001	-	<0.001	<0.001	<0.001	-	<0.001	<0.001
Potassium	2674	367	2160	3050	2661	437	1970	3470
Rubidium	6.05	2.36	3.14	8.85	8.28	6.17	2.39	28.6
Selenium	1.42	1.08	0.21	3.17	0.84	0.61	0.19	2.13
Silver	0.06	0.04	0.02	0.12	0.06	0.06	0.009	0.24
Strontium	0.04	0.02	0.01	0.07	0.036	0.012	0.022	0.059
Thallium	0.0003	0.0002	<0.0001	0.0005	0.0003	0.0004	<0.0001	0.002
Tin	<0.01	-	<0.01	<0.01	<0.01	-	<0.01	<0.01
Uranium	<0.0001	-	<0.0001	<0.0001	<0.0001	-	<0.0001	0.0001
Vanadium	0.002	0.002	<0.001	0.005	0.003	0.004	<0.001	0.017
Zinc	24.0	6.48	19.3	35.4	41.8	25.8	11.9	99.5

Table 9. Mean, SD, minimum, and maximum values summarized for moose muscle harvested in 2012-2016. Concentration is in mg/kg.

Element	Sampling Year 2012 - 2016							
	Muscle							
	Female (n=3)				Male (n=11)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Age (y)	4.00	3.46	2.00	8.00	3.27	1.90	0.00	6.00
Moisture (%)	71.6	1.50	70.2	73.2	74.4	1.21	72.8	77.4
Aluminum	1.81	1.60	0.50	3.60	4.61	7.62	0.54	26.1
Antimony	0.10	0.10	0.02	0.20	0.080	0.174	0.006	0.588
Arsenic	0.006	0.005	<0.001	0.010	0.006	0.011	<0.002	0.038
Barium	0.46	0.74	0.03	1.31	0.12	0.15	0.03	0.51
Beryllium	<0.0001	-	<0.0001	<0.0001	<0.0001	-	<0.0001	0.0009
Bismuth	0.002	0.002	<0.0001	0.004	0.0005	0.0004	<0.0001	0.0016
Cadmium	0.077	0.120	0.008	0.215	0.12	0.24	0.001	0.80
Calcium	551	848	48.5	1530	106	129	35.4	472
Boron	0.22	0.12	0.09	0.31	0.100	0.058	<0.05	0.180
Cesium	0.008	0.005	0.003	0.014	0.033	0.045	0.002	0.143
Chromium	0.058	0.073	0.010	0.142	0.073	0.071	0.007	0.240
Cobalt	0.008	0.005	0.004	0.014	0.009	0.006	0.004	0.025
Copper	1.57	0.36	1.36	1.98	1.46	0.35	0.97	2.06
Gallium	0.003	0.001	0.002	0.004	0.003	0.002	0.002	0.010
Iron	36.3	17.2	24.7	56.0	37.3	10.9	21.3	61.5
Lanthanum	0.002	0.003	0.000	0.006	0.007	0.013	0.0004	0.043
Lead	0.020	0.029	0.002	0.053	0.015	0.017	0.002	0.052
Lithium	<0.01	-	<0.01	0.030	<0.01	-	<0.01	0.02
Magnesium	230	6.43	225	237	212	33.2	141	254
Manganese	0.24	0.13	0.13	0.38	0.23	0.19	0.11	0.78
Mercury	0.002	0.001	<0.001	0.003	<0.002	-	<0.002	0.004
Molybdenum	0.010	0.008	0.003	0.018	0.010	0.005	0.003	0.019
Nickel	0.036	0.036	0.011	0.077	0.22	0.60	0.01	2.02
Palladium	<0.01	-	<0.01	<0.01	<0.01	-	<0.01	<0.01
Platinum	<0.001	-	<0.001	<0.001	<0.001	-	<0.001	<0.001
Potassium	3153	276	2840	3360	3130	677	1890	3810
Rubidium	4.26	2.43	1.77	6.63	5.87	4.37	0.87	16.00
Selenium	0.18	0.03	0.15	0.20	0.16	0.08	0.08	0.33
Silver	0.000	0.000	<0.0001	0.001	0.001	0.001	<0.0001	0.005
Strontium	0.19	0.25	0.03	0.48	0.07	0.08	0.02	0.29
Thallium	<0.0001	-	<0.0001	0.0002	0.0001	0.0001	<0.0001	0.0004
Tin	<0.01	-	<0.01	0.01	0.012	0.009	<0.01	0.03
Uranium	0.0002	0.0001	<0.0001	0.0003	0.0004	0.0006	<0.0001	0.0019
Vanadium	0.007	0.003	0.004	0.010	0.01	0.01	0.002	0.05
Zinc	50.8	3.44	48.8	54.8	54.0	12.7	34.4	81.5

Table 10. Three-way ANCOVA (factors of sex, year, tissue) comparison of 2007 vs. 2016 elemental analysis. Data were compared on a log-transformed dw basis, using age as a covariate

	Sex	2007 vs. 2016	Liver vs. Kidney	Age Effect
Age	P<0.05; F>M	P<0.01; 2007>2016	NS; p>0.05	-
Moisture	NS; P>0.05	P<0.001; 2007>2016	P<0.001; Kidney>Liver	NS; P>0.05
Aluminum	NS; P>0.05	P<0.001; 2016>2007	NS; P>0.05	NS; P>0.05
Arsenic	NS; P>0.05	NS; P>0.05	NS; P>0.05	NS; P>0.05
Barium	NS; P>0.05	NS; P>0.05	P<0.001; Kidney>Liver	NS; P>0.05
Cadmium	NS; P>0.05	P<0.01; 2016>2007	P<0.001; Kidney>Liver	P<0.001
Cesium	NS; P>0.05	P<0.01; 2016>2007	P<0.001; Kidney>Liver	NS; P>0.05
Chromium	NS; P>0.05	NS; P>0.05	P<0.05; Kidney>Liver	NS; P>0.05
Cobalt	NS; P>0.05	P<0.05; 2016>2007	NS; P>0.05	NS; P>0.05
Copper	NS; P>0.05	NS; P>0.05	P<0.001; Liver>Kidney	NS; P>0.05
Iron	NS; P>0.05	P<0.001; 2016>2007	P<0.001; Liver>Kidney	NS; P>0.05
Lead	NS; P>0.05	NS; P>0.05	NS; P>0.05	NS; P>0.05
Manganese	P<0.01; F>M	NS; P>0.05	P=0.001; Kidney>Liver	NS; P>0.05
Mercury	NS; P>0.05	NS; P>0.05	P<0.001; Kidney>Liver	NS; P>0.05
Molybdenum	P<0.05; F>M	P<0.05; 2016>2007	P<0.001; Liver>Kidney	P<0.05
Potassium	NS; P>0.05	P<0.001; 2016>2007	P<0.001; Kidney>Liver	NS; P>0.05
Rubidium	NS; P>0.05	P<0.05; 2016>2007	NS; P>0.05	NS; P>0.05
Selenium	NS; P>0.05	P<0.05; 2016>2007	P<0.01; Kidney>Liver	NS; P>0.05
Strontium	NS; P>0.05	NS; P>0.05	P<0.001; Kidney>Liver	NS; P>0.05
Zinc	P<0.05; M>F	P<0.001; 2016>2007	P<0.001; Kidney>Liver	P<0.001

Cadmium

More detailed analysis of the distribution of Cd concentrations in moose was conducted to evaluate the relationships between tissues, and to examine the differences between sexes and years of analysis. No significant difference in Cd concentration was observed between

sexes in the ANCOVA analysis (Table 10), however Cd concentration increased significantly ($p<0.001$) with age (Figure 3). As a result, age was included as a co-factor when comparing log-transformed Cd concentrations between the two sets of analyses. With age included, the geometric mean of the samples collected in 2011-2016 (mean = 60.5 mg/kg dw, GSD=0.084, n=36) was significantly higher ($p<0.05$) than those collected in 2005-2007 analysis (mean = 33.5 mg/kg dw, GSD=0.073, n=43). When age was removed as a co-factor, there was no significant difference between the 2005-2007 (41.5 mg/kg dw) and 2011-2016 (49.8 mg/kg dw) samples.

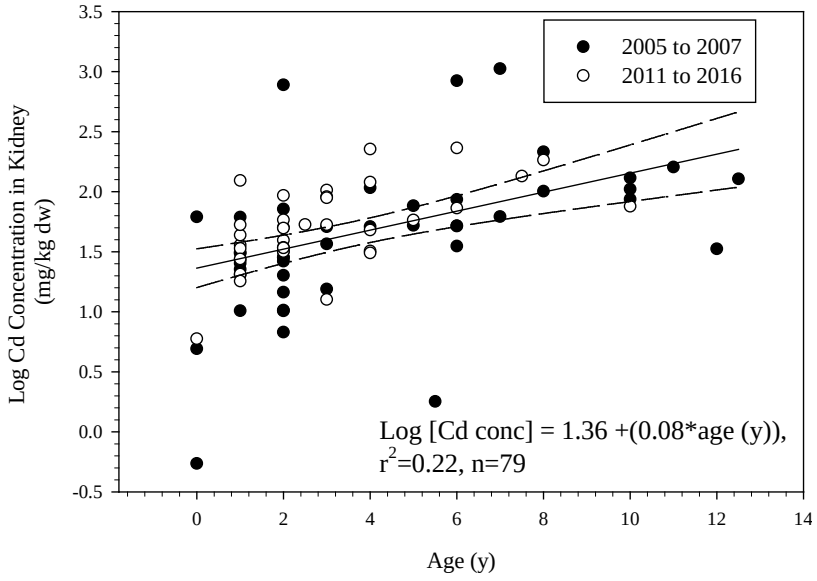

Figure 3. Regression of log transformed Cd concentration in kidney against age of moose. Regression equation (and 95% confidence interval) is for combined data of 2007 and 2016 analyses.

The arithmetic mean Cd concentration for all 81 kidney samples, without correction for age, is 20.8 mg/kg on a ww basis (SD = 35.8; n=81), with a range of 0.21-222 mg/kg. Arithmetic mean concentration on a dw basis is 90.3 mg/kg dw, (SD=167, n=81), with a range of 0.54-1,057 mg/kg.

Geometric means for pooled Cd concentrations data for all harvested moose (both sets of analyses) was 45.2 mg/kg dw, 5.7 mg/kg and 0.10 mg/kg on a dw basis for kidney (n=81), liver (n=60) and muscle (n=16), respectively.

Sixty matched kidney-liver samples allowed the estimation of correlations of Cd concentrations between tissues. Kidney Cd concentration increased significantly ($p<0.001$) with liver Cd concentration (Figure 4, upper panel, Equation 1). Kidney:liver ratio was 11.3 (dw basis), with no significant ($p>0.05$) relationship with age.

Equation 1:

$$\text{Log } [Cd_{kid}] = 0.851 + (1.101 \text{ x } [Cd_{liv}]);\ n=60,\ r^2 = 0.684$$

A smaller subset of matched kidney and muscle samples were available from 16 moose. Kidney Cd concentration increased significantly ($p<0.05$) with muscle Cd concentration (dw basis) (Figure 5, Equation 2). There was no correlation between kidney:muscle ratio and age of the moose ($p>0.05$).

Equation 2:

$$\text{Log } [Cd_{kid}] = 2.019 + (0.314 \text{ x log } [Cd_{mus}]);\ p< 0.05,\ n=16,\ r^2=0.32$$

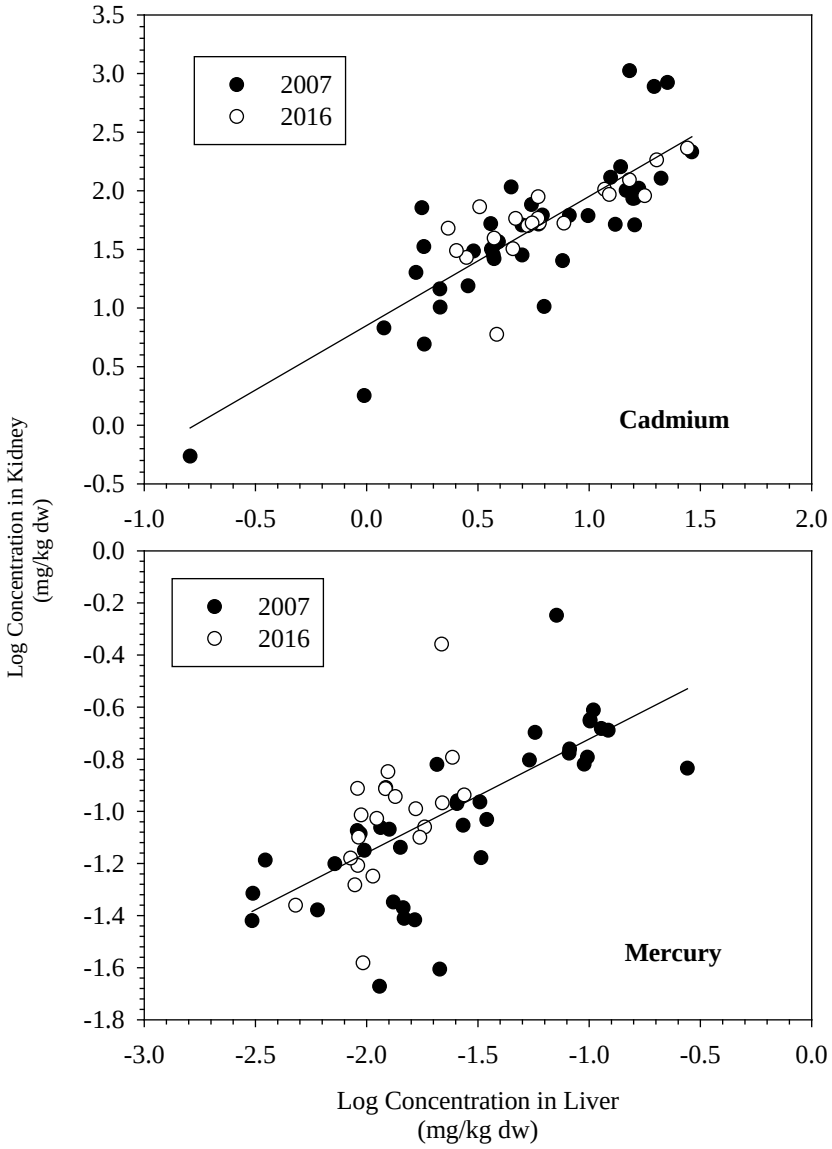

Figure 4. Log-transformed Cd (upper) and Hg-T (lower) concentration in kidney regressed against the concentration in liver. Both regressions are significant at the $p<0.001$ level.

Total Mercury (Hg)

Arithmetic mean Hg-T concentrations for the 2007 and 2016 analyses are presented in Tables 4-9. The results of the comparison of concentrations using sex, tissue and date of analysis as factors using ANCOVA, with age as a covariate, are presented in Table 10. There was no significant difference between sexes, date of analysis or with the age of the moose. Kidney Hg-T concentration increased with age for the samples collected between 2011 and

2016 (p=0.017, r^2=0.16, n=36), but was not significant for the 2007 data, or for the combined data (p=0.08, n=77). Concentration in kidney was significantly higher than in liver (p<0.001).

Kidney Hg-T concentration increased significantly with liver concentration for each set of analyses, and the combined data (Figure 4, lower panel, Equation 3). The kidney:liver ratio for the combined data set was 6.05 (dw basis). Kidney Hg-T concentration was not significantly correlated to muscle Hg-T concentration. The kidney:muscle ratio was 17.6 (dw basis).

