UNIVERSITY OF CALIFORNIA

UC Consortium for Drought and Carbon Management

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Project Overview

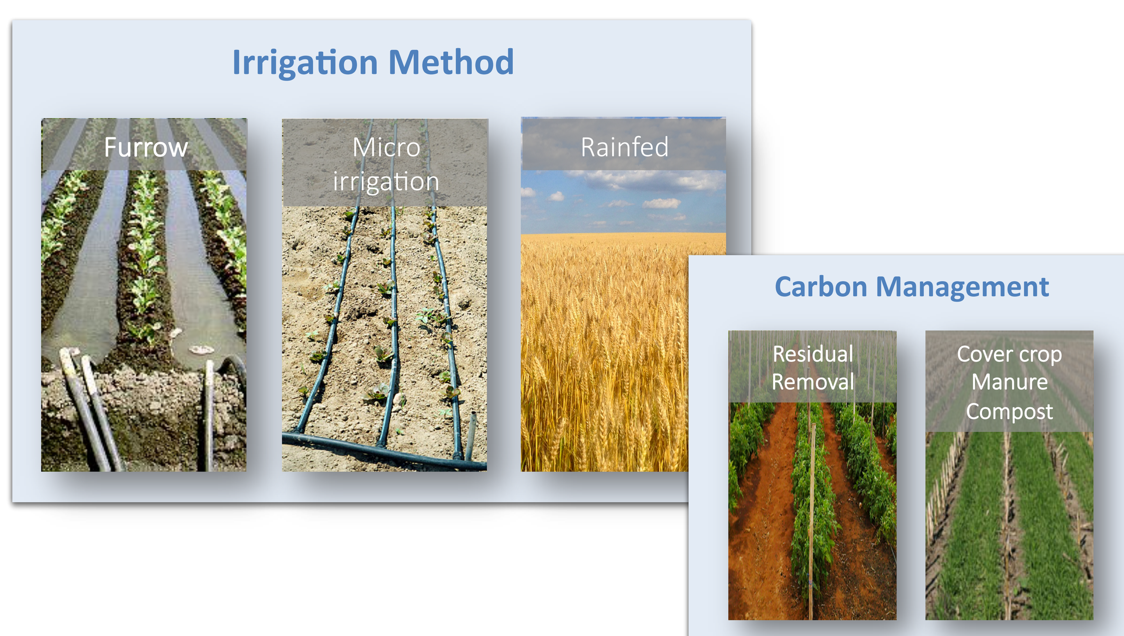
California agriculture faces enormous challenges as climate changes and access to water is reduced and less predictable. California's recent drought cost the state $2.7 billion with a loss of more than 21,100 jobs in 2015 alone. Soil, particularly soil carbon and its microbiome, plays a critical role in crop water-use efficiency and crop response to drought. Physical, chemical, and biological interactions in soil at the micrometer scale form soil aggregates that are critical in storing carbon and contain the small pores needed to retain moisture. We have established a Consortium for Drought and Carbon Management (UC DroCaM) to examine the effects of irrigation method (i.e., furrow and drip or micro-sprinker irrigation) and management practices (e.g., carbon inputs and rotations) on size distribution of soil aggregates, formation of mineral-organic associations, microbial community shifts and extracellular polymeric substance (EPS) production, and carbon storage. Findings are integrated into a regionally-scalable predictive model (*ecosys*) to describe soil carbon dynamics and estimate the response of agricultural systems to drought. Here, we present our program's interdisciplinary approach integrating geochemical, biological, and hydrological processes to determine the affect of irrigation and carbon management practices.

Background and Significance

Soil quality plays a critical role in how a crop responds to drought and even the effectiveness of irrigation. Soil carbon and the soil microbiome play major roles in soil water relations, both in resilience to drought and to flooding. Despite knowledge and evidence of the importance of soil, irrigation remains largely focused on water availability and quality, and frequently ignores that soil plays an equally important role in management. It has been shown that soil with higher organic carbon content and more stable aggregate structure can absorb and hold more water and nutrients during a rain or irrigation event, however, the microbiological, chemical, and physical mechanisms controlling soil aggregate formation as a function of agricultural practice are still poorly understood.

Specific Aims

Using the unique long-term experiments on-going at Russell Ranch Sustainable Agriculture Facility (in combination with Research and Extension Centers in future experiments), we are able to explore the impact of various irrigation methods and carbon management practices (shown below) on aggregate formation.



