Contaminants in Yukon Moose and Caribou - 2003

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Prepared for

Yukon Contaminants Committee
and
Department of Indian and Northern Affairs
Northern Contaminants Program
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EXECUTIVE SUMMARY

This project is part of the ongoing monitoring of contaminants in Yukon wildlife that started in 1992 with a study of the Finlayson caribou herd, continued with a comprehensive look at contaminants in country foods, and is now monitoring temporal and geographical trends using moose and caribou as key species.

Yukon hunters were requested to submit kidney, liver and muscle samples, as well as an incisor, from moose and caribou killed during the 2003 hunting season. Each hunter that submitted samples had their name put into a draw for a charter flight on Alpine Aviation of Whitehorse, up to a value of $1000. The winner was Trevor Castagner of Whitehorse. Samples were submitted from 95 moose, 99 caribou, 11 mule deer, 4 elk and 2 Dall sheep.

Kidneys from the 2002 and 2003 hunter survey collections were analyzed for 26 elements by Elemental Research Inc., Vancouver, BC. Although data for 26 elements were presented in this report, only the following elements of interest were discussed: arsenic, cadmium, copper, lead, mercury, selenium and zinc.

There was little variation in renal arsenic measured in this study, and concentrations averaged 0.20 ppm, suggesting little cause for concern from arsenic toxicity. These levels should be considered background concentrations.

Renal cadmium concentrations were generally higher in Yukon moose than in barren-ground caribou (Porcupine herd), while the woodland caribou (all the other herds) tended to have more variable levels of renal cadmium, and mule deer and elk had quite low levels. This may be explained by differences in diet. The barren-ground caribou in this study had concentrations of renal cadmium similar to those found in five barren-ground herds studied in the Northwest Territories, as would be expected. Renal cadmium concentrations in Yukon moose appear to be high relative to moose from other areas, with the possible exception of Alaska. Some moose from this study had renal cadmium concentrations that fell within the range at which kidney dysfunction has been shown to occur in other species. Sublethal effects would be expected at a much lower level and would be expected in 32% of the moose analyzed in this study, 2% of the caribou, and none of the mule deer or elk. This indicates potential for older moose in some parts of the Yukon to be at risk due to high renal cadmium levels. Health Canada has recommended limiting consumption of moose and caribou kidneys and liver based on previously collected data.

Renal copper concentrations in caribou from this study were very consistent, averaging 20.0 ppm, and should be considered background levels.

Renal lead concentrations were generally low and usually <0.50 ppm. For the most part, concentrations of lead found in this study are well within the range considered normal for domestic cattle (Puls 1994) and should generally be considered background levels.

Renal mercury concentrations were fairly consistent among caribou herds, ranging from an average of 1.25 ppm in the Wolf Lake herd to 2.73 in the Pelly Mountain herd, and were markedly lower in moose, elk and mule deer. These should be considered natural background levels.

Renal selenium in this study ranged from 2.31 to 10.3 ppm, both extremes found in moose. Although renal selenium averages for each species fall into the 'high' to 'toxic-chronic' range for domestic cattle, liver is considered by far the best indicator of selenium status. Hepatic selenium levels measured in Yukon moose in a previous study were somewhat higher than those found in moose from other countries. Since no signs of selenium toxicity have been observed in Yukon animals, we have no reason to believe that these concentrations may be having toxic effects.

Renal zinc in animals from this study ranged from 87.8–329 ppm and averaged 139.6 ppm. These should be considered normal background levels.

Element concentrations in moose, caribou, elk, Dall sheep and mule deer measured in this study should be considered background levels. Some Yukon moose and caribou showed higher renal cadmium and selenium concentrations than in the same species from other areas. It is likely that these contaminants are entering the food chain from natural mineralizations in the Yukon, and have always been part of this environment. We have no evidence that these elements are having toxic effects in the animals. People concerned about the consumption of contaminants from wild game should refer to the health advisory issued by Health Canada.

INTRODUCTION

This project is part of the ongoing monitoring of contaminants in Yukon wildlife that started in 1992 with a study of the Finlayson caribou herd (Gamberg 1993), continued with a comprehensive look at contaminants in country foods (Gamberg 2000a), and is now monitoring temporal and geographical trends using moose and caribou as key species (Gamberg 1997, 1998, 1999, 2000b, 2001, 2002).

METHODS

Collections

Yukon hunters were requested to submit kidney, liver and muscle samples, as well as an incisor, from moose and caribou killed during the 2003 hunting season. The program was advertised in the YTG Hunter Synopsis, the Outdoor Edge magazine (Fish and Game Association) and through posters and newspaper ads.

Each hunter that submitted samples had their name put into a draw, once for each tissue they submitted. The draw was for a charter flight on Alpine Aviation of Whitehorse, up to a value of $1000, and took place on the CBC radio morning show on Dec. 1st, 2003. The winner was Trevor Castagner of Whitehorse.

