Climate and Soil Health in the Inland Pacific Northwest

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Introduction

Soil Organic Matter and Soil Health

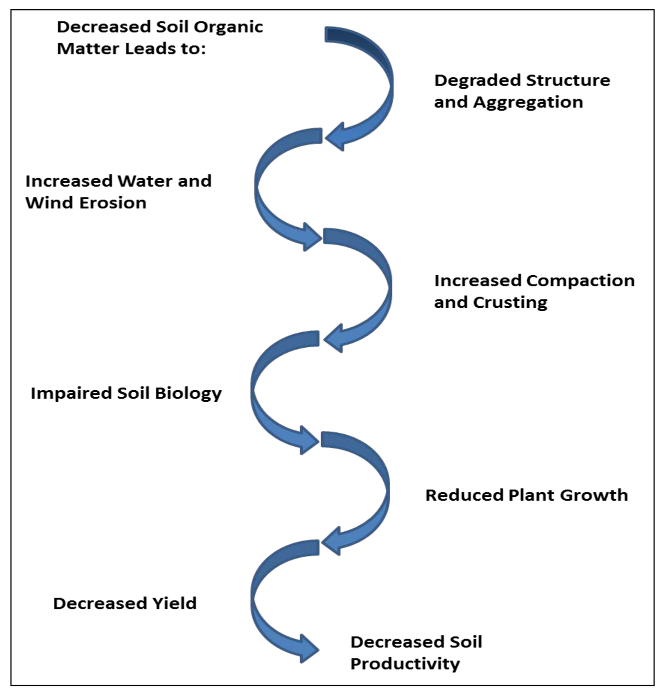

Fig. 1. Consequences of SOM degradation (adapted from Karlen et al. 2015).

- Soil Organic Matter (SOM) is central to critical soil properties and processes such as nutrient cycling, soil structure, and water infiltration.
- SOM is a major source of plant nutrients and directly linked to potential soil productivity (Smith, 2002).

Climate and Soil Health

- Mean Annual Temperature (MAT) and Mean Annual Precipitation (MAP) are important drivers of SOM dynamics:
  - Where growing degree days are sufficient, SOM decreases across a gradient of increasing MAT.
  - SOM typically increases across a gradient of increasing MAP.

Labile and Stable SOM

- For the sake of simplicity, SOM is often divided into two pools, both of which are critical to soil health:
  - The stabile pool contributes to long term increases in SOM: however it is slow to respond to changes in management.
  - The labile pool drives nutrient cycling and impacts many biologically related soil properties that are critical to soil productivity.

REACCH

- Our research includes four sites that span three agroecological classes as part of the project "Regional Approaches to Climate Change" (REACCH) (Fig. 1).
- REACCH will enable researchers, stakeholders, students, the public, and policy makers to better understand the interrelationship of agriculture and climate change and to develop mitigation and adaptation strategies.

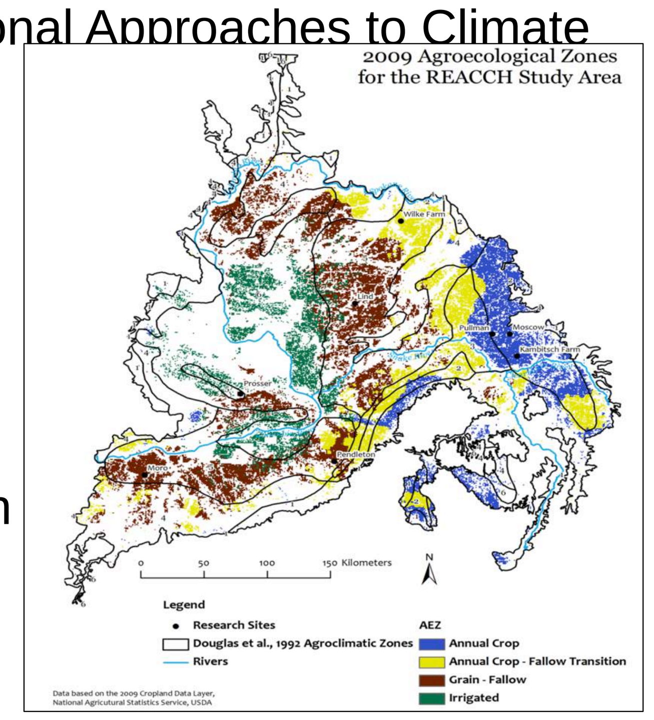

Fig. 1. Location of study sites within REACCH study area including AEZ boundaries.

