POISONS IN THE BASEMENT: AN ANALYSIS OF X-RAY FLUORESCENCE TESTS FOR HEAVY METAL PESTICIDES IN THE UNIVERSITY OF MONTANA'S ETHNOGRAPHIC COLLECTION

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POISONS IN THE BASEMENT: AN ANALYSIS OF X-RAY FLUORESCENCE TESTS FOR HEAVY METAL PESTICIDES IN THE UNIVERSITY OF MONTANA’S ETHNOGRAPHIC COLLECTION

By

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Thesis

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Poisons in the Basement: An Analysis of X-Ray Fluorescence Tests for Heavy Metal Pesticides in the University of Montana’s Ethnographic Collection

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This thesis focuses on the X-Ray Fluorescence (XRF) testing that was performed on the University of Montana’s (UM) ethnographic collection. This collection is housed in a repository in the UM Anthropological Curation Facility (UMACF). The main concern over the artifacts and the reason behind the decision to perform such testing was to determine if any hazardous pesticides were used as part of past conservation treatments on the collection over the course of its history at the University of Montana. The XRF tests were performed during the winter of 2011-2012 on over 350 artifacts. The results had been previously unanalyzed. The result of the scanning yielded 844 graphs showing the levels of nine different heavy metals and elements. These elements included arsenic, lead, mercury, bromine, barium, selenium, cadmium, chromium, and antimony, all of which can be hazardous to humans who may interact with the artifacts. Further, the presence of some of these elements, such as bromine, may indicate that items were treated with pesticides.

A sample of 131 of the artifacts and 258 of the test results showed high concentrations of arsenic, lead, and antimony on a majority of the artifacts. The cause of the readings could be from a variety of means ranging from the manufacturing process of the items, environmental influences, or pesticide dust from a previous application. The pesticide lead arsenate, however, uses all three of the metals, lead, arsenic, and antimony. The presence of these three metals and the high correlation between the concentration of lead and the concentration of arsenic could be indicators that this pesticide was used in the collection.

The conclusion of the testing showed that although these elements may be detected on the artifact, the results of XRF testing are inconclusive. XRF can provide researchers with the information that the element is present but lacks any method to explain the reason behind it. Further tests at the UMACF could prove vital in explaining these results. Until these additional tests are complete, caution, such as using nitrile gloves and respirators should be used in the collection when handling the artifacts.
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Chapter One:
Introduction

Throughout the history of museums and collecting, people have been searching for the best method to prevent their treasured, and sometimes priceless, objects from being destroyed by insects and other pests that can permanently damage the object. Pesticides comprised of high levels of arsenic, mercury, and other toxic elements were frequently used by museums prior to 1972 (Seifert et al. 2000; NMAI 2012). Before this year, the application of the pesticides was commonly employed to eliminate insects, rodents, and other pests (Seifert et al. 2000; Palmer et al. 2003; Pool et al. 2005; Ornstein 2010) and was, for the most part, unregulated and undocumented by either the institutions housing the artifact or the person who collected it. The use of these pesticides on the artifacts did help with the reduction of the amount of destruction caused by pests who would burrow into or eat the object. These pesticides also had numerous negative side effects in human health, often affecting the nervous or respiratory systems. The poisonous nature of these elements can be extremely harmful to humans and has been well documented (Boyer et al. 2005; ATSDR 2007; Ornestin 2010). The contamination of the artifacts by museum professionals and collectors “means that such items cannot effectively be returned to ceremonial use for it would be deadly to wear an arsenic-laced mask or to blow a whistle covered” with any other hazardous materials (Cooper 2008:84).

During the 20th century, many federal laws were passed to encourage the collection of archaeological objects. These laws not only enabled museum collections to grow, but they also allowed for the protection of sites, the creation of new museums, and the evaluation and creation of rights held by Native Americans and their tribal communities in the form of repatriation. Some of these laws include the Antiquities Act of 1906, the Historic Sites Act of 1935 and the National Museum of the American Indian Act of 1989, the latter arriving just a few years before
the passage of the Native American Graves Protection and Repatriation Act (NAGPRA). The passing of NAGPRA in 1990 required museums or other institutions receiving federal funds to repatriate objects in their collection back to native tribes that have a legitimate claim on those items. According to the California Department of Parks and Recreation (CDPR), while consultations took place, “tribal representatives and museum collection managers became aware that many Indian collections had been treated with toxic substances” (CDPR 2013). Because of this, an amendment was added to the original NAGPRA bill in 1995 concerning the pesticide issue (CDPR 2013), but the amendment contained no suggestions as to how to handle the object or how to test for toxic pesticides only that tribes needed to be informed of any known pesticides. Nevertheless, some museums have taken it upon themselves to test for toxic substances (Sirois 2001) before the repatriation process takes place. Testing for pesticides can be accomplished through a variety of ways, both destructive and not, although non-destructive techniques are preferred. Testing should be done before the objects are given back to the tribes because the objects may contain levels of toxicity too high for contact or inhalation (Loma’omvaya 2001).

Due to the fact that the University of Montana Anthropological Curation Facility’s (UMACF) is one of those institutions housing a collection of ethnographic artifacts facing repatriation, the facility negotiated a way to pay for the tests to analyze the presence of toxic substances that may be present on the artifacts. The tests needed to be done prior to repatriation so the tribes receiving the artifact could – and now can – be informed of any dangers. The results and analyses of those tests are the reasons for this thesis. Here, I document the results of the XRF tests on a sample of tests from the UMACF.

During the winter of 2011-2012, staff at the UMACF conducted tests for heavy metal pesticides and other dangerous elements such as selenium and bromine. This test included a
300s scan of each artifact taken by an X-Ray Fluorescence (XRF) machine (Quickshot XRF EDX P330). Although some problems have been documented with using the XRF machine to test for pesticides (Palmer et al. 2003; Fonicello 2007; Hollinger and Hansen 2010; Madden et al. 2010), this tool was chosen for two major reasons. The first is that using XRF allows for a non-invasive and non-destructive way of sampling the artifact. While more accurate results might come from different equipment such as Gas Chromatography/Mass Spectrometry (GC/MS), these tests require a small sample to be taken from the object. The second reason is the total cost (both time and financial) of the project. Using XRF costs considerably less and takes less time than using GC/MS (Makos 2001; Nason 2001; Purewal 2001; Sirois and Sansoucy 2001; Palmer et al. 2003).

For the UMACF’s ethnographic collection, the number of tests conducted on the artifact depended on the size of the object and its material composition. An object made totally from leather required only one or two, while a quirt or a necklace might need three or four due to the different materials adhering to the type of footwear (glass beads or porcupine quills to name a few). This study produced 844 tests on 351 objects. The XRF machine used was calibrated for nine different elements, including lead, arsenic, cadmium, mercury, chromium, bromine, selenium, antimony, and barium – and could potentially have found many more. These nine elements were chosen due to their toxicity in humans and the likelihood of their presence on and in the objects and due to financial limitations. In the case of the objects tested at the UMACF, these elements were detected in both large and small quantities. Mercury, lead, arsenic, chromium, bromine, antimony, and cadmium, were all present but there was no evidence of barium or selenium. In respect to the usage of XRF testing and the detection of heavy metals, Prufer et al. (2009:2) say that:
In some cases where lead was present in trace amounts, it may be due to background levels from automobile exhaust. Likewise, lead, arsenic, and mercury may be present in some pigments used on the objects in question. XRF cannot distinguish the sources of the elements, only their presence or absence. In many cases we cannot explain the origin of an element.

There can be a multitude of reasons that these metals were detected on the artifacts. The manufacturing of beads often included the use of arsenic, lead, and antimony in high levels. Environmental factors can influence whether poisonous metals might be found when performing XRF analyses. Of course, there is always the possibility that hazardous pesticides were used by the museum or institution, but due to the undocumented nature of the practice, it makes it almost impossible to know for certain. However, performing the XRF tests still allows for knowledge to be gained and provide a framework for any future testing that might be performed on the artifacts in the anthropological collections at the University of Montana.

My hypothesis is that the XRF testing will show there is a presence of heavy metals and hazardous elements on the artifacts. A secondary hypothesis is that, because preliminary observations indicate high levels of these elements, then this is the result of usage of toxic pesticides on the ethnographic collection.

Addressing these issues in the UMACF’s ethnographic collection helps the region’s tribal cultures and communities by allowing us to share as much information as possible about the potential dangers associated with the handling of certain artifacts, the reputation and the credibility of the University of Montana will continue to be upheld as a place that responsible and sustainably manages its museum collections. This research is relevant to the ethical principles of the UMACF as stewards of cultural heritage.
The implications for this study are to determine if the objects in the University of Montana’s ethnographic collection are affected by the use of inorganic pesticides. This, in turn, affects how objects should be presented to the tribes who have a claim to these items. “The most important considerations in all these studies is providing data and information to Native Americans and museum professionals which can help them answer questions such as whether or not an item is contaminated, what is the extent of the contamination, what are the potential exposures and risks, and how to take appropriate measures to minimize these risks” (Palmer et al. 2006:31).
Chapter Two: Regulations and Legislation: A History Leading to the Passage of NAGPRA and Issues Associated with the Act

The passage of the Native American Graves Protection and Repatriation Act (NAGPRA) in 1990 was a major turning point in the fight over ownership and the desecration of Native American goods and ancestral remains. Prior to the passage of this act, the only laws that were in effect protected museum collections and archaeological sites across the country and allowed museums to enhance their collections. These laws include the Antiquities Act of 1906, the Historic Sites Act of 1935, the Reservoir Salvage Act of 1960, and National Historic Preservation Act of 1966, the National Environmental Policy Act, the Archaeological and Historic Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, and the Archaeological Resources Protection Act of 1979 (Trope and Echo-Hawk 2000; Fine-Dare 2002; Sullivan and Childs 2003; Buikstra 2006; Campbell 2011). Additional legislation in the years leading up to the passage of NAGPRA ensured proper care or the return of Native American remains and grave goods. The legislation included the National Museum of the American Indian Act of 1989 as well as state level repatriation laws concerning human burials in California, Hawaii, Kansas, Nebraska, and Arizona (Trope and Echo-Hawk 2000; Killion 2001; Quigley 2001; Buikstra 2003).

Along with the passage of NAGPRA came some concerns from the scientific community. Scientists see items from archeological sites as objects that deserve study to better understand the human condition. Native Americans, on the other hand, see those same objects as being desecrated and should not be subjected to the whims of the scientist who, in the past, have seen deceased Native Americans as ‘archaeological resources,’ ‘objects of historic or scientific
interest,’ and ‘federal property’ that could be excavated, disinterred, sent to museums, and otherwise ‘managed’” (Fine-Dare 2002:62).

This chapter will describe archaeological legislation that created the vast collections housed in many institutions, state level repatriation legislation and a few various issues that have arisen after the passage of NAGPRA. Before the issues can be discussed, however, there needs to be an examination of the past legislation and the historical backdrop that lead up to the passage of NAGRPA.

**Legislation in the Early 20th Century**

Early in the 20th century, Congress passed the Antiquities Act of 1906. This law was passed to govern excavations, archaeological sites, and the procurement of cultural items to those who received proper authorization from the State Department. The law states:

That any person who shall appropriate, excavate, injure, or destroy any historic or prehistoric ruin or monument, or any object of antiquity, situated on lands owned or controlled by the Government of the United States, without permission of the Secretary of the Department of the Government having jurisdiction over the lands on which said antiquities are situated, shall, upon conviction, be fined in a sum of not more than five hundred dollars or be imprisoned for a period of not more than ninety days, or shall suffer both fine and imprisonment, in the discretion of the court (16 U.S.C. 431-33).

Along with permits being necessary to excavate and punishment for those without permits, the law also has stipulations in place for the curation of the objects collected. This includes preservation in a pre-determined museum and access to the objects by the public
(Sullivan and Childs 2003; Campbell 2011). While archaeologists saw the passage of the Antiquities Act of 1906 as a positive for them, many other people saw the opposite to be true. Fine-Dare (2002) argues that the act served to reduce the number of amateur archaeologists who were looting on public and Indian lands as well as reinforcing the idea that the Native American past belonged to scientists and not the Native Americans. One of the ideas of the Antiquities Act was that archaeological artifacts recovered on public land are a public resource (Sebastian 2004). Because of this, the Indian dead and their associated funerary goods became seen as federal property and archaeological resources because they were located on government land (Trope and Echo-Hawk 2000). However, the law seemed to lack specificity, which made it almost completely ineffective (Campbell 2011). The effective part of the Antiquities Act was the outcome that many significant archaeological sites were designated as national monuments and continue to be preserved as such (Sebastian 2004).

Almost thirty years later, the second piece of legislation passed by the federal government during the first half of the 20th century was the Historic Sites Act of 1935. It was signed by President Roosevelt as part of his New Deal programs. The Historic Sites Act allowed the National Park Service, along with the Smithsonian, to examine and search federal land for historical and archaeological resources (Campbell 2011). The Act also enabled the creation of a group of eleven private citizens to advise the national government about historic sites, buildings, and monuments as well as any national parks (Fine-Dare 2002). The involvement of any archaeologists in the creation of this law may be in question due to the lack of any mention of artifacts or specimens; rather, the Historic Sites Act emphasizes data from drawings, plans, and photographs (Sullivan and Childs 2003). The law also centralized federal activity concerning preservation with the National Park Service. The Historic Sites Act brought with it the first
successful repatriation event when, in 1938, the Hidatsas were able to re-obtain a sacred Midipadi Bundle (Fine-Dare 2002).

The New Deal programs of the 1930s occurred during a period of massive collection due to the enormous amount of large scale construction activities from the Civilian Conservation Corps and the Works Progress Administration. Regardless if archaeologists and anthropologists were involved in the creation of the New Deal legislation, some of the projects yielded so many artifacts that museums were built just to handle the amount of objects collected. The projects “had significant impacts on U.S. archaeology, both in creating extremely large collections that now serve as major data banks and in formulating new techniques, methods, and theories” (Sullivan and Childs 2003:11).

Post World War II Legislation

The first major piece of legislation passed after World War II was the Reservoir Salvage Act passed in 1960. It was an act in response to the River Basin Salvage Program which, in turn, was a response to the large government construction programs of dams and highways (Sullivan and Childs 2003; Campbell 2011). Before any large amounts of land were to be covered in water from the dams, surveys were conducted and artifacts were collected by the National Park Service and the Smithsonian. The act encourages the Secretary of the Interior to consult with any organization, institution, agency, or citizens in an effort to determine ownership of the object and the best place to keep the object. However, in opposition to the Antiquities Act, “the kinds of institutions to serve as repositories were not named, the public educational value of collections and accessibility issues were not mentioned, and the critical need to make curation arrangements
prior to fieldwork was ignored” (Sullivan and Childs 2003:18). The act does supplement the Historic Sites Act by allowing archaeologists to actually remove the artifacts and relics from the construction site (Fine-Dare 2002). Many items were recovered from mining expeditions, logging camps, and the creation of Spanish missions and other missions. Due to the large quantity of construction programs occurring at the time and the limited amount of man power available, Fine-Dare suggests that only the sites with exceptional significance were to be preserved. Hill (1996) says that this is the main reason for the current collections of Indian objects.

After the passage of the Reservoir Salvage Act, Congress passed the National Historic Preservation Act (NHPA) in 1966. The act established the State Historic Preservation Offices (SHPO) due to an increasing need for preservation because of the many construction projects going on around the country such as urban development and the interstate highway system (Fine-Dare 2002). One of the biggest mandates in the act requires federal construction projects on historic sites to be surveyed (Sullivan and Childs 2003; Campbell 2011), which is defined in its entirety in Section 106 of the law. In his essay, Wood discusses the role of a SHPO office:

The SHPO functions as a federal liaison officer within state government, coordinating certain historic preservation activities within the geographic boundaries of the each state. Under the NHPA, the SHPO’s major responsibilities include review of federal projects for compliance with the provisions of the act, coordinating a comprehensive statewide inventory of historic properties, and administering a statewide program of federal matching grants for historic preservation projects. Other responsibilities include the development of a statewide historic preservation plan and providing technical assistance regarding preservation techniques and procedures (Wood 1990:101).
The NHPA was changed in 1986 with additional regulations. The act now allowed Indian tribes and their cultural leaders to participate if cultural properties were to be affected by any of the federal projects. A 1992 amendment allowed Native American or Hawaiian cultural properties to be allowed on the National Register of Historic Places provided that there was proof of cultural or religious significance (Fine-Dare 2002). Fine-Dare also goes on to state that the major problem of this act is that it requires that Native American tribes provide the proof of an object’s cultural relevance or sacredness. This regulation set forth in the NHPA is often contradictory to many of their belief systems and often consider that nature of information not available for public consumption and the revelation of the information can violate religious and traditional ideas (Tsosie 1997).

The second piece of legislation passed in the 1960s occurred in the last year of the decade, 1969, the National Environmental Policy Act (NEPA). Only a small portion of the law concerns historic and cultural properties and none of it details any information on curation of archaeological collections. NEPA requires only that federal agencies be informed before making any decision concerning environmental impact and development projects (Fine-Dare 2002; Sebastian 2004; Campbell 2011). However, as Fine-Dare (2002) says, just being informed does not ensure that those sites will become protected and, like NHPA, it puts the burden of proving significance on the tribes and having sensitive and private information be, potentially, broadcast publically. While both the NHPA and the NEPA resulted in large collections of recovered material, the national laws put emphasis on preservation of all archaeological objects recovered from federal development projects. There was no mention of repatriation back to the tribes to which the objects belong (Fine-Dare 2002). Although repatriation may not have been on the minds of those at the nation’s capital, Fine-Dare (2002)
states that many of the states were passing their own laws and statutes regarding Native
American goods and remains and these statutes concerned antiquities, historic preservation, and
in some cases, repatriation.

These last four acts that were passed were the Archaeological and Historic Preservation
Act of 1974, the American Indian Religious Freedom Act of 1978, the Archaeological Resources
Archaeological and Historic Preservation Act (AHPA) is also known as the Moss-Bennett Act,
now considered redundant since the addition of section 106 to the National Historic Preservation
Act (Sebastian 2004). At the time of passage, though, the main initiative behind the law was to
have federal projects relay any information to the Department of the Interior concerning the loss
of any significant, historic, or archaeological data resulting from construction. It also gave the
option for the National Park Service (NPS) to be compensated by other federal agencies to
conduct the necessary work of excavation and preservation of archaeological objects (Sullivan
and Childs 2003; Campbell 2011). The amount of compensation paid to the NPS was budgeted
in the project costs and that “up to 1 percent of the costs of a federal project could be spent on
the recovery, protection, or preservation of endangered data” (Sullivan and Childs 2003:24). The
AHPA also had the first mention of long term curation plans and regulations for artifacts and
collections.

