Experimental Maize Farming in Range Creek Canyon: Year One

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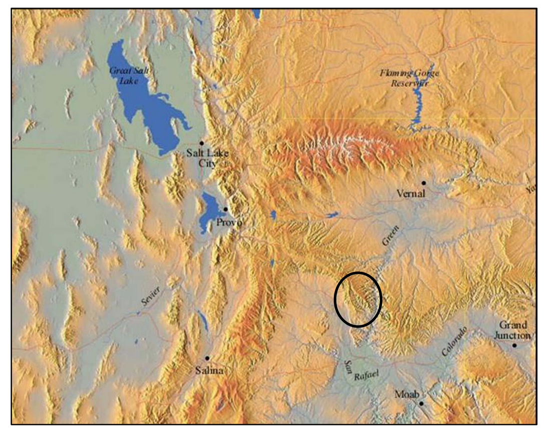
1) Introduction:

Range Creek Canyon (RCC) is a rugged and remote canyon located in the West Tavaputs Plateau, east-central Utah (Figure 1). Range Creek is a perennial stream draining approximately 145 square miles into the Green River. The elevation ranges from 10,200 feet at Bruin Point to 4,200 feet at the confluence with the Green River. The Range Creek Field Station (RCFS) and the University of Utah's Archaeological Field School has spent the last 12 years studying the abundance of pristine archaeological resources and largely intact record of occupation of the canyon by the Fremont people between A.D. 900-1200 years.



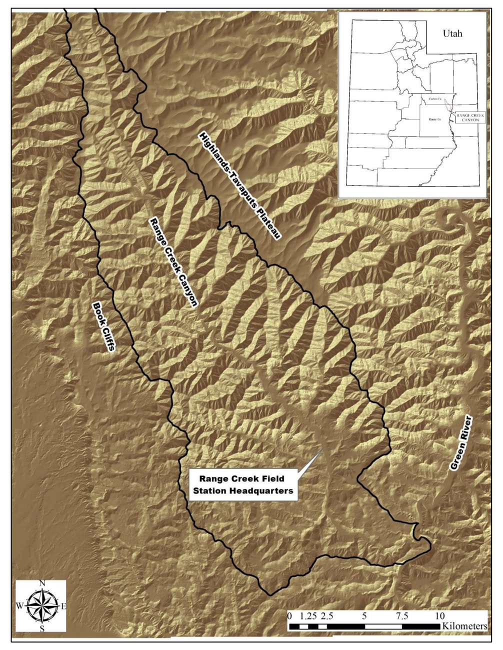


Figure 1. Above: map showing location of Range Creek Canyon in east-central Utah. Right: Relief map of Range Creek Canyon showing drainage limits and Field Station Headquarters.

The goal of the RCFS is to explore adaptations of arid-land foragers and farmers within the broader context of Southwestern prehistory. This pursuit requires coordinating paleoenvironmental, experimental, and archaeological investigations. It is clear from the archaeological evidence found in RCC, that maize agriculture was a significant part of the Fremont diet during the intense prehistoric occupation at around A.D.1050. Of the 470 archaeological sites recorded in the canyon, there are over 100 food storage structures, 116 sites with ground stone tools, and maize has been recorded at over 50 sites. We hypothesize that given such arid conditions, irrigation would have been necessary to successfully grow a significant amount of maize in RCC. An experiment designed to look the amount of water necessary to produce maize in RCC and the costs and benefits of irrigation was carried out during the 2013 growing season.

Figure 5. Photos comparing the height of the plants in Plot 1 (right) to plants in Plot 3(left) late in the growing season, early September. J.Boomgarden is 6 ft. tall for scale.

