
Figure 1. Top: Example of head cut and treated site on Hughes ranch. Bottom, example of building rock run-down from the bottom (splash guard) up at Esquibel ranch.

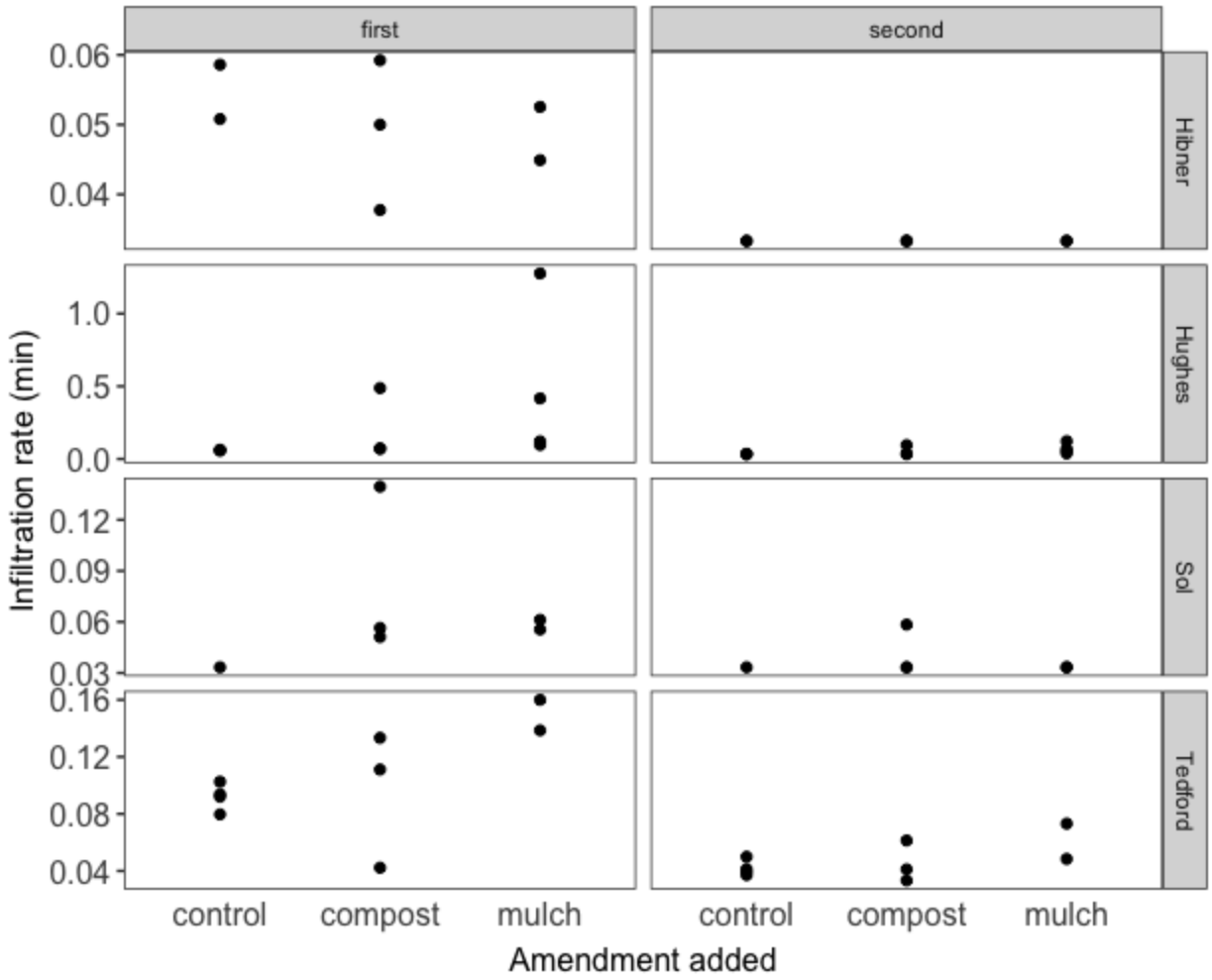


Figure 2. Baseline infiltration rate data for the first and second inch of water by amendment and site. Note. Esquibel Ranch has not yet been recorded due to snow accumulation during field work.

