Assessing Soil Health in the Inland Pacific Northwest

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Soil Health

The capacity of a soil to " provide for human sustainability by functioning as a medium for plant growth, and as an environmental buffer and filter for cycling water, altering chemicals, and cleaning air". (Smith, 2002)

- SOM is central to critical soil processes such as nutrient cycling, soil structure formation and water infiltration.
- SOM is a major source of plant nutrients and directly linked to potential productivity (Smith, 2002).
- Components of an assessment should be easily accessible, low cost, and sensitive to management and climate.

Labile and Stabile SOM

- The stable 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.

Property	Soil Food Web	Chelation	Aggregation	Mineralization	CEC	Water Capacity	Soil Structure	Soil Health
Labile	x	x	x	x				x
Stabile					x	x	x	x

REACCH

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

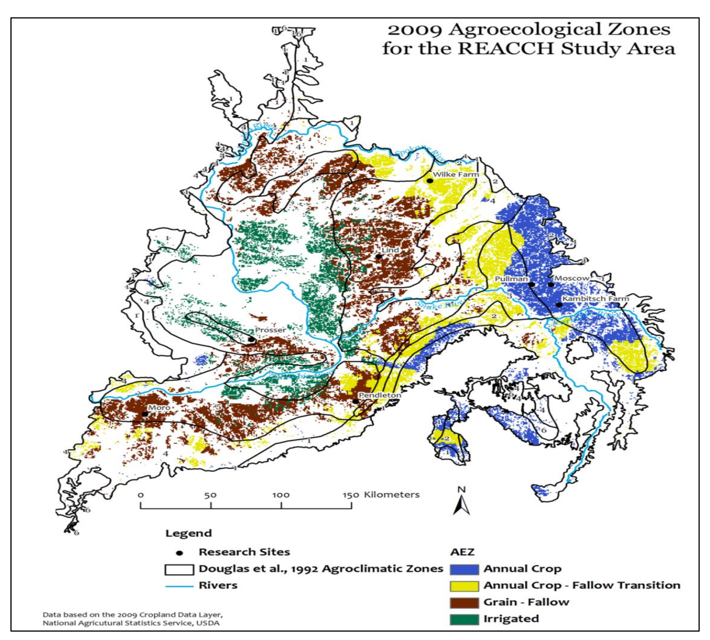

Figure 1. Location of study sites within REACCH study area, including agro-ecological classes (AEC).

Objectives

- Examine present and future climate scenarios for the inland Pacific Northwest and potential implications for soil health.
- Present labile and stabile measures of SOM and their sensitivity to management and ability to act as soil health indicators and sensitivity to important soil processes, particularly PNM (28-day anaerobic potential nitrogen mineralization) and qCO2 (microbial metabolic quotient, $\frac{Cmin_{0-24d} - Cmin_{0-17d}}{microbial\ biomass\ carbon}$, a measure of microbial efficiency).

Methods

- Soil samples (0-10 cm) were collected from the five study sites between June and July, 2013 (Table 1).
- For cropping systems which are winter wheat (WW) based, the WW portion of the rotation was sampled; for other cropping systems, the crop present during sampling is noted.
- Laboratory analysis included total C and N, permanganate oxidizeable carbon (POXC), carbon mineralization (1, 3, 10, 17, and 24 days), water extractable C and N, acid hydrolysis, microbial biomass, PNM, and 1-day PRSTM (western Ag Innovations, Saskatoon, Saskatchewan, Canada) probe incubations.

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)
WSU Irrigated Agricultural Research Center - Prosser, WA (N 46.29°, W 119.74°)	Warden Silt Loam	200	10.9	WW - Sweet Corn - Potato	2011	Double Opener / Disc§
				WW - Sweet Corn - Potato		Ripped/Disc (Till)

Table 1. Summary of 5 study sites. (*WW = winter wheat; SL = spring legume; SB = spring barley; SW = spring wheat; WP = winter pea; § disced during potato sequence; NT = no-till).

