Keeping in Touch: Exchange as an Adaptive Strategy in Southern Nevada

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KEEPING IN TOUCH: EXCHANGE AS AN ADAPTIVE STRATEGY IN SOUTHERN NEVADA

By

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Bachelor of Arts in Art History and Archaeology
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**Keeping in Touch: Exchange as an Adaptive Strategy in Southern Nevada**

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ABSTRACT

Archaeologists have always wondered about the extent of vessel movement in the American Southwest. Identifying vessel movement allows for the study of social interactions across a region and the role of ceramics in the adaptive processes of agriculturalists living in marginal, highly variable environments. In many instances, exchange may act as a way to reduce the risk of resource shortfalls by creating social ties in other areas. This research investigated the changing risk reduction strategies of households in the lowland Virgin region of southern Nevada by using geochemical methods to trace the exchange of locally produced pottery. It was hypothesized that households in southern Nevada traded with households in the St. George Basin in an effort to stymie the loss of diverse trade networks. Results showed that households were not trading with households in the St. George Basin suggesting that prehistoric peoples are not always economically rational.
I received an overwhelming amount of assistance for the project from numerous people. I deeply appreciate all of their effort, support, and interest in this research. I would like to thank my advisor, Dr. Karen Harry, for her constant support, input, and advice on all stages of my research - however nonsensical it may be. The staff at the University of Missouri Research Reactor, specifically Dr. Michael Glascock, Dr. Jeffrey Ferguson, and Dr. Wesley Stoner, have been an integral part of my education. They have provided outstanding opportunities for research and financial assistance. I owe a great deal to their unwavering support and patience. Lastly, I would like to thank John Olsen and Sally Billings for going out of their way to help me gather clays in the St. George Basin and southern Nevada. A significant part of my conclusions are based around the clays that were sampled.
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Chapter 1: Introduction and Background

Archaeologists in the American Southwest have long wondered if ceramics used at different settlements were locally produced or manufactured using a variety of clays from a multitude of regions. Identifying vessel movement allows archaeologists to study the social interaction of peoples at different settlements and the role of ceramics in the adaptation processes of people living in an unpredictable and marginal environment. In many instances, exchange acts as a way to reduce the risk of resource shortfalls by creating social ties in other areas. Some scholars have argued for this scenario for the Chacoan system after extensive resource depletion and arroyo cutting forced local inhabitants to diversify their social and exchange networks to different ecological niches (Toll 1992). However, this ecological approach to understanding social and exchange networks has only been marginally present in research on the Virgin Branch Puebloans of southern Nevada and northern Arizona (Harry et al 2010, Harry 2005, Allison 2001, Larson 1987). Largely this research has been more prevalent in other Puebloan groups to the east (Duff 1998, Cordell 2007). This study will focus on bringing an ecological approach to understanding the Virgin Puebloan trade networks during the Pueblo II (A.D. 1050 – 1250) and Pueblo III period (A.D. 1150 – 1225).

Current research in the Virgin Branch Puebloan region indicates that during the middle Pueblo II period there were strong socio-economic mechanisms linking the lowlands in southern Nevada to the uplands in the Arizona Strip (Figure 1.1). Ties between these two areas are demonstrated by the presence of large numbers of ceramics produced in the uplands that have been recovered from lowland sites. Previous research on Virgin Branch pottery exchange has focused on the production zones and distribution
networks of ceramics manufactured in the uplands (Harry et al 2012, Allison 2000, Sakai 2008); to date, however, little work has been conducted specifically on lowland ceramic production and trade. This study proposes to focus on ceramics believed to have been produced in the lowland Virgin Branch region.

Figure 1.1: Location of the Moapa Valley within the Virgin Branch Puebloan Region

During the Pueblo II period, as many as half of the ceramics used at lowland sites in southern Nevada are believed to have been produced in upland areas (Harry 2005, Harry et al 2013, Allison 2000, Lyneis 1995). By the end of the early Pueblo III period
(A.D. 1250) the trade networks with the uplands had collapsed. Coincident with the collapse of these networks there was an increase in the production of sand tempered ceramics in the lowland Virgin area (Lyneis 1992:41-43). This may be evidence for an increased interdependence between lowland households after the collapse of ties with the upland areas.

In any society, we can expect a balance between resource unpredictability and mechanisms that reduce this variation. Once exchange with the uplands had disappeared, lowland Virgin Branch Puebloan subsistence could have become more unpredictable than before. As many different ecological studies have shown, one way to reduce risk is to diversify resource use to many different environmental zones. If one zone experiences low agricultural yields, another zone may be able to make up the difference. Without the connection with the uplands, the lowland inhabitants could have had an increased risk of subsistence stress because they would have lost access to a more diverse resource base. Yet for any given society, we may expect a number of different risk reducing strategies. Many different ethnographers have shown that sharing, exchange, and ritual redistribution were important coping mechanisms for agriculturalists living in the harsh marginal environment of the American Southwest (Connelly 1979, Ford 1983). Archaeologists (Hegmon 1990, Kohler and Van West 1996) have also argued for exchange and sharing based models for the prehistoric Hopi and Chaco. Thus, the lowland Virgin Branch Puebloan, who had a very similar subsistence economy to ethnographic tribes, may have also used exchange or sharing as a risk avoidance mechanism once the connections with the uplands collapsed.
This research seeks to investigate the changing risk reduction strategies used by local households in the lowland Virgin area. The research model will use Neutron Activation Analysis (NAA) to chemically characterize sand-tempered Tusayan Virgin Series ceramics from two sites within the Lost City Complex of southern Nevada. The first site, Main Ridge, dates to the middle Pueblo II period, the time when the trade networks with the upland region were at their height. The second site, House 47, dates to the early Pueblo III period and post-dates the collapse of those networks. If there is an increase in interdependence and household sharing in the lowlands during the Pueblo III period, then there should be a clear increase in the importation of lowland ceramics at House 47 over Main Ridge.

**Location and Environmental Context**

The lowland Virgin region examined here is situated in the Moapa Valley in southeast Nevada and the St. George Basin in southwest Utah. These areas are in the northern part of the Mojave Desert within the Colorado River drainage. Consequently, valley elevations tend to be lower and temperatures are higher than the Great Basin Desert to the northwest. The region is characterized by north to south trending mountains with peaks up to 10,000 feet above elevation and valleys that reach 246 feet below sea level (Fenneman 1931).

The environment of the Moapa Valley is characterized by hot short summers with temperatures reaching over 100 degrees F and short mild winters where temperatures can drop to freezing. Average precipitation is around 12cm a year with most falling in the winter (Houghton et al 1975). The growing season is relatively long, about 180 days. The
Muddy and Virgin Rivers drain the region and may have attracted migratory water fowl, reptiles, rabbits, and other small animals (Sakai 2009:142). Vegetation includes creosote brush, bursage, and many varieties of mesquite and other riparian plants (Lyneis 1995:204).

The environment of the St. George Basin supports Mohave Desert scrub including creosotebrush in the valleys and ponderosa pine forests, Great Basin Conifer Woodlands, Great Basin Desertscrub, and Interior Chaparral in the surrounding uplands. Average precipitation is close to 21 cm per year and mostly falls during the winter months. The growing season is abnormally long, over 200 days. The Virgin River and Leeds Creek-Quail Creek drainage meet within the Basin and along with numerous surrounding springs, create a rich environment for numerous animals including rabbits, reptiles, and mule deer (Lyneis 1995:203-204).

Cultural Context

The Virgin Branch Puebloan occupation of Southwest Utah, Southern Nevada, and Northwest Arizona ranges from the Basketmaker II period to the Pueblo III period. Unfortunately the Virgin Region has very little data for good chronometric dates so that archaeologists currently utilize a version of the Pecos Classification from the Kayenta Anasazi region to the east (Lyneis 1995:210). Each period’s distinct characteristics will be briefly summarized below.

The Basketmaker II (300 B.C.-A.D. 400) and Basketmaker III (A.D. 400-800) occupation of the region is characterized by living space in the form of a pit structure. During the Basketmaker III period, storage structures were built near the pit structures.
Habitation sites are small and normally supported up to three families (Lyneis 1995:210-211). Cotton is believed to have been introduced as an agricultural product during this period as well as the introduction of ceramics and the transition to bow and arrow technology (Allen 1999:4). The economy during the Basketmaker II period was a mixture of horticulture and hunting and gathering with later aggregation and more reliance on agriculture during the Basketmaker III period (Winslow and Blair 2003).

The Pueblo I period’s (A.D. 800-1000) pit structures are similar to the Basketmaker periods; however, some now have benches and ventilators. Habitation sites tend to be more planned since the pit structure and storage areas now shape outdoor space into an arc or oval with the pit structure being off to one side. There tends to be an increase in storage structures though habitation structures and population densities continue to be small (Lyneis 1995:211). Larson and Michaelsen (1990) believe there was an increase in agricultural intensification during this period in the Virgin lowlands. The ceramic assemblage continues to be dominated by plain gray pottery; however, small quantities of black on gray ceramics do appear (Winslow and Blair 2003:20).

The Pueblo II period (A.D. 1000-1150) is characterized by the pit structure being incorporated into the arc so that a more formal courtyard is formed. Eventually habitation sites, which continue to support a few families, are built on the prehistoric surface rather than compromising semi-subterranean rooms (Lyneis 1995:212). Shutler (1961:14) argues that habitation rooms now utilize doorways instead of roof entrances. During this period there may have also been a greater reliance on agriculture because of a noticeable increase in ceramics and ground stone (Winslow and Blair 2003:20; see Myhrer 1989).
Furthermore, there is an increase in non-local ceramics indicating an expansion of trade networks into other ecological zones (Harry et al 2013:19).

By the Early Pueblo III Period (A.D. 1150-1225), the outdoor courtyard is practically enclosed by a ring of habitation and storage structures. There also seems to be a slight increase in aggregation as indicated by the greater living space and increased number of storage rooms at habitation sites. Data also suggests a reduction in the occupation of the Muddy and Virgin River Valleys in Southern Nevada. Ceramic assemblages tend to be dominated by corrugated over plain ware pottery. New ceramics such as Virgin Black on White and Citadel Polychrome make their appearance in this period. However, by the end of the early Pueblo III period, the trade networks with the uplands seemingly collapse (Harry et al 2013). By about A.D. 1250, the Virgin Anasazi region was fully abandoned (Winslow and Blair 2003:21).

**Background Research at Lost City**

In the mid-1920s, Mark Harrington began excavating Puebloan sites in the Moapa Valley in southern Nevada. He named this area Grande Pueblo de Nevada but local newspapers soon re-named it “Lost City,” a name which became more popular. Later, work by the Civilian Conservation Corps conducted under the direction of Fay Perkins and Willis Evans brought the total number of “houses” excavated up to 121. [Harrington and later excavators used the term “house” to refer to any site that consists of a single room or an arc of habitation and storage rooms that are spatially separated from other sites (Lyneis 1992:5)].
These early excavations, which included work at the Main Ridge Community and House 47, were the first large-scale investigations to be conducted in southern Nevada and eventually led to the framework which defines the different phases of Virgin Branch Puebloan occupation of southern Nevada (Harry and Watson 2010:404; see Shutler 1961; Schroeder 1955). The beginning of World War II and the rising levels of Lake Mead effectively ended these early Puebloan excavations in southern Nevada, and it wasn’t until the 1970s, 1980s, and 2000s that small scale investigations once again occurred in the region under the auspices of the University of Nevada Las Vegas (Lyneis 1992:2-5; Harry et al 2013).