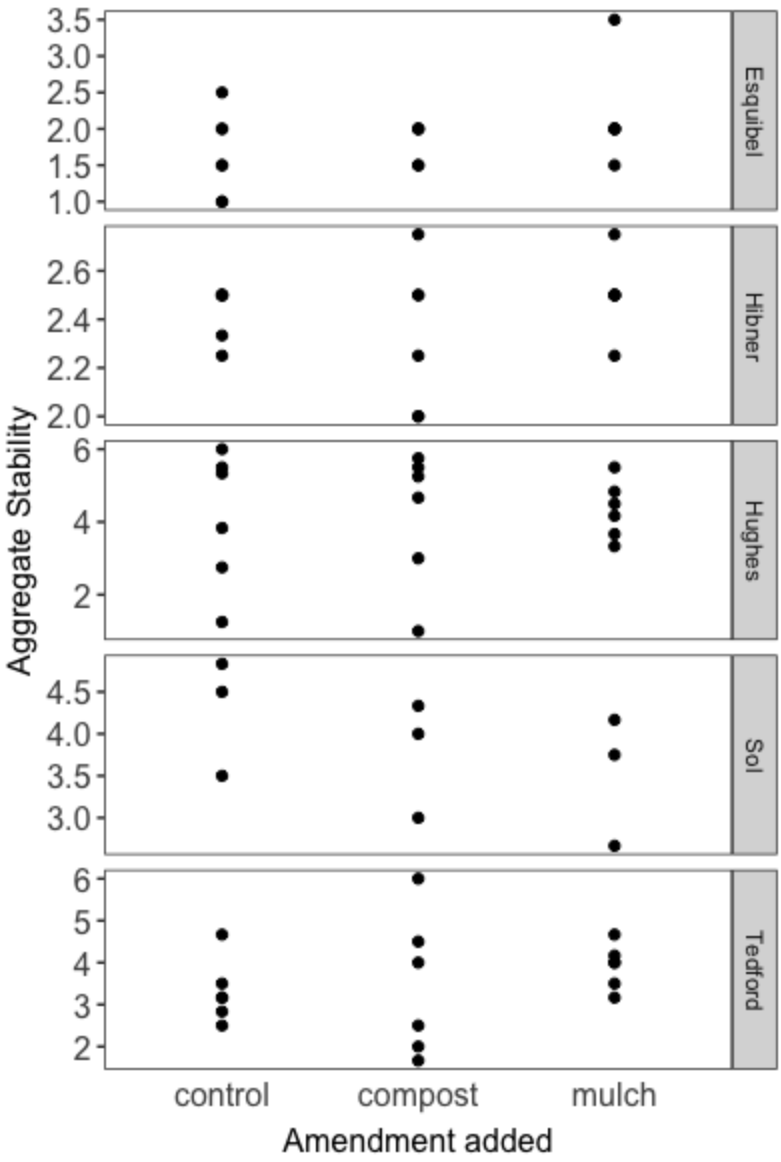


Figure 3. Baseline aggregate stability data (unitless rank) for five ranches by amendment and site. Note that y axis values differ by ranch.