Hunters submitted their samples to their local Renewable Resources office where a YBS (Yukon Biological Submission) form was filled out for each submission. Samples were labeled with the YBS number and stored in -20^{o} C freezers until processed.

Each hunter submitting samples was sent a letter thanking them, giving them the age of their animal if they submitted a tooth and telling them what the project was about. A brief background of cadmium in Yukon wildlife was included, as well as the consumption recommendations from Health Canada (Appendices 1 and 2).

Tissue Processing and Analysis

If incisor bars or entire jaws were submitted, an incisor was extracted and cleaned of extraneous tissue. If possible, age was determined from tooth eruption patterns. Otherwise, incisors were aged using the cementum technique. Moose teeth were aged by the author and caribou teeth were aged by a Yukon Environment technician.

Kidneys were cleaned of extraneous tissue and the kidney capsule removed. If the kidney was damaged (i.e. sliced or in pieces), or the capsule was torn or missing, the tissue was rinsed with distilled water. Partial kidneys were discarded. The samples were then stored in Whirl-paks. Outer portions of each liver and muscle sample were removed leaving 'clean' subsamples, which were then archived in polyethylene vials. Kidneys were stored at -20 ^{O} C until analyzed. Liver and muscle samples were stored at -80^{o} C for possible future analysis of inorganic contaminants. If enough liver tissue was available, a portion was stored in chemically cleaned glass jars and stored at -80^{o} C for possible future analysis of organic contaminants. 'Clean laboratory practices' were used throughout tissue processing.

Contaminant Analysis

Kidneys from the 2002 and 2003 hunter survey collections were analyzed for 26 elements by Elemental Research Inc., Vancouver, BC, by the inductively coupled plasma with mass spectroscopy technique (ICP-MS). These included kidneys from 96 moose, 90 caribou, 3 mule deer and 1 elk. Certified standard reference materials, blanks and duplicates were used to check laboratory performance as part of standard laboratory quality control practices. All results are presented on a dry weight basis.

All elements were discussed in detail as they related to moose and caribou in the 1996 report (Gamberg, 1997). Most of these elements were at background levels and posed no threat to the animals themselves, or to consumers of the animals. Although data for 26 elements are presented in this report (Tables 1 and 2), only the following elements of interest will be discussed: arsenic, cadmium, copper, lead, mercury, selenium and zinc.

Table 1. Element concentrations in Yukon caribou kidneys (ppm dry weight). Samples collected 2002 and 2003.

Herd	**Aishihik**				**Coal River**	**Little Rancheria**	**Nahanni**	**Pelly Mountain**		**Porcupine**			
Year	**2002**		**2003**		**2002**	**2002**	**2003**	**2003**		**2002**		**2003**	
	Mean	SD	Mean	SD				Mean	SD	Mean	SD	Mean	SD
N	3		4		1	1	1	2		21		46	67
Age	4.7	1.2	5.5	1.9	5.0	5.0	4.0	5.5	3.5	5.6	1.8	6.0	3.0
% Moisture	79.5	0.6	81.4	1.6	81.5	80.9	78.7	80.1	0.4	78.5	1.5	78.6	1.2
Aluminum	16.8	26.9	2.7	0.8	1.5	4.1	1.1	2.4	0.1	1.7	0.5	2.7	5.6
Antimony	<0.01	0.01	<0.01	0.00	<0.01	<0.01	<0.01	<0.01	0.00	0.01	0.01	0.01	0.05
Arsenic	0.50	0.48	0.20	0.05	0.23	0.22	0.19	0.22	0.13	0.13	0.06	0.20	0.07
Barium	1.43	0.44	1.28	0.26	1.79	2.71	0.86	3.79	0.71	2.91	1.16	2.82	1.54
Beryllium	<0.01	0.00	<0.01	0.00	<0.01	<0.01	<0.01	<0.01	0.00	<0.01	0.00	0.01	0.00
Boron	<0.5	0.00	4.98	8.66	<0.5	<0.5	<0.5	<0.5	0.00	<0.5	0.38	0.54	0.81
Cadmium	53.0	19.3	51.6	24.0	67.7	33.9	39.3	153.3	152.3	34.7	25.1	45.8	27.1
Calcium	611	40	481	66	664	476	370	409	62	541	84	503	76
Chromium	1.53	0.06	1.33	0.21	1.60	1.80	1.50	0.90	0.14	1.27	0.55	2.81	1.46
Cobalt	0.39	0.13	0.41	0.10	0.42	0.24	0.54	0.46	0.08	0.44	0.16	0.50	0.18
Copper	30.1	2.0	30.6	3.5	25.9	30.0	26.5	26.3	2.5	25.3	3.2	24.6	3.1
Iron	214	72	191	52	180	120	299	183	22	255	101	188	55
Lead	0.14	0.09	0.09	0.04	0.17	0.36	0.23	0.12	0.05	0.14	0.07	0.18	0.13
Magnesium	937	36	867	35	919	920	840	834	16	829	55	818	80
Manganese	6.92	0.84	7.06	1.44	7.67	7.65	6.93	6.44	1.31	7.70	1.21	7.86	1.21
Mercury	1.61	0.57	1.35	0.58	1.86	2.69	1.04	2.73	1.41	1.53	0.33	1.86	1.00
Molybdenum	1.18	0.11	0.95	0.31	0.99	0.80	0.89	1.53	0.23	1.47	0.42	1.33	0.37
Nickel	0.12	0.04	0.12	0.07	0.07	0.14	0.09	0.20	0.06	0.12	0.08	0.15	0.13
Selenium	4.83	0.51	4.73	0.53	7.50	6.00	5.60	5.15	0.21	5.32	0.57	6.08	0.65
Silver	<0.005	0.00	0.00	0.01	<0.005	<0.005	<0.005	<0.005	0.00	<0.005	0.01	0.01	0.02
Strontium	0.88	0.15	1.00	0.18	0.94	0.57	0.62	0.63	0.10	0.52	0.16	0.46	0.13
Thallium	0.02	0.00	0.03	0.01	0.04	0.02	0.06	0.04	0.01	0.03	0.02	0.05	0.03
Tin	<0.01	0.00	0.00	0.02	<0.01	0.01	<0.01	0.01	0.03	0.00	0.03	0.00	0.01
Uranium	<0.005	0.00	<0.005	0.00	<0.005	<0.005	<0.005	0.00	0.01	<0.005	0.00	0.11	0.28
Vanadium	0.34	0.02	0.27	0.05	0.38	0.38	0.30	0.16	0.01	0.22	0.08	0.23	0.11
Zinc	138.0	19.1	141.8	23.5	124.0	158.0	127.0	164.5	37.5	121.3	13.8	124.6	16.8

