Effects of Compost Amendments to Rangelands with Steep Slopes

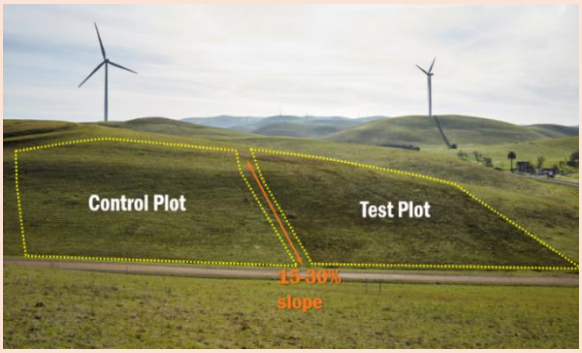
CONTEXT:

The Alameda County Resource Conservation District (ACRCD) seeks to expand the potential for ranchers to benefit from compost cost-share assistance programs on land currently excluded from funding by generating new insight into how compost can be safely and effectively applied to steep slopes. ACRCD has partnered with the Alameda County Waste Management Authority (StopWaste), Paulo Farms, UC Merced, and the USDA Natural Resources Conservation Service on a field experiment started in 2019 on StopWaste's rangeland property in the Altamont Hills, east of Livermore. The study site is grazed year-round as a cow-calf operation, and vegetation is dominated by non-native, naturalized annual grasses and forbs. ACRCD secured state grant funding to evaluate the effects of a one-time compost application on soil carbon, greenhouse gas dynamics, vegetation productivity and composition, and nutrient runoff on rangelands with 15-30% slopes. We measured field data with our research partner Dr. Rebecca Ryals from the Ryals Agroecology Lab at UC Merced during the four-year field experiment.

WHY?

Spreading compost on rangelands has been shown to increase soil carbon storage capacity and to increase vegetation productivity (forage) in some parts of California.[1] [2] In recognition of these benefits, federal and state programs provide incentive payments for compost amendments; however, concerns about nutrient runoff from compost limit eligibility to slopes of 15% or less, excluding substantial areas of California's rangelands. We evaluated the effects of compost application on slopes of 15-30% to understand potential benefits to livestock producers and rangeland managers in Alameda County, and to generate field data to better inform incentive program guidelines and slope limitations. We have also evaluated the costs of compost spreading, compost quality, and compost placement to provide guidance to producers and land managers.[3]

METHODS & RESULTS:



- A ¼-inch layer of compost was applied via blower-truck to five 1-acre test plots. A total of 420 cubic yards of compost was applied across 12 acres. Drainages, creeks, and pond catchments were avoided.
- Each test plot was paired with a control plot, as seen in the figure at left. Paired plots were selected to have varied slopes and aspects.
- Data collected include runoff, greenhouse gas emissions, soil organic carbon, soil bulk density, infiltration, vegetation productivity, plant community composition, and residual dry matter (RDM).

A one-time compost amendment slowed the rate of carbon loss

- Soil carbon was lost from all plots during the study; however, soil carbon loss was reduced on compost-amended plots. Avoided losses of carbon in treatment plots yielded a net benefit of 9.5 megagrams of carbon (MgC; metric tons carbon) per hectare, or 2.7 MgC per hectare per year—equivalent to taking two gasoline cars off the road annually.[4]
- Compost did not increase soil carbon from baseline. This phenomenon may be explained by low precipitation, warmer temperatures, higher soil microbial respiration, and timing of rainfall.

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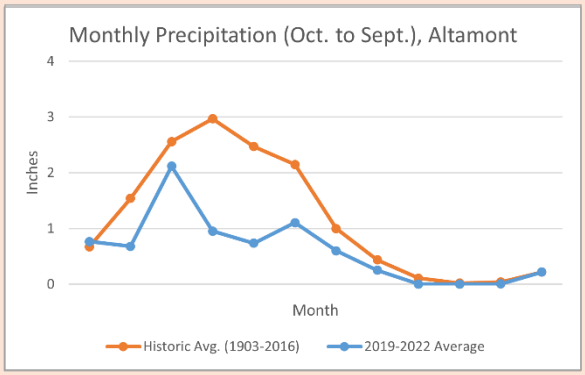
[1] Ryals, R. and Silver, W. (2013). Effects of organic matter amendment on net primary productivity and greenhouse gas emissions in annual grasslands. *Ecological Applications,* 23(1), 46-59.

[2] Ryals, R. et al. (2014). Impacts of organic matter amendments on carbon and nitrogen dynamics in grassland soils. *Soil Biology & Biochemistry, 68,* 52-61.

[3] Download our white paper "Feasibility Assessment of Compost Addition on Alameda County Rangelands: Compost sourcing and spreading costs" https://acrcd.org/projects/carbon-farming/

[4] US EPA Greenhouse Gas Equivalencies Calculator

- Over the 12 acres that received compost, an estimated 1,092 megatons of carbon dioxide equivalent will be sequestered over a 20-year period according to models. [5]



Annual rainfall was the clearest driver of vegetation changes

- The site experienced significant interannual variation in precipitation and persistent drought conditions over the study period.
- Years 1 and 3 both provided less than nine inches of rainfall (59% of historical average), while just over three inches of rain fell during Year 2 (22% of historical average).
- Compost treatment effects on vegetation productivity were insignificant. Vegetation productivity was highly variable across plots, aspect (lower on south-facing slopes, for example), and year in response to rainfall.
- Vegetation composition showed little treatment effect. Native forb cover initially decreased on treatment plots but rebounded more rapidly than in control plots, resulting in no observable difference by the third year.

Compost reduced runoff volume and did not increase nitrogen or phosphorus runoff

- Total volume of runoff from test plots was 17% less than control plots.
- Runoff from each plot was collected after rain events and sampled for nitrate and ammonium concentration.
- Very few rain events produced overland runoff during the study period, limiting our observations.

IMPLICATIONS & TAKE-AWAYS:

A one-time application of compost is effective at slowing soil carbon losses on slopes between 15-30% without increasing greenhouse gas fluxes (soil microbial respiration), indicating that compost application on Alameda County grasslands is a viable climate mitigation strategy. *Increased forage was not observed during three dry years following application, so we cannot confidently conclude that compost will provide direct economic benefits to livestock producers during less-than-average rain years.* The reduction in runoff on test plots indicates compost helped retain water in soil, which may improve forage quality and green phase. However, additional research is needed on nutrient runoff and vegetation response due to the relatively small data set and short duration of the experiment. ACRCD will continue to collect data on the project site to better understand long-term effects. Overall, our results indicate that compost on steep-sloped rangeland is beneficial for carbon sequestration and cost-share programs should consider expanding funding eligibility to include rangeland compost application on slopes of 15-30%.

Our continuing research efforts may help clarify remaining questions. Primarily, does compost application help improve forage quantity and economic value for ranchers during more favorable rain years? We believe vegetation productivity (forage) and vegetation community composition need to be observed on more rangelands and over a longer period before reaching conclusions about compost effects on vegetation. Similarly, runoff volume and nutrient runoff from compost require more study on a larger scale. Lastly, effects of compost on wildlife should be explored, particularly for sensitive species like California tiger salamander (*Ambystoma californienses*) and California red-legged frog *(Rana draytonii*). Current best practices should be followed to avoid potential impacts to wildlife.[6]

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Contact information can be found at https://acrcd.org/

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[5] CDFA COMET-Planner: model run 2/28/2023.
[6] Download our fact sheet "Managing Grasslands for CTS and CRLF: Considerations When Applying Compost" https://acrcd.org/projects/carbon-farming/