In 1978, the Federal government passed the American Indian Religious Freedom Act
(AIRFA). The legislation allowed for American Indians to believe and practice their traditional
religions. It gave American Indians, Eskimos, Aleuts, and Native Hawaiians, the ability to
access sacred sites, use and possess sacred objects, “and the freedom to worship through
ceremonial and traditional rites” (42 U.S.C. 1978). The Act also forced federal agencies to
consult with tribal religious leaders to determine what changes, if any, need to be made in their policy to allow the rights and practices of Native Americans to be protected and preserved. Executive Order 13007, signed in 1996 by President Clinton, furthered the AIRFA by stating that federal agencies were responsible to accommodate access to sacred sites, preserving these sites, and, when necessary, keep the site location information confidential (Clinton 1996).

The subsequent piece of legislation pertaining to archaeological collections discussed in this chapter is the Archaeological Resources Protection Act (ARPA) of 1979. It is, in essence, an updated, expanded, and stricter version of the Antiquities Act of 1906. Due to an increase in looting of archaeological sites in the 1970s, ARPA was passed with the intent to fine individuals caught looting with fines up to $100,000 or 5 years in prison depending on the severity and if it is a repeat offense (Fine-Dare 2002; Sebastian 2004). In order to limit the amount of looting, the law requires permits for excavation before any archaeology can be conducted on federal or Tribal lands. The permits are obtainable from either the land-managing federal agency or the Tribe. This is significant because it recognized Tribal sovereignty over their land and cultural or archaeological items on their land and it allowed them to govern the permitting process along with other Federal agencies. Following the passage of AIRFA, the law also states that Native Americans must now be given notice of any excavations being carried out, even if these are on non-Indian lands. This is especially true if the work might cause damage or disturbance to Indian religious or cultural sites (Fine-Dare 2002). Along with looting, ARPA restricts the interstate trade of illegally gained archaeological materials (Sullivan and Childs 2003; Richman 2004; Sebastian 2004). ARPA can be difficult to enforce because of the openness of federal lands. Large, unpatrolled areas of land make it easy for looters to operate and reduce the risk of discovery and apprehension. Sebastian (2004) says that limiting the effectiveness of ARPA is
the inability of many law enforcement personnel, federal prosecutors, and judges who do not see cultural resource crimes as real or big enough threats to warrant expenditures of limited time and resources.

Turning our attention to archaeological collections and the care involved, ARPA mandates three main things. The first is that it states that objects found on public lands belong to the United States. The second is that the preservation of these materials must be conducted in a suitable institution meeting certain requirements and standards as set forth in 36 CFR 79. The third is that it allows the Secretary of the Interior to make the final decision about exchanges and the final settlement of the collections (Sullivan and Childs 2003).

Despite being passed almost 80 years after the passage of the Antiquities Act, ARPA does not differ much in opinion concerning human remains. Referencing Tsosie (1997), Fine-Dare states that “like the 1906 Act, ARPA refers to Native American human remains and cultural patrimony[^1] as ‘archaeological resources’ that are the property of the entire United States. Second, the fact that ARPA issues excavation permits means that it still condones the destruction of Native American sites” (Fine-Dare 2002:83). Federal courts used ARPA to allow for the scientific study of recovered skeletons (Schneider 2004), stating that “allowing study is fully consistent with applicable statutes and regulations, which are clearly intended to make archaeological information available to the public through scientific research” (Jelderks 2002:1167). In the end, ARPA supported the traditional western ideas of property claims and scientific research interests rather than the concerns of the Tribes.

[^1]: Cultural patrimony is defined as “items of special importance that were communally owned by a group of some kind within a Native American community at the time they were conveyed away” (Echo-Hawk 2002:231)
During the 1980s, repatriation began to emerge as a concept and play a bigger role in the cultural and political struggles of Native Americans. According to Fine-Dare (2002) critiques from anthropologists, archaeologists, historians, art historians, and museum specialists began to voice their concern over Native American material objects and their possession, treatment, and representation. Scientists and social scientists met with Native American intellectuals and activists to debate the treatment of sacred objects. Because of this, legal action at the federal and international levels began to take place. These began as claims for the return of cultural property before federal repatriation laws were passed.

Fine-Dare (2002) recounts one of the first instances of the repatriation process which began in the last few years of the 19th century and continued for almost one hundred years. In 1891, four wampum belts were sold to a general in the US army by a chief of the Onondaga tribe. The members of the tribe attempted to reclaim the belts in 1899 due to the fact that wampum was communally held and the chief had no right to sell the belts. The judge ruled against the tribe and cited them as curiosities and relics. In 1909, New York declared that wampum was to be kept by the state so the belts were donated to the New York State Museum in 1927. In 1970, the Onondaga people fought again for the return of the belts but were blocked by a group of anthropologists. In 1977, the Union of Ontario Indians fought for the return of the belts and had a lawyer examine the Museum of the American Indian’s acquisition records of the belts. The research into the records “convinced the museum board of trustees that the wampum belts should be returned, which was done in an elaborate and moving ceremony in 1988” (Fine-Dare 2002:94) where the belts were returned to the Six Nations Council of Chiefs in Grand River, Ontario.
A further example of repatriation movement that occurred before the federal government passed its mandate, is the return of the Zuni War Gods, carved and painted images of Twin War Gods. In 1978, the Zuni tribe declared that all War Gods, or Ahayu:da, that had been removed from the Zuni territory had to be returned. They declared this, according to Fine-Dare (2002), on universal humanitarian grounds, as well as for self-determination, human rights, and their own sovereignty. The Zuni religion states that the War Gods must be properly instructed as to how to protect the Zuni people and their power must be controlled through the prayers and rituals performed by Zuni priests. In 1987, two War Gods were returned to the Zunis by the Smithsonian but an estimation was given in the 1990s that eighty Ahayu:da had been removed and put in museums. By 1993, “sixty-five War Gods had been located and repatriated to the Zunis” (Fine-Dare 2002:96). These War Gods came from across the United States and Canada and because there was no federal legislation, the Zunis “had to negotiate separately with more than thirty private collectors and institutions, a grueling, time-consuming, and heartrending task” (Fine-Dare 2002:97). The struggle of the Zuni people and the Onondagas for the return of their sacred cultural objects prove that the repatriation movement has been active before the passage of NAGPRA and helped to bring the concerns of the Native Americans to the American people.

In the last year of the 1980s, the federal government started to listen to the Native American Tribes and their cries for the return of their ancestors and sacred objects. In 1989, the National Museum of the American Indian Act (NMAIA) was passed. According to some (Trope and Echo-Hawk 2000; Killion 2001; Lovis et al. 2004), it was the first piece of repatriation legislation passed in Congress and almost served as a precursor to NAGPRA and the first act towards repatriation (Quigley 2001). As well as establishing a National Museum of the American Indian, the Act mandated that the Smithsonian Institution establish an inventory of its
collections and attempt to determine the cultural affiliation of all Indian remains and funerary objects in its possession and that those objects that were positively identified be repatriated to affiliated groups (Killion 2001). This act was aimed exclusively at the Smithsonian Institution due to its large collection of human remains in its possession and the George Gustav Heye collection which consisted of more than 800,000 objects housed at the Museum of the American Indian (NMAI 2014). This collection, as part of the Act, was incorporated into the Smithsonian with the formation of the NMAI. At the time the law was passed, the Smithsonian had approximately 18,400 sets of human remains (Killion 2001; Buikstra 2003) which were identified as Native American; this is considered the largest collection of Native American remains in the country. Killion (2001) argues that the law was passed to appease the complaints of many Native Americans who voiced that their main concern were the human remains and that having such institutions hold onto those remains reminded the Native Americans of the historically unequal treatment accorded Native burial ground. In order to facilitate the repatriation efforts of the institution, the Repatriation Office was established in 1991.

Through the use of biological, geographical, historical, genealogical, archaeological, linguistic, folkloric, ethnological, and archival (Quigley 2001) evidence, efforts have been made to determine the cultural affiliation of the human remains which would then allow for lineal descendants to reclaim their ancestors. According to Killion, the Office has had considerable success with their repatriation efforts and some of the statistics are given:

Since its inception, the Repatriation Office has received 80 official requests for returns from Native Groups. A total of 53 repatriations have been completed to date and more than 4000 sets of Native American remains and associated funerary objects have been returned for reburial to culturally affiliated tribes. Another 1,500 sets of remains are
presently scheduled to be repatriated to several Plains Indian tribes. This will bring the total number of repatriated remains to more than 5,500 individuals amounting to an average return rate of 600 sets of remains per year. This figure represents approximately thirty percent of the total number of human remains potentially subject to repatriation in the NMNH [National Museum of Natural History] (Killion 2001:153).

Repatriation is not the only solution pertaining to the question of human remains or cultural objects. The Smithsonian offers (and encourages) other avenues to consider. Quigley (2001) lists some of these options which include long-term loans, storage in a secure facility, transfer of the remains to regional or native museums, or retention by the museum and have both the institution and the affiliated tribe manage the care of the associated artifacts. Doing any of these measures also allow for future research to be conducted on the artifacts.

State Legislation

Protections for human remains had to be recognized at the state level before the efforts were made at the national level with the passage of NAGPRA. This came in the form of state legislation with the intent to (1) protect unmarked graves and (2) repatriate cultural items back to Native communities (Trope and Echo-Hawk 2000). Through the 1990s and up until the first years of the new millennium, there have been 34 states to pass legislation regarding the protection of unmarked graves and the issue of reburial. These laws include a prohibition of intentional disturbance of unmarked graves, guidelines to protect those graves, and recommendation to rebury any remains after a certain period of time allowing for study. Some states have laws that go beyond Native American remains and cover all human remains – even
those in private collections. These laws established prohibitions against excavating, exhibiting, and curating human remains (Quigley 2001).

Most state laws passed resemble each other in some ways, but they vary in others. The typical state law, however, “sets forth in considerable detail procedures that must be followed whenever anyone, either a lay person or a professional archaeologist, discovers either an unmarked human burial site or a Native American burial site” (Ubelaker and Grant 1989:275-6). Contrasting with the 34 states passing unmarked grave laws, only five (from 1989 to 2000) have passed repatriation laws and include California, Hawaii, Kansas, Nebraska, and Arizona (Trope and Echo-Hawk 2000). Since discussing all of the state legislation would be, in itself its own essay, only a few case studies will be mentioned.

In the 1980s, Delaware, Hawaii, Kansas, Ohio, and Nebraska all passed legislation regarding human remains or participated in some form of repatriation. Ohio was first in 1982 when the Cleveland Museum of Natural History recommended that human remains excavated through the means of salvage archaeology be kept for four years to allow for identification to occur. If identification was not possible, then permanent curation was the best available option. A few years later, in 1987, the same museum in Cleveland developed and implemented policies that prohibited the public display of human remains (Quigley 2001).

That same year, Delaware passed legislation saying that any human remains excavated prior to 1987 had to be reburied within a year. Any Native remains found after that year had 90 days to be reburied with consultation with the Native American Skeletal Remains Committee if there was no medicolegal significance. The legislation was successful and the “remains from all of the state’s museums and repositories were reburied in 1988 in airtight containers, which allows the possibility of future research, but it and the testing of samples taken before reburial
will have to have the consent of the committee” (Quigley 2001:215). The state of Delaware also has in place legislation that completely prohibits any display of human remains in any aspect (Ubelaker and Grant 1989; Quigley 2001).

The final year of the decade saw three repatriation events in three separate states. The state of Hawaii used $500,000 to rebury almost 900 Native remains. They were excavated by a private developer who was attempting to build a hotel on a Native Hawaiian burial ground (Trope and Echo-Hawk 2000). Kansas experienced a similar situation when a tourist attraction had on display 165 Native Americans from a burial ground. Legislation was passed and a reburial agreement reached between the state, the owner of the tourist attraction, and three tribes who would take possession and rebury the remains with the descendent tribes (Trope and Echo-Hawk 2000).

Finally, Nebraska passed general repatriation legislation entitled the “Unmarked Human Burial Sites and Skeletal Remains Protection Act.” The act, according to Trope and Echo-Hawk, “requires all state-recognized museums to repatriate ‘reasonably identifiable’ remains and grave goods to tribes of origin on request” (Trope and Echo-Hawk 2000:135). Due to its passage, the Pawnee Tribe was able to recover approximately 400 sets of human remains from the Nebraska State Historical Society, despite resistance from the group.

During the 1990s, there were four states (Arizona, California, Illinois, and Montana) participating in some form of repatriation, whether it was legislation or acts of goodwill. Arizona had sweeping repatriation legislation in the first year. It required the return of all human remains, funerary objects, sacred objects, and objects of tribal patrimony to the suitable tribe. According to Trope and Echo-Hawk (2000), the law also stated that those remains that were
unable to be culturally identified with a tribe must be reburied within one year and it must be nearest to the place where the remains were discovered.

California passed a law the next year in 1991 making repatriation of both human remains and grave goods a policy of the state. Also in 1991, after the passage of legislation, the State Historical Society in Kansas deaccessioned and returned Pawnee Indian remains that it had in its collection (Trope and Echo-Hawk 2000).

In Illinois, the passage of the Illinois Human Skeletal Remains Protection Act in the year of 1992 “establishes guidelines for excavation and for the disposition of recovered bones. Archaeological remains excavated under permit and unclaimed remain the property of the states and are curated by the museum, which makes them available for scientific inquiry” (Quigley 2001:216).

Montana adopted new legislation in 1991 entitled the Montana Human Skeletal Remains and Burial Site Protection Act. It was passed after many years of work between the state’s tribes and lawmakers to ensure equal protection for all burial sites and graves. The law “provides legal protection to all unmarked burial sites regardless of age, ethnic origin or religious affiliation by preventing unnecessary disturbance and prohibiting unregulated display of human skeletal remains” (MHS 2008).

According to Price, and contrary to the list mentioned above, “all states have laws that address in some manner the disposition of prehistoric aboriginal remains and grave goods. Some merely apply their criminal laws against grave robbing, trespass, and vandalism, or their general public health and cemetery laws” (Price 1991:43). Although not necessarily state legislation, a few states repatriated items or were involved with the process prior to federal legislation. Fine-Dare (2002) compiled a list of repatriation chronology mentioning a few of those events. For
example, in 1985, Michael Bush, the executive director of the American Indian Community House in New York wrote an editorial to the Smithsonian. The editorial called for the institution to allow Native Americans access to their cultural patrimony or to return them to their proper tribes. In 1988, an auctioneer in Baltimore returned three headdresses to the Blackfeet Nation. The Field Museum in Chicago adopted a repatriation policy in 1989 concerning human remains. In 1989, the Blackfeet Tribe in Montana received items from the Smithsonian and performed a reburial ceremony. With many states passing their own bills, laws, and regulations concerning repatriation, the federal government knew it had to act as well. This action came in the form of NMAI, passed in 1989, and two years later, the passage of the Native American Graves Protection and Repatriation Act (NAGPRA).

*The Passage of NAGPRA*

In July 1990, a bill was sponsored by Representative Morris K. Udall from Arizona “to provide for the protection of Native American graves, and for other purposes” (Baker 2001:29). Four months later, on November 16, 1990, the Native American Graves Protection and Repatriation Act (NAGPRA) was passed by Congress and signed into law by President George H. W. Bush. The law established “detailed procedures and legal standards governing the repatriation of human remains, funerary objects, sacred objects, and objects of cultural patrimony and provides for the protection and ownership of materials unearthed on federal and tribal lands” (Trope and Echo-Hawk 2000:139). The law applies to all museums, institutions, departments, agencies, and governments that receive federal funds except the Smithsonian Institution, which is governed by the NMAI. The aforementioned institutions were also required to provide to the
National Park Service and federally recognized Native American tribes a summary of their collections by November 1993 and then two years after that in 1995, all institutions were to have a complete inventory of their collections, which would also indicate a cultural affiliation of the objects (Quigley 2001). The summaries should include an identification of the four types of Native American objects listed in the law. These four types of objects are (1) human remains, (2) funerary objects, (3) sacred objects, and (4) objects of cultural patrimony. The law defines the difference between sacred objects and objects of cultural patrimony as “specific ceremonial objects needed by traditional Native American religious leaders for the practice of traditional Native American religions by their present day adherents” for the former and items “having ongoing historical, traditional, or cultural importance central to the Indian tribe of Native Hawaiian organization itself, rather than property owned by an individual tribal or organization member” for the latter (25 USC 3001).

Some have seen the law first and foremost as a “human rights” act for Native Americans (Trope and Echo-Hawk 2000) and the mistreatment that they have endured at the hands of the United States government. Congress passed NAGPRA in an attempt to rectify past mistakes and to establish trust between the U.S. government and Native tribes. With the law in place, Congress hoped to promote a dialogue between the tribes and museums. Trope and Echo-Hawk (2000) argue that NAGPRA was designed as a way to appease both the needs of museums as repositories of the nation’s cultural heritage and the rights of the Indian people.

Another benefit to NAGPRA is the scientific research that has been done to skeletal collections. Quigley (2001) states that the atmosphere after the passage of the Act stimulated the funding and conducting of research on threatened collections that no one had really bothered to study before. However, some do not see NAGPRA that way. Quigley says earlier that the “law
is derided by some Native Americans who see it as the latest in a long history of attempts to define tribes in ways that facilitate their control and manipulation by oppressive governmental agencies” (2001:213). This issue mostly arises when non-federally recognized tribes (due to a failure to receive recognition or a rejection of recognition) attempt to lay claim to cultural objects (Quigley 2001). Many tribes lost their official status during the Indian Termination Policy implemented in the 1950s (Walsh 1983). This issue, and others like it, is fairly common after the passage of the law and were even mentioned during the testimonies before the Committee of Indian Affairs during the 1st sessions of both the 104th Congress and the 106th Congress (Baker 2001).

Finally, NAGPRA allows for lines of dialogue to emerge between the tribes, museums, and other agencies and for these groups of people to form new, stronger relationships. Consultations between these three factions can result in collaborative decisions regarding artifacts and other cultural items in a collection. These decisions “may involve continued curation, the adoption of more appropriate standards of curation, and/or the repatriation of human remains and material culture” (McLaughlin 2004:185).

Testimonies both for and against NAGPRA were voiced before the Committee. The main emphasis against NAGPRA was the “importance of human remains for scientific study emphasizing the need to learn for the future from the past. Individual scholars expressed concern for remains if they are reburied, in that they will be lost to science forever and, not reachable when future study techniques are developed” (Baker 2001:32). An associate professor of anthropology at the University of Wisconsin-Milwaukee, Lynne Goldstein, argued that point and stated that “even if remains were generally and distantly related to present-day groups, knowledge of past cultures and life ways was part of the heritage of the entire country,
benefitting all people” (Baker 2001:32). The party against NAGPRA went on defending their position when the topic of culturally identifiable human remains was presented. At the time, the Chair of the Society of American Archaeology, Keith W. Kintigh, believed that the information recovered from the study of those remains, and the public interest in those remains, outweigh any claims by Native groups who have no apparent association to the remains or an object. Anthropologists were not the only voices in opposition or concern. According to Baker (2001) both Native American leaders and tribal members were concerned about the repercussions of NAGPRA.