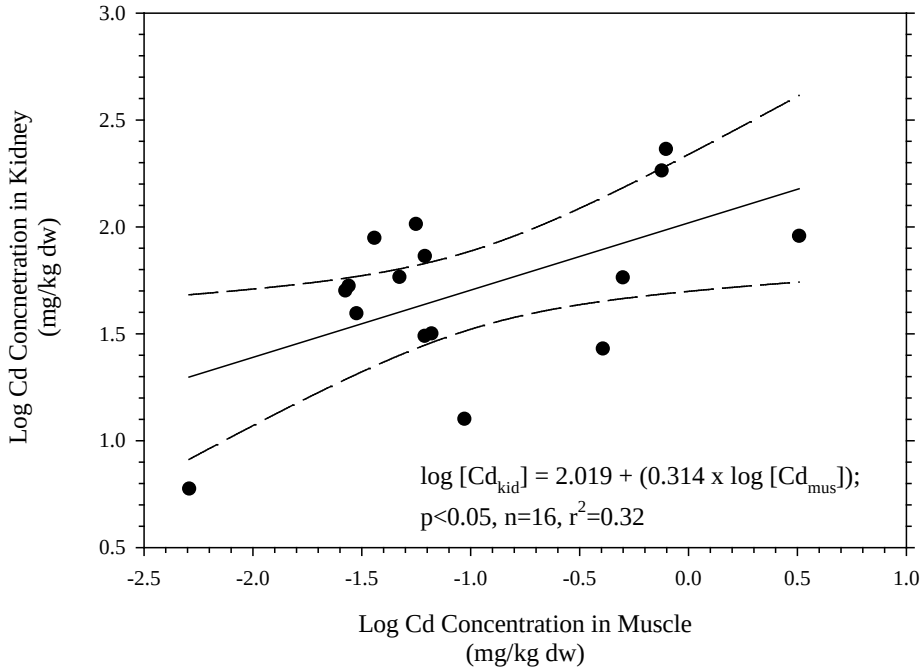

Figure 5. Regression of log transformed kidney Cd concentration versus log transformed Cd concentration in muscle. Broken lines are 95% confidence intervals.

Equation 3:

$$\text{Log } [\text{Hg-T}_{kid}] = -0.286 + (0.437 \text{ x log } [\text{Hg-T}_{liv}], \text{ n=58, } r^2=0.44, p<0.001$$

Geometric mean of the combined Hg-T data was 0.09 mg/kg dw, 0.02 mg/kg dw and 0.007 mg/kg dw for kidney (n=79), liver (n=60) and muscle (n=16), respectively. Assuming dw of 0.26, 0.34 and 0.26 for kidney, liver and muscle, respectively, the pooled Hg-T concentrations would be 0.02, 0.006 and 0.002 mg/kg ww, for kidney, liver and muscle, respectively. Kidney:liver ratio is 3.47 (ww basis) and the kidney:muscle ratio is 12.0 (ww basis).

Other Elements

The mean concentrations of elements that were detectable in the moose tissues are presented in Tables 4-9. The results of the ANCOVA analysis comparing the effects of moose sex, tissue (kidney or liver), and year of analysis are presented in Table 10. Muscle was excluded from the analysis because of the relatively small number of individual samples collected (n=15).

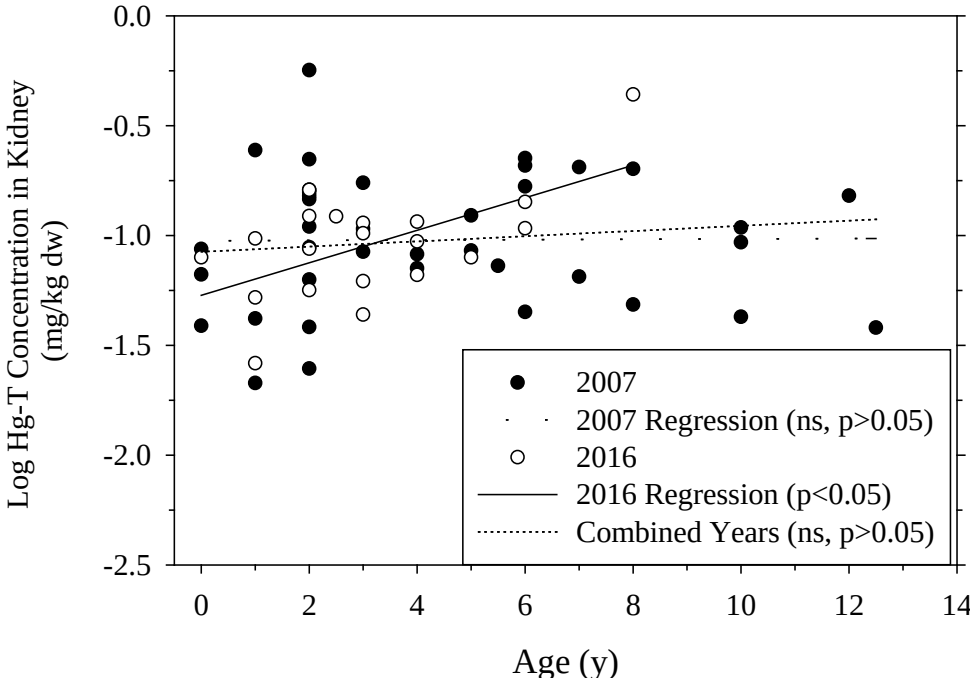

Figure 6. Log Hg-T in kidney versus age for individual sets of analysis and combined data. Regressions for the 2007 and combined data are not significant (ns). Regression for 2016 data is statistically significant ($p<0.05$).

The ANCOVA results indicate that elemental concentrations only varied significantly between sexes for Mg and Mo, in which concentrations in females were significantly higher than in males ($p<0.05$) and for zinc (Zn), in which the concentration were higher in males. Similarly, other than Ca (see Figure 6), increases in tissue concentrations with age were only reported for Mo and Zn.

Log-transformed kidney concentrations regressed against liver concentration reported statistically significant relationships for seven or the 11 elements tested (Table 11). No significant relationship was observed for Aluminum (Al), barium (Ba), copper (Cu) and Mo. The highest kidney:liver ratios were observed for Pb (6.68), Ba (3.2) and strontium (Sr) (3.15).

Table 11. Regression of kidney tissue concentration against liver concentration for 11 elements of potential concern for matched tissue samples. The kidney:liver ratio (last column) was calculated from tissue concentrations on a dw basis. NS – not statistically significant.

Element	Kidney vs. Liver (Combined Data)(n=60)	Kidney:Liver Ratio
Al	NS; $p>0.05$	2.44
As	$\text{Log}[As_{kid}] = -0.895 + (0.602 \times \log[As_{liv}])$, $p<0.001$	1.25
Ba	NS; $p>0.05$	3.2
Co	$\text{Log}[Co_{kid}] = -0.351 + (0.594 \times \log[Co_{liv}])$, $p<0.01$	0.94
Cu	NS; $p>0.05$	0.43
Pb	$\text{Log}[Pb_{kid}] = -1.01 + (0.452 \times \log[Pb_{liv}])$, $p=0.001$	6.68
Mn	$\text{Log}[Mn_{kid}] = 0.388 + (0.650 \times \log[Mn_{liv}])$, $p=0.001$	1.29
Mo	NS; $p>0.05$	0.46
Se	$\text{Log}[Se_{kid}] = 0.389 + (0.292 \times \log[Se_{liv}])$, $p<0.001$	1.67
Sr	$\text{Log}[Sr_{kid}] = -0.253 + (0.206 \times \log[Sr_{liv}])$, $p<0.05$	3.15
Zn	$\text{Log}[Zn_{kid}] = 1.046 + (0.522 \times \log[Zn_{liv}])$, $p<0.001$	1.45

Inter-tissue ratios for muscle were also calculated from matched samples collected from individual moose (Table 12). In general, the concentrations of the elements were higher in

kidney and liver than muscle, except for Al, Pb and Zn. The highest ratios were observed for Mo, Mn and selenium (Se).

Table 12. Inter-tissue ratios for matched samples collected from individual moose.

Element	Kidney:Muscle (n=16)	Liver:Muscle (n=14)
Al	0.29	0.20
As	1.18	1.59
Ba	3.54	1.38
Co	10.7	9.34
Cu	2.89	13.9
Pb	0.70	0.87
Mn	13.3	9.16
Mo	70.3	126
Se	6.56	4.18
Sr	2.21	0.76
Zn	0.72	0.55

DISCUSSION

The elemental analysis reported here is based on tissue samples taken from moose harvested in the Mackenzie River Valley in the Dehcho region of the Northwest Territories (NWT) between 2005 and 2016. The samples were collected as part of a two-part program which included an aerial survey of moose density and calf production and harvest sampling (Larter 2009). GPS locations of the harvest sites (Figure 7) indicate that moose were taken from the Mackenzie River Valley and major tributaries, areas that have been classified as winter use areas (*ca.* 64,391 km^2) and summer use areas (64,785 km^2), where moose are found at higher numbers due to food resources and preferred habitat (Wilson and Haas 2012). Moose in the NWT have been assessed as Secure due to their wide distribution, relatively stable populations, and few threats to the individual populations (WGGSS 2016).

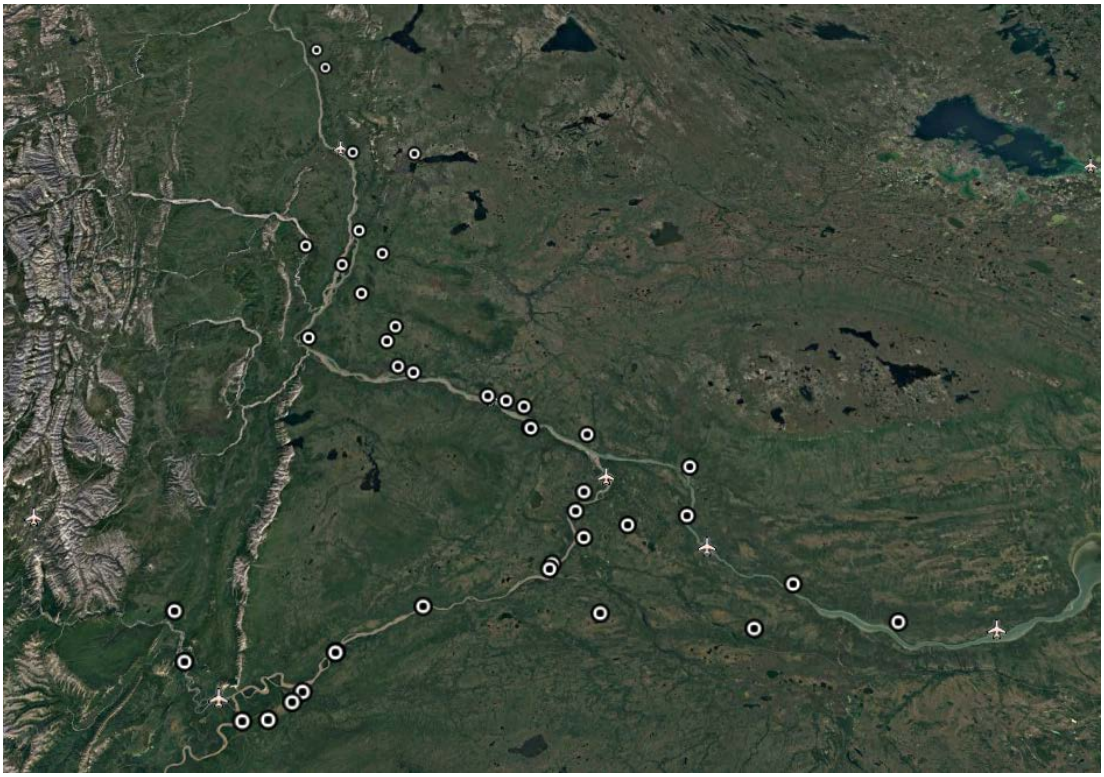

Figure 7. Harvest locations for Mackenzie Valley moose collected from 2011-2016.

The assessment of favourable body condition of individual harvested moose was consistent with surveys of the status of the population. The density estimate for moose in the Dehcho in 2003 was 4.4 moose/100 km^2 with 32.1 calves:100 adult females (Larter 2009). Data from a survey of the Mackenzie Valley population in 2011 showed a higher density of moose (4.9 moose/100 km^2) and higher calf:cow ratio (54 calves:100 adult females, Larter, unpublished data). These results correspond to the body condition (Table 1) reported by harvesters which indicated that most (25 of 43) moose harvested in 2005-2007 were in good condition while 24 of 38 harvested in 2011-2016 were in excellent condition. The 2005-2007 results were supported by the kidney fat index of 75.0 for moose judged to be in excellent condition and 47.6 for those in good condition (Larter 2009). While malnutrition and poor body condition of young moose have been shown to be likely causes of significant clinical signs in young moose, including bone mineral imbalance (Ytrehus et al. 1999) and declining moose abundance (Murray et al. 2006), they are unlikely a factor in the interpretation of the concentrations of elements in moose tissues in the present study.

Cadmium (Cd) continues to be a concern for moose and human consumers due to high concentrations reported in liver and kidney in some populations in the NWT (Larter et al. 2016) and the Yukon (YT) (Gamberg et al. 2005a). The Cd concentrations in the organs of terrestrial mammals is generally much lower than the concentrations found in marine mammals (Outridge et al. 1994) but may still be a major source of the metal for consumers of traditional diets. Berti et al. (1998) have shown that up to 90% of the Cd in the Dene/Métis diet in the NWT can come from consuming caribou and moose liver. The mean Cd concentration for all pooled kidneys reported here for Mackenzie Valley moose (20.8 mg/kg ww) corresponds to values reported elsewhere (Gamberg et al. 2005b) but are much lower than the values reported from the southern Mackenzie Mountains in the NWT (Larter et al. 2016). The latter data led to an advisory to restrict the consumption of moose liver and kidney from the southern Mackenzie Mountains (Larter and Kandola 2010). The advisory has since been updated (GNWT Health 2017) to restrict the consumption of organs from moose harvested in the south Mackenzie Mountains to 56 g of liver per month or 37 g of kidney. By contrast, recommended amounts to be consumed for moose harvested

from the Mackenzie Valley are eight to nine servings (650 g) per month for liver and one to two servings (or 125 g) of kidneys. The amounts are based on the Provisional Tolerable Monthly Intake (PTMI) of 25 µg Cd/kg body weight/month from Health Canada and the World Health Organization (WHO 1992, JECFA 2010).

Several factors have been proposed to explain the national and regional differences in Cd concentrations in moose. Regional studies of soil geochemistry have shown that the concentration of Cd in surface soils varies considerably over large areas and that Cd is selectively accumulated by plant species such as willow (*Salix* spp.) (Gough et al. 2013, Reimann et al. 2015). This geochemical variability and availability of Cd to moose through plant food items has been used to explain very high Cd concentrations in some areas of the YT (Gamberg et al. 2005a) and inferred through stable isotope analysis for moose and other large mammals (Larter et al. 2016). A correlation was observed between Cd in stream sediments and the kidney of moose collected from the same area (Gamberg et al. 2005a). The variation between populations and the difficulty in predicting populations susceptible to elevated Cd accumulation suggests that continued monitoring is required to identify regions and moose populations where elevated Cd may be a hazard to consumers of moose organs.

Studies have shown that Cd accumulation in moose in the NWT largely correspond to studies elsewhere in North America and Europe. The increase in Cd concentrations in moose kidney with age observed in this study has been widely reported in moose elsewhere (Gamberg et al. 2005a, b; Arnold et al. 2006; Danielsson and Frank 2009; Skibniewski et al. 2017), and is a function of the long residence time of Cd in the kidney (ATSDR 2012), where it is bound to protein (Kjellström 1986, Chan et al. 2001). The increasing concentration with age was statistically significant in both the 2007 and 2016 data sets, even though the mean ages in both data sets were low (<5 years). The variation in the distribution of ages in each sample of the moose population makes comparisons between years in kidney Cd concentrations difficult but has led to recommendations to use

age as a covariate in advanced statistics when comparing between populations (Danielsson and Frank 2009). The analysis in the present study used age as a co-factor in an ANCOVA design and determined that Cd levels in kidney were significantly higher in the 2016 analysis than in 2007. Danielsson and Frank (2009) proposed a correction factor for moose age (0.24 for 0-1 years up to 2.50 for 8+ years for males) to adjust the mean for individual ages, which would more than double the estimated Cd concentration in kidney of older moose in this study. The low mean age of the sample in the present study suggests that no correction for the mean age is necessary.

