Case Study by CART

Using Mulch and Compost for Rangeland Restoration

A Case Study on Actionable Science
September 27, 2023

Introduction

Increasing aridity in semi-arid grasslands can initiate a cycle of plant cover loss and soil erosion leading to irreversible ecosystem changes. By the end of this century, the Southwestern United States is projected to experience an increase in temperature of up to 8 °F, a 10% decrease in precipitation, and more variable rainfall (USDA, 2010). A hotter and drier climate will increase evaporation of soil moisture, limiting water available for plant growth. Combined with more variable precipitation, future climate is predicted to favor the growth of woody shrubs, such as mesquite (*Prosopis velutina*) over growth of grasses and forbs. Mesquite encroachment in grassland is driven by a combination of factors and can increase soil erosion when Mesquite cover increases and grass cover decreases because grasses (and other herbaceous vegetation) protect soils from erosion by intercepting raindrops, and stabilizing soil with fine roots (Archer et al. 2017). Mesquite encroachment is resulting in many mesquite removal projects that produce large amounts of branches and wood.

Branch mulch and compost are two organic materials that can be laid on top of soil to restore the cover and abundance of grasses in semi-arid grasslands by improving soil health. However, documentation of their use and effects on soil health remain limited, preventing greater adoption. Researchers from the University of Arizona tested the ability of branch mulch alone, and in combination with additional layers of compost, to reestablish vegetation and improve soil health in the Altar Valley of Southern Arizona over the course of two years. Understanding which properties of soil health are impacted by branch mulch and compost can help rangeland managers focus restoration efforts on the specific soil properties that are degraded and understand if branch mulch or compost are good tools to use to restore the grasslands they steward.

Key Issues Addressed

Little is known about the effectiveness of mesquite branches as mulch for increasing plant cover or how it affects soil health in Southwestern rangelands. More quantitative data and field experiments are needed to understand how mesquite branch mulch can be used to restore degraded and grazed grasslands.

The effects of branch mulch, and mulch in combination with compost, on vegetation reestablishment during drought are uncertain. More data is needed about the effects of organic materials like branch mulch, and mulch in combination with compost on plant growth and soil health during drought.

Organic materials such as compost can be difficult or costly to apply in rangelands. Furthermore, organic materials are often applied using tillage to incorporate organic materials into the top

layer of the soil; however, many rangelands have soils too rocky or steep, or are too remote for tillage to be an option. Additionally, the cost of some organic materials are prohibitively expensive to purchase and transport to restoration sites. Applying a mulch of whole mesquite branches sourced from the restoration area to the soil surface eliminates the need for tillage, and reduces costs of organic materials.

Project Goals

- Measure the effects of branch mulch alone, and branch mulch on top of 3 cm and 6 cm layers compost, on a suite of soil health attributes including: soil microclimate (temperature and moisture), soil aggregate stability (resistance to erosion), amount of soil organic matter, and plant available nitrogen.
- Test the effects of branch mulch, and branch mulch on top of with 3 cm and 6 cm layers compost, on the cover and abundance of seeded native grasses and non-seeded plants in degraded rocky soils.

Image Caption: *Excavating a soil pit on October 2nd 2019, after the second monsoon rain season. In this experimental plot we placed 3cm compost directly on the soil surface, seeded with native grass seeds, and overlaid compost and seeds with a 15cm layer of loosely stacked whole mesquite branches. Notice the robust growth of seeded native grasses in the foreground. Courtesy of Ariel Léger, University of Arizona*

Project Highlights

WASTE AS RESOURCE Mesquite is widely available in many arid landscapes. Rangeland managers can obtain mesquite branches from removal projects, turning waste into a valuable resource for ecological restoration.

- **Experimental Plot Design:** Researchers studied five treatments from 2018-2019 in areas of bare soil on an actively grazed rangeland. Two control plots: one with no treatment, and one seeded with native grasses. And three experimental plots: one with mesquite branch mulch laid on top of seeded soil, a second with branch mulch on top of 3 cm seeded compost, and a third with mulch on 6 cm seeded compost. Researchers laid the mesquite branch mulch in 15-20 cm thick layers that did not completely cover the soil surface. Plots were

hand-seeded with native cool and warm season grasses chosen based on the ecological site description.

- **Cover and Abundance of Grasses:** The study site received more rain in 2018 than 2019, allowing researchers to compare the effectiveness of the treatments during wetter and drier conditions. In drier conditions branch mulch alone, without additional compost, increased the abundance and cover of grasses by 42%, and in wetter conditions increased the abundance of grasses 5.5 times more than any other treatment. In the wetter conditions of 2018, the additional 3 cm of compost resulted in a 15% increase in cover of seeded grasses, 5% more than the mulch only treatment.
- **Woody Shrubs:** Only one mesquite seedling was found over the 2-year study, indicating mesquite branch mulch and compost do not increase mesquite cover in the short term. Cover and abundance of other woody plants were lower in both treatments with compost (3 cm and 6 cm) than in control plots. Mulch-only treatment had similar cover and abundance of woody plants as control plots.
- **Reestablishment of Forbs:** In both wetter and drier conditions, the mulch only treatment increased the abundance of forbs more than the control and compost treatments. The cover of forbs increased the most in response to the mulch only treatment, particularly in the dry year of 2019. Plots with 3 and 6 cm layers of compost, reduced cover and abundance of forbs compared to control plots.
- **Soil Health:** All three treatments with organic materials decreased soil temperatures and increased soil water availability compared to controls, but none of them significantly improved soil stability, plant-available nitrogen content, or amount of soil organic matter. All organic materials increased soil moisture by 50% across both years. Plots with compost had about 10% higher soil moisture content than plots with branch mulch alone, but branch mulch without compost increased soil moisture content more often during the drier seasons in response to small rain events.