The voices in support of NAGPRA had their own positions to defend. Most of the opinions of those in support of the law argued that the law would establish a process which would allow both the museums and Federal agencies to work in cooperation with descendents and recognized tribes to identify artifacts and reach agreements pertaining to human remains and Native objects in museum collections (Bake 2001). Further arguments were made concerning reburial of Native American remains. Walter Echo-Hawk, an attorney for the Native American Rights Fund, supported NAGPRA because of the legal protection it grants tribes over human remains in museums; in addition, a councilman for the Confederated Salish and Kootenai Tribes, Patrick Lefthand, “supported the legislation providing for mechanisms to return human remains, funerary, and other protected objects” (Baker 2001:35). Finally, the arguments in support of NAGPRA cited grave robbing and illegal trafficking as the primary sources of museum acquisitions and that the law would both prohibit further instances of both and allow for the return of those illegally obtained goods. Museum officials also testified on the behalf of NAGPRA, but the Director of the Museum of Northern Arizona, Philip Thompson, stated that in the instances where human remains were unable to be culturally associated to a tribe, museums
should retain the right to complete their studies of the skeletal remains (Baker 2001). Today’s ruling in the issue concerning unassociated cultural items and remains state that the first claimant can be those who claimed the land when the item or remains were removed. The second claimants can include people aboriginal to the area.

NAGPRA was passed by Congress to acknowledge cultural differences and to “incorporate varied native perspectives into the governance and regulation of Native American material culture” (McLaughlin 2004:187). They achieved this through the use of the two different legal categories, “cultural affiliation” and “cultural items.” Cultural affiliation is often found using geographical, linguistic, biological, and archaeological methods. Cultural and material items must be considered sacred objects of cultural patrimony. These sacred objects are those which are necessary by religious leaders to practice their traditional religions by present day people (McLaughlin 2004). Many of these items were taken in the late second half of the 19th century, after many tribes were placed onto the reservations. According to Trope and Echo-Hawk (2000), the pattern in the minds of federal agencies shifted from acquiring real estate to acquiring material goods. These goods were sometime procured through legitimate means, such as trade and purchase, but were also often the result of theft, military confrontations (the spoils of war), or improper sales.

Property laws established in the United States have had difficulties being established in the area of cultural goods and due to the implications that NAGPRA has for the nation, some issues regarding aspects of the law have arisen and have made repatriation a challenge in some manner.

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Cultural affiliation is defined in NAGPRA as “a relationship of shared group identity which can be reasonably traced historically or prehistorically between a present day Indian or Native Hawaiian organization and an identifiable earlier group” (25 USC 3001)
Current Issues Associated With NAGPRA

Fine-Dare (2002) mentions administrative, procedural, and compliancy problems as among the major issues with NAGPRA projects. Due to the intricacies of the law, there are delays and backlogs of inventories submitted to the national NAGPRA, administered by the National Park Service (NPS), and institutions that have yet to complete an inventory due to not receiving federal funds to accomplish this task. Given the noted complexities of compliance with the law, “it seems exceedingly unlikely that any resolution could have been found that would have completely satisfied all the interested parties. Native Americans, archaeologists, physical anthropologists and museum professionals can all find components of the law that they see as problematic” (Lovis et al. 2004:176).

Other issues include “unheard” claims by those tribes that are not federally recognized, disputes and disparities between tribes, and the issue of the Smithsonian being directed by a separate law which requires Native American to file separate paperwork and federal processes. McLaughlin (2004) notes that one of the major issues with the current NAGPRA legislation is federal compliance. Out of all of the independent museums and institutions that contain items facing repatriation, none have gone into forbearance for noncompliance with the regulations established in NAGPRA. This can be explained because smaller institutions can more easily inventory their collections than larger, federal agencies that have collections across the country. Federal agencies, on the other hand, are a different scenario. Both the Bureau of Indian Affairs (BIA) and the Bureau of Land Management (BLM) have acknowledged that they face an enormous challenge due to the large amounts of cultural items. In January 1998, two years after the submission of inventories was to be filed (November 16, 1995), the National Curator for the Bureau of Land Management (BLM) and the United States Department of Interior reported that
it would take decades to inventory the materials subject to NAGPRA in their possession. The exact number is unknown but could be in the millions, counting both cultural items and human remains.

One of the issues concerning NAGPRA, mentioned in Quigley (2001), is the fear that repatriation will herald the loss of museum collections across the nation. Quigley (2001) noted that there were an estimated (by the Native American Rights Fund) 600,000 Native American remains in museums, universities, and historical societies as well as other places. She also mentions that between 1990 and 1997, more than 5,300 human skeletons were repatriated but that there were a total of 100,000 to 200,000 skeletons that were eligible for repatriation. However, even if all 200,000 remains are conferred back to the tribes, that still leaves potentially 400,000 unidentified remains left to study and to have in the collection. Even if the remaining 400,000 are not able to be identified to one specific tribe or region, many states have enacted laws prohibiting the display of any human remains (Ubelaker and Grant 1989; Quigley 2001).

The same concern comes with cultural items. There exists a fear that after repatriation, there will not be anything left for the museums to display in their collections. However, according to the NMAI, there is no need for worry. Out of the more than 800,000 catalogued cultural items in its collection, only approximately 3%, or 25,000 objects, “fall within the four primary categories of eligible items for repatriation: human remains, funerary objects, sacred objects, and objects of cultural patrimony” (NMAI 2014). According to the National Park Service, the National NAGPRA program puts together statistics twice yearly on the number of Native American remains, funerary objects, sacred objects, and objects of cultural patrimony that have been mentioned in Federal Register notices and can be seen in Table 1, reproduced from the National Park Service’s website FAQ section pertaining to NAGPRA.
In order to resolve that issue, the United States Congress asked for recommendations and “hoped that the experience developed by tribes, federal agencies, and museums through the repatriation of affiliated remains, might lead to a resolution” (Lovis et al. 2004:180). The recommendation that emerged was that the Secretary of the Interior should publish regulations stating that culturally unidentified human remains be disposed based on regional consultation meetings.

Table 1. Number of resources in Federal Register Notices (National NAGPRA online FAQ)

<table>
<thead>
<tr>
<th>Number in Federal Register Notices</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Remains (individuals)</td>
<td>38,671</td>
</tr>
<tr>
<td>Associated Funerary Objects (includes many small items such as beads)</td>
<td>998,731</td>
</tr>
<tr>
<td>Unassociated Funerary Objects (includes many small items such as beads)</td>
<td>144,163</td>
</tr>
<tr>
<td>Sacred Objects</td>
<td>4,303</td>
</tr>
<tr>
<td>Objects of Cultural Patrimony</td>
<td>948</td>
</tr>
<tr>
<td>Objects that are both Sacred and Patrimonial</td>
<td>822</td>
</tr>
</tbody>
</table>

Along with culturally unidentifiable human remains, Fine-Dare (2002) and Lovis et al. (2004) mention cultural affiliation and scientific study as the two other major issues and concerns with NAGPRA. Lovis et al. (2004) say that the issue of cultural affiliation is the main component of NAGPRA because most decisions about the disposition of human remains and objects are made with reference to that definition. Cultural affiliation has three main components. These three components are (1) a present day group (federally recognized tribe); (2) an identifiable earlier group; and (3) a relationship between the two (shared group identity). To identify the earlier group, the culture of the material items is examined and is thus defined. The Society for American Archaeology (SAA) has argued that “an identifiable earlier group is a social entity that is analogous to a modern tribe in terms of its composition and scale” (Lovis et
al. 2004:177). Issues arise when groups have a similar shared earlier “identity.” What exactly should be the deciding factor when it comes to the determination of the cultural affiliation?

Fine-Dare mentions multiple instances in her book:

Other issues regarding cultural affiliation have surfaced in the reports that can be considered cultural rather than procedural in nature, including whether oral histories taken outside of living ethnographic contexts can be valid; whether DNA should be a valid determinant of cultural relationship when many tribes have practiced adoption of nontribal or even non-Indian persons into their kinship groups; whether geographical location is sufficient to establish affiliation, since there are tribes with long histories of quite distant migrations; and whether “tribal” affiliation makes sense for peoples whose primary identity was based on cosmic and kin groups such as clans (Fine-Dare 2002:156).

The second issue is the issue of scientific study. Many people are under the impression that there is a strong anti-science sentiment among all Native Americans concerning human remains and that there is a strict distinction between scientist and Native American. This is not the case at all because there are many Native Americans who are, in fact, scientists (Fine-Dare 2002). Mostly, there is opposition to the treatment of such remains as simply objects with future scientific value with no respect given to either the living or the dead. Many NAGPRA consultation discussions reveal that there is little opposition to DNA testing of human remains (Rasmussen et al. 2014). A separate yet related issue on scientific study is the idea that NAGPRA prohibits scientific study. Lovis et al. (2004) argue that NAGPRA does not prohibit new scientific studies; it simply state that the Act cannot be used as the authorization for scientific study. It is almost a necessity in order to determine cultural affiliation and museums
are “permitted to undertake or allow new studies according to their articles of incorporation, statements of purpose, or other legal statements under which they were established” (Lovis et al. 2004:179-80).

NAGPRA may, at times, come across as “murky, patronizing, clumsy, and unrealistic” (Haas 2001:120), but the law is working. All parties involved in the Act are trying to uphold it in its strictest meaning and in its spirit. There have not been any indications that entire collections are going out the door, as many feared. Museums and other such institutions are seeking to help Native Americans define and facilitate the repatriation process while still maintaining the integrity of their institute.

In summation, federal repatriation has been the end result of a multitude of laws passed protecting graves (both marked and unmarked) and other archaeological sites. Before the passage of NAGPRA, many states passed their own version or other similar statutes. Despite the successes of NAGPRA and the efforts put in on both sides, there still remain many issues surrounding NAGPRA. One of these issues concerns the use of pesticides on the objects collected throughout the 1800s and 1900s.

Since the late 1800s, museums have been using dangerous chemicals and metals to halt the infestation process. There are a multitude of health hazards associated with these chemical treatments and they are often applied to objects that post the passage of NAGPRA, are now being repatriated and then being used by members of the receiving tribe. The next section will go into detail about the history of pesticide use and the associated health risks.
Many objects in a museum’s collection are fabricated using materials that are likely to attract the interest of pests such as rodents and insects. These materials are mostly organic and include feathers, furs, leathers, and plant fibers. This problem has been ongoing since museums first started collecting artifacts and ethnographic items. Hawks and Makos (2000) argue that most organic objects from the 1700s exist today only because of the discovery that insects and pests were infesting collections and that conservators used poisons to kill them and put a stop to future infestations. The poisons mostly used, unfortunately, were arsenic and mercury. Arsenic “may seem to be a shocking choice to modern minds, but it was a widely available pesticide in the past, and its heavy use in collections was merely an extension of its use in other venues” (Hawks and Makos 2000:33). This practice continued for almost two hundred years.

According to Cooper (2004), many curators became borderline obsessed with developing ways to protect the artifacts from destruction. Some curators developed a code of ethics in regards to care of objects and these guidelines often superseded the ethical standards that were in place at the time the ethnographic object was collected. Some of the objects in the museum or institution that had undergone intense methods of preservation were “actually created by their makers with the intent that the objects would disintegrate naturally” (Cooper 2004:67).

Pesticides have been used to combat the presence and infestation of various insects in museums and other institutions curating collections throughout the world. Some of the more common insects include: black carpet beetles (Attagenus unicolor), varied carpet beetles (Anthrenus verbasci), common carpet beetles (A. scrophulariae), furniture carpet beetles (A. flavipes), webbing and casemaking clothes moths (Tineola bisselliella and Tinea pellionella),

Today, hazardous pesticides are not used by museums or institutions out of concern for the safety of employees and visitors to the museum. Most follow the protocols described in the Integrated Pest Management (IPM) (Johnson 1998), a decision making process outlined in Part I of the *Museum Handbook* from the NPS. The handbook contains information such as types of museum pests in various organic materials, what steps to take to mitigate those pests, and monitoring for future pests. The biggest impetus for the adoption of the newer forms of pest control was to minimize the health risks associated with chemicals present in pesticides. Arsenic can affect the skin, organs, and can cause cancer and reproductive ailments (Knapp 2000; ATSDR 2007), while mercury mostly affects the nervous system (ATSDR 2007). This chapter mostly confronts the history of pesticide use in museums from the era of arsenic and mercury (1850s to 1950s) to today’s non-chemical practices noting the health risks associated with chronic exposure to hazardous pesticides.

**A History of Pesticide Use**

There exist quite a few sources of literature concerning the history of pesticides in museums and institutions (Burns 1941; Bell and Stanley 1980; Goldberg 1996; Hawks and Makos 2000; Hawks 2001; Pereira and Hammond 2001; Johnson et al. 2005; Pool et al. 2005;
Ornstein 2010). But despite all these histories, determining the exact history of pesticide usage in an institution can be a difficult task to accomplish for many institutions because of policies implemented at the institution. Many museums considered the application of pesticides to be standard practice (NMAI 2012) and these procedures were thus not documented or recorded. Prior to 1972, when the Federal Insecticide, Fungicide, and Rodenticide Act was passed, the use and application of many pesticide chemicals was unregulated (NMAI 2012:2). In her Master’s Thesis from Seton Hall University, Ornstein (2010) says that the pesticide treatments were customary and that records of which specific pesticides were applied to the artifacts and collections were not kept. However, museums have not always been the culprit when it comes to the application of pesticides onto the objects in their collections. Sometimes, the individual who acquired the object subjected the object to pesticide treatment prior to bringing it to the museum. The museum would then accession it into their collection with no knowledge of the chemical application (Ornstein 2010). This problem, of course, had the potential to lead to another. The application of, and therefore the interaction between, two or more different pesticides might create an entirely new hazard that could be even more difficult to mitigate or test for (Purewal 2001).

To know what kinds of interactions might take place, it is essential for collections to attempt to create a history of the collection. The first step is the development of a systematic history of pesticide application to the collections of any given museum. According to Hawks and Makos (2000), a complete history of the usage of pesticides on artifact collections may never be known but the literature seems to suggest that a few of the more common fumigants include naphthalene, dichloro-diphenyltrichloroethane (DDT), paradichlorobenzene, hydrogen cyanide, arsenic, and mercury.
Goldberg (1996) attempted to compile a history of pest control measures performed at the Smithsonian Institution’s National Museum of Natural History and chronicles which pesticides and chemicals were used there starting from the mid-19th century and moving through the 20th century. Although not customarily detailed, the author was able to piece together information concerning pesticides taken from both written (museum and expedition notes and internal reports) and verbal sources. During the second half of the 19th century, Goldberg observed that collectors and museum personnel routinely put poisons on the collections, especially if the collections were scheduled to travel. Her evidence came from notes of the expeditions from Captain Charles Wilkes and documents from the Smithsonian Institution Archives (SIA). Other documents from the SIA have further evidence from field collectors that “indicate that ‘fumigating tobacco,’ camphor, ‘flour of sulphur,’ arsenic, and ‘corrosive sublimate’ (mercuric chloride) were purchased for field collecting use to aid in the preservation of specimens” (Goldberg 1996:28). These documents were mostly receipts and purchase records and not actual documentation of direct application.

By the later part of the 19th century, there was a slight change in the types of pesticides used. The need to apply poisons came mostly from a desire to preserve the object and prevent any loss so many collectors “have sometimes taken draconian measures to protect objects” (Hawks and Makos 2000:32). Mercury and arsenic were widely used although the applicators knew of their danger and labeled their specimens as “poisoned.” In 1887, the head curator of the Anthropology Department at the Smithsonian Institution, Dr. Walter Hough, wrote about poisonous concoctions to be used on the collection. According to Goldberg, “Hough recommended the following as a general insecticide for museum objects: 1 pt. saturated solution of arsenic acid and alcohol, 25 drops strong carbolic acid, 20 grains strychnine, 1 qt. strong
alcohol, and 1 pt. naphtha, crude or refined” (Goldberg 1996:30); Hough (1889) also suggested ways for application including a spray or painting the solution onto fragile items. The use of arsenic at the Smithsonian continued most likely through Hough’s time, and his retirement was in 1935. Felt strips that had been dosed with arsenic, and used to create a pest free seal on cabinets, continued to be used until the museum’s supply ran out (Goldberg 1996). By the mid-19th and early 20th centuries, curators also began to use mercuric chloride, naphthalene, and paradichlorobenzene, with DDT becoming a player in the 20th century. H. W. Krieger was a museum aide and an ethnology curator at the Smithsonian in the Anthropology Department when he wrote that a solution of mercuric chloride mixed with alcohol and water was a good deterrent against moths on objects made of feathers, hair, wools, and fur (Krieger 1931). Concerning the application of the mercuric chloride, Goldberg goes on to say that:

Objects were either dipped in or were painted with the mercuric solution. Early collection records indicate that closed drawers of objects were protected by scattering crystalline mercuric chloride in the corners and over particularly vulnerable objects such as textiles. The 1940 manual confirms this use, and Mr. Allen may have performed this duty until his departure in the 1930s (Goldberg 1996:31).

The manual referred to in the above paragraph was given to the associate director of the National Museum (the Smithsonian’s National Museum of Natural History) in 1940 and was entitled *Manual on Insect Infestations and their Treatments*. It documented which types of treatments to use with the advent of the closed storage cabinet and served as the manual for insect infestations (Barber 1940). Hawks (2001) notes that the majority use of arsenic and mercury may have stopped approximately 100 years ago but some collections were most likely using the effective method well in the second half of the 20th century. However, in general their
usage declined, but it came with an increase of volatile compounds composed of paradichlorobenzene, ethylene dichloride, and carbon tetrachloride.

The first mention of naphthalene was by Hough (1889) as a protectant against potential moth infestations and the use of paradichlorobenzene was first mentioned by Krieger (1931) as a fumigant solution. Both chemicals were used interchangeably after that year and were often referred to as mothballs or flakes (Goldberg 1996). Both of the chemicals were sprinkled into cases containing the objects and more was continually added on a yearly basis when the previous application evaporated (Goldberg 1996). At the National Museum of the American Indian (NMAI), or the Museum of the American Indian (MAI), the use of naphthalene “was the pesticide chemical with the longest history and the widest use at the MAI/NMAI. Its known use was documented from 1918 to 1984 in the museum records. Paradichlorobenzene was known to be selectively used between 1976 and 1984” (Johnson et al. 2005:90).

