Indigenous Resource Management and Environmental Contamination

By

Stanley Richard Holder Jr.

Submitted to the graduate degree program in Indigenous Nations Studies and the Graduate Faculty of the University Of Kansas in partial fulfillment of the requirements for the degree of Master's of Arts.

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Indigenous Resource Management and Environmental Contamination

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Heavy metals are potential contaminants which can produce negative impacts on human health which vary from metal to metal, and are also dependent upon concentration and duration of exposure to the contaminant. This study lists the human health effects of 5 heavy metals; copper, arsenic, cadmium, lead and mercury, and discusses the need for studies to identify potential exposure pathways that are associated with a Native American / Indigenous Lifeways. Gaps in the data include exposure pathways associated with wild edible / medicinal plants as well as understanding of the pathways through which many culturally relevant plants may uptake and store metals. Native American / Indigenous peoples around the world have developed an extensive amount of knowledge of their surroundings. Knowledge of plants, animals, and ecological processes, combined with a non-destructive philosophy based on understanding relationships between species, continues to enable these Indigenous peoples to interact with their surroundings while at the same time, these ways of living may lead to exposure risks from heavy metals through increased water consumption, dust inhalation, and consumption of meat including organ meats that concentrate contaminants and plants that may uptake contaminants as part of their physiological processes.

INTRODUCTION

From the earliest beginnings of many tribal traditions there has been an understanding that the world that in which we live must be respected in a way that allows for resources to be sustainable in such a way those future generations could use these resources to live. In my case, this philosophy has been reinforced through growing up in a very Indigenous (Kitikiti'sh / Lakota) philosophical environment. With this respect Indigenous people of North America were able to live in relative harmony with their surrounding environments for generations immemorial. At a very young age we are taught to be respectful of all life, that if we take something we should not be wasteful or greedy, to do so may result in the loss of the resource as a result of over harvesting or improper management. In the following work I have attempted to construct a view of some Native American cultures in relation to their understanding of how ecosystems function and how the surrounding environment and the culture have shaped one another. All Native American cultures relied and many continue to rely on their surrounding environment for all parts of their daily lives.

Unfortunately living in the respectful manner may put Indigenous peoples, especially children and elders at risk of health problems that come through consumption of traditional subsistence foods that have become contaminated through processes associated with the dominant culture. Problems associated with contamination were first brought to the attention of the American public by authors such as Rachel Carson (1962) in her classic work, *Silent Spring*, which laid out problems associated with organochlorine pesticides such as DDT and DDE.

Given this situation my goal in this thesis is to address potential health problems in Indigenous or subsistence communities that are related to contamination with heavy metals that arise from mining, or other processes. My objectives are to: 1) Provide insight into studies that can help prevent the collapse of a traditional lifestyle within a dramatically changing environment, in particular those areas that are impacted by activities such as mining, and 2) Provide information to individuals and groups to make them aware of the need for further studies encompassing Indigenous resources and environmental toxins.

I will begin by elaborating on cultural practices which bring to light the relationship that Indigenous peoples, namely Native Americans, have with their environment and the philosophical underpinning associated with this relationship. Next, I elaborate on a current example of a Native American Community and the environmental degradation associated with an abandon mine. Next I will provide insight into human health effects of five metals (Arsenic, Cadmium, Copper, Lead and Mercury) as well as exposure pathways associated with resource use associated with cultural lifeways.

In order to insure respect and proper behavior, Native American peoples developed knowledge bases and ceremonial traditions that were derived from careful observation of their surrounding environment. One example of such thinking would be how many Native American cultures understand there is a sustainable yield, so that people will harvest only what is needed and no more. This ensures that the resources (plant, animal, or earth) will be there for future generations. Ceremonies, such as the

First Salmon Ceremony, or the offering of tobacco whenever a plant or animal was harvested, were developed to ensure that individuals would behave in a respectful manner (Pierotti and Wildcat 1999; Pierotti 2005).

In addition, agricultural techniques, such as planting many species together (corn, beans, squash), enabled the community to harvest crops while fertilizing the soil. "…the Indians make heaps like molehills, each about two and a half feet from the others, which they sow or plant in April with maize, in each heap five or six grains" (Cronon ,W., 1983, p. 43). "…with the corn they put in each hill three or four Brazilian beans [kidney beans], which are of different colors. When they grow up, they interlace with the corn, which reaches to the height of from five to six feet; and they keep the ground very free from weeds. We saw there many squashes and pumpkins, and tobacco..." (Cronon, 1983, p. 43).

Species such as beans (*Fabacea*) are nitrogen-fixing, which means that they have a symbiotic relationship with bacteria capable of capturing nitrogen from the atmosphere (Judd, W., Cambell, C., Kellogg, E., Stevens, P., Donoghue, M., 2002). This relationship enables the plant to gain an additional source of nitrogen, while at the same time providing the bacteria with a place to live. The utilization of plants such as beans which can extract nitrogen out of the atmosphere enriches the soil, because Nitrogen is a key nutrient in the production of high quality foodstuffs. This allows for the community to use the same land for long periods of time without depleting the land of the nitrogen essential for the development of proteins needed for the plants' growth and development. At times tribes would leave agricultural land fallow to allow the land to recover its nutrients before the next phase of planting occurred.

Planting several species together increased conservation of soil moisture, because the plant cover reduced evaporation by providing shade and cover in the form of foliage, especially from the squash. This reduced loss of moisture allowed for the people to minimize the need for watering or irrigation. Also planting many species together made their soil use sustainable by protecting the nutrients in the soil from erosion due to wind or rain through the added cover the leaves and vegetation supplied.

Knowledge of natural processes and sustainability was not attained by chance but by observations made across a wide range of generations, which allowed them to note ecological processes and develop techniques that enabled sustainability of the needed resources (Kawagley, A.O., 1995). The tradition of respect for the environment allowed for Native Americans to have a more sustainable ecological relationship with the land, thus enabling the communities to live in a very healthy environmentally minded way.

As an example, giving respect to prey taken in the hunt or in fishing activities shows that the culture not only understands the connection to the prey but illustrates that the culture appreciates that the world does not exist solely for the benefit of human beings. Everything in the environment is connected; the parts have their own need for resources and thus should be respected (Pierotti, R. and Wildcat, D., 1999; Pierotti R., 2005). By consuming the prey its tissues became part of the muscle, bone, nerve tissue, every part of the human, the prey became part of the hunter, his family, and community members (Pierotti and Wildcat 1999, 2000). In turn this respect was rewarded through the healthful benefits of taking good quality wild-reared nutrition into one's body. The understanding that what you eat is indeed what you are (Pierotti and Wildcat 2000) is a very rational way of balancing this relationship.

Personal experience has taught me that the Kitikiti'sh, Lakota, Kiowa, Apache, Comanche, Cheyenne, Paiute, Shoshone, Navajo and so on have a cultural tradition of giving away, this tradition is a way to show thanks for prosperity and ensures that all members of the community receive an item to show the appreciation for the contributions they have made to the communities and cultures. To many Indigenous cultures the ability to give away items, including plants for food and medicine, meant that the culture would have to ensure a resource is managed in a sustainable way. To reinforce the cultural norm of giving away meant that the communities had to manage their resources in a way that would enable them to sustain not only the resource but also the culture.

An example may deal with the management of plants used for medical purposes. If a specific medicine or food was used often by the community, but this resource was not managed in a sustainable manner the resource may have been difficult to acquire in times of need. Many traditional herbalists understand the sustainable process necessary to ensure a "resource" is managed properly. Life experience has shown me that many cultures give great respect to the natural world, asking a plant for permission to take it and use to help humans, ensured that the person picking the plant showed enough humility to ask for permission. By interacting in a respectful manner with the needed plant, the human was able to understand the subtle changes in the environment that allowed the person to manage the resource in a sustainable manner (Cordero-Lamb, J., 2005).

The Lakota people of the northern plains have a practice of giving away belongings to share prosperity throughout the community to strengthen social bonds and to uphold social morals and values (Crawford, S. and Kelly, D., 2005). Understanding that the human community as a whole benefits through the practice of people sharing their material wealth showed that the society understands that the community must work together and share resources to enable the society to sustain into the future by avoiding the Tragedy of the Commons (Anderson, E. N., 1996). Sharing resources that may be difficult for some individuals to attain is a mechanism that results in both reduced exploitation of these items and the burden put on the environment to attain these items.

As younger generations observed generosity in their elders, it would reinforce this value in the youth; thus the culture lives on and the harmony that is achieved continues into the future. In my life I have been told stories of people giving away all their material belongings: their homes, tools, clothing; everything materially. They were able to do this because their sustainable lifeway allowed them to understand that material possessions could always be re-attained in the future if needed.

There have been instances where the people who gave away all their material belongings would be taken in by a host family within the community until they were able to acquire the things they needed to live on their own once again. If a person or family was humble enough to share with the community it was not a great burden to take the person or family into one's home and help them until they were able to live on their own again. This was a way of showing how much concern they had for the community and culture. Also the ability to take these people into one home could be seen as advantageous to the host family. The children of the host family could interact with the visiting family and individuals and learn the values and morals that these people held to the fullest extend possible. Things of value to these cultures, as well as many others, were more concerned with the children and elders being healthy rather than materially rich. If a person is rich beyond their needs but they have no one to share this wealth, are they truly living? If this materially affluent person ignores the needs of the community and regards only their own wealth what will they do in time of need? Such greed-based behavior was seen as inappropriate by the community; people behaving in this way were sometimes expelled from the community until a time came that they proved themselves worthy of returning to community life.

The resources upon which the Lakota people depended were primarily: poles for tepees, hides for clothing and shelter, plants for nutrition and medicine. These resources were harvested for the surrounding environment in a way that ensured that the resource would persist to be utilized at another time, perhaps even by another tribe or culture. The practice of only taking what was needed would minimize the chance of the resource disappearing, because not over harvesting the more mature plants and animals the people ensured that the reproductively mature portions of the ecosystem were able to multiply, thus the resource would have a much better chance of sustaining itself.