Results

Climate - Present:

- A increase in MAP was associated with an increase in SOC (r = 0.76) and total N (r = 0.83), while an increase in MAT was associated with a decrease in SOC (r = -0.64) and total N (r = -0.70).

Climate - Future:

- By 2050, for the inland PNW, some models predict a 5% rise in MAP and 2.2°C rise in MAT, and by 2100 a 15% rise in MAP and a 3.6°C rise in MAT.
- Ratio of MAT/MAP under future scenarios predicts a decrease in soil C and N.

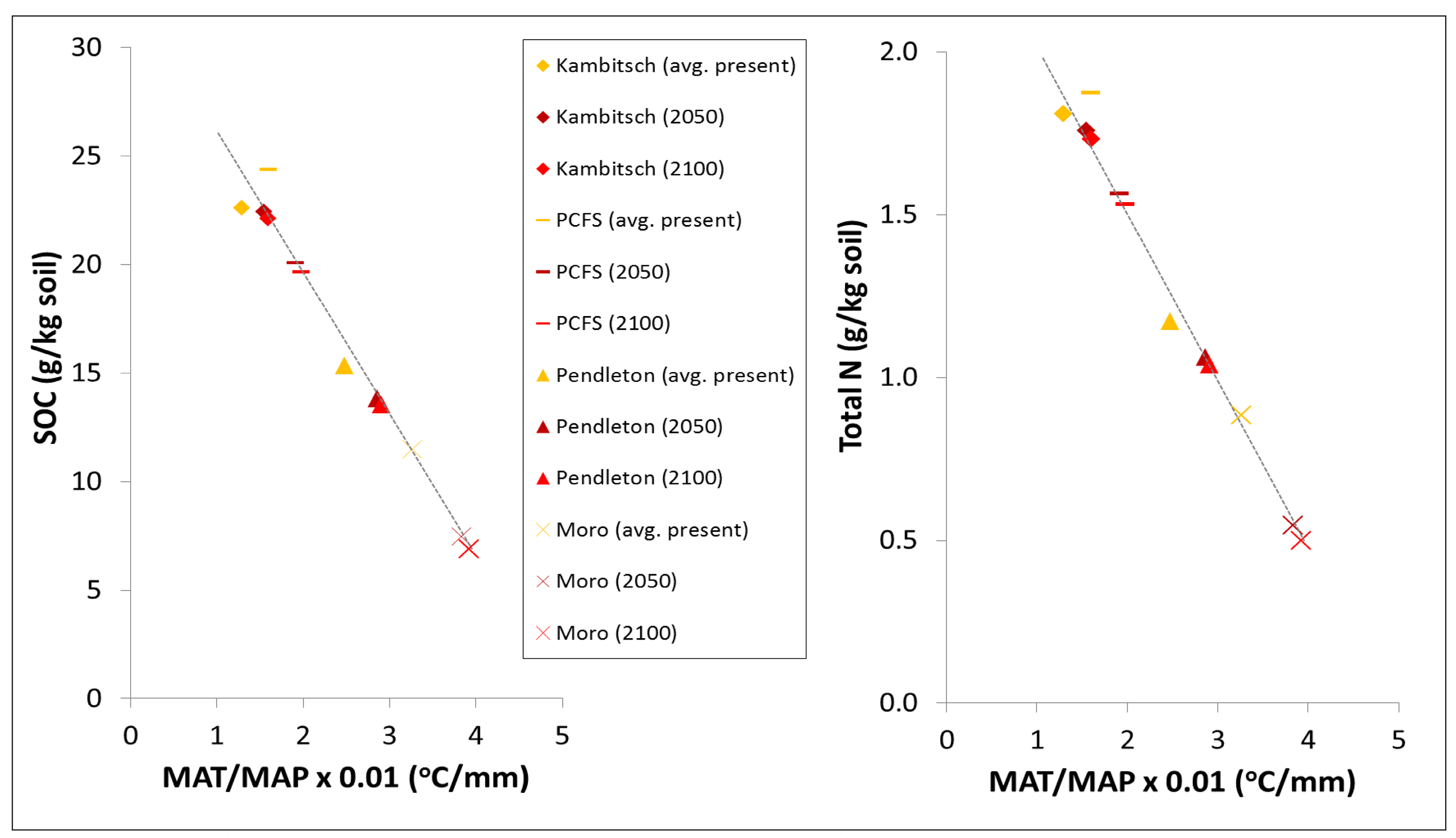

Figure 2. Future climate scenarios and SOC and total N across four dryland study sites (SOC = soil organic carbon; MAT = mean annual temperature, MAP = mean annual precipitation) (Notes: Present average for each site represents average across all treatments. MAT/MAP ratio for 2050 based on 2.2°C rise in MAT and 5% increase in MAP based on current MAP, and for 2100 based on 3.6°C rise in MAT and 15% rise in MAP based on current MAP).

- Microbial response is uncertain under future climate scenarios, but promoting improved soil structure and aggregation is critical to protecting soil C and N and enhancing soil health.

POXC and SOM Stabilization:

- POXC displayed a significant relationship with non-hydrolyzable C (r = 0.84) and N (r = 0.80), and hydrolyzable C (r = 0.90) and N (r = 0.90).
- Therefore, POXC is indicative of stabilized SOM, as was also supported by Culman et al. (2012), who showed it was sensitive to compost additions.
