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Cover Photo: Hafted metal projectile point from the Payette River, Idaho.

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# Articles and Reports

## IMPACTS OF MOISTURE AND TEMPERATURE ON STORED SEEDS IN SUBTERRANEAN PITS

*Susan E. Hawkins*

### INTRODUCTION

There is little ethnographic and historic data on food storage on the Snake River Plain. Steward (1938) notes that storage was an important part of the subsistence strategy; however, recent comparison of archaeological sites show little evidence of storage (Plew 2003). To examine this Dunn (1995) attempted to replicate storage facilities as a means of evaluating the constraints that fungal contamination has on raw and dry seeds. His experiment established that storing seeds in underground pits resulted in almost immediate contamination, suggesting that fungi likely impacts the duration of storage. Dunn's study provides a possible explanation for the few storage features found in the archaeological record which suggests a short-term caching strategy of the type commonly associated with highly mobile foragers. Building on Dunn's study, the objective of this project is to measure moisture and temperature levels in subterranean storage pits using Lascar RH/Temperature Data Loggers to determine if these factors influence the development of fungi on stored seeds. It is hypothesized that increased levels of moisture are a contributing factor to seed contamination that may place limitations on storage.


**Figure 1. Research Area.**

### ENVIRONMENTAL SETTING

The area (Figure 1) is located in the western portion of the Snake River Basin which is characterized as a "fault-bound basin filled by interbedded volcanic rocks and lake bed sediments of Tertiary and Quaternary age" (Maley 1987). Geologic processes of the late Pliocene and Pleistocene uplifted and eroded the region creating deep canyons. The bottom of the canyon floor is scattered with hundreds of basalt boulders left behind from the Bonneville flood that occurred 14,500 years ago (Malde 1965). The climate of the region varies between hot, dry summers and cool, wet winters. Precipitation ranges from 8 to 12 inches annually with temperatures ranging from as high as 100 degrees Fahrenheit in July to 20 degrees Fahrenheit in January.

The semi-desert environment consists of vegetation composed of sagebrush (*Artemisia*), greasewood (*Sarcobatus*), willow (*Salix*), and shadescale (*Atriplex confertifolia*) (Daubenmire 1952). Additional flora species, many of which were used as food resources, include bitterroot (*Lewisia rediviva*), camas (*Camasia quamash*), wild onion (*Allium cernum*), sunflower (*Helianthus annus*), Great Basin wild rye (*Elymus cinereeus*), Indian ricegrass (*Oryzopsis hymenoides*), yampa root (*Perideridia gairdneri*), and tule (*Scirpus acutus*) (Daubenmire 1952). The region also consists of diverse fauna species commonly associated with semi-desert habitat and include mule deer (*Hemionus odocioleus*), mountain sheep (*Ovis canadensis*), and pronghorn antelope (*Antilocapra americana*) (Larrison 1967). Small mammals consist of ground squirrels (*Citellus*), chipmunk (*Callaspermophilus*), badger (*Taxidea taxus*), pack rat (*Neotoma cinerea*), cottontail (*Sylvilagus floridanus*), and beaver (*Castor canadensis*) (Larrison 1967). Avifauna species, some of which are migrating, include geese (*Branta canadensis*), sagehen

(*Centrocerus urophosious*), various ducks, and small birds (Larrison 1967). Snake River fish species were considered an important food resource and include Chinook salmon (*Oncorhynchus tschawytscha*), steelhead trout (*Salmo gairdnerii*), northern squawfish (*Ptychocheilus oregonensis*), bridgelip sucker (*Castostomus columbianus*), and white sturgeon (*Acipenser transmontanus*) (Simpson 1982).

## ETHNOGRAPHIC BACKGROUND OF THE SNAKE RIVER SHOSHONI

The Northern Paiute and Western Shoshone occupied the Southwestern region of Idaho. Both groups shared similar socio-political organizations, subsistence practices and religious and material cultures (Steward 1938). Steward's general subsistence and settlement patterns for the Great Basin were based on hunting and gathering and provide archaeological interpretation for Southern Idaho (Gould and Plew 2001). This traditional ethnographic account implies a collector strategy where mobility and settlements are seasonally constrained and groups tend to collect and store food resources (Kelly 1995). Through the spring, summer and fall, the Snake River Shoshoni moved about in small family groups hunting wildlife and collecting seeds, nuts and berries in a seasonal round, moving from one scattered resource patch to another (Steward 1938). Hunting equipment consisted of bow and arrows, the atlatl, and dart points for large game; sagebrush bark nets and wooden clubs for rabbit hunting; and snares and spring-pole traps for birds (Steward 1943). In the early spring, groups moved to Camas Prairie collecting camas bulbs and other roots. Preparation included boiling the roots in clay pots, as well as grinding and drying them without cooking. Some roots were placed in birch bags and buried or transported to the Snake River Canyon for storage in the canyon rock walls (Steward 1938:167). Seeds, such as sunflower (*Helianthus annus*), Great Basin wild rye (*Elymus cinereeus*), and Indian ricegrass (*Oryzopsis hymenoides*), were also utilized as a common food source and were harvested by hand using seed beaters and collected in baskets (Steward 1938; Simms 1985).

During the fall salmon run, groups moved back along the Snake River to harvest and process fish (Steward 1938; Liljeblad 1957; Murphy and Murphy 1960). Various tools were utilized for fishing, such as weirs made of wicker, basket traps, dip nets, harpoons, sinkers, jigging hooks, and barbs (Steward 1938; Liljeblad 1957; Murphy and Murphy 1960). Equipment associated with the processing of fish included drying racks, split roasting sticks, fish skin bags, deep bowl mortars, cache pits, and framed storage sheds attached to house structures (Steward 1938; Liljeblad 1957; Murphy and Murphy 1960). Although the ethnographic record attests to the harvesting, processing, and storing of fish, the abundance of anadromous resources does not address the problems of aboriginal storage strategies (Plew 1990).

## THE ARCHAEOLOGICAL RECORD OF STORAGE

Storage on the Snake River Plain is presumed to be an important part of the subsistence strategy (Steward 1938; Murphy and Murphy 1960). However, higher costs associated with bulk procurement strategies of the type associated with fall salmon exploitation would almost certainly reduce the optimality of extensive storage (Gould and Plew 2001). Additionally, large storage facilities associated with this sort of strategy are not evident in the archaeological record.

Plew's (2003) assessment of 77 archaeological sites along the Snake River Plain indicates that only ten sites contained significant evidence of storage (Figure 2). Three of the ten sites—Scaredy Cat Cave, Bobcat Cave, and Tomcat Cave—date from the Early to the Late Archaic period and contained evidence of bison remains and sagebrush platforms that may have been a means of preserving meat. A fourth site, Shellbach Cave (10-OE-240) is dated to the Late Archaic and is situated along a basalt south-side rimrock close to Swans Falls. It also contained evidence of an above ground storage feature or cache of layered rock and grass that consisted of 13 fish remains. Of these four cave sites all of the features for storage were above ground and provide the only direct evidence of what might have been stored there. There is little information as to how common these types of storage facilities were because of the lack of data (Plew 1990).