The presence of Cd at elevated concentrations in moose kidney has led to concerns for the health of the moose and human consumers (Larter and Kandola 2010). Cd is a well-known nephrotoxin that can reduce the ability of the kidney to resorb nutrients from urine and can cause a loss of kidney function. Studies by Larter et al. (2016; 2018) examined the kidneys of large mammals in the Dehcho region of the NWT for histological effects and found no correlation between Cd concentration and renal cellular artifacts. A review of Cd in moose kidney by Gamberg et al. (2005b) reported that Cd concentration in moose in the YT were high relative to other areas in North America and Europe, and some individual moose had renal concentrations that were in the range at which renal dysfunction could occur. Outridge et al. (1994) have suggested that concentrations as low as 30 mg/kg ww in kidney could be high enough to cause dysfunction in some individuals. This dysfunction follows histological changes and tissue necrosis observed in experimentally exposed sheep (Stoev et al. 2003), rats (Aughey et al. 1984) and deer (Beiglböck et al. 2002). Based on those criteria and the potential for Cd concentrations exceeding thresholds, especially in older animals, Gamberg et al. (2005b) estimated that sub-lethal effects, such as kidney dysfunction could be present in 29% of the moose analyzed in the YT study.

The present study included three individuals in excess of 150 mg/kg ww indicating the potential for adverse health effects, although all three animals were considered to be healthy at the time of harvest. Similarly, the significant correlation between Cd

concentrations in kidney and liver have been shown to be a general principle of Cd accumulation in a wide variety of avian and mammalian species (Mochizuki et al. 2008) and the two tissues need to be considered together in wildlife health and human health assessments. This is an area where further research on health effects, and possible biochemical mechanisms to mitigate effects in kidney, are warranted.

Mercury (Hg) is generally not considered to be a significant contaminant in terrestrial traditional foods in the NWT (Gamberg et al. 2015) However, documentation of Hg concentrations and trends in traditional foods is vital because high concentrations of total Hg, much of it in the form of methylmercury, may also be present in fish (Lockhart et al. 2005; Depew et al. 2013, Chételat et al. 2015) that are also consumed as part of a traditional diet. Berti et al. (1998) examined the diets of 16 Dene/Métis communities in the NWT and determined that several individuals exceeded the PTWI of 5.0 µg Hg/kg body weight/day (Health Canada 2007) due to the consumption of fish. Of the land mammals tested in the study, baked caribou liver was a significant source of Hg, while moose liver was a minor source. A similar assessment of Hg exposure for consumers of barren-ground caribou in Old Crow, YT showed that the slightly elevated risks from consuming Hg in caribou meat and kidney was more than balanced by the high levels of nutrients in the diet (Schuster et al. 2011).

The concentrations of Hg reported here in moose organs from the Mackenzie Valley agree with other assessments showing that total Hg in moose is considerably lower than barren-ground caribou (Gamberg et al. 2005b) and other large mammals in the NWT (Larter et al. 2016). An assessment of Hg uptake and exposure in moose in southern Canada showed that aquatic macrophytes could be a significant source of total Hg and methylmercury to moose, with large differences in Hg concentration between aquatic plant species (Bergman and Bump 2014). However, estimated exposure levels to methylmercury in that study were well below reference level of 18 µg/kg/d cited by the authors. Total Hg concentrations reported here for Mackenzie Valley moose are far below the concentration of 30 mg/kg ww

proposed as a threshold for Hg toxicity in terrestrial wildlife (Scheuhammer et al. 2015, Thompson 1996). We conclude that there is considerable evidence in several studies (e.g. Larter et al. 2016) that show that moose tissues are not a significant source of Hg to humans and are below the concentrations expected to cause adverse biological effects in moose.

Copper (Cu) is an essential element that is monitored in large mammals due to its role in nutrition and the potential for low levels that may impact moose health reproduction. Cu deficiency has been cited as a wide spread issue in the domestic management of deer in New Zealand, where there is a need for Cu supplements in the diet (Grace and Wilson 2002). Frank et al. (2000) have proposed Cu deficiency from elevated molybdenum (Mo) in the diet to explain a syndrome of clinical symptoms in wild populations of moose in Sweden. Zatta and Frank (2006) cite a number of pathologies and neurological disorders in humans and animals caused by Cu deficiencies.

The role of Cu metabolism and deficiency in the nutritional requirements of large mammals is an active area of research. Cu is an essential nutrient that is stored in the liver (Grace and Wilson 2002) and passed to the developing fetus during gestation. Cu concentrations in the liver of developing fetuses have been shown to increase until parturition, with concentrations in excess of 1,000 mg/kg ww, followed by a decline after birth (Hyvärinen and Nygrėn 1993). The Cu concentrations observed here for Mackenzie River Valley moose are consistent with moose from the southern Mackenzie Mountains (3.25 mg/kg ww in kidney; Larter et al. 2016) and the YT (3.47 mg/kg ww in kidney and 40.32 mg/kg ww in liver; Gamberg et al. 2005a) and show no evidence of elevated concentrations or deficiency. It is not possible to test for variability in Cu stores in the liver of Mackenzie River Valley females throughout the reproductive cycle due to the relatively small number of samples available.

The moose harvested in this study were taken mostly in the spring and fall, and some disparity with other studies could be a result of seasonal variation in diet and habitat and resource use by moose (McLoughlin et al. 2011). Some elements have been observed to vary seasonally due to changes in concentration in major plant items in the diet (Brekken and Steinnes 2004, Deram et al. 2006) and resource use (McLoughlin et al. 2011). Controlled experiments with grasses have shown that the amount of Cd and Zinc (Zn) accumulated in plant shoots varies throughout the year, whether grown on contaminated or natural soil (Deram et al. 2006). McLaughlin et al. (2011) observed seasonal changes in habitat and resource use in moose population in Ontario, usually in response to human activity such as hunting and roads, and functional habitat. For elements with short residence times, in the order of days in the mammalian body (e.g. Cs; Åhman 2007), seasonal changes in diet can lead to significant seasonal variation in organ concentrations as dietary intake changes, while for elements such as Cd, with clearance times of several years (Kjellstrom 1986; ATSDR 2012), seasonality would be less of a factor. The result of this variation in natural history and exposure to elements during the year and biochemical properties of individual elements in mammalian system leads to dynamic balance that needs to be considered when comparing elemental concentrations between populations.

LITERATURE CITED

Åhman, B. 2007. Modeling radiocaesium transfer and long-term changes in reindeer. Journal of Environmental Radioactivity 98:153-165.

Arnold, S.M., R.L. Zarnke, T.V. Lynn, M-A.R. Chimonas and D. Frank. 2006. Public health evaluation of cadmium concentrations in liver and kidney of moose (*Alces alces)* from four areas of Alaska. Science of Total Environment 357:103-111. doi:10.1016/j.scitotenv.2005.02.040.

ATSDR (Agency for Toxic Substances and Disease Registry). 2012. Toxicological profile for cadmium. US Department of Health and Human Services, Public Health Service. 487pp.

Aughey, E., G.S. Fell, R. Scott and M. Black. 1984. Histopathology of early effects of oral cadmium in the rat kidney. Environmental Health Perspectives 54:153-161.

Beiglböck, C., T. Steineck, F. Tataruch and T. Ruf. 2002. Environmental cadmium induces histopathological changes in kidneys of roe deer. Environmental Toxicology and Chemistry 21:1,811-1,816. doi: 10.1002/etc.5620210908.

Bergman, B.G. and J.K. Bump. 2014. Mercury in aquatic forage of large herbivores: impact of environmental conditions, assessment of health threats, and implications for transfer across ecosystem compartments. Science of Total Environment 479/480:66-76.

Berti, P.R., O. Receveur, H.M. Chan and H.V. Kuhnlein. 1998. Dietary exposure to chemical contaminants from traditional food among adult Dene/Metis in the western Northwest Territories, Canada. Environmental Research 76:131-142.

Brekken, A, and E. Steinnes. 2004. Seasonal concentrations of cadmium and zinc in native pasture plants: consequences for grazing animals. Science of Total Environment 326:181-195.

Chan, H.M., C, Kim and D. Leggee. 2001. Cadmium in caribou (*Rangifer tarandus*) kidneys: Speciation, effects of preparation and toxicokinetics. Food Additives & Contaminants 18:607-614. doi: 10.1080/02652030120871.

Chételat, J., M. Amyot, P. Arp, J.M. Blais, D. Depew, C.A. Emmerton, M. Evans, M. Gamberg, N. Gantner, C. Girard, J. Graydon, J. Kirk, D. Lean, I. Lehnherr, D. Muir, M. Nasr, A.J. Poulain, M. Power, P. Roach, G. Stern, H. Swanson and S. van der Velden. 2015. Mercury in freshwater ecosystems of the Canadian Arctic: recent advances on its cycling and fate. Science of the Total Environment 509/510:41-66.

Danielsson, R. and A. Frank. 2009. Cadmium in moose kidney and liver - age and gender dependency, and standardization for environmental monitoring. Environmental Monitoring and Assessment 157, 73-88. doi: 10.1007/s10661-008-0516-y.

Depew, D.C., N.M. Burgess, M.R. Anderson, R. Baker, S.P. Bhavsar, R.A.D. Bodaly, C.S. Eckley, M.S. Evans, N. Gantner, J.A. Graydon, K. Jacobs, J.E. LeBlanc, V. St. Louis and L.M. Campbell. 2013. An overview of mercury concentrations in freshwater fish species: a national fish mercury dataset for Canada. Canadian Journal of Fisheries and Aquatic Sciences 70:436–51.

Deram, A, F.-O. Denayer, D. Petit and A. van Haluwyn. 2006. Seasonal variation of cadmium and zinc in *Arrhenatherum elatius*, a perennial grass species from highly contaminated soils. Environmental Pollution 140:62-70.

Environment Canada. 2015. Methods 2705. Metals in biota. National Laboratory for Environmental testing (NLET), Burlington, ON.

Frank, A., D.R. Sell, R. Danielsson, J.F. Fogarty and V.M. Monnier. 2000. A syndrome of molybdenosis, copper deficiency, and type 2 diabetes in the moose population of south-west Sweden. Science of the Total Environment 249:123-131.

Gamberg, M., M. Palmer and P. Roach. 2005a. Temporal and geographic trends in trace element concentrations in moose from Yukon, Canada. Science of the Total Environment 351/352:530-538. doi: 10.1016/j.scitotenv.2004.05.033.

Gamberg, M., B. Braune, E. Davey, B. Elkin, P.F. Hoekstra, D. Kennedy, C. Macdonald, D. Muir, A. Nirwal, M. Wayland and B. Zeeb. 2005b. Spatial and temporal trends of contaminants in terrestrial biota from the Canadian Arctic. Science of the Total Environment 351/352: 148-164. doi: 10.1016/j.scitotenv.2004.10.032.

Gamberg, M., J. Chételat, A.J. Poulain, C. Zdanowicz and J. Zheng. 2015. Mercury in the Canadian Arctic Terrestrial Environment. Science of the Total Environment 509/510:28-40.

GNWT-HSS (Government of the Northwest Territories Health and Social Services). 2017. Moose organ consumption notice. [www.hss.gov.nt.ca/sites/www.hss.gov.nt.ca/files/resources/moose-organ-consumption-notice.pdf] (Accessed 25 May 2017)

Gough, L.P., P.J. Lamothe, R.F. Sanzolone, L.J. Drew, J.A.K. Maier and J.H. Schuenemeyer. 2013. Cadmium geochemistry of soils and willow in a metamorphic bedrock terrain and its possible relation to moose health, Seward Peninsula, Alaska. Alces 49:99-111.

Grace, N.D. and P.R. Wilson. 2002. Trace element metabolism, dietary requirements, diagnosis and prevention of deficiencies in deer. New Zealand Veterinary Journal 50:252-259.

Health Canada. 2007. Human health risk assessment of mercury in fish and health benefits of fish consumption. Bureau of Chemical Safety, Food Directorate, Health Products and Food Branch. (accessed May 2017).

Health Canada. 2010. Federal contaminated sites risk assessment in Canada. Part I: Guidance on human health preliminary quantitative risk assessment (PQRA), Version 2.0. Contaminated Sites Program, Health Canada, Ottawa. Revised 2012. 52pp.

Hyvärinen, H. and T Nygrén. 1993. Accumulation of copper in the liver of moose in Finland. Journal of Wildlife Management 57:469-474.

JECFA (Joint FAO/WHO Expert Committee on Food Additives). 2010. Summary and conclusions of the seventy-third meeting, Geneva, 8-17 June 2010. Geneva, World Health Organization, Joint FAO/WHO Expert Committee on Food Additives. JECFA/73/SC.

Kjellström, T. 1986. Critical organs, critical concentrations and whole body dose-response relationships. In: Friberg, LT. Cadmium and health: a toxicological and epidemiological appraisal. Boca Raton, Florida: CRC Press. p. 231-246.

Larter, N.C. 2009. A program to monitor moose populations in the Dehcho region, Northwest Territories, Canada. Alces 45:89-99.

Larter, N.C. and K. Kandola. 2010. Levels of arsenic, cadmium, lead, mercury, selenium, and zinc in various tissues of moose harvested in the Dehcho, Northwest Territories. Circumpolar Health Supplement 7:351-355.

Larter, N.C., C.R. Macdonald, B.T. Elkin, X. Wang, N.J. Harms, M. Gamberg and D.C.G. Muir. 2016. Cadmium and other elements in tissues from four ungulate species from the Mackenzie Mountain region of the Northwest Territories, Canada. Ecotoxicology and Environmental Safety 132:9-17.

Larter, N.C., D. Muir, X. Wang, D.G. Allaire, A. Kelly and K. Cox. 2017 Persistent organic pollutants in the livers of moose harvested in the southern Northwest Territories, Canada. Alces 53: 65-83.

Larter, N.C., C.R. Macdonald, and N.J. Harms. 2018. Comparing kidney histology: moose harvested in the Mackenzie Valley versus the Mackeznie Mountains. Environment and Natural Resources Manuscript Report No. 272. 13pp.

Lockhart, W.L., G.A. Stern, G. Low, M. Hendzel, G. Boila, P. Roach, M.S. Evans, B.N. Billeck, J. DeLaronde, S. Friesen, K. Kidd, S. Atkins, D.C.G. Muir, M. Stoddart, G. Stephens, S. Stephenson, S. Harbicht, N. Snowshoe, B. Grey, S. Thompson and N. DeGraff. 2005. A history of total mercury in edible muscle of fish from lakes in northern Canada. Science of the Total Environment 351/352:427-463.

Ma, W.-C. 1996. Lead in mammals. *In* Beyer, W.N., G.H. Heinz and A.W. Redmon-Norwood, editors. Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. Boca Raton, FL: Lewis Publishers; 1996. p.281-296.

Matson, G.M. 1981, Matson's Workbook for Cementum Analysis. Milltown, MT.

McAuley, C. and L.D. Knopper. 2011. Impacts of traditional food consumption advisories: compliance, changes in diet and loss of confidence in traditional foods. Environmental Health 10:55. doi: 10.1186/1476-069X-10-55.

McLoughlin, P.D., E.V. Wal, S.J. Lowe, B.R. Patterson and D.L. Murray. 2011. Seasonal shifts in habitat selection of a large herbivore and the influence of human activity. Basic and Applied Ecology 12:654-663.

Mochizuki, M., M. Mori, R. Hondo and F. Ueda. 2008. A new index for evaluation of cadmium pollution in birds and mammals. Environmental Monitoring and Assessment 137:35-49.

Murray, D.L., E.W. Cox, W.B. Ballard, H.A. Whitlaw, M.S. Lenarz, T.W. Custer, T. Barnett and T.K. Fuller. 2006. Pathogens, nutritional deficiency, and climate influences on a declining moose population. Wildlife Monographs 166:1-30. doi: 10.2193/0084-0173(2006)166[1:PNDACI]2.0.CO;2.

Outridge, P.M., D.D. MacDonald, E. Porter and I.D. Cuthbert. 1994. An evaluation of the ecological hazards associated with cadmium in the Canadian environment. Environmental Reviews 2:91-107.

Reimann, C., P. Englmaier, K. Fabian, L. Gough, P. Lamothe and D. Smith. 2015. Biogeochemical plant-soil interaction: Variable element composition in leaves of four plant species collected along a south-north transect at the southern tip of Norway. Science of the Total Environment 506/507:480-495. doi: 10.1016/j.scitotenv.2014.10.079

Satarug, S., M.R. Haswell-Elkins and M.R. Moore. 2000. Safe levels of cadmium intake to prevent renal toxicity in human subjects. British Journal of Nutrition 84:791-802.