The middle of the 20th century brought about a slight change to pesticide procedures. Burns (1941) wrote a Field Manual for Museums while he was chief of the Museum Division of the National Park Service. In it, he details what procedures to follow when dealing with insects and other pests and the most appropriate methods to eliminate them from the collection or specific artifact. From this, one can assume that all museums in the National Park Service attempted to follow his methods and procedures. Burns starts his tirade against insects by saying that “of all the agencies attacking museum collections insects are the most dangerous. They can be extremely destructive, and they are the hardest to keep out. It is almost inevitable that they will get into a collection sometime, and only eternal vigilance will prevent serious damage” (Burns 1941:198).
The first step in his process was fumigation of the object before it was allowed near the collection, immediately after accession. He suggests a metal lined chest with a rubber gasket on the lid to ensure the chest is gas-tight. The fumigant recommended by Burns is “a mixture of three parts by volume of ethylene dichloride and one part of carbon tetrachloride” and his reasoning is that it “is far less dangerous to humans than hydrocyanic acid gas” (Burns 1941:199).

Another method to deter the infestation of future pests included placing a large quantity of naphthalene and paradichlorobenzene put in the drawers containing the organic artifacts; this was done to stop any infestation of most insects such as carpet beetles and silverfish (Burns 1941). For specific pests, various methods were applied. In case of widespread infestations of moths, bookworms, and tow bugs, hydrocyanic acid gas was thought to be the best measure to ensure no further infestations. The final recommendation in the Field Manual for Museums to mitigate the presence of insects and pests “consists of frequent inspections to detect any infestations at an early stage before it spreads to a dangerous degree. In most instances these inspections should be made once a month” (Burns 1941:200).

The first recorded use of arsenic at the National Park Service came in 1941, the same year that Burns wrote his manual and arsenic continued to be used through 1976 (Pereira and Hammond 2001; Ornstein 2010). Although governed by a different agency, the use of arsenic at the NPS is contradictory with the NMAI’s conservation treatments; there is “no documentation of the use of heavy metal based pesticides (lead, mercury, arsenic or any other metal) by any staff member of the [Museum of the American Indian] MAI or NMAI from 1904 to the present” (Johnson et al. 2005:90) exists.
“As additional pesticides from the agricultural developments of the mid-twentieth century were introduced, museums were able to utilize a greater variety of chemical pesticide products” (Pool et al. 2005:12), such as pyrethrins[^3], chlorinated hydrocarbons, organic phosphates, and dichloro-diphenyltrichloroethane, also known as DDT, developed in 1946. Some collection records at the Smithsonian indicate that DDT was used to fumigate their cases and to stop current infestations from 1947-1955; however research from Goldberg (1996) indicates that it was used beyond 1955. “Archival records for the [Smithsonian’s] Anthropology Department indicate that in 1968 DDT and other pesticides or fumigants were applied to approximately 2,000 storage cases for the preservation of organic materials such as textiles, felts, furs, feathers, mummies, and whale bone” (Goldberg 1996:34). According to the Anthropology Department’s subsequent report to the Federal Commission on Pest Control in 1970, about 10% of the anthropology collection at the Smithsonian at the time had been indirectly exposed to DDT (SIA, RU000155).

The Museum of Natural History in Cleveland also had some experiments with DDT in the 1950s (Pest Control 1959). The registrar at the time, James Skelly, experimentally mixed DDT and chlordane with water and applied the mixture to animal hides as an alternative to refrigeration. DDT, however, was withdrawn from production not because of the safety or concern for human health consequences, but for environmental reasons (Hawks 2001). The largest environmental concern was an increase in eggshell thinning and cracking among bald eagles (Colborn et al. 1993). Another pesticide used at the same era as DDT was a mixture of ethylene dichloride (70%) and carbon tetrachloride (30%) called Dowfume (Goldberg 1996); a variant, Dowfume G, was used from 1961-1977. The formula was, fortunately, discontinued out of the concern for the safety of the individuals required to work with the chemical. (Goldberg

[^3]: Pyrethrins are insecticides that are derived from the extract of chrysanthemum flowers (NPIC 1998)
1996). This information is correlated with findings produced from a survey conducted by Bell and Stanley in 1980. After surveying 300 natural history institutions, quite a few returned responses saying they mixed their own Dowfume due to difficulties obtaining the real chemical. They also produced results saying that ten percent of the institutions use carbon disulfide, which is an extremely toxic and flammable chemical (Bell and Stanley 1980).

Finally, from the late 1970s into the early 1980s, the most popular form of pest control in the Anthropology Department of the Smithsonian Institution was the use of dichlorovinyl dimethyl phosphate (DDVP). Plastic tags containing the insecticide were placed in the cabinets and storage units, but were later proved to be unsuccessful at keeping the pests at bay. This was one of the last fumigations performed at the NMNH. By 1983, fumigation within NMNH had stopped and objects with active or suspect pest problems were given to outside contractors for treatment with the pesticide sulfuryl fluoride, also known by its commercial name, Vikane (Goldberg 1996).

According to Pool et al. (2005), the use of chemical fumigants in museums ended during the last years of the 20th century. The reasons they cite include: greater restrictions of the chemicals, the negative consequences on the environment posed by many of the chemicals, a greater awareness of the effects of pesticide chemicals on the safety of museum workers, and the negative effect on object appearance were becoming apparent (Pool et al. 2005). These reasons prompted many institutions to develop other methods to mitigate the damage and presence of insects in their collections. Hawks and Makos (2000) recognized this issue and the fact that insects are forever pervasive. They argued that modern knowledge of insect life cycles and their habitation needs, new or improved facilities, new display case design, and a decrease in chemical
pesticide reliance should eliminate the need to use hazardous pesticides and instead encourage a focus on non-chemical alternatives

**Health Risks of Chemical Pesticides**

From the discussion of the history of chemical pesticides, most common pesticides used in the past appear to have been arsenic, DDT, mercury, naphthalene, and paradichlorobenzene. Because these were the most popular and most frequently used, it stands to reason that these pesticides are the ones most likely to cause illness to whoever may come into contact with them. Boyer (2005) states that the medical treatments used to combat heavy metal exposures may not be completely effective and it is better to prevent the exposure than to treat it. Some measures do exist which should be undertaken to help reduce exposure to these chemicals and poisons.

Knapp (2000) lists some of these precautions employed to avoid exposure. The first is to assume that all objects dated to before 1980 have been treated with toxic chemicals and that when handling these objects, to wear nitrile gloves and to handle them as little as possible. In order to reduce the chance of transporting the arsenic to other areas or objects, an apron or smock should be worn as well as a respirator with a HEPA (high efficiency particulate air) filter. Museum professional should then discard used gloves into the refuse and always wash their hands (Knapp 2000). Other recommendations are to keep the lab smocks or aprons clean and to wash them separately from other clothing. These are necessary precautions because poisons can enter the body in many ways including through ingestion, dermal exposure, or inhalation (Boyer et al. 2005).
The remaining part of the section details some of the health risks associated with arsenic, mercury, DDT, naphthalene, and paradichlorobenzene. Pesticides and their exposure can produce negative health effects to humans. Peltz and Rossol (1983) and Kearney (2001) say that both acute and chronic illnesses can arise depending on the type of pesticide, the amount of pesticide, and the duration of exposure while some of the more serious consequences may only appear years after the initial exposure. The following table (Table 2) is reproduced from Boyer et al. (2005) and details toxicity levels for pesticides and the exposure limits via dermal, inhalation, and oral exposure. These limits were produced by determining the quantity of the chemical that was required to kill 50% of the animals that the dosage was tested on. The Oral Lethal Dose (OLD) standard was used because it was the “only toxicity standard available for many of the chemicals” (Boyer et al. 2005:80).

### Table 2. Heavy metal acute toxicity and warning levels (Boyer et al. 2005)

<table>
<thead>
<tr>
<th>Categories</th>
<th>LD50 Oral Signal Word</th>
<th>LD50 Dermal mg/kg</th>
<th>LD50 Inhale mg/kg</th>
<th>mg/L</th>
<th>Oral Lethal Dose¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Highly toxic</td>
<td>DANGER, POISON, WARNING</td>
<td>0-50</td>
<td>0-200</td>
<td>0-2,000</td>
<td>A few drops to a teaspoonful</td>
</tr>
<tr>
<td>II: Moderately toxic</td>
<td>CAUTION</td>
<td>50-500</td>
<td>200-2,000</td>
<td>2,000-20,000</td>
<td>&gt;1 teaspoonful to 1 oz</td>
</tr>
<tr>
<td>III: Slightly toxic</td>
<td>CAUTION</td>
<td>500-5,000</td>
<td>2,000-20,000</td>
<td>N/A</td>
<td>&gt;1 oz to 1 pint</td>
</tr>
<tr>
<td>IV: Relatively nontoxic</td>
<td>None</td>
<td>5,000+</td>
<td>20,000+</td>
<td>N/A</td>
<td>&gt;1 pint to 1 pound</td>
</tr>
</tbody>
</table>

¹Probable for a 150-lb. person.

### Carcinogenicity Classes

**EPA: Office of Pesticides Program (OPP)**

- **Group A**: Human carcinogen, not classified by OPP
- **Group B1**: Probable human carcinogens with limited human evidence; not classified by OPP
- **Group B2**: Probable human carcinogens with sufficient evidence in animals and inadequate or no evidence in humans; classified by OPP
- **Group C**: Possible human carcinogens; classified by OPP
The effects of arsenic on the human body have been documented in journals and by the federal government through the Center for Disease Control (CDC) (Hawks and Williams 1986; Boyer et al. 2005; ATSDR 2007). Arsenic is most often absorbed by the body through the skin and lungs. It has been known to cause chronic poisoning as well as mutagenic, teratogenic (a substance which interferes with fetal development), and hepatic (affecting the liver) effects as well as being a carcinogen (Hawks and Williams 1986; Knapp 2000; Boyer et al. 2005; ASTDR 2007). However, the effects of arsenic are mostly determined by the dosage exposed to and the specific chemical formula.

The level of acute toxicity for ingested arsenic is 1mg-10g which can be fatal or 1-3mg/kg which can have such effects such as: hemorrhagic gastroenteritis, chronic renal failure, arrhythmias, paralysis, delirium, and coma. Chronic toxicity results from an ingestion of 3-4mg/day and can cause neuropathy, anemia, Mee’s Lines (white lines that appear in the nails), change in skin pigmentation, and cumulative exposure can cause cancer in the lungs, liver, kidneys, and/or bladder (Hawks and Williams 1986; Knapp 2000; Boyer et al. 2005; ASTDR 2007).

Further effects reported listed on the online profile by the ATSDR (2007) include “nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of ‘pins and needles’ in hands and feet” when exposed to low levels and death when ingestion of high levels occurs. Ingestion of arsenic over long periods of time can also cause warts or corns to appear on the soles of feet, palms of the hands, or the torso while skin contact with arsenic can cause swelling and redness. Referring to Figure 1, the EPA lists arsenic as level I toxicity and the carcinogenicity as A.
The other most popular heavy metal used in pest control was mercury. Mercury is a shiny, silver-white, colorless liquid and has been put on the official list of the EPA’s suspended, cancelled, or restricted pesticide list due to its hazardous nature to aquatic organisms and its acute toxicity (EPA 1990). The acute toxicity of mercury can be noticed minutes after ingestion and include corrosion, kidney injury, and circulatory collapse; dermal exposure may lead to systemic toxicity (ASTDR 1999; Osorio 2001; Boyer et al. 2005). The same source lists the effects of chronic toxicity from ingestion as tremors, gastrointestinal effects, and kidney damage.

Dermal exposure induces slightly different effects on the body such as neuropathy, kidney injury, pigmentation, and mental status changes. This mental change is often referred to as “Mad Hatter Disease” and was so called because it was traditionally associated with a hatter who used mercury in the hat making process between the 17th and 20th centuries (Ornstein 2010). Mercury has a profound effect on the central nervous system and can affect the brain in ways beyond just the “Mad Hatter Disease.” Irritability, changes in hearing or vision, and memory problems are all likely reactions (ATSDR 1999). Infants and toddlers are also at greater risk of mercury poisoning through breast feeding if the mother has been exposed. Even in utero, mercury can be passed on to a fetus by crossing the placental barrier and can cause brain damage, mental retardation, incoordination, blindness, seizures, and an inability to speak in newborns. The EPA has stated that mercuric chloride and methylmercury, a fungicide, are possible human carcinogens (ATSDR 1999) and lists mercuric chloride as a level I for toxicity (Boyer et al. 2005).

Moving onto chemical pesticides, we can now discuss the health risks of DDT which is also on the EPA’s list of cancelled pesticides due to its carcinogenicity, bioaccumulation, and danger to wildlife and other chronic effects (EPA 1990). The EPA also lists DDT as a level II
for its toxicity and B2 for its level of carcinogenicity (Boyer et al. 2005). DDT falls under the classification of organochlorines, chlorinated hydrocarbons used between the 1940s and 1960s (DHSS 2010). Boyer et al. (2005:77) say that “these chemicals are highly persistent and are moderately to highly toxic. DDT does not cross the skin barrier as easily as dichlorvos[^4], but it is more of a problem environmentally. Some of the effects of toxic levels of exposure are nausea/vomiting, coma, seizures, and death.” Although some say that the short term health effects may not be very serious, the long term effects are serious and organochlorines are suspect carcinogens, mutagens, and teratogens and are most often stored in human fat (Peltz and Rossol 1983). The ATSDR states that the effects seen in humans stopped after the exposure to DDT ended and no effects were visible in people who took small dosages over a period of 18 months (2002).

Naphthalene was commonly used and is listed as a level III for its toxicity in the EPA’s list of toxic pesticides (Boyer et al. 2005). Linnie et al. (1990) report that the maximum short term exposure for humans should not exceed 15ppm and definitely should not exceed 10ppm over the course of an eight hour day. Some of the health effects from naphthalene include sweating, nausea, acute kidney failure, headaches and abdominal pain while direct inhalation of the substance can cause hemolysis of the red blood cells (Linnie et al. 1990). This hemolytic anemia causes a person to have too few red blood cells which can cause fatigue, lack of appetite, restlessness, and pale skin in affected individuals (ATSDR 2005). A report showed that one museum worker lost consciousness while another experienced violent vomiting from overexposure (Linnie 1993). Other health effects include sore throat and eyes, dizziness,

[^4]: Dichlorvos is an insecticide used in pest-strips. Exposures of humans to dichlorvos results in sweating, vomiting, diarrhea, drowsiness, fatigue, headache, and at high concentrations, convulsions, and coma (EPA 2000)
dermatitis, increased salivation, chest pains, diarrhea, blood in the urine, and a yellowing of the skin (Linnie 1990; ATSDR 2005).

The final pesticide discussed in this section is paradichlorobenzene, an aromatic chlorinated hydrocarbon. In Table 2, paradichlorobenzene is listed as a level II-III for its toxicity and a level C for its carcinogenicity. Linnie et al. (1990) listed the exposure limits for paradichlorobenzene as 75ppm for long term (8 hours or more) and 110ppm for short term (10 minutes). Linnie et al (1990) say that the chronic effects of long-term exposure to paradichlorobenzene include liver and kidney damage, weight loss, profuse rhinitis and periorbital swelling. Other symptoms of exposure to paradichlorobenzene include headaches, sore eyes and throat, dizziness, nasal irritation, breathing problems, chest pains, vomiting, and body weakness. Some reports have been documented of kidney and liver damage, death, and cirrhosis of the liver all being linked to exposure to paradichlorobenzene (Irwin 1987; Hall 1988).

**Non-chemical Methods of Pest Control**

Without using chemicals, museums and institutions are turning their attentions toward other means to eliminate infestations and damage to their collections. These methods often include thorough regular cleaning, the use of traps, and when occasional infestations do occur, freezing, high heat, and low oxygen (anoxic) methods can often help and have become popular alternatives to pesticides (Florian 1990; Raphael 1994; Goldberg 1996; Nicholson and Von Rotberg 1996; Pinniger 1996; PMNH 1997; Child 1998; Johnson 1998; Pinniger 1998; Burke 1999; Odegaard and Sadongei 2001; Lavrencic and Roach 2003; Rees 2003; Elkin et al. 2010;
Before using one of the afore mentioned techniques, however, considerations must be made concerning the materials present on/in the object because “the use of an inappropriate method can cause damage to collection materials and serious health hazards to the staff and public” (Pinniger 1998:1). Mixing methods can, however, sometime be the best way to stop serious infestations. Integrated Pest Management (IPM) plans can help museums develop a strategy to stop insects from entering a given collection or even the museum. Johnson (1998:8) defines IPM as “a variety of techniques to prevent and solve pest problems using pesticides only as a last resort. It depends on knowledge of a pest’s habits, ecology and the environment in which it thrives and survives. IPM is also site-specific and adaptable to any museum” and Elkin et al. (2010:63) say that it draws on a number of different fields and groups and “the ultimate objective of these groups can differ substantially and coordination of activities is critical for successful pest management.”

The idea of cleaning the objects to rid them of pests is not a new one. As early as 1949, weekly inspections at the Smithsonian Institution took place to look for, and to clean off, any infestations (Goldberg 1996). The Smithsonian continued with this cleaning trend and used vacuums to clean their objects in the early 1980s. The latter half of that decade and into the early 1990s saw a slight shift in procedure and cleaning occurred only when necessary (Goldberg 1996).

The Peabody Museum at Yale includes in their pest policy that museum staff should be on the alert for any pests and report any if found. The policy also states cleaning is a must and that if any objects are on the floor, the arrangement must allow the area underneath and behind the artifact to be cleaned. Other considerations are that all floors, both carpeted and uncarpeted, will be vacuumed on a regular schedule with attention paid to corners, edges, and closets to clean
up debris that provide a food source for pests (PMNH 1997). The final cleaning recommended at the Peabody Museum is wet mopping only when needed followed by dry mopping to reduce moisture. Another recommendation from Pinniger (1998) is to clean any infected area where infestations are found and to destroy any insect body and debris.

The second non-chemical pest control method mentioned above involves the use of traps. Some of the more common types of traps used in museums include “sticky traps,” pheromone traps, and light traps (Johnson 1998); and using them in combinations is the beneficial due to their ability to catch both adult and larvae of flying and ground insects (Child 1998). Using traps to halt infestations has been recorded at the Smithsonian Institution and occurred around the same time that necessary cleaning was implemented in the early 1990s. They used sticky traps to monitor for the insects and as a way to determine which species were infesting the collection (Goldberg 1996). The Peabody Museum has also employed traps in their policy and the traps are placed in collections storage, work areas, administrative space, and wherever else the Pest Control Committee (PCC) determines is necessary (PMNH 1997). After each scheduled inspection of the traps, if any pests are found, then Pest Report Forms must be filled out, which assist with identification and are reviewed by the PCC. Application of traps in museum collections is only half the battle. Knowing where and when insects appear in the building develops an understanding of pest ecology. According to Rees (2003:48), “understanding pest ecology is important especially when dealing with pest outbreaks infesting complex structures such as a factory or building. In addition, comparative data brings with it the possibility of properly testing novel methods of pest control.”