These early excavations had a profound impact on the data available to today’s researchers in the Virgin Branch Puebloan region. In many cases, current scholars do not have the capability to investigate the possibility of trade at the household level or other phenomenon that are commonly studied in other regions of the Southwest. This is primarily due to the excavation methods of the 1920s and 1930s where archaeologists would rarely collect anything besides for whole pots, projectile points, or turquoise. Furthermore, the provenience information associated with most of these artifacts has been lost over the years so that even these artifacts may only be linked to a site rather than specific households or areas. However, Harrington did push the excavators to take more detail-oriented notes than was common among other archaeologists of his time allowing modern scholars to get at some data that otherwise may not have existed. Unfortunately though, most of the notes and artifacts from Harrington’s and the CCC’s excavations were split up between different institutions thus making it difficult to benefit from their research.
Three wares comprise the majority of the ceramic collections from the Lost City sites. These are the sand-tempered Tusayan Virgin Series ceramics, believed to have been produced somewhere in the lowland region; and the Shivwits Ware and Moapa Gray Ware ceramics, both of which are believed to have been produced on the western end of the Colorado Plateau. These ceramics, and the implications of their changing frequencies over time, are discussed below.

Early archaeological research based on ceramics has shown that there are early and strong economic ties between southern Nevada and the Arizona Strip. These ties are present as early as the Pueblo I period, but reach their peak during the middle Pueblo II period (ca. A.D. 1000-1100) (Allison 2000, Lyneis 1992). More recent compositional work supports this notion of an increase in non-local ceramics and an expansion of trade networks into other ecological zones. Early petrographic work by Margaret Lyneis has shown that Moapa Gray Ware is tempered with two different types of xenoliths that are both present near Mount Trumbull and in the Toroweap Valley on the Uinkaret Plateau. It is likely that Moapa Gray Ware was produced near these two locations (Lyneis 1988:2-4; see Figure 1). A pilot study utilizing Neutron Activation Analysis (NAA) has shown that Shivwits Ware pottery belongs to one compositional group and is chemically distinct from other ceramics found in the region (Harry et al 2013; see Figure 1). Based on these results, the authors concluded that Shivwits ware pottery was produced with a single basic paste recipe in the same area. The authors argue that Shivwits Ware pottery was produced on the southern part of the Shivwits Plateau in the Arizona Strip based on the criterion of abundance and the presence of dark firing iron rich clays which Shivwits
Ware is likely produced from. Red wares also seem to be imported from the Kayenta region far to the east (Shutler 1961, Lyneis 1992).

The distribution of Moapa Gray and Shivwits Ware pottery shows that to the north and east of the production locations, there is a clear and substantial drop in the frequency of both of these wares; whereas both are found in abundance in the Moapa Valley to the west. Current understanding of these distribution patterns do not support a simple gravity-model distribution where the interaction between two locations decreases with increased distance, time, and cost. Harry (2005), Allison (2000), and Lyneis (2005) have argued that the formation of this directional trade network likely was due in part to a lack of fuel wood for firing pottery in the Virgin lowlands. Allison (2001) has further argued that these trade networks were based on interactions between families across the landscape.

*Background on Tusayan Virgin Series Ceramics*

Tusayan Virgin Series ceramics are a sand tempered, gray or white firing pottery that occurs in both plain and decorated forms (Colton 1952). Distribution studies indicate that during the middle Pueblo II period Tusayan Virgin series ceramics make up around 60% of site assemblages in the Moapa Valley, with Moapa Gray Ware, Shivwits Ware, and occasional red wares comprising the rest. In late Pueblo II and early Pueblo III site assemblages, Moapa Gray Ware and Shivwits Ware ceramics all but disappear, and Tusayan Virgin series ceramics increase in frequency to comprise more than 95 percent of the assemblage (Lyneis 1992:41-43).
Current archaeological research suggests that at least some of these ceramics were locally produced in the Moapa Valley (Lyneis 2005). Margaret Lyneis has shown that there are at least two different subtypes present, as reflected by the aplastic inclusions. One subtype consists of sherds tempered predominately with well-rounded, clear to white quartz sands, while the other subtype consists of mixed sands. Thin-section analysis suggests that the quartz sands come from Pleistocene gravels underneath the Yamashita sites in the Moapa Valley and that the mixed sands derive either from the Virgin Mountains or the St. George Basin (Lyneis 1992, 2005).

In addition to the variation in the sand temper, refiring experiments conducted by Jim Allison (2000) demonstrate that there are at least eight different color groups and thus at least eight different clays associated with Tusayan Virgin Series ceramics. All of these studies hint that there is sufficient geologic variability within the lowland Virgin region to compositionally differentiate the archaeological ceramics and thus the changing interdependence among lowland households.

**Site Descriptions**

Tusayan Virgin Series ceramics were obtained for this project from two Puebloan sites: Main Ridge and House 47. Both these sites are located in the Moapa Valley of southern Nevada. They were selected for study here because the derived chemical database will shed light on the changes in ceramic production and exchange during the middle Pueblo II and early Pueblo III periods.
Main Ridge

The Main Ridge Community dates to approximately the Pueblo II period and includes Houses 1-42, 44, and 45 of Lost City. The houses are situated on Main Ridge, a northeast to southwest ridge emanating from the Mormon Mesa (Figure 1.2). The ridge allows easy access to the Muddy River floodplain below. The floodplain would have presumably been used for farming or gardening. The Main Ridge Community does not have a site layout in the strictest sense; houses are situated on every available flat part of the ridge. The houses consist largely of multi-room with a few single independent room adobe and rock structures of varying shapes and sizes. The multi-room structures may loosely enclose a circular outside work space. Assuming that smaller structures were used as storage facilities, the multi-room houses can be divided into 32 habitation rooms and 87 storage rooms, thus suggesting a population of about 100 people most likely organized into small familial units (Lyneis 1992).
House 47

House 47 is a collection of 62 habitation and storage rooms set into two broad arcs enclosing two outside courtyards (Figure 1.3). Shutler (1961:15) places House 47 during the Mesa House Phase which is equivalent to the early Pueblo III period in the Pecos Classification. More recent research has shown that most of the ceramics recovered from House 47 were Tusayan Virgin Series ceramics suggesting that either there was increase trade with other lowland groups or that households at House 47 produced its
own ceramics. Similar to Main Ridge, the population was most likely organized into small familial units.

Figure 1.3: Plan map of House 47. Adapted from Shutler 1961
Chapter 2: Subsistence Uncertainty and Human Behavior

What are Risk and Uncertainty?

The world around us is always changing. A unique attribute of humanity is our ability and flexibility to adapt to our ever-changing social and physical environments. Yet the changing nature of these environments can still cause radical disruptions to humanity’s way of life. Shortages of food and other resources continue to plague subsistence farmers of Africa or Asia today. The way people cope with subsistence or other resource uncertainty can have far-reaching cultural ramifications in any society (Halstead and O’Shea 1989:1)

Unfortunately for prehistoric and modern populations, variations in resource availability or other disasters are not predictable. This element of uncertainty increases the risk of resources shortfalls at any given time. In this context, uncertainty or unpredictability refers to incomplete knowledge of outcomes due to random environmental or productive variation (Winterhalder 1999:303). In addition, risk refers to the probability of any household or individual not having enough food to meet its own needs due to this variation.

Central to the concept of risk and uncertainty is variation, or the deviation from the norm. Variation can be seen as environmentally-based, such as that caused by climatic changes; or socially-based, where human decisions play a part in resource availability. This research emphasizes social variability as a means to assess exchange as a coping mechanism for subsistence risk.
For agriculturalists, numerous discussions have focused on the environmental variation and circumstances that increase subsistence risk (see Hegmon 1991, Minnis 1992, Winterhalder 1990). The most significant to desert farmers is drought, with maize being particularly susceptible to fluctuations in moisture during pollination and when the plants are beginning to grow. Productivity may also be reduced by excessive temperatures, flooding, reductions in the water table, insects, birds, rodents, droughts, and plant disease; all of which likely impacted agricultural productivity in the prehistoric American Southwest (Larson et al 1996:223-224). As has been hinted at above, variation and the circumstances that increase risk among farmers have both a temporal and spatial factor. Temporally variation may increase risk more depending on how often it occurs and how long it lasts. Spatially, variation may affect a certain area or region differentially. For instance, plant disease may totally destroy one field, whereas, another field may be practically untouched (Halstead and O’Shea 1989:3).

In an effort to cope with this inherent environmental variation, humans have developed a wide range of buffering mechanisms meant to lessen the effect of environmental variability. These strategies, however, must also match the intensity and scale of the variability they are coping with or the buffering mechanism will fail. Although there are a wide range of different coping strategies, almost all can be placed into four distinct categories: diversification, mobility, exchange and social interaction, and storage (Finney 2000).
Coping Strategies

Diversification

The underlying idea of diversification is to broaden the subsistence base to incorporate a wider range of plant and animal species or in the case of more mobile people, geographic range. In other words, people do not place all their eggs into one basket. There are many different ways that this can be accomplished.

Typically farmers will diversify production by planting different crops. Recent research on agave cultivation suggests that it was used to offset food shortfalls when maize production was low in northern Mexico (Anderies et al 2008). In some instances, farmers have been known to cultivate different varieties of plants in the same areas. Under inhospitable conditions, it was possible that one crop could still be productive (Wilkes 1977). Alternatively, farmers could plant crops in a variety of different microenvironments to ensure that if one field was devastated, the others may be unaffected (see Ford 1972 for an example from the Hopi). Lastly, famine foods may have been consumed when productivity was low. However, diversification may not be sufficient to offset severe perturbations such as severe or prolonged drought (Minnis 1985:33).

Population Mobility

Mobility is probably the simplest form of buffering mechanism, but it is also one of the most effective. Populations may elect to just move away from the scarcity or unpredictability of a given resource. The porosity of territorial boundaries among hunter-gatherers permits populations to move great distances during years of drought (Halstead
and O’Shea 1989:3). However, with strengthening claims of land tenure that come with increasing populations, access to different lands may become difficult and need to be established through social connections, trade, or brute force (Minnis 1985:60)

Storage

Maize and other crops can exhibit wide annual fluctuations in productivity. Poor harvest may be buffered by storage of food surpluses or the accumulation of other goods that may be traded for other resources when in need (Finney 2000:362). However, storage is not useful for prolonged shortages. Stored foodstuffs are vulnerable to rodents, pests, fungi, disease, rot, and raiding. Further, food tends to be bulky. Storing enough to last several years would take a massive amount of space (Minnis 1985:34). Archaeological evidence for storage is best exemplified by underground pits, granaries, or other above ground storage features. It is still problematic to study the use of prehistoric food storage because many of these features may also have been used to store other items besides a single resource.