By utilizing all parts of the plant or animal the people were able to effectively manage all parts of their daily consumption patterns. Experience has taught me that, one buffalo could supply enough meat to feed a family for months while providing hides for clothing and shelter, sinew for sewing, bladders for storage, bones for tools, horns as ladles and spoons. One plant could be utilized for its foliage, flowers, or fruit, its stem fibers for producing rope, and its roots; all portions of the plant may have a nutritional aspect or may have been utilized as a medicine. Through complete utilization of materials that could break down in a relatively short period of time the culture was able to have minimal ecological impact. If an item declines to the point that it was no longer usable it was left on the land to further break down and once again become part of the ecosystem. Perhaps this is one of the reasons why archeologists can only find artifacts that go back 20,000 years before present, they simply turned to dust, but this is an argument for a different arena.

William Cronon elaborates in his book "*Changes in the Land: Indians, Colonists and the Ecology of New England*" on Indigenous land management and how the colonists of the time utilized the resources that the Indigenous peoples had managed for centuries. He speaks of how the forests were so well managed that an entire troop of soldiers could travel easily through the region, how the "Indians" the use of fire perpetuated the growth of edible understory species such as strawberries, and how the surrounding areas were kept clear of trees to provide habitat for wildlife (Cronon 1983, p. 49-51). The Indigenous people of the area managed their resources to be sustainable; through the use of fire the people were more effective at clearing the land as well as replacing nutrients that were lost from the soil in the absence of fire. The effectiveness of this use of fire meant that laborious tasks could be completed in a shorter amount of time, resulting in additional time spent in child rearing, spiritual and cultural development.

The Western science of Ecology is a holistic way of thinking about our surrounding environments. Understanding that disturbing the balance between rock and soil, soil and plant, plant and animal, has repercussions throughout the ecosystem. An example of this disturbance can be seen when comparing soils that have been plowed and left to undergo succession. North of Lawrence, Kansas the University of Kansas acquired ownership of some tracts of virgin prairie. Virgin prairies describe land that has never been broken (plowed) or disturbed by European peoples. Adjacent to this virgin soil are soils that were once plowed. The comparison of diversity of plants (virgin vs. plowed) is astonishing; even though the plowed soils have been left fallow for several decades, the diversity of these areas is miniscule when compared to that of the virgin prairies.

Environmental concerns may result from release of chemicals into environments through practices such as mining, use of fossil fuels, smelting, agriculture, and factories. Examples of elements that have been released into the surrounding environment through economic-related activities include heavy metals. This may create special issues of concern for Indigenous peoples because such contamination can be problematic at both literal and spiritual levels. I will elaborate on these themes by exploring the relationship between ecological factors and human health issues related to heavy metals at length in chapter three.

Several Native American communities in the U.S. share common environmental concerns related to mining, logging, and agriculture. Examples include the Quapaw tribe and lead mining issues, The Navajo Nation and uranium/coal mining/emissions, and The Western Shoshone and the proposed spent uranium storage facility at Yucca Mountain. Releases of noxious substances such as arsenic, copper, cadmium, lead, and mercury into the surrounding environment have been shown to have derogatory effects on the health of the surrounding ecological communities. The release of these heavy metals varies in concentration from source to source and also in relation to the substrate (soil types, rock) that is impacted. The presence of cadmium in agricultural soil resulting from application of phosphorus fertilizers has been shown to accumulate in some plant species (Eriksson J. and Ledin S., 1998). Removal of trees from hill sides has been shown to release metals from the soil into the adjacent riverine systems through erosion. Through processes such as acid mine drainage, heavy metals may be separated from the material to which they are bound and released into the surrounding environments (Site and Radiological

Assessment Branch Division of Health Assessmet and Consultations Agency for Toxic Substances and Disease Registry, 2007).

Today Indigenous peoples continue to rely on the environment but in a more broad way, the food we eat daily may come from our local area or from half way across the world. Along with this disconnect from the environment comes loss of knowledge of our surrounding environments. People that have lived in regions from time immemorial have gained insight into the local geography, weather patterns, and biota (Marshall, J. III, 1995). This knowledge enabled Indigenous peoples to use their surrounding in a very holistic way. Through processes such as assimilation or removal from Indigenous territories, Native Americans have been handed a cataclysm with regard to the spiritual and cultural portions of their societies. However when the peoples were removed from their original homelands they dealt with these situations in ways that allowed them to retain their knowledge of their homelands (Owens L., 1998). Many people brought seeds of food plants and medicines with them when they moved, and many more learned of their new environments from other Native people that already lived there. In this fashion the people were able to carry on their cultures while adapting to new environments. In my own experience I have seen how the Kitikiti'sh continued to cultivate our traditional corn what was carried with us when we were forced onto reservation land in Oklahoma, or stories of how the Kitikiti'sh helped the Kiowa when they first moved into our land, we provided the Kiowa corn seed and teachings that enabled them to produce their own crops.

“Although every tribe has a different culture, tradition, and religious practice, many of these lifestyles are environmentally oriented and generally result in higher environmental contact rates” (Harper, B. L. and Harris, S., 2000, p. 141). Today many Native Americans work to carry on traditional ways of utilizing the surrounding environment examples include how many educational institutions offer language classes, ethnobotanical and ethnobiology courses. Many tribal environmental professionals seek to pass environmental codes that take culture into account in land/resource management decisions. Examples of land/resource utilization include climbing sacred mountains to meditate and pray, harvest of fish from rivers, obtaining drinking water directly from streams, consumption of wild plants for nutritional and medicinal needs or even digging into the soil to harvest the plants needed. Many of the resources that these people utilize may be in areas that have been exposed to environmental toxins. One example is the use of water taken from a source down stream from a mine, for activities such as a sweat lodge/purification ceremony. During this type of ceremony the people involved will pray and meditate in lodges build to contain heated rocks. The rocks and wood used to heat them are generally from the surrounding area. The heat from the rocks allows a person to sweat profusely thus releasing toxins from their body. Often times the practitioners will pour water over the heated rocks to produce steam, this steam touches the body and increases sweat through a sharp increase in humidity inside the lodge, which allows for further extraction of toxins. Also depending on the culture and area medicines may be drunk, smoked, or eaten through out the duration of this ceremony. The water that the people utilize for the ceremony may be consumed during the occasion. I use this example to show that there are several possible exposure routes associated with this one activity. The water that was taken from the stream or spring may be considered sacred by the people; so that not utilizing this water might lead the society over time to lose the stories and knowledge associated with such water sources. The problem is that by utilizing this water the people may be exposing themselves to toxins, e.g. heavy metals found in the water. Many times the sweat lodge may be found along side the stream from which the water is obtained. If the ground where the lodge sits has a higher concentration of metals due to occasional flooding this may be another exposure route in that the hot rocks are placed on the ground thus the ground is heated; as the water hits the rocks and earth it turns to steam, and the portion that does not evaporate accumulates around the rocks and boils. As this process continues the metals in the dust at the bottom of the pit, the metals in the ash on the rocks, as well as those metals found in the water will come in contact with the participants' skin, mouth, lungs, and eyes. Also if the wood that is used to heat the rocks has a tendency to accumulate heavy metals these metals may be released through the smoke and inhaled by the participants while the rocks are heating.

As an example, I will briefly describe issues of concern to the Spokane people, who are faced with serious environmental issues in regards to mining. This example can serve to show what can happen and will continue to occur until tribes can equip themselves with information on human/ecological health risks. Contamination of tribal lands will take place until Indigenous people can effectively motivate the general public to create, enforce and support environmental laws associated with the resources important to Indigenous cultures.

The Spokane reservation, which is located in east central Washington, has specific ongoing problems associated with the abandoned, open-pit Midnite Uranium Mine. "In 1998, EPA performed an Expanded Site Investigation (ESI) and scored the Site using the Hazard Ranking System (HRS) to determine the eligibility of the site for inclusion on the National Priorities List (NPL)" (U.S. U.S. Environmental Protection Agency Region 10, 2006, p. 22). "The NPL is the list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is intended primarily to guide the EPA in determining which sites warrant further investigation" (U.S. EPA National Priorities List website, 2007).

Midnite Mine was officially included on the NPL in May of 2000; in 2005 the U.S. government filed a claim against the mining company to cover costs of clean-up. The 2006 U.S. EPA record of decision elaborates on the preferred clean up alternative including moving the piles of mining waste, protore, and road material to fill the two open pits on site (U.S. EPA, 2006, p. 72-74). The pits would be covered with a membrane that is supposed to be impermeable to water. The impermeability of the liner would result in a reduction of acid rock drainage, which along with a soil cover, would reduce direct exposure, radon flux, and limit uptake of noxious chemicals by overlaying vegetation. Acid rock drainage is caused when water mixes with compounds in the soil causing the water to drop in pH becoming more acidic, thus enabling more metals and other compounds to be freed from the soil. The plan also calls for the instillation and treatment of water systems to treat the water before release.

The heavy metals associated with mining can have extremely harmful effects on human and ecological health. Adriano states that "[s]ome elements are paradoxically intriguing! Too little of them may not be enough for proper nutrition but a little bit more might be too much! This indicates that some elements may serve as a nutrient or a toxin" (Adriano, D.C., 2001, p.133). Copper is one of the metals upon which I later elaborate that can be found in daily supplements such as over-the-counter vitamins, but which can also be poisonous at high concentrations and in certain compounds. Metals such as iron, zinc and copper are essential to proper growth and homeostasis in the body. "The results of [the Midnite Mine] site studies and investigations indicate that metals and radionuclides have migrated from on-site source areas (i.e., open pits, ore/protore/waste rock piles) into local groundwater and surface waters as a result of acid mine drainage" (ATSDR, 2007, p. 7). "The ESI sampling data showed detectable levels of metals and radionuclides in all seven on the on-site sources. These contaminants, which include arsenic, beryllium, cadmium, lead, nickel, and uranium, have been released from the sources through discharges of groundwater (via seeps) and overland transport through runoff. Elevated concentrations of site-related metals and radionuclides were detected in surface water and sediments up to approximately 3.5 miles downstream of the site."… "In addition selected surface water quality benchmarks and ground water standards were exceeded in many of the ESI samples" (ATSDR 2007, p. 8). As mentioned above, the site was included on the NPL and a record of decision is currently in place, work has not yet began to clean up the site but the EPA is attempting to ensure the site will be effectively managed to protect human health and the environment in the area.