Schuster, R.C., M. Gamberg, C. Dickson and H.M. Chan. 2011. Assessing risk of mercury exposure and nutritional benefits of consumption of caribou (*Rangifer tarandus*) in the Vuntut Gwitchin First Nation community of Old Crow, Yukon, Canada. Environmental Research 111:881-887. doi: 10.1016/j.envres.2011.05.025.

Scheuhammer, A., B. Braune, H.M. Chan, H. Frouin, A. Krey, R. Letcher, L. Loseto, M. Noël, S. Ostertag, P. Ross and M. Wayland. 2015. Recent progress on our understanding of the biological effects of mercury and fish and wildlife in the Canadian Arctic. Science of the Total Environment 509/510:91-103.

Skibniewski, M., E.M. Skibniewska, T. Kośla and K. Olbrych. 2017. Relationship between Cd and Zn concentration in the kidneys, liver, and muscles of moose (*Alces alces*) from north-eastern Poland. Environmental Science and Pollution Research 24:598-604.

Stoev, S.D., N. Grozeva, R. Simeonov, I. Borisov, H. Hubenov, Y. Nikolov, M. Tsaneva and S. Lazarova. 2003. Experimental cadmium poisoning in sheep. Experimental and Toxicologic Pathology 55:309-314.

Thompson, D.R. 1996. Mercury in birds and terrestrial mammals. *in* Beyer, W.N., G.H. Heinz, A.W. Redmon-Norwood, editors. Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. Boca Raton, FL: Lewis Publishers; 1996. p.341–356.

Van Oostdam, J., S.G. Donaldson, M. Feeley, D. Arnold, P. Ayotte, G. Bondy, L. Chan, E. Dewaily, C.M. Furgal, H. Kuhnlein, E. Loring, G. Muckle, E. Myles, O. Receveur, B. Tracy, U. Gill and S. Kalhok. 2005. Human health implications of environmental contaminants in Arctic Canada. Science of the Total Environment 351/352:165-246.

WHO (World Health Organization). 1992. Cadmium. Environmental Health Criteria 134. International Programme on Chemical Safety. Geneva.

Wilson, J.M. and C.A. Haas. 2012. Important wildlife areas in the western Northwest Territories. Environment and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 221. 233pp.

WGGSS (Working Group on General Status of Species). 2016. NWT Species 2016-2020 - General Status Ranks of Wild Species in the Northwest Territories. Environment and Natural Resources, Government of the Northwest Territories. 304pp.

Ytrehus, B., H. Skagemo, G. Stuve, T. Sivertsen, K. Handeland and T. Vikøren. 1999. Osteoporosis, bone mineralization, and status of selected trace elements in two populations of moose calves in Norway. Journal of Wildlife Diseases 35:204-211.

Zatta, P. and A. Frank. 2006. Copper deficiency and neurological disorders in man and animals. Brain Research Reviews 54:19-33. doi: 10.1016/j.brainresrev.2006.10.001.

APPENDIX A. Field Data and Raw Data on Harvested Moose

Table A1. Summary of age, sex, reproductive status, month of harvest, kidney fat index (kidney), ratio of fat to kidney weight (Kid), and percent femur marrow fat (marrow) of moose collected from 2005-2007. n/a = not applicable, nd = no data.

Sample ID	Age	Sex	Pregnancy	Lactation	Harvest	Kidney	Kid	Marrow
GEN-13	5.0	F	N	N	9	67.1	0.875	75.8
ADKB-4	0.0	M	n/a	n/a	9	32.3	0.323	nd
GEN-5	2.0	F	Y	N	3	75.3	1.138	96.6
GEN-12	5.5	M	n/a	n/a	9	62.0	0.620	75.0
2005-10	8.0	M	n/a	n/a	9	58.6	0.586	64.7
GEN-9	3.0	M	n/a	n/a	9	155.8	2.101	91.0
ADKB-3	2.0	F	N	N	6	18.8	0.280	56.8
JMR-1	2.0	M	n/a	n/a	8	86.3	0.925	89.7
GEN-10	2.0	M	n/a	n/a	9	145.4	3.534	92.0
GEN-8	2.0	M	n/a	n/a	9	107.7	2.005	79.1
LKFN-2	4.0	M	n/a	n/a	2	50.1	0.612	68.7
NB-1	10.0	F	Y	N	1	55.4	0.624	86.1
GEN-2	6.0	M	n/a	n/a	2	117.9	1.593	90.4
2005-04	2.0	M	n/a	n/a	7	nd	nd	89.8
GEN-11	10.0	M	n/a	n/a	10	18.2	0.182	n/a
GEN-3	1.0	M	n/a	n/a	3	55.9	0.733	87.9
GEN-6	4.0	F	N	N	6	20.6	0.248	74.0
ADKB-5	10.0	F	N	N	1	46.0	0.547	78.8
NB-1FR	1.0	M	n/a	n/a	3	39.6	0.459	77.5
GEN-7	2.0	M	n/a	n/a	9	39.3	0.433	91.7
GEN-14	3.0	M	n/a	n/a	2	nd	0.054	75.0
GEN-15	6.0	F	Y	N	3	nd	0.987	nd
GEN-16	12.0	F	Y	N	3	52.3	0.523	79.4
GEN-17	0.0	F	n/a	n/a	3	nd	0.244	57.1
GEN-18	0.0	M	n/a	n/a	3	nd	0.323	28.9
GEN-19	2.0	M	n/a	n/a	3	50.9	0.530	59.8
JMR-4	5.0	F	Y	N	3	nd	1.930	93.2
2005-6	2.0	F	N	N	5	15.3	0.153	53.3
NB-3	7.0	M	n/a	n/a	3	16.3	0.175	59.3
GEN-20	6.0	M	n/a	n/a	4	28.7	0.326	54.3
GEN-21	3.0	M	n/a	n/a	6	25.6	0.282	81.8
GEN-22	6.0	M	n/a	n/a	7	17.9	0.213	49.0
GEN-23	2.0	M	n/a	n/a	7	20.4	0.208	79.9
GEN-24	2.0	M	n/a	n/a	7	25.7	0.261	86.1
2005-09	1.0	M	n/a	n/a	9	22.8	0.265	86.6
GEN-25	12.5	M	n/a	n/a	1	5.2	0.163	10.8
GEN-26	8.0	F	Y	N	1	142.2	1.759	85.5
JMR-3	7.0	M	n/a	n/a	1	17.6	0.184	21.2
GEN-27	11.0	F	Y	N	2	43.1	0.505	93.6
GEN-28	6.0	F	Y	N	3	93.2	1.070	83.4
GEN-4	1.0	M	n/a	n/a	3	20.1	0.228	51.0
GEN-1	1.0	M	n/a	n/a	2	29.3	0.450	nd
FLML-5	1.0	F	Y	N	2	60.7	0.732	86.1

Table A2. Summary of harvest dates, locations, sex, age, month of harvest, visual body condition rating by harvester (excellent, good, fair, poor), reproductive status, the ratio of fat:kidney weight, percent femur marrow fat, and whether fecal parasite, tissue (kidney, liver, muscle) elements and radionuclide analyses were conducted on moose samples collected from 2011 to 2016.

ID#	Date	Latitude	Longitude	Sex	Age	Harvest Month	Body Condition	Pregnant	Lactating	Kidney:Fat	Femur Fat	Fecal Parasites	Elements for Kidney	Elements for Liver	Elements for Muscle	Radionuclide
Moose#124	26-May-11	61.26557	-119.53470	M	3	5	n/a	n/a	n/a	n/a	n/a	n/a	Y	n/a	Y	n/a
Moose#125	26-May-11	61.38503	-120.12002	F	2	5	n/a	n/a	n/a	n/a	90.3	n/a	Y	n/a	Y	n/a
Moose#189	30-Nov-12	61.15955	-122.76467	M	1	11	n/a	n/a	n/a	n/a	67.8	Y	Y	n/a	n/a	n/a
Moose#199	28-Sep-13	62.75945	-123.12630	M	1	9	E	n/a	n/a	n/a	82.5	Y	Y	n/a	n/a	Y
Moose#201	1-Oct-13	61.04167	-122.91500	M	5	10	E	n/a	n/a	0.8076	81.3	Y	Y	Y	Y	Y
Moose#202	28-Sep-13	61.60922	-120.72820	F	2	9	E	N	N	0.0573	90.2	Y	Y	Y	Y	Y
Moose#203	4-Oct-13	60.95487	-123.21713	M	1	10	G	n/a	n/a	0.4353	79.9	Y	Y	Y	Y	Y
Moose#207	6-Sep-13	62.32033	-122.72417	F	4	9	G	N	Y	0.6485	90.5	Y	Y	n/a	n/a	Y
Moose#210	12-Feb-14	61.57600	-121.09700	M	4	2	G	n/a	n/a	1.2613	23.0	n/a	Y	Y	n/a	n/a
Moose#211	12-Feb-14	61.68885	-121.36859	F	10	2	E	N	N	2.6950	88.4	Y	Y	n/a	n/a	n/a
Moose#212	7-Mar-14	62.04083	-122.02583	F	4	3	E	Y	N	1.3393	91.6	Y	Y	Y	n/a	n/a
Moose#213	4-May-14	61.92118	-121.73220	M	1	5	F	n/a	n/a	1.1615	67.1	Y	Y	n/a	n/a	n/a
Moose#214	3-Sep-14	62.46374	-123.01245	M	2.5	9	E	n/a	n/a	n/a	91.6	Y	Y	Y	n/a	Y
Moose#215	18-Sep-14	62.00126	-121.77788	M	1	9	E	n/a	n/a	n/a	85.8	Y	Y	n/a	n/a	n/a
Moose#216	21-Sep-14	62.02363	-121.89969	M	7.5	9	E	n/a	n/a	2.5077	83.3	n/a	Y	n/a	n/a	Y
Moose#217	20-Sep-14	62.67938	-123.50792	M	n/a	9	G	n/a	n/a	1.4860	n/a	n/a	Y	n/a	n/a	Y
Moose#220	2-Oct-14	62.25753	-122.76811	M	3	10	F	n/a	n/a	0.3987	53.1	Y	Y	Y	Y	Y
Moose#221	2-Oct-14	61.62172	-121.41872	M	2	10	E	n/a	n/a	1.6603	87.2	n/a	Y	n/a	n/a	Y
Moose#222	5-Oct-14	61.15766	-122.76811	M	2	10	G	n/a	n/a	1.1062	n/a	Y	Y	n/a	n/a	Y
Moose#223	4-Oct-14	61.78162	-120.69358	M	3	10	E	n/a	n/a	0.6849	83.0	n/a	Y	n/a	n/a	Y
Moose#226	18-Jan-15	62.59395	-123.19917	F	1	1	G	N	N	1.2748	72.7	Y	Y	n/a	n/a	Y
Moose#227	26-Jan-15	61.30310	-122.29857	F	2	1	E	Y	N	1.9615	91.7	Y	Y	Y	Y	Y
Moose#228	14-Feb-15	61.29099	-121.26376	M	0	2	E	n/a	n/a	1.0887	38.6	Y	Y	Y	Y	Y
Moose#229	19-Feb-15	63.16550	-122.80457	F	8	2	E	Y	N	0.2579	90.3	Y	Y	Y	Y	n/a
Moose#230	11-Apr-15	63.16767	-123.31533	M	2	4	E	n/a	n/a	1.0049	n/a	Y	Y	Y	n/a	n/a
Moose#231	30-May-15	60.96095	-123.07701	M	1	5	E	n/a	n/a	1.4539	86.1	Y	Y	n/a	n/a	n/a
Moose#232	23-Jun-15	62.15331	-122.66218	M	1	6	E	n/a	n/a	1.1681	55.8	Y	Y	n/a	n/a	n/a
Moose#233	9-Sep-15	60.02167	-123.84250	M	4	9	G	n/a	n/a	3.0192	92.0	Y	Y	n/a	n/a	Y
Moose#234	19-Sep-15	61.01200	-122.96300	M	1	9	E	n/a	n/a	0.7268	85.2	Y	Y	Y	n/a	n/a
Moose#235	23-Sep-15	62.13000	-122.55000	M	n/a	9	E	n/a	n/a	n/a	85.5	n/a	Y	n/a	n/a	n/a

ID#	Date	Latitude	Longitude	Sex	Age	Harvest Month	Body Condition	Pregnant	Lactating	Kidney:Fat	Femur Fat	Fecal Parasites	Elements for Kidney	Elements for Liver	Elements for Muscle	Radionuclide
Moose#236	28-Sep-15	62.26500	-123.32400	M	3	9	F	n/a	n/a	1.6121	69.2	n/a	Y	Y	Y	Y
Moose#237	28-Sep-15	62.65063	-122.91440	M	2	9	E	n/a	n/a	1.1698	85.6	n/a	Y	Y	Y	Y
Moose#240	3-Oct-15	61.42800	-121.56800	F	2	10	E	N	N	1.1504	91.4	Y	Y	n/a	n/a	Y
Moose#241	3-Oct-15	61.44400	-121.55300	M	6	10	E	n/a	n/a	0.5926	89.6	n/a	Y	Y	Y	Y
Moose#243	28-Sep-15	61.11667	-123.61667	M	4	9	E	n/a	n/a	0.6294	93.2	n/a	Y	Y	Y	n/a
Moose#247	12-Nov-15	63.66895	-123.74245	M	6	11	E	n/a	n/a	0.4579	80.9	n/a	Y	Y	Y	n/a
Moose#249	8-Oct-15	61.26667	-123.75000	F	1	10	G	n/a	n/a	0.7448	88.9	n/a	Y	Y	n/a	n/a
Moose#250	3-Jan-16	61.89753	-121.35411	M	3	1	F	n/a	n/a	0.1282	11.7	Y	Y	Y	Y	n/a

APPENDIX B. Elemental Concentrations for Samples from Moose Harvested from 2005-2016

Table B1. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg wet weight. Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	GEN-13	GEN-13	ADKB-4	ADKB-4	GEN-5	GEN-5	GEN-12	GEN-12
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	5-Sep-05	5-Sep-05	5-Sep-05	5-Sep-05	3-Mar-05	3-Mar-05	5-Sep-05	5-Sep-05
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	F	F	M	M	F	F	M	M
Age	5	5	0	0	2	2	5.5	5.5
Moist (%)	67.6	50.8	67.7	65.4	71.4	72.2	58.8	64.7
Dry Matter	0.324	0.492	0.323	0.346	0.286	0.278	0.412	0.353
Aluminum	0.04	0.14	0.01	0.12	0.01	0.06	0.01	0.35
Antimony	<0.001	0.002	<0.001	0.001	<0.001	0.001	<0.001	0.001
Arsenic	0.069	0.122	0.001	0.014	0.001	0.014	0.028	0.126
Barium	0.108	0.107	0.232	0.114	0.296	0.179	0.18	0.063
Beryllium	<0.0001	0.0009	0.0001	0.0001	<0.0001	0.0007	0.0001	0.0019
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001
Cadmium	24.70	2.71	19.90	2.82	8.09	1.39	0.74	0.34
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0464	0.0252	0.0084	0.0044	0.0092	0.0035	0.0375	0.0221
Chromium	<0.001	0.011	0.004	0.016	0.007	0.009	0.002	0.008
Cobalt	0.0651	0.0439	0.0545	0.135	0.052	0.0636	0.0375	0.0773
Copper	2.45	4.9	3.94	9.58	3.32	41	4.11	24.6
Gallium	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Iron	30.7	146	42.4	174	60.7	239	47.3	96.5
Lanthanum	0.0001	0.0005	<0.0001	0.001	<0.0001	0.0005	<0.0001	0.0006
Lead	0.0005	0.002	0.0020	0.002	0.0030	0.009	0.0010	0.006
Lithium	<0.01	<0.01	0.02	0.01	<0.01	<0.01	0.16	0.06
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	0.748	1.08	3.3	3.04	2.65	1.91	2.85	4.17
Mercury	0.040	0.006	0.028	0.004	0.018	0.002	0.030	0.005
Molybdenum	0.171	0.607	0.425	1.47	0.484	1.35	0.338	1.16
Nickel	0.032	<0.005	0.196	<0.005	0.064	<0.005	0.012	<0.005
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	1800	2510	2380	2820	2120	2400	2550	3690
Rubidium	9.46	8.14	4.31	6.19	4.82	5.8	5.94	10
Selenium	0.72	0.68	0.95	0.96	0.77	0.47	0.86	1.62
Silver	0.0005	0.151	<0.0001	0.0282	0.0011	0.0692	<0.0001	0.132
Strontium	0.048	0.033	0.061	0.061	0.073	0.062	0.051	0.047
Thallium	0.0024	0.0002	0.0019	0.0003	0.0034	0.0003	0.0035	0.0004
Tin	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	0.0001	<0.0001	0.0005	<0.0001	0.0001	<0.0001	0.0001
Vanadium	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001
Zinc	24.7	20.7	29.0	26.0	24.0	21.1	19.7	26.2