When serious infestations do occur, there are a few ways to remove the pests from the collection. Freezing is a relatively simple process that can be performed at most institutions that
have access to a household freezer and is a common treatment at the National Park Service (Raphael 1994) as well as the Smithsonian Institution which purchased a freezer in 1989 (Goldberg 1996). Because insects can acclimate quickly to their environment when they move, Florian recommends that the infected object, and its accompanying infestation, be brought to room temperature before freezing and then the object “should be cooled to approximately 5°C in at least four hr, so that they cannot move. Materials in a chest freezer with adequate air movement will reach this temperature in less than four hr” (Florian 1990:3).

Raphael (1994) states that freezing is superior to other methods of pest control because most museum pests are freeze-sensitive and are easily killed with the process. The process involved in freezing is relatively easy. There are only a few steps to be followed when freezing for pests (Pinniger 1998). The first step is to put the infected object into a sealed polyethylene plastic bag which is allowed to come to room temperature. The following step is to quickly (within 24 hours) bring the object down to a cold temperature (-18°C) and allow it to cool for two weeks or a colder temperature (-30°C) for only three days. The final step is to take the object out of the freezer, but not be taken out from the bags until they have reached room temperature to prevent condensation from forming on the object. However, if insects still remain in the building or the facility, then objects can be left in the polyethylene bags to provide some protection from further insect attacks (Pinniger 1998).

Towards the opposite end of the spectrum comes another form of pest control, using heat, which can kill insects quicker than cooling (Pinniger 1998). This idea of increasing the temperature of the object to unlivable conditions for pests is not new and according to Pinniger (1996) has been used since the early 1900s. However, since leaving the infested item in ovens overnight and reaching temperatures of 60°C was often the primary way to heat the object, often
multiple times, some objects became cracked, brittle, shrunk, or became distorted (Pinniger 1998). Heat treatment is still an option for many places. Lavrencic and Roach (2003) used heat for borer-infested historic buildings (100-200 years old) in Australia because of the minimal effect it would have on the animals and plants in the vicinity.

A slightly modified version of heat treatment involves the use of a humidity controlled box or chamber (Nicholson and Von Rotberg 1996; Pinniger 1996; Pinniger 1996) and putting the object into a bag. During both the heating up and the cooling down phases of the treatment, the humidity in the chamber is precisely controlled by a computer to ensure that no dehydration of the object occurs. This method is called Thermo Lignum and the method is used most often in commercial aspects to treat a variety of organic materials. This includes furniture, textiles, books, manuscripts, silks and leathers. It is suitable for antiques and museum exhibits (Nicholson and Von Rotberg 1996). Most often, the chamber reaches temperatures near 52°C because it has been shown to be a temperature that is high enough to kill all major museum insect pests at all stages of the life cycle: egg, larvae, pupae, and adult (Pinniger 1996). It is yet another tool used by museums in the battle against insects.

Using low oxygen (anoxia) or other gaseous environments (such as carbon dioxide, argon, or other inert gases) has also become a popular method utilized at museums and institutions housing collections. This is the third method that involves the use of a sealed container or bag which has to be made of a special oxygen barrier film (Pinniger 1998; Burke 1999). After placing the infected object into the bag, an oxygen absorber is used to remove the oxygen from the environment. Depending on the size of the capacity of the absorber, up to one liter of oxygen can be removed. The absorber can reach temperatures above 38°C so a nitrogen
flush is recommended to eliminate most of the oxygen before the bag is sealed; reducing heat and moisture according to Burke (1999).

An oxygen indicator should also be sealed with the object and the oxygen absorber to show when oxygen levels have dropped below 0.1%. This is the concentration level needed to kill the insects and must be left at such low levels for up to three weeks at 25° C or five weeks if below 20° C (Pinniger 1998). The anoxic environment kills insects more from dehydration than suffocation due to widely opened spiracles (Burke 1999). Using carbon dioxide allows for some oxygen to be let through, unlike the nitrogen flush. The level of carbon dioxide in the environment needs to reach 60%. Pinniger (1998) states that using carbon dioxide is more practical than nitrogen for large and/or enclosed objects due to the fact that it allows for some oxygen to be leaked into the enclosure. It is still a slow method and some concerns have been raised about carbon dioxide and water mixing to form carbonic acid but no evidence exists that this would happen under normal humidity and moisture content (Pinniger 1998). The use of other forms of gases, argon and other inert gases, in the environment has had some success but “because they are more expensive than nitrogen or carbon dioxide, it is difficult to justify their use” (Pinniger 1998:3-4).

Today, the University of Montana has the ability to freeze and to heat the artifacts and UMACF staff have even discussed the use of anoxia to use as a deterrent for insects and other pests. Unless these methods were at one time available for the use of the Anthropology Department, chemical pesticides were most likely used to mitigate the presence of those pests. There are multiple ways to detect if chemical pesticides were used on ethnographic collections. One popular method, used in many institutions as well as here at the University, is to use X-Ray Fluorescence and test for heavy metals.
Organic Pesticide Testing

According to the National Museum of the American Indian, organic pesticides “are carbon-based compounds that include pesticides such as Naphthalene and Paradichlorobenzene (PDB), two chemicals commonly known as mothballs. Naphthalene and PDB are applied as a solid (in mothball and flake form) and sublimate, acting as a fumigant” (NMAI 2012). Odegaard et al. (2005) detail some of the organic pesticides, which includes organophosphates (acephate, diazinon, propetamphos), carbamates (bendiocarb, carbaryl, propoxur), and organochlorines (aldrin, DDT, chlorinated naphthalene, mitin FF).

Research into the use of organic pesticides has shown that many institutions have identified organic pesticides in their collections. However, the majority of these studies have used gas chromatography-mass spectrometry (GC/MS) or other methods and not swab/spot tests. The procedure for arsenic spot tests is described in Hawks and Williams (1996). They say that the samples for the test should be small and may be residues from the object, dust collected from vacuuming, feather or skin, or other threads. They find that “fibers cut from a cotton-tipped swab that has been dampened lightly with distilled water and touched on the surface of a specimen provides an excellent sample” (Hawks and Williams 1996:4). The process often involves swabbing an area on the object, adding reagents, and then observing a color change on the swab (Palmer 2001). Spot and swab tests have multiple benefits over GC/MS including: cost-effectiveness, good reliability for positive tests, and in-house testing (Sirois and Sansoucy 2001). Below are a few case studies involving the use of GC/MS and their results to highlight the most common forms of organic pesticides that have been used in museums in the past.
In 2000, Seifert et al. analyzed three objects, repatriated under NAGPRA, for pesticides. These objects were kept confidential with respect to the tribe’s wishes. The materials used in the construction of the objects included leather, grasses, corn husks, feathers, horsehair, yarn, and paint. Metal content was measured using energy-dispersive x-ray analysis and the organic residue of pesticides was determined by GC-MS. Their results showed that only one of the three objects had any residues of organic pesticides. The residue was located on the interior surface and was identified as naphthalene; however there were no records of any kind indicating treatment using naphthalene.

Solid-phase microextraction (SPME) is another technique used in conjunction with GC/MS. Using SPME involves putting a SPME fiber into a plastic bag containing the object for one hour. Ormsby et al. state the fibers can cost less than $100 a piece but are reusable. The fiber is then run through the GC/MS machine to detect any volatile pesticides. According to Ormsby et al. (2006), it is a relatively easy, sensitive, versatile, presents minimal risk to the object, and does not use any solvents. The authors analyzed a Bear Crest hat from the Tlingit Bear Clan using the SPME and GC/MS technique. They found three organic pesticides on the object: naphthalene, paradichlorobenzene (pDCB), and limonene. They also discovered that the levels of humidity and a longer duration of the fiber in the bag increased the amount of pesticides detected.

As stated earlier, Palmer et al. (2006) analyzed objects from six different sources. For their organic pesticide testing, GC/MS was used to detect the presence of pDCB, naphthalene, thymol, dieldrin, lindane, and DDT. The authors tested a total of 105 objects and of those, only 71 were able to be used to test for pDCB, naphthalene, thymol, lindane, and DDT while only 49 were tested for dieldrin. This is due to the limited number of samples available for testing. Of
the 71 samples, pDCB was detected in 8% of the samples at a range of Not Detected (ND)-130 ppm. For naphthalene, it was found in 34% of the samples at a range of ND-1830 ppm. Thymol was in only 1% at a range of ND-10 ppm. Lindane had a frequency of 3% with a range of ND-30 ppm and DDT had the highest frequency at 44% with a range of ND-2900 ppm. Finally, dieldrin was not found in any of the 49 samples. Palmer et al. (2006) explain their use of GC/MS by saying it was the best method for identification and quantifying the pesticides used and detected.

Usage of X-Ray Fluorescence Testing

A literature review showed that X-Ray Fluorescence has been used at other museums that have had their collections tested for pesticides. In 2001, the University of Arizona worked with members of the Hopi tribe to test their objects for the presence of any harmful pesticides (Odegaard et al. 2006). They tested several locations on each artifact and focused on locations that could have potential for eye, nose, or mouth exposure. After testing their objects, they developed a three tiered danger level of red, yellow, and green. “Red” objects contained $\geq 5.0$ mg of arsenic and are dangerous and may pose a significant health risk (Odegaard et al. 2006). “Yellow” objects had levels between 5.0 mg and normal background levels and should be handled with caution. “Green” objects had normal background levels and can be handled normally and allowed to be repatriated safely.

In 2001, Sirois and Sansoucy analyzed over 300 objects from various anthropology collections using an XRF machine. They noticed several trends after performing their analysis. The overall presence of arsenic and mercury in the artifacts totaled 23%. However, this rate
varied in different museums. Their results showed that in one museum, 9% of the collection contained concentrations of arsenic less than 0.1 percent (trace) and in another museum, the number of artifacts with detectable concentrations of arsenic was 42% (Sirois and Sansoucy 2001). They also noticed that arsenic and mercury might be present on one part of the mask (such as the hair) but not a different part (such as the wooden portion). One final observation they made is that due to the varying levels of the metals on the object, it indicates that each museum or collector had their own pesticide program. The results indicate that while some collections or groups of artifacts “appear to have been treated en masse (such as a methyl bromide fumigation), others are more likely to have been treated individually” (Sirois and Sansoucy 2001:62).

The University of Washington underwent XRF testing on objects from their anthropological collections, choosing objects that were likely for repatriation as well as other objects of various material types. The objects represented “acquisitions from every period of the museum’s history and from a variety of sources, including professional collectors, avocational collectors, museum staff research collections, and purchases” (Nason 2001:71). The date of the objects ranged from 1893 to 1999 and included wool rugs, silk garments, fur and bird skin clothing, leather clothing, blankets, pipe bags, baskets, drums, wood masks, beaded objects, feather headdresses, whalebone objects, and human remains. The tribal diversity included the Navajo, Plateau and Plains peoples, the Chilkat, Arctic inhabitants, and peoples from the Northwest Coast. The results showed that half of the tested objects had residual arsenic or mercury and of that, 73% had mercury residue, 16% had arsenic residue, and 11% had both. The arsenic ranges from a low of 700 ppm (parts per million) to a high of 15,000 ppm with most falling between 3,000 and 10,000 ppm. Mercury ranged from 55 ppm to 57,500 ppm with most
falling between 600 and 3,000 ppm. The objects that seemed to show more evidence of pesticides were the leather, fur, and feather objects with 60%, the wooden objects with 67%, and the textile and plant fibers materials with 67% again. Information associated with the object indicated when the object was collected and when the museum acquired it; with this information, the author indicates that private collectors most likely used their own form of pest control before the museum acquired the artifact. He also states that it was more likely than not, that the museum professionals also then applied their own pesticides.

In 2004, members of the Seneca tribe had medicine masks tested for heavy metals using an XRF machine at the National Museum of the American Indian (NMAI). According to Seneca tradition, the medicine masks are believed to be alive and must be treated with the same respect and care one would show to another human and thus the sampling method must be non-destructive (Reuben 2006). The project involved two main objectives of detection and mitigation of contaminants; however the issue of mitigation will be discussed elsewhere. Their tests using a portable XRF revealed lead in 90% of the samples, arsenic in 5%, and mercury in 20% of the samples. A bench-top XRF machine confirmed the presence of arsenic while tests using an Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) were able to detect the presence of those three heavy metals at much lower levels than the XRF is capable of detecting. Reuben says that they took many samples from the same object to increase confidence in the results, but this required a greater financial cost. This allowed for a total composite analysis of the artifact.

Over a twenty-year period, the Canadian Conservation Institute (CCI) in Ottawa has conducted pesticide analyses on objects that would be a representative sample of their collections (Sirois et al. 2010). The sample included artifacts and objects from their ornithology,
mammalogy, and anthropology collections. In order to test an object without destruction, they frequently use X-Ray Fluorescence to test for arsenic, mercury, and lead. Starting in 1986, the team at the CCI takes two areas of an object and allows the XRF to take a 200-300 second scan per area, which has detected arsenic at levels as low as 500 ppm. In 1995 and up until 2004, different methods allowed testing each large object up to three times with a 200 second scan per area, while small objects were only scanned in one area. The lowest level of arsenic detection was again 500 ppm. In 2004, another update in equipment and methods was implemented at the CCI. This included adding a layer of polyethylene placed between the object and the spectrometer to prevent cross contamination. Using an Innov-X Systems handheld XRF spectrometer with an x-ray tube source allowed for scans to be completed in 60 seconds. Again, they tested a minimum of two areas per large object or objects made of a composite of materials. The lower limits of arsenic detection for this machine is much lower than previous equipment; allowing detection down to eight parts per million. The Innov-X machine allowed the CCI to create a more accurate scale concerning the amounts of metals; the table made by Sirois et al. (2010) is reproduced below (Table 3). They discovered that 41% of the objects in the anthropology collection tested positive for arsenic and 12% tested positive for mercury.

Table 3. Canadian Conservation Institute XRF testing heavy metal scale (Sirois et al. 2010)

<table>
<thead>
<tr>
<th></th>
<th>Pre-November 2004a</th>
<th>Post-November 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDb</td>
<td>&lt;500 ppm</td>
<td>ND</td>
</tr>
<tr>
<td>Trace</td>
<td>500 ppm to &lt;0.1%</td>
<td>Trace</td>
</tr>
<tr>
<td>Minor/Moderate(d)</td>
<td>0.1% to &lt;1%</td>
<td>Moderate</td>
</tr>
<tr>
<td>High</td>
<td>1-5%</td>
<td>High</td>
</tr>
<tr>
<td>Very high</td>
<td>&gt;5%</td>
<td>Very high</td>
</tr>
<tr>
<td></td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>NQc</td>
<td>Trace</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>25-100 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100-1000 ppm or &lt;0.1%</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0.1% to &lt;1%</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>1-5%</td>
</tr>
<tr>
<td></td>
<td>Very high</td>
<td>&gt;5%</td>
</tr>
</tbody>
</table>

\(a\)November 2004 marks the date hand-held XRF was introduced
\(b\)ND (not detected): below the lower limit of detection for the specific element
\(c\)NQ (not quantifiable): three times the detection limit
\(d\)Objects with readings in the minor/moderate classifications and higher are considered contaminated and should be handled with caution
But, they also noticed that different collections had different pesticide profiles. A higher concentration of arsenic was detected when using XRF on the whole specimen rather than just one part of the specimen.

In 2006, Peter Palmer and some of his students at San Francisco State University (SFSU) tested artifacts from the Treganza Museum at SFSU, the Phoebe Hearst Museum at UC-Berkeley, and from the Hupa, Elem Pomo, Karuk, and Yurok tribes in California. They used Flame Atomic Absorption Spectrometry (FAAS) to measure arsenic and mercury and GC/MS for organic pesticides. While they did not use XRF in any of their actual studies, the researchers suggest using XRF in future studies for heavy metals because of its efficiency concerning time and because “these instruments are portable, possess adequate sensitivity, and can be used for direct analysis of an object with results available in a timeframe on the order of a minute or less” (Palmer et al. 2006:30).

Almost all museums and institutes examined in this section labeled the artifacts tested with the type of contamination and the level of toxicity to ensure proper handling and safety measures were carried out when working with the contaminated artifacts. The labels on the artifacts also notified recipients of repatriated objects if the objects were hazardous and handling should be kept to a minimum.

**Problems Associated with X-Ray Fluorescence**

Although XRF is very popular amongst museums and institutions to test for pesticides, there are some problems associated with the technique. The main problem with XRF is that it cannot detect the heavy metal accurately if there is material in between the spectrometer and the
object. According to one report (Sirois and Sansoucy 2001), XRF is a surface technique and may not give an accurate reading of the arsenic content. Thick layers of fur or feathers between the contaminated area and the detector can lead to a result which suggests smaller amounts of arsenic present in the skin than is actually the case (Sirois and Sansoucy 2001). Sirois and Sansoucy (2001) also noticed that the detection limit of XRF is higher than other methods including Atomic Absorption Spectrophotometry (AAS) and ICP-AES. Having a high detection limit might inhibit the measuring of minute levels of arsenic, mercury, and lead not being detected. Other problems such as object composition and shape, environmental influence, improper calibration, and no set standards have been documented with using XRF machines to test for pesticides (Sirois and Sansoucy 2001; Palmer et al. 2003; Fonicello 2007; Sirois et al. 2008; Hollinger and Hansen 2010; Madden et al. 2010).

Nancy Fonicello (2007) detailed many problems with using an XRF machine on an ethnographic collection. Fonicello tested items at the Charles M. Russel Museum in Great Falls, Montana. The collection consists of objects associated with indigenous people who lived on the Northern and Southern Plains, as well as from the Columbia Plateau. While testing for lead and arsenic on glass beads, Fonicello observed extremely high readings for lead and arsenic when the test was on any part of an object containing glass beads. Oxides of both arsenic and lead were added during the manufacturing of the beads, and were therefore not present due to pesticides, but due to the manufacture of the glass beads. Fonicello ultimately goes on to say that accurate testing for arsenic and lead on objects with glass beads was close to impossible due to the detection of those two metals.

Fonicello also tested a woolen object dyed blue using XRF which also yielded unusually high levels of mercury and like the beads, was not detected on areas that did not have the blue
wool. The late 1800s yielded a method for the creation of synthetic indigo to dye wools with that contained mercury. The mercury levels most likely came from the wool dying process instead of pesticides, nevertheless, Fonicello concluded that XRF “might have applications as a tool for identifying and dating textiles dyed with synthetic indigo. Namely, the presence of mercury in blue cloth might be used as an indicator that a particular textile was produced between the late 1890’s and the 1930s” (Fonicello 2007:6). Ultimately, knowing the history of the artifact and object can help interpret the results when conducting XRF tests. Having unusually high levels of mercury or lead or arsenic might be indicative of a manufacturing technique instead of pesticide use and should be taken into consideration when creating a report for an object undergoing such testing.