Subterranean storage facilities have been documented at six remaining Middle to Late Archaic sites and include Bliss (10-GG-1), Knox (10-EL-1577), Crutchfield (10-GG-191), Kanaka Rapids (10-GG-273), Three Island Crossing (10-EL-294), and Nahas Cave (10-OE-1674) (Figure 2). The Bliss site located on the north side of a


Figure 2. Archaeological Sites.

river terrace in the Snake River Canyon contained a faunal assemblage dominated by deer and salmon and a possible storage facility that was oval-shaped and 30 cm in diameter. The Knox site is also located on the north side of the Snake River and contained a single oval-shaped cache pit with a rounded bottom and measured 30 x 30 x 35 cm. There was no evidence at either site of pit lining or type of construction and no deposits were recorded.

Although storage features and house structures tend to be associated, there was no evidence of what was being stored at either the Crutchfield or Kanaka Rapids sites. The Crutchfield site, located near a large spring, was used as a winter camp and shows evidence of three house structures, fire pits, and a diverse artifact assemblage. This site contained two cache pits, oval-shaped and measuring 30 x 37 x 18 cm and 20 x 7 x 9 cm but again no deposits were reported. The Kanaka Rapids site also contained evidence of structural features and four "cache" pits delineated by rocks but there was no evidence of what may have been stored.

Situated on the north bank of the Snake River at Glenns Ferry is the Three Island Crossing site (Figure 2). It is described as having an extensive artifact and faunal assemblage, a house structure with a fire pit, fire-cracked rocks, and two storage pits. Both pits measured 1 x 1 meters and there was no evidence of rock or fiber lining, although partial salmon fish remains were recovered from an upper edge wall of one pit. Nahas Cave in the Owyhee Uplands is considered to be a hunting camp and contained various fire pits and two storage pits. These pits measured 50 x 50 x 10 cm and 15 x 15 x 10 cm and both have rounded bottoms, tapered sides, and the smallest pit was fiber lined. The use of fiber was also noted in Shellbach Cave with above ground storage and may have been an attempt at further drying or preservation (Plew 2003).

Large storage facilities associated with bulk procurement are not evident at any of these sites. The only evidence of what may have been stored comes from Scaredy Cat Cave, Bobcat Cave, and Tomcat Cave in the form of drying or storage platforms associated with large faunal assemblages. Shellbach Cave contained evidence of a small cache of fish remains and Three Island Crossing had partial fish remains located in an unprepared storage pit. Based on Binford's model, foragers move groups from one camp to the next gathering food on a daily basis as they encounter them and typically do not store or stockpile food (Kelly 1995). This may be one explanation for the limited cache pits found in the record. In addition, as suggested by Plew (2003) the apparent lack of facilities in prehistoric contexts may relate to what is being stored and for what length of time. Additionally, exploitation of the environment occurred on various levels and the fact that storage is evident may be related to seasonality and not necessarily tied to a particular subsistence or organizational strategy. If groups were highly mobile and made seasonal rounds to resource locations, then these pits might represent recycled storage facilities during other seasons of the year (Plew 2003). A more recent ethnographic interpretation based on archaeological data suggests that groups of foragers were responding to a varied environment, using resources seasonally, and on an irregular and less predictable cycle (Dunn 1995).

## PREVIOUS RELATED RESEARCH

In 1995 Dunn conducted a study along the Snake River by Swans Falls to assess fungal contamination on stored seed, thereby examining the limits that these contaminates might place on storage time. Dunn reconstructed storage pits by excavating two pear-shaped designs that were lined with flat basalt rocks. Twelve liters of *Atriplex* seeds were harvested in November. Half the seeds were parched and the other half were left raw. The raw and parched seeds were washed and sterilized and random samples of each treatment were taken to the lab for analysis. Six liters of raw seeds were loosely placed in one pit and six liters of parched seeds in the other and the pits were covered with more basalt flat rocks. The pits were left unattended until March when additional samples were taken to the lab for analysis and fungal identification. Final inspection from both the harvest samples and storage samples demonstrated that the raw seeds had the greatest amount of fungal contamination than the parched seeds. Although the parched seeds showed less contamination, Dunn (1995) noted that the amount "was still considerable and approached the infestation rate of raw, unstored seeds." He explained "that seed parching is an excellent fungicide in the short-term but its effectiveness is greatly reduced over time" (Dunn 1995). His experiment revealed that seed storage may be limited to short-term caching due to the high rate of fungal contamination.

Underground storage requires some knowledge of the conditions that allow for profitable returns. Hill (2000) notes that fungus is a major cause of seed deterioration during storage. Even in situations where insects and rodents are effectively controlled, storage fungi probably causes more seed spoilage than any other single agent. Hill (2000) suggests that controlling fungi includes storing seeds dry at less than 10% moisture content and storing seeds cool at less than 50 degrees. Each 1% reduction in seed moisture content, down to about 6% doubles the seed life in storage and each 10% reduction in temperature, down to 32 degrees doubles the seed life. While Dunn's study provided the identification of fungal contamination, it is only assumed that levels of increased moisture are a contributing factor to seed contamination. The purpose of this study is to measure moisture and temperature levels in subterranean pits and determine if these factors influence the development of fungi on seeds during storage.

## EXPERIMENTAL METHODS

To measure moisture and temperature levels, five storage pits were constructed on October 21, 2007 along the Snake River at Celebration Park five miles south of Melba, Idaho. Permission to use the site was obtained from the Canyon County Parks, Recreation and

Waterways. The site was utilized for the duration of five months from October to March 7, 2008.

The storage pits were a replication of Dunn's storage pits and were oval-shaped, 50 cm round and 30 cm deep. All pits were photographed, lined with basalt rock, and capped with a basalt rock and finished with a 10 cm sod/soil layer (Figure 3). Each pit was equipped with a Lascar EL-USB-2 Relative Humidity (RH), Temperature and Dew Point Data Logger that gathered relative humidity and temperature data from inside the pits throughout the experiment. An additional data logger was placed outside of the pits to measure above ground moisture and temperature data to determine the relationship between inside and outside pit environment. Storage Pits 1 and 2 each contained 3 liters of raw *Atriplex* seed, Pit 3 contained 3 liters of dry sunflower seed with hulls intact, and Pit 4 contained 3 liters of dry *Atriplex* seed. Pit 5 remained empty with only a Lascar data logger for moisture and temperature readings underground throughout the experiment (Table 1). *Atriplex* seeds replicate Dunn's experiment, while the sunflower seed was used based on ethnographic accounts (Simms 1985). The raw and dry *Atriplex* seeds were not pre-treated or dried in the field as in Dunn's study, but instead gathered by hand in the field and just prior to storage. The sunflower seeds were purchased dried with hulls intact, from a local farm store. This seed is primarily used as wild bird seed and is not pre-treated.

**Figure 3. Rock Lined Pits.**

| | Seed | Data Logger | Weeks in Storage | Average Temperature (Degree F) | Average rH (%) |
|---|---|---|---|---|---|
| Storage Pit 1 | Atriplex (Raw) | Yes | 20 | 40 | 99.0 |
| Storage Pit 2 | Atriplex (Raw) | Yes | 3 | 50 | 92.6 |
| Storage Pit 3 | Sunflower Seed | Yes | 20 | 38 | 79.0 |
| Storage Pit 4 | Atriplex (Dry) | Yes | 13 | 40 | 90.3 |
| Storage Pit 5 | Empty | Yes | 20 | 39 | 99.7 |

**Table 1. Storage Pit Comparison.**

## LABORATORY METHODS

Seed samples and a Lascar data logger were recovered from each pit in three phases—the first after 3 weeks of storage, the second after 13 weeks, and the remaining after 20 weeks of storage—this included the empty pit with only a data logger. All of the samples were taken to the laboratory and wet mounted on slides with lactophenol or cotton blue stain. After about 2 minutes the samples were examined under a standard research laboratory microscope and the slides were micro-photographed at 40x magnification.

