Case Study by CART

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Ecological Benefits of Compost for Rangeland Plant and Soil Health

**A Case Study on Actionable Science**
**October 27, 2023**

## Introduction

Climate change and resulting drought conditions are degrading rangelands across the United States (Derner et al., 2023). In arid and semi-arid grasslands used as rangelands, this degradation can lead to loss of productivity and biodiversity. As a result, tools and management strategies to restore productivity and increase ecosystem resilience to drought and soil erosion are increasingly valuable to land managers and livestock producers.

One grassland restoration tool is the use of organic amendments, such as compost. Compost additions show promise in supporting many aspects of rangeland ecosystem function, including increasing plant productivity and soil water retention, and reducing soil erosion. At least in the short term (1-2 years), even a single application of compost can provide a range of benefits, including increased soil carbon and soil water holding capacity (Grauver et al. 2019). Compost can also protect the soil surface from rain, shade it from UV radiation, reduce water loss, and increase soil biodiversity by potentially adding billions of microbes (Kutos et al. 2023). Increased soil microbe abundance can lead to increased nutrient and carbon cycling, benefitting plant growth (Bender et al. 2016). Compost also supports plant productivity by fertilization and holding water.

One significant barrier to compost use is the monetary and labor cost to producers. To become a widely adopted management practice on rangelands, compost application will need to be economical. This group of researchers focused on the foundational ecological benefits of compost which must be understood and quantified before assessments about economic

viability can be made. This study represents an initial step towards a comprehensive understanding of the role of compost in building rangeland climate resilience.

## Key Issues Addressed

Both in theory and according to existing research, compost application can in many cases be beneficial to rangelands (Kutos et al. 2023). However, finding the most efficient deployment methods are key for scaling. For example, strategic placement according to local conditions and management systems or finding the best kind of compost for a given landscape may lead to more beneficial outcomes at a lower cost to producers. Little is known about the optimal conditions for applying compost in diverse landscapes and under various management systems. As a result, many potential benefits of composting for ranchers remain untapped.

A wide range of compost types are available to producers, but little is known about the effects of different types of compost on specific plant and soil health attributes. Two of the more accessible options are biosolid-based compost, made from municipal sewage, and manure-based compost, made from livestock manure. Both types of compost are relatively affordable and support a broader circular economy principle, showcasing the potential benefits of using waste materials to restore semi-arid rangelands.

## Project Goals

- Measure the ecological benefits of applying biosolid-based compared to manure-based compost to rangeland over time, by monitoring soil, plant, and microbial community responses six months and one year after compost application in study plots.
- Offer information and advice, rather than prescriptive guidelines, that can help inform producer decisions about how to apply compost to their land and which type to choose.

Image Caption: *Collecting a soil subsample in a control plot to measure soil organic carbon at a small in-field demonstration workshop. Courtesy of Eva Stricker, University of New Mexico.*

## Project Highlights

**A DRY YEAR** The first year of this study had below average rainfall. Because microbes and plants typically respond to wet conditions, the dryness could partially explain the minimal changes in microbial community composition.

- **Experiments in the Field:** The research team studied nine 64 m2 loam soil plots with <5% slope on privately-owned rangeland in New Mexico. Each plot was randomly assigned to one of three treatments, with three replicates each: an addition of manure-based compost, biosolid-based compost, or no compost to the soil surface. The team visited these plots both at six months and one year post-treatment to collect soil health and vegetation data.
- **Compost Type Affected Plant Performance:** Six months after treatment, vegetation in plots that received biosolid-based

compost had grown the most, with a non-significant trend of over double the amount of plant biomass than in plots with no compost. Vegetation in plots that received manure-based compost showed intermediate levels of plant growth compared to untreated plots.