Table 1 (Cont'd). Element concentrations in Yukon caribou kidneys (ppm dry weight). Samples collected 2002 and 2003.

Herd	Redstone		Tay				Wolf Lake	
Year	2003		2002		2003		2002	2003
	Mean	SD	Mean	SD	Mean	SD		
N	2		3		3	3	1	1
Age	3.5	0.7			4.0	2.0	4.0	7.0
% Moisture	78.1	0.8	77.5	77.5	80.2	2.2	82.4	79.1
Aluminum	2.8	0.2	1.4	1.4	3.0	0.6	1.3	1.6
Antimony	<0.01	0.00	0.02	0.02	<0.01	0.03	<0.01	<0.01
Arsenic	0.19	0.09	0.17	0.17	0.14	0.02	0.29	0.12
Barium	2.52	1.79	1.69	1.69	1.43	0.57	0.69	2.11
Beryllium	<0.01	0.00	<0.01	<0.01	<0.01	0.00	<0.01	<0.01
Boron	<0.5	0.00	<0.5	<0.5	<0.5	0.00	<0.5	<0.5
Cadmium	87.5	88.4	43.5	43.5	47.4	33.5	32.8	95.9
Calcium	424	103	423	423	435	43	604	369
Chromium	1.20	0.42	1.03	1.03	1.23	0.15	1.60	0.90
Cobalt	0.71	0.34	0.39	0.39	0.31	0.14	0.27	0.38
Copper	22.8	4.1	27.9	27.9	28.1	3.1	27.5	16.9
Iron	299	67	193	193	244	36	184	551
Lead	0.12	0.01	3.05	3.05	1.22	0.72	0.15	0.14
Magnesium	890	64	840	840	817	31	948	675
Manganese	4.97	2.72	8.24	8.24	7.33	0.83	7.36	3.55
Mercury	1.85	0.68	1.32	1.32	1.26	0.54	0.97	1.52
Molybdenum	0.87	0.18	0.93	0.93	0.68	0.40	0.47	0.66
Nickel	0.13	0.01	0.10	0.10	0.05	0.04	0.07	<0.05
Selenium	5.55	0.92	5.10	5.10	5.17	0.61	6.10	3.70
Silver	0.02	0.00	<0.005	<0.005	0.00	0.00	<0.005	<0.005
Strontium	0.78	0.22	0.63	0.63	0.73	0.14	1.31	0.55
Thallium	0.04	0.04	0.06	0.06	0.04	0.02	0.02	0.05
Tin	<0.01	0.00	<0.01	<0.01	0.10	0.00	<0.01	<0.01
Uranium	<0.005	0.00	<0.005	<0.005	<0.005	0.00	<0.005	<0.005
Vanadium	0.24	0.11	0.21	0.21	0.25	0.04	0.36	0.16
Zinc	156.0	65.1	139.7	139.7	135.3	20.4	134.0	119.0

Table 2. Element concentrations in kidneys from Yukon elk, moose and mule deer (ppm dry weight). Samples collected 2002 and 2003.