Heavy metals released into the ecosystem at varying concentrations may result in declines in the health of a variety of different species. Heavy metals may affect the ability of plants to produce compounds vital to their survival, for animals to effectively filter their own blood, and for humans to develop into capable adults. Each of these effects is dependent on the element and concentration. But even more important then the individual or species level is the community level. An ecosystem is made up of a number of species all interacting with the nonliving portions of the environment. Effects such as bioaccumulation means that contaminants may not have a great impact on the lowest trophic levels but these accumulate up the food chain so their impacts increase as the trophic level increases. This is important in studying heavy metals such as lead, which has been shown to be stored in the bones and teeth of vertebrates (U.S. Environmental Protection Agency, Integrated Risk Information System (IRIS), 2007).

The addition of metals at potentially lethal levels means that people who are in close contact with the contaminated environment will be more exposed to these elements. The accumulation of the metals in the environment can have a drastic effect on the health of human as well as nonhuman species (Adriano 2001; Goyer, R., 1996). One example is the effect of elevated lead levels in humans that result from consuming and digesting fish with high levels of lead. Indigenous peoples of these areas will have higher exposure rates because they often use non-domestic plants and animals in daily activities that are related to traditional hunting and gathering practices that may be thousands of years old. "Because these traditional lifestyles are so closely bound to every aspect of the environment, any species is likely to be used in many ways, either directly in the diet as food or medicine or as an item of cultural or religious significance" (Harper et. al. 2001, p. 141).

Before Native American peoples were forced into treaties and the U.S. government forced them onto reservations lands, the people were able to utilize their home territories to the fullest extent possible. Plains tribes traditionally utilized bison on a daily basis for clothing, shelter, nutrition as well as for spiritual purposes. Many cultures in the Northwest United States and Pacific Canada depended upon salmon to such an extent that their whole culture and economy was intertwined with this species. Land management ensured that the salmon runs would not be polluted or obstructed, which ensured that the rivers producing salmon would continue to do so in to the future. "The Spokane traditional lifestyle is governed by ecological seasons and the activities that people undertake in response. A significant portion of the population follows this lifestyle in full or in part. Hunting, fishing, and gathering are essential to support nutritional, cultural, spiritual, and medicinal needs of tribal members" (Harper et al 2002, p. 516). The need for Native Americans to be able to live in a culturally appropriate way, i.e. have resources available to fulfill their cultural needs, means they must be able to manage their lands in a cultural appropriate way. If the people are not able to manage their resources then the resources will soon decline and be lost or the restriction to these resources will result in a loss of cultural knowledge of the area.

The Midnite Mine was the target of several environmental studies and investigations going back to the late 1970's. With the large amount of data that has been accumulated, the mine site provides an excellent opportunity for researchers to examine the accumulation of potentially harmful substances in the food staples of the Spokane diet. In addition, studies pertaining to the persistence of these substances in the ecosystem could provide information to allow better management for future sites; sites that may put Indigenous communities at risk.

Harper et al. (2002) sought to include traditional practices, such as use of medicinal wild plants, edible wild plants and purification ceremonies associated with the sweat lodge in their scenario of possible exposure resulting from subsistence. In addition, they considered activities such as hunting, fishing, and harvesting of plants which may expose individuals to higher rates of environmental contaminants, when compared to other groups in the U.S. Assuming that the Spokane people practiced a culturally traditional lifestyle, the authors took into account potentially higher rates of dust inhalation and water consumption that would be associated with a culturally relevant lifestyle. On this topic, Harper and Harris (2001, p.141) made the statement that, "If traditional practices have to be reduced because environmental contamination makes them unsafe, the culture is diminished". This is the case because the culture would be forced to find another place to harvest medicines, foods or subsistence items that may be outside their reservation area. With this restriction to areas where "wild" plants may be found the passing of knowledge is also restricted and possibly even severed. Native American cultures have vast knowledge of medicines and foods, if the knowledge is not passed on to the younger generations, it is lost. Medicines and foods that grow in abundance in areas that were once managed by Indigenous people may decline in use because of the loss of knowledge by present day generations. Even though the knowledge may still exist, many people will go far from the road side or away from disturbed soils to find the plants they need. This becomes problematic when the people with the knowledge are elderly and long journeys on foot are difficult or impossible.

Based on my own experience in harvesting plants during my youth we were often forced to be mindful of the locations where we harvested certain plants because we were concerned about land owners' use of pesticides. After a time the ability to find edible and medicinal plants off tribal lands has become more challenging because of the tendency of farmers to manage land as a monoculture, with subsequent loss of diversity and cultural knowledge.

In many areas, Indigenous cultures are dying because these damaged ecosystems are directly tied to Indigenous culture and knowledge. Therefore, what happens to one affects the other. The close bond that traditional cultures share with nature almost certainly ensures higher exposure to potentially harmful substances due to activities involved in extraction of natural resources on these lands. It is important to realize that each human society has developed its own unique way of living on this earth, and if that way of living is lost, humanity overall is diminished.

There are several gaps in the data, as well as sources of uncertainty in risk assessment pertaining to Indigenous peoples (Harper et al., 2002). Participation by Indigenous people in specialized activities such as, collection of edible wild plants, hunting, and flint knapping are likely to increase the frequency of exposure to toxins in the environment. Many tribal cultures utilize willows for construction of shelters or baskets because of the plant's flexibility and strength. Erickson and Ledin (1998, p. 171) state “[s]everal investigations have shown a high uptake of cadmium (Cd) into the shoots of Salix (willow) plants.” This is of interest because many people may be susceptible to the exposure pathway of inhalation of cadmium through the burning of plants that have high amounts of cadmium in their tissues. The stems of the trees can be arced to form structures such as arbors. Often times when the arbor is rebuilt or taken down the wood is burned and may be inhaled in the process. The inhalation pathway alone may not contribute to a significantly decline in health but when combined with other aspects of lifestyle and diet the pathway may tilt the scales to the side of adverse effect and diminished health.

More work in the area of Indigenous cultures will improve the data and reduce the gaps in this data that are present today. Exposure such as inhalation of smoke from medicinal plants; smudges; and firewood are good examples of data gaps in risk analysis of Indigenous peoples cultures (Harper et al., 2002).

There is almost certain to be a need to assess the generational effects of toxins in the environment in relation to: age of individual, number of individuals, and duration of exposure to and persistence of the particular toxin will help risk assessors to evaluate situations in a more culturally appropriate way. Even though one site may be the focus in that it is the ultimate source of elevated amounts of noxious materials, tribal members may be exposed to contaminants from other pathways, such as rivers and roads that may not be assessed by the EPA as part of their evaluation of a specific superfund site. When these additional sources are properly taken into account, the daily activities of tribal members can yield a more complete exposure assessment than simply looking at samples of plants or soil.

Chapter 2
Review of Relevant Literature

The literature reviewed does not specifically focus on Indigenous cultures or resources, but the areas where the studies were completed were at one time lands regularly used by Indigenous peoples in their day to day lives. The first paper reviewed involves the study of the effects that trace metals and pH have on the diversity, density, and biomass of grass species along the Soda Butte Creek in Montana and Wyoming. An abandoned gold and copper mine located upstream from the study area has released toxins into the downstream riparian area (Marcus, W. Andrew, and Stoughton, Julie A., 2000).

Soil pH is an important part of the study because of the interactions associated with the pH and the mobility of metals in the environment. "Acid substances have pH values between 0 and 7; alkaline substances range between 7 and 14 and a pH of 7 is considered neutral" (Kemp, D.D., 1998, p. 314). By increasing the acidity (decreasing the pH) of a solution the metals bonded to organic matter are freed by the acidic solution resulting in the loss of hydrogen ions, which allows the bonds to be broken.

Essential trace metals are metals that are essential for proper physiological function, including growth of the organism. "An essential trace metal affects a living organism harmfully in two different ways: 1) as a result of deficient supply, and 2) as a result of over supply" (Mishra et. Al., 2004, p. 91). In contrast, if the concentration is appropriate the plant or animal will have a concentration zone of optimum growth.

The aforementioned concentration zone indicates the level at which there are adequate but not excessive levels for regular metabolic functions and growth. Different species of plants typically require differing concentrations of essential and non-essential metals for normal growth (Mishra et. Al., 2004).

There also exists a category of non-essential metals that affect growth and metabolism of various plants through a number of metabolic pathways. These non-essential metals typically do not affect growth until a "toxicity threshold" is reached or approached, however once past this threshold the plant typically begins to show "toxic symptoms, which increase with increases in the metal concentration until the organism dies"(Mishra, R.K., Sahu, S.K., Shaw, B.P., 2004, p. 91). "Heavy metals, both in acute and chronic exposure, interact with many different cellular components, thereby interfering with the normal metabolic functions, causing cellular injuries, and, in extreme cases, death of the organism" (Mishra et. Al, 2004, p. 97).

Table 1.

Metals	Toxic symptoms
Arsenic	Red brown necrotic spots on old leaves, yellow browning of roots, growth reduction
Cadmium	Brown margin to leaves, chlorosis, necrosis, curled leaves, brown stunted roots, reddish veins and petioles, reduction in growth, purple coloration
Mercury	Severe stunting of seedlings and roots, chlorosis, browning of leaf points, reduction in growth
Lead	Dark green leaves, stunted foliage, increased amounts of shoots
Selenium	Interveined chlorosis, black spots at high selenium, bleaching and yellowing of young leaves, pink spots on roots
Zinc	Chlorosis, stunting, reduction of root elongation
Copper	Chlorosis, yellow
Nickel	Chlorosis, necrosis, stunting, inhibition or root growth, decrease in leaf area
Aluminum	Stunting, Dark green leaves, purpling of stems, leaves and leaf vein, yellowing and death of leaf tips, curling of young leaves and collapse of growing points or petioles, thickening of root tips and later roots, inhibition of root elongation
Manganese	Marginal chlorosis and necrosis of leaves, leaf puckering and necrotic spots on leaves, crinkled leaves
Iron	Dark green foliage, stunted top and root growth, thickening off roots, brown spots on leaves, starting from the tip of lower leaves, dark brown and purple leaves, sometimes in same plant

From Mishra, et. Al.., 2004, p. 97.

