Prehistoric Archaeology in Range Creek Canyon, Utah: A Summary of Activities of the Range Creek Field Station

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Range Creek Canyon is a rugged and remote, mid-elevation canyon in the West Tavaputs Plateau, Utah. The canyon has received much attention because of its remarkably intact record of an intense Fremont occupation from A.D. 900 to 1200. To date, 470 sites have been recorded with only a fraction of the canyon having been surveyed. The University of Utah has held its Archaeological Field School in Range Creek Canyon annually since 2003. This article focuses on the results and direction of research at the University of Utah's Range Creek Field Station, which was established in 2009 for the long-term study, management, and preservation of this rich archaeological resource. Ongoing projects include survey, subsurface testing, experimental farming, wild plant procurement, and paleoenvironmental studies.

Range Creek Canyon is a rugged and remote canyon located in east-central Utah on the West Tavaputs Plateau on the border of Carbon and Emery Counties (Figure 1). Range Creek is a perennial stream draining approximately 145 square miles into the Green River. The elevation ranges from 10,200 ft at Bruin Point to 4,200 ft at the confluence with the Green River. The work of the Range Creek Field Station and the University of Utah's Archaeological Field School has focused primarily on the canyon below the junction with Little Horse Canyon. This is the northern boundary of the field station, and much of the canyon further to the north is privately owned. The archaeological record in the southern part of the canyon is rich, dense, and largely untouched except by time. The lack of disturbance stems from the remote location and strict limits on access enforced by the previous landowners (the Wilcox Family). The vast majority of the sites recorded to date are associated with the Fremont archaeological complex. The majority of radiocarbon dates from these sites fall within the period of A.D. 900–1200.

The Range Creek Field Station includes about 3,000 acres of the canyon bottom in the southern half of the canyon. The field station was established in 2009

> to facilitate the long-term, orderly, scientific investigation, preservation, and protection of cultural resources in the Range Creek drainage and to provide an educational facility to better prepare college students and other qualified parties for professional careers in the field of natural history and other academic disciplines [Comprehensive Management Plan 2012]

About half of the field station was once part of the Wilcox family ranch which is owned by the Utah School and Institutional Trust Lands Administration (SITLA) and managed by the Natural History Museum of Utah at the University of Utah through a Beneficiary Use Agreement. The same arrangement applies to an additional two sections of SITLA land. The remainder of the field station consists of 280 acres recently

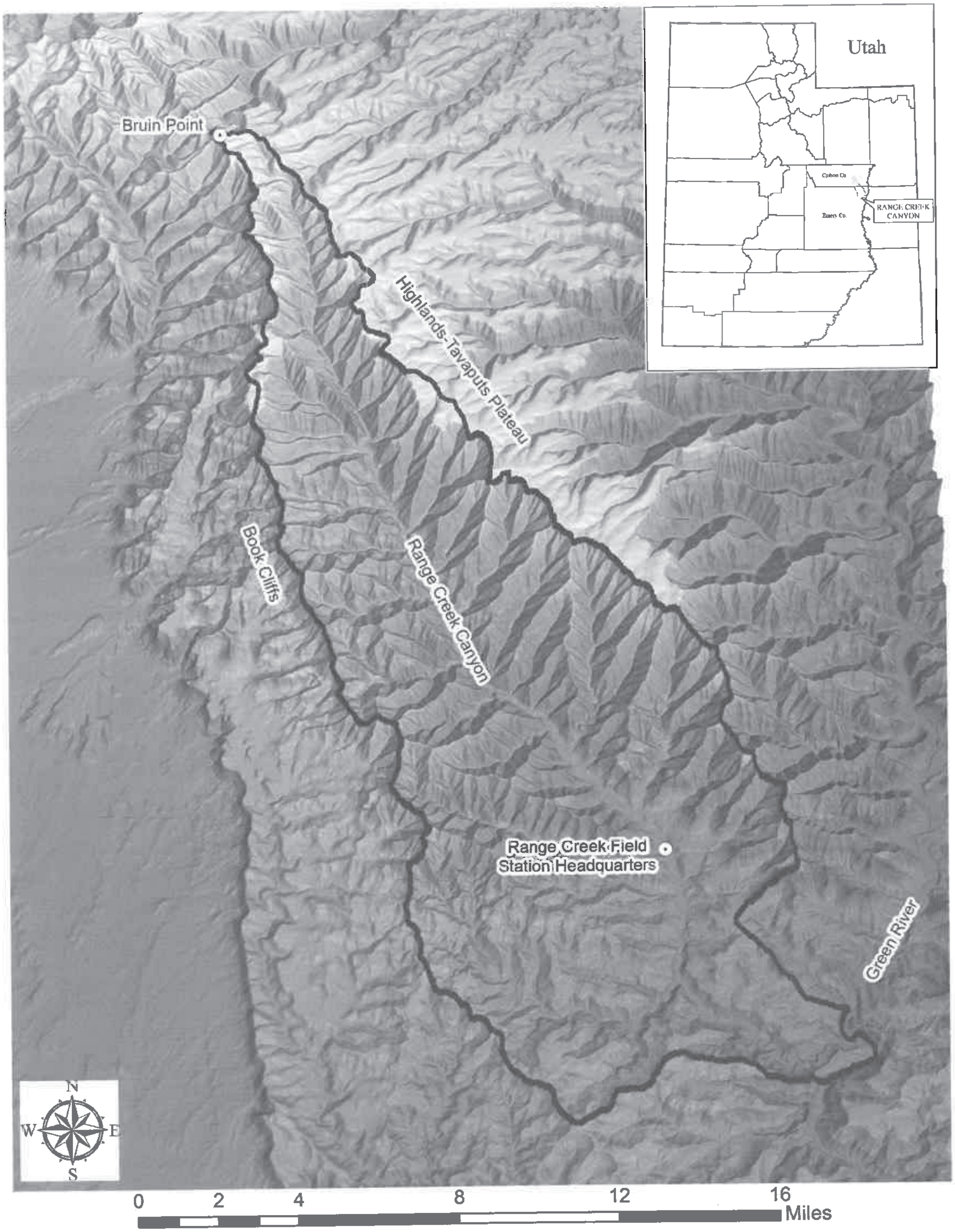

Figure 1. Relief map of Range Creek Canyon showing the hydrologic drainage boundary, major topographic features, and location of the Field Station Headquarters. Inset map of Utah showing location of Range Creek Canyon crossing the border of Carbon and Emery Counties.

gifted to the University of Utah. Management activities on the field station are governed by a conservation easement and a comprehensive management plan. The success of the field station is largely due to the coordinating efforts of SITLA; Utah Division of Forestry, Fire and State Lands; Utah Department of Agriculture and Food; Division of Wildlife Resources; Utah Division of State History and the Bureau of Land Management.

Field stations have a long history in the field of biology—less so in archaeology—but many of the advantages are the same. Field stations provide a spatial focus for diverse but integrated research projects designed to understand a range of ecological questions and phenomena. Field stations provide the time and opportunity to train students in conducting paleoenvironmental and experimental work in the region of archaeological interest. Time is perhaps the greatest benefit of a field station; time to implement elements of research designs that require years to complete, time to discover unique workarounds for the inevitable problems that arise during field operations, and time to employ recent advances in archaeological method and theory.

Project Overview

The University of Utah began work in Range Creek Canyon in 2002 and has conducted an annual Archaeological Field School since 2003 (for summaries, reports, and research designs, see Arnold et al. 2007, 2008; Arnold et al. 2009; Arnold et al. 2010; Arnold et al. 2012; Boomgarden et al. 2014; Metcalfe 2008; Metcalfe et al. 2005; Metcalfe et al. 2012; Spangler et al. 2004; Spangler et al. 2006; Springer and Boomgarden 2012; Yentsch et al. 2010). The Range Creek Field Station's mission is to explore human adaptations of arid-land foragers and farmers within the broader context of Southwestern prehistory. This pursuit requires coordinating paleoenvironmental, experimental, and archaeological investigations. Fortunately, this project does not operate under the time constraints typical of most archaeological investigations conducted in the United States, because the property is protected by a conservation easement which prohibits development projects and the field station provides protection for the archaeological sites and paleoenvironmental proxies by limiting public access.

One of our primary agendas is to teach college-level students the theoretical and methodological aspects of modern archaeological practices. As such, we have geared our research along several critical lines of inquiry to test the validity and/or refine the extant models of what we currently know about Fremont settlement in the canyon. These include chronology, settlement patterns and site structure, and subsistence and storage strategies. Data used to address research questions is gathered primarily by field school students through survey and test excavations.

