Metal and Body Condition Assessment in Aquatic Furbearers from the Porcupine River System, Timmins, Ontario

by

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Abstract

In 2014, MOECC, MNRF, local First Nations, the City of Timmins, and local mines designated the Porcupine Watershed, east of Timmins, Ontario, as an area of concern due to a variety of potential point-source contaminants from over a century of forestry, mining, and urbanization. Further study of the watershed was necessary to determine the existence and, if present, the extent of contamination. This study evaluated metal uptake and its relationship with body condition of *Castor canadensis*, *Ondatra zibethica*, *Lontra canadensis*, and *Mustela vison*. Results indicated that in the industrial area, *Castor canadensis* had an increase of 5% in body condition and 26% decrease in body condition in *Ondatra zibethica*. Moving up the trophic level, aquatic carnivores, *Lontra canadensis* had a 46% lower body condition in industrial areas, while *Mustela vison*'s body condition was lower in the industrial area by 33%. In both trophic levels, arsenic, cadmium, cobalt, copper, iron, and manganese levels in tissues were significantly higher ($P<0.05$) in the industrial area compared to the reference areas. These results indicate that bioavailability of certain metals is higher in the industrialized area of the Porcupine Watershed and that potentially, some pressures on fauna health may exist. No evidence of site-influence or enhanced levels were observed for mercury, lead, antimony, selenium, chromium or zinc. No direct link between higher point-source bioavailability of metals and current and past industry, urban development nor natural variability in local geology was found. However, if remedial measures are implemented, all parties should be involved. In order to protect and restore the health of the watershed, further investigation is necessary to determine the point- sources of the identified metals.

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To my daughter, expected to enter this world in a few short weeks, may you see how supportive your family will be for you and may you work hard for what you feel passionate for. To live and work in passion is the ultimate success.

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1 General Introduction: A Review of the Literature on Metal Uptake in Biological Systems

1.1 The Rise of Environmental Awareness

As human populations continue to grow, understanding of the impacts associated with this change in density and development is vital to ensure healthy populations and environmental sustainability. Since the 1900's and especially following the Industrial Revolution and World War II, there was an awareness that environmental resources were in finite supply and becoming increasingly degraded (Jundt, 2014). The Industrial Revolution brought with it resource harvesting industries whose practices quickly became the center of criticism by a rising environmental movement (Meyers-Schone et al., 1993; Walker & Walsh, 2012; Jundt, 2014). Research brought to light how important maintaining environmental health is for the well-being of planetary life and since then, significant progress has been made to monitor and solve the immeasurable amount of environmental problems that had been created (Meyers-Schone et al., 1993). The rise of environmentalism was also promoted by publications such as Rachel Carson's *Silent Spring* (1962), which had an enormous impact on how society regarded and treated industrial toxins in the environment (Walker & Walsh, 2012; Jundt, 2014). With Carson's publication, issues such as the negative effects of pesticides on non-target species and the development of resistance, chemical persistence and imbalances were publicized and debated by scientists in all parts of society (Rattner et al., 2011). Research programs around the world blossomed and chemical screening programs were initiated to look at toxicity and the potential hazard of chemicals to birds, mammals and humans (Heath et al., 1972; Schafer et al., 1983). As a result, long-term sustainable environmental monitoring programs were initiated (Rattner et al., 2011).

Despite the sudden surge of environmental awareness and concern, by the mid 1990's, the environment continued to degrade, fragment and be polluted at an alarming rate (Meyers-Schone et al., 1993). However, some significant progress was made to solve and monitor environmental problems (Meyers-Schone et al., 1993), as it was recognized that industries such as mining, hydro, oil, and nuclear could cause serious adverse effects to the environment. As a result, it was important that these industries adhere to government regulations or companies could risk severe fines, the loss of a positive public image, and even be forced to close (Caro & O'Doherty, 1999). In Canada, to mitigate environmental degradation, regulations such as the Species at Risk Act and the Canadian Environmental Protection Act worked to address a variety of issues such as pollution prevention, wildlife protection, and emergency management (Environment Canada, 2006).

For industrial purposes, biomonitoring, which involves measuring the burden of toxic elements or compounds, can be an effective method to detect and assess hazardous contaminants and chemicals in an environment (Meyers-Schone et al., 1993). As industries continue to expand in both size and quantity, so did the need to ensure that their practices are not harming the local environment or the species that depend on it (Garson et al., 2002; Burgas et al., 2014).

One of the main groups of pollutants responsible for the degradation of ecosystem health was metals. Metals, due to their toxicity, bio-accumulative, and non-biodegradable nature, can be incredibly dangerous to aquatic, terrestrial, and human life systems (Angelovicova et al., 2014). Once accumulated in animals, plants or humans, metals can be difficult to detoxify, metabolize, or excrete (Shin et al., 2013). This literature review focuses on what is known about the effects of metals and their impact on organisms and how the field of metal ecotoxicology has evolved.

An important field of study essential to understand and combat the negative effects of contaminants on the environment is ecotoxicology. Ecotoxicology studies the movements of environmental contaminants through the environment and their effects on plants, animals, and ecosystems (Beyer & Meador, 2011). The concern of poisoning wildlife initially began in the nineteenth century and at first, focused primarily on identifying environmental problems rather than contaminants in tissues (Rattner et al., 2011). However, as science progressed, reports on pheasant (*Phasianus colchicus*) and waterfowl mortality caused by lead ingestion began to appear in the literature (Calvert, 1876; Grinelle, 1894). To understand the movement of contaminants within organisms and through food chains as well as injuries to both individuals and communities, examining tissue residues of these contaminants is key to ecotoxicology (Beyer & Meador, 2011). The logic of using tissues in wildlife toxicology was introduced by Bill and Lucille Stickel (1973), who described a method of using bird tissues to investigate organochlorine pesticide poisoning (Beyer & Meador, 2011). However as early as 1919, both qualitative and quantitative determination was used to describe the presence of lead in the caeca and stomach of waterfowl (Wetmore, 1919; Magath, 1931). Although soil and sediment analyses are important, tissue contaminant is much more important for toxicologists as it can give more insight to global distribution of a contaminant or even explain the reason and origin of mass die-offs (Beyer & Meador, 2011).

1.2 What are Heavy Metals?

The term 'heavy metals' is used to describe a metallic element with a density of more than 3.5-5g/cm^3 and an atomic number greater than 20 (Malik et al., 2010; Jakimska et al., 2011). Their presence can have deleterious effects because they do not degrade and they bio-accumulate in living tissues giving a rise to symptoms of toxicity. There are a large number of poorly studied metal chemicals (Beyer & Meador, 2011). These compounds and elements can be found in pharmaceuticals, industry effluents, personal care products, pesticides, and much more. Metals are divided into two categories; elements that are necessary for growth and organism life, but are toxic at high concentrations and elements that are toxic even at low concentrations (Jakimsha et al., 2011). At elevated levels, both essential and non-essential metals can negatively affect an organism development, physiology, pathology, feeding, and reproduction, while increases in radicals can severely damage DNA (Jewett & Naidu, 2000; Saunders et al., 2009). Aside from the levels and bioavailability of metals in the area, health risks for mammals depends on many confounding variables such as diet, nutritional status, age, and metabolism (Wei-Chun, 2011). The main sources of these contaminants are anthropogenic: sewage, industrial effluents, fuel combustion, mining, and smelting (Jakimska et al., 2011). Due to a gap in knowledge on metal effects on specific aquatic wildlife, there is a significant need for industry and government to understand and monitor the causal relationships and managing risks to wildlife from heavy metal-bearing waste solutions and tailings (Donato et al., 2007).

Metal pollution, although less visible, is a direct and significant polluter of aquatic ecosystems as they are deposited, assimilated, and incorporated in water, binding to sediment particles and aquatic species (Linnik & Zubenko, 2000).The reasons for metal concern is primarily due to the phenomena of bio-accumulation. This term describes the process of how metals accumulate in species and to other trophic levels, once they have become bioavailable and enter the food system (Vries et al., 2007a). Bio-magnification is another major concern as it is the process of contaminants increasing in concentration as they move up trophic levels (Indian and Northern Affairs, 2004), while accumulating more metals through predation of contaminated prey over time (Vries et al., 2007a). The primary exposure pathway of such pollutants is ingestion (Griffiths et al., 2009). More specifically, the intake of metals is not only related to feeding habits of a species, but also the specifics of behavior are important (Petkovšek et al., 2014). For example, some of the highest metal levels can be found in insectivores as they feed on earthworms, which have strong metal accumulation capabilities (Petkovšek et al., 2014). With such complexities in mind, a multi-trophic level approach as performed by Saunders et al. (2009) is a recommended method to determine concentrations and bioavailability in the environment. The transfer of metals in food chains are described as bio-concentration factors (BCFs) and bio-accumulation factors (BAFs) and they are based on the knowledge of the linear movement of metals through soil, to plants, insects, mammals and other organisms (Saunders et al., 2009). BCF is defined as the ratio of the metal concentration in an organism to the concentration of the original source, which could be water or soil in its steady state. It is used for plants and invertebrates and expressed in wet weight of tissue and dry weight of soil. BAF is the ratio of the metal concentration in the organisms to the concentration of the metal in its food at a steady state (Saunders et al., 2009). It is used commonly to describe the accumulation in birds and mammals and is expressed on a wet weight basis (Vries et al., 2007b).

Various studies have emphasized the need for further research on the accumulation and fate of metal contaminants at different trophic levels and waterbody types. Metals moving through aquatic food webs to fish, other piscivorous animals, and humans cause serious environmental and human health concerns (Chen et al., 2005). High levels of mercury (Hg) in fish from supposedly pristine lakes have resulted in the adoption of conservative fish consumption advisories globally (Håkanson et al., 1988; DiFranco et al., 1995; Yeardley et al., 1998). However, pathways of metal movement through different food webs are not well understood. The understanding of metal movement in freshwater systems has been growing significantly since the 1990's, but there are still large gaps in knowledge as most studies of metals focus on a few taxa, single metals or movement through a single trophic level (Miller et al., 1992). However for marine environments, some metals have been studied almost exclusively, on their own without evaluating impacts of multiple metals causing symptoms together (Eisler, 1994; Suedel et al., 1994). Unfortunately, piscivorous wildlife in freshwater habitats have been found to have higher levels of metal exposure than those in marine habitats, stressing the need for further understanding of freshwater systems (Scheuhammer et al., 2007). Due to a lack of consistency among studies comparing and understanding of transfer processes of different metals across different systems, understanding metal movements through food webs in freshwater lakes has proved to be challenging. Due to technical shortcomings and a significantly poor understanding of community structure, very little of metal movement particularly in the lower trophic levels in freshwater systems is understood (Chen et al., 2005). Furthermore, despite a large amount of research conducted on heavy metal behavior in laboratories on small mammals, very little work had been done before the 1980’s on understanding metal movements in natural environments and their impacts on wildlife (Hunter & Johnson, 1982).

1.3 Metals of Interest

There are several metals that have significantly negative impacts on organisms. The eight most common pollutant metals listed by the Environmental Protection Agency are arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn) (Khayatzadeh & Abbasi, 2010). These metals with the exception of Zn, Cu, and Ni are systemic toxicants and are known to induce extensive organ damage, even at low exposure (Tchounwou et al., 2012). These metals have been classified as either “known” or “probable” carcinogens based on their exposure and cancer incidence in humans and animals by the United States Environmental Protection Agency and the International Agency on Cancer Research (Tchounwou et al., 2012). However, there are a variety of metals that are found in animal and human diets that are essential as they perform several necessary biological functions (Mcgraw, 2003). A deficiency in any of the required trace metals can result in a variety of deficiency syndromes and diseases. Excessive levels of such metals can lead to cellular and tissue damage leading to diseases, and sometimes death (Tchounwou et al., 2012). Some metals of concern have no established biological functions and are considered non-essential metal (Tchounwou et al., 2012). The following metals are of concern and are predicted to be of concern near Timmins, Ontario within the Porcupine River Watershed, based on studies of similar environments and the local industrial infrastructure.

1.3.1 Essential Metals of Concern

1.3.1.1 Cobalt (Co)

Cobalt (Co) is required for a multitude of biochemical and physiological functions including as a constituent of vitamin B_{12} (Khayatzadeh & Abbasi, 2010; Tchounwou et al., 2012). Co alloys are often found in engines, heavy machinery, artificial joints, colorants in glass, ceramics, paints, as catalysts, and as paint driers. Naturally, small amounts of Co are found in rocks, soil, plants, and animals. With the exception of a few hyper-accumulator plant species such as *Berkheyda coddii*, *Alyssum corsicum*, *Lamiaceae*, *Scropular*, most terrestrial plant species do not bio-concentrate Co (Gál et al., 2008). In dissolved or ion form, Co is also found in minute amounts in water. It enters air and water from windblown dust, seawater spray, volcanic eruptions, forest fires, and surface water runoff, leaching from rainwater on contaminated rocks and soil (ATSDR, 2004). Anthropogenic sources originate from vehicle exhaust, industrial activities from mining and processing of Co containing ores, coal-fired power plants and incinerators, and from Co alloy and chemical production (ATSDR, 2004). A dominant dependent of Co bioavailability is a low pH (Gál et al., 2008). Co ions both in vitro and in vivo are genotoxic and carcinogenic in rodents (De Boeck et al., 2003). Co metal dust has also been linked to increased lung cancer risk in mammals and induce DNA strand breaks in hamster ovary cells (Robison et al., 1982). Animal carcinogenicity data has been shown to be sufficient to make such claims, but not enough data is available to prove it is carcinogenic for humans (De Boeck et al., 2003). Because Co is used less industrially than other metals, there are significantly fewer studies on it, especially on vertebrates (De Boeck et al., 2003; Gál et al., 2008).

1.3.1.2 Chromium (Cr)

Cr (chromium) is an important regulator of glucose metabolism and cholesterol (Malik et al., 2010). It is a common metal in leachates from landfill composts, electroplating, leather tanning, cement, mining, dyeing, fertilizer, and photography industries (Mudhoo et al., 2012). Because Cr leaches quickly and is organically complexed in these effluents, it is highly bioavailable and mobile in soil (Sánchez-Chardi & Nadal, 2009). At elevated levels, Cr is associated with abnormal enzyme activity, changes in blood chemistry, a decreased resistance to pathogenic organisms, alterations in behavior, osmoregulatory upset, modifications in population structure, and in plants the inhibition of photosynthesis (Mudhoo et al., 2012).

1.3.1.3 Copper (Cu)

Cu (copper) is essential for many oxidative enzymes, the synthesis of hemoglobin, and antioxidant systems (Goyer & Clarkson, 2001; Malik et al., 2010). However, before the 1980's, no biological function was known and Cu was believed to only have adverse effects on metabolic processes with its bio-accumulation capacities (Hunter & Johnson, 1982). It is a constituent of oxidases, which is important for cartilage formation and regulates redox respiration. When elevated levels are in combination with low pH, Cu can be fatal for aquatic organisms such as fish (Khayatzadeh & Abbasi, 2010). If an animal's liver is damaged when Cu is released into the bloodstream, it can damage the kidneys by gorging on the tissues through hemoglobin breakdown. This in turn causes hepatic necrosis and a possibly fatal hemolytic event (Haas et al., 2009). High exposure levels have been shown to induce anemia, impair thyroid and liver functions, and reduce food intake, growth, and reproduction (Mcgraw, 2003). Cu is known to deposit in the brain, skin, liver, pancreas, and myocardium and in humans causes health problems such as anorexia, migraines, allergies, childhood hyperactivity, and learning disorders (Mudhoo et al., 2012). Since the 1980's, the biological effects of excess Cu and its mobility within food chains has been poorly documented (Hunter & Johnson, 1982).

1.3.1.4 Iron (Fe)

Fe (iron) being one of the most abundant metals on earth, is essential to organisms for hemoglobin, cytochromes, catalysis, and peroxides (Khayatzadeh & Abbasi, 2010). However, at elevated levels, Fe can be associated with many physiological impairments, effecting neurobehavioral developmental, impact blood enzymes, and cause death (Hoffmann et al., 2010).

1.3.1.5 Manganese (Mn)

Mn (manganese) at lower levels can play an important role in protecting the mitochondria from free radical damage (Khayatzadeh & Abbasi, 2010). A study by Hayat et al. (2007) showed that when exposed to elevated levels of Mn for 30 days, three species of carp (*Catla catla*, *Labeo* *rohita*, and *Cirrhina mrigala*) experienced decreased weight. They also noted the carp absorbed Mn mainly through gills and not from ingestion. This may be the norm for most species of freshwater fish.

1.3.1.6 Nickel (Ni)

Ni (nickel) is essential for normal growth and reproduction. Ni most commonly enters the body via food and water consumption as well as inhalation. This heavy metal is commonly found to be associated with industries such as non-ferrous metal and mineral processing, paint formulation, electroplating, porcelain enameling, Cu and sulphate manufacturing, and steam-electric power plants. Toxic effects have been documented in humans and laboratory mammals for cardiovascular, respiratory, gastrointestinal, musculoskeletal, hepatic, renal, dermal, ocular, immunology, developmental, neurological, and reproductive systems (Mudhoo et al., 2012). Elevated rates can also cause carcinogenic effects when consumed (Malik et al., 2008). For sensitive aquatic species, ionic nickel has been observed to be lethal at 11-113 lg/L. However, aquatic bacteria and yeasts are tolerant to Ni. Excretion of Ni is an incredibly slow process compared to its assimilation, causing the kidney to be significantly burdened as Ni tends to accumulate in high levels within it over time (Parker, 2004). Not enough data has been published to support or refute whether organisms from higher trophic levels are more sensitive to Ni exposure than those from lower trophic levels or whether Ni biomagnifies in aquatic and terrestrial environments (DeForest et al., 2012).

1.3.1.7 Selenium (Se)

Se (selenium) is increasingly being recognized for its importance biologically and is increasingly being recognized as a nutraceutical component (Khayatzadeh & Abbasi, 2010). Se is essential for cellular antioxidant defenses (Khayatzadeh and Abbasi, 2010). Furthermore, Se can act as a growth factor, has anticancer properties, and is needed for normal thyroid homeostasis (Ralston & Raymond, 2010). Several studies have observed Se counteracting the effects of Hg (Kruuk & Conroy, 1991; Ikemoto et al., 2004) and protecting animals from both inorganic Hg and MeHg (methylmercury)(Khan & Wang, 2009). According to a study by Ikemoto et al. (2004), Se seems to detoxify metals in the livers of higher topic marine animals. In a laboratory study, animals who were exposed to both Hg and Se had longer life spans, higher growth rates, and higher weight gains compared to those who received Hg without Se. Additionally, they suffered less tissue damage and other toxic effects (Haines et al., 2010). According to Haines et al. (2010), the exact mechanisms that Se uses to protect organisms against Hg are unknown. Whanger (1985) found that while Se seems to counteract the neurotoxicity of Hg, it also seems to increase the levels of Hg in the brain. Whanger (1985) later found that that it is likely Se was causing Hg to be deposited in the brain in a non-toxic form. Furthermore, Haines et al. (2010) found an interesting reaction in the liver and brain as MeHg would de-methylate when exposed to Se. Haines et al. (2010) also claimed that research has focused more so on saltwater fish but more work needs to be done on freshwater fish. They point out that freshwater aquatic mammals such as otters and mink should be exposed to higher levels of Hg than terrestrial mammals and therefore require additional study.

1.3.1.8 Zinc (Zn)

Zn (zinc) is an essential mineral for animals and humans required for normal nucleic acid, protein and membrane metabolism, and cell growth and division (Mudhoo et al., 2012). Although it is essential, Zn also has toxic environmental factors (Khayatzadeh & Abbasi, 2010). In several studies, high exposure levels of Zn have been shown to induce anemia, impair thyroid and liver function, decrease food intake, growth and reproduction (McGraw, 2003).

1.3.2 Non-essential Metals of Concern

1.3.2.1 Arsenic (As)

As (arsenic) is a widespread element that is found associated with many different minerals in rocks and soils (Drouhot et al., 2014). It is responsible for specific growth stimulation, but high levels are usually obtained through inhalation of dust, consumption of food, water, and soil, which can lead to DNA damage, respiratory, reproductive, and immunity problems, cell damage, cancer and even death (Espinosa-Reyes et al., 2010; Khayatzadeh & Abbasi, 2010). Most studies were conducted in laboratories so most of the data resides in an artificial setting. However, in nature, As is taken up by vegetation and various invertebrates that naturally occur on abandoned mine sites (Drouhot et al,, 2014). Acute poisoning of As has been reported since the 1800’s in both domestic and wild animals, but data on wildlife poisoning is scarce. For free-living mammals, metabolic detoxification and rapid excretion is possible. However, as a response to long-term exposure at former mine sites, oxidative stress, histological damage, and some biomarker responses have been associated with As contamination in small mammal species (Drouhot et al., 2014).

1.3.2.2 Mercury (Hg)

Hg (mercury) has no known biological function (Vries et al., 2007b). Being directly mobilized by humans for thousands of years, through industrial activities, the atmosphere is the foremost transport pathway of Hg emissions and then land and ocean/aquatic pathways play an active role in redistributing Hg in terrestrial, freshwater, and marine ecosystems (Driscoll et al., 2013). Both temporal and spatial scales of Hg movement from the atmosphere and then to aquatic and terrestrial environments depends on Hg's chemical and physical form. Once released into the atmosphere, the residence time can be from several months to a year. Elemental Hg (Hg(0)) can be moved long distances before it is oxidized and removed by both particle and gas-phase dry deposition or by precipitation (Driscoll et al., 2013). Hg intoxication can cause effects such as impaired motor coordination. Studies on wildlife populations for Hg intoxication may not always yield population representative results as only individuals who are active and healthy enough to locate bait set by hunters, fishermen or trappers would be captured. Therefore, the relationship between Hg, wild animals and age is still not clear (Klenavic et al., 2008). When assessing Hg toxicity in an organ or individual, the total concentration of the contaminant can be misleading because its toxicity can be dependent on its chemical form (Beyer & Meador, 2011).

1.3.2.3 Methylmercury (MeHg)

The most bioavailable form of Hg is MeHg (methylmercury), which is an extremely toxic compound that easily crosses biological membranes, accumulates in organisms which are exposed and can bio-magnify its way from the bottom to the top of trophic levels in both fish and wildlife (Wiener et al., 2003). MeHg enters the body mainly from digested food. It is quickly absorbed into the intestines where it then enters the red blood cells and circulates throughout the body (Oliveira et al., 1999). For individuals, laboratory studies show that elevated MeHg exposure can cause significant behavioral, physiological, immunological, neurochemical, reproductive, and histological changes (Scheuhammer et al., 2007). For populations, impacts of MeHg vary with the life history of the species and local variability of exposure (Scheuhammer et al., 2007). Many studies document the effects of MeHg in vertebrate individuals, but very few studies look at whether present-day environmental levels of MeHg are a danger to wildlife populations (Scheuhammer et al., 2007). Conditions that enhance methylation in an environment are low alkalinity, low pH, and high organic carbon concentrations (Sandheinrich & Wiener, 2011). Dominant zones for methylation are warm, shallow lakes that have organic-rich sediment and wetlands with anoxic waters with shores that have soil drying and rewetting locations (Engstrom et al., 2007; Sandheinrich & Wiener, 2011) Therefore, due to their anaerobic condition, peatlands for example, have ideal conditions for promoting methylation (UNEP, 2013). Methylated inorganic Hg quickly enters food webs and biomagnifies sometimes to toxic concentrations. Risk-assessment modeling approaches used for wildlife and Hg often work towards the health of wildlife populations as opposed to the health of individuals and the conservation of wildlife habitat is a major consideration (Scheuhammer et al.,2007). However, additions of sulfur dramatically increase methylation and once additions of sulfur are stopped, there is a significant decrease in Hg (Keita-Ouane, 2003). According to Scheuhammer et al. (2007), there is a sufficient amount of evidence to indicate that in North America, a number of species of wild fish, birds, and mammals consume diets with MeHg concentrations that are toxic to individuals. Because MeHg is so bioavailable and easily bio-accumulates in fish, piscovorous wildlife from higher trophic levels such as otter and mink are at significant risk of over-exposure (Hopkins et al., 2007).

1.3.2.4 Lead (Pb)

No biological function is known for Pb (lead) and toxicity is often associated with cognitive impairment when blood levels are above 100 µg/L (Vries et al., 2007a). According to the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health, Pb extraction from ore is often associated with Zn as the two are often found together in nature (CCME, 1999b). Natural sources of Pb are volcanoes, forest fires, and sea salt (CCME, 1999b). Common pathways for mammals include inhalation of wind-blown lead-laden dust and oral intake of water and food (Beyer & Meador, 2011). In the case of developing fetus, Pb can be transferred through the placenta and from maternal blood to the milk, exposing offspring (Hallén et al., 1995). Once in the body, Pb targets several physiological systems such as the central nervous system, the hematopoietic system, the renal system, the cardiovascular system, and the gastrointestinal system (Yeardley et al., 1998; Wei-Chun, 2011). Consequently, elevated Pb exposure can cause anemia, kidney damage, hypertension, encephalopathy, injury to peripheral nerves, excessive salivation, intestinal colic, vomiting, and behavior issues such as insomnia, uncoordinated movement, loss of appetite and lassitude (Wei-Chun, 2011). Extremely high exposure levels may also lead to death (Wei-Chun, 2011).

1.3.2.5 Cadmium (Cd)

Cd (Cadmium) is a widespread element throughout the environment in low concentrations (Cooke, 2011). Cd has no biological function (Vries et al., 2007b), but increased levels of Cd are derived from anthropogenic sources such as fertilizer applications, roasting zinc ores, sewage, and mine waste (CCME, 1999b; Cooke, 2011) Factors such as pH, soil type and particle size influence Cd mobility (CCME, 1999b). Its toxicity may originate through exposure from respiration or ingestion and a study by Hunter and Johnson (1982) revealed that Cd in mammals and invertebrates accumulated in organs such as liver, kidney, and bones. Excessive accumulation can lead to tissue dysfunction, DNA damage and mRNA transcriptional changes in mammal and fish species (Cooke, 2011; Shin et al., 2013). Hoffmann et al. (2010) studied levels of this non-essential metal in wildlife. Cd exposure in wildlife is often a chronic problem due to slow accumulation via the diet (Cooke, 2011). Little evidence supports accumulation of Cd in the brain, lung or testis, even in highly contaminated site (Hunter & Johnson, 1982). Effects on the kidney often involve tubular dysfunction, tubular cell damage and glomerular dysfunction. In a study on mice, rats, and voles by Talmage and Walton (1991), non-lethal levels of Cd in whole body, liver, and kidney were respectively 0.1-0.4, 0.2-1.5, and <0.1-5.6 mg/kg. Levels from shrews with an insectivorous diet in uncontaminated areas were found in the range of 1.2-4, 2.3-25.4, 4.1-25.7 in the whole body, liver, and kidney, respectively (Talmage & Walton, 1991). Higher levels of Cd have been found in animals from higher trophic levels, indicating bio-magnification activity and older animals show higher levels of Cd demonstrating bio-accumulation over longer lifetimes (Cooke, 2011). A study on the greater white toothed shrew (*Crocidura russula*) by Sanchez-Chardi and Nadal (2007) showed that long biological half-lives of Cd in the kidney and liver indicate that tissue concentrations were dependent on age and the dose and the duration of the exposure. There has also been evidence to support the idea that there is a positive relationship between body weight and kidney and liver concentrations within population samples (Milton et al., 2003).

1.3.2.6 Antimony (Sb)

Sb has received little attention in research due to its limited commercial and industrial use, but is most commonly obtained through inhalation and skin contact (De Boeck et al., 2003). Sb is primarily used as a flame retardant in rubber, plastics, textiles, paper, pigments, fireworks, and adhesives. Sb has been found to be a carcinogenic and clastogenic, but does not induce gene mutations in vitro. For people working in smelters and in rodents, inhalation of certain Sb compounds has been reported to cause lung tumours (De Boeck et al., 2003).

1.4 Metal Behavior

1.4.1 Distance from Source

The distance a point source contaminant is from biota can be seen in the concentrations of metals accumulated in an individual. Rose and Parker (1982) studied mineral levels in the plumage of ruffed grouse (*Bonasa urnbellus*) and noted a substantial temporal increase in Cu, Ni, and Fe levels in the plumage of birds living near Falconbridge, an area within the Greater City of Sudbury. In contrast, birds studied from a site 100 km away from the smelter failed to exhibit any significant change in metal levels over the course of the year (Lepage & Parker, 1988). Lepage and Parker (1988) confirm the geological and geographical influence of Sudbury, Ontario Ni Cu smelters on local vertebrate populations. However, according to Scheuhammer et al. (2007), environments remote from point-source releases of metals such as Hg can contain fish with metal accumulation in their tissues, causing the effects of far off point sources to still affect remote piscivorous wildlife. Scheuhammer et al. (2007) also cautioned that the removal of point source effluents does not mean the issue of metal contamination has been eliminated. Fish and piscivorous wildlife have been shown to experience elevated exposure long after the inputs have ceased.

The size of the home range of an animal can have an impact on the levels of metals individuals are exposed to. A study by Hoffman et al. (2010) assessed the levels of Cd, Cu, Fe, and Zn in kidneys of grey wolves (*Canis lupus*) and a population from Alaska showed a bimodal distribution of metal concentrations. One portion of the population had extremely high levels of all four metals, while levels in the other portion of wolves had significantly lower levels. However, there was no observable pattern related to location, sex or age to explain the differences. It was determined that the range and dispersal patterns of the wolves affected their metal levels. The wolves with larger ranges appeared to have been in previously contaminated locations, whereas those with smaller ranges were in cleaner areas and had lower levels (Hoffmann et al., 2010). It was concluded that for determining metal bioavailability and levels, it is vital to select animals with small ranges to ensure their levels are from local exposures and not from other areas outside their range.

1.5 Trophic Level Behavior

It is important to note that for most metals, population impacts vary by life history of the species and differences in exposure levels (Scheuhammer et al., 2007). A study by Chen et al. (2005) looked at aqueous metal levels in lakes and how they move through the food web. Chen et al. (2005) encourages the investigation of upper and lower trophic levels separately to fully understand metal transfer pathways in aquatic food webs. Their primary findings when studying different trophic levels and metal accumulation in aquatic environments was that water quality is not an effective predictor for metal levels in macro-zooplankton. However, metal in food was a good predictor. Hunter and Johnson (1982) also found that for metals such as Cu and Cd, concentrations in surface soils and vegetation were not reliable indicators of food web accumulation between prey and predators, shedding light on the contrasting mobility among different biological systems. Chen et al. (2005) showed that trophic relationships varied among different metals, as Hg, Zn, and Cd bio-magnify, while others such as As and Pb bio-diminish. This study showed the first evidence of Zn bio-magnification. They did conclude that further laboratory and field studies were necessary to understand precise mechanisms of metal trophic transfer (Chen et al., 2005). Fisher and Reinfelder (1995) discovered that concentrations of Cd increased from phytoplankton to zooplankton, but decreased to fish, indicating lower trophic level bio-magnification. Larison et al. (2000) explains how herbivores such as beaver or muskrat, whose preferred food is any type of willow (*Salix spp.),* whether that be ground hugging, alpine or from montane marshes, are in danger of ingesting too much cadmium. Willow act as biological pumps where cadmium is biomagnified, concentrating the metal by two orders of magnitude above background levels. Chen et al. (2005) discovered that in freshwater environments, both diet and exposure to aquatic concentrations are significant sources of metals for zooplankton, but for fish, the sources vary among metals. These studies shed light on the complexities associated bio-magnification of metals and that further research is required for more thorough understanding of this field. According to Scheuhammer et al. (2007), mink and otter, both being top predatory species in an aquatic food chain, are at greater risk for elevated dietary MeHg exposure, accumulation, and toxicity. Greater exposure to metals is a problem for piscovorous wildlife in inland freshwater habitats compared to close marine or estuarine habitats (Scheuhammer et al., 2007).