Metals essential to human growth includes Selenium, Zinc, Copper, Nickel, Manganese and Iron. Arsenic, Cadmium, Mercury, Lead and Aluminum are non-essential metals.
Key terms in table (definitions from Dictionary.com Unabridged (v.1.1)

Necrotic – death of a circumscribed portion of animal or plant tissue

Chlorosis – an abnormally yellow color of plant tissues, resulting from partial failure to develop chlorophyll, caused by a nutrient deficiency or the activities of a pathogen.

Petioles – The stalk by which a leaf is attached to a stem.

In the paper under review, Marcus and Stoughton utilized modern techniques and instruments to analyze samples of plants and earth from 4 meadow sites and 33 plant species. The researchers tested for concentrations of arsenic, copper, iron, lead, and zinc. These metals were chosen because; 1) they were at detectable concentrations; 2) the metals showed variation across the study area; and 3) they are found within the study area at concentrations that surpass toxic levels.

Results indicate that copper is one metal that is a "clear indicator of the mine tailings" (Marcus et. Al., 2000, p.311). At all the study sites copper values of 300 parts per million (ppm) and above were found to be correlated with declines in species diversity. The study also found that in 82% of the plots where acidic (low pH) soils were found, copper concentrations in excess of 300 ppm were also found, which indicates that threshold relationships are likely to be associated with high concentration of metals/ pH and reductions in diversity, biomass, and density. Other factors may also be involved as potential causes of this threshold phenomenon.

It is important that this literature review includes the study of the uptake of heavy metals into the plant tissues because, "Once excess trace metals enter a system, they remain bound to soil components, incorporated into plant tissues, or can be ingested by animals over an extensive time period. Estimates of residence time in soils for trace metals in temperate climates range from 1000 to 3000 years for copper, lead, and zinc" (Marcus, et. Al., 2000, p. 317).

When looking at the mean concentrations of the three meadow sites that were studied arsenic, copper, and lead concentrations were all above acceptable soil levels. Mean arsenic concentrations were at 15, 18, 21, and 5 ppm in Fish, Hollywood, Icebox and Round Prairie meadows respectively. Copper mean concentrations were 234, 209, 149, and 73 ppm for Fish, Hollywood, Icebox and Round Prairie meadows. And mean lead concentrations were 49, 53, 55, and 23 ppm for Fish, Hollywood, Icebox and Round Prairie meadows. As with many heavy metals high soil concentrations may result in elevated concentrations in plant tissue. More research into the uptake of specific metals into the tissue of plants is needed to provide cumulative risk assessors a better look at the potential pathways of heavy metals into the human body.

Elevated levels of copper, arsenic, and lead in the soils may be harmful to human health if the plants used contain high concentrations of heavy metals. But is not the only exposure pathway that should be taken into account. Pathways such as inhalation of dust and ingestion of soil should be taken into account for communities that may be utilizing such studies sites. Elaboration on risk levels and human health will proceed in a later chapter.

The second paper under review establishes the levels of heavy metals and estimates the bodily burden of these elements in the wildlife in the area around Perozavodsk, Russia. Medvedev tested tissues of animals that were shot by hunters during the hunting seasons between 1989 and 1991. He concluded that atmospheric deposition was the most probable cause for the elevated levels of heavy metals found in his study (Medvedev, Nikolai., 1999).

Sampling was performed though veterinary labs, where tests were performed to confirm that the tissues were free of harmful microscopic organisms. Samples were then sent to the Chemistry Department at St Petersburg University for heavy metal testing. Tissue samples included muscle, heart, lung, kidney, liver, and hair from the following species: elk (*Alces alces*, same as American moose), wild forest reindeer

(*Rangifer tarundus*, same as American caribou), brown bear (*Ursus arctos*, same as American grizzly and brown bears), wild boar (*Sus scrofa*, same as domestic pigs also introduced into much of the US), and squirrel (similar to American red squirrel). The age, gender, gross weight, and weight of organs was known to the investigator. Potatoes and shoots of 10-15 year old Scots Pine trees were also sampled from twelve sites within Karelia. Testing for heavy metals in these plant species was carried out to provide additional insight into possible causes of heavy metal accumulation in the wildlife.

In the area surrounding Karelia the human population on average consumes "300 tons or moose meat" (Medvedev, 1999, p.178). They also take reindeer, brown bear, and wild boar to supplement their diet. The importance of this study to people who practice a subsistence lifestyle in part or in whole is to identify various potential risk pathways that may expose subsistence hunters, their families, and their communities to elevated levels of heavy metals. By identifying areas or species that show high concentrations of heavy metals, subsistence foragers will be able to make more informed judgments as to what to hunt and when and where not to hunt. Another benefit to these types of studies is to allow people of these areas to persuade land managers to manage resources in ways that reduce environmental pollutants. Medvedev states that because of high levels of cadmium in the kidneys of moose and the livers and kidneys of Karelian brown bear that these tissues should only be consumed from animals that are less than a year old, because cadmium, which is a particularly deadly contaminant, tends to accumulate affect with age of the animal.

Statistical tests employed in the analysis included Spearman rank correlation, Kruskal-Wallis, and Scheffe's method. The Spearman rank test was used to find correlations between trace elements and age of the organism. The Kruskal-Wallis test was utilized to look for sex related differences in metal concentrations. Contaminant concentrations and pollutant levels were analyzed using the Scherffe's method.

Analysis showed positive correlations between cadmium and lead in the livers of brown bear and squirrel and in the kidney of wild boar. Kidney and liver tend to accumulate toxins because these organs filter impurities out of the blood. But with some toxins the organs are unable to release the substances through normal processes, as a result the organs themselves become to "loaded" with toxins. Analysis of kidney samples from moose and brown bear showed cadmium and lead to be of equal concentrations in these species. The species with the largest concentration of cadmium and lead was reindeer, which feed upon plants that are exposed to atmospheric contaminants. Differences in feeding habits between reindeer and moose might provide an explanation for these results because reindeer feed mainly on lichens, which have been shown to accumulate (these) trace elements. Because both lead and cadmium have cumulative effects on the health of wildlife, land managers and wildlife biologists of the region should be concerned with the amount of these metals found in the tissues that may be eaten by a major portion of the public. Other concerns that may be addressed by land managers and other environmentally minded people of the region are atmospheric deposition from other parts of the earth. With the passage of the Kyoto protocol and issues such as climate change and emissions being in the forefront of today's news, perhaps more attention will be given to studies that analyze the amount of pollution deposited through atmospheric deposition.

The analysis of different plant species showed that cadmium and lead content were highest in the shoots of the Scots Pine, which are growing fast, thus scouring soil for nutrients and picking up associated contamination. This implies that organisms that feed on Scots pine shoots could possibly have higher concentrations of cadmium and lead. Supporting this idea is the finding that the species with the highest lead content was the squirrel, which feeds largely on seeds from coniferous trees. "Cadmium is a ubiquitous, highly toxic metal which accumulates in the kidney and to a lesser extent in the liver. The FAO/WHO (food and agricultural organization/ world health organization) provisional tolerable weekly intake is 0.4-0.5 mg, which corresponds to 0.06-0.07 mg of cadmium on a daily basis. It is probable that the consumption of liver or kidney of Karelian moose (as different from muscle meat which is safe to eat) would cause the consumer to exceed the WHO standard for that particular week when the product was eaten" (Medvedev, 1999, p. 191).

Many Native American life ways have successfully developed strategies allowing them to manage their resources in a sustainable fashion. One development of this lifeway is the respect given to prey, whether it is plant or animal. For many Native American cultures to be wasteful was seen as unfit. By consuming all edible portions parts of an animal; kidney, liver, intestines, spinal cord, and bones (especially marrow) in some instances, the individual and community were efficiently using their resource to an extent not usually seen in other societies. At times cultures may hold special praise for a certain body part or organ, such as kidney and intestinal fat in the Cree tradition (Tanner. A., 1979, p. 136-181). In many situations organ meats are seen as special medicine to help cure specific ills, which may include ingesting that body part, e.g. a person with kidney trouble eating parts of an animal kidney to benefit from its healing properties. The importance for the individual and community to show respect for the prey by acting in a respectful manner ensured that the resource would be utilized in a sustainable way ensuring its availability to future generations.

From the results described by Medvedev it seems likely that these cultural traditions could expose their practitioners to excessive contamination in the contemporary world. At the very least education in tribal communities should discuss the tendency of contaminants to be high in specific organs and tissues, e.g. liver, kidney, fat.

The investigators in this third paper under review, examined levels of heavy metals in the tissue of moose, in Finland. This is one of a few follow-up studies which will enable the researchers to have a more complete picture of heavy metals in game animals, "since the level in these animal tissues reflect the general heavy metal pollution of the environment in that particular area" (Venalainen, E.-R., Antilla, M., and Peltonen, K., 2005, p. 257). The researchers state "in many areas wild animals form a significant part of the traditional diet. For example, moose, caribou and whitefish are the most important sources of food for the Canadian Arctic Indigenous Peoples. The cadmium exposure resulting from consumption of traditional food in

Fort Resolution, Northwest Territories in Canada has been estimated and the highest levels of cadmium were found in the liver and kidney of caribou and moose" (Venalainen et. Al., 2005, p. 526). This study, which was conducted in 1999, is the third study of this kind in the area, with previous studies being conducted in 1980 and 1990. The study of 1980 included 130 animals, and the studies in 1990 and 1999 each included 100 animals. The latest study included analysis of the liver, muscle, and kidney of Moose of various ages.

Techniques used to prepare and analyze the tissue samples included assistance from local hunters who provided the samples to the researchers. The hunters were asked to send in the mandible bone (lower jaw) in order for the researchers to estimate the age of the animals.