## RESULTS AND ANALYSIS

Pit 2 was opened November 11, 2007 after the first three weeks of storage. The sod/soil layer was dry and the raw Atriplex seeds were moist, dark in color with clear visible signs of fungi growing on the seed. Figure 4 shows the cotton blue stain that was absorbed by fungi contaminates. The moisture and temperature readings from the Lascar data logger indicate that over three weeks of storage relative humidity increased from an initial reading of 88.8% to 95.4% approaching 100% and that temperatures decreased from about 52 degrees Fahrenheit to 48 degrees Fahrenheit (Tables 2 and 3). Pit 4 was opened on January 19, 2008 after 13 weeks of storage. The sod/soil layer was frozen solid perhaps acting as an additional seal on the pit.

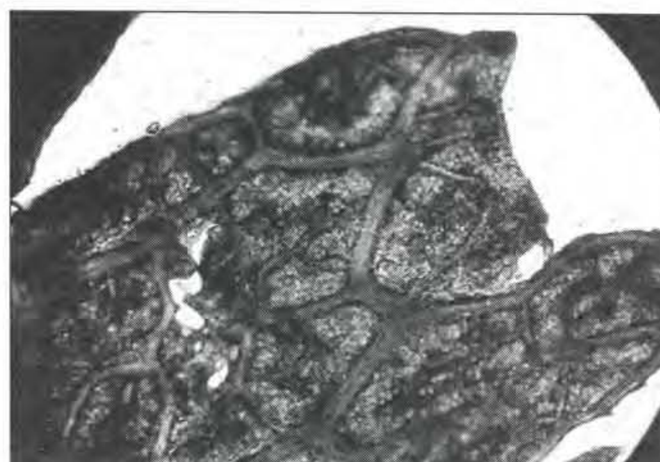
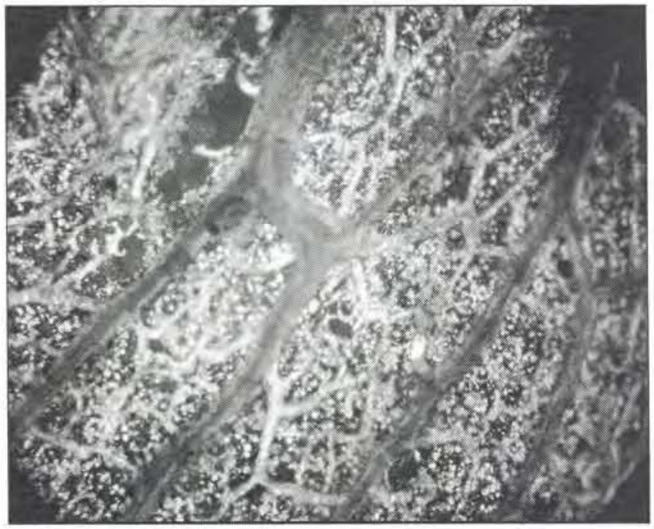


**Figure 4. *Atriplex* Sample from Pit 2 Showing Fungi Contamination (Magnification 40x).**

When the soil layer was lifted there appeared to be a small amount of fungi growing on the *Atriplex* seeds exposed in between the basalt capstone and the soil layer. However, when the basalt capstone was removed, the interior of the pit and the seeds were dry with little or no color change and there was no visible sign of contamination. Two seed samples were taken, one from the exposed area and one from the pit interior. Figure 5 shows that there was less cotton blue stain absorbed by fungi on both samples of the dry *Atriplex* seed in Pit 4 than the raw seed sample taken earlier from Pit 2. As in Dunn's (1995) findings, dry seed showed less contamination than the raw seed. The moisture and temperature readings from the data logger indicate an increase of relative humidity from 76.5% to 94.8% with temperatures declining steadily from 51 degrees Fahrenheit to 35 degrees Fahrenheit (Tables 2 and 3).



(Magnification at 40x)

Figure 5. Pit 4 Center Sample (Left) and Exposed Sample (Right).

| | | Environment | | | Pit 5 - Empty | | | Pit 1 - Atriplex Seed (Raw) | | | Pit 2 - Atriplex Seed (Raw) | | | Pit 3 - Sunflower Seeds | | | Pit 4 - Atriplex Seed (Dry) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max |
| Oct | Week 1 | 40 | 49 | 61 | 51 | 52 | 54 | 54 | 56 | 59 | 52 | 54 | 56 | 52 | 54 | 57 | 51 | 52 | 54 |
| Oct/Nov | Week 2 | 27 | 45 | 60 | 47 | 48 | 49 | 52 | 54 | 57 | 49 | 51 | 53 | 47 | 49 | 51 | 46 | 48 | 49 |
| Nov | Week 3 | 31 | 42 | 58 | 43 | 44 | 45 | 48 | 50 | 52 | 45 | 46 | 48 | 43 | 45 | 45 | 43 | 44 | 45 |
| Nov | Week 4 | 36 | 43 | 51 | 44 | 45 | 46 | 46 | 47 | 49 | | | | 44 | 45 | 46 | 44 | 45 | 47 |
| Nov | Week 5 | 29 | 36 | 44 | 43 | 43 | 45 | 44 | 45 | 46 | | | | 42 | 43 | 44 | 42 | 43 | 45 |
| Nov | Week 6 | 24 | 33 | 41 | 38 | 38 | 39 | 38 | 39 | 40 | | | | 36 | 37 | 38 | 37 | 38 | 38 |
| Dec | Week 7 | 35 | 41 | 47 | 40 | 41 | 41 | 41 | 42 | 44 | | | | 40 | 41 | 42 | 40 | 41 | 42 |
| Dec | Week 8 | 21 | 26 | 32 | 36 | 37 | 37 | 36 | 36 | 37 | | | | 35 | 36 | 36 | 36 | 37 | 37 |
| Dec | Week 9 | 30 | 35 | 40 | 36 | 36 | 37 | 37 | 37 | 38 | | | | 35 | 36 | 37 | 36 | 36 | 37 |
| Dec | Week 10 | 25 | 30 | 35 | 35 | 35 | 35 | 35 | 36 | 36 | | | | 34 | 35 | 35 | 35 | 35 | 36 |
| Dec/Jan | Week 11 | 28 | 34 | 41 | 34 | 34 | 34 | 34 | 35 | 35 | | | | 33 | 34 | 34 | 34 | 34 | 34 |
| Jan | Week 12 | 29 | 34 | 41 | 35 | 35 | 36 | 36 | 36 | 37 | | | | 35 | 35 | 36 | 35 | 35 | 36 |
| Jan | Week 13 | 23 | 29 | 36 | 35 | 36 | 36 | 35 | 35 | 36 | | | | 34 | 35 | 35 | 35 | 36 | 41 |
| Jan | Week 14 | 16 | 22 | 29 | 33 | 33 | 33 | 31 | 32 | 32 | | | | 30 | 31 | 32 | | | |
| Jan/Feb | Week 15 | 29 | 34 | 42 | 33 | 33 | 33 | 33 | 33 | 33 | | | | 32 | 32 | 32 | | | |
| Feb | Week 16 | 28 | 35 | 44 | 34 | 34 | 34 | 35 | 35 | 37 | | | | 34 | 34 | 35 | | | |
| Feb | Week 17 | 29 | 37 | 48 | 36 | 37 | 37 | 37 | 39 | 40 | | | | 36 | 37 | 39 | | | |
| Feb | Week 18 | 27 | 35 | 46 | 36 | 36 | 37 | 37 | 38 | 40 | | | | 36 | 37 | 39 | | | |
| Feb/Mar | Week 19 | 34 | 42 | 53 | 40 | 41 | 42 | 41 | 43 | 44 | | | | 41 | 42 | 44 | | | |
| Mar | Week 20 | 28 | 38 | 52 | 39 | 39 | 40 | 39 | 41 | 43 | | | | 39 | 41 | 44 | | | |