Until recently, the major emphasis of the field school was to identify and document archaeological sites. This emphasis was largely pragmatic, but also recognized that the Range Creek Field Station was likely to be investigating this canyon for the next 30 or more years. The pragmatic aspect related to the fact that the former Wilcox Ranch, which ultimately became the Range Creek Field Station, was managed by another state agency with little interest in prehistory. Under their management a system for public access, both non-commercial and commercial, was established. While protection for archaeological resources was provided by controlling that access through a permit system and providing daily security patrols, it nevertheless seemed prudent to identify all the archaeological sites that might be visited and potentially impacted.

From a research perspective, identifying the range of sites and their locations is the first step in constructing a statistically justified sampling strategy. We have therefore employed several data collection strategies. These include: 1) intuitive archaeological surveys on the canyon floor as well as higher elevations, 2) systematic survey, and 3) limited test excavations. A summary of the ongoing survey and subsurface testing are presented below.

Survey

During the field school, most of the field time is spent instructing students in systematic and intuitive survey techniques. Each summer we try to conduct systematic surveys of several 1 km^2 quadrats. This survey contributes to obtaining a randomly selected 10% sample of the area drained by Range Creek. A total of 440, 1 km^2 quadrats, aligned to the 1000 m increments of the Universal Transverse Mercator (UTM) coordinate system, are required to cover the entire watershed. Forty-four of these 440 quadrats were randomly chosen for survey beginning in 2003. Thirty-six of the randomly selected blocks are located in the southern half of Range Creek Canyon, adjacent to the Field Station's property. These thirty-six have been the focus over the last twelve years and seventeen have been completed (Figure 2) including substitutions of nearby quads when the terrain has proved too difficult to access or the randomly selected block crosses private property. We intend to survey the remaining nineteen blocks over the next twenty years. The remaining incomplete survey blocks are located on BLM wilderness study area and require crews to stay overnight at remote camps. We completed systematic surveys of the bottoms of most of the side canyons that drain into Range Creek Canyon and a 100 m wide, 15-mile long road survey inside the field station gates. Since 2002, there have been several large fires that have impacted the valley floor. After each fire, we systematically surveyed and recorded sites that were previously hidden by the thick vegetation that covers the valley floor. Fires that caused significant impacts at lower elevations occurred in 2003, 2007, and 2012.

Crews continue to conduct intuitive survey as they are working in the canyon on revisits or other projects. When an area that has not been formally surveyed is visited, staff members often find unrecorded archaeological sites. Intuitive survey includes technical climbs to high elevation ridgelines and pinnacles that while extremely precarious to ascend, nonetheless show evidence of Fremont occupation.

Currently, there are 470 identified sites in the University of Utah's Range Creek database: 446 prehistoric, 21 historic, and 3 multi-component sites (Figure 1). The sites are scattered relatively evenly along the valley, north to south and up onto the ridgelines that lead into the main canyon, with only a few outliers. The sites are classified into the following types: residential, storage, rock art, artifact scatters, and combinations of these. Residential sites are those with surface architecture (rock alignments, stacked walls, etc.) and a diverse artifact assemblage. A particularly interesting subset of these appear to be residential sites located at least 200 ft. above the valley floor on sheer sandstone pinnacles and ridgelines. Storage sites include granaries, cists, and artifact caches of various sizes, shapes, locations, and construction types. Petroglyphs and pictographs of anthropomorphic and zoomorphic figures, shields, and various abstract and curvilinear symbols are found throughout the canyon. While most of these appear to fit firmly into the style attributed to the Fremont, there are some rock art panels that appear to have been executed during the Archaic and Protohistoric Periods. Sites associated with source materials for lithic and ceramic production have been searched for extensively but have not been identified within the canyon.

Revisits

A site revisit/monitoring strategy has been implemented to systematically monitor the condition of archaeological sites through time based on a vandalism study conducted in 2006 (Spangler et al. 2006). Sites within 4 km of the north gate and 200 m of the road (Class I) were categorized as those at the highest risk (Figure 3). Class I sites are monitored on a rotating basis so that each is reassessed every three years. Class II sites are defined as being within 2 km of the south gate and 200 m from

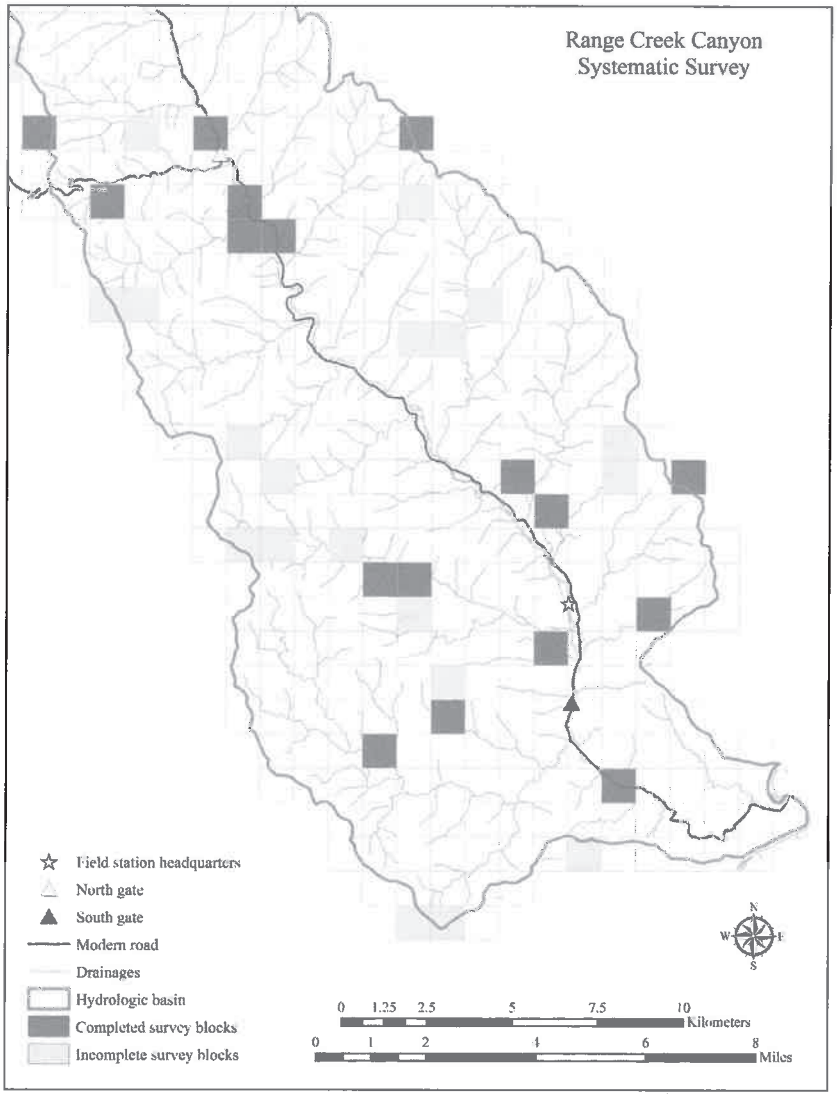

Figure 2. Map of Range Creek Canyon showing the location of randomly selected 1x1 km survey blocks. Seventeen blocks have been systematically surveyed between 2003 and 2013.

the main road. This set of sites is monitored on a five-year rotation and those in Class III (all other sites) on a ten-year rotation (Figure 3). As sites are revisited (and new sites discovered), lengths of rebar are strategically placed as permanent photographic datums in locations to best document the condition of cultural features evident on the surface. Photographs taken from a photo datum can be compared, year-after-year, to visibly document changes to the sites. Crews use the revisits to update the IMACS forms with descriptions of features and artifacts that were not previously recorded or which cannot be relocated since the previous recording. Crews also confirm the location and access information using the most up-to-date technology available.