Levels of cadmium in the liver and kidney were found to be elevated, and there was a positive correlation of these concentrations with the age of the animals, which suggests that bioaccumulation is occurring over the life of the individual. Concentrations in the muscles of the animals did not show an age dependent correlation, which suggests that muscles are regularly purged of contaminant so that bioaccumulation does not take place. This result suggests that the primary risk to hunters who depend on moose as an important part of their diets lies in consumption of organ meats and fat, where bioaccumulation is likely to take place. Cadmium is a non-essential element, meaning it is not needed for normal metabolism and growth in vertebrates, plants, or invertebrates (Adriano, 2001). Cadmium is known to be toxic to plants at relatively low concentrations when compared to other metals such as

Zinc, Lead and Copper (Adriano, 2001). Adriano goes on to elaborate that, “the main clinical signs of Cd toxicity in animals include anemia, retarded gonad development, enlarged joints, scaly skin, liver and kidney damage, and reduced growth” (Adriano, 2001). I will elaborate further on ecological and human health effects of heavy metals in a later chapter.

Support for the interpretation, that organ tissue may result in the subsistence community taking in higher concentrations of heavy metals, comes from the finding that concentrations of lead were highest in the kidney and lowest in the muscle with liver being intermediate. In contrast, concentrations of zinc were highest in the muscles, followed by the kidney, and lowest in the liver. The concentration of copper was highest in the liver, followed by the kidney and then the muscles. Thus each metal showed a different pattern.

The high concentration of cadmium in the liver and kidney shows that these organs should not be consumed by the hunters, who consume these tissues more frequently than do other members of the Finnish population. A person who does not consume these tissues on a regular basis may not need to concern themselves with these increased concentrations, although because of the cumulative effects of mulitpathway exposure individuals may be exposed to cadmium through other routes, such as water and plant consumption. As stated above I will elaborate more in-depth on the human and ecological effects of heavy metals in a later chapter. The muscle did not show concentrations high enough to stop consumption, assuming this is the only exposure pathway. The other metals in the study did not show concentrations high enough to require that contaminated tissue types be taken out of the diet of hunters and the general population; again this may be true if the only exposure pathway was ingestion of tissue from moose populations in the study area, but managers should be concerned with the mulitpathway exposure assessments.

In conclusion the need for further studies assessing routes of exposure to heavy metals in the environment are needed to better understand the human and ecological health risks associated with these elements. Because Indigenous cultures have come to use several different species of plants and animals with possible complex social and health benefits the issue of contamination should be considered a new aspect of traditional knowledge that needs to be communicated across generations. While many industrialized nations have been able to set up networks of trade and commerce that allows them to import food, clothing and other vital needs for their societies, many Indigenous cultures have been able to persist using the import route only when they have developed a need for non-Indigenous techniques, materials and foods. Many Indigenous groups of the United States and North America were forced to assimilate, and processes were set in motion to enable the process to perpetuate such as the Dawes act and the Bureau of Indian Affairs boarding schools to name two. These actions led to the inability of Native Americans to sustain themselves in their own culturally appropriate way, and thus a large amount of cultural knowledge and language was lost or severely hindered. With the passage of the Native American Religion Freedom Act, many tribes were able to reaffirm the values of their cultures and spirituality and continue their life ways without persecution.

More studies into mulitpathway routes of exposure building on studies that have already progressed will enable Indigenous peoples across the globe to show policy makers that small shifts in land management and resource manipulation may have drastic consequences on cultures that have been on this earth for thousands of years. When studying Native American cultures of North American, we can see that heavy metals do not just affect one resource such as game animals, the contaminants affect the entire culture due to the unique relationship these cultures have developed with their own unique environments and resources. Without the ability for Indigenous peoples to influence policy, their ways of life may indeed be coming to an end, as I have elaborated on before. If resources are difficult to acquire because of land management differences with the dominant culture, then the culture is impacted in a derogatory way, from reduction of the passage of knowledge from the older generations to the youth. When Indigenous peoples are able to manage their land and resources in their own cultural context they will be able to continue to prosper and perpetuate into the future.

Chapter 3

Human health effects of five heavy metals

Native American, as well as other Indigenous populations around the world, have developed their own unique ways of using their surrounding environments. It is important for these different cultures to be able to live in a way that perpetuates their culture into the future because these lifeways have enabled them to live in a healthful way for generations immemorial. If these populations lose the ability to control land and water resources this will impact their ability to pass on their accumulated knowledge to younger generations. If there are negative health consequences to living in a cultural appropriate way through harvest of wild plants, animals and fish from their surrounding environments, these issues come into the realm of environmental justice.

For this reason, there is need for future studies and elaboration on cumulative risk assessment to ensure that these unique cultures persist and that the knowledge is passed on to generations far into the future. If the knowledge, lifeways and cultures of Indigenous groups are given serious consideration the environment will benefit as a whole. Also, if we as a society are to move towards an era where these concerns are taken into account, studies into the effects that industrialization and "progress" have on the land and the people will enable man kind to move toward living in harmony with instead of trying to control the environment (Pierotti and Wildcat, 2000).

Many land managers and planners look at the land as an economic resource to be manipulated in a way that ensures maximum profit potential. As a result of this profit driven management many ecosystems have become polluted or damaged in other ways; in some cases they have become unfit for human life. This chapter elaborates on the human health effects of the presence of heavy metals in soils and plants. The health risks associated with the absorption of heavy metals into the human body are varied, ranging from thickening of finger nails to cancer. Effects of such contamination can be managed if detection occurs at early stages of poisoning and if the routes to exposure are properly identified. I discuss human health effects and routes of exposure to 1 essential and five non-essential metals: 1) Copper, 2) Arsenic, 3) Cadmium, 4) Lead and 5) Mercury respectively.

Copper

Copper is the first heavy metal on which I would like to elaborate, because it is actually an essential metal but may become lethal at higher concentrations in the human body. From a technological perspective, "Copper is primarily used as a metal or an alloy (e.g., brass, bronze, gun metal). Copper sulfate is used as a fungicide, algicide, and nutritional supplement" (ATSDR 3, 2004, p. 11). As a nutrient, "Copper is required only in very small amounts; 5 to 20 ppm in crop tissue is adequate for normal growth, while concentrations less than 4 ppm are considered deficient, and concentrations in excess of 20+ ppm are considered toxic" (Adriano, 2001, p. 515). It is often found that concentrations of copper in plant tissue are correlated with concentrations in the soil in which they grow. Thus, in some cases plants experience levels of copper that are insufficient for their metabolic needs. For example, copper deficiencies affect photosynthesis, respiration, nitrogen fixation, protein synthesis, and disease resistance among other impacts (Adriano, 2001).

In contrast, where concentrations of copper are elevated, plants appear to be constrained to take up this metal, even at levels that impair their health and functioning, because copper is an important nutrient. Elevated soil concentrations have been attributed to over application of fertilizers, bactericides, and fungicides that contain copper. Copper toxicity has been associated with symptoms such as "reduced growth vigor, poorly developed and discolored root system, and leaf [yellowing] chlorosis…..reduced branching, thickening, and usually dark coloration in the rootlets of many plants" (Adriano, 2001, p. 522). When linked to chlorosis or yellowing of the leaves, reduced branching and reduced development of the roots occurs, and the result may be reduced efficiency in producing energy through photosynthesis, as a result the growth is slowed and the plant may never be able to reproduce.

Copper deficiencies in humans manifest themselves as "anemia…bone and cardiovascular disorders, and . . . mental and/or nervous system deterioration and defective keratinization of hair [production of keratin which may result in hair loss] …reduction in levels of neurotransmitters, dopamine and norephinephrine, and in defective myelination in the brain stem and spinal cord" (Adriano, 2001, p. 530-531). These manifestations are primarily the result of interactions that copper has with metalloenzyme activity in the body where copper is an essential co-factor in the formation of these enzymes. Several of these enzymes "function to reduce activated oxygen species or molecular oxygen" thus reducing damage cause by free radicals

(ATSDR 3, 2004, p.12). For this reason, "A recommended dietary allowance (RDA) of 0.9 mg/day (0.013 mg/kg/day) has recently been established" (ATSDR 3, 2004, p.12). This means that 0.9 mg per day of copper is needed to enable the human body to maintain its level of healthy development and metabolism.

The human body readily absorbs copper through the gastrointestinal tract. "After nutritional requirements are met, there are several mechanisms that prevent copper overload" (ATSDR 3, 2004, p. 12). Copper that is ingested may bind to the mucosal cells of the intestine and "is excreted when the cell is sloughed off" (ATSDR 3, 2004, p. 12). If the copper is not absorbed by the cells of the intestines then it may be taken up by the liver to be excreted through bile and the feces (ATSDR 3, 2004). Symptoms of copper toxicity in humans may be nausea, abdominal pain, vomiting, developmental problems in children, immunotoxicity, kidney and liver damage. "The observed gastrointestinal effects are not usually persistent and gastrointestinal effects have not been linked with other health effects" (ATSDR 3, 2004, p.12). Signs of damage to the liver include; death of liver cells and excessive stringy/fibrous cells. There are also other signs of damage that may be realized when genetic disorders are displayed such as: Indian childhood cirrhosis and idiopathic copper toxicosis. Both of these disorders have been shown to result from "milk stored in copper or brass containers or from drinking water" (ATSDR 3, 2004, p.14).

ATSDR defines minimal risk level as "An estimate of daily human exposure to a hazardous substance that is likely to be without an appreciable risk of adverse noncancer health effects over a specified route and duration of exposure" (ATSDR 3, 2004, p. 269). An example would be for an intermediate-duration oral exposure MRL of 0.01 mg/kg/day for duration of (15-365 days) is if a person was to consume water containing at most 0.01 mg/kg/day for up to 356 days, this person would not show any adverse health effects associated with copper. ATSDR 3 (2004) states a minimal risk level (MRL) of 0.01 mg/kg/day for acute-duration oral exposure (1-14) days, based on human studies in which human subjects fasted over night after a single exposure to doses ranging from 0.011-0.03 mg/kg (ATSDR 3, 2004). The MRL for acute-duration oral exposure was also estimated based on human studies involving individuals who regularly drank copper-containing water (ATSDR 3, 2004).