Social Interaction and Exchange

Social interaction as a coping strategy for subsistence risk involves the expansion of economic and social networks to exploit a more reliable food supply when food provisioning at a sedentary community is more variable than can be dealt with (Minnis 1995:65). Although in many cases it is assumed that food may have been physically transported to the area in need, more robust research has argued for these networks as lines of communication to gather information about food surpluses, climatic sustainability, or potential migration routes to other areas (Cordell 2007, Braun and Plog
1982). Many researchers have argued that although social and economic interactions may be the most effective for coping with subsistence risk, they are also the most expensive. Families may choose to not honor reciprocal obligations to aid them in the time of need; however, they may also be risking the violation of social norms (Minnis 1996:65). As discussed below, this is quite common in the ethnographic American Southwest, where social institutions exist to encourage the participation of families and individuals in public ceremonies that deal with the redistribution of food.

An increase in social interaction can take many different forms with regards to buffering against subsistence uncertainty. An increase in ritual activity has been recorded to occur during resource shortages in many societies and usually takes the form of redistributing food to less successful households (Jodha 1978; Ford 1972; Firth 1959). Dependents can be married off so that family size is reduced and thus making it easier to support everyone with a less amount of food (Forbes 1989). One other type of social interaction that has until recently been ignored by Southwestern archaeologists is warfare and raiding. Raiding parties may bring back food from victim communities; however, raiding invites retaliation and its effectiveness is only based on how much the raiders can bring back (Minnis 1996:65). Additionally, low scale warfare is difficult to see in the archaeological record; however, arguments have been made for region-wide conflict during the later periods of occupation (Di Peso 1974). Currently there is little evidence for warfare or raiding in the Virgin Puebloan region; however, Shutler (1961) has argued for increased raiding by the Paiute which led to the abandonment of southern Nevada.

For this research, I hypothesize that increased interaction through exchange is an important mechanism for reducing the amount of subsistence risk for sedentary farmers.
Without a high level of mobility, access to a diverse array of resources would have to be through other economic mechanisms such as trade. Exchange reduces unpredictability by creating future obligations that can be invoked in times of need. Exchange buffers against variation by emphasizing temporal and spatial predictability. Exchange and increased interaction may allow resources to be brought in during lean seasons, exchange information about conditions in other areas, or define areas where people could go to exploit needed resources (Braun and Plog 1982). Thus participation in regional exchange and social networks can help buffer against resource shortages by making resources from other areas available to a population (Rautman 1996:199). Although the amount of food actually transported may be negligible, the social networks allow for the communication of information for identifying more productive areas, and may result in sending individuals to those areas (see Colson 1979). Interestingly enough, some societies are known to increase craft production for trade during resource shortfalls (see Ford 1972 for an example from Picuris Pueblo).

The character and scale of the social networks in exchange relationships can vary widely; however, as mentioned previously, social reciprocity tends to be a key component (Smith and Boyd 1990). From a regional perspective, it should be expected that not all neighboring areas will be valued equally. The more valuable areas in exchange-buffering relationships will be the ones that have low risk in resources that may have a higher risk in the original area. Thus the amount of exchange and interaction will not radiate equally in all directions as some areas will be preferentially used over others (see Hantman and Plog 1982). Thus the shape of the economic interaction may become directional (Rautman 1993:405). However, intra-site exchange and sharing is also
common, and as some researchers have shown (Hegmon 1989, 1991), may be an effective way to reduce the amount of risk of household resource shortfalls in the same community.

Hegmon (1991) simulated prehistoric Hopi exchange and storing under three different exchange scenarios: 1) complete household independence (i.e. no sharing); 2) restricted sharing (meet household needs and then divide the remainder among neighbors); and 3) unrestricted sharing (pool and redistribute the yield of all households). Hegmon concluded that only 46% of the households would survive 20 years based on household independence. The probability of survival climbed to 73% for unrestricted sharing and 92% for restricted sharing. In summary, during especially bad years, marginally successful households did not fail when using restricted sharing as a risk reducing strategy. In this mathematical model, a combined storage and exchange strategy helps reduce risk more than just exchange and storage alone. Thus risk reducing strategies are not mutually exclusive and we may expect that there is a correlation between the circumstances that produce scarcity and the ways populations reduce these effects (Halstead 1989:4). In other words, cultures may have different ways of storing and exchanging food items that correspond to the social and environmental circumstances.

Regardless, the model shows that exchange and increasing social interaction works on both an inter-site and intra-site level to buffer against resource shortfalls. However, these are all models based on cross-cultural comparisons of different ethnographic and archaeological coping mechanisms. The question remains if there are any examples of increased exchange or social interaction that can specifically relate to
the prehistoric American Southwest. Fortunately, the modern Pueblo Indians, who live in a very similar environment and in some cases, may be directly related to prehistoric populations, show clear examples of an increase in social interaction and exchange as a way to decrease the probability of household famines. For instance, since the productivity of agriculture is very uncertain in the Southwest, there is an increased obligation for intra-community lending and sharing among clans or between households among the ethnographic Pueblos (Ford 1979:714-716)

*Enthnographic and Archaeological Evidence for Exchange as a Risk Reducing Strategy in the Southwest*

All of the historic pueblo groups in the American Southwest exchanged maize or other food items. Exchange within the community was a regular activity. Children would eat with neighbors or grandparents, marriage contracts involved the contribution of food and ceramics, and new society members’ kinsmen would be required to contribute cornmeal or other items. This even extended to hard times when more successful households may share with less successful households. For instance, there is clear ownership of land by clans in Hopi ideology. As clan size varied over time, if a clan did not have an adequate field for crops, surplus could be assigned to them from a father’s clan (Kennard 1979:554). Relatives in other villages could also be called upon for shelter or assistance (Ford 1979:714-716).

Ritual redistributions were familiar to all Southwestern groups. For example, at mourning ceremonies or weddings at all Pueblos, food and gifts were given to visitors. At times of crisis, relatives could contribute food for feasting ceremonies. Furthermore,
calendrical ceremonies at San Ildefonso Pueblo required contributions of food that was consumed by the participants; these ceremonies thus served to help redistribute food from successful households to those that were less fortunate. Thus ceremonial redistributions could take place at a local level (i.e. within a community) or at a regional level between a multitude of communities. More common, however, was the ceremonial participation of villages in ritual dances. The various Hopi towns often participated in ceremonial dances together which shows a high degree of interdependence some communities have through social rituals (Ford 1979:714-716).

The trading party was probably the most extensive form of exchange among the historic pueblos of the Southwest. Visitors brought “gifts” to another village and by accepting the gifts, reciprocity was guaranteed. Normally groups would visit another Pueblo for bartering; however, visitors could also assist in ceremonial activities and would be given food for their services (Ford 1979:717). Santa Clara Pueblo in New Mexico traded extensively with neighboring villages and intermittently with Hopi and Zuni. Trade with neighboring villages would intensify during ceremonial periods and in many instances large amounts of pottery was made to trade with visitors. Relations with distant Pueblos such as Hopi would be more formalized and reciprocal visits were common. Trade items would have been primarily of foodstuffs such as cornmeal; however, exchange of pottery was also common but was more restricted to areas around Santa Clara Pueblo (Hill 1982: 23, 62-65).

In brief, exchange among the historic Pueblo groups was comprised of a complex set of interactions between intra-village households, relatives at other villages, ceremonialism, and distant trade partners. Ecological circumstances most likely
contributed to the formation of these disparate social networks that emphasize trade and connections with other households or communities. These social and ritual mechanisms were used to reduce the risk of food shortfalls between families or within a region (Ford 1979:722). Richard Ford puts it more plainly: “Traditional Southwest exchange was a splendid example of multiple means for moving goods within an open communication network to insure the adequate provisioning of politically independent, egalitarian communities” (Ford 1979:722). Thus exchange in the Puebloan Southwest was an adaptive strategy for living in a highly variable, marginal environment and was expressed through social hospitality and reciprocity.

Recent archaeological research (Cordell et al. 2007) in the Mesa Verde region of the San Juan Basin suggests that exchange was also used prehistorically as an adaptive strategy to offset risk. However, in this research, archaeologists combine buffering mechanisms with communication and kinship lines. In brief, research suggests that poor and variable agricultural yields were compensated by creating social ties with groups in other areas of Mesa Verde that experienced a different precipitation patterns. Beyond using these networks to bring in food to offset underproduction, these social ties could be used to actively transmit messages. As Hegmon (1994) and Roney (1995) suggest, ceramic stylistic similarities may have served to communicate participation in a large economic and social risk-sharing groups instead of representing a bounded cultural group. Thus the stylistic similarities in Mesa Verde pottery may have reflected social interactions to reduce subsistence risk and create open communication networks linking climatically distinct areas. This is partially substantiated by Glowacki (1995:81) who showed that Mesa Verde was not isolated but was trading with neighboring valleys such
as Sand Canyon. Eventually Mesa Verdeans used these kinship networks to relocate to different more suitable areas and had the added bonus of knowing that these areas were welcoming and could support extra inhabitants (Cordell et al 2007:389,400).

Given that all societies have to deal with resource stress at some point in their history, it should be no surprise that there are a number of ways to deal with this phenomena. Many scholars suggest that there are limited and patterned ways that societies adapt to variation in resource supply including diversification, mobility, storage, and exchange and interaction. Some researchers have suggested that shortages in resources lead to cultural dissolution rather than integration (Saitta 2000). The position taken here, similar to other archaeologists studying buffering mechanisms (Cashdan 1990), is that there is a difference between small shortages caused by variation and catastrophic shortages caused by disasters. The former will normally lead to small cultural changes, whereas, the later has more calamitous consequences.
Chapter 3: Research Model and Methodology

This study proposes that once the trade networks with the uplands collapsed there was an increased reliance on other households in the lowland Virgin area. As discussed in Chapter 1, during the Pueblo II period, ceramics were regularly exchanged from the Shivwits and Uinkaret Plateaus of the Arizona Strip region to the lowlands in southern Nevada. I propose that this exchange network would have served as a buffering mechanism to reduce the risk of subsistence shortfalls in a high-risk environment by diversifying the resource base. Thus the exchange of pottery may have been established as a form of social reciprocity between lowland and upland groups.

As ecological studies have shown, resource buffering mechanisms are most successful when situated in geologically and climatically distinct ecosystems. If there are resource shortfalls in one area, resources from other ecosystems could be imported to alleviate stress (see Abruzzi 1989). The exchange of pottery between the upland and lowland groups, I propose, would have established the social links necessary to diversify the resource base of both areas. During periods of resource shortfalls in one of these areas, foods could have been obtained from the other area through these social ties to alleviate subsistence stress.