Objectives

- Identify the influence of MAT and MAP across the four study sites on surface SOM properties
- Based on the present day relationship between climate and SOM, examine the influence of future climate change on SOM and subsequently soil health.

Methods

- Soil samples were collected from all 4 sites between June and July, 2013.
- For cropping systems which are winter wheat (WW) based, the WW portion for the rotation was sampled; for other cropping systems, the crop present during sampling is noted.
- Laboratory analysis was conducted between July and December 2013 and included total C and N and acid hydrolysis.

Location	Soil Type	MAP (mm)	MAT (°C)	Crop Rotation*	Year Established	Equipment/Tillage
Kambitsch Farm - Genesee, ID (N 46.58°, W 116.95°)	Palouse Silt Loam	663	8.6	WW - SB - SL	2000	Double Opener (NT)
						Chisel Plow (Till)
Palouse Conservation Field Station - Pullman, WA (N 46.73°, W 117.18°)	Palouse/ Thatuna Silt Loam	533	8.4	Native (CRP) Grass	2001	N/A
				Perennial Tall Wheat Grass		
				Alfalfa - Cereal - SL		Sweep/ Single Opener (NT)
				WW - SB - SW		Single Opener (NT)
				WW- SL - SW		
Columbia Basin Agriculture Reseach Center - Pendleton, OR (N 45.44°, W 118.37°)	Walla Walla Silt Loam	417	10.3	WW - NT Fallow	1982	Modified Deep Furrow (NT)
				WW - WP	1997	
				WW - Fallow	1997	Mold-board (Till)
Columbia Basin Agriculture Agriculture Reseach Center - Moro, OR(N 45.48°, W 120.69°)	Walla Walla Silt Loam	288	9.4	WW - NT Fallow	2003	Double Opener (NT)
				WW - WP		
				WW - SB - Fallow		
				WW - Fallow		Chisel Plow (Till)

Table 1. Summary of 4 study sites. (*WW = winter wheat; SL = spring legume; SB = spring barley; SW = spring wheat; WP = winter pea; NT = no-till).

Results

Climate Ratio: The ratio of MAT/MAP provides an approach for looking at the combined effect of these two climate variables on SOM. An increasing ratio represents warmer, drier conditions.

Present Climate

Total C and N: This analysis provides a measure of both the stabile and active pools of C and N, as well as any inorganic carbon that may be present in a soil.

- Across the four sites, both total N and C decrease as the climate ratio increases.
- The differences observed within sites represents the influence of tillage and cropping intensity.
- Climate has a stronger relationship than management with total C and N (r):

Variable	MAT/MAP	Tillage	Cropping Intensity
Total C	0.81	0.12	ns
Total N	0.89	0.08	ns