By the summer of 2013, field school crews had completed all of the Class I and Class II sites and were working on the Class III revisits. Completing a revisit to all 470 sites in

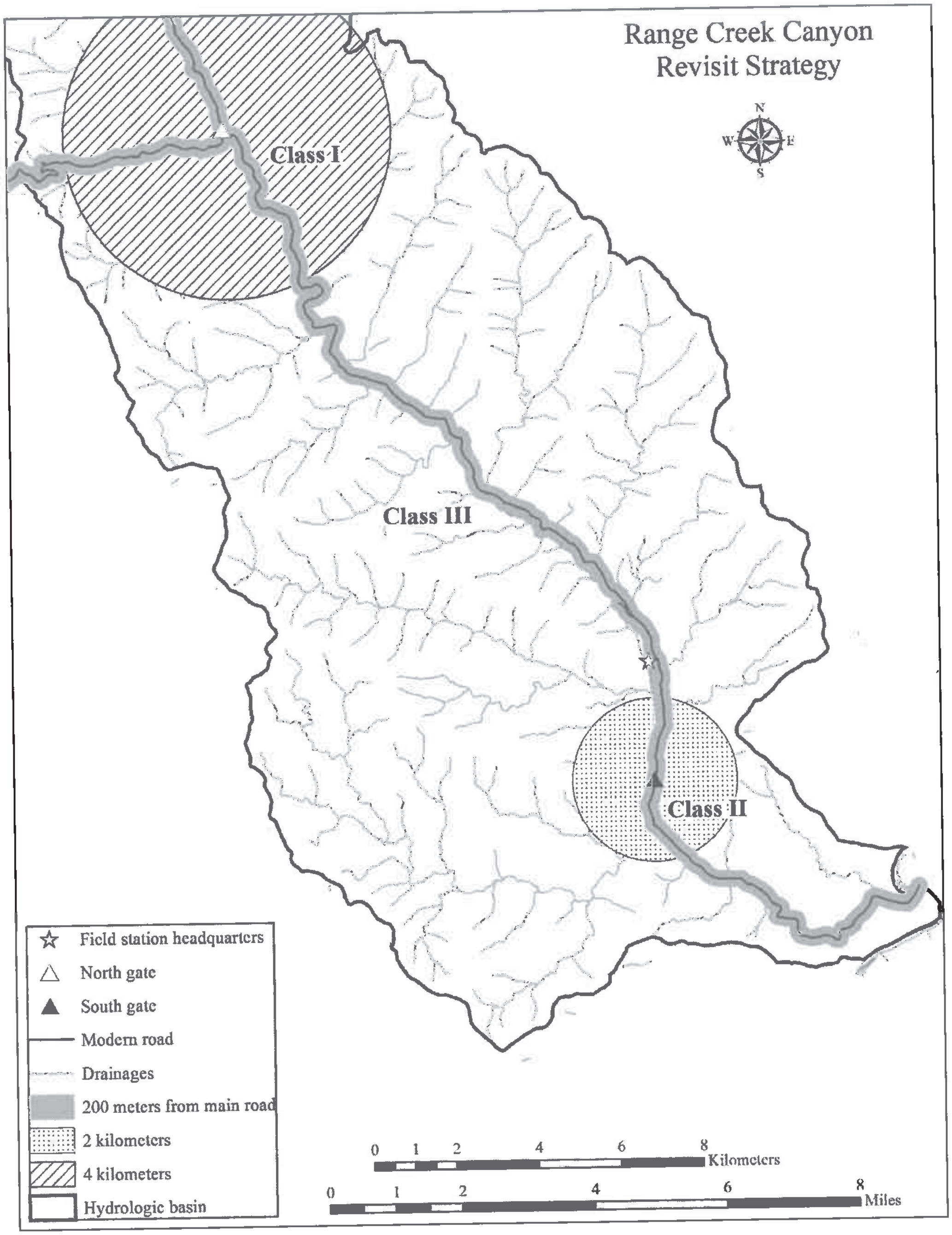

Figure 3. Map of Range Creek Canyon showing the ranking of archaeological sites into three classes based on location and public accessibility. Sites are being revisited on a rotating schedule.

the database is many years off, but the second revisit to the Class I sites is the next step. After a second revisit, we will be better able to assess how well the monitoring strategy is working for site management and protection.

Subsurface Testing

The goal of our limited test excavations (other than training advanced undergraduate and graduate students) is to quantify a set of basic characteristics for archaeological sites in Range Creek Canyon. Specifically we hope to characterize the range of variability in site structure, assemblage variability, feature composition, stratigraphic integrity, preservation, and chronology. We have tested three village sites, but over the last 5 years we have focused on 42EM2861 (Big Village). Big Village is a large (50 m x 115 m) residential site centrally located in Lower Range Creek Canyon, at an elevation of 1,706.6 m (5,600 ft.), on the toe of a west-sloping ridge. The site is located on lands administered by the SITLA and leased by the University. It was recorded on IMACS in 2003 by the Price Chapter of the Utah Statewide Archaeological Society (USAS) under the supervision of Pam and Blaine Miller. Six surface features were described as relatively large and roughly circular alignments of large sandstone boulders and slabs, some set on end. Also noted were three concentrations of charcoal-stained sediment thought to be evidence of middens and a concentration of artifacts in the flat open area near the center of the site. The artifact assemblage consisted of beads, projectile points and other flaked stone tools, debitage, ground stone, and Fremont grayware.

Six test trenches have been excavated at Big Village to explore four of the surface rock alignments and the large open area at the center of the site (Figure 4). These locations were chosen to investigate the variability in surface evidence present, each offering the opportunity to expose structures of varying form and function. In 2008, Time Team America filmed a documentary-style reality show in Range Creek Canyon. Their crews assisted in our excavations and conducted geophysical scans of Big Village under the direction of Dr. Meg Watters. The scans exposed several areas beneath the ground surface that appeared to have burned, both interior and exterior of visible rock alignments. These scans factored into the positioning of our test trenches relative to the surface alignments.

Over several field seasons, Dr. Richard Terry (Brigham Young University), sampled surface soils systematically across village sites and from several of our excavations, to look for geochemical elements associated with prehistoric human activities (Burnet et al. 2011; Eberl et al. 2012; Terry et al. 2012). At Big Village, Terry was looking specifically for evidence of high levels of phosphorus inside *vs*. outside structures that would indicate food related activities. Dr. Terry collected surface samples from an area approximately 25 x 25 m that included two surface features. He did not find significantly higher levels of phosphorus levels within the surface rock alignment features. Two locations show the highest levels of phosphorous (180–210 mg/kg) and both were found outside of the two surface features in the sample area (Terry 2008).

Shallow Burned Pithouse

Trench 1 exposed a large burned pit structure (Figure 4). This shallow pithouse was filled with the collapsed remains of a wood superstructure. The outer layers of a burned beam lying on the bedrock floor of the structure dated to 960 B.P. ± 15 (PRI-08-102-1; wood charcoal; δ^{13} C = -22.4 ‰) with a 2σ calibrated date range of cal A.D. 1020–1160 (calibrated at 2σ with the program IntCal 13, OxCal 4.2 [Bronk Ramsey 2009], see Table 1). A burned upright post in the floor of the pithouse dated to B.P. 1153 ± 24 (UGAMS-3947; wood charcoal; δ^{13} C = -20.43 o/oo). with a 2σ calibrated date range of cal A.D. 770–970 (calibrated at 2σ with the program IntCal 13, OxCal 4.2 [Bronk Ramsey 2009], see Table 1). A clay rimmed hearth was exposed at the center of the structure and the edge of the feature was exposed on the west side. Assuming that the hearth was centrally located, the pit structure was approximately 8 m in diameter. A total of 759 artifacts including 50 bone fragments, 399 ceramic sherds, 294 lithic flakes, 4 projectile points, 3 bifaces, 3 groundstone fragments, and 1 bead were collected from the multi-year