The near disappearance of upland ceramics by the end of the Pueblo II period, however, indicates that by the early Pueblo III period (A.D. 1150-1225), these trade networks had collapsed. I propose then that the buffering mechanism was also lost with this exchange thus increasing subsistence uncertainty or stress in lowland areas.
Possible responses to an increase in subsistence uncertainty in the lowlands could have been an increase in exchange among lowland households. Ecologically, the Virgin River, which flows through the St. George Basin, is fed by snow melt from nearby mountains; however, the Muddy River in southern Nevada is spring fed year round with little deviation in discharge rates. In this case, the Puebloan peoples in the St. George Basin would have farmed by floodwater; whereas, farming in southern Nevada would have been done by irrigation. If there was not enough moisture in the St. George Basin after the collapse of the upland trade networks to sustain agricultural yields, the residents could have relied more heavily on exchange with populations in southern Nevada to buffer against an increase in subsistence risk. This buffering strategy would be paramount for the lowland Virgin Branch Puebloan who were farmers in a marginal, highly variable environment.

As mentioned in Chapter 3, the ethnographic pueblos of the Southwest used exchange and ceremonial redistribution to aid faltering households. Prehistorically, lowland groups could have increased redistribution of food surpluses through feasting; however, a more appropriate analog may be an increase in marriage between lowland communities. An increase in local networks via marriage contracts would have also served the purpose of reducing the unpredictability of food production by increasing local ties. As is common in many historical pueblos such as the Hopi and Zuni, one’s paternal kin are seen as supportive and will typically provide assistance during life crises (Ladd 1979:483-484). Kinship may have also been important for prehistoric support networks.

If lowland communities were linked to the uplands via social networks and marriage contracts during the Pueblo II period as Jim Allison (2000) suggests, then these
same lowland communities would have needed to find other more local partners to avoid incest violations and to sustain their populations through exogamy once the connections with the uplands were lost. Thus it is likely that these increasingly local social networks took the form of marriage contracts. Archaeologically this could be evidence for an increase in traded ceramics because, as is common among the Hopi, the marriage ceremony obligates the bride, mother, and mother in law to exchange Hopi foods and mutton stew in traditional Hopi ceramics to all of the participants (Kennard 1979:557-560). Further, ethnographically, many Hopi and Zuni rituals require the presentation of food items in bowls or jars. This suggests that ceramics socially and ritually move across the landscape and in many but not all ethnographic cases, involved the transportation of food. Because the social system is based in social reciprocity and hospitality, future obligations among established kin groups may serve to distribute food to less fortunate individuals or households during periods of hardship and may be present prehistorically.

Data Expectations for Model

Current archaeological understanding of trade networks during the Pueblo II period in the Virgin lowlands point to an exchange system based heavily on nonlocal trade. As mentioned in Chapter 1, Pueblo II period site assemblages in southern Nevada are comprised of about 50-60% Tusayan Virgin Series ceramics with the remaining 40-50% being made up of non-lowland produced ceramics such as Shivwits, Moapa Gray Ware, and Kayenta red wares. This suggests that external networks may have been emphasized over internal (i.e., intra-lowland) networks in the lowlands during the Pueblo II Period. Jim Allison (2000) has argued that these trade networks were social strategies that linked households across the landscape. Further work by Karen Harry (2005, Harry
et al 2013) has shown that different trade networks in different ecological zones could have been used as buffering strategies for importing needed resources from other areas. If this is the case, ceramics may not have been traded extensively between lowland groups. I propose, then, that during the middle Pueblo II period, most lowland households produced Tusayan Virgin series ceramics and this pottery type was not extensively traded in the Moapa Valley. If this is correct, then the ceramic assemblages at Pueblo II sites (including Main Ridge) should be dominated by largely one compositional group.

On the other hand, during the Pueblo III period ceramic assemblages were dominated by Tusayan Virgin series, with non-lowland ceramics such as Shivwits, Moapa Gray Ware, and Kayenta red ware becoming nearly absent. This suggests that the social and economic ties linking households in different ecological zones had collapsed. The loss of these external social networks may have increased subsistence stress because the resources needed to sustain the population during stressful periods were no longer being brought into the lowlands, especially the St. George Basin where ecological stress would be more prevalent than the Moapa Valley as discussed above. If this is true, then lowland produced Tusayan Virgin Series ceramics may have been traded in the lowlands more extensively than in the Pueblo II period. In this case, House 47 and other Pueblo III sites may have come to rely more extensively on lowland social networks, which could have been maintained by increasing trade with other lowland groups. If this is accurate, compared to Main Ridge, House 47 should have a higher proportion of lowland ceramics more evenly distributed among different lowland production locations.
Methods and Materials

The exchange model was tested by investigating the distribution and compositional variability of Tusayan Virgin Series ceramics in southern Nevada. The sampling strategy for NAA was based on the following criteria: 1) 50 sherds were analyzed from both the Main Ridge Community (middle Pueblo II) and from House 47 (early Pueblo III); 2) selected sherds were large enough to be typologically identified as Tusayan Virgin Series ceramics as well as to permit adequate chemical sampling; 3) each sherd had two 1 cm² samples removed for analysis, one for chemical sampling and one for refiring; and 4) sherds were selected from multiple contexts to reduce the likelihood that multiple samples will be submitted from the same vessel. At Main Ridge, sherds were selected from multiple houses from a range of locations on Mormon Mesa. Sherds selected from House 47 were from the 2012 UNLV field school. It was impossible to assign sherds at House 47 to specific habitation structures due to the way the site was excavated in the 1920s and 1930s by Mark Harrington and the Civilian Conservation Core; however, sherds were selected from a variable array of contexts to avoid sampling from the same vessel.

Before being sent for NAA analysis, a sample from each sherd was re-fired to investigate the possibility of multiple compositional groups. Different paste colorations may be the result of different ceramic-recipes and therefore may be evidence for different production loci. The colors were recorded with a Munsell chart and compared to the compositional groups following NAA analysis.
Five raw clay specimens were sampled from the Muddy Creek formation in the Moapa Valley and six clay specimen from the Chinle Formation in the St. George Basin. Selection of clays was based on clay-bearing outcrops in close proximity to known Virgin Branch Puebloan sites. By establishing the general chemical variability of clay formations, inferences could be made concerning the most likely area of production (see Glowacki 1995). Quartz and mixed sand samples were also collected to recreate the ceramic paste by mathematically mixing the sand and clay data and allowing for a more realistic comparison between raw material sources and the prehistoric ceramics. The Yamashita sands found in some archaeological ceramics were sampled in southern Nevada and two different sands were sampled from the St. George Basin suspected to be used for ceramics produced there.

**Refiring Experiments**

The color of a sherd in an archaeological collection is a function not only of the clay used to make the vessel, but of post depositional processes, firing atmosphere, and any later exposure to fire. Thus the objective of refiring experiments is to remove the effects of these processes by fully oxidizing the clay (Allison 2000:55). With oxidation, hydrous ferric oxides and ferro-ferric oxides are converted to red ferric oxides when water is evaporated at low temperatures (Shepard 1956:104). Thus sherds that refire to the same color may have been made with the same clays, whereas sherds refiring to different colors must have been made from different clays.

Measuring the oxidizing colors of clays is a way to understand the variability between clay composition through inexpensive and relatively quick methods. Although
oxidizing colors are not a true indicator of chemical composition, they can give a general idea of differences in composition. For instance, if sherds from different regions are refired, they should exhibit different oxidizing colors based on differing composition. Unfortunately, it is possible that sherds from diverse sources can exhibit similar oxidizing colors due to a similar iron composition and/or size and distribution of the iron particles (Sheppard 1956:103-104).

Furthermore, different clays may also require different temperatures for oxidation. Shepard (1956:105) and others have noticed that temperature ranges between 750 and 850 degree Celsius produce oxidation in most if not all clays. Usually when clays turn red, orange, yellow, or cream in color, one can be confident that oxidation has successfully occurred. In brief, although there are many issues relating to using oxidation colors as a proxy for clay compositional variability, it is still very useful for understanding the macro differences between clay sources that can be further investigated by techniques such as Neutron Activation Analysis.

**Neutron Activation Analysis and Provenance Based Research**

Neutron Activation Analysis (NAA) was recognized as a useful tool for chemically characterizing materials not long after the invention of nuclear science; however, it wasn’t until the invention of the lithium drifted germanium detector in the 1960s that NAA became useful for provenance research. NAA is a bulk-characterization technique in that it requires the total destruction of the sherd or a piece of sherd for analysis; however, since NAA can successfully analyze extremely small amounts of
material, even museum pieces can be analyzed with only trace amounts of harm (Neff 2000:81).

NAA is explained in detail elsewhere (Glascock 1994) and will only be summarized here. NAA works on the premise of neutron capture. When a neutron interacts with the target nucleus a compound nucleus is formed and a prompt gamma ray is emitted. The compound nucleus will instantaneously form a radioactive isotope that slowly decays into a stable state. The delayed gamma rays emitted during this state can be measured and quantified and allow for the archaeological specimen’s chemical composition to be known (Glascock 1992:11). Archaeologists then can understand the unique chemical signature of each artifact and relate them to likely areas of manufacture. In this case, it is hoped that different production locations within the lowlands can be recognized chemically which would aid in identifying interdependence and sharing within the lowland region.

The main advantages of NAA for compositional studies are: 1) extremely high precision and accuracy; 2) ability to detect a large number of elements; 3) high sensitivity to detecting elements in trace amounts; 4) ability to characterize less than 100mg of sample; 5) relative immunity to matrix effects; 6) ease of sample preparation; and 7) ability to establish calibrations between laboratories (Neff 2000:102; Glascock 1992; Hughes et al 1991).

*Precision* refers to the ability a measurement can be reproduced on the same sample (Landsberg 1994:121). NAA can claim precision scores in the 1-5% range for certain elements which are similar to techniques such as Inductively Coupled Mass
Spectrometry (ICP-MS), Atomic Absorption Spectroscopy (AAS), or high precision x-ray fluorescence; however, mistakes in sample geometry during detection, and sample weighing errors can reduce the level of precision (Neff 2000:102).

**Accuracy** refers to how close the measurement approximates the actual elemental concentrations within the sample. Accuracy is measured by comparing the measured concentrations to known concentrations in standard reference material (Landsberg 1994:121). Logically, if the known concentrations in the standard reference material approximate the measured concentrations, then the irradiation and detection stages have high accuracy and can be assumed that the measured concentrations in the artifact material approximate its true value.

The detection to multiple elements and high sensitivity to trace elements is crucial for successful bulk-characterization of any geologic material. Many geologic sources whether obsidian flows or clay formations can potentially share similarities in elemental concentrations. The more elements that can be determined combined with high sensitivity to trace elements allows for a greater degree of certainty in discriminating potential sources (Goffer 2007:257-258).

**Neutron Activation Analysis Procedures**

One hundred archaeological ceramics from Main Ridge and House 47 and fourteen geological samples underwent Neutron Activation Analysis at the University of Missouri Research Reactor (MURR). Initially samples were burred with a tungsten carbide drill to remove slips, paints, or other external contaminates. Afterwards, samples were homogenized with an agate pestle and mortar. Approximately 150mg of
homogenized sample was placed in high density polyethylene vial and approximately 200mg in a high purity quartz vial (Ferguson and Glascock 2012).