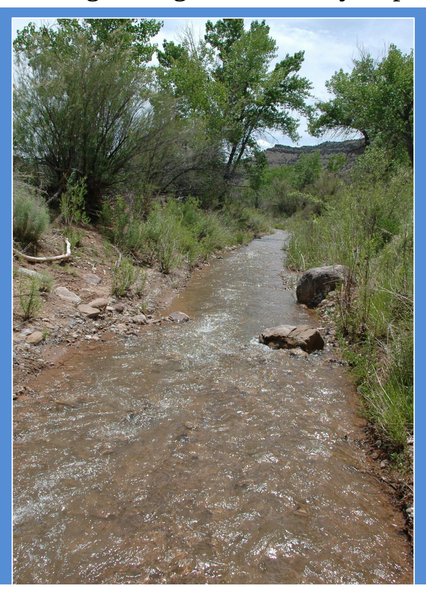


Figure 7. Photo comparing the average size of Range Creek (left) to Range Creek during one of 5 major floods that occurred between August and October (right).

2) Research Objectives and Questions:

In arid and semi-arid environments, adequate water at critical times is an essential aspect of successful farming. Archaeologists traditionally employ precipitation thresholds to gauge adequacy: 20, 30, or 50 cm. during the growing season are considered important thresholds. Although they may be important, these "thresholds" are just snapshots of the relationship between maximum harvest and water. This relationship is likely to take the form of a diminishing returns curve, specifically a sigmoid-curve, with a y-intercept of zero (Figure 2).

In this context, it is useful to divide the water into two sets: available and irrigation water. Available water includes soil moisture at the time of planting, water from direct precipitation, even water from a seep when the field is planted close to such a water source. Irrigation water is obtained by moving water to the field through the use of diversion dams and irrigation ditches, reservoirs, floodwater dams, etc. The principal difference is a matter of the cost to the farmer: available water is rather inexpensive and irrigation water is rather expensive. The features associated with irrigation are often an important part of the archaeological record of farmers in arid environments.

From this perspective, even when there is sufficient available water to produce a harvest, perhaps even a good harvest, it may still be worth incurring the additional costs of providing irrigation water when those costs are less than the benefits from the improved harvest (point A in Figure 2). In other cases, the available water may make irrigating counterproductive (point B). That will depend on the costs associated with irrigating the field and the benefits derived from the harvest. The advantages of stating the tradeoff in this manner is that it draws attention to the relationship between water and harvest, and identifying the costs associated with irrigation, as broadly defined here. Our goal in RCC is to quantify both in order to develop quantitative predictions.

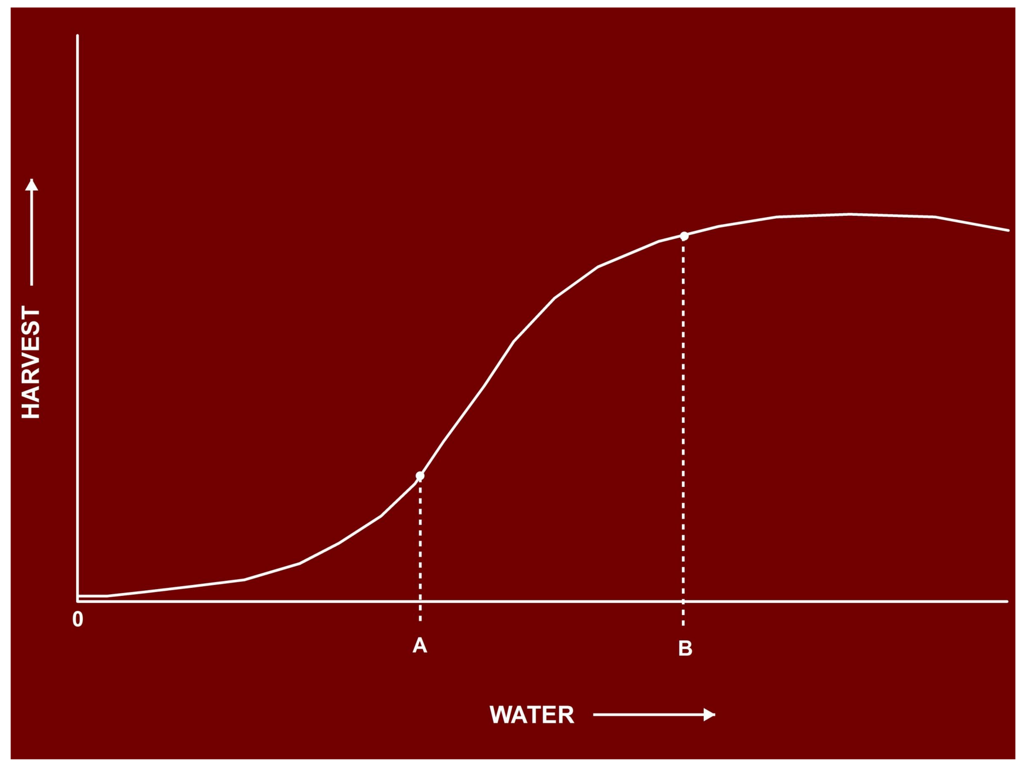
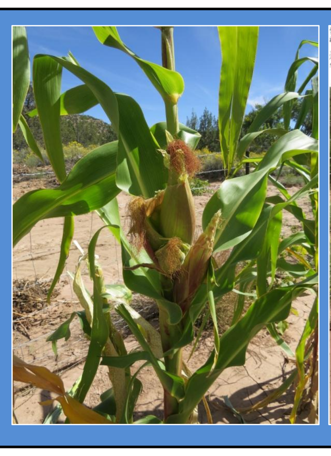