The ATSDR also estimated an MRL for intermediate-duration oral exposure (15-365 days) of 0.01 mg/kg/day based on a study which "exposed groups of 327-355 adults to < 0.01 (control group), 2, 4, 6 ppm copper sulfate in water for 2 months." (ATSDR 3, 2004, p.18). Results showed that there was a significantly higher incidence of gastrointestinal symptoms (nausea, diarrhea, and vomiting) in the 6 ppm study group (Araya M, Olivares M, Pizarro F, et al.., 2003). "Based on available data, people living close to NPL" [national priority list for contaminants] "sites may be at greater risk for exposure to copper than the general population. In this case, exposure can occur through inhalation of airborne particulates from the NPL sites, ingestion of water from private wells which are in close proximity to the sites, ingestion of contaminated soil, and/or uptake of copper into fruits and vegetables raised in gardens of residents living near NPL sites" (ATSDR 3, (2004) pp. 184-185). This might be especially important to Native American or other Indigenous population that live in areas that have experienced environmental degradation due to mining activities such as the people of the Spokane reservation. Mining is almost always for metals, and residue from mining typically contains high levels of the target as well as other metals.

In such situations, activities such as gathering of wild plants for nutrition/medicine, gathering of wood for ceremonies or for construction of houses, storage facilities for food, and even sweat lodges, hunting/fishing would impact the health of the individuals involved simply because of the extra time spent outdoors giving the individuals additional exposure to dust in the air as well as soil that may be on the plant that are used. If exposure from outside activities is compounded with consumption of potentially contaminated water from private wells these populations may be especially susceptible to the health effects caused by excessive copper exposure.

Overall, copper is one of the less noxious contaminants, in that at low levels it can be useful, and only at high levels does it show toxic effects, compared to some of the other metals for which effects are described below.

Arsenic

A heavy metal that can almost always be shown to have adverse health effects on human populations is Arsenic. A steel-gray, brittle crystalline metal, Arsenic is best known for its toxic properties. Arsenic is found at some levels in nearly all soil; it ranks 52nd in crustal abundance when compared to other metals and minerals (Adriano, 2001). The amount of arsenic in the soil does not necessarily reflect the amount that may be found in plants, because unlike copper which is a nutrient, plants do not normally take up arsenic as part of their metabolic activities (Adriano, 2001). The real problem with Arsenic is that heavy soil disturbance, usually by humans, exposes this toxic metal and renders it more volatile. In addition, Arsenic can be a component of some substances used by humans to kill "pests." “The quantity of arsenic released by human activities exceeds amounts released from natural sources by at least threefold. The major sources of arsenic release to the environment are smelters, coal-fired power plants, and pesticides” (ATSDR, 2000, p. 6). In addition, “Arsenic is mainly obtained as a byproduct of the smelting of copper, lead, cobalt, and gold ores” (ATSDR 1, 2004, p. 15). As smelters refine the target ore (copper, lead, gold) arsenic may be released into the environment through the air, after which it can settle onto water and soil by improper removal of waste and improper filtering of the different waste media produced. Elevated levels of Arsenic found in the soil after mining and smelting were stopped in one region recorded topsoil bearing 16 to 975 mg kg^{-1} compared to background levels of 7.7 to 9.0 mg kg^{-1} (Adriano, 2001, p. 255).

There are other sources of Arsenic, for example, coal-fired power plants may also release arsenic into the air through the burning of coal. Pesticide application has also shown to contaminate environments through the use of herbicides containing arsenic, which is toxic to many insects. Another potential source is technology because “high-purity arsenic (99.9999%) is used by the electronics industry for gallium arsenide semiconductors for telecommunications, solar cells, and space research" (ATSDR 1, 2004, p. 15). This means that attempts to improve local economies through the location of electronics manufacturing facilities on reservations or in nearby communities might increase exposure of Indigenous communities to this serious toxin.

Arsenic is routinely found in plants but the concentration decreases from root to leaf, because it is not transported readily through physiological processes. Thus the edible portion contains smaller amount of arsenic. To an Indigenous population, which may use the entire plant, or use roots either as food or medicine, the roots may be a significant source of arsenic exposure. Several plants are used by Native American cultures that include the roots as the edible/medicinal portion which include the prairie turnip (*Psoralea esculenta*), wild onions (*Allium tricoccum*) and Echinacea (*Echinacea angustifolia*) to name a few. In animals, including humans, Arsenic has several absorption pathways including ingestion, inhalation, and absorption through the skin.

One particularly troubling aspect of Arsenic poisoning is that, "[t]he source of exposure is identified in fewer than 50% of arsenic poisonings; however, a careful history and physical examination may improve these statistics. Because arsenic intoxication may affect multiple organ systems, a complete physical examination is imperative. In Chronic ingestion, particular clues to arsenic poisoning may be provided by dermatologic and neurologic findings. In order to locate sources the medical history of exposed individuals should include: occupational history, diet, residential history (proximity to smelters, other industry, and hazardous waste sites), smoking history, condition of household, pets, hobbies (including use of pesticides or herbicides in farming or gardening), medication (including folk or naturopathic medications) [this category may be of particular importance in traditional indigenous communities], source of drinking water, and home heating methods (wood burning stoves and fireplaces)" (ATSDR, 2000, p.16). Symptoms of acute Arsenic exposure include; severe abdominal pain, bloody or milky/rice-water diarrhea, congestive heart failure and pulmonary edema, light-headedness, convulsions, coma, elevated liver enzymes, excessive protein in urine, anemia and garlic odor on breath (ATSDR, 2000).

As indicated above, Arsenic is of particular concern because, "Human data indicates that As [Arsenic] doses of 1 to 3 mg kg^{-1} per day are usually fatal." (Adriano, 2001, p. 248) In contrast, studies have also shown that a level of 0.0008mg/kg-day has no observable effects, and the lowest observable effect level is 0.14 mg/kg-day for chronic oral exposure. (USEPA IRIS, 2007) Despite this slightly comforting news, the EPA's IRIS database shows a possible risk of lung cancer from Arsenic exposure to be 1 in 10,000 people around concentrations as low as 0.02 ug/m^3, 1 in 100,000 at a concentration of 0.002ug/ m^3, and a concentration of 0.0002ug/ m^3 for 1 in one million peoples. (USEPA IRIS, 2007) This reveals an interesting medical conundrum, i.e. Arsenic is often not considered toxic unless it kills quickly. Long-term exposure that can lead to fatal illness is often not considered. The tobacco industry hid behind a similar loophole for almost 50 years. As a result, in any case of Arsenic exposure or suspicion of exposure a through physical examination including a complete medical history and perhaps lab analysis should be taken into account.

Cadmium

Another heavy metal that has been shown to have derogatory human health effects is Cadmium. Cadmium is a lustrous silver-white metal that can be introduced to the environment through fertilizers, mining, smelting, domestic use of cleaning products and industry (Adriano (2001) p. 301-306). The use of phosphate fertilizers has contributed to crop land accumulation of Cadmium. Cadmium uptake in crop species has been shown to increase with a decrease in soil pH, i.e. more acidic soils. As a result, communities that have been exposed to acid rain, i.e. the Northeastern parts of North America, may be of particular concern. Acid rain does not only harm lakes and ponds, it also increases soil pH.

The impacts of Cadmium exposure may be especially important in children. "Clinical signs of Cadmium toxicity in animals include anemia, retarded gonad development, enlarged joints, scaly skin, liver and kidney damage, and reduced growth" (Adriano, 2001, p. 288). In one study conducted in the U.S. mean tissue concentrations in deer, *Odocoileus*, of 310 *u*g of Cadmium per gram Dry Weight were found within 8 km from a smelter site compared to15.5 *u*g per g DW of deer taken more than 100 km from the site (Adriano, 2001, p. 288). This suggests that deer taken in areas close to smelter sites will have higher tissue concentrations of heavy metals when compared to deer that live farther away from the smelter. This suggests that hunters, especially those who rely on venison as an important source of meat should be warned when they are hunting in the vicinity of a smelter or other source of Cadmium, such as plowed agricultural fields.

The most serious problem comes from "The consumption of agronomic-horticultural food crops represents the most critical exposure pathway for Cd in the general population." (Adriano, 2001, p. 290) One study in the New South Wales region of Australia found cadmium concentrations as high as 0.079-2.22 mg kg^{-1} fresh weight in vegetable samples from the community of Boolaroo, which is home to a lead-zinc smelter (Kachenko, A., Sinhg, B., 2006). The vegetables sampled included eight crop species in which the root, leafy portion, and fruit were sampled. The species sampled include; lettuce (*Lactuca sativa L.*), spinach (*Spinacia oleracea L.*), cabbage (*Brassica oleracea L.*), leek (*Allium porrum L.*), rhubarb (*Rheum rhabarbarum L.*) beetroot (*Beta vulgaris*), parsley (*Petroselinum crispum var. crispum*) and mint (*Mentha spicata L.*) (Kachenko et. Al., 2006).

Other routes of exposure include drinking contaminated water, consumption of animal organs especially kidney and liver, and smoking. Again this indicates the risk of consuming organ meats, especially because these "meats" come from tissues that serve as major filters of contaminants within the body. Cultural norms common in Indigenous populations, such as using the entire animal or plant, could contribute to increases in Cadmium uptake in human populations. With the addition of contaminated water, the population would have a high probability of showing signs of Cadmium toxicity.

Clinical symptoms of Cadmium toxicity in humans include; skeletal demineralization through the loss of Calcium in the urine. Cadmium also affects the kidneys through proteinuria (an increase of protein in the urine which is a sign of kidney malfunction), decreased glomerular filtration rate (glomerular is a part of the kidney which functions to filter out substances), and increased frequency of kidney stone formation (Adriano, 2001).

All of these problems can be exacerbated by use of tobacco because, "Data indicate the 0.10 to 0.20 *u*g of Cd is inhaled for each cigarette smoked giving a total intake of about 3 *u*g per pack of cigarettes smoked" (Adriano, 2001, p. 293). Risks of lung cancer estimates from the EPA IRIS data base associated with Cadmium are as follows; 1 in 10,000 people at a concentration of 0.06 $ug/m^{3,}$ 1 in 100,000 people at a concentration of 0.006 ug/m^3, for 1 in one million people the risk of lung cancer is at a concentration of 0.0006 ug/m^3 (USEPA IRIS, 2007). This data shows that people who are exposed to Cadmium for a length of time and who also smoke may have a greatly increased probability of developing lung cancer.