Irradiation procedures at MURR consist of both a long and short irradiation. The short irradiation consisted of exposing samples to a thermal neutron flux of $8 \times 10^{13}$ n/cm$^2$/s for 5 seconds. Exposed samples were allowed to decay for 25 minutes before a 12 minute count on a high purity germanium detector. Data for the following short-lived elements were collected during this detection: aluminum, barium, calcium, dysprosium, potassium, manganese, sodium, titanium, and vanadium. The long irradiation consisted of exposing samples to a thermal neutron flux of $5 \times 10^{13}$ n/cm$^2$/s for 24 hours. After a seven day decay period, samples were placed on high purity germanium detectors and counted for 1,800 seconds. This count collects data for the mid-lived elements: arsenic, lanthanum, lutetium, neodymium, samarium, uranium, and ytterbium. After an additional three to four week decay period, the samples were counted again for 8,500 seconds to measure the following long-lived elements: cerium, cobalt, chromium, cesium, europium, iron, hafnium, nickel, rubidium, antimony, scandium, strontium, tantalum, terbium, thorium, zinc, and zirconium (Ferguson and Glascock 2012).

**Basics of Provenance Based Research**

The purpose of chemically characterizing archaeological materials is to relate artifacts to source zones. The underlying assumption is that artifacts are chemically similar when produced from the same raw material. For ceramics, this can become extremely complicated because of the different processes clay and ceramics are subjected too before being recovered by archaeologists (Neff 2002:5).
Luckily, Weigand, Harbottle, and Sayre developed the Provenance Postulate which states that “there exist differences in chemical composition between different natural sources that exceed, in some recognizable way, the differences observed within a given source” (Weigand et al 1977:24). Hector Neff later believed that for sourcing, the provenance postulate developed by Weigand et al was to narrowly focused on chemical techniques. Neff proposed to change the postulate to account for mineralogical data as well as qualitative data. In other words, the qualitative or quantitative compositional variability between sources must be greater than the qualitative or quantitative compositional variability within a source (Neff 2000:107-108).

Thus the Provenance Postulate attempts to bridge the gap between composition and geographic location. The general purpose is to identify procurement or production centers and local versus non local goods (Glowacki 1995:19). For obsidian this can be extremely easy because of the chemical homogeneity of the material and the localized source zones. Obsidian artifacts can be compared to the sources groups and assigned based on the range of variation between them. Ceramics, however, tend to have wide spread source zone as well as large degrees of chemical variability. In this case, source groups are made from the sherds themselves rather than from the raw material (Neff 2002:6). Thus if there is enough chemical variability between ceramic reference groups, these may be related to different production zones or geographic locations.

More often than not raw clay materials will not chemically match the ceramic reference group. This is mainly due to the chemical heterogeneity of clay, and the additive and reductive processes associated with ceramic manufacture. However, one way many archaeologists overcome this problem is by using the Criterion of Abundance
which states that ceramics of a single reference group are manufactured in the area where they are most common (Bishop 1980; Rands and Bishop 1980). However, the Criterion of Abundance should not be relied upon heavily for provenance based research. As Neff and Glowacki (2002:6) have argued, past consumption may have lead to certain ceramic types to become more dominate in an area far away from the original production zone; however, as Donna Glowacki has argued, establishing the chemical composition of a clay formation and comparing them to ceramic reference groups may lead to inferences regarding likely regions of production (Glowacki 1995:19).

Other chemical or mineralogical techniques may also be employed in tandem with NAA to better match ceramic groups to raw materials. For instance, Laser Ablation Mass Spectrometry (LA-ICP-MS) has the ability to point locate specific areas of the sample. In the case of ceramics, temper and other inclusions may be avoided so that only the clay matrix is being chemically characterized; however, the drawback to LA-ICP-MS is reduced precision and accuracy compared to NAA due to fractionalization (Speakman and Neff 2005:8).

*The Temper Problem*

Neutron Activation Analysis chemically characterizes the entire ceramic sample. In this case, the temper and other clay constituents are also characterized with the clay matrix. Thus differences in chemical reference groups may be the result of temper variability, temper amount, or from adding temper to a chemically homogenous clay (Neff et al 1988, 1989, Neff, Bishop, and Arnold 1988). Therefore it is important to take into the account the elemental effects different tempers will have on group separation. A
a good rule of thumb is that sand temper normally enriches the elements zircon, and sodium; whereas other rock tempers also enrich calcium, potassium, manganese and iron (Glowacki 1995:70-71). If reference groups are distinguished on more than these enriched elements alone then group separation is probably a result of differences in clay matrix. Thus it is pertinent to also chemically characterize raw temper samples in addition to the raw clay and archaeological specimens. This way, the unique chemical make-up of the temper can be accounted for; however, this approach requires in depth knowledge of the prehistorically available and used temper sources in any given region and may not be feasible in every case. It has also been noted by Carr and others through disaggregation experiments (Carr et al 1992) that the chemical results of Neutron Activation Analysis are minimally affected as long as the temper does not exceed 30 percent.

Methods of Statistical Manipulation

A series of sherds that have similar concentrations of many different elements can be systematically grouped based on these isotopic similarities. Further analysis may be able to fit single samples into established compositional groups depending on the deviation from the group’s chemical mean. (Goffer 2007:257). Initially, the chemical data must be transformed into log functions. Baxter (1994:46-47) and Neff (2002:17) both point out that log transformations are not entirely necessary for most multivariate statistical functions, however, logarithms avoid letting the elements with large concentrations have more pull on the pattern recognition techniques commonly used in statistical analysis.
Pattern recognition is one of the most important steps in completing provenance based research. Initially ceramics may be able to be sorted by archaeological variables such as ware, decoration, or region to investigate the possibility of which samples should be grouped together (Goffer 2007:257-258). Other approaches such as partitioning or ordination rely on mathematical and statistical principles to separate ceramics into groups. According to Neff, ordination refers to analysis that utilizes eigenvector extraction (e.g. Principal Component Analysis, bivariate plots) and partitioning refers to cluster analyses such as dendrograms or Euclidean Distance calculations (Bishop and Neff 1989).

Most laboratories will produce more than two elements when chemically characterizing materials. Thus it is impossible to investigate the data fully in only two or three dimensions (i.e. bivariate plots). For instance, MURR gets data for 33 elements, which would require a plot that shows all 33 dimensions for all of the data to be synthesized properly. Luckily, there are innumerable statistical techniques that allow archaeologists to reduce the amount of dimensions to a more reasonable number. Principal Component Analysis (PCA) tends to be the most commonly used in archaeology and archaeometry today (Bishop and Neff 1989).

PCA is based on the principle of eigenvalue and eigenvector extraction. In short, all of the variables (in this case: elements) are included into linear equations that define a transformation into an eigenvector score. Principal component axes obtained from these eigenvectors are arranged into the highest amount of variance that each component can explain. In other words, the linear equations that produce the eigenvectors take into account the different concentrations of elements within each sample. The Principal
components that result from these different eigenvectors explain differing amounts of variation within the dataset. Usually the first two principle components will explain the most variation and, as Neff points out, will normally show source related subgroups in the data. The eigenvectors may also be used to identify the specific element(s) that is causing group separation; which may be crucial for identifying if the grouping is from some post-depositional process or from actual clay chemistry (Neff 2002:21).

The principal objective of cluster analysis is to group specimens together that are more similar to each other than any other specimen or group. The most common form of cluster analysis is the dendrogram which depicts groups linked by lines or routes. Similarities between two different groups or data points can be visually traced by investigating the length of the route between any two different specimens. In other words, the longer the route is between the groups, the more compositionally distinct these groups are from one another (Neff 2002:24).

Once groups are recognized and formed, they must be evaluated before arguments for production zones can be made. This may be done in two different ways, either visually or statistically. Location and shape are the two main criteria for evaluating group membership visually. Location in this case means that each group’s centroid will vary spatially. Basically, the center of each potential compositional group will be in different place on the plot. Shape means how compact each group is, and how they are oriented on the plot. If two potential compositional groups are near one another on a correlation line than it is most likely that these groups are not different production zones, but rather are chemically separated by other post-depositional processes (Neff 2002:24).
Statistically, compositional group structure can be evaluated using methods such as Mahalanobis distance from group centroid to sample (Glowacki 1995:25). As in PCA, Mahalanobis based probability takes the concentrations of all elements in each sample and compares them to the concentrations in the group mean. The probability of group membership then is based on the standard deviation and multivariate distance between the group centroid and the individual specimen. This approach can also be used to test the validity of multiple compositional groups. In effect, it is possible to calculate the Mahalanobis distance of each specimen in each compositional group to all other groups in the analysis. In other words, if the group structure is valid, then the members of one group will have a low probability of belonging to other compositional groups and a high probability of belonging to the groups that they are assigned (Neff 2002:30-33).

One limit to using Mahalanobis based calculations is that the technique requires a high specimen to element ratio. For data produced at MURR, optimal Mahalanobis based calculations require about 83 specimens per compositional group, or about 2.5 times the number of elements (33). If there are fewer specimen per group, inclusion or exclusion of specimens would have a larger impact on the group mean and thus the calculations (Neff 2002:30).

In summary, these are some of the techniques, procedures, theories, and quantitative methods used in compositional studies. For the most part, these techniques are successful in producing highly precise and accurate data for investigating the chemical difference between artifacts. However, it must be noted that the quantitative methods are more of an art than a science. In many cases, the techniques used and their results are open to numerous interpretations. The decisions lie squarely with the
researcher and should not be separated from the research design, sampling, and hypothesis.
Chapter 4: Results of the Experiments

One hundred Tusayan Virgin Series sherds from House 47 and Main Ridge, along with 5 clays from the Moapa Valley and 6 clays from the St. George Basin underwent refiring experiments and Neutron Activation Analysis. The purpose of both techniques was to understand the ceramics’ chemical variability in an effort to understand the variability in production. The results of both techniques are discussed in detail below.

Refiring Experiments

After refiring, the color of each sherd was matched to the closest tile on a Munsell Color Chart. Ceramics were then separated into five groups based on the color groups that Allison (2000), Windes (1977), and Mills et al. (1993) identified in previous refiring studies (Table 4.1).

Table 4.1: Munsell colors associated with each color group

<table>
<thead>
<tr>
<th>Color Group</th>
<th>Munsell Colors Included</th>
<th>Color Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10YR 7/4, 8/2, 8/3</td>
<td>Very Pale Brown</td>
</tr>
<tr>
<td>2</td>
<td>7.5YR 7/4, 7/3, 7/6, 8/2, 8/3, 8/4</td>
<td>Pink, Pinkish White</td>
</tr>
<tr>
<td>3</td>
<td>5YR 7/4</td>
<td>Pink</td>
</tr>
<tr>
<td>4</td>
<td>7.5YR 6/4, 6/6, 7/6</td>
<td>Light Brown, Reddish Yellow</td>
</tr>
<tr>
<td>5</td>
<td>5YR 5/6, 6/4, 6/6, 7/6</td>
<td>Yellowish Red, Light Reddish Brown, Reddish Yellow</td>
</tr>
</tbody>
</table>

All the clays refired to five different Munsell color tiles. The clay colors were spread fairly evenly across the color groups (Table 4.2). All of the St. George Basin clays fall within the light firing groups (Color Groups 1-3) and clays from the Moapa Valley
fall within a broader range of color groups but still tend to be from the light firing Groups (Color Groups 1, 2, 4) with one falling inside the dark firing Color Group (Color Group 5; Table 4.3). These data suggest that there are clays present in both the Moapa Valley and St. George Basin that have low concentrations for iron.

