Linking Edge-of-Field Water Quality to Soil Health - Great Lakes Project

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Abstract

- Agriculturally dominated river systems impact the quality of water entering the Great Lakes[1,2]. In 2012, the USGS, NRCS and local partners began monitoring sediment and nutrient export in surface and tile runoff from select farm fields in four priority watersheds of the Great Lakes[3]. The aim of the edge-of-field (EoF) program is to document the impacts of nutrient management and cropland strategies for reducing downstream nutrient and sediment loads[3].
- The focus of our project is to create a robust dataset of soil health at EoF sites and to connect field-scale soil health parameters with the water quality leaving these fields. We are working across 14 EoF monitoring sites located in Wisconsin, Michigan, Indiana, Ohio, and New York. Baseline soil sampling took place in 2016 and 2017. Second round sampling was completed in May 2018.
- Our study includes nearly all of the SHI endorsed Tier 1 soil health measurements and many of the potential Tier 2 measurements[4].
- We have begun investigating relationships among microbial properties (e.g. soil microbial biomass, diversity, and activity), general soil structure (e.g. bulk density, aggregate structure, water holding capacity, texture, and infiltration rates), soil resources (e.g. organic matter, reactive carbon, C, N, WEP, and Bray P), and exported resources (e.g. water-exported soil, total P, soluble P, total N, and total C).
- This work focuses on the pre-establishment and early post-establishment phases of Best Management Practice (BMPs) implementation at EoF sites.
- We will use changes in soil biology, biochemical responses, and key soil physical qualities as early predictors of critical changes needed within field systems, and to demonstrate to producers why these are important.
- This five year project will provide fundamental knowledge about linkages among field management, soil health and water quality.

Site Information & Management

Study Site	Type of EoF Monitoring	Site Basin Size (Acres)	Soil Health Sample Points	Best Management Practice	Crop Rotation
IN – 01	Surface & Tile	36	15	Paired-basin study: Cover crops, gypsum & P placement	Corn & soybeans
IN – 02		63	16		
MI – 01	Surface & Tile	70+	16	Before/After study: Nutrient management & buffer	Corn & soybeans
MI – 02	Surface & Tile	16	7	Before/After study: Cover crops & other BMPs	Corn & soybeans
NY – 01	Surface	6	5	Paired-basin study: Grassed waterway	Strip crop (corn, soybeans & alfalfa)
NY – 02		7	5		
NY – 03	Surface & Tile	6	5	Paired-basin study: Cover crops	Corn silage
NY – 04		4	5		
OH – 01	Surface & Tile	10	6	Before/After study: Cover crops & nutrient management	Corn & soybeans
WI – 01	Surface	9	5	Before/After study: Grassed waterway & other BMPs	Corn silage & alfalfa
WI – 02	Surface	28	12	Before/After study: Grassed waterway & other BMPs	Corn silage
WI – 03	Surface & Tile	8 26	5	Before/After study: Cover crops/no-till	Corn silage
WI – 04	Surface	5	5	Paired-basin study: Cover crops/no-till	Corn silage
WI – 05		5	5		
	Total	270	112		

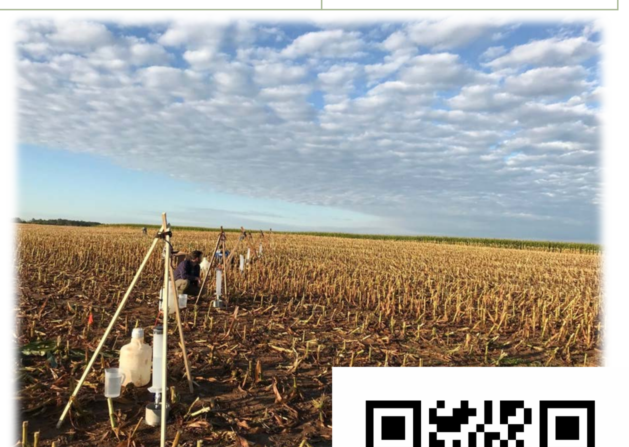

Figure 1. MI-02 catchment boundary, sampling points from spring 2016 (distributed across field) and fall 2017 (transect; 21 points at 5 m interval)