Image Caption: *The mulch plots were broadcast seeded with native grass mix by hand before a 15cm deep mulch of rough hewn mesquite branches was laid on top of the plot and seeds. Branches up to 1" in diameter were cut into 2-4" lengths with handheld tree pruners. The green leaves from mesquite are visible in this picture as the branches were recently cut while no seedpods were present. Courtesy of Ariel Léger, University of Arizona*

Lessons Learned

Because the southwestern United States is becoming more arid, researchers emphasized the importance of the results of treatments in the drier 2019 growing season. Although branch mulch with 3 cm of compost tended to result in the largest increases in cover of grasses during the wetter conditions of 2018, researchers discovered a negative relationship between the amount of compost and abundance of vegetation in drier

conditions. In drier conditions of 2019, branch mulch alone produced the greatest increases in cover and abundance of grasses.

The different responses in plant growth to mulch and compost may be due to the structural differences between these two organic materials. Branch mulch partially covers the soil which protects the soil surface from the impact of raindrops, a major cause of erosion, and allows rain to slowly infiltrate the soil surface. Unlike branch mulch, compost completely covers the soil surface. Although the complete cover of compost decreases the temperature of soil surfaces and prevents evaporation better than branch mulch alone, it also reduced the emergence of seedlings from the soil seedbank and impeded water from reaching the soil during smaller rain events and during drier times of the year because compost repels water when dry. This is of particular importance in the southwest, where moisture from small rain events is important.

The success of surface-applied mulch of whole mesquite branches alone, without additional compost, was attributed mainly to its ability to improve the soil microclimate and promote growth of seeds from the soil seedbank as it did not have strong effects on other soil health metrics. When using mesquite branch mulch in restoration projects it is important to harvest the branches before seed pods emerge to avoid contributing to woody plant encroachment. Branch mulch has been used as a restoration material at a larger scale at Big Bend National Park in Texas. Mesquite branches from mesquite removal projects have the potential to be leveraged for restoration in other rangelands across the Southwest.

Image Caption: *Soil sampling after the first monsoon rain in a plot with 3 cm compost and mesquite mulch. Note the grasses in the center of the plot. Courtesy of Ariel Léger, University of Arizona*

Next Steps

- Conduct a similar experiment but on a larger temporal and spatial scale to measure the changes in the plant community on multiple acres of rangeland and identify best practices for applying mulch at larger spatial scales (e.g., providing guidance for project managers and machine operators conducting brush treatments).
- Research the effects of smaller quantities of compost, such as 1 cm thick layers, on plant growth. Smaller quantities of compost may prove more beneficial than larger quantities by not preventing infiltration of rain and seedling emergence.
- Conduct similar experiments on a variety of soil types to measure the efficacy of branch mulch and compost for restoration on different soil environments.
- Trial different spatial arrangements for branch mulch and compost to reduce soil erosion: contour lines, chevrons (v-

shaped treatments), media lunas (half moons), etc.

Image Caption: *After two years of monitoring and two summer rainy seasons the plots with mulch alone continued to support and recruit a diverse array of grasses, forbs, and perennial shrubs. Courtesy of Ariel Léger, University of Arizona*

Resources

September 2023 Case Study Handout

Collaborators

- The University of Arizona
- The Joey Blankinship Soil Health Lab

Funding Partners

- The University of Arizona

Resources

- CART Case Study: Using Soil Science to Restore Desert Grasslands in Big Bend National Park
- Berdugo et al. (2020). "Global ecosystem thresholds driven by aridity". *Science* 367: 787-790.
- Archer et al. (2017) "Woody Plant Encroachment: Causes and Consequences". *Rangeland Systems* 25–84
- Conservation and Adaptation Resources Toolbox. 2023. Rock and Branch Mulch for Grassland Restoration.
- Copeland et al. (2017). "Potential impacts of overlapping land-use and climate in a sensitive dryland: a case study of the Colorado Plateau, USA." *Ecosphere* 8(5):e01823.
- Feng et al. (2013). "Expansion of global drylands under a warming climate." *Atmospheric Chemistry and Physics* 13: 10081-10094.
- Huang et al. (2017). "Dryland climate change: recent progress and challenges." *Reviews of Geophysics* 55: 719-778.
- International Union for Conservation of Nature. (2019). "Drylands and climate change."
- Léger et al. (2022). "Mulch more so than compost improves soil health to reestablish vegetation in a semiarid rangeland." *Restoration Ecology*
- United States Geological Survey. (2016). Dryland Ecosystems.

Photo Gallery

- Photo Album and Credits

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Image Caption: *After the first monsoon season the plots with lower applications of compost (3cm) saw emergence of some of the seeded grasses which grew to much larger sizes than the plots with mulch alone but had fewer individuals. Courtesy of Ariel Léger, UArizona*

More Information on CART