Potential for Soil Carbon Sequestration Through California Rangeland Management

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Introduction

Land management approaches that increase plant growth and/or add C directly to soils have been proposed as climate change mitigation strategies, as these practices have the potential to increase soil organic carbon (SOC) storage ("soil C sequestration"). Field studies from managed grasslands in Marin and Yuba counties showed that a one-time addition of compost can have a lasting and climate-beneficial impact on plant productivity and soil C storage (Ryals & Silver, 2013; Ryals et al., 2014). Applying composted organic waste to soil has an added climate change mitigation benefit of diverting waste from landfills or manure ponds, which are significant sources of greenhouse gas emissions (Delonge et al., 2013).

Here, we used the DayCent biogeochemical model (DelGrosso et al. 2001) to explore the effects of compost application across a latitudinal and climate gradient throughout California. The model simulates grassland productivity and the movement of C between soil, vegetation, and the atmosphere over time and under different climate and management conditions.

Objectives

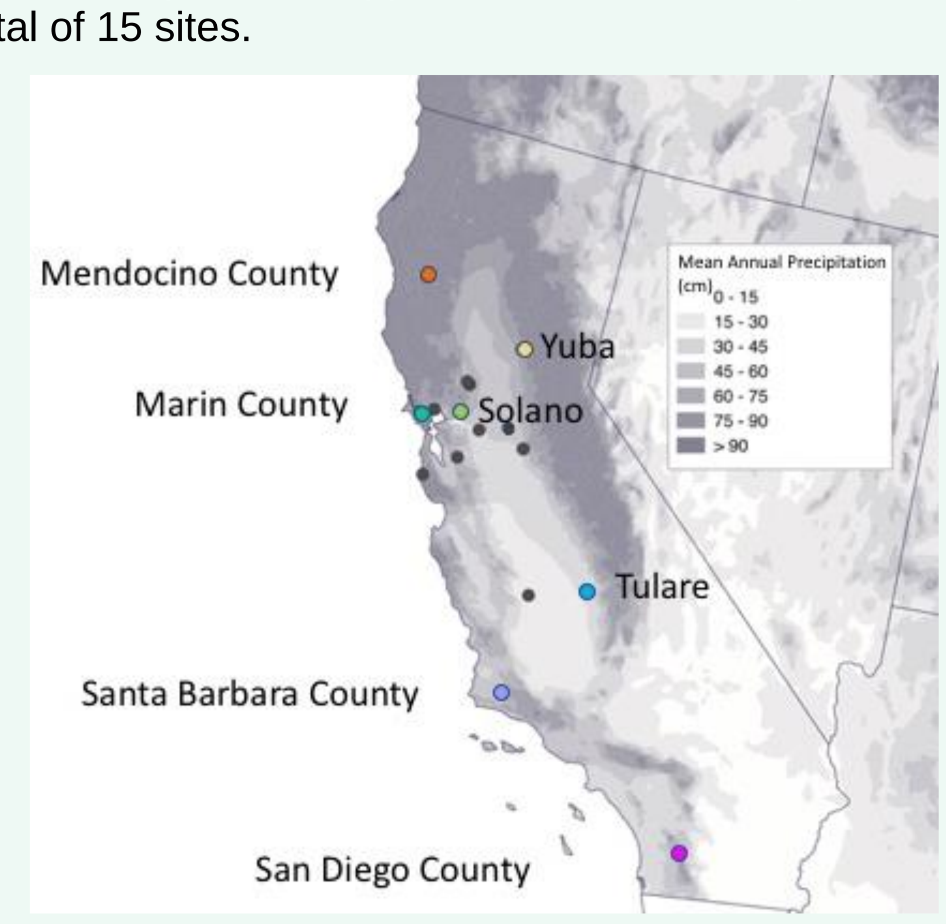
How does compost addition affect **long-term net primary production** and **soil C storage** in California rangelands?

How do **environmental variables** affect biogeochemical cycling in rangelands, and how does background climate interact with compost impacts?

How does projected future **climate change** influence **soil C storage**, and how does compost application impact **C dynamics** under potential future climate conditions?