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Methods

EoF Water Quality Parameters
- Discharge rate
- Total N
- Organic N
- Ammonia
- Nitrate plus nitrite
- Orthophosphate
- Total P
- Chloride
- Suspended sediment
- Organic carbon

Soil Health Parameters
Physical Chemical Biological

Point Core Sampling
- Sample location paired with composite core samples
- ≥ 5 samples per site
- 0-30 cm depth: 0-5, 5-15, 15-30 cm

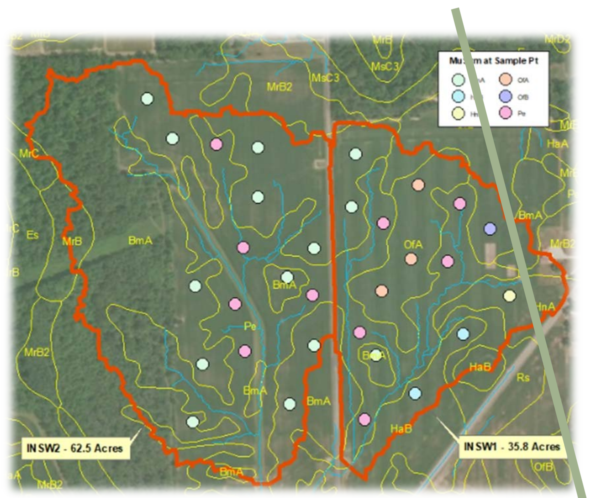
Composite Core Sampling
- Composite "grid" (~1 per 2 ac)
- ≥ 5 samples per site
- 0-15 cm depth: 0-5, 5-15 cm

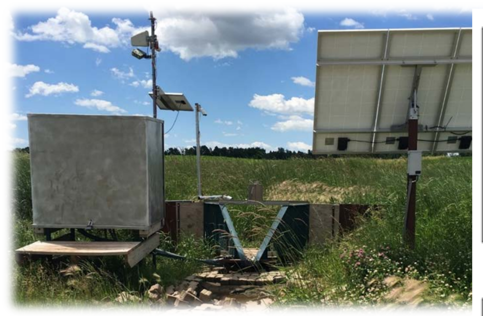
Physical Sampling
- Transect on dominant soil type and landscape position
- ~21 measurements per site

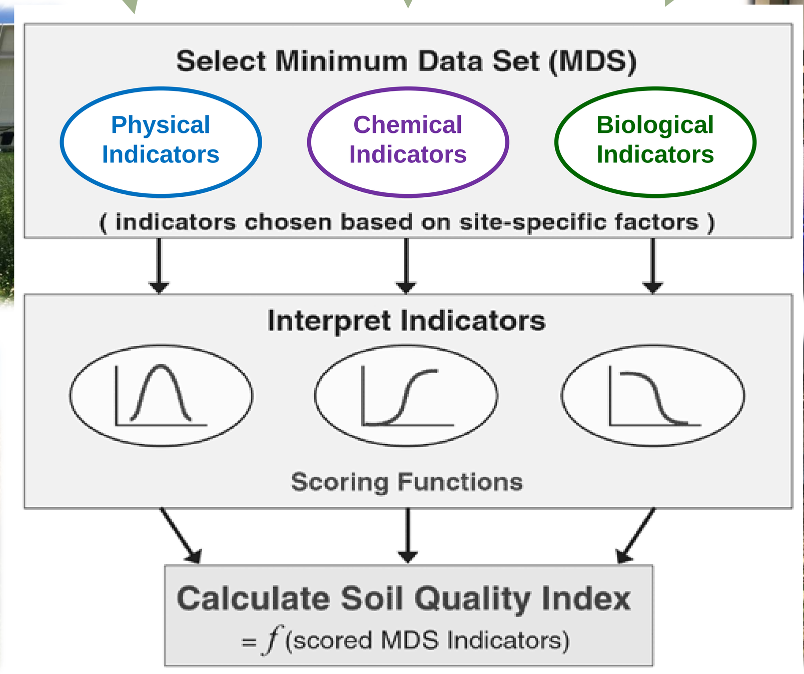
Soil Health Parameters
- Bulk Density
- Gravel content
- Soil texture (only in 2016)