1.6 Body Condition

Body condition can be defined as the energy capital accumulated in an animal's body from feeding, which is an indicator of health and quality of life (Peig & Green, 2009). For the calculation of a CI (condition index) to be successful, it should take into consideration the fundamentals of growth, which are time and mass (Peig & Green, 2009). Calculating CI can help in understanding metal effects on an individual's health. Heavy metals are known to cause many issues, which lead to a degradation in overall wellbeing and a loss of weight and body fat (Jakimsha et al., 2011; Tête et al., 2013; Giżejewska et al., 2015). There are many methods for calculating CI, including the Soxhlet procedure for understanding body fat. This procedure involves grinding or mincing the carcass and drying the samples to determine a lipid index (Harder & Kirkpatrick, 1996). Bailey (1968) used the following formula to calculate body condition in cottontail rabbits (*Sylvilagus floridanus*) in Illinois:

$$CI = (W-16)\ L^3$$

CI= Condition Index
W= Weight in grams
L= Length in decimeters

A body condition formula developed for aquatic mammals such as the otter (*Lutra lutra*), was developed by Kruuk & Conroy (1987), which gives a low value for poor condition and a high value for good condition:

Body Condition = W($_a$L^n)

W= Mean body weight (kg)
a=5.02
L= contour length (m)
n=2.33

In cervids, antler beam diameter can be used to evaluate body condition (Severinghaus, et al., 1950; Riney, 1955). First described by Cheatum (1949, 1977), bone marrow is also a widely used index for nutritional status in animals. Considered to be the last fat source depleted in a poorly nourished animal, low bone marrow fat indicates poor nutrition over an extended period of time (Harder & Kirkpatrick, 1996). However, according to Tête et al. (2013), caution should be observed when using indices to make conclusions on exposure to toxic contaminants as they are highly influenced by several biological and environmental parameters.

1.7 Animal Tissues for Biomonitoring

There is a variety of methods available for metal evaluation in wildlife. Tissue harvest as done by Parker & Hamr (2001) is an excellent way to study metal accumulation in wildlife, as it gives a thorough understanding of accumulation in the body. Tissues such as muscle, heart, diaphragm, liver, kidney, and adipose are common tissues used for metal analysis (Bennett et al., 2001; Alleva et al., 2006; Rosa et al., 2008; Giżejewska et al., 2015) . Additionally, Hunter and Johnson (1982) have demonstrated that brain tissue can be used as well. However, tissue sample methods are invasive and requires an ethical source of carcasses. When this is not an option, studies such as Lepage & Parker (1988), Hunter and Johnson (1982) and Curi et al. (2012) using hair samples provided adequate data as well. There is some criticism of this method as Lepage and Parker (1988) found there to be too many temporal variations associated with different seasonal pelage. For avian species, eggs, feathers, and urine have been used with success for metal analysis (Rose & Parker, 1982; Clapp, et al., 2012).

Different metals target different organs, which can impact overall body condition. Many studies have shown that heavy metals tend to accumulate more in soft tissues such as liver and kidneys (Petkovšek et al., 2014; Amuno et al., 2016). In wild aquatic mammals, higher levels are assumed to be found in the kidney, the primary accumulator organ (Parker, 2004) and in the liver, an organ crucial for ecotoxicological studies (Petkovšek et al., 2014).

There are limitations to consider when sourcing animals from the wild. Due to yearly trapping and hunting pressure, animals from popular trapping and hunting grounds are usually young animals (the most common age class) causing a weighted age effect in sample sizes (Evans et al., 2000). Additionally, when searching for contaminants that may impair motor coordination such as Hg, only animals active and healthy enough to look for bait set by trapper would have been captured skewing data results (Evans et al., 2000; Mierle et al., 2000).

When analyzing the impact of metals on aquatic environments, most studies focus on fish as their indicator species due to their sensitive nature (Tayefi-Nasrabadi & Rahmani, 2012). However, aquatic mammals from fresh water systems seem to be less researched, perhaps due to the ease of catching fish and difficulty of trapping and sampling mammals.

1.8 Soil and Geology

Metals occur in small amounts naturally and are dependent to the geology of the area. They can enter aquatic systems through ore-bearing rocks, wind-blown sediments, volcanoes, forest fires, and metal accumulating vegetation (CCME, 1999a; Fernandez-Leborans & Olalla Herrero, 2000). Not all studies consider the geology of the area when evaluating metal presence in wildlife. This can lead to misunderstandings in what natural levels in tissues should be in a specific region. Metals are always present at natural non-anthropogenic levels. Their introduction into ecosystem can be from processes as simple as the weathering of parent rocks and pedogenesis, inputting metals into soils and up trophic levels (Figure 1)(Facchinelli et al., 2001). Wren et al. (1988) for example, found different tissue metal concentrations in wild animals such as mink and river otter that can be attribute to natural geological and regional differences. Holmgren et al. (1993) studied the natural differences of metals across the United States of America and using GIS, found observable patterns of natural metal levels associated with different landscape types from valleys to coastal ranges. For the province of Ontario, natural chemical and metal levels for soils and vegetation are publicly accessible for reference through the Ministry of Environment and Energy (MOEE, 1993). To make a thorough assessment of metal impact on wildlife, a distinction needs to be made between the effects of metals related to anthropogenic influences and those related to soil and geological systems in the area being assessed (Vries et al., 2007a).

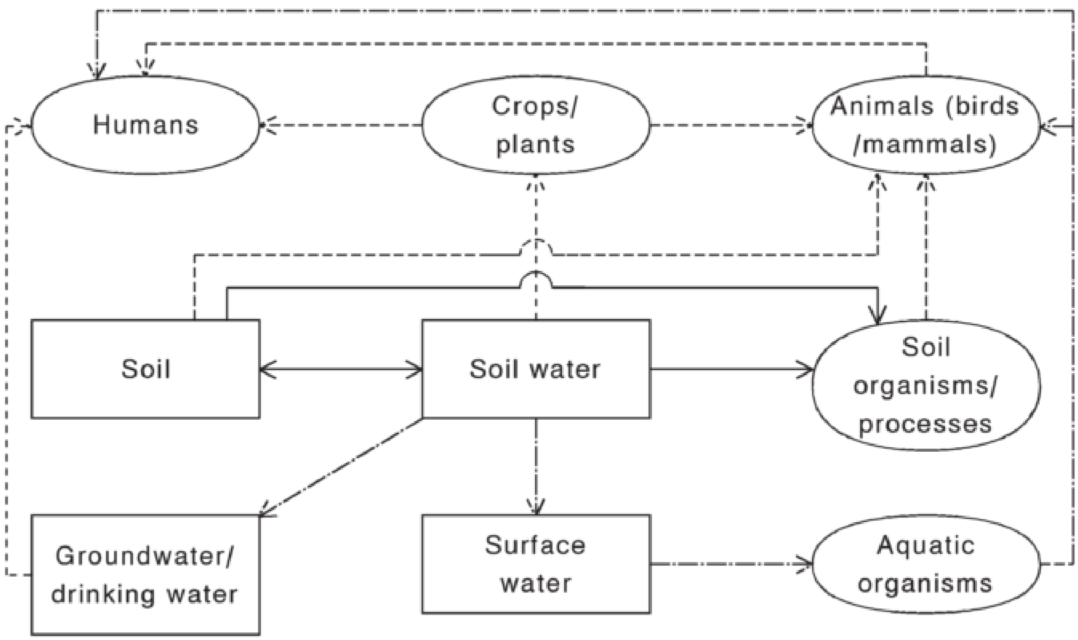

Figure 1. The relationships and fluxes of metal from the soil to other areas of an ecosystem from Vries et al. (2007a). Solid arrows show impact on the soil ecosystems whereas the dotted arrows refer to impacts on health or food quality of biota.

1.9 General Conclusions

Metals originating from the environment are re-introduced often in bioavailable forms from anthropogenic activities. Their movement throughout our natural systems is not always visible, making them difficult to study and understand. Although the effects of individual metals has been studied extensively, the amalgamated effects of multiple metals on individuals are not well understood. There are very few studies on the effects of many metals in a wetland on a range of furbearers from multiple trophic levels. Understanding this level of ecotoxicology can be useful in understanding the in-situ effects that urban development and industries such as mining and forestry have on the local environment.

This study will test the bioavailability of the metals and whether individuals within the treatment areas have higher levels of metals than those in the reference areas. A spatial association is predicted between local tailings from both active and decommissioned mines and elevated levels of metals in furbearer tissues. Study results may also indicate a relationship between metals and individual body condition. If metal exposure affects body condition, then individuals with higher metal levels in their tissues may have lower body condition scores which in many species may be associated with lower reproductive success (Hall, 1989; Mallory & Hall, 1993).

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2 Metal Accumulation and Body Condition in Beaver (*Castor canadensis*) and Muskrat (*Ondatra zibethicus*) from the Porcupine River Watershed

2.1 Introduction

Understanding how a point source contaminant influences biota in the environment is key to managing industrial practices. With growing concern on the effects of anthropogenic activity and environmental health in areas of substantial point-source emissions, assessment of environmental health and sustainability and the identification of potential harmful effects resulting from urbanization and industrial practices is essential (Hillis & Parker, 1993). This study evaluated the industrial and urban influences on aquatic furbearers in the Porcupine River Watershed. Local residents use the area recreationally and fish and small mammals are occasionally food sources for some trappers and local First Nation members.

Aquatic mammalian herbivores make good indicator species for metal presence in ecosystems. Their ecological niche and place within the food chain make them ideal for the evaluation of metal contaminants, as they have small ranges, are good representatives of target areas, for both aquatic and terrestrial habitats (Borchert et al., 2019). Additionally, they spend a large portion of their time in the water and eating woody and herbaceous plant material, mediums of which often contain contamination. For this study, measuring metal accumulation in tissues of furbearing species is particularly good, as sample sizes are adequate when partnering with local fur trappers facilitates the retrieval of many carcasses.

2.2 Species

2.2.1 Beaver

The beaver (*Castor canadensis*) is specialized anatomically, morphologically, and ethologically for swimming. Found throughout North America, their habitat preference is relatively flat terrain in fertile valleys that produce their preferred winter food (Skewes et al., 2006). Adult beavers weigh in at approximately 16-31.5kg and measure to around 120cm in length. Their reproductive organs are internal and they have paired castor glands beneath the skin anterior to cloacal opening (Chapman, 1983). The castor glands are used during scent marking to establish territory and for intraspecific communication (Svendsen, 1978).

Sexual maturity in beavers is reached at approximately three years of age. Monogamous breeding occurs between January and March in water, bank dens or lodges. Litter size ranges from one to nine, but are usually three to four. Beaver midwinter colonies usually consist of an adult pair, two to four kits from the last litter, and sometimes an older kit that is two years old. Habitat quality is known to influence reproductive performance and colony composition. Colony movement and dispersion happens in four different ways, (1) entire colony, (2) wandering of yearlings, (3) dispersal of two year old beavers to establish new colonies, and (4) miscellaneous movements of adults, who may have lost their mates (Chapman, 1983).

Beavers are more active at night and wolves (*Canis lupus*), coyotes (*Canis latrans)*, and trappers are their main predators. These large rodents are central place foragers; they come onto land to cut branches, haul some back into the water for either dam construction or food (Mcginley & Whitham, 1985). Due to their herbivorous diet, beaver can easily consume contaminated mud and silt particulates (Dewit et al., 2002) Because of their diet and sedentary behaviour, beavers are suitable bio-indicators of local environmental pollution (Giżejewska et al., 2015).

2.2.2 Muskrat

Muskrats (*Ondatra zibethicus*) are widely distributed throughout North America. They are semi-aquatic rodents that prefer habitats with stable precipitation. They can be found in a variety of aquatic areas such as lakes, rivers, ponds, sloughs, and marshes, where they reside in burrows and lodges (Viljugrein et al., 2001).

Habitat shifts generally occur in the autumn and spring during which they are most susceptible to predation by red foxes (*Vulpes fulva*), coyotes, wolves, black bear (*Ursus americanus*), river otters (*Lontra canadensis*), lynx (*Lynx canadensis*), mink (*Mustela vison)*, and large avian raptors. Muskrats are a well-known furbearing species who are often trapped in the fall and spring (Viljugrein et al., 2001).

Muskrats are mainly herbivores, eating stems, tubers, and roots of aquatic macrophytes, but occasionally also eat insects, clams, fish, and freshwater mussels (Viljugrein et al., 2001). Due to their diet, muskrats can easily consume contaminated mud and silt (Dewit et al., 2002). Muskrats often have more than one litter a year with five to nine kits (Viljugrein et al., 2001) and due to their size, abundance, and ease to capture, muskrats make good indicator animals for aquatic areas.

2.3 Materials and Methods

2.3.1 Study Area

Located east of Timmins, Ontario, the Porcupine River Watershed (Figure 2) spans across nine townships. The watershed is situated at the transition of the Precambrian Shield to the south and southwest and the flat glaciolactrine clay and silt plains to the northeast (AMEC, 2008). The terrain is comprised of rolling hills with draining areas composed mostly of wetlands on clay plains and slow-flowing meandering rivers approximately 280 metres above sea level (AMEC, 2008). The watershed is heavily impacted, having absorbed the effects of mining, forestry, and urbanization over the last century and therefore it was felt that a study evaluating metal accumulation in the area was important to determine whether the watershed was contaminated and required remediation consideration (Mcfarlane et al., 2014).

Local residents predicted that all areas in the watershed south of Bell Creek were contaminated due to the high level of industrialization and type of development. This overall area was classified as 'not clean' but for the purpose of this study, will be referred to as the industrial area. Several anthropogenic disturbances exist within this watershed such as 2 water treatment plants, 5 active mines, 13 historic mines, a two-lane highway, the City of Timmins to the West, and the Township of Porcupine to the East. Areas surrounding Bigwater Lake and the portion of the North Porcupine River upstream from Bell Creek were selected as reference areas due to a lack of industrial activity and little development (Jodie Russel, *pers comm.).*

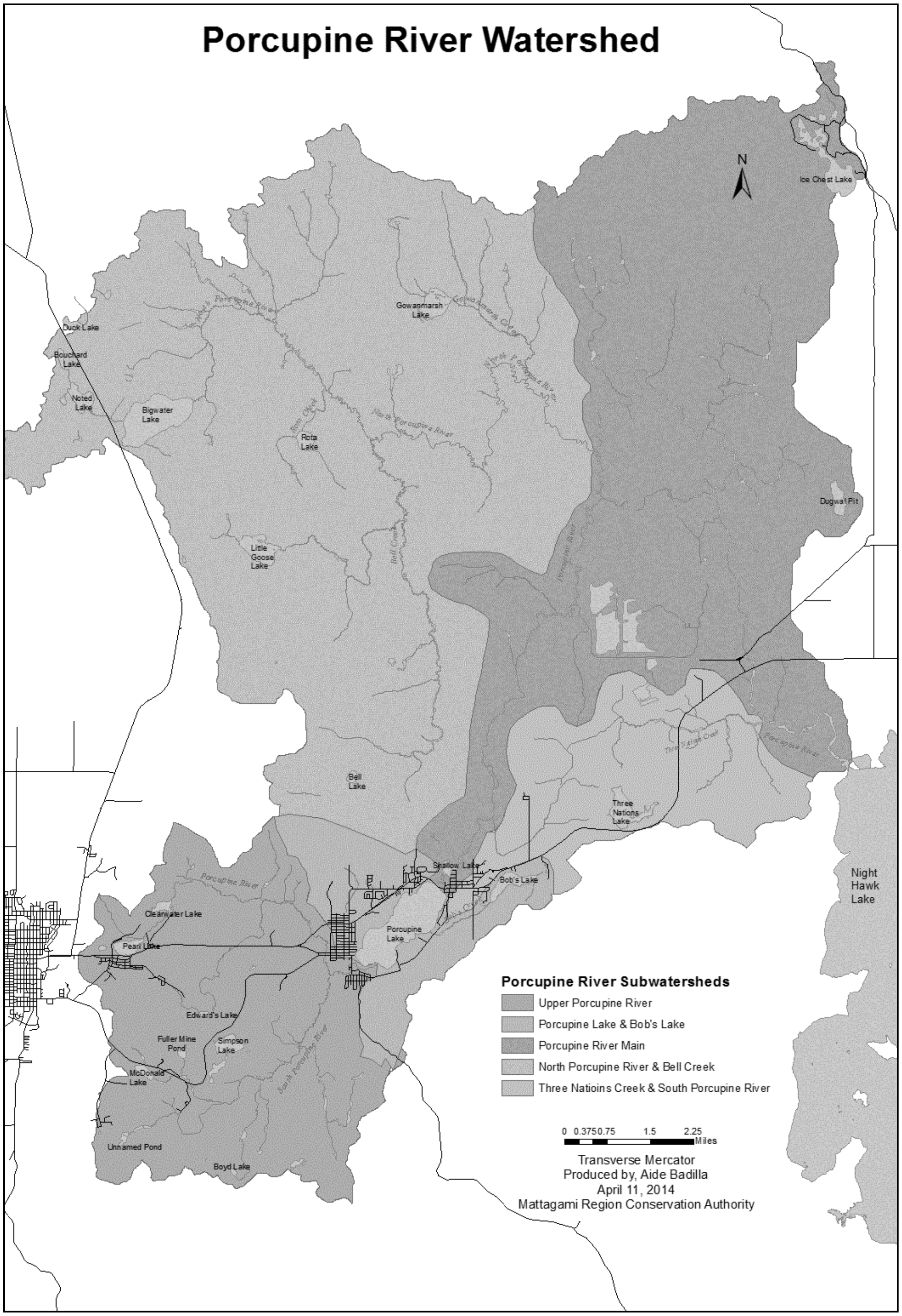

Figure 2: The Porcupine River Watershed and Subwatersheds.

2.3.2 Sample Collection

During the 2016 and 2017 trapping season, animals were obtained from the Timmins Fur Trappers Association, First Nation trappers, and trappers from the Sudbury area from both the potentially contaminated and uncontaminated sections of the Porcupine River Watershed. Some reference samples were sourced outside of the watershed to understand background levels. These were from selected reference sites chosen due to similar environmental conditions to the watershed and lack of contaminants (Figure 2.0). Twenty beaver were collected from the industrialized areas and 27 were collected from the reference sites. Regarding Muskrats, 17 were collected from the industrialized sites and 10 were collected from the reference sites. Once obtained, carcasses were skinned, bagged in sealed plastic bags and labelled (trapper name, location, trap line number, date collected) before being placed in a freezer kept at -15°C. For tissue harvest, the carcass was placed in a standard fume hood to thaw. Standard body measurements were recorded including age (juvenile or adult), contour length (cm) (nose to tail), and weight (kg) (Appendix 1). Visible endoparasites such as the giant kidney worm were searched for by looking in commonly hosted tissues such as the kidney. Using stainless steel utensils, seven tissues were collected per individual: liver, kidney, lung, spleen, adipose, skeletal muscle, and reproductive organs. Tissues were placed in digestion tubes with an average of 4.5 grams per sample collected and then frozen at -15°C.

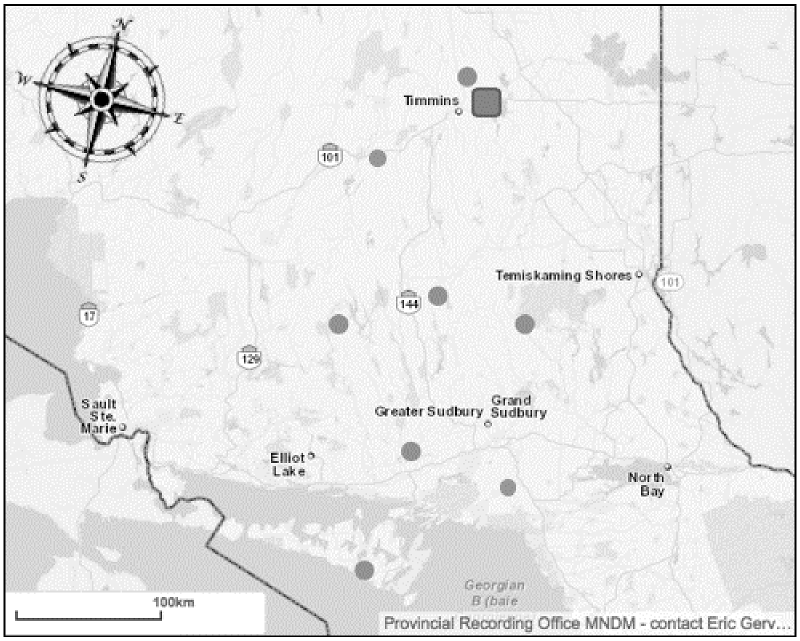

Figure 3. Reference site locations including the northern section of the watershed, and the Porter, Hennessy, Cortez, and Selkirk townships indicated with the circles. Watershed of concern in the square.

2.3.3 Tissue Sample Analyses

Samples were freeze-dried for seven days, in a Labconco 12-L FreeZone (Labconco, Kansas City, United States of America) at an internal pressure of < 0.100 mBar, and condenser temperature of < -47°C.

Freeze-dried samples were divided into 0.5 ±0.2 grams sub-samples per tube and the extra mass from tissue samples were put into a separate tube as a replicate. Blanks and certified reference materials (CRM: TORT-2,DOLT-3, and DORM-2, from the National Research Council, Canada) were prepared and analyzed with the samples. Replicates, blanks, and CRMs were done for every 20 samples. To digest, 9mL of concentrated metal grade nitric acid was added to 3mL of trace metal grade HCI (75%:25% by volume ration). Samples were left overnight to cool and then reflux caps were placed on vials and the solutions were heated to 110°C for 240 minutes. The digestion tubes were topped up to 50mL with ultrapure water. The solution was then diluted 1:10, mixed, and run on the ICP-MS (Varian 810 running ICP-MS Expert Software). All detectable metals were analyzed and results measured in mg/kg.

It should be noted that the detection limit for Hg was quite high, at 2mg/kg. This is a relatively high detection limit and is a technological restraints to consider when evaluating the Hg results for this study.

2.3.4 Body Condition

Body condition, a measure of the nutritional status of the animal and including the relative size of fat energy reserves and overall body development (Peig & Green, 2009), was assessed using a formula developed for aquatic mammals such as the otter (*Lutra lutra*). The formula, developed by Kruuk et al. (1987) gives a low value for poor condition and a high value for good condition:

Body Condition = $W({}_{a}L^{\wedge}n)$

W= Mean body weight (kg)
a=5.02
L= contour length (m)
n=2.33

2.3.5 Statistical Analyses

To determine if the reference and industrial sites were significantly different from each other, ProUCL (version 5.1.002(5.1)), a statistical software designed for environmental applications of data sets with and without non-detect observations, was used. The Gehan test, a non-parametric test specifically designed for data sets that may have data below detection limits, was applied to the data between the different sites for each animal, tissue and metal analyzed.

For understanding whether metal accumulation was impacting variability of body condition, correlation matrices and linear regression with R values, slopes, and intercepts were used to understand relationships between metal accumulation and body condition with ioGAS (version 7.0). This was completed for all herbivores, tissues and metals that demonstrated a significant value in the Gehan test.

2.4 Results

2.4.1 Site Differences

The Gehan test was applied to data from beaver and muskrat kidneys, livers, lungs, spleens, adipose, muscle and reproductive organs between the reference sites and the industrial sites. The test evaluated differences in metal concentrations for As (Arsenic), Cd (Cadmium), Cr (Chromium), Co (Cobalt), Cu (Copper), Fe (Iron), Hg (Mercury), Mn (Manganese), Ni (Nickel), Pb (Lead), Sb (Antimony), Se (Selenium), Zn (Zinc). The metals that showed significantly higher differences in industrial sites versus reference sites for beavers were As, Cd, Cu, and Fe. For muskrats, the metals that showed significantly ($p<0.05$) higher differences between industrial sites versus reference sites were As, Co, Cu, and Mn. In contrast, Cr, Hg, Ni, Pb, Sb, Se, and Zn had no statistical differences between sites for all beaver and muskrat tissues between (Table 1). Sb and Hg had many results without a conclusion, due to too many values being below the detection limit during the analysis (Appendix 2).

Table 1. Reference and Industrial Site averages for beaver and muskrat tissues that demonstrated significantly higher industrial metal levels than reference metal levels. Metal levels in mg/kg.

Beaver					Muskrat				
Tissue	Reference Site	Industrial Site	n	Gehan P Value	Tissue	Reference Sites	Industrial Site	n	Gehan P Value
As					**As**				
Liver	0.2	0.241	47	0.033	Liver	0.002	6.892	28	8.10E-06
Lung	0.209	0.247	46	0.046	Kidney	0.201	13.59	27	1.40E-05
Spleen	0.2	0.21	47	0.0082	Lung	0.2	1.177	28	0.005
Muscle	0.2	0.23	46	6.21E-04	Spleen	0.2	0.955	24	0.048
Reproductive Organ	0.202	0.247	44	0.034	Muscle	0.2	2.1	28	6.21E-04
Cd					**Co**				
Muscle	0.05	0.0675	46	0.022	Kidney	0.276	0.472	27	0.009
Cu					Lung	0.033	0.102	28	1.45E-02
Kidney	11.27	15.03	47	2.99E-04	**Cu**				
Liver	7.398	11.86	47	3.11E-06	Adipose	0.806	4.342	26	0.029

Lung	5.238	7.887	46	2.51E-05	**Mn**				
Spleen	3.158	5.975	47	2.13E-07	Kidney	13.73	29.09	27	0.017
Adipose	0.09	1.03	44	2.00E-08	Liver	13.7	11.8	28	0.003
Muscle	1.13	4.527	46	1.51E-08	Muscle	2.152	6.037	28	0.011
Reproductive Organ	3.849	5.641	44	0.005	Reproductive Organ	10.64	46.89	24	0.020
Fe									
Adipose	6.085	13.01	44	7.77E-04					
Muscle	72.96	144.2	46	0.004					

2.4.2 Body Condition

Body condition in beaver between both site types did not signify a significant difference with the two sample t-test. In muskrats, a significant (P<0.05) difference was evident with the two-sample T test (Table 2). In assessing relationship between body condition and metal accumulation, beaver showed no significant (P<0.05) relationship between body condition and metal accumulation in tissues. Only muskrat lung with As and Co showed a significant positive correlation with body condition (Table 3).

Table 2. Average body condition of beavers and muskrats: a comparison between industrial and reference sites.

Beaver Body Condition: Comparison of Sites				
	Reference Site	Industrial Site	P value	T Test Value
n	27	20		
Minimum	0.63	1.7		
Maximum	4.22	3.25	0.73	-0.62
Mean	2.43	2.53		
SE	0.12	0.89		
SD	0.61	0.39		

Muskrat Body Condition: Comparison of Sites				
	Reference Site	Industrial Site	P value	T Test Value
n	17	12	0	4.19

Minimum	0.27	0.27
Maximum	0.85	0.73
Mean	0.51	0.38
SE	0.02	0.01
SD	0.17	0.09

*Table 3. Correlation coefficients (r), intercepts, slope coefficients for all tissues and metals of interest in herbivores from both reference and industrial sites across central and northern Ontario. Body condition and metal levels presented positive relationships of significance for muskrat lung As and Co (P<0.05). *P<0.05*

Beaver	**Metal**	**Correlation**	**Intercept**	**Slope**	**P-Value**
Lung	As	0.11	2.3782	0.5124	0.4593
	Cu	0.12	2.3335	0.02535	0.4414
Kidney	Cu	-0.033	2.5462	-0.00425	0.8321
Liver	As	-0.044	2.5766	-0.38	0.7738
	Cu	-0.17	-0.02493	2.7239	0.2657
Spleen	As	0.13	1.7129	3.7589	0.3928
	Cu	0.12	2.3464	0.03133	0.4271
Muscle	As	-0.02	2.5326	-0.204	0.9006
	Cd	0.14	2.3677	2.0848	0.3692
	Cu	-0.029	2.5101	-0.00799	0.8556
	Fe	0.051	2.4569	3.13E-04	0.7473
Reproductive Organ	As	0.18	2.2336	1.1051	0.238
	Cu	0.058	2.4473	0.006858	0.7131

Muskrat	**Metal**	**Correlation**	**Intercept**	**Slope**	**P-Value**
Liver	As	-0.21	0.4691	-0.00695	0.2808
	Mn	-0.043	0.462	-4.72E-04	0.8273
Kidney	As	-0.24	0.4672	-0.00174	0.2228
	Co	0.32	0.3671	0.2191	0.1049
	Mn	0.03	0.4471	2.59E-04	0.8824
Lung	As	0.56	0.407	0.1023	*0.0022**
	Co	0.41	0.4083	1.0682	*0.0287**
Spleen	As	0.021	0.4625	0.002623	0.9212
Adipose	Cu	-0.052	0.4611	-0.00483	0.8013
Muscle	As	-0.17	0.4668	-0.01065	0.3876

	Mn	0.17	0.425	0.006081	0.387
Reproductive Organ	Mn	-0.14	0.4736	-4.77E-04	0.5227

2.5 Discussion

When evaluating the level and origin of both natural and anthropogenic environmental contaminants, wild animals which are exposed to contaminants of both origins, make for suitable bio-indicators (Giżejewska et al., 2015). This study used aquatic furbearers as bio-indicators to investigate the hypothesis that mammals from the Porcupine River Watershed have higher levels of metals than those from areas of little to no industrial or urbanized development. Aquatic furbearers investigated in this chapter were beaver and muskrat as they were easily accessible due to high numbers harvested by fur-trappers. Additionally, their sedentary behaviour, ecological niche, and place within the food chain make them ideal species to evaluate (Giżejewska et al., 2015).

2.5.1 Abiotic evaluation

In the industrial area of the Porcupine River Watershed, metal levels in the water were considered before any animal tissues were harvested and analyzed. Water is consistently tested by the local mines throughout the industrialized areas of the watershed, most specifically within the southern industrialized portion. These tests analysis water and water sediments for metals and contaminants such as cyanide, Hg, Cd, B, and As. Water test results conducted by local mines can be viewed upon request. Additionally, a Non-Profit Organization (Water Rangers) runs water quality tests which are open for public access that can be found at: https://app.waterrangers.ca/observations/37082. Water Rangers reports water quality parameters such as pH, dissolved oxygen, chlorine, hardness, alkalinity, water depth, conductivity, and temperature.

2.5.2 Beaver: Metal Accumulation

Metals that showed significantly higher levels in industrial sites versus reference sites for beavers were As, Cd, Cu and Fe. As levels in liver were higher in the industrial sites by 19%, in lung tissues by 17%, in spleen tissues by 5%, in muscle tissues by 14% and in reproductive organ tissue by 20%. Cd was higher in muscle tissue in the industrial sites by 30%. Cu was higher in the industrial sites for kidney by 29%, for liver by 46%, for lung by 40%, for spleen by 62%, for adipose by 167%, for muscle by 120%, and for reproductive organ by 38%. Fe levels in industrial sites were higher in adipose tissue by 73% and in muscle by 66%.

2.5.3 Muskrat: Metal Accumulation

Metals that showed significantly higher levels in the industrial sites than the reference sites for muskrat were As, Co, Cu, and Mn. As in liver was higher in the industrial sites by 180%. As in kidney tissues was higher in industrial sites by 194%, As in lung tissues was higher in in the industrial sites by 142%. As in spleen tissue was higher in the industrial sites by 131%. As in muscle tissue was higher in in the industrial sites by 165%. Cu was higher in adipose tissue in the industrial sites by 64%, while Co in kidney was higher in in the industrial sites by 52% and for lung by 103%. For Mn, kidney was higher in industrial sites by 72%, liver by 73%, muscle by 95%, and in reproductive organs by 126%.

2.5.4 Metal Breakdown

2.5.4.1 As

Studies investigating chronic levels of As in wildlife are scarce as toxic poisoning is uncommon in free-living mammals due rapid metabolic detoxification and rapid excretion (Drouhot et al., 2014). However, some studies have found evidence of As contamination in small mammals subjected to long-term exposure from living near former mine sites (Saunders et al., 2009; Drouhot et al., 2014). In Canada, one of the main anthropogenic sources of As release are tailings ponds (Saunders et al., 2010). This may be why As levels were significantly higher in many of the tissues from the industrial sites of the Porcupine River Watershed. Muskrat As levels in liver, kidney and muscle were especially concerning in industrial areas as their increase was more than 150% from background levels. Saunders et al. (2010) also found substantially higher concentrations of As in the liver of meadow voles (*Microtus pennsylvanicus*) living on contaminated mine sites. Median levels in vole livers from potentially contaminated sources ranged from 0.51 mg/kg to 0.38mg/kg and it was concluded that although it was obvious that bio-magnification was occurring through the trophic levels, the As levels were not of major concern in the area. Because As levels in liver from the Porcupine River Watershed were of similar levels for muskrats, but much lower in beavers, it suggests that these levels should be of minor concern.