- A coupling of POXC with more labile measurements of soil C and N can provide complimentary information on soil health and help inform management decisions aimed at improving soil health.

Site	Treatment†	POXC (g kg^{-1} soil)	PRS™ N_{0-1d} (ug 10 cm^{-2} 24 hrs^{-1})	$Cmin_{0-1d}$ (g kg^{-1} soil)	SH_{Index}
Kambitsch	1) WW/SB/SL - NT	0.466 a (8)	25.6 (55)	0.081 (16)	7.2 (19)
	2) WW/SB/SL - Till	0.388 b (6)	37.63 (44)	0.072 (23)	8.8 (27)
PCFS	3) WW/SL/SW - NT	0.399 (11)	39.9 (45)	0.047 (9)	6.1 (22)
	4) WW/SB/SW - NT	0.416 (9)	32.5 (50)	0.064 (53)	7.9 (37)
	5) Alf/SC/SL (organic) - NT	0.358 (11)	26.8 (30)	0.056 (50)	5.6 (33)
	6) Perennial Tall Wheat Grass	0.361 (8)	17.9 (32)	0.040 (8)	4.7 (7)
	7) Native/CRP Grass	0.349 (10)	13.1 (35)	0.045 (29)	5.4 (16)
Pendleton	8) WW/ NT Fallow - NT	0.315 a (10)	19.6 (35)	0.055 a (3)	5.8 a (4)
	9) WW/Pea - NT	0.305 a (11)	25.3 (26)	0.060 a (12)	6.0 a (7)
	10) WW/Fallow - Till	0.193 b (48)	15.0 (40)	0.038 b (7)	4.1 b (8)
Moro	11) WW/WP - NT	0.230 a (4)	25.0 a (12)	0.054 (24)	5.4 (15)
	12) WW/NT Fallow - NT	0.209 b (10)	11.3 b (13)	0.041 (34)	4.3 (17)
	13) WW/SB/NT Fallow - NT	0.225 ab (3)	6.9 b (51)	0.051 (42)	4.9 (28)
	14) WW/Fallow - Till	0.183 c (5)	8.7 b (45)	0.034 (16)	3.6 (13)
Prosser	15) WW/Sw. Cn./Potato - NT	0.162 (10)	21.5 (35)	0.050 (14)	4.8 (32)
	16) WW/Sw. Cn./Potato - Till	0.139 (28)	18.8 (9)	0.049 (18)	5.2 (13)

Table 2. Results for POXC and three labile measurements across five study sites (significant differences between treatments within a site indicated by different letters (p < 0.10); numbers in parenthesis is CV).