Soil Health Parameters
- Organic matter
- Bray P
- K, Mg, Ca
- Cation exchange capacity
- Total P (nitric acid/peroxide)
- Water extractable P (1:50)
- Soluble N and C
- Reactive soil C (POXC)
- Soil C and N (dry combustion)
- Microbial biomass (SIR)
- Microbial respiration (BR)
- Microbial enzyme activity (APase, chitinase, Bgase)
- Microbial diversity (PLFA, DNA extraction, PCR, ITS-DGGE)

Soil Health Parameters
- Penetrometer measurements
- Infiltration rate (Saturo Infiltrometer)
- Water holding capacity
- Volumetric moisture content
- Wet aggregate stability
- Bulk density (0-7 cm)
- Organic matter (0-7 cm)







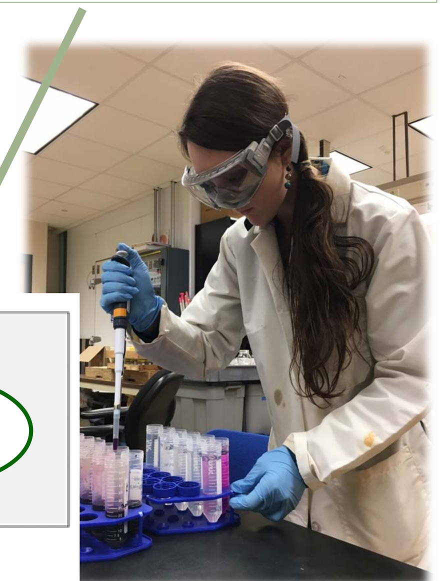


Figure 2. Soil health sampling strategy and parameters, and an example framework that may be used to link soil health to water quality (Andrews et al., 2001[5]).

Acknowledgements and Partners

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Preliminary Data and Observations

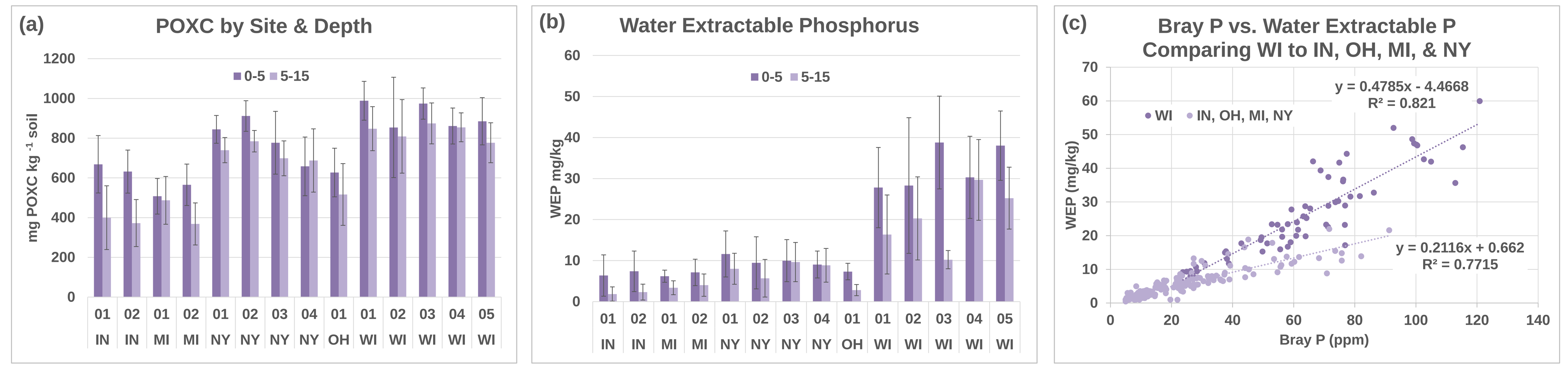

Figure 3. Examples of chemical parameters. Mean ± 1SD labile carbon (POXC; (a)) and water extractable P (WEP, (b)) by site and depth; and the relationship between Bray-P and WEP for 2016 baseline samples (c).