However, in muskrat kidney, lung, spleen and muscle, the average As levels from the industrial sites ranged from 0.9 to 13.59 mg/kg, indicating that As is accumulating in high levels in these herbivores. For beavers, industrial site tissue levels for lung, spleen, muscle, and reproductive organs ranged from 0.21 to 0.247 mg/kg. One of the most common pathways to As ingestion from wild mammals is through accidental consumption of contaminated soil (Fritsch et al., 2010). In contrast to beaver, which feed on above ground vegetation, mammals such as the muskrat, which feed heavily on cattail roots (*Typha latifolia*) can have a high exposure to As due to sediment consumption. This could explain the significantly lower body condition found in muskrat but this conclusion is not certain and would need to be explored more thoroughly (Espinosa-Reyes et al., 2010).

2.5.4.2 Cadmium (Cd) and Copper (Cu)

Cd levels in beaver from the Porcupine Watershed were high in muscle tissues, which may be related to diet. Larison et al. (2000) found that in many instances, Cd is biomagnified by one particular genus of plant, the willow (*Salix spp.)*, which is a favourite of beaver. Whether ground hugging or free standing or growing in the alpine or in montane marshes, willow species act as biological pumps, concentrating Cd by two orders of magnitude above background concentrations (Larison et al., 2000). Cd concentrations in beaver in particular have demonstrated a large variability in accumulation levels from different areas of Canada. Possible explanations include geology, soil types and water chemistry, bioavailability, predominant vegetation and climate (Shotyk et al., 2019). For example, in the Slave River Delta and the Mackenzie River Delta in the Northwest Territories, Canada, Gamberg et al. (2005) found the average Cd concentrations in mink to be 39 and 53 times greater than values reported in beaver of central Ontario (Wren 1984). However, that observation could be due to bio-magnification processes. Parker (2004) reported muskrat Cd levels closest to ore smelters at 0.44 mg/kg for liver and 1.81mg/kg in kidneys. Cd values published by Wren (1984) are lower than the values reported by Shotyk et al. (2019), but both sets of data are much lower than those reported by Hillis & Parker (1993) in a Cu/Ni mining and smelting area. Shotyk et al. (2019) reported Cd concentrations in beaver liver to be 0.9mg/kg and 3.2mg/kg in kidney. Hillis and Parker (1993) found that among beaver, Cd levels averaged at 2.3mg/kg for liver and 18.8mg/kg for kidney tissues. Cd tissue levels from their study reached mean values 2-3 times higher than values reported in other literature. In this study, Cd was not found to be significantly higher in beaver and muskrat liver and kidneys, but it was in beaver muscle tissues, which measured at 0.06mg/kg in the industrial area. These levels were much lower than the levels reported by Hillis and Parker (1993) and Shotyk et al. (2019). Nordberg et al. (2011) explain that Zn and Cd, both of which have similar chemical properties, are often found as mineral combinations in the environment. In wildlife, this can lead to the protein, metallothionein, binding Cd, Cu, and Zn, causing Cd to be stored in the kidney. This was not a topic of concern in the beavers in this study as only Cd levels in muscle and Cu levels in reproductive organs were significantly higher in industrial sites. In Ontario, muskrats sampled from similar industrial areas, Parker (2004) also found elevated Cd levels. However, not coinciding with this study, Parker (2004) also found elevated Ni levels in muskrat.

For muskrat, Cu was significantly higher in industrial area adipose tissue by 64%. In addition, Cu and Cd were not an industrial area issue in this study suggesting that behavioural differences between both herbivores includeng dietary preferences and/or metabolism may have accounted for differences in accumulation. Parker (2004) reported muskrat Cu levels closest to ore smelters that measured in at 13.77mg/kg for liver and 13.11 mg/kg in kidneys. A study by Hillis and Parker (1993) in Sudbury, Ontario found levels of Zn in beavers to be quite high; however, the same conclusion was not made in this study. Naturally, beaver and muskrat diets are high in Cu and Zn, but industrial site samples were not extremely different in both the Hillis and Parker (1993) study and this study. Cu levels averaged at 8.0 mg/kg for liver and 9.3 mg/kg for kidney (Hillis & Parker (1993), but they did not find a distance-related trend in Cu tissue levels, which was unexpected in their study due to the high Cu concentrations in Sudbury ores. They concluded that this may be due to the fact that Cu is an physiological requirement for mammals and that it is highly like that beavers have an effective method for regulating the metal's uptake and/or metabolization (Hillis & Parker, 1993).

2.5.4.3 Lead (Pb)

Pb levels were not significantly higher in the industrial sites, which was unexpected because many of the traplines from the industrial sites were located next to highways and mining haul roads. Elevated Pb levels in tissues have been found to be related to automotive-related emissions associated to proximity to highways as seen in Hillis and Parker's (1993) study.

2.5.4.4 Cobalt (Co) and Manganese (Mn)

Co and Mn accumulation in furbearing species in the wild is not extensively studied; however, muskrats in the industrial areas accumulated higher levels of both Co and Mn. According to Gál et al. (2008), the two metals are often associated with each other in ore bodies and Co is structurally incorporated into Mn minerals so absorption of both metals together is likely (Gál et al., 2008). Muskrat diet consists of aquatic roots and tubers, which sit in sediments. Sediments being long-term sinks for metals would result in accumulation of Mn and Co, which would be consumed considering their eating habits (Loumbourdis & Wray, 1998; Viljugrein et al., 2001). Loumbourdis & Wray (1998) found high levels of Co in *Rana ribidunda*, a frog from Macedonia in Northern Greece. These high levels were associated with fertilizers used for agriculture, urban runoff and various industries that discharge effluents into the river. Although Co was not a significant metal in beaver tissue, muskrat lung and kidney from the industrial areas had higher levels than muskrats from reference areas by 52% and 103%, respectively. This could be due to urban runoff and industrial effluents, but not from agriculture as this is not a common practice in the area surrounding the Porcupine River Watershed.

2.5.4.5 Iron (Fe)

Fe levels were found at significantly elevated levels in beaver muscle and adipose tissues. Reasoning behind this is unclear, as studies investigating Fe did not seem to find patterns or sources for Fe accumulation. For example, a study by Ninomiya et al. (2004) on evaluating metals in aquatic mammals found that in liver and kidney tissues, Fe concentrations varied more by individual than by species and were unable to determine the factor responsible for such a variance. Rose and Parker (1982) also found that in ruffed grouse (*Bonasa urnbellus*), Fe levels in plumage did not vary between highly contaminated smelter sites and a clean reference sites. It has been suggested that for beavers, Fe levels may be naturally higher than in other rodents (Haas et al., 2009). Haas et al. (2009) reported Californian mountain beaver (*Aplodontia rufa)* kidney concentrations to range from 91 to 366 mg/kg, which were higher than the muscle and adipose levels from the industrial site of the Porcupine River Watershed (13.01 and 144.2mg/kg, respectively). For these reasons and because Fe is an essential metal, concern for higher Fe levels in beaver muscle and adipose is minimal.

2.5.4.6 Variables: Sex and Age

No differences were found between males and females in several studies and was not investigated in this study. Metal accumulation differences in sexes was not different for beavers in Giżejewska et al's (2015) study on Cd, Pb, Cu, and Zn nor for Parker and Hillis' (1993) study on Cu, Cd, Zn, and Ni. Hopkins et al. (2007) studied Hg in osprey tissues and found no statistical significance between sexes. Giżejewska et al. (2015) in Poland did find that Cu concentrations were higher in juvenile beavers than adults. However in a study conducted in Sudbury, Ontario, only 293.8km away, Parker (2004) found no differences in metal accumulation between juvenile and adult muskrat. Not enough juveniles of beaver nor muskrat were trapped in this study to gain an appropriate sample size to draw a proper conclusion.

2.5.5 Body Condition

Body condition was not impacted negatively in the industrial sites for beaver, but was significantly reduced in muskrats. Beaver had body condition indexes 5% higher in the industrial areas versus the reference areas, while muskrat had body condition that was significantly lower in the industrial site using the two sample Student t-test (F ; P values). Bulrush (*Scirpus spp.)* and cattails (*Typha latifolia*), favourite foods of muskrat and willow (*Salix spp.), a.* favourite food of beaver, grow well in metal rich areas and in areas of disturbance (Larison et al., 2000). It is possible that this study's industrial area provided optimum habitat for beaver's ideal foods. Hillis and Parker (1993) found an inverse correlation between Cu and body weight and a positive correlation in Cd burdens and body weight, mirroring the findings of this study. In the Porcupine

River Watershed, in both herbivore tissues and metals of interest, only Co and As levels in muskrat lung showed a significantly positive relationship ($P<0.05$) with body condition (Table 3). This observation was unexpected, indicating that individuals with higher body conditions may also have higher levels of As and Co in their lungs. This may be due to the concept that healthier individuals are more active and consuming more, increasing their metal accumulation. These findings may be due to the muskrat's foraging activities as it digs through sediments in search of roots and tubers, inhaling and ingesting sediments with metals, causing a loading of As and Co in the lungs. Nunes et al. (2001) found the opposite effect; that body length in the mouse, *Mus spretus* was longer in reference areas than those from metal contaminated sites. However, weight was influenced more by gender and reproductive activity than by exposure to pollution. Tête et al. (2013) lists several limitations on their study including low sample size. In large-scale smelter impacted areas in northern France on wood mice (*Apodemus sylvaticus*), Tête et al. (2013) found correlations between Cd in both liver and kidney tissues and body condition, but not for Pb. They also concluded that landscape/habitat type had no influence on body condition, but that condition variability may be related to local unknown ecological factors.

Fat content was not evaluated in this study for two reasons. First, herbivores were obtained from fur trappers throughout the year. Muskrats were caught throughout the trapping season from fall until late winter. Beavers were harvested during the winter trapping season, when pelts are at their prime. However, nuisance beaver causing damage to property and infrastructure were trapped at any time, even when their pelts have no value. This meant there was a large variety of harvest periods and fat levels vary throughout the year due to food availability and fat cycles. Secondly, as cautioned by Virgl and Messier (1993), unless the ratio between body mass and fat content has been analyzed in a study, evaluating fat alone as an indication of physical mass and subsequent health is not an accurate measure. If one is to look at fat content successfully, the use of isotopic water is a reliable and non-destructive method to evaluate fat and protein content in muskrats. That method in combination with fecal and urine analysis can help evaluate possible habitat effects on body condition in animals (Virgl & Messier, 1993). Bone marrow fat content was initially investigated for this study to evaluate the body condition of individuals, but later eliminated. Mech and Delgiudice (1985) strongly cautioned against this method as it is the last storage of fat used by the animal. If an individual's bone marrow was high in fat, it does not mean it is healthy. As an animal's nutritional status declines, subcutaneous fat is used first, then omental, renal, pericardial, and ultimately bone marrow fat. If an individual lost significant fat due to illness, but still had high levels of bone marrow fat, it would be inaccurate to say it is a healthy individual (Mech & Delguidice, 1985). If this study had the technology available, the combination of the two latter 27 of nutritional status would give a thorough picture of both the current and long-term history of an individual's health. Overall, the interpretation of body condition indices should be done with caution due to a wide variability of confounding variables such as individual and environmental factors (Tête et al., 2013).

2.6 Conclusions

1. No significant differences were observed in tissues of muskrats and beavers from the industrial exposed area and a reference area for the following elements: Cr, Hg, Ni, Pb, Sb, Se, and Zn.
2. For beavers, metals As, Cd, Cu, and Fe were significantly higher in industrial sites compared to reference sites and in different organs.
3. For muskrats, metals As, Co, Cu, and Mn were significantly higher in industrial sites compared to reference sites and in different organs.
4. Only muskrat lung showed a positive correlation to Co and As levels in lung and body condition which could be due to increased foraging behaviours in healthier individuals.
5. Body condition of beaver was not significantly different between industrial and reference sites.
6. Body condition of muskrat was significantly different between industrial and reference sites with specimens from industrial sites having lower body condition.
7. The data supports the conclusion that there is likely little risk to First Nation peoples nor trappers due to the occasional consumption of beaver meat. However, due to the technical limitations of the Hg analysis, safe consumption of beaver cannot be guaranteed.
8. No direct links were found between higher point-source bioavailability of metals and current and past industry, urban development nor natural variability in local geology; if remedial measures are implemented to reduce metal contaminant of the Porcupine River Watershed, all possible parties should be involved.

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3 Metal Accumulation and Body Condition in River Otter (*Lontra canadensis*) and Mink (*Mustela vison*) from the Porcupine River Watershed

3.1 Introduction

How a point source contaminant influences biota in its environment is key to managing industrial practices. It is imminent that no harmful effects result from urbanization and industrial practices so assessment of environmental health and sustainability is essential. This study evaluated the industrial and urban influences on aquatic furbearers in the Porcupine River Watershed. Local residents use the area recreationally and fish and small mammals are occasionally food sources for some trappers and local First Nation members. The animals of interest include two carnivore species to evaluate metal accumulation and body condition differences between the trophic levels (Ebrahimpour, Pourkhabbaz, Baramaki, Babaei, & Rezaei, 2011)(Ebrahimpour et al., 2011). Small carnivorous mammals, located on top or high on the food chain such as mink (*Mustela vison*) and river otter (*Lontra canadensis*) are vulnerable to local bio-magnification processes, making them good bio-indicators of habitat quality (Ramos-Rosas et al., 2013; Alomar et al., 2016; Perez-Lopez et al., 2016; Ebrahimpour et al., 2011). River otters and mink in particular, make for great indicators for metal presence as they are known to accumulate high levels of metals due to their piscivorous diets (Klenavic et al., 2008). Due to the frequent recreational use of watershed's resources, an investigation into the safety of such use was requested by local resides to determine watershed health. For this study, it was hypothesized that due to bio-magnification, carnivores from the Porcupine River Watershed would have higher levels of metals than those from areas of little to no industrial or urban development. Secondly, body condition was predicted to be much lower due to the metal accumulation in carnivore tissues.

3.2 Species

3.2.1 River Otter

The river otter (*Lontra canadensis*) is well adapted to freshwater habitats. Its distribution extends from Florida to Alaska, USA and from eastern Newfoundland, Canada to the Aleutian Islands. Due to their aquatic adaptations, primary barriers to their dispersal are arid areas, mountain ranges, glaciated area and salt water straits (Chapman, 1983).

Adult river otters measure between 915-1270 mm in length (tail accounting for 1/3 of their total length). They weigh 5 – 13.7 kg, but females are sometimes smaller. Otters have anal scent glands that release scent in times of anger or fear. They also use the glands to mark scent posts to establish territories (Chapman, 1983).

In female river otters, ovary and uterus do not reach adult size until approximately two years of age and males also become sexually mature around two years of age and successful breeding starts around five to seven years of age. Otter copulation occurs for three or more months in late winter and early spring and they have delayed implantation as litters of one to six individuals are born between the following January and February (Chapman, 1983).

Otters care for their young for a relatively long period of time, investing lots of energy into raising them, which affects their reproduction success. Because of low reproductive rates, small increases in adult mortality, decreases in pup recruitment can have drastic effects on the entire population (Diggs, 2013).

Males have a much larger home ranges than females and are therefore more often trapped as they explore larger territories. Trapping has a greater impact on otter populations than habitat destruction. River otters have very few natural predators and parasitism and disease are known to have very little population impact. Parasites found in otters are internal roundworms such as *Strongyloides lutrae* and *Gnathostoma miyazaki*. The life expectancy for North American river otters is eight to nine years (National Geographic, 2017).

The diet of the river otter is mostly fish but also consists of crustaceans, amphibians, insects, birds and mammals in smaller amounts. Otters forage by diving after fish and digging in substrate of water bodies (Chapman, 1983).

3.2.2 Mink

The mink (*Mustela vison*) is a small mammal of the mustelid family. Minks can be found in low swampy terrain near large waterbodies throughout North America (Viljugrein et al., 2001).

However, they can survive in a variety of habitats, when food availability is low. A male's home range can be over 2630m in stream length, while a female's home range is approximately 1850m in stream length (Chapman, 1983).

Adult males weigh 0.9-1.6kg and are 580 – 700 mm in length, while adult females weigh 0.7-1.1 kg and measure 460 – 575 mm in length. As all mustelids, minks have an anal scent gland that emit scent when excited or aggravated and to mark territories (Chapman, 1983).

Mink become sexually mature at 10 months of age and are fecund for approximately seven years. They breed from late February to early April and the gestation period lasts 51 days. Litters are born from late April to the end of May. Warm dry weather is correlated with greater kit survival. Mink only have one litter per year with an average of five kits per year (Viljugrein et al., 2001).

Mink are extremely sensitive to PCBs, some metals and are known to host many types of endoparasites and ectoparasites. Mink do not have any major predators other than humans who commonly trap them during November and December (Viljugrein et al., 2001). Mink diet consists of small mammals, fish, birds, amphibians, crustaceans, insects, and reptiles, but fish are a large portion of their diet (Chapman, 1983).

3.3 Materials and Methods

3.3.1 Study Area

Located east of Timmins, Ontario, the Porcupine River Watershed spans across nine townships (Figure 1). The watershed is situated at the transition of the Precambrian Shield to the south and southwest and the flat glaciolactrine clay and silt plains to the northeast (AMEC, 2008). The terrain is comprised of rolling hills with drainage areas composed mostly of wetlands on clay plains and slow-flowing meandering rivers approximately 280m above sea level (AMEC, 2008). The watershed is heavily impacted, having absorbed the effects of mining, forestry, and urbanization over the last century. Therefore a study evaluating metal accumulation in the area is important to determine whether the watershed is contaminated and poses a risk to wildlife and humans (Mcfarlane et al., 2014).

Local residents predicted that all areas in the watershed south of Bell Creek were contaminated due to the high level of industrialization and type of development. This overall area was classified as ‘not clean’ but for the purpose of this study, will be referred to as the industrial area. Several anthropogenic disturbances exist within this watershed such as two water treatment plants, five active mines, 13 historic mines, a two-lane highway and the City of Timmins to the West and the Township of Porcupine to the East. Areas surrounding Bigwater Lake and the North Porcupine River upstream of Bell Creek have been selected as reference areas due to the absence of industrial activity and development (Jodie Russell, pers. comm.).

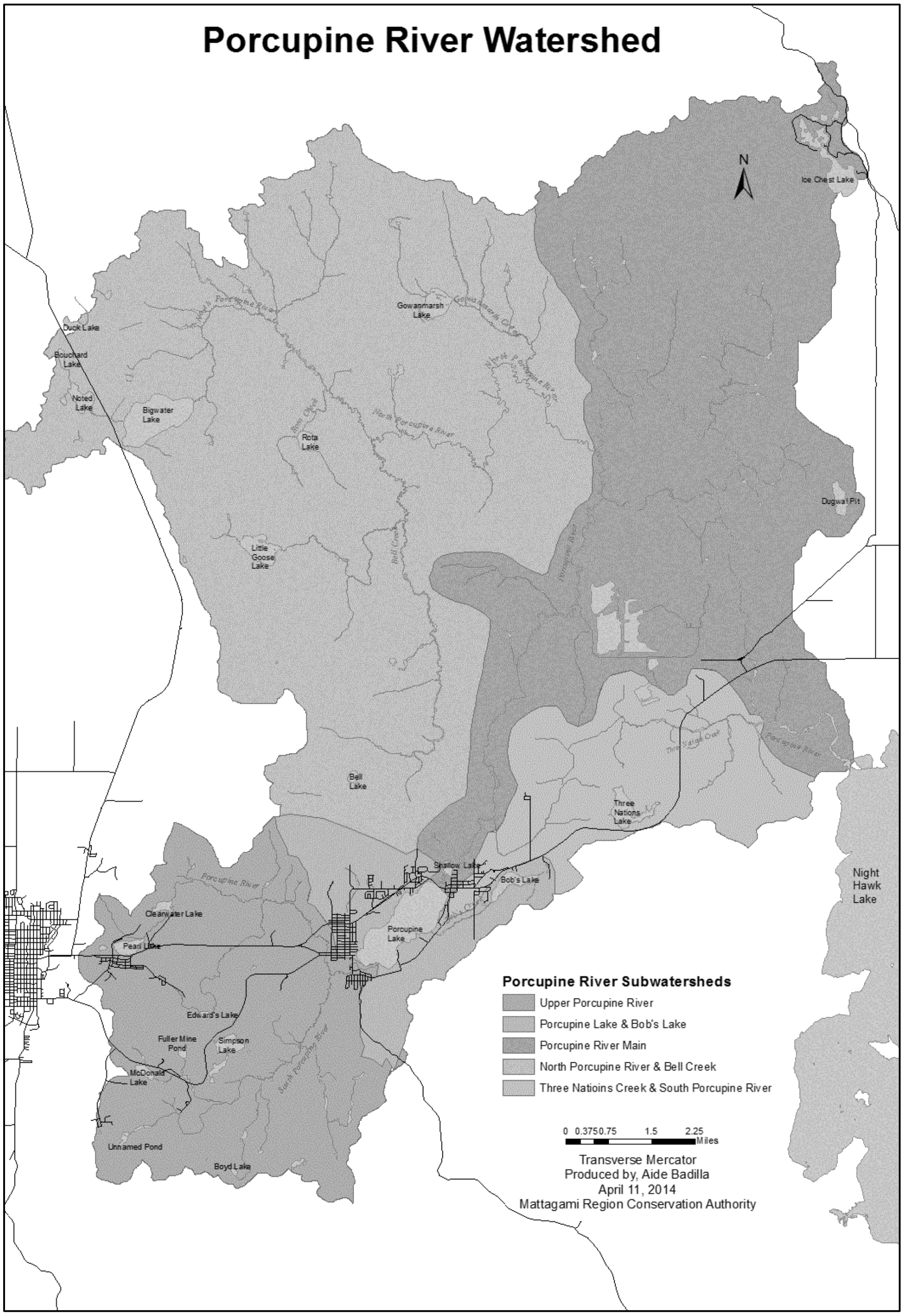

Figure 4: The Porcupine River Watershed and its sub-watersheds.

3.3.2 Sample Collection

Animal carcasses were obtained from the Timmins Fur Trappers Association, First Nation trappers from both potentially contaminated and uncontaminated sections of the Porcupine River Watershed in 2016 and 2017. Additionally, carcasses were obtained from trappers in the Sudbury area, as reference specimens. Some control samples were also sourced from outside the watershed from reference sites selected based on similar environmental conditions and lack of contaminants (Figure 2.0). A total of 10 mink were collected from the industrialized areas and 14 were collected from the reference sites. For river otters, only 2 were collected from the industrialized sites and 6 were collected from the reference sites. Once obtained, carcasses were skinned, bagged in sealed plastic bags and labelled (trapper name, location, trap line number, date collected) before being placed in a freezer kept at -15°C. Once ready for the necropsy, the carcass was placed in a standard fume hood to thaw. Standard body measurements were recorded including: age (juvenile or adult), total body length (cm) (nose to tail), weight (kg), and body condition (Appendix 1). Visible endoparasites, such as the giant kidney worm were searched for by looking in commonly hosted tissues such as the kidney. Using stainless steel utensils, 7 tissues were collected per individual: liver, kidney, lung, spleen, adipose, skeletal muscle and reproductive organs. Tissues were placed in digestion tubes with an average of 4.5 grams per sample and then frozen at -15°C.

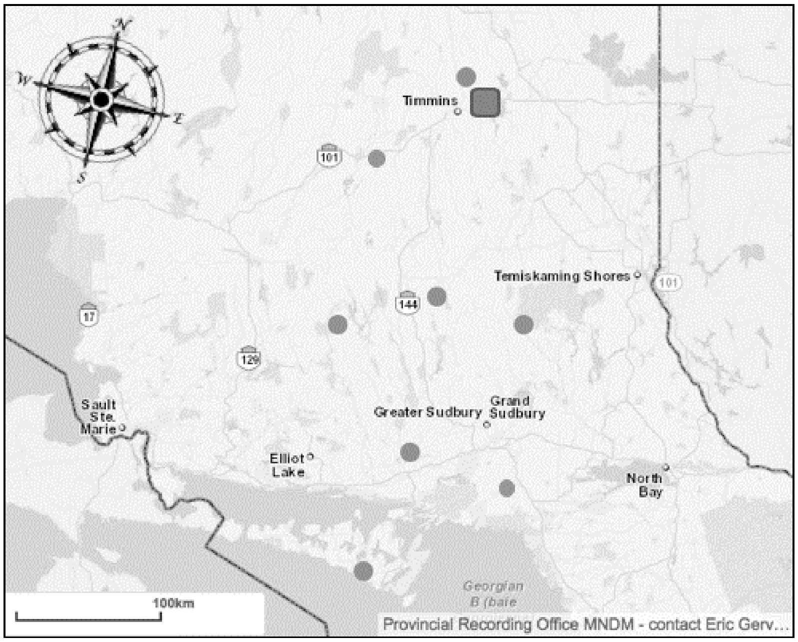

Figure 5. Reference site locations including the northern section of the watershed, and the Porter, Hennessy, Cortez, and Selkirk townships indicated with the circles. Watershed of concern in the square.

3.3.3 Tissue Sample Analyses

Samples were freeze-dried at an internal pressure of < 0.100 mBar and a temperature of < -47°C for seven days in a Labconco 12-L FreeZone Freeze Dryer (Labconco, Kansas City, United States of America).

Freeze dried samples were divided into approximate subsamples of 0.5 ±0.2 grams per tube. The extra mass from tissue samples was put into a separate tube as a replicate. Blanks and certified reference materials (CRM: TORT-2,DOLT-3, and DORM-2, from the National Research Council, Canada) were prepared and analyzed with the samples. For digestion, 9mL of concentrated metal grade nitric acid was added to 3mL of trace metal grade HCI (75%:25% by volume ration) for each sample. This solution was left overnight to cool and then reflux caps were placed on vials and the solutions were heated to 110°C for 240 minutes. The digestion tubes were then topped up to 50mL with ultrapure water. The solution was subsequently diluted to 1:10, mixed, and run on the ICP-MS (Varian 810 running ICP-MS Expert Software). All detectable metals were analyzed and the results measured in mg/kg.

It should be noted that the detection limit for Hg was quite high, at 2mg/kg. This is a relatively high detection limit and is a technological restraints to consider when evaluating the Hg results for this study.

3.3.4 Body Condition

Body condition, a measure of the nutritional state of the animal and the relative fat reserves (Peig & Green, 2009), was assessed using a formula developed for aquatic mammals such as the otter (*Lutra lutra*). The formula, developed by Kruuk & Conroy (1987) gives a low value for poor condition and a high value for good condition:

Body Condition = W($_a$L^n)

W= Mean body weight (kg)
a=5.02
L= contour length (m)
n=2.33

3.3.5 Statistical Analyses

To determine whether sites were different from each other, ProUCL (version 5.1.002(5.1), a statistical software designed for environmental applications for data sets with and without non-detect observations was used. The Gehan test, a non-parametric test specifically for handling data sets that sometimes have data below detection limits, was applied to the data between the different sites for each species, animal tissue and metal studied.

To study whether metal accumulation was impacting body condition, correlation matrices and linear regression with R values, slopes, and intercepts were used to understand relationships between metal accumulation and body condition with ioGAS (version 7.0). This was completed for each species, the seven tissue types and metals that had a significant value in the Gehan test.

3.4 Results

3.4.1 Site Differences

The Gehan test was applied for river otter and mink kidneys, livers, lungs, spleens, adipose, muscle and reproductive organs to compare differences between reference sites and the industrial sites. The test evaluated differences in metal concentrations for As (Arsenic), Cd (Cadmium), Cr (Chromium), Co (Cobalt), Cu (Copper), Fe (Iron), Hg (Mercury), Mn (Manganese), Ni (Nickel), Pb (Lead), Sb (Antimony), Se (Selenium), and Zn (Zinc). In river otters, the metals that had significant differences between industrial and reference sites were Mn, Co and Fe (Table 4). In mink, As, Cd, Cu, and Fe levels were higher in the industrial sites than in the reference sites (Table 4). For Sb and Hg, most values were below the detection limit and therefore, no conclusions were made as to their impact in the watershed (Appendix 2).

Table 4. Reference and Industrial Site averages for river otter and mink tissues that demonstrated significantly higher industrial metal levels than reference metal levels. Metal levels in mg/kg.

River Otter					**Mink**				
Tissue	Reference Site	Industrial Site	n	Gehan Test P value	Tissue	Reference Sites	Industrial Site	n	Gehan Test P value
		Co				**As**			
Kidney	0.067	0.142	5	0.042	Liver	0.217	1.543	24	0.012
Liver	0.056	0.165	5	0.042	Kidney	0.21	1.361	24	0.005
		Fe			Spleen	0.2	1.08	23	0.003
Adipose	1	19.8	5	0.026	Muscle	0.205	1.262	23	0.024
		Mn			Reproductive Organs	0.2	0.71	20	0.022
Kidney	2.693	3.33	5	0.042		**Cd**			
					Spleen	0.103	0.185	23	0.002
						Cu			
					Adipose	0.184	0.704	26	0.029
					Reproductive Organs	1.185	5.393	20	0.004
						Fe			
					Reproductive Organs	103	220.3	20	0.0355

3.4.2 Body Condition:

Body condition of mink were not significantly different between the industrialized and reference sites. River otters had significantly poorer body condition in the industrial areas compared to the reference areas ($F = 5.73$; $P<0.05$)(Table 5). In assessing relationship between body condition and individual metal accumulation, neither mink nor otters showed a significant relationship between body condition and any of the metals of concern (Table 6).

Table 5. Average body condition of otters and mink: a comparison between industrial and reference sites.

Mink Body Condition: Comparison of Sites				
	Reference Site	Industrial Site	P value	T Test Value
n	14	10		
Minimum	0.07	0.07		
Maximum	1.98	0.93	0.08	1.42
Mean	0.49	0.37		
SE	0.07	0.04		
SD	0.42	0.28		
Otter Body Condition: Comparison of Sites				
	Reference Site	Industrial Site	P value	T Test Value
n	6	4		
Minimum	1.04	0.59		
Maximum	1.74	0.96	0	5.73
Mean	1.31	0.77		
SE	0.06	0.05		
SD	0.31	0.19		

Table 6. Correlation coefficients (r), intercepts, slope coefficients for all tissues and metals of interest in carnivores from both reference and industrial sites across central and northern Ontario. Body condition and metal levels presented no relationships of significance (P<0.05).

River Otter	**Metal**	**Correlation**	**Intercept**	**Slope**	**P-Value**
Kidney	Co	-0.75	1.6967	-6.1867	0.1417
	Mn	-0.23	1.6882	-0.2005	0.7148
Liver	Co	-0.73	1.4701	-3.7111	0.1603
Adipose	Fe	-0.44	1.2252	-0.015	0.464

Mink	Metal	Correlation	Intercept	Slope	P-Value
Liver	As	0.058	0.4359	0.0119	0.7892
Kidney	As	0.051	0.436	0.0123	0.8147
Spleen	As	0.044	0.4429	0.0131	0.8423
	Cd	-0.02	0.5489	-0.7123	0.3492
Adipose	Cu	-0.12	0.4984	-0.106	0.6105
Muscle	As	0.034	0.4389	0.0075	0.8766
Reproductive Organ	As	0.086	0.3716	0.216	0.7183
	Cu	-0.1	0.3903	-0.0031	0.6596
	Fe	-0.17	0.4027	-0.0001	0.465

3.5 Discussion

Understanding how point source contaminants influences biota in the environment is essential for managing industrial practices and sustaining a habitable environment. It is imminent that no harmful effects result from urbanization and industrial practices so assessment of environmental health and sustainability is key. This study evaluated the industrial and urban influences on aquatic furbearers in the Porcupine River Watershed. This chapter investigates metal accumulation and subsequent body condition in carnivores, mink and river otter. Due to their location in the food chain, these two carnivore species were studied to assess metal movement through the trophic levels and to determine if these species are being negatively impacted by these anthropogenic stresses.