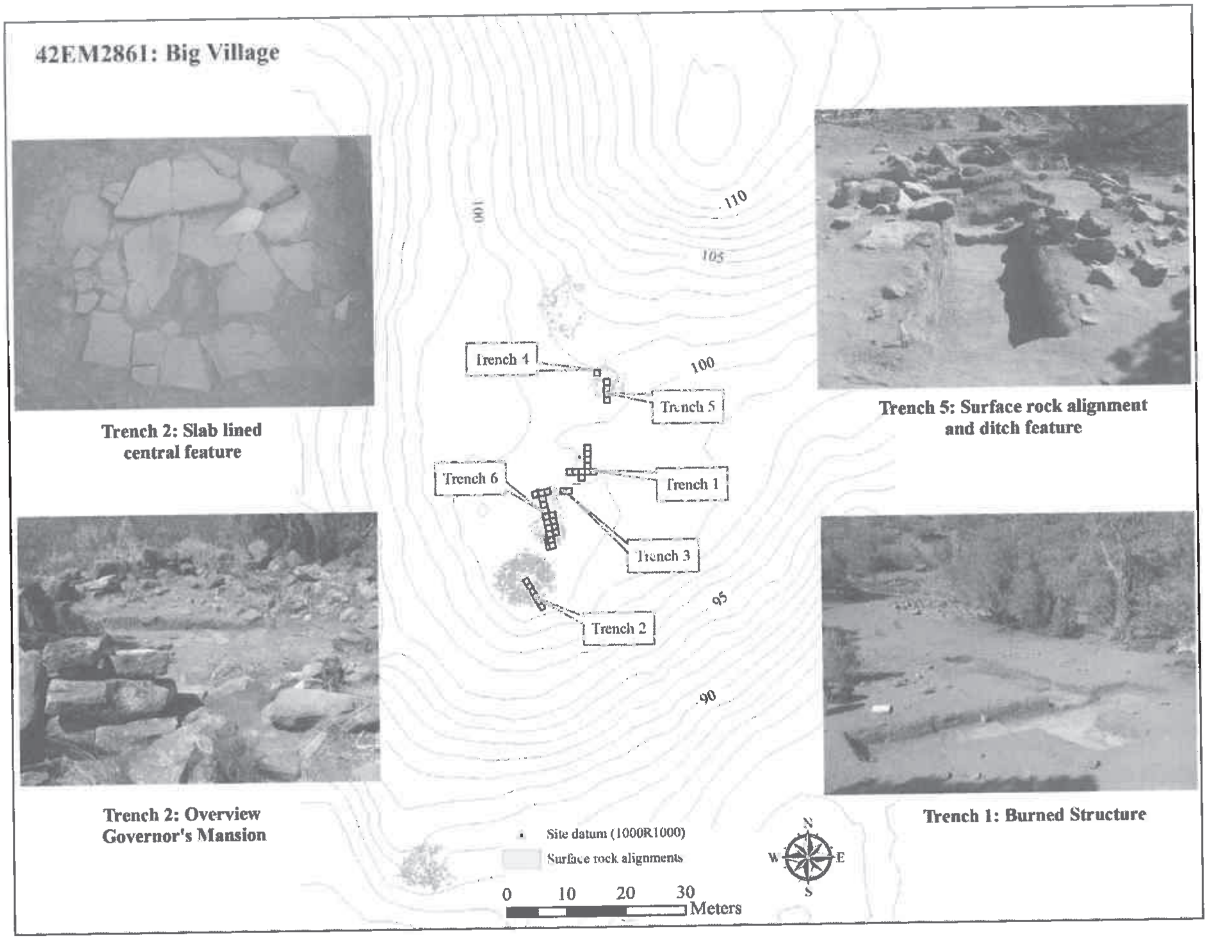

Figure 4. Contour map of Big Village showing the location of surface rock alignments, test excavations conducted over the last seven years, and photographs of the excavations.

excavation of this feature. The majority of the artifacts came from the burned stratum (3–7 cm in thickness) at the interface with the bedrock floor (n = 202) and the overlying loose surface sediment 3–5 cm in thickness (n = 427).

Governor's Mansion

The large surface rock alignment/rubble mound, nicknamed the Governor's Mansion, is located on the southeast side of the site (Trench 2, Figure 4). It is one of the most substantial surface rock alignments identified in Range Creek Canyon. It is composed of locally available tabular rocks placed in a roughly circular alignment. Some of these rocks weigh well over 100 kilograms including some that are set with their long axes vertical. The interior diameter of the feature is approximately 3.5–4 m and the outside diameter, including all the fallen debris, measures 8 m. A few sections of the alignment still show some horizontal coursing. Given that sediment accumulation at this edge of the ridge appears to be very thin, a pithouse in this location would be very shallow.

Accounts from the previous landowner and surface evidence indicated that this structure had been damaged prior to excavation. It was therefore not surprising that the excavation resulted in more questions than answers. No clear residential features were identified, e.g. hearth, roof material, posts. Geophysical scans showed

Table 1. Radiocarbon dates from Range Creek Canyon.

Site Number	Sample No.	Material Type	Isotopic Value	Radiocarbon Age (BP)		Calibrated Age (AD)*			Provenience
				Mean BP	SE	Low	High	Median	
42Em3315	Beta-235068	unburned plant	-22.6	110	60	1670	1950	1830	Wild tobacco bundle
LC-13-06	UGAMS-16506	unburned plant	-24.9	880	25	1040	1220	1170	Wood from granary
42Em2861	UGAMS-12221	charcoal	-22.50	900	20	1040	1210	1110	Beam from pithouse
42Em3213	Beta-202190	wood	-22.9	930	40	1020	1190	1100	Beam from pithouse
42Em3048	UGAMS-3951	unburned plant	-11.42	932	24	1030	1160	1100	Corn cob
42Em3585	Beta-214831	unburned plant	-23	940	40	1010	1190	1100	Snares
42Em3217	UGAMS-12220	unburned plant	-23.2	940	20	1030	1160	1100	Binding from granary
42Em2885	Beta-175755	unburned plant	-9.1	940	50	1000	1220	1100	Corn cob
42Em2886	UGAMS-3950	unburned plant	-23.74	948	23	1020	1160	1100	Basket
42Em0019	Beta-235067	charcoal	-21.1	950	40	1010	1190	1100	Beam from pithouse
42Em0761	Beta-202189	unburned plant	-21.1	950	40	1010	1190	1100	Grass
42Em2837	Beta-175753	unburned plant	-8.7	950	40	1010	1190	1100	Corn cob
42Em0019	UGAMS-3944	charcoal	-20.36	951	24	1020	1160	1100	Hearth
42Em3424	UGAMS-3952	unburned plant	-10.63	958	23	1020	1160	1100	Corn cob
42Em2861	PRI-08-102-1	charcoal	-22.4	960	15	1020	1160	1100	Beam from pithouse
42Em3998	UGAMS-3953	unburned plant	-20.78	963	24	1050	1160	1100	Snares
42Em2885	UGAMS-3949	unburned plant	-10.65	965	23	1010	1160	1090	Corn cob
42Em4318	UGAMS-12223	unburned plant	-10.30	980	20	1010	1160	1040	Corn cob
42Em0741	Beta-202191	wood	-21.7	980	40	990	1160	1080	Beam from granary
42Em3117	Beta-202188	unburned plant	-9.5	980	40	990	1160	1080	Corn cob
42Em3294	Beta-214832	unburned plant	-22.8	990	40	980	1160	1050	Arrow
42Em2849	Beta-203630	unburned plant	-8.9	1000	40	970	1160	1030	Corn cob
42Em3359	UGAMS-12222	wood	-25.2	1010	20	980	1040	1020	Binding from granary
42Em4261	UGAMS-12219	unburned plant	-9.50	1050	20	960	1030	1000	Corn cob
42Em0019	UGAMS-3945	charcoal	-20.35	1053	24	900	1030	1000	Beam from pithouse
42Em2843	UGAMS-3946	unburned plant	-27.97	1077	24	890	1020	970	Arrow

*Calibrated using IntCal 13, OxCal 4.2 (Bronk Ramsey 2009)

Table 1. continued

Site Number	Sample No.	Material Type	Isotopic Value	Radiocarbon Age (BP)		Calibrated Age (AD)*			Provenience
				Mean BP	SE	Low	High	Median	
42Em2861	UGAMS-16504	charcoal	-25.2	1115	24	880	990	940	Hearth
42Em2881	Beta-175754	unburned plant	-10.9	1130	40	770	990	920	Corn cob
42Em2865	UGAMS-3948	unburned plant	-11.43	1133	23	770	990	930	Corn cob
42Em2861	UGAMS-3947	charcoal	-20.43	1153	24	770	970	890	Beam from pithouse
42Em2861	UGAMS-16505	charcoal	-21.50	1185	24	770	940	830	Hearth
42Em2861	UGAMS-16503	charcoal	-22.30	1540	24	420	580	490	Hearth
32Em3170	Beta-202187	unburned plant	-26	1660	40	250	540	390	Basket

*Calibrated using IntCal 13, OxCal 4.2 (Bronk Ramsey 2009)

only faint evidence of an interior anomaly but upon excavation the center did not have a typical hearth, but rather a collection of tabular rocks arranged in an oval shape (Figure 4). Charcoal stained soil lenses and flecks of charcoal were found throughout the trench but there was no burned material associated with the interior slab feature. At present the function of this tabular feature is unclear but a sample was taken for pollen and starch analysis.

One hypothesis is that the structure was a large surface storage feature. Samples were collected under the direction of Dr. Richard Terry to compare the interior phosphorous levels with those outside the feature and with other features on the site. The reasoning was that high phosphorous levels inside the feature might indicate the decomposition of a significant amount of organic remains compared to outside the feature (Burnet et al. 2011; Eberl et al. 2012; Terry et al. 2012). Terry's analysis did not find a significant difference in phosphorus levels within structures *vs*. outside at Big Village. Governor's Mansion did not have the elevated levels of phosphorus that would indicate use of the feature to store organic material.