Table B2. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	2005-10	2005-10	GEN-9	GEN-9	ADKB-3	ADKB-3	JMR-1	JMR-1
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	5-Sep-05	5-Sep-05	21-Sep-05	21-Sep-05	20-Jun-05	20-Jun-05	7-Aug-05	7-Aug-05
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	M	M	M	M	F	F	M	M
Age	8	8	3	3	2	2	2	2
Moist (%)	76.1	63.3	73.9	66.9	59.7	67.2	63.5	69.6
Dry Matter	0.239	0.367	0.261	0.331	0.403	0.328	0.365	0.304
Aluminum	0.04	2.62	0.01	0.21	0.13	<0.02	0.01	1.13
Antimony	0.001	0.001	<0.001	0.034	<0.001	0.001	<0.001	0.002
Arsenic	0.072	0.283	0.028	0.034	0.001	0.007	0.001	0.006
Barium	0.133	0.122	0.144	0.113	0.159	0.177	0.097	0.094
Beryllium	0.0001	0.0006	<0.0001	0.0015	0.0001	<0.0001	<0.0001	0.0001
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	24.10	5.39	13.30	1.65	4.15	2.06	3.71	0.65
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0486	0.0647	0.0769	0.0446	0.0086	0.0091	0.0051	0.0032
Chromium	0.005	0.036	0.009	0.028	0.012	0.011	0.001	0.343
Cobalt	0.0726	0.0692	0.079	0.0855	0.0291	0.0902	0.0782	0.127
Copper	2.66	8	2.47	11	4.18	10.4	3.66	5.76
Gallium	<0.0001	0.0007	<0.0001	<0.0001	0.0001	0.0002	<0.0001	0.0003
Iron	32.6	186	50.2	211	42.6	77	66.7	91.5
Lanthanum	<0.0001	0.0019	<0.0001	0.0013	<0.0001	0.0003	<0.0001	0.0008
Lead	0.0110	0.019	0.0005	0.057	0.0030	0.005	0.0010	0.005
Lithium	<0.01	0.01	0.02	0.01	0.03	0.01	0.01	0.01
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	0.798	1.7	1.1	1.33	2.92	3.7	2.36	4.78
Mercury	0.048	0.021	0.022	0.003	0.010	0.007	0.014	0.005
Molybdenum	0.192	1.08	0.219	0.678	0.168	1.55	0.162	0.702
Nickel	0.037	0.013	0.096	<0.005	0.134	<0.005	0.073	0.226
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	1960	2270	2120	2950	2540	2640	2230	2460
Rubidium	9.4	14.5	10.8	13.1	5.02	5.37	1.98	2.58
Selenium	0.77	2.17	0.77	0.52	0.77	0.77	0.71	0.23
Silver	0.0004	0.424	<0.0001	0.0742	<0.0001	0.0496	<0.0001	0.0014
Strontium	0.094	0.04	0.062	0.036	0.128	0.038	0.119	0.073
Thallium	0.0025	0.0003	0.0026	0.0002	0.0012	0.0002	0.0026	0.0002
Tin	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	0.0003	<0.0001	0.0003	<0.0001	<0.0001	<0.0001	0.0001
Vanadium	<0.001	0.008	<0.001	0.002	<0.001	<0.001	<0.001	0.003
Zinc	26.1	32.1	21.9	15.2	22.6	29.7	20.5	31.2

Table B3. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	GEN-10	GEN-10	GEN-8	GEN-8	LKFN-2	LKFN-2	NB-1	NB-1
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	23-Sep-05	23-Sep-05	19-Sep-05	19-Sep-05	10-Feb-05	10-Feb-05	29-Jan-05	29-Jan-05
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	M	M	M	M	M	M	F	F
Age	2	2	2	2	4	4	10	10
Moist (%)	72.2	65.0	74.2	66.2	64.7	67.9	76.5	65.7
Dry Matter	0.278	0.350	0.258	0.338	0.353	0.321	0.235	0.343
Aluminum	0.01	0.22	0.07	0.05	0.13	<0.02	0.05	<0.02
Antimony	<0.001	0.003	<0.001	0.001	0.002	0.001	<0.001	0.004
Arsenic	0.035	0.097	0.006	0.019	0.005	0.008	0.001	0.012
Barium	0.177	0.131	0.119	0.081	0.17	0.069	0.28	0.087
Beryllium	0.0001	0.0006	<0.0001	0.001	0.0004	0.0009	0.0001	0.0015
Bismuth	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	7.87	1.30	8.18	1.23	38.00	1.43	30.50	4.28
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0846	0.0505	0.0308	0.0233	0.0559	0.0026	0.0037	0.002
Chromium	0.02	0.233	0.014	0.096	0.022	0.005	0.025	0.009
Cobalt	0.0406	0.0737	0.0543	0.0881	0.064	0.066	0.078	0.114
Copper	3.53	7	3.39	5.11	3.06	35.1	3.95	24.8
Gallium	0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.0001
Iron	46.7	190	30.2	124	35.5	240	48.6	325
Lanthanum	<0.0001	0.0056	0.0001	0.0001	0.0007	0.0004	0.0001	0.0026
Lead	0.0030	0.017	0.0070	0.011	0.0040	0.003	0.0080	0.008
Lithium	0.01	0.01	0.04	0.01	0.24	0.01	0.11	0.04
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	2.14	1.71	1.71	1.54	1.13	2.04	2.94	2.87
Mercury	0.157	0.025	0.039	0.007	0.029	0.003	0.010	0.005
Molybdenum	0.503	1.42	0.308	0.948	0.296	1.2	0.418	2.35
Nickel	0.018	0.164	0.511	0.049	0.033	<0.005	0.081	<0.005
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2400	3000	2410	3330	2350	2770	2360	3260
Rubidium	16.9	21.7	18.5	24	10.3	4.42	2.38	3.77
Selenium	0.76	0.51	0.84	0.43	0.87	0.39	0.46	0.54
Silver	0.0008	0.103	0.0003	0.0364	<0.0001	0.0193	<0.0001	0.0216
Strontium	0.089	0.053	0.093	0.062	0.131	0.047	0.178	0.048
Thallium	0.026	0.0012	0.0033	0.0002	0.0021	0.0001	0.001	0.0002
Tin	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.04	<0.01
Uranium	<0.0001	0.0001	<0.0001	0.0001	0.0001	<0.0001	<0.0001	<0.0001
Vanadium	<0.001	0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001
Zinc	23.5	22.1	22.3	19.3	27.0	30.3	38.4	31.3

Table B4. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	GEN-2	GEN-2	2005-04	2005-04	GEN-11	GEN-11	GEN-3	GEN-3
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	26-Feb-05	26-Feb-05	30-Jul-05	30-Jul-05	5-Oct-05	5-Oct-05	6-Mar-05	6-Mar-05
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	M	M	M	M	M	M	M	M
Age	6	6	2	2	10	10	1	1
Moist (%)	57.6	69.6	69.9	65.3	68.7	69.0	67.1	65.0
Dry Matter	0.424	0.304	0.301	0.347	0.313	0.310	0.329	0.350
Aluminum	0.01	<0.02	0.18	<0.02	0.02	0.13	0.01	0.06
Antimony	0.001	0.065	<0.001	0.002	<0.001	0.005	0.001	0.002
Arsenic	0.001	0.011	0.002	0.013	0.008	0.040	0.001	0.017
Barium	0.601	0.11	0.228	112	0.181	13	0.223	118
Beryllium	<0.0001	0.0008	0.0001	0.0004	<0.0001	0.0002	0.0001	0.0002
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Cadmium	21.90	3.98	21.50	0.62	27.10	4.96	8.32	2.66
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0045	0.0024	0.0125	0.0062	0.0071	0.003	0.0013	0.0007
Chromium	0.009	0.005	0.005	0.011	0.012	0.019	0.004	0.01
Cobalt	0.0318	0.0788	0.0803	0.064	0.0427	0.0715	0.0958	0.0884
Copper	3.55	18.4	4.52	21.4	4.23	10.8	3.05	161
Gallium	<0.0001	<0.0001	0.0001	<0.0001	0.0001	0.0002	<0.0001	0.0001
Iron	33.7	186	32.3	134	64.6	173	45.6	231
Lanthanum	<0.0001	0.0004	<0.0001	0.0003	<0.0001	0.001	<0.0001	0.0005
Lead	0.0270	0.018	0.0030	0.001	0.0060	0.003	0.0020	0.009
Lithium	<0.01	<0.01	0.02	0.01	0.03	0.01	0.01	<0.01
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	3.13	3.03	2.83	3.79	2.64	2.11	2.78	3.06
Mercury	0.019	0.004	0.044	0.096	0.034	0.010	0.007	0.004
Molybdenum	0.415	1.61	0.388	1.05	0.408	1.31	0.353	1.48
Nickel	0.136	<0.005	0.09	<0.005	0.22	<0.005	0.066	0.021
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2380	2930	2500	3130	2620	2690	2330	2700
Rubidium	3.7	3.46	5.03	7.5	6.21	6.8	2.73	2.87
Selenium	0.92	1.40	0.94	1.21	0.90	0.96	1.35	7.85
Silver	<0.0001	0.0423	<0.0001	0.0115	0.0057	0.129	<0.0001	0.0505
Strontium	0.195	0.047	0.283	0.032	0.103	0.052	0.15	0.075
Thallium	0.0017	0.0002	0.0045	0.0002	0.0013	0.0001	0.0063	0.0005
Tin	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	0.001
Zinc	32.4	28.2	33.3	21.6	30.6	23.2	23.7	24.9

Table B5. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	GEN-6	GEN-6	ADKB-5	ADKB-5	NB-1FR	NB-1FR	GEN-7	GEN-7
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	20-Jun-05	20-Jun-05	23-Jan-05	23-Jan-05	9-Mar-05	9-Mar-05	13-Sep-05	13-Sep-05
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	F	F	F	F	M	M	M	M
Age	4	4	10	10	1	1	2	2
Moist (%)	74.6	69.3	66.7	65.4	66.5	66.8	62.7	66.8
Dry Matter	0.254	0.307	0.333	0.346	0.335	0.332	0.373	0.332
Aluminum	0.01	<0.02	0.01	0.06	0.06	<0.02	0.01	0.05
Antimony	<0.001	0.001	<0.001	0.001	0.001	<0.001	<0.001	0.002
Arsenic	0.001	0.014	0.001	<0.002	0.003	<0.002	0.002	0.005
Barium	0.45	0.067	0.177	0.038	0.328	0.109	0.068	0.068
Beryllium	<0.0001	0.0005	0.0001	<0.0001	0.0004	<0.0001	<0.0001	<0.0001
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	13.00	4.92	34.90	5.79	20.50	3.29	2.52	0.40
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0152	0.007	0.0107	0.0051	0.0019	0.0006	0.0201	0.0128
Chromium	<0.001	0.008	0.009	0.012	0.002	0.053	<0.001	0.093
Cobalt	0.0371	0.112	0.133	0.111	0.0405	0.0707	0.0309	0.0645
Copper	3.77	78.3	3.55	16	3.81	37.8	3.21	3.07
Gallium	<0.0001	<0.0001	0.0001	0.0001	0.0001	0.0002	<0.0001	0.0003
Iron	38.7	127	40.6	146	55.8	257	24.1	1050
Lanthanum	<0.0001	0.0005	<0.0001	0.0014	0.0006	0.0001	<0.0001	0.0013
Lead	0.0010	0.005	0.0020	0.009	0.0030	0.005	0.0040	0.021
Lithium	0.01	<0.01	0.02	0.01	0.03	0.01	<0.01	<0.01
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	1.96	4.17	4.37	2.74	3.88	2.91	1.79	1.7
Mercury	0.018	0.003	0.031	0.012	0.014	0.002	0.033	0.009
Molybdenum	0.254	1.19	0.492	2.14	0.327	1.12	0.361	1.28
Nickel	0.059	<0.005	0.023	<0.005	0.045	0.018	0.012	0.037
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2030	2750	2560	2880	2910	2890	2250	3580
Rubidium	3.59	7.61	5.55	7.96	2.49	2.7	7.23	10.5
Selenium	0.75	0.77	0.76	0.57	1.05	2.16	0.93	0.62
Silver	<0.0001	0.0792	<0.0001	0.0865	<0.0001	0.0069	0.0001	0.0213
Strontium	0.08	0.029	0.139	0.047	0.134	0.045	0.057	0.043
Thallium	0.001	0.0003	0.0034	0.0003	0.0051	0.0004	0.0042	0.0002
Tin	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	28.7	25.5	38.6	39.9	29.0	20.5	18.7	16.7

Table B6. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	GEN-14	GEN-14	GEN-15	GEN-15	GEN-16	GEN-16	GEN-17	GEN-17
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	21-Feb-06	21-Feb-06	2-Mar-06	2-Mar-06	6-Mar-06	6-Mar-06	6-Mar-06	6-Mar-06
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	M	M	F	F	F	F	F	F
Age	3	3	6	6	12	12	0	0
Moist (%)	62.7	64.7	65.3	74.2	63.7	63.2	60.8	69.4
Dry Matter	0.373	0.353	0.347	0.258	0.363	0.368	0.392	0.306
Aluminum	0.01	0.03	0.01	0.03	0.01	0.09	0.01	0.03
Antimony	0.009	<0.001	<0.001	0.003	<0.001	0.01	<0.001	0.001
Arsenic	0.001	0.002	0.002	0.004	0.003	0.010	0.001	0.002
Barium	0.153	0.051	0.841	0.178	0.434	0.153	0.216	0.089
Beryllium	<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0001
Bismuth	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	5.76	1.01	18.00	1.53	12.10	0.67	0.21	0.05
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0135	0.0044	0.0109	0.0032	0.0161	0.0103	0.0232	0.0118
Chromium	0.002	0.012	0.002	0.038	0.009	0.06	0.034	0.003
Cobalt	0.0423	0.0616	0.02	0.0751	0.0189	0.0336	0.0163	0.0319
Copper	3.64	24.8	4.05	78.8	3.13	3.13	3.88	11.6
Gallium	<0.0001	0.0001	<0.0001	0.0002	<0.0001	<0.0001	0.0001	<0.0001
Iron	40.8	223	36.5	155	47.7	1030	64.1	151
Lanthanum	<0.0001	0.0002	<0.0001	0.0005	<0.0001	0.0008	<0.0001	<0.0001
Lead	1.6600	0.005	0.0030	0.006	0.0050	0.026	0.0020	0.002
Lithium	0.03	0.01	0.06	0.02	0.04	0.02	0.03	0.01
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	4.1	2.92	3.52	3.05	3.83	3.52	3.55	3.66
Mercury	0.040	0.009	0.058	0.021	0.055	0.035	0.026	0.010
Molybdenum	0.395	1.15	0.425	2.38	0.475	2.98	0.395	1.16
Nickel	<0.005	0.019	0.043	0.024	<0.005	<0.005	0.564	0.118
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2380	2920	2760	2720	2320	3150	2470	2830
Rubidium	3.98	5.94	7.17	7.94	4.98	8.31	5.32	8
Selenium	0.78	0.44	0.70	2.49	0.38	0.13	0.33	0.05
Silver	<0.0001	0.105	<0.0001	0.158	<0.0001	0.0518	0.0002	0.0464
Strontium	0.112	0.049	0.164	0.107	0.139	0.091	0.08	0.081
Thallium	0.0054	0.0006	0.0024	0.0003	0.0066	0.0008	0.0136	0.0011
Tin	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
Vanadium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	25.2	22.6	29.5	20.6	26.6	24.1	18.5	17.5