3.5.1 Abiotic evaluation

In the industrial area of the Porcupine River Watershed, metal levels in the water were considered before any animal tissues were harvested and analyzed. Water is tested consistently by the local mines throughout the industrialized areas of the watershed, most specifically within the southern industrialized portion of it. These tests analysis water and water sediments for metals and contaminants, such as cyanide, Hg, Cd, B, and As. Water test results conducted by local mines are available upon request. Additionally, a Non-Profit Organization (Water Rangers) runs water quality tests which are open for public access that can be found at: https://app.waterrangers.ca/observations/37082. Water Rangers reports water quality parameters such as pH, dissolved oxygen, chlorine, hardness, alkalinity, water depth, conductivity, and temperature.

3.5.2 River Otter: Metal Accumulation

Metals that showed significantly higher differences in industrial sites versus reference sites for river otters were Co, Fe, and Mn. Co levels in liver were higher in the industrial sites by 98%, and in kidney tissues by 72%. Fe was higher in adipose tissue in the industrial sites by 181%. Finally, Mn was higher in kidney tissues by 21%.

3.5.3 Mink: Metal Accumulation

Metals that showed significantly higher levels in the industrial sites than the reference sites for mink were As, Cd, Cu, and Fe. As in liver was higher in the industrial sites by 151%. As in kidney tissues was higher in industrial sites by 147%, As in spleen tissues was higher in in the industrial sites by 138%. As in muscle tissue was higher in in the industrial sites by 144%. Finally, As in reproductive organ tissue was 112% higher in industrial sites than in reference sites. Cd in spleen tissue was higher in industrial sites by 57%. Cu was higher in adipose tissue in the industrial sites by 117%. Cu in reproductive organ tissue was higher in in the industrial sites by 128%. For Fe, reproductive organ tissue was higher in industrial sites by 73%.

3.5.4 Metal Breakdown

Parasitic infection in mink may affect its susceptibility to contaminants such as metals (Wren, 1986); however, the extent to which this occurs remains unknown (Capodagli, 2002). Mink are the preferred host for the nematode parasite, *D. renale*, also known as the Giant Kidney Worm, which can severely damage the entire right kidney (Mace & Anderson, 1975; Capodagli, 2002) and result in an approximate doubling of the size of the left kidney to compensate for this loss in renal capacity (Klenavic et al., 2008). During the harvesting of tissues for metal analysis, all individuals were inspected thoroughly for parasite presence, but none were found. Parasitic presence is often correlated to significantly high mercury levels (Klenavic et al., 2008; Martin et al., 2011). With Hg levels too low for detection (detection limit 2mg/kg) in this study, a lack of parasites was not surprising. There are numerous studies which found that sex did not influence the accumulation of the metals of concern (Sanchez-Chardi & Nadal, 2007; Fritsch et al., 2010;

Hoffmann et al., 2010; Diggs, 2013; Kang et al., 2015). A study by Lanszki et al. (2009) on Cd, Cu, Hg, Pb, and Zi searched for differences and found that females only accumulated significantly higher levels of Zi. Martin et al. (2011) found significant sex effects with Cd. However, the study found that only notably older female mink accumulated higher levels of the metal. For this study, due to the high trapping efforts in the areas of which the animals were from, most individuals were young adults and this age and sex effect found by Martin et al. (2011) would not be present in this study. With this in mind, age and sex effects on metal accumulation were not explored in this study. In terms of metal accumulation by tissue in otters, liver, kidney, and adipose where the only tissues that showed significant accumulation in the industrial area. For mink, tissues that accumulated significantly in the industrial area were liver, kidney, spleen, muscle, adipose tissues and reproductive organs. The only tissue in carnivores that did not accumulate significantly was lung, which was also observed in a study of the Eurasian otter (*Lutra lutra*) in South Korea (Kang et al., 2015).

3.5.4.1 Arsenic (As)

Studies investigating chronic levels of As in wildlife are scarce as toxic poisoning is uncommon in free-living mammals due rapid metabolic detoxification and rapid excretion (Drouhot et al., 2014). However, some studies have found evidence of arsenic contamination in small mammals subjected to long-term exposure from living near former mine sites (Saunders et al., 2009; Drouhot et al., 2014). In Canada, one of the main anthropogenic sources of arsenic release are tailings ponds (Saunders et al., 2010). This appears be the reason for why As levels were significantly higher in many of the tissues from the industrial sites of the Porcupine River Watershed. Saunders et al. (2010) also found substantially higher concentrations of arsenic in live meadow voles living on contaminated mine sites. Most cases of As poisoning in wildlife are from accidental ingestion of contaminated soil, particularly in carnivores when striking prey (Espinosa-Reyes et al., 2010). As levels in wolf (*Canis lupus*) kidneys in a study by Gamberg and Braune, (1999) had levels magnitudes higher than levels from this study, but their results still did not approach levels known to cause adverse effects in wild animals.

3.5.4.2 Cadmium (Cd)

Several studies have found that in mammals, bio-magnification of Cd is evident when studying the different trophic levels and predator-prey relationships (Veltman et al., 2007; Klenavic et al., 2008). There is a relationship between the accumulation of Cd in liver and kidneys of small mammals and Cd levels in soil (Fritsch et al., 2010). Furthermore, Cd levels are often observed in magnitudes higher in carnivores compared to herbivores (Hunter & Johnson, 1982; Veltman et al., 2007; Perez-Lopez et al., 2016). Because Cd is a non-essential metal, many species are unable to regulate their bioaccumulation of it (Fritsch et al., 2010; Perez-Lopez et al., 2016). However in comparison to this study, such a magnitude of difference was not observed between trophic levels. Geological and environmental factors such as type of metal (nonessential and essential), species of study, pH and amount of organic matter in the soil can impact metal uptake and these factors may have played a role in reducing extreme bio-magnification in the carnivore species (Veltman et al., 2007). Studies investigating Cd levels often see preferential accumulation in liver and kidney tissues (Hunter & Johnson, 1982; Fritsch et al., 2010). Cd levels in mink kidney in a study by Gamberg et al. (2005) and Harding (2004) had Cd levels higher than levels from this study, but their results still did not approach levels known to cause adverse effects in animals based on other dietary background studies. Unfortunately, most studies evaluate only Cd uptake in liver and kidney, so published levels of accumulation were not available to be compared to Cd levels in mink spleen from this study. Only spleen tissues in mink in this study held elevated levels of Cd related to the industrial area. Toxicity thresholds are not well established for river otters and mink; however, Cd concentrations from this study were magnitudes lower than levels of 100-200 mg/kg associated with kidney dysfunction in humans and experimental mammals (Martin et al., 2011). Cd levels in wolf kidney and liver in a study by Gamberg and Braune (1999) and Cd levels in Yukon mink kidneys by Gamberg et al., (2005) had levels magnitudes higher than levels from this study, but their results still did not approach levels known to cause adverse effects in animals. Kang et al. (2015) reports that tissue Cd concentrations of 5-30mg/kg are considered toxic. The Cd levels for this study are much lower (Table 4).

3.5.4.3 Copper (Cu)

Cu was only significantly higher levels in mink adipose tissue and reproductive organs. Being an essential metal, Veltman et al. (2007) found that copper is usually regulated efficiently by small mammals through increased excretion and reducing uptake. Exceedingly high levels of copper are less common in carnivores due to the fact that most plants and invertebrates which are lower in the food chain, can effectively regulate their internal concentrations, limiting the metal's ability to bio-magnify up the food chain (Veltman et al., 2007). Liver damage from heavy metals can cause Cu release into the bloodstream triggering hemolysis. Hemolysis can damage kidneys with hemoglobin breakdown products, increasing the liver : kidney ratios of Cu and Fe (Haas et al., 2009). It is possible this Cu and Fe relationship to be occurring in this study as only in mink where these two metals found to be of concern in the reproductive organs. Cu and Zn levels also correlated in the livers and kidneys in a study of Eurasian otters (*Lutra lutra*) by Kang et al. (2015), but Zn was not a metal of concern in the Porcupine River Watershed. Mean Cu levels in mink kidney from Kootenay River, BC, and the Fraser River, BC were 12.1 and 12.4 mg/kg respectively (Harding et al., 1998), which were much higher than Cu levels in mink adipose tissue and reproductive organ from the Porcupine River Watershed. The levels found in British Columbia were not high enough to be of concern to the wildlife in that study and therefore, the levels from this study were not considered harmful.

3.5.4.4 Iron (Fe)

Being an essential metal and also one of the most abundant metals on earth (Khayatzadeh & Abbasi, 2010), Fe is a more challenging metal to study for bioaccumulation, as it is often regulated better in the body than non-essential metals (Veltman et al., 2007). Fe concentrations in tissues can vary immensely amongst individuals. Ninomiya et al. (2004) found that Fe levels varied more among individuals than it did among different species and several studies reported a large variance in hepatic and renal concentrations in aquatic mammals (Harding et al., 1989; Wren, 1984; Zhou et al., 2001; Ninomiya et al., 2004). Factors responsible for such variances remain unknown (Ninomiya et al., 2004) and for these reasons, drawing conclusions on wildlife and ecosystem health based on Fe accumulations can be difficult. In a study on river otters in Idaho, Diggs (2013) found Fe levels to much higher in liver than was found in this study. River otter livers had mean Fe levels of 284 mg/kg in Diggs' (2013) study, while mean levels of river otter adipose tissue in this study were 19.8 mg/kg in the industrial areas. Mean levels in mink were more similar, with reproductive organ levels at 220 mg/kg in the industrial areas. Diggs' (2013) metal levels were well within background levels for the area indicating that the levels measured in this study, although in Ontario and not Idaho, should be considered relatively safe. Mink Fe reproductive organ concentrations from this study were much lower than the kidney levels from the study of Harding et al. (1998), which were at 715 and 456 mg/kg from Kootenay River and Fraser River, respectively. Otter kidney Fe levels (Harding et al. 1998) were significantly higher than river otter adipose tissue from this study with means from British Columbian ranging from 921 to 1330 mg/kg. The levels from Harding et al. (1998) are considered adequate reference concentrations for wild mink and river otters. Unfortunately, most studies evaluate only Fe uptake in liver and kidney, so published levels of accumulation are not available to be compared to the significantly higher Fe levels in mink reproductive organs and river otter adipose tissue from this study.

3.5.4.5 Manganese (Mn)

In the Porcupine River Watershed, Mn was significantly higher in river otter kidneys from the industrial areas than in the reference areas. In Kang et al.'s (2006) study on Eurasian otters (*Lutra lutra*), liver contained the highest Mn levels. Higher concentrations of Mn were found in diseased and emaciated sea otters in a study on the Californian coast by Kannan et al. (2006). This is parallel to the body condition decrease observed in the river otters of this study, where body condition in industrial areas for river otter was 46% lower than in the reference area. Kannan et al. (2006) also found that essential elements Co and Mn were significantly correlated with each other and with several other trace metals. These results were also seen with the river otter tissue accumulation in this study. Both Co, Mn, and Fe were the only metals that had significantly higher levels in the industrial area in the river otters. Both Co and Mn, for some unknown reason were not paired together to accumulate significantly in mink in the industrial areas. This association between essential and non-essential metals in diseased otters may be from sequestration of the metals by binding to proteins such as metallothioneins, which are key for regulating metal availability (Kannan et al., 2006). Kannan et al. (2006) found that in situations where there is an increase in essential metals such as Mn, it could be due to infection and exposure to toxic contaminants, which causes oxidative stress, which can lead to an adverse effects to the immune system. Mean Mn levels in Idaho river otter liver, which were within background levels, was 165.7mg/kg (Diggs, 2013). This was well above river otter kidney levels from this study, which was at 2.7mg/kg. Mean Mn levels in river otter kidney from several British Columbian rivers ranged from 13.1-10.7 mg/kg (Harding et al., 1998), which was much higher than river otter kidney Mn levels from the Porcupine River Watershed (average of 2.7 mg/kg). The levels from Harding et al. (1998) are considered adequate reference concentrations for wild river otters.

3.5.4.6 Cobalt (Co)

Co levels were significantly higher in river otter kidney and liver tissues in the industrial areas than in the reference areas. Diggs (2013) measured Co in Idaho river otter livers and found a mean of 0.07 mg/kg, while the liver in river otters in industrial areas from this study contained higher concentrations at 0.16 mg/kg. However, these results were lower than river otter kidney from British Columbian, which had Co means of 0.29, <0.4 and 0.3mg/kg (Harding et al., 1998). The levels from Harding et al. (1998) are considered adequate reference concentrations for river otters. Kannan et al. (2006) found that concentrations of Co were elevated in diseased and emaciated sea otters of the Californian coast. These higher levels of Co may partially explained due to the decrease in body condition of the otters in the industrial area in this study.

3.5.5 Body Condition

Body condition in both carnivores were impacted negatively in the industrial sites as mink had a body condition 33% lower in the industrial area, while otters had a body condition that was 46% lower in the industrial area. When comparing site differences of each species using a two-sample student t-test, only river otters in industrial sites were significantly lower than in the reference areas. Therefore, it was concluded that bio-magnification was a factor impacting the river otters. Their threshold for metals or other contaminants may be low and the accumulation of metals from their prey-based diet could negatively impact body growth and development. River otters have diets that are almost exclusively aquatic (fish), while mink have a more terrestrial diet, which may reduce metal accumulation. The industrial area is subject to variety of anthropogenic factors, such as vehicle and pedestrian traffic, fishing, hunting, eutrophication, and noise and light pollution. These stresses may affect the carnivores directly or affect prey availability (Kang et al., 2015). There are also local concerns among the population on local water treatment plants discharge into the watershed. Some locals claim that the discharge concentrations are polluting the water systems and while this would not be considered metal pollution, organic pollution could be a factor affecting body condition and health.

Fat content was not evaluated in this study, as carnivores were harvested by fur trappers from fall until early spring. This meant there was a large variety of harvest periods and fat levels naturally vary throughout the year. Secondly, as cautioned by Virgl and Messier (1993), unless the ratio between body mass and fat content has been analyzed, evaluating fat alone as an indication of subsequent health is not an accurate measure. If one is to look at fat content successfully, the use of isotopic water is a reliable and non-destructive method to evaluate fat and protein content. That method in combination with fecal and urine analysis can help evaluate possible habitat effects on body condition (Virgl & Messier, 1993).

Bone marrow fat content was investigated initially in this study to evaluate the body condition, but was later eliminated. Mech and Delgiudice (1985) strongly cautioned against this method, as it is the last storage of fat used by the animal. If an individual's bone marrow was high in fat, it does not mean it is healthy. As an animal's nutritional status declines, first, subcutaneous fat is used, then omental, renal, pericardial, and then bone marrow fat is used. If an individual lost significant fat due to illness, but still had high levels of bone marrow fat, it would be inaccurate to say it is a healthy individual (Mech & Delguidice, 1985). If this study had the technology available, the combination of the two latter methods of nutritional status would give a thorough picture of both the current and long-term history of an individual's health. Overall, the interpretation of body condition indices should be done with caution due to a wide variability of confounding variables such as individual and environmental factors (Tête et al., 2013).

3.6 Conclusions

9. No significant differences were observed in tissues of mink and river otter from the industrial exposed area and a reference area for the following elements: Cr, Hg, Ni, Pb, Sb, Se, and ZnMetals that were significantly higher in industrial sites versus reference sites were As, Cd, Co, Cu, Mn and Fe.
1. Metals that were significantly higher in industrial sites versus reference sites were As, Cd, Co, Cu, Mn and Fe.

2. For mink, metals As, Cd, Cu, and Fe were significantly higher in industrial sites compared to reference sites and in different organs.
3. For otters, metals Co, Mn and Fe were significantly higher in industrial sites compared to reference sites and in different organs.
4. Body condition of mink were lower but not significantly different between the industrialized and reference sites.
5. Body condition of otters was significantly lower in the industrial areas compared to the reference areas.
6. In assessing relationship between body condition and individual metal accumulation, neither mink nor otters showed a significant relationship between body condition and any specific metal of concern.
7. No direct link between higher point-source bioavailability of metals and current and past industry, urban development nor natural variability in local geology were found; if remedial measures are implemented to reduce metal contaminant of the Porcupine River Watershed, all possible parties should be involved.
8. Overall metal level accumulation levels in both river otter and mink are of likely no concern when compared to other similar studies.

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4 General Conclusions and Recommendations

- Metals of no concern in the Porcupine River Watershed were Cr, Hg, Ni, Pb, Sb, Se, and Zn.
- Metals that were significantly higher in industrial sites versus reference sites were As, Cd, Co, Cu, Mn and Fe.
- For beavers, metals As, Cd, Cu, and Fe were significantly higher in industrial sites compared to reference sites and in different organs.
- For muskrats, metals As, Co, Cu, and Mn were significantly higher in industrial sites compared to reference sites and in different organs.
- Only muskrat lung showed a positive correlation to Co and As levels in lung and body condition which could be due to increased foraging behaviours in healthier individuals.
- Body condition of beaver was not significantly different between industrial and reference sites.
- Body condition of muskrat was significantly different between industrial and reference sites with specimens from industrial sites having lower body condition.
- The data supports the conclusion that there is no risk to First Nation peoples nor trappers due to the occasional consumption of beaver meat.
- For mink, metals As, Cd, Cu, and Fe were significantly higher in industrial sites compared to reference sites and in different organs.
- For otters, metals Co, Mn and Fe were significantly higher in industrial sites compared to reference sites and in different organs.
- Body condition of mink were lower but not significantly different between the industrialized and reference sites.
- Body condition of otters was significantly lower in the industrial areas compared to the reference areas.
- In assessing relationship between body condition and individual metal accumulation, neither mink nor otters showed a significant relationship between body condition and any specific metal of concern.
- Overall metal level accumulation levels in both river otter and muskrat were not of concern.

- No direct link between higher point-source bioavailability of metals and current and past industry, urban development nor natural variability in local geology were found; however, if remedial measures are implemented to reduce metal contaminant of the Porcupine River Watershed, all possible parties should be involved.

Appendix 1

Baseline data for each individual captured in the study. Contour length values in bold italics are estimates as the tail of these animals was missing and estimates of tail length were determined based on similar individuals of the same species.

Code	Species	Area Type	Sex	Age	Weight (kg)	Contour Length (m)	Date of Capture	Date of Necropsy	Body Condition
B1a	*Castor canadensis*	Industrial	M	A	16.5	1.19	1-Nov-16	22-Nov-16	2.192
M1a	*Ondatra zibethica*	Industrial	F	A	0.49	0.49	1-Nov-16	23-Nov-16	0.514
M2a	*Ondatra zibethica*	Industrial	F	A	0.77	0.57	1-Nov-16	23-Nov-16	0.568
B2a	*Castor canadensis*	Industrial	F	A	14.5	***0.95***	1-Nov-16	28-Nov-16	3.255
B3a	*Castor canadensis*	Industrial	M	A	13.5	1.03	1-Nov-16	29-Nov-16	2.510
B4a	*Castor canadensis*	Industrial	F	A	15	1.13	1-Nov-16	29-Nov-16	2.248
Mi1a	*Neovison vison*	Industrial	F	A	0.05	0.43	1-Nov-16	30-Nov-16	0.071
B5a	*Castor canadensis*	Industrial	F	J	6.5	***0.84***	3-Nov-16	1-Dec-16	1.944
B6a	*Castor canadensis*	Industrial	M	A	11	***0.43***	1-Nov-16	2-Dec-16	15.657
Mi2a	*Neovison vison*	Industrial	M	A	0.2	0.5	3-Nov-16	6-Dec-16	0.200
Mi3a	*Neovison vison*	Industrial	F	A	0.21	0.46	3-Nov-16	6-Dec-16	0.255
B7a	*Castor canadensis*	Industrial	M	A	10.05	***0.96***	1-Nov-16	7-Dec-16	2.202
B8a	*Castor canadensis*	Industrial	M	A	12.5	0.95	1-Nov-16	9-Dec-16	2.806
B9a	*Castor canadensis*	Industrial	F	A	13	***0.98***	1-Nov-16	16-Dec-16	2.714
B10a	*Castor canadensis*	Industrial	M	A	13.5	1.04	1-Nov-16	19-Dec-16	2.454
M3a	*Ondatra zibethica*	Industrial	F	A	0.7	0.515	1-Nov-16	20-Dec-16	0.654
M4a	*Ondatra zibethica*	Industrial	F	A	0.65	0.54	1-Nov-16	20-Dec-16	0.544
Mi4a	*Neovison vison*	Industrial	F	A	0.41	0.455	1-Nov-16	21-Dec-16	0.512
Mi5a	*Neovison vison*	Industrial	M	A	0.61	0.53	1-Nov-16	21-Dec-16	0.533
B11a	*Castor canadensis*	Industrial	F	A	5	0.795	1-Nov-16	22-Dec-16	1.700
B12a	*Castor canadensis*	Industrial	F	A	9.5	0.87	1-Nov-16	22-Dec-16	2.618
Mi6a	*Neovison vison*	Industrial	M	A	1.425	0.6	11-Nov-16	11-Jan-17	0.933
M5a	*Ondatra zibethica*	Industrial	F	A	0.8	0.51	11-Nov-16	11-Jan-17	0.765
M6a	*Ondatra zibethica*	Industrial	F	A	0.95	0.54	10-Nov-16	11-Jan-17	0.795

O1a	*Lontra canadensis*	Industrial	F	A	4	1.14	24-Nov-16	11-Jan-17	0.587
M7a	*Ondatra zibethica*	Industrial	M	A	1.2	0.58	7-Nov-16	8-Feb-17	0.851
M8a	*Ondatra zibethica*	Industrial	M	A	0.85	0.57	27-Oct-16	8-Feb-17	0.627
M9a	*Ondatra zibethica*	Industrial	F	A	0.453	0.51	2-Nov-16	8-Feb-17	0.433
Mi7a	*Neovison vison*	Industrial	F	A	0.456	0.56	29-Oct-16	8-Feb-17	0.351
O2a	*Lontra canadensis*	Industrial	M	A	5.4	1.05	24-Nov-16	8-Feb-17	0.960
B13a	*castor canadensis*	Industrial	F	A	11	0.87	24-Nov-16	17-Feb-17	3.031
Mi8a	*Neovison vison*	Industrial	F	A	0.15	0.53	31-Oct-16	21-Feb-17	0.131
Mi9a	*Neovison vison*	Industrial	M	A	0.453	0.6	29-Oct-16	21-Feb-17	0.297
Mi10a	*Neovison vison*	Industrial	M	A	0.5	0.6	31-Oct-16	21-Feb-17	0.327
B14a	*Castor canadensis*	Industrial	F	A	18	***1.08***	24-Nov-16	23-Feb-17	2.997
B15a	*Castor canadensis*	Industrial	F	A	10	0.875	24-Nov-16	27-Feb-17	2.719
B16a	*Castor canadensis*	Industrial	F	J	6.5	0.72	24-Nov-16	27-Feb-17	2.784
B17a	*Castor canadensis*	Industrial	F	A	13.6	1.03	24-Nov-16	3-Mar-17	2.529
B18a	*Castor canadensis*	Industrial	M	A	14.9	1.04	24-Nov-16	15-Mar-17	2.709
B19a	*Castor canadensis*	Industrial	F	A	13.5	***1.03***	24-Nov-16	15-Mar-17	2.510
M10a	*Ondatra zibethica*	Industrial	F	A	0.261	0.495	27-Oct-16	9-May-17	0.268
M11a	*Ondatra zibethica*	Industrial	M	A	0.5	0.551	27-Oct-16	5-Sep-17	0.399
M12a	*Ondatra zibethica*	Industrial	M	A	0.426	0.528	27-Oct-16	6-Sep-17	0.376
M13a	*Ondatra zibethica*	Industrial	F	A	0.41	0.533	27-Oct-16	6-Sep-17	0.354
M14a	*Ondatra zibethica*	Industrial	M	A	0.45	0.507	27-Oct-16	6-Sep-17	0.436
M15a	*Ondatra zibethica*	Industrial	M	A	0.475	0.49	27-Oct-16	6-Sep-17	0.499
B1b	*Castor canadensis*	Reference	F	A	16.2	***1.07***	2-Dec-17	15-Sep-17	2.756
B20a	*Castor canadensis*	Industrial	M	J	5.2	0.791	2-Dec-17	20-Sep-17	1.789
M16a	*Ondatra zibethica*	Industrial	M	A	0.398	0.558	2-Dec-17	20-Sep-17	0.309
M17a	*Ondatra zibethica*	Industrial	M	A	0.352	0.493	2-Dec-17	20-Sep-17	0.364
B2b	*Castor canadensis*	Reference	F	J	11	0.93	30-Oct-17	8-Nov-17	2.595
B3b	*Castor canadensis*	Reference	M	A	17	1.08	30-Oct-17	8-Nov-17	2.831
B4b	*Castor canadensis*	Reference	M	A	18	1.115	11-Nov-17	15-Nov-19	2.782
B5b	*Castor canadensis*	Reference	M	J	11	0.93	11-Nov-17	17-Nov-17	2.595

B6b	*Castor canadensis*	Reference	F	A	12.5	1.04	11-Nov-17	17-Nov-17	2.273
B7b	*Castor canadensis*	Reference	M	A	11.2	0.985	18-Nov-17	22-Nov-17	2.311
B8b	*Castor canadensis*	Reference	F	A	12.1	1.03	18-Nov-17	22-Nov-17	2.250
B9b	*Castor canadensis*	Reference	F	A	15.5	1.069	18-Nov-17	22-Nov-17	2.643
B10b	*Castor canadensis*	Reference	F	A	13.2	1.04	26-Nov-17	28-Nov-17	2.400
B11b	*Castor canadensis*	Reference	F	A	10	0.96	26-Nov-17	28-Nov-17	2.191
B12b	*Castor canadensis*	Reference	F	A	11	0.94	26-Nov-17	28-Nov-17	2.531
M1b	*Ondatra zibethica*	Reference	F	A	0.48	0.61	2-Dec-17	4-Dec-17	0.302
M2b	*Ondatra zibethica*	Reference	M	A	0.477	0.641	2-Dec-17	4-Dec-17	0.268
M3b	*Ondatra zibethica*	Reference	F	A	0.502	0.575	2-Dec-17	4-Dec-17	0.363
M4b	*Ondatra zibethica*	Reference	F	A	0.485	0.6	2-Dec-17	4-Dec-17	0.318
M5a	*Ondatra zibethica*	Reference	M	A	0.45	0.558	2-Dec-17	4-Dec-17	0.349
B13b	*Castor canadensis*	Reference	M	A	21	1.227	28-Nov-17	4-Dec-17	2.597
B14b	*Castor canadensis*	Reference	F	A	12.9	***0.98***	2-Dec-17	4-Dec-17	2.694
B15b	*Castor canadensis*	Reference	F	A	18	***1.01***	2-Dec-17	4-Dec-17	3.503
O1b	*Lontra canadensis*	Reference	F	A	5.8	0.998	2-Dec-17	4-Dec-17	1.161
B16b	*Castor canadensis*	Reference	F	J	8.6	0.93	9-Dec-17	11-Dec-17	2.029
B17b	*Castor canadensis*	Reference	F	J	10.6	0.937	9-Dec-17	11-Dec-17	2.457
B18b	*Castor canadensis*	Reference	M	A	18	1.105	9-Dec-17	11-Dec-17	2.841
B19b	*Castor canadensis*	Reference	M	A	14.6	***1.07***	9-Dec-17	12-Dec-17	2.484
B20b	*Castor canadensis*	Reference	F	A	14.9	***0.86***	9-Dec-17	12-Dec-17	4.218
O2b	*Lontra canadensis*	Reference	F	A	7	1.135	9-Dec-17	12-Dec-17	1.038
B21	*Castor canadensis*	Reference	M	A	12	1.08	16-Dec-17	18-Dec-17	1.998
B22	*Castor canadensis*	Reference	M	J	10.5	0.93	16-Dec-17	18-Dec-17	2.477
B23	*Castor canadensis*	Reference	F	J	10	0.92	16-Dec-17	18-Dec-17	2.419
B24b	*Castor canadensis*	Reference	F	J	5.5	0.797	1-Nov-17	20-Dec-17	1.859

B25b	*Castor canadensis*	Reference	F	J	3.5	1.047	1-Nov-17	20-Dec-17	0.626
M6b	*Ondatra zibethica*	Reference	M	A	0.515	0.577	1-Nov-17	20-Dec-17	0.369
M7b	*Ondatra zibethica*	Reference	M	A	0.52	0.547	1-Nov-17	20-Dec-17	0.422
M8b	*Ondatra zibethica*	Reference	M	A	0.51	0.568	1-Nov-17	20-Dec-17	0.380
M9b	*Ondatra zibethica*	Reference	M	A	0.525	0.584	1-Nov-17	20-Dec-17	0.366
M10b	*Ondatra zibethica*	Reference	F	A	0.54	0.589	1-Nov-17	20-Dec-17	0.369
M11b	*Ondatra zibethica*	Reference	F	A	0.505	0.551	1-Nov-17	20-Dec-17	0.403
Mi1b	*Neovison vison*	Reference	M	A	0.405	0.59	1-Dec-17	21-Dec-17	0.276
Mi2b	*Neovison vison*	Reference	F	J	0.29	0.43	1-Dec-17	21-Dec-17	0.413
Mi3b	*Neovison vison*	Reference	M	A	0.45	0.515	1-Dec-17	21-Dec-17	0.421
Mi4b	*Neovison vison*	Reference	M	A	0.5	0.55	1-Dec-17	21-Dec-17	0.401
B26b	*Castor canadensis*	Reference	M	A	12.5	1.115	13-Dec-18	13-Jan-18	1.932
B27b	*Castor canadensis*	Reference	F	A	13.75	1.06	13-Dec-18	13-Jan-18	2.391
O3b	*Lontra canadensis*	Reference	F	A	5.5	0.82	13-Dec-18	13-Jan-18	1.740
O4b	*Lontra canadensis*	Reference	M	A	3.5	0.98	2-Dec-18	13-Jan-18	0.731
O5b	*Lontra canadensis*	Reference	M	A	7.4	0.971	1-Nov-17	16-Jan-18	1.579
O6b	*Lontra canadensis*	Reference	F	A	6.1	1.028	1-Nov-17	16-Jan-18	1.139
Mi5b	*Neovison vison*	Reference	M	A	0.35	0.53	1-Dec-17	6-Feb-18	0.306
Mi6b	*Neovison vison*	Reference	M	A	0.65	0.56	1-Dec-17	6-Feb-18	0.500
M10b	*Ondatra zibethica*	Reference	M	A	0.95	0.56	1-Dec-17	6-Feb-18	0.731
Mi7b	*Neovison vison*	Reference	F	J	0.2	0.46	1-Dec-17	6-Feb-18	0.243
Mi8b	*Neovison vison*	Reference	M	J	0.6	0.3	1-Dec-17	6-Feb-18	1.976
Mi9b	*Neovison vison*	Reference	M	A	0.55	0.56	1-Dec-17	6-Feb-18	0.423
Mi10b	*Neovison vison*	Reference	M	A	0.5	0.52	1-Dec-17	8-Feb-18	0.457
Mi11b	*Neovison vison*	Reference	M	A	0.45	0.51	1-Dec-17	8-Feb-18	0.430
Mi12b	*Neovison vison*	Reference	F	A	0.325	0.49	1-Dec-17	8-Feb-18	0.341
Mi13b	*Neovison vison*	Reference	M	A	0.55	0.56	1-Dec-17	8-Feb-18	0.423
Mi14b	*Neovison vison*	Reference	M	A	0.455	0.505	1-Dec-17	8-Feb-18	0.445

Appendix 2

Values obtained for each sample for metals of interest (mg/Kg). DL signifies that the tissue sample was below the detection limit for that metal. For the label, M stands for muskrat, Mi for mink, B for beaver, and O for river otter. The number following the species indicator is the individual's assigned number. The A following the individual number stands for industrial area and B stands for reference area.