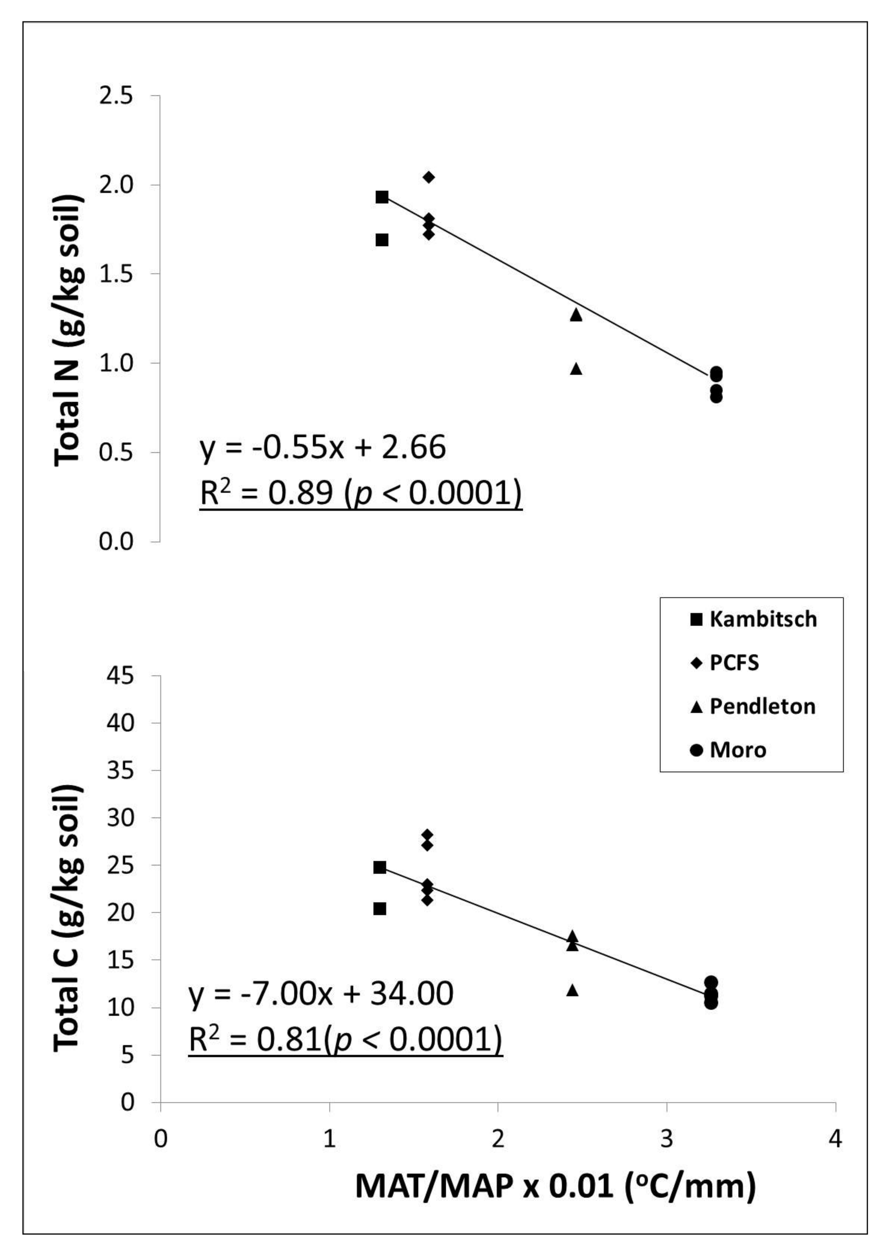

Fig. 2. Total Carbon and Nitrogen with MAT/MAT across four study sites.

Hydrolyzable and Non-hydrolyzable C and N: This analysis divides total C and N into two pools:

- Non-hydrolyzable C and N (NHC, NHN) has been identified as an older and more stable pool of C and N (Paul et al., 2001).
- Hydrolyzable C and N (HC, HN) is much younger than NHC and NHN and captures labile SOM.

- Comparing the slopes of the regression lines shows hydrolyzable N is more sensitive to MAT/MAP than non-hydrolyzable N.
- Both non-hydrolyzable C and hydrolyzable C are equally sensitive to the MAT/MAP gradient.
- As with total C and N, climate displays a stronger relationship with NHC, HC, NHN, and HN than both tillage and cropping intensity (r):

Variable	MAT/MAP	Tillage	Cropping Intensity
NHC	-0.75	-0.31	0.26
HC	-0.79	-0.27	ns
NHN	-0.75	ns	ns
HN	-0.86	-0.32	ns