Table 2. Storage Pit Temperature Profile.

| | | Environment | | | Pit 5 - Empty | | | Pit 1 - Atriplex Seed (Raw) | | | Pit 2 - Atriplex Seed (Raw) | | | Pit 3 - Sunflower Seeds | | | Pit 4 - Atriplex Seed (Dry) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max |
| Oct | Week 1 | 42.1 | 60.9 | 77.4 | 95 | 96.2 | 96.7 | 90.5 | 91.3 | 92.2 | 88.8 | 89.6 | 90.4 | 54.6 | 55.2 | 56.1 | 76.5 | 77.7 | 78.8 |
| Oct/Nov | Week 2 | 41.9 | 64.6 | 80.9 | 99 | 99.2 | 99.4 | 95.1 | 95.5 | 96.2 | 93.1 | 93.4 | 93.7 | 64.5 | 65.0 | 65.6 | 84.5 | 84.8 | 85.2 |
| Nov | Week 3 | 50.9 | 71.9 | 86.1 | 100 | 100 | 100 | 96.6 | 97.1 | 97.8 | 94.7 | 94.9 | 95.4 | 69.7 | 70.1 | 70.4 | 86.9 | 87.2 | 87.6 |
| Nov | Week 4 | 60.7 | 77.4 | 90.6 | 100 | 100 | 100 | 97.7 | 98.0 | 98.3 | | | | 73.1 | 73.3 | 73.5 | 88.6 | 88.9 | 89.1 |
| Nov | Week 5 | 66.7 | 81.7 | 90.4 | 100 | 100 | 100 | 98.4 | 98.6 | 99.0 | | | | 75.4 | 75.6 | 75.9 | 89.9 | 90.2 | 90.4 |
| Nov | Week 6 | 59.5 | 74.6 | 86.9 | 100 | 100 | 100 | 99.1 | 99.1 | 99.4 | | | | 76.9 | 77.0 | 77.1 | 90.7 | 90.8 | 91.0 |
| Dec | Week 7 | 67.2 | 75.8 | 83.9 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 78.1 | 78.3 | 78.5 | 91.6 | 91.7 | 91.9 |
| Dec | Week 8 | 73.2 | 81.9 | 88.8 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 79.4 | 79.5 | 79.6 | 92.5 | 92.6 | 92.6 |
| Dec | Week 9 | 67.4 | 77.9 | 86.9 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 80.3 | 80.5 | 80.6 | 93.1 | 93.2 | 93.3 |
| Dec | Week 10 | 70.6 | 81.0 | 88.2 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 81.1 | 81.2 | 81.3 | 93.6 | 93.6 | 93.6 |
| Dec/Jan | Week 11 | 48.9 | 60.3 | 75.8 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 81.9 | 82.0 | 82.1 | 94.0 | 94.0 | 94.0 |
| Jan | Week 12 | 60.2 | 74.6 | 86.9 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 82.5 | 82.6 | 82.6 | 94.2 | 94.3 | 94.6 |
| Jan | Week 13 | 63.6 | 76.3 | 84.6 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 83.1 | 83.3 | 83.4 | 94.6 | 94.7 | 94.8 |
| Jan | Week 14 | 64.8 | 76.6 | 85.1 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 83.9 | 83.9 | 84.0 | | | |
| Jan/Feb | Week 15 | 56.0 | 70.0 | 85.0 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 84.2 | 84.2 | 84.3 | | | |
| Feb | Week 16 | 57.2 | 73.5 | 84.7 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 84.5 | 84.6 | 84.7 | | | |
| Feb | Week 17 | 52.0 | 71.3 | 85.4 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 84.9 | 85.2 | 85.4 | | | |
| Feb | Week 18 | 56.1 | 75.1 | 86.8 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 85.4 | 85.7 | 86.0 | | | |
| Feb/Mar | Week 19 | 57.8 | 79.5 | 90.0 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 86.1 | 86.3 | 86.5 | | | |
| Mar | Week 20 | 38.6 | 60.6 | 78.3 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 86.8 | 87.0 | 87.3 | | | |

**Table 3. Storage Pit Relative Humidity Profile.**

Pits 1, 3, and 5 were opened March 7, 2008 after 20 weeks of storage. The soil/sod layer for Pit 1 was wet but not saturated. When the basalt capstone was removed, the pit showed extensive fungal contamination throughout. The raw *Atriplex* seeds in the pit were noticeably deteriorated and as equally contaminated as Pit 2. Figure 6 shows similar cotton blue stain absorption as in Pit 2. The moisture and temperature data show that relative humidity increased from 90.5% to 100% within the first eight weeks of storage and remained at 100% throughout the remaining 12 weeks of storage. The temperatures declined from 54 degrees Fahrenheit upon storage to a low of 33 degrees Fahrenheit at week 14 and then increased to 43 degrees Fahrenheit at week 20 (Tables 2 and 3).

Pit 3 exhibited a wet but not saturated soil/sod layer as in Pit 1. When the soil layer was removed, fungi appeared on sunflower seeds along the exposed areas around the top basalt capstone, and some of the seeds were beginning to sprout. After the capstone was lifted there was a thin white fungi webbing that covered the top 2 cm layer of seed (Figure 7). Following the removal of this fungi layer the pit interior and seeds were thoroughly dry. There was no visible evidence of fungi growth on the seed and the hulls showed no sign of moisture or deterioration.

The seed samples that were recovered from the top 2 cm were visibly contaminated with fungi on the outer hulls of the seed. The inside kernels from this sample were wet mounted with cotton blue stain and Figure 8

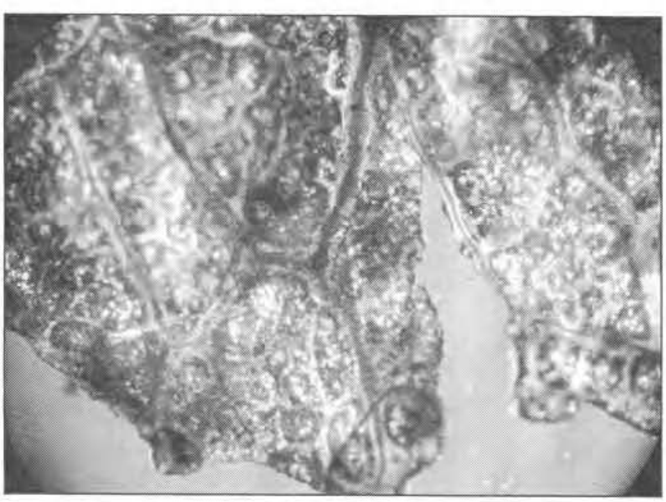


**Figure 6. Pit 1 Raw *Atriplex* (Magnification 40x).**

**Figure 7. Pit 3 White Fungi.**

shows that fungus had started to penetrate the hulls. The seed samples recovered from the dry interior of the pit revealed no visible fungi contamination and the seed kernels revealed minimal, if any, trace of fungal contaminates (Figure 9). The moisture and temperature data show that relative humidity increased from 54.6% to 87.3% during 20 weeks of storage. The temperatures decreased from 52 degrees Fahrenheit to 30 degrees Fahrenheit by week 14 and began to increase to 44 degrees Fahrenheit by week 20 (Tables 2 and 3).