In 2003, Palmer et al. presented their work with the Hupa Tribe of California, reporting on their tests for pesticides prior to repatriation. The objects chosen were culturally significant items that had been repatriated. The analytical team consisted of a chemistry professor and students, Hupa Tribal members, and anthropology and museum professionals. With full consultation and collaboration with the Hupa Tribe, the analysts did not use XRF in their tests and instead used the destructive testing method of FAAS for inorganic pesticides and GC/MS to test for organic pesticides (Caldararo et al. 2001). The authors drew attention to the advantages of XRF but they chose not to use it, arguing against it in a way that mirrors the criticism of Sirois and Sansoucy (2001): irregularly shaped objects may result in skewed readings and cannot differentiate between external and internal contaminations (Palmer et al. 2003).

Sirois et al. (2008), say that in order to use XRF to its full potential, the machine must be calibrated before use. An issue that might arise from needing proper calibration curves is that multiple institutes might create their own instead of relying on a single method. The authors say
that in 2005, both the University of Arizona and the Smithsonian Institution’s Museum Conservation Institute (MCI) created calibration curves. The University of Arizona’s calibration curves covered arsenic, mercury, and lead while that of the MCI only included arsenic. However, these are not yet where we need to be. While some standards have been created using pellets for arsenic and thin-film analyses for lead, “single-element standards for mercury, as well as thin-film standards for arsenic and pellet-style standards for lead, have not yet been developed. More multi-element standards are also needed to model inter-element interferences that can skew XRF data” (Sirois et al. 2008:181).

As mentioned above in the article from Sirois et al. in 2010, having an older XRF machine may not be able to detect the low levels of mercury, arsenic, or lead that could be present in the object. Their detection limits decreased dramatically over the twenty year period that they tested, going from “not detectable” at under 500 ppm before 2004 to having a “trace” amount of 25-100 ppm in 2004. The tests that the authors ran on their objects also included Scanning Electron Microscopy/Energy Dispersive X-Ray Spectrometry (SEM/EDS) at gave different results. XRF gave different readings of arsenic than the SEM/EDS and might “be due to the arsenic present in the specimen not being present in detectable amounts on the exterior feathers or fur sampled, but being present inside the skin. The lower detection limit of the XRF technique also might contribute to this” (Sirois et al. 2010:38). This proves that having an older model of the XRF machine can skew results and might label something as “not dangerous” when in fact it does contain levels of mercury, arsenic, or lead.

Madden et al. (2010) underline some of the obstacles that might be present when attempting to analyze objects using XRF and establishing standards. They say that there are three main factors that can affect XRF data and include: instrumental factors, working practice,
and statistical considerations. Instrumental factors are those that affect the machine such as: voltage and current of the tube, duration of the measurements, and application of the right filters. Although calibration of the machine can be achieved, choosing the calibration standards or not calibrating at all might give unwanted or inaccurate results. Working practices are less manageable due to the human factor. Again, some recommendations have been proposed to limit the variability gained from multiple operators but if not followed, inter and intra-observer errors may occur. These include a consistent working distance between instrument and artifact, eliminating background signal, holding the instrument still, and avoiding contamination of the instrument head (Madden et al. 2010). Finally, the statistical factors are subject to the number of analyses that the object is put through. If only one spot (or zone) of the artifact is tested, then the whole picture might not be represented and one untested zone may have high concentrations of a hazardous pesticide and might be a part of the object that presents more of a handling or contact risk.

Finally, an article written by R. Eric Hollinger and Greta Hansen in 2010 does an excellent job of summarizing the standardization issue associated with XRF testing. They reiterate that no standards or protocols have been issued by the Smithsonian or any other institute, echoing the observations of Sirois et al. (2008). Even two separate museums run by the Smithsonian – the National Museum of the American Indian and the National Museum of Natural History – have different protocols because of the differences in their collections. This trend is likely to continue and “museums are likely to develop XRF testing procedures that are unique to their collections and goals although standardization of approaches, where practical, remains a worthy goal” (Hollinger and Hansen 2010:68).
While XRF has been used to determine the levels of inorganic pesticides including heavy metals, GC/MS and swab/spot tests have been used to estimate the levels of organic pesticides. As with XRF, there have been some reported usages of the technique as well as some documented problems. Environmental influences and unique “materials found on ethnographic objects may result in readings for arsenic, mercury, and lead that can be interpreted as pesticide residue, and it is important that these materials be taken into consideration when conducting pesticide surveys” (Fonicello 2007:8). The XRF technique still has its advantages and the readings of the objects can reveal information about the chemistry, and ideally the history, of the ethnographic collection.

I believe that at the University of Montana, the ethnographic collection housed on campus has had some form of pesticides applied to the collection. Prior to repatriation, the tests for pesticides should be completed in order to ensure the safety of the tribal communities receiving the objects. Those objects that are not meant for repatriation can benefit from the testing as well, allowing individuals studying the objects to be aware of the dangers in the repository and to take precautions to prevent potential illness. Future testing using other, more accurate measures can further this idea and provide a more complete overview of the situation. The XRF tests done at the UMACF, nevertheless, provide a good first step.
Chapter Four: 
Materials and Methods

At the University of Montana, the ethnographic collection housed on campus may have had pesticides applied to the artifacts to attempt to halt the infestation of pests such as insects and rodents. Few to no records exist indicating what kind of pesticides and fungicides were used on the collections in the past, and so an attempt was made to estimate the types of pesticides used. In the winter of 2011-2012, two UMACF employees, Bethany Hauer, MA and Mary Bobbitt, assisted by an anthropology student intern, initiated a test for heavy metals used to control pests. Before decisions were made as to which method to use, UMACF staff concluded that objects sacred to Native tribes must be tested in ways that would be non-invasive and that would not conflict with belief systems or other issues in the name of cultural sensitivity. The testing process done at the UMACF was done in consultation with tribal representatives to ensure such sensitivity. The research was funded by the tribal representatives through the Center for American Indian Policy and Applied Research (CAIPAR), and X-Ray Fluorescence was chosen as a test method due to it being a non-destructive and non-invasive technique.

Despite the problems reported with using an X-Ray Fluorescence (XRF) machine (outlined in the previous chapter), this technique was chosen for three main reasons. The first is that using XRF allowed for a non-destructive way of sampling artifacts. While more accurate results might come from different techniques, these can often require a small sample to be taken, resulting in damage of the object. According to Palmer et al. (2006), non-destructive sampling is usually preferred by the conservator to keep the artifact intact but methods requiring destructive sampling are preferred from an analytical viewpoint in order because they have the ability to produce more accurate results. The second reason is the total cost (both time and financial) of the project. Using XRF costs considerably less and takes less time than using other methods and
promised to be a fairly quick method to detect the presence of inorganic pesticides. The final reason that the UMACF staff used XRF to test for pesticides is the fact that XRF is highly sensitive to the presence of heavy metals.

The technique involved with X-Ray Fluorescence makes use of the presence of an element in or on an object. X-Rays were first discovered by Wilhelm K. Röntgen, a German physicist in 1895 (Shackley 2011). It wasn’t until the mid-1910s when Henry G.J. Moseley “laid the foundation for identifying elements in X-ray spectroscopy by establishing a relationship between frequency (energy) and the atomic number, a basis of X-ray spectroscopy” (Shackley 2011:7-8). In the 1950s, Energy Dispersive X-Ray Fluorescence (EDXRF) technology was developed (Quickshot XRF 2013), which was the technique used to analyze artifacts. In order for elements to be detected, an x-ray source (usually an x-ray tube) emits an x-ray beam into the object being tested. According the manufacturer of the handheld XRF machine used, the beam then excites and displaces the electrons in the elements. After the electrons are excited, an energy characteristic to each element is emitted as a wavelength and collected by the detection system or tube (Quickshot XRF 2013). The results can then be examined on the screen for quick analysis or transferred digitally for long term storage or future analysis. XRF uses radioisotope excitation to detect any chemical element which has an atomic number greater than 20 (Sirois and Sansoucy 2001). Anything above the atomic number of 20 (calcium) can be detected in parts per million but anything between silicon and potassium can only be detected as a percentage (Sirois et al. 2008).
X-Ray Fluorescence Testing at the University of Montana

During the winter of 2011-2012, a research team at the University of Montana’s UMACF ran 844 tests using an XRF machine on 351 different artifacts held in the University of Montana’s UMACF. The team comprised of the UMACF Curator, Bethany Hauer, Curation Assistant, Mary Bobbitt, two anthropology interns, and a Native American volunteer to assist with handling certain cultural items. The purpose of the testing was to determine if any of the artifacts contained hazardous levels of any of nine different hazardous elements commonly used in pesticides. The elements that the machine was calibrated to detect were chromium (Cr), arsenic (Ar), bromine (Br), cadmium (Cd), mercury (Hg), lead (Pb), antimony (Sb), barium (Ba), and selenium (Se). The artifacts tested positive for all of the metals except selenium and barium. Receiving positive results using XRF to test for heavy metal pesticides is not an uncommon occurrence for museums and institutions. According to Fonicello, environmental influences and unique materials that are found on ethnographic items “may result in readings for arsenic, mercury, and lead that can be interpreted as pesticide residue, and it is important that these materials be taken into consideration when conducting pesticide surveys” (Fonicello 2007:8). The XRF technique still has its advantages and the readings of the objects can reveal information about the chemistry and maybe the reveal more information about the ethnographic collection at the UMACF. The repository contains some records of the objects and their acquisition but most are incomplete. There exist multiple accession numbers, artifact numbers, and descriptions for many of the objects.

According to firsthand accounts of the collection at the UMACF, H. Turney-High wrote in a letter to the President of the University, “to my knowledge the feather work has not been fumigated since we owned it” (Turney-High 1941). Turney-High was the curator of the
University of Montana’s ethnographic collection and was commenting on the deteriorating condition of the collection and the need for a better space to store it. A further report from a few years later was written by Paul C Phillips in 1944. He stated that the “Northwest History Collection [referring to the UMACF’s ethnographic collection] has been kept clean and free from moth and other vermin. This present condition is remarkable for I can find no evidence that during the past seven years the specimens have received more care than that given by the ordinary janitorial service” (Phillips 1944). Between the years of 1944 and 2011, there may have been some attempt at creating a conservation history for the collection but there were no records found that documented the attempt. This lack of a history, and the gap of any documentation between 1944 and 2011, led to the testing of the collection with the XRF.

The machine was first calibrated by the supplier on December 14, 2011; five days prior to the commencement of the testing. Recalibration of the machine was required to ensure accurate results of the presence for the elements on ethnographic objects in the UMACF. Over the course of the testing UMACF objects, the machine was recalibrated 65 times at regular intervals.

UMACF artifacts were tested included moccasins, quivers, headdresses, shirts, dresses, blankets, corn husk bags, drums, quirts, baskets, pot rests, and clubs. These artifacts were made of organic materials such as bone, hide, feathers, and plant fibers. Most of the artifacts date from the middle of the 19th century to the early 20th century and belong to various collections housed in the UMACF’s repository. Testing of the artifacts began on December 19, 2011 and proceeded for approximately one month, ending on January 13, 2012. Due to the fact that the records at the UMACF contain limited histories of the objects, the decision was made to simultaneously take additional XRF tests of the beads and dyes on the objects with the hope that in the future, the XRF results will help to date these items.
Using a Quickshot XRF EDX P330, the research team took a 300 second scan for each test location. Multiple scans of the object were required if the object was large or if made up of multiple components. One to four (or more in some cases) tests were taken on each artifact depending on the size and the material composition of the object. An object made totally from leather required only one or two tests, while a pair of moccasins might need three or four due to the different materials present in the moccasins. The reasoning behind this methodology intended to detect whether a pesticide was applied to only a section of the entire object due to its orientation or position in storage. Palmer et al. (2006) state that multiple area tests from a single object are preferred in order to obtain a complete picture of the pesticides used. The entirety of the scanning resulted in 844 tests on 350 objects. However, due to the presence of beads on some of the artifacts and the fact that beads can skew readings for arsenic, lead, and mercury, most of the items containing beads were not included in the study and was eliminated from the analysis. The tests taken for dating purposes were also eliminated from the analysis. However, a few beaded artifacts were included in the sample set due to the fact that the test location was not on a beaded area of the artifact. This left 258 tests on 131 bead-free objects.

To reduce the risk to the researchers, nitrile gloves were worn by the handlers and strict cultural handling rules were followed during the course of the testing. There were two major requirements that were used to determine which objects were tested; these were adopted from existing literature on XRF Testing Methodologies:

1) The object contained organic materials that would be susceptible to pest damage; and

2) The object could reasonably be subject to NAGPRA or handling by descendant communities.
Testing was performed on the surface of the item, thus eliminating the necessity to remove any part of the item. The tests were performed with the test location as close to the object as possible. An inert mylar film was placed between the gun opening and the artifact and was changed after every test in an attempt to eliminate contamination. The artifacts were placed on the surface of a glass table and were only kept in their foam if the artifact was too fragile to be moved or handled.

As testing progressed, notes were kept detailing the artifact number, the test numbers it received, the location on the artifact of the scan, and the readouts for each scan. The notes were kept in three spiral bound notebooks and are stored in the UMACF. The results were placed into a spreadsheet for easy comparison and analysis. The objects tested were photographed with scale, often from various angles depending on the piece. These photos were then printed out onto a UMACF Conservation Report Form allowing the testers to mark and number each testing location. This documentation was subsequently placed in each artifact’s hard copy file.

Of the remaining 131 bead free artifacts, there were 261 XRF test results, which means that, on average, each artifact had 1.977 tests. Artifacts receiving two tests were the most common with 70 tests. This is followed by 39 of the artifacts receiving only one test, 11 of the artifacts had three test performed on them, 10 of the artifacts had four tests, no artifacts had five tests and only one artifact received six XRF tests (Figure 1).

In order to conduct statistical analyses on the data collected, the artifacts were labeled with a description number one through six (Table 4), representing the material from where the XRF tests were taken on the various ethnographic artifacts in the UMACF. Test locations on plant and wood were grouped together, and so were locations comprised of hide or leather,
canvas or cloth, and fur or wool. The remaining two categories were miscellaneous faunal elements such as hoof, tooth, antler, or quills, as well as test locations that were on feathers.

![Number of Tests per Artifact](image)

Figure 1. Number of XRF tests each UMACF artifact examined here received

<table>
<thead>
<tr>
<th>Description Number</th>
<th>Test Location Material</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plant/wood</td>
<td>67</td>
</tr>
<tr>
<td>2</td>
<td>Hide/leather</td>
<td>121</td>
</tr>
<tr>
<td>3</td>
<td>Canvas/cloth</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>Fur/wool</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>Misc. animal</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>Feather</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 4. Artifact materials associated with each XRF test

The statistical tests were all performed in Statistical Package for the Social Sciences (SPSS) 21, developed by IBM for Windows. The first round of statistics performed included a distance correlation to develop a similarity matrix. Following that, the data was put through a one-way ANOVA test using the “Description” variable as the Factor and each of the seven
elements that had results as the Dependent. This lead to discovering which of the elements were significant. Those that were significant were put through the one-way ANOVA analysis again but this time using a Tukey post-hoc analysis to compare which materials have higher or lower levels than the others.

Some tests and artifacts had to be excluded from the analysis for a couple of different reasons, including if the composition of inorganic (mainly stone or rock) materials that would not have received a pesticide treatment, if the artifact contained a trace of human remains, or the delicate nature of the artifact excluded it from being analyzed. The main reason, and the one that eliminated many of the artifacts from analysis, is if the artifact contained any amount of beadwork. The entire list of the artifacts used for the analysis, including item description, artifact number, collection, test number and location, composition of the test location, and the results for the seven detectable elements, is included in Appendix A.
Chapter Five: Results

The statistical testing provided some interesting results for each of the nine different elements. Two of the elements were completely absent from any of the artifacts, meaning they were either not present at all or, if they were, it was at a concentration that was too low to be detected by the XRF machine. These two elements were barium and selenium. The other seven elements did have various amounts of detectable concentrations of the elements on the artifacts. For example, out of the 258 tests, chromium was detected in 217 of the tests.

The statistical analyses that were performed included a correlation analysis of all seven of the elements (variables), a Bivariate correlation analysis to determine significance, a One-Way ANOVA analysis to determine which elements vary significantly over the nine categories, and then another ANOVA analysis on the significant elements with a Tukey post-hoc test to determine which material have higher and lower values (Skelton 2014).

The first correlation analysis provided a Proximity Analysis. This showed the correlation between all of the elements that were tested but does not show any of the significance between the elements. This significance can be seen in more detail after running a Bivariate correlation analysis, as seen in Table 5. This figure from SPSS shows the significance between all of the elements in the data set. The table shows that the only two pairs of elements that have significance with each other are bromine and mercury with a Pearson Correlation at .824 and arsenic and lead with a Pearson Correlation at .969.
The results from the One-Way Analysis of Variance (ANOVA) show the mean of each elements and if they were statistically significant or not. Table 6 shows the One-Way ANOVA test for each element across the six separate categories of artifacts. The results from the ANOVA test show that the only elements which are significant at the 95% confidence level, is cadmium at p=.000 and antimony at p=.038. There were no elements significant at the 90% confidence level, but there was one element that expressed significance at the 85% level. This element was arsenic which showed significance at p=.142. Because of these results, a Tukey post-hoc test was performed on all of the elements to determine where significance might lie across the elements in the separate categories. The ANOVA test of the seven elements showed

Table 5. Results of bivariate correlation analysis

<table>
<thead>
<tr>
<th></th>
<th>Cr</th>
<th>As</th>
<th>Br</th>
<th>Cd</th>
<th>Hg</th>
<th>Pb</th>
<th>Sb</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Correlations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td></td>
<td></td>
<td></td>
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**. Correlation is significant at the 0.01 level (2-tailed).
that only three elements were significant: arsenic, cadmium, and antimony. Because of this, these will be the elements discussed below.

Table 6. One-Way ANOVA of the seven elements

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Table 7 shows the results from the Tukey post-hoc test run alongside the One-Way ANOVA. The Tukey test performs t-tests of mean values between different pairs of the six categories. It will also show which pairs of categories have higher or lower levels than others.
Table 7. Tukey post-hoc test for all seven elements across the six categories

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*. The mean difference is significant at the 0.05 level.

The results discussed below will be only those that showed significance for the ANOVA test, arsenic, cadmium, and antimony.

**Arsenic Results**

All of the tests showed some level of arsenic present on the artifact. However, 119 of the tests were below the trace (25-100 ppm or up to 0.01%) level. The numbers for each were 106 tests had trace and 30 tests had low (100-1000 ppm or up to 0.1%) results. The moderate (1000-10000 ppm, up to 1%) level appeared on three tests. No objects had high (10000-50000 ppm, between 1-5%) or very high (50000+ ppm) concentrations.