A major problem, considering the potential health effects of children is that pregnant mothers may transfer cadmium to the fetus, so that concentrations that are 40% to 70% of the maternal blood cadmium concentrations may be found in the fetus. In general, infants are born with cadmium levels that parallel that of the mother (Goyer, 1995).

Lead

Another metal found to contribute to human health problems, especially in developing children, is lead. Lead is a bluish-gray metal lead that has been valued by humans for thousands of years for making of bowls, cups, and eating utensils, and also in paint. Today the greatest percentage of lead is utilized in rechargeable batteries (Adriano, 2001). Modern uses of lead include pigments and other compounds, rolled and extruded products, cable sheathing, alloys, shot and ammunition, gasoline additives, radiation shielding, ceramic glazes, crystal, and fishing weights. (Adriano, 2001)

The predictability of lead concentrations in plants is species dependent. (Adriano, 2001) Studies have shown that lead may be absorbed by plants, but the transport of lead from the roots to other parts of the plant is limited because lead is not a nutrient that is of physiological importance. As with Arsenic, lead may continue to be an issue where a community may utilize the roots of indigenous plants for their medicinal or nutritional value, e.g. prairie turnips, ginseng, Echinacea.

Another route of lead accumulation is through atmospheric deposition of lead particles on the surfaces of the plant, especially on leaves and flowers that can be used as either food or medicine. The major sources of atmospheric deposition are coal fired power plants, smelters, and vehicle emissions. Lead contamination is the major reason that the US has reduced use of leaded gasoline, except in military vehicles and NASCAR where leaded fuel is still the norm. The surface texture has been found to contribute to levels of accumulation of lead on the surface of plants, with leaves with hairy or complex surfaces accumulating higher concentrations because there are more areas for lead to adhere (Wedding, J.B., R.W. Carlson, J.I. Stukel, and F.A. Bazzaz., 1975). When a leaf with a smooth surface was compared to a leaf with a pubescent (hairy) surface, the hairy surface accumulated up to ten times the amount of lead that was found on the smooth surfaced leaves. This is important when looking at plants which may be smoked by individuals to cure certain ailments. Smoking plant leaves with a hairy surface the plant may expose the human to high levels of lead. This is very import because lead is completely absorbed in the lower respiratory tract.

Contamination resulting from atmospheric deposition of lead on the surface of edible plants can be reduced by washing the plant with vinegar (Adriano, 2001). This form of deposition may be a significant exposure pathway through inhalation if the leafy tissue is used in a culturally significant application such as smudges or smoked. Harvesting plants near roadsides is seen as undesirable for many Native Americans due to the accumulation of toxins associated with vehicle emissions and pesticides, even though lead was removed from gasoline in the 1970's.

Pathways of exposure to humans include inhalation, ingestion and transfer of blood between mother and fetus. There used to be a major risk from young children eating chips of peeling paint, which contains lead. In fact, lead has also been the source of the recent controversy over toys imported from the People's Republic of China, where environmental regulations are much weaker than in the U.S. This continues to be a risk in older houses and cheaper paints, which may be found in communities with lower incomes, also as with the development of countries like China, toys painted with lead based paints may find their way state side and into communities. "Inhaled [lead] Pb deposited in the lower respiratory tract is completely absorbed" (Adriano, 2001, p. 386). Deficiencies in iron and calcium may increase absorption of lead, therefore, poor diet which is a problem associated with diabetes in many Native American communities can enhance the effects of lead poisoning. Many Native Americans are lactose intolerant, which causes many Native families to not have dairy products, especially milk in their households, resulting in children receiving less calcium, which also makes them more likely to absorb lead. (Harper and Harris, 2001) "Once in the blood, Pb is distributed primarily among three compartments – blood, soft tissue (kidney, bone marrow, liver, and brain), and mineralizing tissue" (Adriano, 2001, p. 386)

Mild symptoms resulting from lead toxicity include; mild fatigue, lethargy, and occasional abdominal discomfort. Moderate toxicity symptoms include weight loss, constipation, headache, muscular exhaustibility, and tremor. Symptoms of severe toxicity include paralysis, black-blue gingival (gum) tissue, seizures, coma and death. (Adriano, 2001)

Lead is often stored in the bones and teeth, which means that it may take a long period of time before the lead is expelled from the body. In addition, because lead accumulates gradually over time in the body, these adverse effects may not be seen immediately. Blood lead levels of a developing fetus and mother are similar. "Lead content of fetal tissues tends to parallel that of calcium." (Goyer, 1996, p.13)

Thus, by replacing calcium in the brain, lead accumulation results in reduced neuron branching and activity of neurotransmitters. The reductions of neuron branching and neurotransmitter activity result in a decrease in the normal functioning or in the Intelligence Quotient (IQ) of the developing mind. An inverse relationship has been found between lead concentration and birth weight, length, and length of pregnancy. This is an area where more study will help to fill in the data gaps especially studies which look at the effects of lead on the health of Indigenous communities.

As of July 2004 the U.S. EPA had not estimated a No Observable Adverse Effect Level (NOAEL) or a Lowest Observable Adverse Effect Level (LOAEL) for lead (U.S.EPA IRIS, 2007). As indicated above, because of the storage of lead in the bones and teeth, accumulation of lead in the body is difficult to access through external observation and blood tests. Physiological stresses such as pregnancy, age, health status, nutritional state, and lactation compound the assessment of lead concentration in the body. For example when a mother is pregnant or feeding a child breast milk, the stress the developing child puts on the mother results in the need for the mother to attain increased concentrations of certain essential elements, especially calcium, which as we have seen above is linked to lead. At times when a mother is not receiving enough of a certain element such as calcium, the body will begin to borrow calcium from the skeleton of the mother. This becomes problematic if the mother has been exposed to lead because the lead may be stored in the bones and may be released into the blood and eventually into the breast milk, thus exposing the child. As stated above Lead exposure is particularly destructive on the mental ability of the developing child because of the reduced neuron branching associated with lead exposure.

In a community that is using natural ecological resources on a daily basis the addition of all these factors over time may result in adverse health effects. This is of importance to communities that spend a greater percentage of their time outdoors breathing in dust or gathering plants from their surrounding area. Much of the knowledge that Indigenous communities have on the plants and animals of the area was from a time when environmental pollution was low to nonexistent.

With the introduction of heavy industry and the loss of the ability to manage the land and resources Indigenous communities have been forced to deal with problems that are not their cause, but they must ensure that their culture lives on, so they have to find ways to deal with the problems. Some solutions may be to find sources of lead deposition on and off of their lands, and make adjustments to enable them to live in a culturally perpetuating / healthy lifeway.

Mercury

A fifth heavy metal of concern to human health is Mercury. A silvery metal that is liquid at room temperature, mercury is currently used in the electrolysis industry, the production of laboratory products, agriculture to combat disease, the dental industry (amalgams), and what is of greatest environmental concern to Indigenous communities, gold mining. Mercury is considered a serious metabolic poison that humans are proscribed from handling it in its pure form. If mercury is spilled this requires its removal by a biohazard team.

Through both aerobic and anaerobic process mercury can be readily incorporated into an organic molecular form termed methyl mercury. Some plant species have been shown to absorb organic mercury at a higher rate then the inorganic form. Studies have also shown concentrations of mercury in fruit to decrease initially after contact but these concentrations may increase as the fruit matures (Adriano, 2001). This accumulation occurs as the plant converts other materials into the fruit, which is a dispersal mechanism evolved by plants to spread fertilized seeds. Ripe fruit attracts fruit-eating birds and mammals that spread the seeds after digesting the fruit covering.

Concerns over mercury contamination have risen over the last three decades because as pests have evolved immunity to earlier forms of pesticide, the chemical industry has turned increasingly to mercury based compounds in its manufacture of pesticides to control plant diseases. Products such as mercurous chloride, mercuric oxide, and mercuric chloride have been used on crops such as potatoes, onions, and apples. The toxic effects of mercury on certain plant species include reductions in rate of protein synthesis, yield, and chlorophyll content (Adriano, 2001, p. 431-432).

A key step to mercury entering the food chain is through methyl mercury where mercury enters the chain at lower trophic levels and biomagnifies as the trophic levels increases to the top predators such as eagles and minks. A similar problem was found with other organic pesticides, including those based on organochlorines, such as DDT and DDE. "A relationship exists between the methyl Hg content in fish and lake pH, with higher methyl Hg content in fish tissue typically found in more acidic lakes" (Adriano, 2001, p. 433). Although this relationship is poorly understood (by the scientific community), it may be a point of interest at mining sites where acid mine drainage occurs, allowing for lower pH levels. This also suggest that areas subject to acid rain will be more susceptible to mercury poisoning as well.

Mercury has been shown to have adverse health effects in wild life. As with DDT and DDE, in bird populations reproductive effects are the foremost concern especially reduction in survival due to contaminated eggs. In mammals damage to the liver and kidney are signs of mercury exposure. This is important to populations that depend on wildlife to sustain their health. As previously stated many Native American cultures believe that wastefulness is not a quality to be desired. By utilizing every part of an animal or plant means that the individual is very efficiently using the resources available. This level of efficiency means that the culture will have less of an impact on the surrounding resources and the environment as well as animal and plant populations, so that human life will benefit as well.

With regards to Native American lifeways, the amount of diversity is a result of cultures that have co-evolved with and developed special relationships with their immediate surrounding environment (Pierotti and Wildcat 2000). Because of this, species that hold special significance, e.g. spiritual, nutritional, or cultural, to one culture may be different to another. Consideration of the effects that environmental contaminants have on the non-human component of the environment increases the chances that the human culture will perpetuate itself for seven generations. As an example, the near extinction of species such as the Bald Eagle, which holds a strong spiritual significance to many Native American groups, because of DDT biomagnification in its food web, has had drastic effects on many Native American cultures. The decrease in the eagle population can be linked to declines in many spiritual customs, which became less active or were lost because the cultures were unable to connect with and understand the significance this species held to the people. With the recent increase in population of some species of eagle such as the bald eagle (*Haliaeetus leucocephalus*), many more Native American people will have access to this species and important spiritual symbol. This means that spiritual customs associated with the bald eagle will strengthen and thus this part of the culture will be ensured into the future.