Table 4.2: Diversity of color groups the clay and ceramics are assigned to

<table>
<thead>
<tr>
<th>Color Group</th>
<th>Material Crosstabulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clay</td>
</tr>
<tr>
<td><strong>Group 1</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>Group 3</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Group 4</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Group 5</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>11</td>
</tr>
</tbody>
</table>

Analysis of the clay refiring colors sorted by region suggests that certain colors and groups may be indicative of clays found in either the Moapa Valley or the St. George Basin (Table 4.3). Color Groups 4 and 5 only have clays assigned to them that are found in the Moapa Valley, whereas, Color Group 3 may belong to the St. George Basin. However, this is a tentative assumption because of the variability of refiring colors that can be associated with clay found in a region and the limited amount of clay samples included in the study. Color Groups 1 and 2 contain clays from both the Moapa Valley and St. George Basin; however, there seems to be a higher proportion of St. George Basin clays assigned to Group 2 than clays collected from the Moapa Valley. Further, the one
clay from the Moapa Valley that was assigned to Group 2 had a color that was very similar to the Moapa Valley clay that was assigned to Group 1 than the St. George Basin clays also assigned to Group 2. This clay then was on the fringes of both color groups and may be more appropriately assigned to Group 1 because of its lack of similarity with the rest of the Group 2 samples.

Table 4.3: Clay color groups present in the Moapa Valley and the St. George Basin

<table>
<thead>
<tr>
<th>Color Group</th>
<th>Location</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>Moapa Valley</td>
<td>2</td>
</tr>
<tr>
<td>Group 2</td>
<td>Moapa Valley</td>
<td>1</td>
</tr>
<tr>
<td>Group 3</td>
<td>St. George Basin</td>
<td>0</td>
</tr>
<tr>
<td>Group 4</td>
<td>St. George Basin</td>
<td>1</td>
</tr>
<tr>
<td>Group 5</td>
<td>Total</td>
<td>5</td>
</tr>
</tbody>
</table>

The Tusayan Virgin Series sherds refired to sixteen different Munsell color tiles. Most of the colors fall within the light firing groups (Color Groups 1, 2, 4) and very few into a dark firing group (Color Group 5). This demonstrates that the majority of the Tusayan Virgin Series ceramics were made from clays having a low iron content, or alternatively, from a variety of different paste recipes (Table 4.2).

Further analysis shows that there is a difference between the color groups present at Main Ridge and House 47 (Table 4.4). Refiring colors present at Main Ridge fall in
Color Groups 1, 2, 4, and 5. Color Group 4 has a much higher proportion of the refiring colors (64%) than any of the other groups present in the assemblage (Table 4.4).

Tentatively, Color Group 4 may represent sherds that were locally produced in the vicinity of Main Ridge and House 47 based on the assumption that sherds will be found most abundant where they are being produced and the similarity of Group 4 with refiring colors associated with Moapa Valley clays. Relative to Main Ridge, at House 47 there seems to have been a decrease in the amount of ceramics imported from Color Groups 1 and 5, with the greatest decrease from Color Group 4 which is assumed to be produced in the vicinity. There also seems to be a clear increase in the use of ceramics belonging to Color Group 2 (Table 4.4). The differing proportions of color groups at House 47 suggests that there was a realigning of trade and social networks during the later years of occupation with the reemphasis of networks on sites that produced the ceramics belonging to Color Group 2.
Table 4.4: Ceramic color groups assigned to both Main Ridge and House 47

<table>
<thead>
<tr>
<th>Color Group * Site Crosstabulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
</tr>
<tr>
<td><strong>Group 4</strong></td>
</tr>
<tr>
<td><strong>Group 5</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Color Group</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 4</th>
<th>Group 5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Ridge</td>
<td>2</td>
<td>6</td>
<td>32</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>House 47</td>
<td>0</td>
<td>26</td>
<td>17</td>
<td>7</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2</td>
<td>32</td>
<td>49</td>
<td>17</td>
<td>100</td>
</tr>
</tbody>
</table>

Italicize = light firing color groups
Bold = dark firing color groups

The variability in color groups suggests changing social and trade networks over time. During the middle Pueblo II period, Main Ridge may have produced a good portion of the ceramics in use, but also may have either imported ceramics from two distinct production locations or used different clays to produce pottery. During the Pueblo III period, there may have been a reemphasis on different producers of Tusayan Virgin Series ceramics with the preferred acquisition of Color Group 2. However, other possibilities are that the Munsell colors are very similar due to the ceramics being produced from very chemically similar clays or that iron was leached out of the sherds by the covering of House 47 by Lake Mead. The high degree of variability in the refiring colors of the clays and the low sample count do not allow for any conclusive argument to be made concerning likely areas of production.

Admittedly, refiring experiments cannot be used alone to understand the compositional variability between ceramics or the relation of ceramics to raw clay sources. However, oxidation colors can be used in a rather crude way to understand the
generalized compositional differences between ceramics and clays that can be further tested with more precise and accurate chemical based techniques.

Results of Neutron Activation Analysis

Ceramic, raw clay, and sand samples were sent to the University of Missouri Research Reactor (MURR) to undergo Neutron Activation Analysis (NAA). The goal of this analysis was to chemically evaluate the variability in manufacturing locations of Tusayan Virgin Series ceramics. As discussed below, results suggest that there were least three to four different clays that Tusayan Virgin series may have been produced from; however, more samples are needed to fully evaluate the chemical patterns observed.

As a first step in the analysis of the chemical data, a RQ-mode principal component analysis was undertaken on the ceramic samples. Ni was below detection limits on most samples and thus was removed from the analysis. Greater than 90% of the total variance was explained by the first nine principal components (PCs). Bivariate plots of the first two PCs were evaluated visually to establish tentative compositional groups (Figure 4.1). The data were separated into two main groups \( n_1=57, n_2=14 \) and two small outlier groups \( n_3=2, n_4=4 \); Table 4.5). As further discussed below, Group 1 could be further separated into two subgroups (Group 1A, \( n=17 \) and Group 1B, \( n=29 \); Table 4.6). It should be noted that groups with small numbers of specimen should be considered tentative because robust statistical techniques cannot be used to evaluate them. However, membership probabilities of the two main groups and subgroups based on nine PCs (90% of the total variation) show that these groups are likely real (see Appendix: Tables 1-3).
Table 4.5: Chemical groups by site

<table>
<thead>
<tr>
<th>Chemical Group</th>
<th>Site</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>House 47</td>
<td>Main Ridge</td>
<td>Total</td>
</tr>
<tr>
<td>Group 1</td>
<td>35</td>
<td>18</td>
<td>53</td>
</tr>
<tr>
<td>Group 2</td>
<td>2</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Group 3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Group 4</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Unas</td>
<td>11</td>
<td>16</td>
<td>27</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>50</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 4.6: Chemical Group 1 split by site

<table>
<thead>
<tr>
<th>Chemical Group</th>
<th>Site</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>House 47</td>
<td>Main Ridge</td>
<td>Total</td>
</tr>
<tr>
<td>Group 1A</td>
<td>16</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Group 1B</td>
<td>13</td>
<td>16</td>
<td>29</td>
</tr>
<tr>
<td>Group 1 Unas</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>50</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Reference Group 1

Group 1 contains 53 sherds that contain higher concentrations for Cesium, Calcium, Arsenic, Strontium, and Rubidium than the rest of the dataset. Group 1 contains 35 sherds from House 47 and 18 sherds from Main Ridge. Further investigations of Group 1 in elemental space showed that Group 1 could be separated into two subgroups (Figure 4.2). Group structure was validated by performing a Principal Component Analysis of Group 1 and using the resulting PCs to calculate the Mahalanobis membership probabilities of the subgroups (see Appendix: Tables 4-5). Group 1A (n=17)
contains 16 sherds from House 47 and 1 sherd from Main Ridge. Group 1B (n=29) contains 13 sherds from House 47 and 16 sherds from Main Ridge. The remaining sherds from Group 1 could not be statistically assigned to either subgroup (see Appendix: Table 6). Two sherds (TJM028 and TJM042) were left unassigned even though they have a high probability of membership into Group 1A because they visually blur the distinction between the two subgroups in elemental space. This may be due to the fact that both subgroups have a low amount of samples making robust statistical analysis impossible. If more samples are added to both subgroups, the resulting probabilities and group membership may change. Group 1 may also split into another subgroup based on higher concentrations for uranium; however, not enough samples were present to justify separating Group 1 further (Figure 4.3).
Figure 4.1: Principal Component Plot showing group separation
Figure 4.2: Elemental Plot of Tantalum and Europium
Figure 4.3: Elemental Plot of Uranium and Thorium
Reference Group 2

Group 2 contains 14 sherds that are compositionally distinct from Group 1 based on higher concentrations for the rare earth elements (Eu, Tb, Dy, U, Th, Ta, La). Because group separation is based on the rare earth elements, it is likely that separation is due to minute differences within the clay chemistry rather than differences between temper. Group 2 contains two samples from House 47 and 12 samples from Main Ridge.

Outlier Groups 3 and 4

Although two to four samples do not make a statistically robust compositional group, members of these groups tend to plot near each other in principal component and elemental space consistently. Groups 3 and 4 tend to separate from the rest of the dataset by much lower concentrations for chromium, manganese, and cobalt and higher concentrations for tantalum and thorium. Group 3 consists of two sherds from House 47; whereas Group 4 consists of four sherds from Main Ridge. It is possible that these two groups will become more pronounced when more samples are added.

Unassigned Specimens

The remaining 29 sherds are unassigned to any reference group. Outlier samples were left unassigned due to a low probability of group membership based on Mahalanobis distance calculations from group centroids using PCs. Unassigned sherds may be the product of distinct clay sources that are poorly represented in the current sample or compositional differences such as unique paste preparation or temper.
Comparisons with Clays and Sands

In the American Southwest, temper makes up approximately 30% of the body of prehistoric ceramics. Thus in this project, clay and sand chemistry were mixed mathematically at a ratio of 70% clay and 30% sand to better approximate prehistoric ceramics. Each clay specimen was only mixed with sand from its respective region. Mahalanobis membership probabilities show that there is not a high probability that any of the ceramics were made with these specific clay and sand combinations (see Appendix: Tables 7-9); however, a Canonical Discriminant Analysis (Figure 4.4) shows that Groups 1 and 2 are more closely related to clays and sands coming from the Moapa Valley than the St. George Basin. Groups 3 and 4 do not have any close relation to either clays originating in the Moapa Valley or the St. George Basin.
Figure 4.4: Canonical Discriminant Plot comparing groups and clay/sand mixtures
Discussion

From a generalized perspective, tentatively the data suggest that a lot of the sherds from both House 47 and Main Ridge were being produced in southern Nevada and possibly in the Moapa Valley. It is interesting that no sherds had any kind of chemical similarity with clays and sands originating in the St. George Basin. This suggests that local production and exchange may have been more important than previously thought for the Virgin Branch Puebloan in southern Nevada. However, more samples will need to be sent from both the St. George Basin and from other sites in southern Nevada to see if there was a lack of trade between the two regions or directional trade between southern Nevada and the St. George Basin.