**Figure 8. Pit 3 Fungi Contaminates on Exposed Sample (Magnification 40x).**

The soil in Pit 5 was wet but not saturated as in Pit 1 and 3. The temperature in the empty pit averaged 52 degrees Fahrenheit during the first week of storage and fell to an average of 33 degrees Fahrenheit after 14 weeks. Temperatures had increased to 40 degrees Fahrenheit by the end of week 20. The relative humidity increased from 95% during the first week of storage and increased to 100% at week 3 and maintained this level throughout the remaining 17 weeks of storage. The data logger measuring the outside temperature fluctuated throughout the 20 weeks of storage ranging from 16 to 60 degrees Fahrenheit. The relative humidity fluctuated as well and ranged from 41.9% to 90.6% throughout the 20 weeks of storage (Tables 2 and 3).

Final analysis reveals that raw *Atriplex* seed samples from Pits 1 and 2 exhibited greater fungal contamination than the dry *Atriplex* and dry sunflower seeds from Pits 3 and 4. Pits 1 and 2 seed samples had deteriorated and were dark in color after 3 weeks and 20 weeks in storage. They both exhibited clear visible signs that the seeds were contaminated with fungi. The cotton blue stain was absorbed by fungal contaminates and appeared dark blue in color. Relative humidity data from both Pits 1 and 2 as compared to the data from Pit 5 demonstrated that a high increase in moisture occurred almost immediately upon storage to nearly 100% (Tables 4 and 5). Dry *Atriplex* seed samples from Pit 4 and dry sunflower seed from Pit 3 showed somewhat different results after 13 weeks and 20 weeks in storage. Both pits exhibited fungi contaminates on seeds exposed in areas between the soil/sod layer and basalt rock capstone but the interiors of both pits were dry. The exposed dry seeds showed similar dark blue color stain as the raw seed samples, suggesting the exposed areas were susceptible to greater moisture levels than the interior of the pit. This greater level of moisture may have been the contributing factor of increased fungal contamination of