LABEL	Tissue/ Code	As	Cd	Co	Cr	Cu	Fe	Hg	Mg	Mn	Ni	Pb	Sb	Se	Zn
		mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
		0.2	0.05	0.03	0.4	0.05	1	2	0.1	0.02	0.2	0.06	0.07	0.6	0.06
M10a	Liver	23.4	<DL	0.264	1.63	19.8	2130	<DL	1080	13.8	0.398	<DL	<DL	<DL	116
M10a	Kidney	103	0.06	0.283	1.27	137	550	<DL	1130	14.4	0.896	0.418	<DL	7.2	108
M10a	Lung	3.2	<DL	<DL	3.14	4.05	2270	<DL	712	2.39	1.22	0.212	<DL	<DL	67
M10a	Adipose	4.66	<DL	<DL	1.66	0.944	<DL	<DL	571	10.1	<DL	<DL	<DL	<DL	56.7
M10a	Muscle	9	<DL	<DL	1.75	3.46	19.9	<DL	1370	1.5	0.327	0.122	<DL	<DL	49.8
M10a	Rep. Org	1.7	<DL	0.0411	1.34	0.564	<DL	<DL	257	6.22	<DL	<DL	<DL	<DL	19.1
M11a	Liver	8.57	<DL	0.268	1.09	13.4	619	<DL	798	18.5	<DL	0.0605	<DL	1.06	101
M11a	Kidney	53.5	0.0516	0.308	0.802	77.2	644	<DL	540	12.3	0.424	<DL	<DL	5.59	65.8
M11a	Lung	5.9	<DL	0.275	7.51	5.25	999	<DL	695	7.11	9.38	0.632	<DL	<DL	60.9
M11a	Muscle	4.85	<DL	0.0495	1.03	2.95	3.31	<DL	1130	4.67	0.439	0.231	<DL	0.763	43.8
M11a	Muscle	5.12	<DL	0.053	1.1	2.98	11.8	<DL	1150	4.76	0.444	0.233	<DL	<DL	44.9
M12a	Liver	1.56	<DL	0.254	1.19	11.8	389	<DL	844	67.8	<DL	<DL	<DL	<DL	127
M12a	Kidney	1.11	<DL	0.524	0.756	11.3	307	<DL	640	92.1	0.353	<DL	<DL	2.76	88
M12a	Lung	<DL	<DL	0.0583	0.851	3.16	1190	<DL	732	9.05	0.499	<DL	<DL	<DL	71.2
M12a	Spleen	<DL	<DL	0.464	4.48	2.35	<DL	<DL	547	79.1	3.8	<DL	<DL	<DL	110
M12a	Adipose	<DL	<DL	<DL	<DL	7.85	<DL	<DL	351	3.06	<DL	<DL	<DL	<DL	147
M12a	Muscle	9.93	<DL	<DL	1.03	4.33	27.6	<DL	1190	2.69	<DL	<DL	<DL	<DL	87.6
M12a	Rep. Org	<DL	<DL	0.406	<DL	1.67	<DL	<DL	908	89	1.51	<DL	<DL	<DL	99.8
M13a	Liver	9.71	<DL	0.15	<DL	5.43	425	<DL	295	10.2	<DL	<DL	<DL	<DL	46.2
M13a	Kidney	37.6	0.0815	0.484	0.764	41.2	542	<DL	580	16.3	0.435	<DL	<DL	4.24	82.6
M13a	Lung	2.96	<DL	<DL	<DL	3.9	1560	<DL	543	4.4	<DL	<DL	<DL	4.27	74.8
M13a	Spleen	6.34	<DL	<DL	<DL	1.84	<DL	<DL	598	18.9	<DL	<DL	<DL	<DL	142
M13a	Adipose	6.01	<DL	0.262	2.42	0.741	<DL	<DL	1070	73.1	0.938	<DL	<DL	<DL	43.9
M13a	Muscle	2.46	<DL	0.064	1.2	2.96	103	<DL	1350	6.87	1.23	<DL	<DL	<DL	68.1
M13a	Rep. Org	4.32	<DL	0.217	1.79	1	<DL	<DL	350	18.4	<DL	<DL	<DL	<DL	43.8
M13a	Rep. Org	4.6	<DL	0.213	1.92	0.952	<DL	<DL	358	18.7	<DL	<DL	<DL	<DL	45.5
M14a	Liver	0.866	<DL	0.273	1.18	5.51	990	<DL	663	16.8	0.255	<DL	<DL	1.89	85.5
M14a	Kidney	0.667	<DL	0.399	0.754	7.83	494	<DL	641	14.6	0.513	<DL	<DL	5.71	70.4
M14a	Lung	<DL	<DL	0.195	1.18	3	2090	<DL	763	1.89	<DL	<DL	<DL	<DL	56.1
M14a	Spleen	<DL	<DL	<DL	3.6	2.06	<DL	<DL	1040	19	2	<DL	<DL	<DL	127
M14a	Muscle	3.25	<DL	0.228	1.3	2.81	47.8	<DL	1240	43.5	0.327	<DL	<DL	0.815	62.9
M15a	Liver	5.36	<DL	0.516	0.972	6.55	1030	<DL	1300	14.5	<DL	<DL	<DL	2.12	99.1
M15a	Kidney	4	<DL	0.951	0.927	10.8	554	<DL	820	25.1	<DL	<DL	<DL	8.17	84.2

M15a	Lung	1.13	<DL	0.267	1.2	2.01	1960	<DL	555	2.26	<DL	<DL	<DL	2.35	45.6
M15a	Adipose	<DL	<DL	0.188	1.39	0.211	<DL	<DL	200	25	<DL	<DL	<DL	1.36	26.8
M15a	Muscle	0.813	<DL	0.0823	1.06	2.33	<DL	<DL	1180	3.91	<DL	<DL	<DL	<DL	58.8
M16a	Liver	1.08	<DL	0.189	1.07	7.93	749	<DL	848	39	<DL	0.138	<DL	1.37	109
M16a	Kidney	1.12	0.0814	0.248	0.782	10.2	524	<DL	665	35.1	<DL	<DL	<DL	3.28	79.4
M16a	Lung	<DL	<DL	<DL	0.894	2.88	1550	<DL	679	2.44	<DL	<DL	<DL	<DL	53.1
M16a	Spleen	<DL	<DL	<DL	<DL	1.74	<DL	<DL	1190	49.5	<DL	<DL	<DL	<DL	66.7
M16a	Adipose	<DL	<DL	0.184	1.72	0.709	<DL	<DL	323	69.9	<DL	0.195	<DL	<DL	21.3
M16a	Muscle	<DL	<DL	<DL	1.35	3.56	23.4	<DL	1290	3.82	<DL	<DL	<DL	<DL	82.3
M16a	Rep. Org	<DL	<DL	0.573	<DL	2.89	<DL	<DL	1850	208	<DL	3.2	<DL	<DL	382
M17a	Liver	2.23	<DL	0.264	1.06	7.35	1770	<DL	550	43.2	<DL	<DL	<DL	<DL	94.7
M17a	Kidney	1.21	<DL	0.346	0.96	9.72	429	<DL	643	28.6	0.386	<DL	<DL	3.28	76.4
M17a	Lung	<DL	<DL	<DL	2.17	3.05	1900	<DL	754	9.97	0.919	<DL	<DL	3.8	77.6
M17a	Adipose	<DL	<DL	0.203	1.76	0.688	<DL	<DL	524	36.7	1.05	<DL	<DL	<DL	57.7
M17a	Muscle	0.673	<DL	<DL	1.2	5.66	52.1	<DL	1230	2.77	<DL	<DL	<DL	<DL	113
B17a	Liver	<DL	1.75	0.231	1.49	13.4	616	<DL	1000	16.1	0.51	0.19	<DL	1.97	205
B17a	Liver	<DL	1.73	0.23	1.46	13.3	609	<DL	995	16.2	0.506	0.189	<DL	<DL	203
B17a	Kidney	<DL	15.1	0.273	1.22	17.2	449	<DL	1160	30.6	0.482	<DL	<DL	4.22	161
B17a	Lung	<DL	0.156	<DL	1.17	7.04	2140	<DL	471	1.21	1.37	0.106	<DL	0.848	63.1
B17a	Spleen	<DL	0.645	0.13	1.3	5.78	378	<DL	1080	15.4	<DL	<DL	<DL	<DL	131
B17a	Adipose	<DL	<DL	<DL	1.99	0.16	<DL	<DL	45.7	0.562	0.323	<DL	<DL	<DL	4.35
B17a	Muscle	<DL	<DL	<DL	1.16	5.05	105	<DL	1190	2.67	0.278	0.0626	<DL	<DL	236
B17a	Rep. Org	<DL	0.536	0.0649	2.11	3.84	101	<DL	1080	35.8	0.281	<DL	<DL	0.456	64.7
B18a	Liver	<DL	2.12	0.284	1.66	5.21	388	<DL	1000	75.2	0.585	0.119	<DL	0.569	115
B18a	Kidney	<DL	21.3	0.37	1.53	15.5	173	<DL	1230	74.1	0.538	<DL	<DL	6.55	170
B18a	Lung	<DL	1.36	0.158	1.52	11.8	1490	<DL	1230	24.9	0.293	<DL	<DL	<DL	133
B18a	Spleen	0.221	0.83	0.353	1.7	8.81	786	<DL	2100	135	0.584	<DL	<DL	1.38	142
B18a	Adipose	<DL	<DL	<DL	1.94	0.0996	<DL	<DL	32.6	1.1	<DL	0.142	<DL	<DL	3.93
B18a	Muscle	<DL	0.0528	0.0765	1.73	2.64	<DL	<DL	1150	101	<DL	<DL	<DL	0.771	108
B18a	Rep. Org	<DL	0.283	0.178	1.39	7.62	7.92	<DL	881	22.4	<DL	<DL	<DL	2.51	90
B19a	Liver	<DL	4.71	0.111	1.21	13.2	891	<DL	680	23.4	<DL	<DL	<DL	1.16	115
B19a	Kidney	<DL	134	0.283	1.56	21.7	317	<DL	1230	36.1	0.33	<DL	<DL	4.95	217
B19a	Lung	<DL	0.411	<DL	1.06	9.65	1350	<DL	601	3.64	<DL	<DL	<DL	1.92	52.3
B19a	Spleen	<DL	1.23	0.0588	0.874	8.21	898	<DL	896	55	0.239	<DL	<DL	1.03	104
B19a	Adipose	<DL	0.0582	<DL	1.69	0.54	<DL	<DL	131	2.2	<DL	<DL	<DL	<DL	17.8
B19a	Muscle	<DL	0.187	<DL	1.32	2.13	<DL	<DL	1120	0.154	<DL	<DL	<DL	<DL	47.1
B19a	Rep. Org	<DL	0.282	<DL	1.52	1.87	<DL	<DL	168	8.34	0.233	<DL	<DL	<DL	19
B20a	Liver	<DL	0.844	0.131	1.27	15.4	782	<DL	998	11.6	<DL	0.0813	<DL	1.01	125
B20a	Kidney	0.251	3.82	0.13	1.78	13.5	332	<DL	893	6.82	0.562	<DL	<DL	4.89	131
B20a	Lung	<DL	0.137	<DL	1.03	6.67	1200	<DL	596	1.35	<DL	<DL	<DL	1.45	64.1
B20a	Spleen	<DL	0.538	0.118	0.998	5.32	458	<DL	1110	7.47	<DL	<DL	<DL	1.32	115
B20a	Adipose	<DL	0.0598	<DL	2.11	1.43	<DL	<DL	173	3.49	0.299	0.185	<DL	<DL	19.3
B20a	Adipose	<DL	0.062	<DL	2.18	1.48	<DL	<DL	177	3.58	0.286	0.189	<DL	<DL	20

B20a	Muscle	<DL	<DL	<DL	1.15	5.55	129	<DL	1300	1	<DL	<DL	<DL	1.66	194
B20a	Rep. Org	<DL	0.202	<DL	1.27	5.21	155	<DL	1030	12.4	<DL	<DL	<DL	1.23	67.7
M1b	Liver	<DL	0.081	0.0963	1.42	10.1	910	<DL	981	9.49	0.341	<DL	<DL	4.6	111
M1b	Kidney	0.146	0.405	0.144	1.1	13.7	718	<DL	1350	18.8	0.463	0.0547	<DL	8.64	88.1
M1b	Lung	<DL	<DL	<DL	0.973	7.27	1020	<DL	819	2.46	<DL	<DL	<DL	3.94	76.7
M1b	Spleen	<DL	<DL	<DL	2.55	7.1	178	<DL	1410	26.8	<DL	<DL	<DL	<DL	179
M1b	Adipose	<DL	<DL	<DL	1.55	0.341	<DL	<DL	107	2.43	<DL	0.113	<DL	<DL	21.4
M1b	Muscle	<DL	<DL	<DL	1.16	4.24	126	<DL	915	2.65	0.426	0.128	<DL	2.61	80
M1b	Rep. Org	<DL	<DL	0.264	1.76	0.986	<DL	<DL	725	12.2	<DL	<DL	<DL	<DL	27.8
M2b	Liver	<DL	0.0787	0.0764	1.06	12.1	667	<DL	1090	11.4	0.357	<DL	<DL	6.7	96.7
M2b	Kidney	<DL	0.263	0.0705	0.895	15.5	297	<DL	785	11.6	0.517	0.0691	<DL	10.3	86.7
M2b	Kidney	0.217	0.272	0.0695	0.888	15.5	295	<DL	784	11.4	0.485	0.0703	<DL	10.5	86.5
M2b	Lung	<DL	<DL	<DL	0.959	6.62	894	<DL	703	2.45	<DL	<DL	<DL	4.35	67.3
M2b	Spleen	<DL	<DL	<DL	<DL	8.22	237	<DL	1020	17.2	<DL	0.295	<DL	5.88	92.8
M2b	Adipose	<DL	<DL	0.386	<DL	3.43	71	<DL	2220	33.3	<DL	0.848	<DL	<DL	132
M2b	Muscle	<DL	<DL	0.0254	0.969	4.19	119	<DL	949	2.87	<DL	<DL	<DL	2.63	110
M2b	Rep. Org	<DL	<DL	<DL	<DL	5.65	<DL	<DL	3590	38.3	<DL	<DL	<DL	<DL	115
M3b	Liver	<DL	0.0996	0.368	1.44	16.2	938	<DL	934	9.19	0.287	<DL	<DL	2.68	109
M3b	Kidney	0.216	0.277	0.596	1.29	15.6	595	<DL	804	7.48	2.92	0.147	<DL	10.1	98.3
M3b	Lung	<DL	<DL	<DL	<DL	3.93	1390	<DL	452	1.16	<DL	<DL	<DL	3.2	48.7
M3b	Spleen	<DL	<DL	<DL	<DL	3.21	147	<DL	837	1.94	<DL	<DL	<DL	<DL	94.5
M3b	Adipose	<DL	<DL	<DL	1.64	0.242	<DL	<DL	45	0.488	<DL	0.0583	<DL	<DL	13.3
M3b	Muscle	0.172	<DL	0.0308	1.19	5.74	123	<DL	1000	3.69	<DL	0.303	<DL	<DL	117
M3b	Rep. Org	<DL	<DL	<DL	1.56	0.873	<DL	<DL	238	1.46	<DL	<DL	<DL	<DL	30.9
M4b	Liver	<DL	<DL	0.145	1.04	10.2	896	<DL	712	10.3	<DL	<DL	<DL	3.12	117
M4b	Kidney	0.204	0.133	0.391	1.08	13.9	683	<DL	695	13.6	2.05	0.0643	<DL	9.15	91.1
M4b	Kidney	0.237	0.124	0.393	1.1	14	691	<DL	703	13.6	2.09	0.0584	<DL	10.2	91.4
M4b	Lung	<DL	<DL	<DL	<DL	6.27	1150	<DL	709	5.08	<DL	<DL	<DL	3.69	138
M4b	Spleen	<DL	<DL	<DL	<DL	3.34	6090	<DL	1010	31.8	<DL	<DL	<DL	5.24	176
M4b	Adipose	<DL	<DL	0.147	4.35	2.58	<DL	<DL	704	6.67	<DL	0.268	<DL	<DL	73.8
M4b	Muscle	<DL	<DL	0.091	1.32	5.79	<DL	<DL	699	1.78	2.21	0.335	<DL	2.17	159
M4b	Rep. Org	0.331	<DL	0.0925	1.72	0.176	<DL	<DL	185	5.53	<DL	<DL	<DL	<DL	20.1
M5b	Liver	<DL	0.0403	0.468	1.21	11	837	<DL	776	9.01	0.27	0.148	<DL	5.35	128
M5b	Kidney	<DL	0.163	0.442	0.918	12.8	718	<DL	679	8.33	1.21	0.0969	<DL	9.67	91.9
M5b	Lung	<DL	<DL	0.0598	0.893	4.28	1420	<DL	492	1.53	<DL	<DL	<DL	<DL	53.4
M5b	Spleen	<DL	<DL	0.441	4.51	9.61	1210	<DL	1750	15.1	2.57	0.217	<DL	3.07	142
M5b	Adipose	<DL	<DL	0.0614	2.58	0.248	<DL	<DL	153	2.12	0.612	0.23	<DL	<DL	6.05
M5b	Muscle	<DL	<DL	0.0478	2.03	6.66	272	<DL	1330	3.2	0.541	0.0771	<DL	0.867	108
M5b	Rep. Org	<DL	<DL	0.308	4.11	3.71	795	<DL	561	16.2	2.08	0.135	<DL	<DL	35.8
M6b	Liver	<DL	<DL	0.277	2.45	18.8	842	<DL	1240	24.2	0.466	<DL	<DL	1.68	159
M6b	Kidney	<DL	0.154	0.264	1.6	13.5	497	<DL	817	24.3	1.05	<DL	<DL	3.96	97.4
M6b	Lung	<DL	<DL	<DL	2.27	5.79	1740	<DL	785	3.61	0.542	3.72	<DL	<DL	48.8
M6b	Spleen	<DL	<DL	<DL	3.04	<DL	<DL	<DL	329	16.6	1.6	<DL	<DL	<DL	26.7

M6b	Adipose	<DL	<DL	<DL	2.19	<DL	<DL	<DL	83.7	0.612	0.177	<DL	<DL	<DL	2.55
M6b	Muscle	<DL	<DL	<DL	1.57	4.4	188	<DL	1040	2.38	0.278	<DL	<DL	0.849	110
M6b	Muscle	<DL	<DL	<DL	1.55	4.44	194	<DL	1070	2.44	0.273	<DL	<DL	0.699	111
M6b	Rep. Org	<DL	<DL	0.102	4.19	3.07	228	<DL	830	10.2	0.744	0.189	<DL	<DL	81.1
M7b	Liver	<DL	<DL	0.278	1.72	9.58	525	<DL	851	17.6	0.848	<DL	<DL	1.29	90.9
M7b	Kidney	<DL	<DL	0.27	1.4	11	390	<DL	1050	22.1	1.3	<DL	<DL	3.11	84
M7b	Lung	<DL	<DL	<DL	1.96	4.19	1930	<DL	686	2.52	0.49	0.984	<DL	<DL	58.8
M7b	Spleen	<DL	<DL	0.251	1.99	4.71	520	<DL	1890	33.7	2.24	<DL	<DL	2.28	113
M7b	Adipose	<DL	<DL	<DL	1.79	0.203	24.7	<DL	334	4.33	0.353	0.043	<DL	<DL	11.7
M7b	Muscle	<DL	<DL	<DL	1.32	2.22	40.6	<DL	1270	1.52	0.27	<DL	<DL	<DL	47.5
M7b	Rep. Org	<DL	<DL	1.22	4.84	4.66	<DL	<DL	1450	10.8	1.78	<DL	<DL	<DL	77.4
M8b	Liver	<DL	<DL	0.138	1.11	10.5	821	<DL	480	7.08	0.165	<DL	<DL	0.564	85.9
M8b	Kidney	<DL	<DL	0.218	1.2	9.02	382	<DL	553	13.1	0.927	<DL	<DL	2.7	76.5
M8b	Lung	<DL	<DL	<DL	1.91	4.01	1980	<DL	602	1.88	0.383	<DL	<DL	1.41	60.6
M8b	Spleen	<DL	<DL	0.146	2.14	13.4	559	<DL	682	9.19	0.729	2.43	<DL	<DL	132
M8b	Adipose	<DL	<DL	<DL	2.59	<DL	<DL	<DL	215	2.42	0.393	0.0949	<DL	<DL	11.7
M8b	Muscle	<DL	<DL	<DL	2.12	6.41	193	<DL	1770	1.85	0.374	0.829	<DL	<DL	130
M8b	Muscle	<DL	<DL	<DL	1.49	4.31	92	<DL	1170	1.23	0.239	0.572	<DL	0.654	90.6
M8b	Rep. Org	<DL	<DL	<DL	2.77	0.121	<DL	<DL	105	1.86	0.466	<DL	<DL	<DL	23.3
M10b	Liver	0.194	<DL	0.394	1.97	14.4	958	<DL	1180	15.2	0.904	<DL	<DL	0.721	143
M10b	Kidney	<DL	0.095	0.161	1.03	7.43	421	<DL	591	9.87	0.937	<DL	<DL	2.08	62.1
M10b	Lung	<DL	<DL	0.0334	1.34	5.16	1590	<DL	556	2	0.275	<DL	<DL	0.953	47.2
M10b	Spleen	<DL	<DL	0.185	3.05	3.58	348	<DL	1080	22.9	1.97	<DL	<DL	<DL	98.9
M10b	Adipose	<DL	<DL	<DL	2.42	0.457	<DL	<DL	165	1.62	0.442	0.106	<DL	<DL	8.1
M10b	Muscle	<DL	<DL	<DL	1.18	2.76	69.6	<DL	888	0.853	0.263	<DL	<DL	<DL	75.9
M10b	Rep. Org	<DL	<DL	0.128	1.54	2.22	514	<DL	463	8.28	0.83	<DL	<DL	<DL	33.5
M11b	Liver	<DL	<DL	0.288	1.84	15.6	1630	<DL	931	10.2	0.329	<DL	<DL	0.752	135
M11b	Kidney	<DL	<DL	0.222	1.2	8.03	379	<DL	801	14.6	1.11	<DL	<DL	2.01	70.8
M11b	Lung	<DL	<DL	<DL	1.84	3.67	1470	<DL	680	2.7	0.569	<DL	<DL	<DL	55.1
M11b	Spleen	<DL	<DL	0.169	1.78	1.87	369	<DL	936	46.9	1.16	<DL	<DL	<DL	64.9
M11b	Adipose	<DL	<DL	<DL	2.71	1.22	<DL	<DL	262	2.5	0.494	0.156	<DL	<DL	21.8
M11b	Muscle	<DL	<DL	<DL	1.53	3.48	30.8	<DL	1060	0.832	0.308	<DL	<DL	<DL	107
M11b	Rep. Org	<DL	<DL	<DL	2.46	<DL	<DL	<DL	296	8.66	0.805	1.15	<DL	<DL	36.2
Mi1b	Liver	<DL	0.35	0.0577	1.1	43.8	1480	4.16	514	10.7	<DL	0.106	<DL	3.38	137
Mi1b	Kidney	<DL	1.93	0.119	1.09	23.1	729	3.35	573	3.64	<DL	0.0598	<DL	5.34	123
Mi1b	Lung	<DL	<DL	<DL	1.38	3.72	1350	<DL	424	0.37	<DL	<DL	<DL	3.31	44.8
Mi1b	Spleen	<DL	<DL	<DL	2.43	8.28	3770	<DL	1040	2.84	0.523	<DL	<DL	4.66	241
Mi1b	Muscle	<DL	<DL	0.0421	1.83	12	303	3.13	1090	1.67	0.713	0.498	<DL	1.28	157
Mi2b	Liver	<DL	0.101	<DL	1.08	35.3	1120	8.12	574	11	<DL	4.38	<DL	3.6	68.8
Mi2b	Kidney	<DL	0.573	0.0824	1.43	14.2	884	7.73	562	3.16	<DL	0.331	<DL	5.82	71.1
Mi2b	Lung	<DL	<DL	<DL	0.816	1.31	475	<DL	297	0.541	<DL	<DL	<DL	1.14	44.4
Mi2b	Lung	<DL	<DL	<DL	0.734	1.22	438	<DL	280	0.498	<DL	<DL	<DL	1.11	42.8
Mi2b	Spleen	<DL	<DL	<DL	4.33	8.04	3840	10.3	1440	3.21	0.667	<DL	<DL	6.08	172

Mi2b	Adipose	<DL	<DL	<DL	1.69	<DL	<DL	<DL	40.9	0.102	<DL	0.129	<DL	<DL	10.7
Mi2b	Muscle	<DL	<DL	<DL	1.53	8.65	112	5.7	905	1.21	0.283	0.167	<DL	1.3	96.4
Mi2b	Rep. Org	<DL	<DL	<DL	2.1	1.34	211	<DL	150	0.621	<DL	<DL	<DL	1.08	15.4
Mi3b	Liver	<DL	0.479	0.0768	1.43	62.3	2070	7.3	807	18.9	<DL	0.0897	<DL	3.4	140
Mi3b	Kidney	<DL	2.29	0.172	1.56	18.4	797	5.33	835	5.39	<DL	0.119	<DL	8.17	117
Mi3b	Lung	<DL	<DL	0.0439	2.21	4.39	1640	<DL	848	1.31	0.969	<DL	<DL	3.22	116
Mi3b	Spleen	<DL	<DL	0.0995	1.81	3.29	1580	<DL	728	1.21	<DL	<DL	<DL	3.38	112
Mi3b	Adipose	<DL	<DL	<DL	2.5	0.106	<DL	<DL	31.7	0.133	0.278	<DL	<DL	<DL	4.42
Mi3b	Muscle	<DL	<DL	<DL	1.69	12.3	160	4.11	1150	1.43	0.283	<DL	<DL	1.3	94.8
Mi3b	Rep. Org	<DL	<DL	<DL	2.12	1.1	<DL	<DL	389	0.709	<DL	<DL	<DL	<DL	53.1
Mi4b	Liver	<DL	0.28	0.0873	2.24	27.7	3440	9.5	962	11.3	<DL	0.11	<DL	4.34	94.6
Mi4b	Kidney	<DL	1.77	0.23	1.32	20.2	675	6.73	744	5.34	<DL	0.0649	<DL	6.54	104
Mi4b	Lung	<DL	<DL	0.0511	1.25	4.83	1500	2.89	684	1.16	<DL	<DL	<DL	3.19	88.3
Mi4b	Spleen	<DL	0.0927	0.0392	1.29	3.44	1100	2.71	544	0.879	<DL	<DL	<DL	2.04	72
Mi4b	Muscle	<DL	<DL	<DL	1.64	8.12	65.9	4.8	871	0.94	0.182	<DL	<DL	0.806	99.3
Mi4b	Rep. Org	<DL	<DL	<DL	2.74	2.27	<DL	<DL	434	0.874	0.673	0.511	<DL	<DL	63.5
O1b	Liver	<DL	0.59	0.0921	1.35	25.1	509	4.87	675	9.76	<DL	0.0424	<DL	5.27	89.3
O1b	Kidney	<DL	2.26	0.114	1.37	12.7	249	3.6	584	2.21	<DL	0.0697	<DL	5.03	79.8
O1b	Lung	0.213	<DL	0.202	1.53	5.68	1710	<DL	641	1.58	0.297	0.0556	<DL	3.63	72.8
O1b	Spleen	<DL	<DL	0.0351	1.6	2.89	2340	<DL	482	1.03	0.301	<DL	<DL	3.22	50.4
O1b	Adipose	<DL	<DL	<DL	1.99	0.408	<DL	<DL	140	0.838	0.384	<DL	<DL	0.783	16.6
O1b	Muscle	<DL	<DL	0.0559	1.76	9.94	410	2.65	1130	1.93	0.36	0.0792	<DL	2.13	168
O1b	Rep. Org	<DL	0.157	0.108	1.51	5.19	264	1.58	715	1.6	0.206	<DL	<DL	2.75	70.6
O2b	Liver	<DL	0.304	<DL	1.73	52.5	1290	13.6	784	10.4	0.317	<DL	<DL	6.48	79.2
O2b	Liver	<DL	0.3	<DL	1.48	47.5	1160	12.3	714	9.43	<DL	<DL	<DL	6.13	76
O2b	Kidney	<DL	1.9	0.0441	1.8	17.4	616	13.8	643	2.78	0.477	0.0736	<DL	7.21	63.6
O2b	Lung	0.262	<DL	0.0438	2.16	8.81	2230	4.55	779	2.17	0.22	<DL	<DL	4.99	65.8
O2b	Spleen	0.153	0.177	0.0237	1.34	4.32	2030	12.7	884	1.03	<DL	<DL	<DL	5.65	75.5
O2b	Adipose	<DL	<DL	<DL	2.86	1.06	<DL	4.47	106	0.286	0.318	<DL	<DL	1.61	12
O2b	Muscle	<DL	<DL	0.174	1.86	10.9	4030	6.89	1080	14	1.43	0.219	<DL	1.45	108
O2b	Rep. Org	<DL	0.211	0.0282	1.75	7.93	336	11.9	601	1.48	0.444	<DL	<DL	5.06	58
O3b	Liver	<DL	0.0853	0.0467	1.39	71.9	1030	7.52	721	12.1	<DL	0.0537	<DL	5.44	82.5
O3b	Kidney	<DL	0.272	0.0424	1.58	14.3	1270	4.29	704	3.09	<DL	0.241	<DL	5.46	79.5
O3b	Lung	0.165	<DL	<DL	1.71	4.36	2020	<DL	553	0.932	0.333	<DL	<DL	2.98	49.1
O3b	Spleen	0.188	<DL	0.0563	1.63	5.8	1950	1.95	1230	2.47	<DL	<DL	<DL	3.62	96.4
O3b	Adipose	<DL	<DL	<DL	3.12	0.499	<DL	<DL	133	0.677	1.21	<DL	<DL	<DL	10
O3b	Adipose	<DL	<DL	<DL	2	0.173	<DL	<DL	70	0.397	0.729	<DL	<DL	<DL	5.28
O3b	Muscle	<DL	<DL	<DL	1.65	13.3	374	2.41	1210	1.59	<DL	<DL	<DL	1.49	174
O3b	Rep. Org	<DL	<DL	<DL	1.61	3.66	210	<DL	416	1.42	<DL	<DL	<DL	1.33	52.9
O4b	Liver	0.274	<DL	0.0738	1.58	88.7	1870	15.9	884	15.3	<DL	0.0927	<DL	4.7	123
O4b	Kidney	<DL	0.127	<DL	1.72	11.5	845	8.27	606	2.72	<DL	<DL	<DL	5.36	76
O4b	Lung	<DL	<DL	<DL	1.71	6.43	2270	2.79	631	0.708	<DL	<DL	<DL	3.02	64.5
O4b	Spleen	<DL	<DL	<DL	1.52	4.07	1340	3.44	706	0.685	0.416	0.403	<DL	3.31	82.1