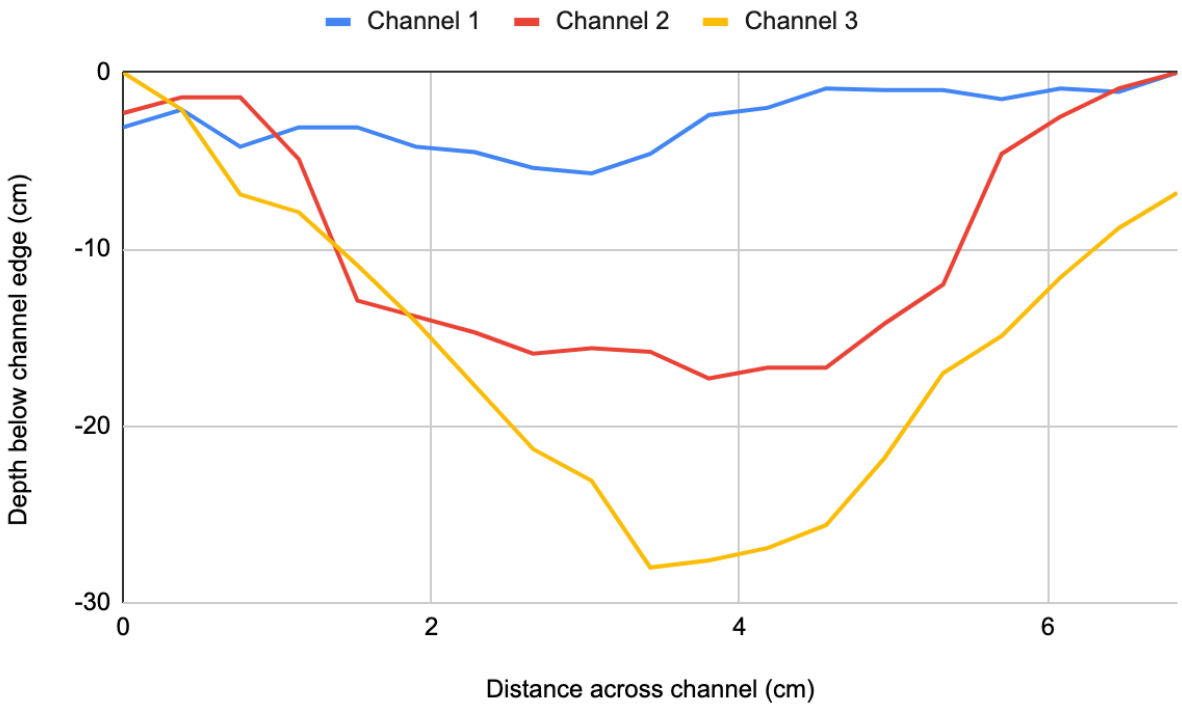


Figure 4. Example of three channel cross sections from Tedford Ranch with depth (cm) on y axis and distance across channel (cm) perpendicularly on the x axis.

Figure 5. Example of two completed plots from Hughes Ranch, December 2021.

**Abstract:**

Erosion on rangelands threatens soil health and in turn the productivity of plants, livestock, and producers. Extreme rainfall and drought are exacerbating risks of sheet erosion, and thus we must find rapid, effective ways to reduce erosion. To increase plant establishment and productivity, interest is growing in using organic amendments and native seeding with erosion control structures. We want to ask 1) does adding organic matter and/or 2) does adding propagules improve vegetation development in an actively eroding area? We propose to build rock run-downs on 9-18 headcuts on each of five dryland ranches and compare compost, mulch, and no organic amendments, with and without dryland grass seed additions. We will measure vegetation composition and biomass, soil moisture, infiltration rate, aggregate stability and other physical and chemical properties, and erosion or accretion in headcut channels. Understanding which treatment combinations yield the most rapid benefits will allow ranchers to evaluate costs and outcomes for better decision making. We will hold workshops at each ranch, three to demonstrate how to build the structures and deploy the organic amendments, and two to demonstrate how to monitor for plant and soil health after one year. We will additionally write white papers of economic analyses and peer-reviewed publications of the ecological results and present at the REGENERATE conference and Down to Earth podcast to disseminate to both producers and technical service providers working in these highly erodible lands. We will build soil health through living roots and surface cover to restore degraded working drylands.

**Project Objectives:**

Objective 1: Ameliorate 18 active headcuts on each of four ranches and 9 headcuts on 1 ranch using erosion control structures and determine the optimal combination of organic amendment and seeding to improve plant productivity, soil health, and reduce erosion

- Submit peer-reviewed publication of results.

Objective 2: Determine the cost of each combination relative to the outcome

- Write white paper of results

Objective 3: Empower local producers to make changes in their operations to reduce erosion and improve soil health

- Conduct 5 workshops, present at the REGENERATE conference and Down to Earth podcast for regional outreach.

**Timeline:**

**Materials and methods**

Describe the process involved in conducting the project and the logic behind the choices you made. Please be specific so that other farmers

and ranchers can consider what would apply to their operations and gain from your experience

1. Make all erosion control structures

The ranchers marked 18-30 sites that were actively eroding. They then collected rock material onsite, or, in one case, purchased stone from a local landscaping company.
We held two workshops with expert guidance (Aaron Kaufman, Esquibel Ranch; Mori Hensley, Sol Ranch) leading groups of volunteers to learn how to build one rock dams to armor the site of active erosion to reduce further degradation (See Figure X). For sites without the expert guidance, we provided guidance and publications such as the erosion control field guide (https://quiviracoalition.org/erosion-control-fg/).

2. Baseline monitoring.

All baseline monitoring occurred in the area 4m x 4m upslope of the erosion control structure.