PRS™ Probes:

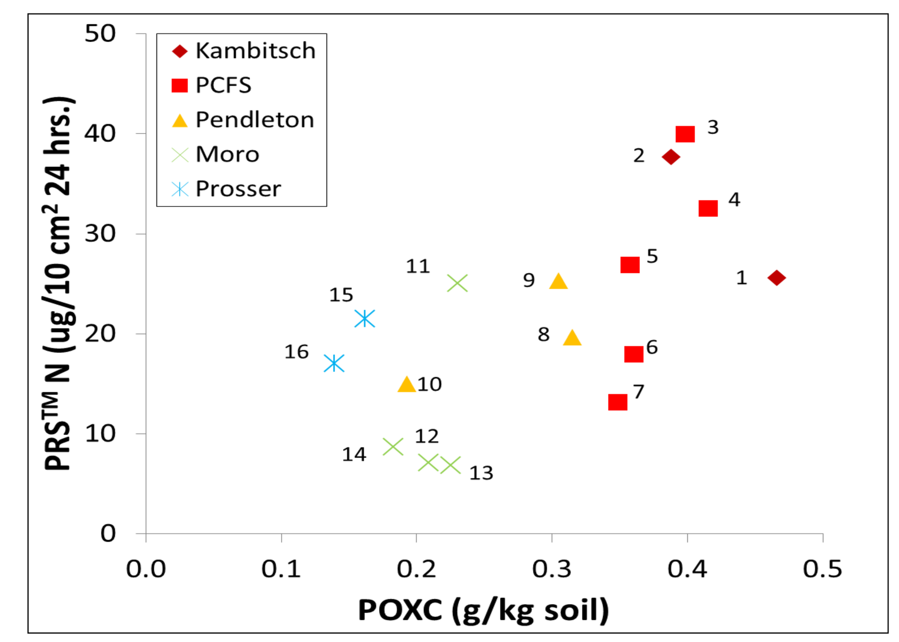

Figure 3. POXC and PRS N across study sites (See Table 2 for number).

- Capture plant available nutrients, linked to fertilizer recommendations
- Significant correlation with PNM (r = 0.40) and qCO_2 (r = -0.29)
- On average, higher CV (35) than $Cmin_{0-1d}$ (22) and SH_{Index} (19)

C Mineralization:

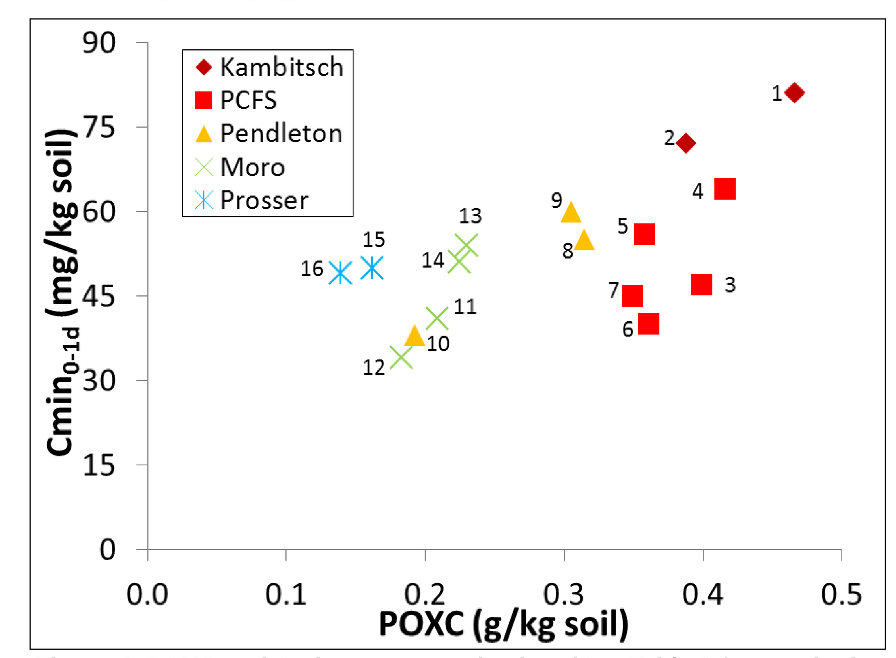

Figure 4. POXC and Cmin across study sites (See Table 2 for number).