O4b	Adipose	<DL	<DL	<DL	2.11	0.0696	<DL	<DL	23	0.113	<DL	<DL	<DL	<DL	12.4
O4b	Muscle	<DL	<DL	<DL	1.6	10.4	153	5.46	1010	1.28	<DL	<DL	<DL	1.55	144
O4b	Rep. Org	<DL	<DL	<DL	1.67	2.11	111	<DL	344	0.759	<DL	<DL	<DL	1.69	34.3
O5b	Liver	<DL	<DL	0.0255	1.48	22.3	1590	6	635	10.8	0.156	<DL	<DL	5.5	84.3
O5b	Kidney	<DL	0.256	<DL	2.61	16.5	764	6.42	932	3.33	0.426	<DL	<DL	9.15	102
O5b	Lung	0.234	<DL	<DL	1.54	5.3	1770	<DL	593	0.833	0.327	0.046	<DL	3.63	54.3
O5b	Spleen	<DL	<DL	<DL	1.71	4.58	1480	<DL	809	1.09	<DL	<DL	<DL	3.01	90
O5b	Adipose	<DL	<DL	<DL	2.99	<DL	<DL	<DL	32.2	0.182	0.559	<DL	<DL	<DL	11.8
O5b	Adipose	<DL	<DL	<DL	2.87	<DL	<DL	<DL	29.9	0.155	0.552	<DL	<DL	<DL	13.4
O5b	Muscle	<DL	<DL	0.0673	1.86	4.84	1370	<DL	930	1.79	0.284	<DL	<DL	3.29	98.6
O5b	Rep. Org	<DL	<DL	<DL	1.96	7.38	<DL	<DL	46.1	0.45	0.325	0.0636	<DL	<DL	6.01
O6b	Liver	0.228	<DL	0.0641	2.52	17	582	<DL	1810	2.02	0.67	0.117	<DL	2.08	279
O6b	Kidney	<DL	<DL	0.0827	4.17	29.4	878	<DL	3030	6	1.44	0.191	<DL	3.08	478
O6b	Lung	<DL	<DL	<DL	3.38	2.01	263	<DL	360	0.386	0.258	<DL	<DL	1.5	46.7
O6b	Spleen	<DL	0.198	0.106	1.42	24.5	1170	1.84	641	7.23	0.206	<DL	<DL	3.69	72.1
O6b	Adipose	0.222	0.446	0.0413	1.18	5.47	225	<DL	440	1.45	0.27	<DL	<DL	2.49	44.4
O6b	Muscle	0.151	<DL	0.0375	1.34	5.17	1610	<DL	485	0.984	0.193	<DL	<DL	2.78	44.7
O6b	Rep. Org	<DL	<DL	<DL	1.84	1.04	146	<DL	300	0.689	0.288	<DL	0.283	<DL	68.7
B1b	Liver	0.152	20.7	0.253	1.69	9.14	552	<DL	709	20.3	0.4	<DL	0.134	<DL	152
B1b	Kidney	0.264	280	0.219	1.6	16.9	332	<DL	1590	30.1	0.912	<DL	0.111	2.42	253
B1b	Lung	<DL	7.01	0.106	1.59	6.47	1530	<DL	645	2.23	0.655	<DL	0.0934	0.714	102
B1b	Spleen	<DL	7.48	0.122	1.68	4.58	319	<DL	1490	46.3	0.835	<DL	0.0708	1.36	118
B1b	Adipose	<DL	<DL	0.023	2.22	<DL	36.1	<DL	137	2.87	0.492	0.0727	0.084	0.873	21.8
B1b	Rep. Org	<DL	5.08	0.0977	1.4	5.04	445	<DL	1330	33.8	0.482	<DL	<DL	1.54	90.8
B2b	Liver	<DL	0.999	0.172	1.04	6.68	256	<DL	476	10.7	0.386	<DL	<DL	1.5	123
B2b	Kidney	<DL	8.63	0.381	1.4	8.68	89.7	<DL	685	8.28	1.05	<DL	<DL	4.28	123
B2b	Lung	<DL	<DL	<DL	0.914	1.93	1410	<DL	177	0.42	0.275	<DL	<DL	1.93	28.9
B2b	Lung	<DL	<DL	<DL	0.919	1.98	1410	<DL	178	0.425	0.242	<DL	<DL	2.26	29.3
B2b	Spleen	<DL	<DL	0.076	1.47	4.5	1040	<DL	847	19.2	0.624	<DL	<DL	2.13	89.6
B2b	Adipose	<DL	<DL	<DL	2.46	0.322	<DL	<DL	100	0.568	0.26	<DL	<DL	1.49	13.9
B2b	Muscle	<DL	<DL	<DL	2.15	0.446	64.4	<DL	130	0.611	0.382	0.182	<DL	1.64	49.7
B2b	Rep. Org	<DL	<DL	<DL	5.12	<DL	<DL	<DL	893	56.3	1.51	<DL	<DL	14.9	131
B2b	C.gland	1.57	<DL	0.243	1.65	1.31	135	<DL	1120	0.186	0.483	<DL	<DL	1.22	30.9
B2b	Myst.lump	<DL	<DL	<DL	1.59	<DL	<DL	<DL	241	2.28	<DL	<DL	<DL	3.8	42.1
B3b	Liver	<DL	1.75	0.107	2.65	9.37	870	<DL	564	7.35	1.58	<DL	<DL	1.86	119
B3b	Kidney	<DL	14	0.281	1.29	6.96	160	<DL	556	6.54	0.82	<DL	<DL	4.58	116
B3b	Lung	<DL	<DL	0.0671	1.39	5.44	1370	<DL	586	1.69	1.29	<DL	<DL	2.28	57.7
B3b	Spleen	<DL	0.224	0.105	1.24	5.12	549	<DL	941	7.17	0.774	<DL	<DL	1.88	104
B3b	Muscle	<DL	<DL	<DL	1.46	1.71	131	<DL	916	0.533	0.511	<DL	<DL	2.34	214
B4b	Liver	<DL	4.09	0.196	1.42	8.84	660	<DL	741	50.2	0.429	<DL	<DL	1.91	149
B4b	Kidney	<DL	36.4	0.125	1.33	8.28	193	<DL	680	23	0.569	<DL	<DL	4.23	146
B4b	Lung	<DL	<DL	<DL	1.98	7.69	1880	<DL	430	1.59	0.63	<DL	<DL	3.35	49
B4b	Lung	<DL	<DL	<DL	1.65	6.16	1580	<DL	345	1.32	0.604	<DL	<DL	3.01	46.4

B4b	Spleen	<DL	0.328	0.0554	1.49	4.31	412	<DL	1110	138	0.63	<DL	<DL	2.46	122
B4b	Adipose	<DL	<DL	0.0582	1.21	0.573	<DL	<DL	<DL	0.274	<DL	<DL	<DL	2.35	13.5
B4b	Muscle	<DL	<DL	<DL	1.51	0.761	87.1	<DL	1240	0.492	<DL	<DL	<DL	1.83	88.9
B5b	Liver	<DL	1.66	0.214	1.42	7.2	781	<DL	655	24	0.423	<DL	<DL	2.14	132
B5b	Kidney	<DL	20.4	0.422	1.54	12.2	287	<DL	1230	26.9	0.679	<DL	<DL	4.63	175
B5b	Lung	<DL	0.196	0.0316	1.35	5.08	1800	<DL	438	1.77	0.702	<DL	<DL	2.02	57.3
B5b	Spleen	<DL	0.287	0.0616	1.58	3.15	447	<DL	1140	21.8	0.48	<DL	<DL	3.01	125
B5b	Adipose	<DL	<DL	<DL	3.11	<DL	<DL	<DL	<DL	0.215	0.254	<DL	<DL	2.28	8.11
B5b	Muscle	<DL	<DL	<DL	1.68	1.35	35.3	<DL	1120	0.428	0.323	<DL	<DL	2.21	96
B5b	Rep. Org	<DL	0.0559	0.0491	2.32	2.28	126	<DL	499	13.2	0.345	<DL	<DL	2.64	57.7
B6b	Liver	<DL	8.82	0.303	1.47	9.64	796	<DL	699	10.3	0.434	<DL	<DL	2.09	156
B6b	Kidney	<DL	128	0.409	2	15.7	259	<DL	1080	22.3	0.851	<DL	<DL	5.52	287
B6b	Lung	<DL	0.595	0.108	1.64	5.38	1400	<DL	453	1.62	0.772	<DL	<DL	2.98	72.1
B6b	Spleen	<DL	0.558	0.105	1.42	3.74	427	<DL	939	14.9	0.412	<DL	<DL	2.24	100
B6b	Adipose	<DL	0.193	<DL	2.93	<DL	<DL	<DL	<DL	0.298	<DL	<DL	<DL	1.39	9.14
B6b	Muscle	<DL	<DL	<DL	1.51	2.57	139	<DL	1250	0.703	0.178	<DL	<DL	1.57	82.3
B6b	Rep. Org	<DL	0.828	0.0228	2.19	2.58	70.6	<DL	366	18.8	0.229	<DL	<DL	1.33	41.5
B7b	Liver	<DL	1.61	0.234	1.55	6.19	1030	<DL	680	90.2	3.56	<DL	<DL	2.35	130
B7b	Kidney	<DL	14.8	0.451	1.48	9.12	302	<DL	937	16.7	2.64	<DL	<DL	4.6	129
B7b	Lung	<DL	0.152	0.0756	1.72	6.73	1770	<DL	622	3.54	1.07	<DL	<DL	2.43	76.9
B7b	Spleen	<DL	1.57	0.18	1.26	2.95	454	<DL	1140	151	5.3	<DL	<DL	2.48	97.4
B7b	Adipose	<DL	<DL	<DL	2.49	<DL	<DL	<DL	<DL	0.543	0.216	<DL	<DL	1.29	9.14
B7b	Muscle	<DL	<DL	<DL	1.28	2.24	180	<DL	792	1.34	0.206	<DL	<DL	2.07	222
B7b	Muscle	<DL	<DL	<DL	1.24	2.18	176	<DL	779	1.31	0.22	<DL	<DL	1.94	218
B7b	Rep. Org	<DL	0.15	0.23	1.83	3.65	132	<DL	1010	47.1	4.17	0.0722	<DL	2.73	106
B8b	Liver	<DL	2.58	0.174	1.41	6.87	880	<DL	707	22.4	0.47	0.0704	<DL	2.01	126
B8b	Kidney	<DL	26.6	0.278	1.91	10	294	<DL	899	21.3	0.664	0.0972	<DL	3.62	160
B8b	Lung	<DL	0.509	<DL	1.82	3.81	1890	<DL	493	3.83	0.797	<DL	<DL	2.29	70.5
B8b	Spleen	<DL	1.13	0.138	1.62	3.78	270	<DL	1150	21.9	0.573	<DL	<DL	<DL	124
B8b	Adipose	<DL	<DL	<DL	2.38	<DL	<DL	<DL	<DL	0.161	<DL	<DL	<DL	<DL	8.73
B8b	Muscle	<DL	<DL	<DL	0.814	0.297	<DL	<DL	384	0.804	<DL	<DL	<DL	<DL	109
B8b	Rep. Org	<DL	0.0996	<DL	1.91	0.459	<DL	<DL	132	10	0.466	<DL	<DL	<DL	25.3
B9b	Liver	<DL	2.32	0.15	1.23	5.16	177	<DL	489	22.4	<DL	<DL	<DL	<DL	123
B9b	Kidney	<DL	41.3	0.271	1.59	11.1	211	<DL	908	12.4	0.707	<DL	<DL	1.89	189
B9b	Lung	<DL	0.32	<DL	1.29	3.2	1740	<DL	312	1.59	0.596	<DL	<DL	<DL	46.8
B9b	Spleen	<DL	0.886	0.0826	1.42	2.93	221	<DL	1190	52.7	0.568	<DL	<DL	<DL	114
B9b	Adipose	<DL	<DL	<DL	1.9	<DL	<DL	<DL	<DL	0.149	<DL	<DL	<DL	<DL	6.56
B9b	Muscle	<DL	<DL	<DL	1.26	0.934	17.9	<DL	668	0.695	<DL	<DL	<DL	<DL	199
B9b	Rep. Org	<DL	0.421	<DL	1.65	1.13	<DL	<DL	365	23.7	0.295	<DL	<DL	<DL	34.2
B10b	Liver	<DL	0.914	0.166	1.28	5.3	402	<DL	503	13.6	<DL	<DL	<DL	<DL	114
B10b	Kidney	<DL	8.76	0.25	1.41	9.36	204	<DL	709	9.22	0.394	<DL	<DL	0.666	126
B10b	Lung	<DL	<DL	0.0333	1.47	3.68	1650	<DL	334	1.2	0.679	<DL	<DL	<DL	56.6
B10b	Spleen	<DL	0.396	0.0762	1.43	2.43	322	<DL	1040	49.1	0.501	<DL	<DL	<DL	106

B10b	Adipose	<DL	<DL	<DL	1.94	<DL	<DL	<DL	82.1	0.666	0.343	<DL	<DL	<DL	17.5
B10b	Muscle	<DL	<DL	<DL	1.48	1.49	36.7	<DL	582	1.23	0.29	<DL	<DL	<DL	149
B10b	Rep. Org	<DL	0.607	0.159	1.33	3.27	357	<DL	955	46.4	3.16	<DL	<DL	<DL	97.7
B11b	Liver	<DL	1.9	0.324	1.6	7.72	394	<DL	650	12.5	0.282	<DL	<DL	<DL	153
B11b	Kidney	<DL	59.9	0.609	1.42	10.7	316	<DL	701	11.7	2.61	<DL	<DL	1.53	145
B11b	Lung	<DL	0.27	0.0829	1.81	4.38	2050	<DL	573	2.44	0.643	<DL	<DL	<DL	110
B11b	Lung	<DL	0.234	0.0796	1.8	4.34	2020	<DL	572	2.44	0.612	<DL	<DL	<DL	110
B11b	Spleen	<DL	<DL	<DL	10.5	<DL	<DL	<DL	946	129	12.5	<DL	<DL	<DL	134
B11b	Adipose	<DL	<DL	<DL	2.21	<DL	<DL	<DL	<DL	0.389	<DL	<DL	<DL	<DL	5.83
B11b	Muscle	<DL	<DL	0.153	1.48	1.14	35.4	<DL	959	0.412	0.429	<DL	<DL	<DL	98.1
B11b	Rep. Org	<DL	0.929	0.126	1.57	4.94	54.6	<DL	1120	146	6.91	<DL	<DL	<DL	63.8
B12b	Liver	<DL	3.55	0.238	1.02	4.87	155	<DL	380	9.93	0.745	<DL	<DL	<DL	89.8
B12b	Kidney	<DL	7.63	0.257	0.68	3.97	9.53	<DL	360	9.75	<DL	<DL	<DL	<DL	67.9
B12b	Lung	<DL	<DL	<DL	1.13	4.92	1440	<DL	216	0.753	0.832	<DL	<DL	<DL	32.4
B12b	Spleen	<DL	0.112	<DL	1.66	<DL	<DL	<DL	126	5.5	0.212	<DL	<DL	<DL	21.2
B12b	Adipose	<DL	<DL	<DL	2.57	<DL	<DL	<DL	<DL	0.952	<DL	0.197	<DL	<DL	8.26
B12b	Muscle	<DL	<DL	<DL	1.69	1.64	35.6	<DL	944	0.713	0.215	0.205	<DL	<DL	151
B12b	Rep. Org	<DL	<DL	<DL	1.53	1.35	<DL	<DL	340	28	0.277	<DL	<DL	<DL	29.8
B12b	Rep. Org	<DL	<DL	<DL	1.53	1.34	<DL	<DL	340	27.7	0.224	<DL	<DL	<DL	29.2
B13b	Liver	<DL	0.942	0.0339	1.21	4.26	655	<DL	517	17.1	0.318	<DL	<DL	<DL	98.5
B13b	Kidney	<DL	26.5	0.188	1.32	7.51	485	<DL	736	15.6	0.618	<DL	<DL	<DL	164
B13b	Lung	<DL	0.512	<DL	1.08	7.7	1150	<DL	442	3.69	0.498	<DL	<DL	<DL	65.2
B13b	Spleen	<DL	1.39	<DL	1.13	3.16	364	<DL	369	16	0.566	<DL	<DL	<DL	114
B13b	Adipose	<DL	<DL	<DL	1.72	<DL	<DL	<DL	59.8	1.87	0.194	<DL	<DL	<DL	18.7
B13b	Muscle	<DL	<DL	<DL	1.33	0.517	<DL	<DL	601	1.2	<DL	<DL	<DL	<DL	118
B13b	Rep. Org	<DL	0.0918	0.0941	0.865	1.5	175	<DL	565	18.7	0.46	<DL	<DL	<DL	60.4
B14b	Liver	<DL	0.811	<DL	<DL	<DL	<DL	<DL	<DL	14	0.899	0.888	<DL	<DL	56.2
B14b	Kidney	<DL	71.5	0.572	1.07	8.95	276	<DL	644	12.9	2.32	<DL	<DL	2.04	143
B14b	Lung	<DL	7.54	0.512	2.68	9.32	685	<DL	1910	87.7	7.24	<DL	<DL	<DL	222
B14b	Spleen	<DL	0.346	0.038	0.566	1.75	433	<DL	115	1.36	0.437	<DL	<DL	<DL	13.5
B14b	Adipose	<DL	<DL	<DL	1.83	<DL	<DL	<DL	<DL	0.361	<DL	<DL	<DL	<DL	3.45
B14b	Muscle	<DL	<DL	<DL	0.971	0.289	4.24	<DL	544	0.363	<DL	<DL	<DL	<DL	106
B14b	Rep. Org	<DL	0.62	0.145	1.15	4.38	79.5	<DL	575	85.1	4.91	<DL	<DL	<DL	41.2
B14b	Rep. Org	<DL	0.607	0.142	1.08	4.14	72.2	<DL	545	81.6	4.85	<DL	<DL	<DL	41.2
B15b	Liver	<DL	13	<DL	2.04	2.63	492	<DL	272	12.4	<DL	0.332	<DL	<DL	125
B15b	Kidney	<DL	171	0.43	1.6	10.1	345	<DL	717	12.8	1.45	1.99	<DL	0.971	227
B15b	Lung	<DL	2.28	<DL	1.72	1.62	1600	<DL	175	1.37	<DL	<DL	<DL	<DL	39.7
B15b	Spleen	<DL	3.04	0.368	1.67	2.02	633	<DL	906	28.6	1.16	<DL	<DL	<DL	122
B15b	Adipose	<DL	<DL	<DL	2.34	<DL	<DL	<DL	<DL	0.315	<DL	<DL	<DL	<DL	<DL
B15b	Muscle	<DL	<DL	<DL	1.43	0.783	<DL	<DL	533	0.756	0.748	<DL	<DL	<DL	220
B15b	Rep. Org	<DL	2.47	0.064	1.2	3.14	217	<DL	586	33.7	1.91	<DL	<DL	<DL	69.5
B16b	Liver	<DL	0.488	0.0486	1.08	3.34	531	<DL	460	17.2	0.289	<DL	<DL	<DL	94
B16b	Kidney	0.356	28.8	0.342	4.24	23.5	1080	<DL	1990	53.3	0.986	3.61	<DL	6.68	334

B16b	Lung	0.426	0.461	<DL	1.94	4.03	2880	<DL	798	8.6	0.348	<DL	<DL	1.46	75.9
B16b	Spleen	<DL	0.472	<DL	1.03	1.09	1720	<DL	899	144	0.48	<DL	<DL	1.76	127
B16b	Adipose	<DL	<DL	<DL	1.91	<DL	<DL	<DL	67.1	0.809	0.403	<DL	<DL	<DL	7.62
B16b	Muscle	<DL	<DL	<DL	1.15	1.55	19	<DL	1010	0.943	<DL	<DL	<DL	1.5	297
B16b	Rep. Org	0.25	0.416	0.0303	1.71	3.65	264	<DL	910	140	0.296	<DL	<DL	0.859	84.3
B17b	Liver	<DL	1.91	0.163	2.02	7.69	1090	<DL	1090	34.2	<DL	<DL	<DL	4.7	169
B17b	Kidney	<DL	16.1	0.245	1.26	9.57	256	<DL	1000	7.88	0.325	<DL	<DL	3.05	149
B17b	Lung	<DL	0.0988	<DL	1.27	5.16	2120	<DL	502	1.61	<DL	<DL	<DL	0.819	52
B17b	Spleen	<DL	0.275	0.0374	2.11	4.09	1570	<DL	1350	62.2	0.468	<DL	<DL	1.65	114
B17b	Spleen	<DL	0.227	<DL	1.66	2.97	1290	<DL	1120	51.2	0.359	<DL	<DL	1.32	99.1
B17b	Adipose	<DL	0.27	<DL	3.48	0.354	98.1	<DL	377	2.32	0.351	0.907	0.055	0.519	3.46
B17b	Muscle	<DL	<DL	<DL	1.35	<DL	<DL	<DL	824	0.715	<DL	<DL	<DL	1.52	224
B17b	Rep. Org	<DL	0.112	<DL	2.34	0.288	<DL	<DL	245	13	0.194	<DL	<DL	<DL	9.58
B18b	Liver	<DL	5.5	0.176	1.36	14.7	822	<DL	857	15.6	0.23	0.0676	<DL	1.04	165
B18b	Kidney	<DL	38.9	0.418	1.66	10	503	<DL	983	13.1	0.51	<DL	<DL	3.18	163
B18b	Lung	<DL	0.256	<DL	1.09	2.77	1360	<DL	582	2.03	<DL	<DL	<DL	1.68	54.6
B18b	Spleen	<DL	0.353	0.148	1.42	6.19	1320	<DL	1050	5.95	0.503	<DL	<DL	0.941	89.2
B18b	Adipose	<DL	<DL	<DL	3.05	<DL	<DL	<DL	23.9	0.381	0.399	0.129	<DL	<DL	<DL
B18b	Muscle	<DL	<DL	0.0826	1.46	3.92	252	<DL	1260	0.914	<DL	<DL	<DL	1.22	277
B18b	Rep. Org	<DL	0.356	0.287	1.31	5.18	162	<DL	793	2.7	0.196	<DL	<DL	1.72	85.3
B19b	Liver	<DL	3.89	0.365	1.6	8.06	845	<DL	867	10.7	0.564	<DL	<DL	1.48	166
B19b	Kidney	<DL	51.8	0.644	1.53	14.3	645	<DL	1350	25.8	1.94	<DL	<DL	4.38	231
B19b	Lung	<DL	0.603	0.129	1.64	7.69	2450	<DL	617	1.9	0.308	<DL	<DL	1.49	62.6
B19b	Spleen	<DL	0.55	0.3	1.49	2.94	250	<DL	1080	42.5	2.51	<DL	<DL	1.69	91.8
B19b	Spleen	<DL	0.536	0.288	1.43	2.78	241	<DL	1040	41	2.28	<DL	<DL	1.26	91
B19b	Adipose	<DL	0.106	<DL	1.85	<DL	<DL	<DL	250	1.59	0.455	<DL	<DL	<DL	20.3
B19b	Muscle	<DL	0.052	<DL	1.57	2.06	111	<DL	1800	0.941	0.203	<DL	<DL	1.03	87.9
B19b	Rep. Org	<DL	0.47	0.369	1.93	5.24	194	<DL	1080	7.37	0.583	<DL	<DL	2.15	116
B20b	Liver	<DL	0.37	0.544	1.43	7.24	421	<DL	868	36.2	1.05	<DL	<DL	0.962	148
B20b	Kidney	<DL	2.21	0.549	1.11	10.2	288	<DL	1150	32	2.99	<DL	<DL	2.93	132
B20b	Lung	<DL	<DL	0.244	1.46	4.68	1940	<DL	675	4.02	0.743	0.599	<DL	1.96	69
B20b	Spleen	<DL	0.166	0.202	1.04	2.23	369	<DL	1150	83.6	2.61	<DL	<DL	1.19	112
B20b	Adipose	<DL	<DL	<DL	2.14	<DL	<DL	<DL	31.4	0.493	0.175	<DL	<DL	<DL	4.07
B20b	Muscle	<DL	<DL	<DL	1.4	1.73	212	<DL	1190	4.54	0.264	<DL	<DL	0.576	152
B20b	Rep. Org	<DL	0.237	0.143	1.73	3.02	191	<DL	867	98.1	2.85	<DL	<DL	0.811	60.3
B21b	Liver	<DL	1.6	0.0473	1.38	8.99	2030	<DL	833	59.5	0.29	<DL	<DL	1.26	143
B21b	Kidney	<DL	14.6	0.0692	1.08	9.52	384	<DL	923	18.4	0.205	<DL	<DL	2.05	136
B21b	Lung	<DL	0.218	<DL	1.18	3.47	2230	<DL	718	2.54	<DL	<DL	<DL	1.23	52
B21b	Spleen	<DL	1.11	<DL	1.04	2.34	1340	<DL	1020	32.2	<DL	<DL	<DL	2.03	110
B21b	Adipose	<DL	<DL	<DL	2.36	<DL	<DL	<DL	84.8	8.25	0.368	<DL	<DL	0.863	<DL
B21b	Muscle	<DL	<DL	<DL	1.34	1.43	106	<DL	1240	1.74	<DL	<DL	<DL	2.02	291
B21b	Rep. Org	<DL	0.234	0.24	1.29	6.66	310	<DL	1320	18.7	0.153	<DL	<DL	2.64	132
B22b	Liver	<DL	1.52	0.718	1.41	10.7	833	<DL	1160	20.4	5.79	0.402	<DL	1.83	160

B22b	Kidney	0.316	38.8	1.3	1.71	12.3	694	<DL	1500	19.6	7.11	0.716	<DL	4.69	191
B22b	Lung	<DL	0.552	0.144	1.71	12.5	2580	<DL	856	3.98	1.48	0.258	<DL	1.85	69.6
B22b	Spleen	<DL	1.98	0.403	1.55	4.76	1310	<DL	1420	17.9	7.63	0.713	<DL	2.24	150
B22b	Adipose	<DL	<DL	<DL	1.89	<DL	<DL	<DL	37	0.135	0.166	<DL	<DL	<DL	3.53
B22b	Muscle	<DL	<DL	0.0891	<DL	0.414	<DL	<DL	548	0.427	<DL	<DL	<DL	1.97	131
B22b	Muscle	<DL	<DL	0.0755	<DL	0.227	<DL	<DL	500	0.417	<DL	<DL	<DL	1.96	124
B22b	Rep. Org	<DL	0.297	0.405	1.32	4.72	233	<DL	911	3.66	2.21	<DL	<DL	2.04	81.3
B23b	Liver	<DL	2.25	0.216	1.53	11	591	<DL	900	15	0.203	<DL	<DL	1.35	160
B23b	Kidney	<DL	24.4	0.628	1.82	18.2	417	<DL	1300	10.7	0.405	<DL	<DL	5.19	200
B23b	Lung	<DL	0.193	<DL	1.01	5.71	1130	<DL	533	1.4	<DL	<DL	<DL	1.41	55.1
B23b	Spleen	<DL	0.232	0.0441	1.08	3.9	1010	<DL	828	13.6	0.18	<DL	<DL	0.955	83.5
B23b	Adipose	<DL	<DL	<DL	1.92	<DL	<DL	<DL	35.3	<DL	<DL	<DL	<DL	<DL	0.368
B23b	Muscle	<DL	<DL	<DL	0.847	1.34	7.5	<DL	874	0.218	<DL	<DL	<DL	0.846	221
B23b	Rep. Org	<DL	0.141	<DL	1.75	1.64	18.3	<DL	557	23.4	0.291	<DL	<DL	0.676	30.6
B24b	Liver	<DL	0.778	0.308	1.1	9.29	387	<DL	657	19.4	0.464	0.15	<DL	0.777	162
B24b	Kidney	<DL	3.34	0.541	1.18	11.3	314	<DL	1380	42.7	1.19	0.189	<DL	3	145
B24b	Lung	<DL	0.312	<DL	1.59	2.09	153	<DL	985	11.1	1.15	<DL	<DL	<DL	105
B24b	Spleen	<DL	0.625	0.157	1.16	3.01	441	<DL	948	36.5	0.921	<DL	<DL	0.668	100
B24b	Adipose	<DL	<DL	<DL	2.42	<DL	<DL	<DL	91.4	2.99	0.474	<DL	<DL	<DL	8.36
B24b	Muscle	<DL	<DL	<DL	<DL	<DL	<DL	<DL	906	9.99	0.614	<DL	<DL	<DL	62.1
B24b	Rep. Org	<DL	0.143	0.217	1.32	2.1	59.5	<DL	744	30.2	0.817	<DL	<DL	0.82	70.8
B25b	Liver	<DL	1.18	0.342	1.16	8.86	1120	<DL	1010	91.5	1.54	<DL	<DL	0.863	132
B25b	Kidney	0.051	5.67	0.359	0.898	7.65	313	<DL	993	39.8	0.932	0.0353	<DL	2.78	106
B25b	Lung	<DL	0.104	<DL	1.21	4.48	2390	<DL	508	2.65	0.24	<DL	<DL	<DL	45.9
B25b	Spleen	<DL	0.178	0.262	1.55	2.13	1240	<DL	1290	76.2	4.81	<DL	<DL	0.85	72.9
B25b	Adipose	<DL	<DL	<DL	2.11	<DL	<DL	<DL	61.7	0.211	<DL	<DL	<DL	<DL	<DL
B25b	Muscle	<DL	<DL	<DL	1.3	3.03	165	<DL	1280	2.02	0.255	0.855	<DL	0.889	202
B25b	Rep. Org	<DL	<DL	0.289	1.47	2.89	16	<DL	1480	23.8	1.2	<DL	<DL	1.64	148
B26b	Liver	<DL	4.64	0.156	1.2	9.31	941	<DL	711	31.8	0.143	<DL	<DL	0.491	148
B26b	Kidney	<DL	87.9	0.258	1.97	16.3	676	<DL	1350	28.6	0.304	<DL	<DL	2.48	236
B26b	Spleen	<DL	3.58	0.0638	2.2	5.21	431	<DL	1660	136	0.369	<DL	<DL	0.952	151
B26b	Spleen	<DL	2.28	<DL	1.38	2.85	244	<DL	1100	83.7	<DL	<DL	<DL	0.91	100
B26b	Adipose	<DL	<DL	<DL	2.15	<DL	<DL	<DL	29.2	0.0822	<DL	<DL	<DL	<DL	<DL
B26b	Muscle	<DL	<DL	<DL	1.36	1.51	175	<DL	1280	0.376	<DL	<DL	<DL	<DL	151
B26b	Rep. Org	<DL	0.309	0.0389	2.55	2.67	105	<DL	786	43.1	0.315	<DL	<DL	<DL	95
B27b	Liver	<DL	3.29	0.128	1.23	6.65	970	<DL	549	18.5	<DL	<DL	<DL	0.493	103
B27b	Kidney	<DL	90.3	0.273	1.41	11.9	629	<DL	934	15.8	0.188	<DL	<DL	3	198
B27b	Lung	<DL	0.749	0.0808	1.08	6.26	673	<DL	542	1.68	0.202	<DL	<DL	0.731	71
B27b	Spleen	<DL	4.51	0.0581	1	2.85	527	<DL	507	7.64	<DL	<DL	<DL	0.569	83.3
B27b	Adipose	<DL	<DL	<DL	2.98	<DL	<DL	<DL	23.5	0.554	<DL	<DL	<DL	<DL	3.42
B27b	Muscle	<DL	0.0515	0.0413	1.42	0.882	76.9	<DL	1250	0.208	<DL	<DL	<DL	<DL	95.9
B27b	Rep. Org	<DL	0.178	0.0789	1.04	24.4	1790	8.72	649	9.19	<DL	<DL	<DL	3.23	102
B27b	Rep. Org	<DL	0.168	0.0739	0.872	22.3	1640	8.05	592	8.44	<DL	<DL	<DL	3.14	93.2