Study Sites

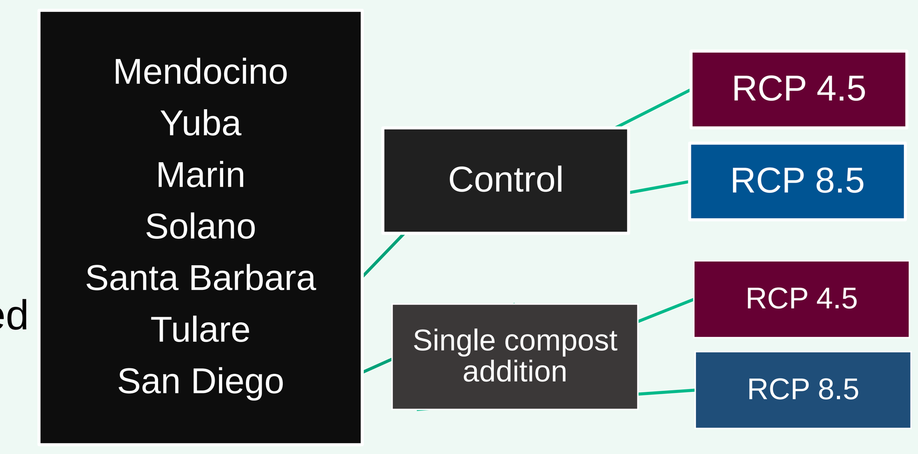
We parameterized the model using seven annual grassland sites that are representative of a broad range of California's grassland climates. These seven sites are part of a larger NRCS and UC Berkeley field experiment where compost was applied in fall of 2016 to plots in a total of 15 sites.



Methods

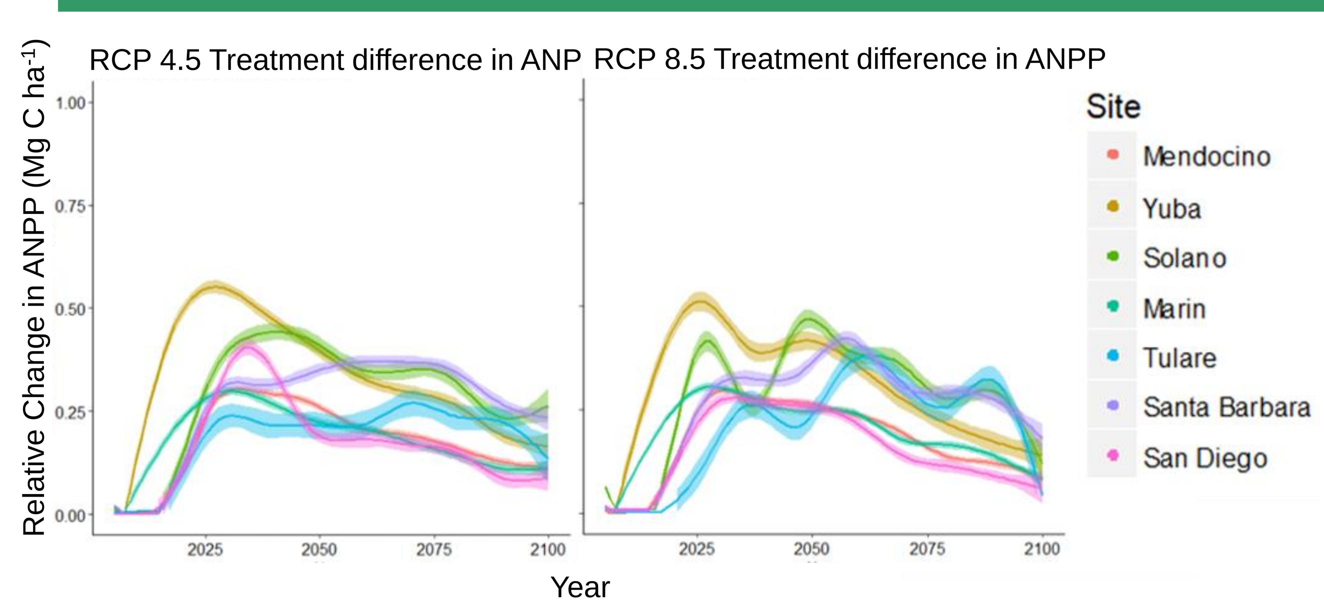
DayCent (Parton et al. 1998) was used to simulate climate and management driven changes in each rangeland system. The model is driven with site-specific historic climate data, measured soil texture, bulk density, and annual forage production values. Soil C flows and NPP are both strongly dependent on water availability in DayCent.

Simulations of future conditions were driven by daily climate data extracted from the **CanESM2 Earth System Model**, one of the four models recommended by the California 4th Climate Assessment for analyses of climate impacts in California.