- Measure of microbial activity
- Not significantly related to qCO_2
- Detected differences only at Pendleton between Till and NT
- Weak correlation with PNM (r = 0.28) and PRS N_{0-28d} (r = 0.28); therefore may not always be a good indicator of nutrient mineralization

Soil Health Index:

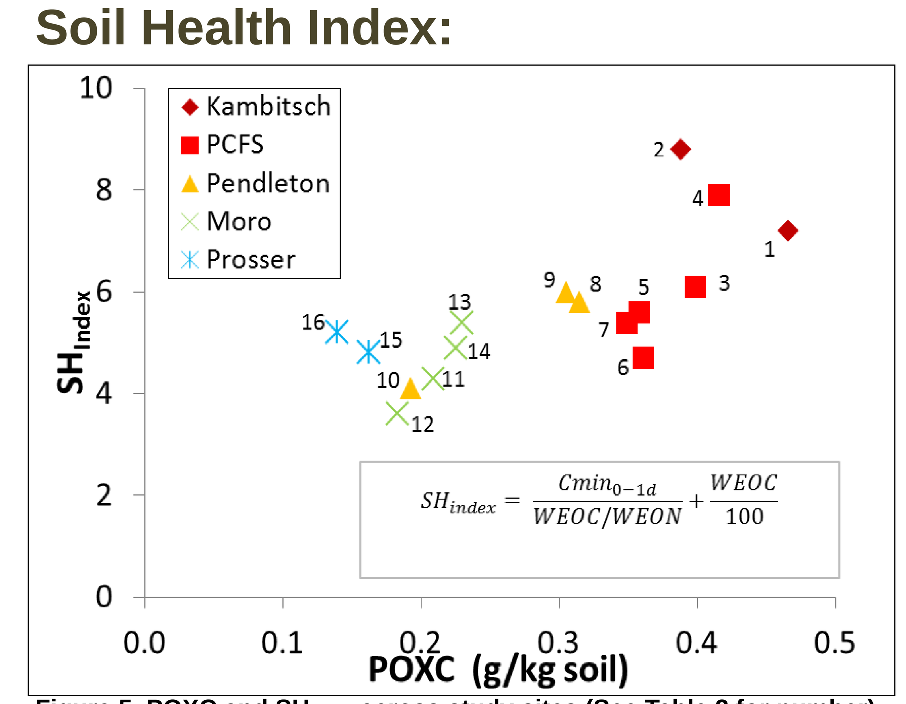

Figure 5. POXC and SH_{Index} across study sites (See Table 2 for number).

$$SH_{Index} = \frac{Cmin_{0-1d}}{WEOC/WEON} + \frac{WEOC}{100}$$

- Captures importance of C/N ratio in nutrient dynamics
- Index range is 0-50; 0-14 more appropriate for inland PNW (Morrow, 2014)
- Significant, but weak correlation with qCO_2 (r = -0.29), PNM (r = 0.38) and PRS N_{0-1d} (r = 0.48)
- Detection of treatment differences not improved above just $Cmin_{0-1d}$

- Select PRS™ N along with POXC for monitoring N mineralization and improved fertilizer management.
- Select Cmin along with POXC for monitoring microbial activity.
- Select SH_{Index} along with POXC for monitoring microbial activity and informing cover cropping legume/grass mixtures.

References

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3) Smith, J.L. 2003. *Soil quality: the role of microorganisms.* Encyclopedia of Environmental Microbiology.

Acknowledgement: This study is part of the project, "Regional Approaches to Climate Change for PNW agriculture", funded through award #2011-68002-30191 from the USDA National Institute for Food and Agriculture.