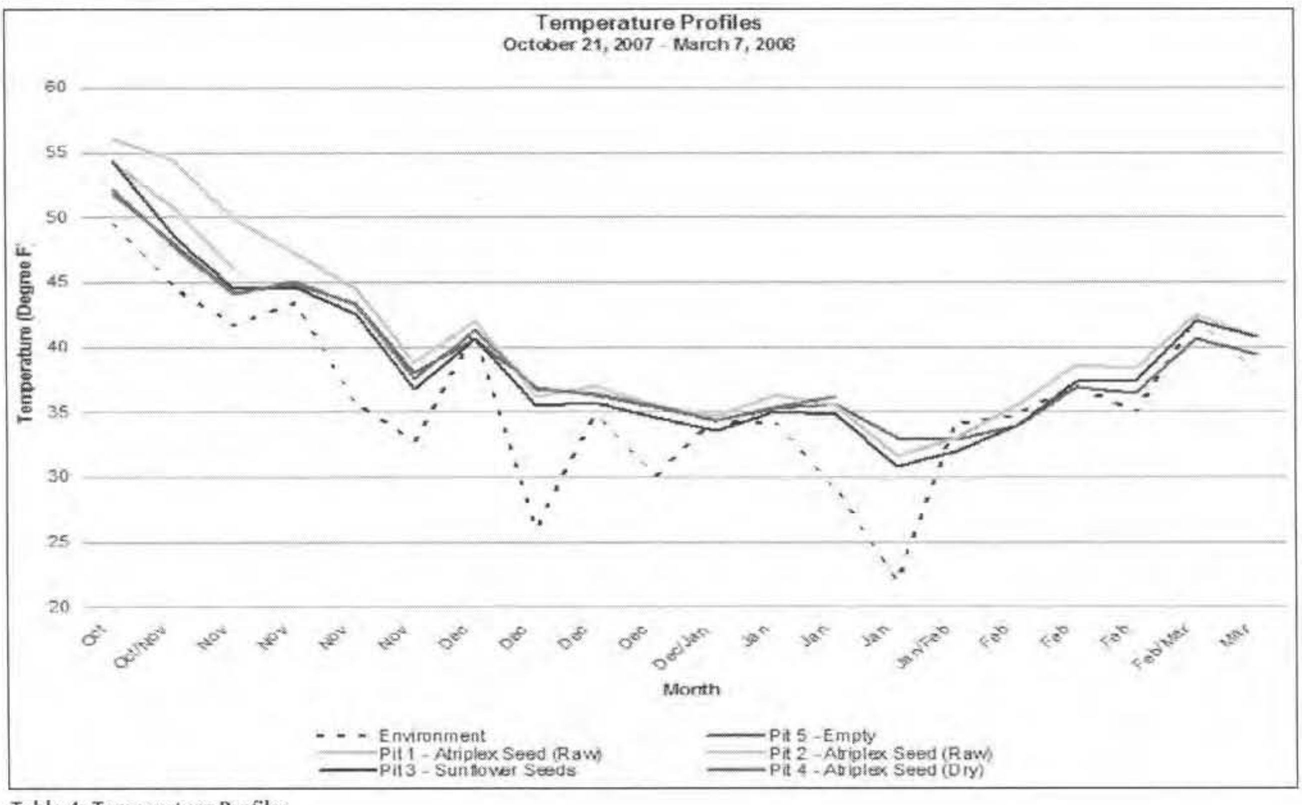



**Table 4. Temperature Profiles.**

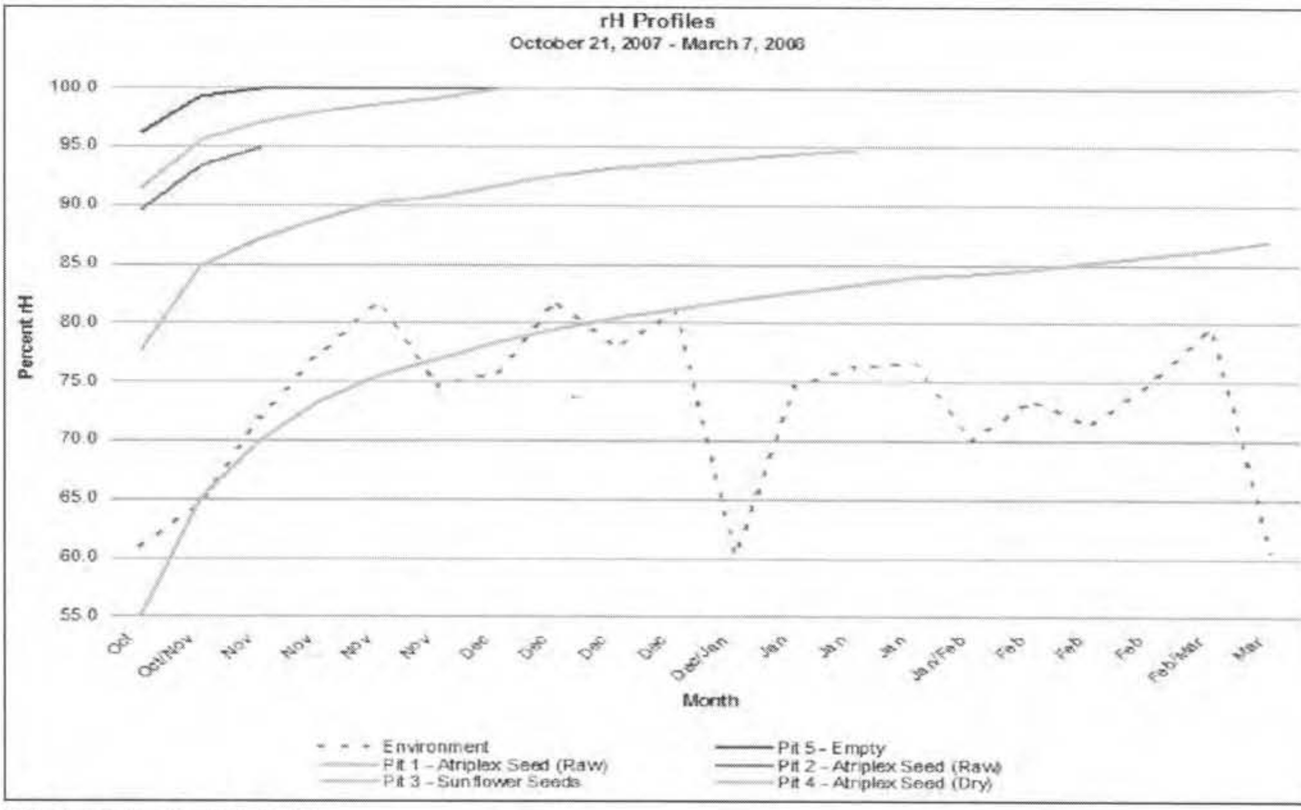



**Table 5. Relative Humidity Profiles.**

exposed seed. The interior samples from both pits showed less absorption of cotton blue stain than the raw samples, indicating that less moisture could have contributed to less fungi contamination. Of the two samples of sunflower seeds from Pit 3, the exposed seed from the top 2 cm layer were clearly contaminated and contaminates had penetrated the hulls (Figure 8). The sample taken from the interior of the pit was visibly free of fungi. Some of the hulls were removed from the interior seed to determine if fungi had penetrated to the seed kernels. Figure 9 shows little, if any, contaminates. The relative humidity for Pit 4 was lower than Pits 1, 2, and 5 ranging from 76.5 % and slowly approaching 100% at 94.8% by week 13. The relative humidity levels increased slowly for Pit 3 throughout the experiment and were much lower. They ranged from 54.6% to 87.3%, never approaching 100% as in the other pits. The temperature readings from all the pits were proportionally the same as Pit 5, decreasing over time and then slightly rebounding after about 15 weeks of storage. Outside temperatures and relative humidity did not have a great impact on pit environment and fluctuated up and down throughout the experiment (Tables 4 and 5).

**Figure 9. Pit 3 Center Samples.**

## DISCUSSION

This study confirms Dunn's (1995) findings that storing seeds in underground pits resulted in almost immediate contamination. The experiment demonstrated that the raw seed were contaminated by the third week of storage and that the dry *Atriplex* and dry sunflower seed were visibly less contaminated than the raw seed. Additionally, the hull on the sunflower seed may have provided an additional buffer against moisture absorption, perhaps allowing for improved storage. Environmental factors such as temperature and relative humidity are important in determining whether fungi can grow. Pits 1, 2, and 5 demonstrated that humidity levels had increased rapidly to nearly 100% in the first three weeks but Pits 3 and 4 that contained dry seed increased slowly with the sunflower seeds never reaching 90% (Table 3). It has been shown that a large number of fungi found associated with grain were able to develop at a relative humidity of 90 to 100 percent (Bonner 1960). However, some species of *Penicillium* will grow at humidity levels as low as 75% and members of the *Aspergillus glaucus* group have even been found growing in relative humidity as low as 65% (Bonner 1960). Adjustment of moisture content of feed grains equivalent to 65% relative humidity is borderline for long-term storage while higher moisture contents of feed grains, equivalent to 70% relative humidity, may be allowed for short-term storage at low temperatures (Semeniuk 1954). Temperatures proportionally declined in all the pits throughout the duration of storage and ranged from 59 degrees Fahrenheit to 30 degrees Fahrenheit (Table 2). Low temperatures only reduce or control the activity of most fungi since they can survive very low temperatures but they will not survive high temperatures of 50 degrees or more (Semeniuk 1954). This may attest to the lesser amount of contamination in Pits 3 and 4 when fungi may have begun to grow rapidly in the first month and then tapered off during the hard freeze of winter.

As demonstrated here and in Dunn's (1995) experiment, effective storage is limited due to the nature of fungal contaminates. This continues to suggest that storage is limited to short-term caching of the type associated with highly mobile foragers. In this regard, Dunn (1995) explained that empirical data on storage losses may provide clues to predicting prehistoric economic strategies. As noted in the ethnographic record, sunflower seeds were used as a food resource, and as demonstrated in this experiment the sunflower seeds showed a lesser amount of contamination. By comparing the soft *Atriplex* seed coat and losses after the first three weeks in storage with the sunflower hard seed coat and greater success in storage we might assume that the sunflower seed may have endured longer storage. Yet Dunn (1995) suggests that drying seed is an effective fungicide only if seeds are harvested for near immediate consumption and not long-term storage. Further testing with hard coat seeds in various storage environments and possible additional processing after storage may generate new empirical data valuable in understanding prehistoric storage decisions.

As noted by Steward's ethnographic account, Great Basin groups responded to diverse environments by gathering for short seasonal periods at rich resource locations such as the Snake River. While wintering along the Snake River Canyon in scattered camps subsiding on fish, deer, and small game, Steward indicated a heavy dependency upon stored fish, roots, and dried meat (Steward 1938). In contrast to the ethnographic record there are few archaeological sites that confirm evidence of subterranean storage. Plew (2003) suggests that the small caches in the record might represent short-term storage facilities that were utilized during seasonal rounds. Nevertheless, the benefits of storage must outrank the cost of encounter, harvest, handling time, and loss during storage in order for it to be an effective subsistence strategy. In view of this, seed storage seems an unprofitable strategy given the fact that their search and handling time is varied throughout the environment, and their storability is unpredictable (Simms 1985). Since resources are not homogenized across the Snake River Plain, hunter-gatherers depended on their ability to shift from one strategy to another during hard times. A response to diminished and varied resources may have included expanding their diets to acquire foods not typically eaten as well as moving to areas not generally occupied. Organizational strategies for hunter-gatherers on the Snake River Plain are not locked into one approach and assume a mixed foraging semi-sedentary pattern. As this study demonstrates, moisture and temperatures in subterranean pits have a definite impact on storage, and continuing to use experimental methods such as these allows us to better understand the variables that may have conditioned aboriginal strategies.

**ACKNOWLEDGEMENTS**

I wish to thank those who supported this project from the beginning. Foremost, Dr. Michael Dunn of Cameron University whose previous research inspired the study and Dr. Mark Plew, BSU Anthropology Department, who encouraged and advised me throughout the experiment. I would also like to acknowledge Canyon County Parks and Tom Bicak for the use of the facility to conduct the experiment. I also want to thank Dr. Merlin White, BSU Biology Department, for his contribution of lactophenol stain and Dr. Margaret Streeter for her advice and providing the use of the laboratory microscope. I especially want to thank Dan Hawkins for his contribution in pit construction, data recovery, and support of this project and all my endeavors. I'd like to acknowledge that partial funding was provided to me by a BSU Anthropology Department Scholarship. A note of appreciation is also due Chris Willson for his advice and the maps he provided for the paper. Without everyone's encouragement, advice, and contributions this project would still be in the planning stage.