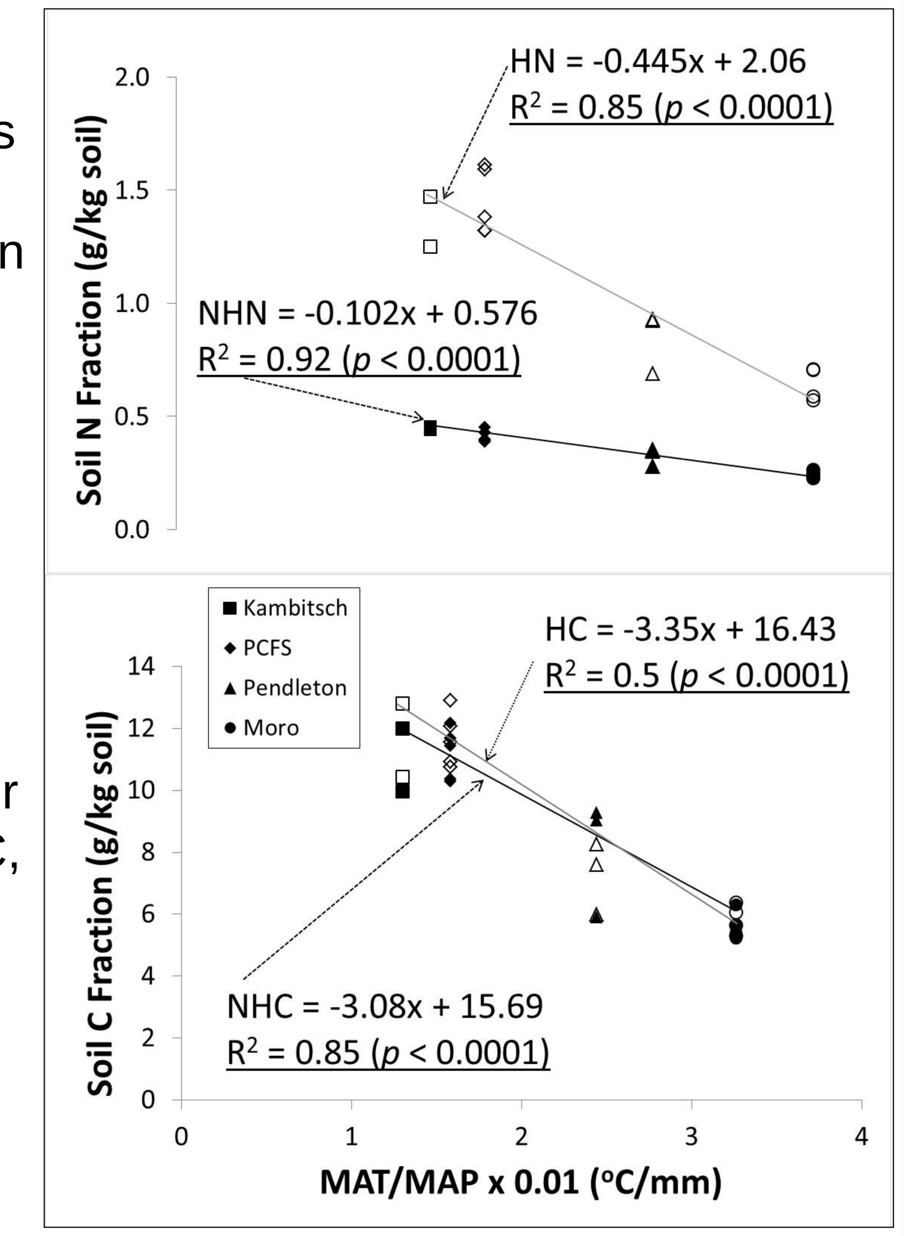

Fig. 3. Present MAT/MAP with hydrolyzable and non-hydrolyzable C and N.