The test with the highest arsenic level was Test 134 (test area in red square), which had a reading of 1772.66376. The artifact (XX-157) is from the Carling Malouf collection and is a pictograph canvas wall covering for a teepee with painting on both sides and brass bells along one of the edges (Figure 2); Appendix A provides a key to all of the artifact numbers noted...
herein and in Appendix B. Test 134 was taken on one of the figures depicted in the paintings, although the artifact had a total of six XRF tests performed on it.

![Artifact XX-157 Canvas Teepee Wall Covering](image)

**Figure 2.** Artifact XX-157 Canvas Teepee Wall Covering (photo courtesy of Bethany Hauer)

The high correlation between lead and arsenic shown in the Pearson Correlation analysis (.969), and the fact that Test 134 had the second highest lead concentration (10969.74614 ppm), could be due to the fact of an application of the pesticide lead arsenate (Sirois and Sansoucy 2001; Hamann 2006) which was in use in museums from 1892 up until the 1960s (Karydas et al. 2014). This correlation can be seen in Figure 3.
Out of the 258 tests, 232 of them did not have any concentrations able to be detected.

Out of the 26 tests remaining, 11 of them had concentrations that were detected but below the 25 ppm threshold. So, of the 15 tests that remain, 12 fell into the trace (25-100 ppm) category while the outstanding tests (three in total) were all together in the low (100-1000 ppm) category.

The highest level of cadmium was found with Test 622 (test area in red square) and registered 182.78297 ppm. The test belongs to artifact XX-133 and the test was taken from the fabric side of a saddle piece made from a combination of fur and fabric (Figure 4).
Antimony Result

The results for antimony showed that 25 tests had concentrations that were not detected by the XRF machine. The less than 25 ppm cohort included 103 of the tests. There were 118 tests that fell in the 25-100 ppm (trace) category. After that, 12 tests had low (100-1000 ppm) results, and none of the XRF tests had moderate (1000-10000 ppm) concentrations of antimony.

The test with the highest antimony concentrations belongs to Test 621 (area in red square). Test 621 was taken on artifact XX-133, a saddle piece made from fur and fabric. The test was performed on the fur side of the object (Figure 5). Test 622 had the third highest concentration of antimony and was taken on the fabric side of the artifact, indicating that there may be an antimony based pesticide in use on the object.
These items are only those that had the highest readings for the significant elements detected. Not having high significance in the SPSS analysis does not mean that these artifacts do not pose some health hazards. Although these artifacts had high readings of antimony, cadmium, and arsenic, it is still unclear as to why they are present. Further tests performed by more qualified individuals should be conducted and steps need to be put in place to protect not only the employees of the UMACF but also to protect the artifacts. These steps are outlined in the discussion section below.

Due to the fact that the XRF tests did show that there was a presence of heavy metals and other dangerous elements, I can confirm my first hypothesis that the XRF testing would show the presence of hazardous elements on the ethnographic collection at the UMACF. I believe that my second hypothesis, stating that the artifacts at the University of Montana, housed in the repository of the Anthropology Department in the UMACF, have been treated for pesticides in
the past, can be partially rejected. At this time, the methodology used does not provide adequate means to determine why exactly these elements are being detected. The XRF can only provide the means to detect that the elements are present and cannot provide us with a definite reason as to why they are there. The presence of arsenic, especially due to its correlation to lead, could be indicative of the use of lead arsenate especially considering the high correlation between lead and arsenic. This, coupled with the fact that antimony was associated with the manufacturing of the pesticide indicates even more so the usage of lead arsenate. However, for the most part, the concentrations of arsenic were fairly low and may not present high levels of risk.
Chapter Six: Discussion and Conclusion

Usage of XRF to test for the presence of certain elements has many benefits. In 2009, Prufer et al. performed similar tests and briefly reiterated those positive attributes by saying that the XRF is widely used to detect non-organic compounds because it can be easily transported, it can rapidly determine the presence of toxic elements, and is entirely non-destructive. Similar to the testing performed at the UMACF, Prufer et al. (2009) tested for lead, mercury, arsenic, and bromine knowing that these metals were both hazardous to humans and present in common insecticides such as: mercuric chloride, naphthalene, PDB, DDT, methyl bromide, cyanide, and arsenic-based moth proofing techniques.

In the contrasting opinion, the presence of mercury, arsenic, lead, and other metals “may be mistaken for the presence of pesticides. Environmental factors can introduce detectable levels of metallic pollutants into collections” (Fonicello 2007:4). Not only can environmental factors allow artifacts to exhibit the characteristics of pesticide contamination, but the chemical composition and manufacturing process of beads and dyes often include the usage of arsenic and lead as well as other elements (Morey 1936; Davison et al. 1971; Kurkjian and Prindle 1998; Sempowski et al. 2000; Fonicello 2007; Prufer et al. 2009). The argument can also be made that the presence of these hazardous elements whether from pesticide application, environment, or manufacturing techniques are still dangerous to humans. By testing for their presence, we become more informed about the collections we are handling and are able to know exactly what types of elements we are exposing ourselves and descendent communities to when working with ethnographic objects from the UMACF.
Arsenic was found in its highest concentration (non-bead) on some paint pigment from a robe which had painted scenes on both the front and the back. Although it does have a history of being used as pesticide, arsenic has also been discovered during analyses of pigment creations (Moffatt et al. 1997; Clark 2002; Corbeil et al. 2002; Hamann and Martin 2003; Rosi et al. 2004; Barnett et al. 2006; Rifkin 2011). The drawn object was a bright orange color and seemed to have been an oil based pigment due to its appearance and the fact that the color bled through to the other side.

The mineral Realgar, arsenic sulfide, was used in the past to make a form of red pigment and was used from the 16th century BCE up until the 19th century CE (Barnett, Miller, and Pierce 2006) and could explain the concentration of arsenic found on just the painted figure of this robe. However, Realgar stopped being used when cadmium orange was introduced in the late 19th century (Clark 2002). Sirois and Sansoucy (2001) performed XRF tests for lead and arsenic on an ethnographic collection and they noted that the presence of those two metals did not come from paint pigments such as red lead, lead white, realgar, orpiment, or emerald green (from copper aceto-arsenite). This could be similar to the situation at the repository at the University of Montana.

In theory, knowing if an artifact has actually been contaminated due to pesticide treatment or because of the manufacturing process can be difficult, if not impossible. To determine using XRF testing if high concentrations of arsenic and lead are present, as was the case for our tests. Fonicello suggests that “wipe tests and alternative chemical analyses should be considered where heavily beaded objects are suspected of being contaminated with pesticides” (2007:5). Since arsenic does not deteriorate with time, the arsenic used during application can still be present today. Another explanation could be that, when the robe was
found in the UMACF, it was stored alongside other artifacts. These artifacts could also have been contaminated with arsenic dust; thus, the presence of the arsenic could likely be the result of transference of those neighboring artifacts that had been treated with arsenic based powders or pastes (Gribovich 2012).

Bromine has a history of being used as pesticide in multiple forms. Ethylmercury bromine was used as a fungicide to deter the growth of mold. Ethylmercury bromine combines two of the heavy metals that were detected, mercury and bromine. According to Karydas et al. (2014), Bromadialone and other bromine-containing pesticides were also used to combat the presence of insects and rodents. Another use of bromine is in the fumigants, methyl bromide and ethylene dibromide. The common names for this compound are Bromomethane, Brozone, Bromo-o-Gas, Methogas, and MeBr (Linnie et al. 1990). The National Park Service has used Methyl Bromine, a fumigant, starting in the 1930s and used as late as 1999 (Pereira and Hammond 2001) to control for moths, beetles, roaches, crickets, rodents and wood borers. Restrictions against Methyl Bromine were put in place in 1978 and most institutions stopped using Methyl Bromine by 1999 (Pool et al. 2005).

Bromine, in one of its forms, was used to make a dye called Tyrian purple (Clark 2002). In its natural fabrication, marine mollusks were used since 1400 BCE to create the color and then the purple color became synthetically made starting in 1903. Since the test came from the quillwork dyed red and not purple, the presence of bromine due to the dye is not likely. The Montana Native Plant Society described that some tribes located in Montana often used the juice from the Twin-Berry Honeysuckle (Lonicera involucrata) plant to make a red dye used to color baskets, paint doll faces, and dye hair (Lloyd 2014a).
Cadmium is mixed with sulfide in order to obtain a yellow pigment and usage in this manner began in the 1840s (Douma 2008). This could explain the presence of cadmium in the green fabric of the fur and fabric saddle piece. However, the concentration that was detected was extremely low at 182.78297 ppm. Yellow was, however, a common color throughout the artifacts containing plant fibers. These artifacts include corn husk bags and woven baskets. According to the Montana Native Plant Society, several western tribes used a tree called the black cottonwood (Populus balsamifera) to make a yellow dye from the yellow buds of the tree (Lloyd b). The tribes also used the tree to make mats, cords, baskets, and bedding. The yellow dye could have been cadmium based and could explain the significant relationship between canvas/cloth items and objects comprised of mainly plant fibers.

Antimony was found in its highest concentrations on an artifact composed of fur and fabric. The literature suggests that antimony was used primarily as an additive to the bead making process. Because we eliminated beads from the discussion, it does not apply. There has been some research to suggest that only trace amounts of antimony were found in a collection of natural history that had a white powder on a specimen. It proved to be mainly arsenic with trace amounts of antimony (Sirois 2001).

Other research indicates that antimony can be found as an impurity in the process of making lead arsenate. Wagner et al. (2003) discovered that arsenic-containing copper ore is used in the process to make the insecticide, lead arsenate. These copper ores also contain amounts of antimony, which cannot be eliminated. The research indicates that “as a result, it is possible that lead arsenate insecticide products may have contained appreciable amounts of Sb as an impurity” (Wagner et al. 2003:736). Further findings within the study by Wagner et al. showed that the
amount of antimony that was found during their analysis was too low for it to be a concern to human health.

Another problem, which was not mentioned earlier, exists with the samples available for the XRF testing. The items in an ethnographic collection are all different shapes, sizes, and thicknesses and are completely different in nature. Because of these differences, it can be hard to obtain accurate, reliable, and replicable results from the artifacts and across the sample set. In their article, Shugar and Sirois state that because of the differences in the artifacts, they can never fully be used to obtain a comprehensive quantitative analysis and that “only destructive analysis through ICP-MS, for example, will produce truly quantitative results, and even these results will not be readily reproducible given the inhomogeneity of the materials being studied” (Shugar and Sirois 2012:341). This sentiment is echoed in the article by Karydas et al. (2013) when they state that the use of XRF can be utilized properly to determine the presence of the heavy metals like arsenic, mercury, and lead but falters during the determination of the amount “because of the diverged composition, structure and morphology of ethnographic artifacts where pesticides are used (feathers, skin, wood, textiles, etc.) and the various means of their application, for example by spreading, spraying, aerolising or immersing” (Karydas et al. 2013:2).

In conclusion, if a more precise and complete profile of the artifact needs to be conducted, further, non-XRF tests need to be performed on artifacts from the UMACF ethnographic collection in order to gauge the exact chemical history of the items. XRF has amazing capabilities to tell museum curators of the presence of hazardous elements with the added benefit of being non-destructive but has weaknesses when it comes to quantification. Other, more analytical, methods exist which can tell us more precisely the concentrations and the
chemical makeup but come with the price of artifact destruction. Until then, however, it can be enough to know that there are artifacts that should be treated with caution.

Too many variables exist in order to say for certain if the heavy metal detected came from the application of pesticides or from the manufacturing process of the artifact. As stated in the article from Prufer et al. (2009), anthropologists are not the most qualified people to determine the health aspects of exposures to these elements and chemicals and should not be the determining factor if these elements pose any health risks. We should only offer up the evidence that these metals are present on the artifact and allow other, more qualified individuals, the opportunity state what the risks associated with the handling of these artifacts are. This thought is again echoed by Odgegaard and Sadongei (2001) when they suggest that museum personnel work closely with medical or industrial hygiene professionals to determine risk levels.

A couple of recommendations for the UMACF need to be mentioned before closing. The first would be to establish that the artifacts may, in fact, be contaminated with these poisons. The first step would be to warn employees and visitors about the risk with a sign near the front door, saying “Caution: Artifacts may have been treated with hazardous pesticides! Handle with care.” Further steps include also wearing nitrile gloves when handling the artifacts and/or a respirator. The final step would be to create a color coding scale similar to the one created by Odegaard et al. (2006). By forming a team consisting of chemists, industrial hygienists, members in the health care field, and anthropologists, the researchers were able to develop a coding scaled to determine the risk levels of the artifacts tested.

Further tests at the UMACF using different methodology, such as GC/MS, would provide a more accurate analysis of the elements detected and would help to develop a similar color coded system for the UMACF and would help plan for the long-term care and handling of
UMACF objects that have been treated with the chemicals discussed here. A simple coding system was developed just through the examination of the concentrations of lead and arsenic. The results of this scale show that there are seventeen tests which have moderate or higher ppm concentrations of lead or arsenic, see Table 8. These tests have been coded as “high,” similar to the labels by Odegaard et al. (2006) and those mentioned in Gribovich (2012). Additional categories include “moderate” and “low” and can be seen in the entire artifact test table in Appendix A. Photographs of these artifacts, their testing areas, and the XRF graphs can be seen in Appendix B. A scale would prove useful to the ethnographic collection at the University of Montana. A collaborative effort between the curators of the UMACF, tribal representatives, and chemists would be the best step in establishing the scale and creating tags for the objects. Until this team comes together, however, we must take all precautions to protect ourselves and to protect the artifacts. But for now, at a minimum, anything that has a moderate, or higher, concentration of arsenic and lead should be tagged due to the fact that the pesticide lead arsenate has the greatest likelihood of having been used at the UMACF.

The artifacts located in the University of Montana’s Anthropological Curation Facility cover a wide type range. Anything from buckskin dresses to hammer stones can be found in the facility. It is the ones made from organic material that have the greatest concern. The application of hazardous chemicals to mitigate the presence of destructive pests puts these artifacts at a risk to affect the health of the humans who may have contact with them. The significance of arsenic, lead, and antimony could potentially indicate the usage of lead arsenate on the collection sometime in the past. Testing for these chemicals ensures that precautions are taken to reduce that risk. Informing all participating parties of the potential presence of these chemicals will not only reduce the risk of contamination but also foster good will and collaboration between groups.
Table 8. Artifact Tests with High Threat Level

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References


Phillips PC. 1944. Report on the Northwest History Collection to the President of the Montana State University. The University of Montana President’s Office Records. K . Ross Toole Archives. The University of Montana, Missoula MT.


Prufer KM, Nazaroff A, and Aquino V. 2009. Testing by portable XRF or ethnographic objects at the Indian Arts Research Center, Santa Fe. SAR Report, University of New Mexico, Albuquerque.


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Smithsonian Institution Archives (SIA). Record Unit 000155. Office of the Director, National Museum of Natural History records. Smithsonian Institution, Washington, D.C.


Turney-High H. 1941. Personal opinion to the President of the Montana State University. The University of Montana President’s Office Records. K . Ross Toole Archives. The University of Montana, Missoula MT.


Appendix A: Artifact Table

The following table represents the artifacts used as a sample set for the analysis. The list contains the artifact count number, artifact number, the collection it belongs to, a brief item description, the test numbers associated with the artifact, the test locations, the material composition of the test location, the material code assigned to it, and the results from the seven elements detected. The threat levels were based on the ppm of the element, lead. This was due to the fact that out of the seven that returned results, lead had the highest concentrations. A few of the results were in 10,000-50,000 ppm (high) concentrations. This made lead the most logical to base the remaining threat levels. The category of “high” contains those artifacts that had a lead concentration higher than 1,000 ppm. The “moderate” category contains those artifacts that have a lead concentration between 100 and 1,000 ppm. Anything lower than 100 ppm for lead concentrations fell into the “low” category.
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<td>As</td>
<td>Br</td>
<td>Cd</td>
<td>Hg</td>
<td>Pb</td>
<td>Sb</td>
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Appendix B: Artifact Pictures and XRF Graphs

The following pictures and graphs represent those that were mentioned in the results section of the essay based on the UMACF Conservation Forms that were completed when the XRF tests were initially carried out during the winter of 2011-2012. Each entry in this appendix includes an artifact photo, where the test was taken from on each object, and the XRF test graph showing the highest concentration of arsenic, cadmium, and antimony.
Artifact Number: XX-146
Item Description: Shield
Collection: Averill
Test Number: 364, 365, 366
Threat: Moderate
Photo Courtesy: Lucy Capehart

Picture removed due to cultural sensitivity issues.
If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.

Test 364 located front top
Test 365 located front middle
Test 366 located front bottom
Artifact Number: 6507
Item Description: Corn husk bag
Collection: Big Crane
Test Number: 583, 584
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: XX-122
Item Description: Deer hoof rattle
Collection: Blackfeet Arts and Crafts
Test Number: 700
Threat: High
Photo Courtesy: Bethany Hauer

Picture removed due to cultural sensitivity issues.

If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number: 6663
Item Description: Horse trapping
Collection: Blackfeet Arts and Crafts
Test Number: 808
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number: E92.074.29
Item Description: Eagle feather
Collection: Blackfeet Arts and Crafts
Test Number: 800
Threat: Low
Photo Courtesy: Mary Bobbitt

Picture removed due to cultural sensitivity issues.

If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number: 59-2
Item Description: Corn husk bag
Collection: Conway
Test Number: 569, 570
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 569 located front

Test 570 located back
Artifact Number: 59-1
Item Description: Corn husk bag
Collection: Conway
Test Number: 573, 574
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: XX-103
Item Description: Corn husk bag
Collection: Dodds
Test Number: 575, 576
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: E-11-14-89/6
Item Description: Corn husk bag
Collection: Elwell-Elmore
Test Number: 503, 504
Threat: Moderate
Photo Courtesy: Mary Bobbitt

Front

Test 503 located front

Back

Test 504 located back
Artifact Number: E-11-14-89/7
Item Description: Corn husk bag
Collection: Elwell-Elmore
Test Number: 505, 506
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number:  E-11-14-89/8
Item Description:  Corn husk bag
Collection:  Elwell-Elmore
Test Number:  507, 508
Threat:  Low
Photo Courtesy:  Mary Bobbitt
Artifact Number: 6568
Item Description: Needle case
Collection: Finley
Test Number: 121, 122
Threat: Moderate
Photo Courtesy: Bethany Hauer
Artifact Number: 7137  
Item Description: Parfleche bag  
Collection: Flathead Arts and Crafts  
Test Number: 782, 783  
Threat: Low  
Photo Courtesy: Mary Bobbitt
Artifact Number:  E92.063.05
Item Description:  Bone necklace
Collection:  Flathead Arts and Crafts
Test Number:  298
Threat:  Low
Photo Courtesy:  Mary Bobbitt
Artifact Number:  E91.96.01
Item Description:  Corn husk bag
Collection:  Flint
Test Number:  597, 598
Threat:  Moderate
Photo Courtesy:  Mary Bobbitt
Artifact Number: 4872
Item Description: Corn husk bag
Collection: Flint
Test Number: 577, 578
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 577 located front

Test 578 located back
Artifact Number: 5624
Item Description: Moccasins
Collection: Gibson
Test Number: 185, 186
Threat: Moderate
Photo Courtesy: Bethany Hauer

Front

Back

Test 185 located front
Test 186 located back
Artifact Number: 5625
Item Description: Doll
Collection: Gibson
Test Number: 806, 807
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5667
Item Description: Rawhide rattle
Collection: Gibson
Test Number: 705
Threat: Low
Photo Courtesy: Mary Bobbitt

Picture removed due to cultural sensitivity issues.