Relative frequencies of sherds within each group and subgroup suggest changing trade ties from the Pueblo II to Pueblo III periods. Tusayan Virgin Series ceramics found at Main Ridge tend to be dominated by chemical Groups 1 and 2, whereas, House 47 tends to have ceramics overwhelmingly assigned to chemical Group 1. According to the criterion of abundance, ceramics are produced where they are most frequently found. Since most of the sherds from Main Ridge and House 47 make up chemical Group 1, it suggests that chemical Group 1 may represent the sherds that are being locally produced in the vicinity of Main Ridge and House 47. This suggests that Main Ridge may have had more diverse trade ties in southern Nevada than House 47 because of a greater emphasis on other production locations presumably local to southern Nevada rather than just one. Sherd frequencies in subgroups show that House 47 emphasized both Group 1A and Group 1B; whereas Main Ridge emphasized Groups 1B and 2. These data suggest that during the Pueblo III period there was either a realigning of trade ties to emphasize the
acquisition of Group 1 ceramics over that of Group 2 or the increased production of ceramics in the surrounding areas of House 47.

Finally, it is interesting that the groups made from the refiring colors do not match the chemical groups based on Neutron Activation Analysis (Table 4.7). This is probably due to the fact that Tusayan Virgin Series ceramics are so chemically similar that a generalized technique such as refiring experiments may not be useful for differentiating groups and thus production locations. Further petrographic analyses have shown that the clay and sand temper in Tusayan Virgin series pottery is very similar but slight differences are discernable under a microscope (Ownby 2012). This supports the notion that the clay and temper found in these ceramics may be too homogenous for refiring experiments to differentiate between manufacturing locations.

Table 4.7: Number of specimens assigned to each chemical and color group

<table>
<thead>
<tr>
<th>Chem Group</th>
<th>Color Group 1</th>
<th>Color Group 2</th>
<th>Color Group 4</th>
<th>Color Group 5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>0</td>
<td>21</td>
<td>26</td>
<td>6</td>
<td>53</td>
</tr>
<tr>
<td>Group 2</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Group 3</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Group 4</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Unas</td>
<td>0</td>
<td>7</td>
<td>10</td>
<td>10</td>
<td>27</td>
</tr>
<tr>
<td>Grand Total</td>
<td>2</td>
<td>32</td>
<td>49</td>
<td>17</td>
<td>100</td>
</tr>
</tbody>
</table>
Chapter 5: Testing the Model and Conclusions

This research was intended to serve as a pilot study to gain a better understanding of the production and trade of Tusayan Virgin Series ceramics in the lowland Virgin Pueblian region during the Pueblo II to Pueblo III periods. Results suggest that most of the ceramics sampled from both House 47 and Main Ridge were likely produced in southern Nevada. Additionally, Main Ridge tends to have a greater diversity of trade networks than House 47; however, House 47 tends to emphasize ceramics being produced in the vicinity of Reference Group 1. More importantly, this research tested the hypothesis that there were increased ties with the St. George Basin during the early Pueblo III period to reduce the risk of food stress in the lowland Virgin Pueblian region. Instead, the data suggest that Tusayan Virgin series ceramics were not moving between the St. George Basin and southern Nevada. As a result, the risk reducing hypothesis was not supported.

Arnold (1981, 1985) estimated that the average ethnographic resource procurement zone was approximately 7 km around the manufacturing location. Most of the sherds from House 47 and about half the sherds from Main Ridge belong to Group 1. Based on the Criterion of Abundance and because Main Ridge and House 47 are about 2 miles apart, it is possible that Group 1 was produced in the vicinity of House 47 and Main Ridge. If this is the case, and Arnold is correct in estimating the procurement zones, then Group 2 may be from a much farther distance in southern Nevada such as the Mesquite, Nevada locality. If this assumption is correct, Main Ridge and by proxy the Pueblo II Period, would have been trading broadly in southern Nevada at the same time as the trade with the uplands in northern Arizona was at its peak.
On the other hand, House 47 and other Pueblo III period settlements seem to have been trading less with other settlements in southern Nevada at the same time that the trade connections with the uplands were lost. In this case, Pueblo III settlements may have become more insular during the later years of occupation because of a lack of evidence for non-local ceramics and by proxy external trade ties. The dissolution of trade networks with the uplands could have made the resource base in southern Nevada so unpredictable that households became more concerned with their own survival. This has been noticed in ethnographic cases, where families tend to look after their own instead of trying to help other members of a community in times of stress (Colson 1979).

It is possible that the insular nature of Pueblo III settlements contributed to the abandonment of the region because of the lack of subsistence risk reducing strategies or possibly, from a lack of social connections with other settlements. As previously mentioned in Chapter 1, Jim Allison (2000) has argued that the trade with the uplands may have taken the form of social rituals based around agriculture. If this is the case, then the breakdown of social rituals, which has been shown to be very important to the ethnographic pueblos, and the increasing isolationism of settlements may have been detrimental to the continuance of Puebloan society in southern Nevada. Further compounding the issue would be the lack of exogamous families or clans for young individuals to marry into.

Consequently, there seems to be different levels of inclusiveness depending on the severity of the stress (Figure 5.1). If a lower level response cannot handle the stress adequately, then higher level responses will be used. In exchange relationships these may follow the pattern of household, kin group, community, and extra community (Minnis

Higher level mechanisms such as community or extra-community interaction may take the form of increased sharing or ritual redistribution respectively. However, these higher level mechanisms may not adequately handle the issue. For instance, Sahlins (1972) created a model of intercommunity sharing during times of food stress (Figure 5.2). He suggests that sharing will increase during times of minor food perturbations; however, during prolonged or major shortage, inter-site sharing decreases significantly. This argument has also been made by Kohler and Van West (1996) who argue that households in the Mesa Verde region withdrew from intragroup sharing when agricultural yields were extremely poor.

In an ideal world, higher level responses should be complimentary to lower level responses. However, in some cases, higher level responses may invalidate or even destabilize lower level responses (see Jongman and Decker 1989). For instance, ritual redistribution may make sharing or exchange among kinship lines irrelevant depending on the scale of stress. Nevertheless, different levels of response are not mutually exclusive. It should be expected that more socially and politically complex societies will incorporate many different levels of response. There may also be significant overlap between responses as the next level is incorporated into the existing buffering strategy. This may occur for example, when community sharing is assimilated onto kinship exchange. For example, Ford (1972b) has noticed that at Tewa villages rituals based around the redistribution of food increase when stored food was at its lowest. Thus there
is evidence that in the Puebloan Southwest, there were different levels of responses that were enacted depending on the level of subsistence stress.

Figure 5.1: Sequence of responses to stress. Adapted from Minnis 1986
Figure 5.2: Sahlin’s suggestion of intra-group sharing and stress severity

With the small sample size used in this study, it is almost entirely impossible to investigate different levels of responses at House 47 based just on the chemical data analyzed here. However, other lines of evidence suggest that there were different responses to stress over time. Existing site maps of Main Ridge and House 47 (Figures 5.3 and 5.4) show a clear change in settlement patterns from the Pueblo II to Pueblo III periods. Main Ridge tends to be spread out onto every available area on the Mesa, whereas, House 47 tends to from clusters of habitation and storage rooms set into arcs around central courtyards. This change in settlement pattern may suggest a higher degree of social integration among the residents of House 47. Although speculative, courtyard groups may be formed due to increasing demands of land tenure and the communal nature of cleaning out and digging out irrigation canals. Further architectural analysis in the Moapa Valley has shown that there is an increasing amount of storage rooms and storage space per habitation room from the Pueblo II to Pueblo III periods (Lyneis 1986).
Analyses of rim diameters show that there are a higher proportion of jars with larger orifices present in House 47’s assemblage than are present at Main Ridge. There also are a number of jars with a lot larger rim diameters than any other jars at House 47 (Figure 5.5). Courtyard groups, larger jars, and a clear increase in the number of storage structures per habitation room may suggest that restricted sharing may have been important at House 47; whereas, these types of interactions were less important for Main Ridge due to the lack of these traits. In other words, the increase in storage structures and larger jars may indicate that families wanted to keep their resources separate from others; however, the communal nature of irrigation maintenance and courtyard groups may subsume some degree of cooperation and sharing. Thus families may have predominately stored and used their own resources; however, if another family did not have enough at any given time, surplus could be given to them from another family. Unrestricted sharing was first noticed by Ford (1972) among the Hopi Indians and later used in mathematical models by Hegmon (1991) that proposed that this type of exchange was the most successful for avoiding subsistence shortfalls in a high risk environment.

These data suggest that, similar to ethnographic southwestern groups, House 47 residents attempted to incorporate higher levels of responses to scarcity once the connections with the uplands were lost. Tentatively, courtyard groups and larger jars may be evidence for restricted sharing among kinship groups. In the model posited above, House 47 residents attempted to incorporate a community based response to stress. However, perhaps this higher level response was insufficient since there is a near dissolution of the Puebloan occupation of southern Nevada not long into the Pueblo III Period.
Figure 5.3: Site map of Main Ridge
Figure 5.4: Site map of House 47
Figure 5.5: Histogram comparing jar orifice diameters at House 47 and Main Ridge

Uncertainty Avoidance Index

All of our resources are in a state of flux. The food we eat, the air we breathe, and the water we drink all are imbued with degrees of uncertainty. Risk management practices allows for the prioritizing of and taking necessary steps to avert or minimize uncertainty and risk. Without managing risk or uncertainty, catastrophic problems may occur. The BP Oil spill in April of 2010 is a clear and horrendous example of the environmental and cultural ramifications a lack of risk and uncertainty management can bring.
As appalling as the BP oil spill was, societies view risk and uncertainty in different ways (Boholm 2010). In other words, what is viewed as “acceptable” risk is dependent on worldview. In response, social psychologists (Hofstede 2001, House et al 2004) developed the Uncertainty Avoidance Index (UAI). These indices reflect how uncomfortable a society feels with ambiguity or uncertainty. Cultures with strong UAI indices tend to exhibit ideas of strong social control and are intolerant of eccentric behaviors. Cultures with low UAI behaviors tend to be comfortable with unstructured environments with little regulations.

In the case of the American Southwest, ethnographic pueblos tend to have a high degree of social control and intolerance of peculiar behavior. Among the Tewa Pueblos, for instance, war chiefs guarded the village, maintained religious hegemony, and guarded against deviations in ideology. War chiefs could punish anyone who refused to participate in ceremonies or who were neglecting social obligations (Arnon and Hill 1979:300-302). This suggests that ethnographic Pueblos had a relatively high avoidance index. This is not surprising considering the high degree of risk involved in pursuing agriculture in a desert environment with low moisture patterns. A lack of risk/uncertainty management behaviors would spell almost certain catastrophe for maintaining an appropriate level of food. As Ford (1972) has pointed out, exchange was used as a way to manage the risk of not having enough food in a highly variable environment.