Table B7. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	GEN-18	GEN-18	GEN-19	GEN-19	JMR-4	JMR-4	2005-6	2005-6
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	24-Mar-06	24-Mar-06	18-Mar-06	18-Mar-06	24-Mar-06	24-Mar-06	28-May-06	28-May-06
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	M	M	M	M	F	F	F	F
Age	0	0	2	2	5	5	2	2
Moist (%)	64.0	59.3	64.4	68.7	73.0	60.4	76.6	68.3
Dry Matter	0.360	0.407	0.356	0.313	0.270	0.396	0.234	0.317
Aluminum	0.18	0.01	0.01	0.07	0.01	0.05	0.1	0.17
Antimony	5.84	<0.001	0.002	<0.001	<0.001	0.001	0.001	<0.001
Arsenic	0.066	0.003	0.003	0.003	0.003	0.002	0.006	0.007
Barium	0.386	0.155	0.353	0.125	0.259	0.166	0.258	0.187
Beryllium	<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	<0.0001	0.001
Bismuth	0.0451	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	1.77	0.74	5.17	0.67	14.10	1.43	4.70	0.53
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0014	0.0008	0.0022	0.0009	0.0055	0.0011	0.0188	0.0085
Chromium	0.023	0.008	0.01	0.057	0.006	0.019	0.086	0.264
Cobalt	0.0392	0.0889	0.0266	0.064	0.0332	0.097	0.0468	0.069
Copper	3.67	91.5	3.46	25.4	3.61	25.9	5.18	14
Gallium	<0.0001	0.0001	<0.0001	0.0001	<0.0001	0.0001	0.0002	0.0002
Iron	58.7	174	39.1	358	56.1	266	39.7	178
Lanthanum	0.0006	0.0004	<0.0001	0.0001	<0.0001	0.0007	0.0001	0.0003
Lead	434.0000	0.015	0.0600	0.006	0.0010	0.005	0.0050	0.005
Lithium	0.01	<0.01	0.02	<0.01	0.01	<0.01	0.01	<0.01
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	3.49	3.85	3.31	2.33	3.19	3.48	3.52	3.98
Mercury	0.014	0.006	0.039	0.008	0.023	0.005	0.052	0.032
Molybdenum	0.432	1.39	0.422	1.04	0.351	1.45	0.282	1.03
Nickel	0.095	0.022	0.014	0.065	0.015	0.044	0.11	0.175
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2050	2430	2430	2960	2510	2660	2600	2820
Rubidium	1.04	1.6	2.49	3.25	2.65	1.99	5.7	6.74
Selenium	0.80	0.85	0.57	0.20	0.74	0.60	0.89	0.89
Silver	0.0168	0.117	<0.0001	0.0206	<0.0001	0.11	<0.0001	0.0179
Strontium	0.155	0.112	0.102	0.089	0.11	0.108	0.114	0.073
Thallium	0.0061	0.0001	0.0017	0.0001	0.0008	0.0002	0.0022	0.0002
Tin	1.04	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	0.001	0.002	<0.001	0.001	<0.001	<0.001	0.001	0.001
Zinc	19.4	18.8	21.9	17.7	28.8	22.0	25.3	18.6

Table B8. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	NB-3	NB-3	GEN-20	GEN-20	GEN-21	GEN-21	GEN-22	GEN-22
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	1-Mar-06	1-Mar-06	26-Apr-06	26-Apr-06	8-Jun-06	8-Jun-06	10-Jun-06	10-Jun-06
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	M	M	M	M	M	M	M	M
Age	7	7	6	6	3	3	6	6
Moist (%)	79.0	68.0	76.4	68.2	76.4	59.7	78.2	66.3
Dry Matter	0.210	0.320	0.236	0.318	0.236	0.403	0.218	0.337
Aluminum	<0.02	0.03	0.11	0.21	0.05	0.04	0.61	0.03
Antimony	<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001
Arsenic	0.004	0.006	0.005	0.008	0.005	0.007	0.003	0.006
Barium	0.239	0.129	0.456	0.476	0.265	0.206	0.231	0.129
Beryllium	0.0002	0.0009	<0.0001	0.001	<0.0001	0.0008	<0.0001	0.0008
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	222.00	4.86	20.30	4.99	8.68	1.58	183.00	7.58
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0038	0.0017	0.0034	0.0016	0.02	0.0079	0.0073	0.0058
Chromium	0.002	0.086	0.002	0.125	0.048	0.068	0.04	0.032
Cobalt	0.046	0.101	0.0334	0.0666	0.0263	0.0475	0.0256	0.0664
Copper	3.78	70.6	4.22	112	4.87	69.1	4.37	13.5
Gallium	<0.0001	<0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.0002
Iron	39.5	350	52.8	188	55.9	140	24.8	133
Lanthanum	0.0001	0.0006	0.0001	0.0004	0.0001	0.0004	0.0001	0.0003
Lead	0.0110	0.012	0.0110	0.004	0.0030	0.003	0.0040	0.002
Lithium	0.01	<0.01	0.02	0.01	0.01	<0.01	0.03	0.01
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	2.98	2.38	2.93	3.44	3.12	4.31	2.35	4.88
Mercury	0.043	0.039	0.049	0.036	0.041	0.033	0.049	0.034
Molybdenum	0.425	1.28	0.275	1.23	0.322	0.912	0.233	1.02
Nickel	0.039	0.085	0.039	0.096	0.121	0.02	0.081	0.028
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2400	3010	2820	2630	2640	2340	2540	3400
Rubidium	3.22	5.52	6.16	6.85	8	8.72	6.97	13.3
Selenium	0.94	1.58	1.16	3.97	0.90	1.56	0.98	0.92
Silver	<0.0001	0.0154	<0.0001	0.0364	<0.0001	0.0178	<0.0001	0.0333
Strontium	0.074	0.018	0.214	0.321	0.15	0.031	0.149	0.047
Thallium	0.0011	0.0001	0.0029	0.0002	0.0029	0.0001	0.0012	0.0001
Tin	<0.01	<0.01	0.02	<0.01	0.05	<0.01	0.02	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	<0.001	<0.001	0.001	0.001	<0.001	<0.001	0.002	<0.001
Zinc	39.3	33.9	32.2	36.8	25.1	19.9	51.6	62.6

Table B9. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	GEN-23	GEN-23	GEN-24	GEN-24	2005-9	2005-9	GEN-25	GEN-25
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	14-Jul-06	14-Jul-06	19-Jul-06	19-Jul-06	28-Sep-06	28-Sep-06	14-Jan-07	14-Jan-07
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	M	M	M	M	M	M	M	M
Age	2	2	2	2	1	1	12.5	12.5
Moist (%)	79.0	72.2	78.3	69.5	78.7	65.6	79.0	67.3
Dry Matter	0.210	0.278	0.217	0.305	0.213	0.344	0.210	0.327
Aluminum	0.08	0.12	0.05	0.75	0.06	0.19	0.17	0.02
Antimony	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	0.004	0.005	0.006	0.006	0.008	0.009	<0.002	<0.002
Barium	0.153	0.177	0.271	0.208	0.143	0.217	0.24	0.02
Beryllium	<0.0001	0.0005	<0.0001	0.0008	<0.0001	0.0016	<0.0001	<0.0001
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	5.53	1.04	168.00	5.98	6.51	1.04	26.90	6.89
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0117	0.0073	0.0167	0.013	0.0066	0.003	0.0048	0.003
Chromium	0.016	0.314	0.018	0.254	0.024	0.14	0.012	0.066
Cobalt	0.0318	0.0711	0.0778	0.11	0.0316	0.0767	0.0552	0.099
Copper	4.69	20.3	4.49	26.7	4.11	7.21	2.96	33.2
Gallium	0.0001	0.0004	<0.0001	0.0003	0.0001	0.0003	0.0074	0.012
Iron	34.2	104	39.1	89.6	44.1	151	36.8	201
Lanthanum	0.0001	0.0005	<0.0001	0.0013	0.0001	0.0004	0.0001	0.0002
Lead	0.0050	0.004	0.0040	0.002	0.0020	0.004	0.0210	0.020
Lithium	0.04	0.02	0.03	0.01	0.02	0.01	0.01	<0.01
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	2.18	3.51	1.78	4.49	2.48	3.06	2.57	2.71
Mercury	0.033	0.015	0.035	0.030	0.052	0.036	0.008	<0.002
Molybdenum	0.228	1.21	0.407	1.44	0.278	1.22	0.411	1.53
Nickel	0.14	0.243	0.138	0.185	0.056	0.117	0.025	0.025
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	1880	2270	2190	3120	2460	2800	2390	2880
Rubidium	8.3	10.8	10.4	15.3	6.47	9.17	3.35	5.53
Selenium	0.80	0.85	0.84	0.90	1.00	0.77	0.79	1.71
Silver	<0.0001	0.0108	<0.0001	0.0122	<0.0001	0.0195	0.0012	0.0063
Strontium	0.077	0.047	0.061	0.092	0.081	0.055	0.112	0.035
Thallium	0.0028	0.0002	0.004	0.0003	0.0009	0.0001	0.0034	0.0005
Tin	<0.01	0.01	0.04	0.02	0.02	<0.01	<0.01	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	0.001	0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Zinc	28.0	38.2	37.4	55.3	23.5	21.6	32.8	23.8

Table B10. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	GEN-26	GEN-26	JMR-3	JMR-3	GEN-27	GEN-27	GEN-28	GEN-28
Tissue	Kidney	Liver	Kidney	Liver	Kidney	Liver	Kidney	Liver
Harvest	17-Jan-07	17-Jan-07	19-Jan-07	19-Jan-07	15-Feb-07	15-Feb-07	5-Mar-07	5-Mar-07
Analysis	2007	2007	2007	2007	2007	2007	2007	2007
Sex	F	F	M	M	F	F	F	F
Age	8	8	7	7	11	11	6	6
Moist (%)	77.3	67.5	80.0	71.5	82.9	70.9	79.5	69.3
Dry Matter	0.227	0.325	0.200	0.285	0.171	0.291	0.205	0.307
Aluminum	0.06	<0.02	0.07	0.06	0.04	0.2	0.11	0.11
Antimony	0.001	<0.001	<0.001	0.034	0.008	0.046	0.003	0.054
Arsenic	<0.002	<0.002	<0.002	<0.002	0.004	0.005	0.004	0.007
Barium	0.29	0.09	0.33	0.12	0.25	0.05	0.26	0.14
Beryllium	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	<0.0001	<0.0001	0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0005
Cadmium	48.70	9.39	12.40	1.76	27.30	4.03	7.20	1.16
Calcium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cesium	0.0035	0.0018	0.0036	0.0007	0.005	0.0032	0.0012	0.0008
Chromium	0.013	0.031	0.004	0.032	0.005	0.115	1.14	0.032
Cobalt	0.0652	0.0781	0.0669	0.0865	0.048	0.0795	0.0875	0.0847
Copper	3.81	58.3	3.82	27.2	2.95	47.4	4.11	57.9
Gallium	0.0074	0.0124	0.0059	0.0093	0.0058	0.0109	0.007	0.0108
Iron	35.1	130	32.2	234	30.8	188	37.7	188
Lanthanum	<0.0001	0.0003	<0.0001	0.0003	<0.0001	0.0007	<0.0001	0.0007
Lead	0.0070	0.003	0.0050	0.021	0.0420	0.016	0.1960	4.260
Lithium	0.02	0.01	0.03	0.01	0.01	<0.01	0.02	0.01
Magnesium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Manganese	3.16	2.73	2.71	2.19	2.39	1.9	2.64	2.49
Mercury	0.011	<0.002	0.013	<0.002	<0.002	<0.002	<0.002	<0.002
Molybdenum	0.383	1.63	0.309	1.23	0.25	1.22	0.283	1.09
Nickel	0.084	<0.005	0.017	0.016	0.036	0.052	0.583	0.014
Palladium	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	0.001	0.001	0.002	0.002	0.001	0.002	0.001	0.001
Potassium	2310	2950	2290	3710	1880	2580	2170	2730
Rubidium	4.13	6.73	1.76	3.41	2.29	4.18	1.65	2.29
Selenium	1.30	3.60	0.74	0.68	0.52	0.35	0.56	0.60
Silver	0.0001	0.0242	<0.0001	0.0089	<0.0001	0.113	<0.0001	0.121
Strontium	0.108	0.029	0.091	0.038	0.051	0.037	0.13	0.093
Thallium	0.0026	0.0002	0.0002	0.0002	0.0018	0.0005	0.0012	0.0004
Tin	<0.01	<0.01	0.05	0.16	<0.01	0.01	0.05	0.01
Uranium	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	<0.001	<0.001	0.001	<0.001	0.001	0.001	0.007	0.001
Zinc	35.8	25.3	41.2	32.9	30.3	23.2	22.9	25.4

Table B11. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below. n/a indicates not analyzed.

Sample ID	GEN-4	GEN-1	FLML-5	Moose 124M	Moose 124K	Moose 125M	Moose 125K	Moose 189K
Tissue	Kidney	Kidney	Kidney	Muscle	Kidney	Muscle	Kidney	Kidney
Harvest	6-Mar-05	17-Feb-05	7-Feb-05	26-May-11	26-May-11	26-May-11	26-May-11	30-Nov-12
Analysis	2007	2007	2007	2011	2011	2011	2011	2015
Sex	M	M	F	M	M	F	F	M
Age	1	1	1	3	3	2	2	1
Moist (%)	66.9	62.9	69.3	72.1	78.8	73.6	79.5	81.08
Dry Matter	0.331	0.371	0.307	0.28	0.21	0.26	0.20	0.189
Aluminum	0.01	0.01	0.01	6.08	0.59	6.34	< 0.02	0.64
Antimony	<0.001	<0.001	<0.001	0.003	< 0.002	0.014	< 0.002	0.005
Arsenic	0.001	0.001	0.001	0.004	< 0.004	0.006	< 0.004	0.002
Barium	0.249	0.365	0.258	0.364	0.076	0.162	0.096	0.218
Beryllium	<0.0001	<0.0001	0.0001	0.0001	< 0.0002	0.0002	< 0.0002	<0.0001
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002	<0.0001	< 0.0002	0.0003
Cadmium	7.46	3.78	9.57	0.0261	2.68	0.0174	6.49	6.8
Calcium	n/a	n/a	n/a	106	86.5	109	93.8	110
Boron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.14
Cesium	0.0008	0.0188	0.0055	0.004	0.0044	0.0033	0.0053	0.009
Chromium	0.002	0.006	0.001	0.364	0.008	0.286	0.005	0.077
Cobalt	0.0601	0.0564	0.0447	0.0112	0.0393	0.0132	0.0817	0.0459
Copper	3.77	3.3	3.9	2.24	3.13	1.06	3.88	4
Gallium	0.0001	0.0001	0.0001	0.0032	0.0002	0.0027	0.0004	0.0034
Iron	54	59.5	64.4	55.8	59.5	30	23.1	47.9
Lanthanum	0.0001	<0.0001	<0.0001	0.006	< 0.0002	0.0043	< 0.0002	0.0002
Lead	0.002	0.004	0.003	0.009	0.006	0.014	0.004	0.004
Lithium	0.02	<0.01	0.01	0.01	0.02	0.03	0.06	<0.01
Magnesium	n/a	n/a	n/a	186	129	144	140	175
Manganese	3.02	4.08	3.22	0.497	2.57	0.341	2.87	3.8
Mercury	0.007	0.009	0.01	0.0050	0.022	0.0050	0.005	0.016
Molybdenum	0.462	0.507	0.429	0.009	0.176	0.007	0.208	0.41
Nickel	0.04	0.077	0.097	0.039	0.022	0.028	0.062	0.847
Palladium	<0.01	<0.01	<0.01	< 0.01	< 0.02	< 0.01	< 0.02	<0.01
Platinum	<0.001	<0.001	<0.001	< 0.001	< 0.002	< 0.001	< 0.002	<0.001
Potassium	2460	2550	2620	2680	1930	1890	2060	1920
Rubidium	1.87	6.52	4.56	2.46	2.31	2.44	4.62	4.06
Selenium	1.33	0.72	1.44	0.09	0.49	0.13	0.7	0.61
Silver	<0.0001	<0.0001	<0.0001	< 0.0001	< 0.0002	< 0.0001	0.0002	0.0001
Strontium	0.094	0.093	0.11	0.129	0.089	0.202	0.107	0.12
Thallium	0.0034	0.0031	0.0041	0.0002	0.002	< 0.0001	0.0014	0.0035
Tin	<0.01	<0.01	<0.01	0.02	< 0.02	0.03	< 0.02	<0.01
Uranium	<0.0001	<0.0001	<0.0001	0.0004	< 0.0002	0.0004	< 0.0002	<0.0001
Vanadium	<0.001	<0.001	<0.001	0.041	< 0.002	0.016	< 0.002	0.002
Zinc	23.3	22	24.5	51.6	18.3	85	24.3	30.1

Table B12. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below.