Mi5b	Liver	<DL	0.349	<DL	1.69	<DL	<DL	<DL	396	4.51	0.261	<DL	<DL	<DL	123
Mi5b	Kidney	<DL	0.742	0.117	1.31	16.2	1040	5.37	598	3.92	0.128	<DL	<DL	4.42	97.7
Mi5b	Adipose	<DL	<DL	<DL	1.85	<DL	17	<DL	75.3	0.186	0.203	<DL	<DL	<DL	6.54
Mi5b	Muscle	<DL	<DL	<DL	1.02	4.84	89.7	4.85	823	0.762	<DL	<DL	<DL	1.19	101
Mi5b	Rep. Org	<DL	<DL	<DL	<DL	<DL	<DL	<DL	475	0.357	<DL	<DL	<DL	<DL	56.5
Mi6b	Liver	<DL	0.188	<DL	1.14	7.44	1260	10.6	667	8	0.317	<DL	<DL	2.81	111
Mi6b	Kidney	<DL	0.244	0.0755	1.2	4.42	404	4.5	399	2.37	<DL	<DL	<DL	3.04	54.2
Mi6b	Spleen	<DL	0.0479	<DL	1.15	0.456	724	3.95	550	1.22	<DL	<DL	<DL	1.76	76.3
Mi6b	Adipose	<DL	<DL	<DL	1.66	<DL	<DL	<DL	24.3	0.212	<DL	<DL	<DL	<DL	2.65
Mi6b	Muscle	<DL	<DL	<DL	1.39	6.08	154	6.86	909	0.972	0.37	<DL	<DL	0.881	90.8
Mi6b	Rep. Org	<DL	<DL	<DL	1.9	<DL	43.8	<DL	263	0.321	0.295	<DL	<DL	<DL	20
Mi7b	Liver	<DL	0.474	0.0722	1.24	25.5	1850	18	847	20.4	<DL	0.0501	<DL	5.29	137
Mi7b	Kidney	0.214	1.38	0.138	1.52	14.9	1150	13.9	882	3.78	0.148	0.0433	<DL	7.25	125
Mi7b	Spleen	<DL	<DL	<DL	2.88	<DL	<DL	<DL	264	0.289	<DL	<DL	<DL	<DL	43.7
Mi7b	Spleen	<DL	<DL	<DL	2.84	<DL	<DL	<DL	258	0.256	<DL	<DL	<DL	<DL	42.7
Mi7b	Adipose	<DL	<DL	<DL	0.82	<DL	214	4.72	400	0.65	<DL	<DL	<DL	1.12	71.2
Mi7b	Muscle	<DL	<DL	<DL	1.92	6.95	135	12.7	1370	1.24	0.635	<DL	<DL	<DL	140
Mi7b	Rep. Org	<DL	<DL	<DL	<DL	<DL	<DL	<DL	343	0.162	<DL	<DL	<DL	<DL	61.5
Mi8b	Liver	<DL	1.43	<DL	1.19	7.16	2120	<DL	665	8.57	4.28	<DL	<DL	3.43	111
Mi8b	Kidney	<DL	4.55	0.0643	1.75	8.19	498	<DL	747	2.58	0.338	<DL	<DL	4.43	97.7
Mi8b	Spleen	<DL	0.0316	0.0501	<DL	<DL	<DL	<DL	49.4	0.0459	<DL	<DL	<DL	<DL	4.77
Mi8b	Adipose	<DL	<DL	<DL	3.14	0.296	<DL	<DL	205	0.863	0.655	<DL	<DL	<DL	39.5
Mi8b	Muscle	<DL	<DL	<DL	3.17	6.86	<DL	<DL	1050	3.07	1.61	<DL	<DL	<DL	63.1
Mi9b	Liver	<DL	0.533	0.384	1.98	53.4	1700	21.6	806	22.9	0.82	<DL	<DL	6.56	147
Mi9b	Kidney	<DL	0.927	0.184	1.46	8.74	882	8.24	529	9.03	0.556	<DL	<DL	4	75
Mi9b	Spleen	<DL	0.0765	0.226	1.66	2.23	607	3.89	462	9.98	0.691	<DL	<DL	2.03	78.7
Mi9b	Adipose	<DL	<DL	0.145	3.4	<DL	162	<DL	111	2.87	0.522	0.556	<DL	<DL	7.19
Mi9b	Muscle	0.26	14.2	0.238	3.84	15.4	2910	16.2	1520	13.2	1.82	2.87	<DL	1.87	152
Mi9b	Rep. Org	<DL	<DL	<DL	7.18	<DL	<DL	<DL	964	2.94	3.21	<DL	<DL	<DL	46.8
Mi10b	Liver	<DL	0.687	0.0903	1.44	39.4	2160	12.3	754	13.8	0.492	0.134	<DL	3.76	158
Mi10b	Kidney	<DL	1.99	0.138	1.43	15.5	796	8.65	692	4.89	0.643	0.0585	<DL	6.21	113
Mi10b	Kidney	<DL	2.04	0.133	1.45	15.7	806	8.64	710	4.96	0.598	0.0543	<DL	5.92	113
Mi10b	Lung	<DL	<DL	0.0776	1.56	7.59	255	6.41	895	1.35	0.654	0.444	<DL	0.805	87.5
Mi10b	Spleen	<DL	<DL	<DL	1.38	2.13	2630	2.92	465	0.899	0.653	<DL	<DL	2.07	46.4
Mi10b	Adipose	<DL	<DL	0.117	2.4	<DL	12.7	<DL	83.3	0.651	0.817	<DL	<DL	<DL	9.06
Mi10b	Rep. Org	<DL	<DL	<DL	7.39	2.07	589	<DL	875	3.81	1.5	0.468	<DL	2.53	71.1
Mi11b	Liver	0.293	0.576	0.171	2.46	121	3410	7.77	1080	19.2	0.721	0.191	<DL	4.49	256
Mi11b	Kidney	0.32	0.764	0.167	1.61	19.6	686	3.23	665	3.22	0.702	<DL	<DL	5.46	132
Mi11b	Lung	0.23	<DL	<DL	1.66	8.66	1850	<DL	993	1.62	0.913	0.885	<DL	2.68	109
Mi11b	Spleen	<DL	<DL	<DL	2.2	6.03	3600	<DL	628	2.04	0.842	<DL	<DL	3.28	124
Mi11b	Muscle	<DL	<DL	0.16	4.13	11.6	680	3.8	1550	2.54	1.03	0.426	<DL	1.24	153
Mi11b	Rep. Org	<DL	<DL	<DL	10.8	<DL	<DL	<DL	2090	2.56	4.21	<DL	<DL	<DL	82.3
Mi12b	Liver	<DL	1.21	0.0277	2.7	18.2	1340	3.88	750	14.7	0.207	0.0593	<DL	3.42	93.5

Mi12b	Kidney	<DL	3.52	0.0755	2.35	15.1	816	3.53	579	3.9	0.273	0.0963	<DL	4.45	84.9
Mi12b	Lung	<DL	<DL	<DL	2.64	2.33	1950	<DL	783	0.759	0.627	0.0882	<DL	3.24	62.1
Mi12b	Spleen	<DL	0.213	<DL	3.3	3.08	694	<DL	1020	2.06	0.936	<DL	<DL	2.49	113
Mi12b	Spleen	<DL	0.157	<DL	2.32	1.57	444	<DL	771	1.53	0.487	<DL	<DL	2.82	81.3
Mi12b	Adipose	<DL	<DL	<DL	0.427	<DL	<DL	<DL	13.6	0.164	<DL	<DL	<DL	<DL	<DL
Mi12b	Muscle	<DL	<DL	0.0855	3.43	11	250	3.99	1100	1.96	0.847	0.246	<DL	1.45	100
Mi13b	Liver	<DL	0.202	0.0246	1.68	16	896	<DL	464	8.2	0.305	<DL	<DL	2.47	62.2
Mi13b	Kidney	<DL	1.89	0.186	3.57	24.3	969	<DL	1050	9.83	0.8	0.273	<DL	7.29	146
Mi13b	Lung	<DL	<DL	<DL	2.95	4.36	2190	<DL	859	1.29	0.837	<DL	<DL	3.3	88.5
Mi13b	Spleen	<DL	0.0675	0.0238	2.22	2.21	924	<DL	607	2.02	0.6	<DL	<DL	1.89	74.7
Mi13b	Adipose	<DL	<DL	<DL	<DL	<DL	<DL	<DL	1.65	0.0363	<DL	0.347	<DL	<DL	<DL
Mi13b	Muscle	<DL	<DL	<DL	4.64	18.3	285	2.81	1880	2.28	0.844	0.953	<DL	3.21	313
Mi13b	Rep. Org	<DL	<DL	<DL	3.32	0.927	<DL	<DL	561	1.23	1.13	<DL	<DL	2.56	24.4
Mi14b	Liver	<DL	0.847	0.21	3.56	38.5	1720	6.79	965	14	0.519	0.326	<DL	6.8	124
Mi14b	Kidney	<DL	1.15	0.279	2.48	16.7	558	3.36	631	3.61	0.534	0.235	<DL	6.13	96.1
Mi14b	Lung	0.242	0.119	0.0448	2.65	6.76	2070	2.06	716	1.83	0.428	<DL	<DL	3.98	57.1
Mi14b	Spleen	<DL	0.483	0.38	4.35	9.51	978	<DL	1080	3.03	1.44	<DL	<DL	4.45	168
Mi14b	Adipose	<DL	<DL	0.061	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
Mi14b	Muscle	<DL	<DL	0.233	5.1	19.6	469	6.51	1600	2.96	3.61	0.72	<DL	4.08	156
M10b	Liver	<DL	0.224	0.524	3.44	16.6	988	<DL	1140	15.4	0.565	0.21	<DL	2.72	121
M10b	Adipose	<DL	<DL	<DL	1.8	0.0598	67.7	<DL	161	1.05	0.358	0.208	<DL	<DL	5.07
M10b	Muscle	<DL	<DL	0.0394	2.63	4.35	253	<DL	1250	1.28	0.348	0.0833	<DL	0.755	64.4
M10b	Rep. Org	<DL	<DL	<DL	4.48	1.62	313	<DL	2110	7.92	1.54	<DL	<DL	<DL	103
M9b	Liver	<DL	0.171	0.365	2.26	9.56	578	<DL	573	7.39	1.02	<DL	<DL	2.21	91
M9b	Kidney	<DL	0.926	0.262	2.37	12	707	<DL	664	7.27	1.27	<DL	<DL	5.02	93.8
M9b	Lung	<DL	<DL	<DL	3.4	4.19	1560	<DL	712	3.38	0.774	<DL	<DL	<DL	40
M9b	Lung	<DL	<DL	<DL	2.76	2.8	1190	<DL	572	2.74	0.631	<DL	<DL	2.01	29.1
M9b	Spleen	<DL	<DL	<DL	3.79	4.52	543	<DL	1370	4.66	1.02	<DL	<DL	2.85	100
M9b	Adipose	<DL	<DL	0.0325	2.57	0.0424	114	<DL	388	3.39	0.438	0.16	<DL	<DL	10
M9b	Muscle	<DL	<DL	<DL	2.24	2.48	111	<DL	911	2.05	0.385	0.826	<DL	0.653	76.2
M9b	Rep. Org	<DL	<DL	0.0476	0.579	<DL	<DL	<DL	142	1.58	0.434	<DL	<DL	<DL	5.2
CS1	B1aLiver	<DL	12	0.39	0.82	15.2	569	<DL	750	8.23	0.208	<DL	<DL	2.58	144
CS2	B1aKidney	<DL	97	0.418	1.01	18	460	<DL	813	6.53	0.231	0.0629	<DL	4.37	197
CS3	B1aLung	<DL	0.566	0.296	0.583	7.07	1120	<DL	339	0.932	<DL	<DL	<DL	2.36	43.4
CS4	B1aSpleen	<DL	3.12	0.388	0.647	7.52	585	<DL	1270	15.4	0.647	<DL	<DL	2.38	104
CS6	B1aMuscle	<DL	<DL	0.0603	0.854	7.49	315	<DL	983	0.876	<DL	<DL	<DL	2.79	193
CS8	B2aLiver	<DL	2.22	0.376	0.717	10.6	539	<DL	454	5.94	0.285	0.317	<DL	2.74	118
CS9	B2aKidney	<DL	30.5	0.34	1.02	14.4	324	<DL	1060	6.45	0.4	0.113	<DL	3.98	132
CS10	B2aLung	<DL	1.4	0.137	0.724	8.79	1160	<DL	580	3.54	0.217	0.0966	<DL	2.39	62.7
CS11	B2aSpleen	<DL	3.52	0.217	0.592	6.04	468	<DL	1040	9.13	0.476	<DL	<DL	2.43	120
CS12	B2aAdi	<DL	<DL	<DL	1.05	7.53	<DL	<DL	34.3	0.336	<DL	0.797	<DL	1.34	7.91
CS13	B2aMuscle	<DL	<DL	0.0588	0.796	5.72	252	<DL	1050	1.22	0.156	<DL	<DL	1.86	65.1
CS14	B2aRepOrg	<DL	<DL	0.0578	1.21	2.72	95.7	<DL	364	3.62	0.215	<DL	<DL	2.48	30.9

CS16	B3aLiver	<DL	1.64	0.111	0.643	11.2	593	<DL	592	6.4	0.174	<DL	<DL	2.23	79.6
CS17	B3aKidney	<DL	0.127	0.029	0.566	6.47	1590	<DL	328	1.4	<DL	<DL	<DL	2.23	38.7
CS18	B3aLung	<DL	<DL	0.061	<DL	5.74	1300	<DL	488	1.16	0.411	<DL	<DL	8.86	46.8
CS19	B3aSpleen	<DL	3.07	0.0864	0.667	6.86	494	<DL	817	11.5	0.209	<DL	<DL	1.97	78.4
CS20	B3aAdi	<DL	<DL	<DL	1.16	0.697	23.1	<DL	108	3.23	<DL	<DL	<DL	1.08	8.84
CS21	B3aMuscle	<DL	<DL	<DL	0.686	3.87	103	<DL	1030	0.551	<DL	<DL	<DL	1.46	53.6
CS22	B3aRepOrg	<DL	0.514	0.24	0.783	7.47	180	<DL	919	3.98	<DL	0.0854	<DL	3.16	85.8
CS23	B4aLiver	<DL	7.07	0.121	0.666	11.5	997	<DL	699	14.1	<DL	0.0683	<DL	2.03	110
CS24	B4aKidney	<DL	80.7	0.242	0.829	17.4	430	<DL	903	9.65	0.321	0.118	<DL	2.86	151
CS25	B4aLung	<DL	0.666	0.0375	0.662	6.84	1680	<DL	401	1.48	<DL	<DL	<DL	1.58	41.5
CS26	B4aSpleen	<DL	2.49	0.0815	0.628	5.59	354	<DL	922	15.4	<DL	<DL	<DL	1.82	100
CS27	B4aAdi	<DL	<DL	<DL	1.05	0.664	26.2	<DL	112	0.393	<DL	<DL	<DL	1.36	6.07
CS28	B4aMuscle	<DL	<DL	<DL	0.822	3.93	215	<DL	1020	0.859	0.138	<DL	<DL	1.21	114
CS29	B4aRepOrg	<DL	1.24	0.0328	0.761	5.69	692	<DL	562	13.6	<DL	0.0606	<DL	1.84	49.1
CS30	B5aLiver	<DL	0.302	0.117	0.701	12.4	1130	<DL	738	7.35	0.183	0.0997	<DL	1.51	124
CS31	B5aKidney	<DL	2.78	0.216	0.664	14.8	285	<DL	926	6.12	0.383	<DL	<DL	2.62	105
CS32	B5aLung	<DL	<DL	<DL	0.66	7.13	1530	<DL	432	0.946	0.208	<DL	<DL	1.62	48
CS33	B5aSpleen	<DL	<DL	0.068	0.731	4.23	228	<DL	910	7.22	0.465	<DL	<DL	1.48	81.3
CS34	B5aAdi	<DL	<DL	<DL	1.21	0.613	1.54	<DL	47.4	0.968	0.2	<DL	<DL	1.12	7.05
CS35	B5aMuscle	<DL	<DL	<DL	0.814	3.3	67.8	<DL	934	0.558	0.303	<DL	<DL	1.36	61
CS36	B5aRepOrg	<DL	0.0924	0.0362	0.825	4.37	73.9	<DL	635	4.82	0.295	<DL	<DL	1.42	48.5
CS37	B6aLiver	<DL	2.88	0.0761	0.741	9.06	932	<DL	624	6.95	<DL	0.065	<DL	1.76	94.3
CS38	B6aKidney	<DL	41.7	0.152	0.785	13.7	453	<DL	818	11.2	0.287	<DL	<DL	2.75	118
CS39	B6aLung	<DL	0.13	<DL	0.724	9.1	1420	<DL	540	1.76	0.205	<DL	<DL	1.21	45.9
CS40	B6aSpleen	<DL	2.59	0.0492	0.738	6.04	477	<DL	1110	29.6	0.279	<DL	<DL	2	93.6
CS42	B6aMuscle	<DL	<DL	<DL	0.806	5.96	181	<DL	901	4.92	0.243	<DL	<DL	1.4	155
CS43	B6aRepOrg	<DL	0.118	0.141	0.908	5.39	112	<DL	664	8.07	0.2	<DL	<DL	1.57	54.1
CS44	B7aLiver	<DL	0.904	0.158	0.819	12	994	<DL	857	13.2	0.497	<DL	<DL	2.09	121
CS45	B7aKidney	<DL	6.87	0.324	0.66	14	321	<DL	945	15.9	0.668	<DL	<DL	2.66	115
CS46	B7aLung	<DL	<DL	<DL	0.645	6.86	1670	<DL	402	1.28	0.335	<DL	<DL	1.79	44.8
CS47	B7aSpleen	<DL	0.98	0.139	0.995	6.28	429	<DL	1060	14.4	0.813	<DL	<DL	2.22	106
CS48	B7aAdi	<DL	<DL	<DL	1.29	0.82	7.81	<DL	172	1.27	0.251	<DL	<DL	1.3	13.4
CS49	B7aMuscle	<DL	<DL	<DL	0.897	4.33	136	<DL	932	0.729	0.399	<DL	<DL	1.66	75.4
CS50	B7aRepOrg	<DL	<DL	0.159	0.97	7.3	144	<DL	886	3.34	0.363	<DL	<DL	2.07	80.5
CS51	B8aLiver	<DL	0.709	0.0866	0.634	10.8	1170	<DL	585	7.39	0.251	<DL	<DL	1.72	104
CS52	B8aKidney	<DL	8.28	0.211	0.681	15.7	389	<DL	892	7.59	0.57	0.201	<DL	3.13	110
CS53	B8aLung	0.267	<DL	0.096	0.699	9.86	1610	<DL	437	0.572	0.223	<DL	<DL	<DL	44.1
CS54	B8aSpleen	0.31	0.18	0.128	0.651	5.07	468	<DL	760	6.72	0.483	<DL	<DL	<DL	83.1
CS55	B8aAdi	<DL	<DL	0.0606	1.26	0.295	2.95	<DL	49.1	<DL	<DL	<DL	<DL	<DL	4.82
CS56	B8aMuscle	0.21	<DL	0.0727	0.868	5.07	158	<DL	1200	1.39	0.382	0.0595	<DL	<DL	109
CS57	B8aRepOrg	0.353	<DL	0.228	0.831	7.19	195	<DL	811	4.71	0.329	<DL	<DL	<DL	69.6
CS58	B9aLiver	0.502	1.94	0.183	0.805	12.9	784	<DL	657	9.12	0.288	0.0759	<DL	<DL	127
CS59	B9aKidney	<DL	14.9	0.292	0.814	14	437	<DL	1110	19.5	0.357	<DL	<DL	<DL	146

CS60	B9aLung	0.285	0.156	0.0529	0.613	7.13	1620	<DL	470	0.996	0.221	<DL	<DL	<DL	56.6
CS61	B9aSpleen	0.241	0.537	0.114	0.608	5.52	523	<DL	1130	22.2	0.261	<DL	<DL	<DL	95.9
CS62	B9aAdi	<DL	<DL	<DL	1.25	0.329	8.58	<DL	43.7	0.211	0.297	<DL	<DL	<DL	4.29
CS63	B9aMuscle	<DL	<DL	0.0373	0.875	4.1	251	<DL	988	3.99	0.434	<DL	<DL	<DL	87.1
CS64	B9aRepOrg	0.317	0.384	0.0931	0.837	6.05	251	<DL	904	20.4	0.433	<DL	<DL	<DL	69.4
CS65	B10aLiver	0.4	1.06	0.197	0.884	12.3	580	<DL	779	8.15	0.387	0.0667	<DL	<DL	133
CS66	B10aKidney	0.334	9.19	0.215	0.697	12.9	297	<DL	915	12.5	0.315	<DL	<DL	<DL	101
CS67	B10aLung	<DL	0.0922	0.0551	0.606	7.14	1170	<DL	513	1.67	0.399	<DL	<DL	<DL	57.4
CS68	B10aSpleen	<DL	1.37	0.115	0.772	4.72	339	<DL	830	8.75	0.385	<DL	<DL	<DL	77.8
CS69	B10aAdi	<DL	<DL	<DL	1.26	0.316	<DL	<DL	34.4	<DL	0.415	0.173	<DL	<DL	5.22
CS70	B10aMuscle	<DL	<DL	<DL	0.706	4.54	149	<DL	959	1.11	0.332	<DL	<DL	<DL	92.5
CS71	B10aRepOrg	<DL	<DL	0.103	1.53	4.89	102	<DL	555	12.2	0.374	0.803	<DL	<DL	50.2
CS72	B11aLiver	0.39	0.397	0.192	0.747	14.9	655	<DL	700	7.92	0.33	0.0553	<DL	<DL	129
CS73	B11aKidney	0.474	2.18	0.345	0.709	15.1	271	<DL	806	6.02	0.674	<DL	<DL	0.53	122
CS74	B11aLung	0.241	<DL	0.0456	0.769	7.22	2070	<DL	433	0.717	0.534	<DL	<DL	<DL	45.8
CS75	B11aSpleen	0.185	<DL	0.1	0.734	4.64	330	<DL	785	8.09	0.445	<DL	<DL	<DL	96.2
CS76	B11aAdi	<DL	<DL	0.0427	0.98	2.48	135	<DL	233	0.718	0.315	<DL	<DL	<DL	21.2
CS77	B11aMuscle	0.377	<DL	0.0293	0.571	5.23	170	<DL	939	0.639	0.256	<DL	<DL	<DL	215
CS78	B11aRepOrg	<DL	<DL	0.0496	0.851	3.95	126	<DL	502	6.83	0.467	<DL	<DL	<DL	35.3
CS79	B12aLiver	0.299	0.766	0.136	0.603	12.8	1650	<DL	793	7.99	0.47	<DL	<DL	<DL	110
CS80	B12aKidney	0.311	8.19	0.279	0.748	15.5	316	<DL	873	7	0.78	<DL	<DL	0.583	123
CS81	B12aLung	0.193	<DL	0.0563	0.637	7.85	1540	<DL	389	0.745	0.502	<DL	<DL	<DL	39.1
CS82	B12aSpleen	0.237	0.0591	0.0935	0.678	5.38	409	<DL	902	10.2	0.698	<DL	<DL	<DL	90.3
CS83	B12aAdi	<DL	<DL	<DL	1.16	0.86	1.4	<DL	89.5	<DL	0.433	<DL	<DL	<DL	7
CS84	B12aMuscle	0.459	<DL	<DL	0.616	4.56	129	<DL	921	1.09	0.46	0.0901	<DL	<DL	152
CS85	B12aRepOrg	0.262	<DL	0.0503	0.962	2.96	133	<DL	379	6.18	0.617	<DL	<DL	<DL	34.1
CS86	B13aLiver	0.233	2.34	0.209	0.631	7.73	533	<DL	651	10.7	1.09	0.14	<DL	<DL	103
CS87	B13aKidney	0.259	24.3	0.222	0.645	12.5	840	<DL	703	7.99	1.02	0.103	<DL	<DL	113
CS88	B13aLung	0.946	0.999	0.106	0.817	6.84	1560	<DL	673	2	0.983	0.142	<DL	<DL	56.5
CS89	B13aSpleen	<DL	1.86	0.0998	0.732	3.95	266	<DL	847	4.83	1.22	<DL	<DL	<DL	113
CS90	B13aAdi	<DL	<DL	<DL	1.37	0.427	6.34	<DL	45.7	<DL	0.269	<DL	<DL	<DL	1.87
CS91	B13aMuscle	0.348	0.247	0.0229	0.755	4.01	185	<DL	896	0.861	0.525	<DL	<DL	<DL	87.9
CS92	B13aRepOrg	0.762	16.7	0.392	3.59	21.3	960	<DL	3500	38.7	4.48	0.178	<DL	<DL	244
CS93	B14aLiver	<DL	18.9	0.136	0.651	13.2	924	<DL	596	7.95	0.592	0.388	<DL	6.24	133
CS94	B14aKidney	0.15	134	0.174	0.631	15.7	435	<DL	759	7	0.505	1.58	<DL	5.98	194
CS95	B14aLung	<DL	0.608	0.0385	0.595	9.19	1530	<DL	366	0.417	0.419	0.144	<DL	1.08	39.5
CS96	B14aSpleen	<DL	2.9	0.0909	0.637	8.65	534	<DL	967	13.3	0.747	<DL	<DL	1.34	99.7
CS97	B14aAdi	<DL	<DL	<DL	1.28	0.491	13.2	<DL	40	0.0522	0.376	1.19	<DL	<DL	9.89
CS98	B14aMuscle	0.205	<DL	0.0228	0.699	3.76	170	<DL	1010	0.0605	0.417	<DL	<DL	5.22	70.5
CS99	B14aRepOrg	0.159	0.134	<DL	1.2	1.44	27.8	<DL	147	2.96	0.32	<DL	<DL	<DL	10.5
CS100	B15aLiver	0.196	7.34	0.14	0.874	12.8	205	<DL	758	7.62	0.56	0.105	<DL	3.04	159
CS101	B15aKidney	<DL	45.8	<DL	1.33	17.3	362	<DL	978	9.02	<DL	<DL	<DL	5.62	202

CS102	B15aLung	<DL	1.03	<DL	1.45	6.79	1000	<DL	789	1.83	<DL	<DL	<DL	2.95	73.1
CS103	B15aSpleen	<DL	1.83	<DL	1.35	5.29	483	<DL	682	5.91	<DL	<DL	<DL	2.03	74.9
CS104	B15aAdi	<DL	<DL	<DL	2.12	0.288	<DL	<DL	13.4	0.392	<DL	<DL	<DL	<DL	2.28
CS105	B15aMuscle	<DL	<DL	<DL	1.5	3.75	45.1	<DL	751	0.544	<DL	<DL	<DL	5.15	94.5
CS106	B15aRepOrg	<DL	2.4	<DL	1.51	5.03	189	<DL	829	8.39	<DL	<DL	<DL	1.19	52.8
CS107	B16aLiver	<DL	0.404	<DL	1.1	10.6	682	<DL	560	6.99	<DL	<DL	<DL	<DL	110
CS108	B16aKidney	<DL	2.6	0.0636	1.22	15.2	509	<DL	900	8.26	<DL	<DL	<DL	0.751	113
CS109	B16aLung	<DL	0.0589	<DL	1.13	9.03	1420	<DL	475	1.21	<DL	<DL	<DL	<DL	51.4
CS110	B16aSpleen	<DL	0.185	<DL	1.13	5.6	466	<DL	922	6.19	<DL	<DL	<DL	<DL	96.3
CS111	B16aAdi	<DL	<DL	<DL	1.79	0.505	<DL	<DL	53.6	0.614	<DL	<DL	<DL	<DL	5.44
CS112	B16aMuscle	<DL	0.0641	<DL	1.17	5.55	122	<DL	985	6.93	<DL	<DL	<DL	<DL	92.9
CS113	B16aRepOrg	<DL	0.0834	<DL	1.61	2.88	104	<DL	392	5.39	<DL	<DL	<DL	<DL	32.5
CS128	M1aLiver	4.6	<DL	0.698	1.15	7.71	710	<DL	676	38.2	<DL	<DL	<DL	<DL	80.5
CS129	M1aKidney	3.26	0.0593	0.728	1.13	11.4	500	<DL	806	37.8	<DL	<DL	<DL	1.6	67.1
CS130	M1aLung	1.8	<DL	0.125	0.994	3.71	1190	<DL	650	4.37	<DL	<DL	<DL	<DL	51
CS131	M1aSpleen	<DL	<DL	<DL	3.52	4.51	<DL	<DL	1130	41	<DL	<DL	<DL	<DL	96.3
CS132	M1aAdi	<DL	<DL	<DL	1.98	0.495	<DL	<DL	85.1	2.35	<DL	<DL	<DL	<DL	3.7
CS133	M1aMuscle	2.5	<DL	<DL	1.1	3.99	80.3	<DL	907	8.54	<DL	<DL	<DL	<DL	46.8
CS134	M1aRepOrg	<DL	<DL	<DL	2.21	1.04	62.8	<DL	305	14.9	<DL	<DL	<DL	<DL	24.9
CS135	M2aLiver	1.08	0.0629	0.227	1.1	9.43	597	<DL	867	36.2	<DL	<DL	<DL	<DL	74.6
CS136	M2aKidney	1.92	0.204	0.304	1.08	11.2	459	<DL	805	40.5	<DL	<DL	<DL	1.62	69.8
CS137	M2aLung	<DL	<DL	<DL	1.15	4.76	1360	<DL	627	3.64	<DL	<DL	<DL	<DL	41.1
CS138	M2aSpleen	<DL	<DL	<DL	3.57	5.04	776	<DL	1070	92.9	<DL	<DL	<DL	<DL	121
CS139	M2aAdi	<DL	<DL	<DL	1.97	4.85	172	<DL	1050	3.19	<DL	<DL	<DL	<DL	75.1
CS140	M2aMuscle	<DL	<DL	<DL	1.09	4.83	201	<DL	986	2.85	<DL	<DL	<DL	<DL	69.5
CS141	M2aRepOrg	<DL	<DL	<DL	1.86	3.84	249	<DL	909	48.8	<DL	<DL	<DL	<DL	85.5
CS142	M3aLiver	<DL	0.0629	0.194	0.964	13.9	813	<DL	785	21.6	<DL	<DL	<DL	<DL	96.2
CS143	M3aKidney	<DL	0.126	0.352	1.14	12.8	646	<DL	893	53.2	<DL	<DL	<DL	1.07	72.7
CS144	M3aLung	<DL	<DL	<DL	5.36	6.99	845	<DL	744	6.9	<DL	<DL	<DL	<DL	61.7
CS145	M3aSpleen	<DL	<DL	<DL	2	5.46	687	<DL	976	120	<DL	<DL	<DL	<DL	93.2
CS146	M3aAdi	<DL	<DL	<DL	1.85	1.06	<DL	<DL	104	4.89	<DL	<DL	<DL	<DL	15.6
CS147	M3aMuscle	<DL	<DL	<DL	1.11	5.54	232	<DL	1020	12	<DL	<DL	<DL	<DL	60.5
CS148	M3aRepOrg	<DL	<DL	<DL	1.44	1.37	256	<DL	218	29.6	<DL	<DL	<DL	<DL	20.6
CS149	M4aLiver	0.509	<DL	<DL	1.1	7.95	810	<DL	676	34.1	<DL	<DL	<DL	<DL	74.3
CS150	M4aKidney	0.291	0.0854	<DL	1.06	11.5	769	<DL	720	44.5	<DL	<DL	<DL	<DL	66.7
CS151	M4aLung	<DL	<DL	<DL	1.41	4.36	1510	<DL	578	2.79	<DL	<DL	<DL	<DL	53.1
CS152	M4aSpleen	<DL	<DL	<DL	1.56	5.01	352	<DL	1190	122	<DL	<DL	<DL	<DL	98.1
CS153	M4aAdi	<DL	<DL	<DL	2.12	2.12	<DL	<DL	351	27.2	<DL	<DL	<DL	<DL	22.1
CS154	M4aMuscle	<DL	<DL	<DL	1.18	5.19	109	<DL	891	7.5	<DL	<DL	<DL	<DL	63
CS155	M4aRepOrg	<DL	<DL	<DL	2.94	3.95	417	<DL	937	135	<DL	<DL	<DL	<DL	71.2
CS156	M5aLiver	0.82	0.337	0.362	0.978	12.7	674	<DL	662	17.9	<DL	<DL	<DL	10.5	73.7
CS157	M5aKidney	0.48	1.45	0.702	1.06	13.3	620	<DL	710	18.7	<DL	<DL	<DL	11.6	70.4
CS158	M5aLung	<DL	<DL	<DL	1.46	7.28	1320	<DL	553	1.95	<DL	<DL	<DL	2.59	49.7