Consequently, the Virgin Branch Puebloan may have also had a strong Uncertainty Avoidance Index and it is possible that they also used exchange as a way to buffer against uncertain food production. Therefore, it is interesting that they did not trade with the St. George Basin as a way to continue to use exchange as a risk-reducing
strategy. However, the strong UAI may aid in explaining the divergence from the St. George Basin. As mentioned previously, high UAI cultures tend to not like change. If as Allison (2000) suggests, trade networks were based on agricultural rituals between southern Nevada and Arizona, the breakdown of these social rituals would have been detrimental to Puebloan society. Thus exchange with the St. George Basin may not have been a perceived option because those households were not originally included into the directional exchange system between southern Nevada and Arizona.

Conclusions

At some point, all societies will have to manage their resources to cope with changing variability. Many scholars argue that societies have a myriad of responses available to them including: diversification, exchange, mobility, and storage (Winterhalter 2000; Halstead and O’shea 1989). In many cases, these responses can be combined to create a more effective response. For the American Southwest, storage and exchange were probably the two most used coping mechanisms to deal with resource variation after the Archaic Period (see Harry et al 2013, Cordell 2007).

Many ecological studies propose that exchange works best as a buffering strategy when communities are situated in different environmental zones (see Abruzzi 1989). It was hypothesized that Virgin households in southern Nevada would have traded more with the St. George Basin during the Pueblo III period to stymie the loss of trade with the uplands. Current data suggest that trade may not have occurred between southern Nevada and the St. George Basin. This is interesting because of the possibility of needing other resource buffering mechanisms for households living in southern Nevada and the St.
George Basin. The Virgin River, which flows through the St. George Basin, is fed by snow melt from nearby mountains. In this case, the Puebloan peoples in the St. George Basin would have farmed by floodwater. If there was not enough moisture in the St. George Basin after the collapse of the upland trade networks to sustain agricultural yields, the residents would have been under extreme subsistence stress. Although the Muddy River in southern Nevada is spring fed and thus has little variation in discharge rates, the water contains salt. Any increase in salt would have contributed to the salinization of surrounding farmlands and thus would have been also detrimental to southern Nevada. Admittedly, very little environmental studies have been done in southern Nevada so it is unclear if salinization was or ever became a problem for prehistoric peoples. However, the potential for salinization would have certainly caused the need for different strategies for reducing resource stress.

Although little data exist on the Lost City Complex due to how it was originally excavated, there does seem to be some evidence that different responses were attempted to alleviate resource stress. As Minnis (1985) has argued, when resource stress increases, so does inclusivity. Thus if households cannot alleviate stress, then community or extra-community responses can be activated. Based on site layout and an increase in jar rim diameters, House 47 may have attempted to incorporate an unrestricted sharing response to stress. However the insular nature of House 47 may have caused a severe breakdown in social rituals that were important in the Pueblo II Period (see Allison 2000).

It has been further argued that the reason for the lack of trade between the St. George Basin and southern Nevada may have been from a high score on the Uncertainty Avoidance Index (UAI). Social psychologists have found correlations between societies
that have a high UAI and ideas of social control and a general dislike for change. Based on these characteristics, the Tewa and other tribes of the historic Southwest may possess a high UAI because of the risks associated with farming in an environment with highly variable moisture patterns. Thus prehistoric peoples in some regions of the Southwest may have also had a high UAI due to having a similar subsistence strategy. Consequently, trade with the St. George Basin may have been viewed as inappropriate because that region was not part of the original social rituals between southern Nevada and the Arizona Strip.

Although this project does not offer any conclusive results, this research provides valuable information on risk sensitivity and avoidance in marginal environments. As humans approach the limits of the carrying capacity of their environment, local populations may attempt alternative strategies to alleviate stress. Furthermore, there is an enormous potential for an interdisciplinary sharing of theory and models. Archaeologists, anthropologists, and psychologists interested in human responses to risk can collaborate to understand the exact perceptual and social mechanisms by which humans assess and respond to risk. The unique contribution of archaeology to risk adaption research is the vast temporal scale. Archaeology can provide valuable information on what adaptive mechanisms worked and which did not. With this type of information, we can understand how different societies respond to risk, uncertainty, and disaster and better respond to each unique circumstance in the present and future.
Future Directions

This study could be improved by a more systematic and widespread sampling of raw clay and sand sources. In particular, more samples from both Mesa tops and valleys in the St George Basin, Moapa Valley, and near Mesquite, Nevada would aid in determining the available geologic sources for the production of Tusayan Virgin Series ceramics. It is possible that prehistoric potters could have obtained clays and sands from mesa tops, valleys, and near rivers. Characterizing a wider range of geologic formations will allow for a better comparison of the raw sources available to prehistoric potters.

This pilot study has verified that geochemistry is a useful method for investigating ceramic production and exchange in the lowland Virgin region. Additionally, more ceramics should undergo Neutron Activation Analysis from the Moapa Valley, the Mesquite, Nevada locality, and the St. George Basin. This would allow a more complete understanding of vessel movement and production in the lowlands. Moreover, the sand tempered ceramics from the Shivwits Plateau should be compared to the ceramics found in southern Nevada and the St. George Basin. It is possible that only one or both of these localities were trading with the uplands in northern Arizona. Lastly, this research provides a starting point to test more involved and complex research questions into the production and movement of Tusayan Virgin Series ceramics in southern Nevada.
### Appendix: Mahalanobis Membership Probabilities

Table 1: Mahalanobis Membership Probabilities for Samples Belonging to Group 1

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Table 6: Mahalanobis Membership Probabilities for Unassigned Samples

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Table 8: Mahalanobis Membership Probabilities for Muddy Creek Sand and Clay Mixtures Belonging to Groups 1 and 2.

<table>
<thead>
<tr>
<th>ANID</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>TJM051</td>
<td>0.000</td>
<td>0.052</td>
</tr>
<tr>
<td>TJM052</td>
<td>1.877</td>
<td>0.078</td>
</tr>
<tr>
<td>TJM053</td>
<td>0.089</td>
<td>0.157</td>
</tr>
<tr>
<td>TJM054</td>
<td>0.000</td>
<td>0.298</td>
</tr>
<tr>
<td>TJM055</td>
<td>0.009</td>
<td>0.005</td>
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</tbody>
</table>

Table 9: Malahanobis Membership Probabilities for Yamashita Sand and Muddy Creek Clay Mixtures Belonging to Groups 1 and 2.

<table>
<thead>
<tr>
<th>ANID</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>TJM051</td>
<td>0.001</td>
<td>0.062</td>
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<tr>
<td>TJM052</td>
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<td>TJM053</td>
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<td>0.304</td>
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<tr>
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<td>0.002</td>
<td>0.005</td>
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</table>
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Winslow, Diane L. and Lynda Blair


Winterhalder, Bruce


Winterhalder, Bruce, Flora Lu, and Bram Rucker

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Education

2014 M.A in Anthropology and Ethnic Studies, University of Nevada, Las Vegas

2010 B.A. in Art History and Archaeology, University of Missouri Columbia

Summa cum laude

Relevant Coursework: Archaeological and Historic Preservation: Laws and Practice, Lithic Analysis, Environmental Archaeology, Computing for Anthropologists, Archaeology of the American Southwest, Statistics, Ceramic Analysis

Grants and Honors

2014 Graduate and Professional Student Association Research Forum, University of Nevada Las Vegas, Poster Award: Honorable Mention


2013 Graduate and Professional Student Association Research Sponsorship Program, University of Nevada Las Vegas ($1,200)

2013 Rocchio Research Grant – Department of Anthropology, University of Nevada Las Vegas ($620)

2013 Angela Peterson Research Grant – Department of Anthropology, University of Nevada Las Vegas ($1,400)

2013 Nevada Archaeological Association Research Grant ($1,000)

2013 Nevada Archaeological Association Best Poster Award ($100)
2013  National Science Foundation Graduate Research Fellowship: Honorable Mention

2013  University of Missouri Research Reactor Subsidy Program. For project titled: “Examining the Production and Exchange of Moapa Wares in the Virgin Branch Puebloan Region.” Co-PI with Karen G. Harry (Amount subsidized: $14,980)

2012  National Science Foundation Graduate Research Fellowship: Honorable Mention

2005  Bronze Palm Eagle Scout: Boy Scouts of America

**Professional Experience**

2013-present  *Laboratory Director* – University of Nevada Las Vegas. Directed by Dr. Karen G. Harry  
Duties: Cataloging and Accessioning artifacts, supervising and instructing students in archaeological laboratory methods, ceramic analysis, report writing, managing active laboratory projects.

2012-2013  *Graduate Assistant* – University of Nevada Las Vegas. Directed by Dr. Karen G. Harry  
Duties: Accessioning artifacts, interpreting compositional data, supervising and instructing undergraduates in ceramic analysis, and archaeological field methods.

2011-2012  *Senior Research Assistant and Technician* – University of Missouri Research Reactor: Archaeometry Group. Columbia, Missouri  
Duties: Manage student technicians, collect and interpret chemical data from neutron activation analysis (NAA), X-ray fluorescence (XRF), and laser ablation mass spectrometry (LA-ICP-MS) experiments, compile and write technical reports, manage incoming and outgoing projects.

2010-2011  *Student Technician* – University of Missouri Research Reactor: Archaeometry Group. Columbia, Missouri  
Duties: Prepare and irradiate samples, record data in log books, compile data to aid in creating an online database for compositional data.

Summer 2009  *Curator Intern* – Art History and Archaeology Museum. Columbia, Missouri  
Description: Collaborate with museum professionals on researching, designing and setting up exhibits on the “sacred feminine” in archaeology.
Field Experience

Summer 2014 *Crew Chief/Field Director*, Shivwits Archaeological Field School, Parashant National Monument, Arizona. Excavations on a small pueblo. (5 weeks)

Summer 2013 *Crew Chief*, Shivwits Archaeological Field School, Parashant National Monument, Arizona. Excavations on pueblo and roasting pits. (5 weeks)

Fall 2012 *Crew Chief*, Lost City Research Project, Overton, Nevada. Excavations at House 47 of the Lost City Complex. (4 weeks)

June 2011 *Crew Member*, Shivwits Research Project, Parashant National Monument, Arizona. Excavations on a small pueblo. (1 week)

Summer 2010 *Crew Member*, Shivwits Archaeological Field School, Parashant National Monument, Arizona. Excavations at Granary House and Site 82, pedestrian survey, site mapping. (6 weeks)

June 2007 *Crew Member*, Arbeia Roman Fort Excavations, South Shields, England. Excavations on barrack buildings and granary. (2 weeks)

June 2006 *Crew Member*, Cahokia Mounds, St. Louis, Missouri. Excavations on eastern palisade and lithic workshop. (2 weeks)

Publications


Unpublished Technical Reports


### Presentations and Professional Papers


### Public Service

2014  Department of Anthropology Open House (UNLV), Anthropology Graduate Mentorship Program (UNLV)

2013  Decker Elementary School Career Day, Department of Anthropology Open House (UNLV), Anthropology Graduate Mentorship Program (UNLV)

2012  Department of Anthropology Open House (UNLV)

### Professional Organizations

Society for American Archaeology, Nevada Archaeological Association, Anthropology Society (University of Nevada Las Vegas)