Sample ID	Moose 199K	Moose 201K	Moose 202K	Moose 203K	Moose 207K	Moose 210K	Moose 211K	Moose 212K
Tissue	Kidney	Kidney	Kidney	Kidney	Kidney	Kidney	Kidney	Kidney
Harvest	28-Sep-13	1-Oct-13	28-Sep-13	4-Oct-13	6-Sep-13	12-Feb-14	12-Feb-14	7-Mar-14
Analysis	2015	2015	2015	2015	2015	2015	2015	2015
Sex	M	M	F	M	F	M	F	F
Age	1	5	2	1	4	4	10	4
Moist (%)	77.801	82.404	78.178	80.847	80.551	78.364	76.926	77.626
Dry Matter	0.222	0.176	0.218	0.192	0.194	0.216	0.231	0.224
Aluminum	0.7	0.45	0.24	0.18	0.12	0.04	0.05	0.21
Antimony	0.121	0.022	0.011	0.002	0.002	<0.001	0.002	0.003
Arsenic	0.003	<0.002	<0.002	<0.002	0.301	0.002	0.002	<0.002
Barium	0.306	0.214	0.127	0.129	0.135	0.324	1.68	0.192
Beryllium	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	4.49	10.2	8.6	5.16	23.3	6.92	17.4	10.7
Calcium	97.2	77.1	116	72.6	92.5	92.7	350	150
Boron	0.3	0.07	0.45	0.33	0.19	0.13	0.21	0.14
Cesium	0.031	0.0189	0.0038	0.023	1.12	0.0309	0.0089	0.0078
Chromium	0.3	0.3	0.038	0.008	0.008	0.027	0.011	0.063
Cobalt	0.0475	0.0544	0.0762	0.0362	0.0643	0.02	0.0222	0.0325
Copper	4.33	2.12	3.49	2.9	3.82	3.67	3.48	4.08
Gallium	0.0044	0.0034	0.0045	0.0035	0.0039	0.0047	0.0042	0.0044
Iron	34.4	34.8	47.4	49.9	25.2	44.4	55.7	47.2
Lanthanum	0.0018	0.0006	0.0005	0.0001	<0.0001	<0.0001	<0.0001	0.0001
Lead	0.004	0.011	0.002	<0.001	<0.001	0.001	<0.001	0.001
Lithium	0.02	<0.01	0.03	0.02	0.01	0.04	0.01	<0.01
Magnesium	168	130	153	137	157	176	166	179
Manganese	2.58	0.936	2.9	1.27	2.6	3.45	3.13	3.74
Mercury	0.025	0.014	0.019	0.01	0.036	0.025	0.027	0.021
Molybdenum	0.524	0.205	0.383	0.304	0.287	0.391	0.491	0.446
Nickel	0.71	1.54	1.11	0.041	0.066	0.05	0.128	0.061
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2630	2170	2620	2400	2550	2710	2450	2770
Rubidium	7.89	7.34	2.38	3.34	29.2	5.06	4.5	6.22
Selenium	0.88	0.67	0.86	0.94	1.43	0.6	0.83	0.78
Silver	<0.0001	0.0003	0.0002	0.0004	0.0016	<0.0001	<0.0001	0.0002
Strontium	0.106	0.071	0.122	0.05	0.049	0.08	0.316	0.152
Thallium	0.0048	0.0021	0.0014	0.0034	0.0786	0.0093	0.0041	0.0024
Tin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	0.005	0.005	0.002	0.004	0.004	0.003	0.005	0.002
Zinc	25.3	23	24.5	24.1	28.4	28	30.1	32.3

Table B13. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below.

Sample ID	Moose 213-K	Moose 214-K	Moose 215-K	Moose 216-K	Moose 217-K	Moose 220-K	Moose 221-K	Moose 222-K
Tissue	Kidney	Kidney	Kidney	Kidney	Kidney	Kidney	Kidney	Kidney
Harvest	4-May-14	2-Sep-14	18-Sep-14	21-Sep-14	20-Sep-14	2-Oct-14	2-Oct-14	5-Oct-14
Analysis	2015	2015	2015	2015	2015	2015	2015	2015
Sex	M	M	M	M	M	M	M	M
Age	1	2	1	7	n/a	3	2	2
Moist (%)	77.351	77.067	76.260	79.358	79.076	81.565	82.106	77.137
Dry Matter	0.226	0.229	0.237	0.206	0.209	0.184	0.179	0.229
Aluminum	0.18	0.51	0.45	0.21	0.33	0.25	0.08	0.17
Antimony	<0.001	0.001	0.001	0.003	0.002	0.001	0.002	0.012
Arsenic	0.002	0.009	0.01	<0.002	0.004	0.002	0.004	0.02
Barium	0.246	0.168	0.172	0.258	0.116	0.128	0.174	0.209
Beryllium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	9.83	12.2	4.88	27.8	5.77	19	6.13	7.78
Calcium	113	78.9	117	96	86.8	63.9	59.7	89.9
Boron	0.18	0.23	0.43	0.08	0.15	0.13	0.05	0.18
Cesium	0.0072	0.0537	0.023	0.0066	0.0103	0.0084	0.0273	0.0465
Chromium	0.025	0.11	0.148	0.026	0.039	0.009	0.033	0.1
Cobalt	0.15	0.0771	0.0605	0.0432	0.0896	0.0777	0.0343	0.0748
Copper	4.43	4.79	4.38	2.42	3.46	3.01	2.33	3.8
Gallium	0.0044	0.005	0.0047	0.0029	0.0042	0.0037	0.0038	0.0047
Iron	81.6	61.8	47.3	121	24.1	51.2	38.6	63.1
Lanthanum	<0.0001	<0.0001	0.0002	0.0002	<0.0001	<0.0001	<0.0001	0.0002
Lead	0.002	0.007	<0.001	<0.001	<0.001	<0.001	0.003	0.002
Lithium	0.04	0.03	0.05	<0.01	0.06	0.03	0.01	<0.01
Magnesium	166	182	169	126	170	149	143	173
Manganese	3.42	2.99	2.58	0.687	1.83	1.23	0.738	1.77
Mercury	0.016	0.028	0.025	0.015	0.012	0.021	0.025	0.044
Molybdenum	0.323	0.422	0.368	0.187	0.362	0.267	0.168	0.483
Nickel	0.085	0.112	0.118	0.043	0.114	0.054	0.266	0.771
Palladium	<0.01	<0.01	<0.01	0.03	<0.01	0.02	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2620	2880	2850	1860	2530	2330	2120	2470
Rubidium	3.15	7.72	9.27	4.72	3.46	3.81	9.16	11.2
Selenium	0.8	1.03	1.02	0.71	0.65	0.77	0.55	0.99
Silver	<0.0001	0.0004	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0001
Strontium	0.112	0.045	0.084	0.077	0.061	0.053	0.049	0.062
Thallium	0.0021	0.0049	0.0067	0.003	0.002	0.0007	0.0032	0.0035
Tin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.86
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	0.005	0.01	0.013	0.008	0.006	0.011	0.008	0.01
Zinc	31.4	53.4	29.6	22.4	26	31.8	17.4	36

Table B14. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below.

Sample ID	Moose 223-L	Moose 223-K	Moose 223-M	Moose 226-K	Moose 227-K	Moose 228-K	Moose 229-K	Moose 230-K
Tissue	Liver	Kidney	Muscle	Kidney	Kidney	Kidney	Kidney	Kidney
Harvest	4-Oct-14	4-Oct-14	4-Oct-14	18-Jan-15	26-Jan-15	14-Feb-15	19-Feb-15	11-Apr-15
Analysis	2015	2015	2015	2015	2015	2015	2015	2015
Sex	M	M	M	F	F	M	F	M
Age	3	3	3	1	2	0	8	2
Moist (%)	78.098	72.562	75.122	77.816	78.722	77.357	81.285	78.777
Dry Matter	0.219	0.274	0.249	0.222	0.213	0.226	0.187	0.212
Aluminum	0.08	0.64	0.54	0.33	0.11	0.08	0.1	0.26
Antimony	<0.001	0.004	0.014	0.01	0.004	0.005	0.006	0.003
Arsenic	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002
Barium	0.082	0.13	0.035	0.203	0.367	0.24	0.147	0.178
Beryllium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	<0.0001	<0.0001	0.0009	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	3.89	24.9	0.8	7.47	10.7	1.35	34.3	19.7
Calcium	43.3	104	64.1	89.3	124	109	114	92.6
Boron	0.18	0.23	0.18	0.19	0.19	0.19	0.3	0.2
Cesium	0.0009	0.0016	0.0017	0.0196	0.0117	0.0247	0.0208	0.0033
Chromium	0.223	0.039	0.169	0.06	0.011	0.016	0.036	0.02
Cobalt	0.0678	0.102	0.0251	0.0326	0.0504	0.0477	0.093	0.0249
Copper	17.6	3.01	1.86	3.65	3.53	3.89	3.45	3.93
Gallium	0.0041	0.0032	0.0036	0.0045	0.0038	0.0047	0.0042	0.0045
Iron	212	77.9	37.2	48.5	55.6	60.3	38.9	46
Lanthanum	0.0003	0.0002	0.0007	0.0003	0.0004	<0.0001	<0.0001	0.0002
Lead	0.003	0.005	0.023	0.003	0.003	0.004	0.004	0.007
Lithium	<0.01	0.03	<0.01	0.01	<0.01	<0.01	0.04	<0.01
Magnesium	119	150	249	163	155	189	171	166
Manganese	1.63	1.14	0.234	3.61	3.25	3.78	3.02	3.42
Mercury	0.002	0.017	0.002	0.023	0.012	0.018	0.082	0.026
Molybdenum	0.641	0.205	0.019	0.465	0.403	0.427	0.335	0.383
Nickel	0.217	1.18	2.02	0.065	0.089	0.023	0.121	0.117
Palladium	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2400	2210	3490	2920	2430	2800	2700	2680
Rubidium	2.39	2.44	2.32	5.02	8.42	8.46	6.56	2.81
Selenium	0.39	0.62	0.14	0.74	0.9	0.62	0.9	0.96
Silver	0.009	<0.0001	0.0002	<0.0001	0.0003	<0.0001	<0.0001	<0.0001
Strontium	0.039	0.128	0.039	0.073	0.134	0.086	0.051	0.082
Thallium	<0.0001	0.0014	<0.0001	0.0029	0.0016	0.0032	0.0043	0.0017
Tin	<0.01	0.03	0.03	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	0.017	0.008	0.005	0.019	0.017	0.005	0.005	0.004
Zinc	43	27.5	64.4	25	28.6	24.2	43.4	34.6

Table B15. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below.

Sample ID	Moose 231-K	Moose 232-K	Moose 233-K	Moose 234-K	Moose 235-K	Moose 236-K	Moose 237-K	Moose 240-K
Tissue	Kidney	Kidney	Kidney	Kidney	Kidney	Kidney	Kidney	Kidney
Harvest	30-May-15	23-Jun-15	9-Sep-15	19-Sep-15	23-Sep-15	28-Sep-15	28-Sep-15	3-Oct-15
Analysis	2015	2015	2015	2015	2015	2015	2015	2015
Sex	M	M	M	M	M	M	M	F
Age	1	1	4	1	n/a	3	2	2
Moist (%)	78.519	82.221	79.250	77.104	81.066	81.648	80.760	78.656
Dry Matter	0.215	0.178	0.208	0.229	0.189	0.184	0.192	0.213
Aluminum	0.2	0.07	0.33	0.14	0.22	0.14	0.6	0.28
Antimony	0.003	0.001	<0.001	<0.001	0.001	0.002	0.002	0.004
Arsenic	0.003	<0.002	<0.002	0.003	<0.002	0.002	0.045	<0.002
Barium	0.155	0.134	0.1	0.206	0.259	0.137	0.087	0.369
Beryllium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0004	0.0001
Cadmium	5.9	3.2	46.9	12.1	13.6	16.3	11.2	10.6
Calcium	85.8	82.8	97.2	92.8	69	84	84.6	125
Boron	0.23	0.23	0.41	0.38	0.06	<0.05	0.22	0.2
Cesium	0.0562	0.0035	0.0055	0.0311	0.0105	0.0479	0.125	0.0339
Chromium	0.008	0.04	0.02	0.01	0.016	0.054	0.037	0.014
Cobalt	0.0416	0.0292	0.0412	0.0791	0.0504	0.0578	0.0428	0.0898
Copper	4.63	3.23	3.75	4.4	2.59	2.57	3.84	3.86
Gallium	0.0041	0.0031	0.004	0.0045	0.0037	0.0034	0.0041	0.004
Iron	56.2	54.7	50.3	54.2	34.8	67.7	39.4	50.4
Lanthanum	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0003	0.0002
Lead	0.012	0.004	0.002	0.004	0.007	0.003	0.003	0.02
Lithium	<0.01	0.02	0.05	0.03	<0.01	0.04	0.02	0.03
Magnesium	150	125	154	171	143	144	142	158
Manganese	2.45	2.2	1.78	2.72	0.695	0.647	1.81	3.29
Mercury	0.008	0.006	0.017	0.006	0.012	0.008	0.031	0.018
Molybdenum	0.258	0.09	0.366	0.406	0.163	0.596	0.379	0.368
Nickel	0.153	0.388	0.46	0.103	0.09	0.289	0.093	0.073
Palladium	<0.01	<0.01	0.02	<0.01	0.01	0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2350	1790	2390	3110	2270	2400	2400	2700
Rubidium	13.4	4.87	2.49	7.04	6.92	9.67	20.7	9.95
Selenium	0.89	0.57	1.03	1.5	0.48	0.58	1.09	0.86
Silver	<0.0001	<0.0001	0.0001	0.0004	<0.0001	0.0007	0.0001	<0.0001
Strontium	0.056	0.081	0.035	0.058	0.069	0.08	0.054	0.101
Thallium	0.0023	0.0027	0.0009	0.0028	0.0012	0.0034	0.0028	0.0093
Tin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	0.004	0.007	0.007	0.008	0.008	0.011	0.007	0.006
Zinc	24.2	19	31.6	29.4	21.4	32.6	25.4	29.7

Table B16. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below.