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# SHORT CONTRIBUTIONS

## *A HAFTED, METAL PROJECTILE POINT FROM THE PAYETTE RIVER, IDAHO*

*Christopher A. Willson*

This note describes a hafted metal projectile point from the John and Florence Shaertl collection recovered along the Payette River, in Idaho (Figure 1). The uniqueness of the item relates to the rarity of aboriginal tools constructed from historic metals found in the region. Such items likely represent the Protohistoric/Historic period in the region and are important in the understanding of the transition in tool mediums in Idaho during this period.

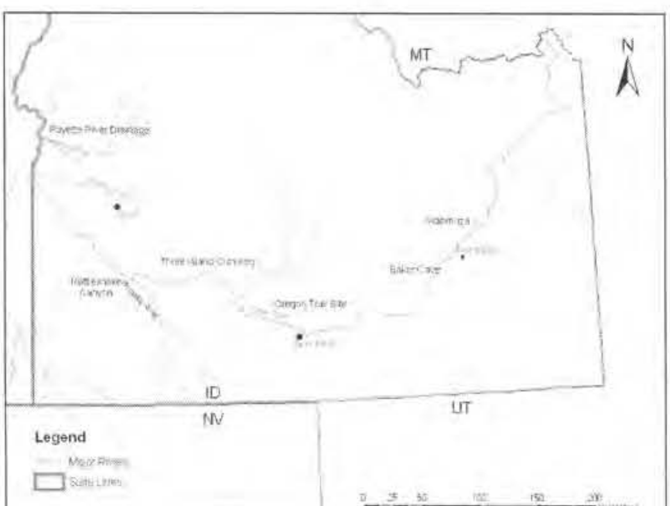


**Figure 1. General location of the Payette River and sites noted in the text.**

The specimen is triangular in form and has a stemmed base that is equal to its blade length. The blade is 3.52 cm in length, 2.22 cm wide and has a thickness of .3 cm. It is relatively flat, with bifacial modification of the edges. Under magnification, striations run perpendicular to the blade edge with the margins appearing smooth and uniform. The striations on the blade margins and the smooth edges support grinding as the primary technique for manufacture. Though Crabtree (1968) suggested that battering was also used as a method for shaping and refining the artifacts this item shows no signs of this technique.

The base is 3.5 cm in length by 1.11 cm wide and the resulting notches are asymmetrical. The base of the projectile point is inserted deep into a split shaft and evidence of adhesive, possibly pine pitch, is present under 10x magnification. This adhesive appears amber in color with a slight sheen and evidence of exfoliation. The shaft is pine and measures 15.53 cm in total length, 1.1 cm in diameter, and is broken laterally at the midsection, 7.6 cm from the proximal end.

The hafting is a single piece of cord that is 12-15 cm in length and .01 cm in diameter, machine wound, finely braided, and appears to be "string like" in appearance. The hafting is wrapped more than 60 times around the shaft 5.5 cm from the proximal end of the shaft. The distal end of the hafting is laid along the shaft and then wrapped over, and then doubled back 1.1 cm at the proximal end near the base of the blade. The cordage is then tied off and sealed with an adhesive.

Accelerated Mass Spectrometry (AMS) analysis was conducted by Virginia Gillerman, a geoscientist at Boise State University. Her analysis determined a high concentration of steel/iron with silicon but no alloys. Based on Customs Tariff, Schedule III, Section 15 for iron composites, it is likely that the material is in fact mid-to-late 19$^{th}$ century iron (1850-1900).

The inclusion of Euro-American metals in the indigenous toolkit appears more common in the east, on the plains, and in the southwest, particularly in parts of Texas (Brown et al. 1989; Chandler 1993; Flaigg 1995). The use of metals occurs more frequently by the middle of the 19$^{th}$ Century (Tuohy 1992:19). Items are occasionally recovered in the archaeological context in Idaho supporting at least some use of recycled Euro-American materials during the Protohistoric period (see Arkush 1990; Brooks 1977; Collins 1860). Arkush (1990) describes this period as dating between A.D. 1700-1850, a period punctuated by the increased presence of glass trade beads, metals, and other Euro-American items in archaeological sites in the region.


**Figure 2. Photograph of hafted metal projectile point and shaft.**

Ethnographically, there is sparse documentation of indigenous use of metal for creating tools and as with many ethnographic works there is no discussion of how these materials were acculturated. Collins (1860:470) describes the Paiute word for "iron" also meaning "knife" which suggests knowledge of metals and its potential usefulness to aboriginal peoples during this time period.

The most comprehensive discussion regarding the aboriginal use of metal tools in Idaho's archaeological record is Crabtree's (1968) discussion of acculturation along the Oregon Trail. The metal objects discussed in his paper include four completed metal projectile points, a broken metal knife, and artifacts discarded at various stages of manufacture (1968:38). Crabtree suggests that the metal objects were modified by stone tools. This conclusion is based on the presence of anvil stones, possessing battering scars as well as a variety of broken hammerstones. He concludes that due to the irregular scarring on the metal objects, these tools were fashioned by stone and not by cold chisel (Crabtree 1968:38). This technique of manufacture supports a transitional period of tool mediums and technologies.

Beyond these described by Crabtree (1968), metal items have been reported in archaeological sites in Idaho and the surrounding region. These include a cremation burial at Rattlesnake Canyon near Mountain Home, Idaho, which contained copper sheet fragments (Bonnichsen 1961) and copper artifacts in the Hells Canyon area of Idaho (Caldwell et al. 1967). Analysis conducted at the time suggested that the copper from the Rattlesnake Canyon site was of European origin and was used to date the site within a Protohistoric time frame. However, Yohe (1998) argues for a much earlier occupation.

At Three Island Crossing (10-EL-294) near Glenn's Ferry, Idaho, a single brass bi-point was recovered (Plew and Meyer 1987). This item is a diamond-shaped brass point measuring 6.2 cm x 2.4 cm, with beveled margins. Striations perpendicular to the blade edge suggest a similar manufacturing technique similar to that described by Crabtree (1968).

In the same general area, two metal projectile points are reported to have been recovered in Swiss Valley, near King Hill, Idaho (Plew 1987). Specimen (a) is a triangular blade, measuring 2.8 cm x 1.6 cm with the stem equal to the length of the blade. Specimen (b) is a larger, diamond-shaped bipoint measuring 6.8 cm x 4.3 cm. In this case, neither item exhibits evidence of manufacturing related wear patterns.

In eastern Idaho, excavations at the Wahmuza site provided evidence of Protohistoric/Historic period activity supported by the recovery of spear points, musket balls, and other items made from European metals. It is, however, unclear whether the metal items are associated with the historic component superimposed onto a prehistoric occupation (Holmer and Ringe 1994). In Caribou County, Croney (2008) reports an isolated find of a metal projectile shaped similarly to those described in Crabtree (1968).

Nearby, in Wyoming's Teton Range, Willingham (1991) describes a brass knife measuring over 23 cm in length and 4.9 cm wide. This fairly large piece appears cold hammered, and folded at the proximal end on both sides, possibly to make the blade suitable for hafting.

In Nevada, a variety of metal objects and a few hafted knives made from historic metals were recovered in the Black Rock Desert (Tuohy 1992). It is proposed that these knives were created from objects recovered from late 19th century and early 20th century wagons, primarily the "tires" that wrapped the wooden wheels. To date, sites located in the Great Basin have produced the most metal objects reused and adapted by indigenous peoples.