Herd	Elk	Moose				Mule Deer	
Year		2002		2003		2002	
		Mean	SD	Mean	SD	Mean	SD
N	1	53		43		3	
Age	5.0	5.4	2.8	5.0	2.7	3.0	2.6
% Moisture	78.5	79.9	1.6	80.2	1.6	80.1	0.7
Aluminum	0.4	1.4	1.9	2.2	5.1	0.8	0.6
Antimony	<0.01	0.00	0.04	0.01	0.01	<0.01	0.00
Arsenic	0.06	0.18	0.11	0.27	0.77	0.11	0.05
Barium	0.63	1.23	0.67	1.15	0.67	0.85	0.19
Beryllium	<0.01	<0.01	0.00	<0.01	0.00	<0.01	0.00
Boron	2.40	1.18	0.95	1.16	1.01	3.90	1.25
Cadmium	28.8	146.6	120.0	122.6	88.1	7.5	8.2
Calcium	493	431	51	474	85	479	28
Chromium	0.80	0.79	0.87	0.93	0.59	0.87	0.12
Cobalt	0.18	0.33	0.16	0.35	0.11	0.13	0.04
Copper	15.0	14.6	2.6	15.7	3.0	17.7	5.4
Iron	389	258	95	228	62	378	205
Lead	0.02	0.41	2.32	0.05	0.06	0.10	0.06
Magnesium	715	751	59	809	73	841	107
Manganese	2.77	7.09	3.13	7.60	3.29	5.26	3.24
Mercury	0.21	0.04	0.08	0.04	0.07	0.20	0.15
Molybdenum	1.68	1.33	0.50	1.44	0.61	1.28	0.29
Nickel	0.07	0.34	0.21	0.37	0.20	<0.05	0.08
Selenium	7.70	4.86	1.49	5.57	1.27	6.43	1.39
Silver	0.01	0.00	0.01	0.01	0.02	0.01	0.01
Strontium	0.99	0.51	0.15	0.49	0.15	0.93	0.11
Thallium	0.02	0.01	0.04	0.01	0.02	0.18	0.27
Tin	<0.01	<0.01	0.01	<0.01	0.01	0.00	0.01
Uranium	<0.005	<0.005	0.00	<0.005	0.00	<0.005	0.00
Vanadium	0.18	0.17	0.28	0.19	0.15	0.20	0.04
Zinc	260.0	146.0	40.5	156.1	54.6	101.8	12.8

RESULTS and DISCUSSION

Hunter Response

Samples were submitted from 95 moose, 99 caribou, 11 mule deer, 4 elk and 2 Dall sheep. Of these, samples from the mule deer, elk, 6 caribou and 2 moose were taken by YTG personnel from road-killed animals. Kidneys from 57 Porcupine caribou were submitted as part of a YTG body condition study. Samples from 3 Finlayson caribou and 1 moose were submitted from game guardians. Samples were also taken from 1 moose and 1 sheep by YTG personnel. Hunters contributed the remaining 1 sheep, 91 moose and 33 caribou samples.

Of the 211 submissions, 55% included liver, 77% included kidney, 53% included muscle, 78% included a tooth, and 32% included all four tissues. 5% of submissions only included teeth.

Tissue Analysis – Quality Assurance

Requested detection limits were met for all 26 elements analyzed by Elemental Research Inc (Appendix 3). Average recovery of three elements fell below the requested 85% minimum in the standard reference materials - chromium (80%), cobalt (79%) and mercury (84%). Three duplicate samples did not meet the requested maximum difference of 15%, aluminum (21%), arsenic (18%) and boron (35%). For all elements combined, the average percent recovery was 92% and the average relative percent difference between duplicates was 7%. This is considered acceptable quality control for this project.

CONTAMINANT ANALYSIS

Arsenic

There was little variation in renal arsenic measured in this study. Concentrations averaged 0.20 ppm for all species and ranged from less than the detection limit (0.01 ppm) in three moose to 4.97 ppm in a moose from the McQuesten River area. Although this individual moose had a renal arsenic level that would be considered high for domestic cattle (Puls 1994), all other animals measured in this study had concentrations that would be considered normal. This suggests little cause for concern from arsenic toxicity and these levels should be considered background concentrations.

> Although **arsenic** is generally considered a non-essential element, it has been identified as an essential trace element for domestic goats (Puls 1994). It can be absorbed by ingestion, inhalation and permeation of skin or mucous membranes and accumulates in the liver, kidney, spleen, muscle, skin and hair. Toxic effects include respiratory cancer, peripheral nervous system disorders and dermatitis (Jaworski 1980). Toxicity depends on the concentration and form, trivalent arsenic (arsenite) being 5 to 10 times more toxic than pentavalent (arsenate). Elemental arsenic is non-toxic. Since the use of arsenic in herbicides, insecticides, fungicides and rodenticides has been largely discontinued, the main sources of arsenic to the environment are mine tailings, smelter waste and natural mineralizations (Jaworski 1980).