Sample ID	Moose 210-L	Moose 212-L	Moose 214-L	Moose 220-L	Moose 220-M	Moose 227-L	Moose 227-M	Moose 228-L
Tissue	Liver	Liver	Liver	Liver	Muscle	Liver	Muscle	Liver
Harvest	12-Feb-14	7-Mar-14	3-Sep-14	2-Oct-14	2-Oct-14	26-Jan-15	26-Jan-15	14-Feb-15
Analysis	2016	2016	2016	2016	2016	2016	2016	2016
Sex	M	F	M	M	M	F	F	M
Age	4	4	2.5	3	3	2	2	0
Moist (%)	67.227	63.969	67.064	62.841	74.634	71.885	70.214	65.416
Dry Matter	0.328	0.360	0.329	0.372	0.254	0.281	0.298	0.346
Aluminum	0.13	0.28	0.29	0.31	1.92	0.18	0.5	0.68
Antimony	<0.001	0.003	0.002	<0.001	0.058	<0.001	0.017	<0.001
Arsenic	0.004	0.004	0.01	<0.002	0.002	0.009	0.006	0.004
Barium	0.152	0.074	0.13	0.126	0.056	0.141	0.034	0.063
Beryllium	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	<0.0001	<0.0001	<0.0001
Cadmium	1.49	0.838	1.97	4.36	0.0142	1.49	0.0079	1.33
Calcium	47.7	57.6	52.9	47.5	46.4	58.9	48.5	40.2
Boron	0.16	0.12	0.24	0.08	0.06	0.13	0.09	0.17
Cesium	0.0145	0.0025	0.0226	0.0034	0.0115	0.0038	0.0137	0.0078
Chromium	<0.001	0.011	<0.001	<0.001	0.029	0.009	0.01	0.016
Cobalt	0.0556	0.0575	0.107	0.0903	0.0076	0.0818	0.0035	0.0829
Copper	55.6	3.53	8.93	11.8	1.61	36.1	1.36	58.8
Gallium	0.0043	0.0042	0.0041	0.0026	0.0029	0.0037	0.0019	0.0036
Iron	417	1660	216	203	28.8	281	28.1	170
Lanthanum	0.0003	0.0005	0.001	0.0004	0.0032	0.0008	0.0004	0.0011
Lead	0.004	0.015	0.006	0.005	0.01	0.003	0.002	0.004
Lithium	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Magnesium	161	147	178	126	222	131	225	157
Manganese	3.26	2.83	2.74	2.12	0.163	2.33	0.134	2.68
Mercury	0.009	0.004	0.004	0.005	<0.002	0.003	<0.002	0.006
Molybdenum	1.58	1.48	0.954	0.949	0.009	1.18	0.008	1.43
Nickel	<0.005	0.006	0.006	0.007	0.028	0.006	0.011	0.008
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2880	2440	3470	1970	3490	2160	3360	2550
Rubidium	7.92	6.25	10.2	3.26	3.77	7.73	6.63	6.38
Selenium	0.19	0.21	0.55	0.63	0.2	1.16	0.15	0.57
Silver	0.243	0.0232	0.0705	0.0297	0.0001	0.0669	<0.0001	0.107
Strontium	0.03	0.037	0.027	0.041	0.033	0.073	0.034	0.039
Thallium	0.0015	0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	0.0004
Tin	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	0.001	0.005	<0.001	0.006	0.004	<0.001	0.004	0.003
Zinc	27.9	19.3	68.9	99.5	62.7	22.4	48.9	19.8

Table B17. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below.

Sample ID	Moose 228-M	Moose 229-L	Moose 229-M	Moose 230-L	Moose 234-L	Moose 236-L	Moose 236-M	Moose 237-L
Tissue	Muscle	Liver	Muscle	Liver	Liver	Liver	Muscle	Liver
Harvest	14-Feb-15	19-Feb-15	19-Feb-15	11-Apr-15	19-Sep-15	28-Sep-15	28-Sep-15	28-Sep-15
Analysis	2016	2016	2016	2016	2016	2016	2016	2016
Sex	M	F	F	M	M	M	M	M
Age	0	8	8	2	1	3	3	2
Moist (%)	74.472	67.794	71.384	67.049	68.843	58.307	73.386	67.072
Dry Matter	0.255	0.322	0.286	0.330	0.312	0.417	0.266	0.329
Aluminum	0.68	0.15	3.6	0.38	0.36	0.56	1.25	0.14
Antimony	0.008	<0.001	0.204	<0.001	0.001	<0.001	0.017	0.003
Arsenic	0.002	0.004	0.01	<0.002	0.004	0.004	0.002	0.162
Barium	0.032	0.033	1.31	0.046	0.121	0.19	0.049	0.049
Beryllium	<0.0001	0.0001	<0.0001	<0.0001	0.0001	0.0002	<0.0001	0.0001
Bismuth	<0.0001	<0.0001	0.004	<0.0001	<0.0001	<0.0001	0.0004	<0.0001
Cadmium	0.0013	6.48	0.215	4.06	2.4	2.46	0.0096	1.94
Calcium	35.4	42.7	1530	34.2	48.8	56.7	42.6	44.1
Boron	0.13	0.14	0.26	0.23	0.33	<0.05	<0.05	0.18
Cesium	0.0135	0.0101	0.0071	0.0013	0.0137	0.0175	0.0363	0.0598
Chromium	0.063	<0.001	0.142	0.011	0.065	<0.001	0.017	0.003
Cobalt	0.0078	0.0905	0.014	0.0647	0.137	0.0658	0.004	0.0989
Copper	2.06	88.7	1.98	55.6	5.03	20.4	1.1	24.7
Gallium	0.0024	0.0039	0.0038	0.0043	0.0038	0.0034	0.0024	0.004
Iron	32.5	199	56	199	156	175	32.7	203
Lanthanum	0.0004	0.0003	0.0057	0.0002	0.0006	0.0004	0.0012	0.0003
Lead	0.002	0.002	0.053	0.002	0.007	0.023	0.007	0.003
Lithium	<0.01	0.03	0.03	<0.01	<0.01	<0.01	0.01	<0.01
Magnesium	254	164	227	174	166	143	230	169
Manganese	0.206	3.21	0.384	3.07	2.51	1.07	0.108	2
Mercury	0.003	0.007	0.003	0.003	0.003	0.002	<0.002	0.008
Molybdenum	0.003	1.4	0.018	1.35	1.13	0.812	0.005	1.35
Nickel	0.023	<0.005	0.077	0.011	0.05	0.015	0.016	0.007
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	3810	3050	2840	2860	3030	2360	3810	3230
Rubidium	6.49	8.85	4.39	3.95	9.73	8.51	9	28.6
Selenium	0.08	1.47	0.19	0.73	2.13	0.5	0.15	2.1
Silver	<0.0001	0.116	0.0007	0.0206	0.0289	0.0096	0.0001	0.131
Strontium	0.024	0.014	0.475	0.027	0.038	0.052	0.026	0.024
Thallium	0.0002	0.0005	0.0002	0.0002	0.0002	0.0001	0.0001	0.0002
Tin	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	0.002	0.001	0.01	<0.001	0.003	0.001	0.003	0.002
Zinc	39.9	35.4	54.8	26.6	21.4	52.7	45.1	23.6

Table B18. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below.

Sample ID	Moose 241-K	Moose 243-K	Moose 201-L	Moose 201-M	Moose 202-L	Moose 202-M	Moose 203-L	Moose 203-M
Tissue	Kidney	Kidney	Liver	Muscle	Liver	Muscle	Liver	Muscle
Harvest	3-Oct-15	28-Sep-15	1-Oct-13	1-Oct-13	28-Sep-13	28-Sep-13	4-Oct-13	4-Oct-13
Analysis	2015	2015	2016	2016	2016	2016	2016	2016
Sex	M	M	M	M	F	F	M	M
Age	6	4	5	5	2	2	1	1
Moist (%)	80.278	80.334	56.522	74.339	67.104	73.200	54.816	73.723
Dry Matter	0.197	0.197	0.435	0.257	0.329	0.268	0.452	0.263
Aluminum	0.15	0.4	2.32	4.24	0.19	1.33	0.44	1.56
Antimony	<0.001	0.001	0.003	0.588	0.001	0.07	0.001	0.149
Arsenic	0.005	0.008	0.002	0.004	0.002	<0.002	0.002	0.002
Barium	0.196	0.096	0.232	0.105	0.032	0.032	0.084	0.042
Beryllium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
Bismuth	<0.0001	<0.0001	0.0003	0.0004	<0.0001	0.0005	0.0001	0.0002
Cadmium	14.4	6.07	2.03	0.128	1.23	0.008	1.27	0.106
Calcium	82.5	73.9	67	56.3	40.2	73.3	43.4	38
Boron	<0.05	0.09	<0.05	<0.05	0.38	0.31	0.24	0.18
Cesium	0.108	0.0426	0.009	0.0188	0.0011	0.0031	0.0145	0.0281
Chromium	0.008	0.097	0.012	0.054	<0.001	0.023	0.044	0.023
Cobalt	0.0506	0.0523	0.0678	0.0066	0.134	0.0063	0.0972	0.0051
Copper	2.59	2.48	4.15	1.5	4.66	1.37	3.35	1.11
Gallium	0.0038	0.0041	0.0043	0.0031	0.0035	0.0023	0.0042	0.0024
Iron	46.4	39.6	133	39.5	181	24.7	307	27.3
Lanthanum	0.0003	0.0004	0.0017	0.0426	0.0009	0.0012	0.0009	0.0029
Lead	0.006	0.003	0.052	0.041	0.003	0.004	0.002	0.009
Lithium	0.02	0.02	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Magnesium	162	140	148	199	154	237	181	211
Manganese	0.83	0.973	1.33	0.215	2.67	0.197	2.27	0.163
Mercury	0.028	0.013	0.004	0.004	0.006	0.003	0.004	<0.002
Molybdenum	0.752	0.861	1.02	0.008	1.53	0.003	1.04	0.006
Nickel	0.019	0.051	0.011	0.043	0.009	0.019	0.025	0.028
Palladium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2220	2100	2410	3140	2790	3260	3190	3340
Rubidium	17.8	8.98	8.07	6.4	3.14	1.77	5.68	3.08
Selenium	0.54	0.84	0.67	0.17	1.1	0.2	1.53	0.27
Silver	0.0018	0.0005	0.0187	0.0008	0.0175	0.0003	0.0269	0.0002
Strontium	0.061	0.058	0.059	0.05	0.042	0.047	0.022	0.025
Thallium	0.005	0.0034	0.0002	0.0002	<0.0001	<0.0001	0.0002	<0.0001
Tin	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	<0.0001	0.0001	0.0019	<0.0001	0.0001	<0.0001	0.0001
Vanadium	0.006	0.049	0.005	0.006	0.001	0.006	0.003	0.004
Zinc	30.5	19.4	87.1	54.9	21.4	48.8	35.5	81.5

Table B19. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below.

Sample ID	Moose 237-M	Moose 241-L	Moose 241-M	Moose 243-L	Moose 243-M	Moose 247-K	Moose 247-L	Moose 247-M
Tissue	Muscle	Liver	Muscle	Liver	Muscle	Kidney	Liver	Muscle
Harvest	28-Sep-15	3-Oct-15	3-Oct-15	28-Sep-15	28-Sep-15	12-Nov-15	12-Nov-15	12-Nov-15
Analysis	2016	2016	2016	2016	2016	2016	2016	2016
Sex	M	M	M	M	M	M	M	M
Age	2	6	6	4	4	6	6	6
Moist (%)	72.757	51.905	73.661	64.600	74.061	74.933	68.014	74.430
Dry Matter	0.272	0.481	0.263	0.354	0.259	0.251	0.320	0.256
Aluminum	26.1	0.43	9.97	0.12	1.37	1.03	0.34	0.88
Antimony	0.012	0.003	0.015	0.002	0.006	<0.001	0.003	0.007
Arsenic	0.038	0.005	0.011	0.013	0.002	0.002	0.005	<0.002
Barium	0.328	0.135	0.508	0.063	0.076	0.268	0.176	0.086
Beryllium	0.0009	0.0001	0.0003	<0.0001	<0.0001	<0.0001	0.0002	<0.0001
Bismuth	0.0006	0.0002	0.0016	0.0002	0.0008	0.0001	0.0005	0.0004
Cadmium	0.0128	1.55	0.0162	0.897	0.0159	57.9	8.85	0.201
Calcium	149	37.8	472	35	65.1	128	40.1	160
Boron	0.16	<0.05	0.05	0.07	0.08	0.26	0.16	0.09
Cesium	0.143	0.0395	0.0918	0.0274	0.0018	0.0085	0.0036	0.004
Chromium	0.048	0.004	0.085	0.006	0.007	0.011	0.033	0.24
Cobalt	0.0117	0.04	0.0077	0.0433	0.0051	0.0554	0.0702	0.009
Copper	1.85	3.16	1.38	6.38	0.97	4.26	61.5	1.29
Gallium	0.0097	0.0024	0.0047	0.0028	0.0016	0.0033	0.0039	0.0015
Iron	61.5	139	41.8	220	21.3	53.2	183	46.1
Lanthanum	0.0142	0.0007	0.0068	0.0003	0.0007	<0.0001	0.0007	0.0008
Lead	0.052	0.021	0.01	0.003	0.004	0.003	0.006	0.003
Lithium	0.02	<0.01	0.01	<0.01	0.01	0.01	<0.01	<0.01
Magnesium	233	118	205	152	170	175	150	141
Manganese	0.784	0.811	0.24	1.25	0.111	3.04	3.04	0.145
Mercury	<0.002	0.006	<0.002	0.003	<0.002	0.027	0.007	<0.002
Molybdenum	0.007	0.753	0.014	0.537	0.01	0.339	1.38	0.019
Nickel	0.036	0.006	0.047	0.007	0.012	0.063	0.024	0.088
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	3420	2080	2740	2690	1890	2710	2360	1900
Rubidium	16	10.6	9.8	8.6	0.867	6.07	5.35	3.04
Selenium	0.33	0.31	0.09	0.99	0.16	0.93	0.84	0.11
Silver	0.0015	0.0998	0.005	0.0219	<0.0001	<0.0001	0.0919	<0.0001
Strontium	0.117	0.025	0.293	0.022	0.052	0.156	0.047	0.108
Thallium	0.0003	0.0003	0.0004	0.0002	<0.0001	0.0018	0.0002	0.0001
Tin	0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.02
Uranium	0.0012	<0.0001	0.0005	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Vanadium	0.048	<0.001	0.022	<0.001	0.003	<0.001	0.002	0.025
Zinc	51.7	52	53.2	11.9	52.5	53.7	33.7	34.4

Table B20. A summary of the moisture content (%), dry matter, and elemental concentrations found in various moose tissue samples. Elemental concentrations are in mg/kg (ww). Sample ID, type of tissue analyzed (kidney, liver, muscle), analysis year, sex and age are indicated. Age of 0 is a calf of the year. Ages with a decimal means the best estimate was from a range of 1 year above and 1 year below.

Sample ID	Moose 249-K	Moose 239-L	Moose 250-K	Moose 250-L	Moose 250-M
Tissue	Kidney	Liver	Kidney	Liver	Muscle
Harvest	8-Oct-15	8-Oct-15	3-Jan-16	3-Jan-16	3-Jan-16
Analysis	2016	2016	2016	2016	2016
Sex	F	F	M	M	M
Age	1	1	3	3	3
Moist (%)	76.245	68.242	78.490	69.903	77.434
Dry Matter	0.238	0.318	0.215	0.301	0.226
Aluminum	1.04	0.24	1.03	0.31	2.15
Antimony	0.002	<0.001	<0.001	<0.001	0.007
Arsenic	<0.002	0.003	0.002	0.004	0.003
Barium	0.244	0.113	0.144	0.055	0.042
Beryllium	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Bismuth	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Cadmium	29.4	4.82	11.4	1.67	0.0062
Calcium	122	44.1	94.4	54.7	42
Boron	0.29	0.24	0.23	0.42	0.12
Cesium	0.0189	0.0057	0.0169	0.0065	0.0098
Chromium	0.005	<0.001	0.004	<0.001	0.063
Cobalt	0.0471	0.0843	0.0441	0.0705	0.0038
Copper	4.06	5.71	3.59	28.9	1.28
Gallium	0.0031	0.0032	0.0029	0.0036	0.0025
Iron	51.1	253	57.5	256	42
Lanthanum	0.0002	0.0004	<0.0001	0.0005	0.0012
Lead	0.003	0.001	0.005	0.02	0.009
Lithium	0.02	<0.01	0.01	<0.01	<0.01
Magnesium	154	135	154	143	214
Manganese	2.83	2.22	3.82	3.24	0.136
Mercury	0.023	0.003	0.022	0.005	0.003
Molybdenum	0.507	1.34	0.26	0.989	0.008
Nickel	0.14	0.018	0.016	0.005	0.037
Palladium	<0.01	<0.01	<0.01	<0.01	<0.01
Platinum	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium	2900	2930	2510	2440	3400
Rubidium	4	4.28	4.03	4.99	3.76
Selenium	1.78	3.17	0.78	0.42	0.11
Silver	0.0006	0.0927	<0.0001	0.052	0.0001
Strontium	0.13	0.051	0.094	0.053	0.039
Thallium	0.0059	0.0004	0.0018	0.0003	<0.0001
Tin	0.01	<0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
Vanadium	0.003	0.002	0.002	0.001	0.004
Zinc	35.9	21.4	31.2	23.2	53.7