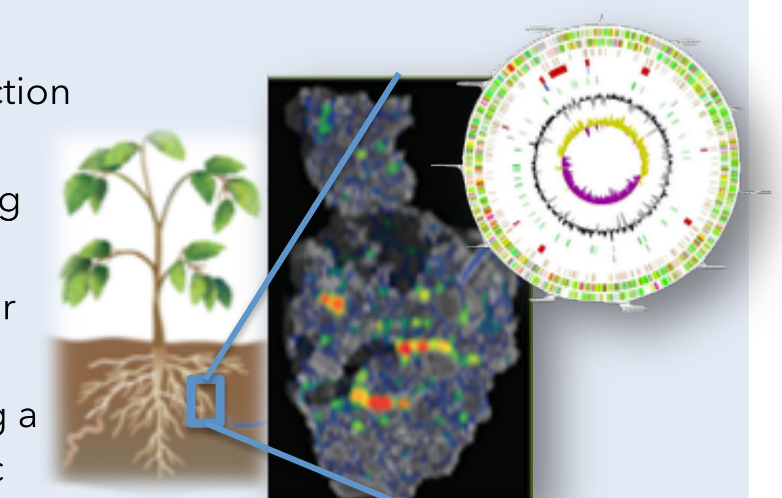
Specifically, **we aim to**:

1. Determine how irrigation methods and carbon inputs impact soil microbial communities and their metabolic functions
2. Establish the impact of different irrigation and carbon management practices on the abundance and type of organo-mineral complexes and soil aggregates. We will then relate these changes to impacts on infiltration, water use efficiency, and carbon storage
3. Determine the conditions and treatments under which soil aggregation will lead to excess infiltration, causing deep percolation beyond the root zone

The findings will then be used to develop a regionally-scalable model (See A. Marklein et al. Field Day presentation) to describe carbon dynamics and to project shifts in water storage as global climate continues to change.

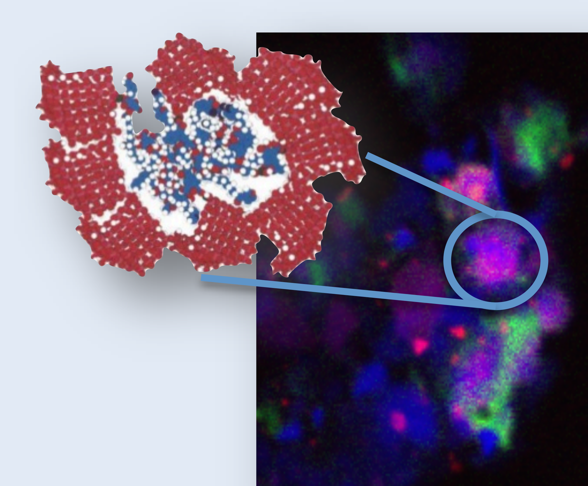
1. Role of Soil Microbiome

Soil microbial communities contribute to improved soil structure through the production of extracellular polymeric substances (EPS) which adhere soil particles together forming soil aggregates. We hypothesize that more dramatic wet-dry cycles caused by furrow or flood irrigation will lead to increased EPS production. We explore this objective using a combination of cutting-edge spectroscopic and metagenomic tools.

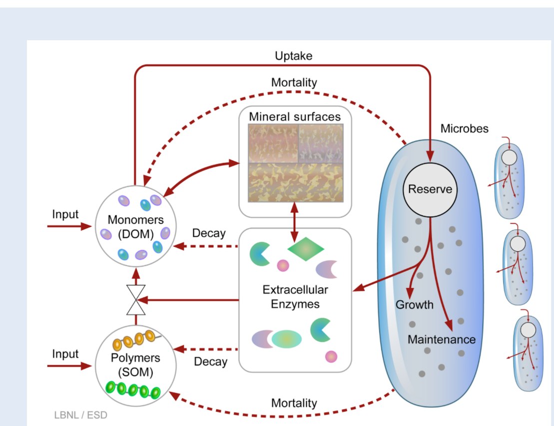


2. Formation of Mineral-Organic Associations

Over the long term, soil carbon persistence in soils is controlled by the formation of intimate stable mixtures of mineral grains/metals (e.g., Fe and Al) and organic compounds called mineral-organic associations (MOAs). These assemblages are critical building blocks of the soil aggregates that help soil retain water while at the same time providing good infiltration. To understand MOA formation and its interplay with the soil microbiome across different soil types and treatments, we will perform a detailed analysis of the size and abundance of soil aggregates and the chemical composition of the MOAs within them using a complementary suite of laboratory analyses and cutting edge synchrotron spectro-microscopic techniques.