A total of 551 artifacts were collected from the multi-year excavation of Trench 2 (94 from exterior deposits and 457 from interior deposits). Artifacts from the fill of the structure include 42 bone fragments, 80 ceramic sherds, 311 lithic flakes, six bifaces, and five beads. A single burned corn cob fragment was found in the screens. The majority of the artifacts came from the stratum deposited above and at the interface with the slab lined feature (n = 270).

Burned Anomalies

Trenches 3 and 4 were excavated in 2008 to investigate anomalies recorded by the Time Team America geophysical analysis (for full descriptions of the Time Team America findings, see Arnold et al. 2008). The magnetometer scans showed areas of intense burning below the surface sediments. A 2 x 1 m test trench (Trench 3) was excavated southwest of the large pit structure excavation of Trench 2 (Figure 4). It was thought that the isolated, heavily burned spot might be an outdoor hearth associated with the pit structure. It was determined to be a natural burn, and not a cultural feature. The excavation of Trench 3 yielded 151 artifacts.

The second anomaly was located on the northwest edge of a circular rock alignment on the north end of the site (Trench 4, Figure 4). This feature showed three small heavily burned anomalies along the edges of the rock ring and a lightly burned central anomaly. We thought that these features might represent burned posts and a central hearth associated with a residential structure. Because of time constraints, only part of a 1 m^2 test unit was excavated and the anomaly was not discovered. Further excavation was necessary to understand the subsurface character of this feature, but in 2009 it was decided that Trench 4 would not be reopened. Twenty-four artifacts were collected.

Circular Rock Alignment

Trench 5 was established to investigate three small heavily burned anomalies along the edges of the circular surface rock alignment and a lightly burned central anomaly. The circular rock alignment is roughly 4 m in diameter and is composed of medium-sized unmodified sandstone boulders. Although none of these rocks exhibit signs of stacking, several along the northern edge of the alignment have been oriented on their long axis, suggesting intentional placement.

Trench 5, a 1 x 4 m test trench, was excavated in the southwest portion of the feature (Figure 4). This test provided no evidence that the circular alignment was a residential structure and failed to locate the burned anomalies identified on the magnetometer scans. However, a subsurface, u-shaped, linear feature was exposed running north-south beneath the rock alignment. This ditch-like feature is wider and deeper on one end, measuring 165 x 47 cm, and narrower and shallower on the other end, measuring 120 cm wide and 31 cm deep. Because of the limited nature of this excavation, we were unable to identify a relationship between the subsurface linear feature and the surface rock alignment. The excavation yielded 196 artifacts including two bone fragments, 125 lithic flakes, 54 ceramic sherds, four bifaces, and two beads.

Superimposed Structures

Excavation of Trench 6 revealed the first example of feature superposition in Range Creek Canyon with at least three superimposed features exposed in the trench (Figures 5 and 6). A larger scale excavation is needed to fully understand the sequence of occupation and the relationship of the features. Thus far, it is clear that there are two residential structures. The older structure, Structure 1, measures 8.8 m long in profile (Figure 5). It was defined by the presence of a collapsed burned roof layer consisting of patchy hardened clay and intact carbonized beams lying on an unprepared floor; the floor has a clay-rimmed, slab-lined, central hearth (Figure 6). A sample from the outer layers of a roof beam dated to 900 B.P. ± 20 (UGAMS-12221 δ^{13} C = - 22.50 o/oo) with a 2σ calibrated date range of cal A.D. 1040–1210 (calibrated at 2σ with the program IntCal 13, OxCal 4.2 [Bronk Ramsey 2009], see Table 1). The hearth located at the center of Structure 1 was dated to 1540 B.P. ± 24 (UGAMS-16503; wood charcoal; δ^{13} C = -22.30 o/oo) with a 2σ calibrated date range of cal A.D. 420–580 (calibrated at 2σ with the program IntCal 13, OxCal 4.2 [Bronk Ramsey 2009], see Table 1). Given the stratigraphic location of this feature and those dated beneath it, this would result in an age reversal. We suspect that this date is from old wood. Unfortunately, only a single piece of charcoal was recovered from this excavation and the rest of the fill was ash. Bulk sediment was collected from this feature but has not been analyzed. Perhaps floatation of this material will provide a higher quality datable material.

Structure 2 is located directly above Structure 1 in the southern half of Trench 6 (Figures 5 and 6) and measures nearly half the diameter of the underlying structure. This structure consists of a flat unprepared floor, a slab-lined central hearth, and a circular rock slab wall stacked two courses

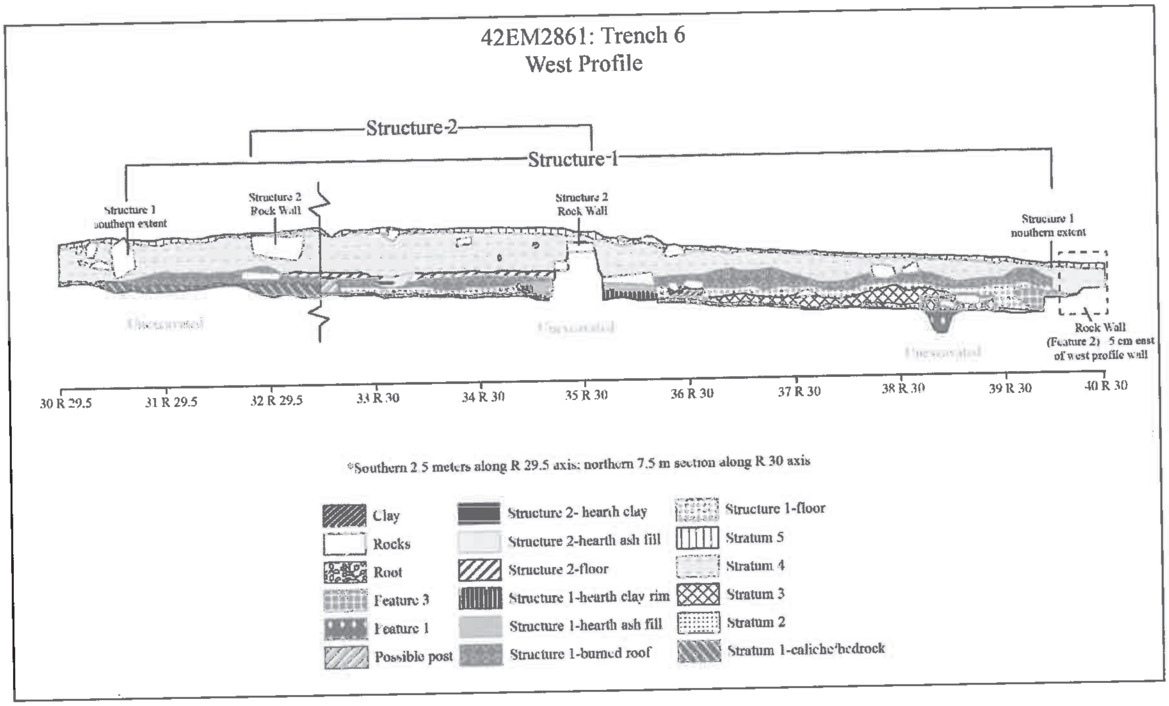

Figure 5. West profile of Trench 6 showing the stratigraphy associated with two superimposed residential structures and associated interior features.

high (Figure 6). The associated surface rubble suggests the walls were stacked several courses higher, but have eroded and fallen in a circular pattern around the perimeter. The wall of Structure 2 bisects the central hearth of Structure 1 (Figure 6).

In addition to the two structures, Trench 6 partially exposed several other features. These include a possible post, a bedrock feature tentatively designated as a roasting pit (Feature 1), another rock wall (Feature 2) bisecting the northern end of the trench, and a hearth (Feature 3) on the north end beneath the rock wall that appears to 'float' in the depositional layers unrelated to surrounding features (Figures 5 and 6).

Feature 1 (Figure 5, 38R30, and Figure 6) is a charcoal filled pit capped with two layers of stone slabs. The shape and extent of this feature is unknown as only a small portion was exposed in Trench 6, and an even smaller portion has been excavated. Several of the stacked stone slabs were removed on the southern edge of the feature and the charcoal fill beneath these was removed and collected down to bedrock. The maximum depth of the excavated pit is 35 cm. Charcoal was also collected from between the stone slabs. A sample taken from the bottom of this feature dated to 1115 B.P. ± 24 (UGAMS-16504; wood charcoal; δ^{13} C = - 25.2 o/oo) with a 2σ calibrated date range of cal A.D. 880–990 (calibrated at 2σ with the program IntCal 13, OxCal 4.2 [Bronk Ramsey 2009], see Table 1). Further excavation is needed to understand the form and function of this feature and its relationship with the surrounding structures.