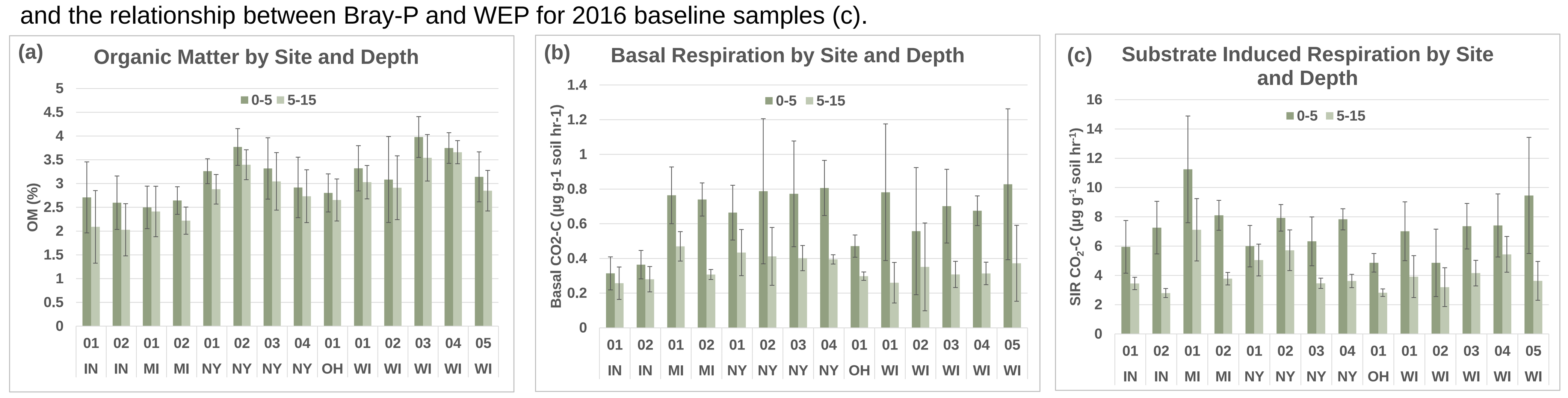

Figure 4. Examples of biological parameters. Mean ± 1SD Organic Matter (a), basal respiration (b) and substrate induced respiration (SIR, 1-hr; (c)) by site and depth for 2016 baseline samples.