Figure 2. A sigmoid curve demonstrating the utility of water (either naturally available or supplemented through irrigation) for maize harvests. There is an inherent difference in cost between available water (which is essentially free) and irrigation water (which requires some investment by farmers). At point A, there is enough available water to produce a harvest but the harvest could still improve with irrigation water. In this situation the costs of irrigation may be less than the benefit of the additional harvest. On the other hand. if there is plenty of naturally available water for a productive harvest (point B) then irrigation will be counterproductive.



3) The Experiment:

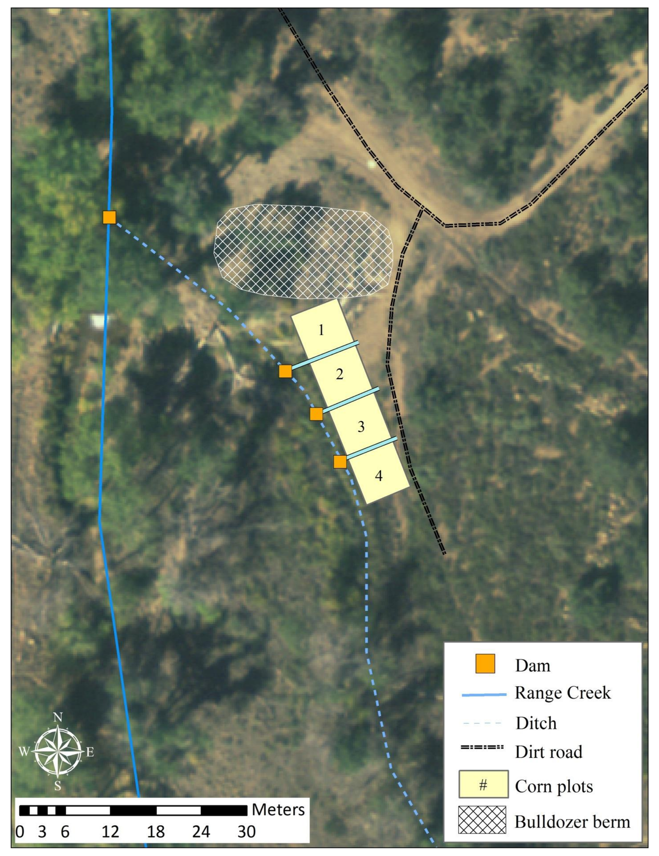


Figure 3. Overview of the experimental maize plots. Water was diverted from Range Creek into a historic irrigation ditch. Dams were built on the ditch to divert water into plots 2-4 on a variable schedule. Plot 1 was not watered.