CS159	M5aSpleen	<DL	0.176	<DL	1.58	5.74	416	<DL	1000	28.8	<DL	<DL	<DL	3.66	84.3
CS160	M5aAdi	<DL	<DL	<DL	2.85	1.7	<DL	<DL	156	12.6	<DL	<DL	<DL	<DL	19.4
CS161	M5aMuscle	<DL	<DL	<DL	1.19	5.83	96.4	<DL	1010	1.19	<DL	<DL	<DL	4.32	69.9
CS162	M5aRepOrg	<DL	0.0416	0.0231	1.37	1.81	116	<DL	230	10.1	<DL	<DL	<DL	<DL	18.9
CS163	M6aLiver	1.07	0.24	0.0363	1.11	14.8	688	<DL	670	9.37	<DL	<DL	<DL	0.952	86.4
CS164	M6aKidney	4.89	1.09	0.555	1.07	16.8	420	<DL	773	9.21	1.06	<DL	<DL	4.91	74.4
CS165	M6aLung	1.06	<DL	0.155	2.18	5.15	1300	<DL	565	0.17	<DL	<DL	<DL	<DL	55
CS166	M6aSpleen	1.31	<DL	0.181	2.35	4.87	510	<DL	1060	5.97	<DL	<DL	<DL	<DL	104
CS167	M6aAdi	<DL	<DL	<DL	1.44	0.408	<DL	<DL	87.3	0.748	<DL	<DL	<DL	<DL	5.93
CS168	M6aMuscle	1.43	<DL	0.0425	1.43	4.1	44.2	<DL	1040	0.837	0.203	<DL	<DL	0.581	44.2
CS169	M6aRepOrg	0.211	<DL	0.0413	1.5	0.781	22.9	<DL	143	2.84	0.197	<DL	<DL	<DL	12.5
CS170	M7aLiver	0.613	<DL	0.247	1.07	8.32	593	<DL	635	10.5	<DL	<DL	<DL	1.24	79.4
CS171	M7aKidney	0.624	0.159	0.422	1.13	10.3	466	<DL	692	8.87	0.408	<DL	<DL	2.96	66.1
CS172	M7aLung	<DL	<DL	<DL	2.25	3.88	1100	<DL	619	1.3	<DL	<DL	<DL	<DL	52.9
CS173	M7aSpleen	<DL	<DL	<DL	2.57	2.8	23.3	<DL	638	6.37	<DL	<DL	<DL	<DL	75.1
CS174	M7aAdi	<DL	<DL	<DL	1.45	0.206	47.4	<DL	39.7	0.212	<DL	1.88	<DL	<DL	3.41
CS175	M7aMuscle	0.57	<DL	0.0508	1.11	4.01	101	<DL	820	8.54	0.257	<DL	<DL	<DL	78.8
CS176	M7aRepOrg	<DL	<DL	<DL	1.77	2	36.3	<DL	415	8.82	<DL	<DL	<DL	<DL	40.4
CS177	M8aLiver	2.77	0.337	0.235	1.17	15.6	833	<DL	603	10.4	0.265	<DL	<DL	1.74	72.7
CS178	M8aKidney	3.56	1.69	0.37	1.12	12	489	<DL	706	6.97	1.01	<DL	<DL	4.66	66.1
CS179	M8aLung	1.5	<DL	0.0954	1.09	6.01	1350	<DL	572	0.968	0.306	<DL	<DL	0.683	39.9
CS180	M8aSpleen	2.76	<DL	<DL	2.27	4.46	802	<DL	1030	12.6	0.896	<DL	<DL	<DL	89.6
CS181	M8aAdi	<DL	<DL	<DL	1.53	0.946	<DL	<DL	71.4	0.137	0.543	<DL	<DL	<DL	5.01
CS182	M8aMuscle	1.97	0.074	0.0321	1.32	6.13	246	<DL	1000	1.64	0.668	<DL	<DL	<DL	56.2
CS183	M8aRepOrg	1.11	<DL	0.108	1.33	3.19	775	<DL	472	3.19	0.727	<DL	<DL	<DL	26.9
CS184	M9aLiver	0.528	0.272	0.644	1.06	13.1	249	<DL	757	35.5	0.337	<DL	<DL	13.9	81.2
CS185	M9aKidney	0.671	0.854	0.948	1.05	12.8	214	<DL	783	21.8	0.438	<DL	<DL	14	75.4
CS186	M9aLung	<DL	<DL	0.0895	1.79	6.7	556	<DL	677	1.23	1.19	<DL	<DL	5.88	62.7
CS187	M9aSpleen	<DL	<DL	0.49	1.86	4.21	67.8	<DL	1100	29.7	0.949	<DL	<DL	7.54	93.9
CS188	M9aAdi	<DL	<DL	0.0934	1.57	0.667	<DL	<DL	124	6.26	0.47	<DL	<DL	<DL	11
CS189	M9aMuscle	0.298	<DL	0.174	1.11	5.31	53	<DL	901	14.3	0.558	<DL	<DL	5.38	64.1
CS190	M9aRepOrg	<DL	<DL	0.449	2.42	1.52	<DL	<DL	450	38.1	1.58	<DL	<DL	<DL	38.9
CS191	Mi1aLiver	0.368	1.14	0.0671	1.57	41	2060	2.82	1050	19.3	0.417	<DL	<DL	3.53	143
CS192	Mi1aKidney	<DL	2.78	0.0757	0.998	22.6	565	1.75	527	3.28	0.393	<DL	<DL	3.62	80.5
CS193	Mi1aLung	<DL	<DL	<DL	1.28	5.93	1550	<DL	543	1.12	<DL	<DL	<DL	2.82	57.9
CS194	Mi1aSpleen	<DL	0.248	<DL	1.24	5.17	1090	2.7	742	3.26	<DL	<DL	<DL	2.04	94.2
CS195	Mi1aAdi	<DL	<DL	<DL	1.49	1.36	<DL	<DL	164	0.269	<DL	<DL	<DL	<DL	21
CS196	Mi1aMuscle	<DL	<DL	<DL	1.15	10.7	149	2.26	916	1.35	<DL	<DL	<DL	1.14	87.1
CS197	Mi1aRepOrg	<DL	0.232	<DL	1.76	5.08	282	<DL	418	2.91	<DL	<DL	<DL	<DL	58.7
CS198	Mi2aLiver	<DL	0.361	0.115	1.59	36.4	1900	2.38	847	15.7	<DL	<DL	<DL	3.85	169
CS199	Mi2aKidney	0.912	2.45	0.797	3.24	47.3	2570	3.53	1580	17.2	<DL	<DL	<DL	13.6	282
CS200	Mi2aLung	<DL	<DL	<DL	0.808	4.05	939	<DL	331	0.829	<DL	<DL	<DL	1.53	49.2
CS201	Mi2aSpleen	<DL	0.119	<DL	1.35	6.25	727	<DL	579	1.77	<DL	<DL	<DL	1.2	123

CS202	Mi2aAdi	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	5.18
CS203	Mi2aMuscle	<DL	<DL	<DL	0.977	7.04	116	2.14	829	1.38	<DL	<DL	<DL	<DL	53.9
CS204	Mi2aRepOrg	<DL	<DL	0.143	0.882	0.765	<DL	<DL	105	0.102	<DL	<DL	<DL	<DL	22.1
CS205	Mi3aLiver	<DL	1.15	<DL	2.14	39.2	2200	<DL	1220	17.9	<DL	0.321	<DL	5.04	172
CS206	Mi3aKidney	<DL	6.3	0.128	3.24	47.5	1650	2.19	1340	10.9	<DL	0.454	<DL	11.9	211
CS207	Mi3aLung	<DL	0.117	<DL	0.951	6.15	1100	<DL	536	1.74	<DL	<DL	<DL	1.01	58.1
CS208	Mi3aSpleen	<DL	0.285	<DL	1.36	7.46	945	<DL	709	2.15	<DL	<DL	<DL	1.97	103
CS209	Mi3aAdi	<DL	<DL	<DL	2.15	0.753	<DL	<DL	82.2	0.3	<DL	<DL	<DL	<DL	12.2
CS210	Mi3aMuscle	<DL	<DL	<DL	1.16	7.56	81.5	<DL	838	1.12	<DL	<DL	<DL	<DL	55.2
CS211	Mi3aRepOrg	<DL	0.0525	<DL	1.18	1.83	79.1	<DL	101	1.05	<DL	<DL	<DL	<DL	20.9
CS212	Mi4aLiver	8.72	0.241	<DL	1.03	23.6	966	<DL	521	5.92	<DL	<DL	<DL	1.59	77.6
CS213	Mi4aKidney	7.42	1.6	0.0312	1.09	17.6	544	<DL	509	3.6	<DL	<DL	<DL	4.16	85.7
CS214	Mi4aLung	4.33	<DL	<DL	1.8	8.15	924	<DL	866	1.67	<DL	<DL	<DL	2.08	121
CS215	Mi4aSpleen	6.13	0.182	<DL	1.27	4.91	499	<DL	578	1.6	<DL	<DL	<DL	2.31	93.1
CS216	Mi4aAdi	0.703	<DL	<DL	1.73	1	<DL	<DL	286	1.01	<DL	<DL	<DL	<DL	18.6
CS217	Mi4aMuscle	8.38	<DL	<DL	1.94	10.7	108	<DL	864	2.85	<DL	<DL	<DL	<DL	98.6
CS218	Mi4aRepOrg	3.07	0.0382	<DL	1.3	2.8	160	<DL	332	1.51	<DL	0.054	<DL	0.594	32.1
CS219	Mi5aLiver	<DL	0.393	<DL	1.07	14.7	1190	<DL	568	12.5	<DL	<DL	<DL	2.01	98.9
CS220	Mi5aKidney	<DL	1.9	<DL	1	13.5	594	<DL	605	3.53	<DL	<DL	<DL	4.14	103
CS221	Mi5aLung	<DL	<DL	<DL	1.25	5.18	1460	<DL	631	1.47	<DL	<DL	<DL	2.31	85.3
CS222	Mi5aSpleen	<DL	0.163	<DL	0.979	4.83	1130	<DL	627	2.85	<DL	<DL	<DL	1.65	115
CS223	Mi5aAdi	<DL	<DL	<DL	1.28	0.687	<DL	<DL	51.6	0.284	<DL	<DL	<DL	<DL	10.9
CS224	Mi5aMuscle	<DL	<DL	<DL	1.5	9.71	74.3	<DL	823	0.916	<DL	<DL	<DL	<DL	89.9
CS225	Mi5aRepOrg	<DL	<DL	<DL	2.26	3.4	106	<DL	480	0.348	<DL	<DL	<DL	<DL	56.5
CS226	Mi6aLiver	1.98	0.679	<DL	1.12	20.3	1630	<DL	578	10.7	<DL	<DL	<DL	2.36	89.7
CS227	Mi6aKidney	1.87	2.62	<DL	1.09	16.1	738	<DL	603	4.19	<DL	<DL	<DL	4.37	77.1
CS228	Mi6aLung	0.966	<DL	<DL	0.924	4.52	1760	<DL	645	1.07	<DL	<DL	<DL	2.07	67.2
CS229	Mi6aSpleen	1.16	0.161	<DL	1	3.91	1030	<DL	629	0.981	<DL	<DL	<DL	1.16	70.2
CS230	Mi6aAdi	<DL	<DL	<DL	1.49	0.6	<DL	<DL	35.2	<DL	<DL	<DL	<DL	<DL	9.44
CS231	Mi6aMuscle	0.985	<DL	<DL	1.63	9.84	56.5	<DL	887	1.45	<DL	<DL	<DL	<DL	114
CS232	Mi6aRepOrg	<DL	<DL	<DL	1.91	3.18	31.2	<DL	447	0.709	<DL	<DL	<DL	<DL	48.5
CS233	Mi7aLiver	0.256	0.616	<DL	1.04	21.7	1870	<DL	617	9.88	<DL	0.253	<DL	3.17	76.4
CS234	Mi7aKidney	0.785	2.32	<DL	1.09	15.4	856	<DL	602	3.89	<DL	0.605	<DL	4.88	83.6
CS235	Mi7aLung	<DL	<DL	<DL	1.59	5.11	1070	<DL	1020	1.2	<DL	<DL	<DL	1.97	98
CS236	Mi7aSpleen	1.26	0.234	<DL	1.02	4.51	827	<DL	635	1.91	<DL	<DL	<DL	1.65	87.5
CS237	Mi7aAdi	<DL	<DL	<DL	1.26	0.752	<DL	<DL	53.2	0.0193	<DL	<DL	<DL	<DL	10.3
CS238	Mi7aMuscle	0.499	<DL	<DL	1.33	8.46	38	<DL	824	1.24	<DL	<DL	<DL	<DL	100
CS239	Mi7aRepOrg	<DL	0.181	<DL	1.22	2.32	221	<DL	259	0.633	<DL	<DL	<DL	2.68	43.8
CS240	Mi8aLiver	1.77	0.681	0.0666	0.644	19.5	904	<DL	401	9.7	<DL	0.165	<DL	5.99	83.3
CS241	Mi8aKidney	1.53	3.92	0.177	0.805	16.9	611	<DL	400	3.8	<DL	0.255	<DL	7.62	88.3
CS242	Mi8aLung	<DL	<DL	<DL	<DL	4.3	874	<DL	566	1.25	<DL	<DL	<DL	6.28	93.3
CS243	Mi8aSpleen	1.03	0.215	<DL	0.786	3.16	487	<DL	390	1.1	<DL	<DL	<DL	3.77	80.7
CS244	Mi8aAdi	<DL	<DL	<DL	1.05	0.495	22.1	<DL	37.2	<DL	<DL	<DL	<DL	0.863	12.3

CS245	Mi8aMuscle	1.56	<DL	<DL	0.991	10.3	166	<DL	602	0.978	<DL	0.13	<DL	2.63	70.7
CS246	Mi8aRepOrg	0.314	0.151	<DL	1.03	2.3	209	<DL	173	0.982	<DL	<DL	<DL	1.94	37.4
CS247	Mi9aLiver	0.359	0.483	0.0444	0.928	30.5	1000	<DL	615	12.2	<DL	<DL	<DL	5.14	136
CS248	Mi9aKidney	0.289	2.08	0.104	0.766	19	508	<DL	453	4.13	<DL	0.0882	<DL	6.67	90.7
CS249	Mi9aLung	<DL	<DL	<DL	<DL	4.19	1420	<DL	403	0.316	<DL	<DL	<DL	5.93	67.8
CS250	Mi9aSpleen	0.224	0.0882	0.047	0.715	5.7	1400	<DL	552	1.43	0.232	<DL	<DL	2.77	78.7
CS251	Mi9aAdi	<DL	<DL	0.0738	1.18	1.19	68.4	<DL	72.1	0.218	0.598	0.107	<DL	0.776	18.7
CS252	Mi9aMuscle	0.197	<DL	<DL	1.08	8.41	187	<DL	642	1.08	0.182	0.245	<DL	2.29	81.3
CS253	Mi9aRepOrg	1.81	<DL	0.576	2.22	28.5	841	<DL	817	78.5	1.34	0.992	<DL	3.01	67.3
CS254	Mi10Liver	<DL	0.39	<DL	0.689	21.1	996	<DL	455	11.7	<DL	<DL	<DL	6.48	91.4
CS255	Mi10Kidney	<DL	1.91	0.0835	0.703	13.2	460	<DL	422	3.62	<DL	0.0454	<DL	7.69	73.4
CS256	Mi10Lung	<DL	<DL	<DL	0.682	3.86	1080	<DL	353	0.858	<DL	<DL	<DL	4.95	60.6
CS257	Mi10Spleen	<DL	0.15	<DL	0.673	4.13	2310	<DL	642	1.71	<DL	<DL	<DL	4.43	84.8
CS258	Mi10Adi	<DL	<DL	<DL	1	0.806	49.7	<DL	58.5	<DL	<DL	<DL	<DL	0.864	8.96
CS259	Mi10Muscle	<DL	<DL	<DL	0.876	7.3	153	<DL	611	1.32	<DL	0.207	<DL	3.58	97.2
CS260	Mi10RepOrg	<DL	<DL	<DL	<DL	3.44	334	<DL	404	0.563	<DL	<DL	<DL	5.26	59.6
CS261	O1aLiver	0.501	0.217	0.239	0.651	47.3	651	<DL	435	15.4	0.237	<DL	<DL	13	67.1
CS262	O1aKidney	0.443	0.953	0.153	0.717	13.8	478	<DL	407	3.29	0.173	<DL	<DL	10.3	68.4
CS263	O1aLung	<DL	64.9	0.21	0.686	11.4	409	<DL	554	14.5	<DL	<DL	<DL	1.93	115
CS264	O1aSpleen	<DL	0.135	0.0464	0.705	4.25	553	<DL	558	0.937	<DL	<DL	<DL	6.14	86.8
CS265	O1aAdi	<DL	<DL	<DL	1.06	0.264	10.8	<DL	32.1	<DL	<DL	<DL	<DL	0.922	5.77
CS266	O1aMuscle	0.272	<DL	<DL	0.825	8.25	227	<DL	608	0.951	<DL	<DL	<DL	5.17	132
CS267	O1aRepOrg	0.295	<DL	0.117	1.05	2.57	107	<DL	172	2.68	0.171	<DL	<DL	2.18	16.6
CS268	O2aLiver	<DL	0.26	0.0946	0.722	50.1	607	4	448	11.3	0.24	<DL	<DL	6.24	88.1
CS269	O2aKidney	0.18	1.6	0.131	0.728	16	351	4.64	440	3.37	<DL	0.0928	<DL	7.22	82.3
CS270	O2aLung	<DL	<DL	0.0797	0.699	3.07	1210	<DL	306	0.252	<DL	<DL	<DL	2.82	42
CS271	O2aSpleen	<DL	0.121	0.0461	0.75	4.17	458	<DL	474	1.55	<DL	<DL	<DL	3.3	92.5
CS272	O2aAdi	<DL	<DL	<DL	1.05	0.536	28.8	<DL	56.8	<DL	<DL	<DL	<DL	0.648	9.93
CS273	O2aMuscle	<DL	<DL	<DL	0.805	8.27	257	1.93	616	0.819	<DL	<DL	<DL	1.9	127
CS274	O2aRepOrg	0.153	<DL	0.0506	0.827	2.52	306	6.27	466	1.01	0.153	<DL	<DL	4.2	62.3

Appendix 3

Insignificant Gehan test results from the herbivore species studied.

Beaver					Muskrat				
Tissue	Reference Site	Industrial Site	n	Gehan P Value	Tissue	Reference Sites	Industrial Site	n	Gehan P Value
	As					**As**			
Kidney	0.312	0.326	47	0.118	Adipose	n/a	5.335	26	0.108
Adipose	n/a	n/a	44	n/a	Reproductive Organ	0.331	2.118	24	0.067
	Cd					**Cd**			
Kidney	48.82	34.17	47	0.902	Kidney	0.287	0.582	28	0.586
Liver	3.447	3.608	47	0.781	Liver	0.196	0.219	29	0.61
Lung	1.147	0.555	46	0.704	Lung	n/a	n/a	28	n/a
Spleen	1.271	1.55	47	0.213	Adipose	n/a	n/a	26	n/a
Adipose	0.19	0.059	44	0.569	Muscle	n/a	0.074	28	0.211
Reproductive Organ	0.676	1.767	44	0.833	Reproductive Organ	n/a	n/a	24	n/a
	Cr					**Cr**			
Kidney	1.537	0.955	47	1	Kidney	1.28	1.006	27	0.981
Liver	1.443	0.883	47	1	Liver	1.593	1.118	28	0.998
Lung	1.491	0.847	46	1	Lung	1.727	2.138	23	0.294
Spleen	1.734	0.858	47	1	Spleen	2.856	2.449	24	0.581
Adipose	2.291	1.442	44	1	Adipose	2.439	1.836	26	0.969
Muscle	1.385	0.94	46	1	Muscle	1.512	1.345	28	0.961
Reproductive Organ	1.753	1.298	44	0.998	Reproductive Organ	2.563	1.773	24	0.879
	Co					**Co**			
Kidney	0.399	0.253	47	0.998	Liver	0.263	0.319	28	0.673
Lung	0.155	0.106	46	0.384	Spleen	0.238	0.333	24	0.643
Spleen	0.15	0.135	47	0.218	Adipose	0.198	0.186	26	0.34
Adipose	0.058	0.052	44	0.177	Muscle	0.069	0.077	28	0.173
Muscle	0.092	0.067	46	0.394	Reproductive Organ	0.309	0.258	24	0.685
Reproductive Organ	0.187	0.146	44	0.736		**Cu**			
	Fe				Kidney	12.04	25.6	27	0.422
Kidney	369	449.5	47	0.0581	Liver	12.55	10.66	28	0.937
Liver	718.5	780.7	47	0.156	Lung	5.035	4.763	28	0.722
Lung	1664	1479	46	0.934	Spleen	5.956	3.925	24	0.783
Spleen	696.8	468.7	47	0.602	Muscle	4.397	4.249	28	0.655
Reproductive Organ	250	202.7	44	0.361	Reproductive Organ	2.385	2.031	24	0.363
	Hg					**Fe**			

Kidney	n/a	n/a	47	n/a
Liver	n/a	n/a	47	n/a
Lung	n/a	n/a	46	n/a
Spleen	n/a	n/a	47	n/a
Adipose	n/a	n/a	44	n/a
Muscle	n/a	n/a	46	n/a
Reproductive Organ	8.72	n/a	44	0.808
Mn				
Kidney	20.27	14.49	47	0.999
Liver	26.2	13.12	47	1
Lung	6.036	2.618	46	0.997
Spleen	50.4	20.09	47	0.997
Adipose	1.098	1.11	44	0.566
Muscle	1.281	6.558	46	0.085
Reproductive Organ	38.96	11.69	44	1
Ni				
Kidney	1.374	0.495	47	0.999
Liver	0.969	0.466	47	0.875
Lung	1.047	0.451	46	0.986
Spleen	1.911	0.53	47	0.989
Adipose	0.365	0.331	44	0.433
Muscle	0.403	0.366	46	0.155
Reproductive Organ	1.604	0.701	44	0.99
Sb				
Kidney	0.111	n/a	47	0.805
Liver	0.134	n/a	47	0.805
Lung	0.0934	n/a	46	0.81
Spleen	n/a	n/a	47	n/a
Adipose	0.084	n/a	44	0.797
Muscle	n/a	n/a	46	n/a
Reproductive Organ	n/a	n/a	44	n/a
Se				
Kidney	3.375	3.837	47	0.659
Liver	1.758	2.206	47	0.211
Lung	1.801	2.338	46	0.599
Spleen	1.694	1.783	47	0.579
Adipose	1.505	1.24	44	0.53
Muscle	1.451	2.231	46	0.363
Reproductive Organ	2.648	1.941	44	0.761
Pb				
Kidney	1.32	0.423	47	0.348
Liver	0.368	0.166	47	0.091
Lung	0.429	0.122	46	1.45

Kidney	526.1	508.3	27	0.52
Liver	872.9	827.6	28	0.866
Lung	1468	1321	28	0.875
Spleen	1020	636	24	0.784
Adipose	69.9	109.7	26	0.786
Muscle	127.3	92.81	28	0.918
Reproductive Organ	512.3	220.3	24	0.166
Hg				
Kidney	n/a	n/a	28	n/a
Liver	n/a	n/a	29	n/a
Lung	n/a	n/a	28	n/a
Spleen	n/a	n/a	24	n/a
Adipose	n/a	n/a	26	n/a
Muscle	n/a	n/a	28	n/a
Reproductive Organ	n/a	n/a	24	n/a
Mn				
Lung	2.615	4.443	28	0.219
Spleen	17.2	29.7	24	0.096
Adipose	5.44	18.36	26	0.07
Ni				
Kidney	1.25	0.601	27	1
Liver	0.536	0.314	28	1
Lung	0.506	2.004	28	0.551
Spleen	1.613	1.882	24	0.976
Adipose	0.455	0.75	26	0.797
Muscle	0.562	0.783	28	0.903
Reproductive Organ	1.056	1.036	24	0.942
Sb				
Kidney	n/a	n/a	27	n/a
Liver	n/a	n/a	28	n/a
Lung	n/a	n/a	28	n/a
Spleen	n/a	n/a	24	n/a
Adipose	n/a	n/a	26	n/a
Muscle	n/a	n/a	28	n/a
Reproductive Organ	n/a	n/a	24	n/a
Se				
Kidney	5.519	5.166	28	0.638
Liver	3.26	3.864	29	0.981
Lung	2.924	3.612	28	0.668
Spleen	3.864	5.6	24	0.909
Adipose	n/a	1.36	26	0.196
Muscle	1.63	3.488	28	0.958
Reproductive Organ	n/a	0.815	24	0.199

Spleen	0.713	n/a	47	0.805
Adipose	0.326	0.497	44	0.139
Muscle	0.414	0.09	46	0.799
Reproductive Organ	0.072	0.355	44	0.081
Zn				
Kidney	173	138	47	0.988
Liver	133.2	122.9	47	0.968
Lung	69.22	55.46	46	0.983
Spleen	103.3	100.1	47	0.912
Adipose	9.321	8.37	44	0.275
Muscle	157.5	115.2	46	0.985
Reproductive Organ	74.56	62.56	44	0.948

Pb				
Kidney	0.124	0.418	28	0.924
Liver	0.148	0.138	29	0.643
Lung	2.352	0.422	28	0.732
Spleen	0.981	n/a	24	0.975
Adipose	0.247	1.038	26	0.995
Muscle	0.409	0.177	28	0.993
Reproductive Organ	0.162	3.2	24	0.792
Zn				
Kidney	85.52	75.82	27	0.99
Liver	115.1	88.09	28	0.998
Lung	63.15	58.1	28	0.453
Spleen	110.9	94.64	24	0.894
Adipose	28.4	34.31	26	0.258
Muscle	101.9	69.61	28	0.996
Reproductive Organ	45.01	67.67	24	0.407

Appendix 4

Insignificant Gehan test results from the carnivore species studied.

River Otter				
Tissue	Reference Site	Industrial Site	n	Gehan P value
		As		
Kidney	n/a	0.443	5	0.11
Liver	n/a	0.501	5	0.11
Lung	0.238	n/a	5	0.805
Spleen	n/a	n/a	5	n/a
Adipose	n/a	n/a	5	n/a
Muscle	n/a	0.272	5	0.11
		Cd		
Kidney	1.477	1.277	5	0.718
Liver	0.326	0.239	5	0.718
Lung	n/a	64.9	5	0.11
Spleen	0.177	0.128	5	0.277
Adipose	n/a	n/a	5	n/a
Muscle	n/a	n/a	5	n/a
Reproductive Organ	0.184	n/a	5	0.902
		Co		
Lung	0.123	0.145	5	0.124
Spleen	0.056	0.0463	5	0.277
Adipose	n/a	n/a	5	n/a
Muscle	0.115	n/a	5	0.902
Reproductive Organ	0.108	0.084	5	0.118
		Cr		
Kidney	1.583	0.723	5	0.958
Liver	1.39	0.687	5	0.958
Lung	1.8	0.693	5	0.958
Spleen	1.523	0.728	5	0.958
Adipose	2.657	1.055	5	0.958
Muscle	1.757	0.815	5	0.958
Reproductive Organ	1.623	0.939	5	0.958

Mink				
Tissue	Reference Sites	Industrial Site	n	Gehan P value
		As		
Lung	0.236	2.648	19	0.399
		Cd		
Kidney	1.492	1.72	24	0.995
Liver	0.59	0.539	24	0.512
Lung	0.119	0.117	19	0.5
Muscle	14.2	n/a	23	0.81
Reproductive Organ	0.232	0.128	20	0.127
		Cr		
Kidney	1.492	1.72	24	0.995
Liver	1.767	1.139	24	0.997
Lung	1.144	1.84	19	0.994
Spleen	2.417	1.039	23	0.999
Muscle	2.718	1.263	23	0.999
Reproductive Organ	4.368	1.5	20	9.57
		Cu		
Kidney	15.68	22.91	24	0.16
Liver	38.34	25.22	24	0.822
Lung	4.988	5.057	19	0.5
Spleen	4.427	5.003	23	0.061
Muscle	10.9	9.002	23	0.79
		Co		
Kidney	0.145	0.199	24	0.955
Liver	0.141	0.075	24	0.914
Lung	0.0544	n/a	19	0.98
Spleen	0.189	0.047	23	0.908
Muscle	0.152	n/a	23	0.984
Reproductive Organ	n/a	0.36	20	0.054
		Fe		

Cu				
Kidney	14.8	14.9	5	0.5
Lung	6.283	7.235	5	0.5
Spleen	4.337	4.21	5	0.807
Adipose	0.656	0.4	5	0.718
Muscle	11.38	8.26	5	0.958
Reproductive Organ	5.593	2.545	5	0.958
Fe				
Kidney	711.7	414.5	5	0.718
Liver	49.83	48.7	5	0.718
Lung	1987	809.5	5	0.958
Spleen	2107	505.5	5	0.958
Muscle	1605	242	5	0.958
Reproductive Organ	270	206.5	5	0.718
Hg				
Kidney	8.663	4	5	0.958
Liver	7.23	4.64	5	0.718
Lung	4.55	n/a	5	0.793
Spleen	12.7	n.a	5	0.793
Adipose	4.47	n/a	5	0.793
Muscle	3.983	n/a	5	0.962
Reproductive Organ	11.9	6.27	5	0.5
Mn				
Liver	10.75	13.35	5	0.124
Lung	1.561	7.376	5	0.614
Spleen	1.51	1.51	5	0.862
Adipose	0.6	n/a	5	0.962
Reproductive Organ	1.5	1.84	5	0.5
Ni				
Kidney	0.477	n/a	5	0.793
Liver	0.317	0.239	5	0.277
Lung	n/a	n/a	5	n/a
Spleen	0.301	n/a	5	0.793
Adipose	0.637	n/a	5	0.962
Muscle	0.895	n/a	5	0.902
Reproductive Organ	0.325	n/a	5	0.902
Pb				
Kidney	0.157	0.093	5	0.616
Liver	n/a	n/a	5	n/a
Lung	n/a	n/a	5	n/a
Spleen	n/a	n/a	5	n/a
Adipose	n/a	n/a	5	n/a
Muscle	0.149	n/a	5	0.902

Kidney	777.4	909.6	24	0.777
Liver	1902	1406	24	0.878
Lung	1483	1181	19	0.957
Spleen	1859	1045	23	0.645
Muscle	467.8	112.9	23	0.959
Hg				
Liver	9.403	2.38	24	1
Lung	3.787	n/a	19	0.959
Spleen	4.754	2.7	23	0.954
Muscle	6.288	2.2	23	1
Mn				
Kidney	5.814	4.619	24	0.341
Liver	13.7	11.8	24	0.79
Lung	1.135	1.156	19	0.5
Spleen	2.286	1.876	23	0.402
Muscle	2.633	1.368	23	0.893
Reproductive Organ	1.499	9.377	20	0.689
Ni				
Kidney	0.549	0.393	24	0.98
Liver	0.904	n/a	24	0.997
Lung	0.738	n/a	19	0.996
Spleen	0.794	0.232	23	0.996
Muscle	1.095	n/a	23	1
Reproductive Organ	1.836	1.34	20	0.972
Pb				
Liver	0.246	0.762	24	0.643
Lung	0.472	n/a	19	0.959
Spleen	n/a	n/a	23	n/a
Muscle	0.84	0.226	23	0.971
Reproductive Organ	0.49	0.992	20	0.62
Sb				
Kidney	n/a	n/a	24	n/a
Liver	n/a	n/a	24	n/a
Lung	n/a	n/a	19	n/a
Spleen	n/a	n/a	23	n/a
Muscle	n/a	n/a	23	n/a
Reproductive Organ	n/a	n/a	20	n/a
Se				
Liver	4.091	3.959	24	0.536
Lung	2.769	3.126	19	0.628
Spleen	3.103	2.295	23	0.79
Muscle	1.692	2.41	23	0.908
Reproductive Organ	2.057	3.223	20	0.133

Reproductive Organ	n/a	n/a	5	n/a
Sb				
Kidney	n/a	n/a	5	n/a
Liver	n/a	n/a	5	n/a
Lung	n/a	n/a	5	n/a
Spleen	n/a	n/a	5	n/a
Adipose	n/a	n/a	5	n/a
Muscle	n/a	n/a	5	n/a
Reproductive Organ	n/a	n/a	5	n/a
Se				
Kidney	5.6	8.76	5	0.0416
Liver	5.73	9.62	5	0.124
Lung	3.867	2.375	5	0.958
Spleen	4.163	4.72	5	0.282
Adipose	1.197	0.785	5	0.5
Muscle	1.49	3.535	5	0.124
Reproductive Organ	3.047	3.19	5	0.5
Zn				
Kidney	75.35	74.3	5	0.282
Liver	83.67	77.6	5	0.718
Lung	62.57	78.5	5	0.5
Adipose	12.87	7.85	5	0.958
Muscle	150	129.5	5	0.718
Reproductive Organ	60.5	39.45	5	0.718

Zn				
Kidney	102.6	117.5	24	0.759
Liver	127.1	110.5	24	0.852
Lung	75.56	77.83	19	0.312
Spleen	102	93.01	23	0.402
Muscle	132	84.79	23	0.995
Reproductive Organ	50.3	43.13	20	0.809