- **Soil Characteristics Changed Over Time:** Aggregate stability, an indicator of soil health and quality, initially decreased at six months. This may have been a result of increased livestock movement, trodding on the compost plots. After one year, aggregate stability in plots with manure-based compost recovered to native soil stability values, and increased at intermediate levels in plots with biosolid-based compost as well.
- **Resilient Native Soils:** Both compost types host diverse communities of fungi and bacteria. Researchers therefore expected large changes in microbial diversity in plots with compost additions. However, they found that six months and one year after treatment, microbial communities in native soils in all plots did not shift dramatically. This surprising result indicates that microbial ecosystems in native soils are well-established and not destabilized by new microbes from compost. In practice, this suggests that while compost improved some soil health metrics, the dominant microbes were not primarily responsible for observed changes in soil or plant responses.

Image Caption: *Setting up a livestock exclosure on a new compost addition plot. Courtesy of Eva Stricker, University of New Mexico.*

## Lessons Learned

Despite varied results between compost types and at different time intervals, compost additions overall increased plant growth and improved some soil properties. At this stage in the research, one compost type has not proven to be dramatically more effective than the other. These mixed preliminary results indicate that compost shows some promise as a tool to increase rangeland productivity. Importantly, they also highlight the importance of continued research on the ecological effects of compost. By quantifying the potential ecological benefits of compost, researchers can help producers to make a more informed decision about investing time and money into this practice.

This study demonstrates one way in which waste can be used productively on rangelands, contributing to a broader rangeland

circular economy. The research team hopes in the long-term, their findings can help shift producers' perspective on waste towards increased strategic use. Here they show that, for example, composted excess manure from dairy cows could be beneficial for soil health. Ultimately, the research team aims to integrate waste transformation into improved ecological, social, and economic outcomes for rangeland producers. This mindset change is one important step towards regenerative management.

Image Caption: *Drone image of compost plots in spring 2021. Courtesy of Eva Stricker, University of New Mexico.*


## Next Steps

- Continue this line of research: When currently funded components of the project conclude in 2024, researchers will have collected two years of data; this slightly longer time scale

will help researchers investigate whether or not the benefits of compost vary over time.

- Conduct additional experiments in summer 2023 to study how far microbes travel from the plots where compost is added: Understanding the microbes' dispersal capability from the application of compost will help researchers make recommendations on optimizing compost placement and amount needed to see benefits.
- Initiate further research on if compost will build resistance or resilience to drought.
- Collaborate with economic experts to conduct cost analyses of using compost: Once researchers have a clearer understanding of the ecological benefits of compost, they hope to incorporate both ecological and economic context to present the cost-benefit ratio of compost to producers. They recognize that compost is an expensive tool, but that the benefits may outweigh the cost. The research team aims to consider the net outcome of using compost for producers, not just the absolute cost.

Image Caption: *A compost plot during the monsoon season. Courtesy of Eva Stricker, University of New Mexico.*

# Resources

**October 2023 Case Study Handout**

## Collaborators

- Quivira Coalition's Carbon Ranch Initiative

## Funding Partners

- United States Department of Agriculture National Institute of Food and Agriculture, Grant 2021-67019-34249

## Resources


- Bender et al. (2016). "An underground revolution: Biodiversity and soil ecological engineering for agricultural sustainability."

*Trends in Ecology and Evolution* 31(6), 440-452.

- Derner et al. (2023). "Practical considerations for adaptive strategies by US grazing land managers with a changing climate." *Agrosystems Geosci & Env* 6(1): e20356.
- Grauver et al. (2019). "Organic amendment additions to rangelands: A meta-analysis of multiple ecosystem outcomes." *Global Change Biology* 25(3): 1152-1170.
- Kutos et al. (2023). "Compost amendment to enhance carbon sequestration in rangelands." *Journal of Soil and Water Conservation* 78(2): 163-177.

## Photo Gallery

- Photo Album and Credits

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Image Caption: *Undergraduate students from the Sevilleta National Wildlife Refuge learning to monitor soil health and productivity. Courtesy of Julie Bethany Rakes, University of New Mexico.*

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