Future Climate

- The average from 19 climate models based on RCP 4.5 indicates MAP will increase in the region 5.2% to 5.9% by 2070 while MAT will increase 20% to 31% (°C) by 2070.
- Based on the present day relationship between MAT/MAP and total C and N (Fig. 2), in the top 4 inches 64 lbs./acre of total N and 810 lbs./acre of total C will be lost for every 1/10 increase in MAT/MAP.
- Soil Health Impacts: reduced nutrient availability, CEC, degraded soil structure and water holding capacity.
- **What can be done?** Build soil resiliency by minimizing disturbance, diversifying and intensifying crop rotations and monitoring soil health.

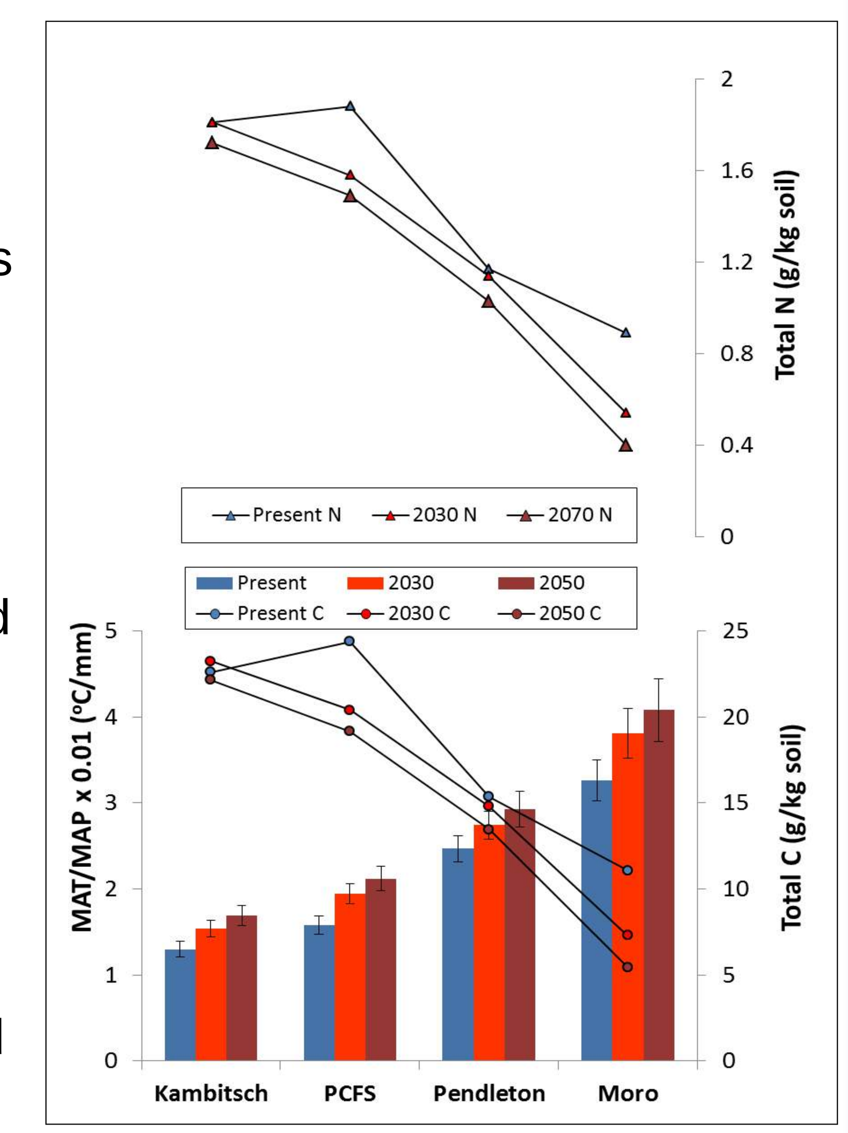

Fig. 4. Present and future MAT/MAP for 2030 and 2070 with total C and N.

References

1. Smith, J.L. 2003. *Soil quality: the role of microorganisms.* Encyclopedia of Environmental Microbiology.
2. Paul, E.A., H.P. Collins, and S.W. Leavitt. 2001. Dynamics of resistant carbon of Midwestern agricultural soils measured by naturally occurring [14]C abundance. *Geoderma.* 104(3/4): 239-256.

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