- Four experimental plots ~ 175 m² (Figure 3)
- Nine hills per plot
- Five seeds were planted in each hill. Onaveño (Figure 4) is one of several modern landraces that is closely ascribed to Fremont varieties.
- Variable of interest: Water (all other variables remained the same for all plots, e.g. weeding, fencing, soil, shade)
    - Plot 1: no supplemental water
    - Plot 2: watered once per week
    - Plot 3: watered twice per week
    - Plot 4: watered as needed

To keep the project as simple as possible our first year, we chose not to dig a new ditch. Irrigation water was pulled from a historic ditch that is still in use by the RCFS.

We also used some modern technology (tarp for dams and shovels) as well as digging sticks, but in future experiments we will gather data on costs of irrigation using only materials and technology available to the Fremont.

Figure 4. Example of Onaveño cob (from Plot 4) showing color and size of a fully mature cob.

4) Results:

We found that supplemental water from irrigation would have been necessary to grow corn under conditions similar to or dryer than the 2013 season in RCC. The experimental plot that received only rain water (Plot 1) produced only seven stunted plants (Figure 5) with no viable cobs. All three of the plots watered by irrigation successfully grew 3-5 plants per hill, all with viable cobs (Table 1). The seven plants that grew in Plot 1 were those able to hang on until the monsoon/flood season began in late August.

While we did show that no supplemental water meant no corn, other factors resulted in a low yield in the plots that did produce (see box 5). The comparison of total cobs to mature cobs in Table 1 suggests that if our growing season had been long enough, many more cobs would have reached maturity. Despite our low yields, a pattern of diminishing returns is evident in the amount of mature cobs which decreased in number with the amount of supplemental water provided (Table 1). Using what we have learned from this pilot study we hope to see this pattern become more evident and quantifiable as we increase our yields in future experiments.

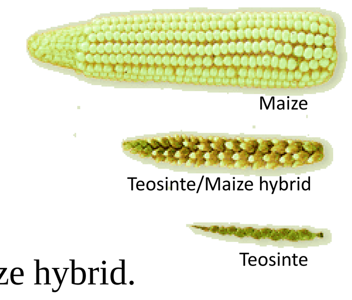
Plot number	Seeds planted	Total stalks	Total tassled	Ave. Max plant ht (cm)	Total cobs	Mature cobs
1	45	7	4	33.334	1	0
2	45	32	30	201.34	42	5
3	49	40	37	215.25	40	7
4	45	36	31	217	44	7
Total	184	115	102	166.73	127	19

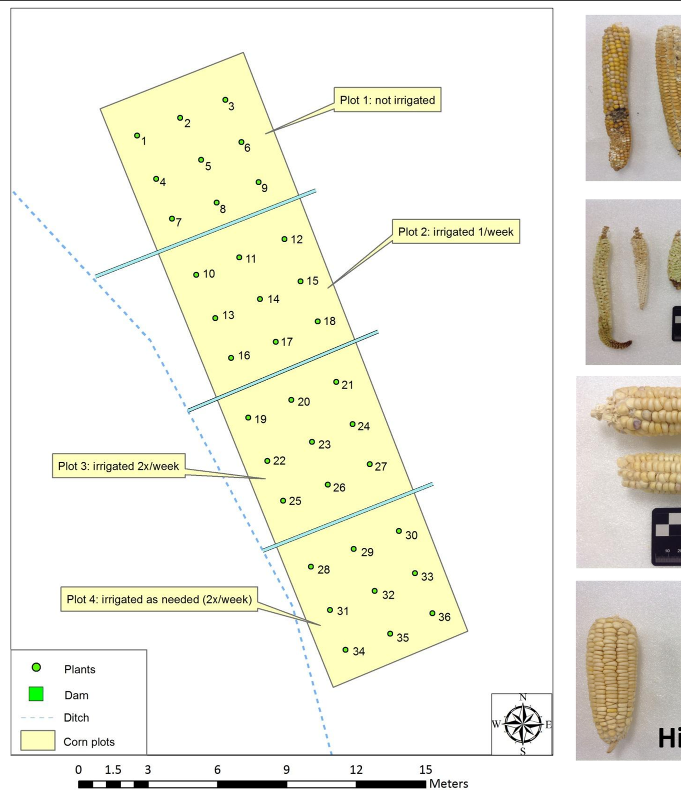
Table 1. Summary of the yield from all experimental plots.

