The Effects of Grazing on Above Ground Plant Biomass, Microbial Respiration, Net Ammonification, and Select Physical Properties of Coastal Prairie Soils.

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Abstract

A paired-plot analysis was conducted to quantify the effects that grazing has on select soil physical and biological properties. Utilization cages measuring 1 m^2 were placed on several grazed sites throughout Redwood Creek Ranch, 20 miles east of Blue Lake, CA, during the summer of 2012. They were revisited about two years later on February 15, 2015 and March 29, 2015. Seven coastal prairie grassland soils were sampled from inside and directly next to exclosures (caged) to determine the influence that cattle grazing imparts on above ground plant biomass, bulk density, percent of soil organic matter (SOM), microbial respiration, and net ammonification. More above ground plant biomass was found within cages and bulk density measurements were higher on the grazed sites. There were no other significant findings between the two management practices (no grazing and continuous grazing); we attribute this to the lack of time the caged plots had to recover from previous seasons.

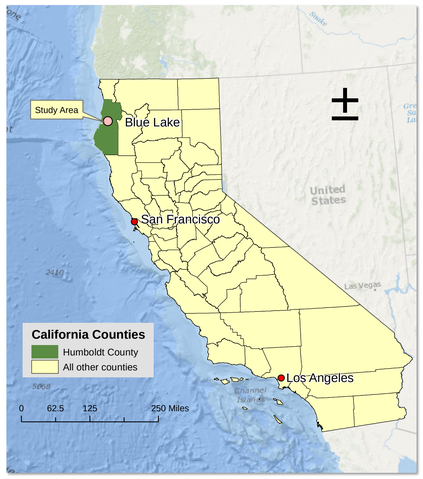

Figure 1: Redwood Creek Ranch is located in Humboldt County, approximately 30 miles east of the California coast.

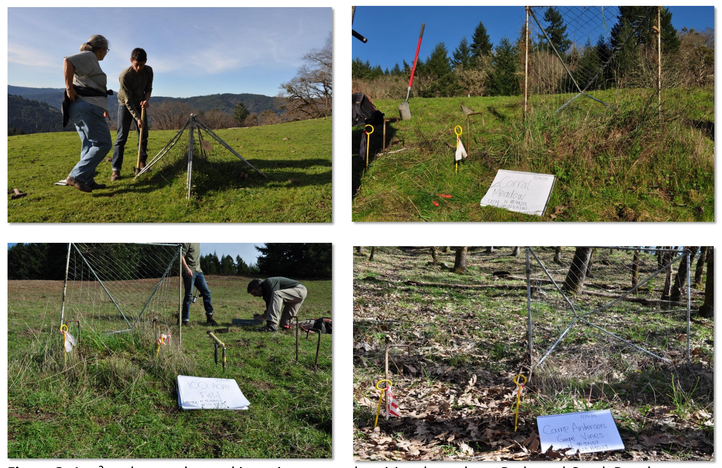

Figure 2: 1 m^2 exclosures located in various coastal prairies throughout Redwood Creek Ranch. Paired plots of soils inside and outside of exclosure cages to compare various physical and biological properties.

Objective

To quantify changes that occur in bulk density, soil organic matter, microbial respiration, plant biomass, and net ammonification measurements as a result of excluding cattle grazing for a short period of time (2 years). To identify correlations between soil microbial respiration and volumetric water content along with soil microbial respiration and soil organic matter.

Methods

Field Site

- Seven paired plots (14 total)
- 1 m^2 exclosures: samples taken from within 25 cm x 50 cm subplot

Data Collection

- Soil core taken from the top 10 cm of the soil surface
- Buried bag incubation: adapted from Zou et al. (1992).

Data analysis and interpretation

- Microbial respiration: Adapted from Substrate Induced Respiration (SIR) method (Horwath and Paul, 1994)
- Net ammonification: Extraction and analysis adapted from Maynard et al. (2006)
- Bulk density: rock correction method (Soil Survey Staff, 1996)
- Soil organic carbon: loss on ignition method (Schulte and Hopkins, 1996)
- Above ground biomass: clipped to within 1 cm of soil surface; dried, weighed, and sorted in lab.
- Statistical analysis: paired t-test with alpha of 0.05

Acknowledgements

We would like to thank Dr. Susan Edinger Marshall, Dr. Edward Vasquez, Dr. David S. Baston for technical support and access to necessary facilities. An additional thanks to The Barnum Timber Company and the Holm Family for continually granting access to Redwood Creek Ranch.

Results

Table 1: Mean values derived from the various analyses conducted on samples obtained from the Redwood Creek Ranch. Seven sites were sampled in this study. Nominal variables contrasted in the paired t-test were: continuous grazing and the exclusion of grazing over a two year period; alpha was set to 0.05.