The rock alignment (Feature 2) was discovered in the northernmost unit (Figures 5 and 6). The alignment consists of five boulders (possibly more unexcavated) with at least one placed up-right with a pointed end placed into a hole. Three of the boulders were exposed in profile bisected at an angle by Trench 6 with the other two boulders visible in alignment on either side of the trench and assumed to be part of the same wall. One of the rocks was excavated and

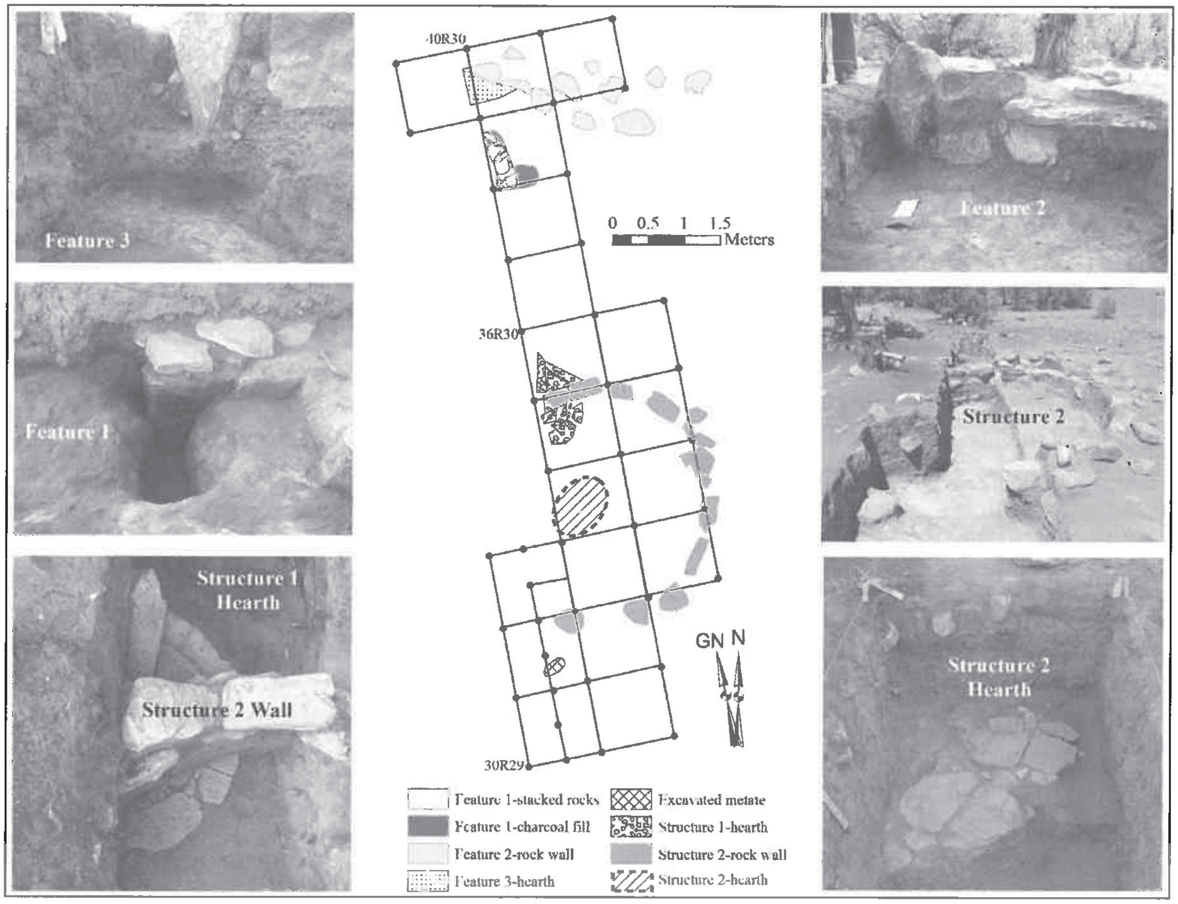

Figure 6. Plan view map of Trench 6 showing the location of features associated with two superimposed residential structures and photographs of the interior features.

found to be positioned directly on the collapsed burned roof of Structure 1 while the unexcavated boulders exposed in profile appear to be set-in, cutting through the strata of Structure 1 and into a lower hearth (Feature 3). The level of origin for this alignment is above Structure 1 but the form, function, and relationship to other features in the area is unclear.

Feature 3 is a hearth found within a stratum below the floor of Structure 1 on the north end of Trench 6 (Figures 5 and 6). Only a small portion of this hearth was exposed in the trench and the rock wall above cuts into and disturbs the visibility of this feature in plan view. The hearth appears to extend into the north and west profiles. A sample dated to 1185 B.P. ± 24 (UGAMS-16505; wood charcoal; δ^{13} C = -21.50 o/oo) with a 2σ calibrated date range of cal A.D. 770–940 (calibrated at 2σ with the program IntCal 13, OxCal 4.2 [Bronk Ramsey 2009], see Table 1). Further excavation is needed to understand the size of this feature and its relationship with the surrounding features. Bulk soil was collected from this feature, but floatation of a portion did not yield higher-quality, datable material.

A total of 2,588 artifacts were collected from the excavation of Trench 6 including bone fragments, beads, shale bead fragments, bifaces, ceramic sherds, lithic debitage, projectile points, flaked stone tools, ground stone, and maize (see Table 2 for additional items and numbers). A strikingly large number of artifacts (n = 909)

Table 2. Artifacts collected from Trench 6, Big Village (42EM2861)

Provenience	Bone	Bead	Shale/ bead material	Biface	Ceramic	Debitage	Projectile point	Other flaked stone tool	Teeth	Maize	Seeds	Turquoise	Ochre/ pigment	Mano	Metate	Manuport	Wood	Groundstone other	Shell fragment	Total
Surface (Stratum 5)	10	1	92	2	13	108	0	0	5	0	0	0	0	0	0	0	0	0	0	231
Stratum 4-Structure 2 exterior	136	6	39	5	63	276	0	2	11	1	0	0	12	0	0	1	0	3	1	556
Stratum 4-Structure 2 interior	88	1	6	2	53	171	2	2	9	0	0	1	2	1	0	6	0	0	0	344
Stratum 3 and Stratum 2	50	1	0	0	15	27	0	0	0	0	0	0	0	0	0	0	1	0	0	94
Stratum 1	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Structure 2 hearth	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Structure 2 floor	16	0	6	2	11	12	2	1	0	0	1	0	0	1	0	0	2	0	0	54
Structure 1 roof	247	12	86	2	171	342	3	1	13	0	0	1	16	0	3	0	9	3	0	909
Structure 1 floor	69	7	6	2	78	94	1	1	1	0	0	0	3	0	0	0	0	0	0	262
Structure 1 hearth	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	5
Feature 1	1	0	0	0	7	11	0	0	0	0	0	0	0	0	0	0	2	0	0	21
Feature 3	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4
Unprovenienced	16	3	4	0	12	55	0	1	0	0	7	0	0	0	0	0	0	0	0	98
Total	636	31	240	15	427	1104	8	8	39	1	8	2	33	2	3	7	17	6	1	2588

came from the stratum that we initially interpreted as a burned roof associated with Structure 1. These artifacts tend to be small broken items, not typical of items that might be stored on or under a roof (primary refuse). Since a roof would not typically exhibit such a high density of secondary refuse, this phenomenon requires further investigation. Perhaps after Structure 1 was abandoned and the roof burned, the shallow pithouse depression was used as a trash pit prior to the building of Structure 2.

The next phase in the investigation of Big Village is full scale excavation. Rather than answering questions about the subsurface features of this site, testing is adding more questions by exposing such a limited area. Little progress can be made in interpretation with such small exposures. We propose excavating the western half of the two structures and exposing the full extent of the underlying features to more clearly define their nature and improve our understanding of the sequence of occupation at this site.

Chronology

Developing chronologies has proven to be a surprisingly vexing problem in Range Creek Canyon. Radiocarbon dates from cultural contexts have offered little in terms of variation to help explain the sequence of occupation of the canyon and the 470 sites recorded thus far. While the lack of variation likely indicates a rapid influx of many people, it is difficult to imagine all the sites being occupied all at once. There appears to be several strategies for residential occupation (high elevation *vs.* low elevation) as well as several storage strategies (small hidden caches *vs.* large highly visible structures; Boomgarden 2009). Were all of these strategies being implemented simultaneously and throughout the entire occupation? Radiocarbon dating alone is not going to give us the detailed chronology that would aid in determining the settlement patterns and land use strategies that occurred over a seemingly very short interval of time.