Adverse health effects of mercury in humans include; mental retardation, cerebral palsy, and blindness in infants. In adults mercury has been correlated to central nervous system damage, increased excitability, tremor, irritability, shyness, speech difficulties, and blurred vision with kidney damage being the major effect of mercury toxicity. This is especially important to cultures that are strongly linked to aquatic ecosystems, and that depend on fish or aquatic mammals, because these species tend to function at high trophic levels, which means that biomagnification of mercury in these food webs is particularly significant. "Populations with potentially high exposure include recreational and subsistence fishers and hunters, Native

American populations who routinely consume larger amounts of locally caught fish then the general population or who consume marine mammals in their diet" (ATSDR 5, 2004, p. 464). ATSDR 5 (2004) quoted a study in which urine analysis of a Native American population in Clear Lake California near an inactive mercury mine showed levels of mercury concentration comparable to background levels, which indicated that "soil and dust exposures were not substantially elevated in the resident population" (ATSDR 5, 2004, p. 465). In contrast, urine analysis of the part of the population that consumed fish from nearby Clear Lake was analyzed, results showed that the urine mercury concentration was "7 times higher than the mean blood level in individuals that did not consume fish from the lake" (ATSDR 5, 2004, p. 465).

Increased study into the cumulative health effects of heavy metals especially in Indigenous communities will ensure not only the health of the human component of the environment but also the health of the non-human components. By understanding where heavy metals are found and how they enter human bodies, Indigenous populations will be much more able to continue subsistence lifeways and also perpetuate their knowledge and cultures into the future. More studies into pathways that can lead to cumulative and multiple exposure will help to strengthen the argument that land managers and planners should take Indigenous culture and lifeways into account before they decide to manipulate the environment. Education concerning these issues should also enable Indigenous peoples to have more of a voice in influencing policy and laws that will shape the environmental landscape of the future.

Conclusion

Effects of environmental toxins upon human health have been well documented for urban/non-subsistence populations. Human activities such as agriculture, power generation through the use of fossil fuels, smelting, mining, and improper management of waste generated during these activities have and will continue to degrade ecosystems. Many groups in the United States and worldwide continue to deal with the effects of resource management driven by profits as opposed to sustainability. Industrialization, population growth, short sighted resource management and inability to fully understand human effects on the environment will continue to degrade our air, water and soils. Integration of many existing paradigms is needed in order to ensure that seven generations into the future will live in a world capable of sustaining life in a comfortable manner.

Native Americans, as well as other Indigenous cultures, have maintained unique relationships with their surrounding environments for much longer then the length of the "industrialized" era / societies, without creating the destructive impact the latter has had on the earth. Creating a culture that shows respect for all aspects of the surrounding ecosystem has allowed these peoples to have a sustainable / non-destructive impact on the earth they call home (Anderson, 1996).

Knowledge gained through interacting with, as opposed to controlling, their lands means Indigenous peoples have advanced their relationship with the surroundings much further than have peoples that live in a state of perpetual disconnectedness from the ecosystem in which they live. Advances such as sustainable agriculture, combined with intimate knowledge of plants, animals, climate, and environmental processes have contributed to the longevity Indigenous cultures have enjoyed.

It is important to recognize that human beings, regardless of race, lifeway and degree of industrialization, are capable of very deep philosophy that can ensure the continuance of life. Theories such as social Darwinism, civilization, and progress, all of which assume that human life is improved by technological advances, have in many instances actually diminished the capability for humankind to reach our full potential. Realizations that cultures which operate under different paradigms provides humanity with a new view of reality and a range of choices, which ensures that all knowledge bases will be able to influence the decisions which affect us all. Understanding that each paradigm is created by all the values, norms, knowledge, and beliefs that a society has can be attributed to people thinking deeply about situations which affect the world in which they live. Integration of Indigenous knowledge will result in adopting techniques, processes, and understanding that should ensure that the world in which we live will continue to exist in a form that can sustain human populations.

Native American cultures have been able to perpetuate their culture, knowledge and beliefs in the face of discrimination, assimilation, racism and genocide; because these cultures understand that their knowledge is valid, valuable and reliable. Such knowledge is needed to ensure that the people see themselves as human beings and that continuing respect will be given to all portions of an ecosystem. Passing knowledge on to the next generation, even when such traditions were proscribed by the laws of the dominant culture, is a testament to the value that Native Americans placed in their knowledge and connection to the world. Perhaps mainstream Eurocentric American will never see Indigenous knowledge as valid; however, by ignoring this knowledge America as a nation will never reach the fullest of its human and resource management potential.

Contaminated resources may have an indirect impact on a society that seldom interacts with the natural world; the technological dependency that industrialized nations have developed hinders their ability to fully appreciate the consequences of resource contamination. For a society that holds this interaction as vital to its survival; contamination of culturally important resources is a very important issue. As has been elaborated above, the knowledge that Native Americans as well as other Indigenous peoples have attained through their observation of the natural world may put these cultures at risk if they are uninformed of the possible consequences of contamination. Risks associated with mining, coal fired power plants, atmospheric deposition, pesticides, smelting, fertilizers and emissions need to be assessed in a way that takes all exposure routes into account. Cumulative risk analysis attempts to consider all routes that contaminants may take when entering ecosystems and how these toxins can impact life. Special consideration must be given to cultures, such as Native Americans, that utilize their natural surroundings more regularly than do other groups in America.

Not all ecosystems are contaminated at levels that are harmful to human health, but many landscapes have undergone contaminations at levels which have the potential to be harmful to humans if these areas are utilized in a culturally appropriate way by people that have a vast knowledge of the biota in the region. If a community lacks the knowledge of plants and animals in their surrounding areas then its individual members are much less likely to know what plants or plant parts to gather. This same community may also lack the information needed to track, takedown, and butcher animals, as well as how to prepare the edible portions. If this same community is from a tradition that nature and its bounty was created to benefit only man, then the natural non-human world will be seen only as a belonging and will be treated as such (Pierotti and Wildcat, 2000). Instead of acting in a way in which the ecosystem is treated with respect and care these kinds of traditions "take" often without thinking about the consequences of their mismanagement (Anderson, 1996). This difference of both knowledge and attitude is a major reason why Indigenous peoples such as Native Americans should be given special consideration in dealing with cumulative risk assessment that addresses cultural knowledge in the analysis of exposure pathways.

Data Gaps and the need for cumulative risk assessment that takes culture into account.

Communities concerned with contamination of their resources may be able to study the culturally relevant plants and animals to understand the relationship between uptake and storage of metals in plants and soil. Many Native American communities are concerned with insensitive or disrespectful individuals taking their knowledge and resources for their own advantage, which means that many traditional indigenous peoples decline to work with outsiders. This carries its own risk, because they may remain uninformed of possible sources and routes of contamination, e.g. through consumption of organ meats, which are part of the concept of not wasting parts. The knowledge bases that Native Americans have accumulated through generations by people who understand that humility and patience is needed in order to gain deep ecological knowledge, must be respected and acknowledged (Anderson 1996). By respecting all life and the processes encompassing it, Native Americans were and will be able to manage their resources in a very sustainable way. This knowledge base has taken thousands of years to accumulate; as such the right to this knowledge should be held by the people who developed it. As a way to keep this knowledge base in the hand of its rightful owners, Native American entities may be able to complete their own studies. Studies that analyze which plants, parts of plants, and how metals, at various concentrations can be transported into the plant through the soil will help to fill in the gaps that are currently present. Analyzing and interpreting correlations between metal concentrations in soils and the plants that grow in these soils will ensure more comprehensive analysis of exposure pathways.

Watershed analysis of soils to assess presence of contaminants will provide information to tribal members of contaminated areas. This type of information will benefit the communities in various ways. Identifying areas where metal concentrations in soil are safe will allow community planners and managers to develop usage plans and manipulate the area to provide access to elderly members that may other wise not be able to travel to remote locations, thus the passage of knowledge will continue. Studies that examine metals within a watershed can be combined with other issues such as noxious weed control, cattle leasing, and the use of fire to more effectively ensure that the resources are managed in a sustainable way. Identification of areas where contamination is elevated allows the communities to examine sources of the pollution and work with the local or surrounding government to mitigate the amount of pollution affecting their lands.

Educational information on the ecological and human health effects of contaminants will enable all people, regardless of ethnicity to live in a healthful way. Access to information for many Indigenous peoples is lacking, many people do not have access to electricity, much less, libraries, internet, or media that may inform them of issues. Classes and informational packets that target resources that Native Americans and other Indigenous peoples use and address the sources, uptake and effect that contaminants have on ecosystems will ensure that these cultures prosper into the future.

Access to higher education or lack thereof, is also problematic for many Native American as well as other Indigenous cultures. Economic depression seems to be a trait shared by many Native American communities. The depression has many causes and effects; one of the effects is the inability for people to attain a college degree or attain the resources needed to live in a culturally appropriate way. Educated Indigenous environmental professionals, scientists, and lawyers are needed to help their communities to deal with pollution and its health effects. The advantage that Indigenous professionals bring to the field is that they are more inclined to understand the cultural norms, values and morals that the community wishes to integrate with their surrounding environment and resource management. This understanding will benefit the community by ensuring that culturally relevant places, plants, animals and processes are allowed to continue along with the culture.

Educational advancement, environmental analysis, cultural appropriate cumulative risk analysis and further study of culturally important foods are areas were Native Americans and Indigenous peoples will prosper when these areas are further advanced. Humans are just one portion of the ecosystem; the ability for humans to influence the ecosystems in which we live and depend upon is a great responsibility. Adapting and integrating different paradigms into resource management and planning will enable human beings to attain a new / nondestructive philosophy for future generations, of all life, to benefit from. The decisions and philosophy that we develop at this point in time will have ripple effects for years to come, a philosophy of environmental sustainability will ensure that all life will continue to prosper.

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