Cadmium

Renal cadmium ranged from 0.8 ppm in a 1-year-old mule deer to 651 ppm in a 10-year-old moose from the Watson Lake area. This moose was considered an outlier and for clarity of the graphic, was not included in Figure 1. Because renal cadmium levels increase with age of the animal (Friberg, 1992), it is important to consider age as a factor when comparing cadmium levels among species, herds, or over time. Figure 1 shows renal cadmium concentrations for each species and herd, by age.

Renal cadmium concentrations were generally higher in Yukon moose than in barren-ground caribou (Porcupine herd), while the woodland caribou (all the other Yukon herds) tended to have more variable levels of renal cadmium, and mule deer and elk had quite low levels. This may be explained by differences in diet. Willows (*Salix* sp.) are cadmium hyperaccumulators (Vandecasteele et al., 2002), and are also a preferred food for moose (Risenhoover, 1989). Barren-ground caribou feed mainly on lichen, which absorb contaminants along with necessary nutrients from the air. Having no root system, lichens do not absorb anything from the soil on which they grow. Arctic lichens are blanketed with low concentrations of cadmium brought to the north by long-range transport via large air masses. In the absence of local point sources of airborne cadmium, this is virtually the only route of cadmium contamination for barren-ground

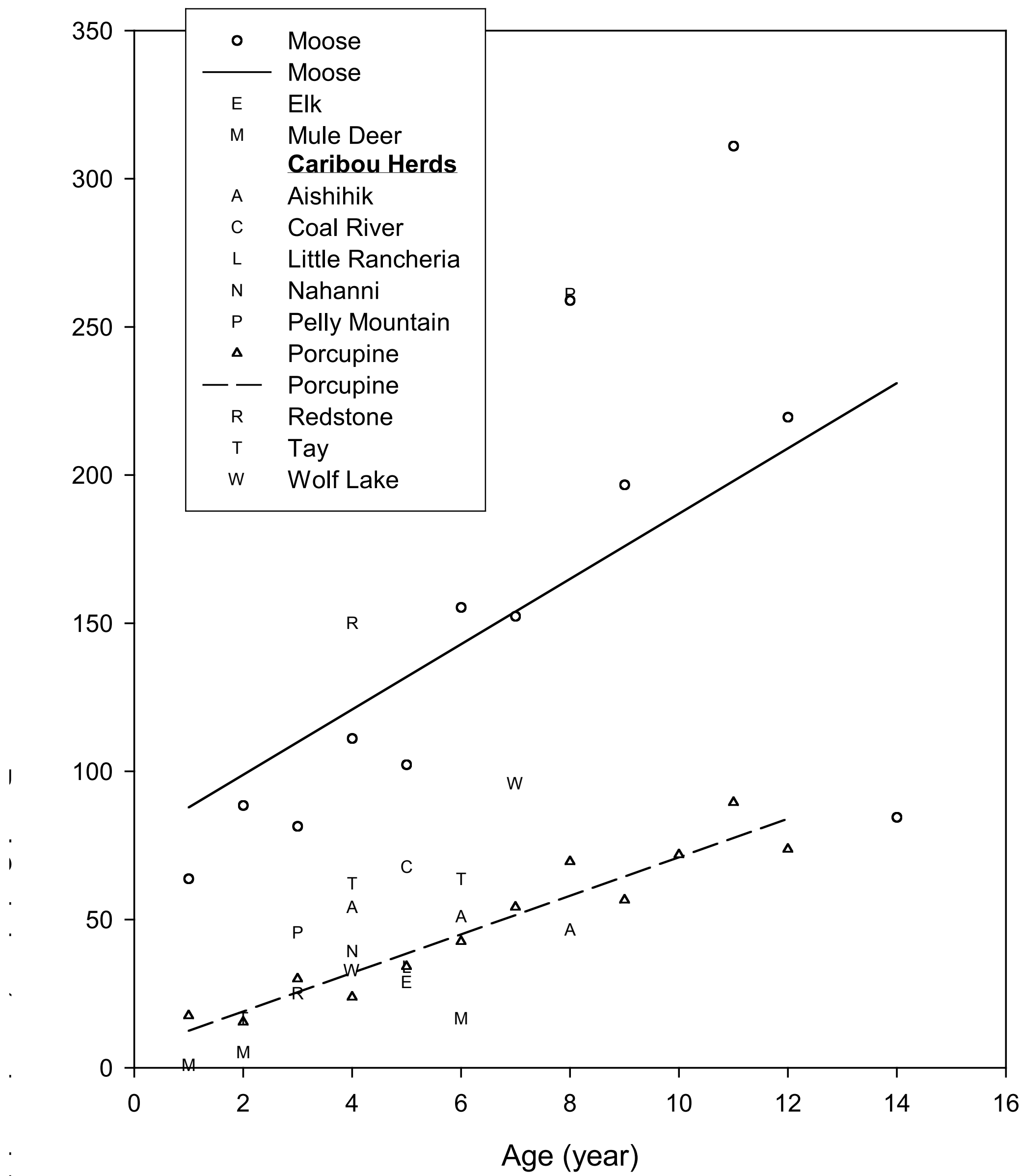

Figure 1. Renal cadmium concentrations in Yukon moose, caribou, elk and mule deer. Samples collected in 2002 and 2003.