We have instead looked at other indicators of variation through time in the use of the landscape as well as other dating techniques to try and understand the sequence of occupation. One strategy has been to reconstruct the past environment and the geomorphology of the area to see how prehistoric subsistence strategies might have been impacted. We have cored sediments in several locations in the canyon likely to have been profitable areas for farming in the past and we have profiled and sampled large exposures of the cut creek bed. We have used these sediments to identify dateable material, count the amount of charcoal accumulating through time, identify pollen (especially associated with maize), and collect isotopic data. All of these pieces of the puzzle can inform on the sequence and intensity of human activities in the canyon. The dates on charcoal and pollen from these natural stratigraphic profiles and soil cores are producing age reversals that cannot yet be explained through years of repeated stratigraphic investigation and dating has not resolved. Unfortunately the explanatory power of all the data collected from these cores and profiles hinges on the ability to reliably date the material. As a consequence, we have embarked on several new avenues of research to overcome, or at least understand, these problems.

Radiocarbon Dating

A total of 33 radiocarbon samples from secure archaeological contexts have been dated (Table 1). These samples come from the length of the canyon and include a broad range of organic remains including structural elements, tools, and corn cobs. Over half the radiocarbon dates (n = 17) have median dates that fall between A.D. 1080 and 1120, and the 95 percent confidence intervals are captured in the span of A.D. 990–1210. The 95 percent confidence intervals of 27 of the dates are contained within the span A.D. 780–1210 (Figure 7). One item, a basket fragment, dates significantly older at A.D. 400; a prepared bundle of wild tobacco dates to around A.D. 1800.

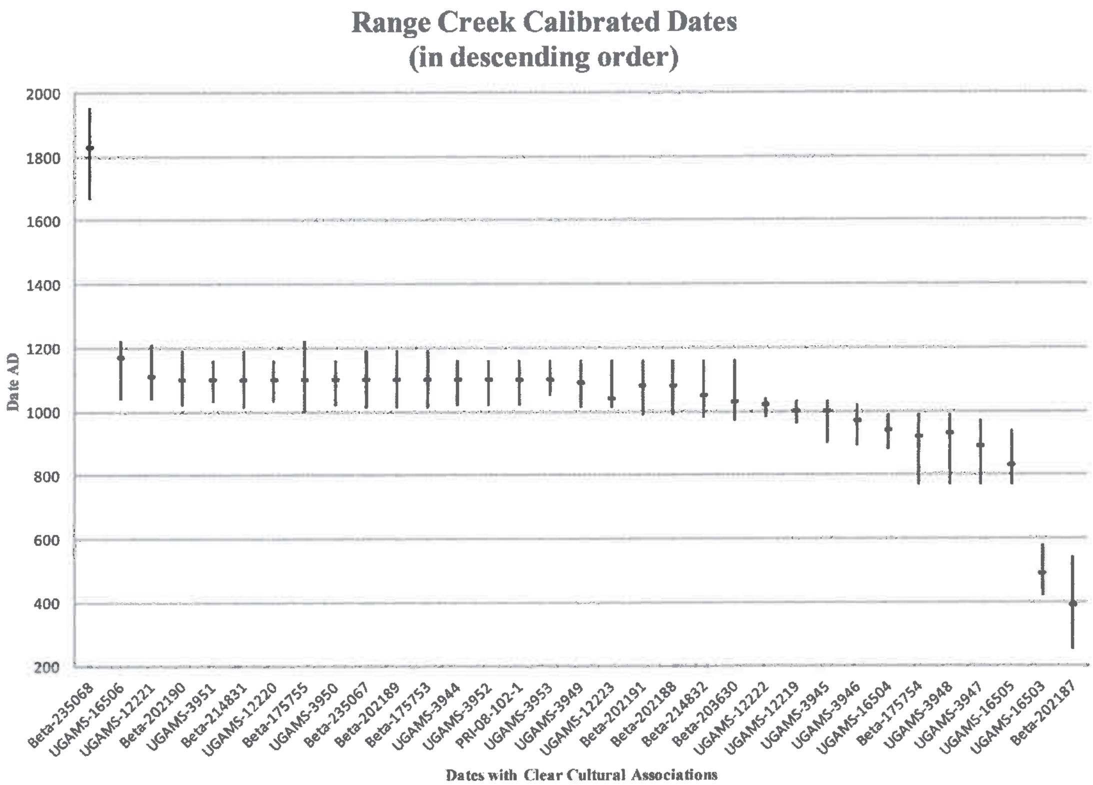

Figure 7. Calibrated radiocarbon dates from Range Creek Canyon sorted in descending order.

Improving the precision of the radiocarbon dates will only marginally improve the resolution of the calibrated dates (Metcalfe 2011). This section of the radiocarbon calibration curve (IntCal09, Reimer et al. 2009) is ill-behaved because it is characterized by multiple intercepts. The effect of multiple intercepts is to expand the calendar age range relative to the radiocarbon age range. Because of this, if the radiocarbon samples dated so far are representative of the universe of cultural dates in Range Creek, then radiocarbon dating will not have sufficient resolution to temporally subdivide the Fremont occupation of this canyon.

About two dozen additional radiocarbon dates have been analyzed from sediments exposed in the banks of the creek and from a series of sediment cores obtained for paleoenvironmental analyses (isotope, pollen, magnetic susceptibility, and charcoal abundance analysis). In all cases where three or more dates have been analyzed from a single column, at least one is out of position; that is, it is out of sequence with respect to the other dates. This was true for sediment columns recovered from more than one location in the canyon. We originally concluded that the sediments must have been disturbed by bioturbation or some other post-depositional agent because our earliest work focused on sediment cores where such disturbance might well escape identification. The result is that we refocused our attention to broad exposures of sediments in the banks of Range Creek. The same mishmash of dates was obtained from these contexts.

We finally concluded that the anomalous dates were the result of contamination from very old carbon originating in the Eocene and

Paleocene deposits exposed in the canyon walls. Some of these deposits are rich in carbon, albeit not the radioactive isotope of carbon. Geologically, these deposits are quite young and have not been subjected to the heat and pressure required to convert the original organic material to coal. We therefore suspected that bitumen or kerogen, antecedents to coal, might be the source of contamination. We sent three sediment samples recovered from the bank of Range Creek in the vicinity of Billy Slope Bog to the Organic Geochemistry Laboratory, Energy & Geochemistry Institute at the University of Utah for analysis of bitumen. Soluble bitumen was isolated using soxhlet extraction and dichloromethane, and analyzed using gas chromatography-flame ionization detector. Bitumen was identified in each sample, but the amounts were too small to account for the anomalous dates (0.01 to 0.02 percent weights). While it is also possible that solid bitumen or kerogen, both of which are insoluble and consequently much more difficult to isolate and quantify, were contaminating the ^{14}C samples, we decided instead to try dating these sediments using optically stimulated luminescence.

Dendrochronology

In 2005, the Range Creek Tree-Ring Project began as a National Science Foundation (NSF) collaborative effort by researchers from the Laboratory of Tree-Ring Research (LTRR) at the University of Arizona, Tucson, Salt Lake Community College (SLCC), the Natural History Museum of Utah (NHMU) at the University of Utah, and the Department of Anthropology at the University of Utah (Towner et al. 2009). The goals of the project were to employ dendrochronological methods to build master chronologies for Range Creek Canyon and those canyons that drain into Range Creek based on five different tree species within the canyon: pinyon pine (*Pinus edulis)*, juniper (*Juniperus spp*), Gambel oak (*Quercus gambelii*), ponderosa pine (*Pinus ponderosa*), and Douglas fir (*Pseudotsuga menziesii*). Goals also include teaching students basic theoretical and methodological aspects of dendrochronology and to date prehistoric and historic sites within Range Creek.

Researchers involved in this project collected live-tree samples, archaeological samples, and remnant wood (logs) for purposes of chronology building. A total of 197 samples were collected from prehistoric granaries, of which 19 yielded dates, only four of which were cutting or near-cutting dates. Although the specific dates were not published, the researchers state that the prehistoric date range is A.D. 609–1126 (Towner 2009:120). The low rate of success was attributed to the wide range of tree species comprising the Fremont samples, small diameter of the sampled timbers, and the lack of species-specific master sequences for the area.