*Infiltration Rate.* Infiltration rate was collected from the center of each plot in an interspace area free of perennial vegetation. We used the single ring infiltrometer method (NRCS) and timed both the first and second inch (Figure 2).

*Aggregate Stability.* We assess surface aggregate stability using standard methods and the soil stability kit (Herrick et al. 2017) for 4-6 aggregates per plot (Figure 3). Aggregates were collected haphazardly from interspace locations throughout the plot.

*Erosion/Accretion.* If the channel below the erosion control structure was shallow (<50cm) and narrow (<1m) enough, we added wooden stakes to either side and used a level to ensure that they were completely level. We then used a contour measuring device (Kornecki et al. 2008) to record the cross cross sectional area of each channel with 19 points (Figure 4).

*Vegetation structure.* Note- because we set up plots in December, all plants were senesced and we could not ascertain if plants were living and thus we did not take baseline point-intercept measurements. After 1y, we will collect point intercept data of ground surface cover, herbaceous layer, shrub layer, and canopy layer following standard protocols (Herrick et al. 2017).

*Photos.* We took photos looking upslope from the rock structure to the plot for each plot after completing treatments (See Figure 5).

3. Experimental set-up

We blocked the structures by similar slope, aspect, and distance to one another within each ranch and randomly assigned treatment combinations within each block. For Sol Ranch, there was such high vegetative cover that they chose not to add additional seed; thus, they had only three replicates each of control, mulch, and compost. For all other ranches, there were three replicates each of control, mulch, and compost fully crossed with control and native seed.

Plots were measured to 4m x 4m above each erosion control structure and marked with flags and a metal tag. Plots were set up perpendicular to the slope, centered on the erosion control structure. Railroad pins were added .5m inside from the NW corner and SE corner for vegetation transect monitoring.

*Compost addition:* Compost for Sol, Hughes, and Tedford was purchased from Soilutions (Albuquerque, NM) and was composed of local manures, greenwaste and other select ingredients, composted for a minimum of 1 year and screened to 1/2 inch. Compost from Esquibel and Hibner was purchased from Polk's Folly Farm, composed of pig waste, food waste, wood chips, composted for approximately 9m and unscreened. Compost was added to 0.25" thick with shovels, approximately 3 wheelbarrow fulls per plot.

*Mulch addition:* Mulch ("Native mulch") for all ranches was purchased from Soilutions (Albuquerque, NM). Mulch was added to ~0.25" thick with shovels, approximately 4 wheelbarrow fulls per plot.

*Native seed addition.* Locally-sourced native seed was purchased from Plants of the Southwest (Santa Fe, NM) based on the composition of each site.

For Hughes (zone 8) we used *Bouteloua curtipendula* and *Eragrostis trichodes*.

For Tedford (zone 6) we used the Dryland seed mix (*Bouteloua gracilis, Bouteloua curtipendula, Achnatherum hymenoides, Elymus lanceolatus, Pleuraphis jamesii, Sporobolus airoides, Festuca ovina,* and *Schizachyrium scoparium*)

For Hibner and Esquibel (zone 4), we used *Sporobolus airoides* and *Elymus trachycaulus.*

All seeds were thoroughly mixed in a bucket and a 500mL was collected and sprinkled by hand across the entire plot.

Sol Ranch had abundant biomass and diversity on site so we did not add additional seed.

## Education and outreach description

Describe the activities indicated above as well as outreach in progress (e.g. newsletter, journal articles, upcoming presentations, etc.).

We held two workshops in 2021 and a third was canceled due to low enrollment. We requested that workshop be exchanged for a erosion control tutorial with Tribal partners with is being scheduled for summer 2022.

At the workshops, we covered why organic amendments relate to healthy soil principles, and then had hands-on time to build rock structures.

Workshop attendees: ~10 per workshop
Total acres under participant stewardship: 290,304.
Workshop participants rated (out of 5)
I had a high quality learning experience: 4.89
The content of this workshop was communicated well and presented in an organized manner: 4.55
The instructors were knowledgeable and communicated clearly: 4.44
I gained new knowledge and/or built upon previous knowledge during this workshop: 4.75
I can apply the concepts I learned during this workshop: 4.44
I would recommend others to attend this workshop: 4.78.