caribou, and it tends to be fairly consistent across the arctic. Woodland caribou habitat is much more wooded than the tundra preferred by barren-ground caribou. Woodland caribou are also less migratory, inhabiting a much smaller home range. They feed on lichens, but also have a variety of browse available to them in their wooded habitat. One of the preferred species of browse is willow, a cadmium hyperaccumulator (Vandecasteele et al., 2002). Woodland caribou inhabiting a home range naturally high in cadmium, then, would be exposed to much higher levels of cadmium over their lifetime than barren-ground caribou feeding only on lichen. Conversely, woodland caribou inhabiting an area low in natural cadmium would have far less of this particular contaminant accumulating in their organs. Although mule deer and elk will forage on willows, they consume significantly less as part of their overall diet than moose.

The barren-ground caribou in this study (Porcupine herd) had concentrations of renal cadmium similar to those found in five barren-ground herds studied in the Northwest Territories (Elkin and Bethke, 1995), as would be expected. Renal cadmium concentrations in Yukon moose appear to be high relative to moose from other areas, with the possible exception of Alaska (Frøslie et al., 1986; Scanlon et al., 1986; Glooschenko et al., 1988; Brazil and Ferguson, 1989; Crichton and Paquet, 2000; O'Hara et al., 2001). Some of the moose from this study, particularly those from the southeastern Yukon, had renal cadmium concentrations that fell within the threshold range of 400-800 ppm (dry weight) at which renal tubule dysfunction has been shown to occur (Kjellstrom, 1986). Sublethal effects would be expected at a much lower level (150 ppm dry weight; Outridge et al., 1994) and would be expected in 32% of the moose analyzed in this study, but only 2% of the caribou, and none of the mule deer or elk. This indicates potential for older moose in some parts of the Yukon to be at risk due to high renal cadmium levels.

Health Canada has recommended limiting consumption of moose and caribou kidneys based on previously collected data (Appendix 2).

Cadmium is a toxic element that accumulates in animals over time (and therefore with age), primarily in the kidneys and liver. Chronic exposure may lead to anemia, enteropathy, renal damage, osteoporosis and osteomalacia. Long-range transport distributes cadmium widely over the environment, and natural mineralizations may serve as point sources. Lichens absorb cadmium directly from the air, eventually passing it on to caribou that feed on the lichen. Plants differ in their ability to absorb cadmium from soil and water, some species accumulating relatively high concentrations if they grow in cadmium-rich soil. Cadmium accumulates in long-lived herbivores, generally not in high enough levels to impair their health. Industrial uses of cadmium include production of cadmium-plated metal, nickel-cadmium batteries, pigments and plastic stabilizers, mining and refining of copper, lead and zinc (Jaworski 1980).

Copper

Renal copper concentrations in caribou from this study were very consistent, averaging 20.0 ppm dry weight, and ranging from 9.7 to 36.1 ppm (Tables 1 and 2). While these levels are somewhat lower than those found in barren-ground caribou in NWT (means ranged from 27.8-49.7 ppm; Elkin and Bethke 1995), they are within the range considered adequate for domestic cattle (Puls 1994). These concentrations should be considered background levels.

Copper is an essential element. Since it is homeostatically controlled, excess copper is excreted in the urine, and toxicity is rare under normal conditions. Toxic effects may occur, however, and can include dermatitis, anemia, gastric ulcers, renal damage and hemolysis (Aaseth and Norseth 1986). Copper deficiency has been noted in Alaskan moose with faulty hoof keratinization and reduced reproductive rates (Flynn et al. 1977). Industrial uses include production of electrical equipment and alloys, plating, plumbing, heating, and uses in mining and smelting.

Lead

Renal lead concentrations were generally low and usually <0.50 ppm (Tables 1 and 2). Exceptions to this included five caribou from the Tay herd, and three moose, two from the Watson Lake area and one from the Haines Junction area. Of these, one 5-year-old moose from south of Watson Lake had a renal lead concentration of 16.9 ppm, which should be considered an outlier. However, even this concentration was well below the threshold level of 80 ppm that is thought to be indicative of lead poisoning (Scheuhammer 1991). For the most part, concentrations of lead found in this study are well within the range considered normal for domestic cattle (Puls 1994) and should generally be considered background levels.