In 2013, a graduate student (Ryan Bares) initiated a study focused on assessing whether using variation in the stable isotopic variation in tree rings, in addition to variation in the thickness of tree rings, might produce a higher dating success rate. Oxygen isotopes should assist in identifying false rings, which are an important impediment to tree ring dating of juniper; to the degree that isotopes and tree ring thickness vary independently through time, this multi-dimensional approach should allow the dating of shorter tree ring sequences. Bares has sampled six juniper trees from different areas of the canyon, measured their tree ring thicknesses, and then sampled each of the newest 30 tree rings using a high-precision, computer-controlled micromill in the Cerling Laboratory at the University of Utah. Cellulose was isolated from each of the subsamples and then analyzed for stable carbon ratios on the mass spectrometer at the Stable Isotope Ratio Facility for Environmental Research (SIRFER) at the University of Utah. The analysis explores using stable carbon isotopes to unambiguously identify false rings, examine the amplitude of the variation in stable isotopes, and the coherence of patterning in that variation among the sampled trees. If the results prove productive, then the samples will be analyzed for the stable isotopes of oxygen, hydrogen, and possibly nitrogen. The results will be available through the Department of Geography in 2014.

Optically Stimulated Luminescence

Optically Stimulated Luminescence (OSL) is a technique for measuring the time that has elapsed since a sample of material with a crystalline structure was last exposed to light or heat (Aiken 1998). We are especially fortunate that Dr. Rittenour joined the faculty at Utah State University and established the Luminescence Laboratory in 2007. Rittenour specializes in the geomorphology of fluvial systems and has sampled the same column of sediments near Billy Slope Bog that produced many of the troublesome ^{14}C dates that were analyzed for contaminating "old carbon."

The precision of OSL dating was improved dramatically with the development of the single aliquot regenerative dose protocol which allows researchers to calculate dose equivalents (Murray and Wintle 2000). In addition, with increasingly precise instruments to measure the luminescence signal, single grains of quartz can now be analyzed. This is important for dating fluvial sediments because fluvial transport can often result in the incomplete bleaching of the quartz grains at the time of deposition, the event we are trying to date. By analyzing hundreds of individual grains from a single sample, a frequency distribution of ages is produced that is then interpreted based on the fluvial geomorphology of the deposits from which the sample was taken.

Rittenour recovered five samples for OSL dating from the stratigraphic profiles previously radiocarbon dated and analyzed and several dozen additional sediment samples for grain-size analysis to assist with the interpretation of the OSL results. We anticipate receiving the OSL dates prior to beginning the 2014 field season. While this technique is unlikely to allow fine parsing of Fremont age sites, it will aid in understanding the age of our problematic profiles and sediment cores.

Experimental

The archaeological field school at Range Creek is explicitly embarking on new directions of research. While most of our time is devoted to teaching students methods and techniques for survey and excavation, students are also involved in experiments designed to calculate the costs and benefits associated with exploiting various wild resources. Students learn and employ techniques for quantifying various aspects of the environment, such as the distribution and seasonality of plant resources that were likely economically important to the prehistoric residents of the canyon.

Students in the field school harvest and process a number of wild plant resources, recording the time spent in the activity and the amount collected. The first year the focus was on four resources: pinyon pine (*Pinus edulis*), three-leaf sumac (*Rhus trilobata*), sego lily (*Calachortus nuttallii*), and Indian ricegrass (*Achnatherum hymenoides*). Students were involved in the collection of particular resources, and each wild resource was procured from various locations in the canyon. Collecting times were recorded as well as the amount collected. The collected resources were processed using historically recorded techniques. These data will allow us to estimate individual learning curves, as well as how specific features of the exploited patches influence return rates. The harvested resources may be analyzed to determine the energy they produce (caloric values are available for a number of wild resources) and for their stable isotope ratios, which are recorded in the tissues of individuals consuming these foods.

In 2013, we initiated a series of small farm plots, focusing on the costs and benefits of irrigation. We dug an irrigation ditch and built diversion dams, measuring the time that goes into their construction. Four small corn plots were planted and irrigated at different schedules to begin to identify the costs and benefits of this important arid land farming activity. Samples of the soils in the field and water samples from the creek and growing season precipitation were recovered for baseline data for stable isotope analysis. Finally, the kernels and cobs were analyzed to determine how these different sources of water influence the stable isotope composition of the harvest. All experimental field times were measured, as were the yields of the resulting harvests. The pilot study showed that irrigation water was necessary for any maize to grow. We also learned about the length of the growing season, the influence of flooding and monsoon rains, and the pest problem. This study will continue for several years before the results are compiled and reported.

The field station currently has a single weather station located a couple of miles north of the field station headquarters. Initial analysis of precipitation events recorded by the weather station and fluctuations of the stable isotope composition of the creek water failed to demonstrate any correlation, likely the consequence of the patchy nature of summer precipitation in Range Creek. Another weather station was established at the north end of the field station in 2013, and we are investigating the possibilities of adding a flow meter to monitor flow variation in the creek near the original weather station. The weather stations use standalone instrumentation that only requires downloading data a couple of times each year, but to fully understand the precipitation dynamics of the canyon, we have placed twenty or so manual precipitation gauges along the length of the field station. When checked after each precipitation event, the manual gauges not only record precipitation amounts, but also provide water samples for isotope analysis.

Taken together, these studies will be the first steps in developing a comprehensive database addressing the cost/benefits of conducting activities with simple technologies for living in Range Creek. The results from this first year will inform the character of experiments in each successive year. We believe that this approach to building an interpretive framework for exploring the archaeology in Range Creek will be productive and rewarding.

Conclusion

There was an intense Fremont occupation of Range Creek Canyon from A.D. 900–1200. There was a heavy reliance on maize agriculture and a high level of internal strife, likely stimulated by competition over limited resources including water and arable land. Evidence supporting these hypotheses includes defensive structures and defensive food storage strategies. To understand the difficulties faced by Fremont farmers in this relatively small area, we must reconstruct the paleoenvironmental conditions that drove the adaptation and behavioral responses of the inhabitants. There is a considerable amount of work that needs to be done in Range Creek Canyon. Our future work will emphasize building the modern and paleoenvironmental context for rigorously exploring the archaeological record of the Fremont who occupied this canyon 900 years ago. The advantage of conducting research from a field station is that it allows the study of variability in the modern environment and the paleoenvironment of the same geographic location as the archaeological research.

This aspect of working at a field station is especially advantageous for researchers using models from behavioral ecology to test propositions about human behavior in the past (Metcalfe et al. 2012). These models require that various environmental and social parameters be accurately estimated, and this task is difficult in a region that is as biologically, topographically, meteorologically, and geologically diverse as the state of Utah. There is always some uncertainty about how data on the spatial and seasonal distribution of rainfall from one valley, for instance, inform those same patterns in a neighboring valley or adjoining mountains. Similarly, it is informed speculation (which is much better than uninformed speculation) as to how well historically recorded rates of return for corn grown in Mexico bracket the same return rates in a very specific part of Utah. While we may believe that we have fairly good data about the return rates for pinion pine nut collecting, those rates can only be conditionally applied to any particular place other than where they were obtained.

Reconstructing the paleoclimate for Range Creek is only a means to an end: reconstructing the physical environment during the 400 year period when the Fremont occupied this remote canyon. Fortunately, not all aspects of the past environment need to be reconstructed, just those parts likely to have been important to the people living there. Clearly knowing how changes in climate affected the degree of down cutting of Range Creek into its channel has important implications for the costs and benefits of farmers trying to use its waters to irrigate their fields. Understanding the affect of long-term droughts on the distribution and abundance of wild foods that were likely important (high ranked in terms of their impact upon encounter benefit/cost ratio) is important for understanding the options available to the Fremont when farming either began to be less profitable or the hunting and gathering of wild resources became more profitable (Barlow 2002). Reconstructing the spatial distribution of the suite of important resources (water, arable land, wild food resources, lithic raw material, wood for fuel and construction, etc.) is required to predict how the Fremont would have negotiated the tradeoff of living in a patchy environment and how that tradeoff should be reflected in assemblage composition (Barlow and Metcalfe 1996; Beck 2008; Metcalfe and Barlow 1992). Without reasonably precise reconstructions of the spatial distribution of selected resources, all explanations of settlement pattern are essentially *ad hoc* storytelling.

Fortunately, some of the shorter-term consequences of variation in weather can be monitored in Range Creek Canyon today. Systematically measuring the flow of water in the creek, monitoring and mapping the distribution of wild resources, planting experimental corn fields, as well as carefully measuring changes in weather can show how one influences the others. The two Range Creek weather stations will provide baseline weather data against which variations in the success of corn farming, and the costs and benefits of hunting and gathering wild foods can be explored.

In addition to climatic reconstruction, we will continue to survey, excavate, experiment, and instruct students in archaeological method and theory. Clearly there is much more work to be done. ■

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