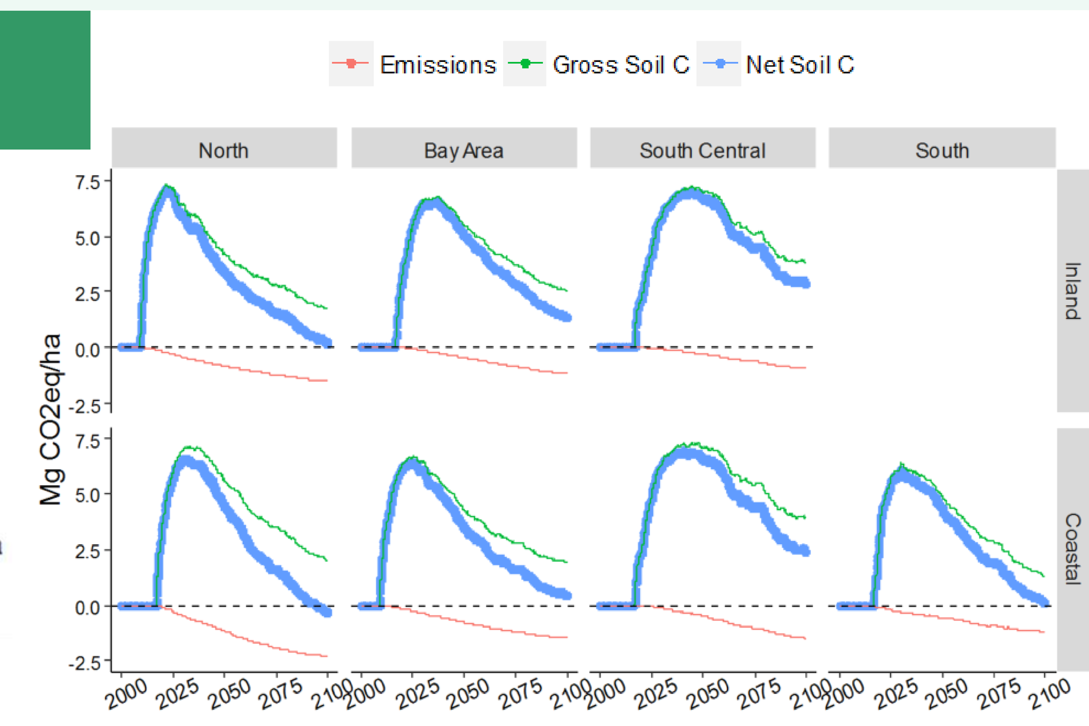


Site-specific weather simulations were run under **reduced emissions scenario (RCP4.5)**, which has relatively small changes in climate from recent historical conditions, and **high emissions scenario (RCP8.5)**, which has relatively warmer and wetter conditions compared to recent historical conditions.