Lead is a toxic element that is stored for the long term in bone tissue, and in the short-term, in liver and kidney. Toxic signs include anemia, anorexia, fatigue and blindness. Common sources of lead include mining, smelting and refining of lead and other ores, burning petroleum fuels containing lead additives, burning coal and oil and use in shotgun pellets. Lead may also be found in paint (even ‘lead-free paint may contain up to 1% lead), waste engine oil, lead batteries, putty, roofing tiles, linoleum, solder and golf balls. Some pipe joint or thread compounds (used on drilling sites) can contain up to 40% lead powder (Puls 1994)

Mercury

Renal mercury concentrations were fairly consistent among caribou herds, ranging from an average of 1.25 ppm in the Wolf Lake herd to 2.73 in the Pelly Mountain herd, and were markedly lower in moose, elk and mule deer (Tables 1 and 2). Renal mercury concentrations found in caribou from this study were low relative to those found in NWT caribou (2.76-14.14 ppm dry weight; Elkin and Bethke, 1995). Even the highest mercury level measured in this study, (5.6 ppm dry weight or 1.2 ppm wet weight in a Porcupine caribou) is far below the threshold level of 30 ppm wet weight cited by Scheuhammer (1991) at which neurological effects might be expected to occur. Braune et al. (1991) suggested that high mercury levels in the Canadian arctic reflect naturally occurring geological sources rather than industrial pollution. Mercury levels found in this study should be considered natural background levels.

Mercury is a toxic element that accumulates in brain and kidney tissue, affects neurological functions and may cause gastrointestinal disturbance, reduction of food intake, poor growth, renal damage or death. Prenatal exposure may lead to cerebral palsy (Berlin, 1986). Inorganic mercury may be transformed to methylmercury (a more toxic form of mercury) by natural microbial action in lakes. This process may be promoted by excess sulphides from atmospheric deposition or nutrification of lakes. Aquatic life is generally more sensitive to methylmercury than terrestrial species. Environmental sources of mercury include mining, milling and smelting of mercury-containing ores, chlor-alkali plants, coal-burning plants, municipal wastewater treatment plants, pulp and paper mills and fungicides. Natural mercury occurs as volcanic gases, natural mineralizations and evaporation from oceans (World Health Organization, 1989).

Selenium

Renal selenium in this study ranged from 2.31 to 10.3 ppm, both extremes found in moose. Although renal selenium averages for each species fall into the ‘high’ to ‘toxic-chronic’ range for domestic cattle (Puls 1994), liver is considered by far the best indicator of selenium status. Hepatic selenium levels measured in Yukon moose in a previous study (Gamberg, 2000a) were somewhat higher than those found in moose from Sweden (Frank et al., 2000) and Norway (Frøslie et al., 1984) and also fell within the range considered toxic-chronic for domestic cattle (Puls, 1994). Selenium tends to concentrate in the black shales of the Selwyn Basin, Yukon, and can be found at very high levels (up to 1 ppm in rock) in some Yukon locations (pers. comm. G. Abbott, Chief Geologist, Yukon Geological Survey). It is not surprising, therefore, that some animals accumulate relatively high concentrations in their organs. However, since no signs of selenium toxicity have been observed in Yukon animals, we have no reason to believe that these concentrations may be having toxic effects.

Selenium is an essential element, which interacts with vitamin E to ensure optimum functioning of the immune and reproductive systems. Because some geographical areas are naturally low in selenium, deficiencies are possible, causing white muscle disease, reduced growth and reproductive rates, and reduced immune response. Signs of toxicity may include emaciation, lameness, cracked or deformed hooves and loss of hair. It has been thought that excess selenium also caused ‘blind staggers’, but this may be due to other compounds in the selenium-accumulating plants (*Astralagus* sp.) responsible for this disease (Puls, 1994). Industrial uses of selenium include electronics, photography, glass production, fungicides, insecticides and pigments in plastics, paints, enamels, inks and rubber.

Zinc

Renal zinc in animals from this study ranged from 87.8–329 ppm and averaged 139.6 ppm. These concentrations fall within the ‘normal’ to ‘high’ range for domestic cattle (Puls, 1994) and are similar to those found in caribou from NWT (96.75 - 120.86 ppm dry wt; Elkin and Bethke, 1995). Concentrations of zinc found in this study should be considered normal background levels.

Zinc is an essential, homeostatically controlled element, and is an important component of many proteins and enzymes. Zinc deficiency may result in reduced conception rate, reduced feed intake and growth rate, and thickening and shortening of bones. Toxic effects include anemia, poor bone mineralization, arthritis, general osteochondrosis and lameness (Sileo and Beyer, 1985). Zinc is released into the environment through mining, smelting and residential and industrial effluents and is used industrially in electroplating, the combustion of fossil fuels, petroleum by-products and solid wastes.