	Soil Bulk Density (g/cm^3)	Soil Organic Matter (%)	Microbial Respiration (CO_2/ g soil)	Live Plant Biomass (g)	Decadent Plant Biomass (g)	Total Plant Biomass (g)	Net Ammonification (ug/g)
Caged	1.04	12.32	0.024	19.35	25.22	22.28	12.42
Grazed	1.28	12.97	0.023	7.28	13.19	10.23	10.19
P-value	0.007	NS	NS	NS	NS	0.021	NS

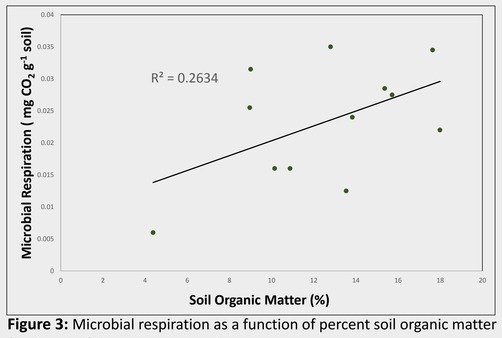

Figure 3: Microbial respiration as a function of percent soil organic matter for six out of the seven survey sites.

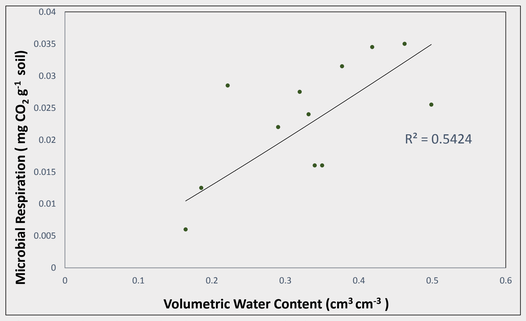

Figure 4: The relationship between microbial respiration and volumetric water content for six out of the seven sites surveyed.

Discussion

Several points were taken into account while drawing conclusions from our data:

- Increased microbial respiration and soil organic matter are associated with increased amounts of high quality substrate and soil moisture (Ingram et al., 2007).
- Herbivory stimulates plant growth, which results in increased carbon flux to the root system and root exudates of the plant (Cheng et al., 1996), this may result in increased microbial respiration as soil organic matter inputs are increased by stimulated plant growth (Northrup et al., 1999).
- Higher bulk density measurements in grazed areas may be a result of livestock trampling and can lead to a decrease in water infiltration (Dudley et al., 2002), which can lead to a decrease in soil moisture and a subsequent decrease in microbial respiration.

Bulk density measurements taken from our non-grazed plots proved to be significantly less than their grazed counterparts (Table 1). Soil organic matter and microbial respiration measurements reported no statically significant differences. Larger quantities of plant biomass were found inside of cages. Caged plots reported higher ammonium concentrations, but no statistical difference was found after running a paired t-test (Table 1). Our results conveyed a positive correlation between % SOM and soil microbial respiration (Figure 3) as well as a positive correlation between volumetric water content and soil microbial respiration (Figure 4).

Total plant biomass was categorized as being live or decadent (dead) material. It was hypothesized that the lack of herbivory would allow for decadent materials to accumulate and shade out any potential new growth. The correlation between SOM and microbial respiration was observed with the understanding that SOM is a key component in soil health, and influences many physical, chemical and biological properties (Paul, 2014). No significant differences were observed in the amount of SOM present between the management types (grazing/not grazing), but a reduction in bulk density inside of cages was observed—which in turn can be associated with increased SOM altering the soil physical composition.

This study intended to measure soil microbial biomass by utilizing a substrate induced respiration method. However, due to technical difficulties, microbial respiration measurements were extracted instead. Soil microbial respiration can still give relative insight into microbial activity, as more respiration would ideally correspond to greater microbial biomass. Studies have shown that soil microbial communities rely on water films to diffuse substrate and combat desiccation (Davidson et al., 1998). This relationship was observed in the positive correlation identified between microbial respiration and volumetric water content (Figure 4), and can in part, be tied in with lower bulk density values that allow for increased infiltration and standing above ground plant biomass that helps to retain moisture.

High bulk density values are an indicator of compaction and low porosity, which in turn reduces the ability of water to infiltrate into subsurface horizons. The reduction in bulk density seen within the exclosures after just 2 years is an optimistic reflection of the improvements that can be made in soil structural components within a short period of time. The short temporal scale of which this study encompasses may not have been long enough for significant changes to occur between the management methods and should be taken into account for future studies.

Improvements

- Select an alternative respiration measurement technique such as infrared gas analysis, chloroform fumigation methods and the Solvita gel system (Haney et al., 2008; Horwath and Paul, 1994).
- Perform complete net mineralization experiment as opposed to just net ammonification.
- Employ larger exclosure cages to decrease edge effects and other variables commonly associated with plot sampling.
- Extend the temporal scale to allow for greater recovery of soil habitat.

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