Another interesting observation is the variability in cob morphology and maturity within plots and within hills (Figure 6). Some of the variability that is often attributed to different subspecies can be found within the same hill.

Variability in size and morphology:

- Row number ranged from 6-14 within hills
- Length of mature cobs, from plots 2-4, ranged from 72 cm. to 240 cm.
- Cobs at all sizes and stages of maturity were collected from all plots and hills
- Some cobs are distichous (paired rows) and a thin diameter cob like a Teosinte/maize hybrid.





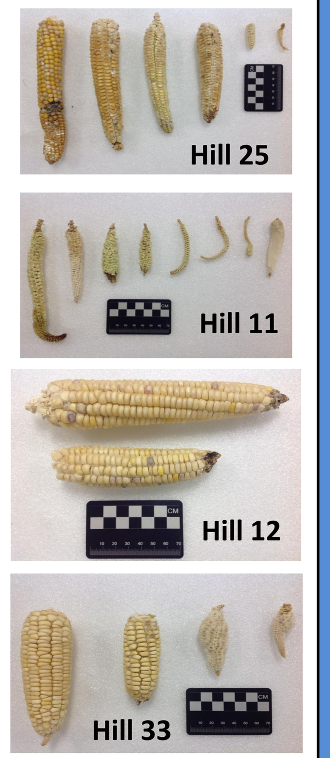


Figure 6. Map of experimental plots showing the numbered hills. Photos at right show examples of the variability in morphology and maturity throughout the plots. Image at left showing differences similar to RCC.

5) Lessons Learned and Future Experiments:

Floods: August-September 2013 was a particularly strong flood season (Figure 7). Flooding destroyed our dams and ditches several times and nearly wiped out our maize plots entirely. Only the location of a historic bulldozer berm saved the experiment (Figure 3). Attempts to capture run-off from floods as an irrigation strategy would be extremely difficult and risky. Fields need to be positioned to take advantage of irrigation water but the same location might be in danger if the creek jumps its banks during flood season. When calculating the costs of irrigation, constant maintenance of ditches and dams needs to be considered. Trying to capture floodwater and divert it onto farm fields would be a risky strategy in RCC.

Pests: We learned the hard way that rabbits can eat an entire field of early stage growth in a single weekend. Our May-June growth was eaten down to stalks while the field school was on break. We put up a rabbit proof fence mid-June and the plants rebounded quickly but the set back for the growing season was devastating. The 2014 experiment will have rabbit proof fences in place before the seed is planted. We also intend to set rabbit snares outside the corn plots and collect data on rabbit populations.

Seeds: Onaveño was chosen because it resembles Fremont maize races morphologically. Unfortunately, Onaveño has a 120 day growing season and is suited to a lower elevation than RCC. This, along with the rabbit problem, resulted in many immature cobs by October. Tohono O'odham 60 day (Figure 8) has been chosen for the 2014 experiment. It has a much shorter growing season and has been growing successfully in southern Arizona on rainwater alone.

Location: The location of the first experiment was chosen for its proximity to an existing ditch and dam, but was to far from our headquarters to be easily accessed. The set up of the irrigation system was not ideal in that we had to build three dams to push water onto the plots. We plan to move the experiment to the Field Station Headquarters (Figure 8) where we can monitor the plots daily and irrigate using the natural down slope gradient, moving water from the irrigation ditch onto the plots with more control. The new location is still out of the flood zone.

Figure 8. Map of next plot location and Tohono O'odham seeds.