CONCLUSIONS

Element concentrations in moose, caribou, elk, Dall sheep and mule deer measured in this study should be considered background levels. Some Yukon moose and caribou showed higher renal cadmium and selenium concentrations than in the same species from other areas. It is likely that these contaminants are entering the food chain from natural mineralizations in the Yukon, and have always been part of this environment. We have no evidence that these elements are having toxic effects in the animals. People concerned about the consumption of contaminants from wild game should refer to the health advisory issued by Health Canada (Appendix 2).

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Appendix 1. Cadmium in Yukon Wildlife

Ongoing research on contaminants in wild foods has shown that, for the most part, mammals, birds and plants in the Yukon are free from contamination. However, some animals do have high levels of cadmium in their livers and kidneys.

Cadmium is a toxic heavy metal that is found in abundance in natural ecosystems in the Yukon. Our unique geology that makes mining so profitable here, also means that certain metals work their way into some ecosystems. Cadmium is one of those troublesome metals. The cadmium works its way into the soil, and then into plants through the roots. Animals eating those plants will then absorb the cadmium.

Once it is in the body, the liver and kidney work at removing the cadmium. They are effective to a degree, but if the animal (or person) takes in more cadmium than these organs can get rid of, it will accumulate in the liver and kidney over the lifetime of the animal. For this reason, older animals (or people) tend to have higher levels of cadmium than younger ones. If cadmium levels reach a threshold level in the kidney, there is potential for kidney dysfunction.

The World Health Organization (WHO) has determined the level of cadmium intake that is considered safe for humans. Health Canada has used this level, along with concentrations found in Yukon wildlife, to recommend limiting consumption of kidneys and livers of certain animals. For some, the limit is quite high - 485 snowshoe hare kidneys per person per year, and 382 Mountain Goat kidneys. For caribou the recommendation varies among herds, but ranges from 7-32 kidneys/person/year, and 4-16 livers/person /year. The recommended limit for moose liver and kidney is one of each per person per year. It should be noted that cadmium does not accumulate in the meat or the muscle tissue of any animal, and Health Canada has not recommended limiting consumption of meat from any species.

While health advisories of this sort are relatively new to the Yukon, advisories against eating livers and kidneys of certain species have been issued in other provinces of Canada. Manitoba has a health advisory for moose and elk, Ontario for moose and deer, Quebec for moose and caribou and Newfoundlanders have been advised that the consumption of moose liver or kidney would probably result in their exceeding the WHO standard intake limits for cadmium for that week of consumption. Most of these advisories do not recommend limiting consumption, but advise avoiding consumption completely. Health officials in the Yukon have attempted to be sensitive to the culture and desires of Yukoners, and gone through the extra step of determining what a safe level of consumption would be.

The federal Northern Contaminants Program is conducting an ongoing program to monitor contaminant levels in Yukon moose and caribou. The conclusion after nine years of the program is that cadmium, the major contaminant of concern, is stable and levels do not appear to be changing.

Anyone with further concerns or questions about levels of contamination in Yukon wildlife should contact Yukon Health and Social Services, or their local Yukon Environment Office.

Updated February 2004

Appendix 2. Health Advisory

ANIMAL	Maximum # of Kidneys per year Recommended for Consumption	Maximum # of Livers per year Recommended for Consumption
Caribou		
Bonnet Plume	32	16
Nahanni	28	13
Porcupine	25	12
Forty-mile	20	12
Wolf Lake	15	8
Finlayson	8	5
Tay	7	4
Moose	1	1
Sheep	178	no limit
Goat	382	26
Beaver	15	46
Porcupine	13	17
Snowshoe Hare	485	no limit

There is no limit on the amount of muscle (meat) recommended for consumption from any Yukon wild game.

For more information please contact YTG Health and Social Services.

Appendix 3. Quality control data for laboratory analysis: element concentrations (ppm) in preparation blanks, recoveries for standard reference materials and relative differences between duplicate samples. % Differences and recoveries were calculated only when element concentrations were greater than 10 times the detection limit.

	Preparation Blanks (Detection Limit for samples)	% Recovery Standard Reference Materials	Relative Percent Difference between Duplicates
Aluminum	0.1	102	21
Antimony	0.01		
Arsenic	0.01	89	18
Barium	0.01		2
Beryllium	0.01		
Boron	0.5		35
Cadmium	0.01	92	2
Calcium	1		3
Chromium	0.2	80	8
Cobalt	0.01	79	3
Copper	0.05	99	2
Iron	0.5	89	3
Lead	0.01	89	10
Magnesium	0.1		2
Manganese	0.01	80	2
Mercury	0.05	84	2
Molybdenum	0.01		2
Nickel	0.05	85	9
Selenium	0.1	111	4
Silver	0.05	106	4
Strontium	0.01		2
Thallium	0.01		0
Tin	0.01	96	
Uranium	0.005		15
Vanadium	0.05		7
Zinc	0.1	96	1
Average		92	7