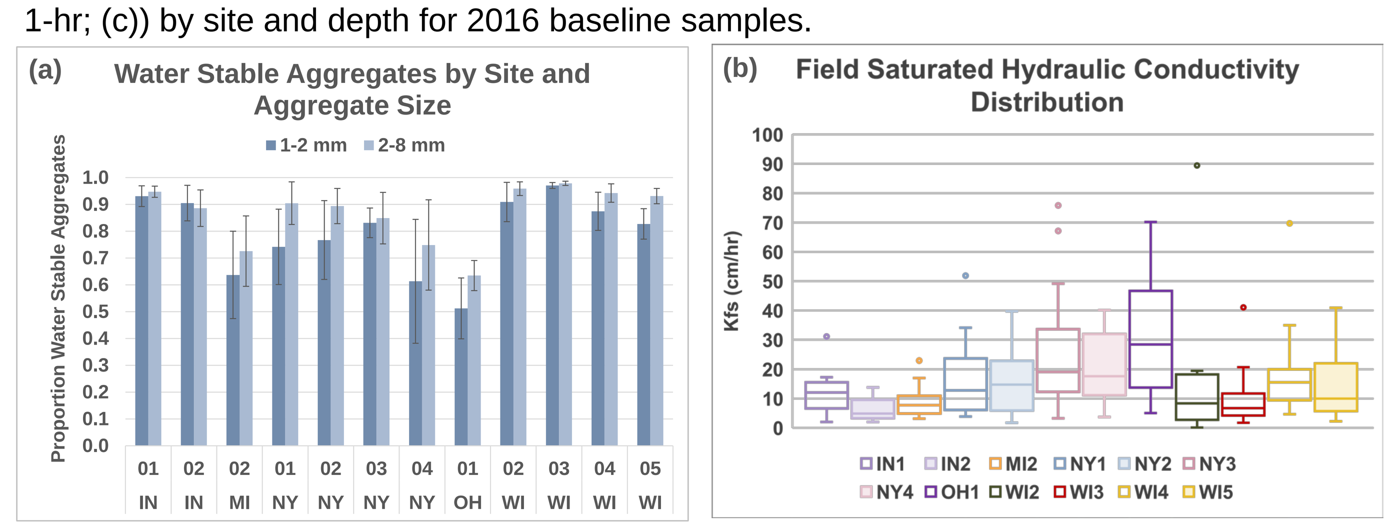

Figure 5. Examples of physical parameters. Mean ± 1SD proportion of water stable aggregates (a) and distribution of field saturated hydraulic conductivity (Kfs; (b)), fall 2017.

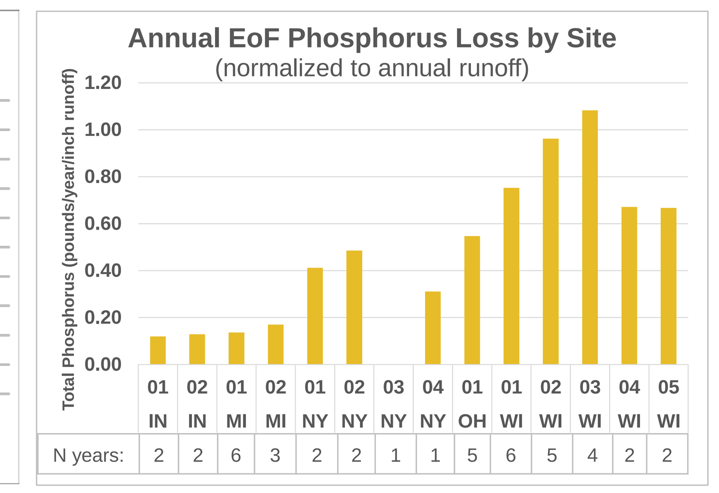

Figure 6. Example EoF water quality data (provisional data). Note limited number of years at several sites.

Preliminary Observations:
- Wisconsin and New York sites with dairy system crops and manure trend higher in labile C and WEP (Fig. 3) and EoF P loss (Fig. 6).
- Corn-Soy sites in Indiana and Ohio appear to have lower SOM and respiration (Fig. 4).