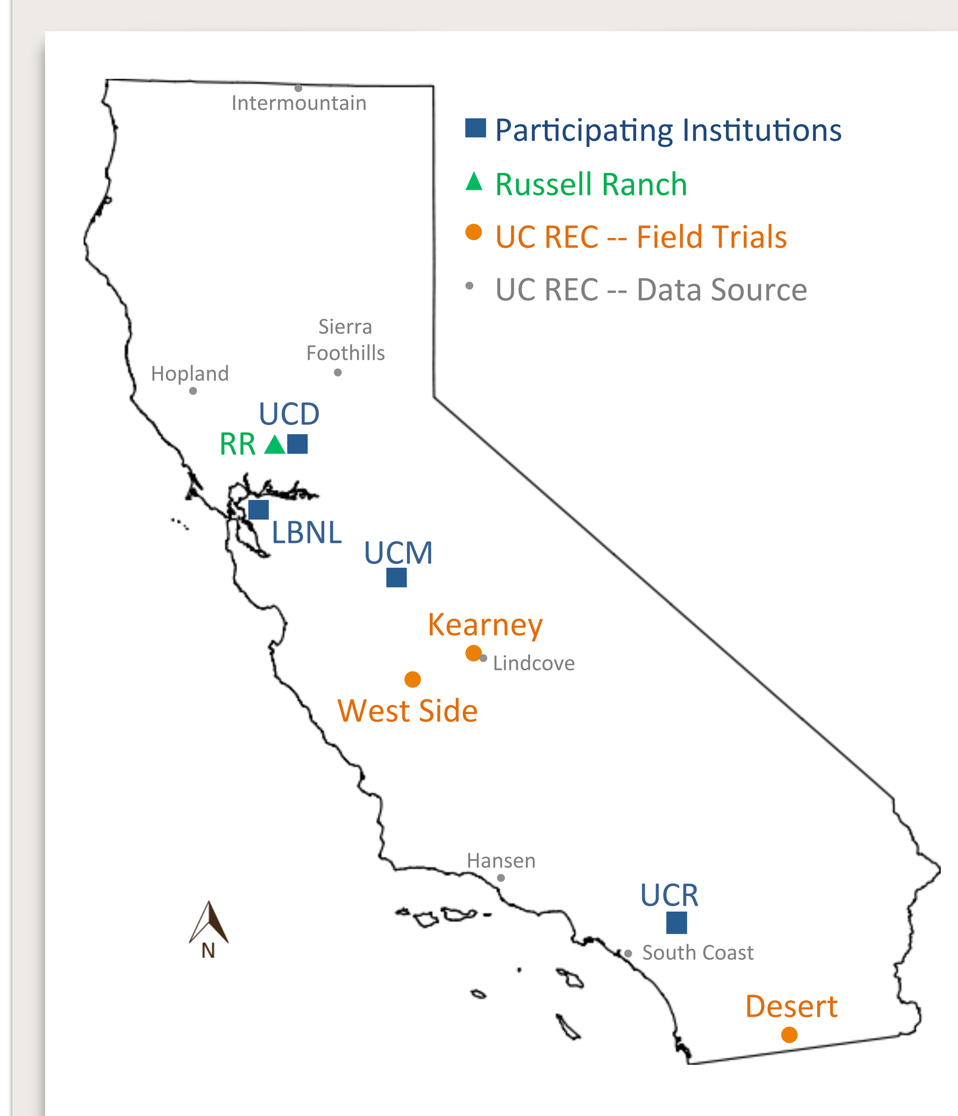
3. Development of a Regionally-Scalable Model



Predicting soil carbon dynamics in agricultural systems requires a model that represents soil carbon and nutrient biological processes, interactions with soil hydrology, crops and land management. We utilize a regionally-scalable model *ecosys* to represent these basic processes to improve our understanding of coupled carbon, hydrology, and abiotic interactions in California agricultural systems.

A California-wide Collaborative

The UC Consortium for Drought and Carbon Management currently brings together researchers, faculty, and students from four UC campuses (Berkeley, Davis, Merced, and Riverside) and one national lab (Lawrence Berkeley National Lab) with expertise in a wide range of fields including soil microbiology and ecology, metagenomics, soil chemistry and biogeochemistry, soil physics, numerical modeling, hydrology. We will continue to recruit new faculty, extension specialists, and other researchers across the UC campuses and farmers and industry experts across California as our project expands. Our long-term aim is to help establish a network for cross-discipline collaborations aimed to continually improve our understanding of how soil structure is altered by irrigation and carbon management.



Acknowledgements

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