What makes the item described in this paper unique is that it is hafted. In general, hafted objects are very rare. Although the archaeological and ethnographic evidence supports this practice, due in part to preservation of the record, recovering items still hafted is unusual. At the Manning site (Gruhn 1961) located in Idaho, a single leaf-shaped artifact made from buff-colored chalcedony hafted to a shaft of current wood (*Ribes antenum*) was recorded. The end of the shaft was split and then secured with some adhesive material, then wrapped with fine cord made from plant fiber. Excavations at Baker Cave (Plew et al. 1987) recovered a hafted stone knife, set into split juniper, with evidence of adhesives.

Since metal items fashioned into aboriginal tools are rarely recovered from the archaeological record, it is interesting when such an item is reported. The recovery of a metal tool that is hafted is particularly unique.

Although a few metal points have been reported in Idaho, this appears to be the only hafted metal tool recorded in the state. Analysis of the iron composition suggests an 1850-1900 time frame, analysis of the cordage used to haft the item demonstrates uniformity in the braiding technique which suggests that it was machine wound and appears to be a late 19th century or early 20th century product. This makes it difficult to assign an age to the artifact. Regardless, it is likely representative of the Protohistoric/Historic transition from stone to metal. Items like these are unique and provide insight regarding transitions in Late Archaic/Protohistoric technologies in Idaho archaeology.

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# *AN IRON TRADE POINT FROM CARIBOU COUNTY, IDAHO*

*Cohen E. Croney*

This note describes an iron point found in northern Caribou County, Idaho (Figure 1). Metal points of the type reported here are of note as they are relatively rare in area archaeological contexts. In October 2004, local rancher John Banks found the metal arrow point described here lying in the rocks on the spine of a high ridge (ca. 6800 ft. ASL) at the north end of the Chesterfield Range, north of Twenty-four Mile Reservoir. The site of discovery is on a section of private land upon which a 1920s homestead was constructed and is still used for summer cattle grazing.

The artifact may be described as a triangular bladed point with slightly inverted shoulders (Figure 2). The blade is 7.82 cm long, 2.23 cm wide and 0.21 cm thick with a neck width 0.65 cm. The artifact weighs 11.9 g and is thin, straight, and very sharp. Just enough of the tang remains to show that it was serrated. The point is perfectly symmetrical with slightly convex blade edges and a rounded tip. The blank was sharpened on both faces with a bevel about 0.65 cm wide. It is in sufficiently good condition that grinding striations are easily visible macroscopically, with only light surface rust. The shoulders slope back toward the stem, a style Hanson (1972, 1975) calls an inverted shoulder. He notes that points of this style are less common than square-shouldered types. Frison (1991:124, b) illustrates a virtually identical iron point except that his specimen has been sharpened to an acute tip. Hanson (1972:7, 5) shows a similar projectile (see also Mason 1893: Plate XLV). The metal appears to have been stamp-cut from a thin sheet of hand-forged iron (Thomas Moore, local metalworker, personal communication) indicating its probable commercial manufacture.

Its excellent condition makes it highly unusual as well. Frison (1991:123) notes that iron points were relatively common surface finds a few decades ago, but most have now rusted away. Soils in Caribou County are alkaline and are not kind to thin iron objects. This point survived owing to the relatively dry conditions and its location in the rocks out of the soil. Scott and Fox (1987:85, c-f) illustrate four projectiles from the Custer Battlefield which well-document the corrosive processes that iron points are subject to when buried in the soil.

Metal projectile points have a long history in the area. Lewis and Clark (1904-1905:19) noted their use among the Lemhi Shoshones at the time of their contact. The native populations had access to metals through intertribal trade, trappers' rendezvous and posts like Fort Hall throughout the nineteenth century. They also had access to scrap metal (iron, brass, and copper) as well as tools to work it (saws and chisels) after white contact (Hanson 1972:4). Indian-made cold-cut points, however, seem to


**Figure 1. Map showing general location of Caribou County.**


**Figure 2. Iron point.**

be most common in regional archaeological literature. Metal projectile points that appear to have been produced from scavenged metals have been reported along the Snake River in Idaho and the nearby Teton Range (Crabtree 1968; Plew 1989; Willingham 1991; Tuohy 1992).

If the present artifact was produced using post-contact tools then the projectile described here may be somewhat more unique. This note adds to the expanding literature on metal points in Idaho.


## ACKNOWLEDGMENTS

The author wishes to thank Mr. John Banks who kindly loaned the projectile described herein for both documentation and curation. Gratitude is also due Mr. Thomas Moore (now deceased) for his examination of the artifact and his knowledge of some of the processes used in its manufacture.


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# BOOK REVIEW

## *THE OSTEOLOGY OF INFANTS AND CHILDREN*

Brenda J. Baker, Tosha L. Dupras, and Matthew W. Tocheri; drawings by Sandra M. Wheeler.
College Station: Texas A&M University Press, 2005.
178 pp., paperback, US $34.95, illustrations, quick reference, bibliographical references, index.

*Reviewed by* Katharine Drahold-Cross

*The Osteology of Infants and Children* is a valuable addition to the limited literature on subadult osteology. It serves as a lab manual and field guide for analyzing subadult skeletons. Many osteology courses tend to focus on the adult skeleton and little attention is given to the skeleton of children. Compared to adult skeletons, subadults present a set of unique challenges. Challenges include recognizing and identifying the different skeletal elements, especially in fetuses and infants. Subadult remains are often poorly preserved and subject to diagenesis and postmortem degradation which requires more delicate and thorough excavation techniques. The illustrations and detailed descriptions of skeletal elements at varying stages of development in this book would be useful to the investigator when identifying human subadult remains, especially since access to study collections is often limited and sometimes not possible.

This book discusses the skeletal and dental development of fetuses, infants, children, and adolescents. The major stages of development for each individual bone are described. Techniques for siding the bone and differentiating between other bones are also provided. There are detailed and labeled illustrations for each bone and its separate elements. Illustrations of the bones from the infracranial skeleton show the stages of ossification and the changes in the appearance of the epiphyses through the different stages of development. Age estimates are provided based on the stage of development and overall morphology of the bone, tooth, or skeletal element.

The book is divided into four parts with a total of ten chapters. Part one, chapters one and two, discuss the importance of studying subadults especially for interpreting the archaeological record. Anatomical terms, bone growth, preservation, excavation techniques, laboratory treatment, and curation of subadult remains are also discussed. The many photographs and illustrations in these chapters complement the text. Part two, chapters three through five, describe and illustrate the bones of the skull and teeth. Part three, chapters six through nine, focus on the infracranial skeleton, providing detailed descriptions and many illustrations. Part four, chapter ten, is a "quick reference," a useful and handy chapter that consists of visual inventories of subadult skeletons at various ages, including an inventory of the hands and feet and drawings of long bones depicting the different stages of development from the first trimester up through adolescence. Also included are tables indicating the timing of appearance and fusion of different ossification centers. This chapter is intended as a quick reference for identifying and estimating age of subadult remains.

Overall, *The Osteology of Infants and Children* provides the reader with highly detailed descriptions and illustrations of the subadult skeleton, in particular fetuses and infants. Much of the information in this book comes from the authors' experiences working with well preserved burials of subadult skeletons from ancient Egypt. This book is one of a few specializing in subadult osteology and is recommended for those who are working with subadult remains, whether it is in a laboratory or out in the field.