Participants reported things that they enjoyed such as
““The ability to help the landowners out and the different point of view each member had.”
“I really appreciated that there was a good mix of landowners and qualified professionals.”
“hands on and learning from others”
And one suggestion for improvement: “Extend course into afternoon, have a part 2 of the course”

We will hold two workshops in 2022 focusing on monitoring and evaluation of healthy soil and hydrology in October/November (end of the growing season).

## Project outcomes

### Describe and assess how your project has affected agricultural sustainability or will contribute to future sustainability. Include economic, environmental, and social benefits for farmers.

Direct economic benefits to farmers included paying them to build erosion control structures. Many people expressed that they had been interested in trying it, but had not carved out the time. The financial and social incentive led them to devote time to an activity that they anticipate to be beneficial. No one has yet reported economic benefits to the trials, but Sol Ranch uses their engagement with research and monitoring in their social media presence as a way to help advertise the value of their certified grassfed beef.

All of the ranchers we worked with are concerned with building soil resilience - while NM has been in a prolonged drought, everyone is concerned with what happens when a large storm drops  on all of the bare soil. One rancher is concerned with his house which is built near an expanding arroyo. Several ranchers are concerned with water quality and quantity as much erosion is happening near water sources

for their cattle (either dirt tanks or streams) and thus want to reduce runoff and sediment transport as much as possible.

The social benefits so far have largely come from the workshops, where ranchers met neighbors as well as other people interested in erosion control and worked alongside them. Lucas of Esquibel Ranch expressed that he would like to continue this model - where neighbors come together over a weekend to get a lot of work done on one ranch, then the next weekend do that work on a nearby ranch, especially the folks who share the same watershed. Helping to facilitate these cooperative efforts can reduce barriers to change, even without additional financial resources.

## Success stories

(optional)
You may enter one or more individual stories, examples of success or quotes from participants that illustrate the value of the project to farmer beneficiaries. Farmers' quotes and stories are a valuable means of helping others understand the project's influence on farmers. Please do not use individual's names, but instead describe their business and location (e.g. a dairy farmer from western Pennsylvania).

## Assessment of project approach / areas of further study needed

(optional)
You may provide a brief assessment of research and/or educational methods, or other aspects of the project approach and implementation you think were key to the project's success or that presented challenges. State why you think these aspects were important and/or what you might do differently that could be beneficial for future endeavors by you or others. You may also offer insight from lessons learned about future research and/or educational work needed on the topic.

*Successes*

As mentioned previously, ranchers know that to build resilience, they need to be looking forward to when drought ends and severe weather occurs. For this reason, all of them have been eager to proactively address sites of active erosion and were excited to see how additional amendments could help. We all talked about what could be used from on-site in the future so they wouldn't have to purchase commercial mulch or compost. We talked about using juniper branches, some people have food waste compost, and others already are interested in collecting and storing native seeds, so all of those activities may fit together in the future.

We appreciate the flexibility of WSARE grant administrators when we asked if we could move one workshop from our experimental site to that of a Tribal partner who had expressed interest late last year. Supporting Tribal-led efforts and interests supports Quivira's work of becoming an anti-racist organization and so we were glad that we were able to think through how our existing funding could be used to advance the goals of Tribal partners.

*Challenges*

For the research, the main issue is how challenging it was to find enough head cuts of the appropriate size grouped together enough to make blocks for treatments. I am expecting high variability of results based on lots of different people implementing the practice (eg. One person used a loader to drop rocks and soil into the channel and then placed the rocks up at the lip of the head cut by hand while others had to haul all rock by hand and thus only the top of the headcut had any

armoring). Thus the baseline for each plot will likely be crucial to detect changes due to our treatments.

Timing was an additional challenge. We had staff turnover exactly during the growing season so were not able to plan our field work until new staff were brought on; hence, setting up plots in December. Given the mild and dry fall, I don't think that the late timing will have too substantial an impact on what we find once it starts raining, but at one ranch 6" of snow fell overnight and so we were unable to get the baseline infiltration rate. Luckily, we have some infiltration rates from nearby on that ranch that can be used as a proxy, but it's not ideal.

References

Herrick et al. 2017. Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems. USDA-ARS Jornada Experimental Range. https://jornada.nmsu.edu/files/Core_Methods.pdf

Kornecki et al. 2008. A portable device to measure soil erosion/deposition in quarter-drains. Soil use and management 24:401-408.