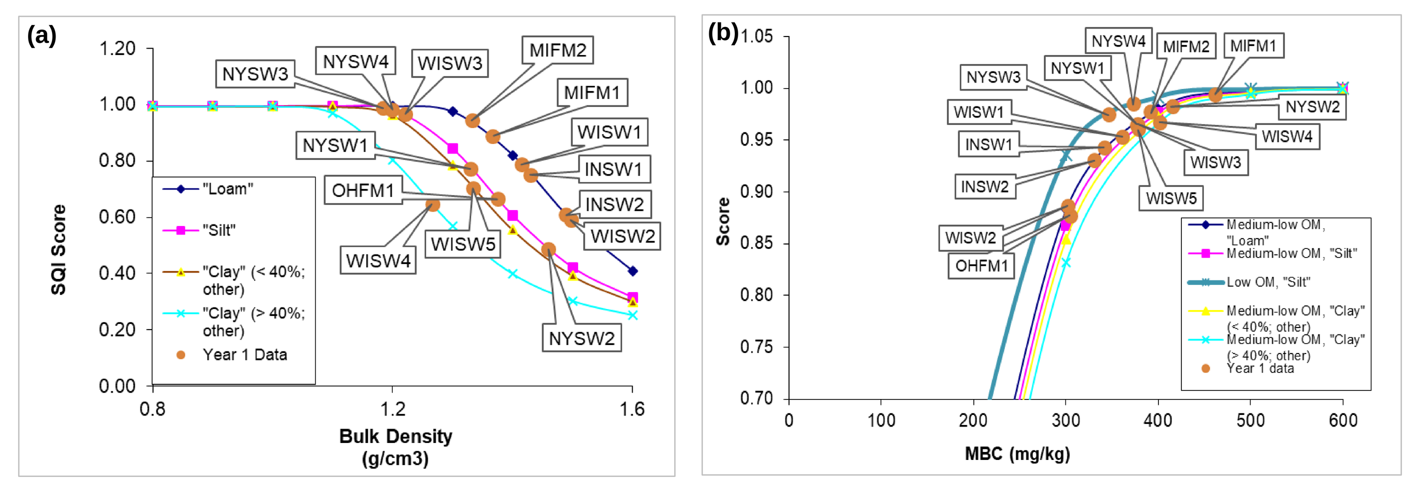

Figure 7. Preliminary example distributions of site average bulk density (a) and microbial biomass carbon (MBC; (b)) using Soil Management Assessment Framework[5] (SMAF) scoring curves.
- Other soil health scoring and indexing approaches will be explored.

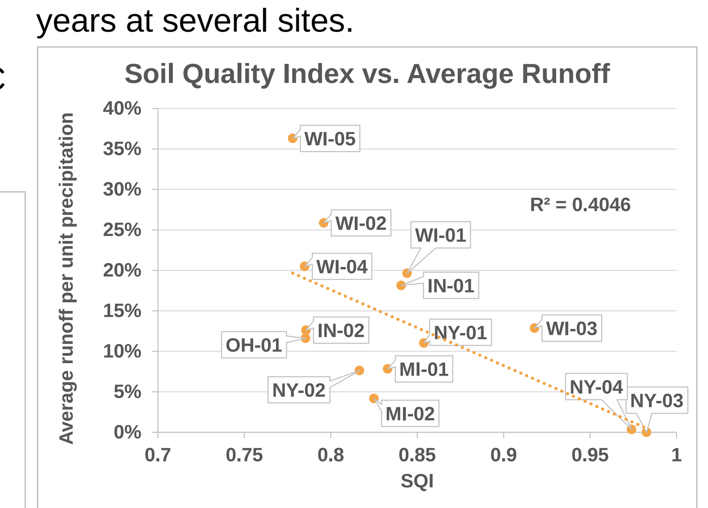

Figure 8. Provisional example linking a simple soil quality index (SQI) to EoF water export. SQI only included bulk density, SOC, MBC and pH for this draft example.
- Multifactor EoF export indices, selective SQI's and management relationships will be explored.

References

[1] Dolan D.M. and S.C. Chapra, 2012. Great Lakes total phosphorus revisited: 1. Loadings and update (1994–2008). J. Great Lakes Res., 38: 730-740.

[2]Robertson, D.M., Saad, D.A., 2011. Landscape-derived nutrient inputs to the Laurentian Great Lakes by Source and Watershed. J. Am. Water Resour. Assoc. 47: 1011-1033.

[3]U.S. Geological Survey. Great Lakes Restoration Initiative: Edge-of-Field Monitoring (wim.usgs.gov/geonarrative/glri-eof/; accessed 7/24/2018)

[4]Soil Health Institute. 2018. National Soil Health Measurements (soilhealthinstitute.org; accessed 7/24/2018)

[5] Andrews, S.S., D.L. Karlen, J.P. Mitchell. 2001. A comparison of soil quality indexing methods for vegetable production systems in Northern California. Agriculture, Ecosystems and Environment 1760: 1-21.

8/1/2018 SHI meeting