If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number:  5685  
Item Description:  Winnowing tray  
Collection:  Gibson  
Test Number:  029, 030  
Threat:  Low  
Photo Courtesy:  Mary Bobbitt
Artifact Number: 5685
Item Description: Winnowing tray
Collection: Gibson
Test Number: 035, 036
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 035 located front

Test 036 located back
Artifact Number: 5691
Item Description: Plaited purse
Collection: Gibson
Test Number: 031, 032
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 032 located front

Test 031 located back
Artifact Number: 5634
Item Description: Pouch
Collection: Gibson
Test Number: 765, 766
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 765 located front

Test 766 located back
Artifact Number: 5612
Item Description: Corn husk bag
Collection: Gibson
Test Number: 589, 590
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5613
Item Description: Doll
Collection: Gibson
Test Number: 470, 471
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 470 located front

Test 471 located back
Artifact Number: 5626
Item Description: Doll
Collection: Gibson
Test Number: 478, 479
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 478 located front

Test 479 located back
Artifact Number: 5674
Item Description: Hat
Collection: Gibson
Test Number: 033, 034
Threat: High
Photo Courtesy: Bethany Hauer
Artifact Number: XX-102
Item Description: Corn husk bag
Collection: Gibson
Test Number: 591, 592
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5656
Item Description: Toy awl case
Collection: Gibson
Test Number: 480
Threat: High
Photo Courtesy: Bethany Hauer
Artifact Number:  E91.124.02
Item Description:  Toy canoe
Collection:  Gibson
Test Number:  481
Threat:  Low
Photo Courtesy:  Mary Bobbitt

Right

Test 481
Artifact Number:  E92.069.23
Item Description:  Eagle feathers
Collection:  Boos
Test Number:  192
Threat:  Moderate
Photo Courtesy:  Bethany Hauer
Artifact Number: 62-20
Item Description: Parfleche bag
Collection: Hale
Test Number: 775, 776
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 62-13
Item Description: Skirt
Collection: Hale
Test Number: 315, 316
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 56-93
Item Description: Wall hanging
Collection: Harrison and Simpson
Test Number: 608
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 4868
Item Description: Moccasin boots
Collection: Harrison and Simpson
Test Number: 48, 49, 50, 51
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number: 5899
Item Description: Drum
Collection: Harrison and Simpson
Test Number: 702
Threat: High
Photo Courtesy: Mary Bobbitt
Artifact Number: 4869
Item Description: Pipe bag
Collection: Harrison and Simpson
Test Number: 490, 491
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 4896
Item Description: Doll
Collection: Harrison and Simpson
Test Number: 472, 473
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number: 4871
Item Description: Blanket
Collection: Harrison and Simpson
Test Number: 607
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number: 4885
Item Description: Sash
Collection: Harrison and Simpson
Test Number: 606
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number: 203
Item Description: Pouch
Collection: Harrison and Simpson
Test Number: 786
Threat: Low
Photo Courtesy: Mary Bobbitt

Picture removed due to cultural sensitivity issues.
If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number:  56-90
Item Description:  Wall hanging
Collection:  Harrison and Simpson
Test Number:  609
Threat:  Low
Photo Courtesy:  Mary Bobbitt

Front

Test 609
Artifact Number: 56-91
Item Description: Wall hanging
Collection: Harrison and Simpson
Test Number: 610
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 56-92
Item Description: Wall hanging
Collection: Harrison and Simpson
Test Number: 611
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Test 611
Artifact Number: XX-98
Item Description: Horse blanket
Collection: Higgins
Test Number: 415, 416
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 415 located front

Test 416 located back
Artifact Number:  XX-88
Item Description:  Horse blanket
Collection:  Higgins
Test Number:  423, 424
Threat:  Low
Photo Courtesy:  Mary Bobbitt

Front

Back

Test 423 located front

Test 424 located back
Artifact Number: 84-136
Item Description: Parfleche bag
Collection: Johnson
Test Number: 797, 798
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 797 located front

Test 798 located back
Artifact Number: 84-147
Item Description: Hide
Collection: Unknown
Test Number: 840
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Test 840
Artifact Number: 84-149
Item Description: Basket
Collection: Unknown
Test Number: 837
Threat: Low
Photo Courtesy: Mary Bobbitt

Front and top

Test 837
Artifact Number: 5861
Item Description: War bonnet
Collection: Lewis
Test Number: 200, 201
Threat: Moderate
Photo Courtesy: Mary Bobbitt

Front

Back

Test 200 located front

Test 201 located back
Artifact Number: XX-132
Item Description: Dance bustle
Collection: Lewis
Test Number: 655, 656, 657, 658
Threat: Moderate
Photo Courtesy: Bethany Hauer

Front

Back

Test 655 located front top

Test 657 located back top

Test 656 located front middle

Test 658 located back middle
Artifact Number: 5831
Item Description: Flute
Collection: Lewis
Test Number: 701
Threat: Low
Photo Courtesy: Mary Bobbitt

Picture removed due to cultural sensitivity issues.

If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number: 5884
Item Description: Sealskin boots
Collection: Lewis
Test Number: 602, 603, 604, 605
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number: 5802 A
Item Description: Toy canoe
Collection: Lewis
Test Number: 629
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5802 B
Item Description: Toy canoe
Collection: Lewis
Test Number: 630
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5930
Item Description: Knife and sheath
Collection: Lewis
Test Number: 713, 714
Threat: High
Photo Courtesy: Bethany Hauer

Front

Back

Test 713 located front

Test 714 located back
Artifact Number: 5801
Item Description: Rope
Collection: Lewis
Test Number: 400, 401
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number: 5916
Item Description: Cradleboard
Collection: Lewis
Test Number: 789, 790, 791
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5818
Item Description: Pipe bag
Collection: Lewis
Test Number: 535, 536, 537
Threat: Moderate
Photo Courtesy: Lucy Capehart

Front

Back

Test 535 located front top
Test 536 located front middle
Test 537 located back
**Artifact Number:** 5890  
**Item Description:** Moccasins  
**Collection:** Lewis  
**Test Number:** 231, 232, 233, 234  
**Threat:** Moderate  
**Photo Courtesy:** Bethany Hauer
Artifact Number: 5858
Item Description: War bonnet
Collection: Lewis
Test Number: 800, 801
Threat: Moderate
Photo Courtesy: Lucy Capehart and Mary Bobbitt

Full view of left side

Test 800 located on red band
Test 801 located on leather

War bonnet in box; not removed for testing
Artifact Number: XXX-46
Item Description: War bonnet
Collection: Lewis
Test Number: 373, 374
Threat: Moderate
Photo Courtesy: Bethany Hauer and Mary Bobbitt

Full view

War bonnet in box; not removed for testing

Test 373 located on top

Test 374 located on feathers
Artifact Number: 5851
Item Description: Bow case
Collection: Lewis
Test Number: 697, 698, 699
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artificial Number: 5819
Item Description: Pipe bag
Collection: Lewis
Test Number: 529, 530, 531
Threat: High
Photo Courtesy: Lucy Capehart
Artifact Number: 5892
Item Description: Leggings
Collection: Lewis
Test Number: 680, 681, 682, 683
Threat: High
Photo Courtesy: Bethany Hauer

Front

Test 680 located front right legging

Test 681 located back right legging

Back

Test 682 located back left legging

Test 683 located front left legging
Artifact Number: 5894
Item Description: Leggings
Collection: Lewis
Test Number: 829, 830, 831, 832
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number: XX-193
Item Description: War bonnet
Collection: Lewis
Test Number: 780, 781
Threat: Moderate
Photo Courtesy: Lucy Capehart
Artifact Number: 5800
Item Description: Quirt
Collection: Lewis
Test Number: 405
Threat: Moderate
Photo Courtesy: Bethany Hauer
Artifact Number: 5773
Item Description: Pouch
Collection: Lewis
Test Number: 627, 628
Threat: Moderate
Photo Courtesy: Bethany Hauer
Artifact Number: 5863
Item Description: War shirt
Collection: Lewis
Test Number: 695, 696
Threat: High
Photo Courtesy: Lucy Capehart
Artifact Number: XX-170
Item Description: Dress
Collection: Lewis
Test Number: 383, 384
Threat: High
Photo Courtesy: Lucy Capehart
Artifact Number: 5883
Item Description: Moccasins
Collection: Lewis
Test Number: 015, 016, 017, 018
Threat: Moderate
Photo Courtesy: Bethany Hauer

Top

Bottom

Test 015 located top left toe
Test 017 top right toe
Test 016 located bottom left toe
Test 018 bottom right heel
Artifact Number: 5857
Item Description: War bonnet
Collection: Lewis
Test Number: 149, 150, 151
Threat: Low
Photo Courtesy: Lucy Capehart

Right

Left

Test 149 located right feathers
Test 150 located right fur
Test 151 located interior headband
Artifact Number:  5765
Item Description:  Corn husk bag
Collection:  Lewis
Test Number:  579, 580
Threat:  Moderate
Photo Courtesy:  Mary Bobbitt

Front

Back

Test 579 located front

Test 580 located back
Artifact Number: 5766
Item Description: Corn husk bag
Collection: Lewis
Test Number: 595, 596
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5767
Item Description: Corn husk bag
Collection: Lewis
Test Number: 787, 788
Threat: Low
Photo Courtesy: Lucy Capehart
Artifact Number: 5830
Item Description: Drum
Collection: Lewis
Test Number: 703
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5796
Item Description: Quirt
Collection: Lewis
Test Number: 409
Threat: Moderate
Photo Courtesy: Bethany Hauer
Artifact Number: 5559
Item Description: Quirt
Collection: Lewis
Test Number: 410, 411
Threat: Moderate
Photo Courtesy: Lucy Capehart

Top

Test 410 located on handle

Test 411 located on leather
Artifact Number: 5797
Item Description: Quirt
Collection: Lewis
Test Number: 399
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number:  XX-157
Item Description:  Teepee wall covering
Collection:  Malouf
Test Number:  130, 131, 132, 133, 134, 135
Threat:  High
Photo Courtesy:  Bethany Hauer
Artifact Number: 6447
Item Description: War club
Collection: McGill
Test Number: 707
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: XX-90
Item Description: Gloves
Collection: McGill
Test Number: 663, 664, 665, 666
Threat: Moderate
Photo Courtesy: Mary Bobbitt

Top

Bottom

Test 663 located bottom left cuff

Test 665 bottom right cuff

Test 664 located top left hand

Test 666 top right hand
Artifact Number: 6425
Item Description: Quiver
Collection: McGill
Test Number: 625, 626
Threat: Moderate
Photo Courtesy: Mary Bobbitt

Front

Back

Test 625 located front

Test 626 located back
Artifact Number: 6424
Item Description: Bear claw necklace
Collection: McGill
Test Number: 005, 006
Threat: Low
Photo Courtesy: Bethany Hauer

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If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number: 6415  
Item Description: Headdress  
Collection: McGill  
Test Number: 146, 147, 148  
Threat: Low  
Photo Courtesy: Mary Bobbitt and Lucy Capehart

Front

Right entire

Test 146 located front feathers  
Test 147 located front fur  
Test 148 located interior headband
Artifact Number: 6414
Item Description: Headdress
Collection: McGill
Test Number: 203, 204
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number:  5459 B
Item Description:  Wooden masher
Collection:  Moiese
Test Number:  246
Threat:  Low
Photo Courtesy:  Mary Bobbitt
Artifact Number: 5464
Item Description: War club
Collection: Parsons
Test Number: 720
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number: 5748
Item Description: Moccasins
Collection: Parsons
Test Number: 091, 092
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number: 83-6
Item Description: Leggings
Collection: Paxson
Test Number: 802, 803
Threat: Moderate
Photo Courtesy: Mary Bobbitt

Front

Back

Test 802 located back

Test 803 located front
Artifact Number:  XX-155
Item Description:  Head piece
Collection:  Pichette
Test Number:  202
Threat:  Low
Photo Courtesy:  Mary Bobbitt

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If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number: XX-145
Item Description: Shield
Collection: Pichette
Test Number: 779
Threat: Low
Photo Courtesy: Mary Bobbitt

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If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number:  E92.043.06
Item Description:  Sash
Collection:  Sheppard
Test Number:  294
Threat:  Low
Photo Courtesy:  Mary Bobbitt
Artifact Number: 83-14
Item Description: Pot rest
Collection: University of Utah
Test Number: 019, 020
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number: 83-24
Item Description: Dress
Collection: White
Test Number: 331, 332, 333, 334
Threat: Moderate
Photo Courtesy: Mary Bobbitt

Front

Back

Test 331 located front collar

Test 332 located front bottom

Test 333 located back sleeve

Test 334 located back body
Artifact Number: 83-23
Item Description: Moccasins
Collection: White
Test Number: 167, 168, 169
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number:  E91.121.02
Item Description:  Doll
Collection:  Woodworth
Test Number:  474, 475
Threat:  Moderate
Photo Courtesy:  Mary Bobbitt

Front

Back

Test 474 located front

Test 475 located back
Artifact Number: 6395
Item Description: Doll
Collection: Woodworth
Test Number: 476, 477
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number: 6393
Item Description: Doll
Collection: Woodworth
Test Number: 804, 805
Threat: High
Photo Courtesy: Bethany Hauer
Artifact Number: 6391
Item Description: War club
Collection: Woodworth
Test Number: 716
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 6466
Item Description: Moccasins
Collection: Worden
Test Number: 220, 221, 222
Threat: Moderate
Photo Courtesy: Bethany Hauer
Artifact Number:  6493  
Item Description: Corn husk bag  
Collection:  Worden  
Test Number:  587, 588  
Threat:  Low  
Photo Courtesy:  Mary Bobbitt
Artifact Number: 6492
Item Description: Corn husk bag
Collection: Worden
Test Number: 581, 582
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 6491
Item Description: Corn husk bag
Collection: Worden
Test Number: 567, 568
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 567 located front

Test 568 located back
Artifact Number: 6676
Item Description: Toy parfleche bag
Collection: Blackfeet Arts and Crafts
Test Number: 812, 813
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 812 located front

Test 813 located back
Artifact Number: XX-184
Item Description: Pipe
Collection: Unknown
Test Number: 024, 025
Threat: Low
Photo Courtesy: Bethany Hauer

Right

Test 024 located feathers

Test 025 located strap
Artifact Number: 83-16
Item Description: Eagle feather
Collection: Unknown
Test Number: 193
Threat: Low
Photo Courtesy: Mary Bobbitt

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If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number: XX-39
Item Description: Bonnet
Collection: Unknown
Test Number: 550, 551
Threat: Low
Photo Courtesy: Mary Bobbitt

Right

Test 550 located right

Left

Test 551 located left
Artifact Number: XX-144
Item Description: Shirt
Collection: Unknown
Test Number: 722, 723
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5465
Item Description: War club
Collection: Unknown
Test Number: 718
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number: 4941
Item Description: War club
Collection: Unknown
Test Number: 715
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5523
Item Description: Sheath
Collection: Boos
Test Number: 711, 712
Threat: Low
Photo Courtesy: Mary Bobbitt

Front
Back

Test 711 located front
Test 712 located back
Artifact Number: 15019
Item Description: Vest
Collection: Unknown
Test Number: 684, 685
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 684 located front

Test 685 located back
Artifact Number: 1016-0
Item Description: Fishing bag
Collection: Unknown
Test Number: 614, 615
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number:  XX-114
Item Description:  Sealskin moccasins
Collection:  Unknown
Test Number:  599, 600, 601
Threat:  Low
Photo Courtesy:  Mary Bobbitt

Top and right

Bottom and left

Test 599 located A
Test 600 located B
Test 601 located C
Artifact Number: 4893
Item Description: Corn husk bag
Collection: Unknown
Test Number: 585, 586
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5736
Item Description: Corn husk bag
Collection: Gibson
Test Number: 593, 594
Threat: Low
Photo Courtesy: Mary Bobbitt

Front

Back

Test 593 located front

Test 594 located back
Artifact Number: 5737
Item Description: Corn husk bag
Collection: Unknown
Test Number: 571, 572
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number: XXX-33
Item Description: Quilt
Collection: Unknown
Test Number: 561, 562
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 4952
Item Description: Pipe bag
Collection: Unknown
Test Number: 488, 489
Threat: High
Photo Courtesy: Bethany Hauer
Artifact Number: 5463
Item Description: Quirt
Collection: Unknown
Test Number: 406
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5466
Item Description: Quirt
Collection: Unknown
Test Number: 402
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number: 4866
Item Description: Tooth necklace
Collection: Blackfeet Arts and Crafts
Test Number: 301, 302
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number: 5469
Item Description: Gun case and sheath
Collection: Unknown
Test Number: 263, 264, 265, 266
Threat: Moderate
Photo Courtesy: Bethany Hauer

Front

Test 263 located front sheath
Test 264 located back sheath
Test 265 located back gun case
Test 266 located front gun case
Artifact Number: 5459 A
Item Description: Wooden masher
Collection: Moiese
Test Number: 244
Threat: Low
Photo Courtesy: Bethany Hauer
Artifact Number: 4902
Item Description: Basket
Collection: Unknown
Test Number: 037, 038, 039
Threat: Moderate
Photo Courtesy: Mary Bobbitt
Artifact Number: XX-133
Item Description: Saddle piece
Collection: Unknown
Test Number: 621, 622
Threat: Low
Photo Courtesy: Mary Bobbitt
Artifact Number: 5972
Item Description: Hide
Collection: Unknown
Test Number: 841, 842
Threat: High
Photo Courtesy: Bethany Hauer
Artifact Number: 5826
Item Description: Shield
Collection: Lewis
Test Number: 799
Threat: Moderate
Photo Courtesy: Bethany Hauer

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If you wish to see this document in its entirety please contact the UM Anthropological Curation Facility.
Artifact Number: 83-2
Item Description: Backrest
Collection: White
Test Number: 289, 290
Threat: Moderate
Photo Courtesy: Mary Bobbitt