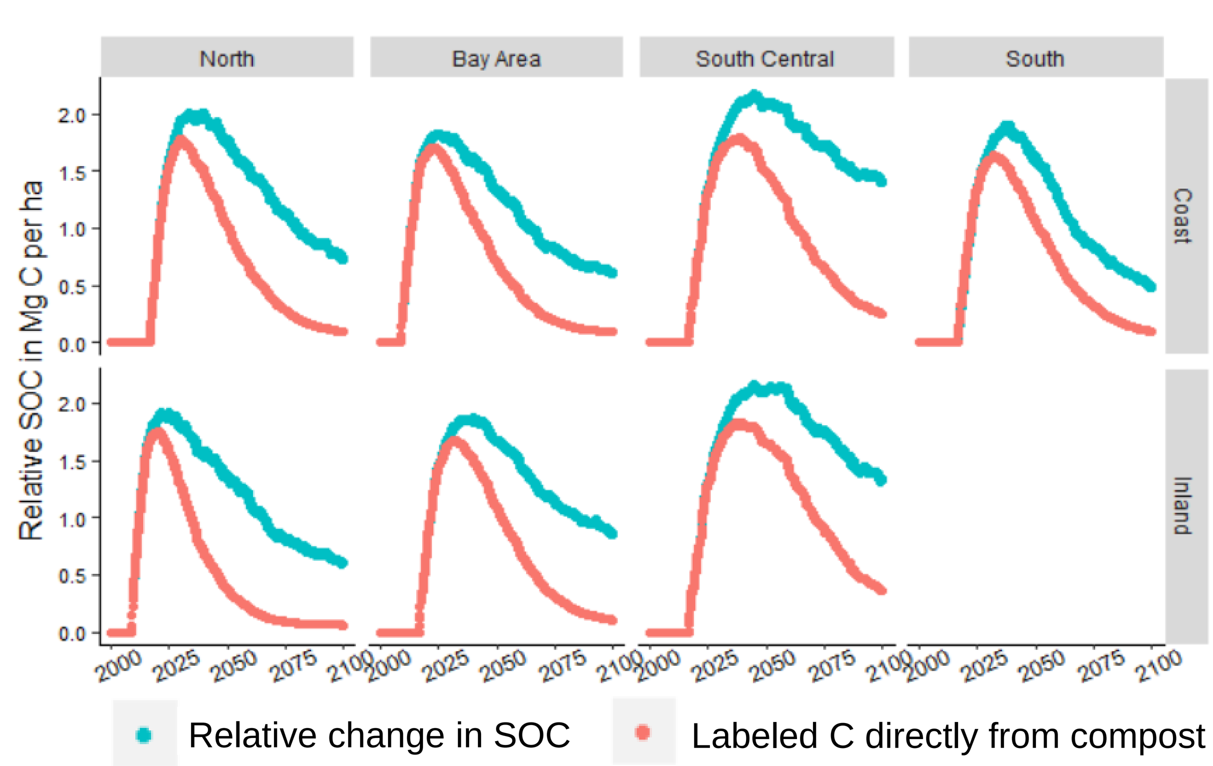
Results



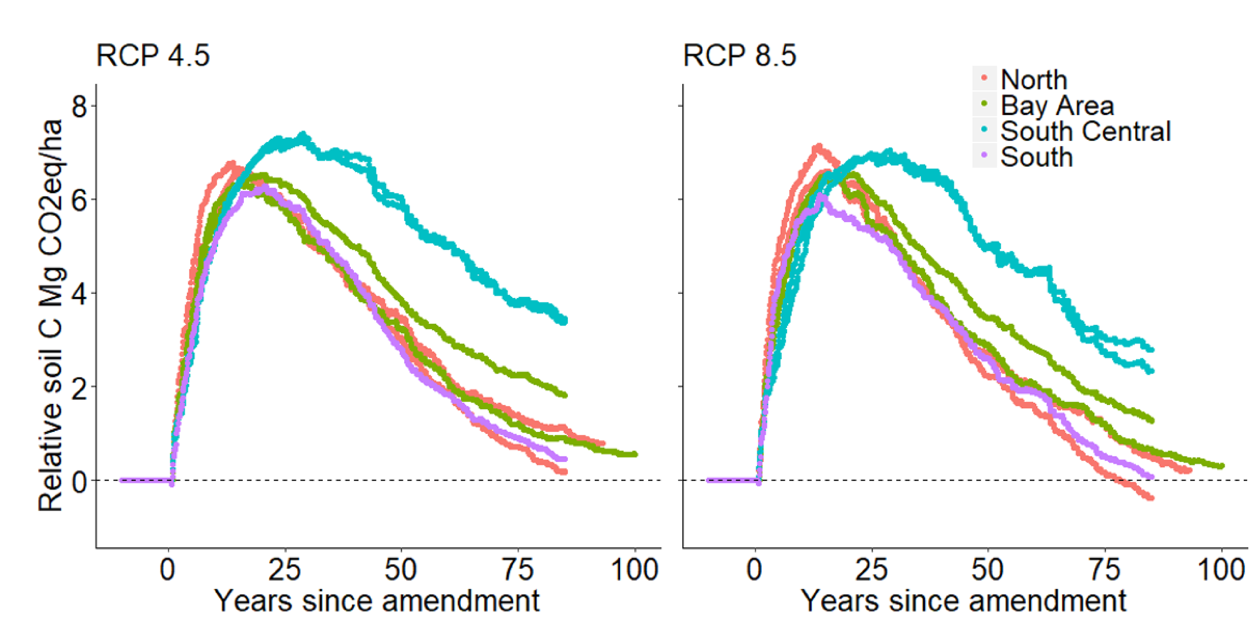
Net primary productivity increased in the compost treated plot relative to the control plot in all seven sites. The increase in net primary productivity lasted through the end of the century under both climate scenarios.



Total enhanced soil C storage due to compost (Gross soil C) was greater than greenhouse gas emissions stimulated by compost application to soil , resulting in a net climate benefit (Net soil C sequestration: blue line) for all sites through the end of the century (RCP 4.5).



The increase in soil C was due to both the direct addition of C through the compost amendment as well as an indirect increase in soil C inputs from NPP (Figure 3.3b). Compost C had largely decomposed by the end of the century.



Net climate benefit (Gross soil C inputs minus greenhouse gas emissions) for all seven sites were positive through the end of the century under RCP 4.5. With greater climate change in the RCP 8.5 scenario, all sites exhibited reduced climate benefit in the latter half of the century.

Conclusions

Soil C sequestration rates are maximized ~15 years after a single compost application, and **more than offset greenhouse gas emissions** for at least five decades longer

The net C sequestration due to compost application is higher at the drier (south central) sites for both RCP scenarios, indicating that the **compost effect at drier sites are less sensitive to climate change**.

Emissions reductions at a global scale (i.e. the RCP4.5 scenario) lead to **longer term climate benefits** of land-based mitigation strategies such as compost amendments, creating a virtuous cycle.

Literature Cited

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