New York Soil Health 2022:

What have we learned and done?

Joseph Amsili
Debbie Aller
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NEW YORK SOIL HEALTH

Cornell CALS College of Agriculture and Life Sciences

Comprehensive Assessment of Soil Health

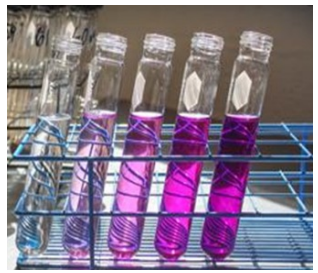
Soil health laboratory launched in 2006

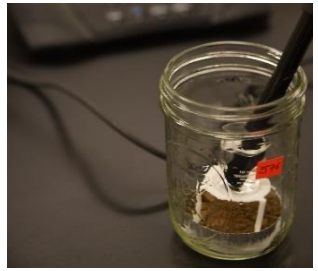
CASH test captures all important soil processes (physical, biological, chemical)

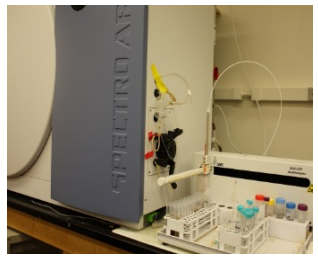
Focus on

- Practical soil health testing services
- Interprets measured values
- Identifies soil constraints
- Guidance for management

32,000+ samples processed, 20,000 in past 5 yrs







Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences
School of Integrative Plant Science, Cornell University, Ithaca, NY 14853
https://soilhealthlab.cals.cornell.edu

Sample ID:
Field ID: Continuous Corn Field
Date Sampled: 04/26/2022
Tillage: 1-7 inches

Agricultural Service Provider:
Joseph Amsili
New York Soil Health / NYSH
jpa28@cornell.edu

Measured Soil Textural Class: **loam**

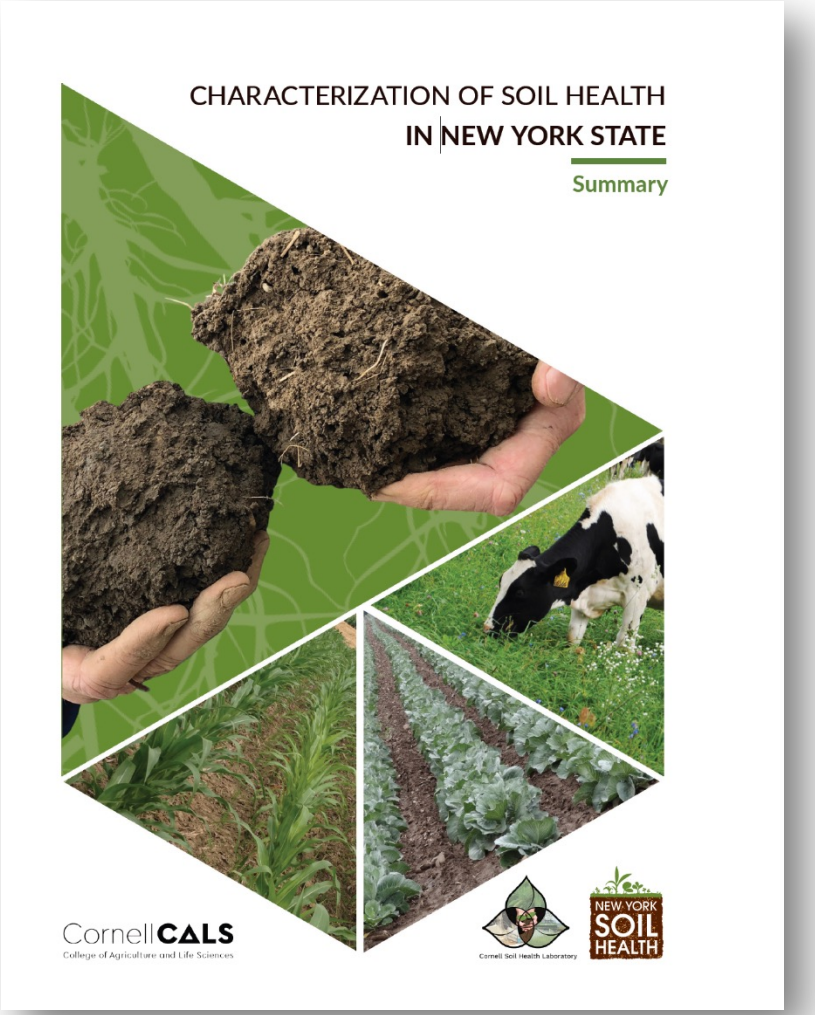
Sand: **45%** - Silt: **37%** - Clay: **17%**

Group	Indicator	Value	Rating	Constraints
physical	Predicted Available Water Capacity	0.21	78	
physical	Surface Hardness	131	64	
physical	Subsurface Hardness	346	33	
physical	Aggregate Stability	4.1	6	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter Soil Organic Carbon: 1.84 / Total Carbon: 1.96 / Total Nitrogen: 0.17	2.9	45	
biological	Predicted Soil Protein	5.30	36	
biological	Soil Respiration	0.5	33	
biological	Active Carbon	543	59	
chemical	Soil pH	8.0	21	
chemical	Extractable Phosphorus	1.6	47	
chemical	Extractable Potassium	30.2	39	
chemical	Additional Nutrients Ca: 1384.0 / Mg: 121.6 / S: 2.7 Al: 2.1 / Cu: 0.10 / Fe: 0.4 Mn: 2.9 / **Zn: 0.2**		88	

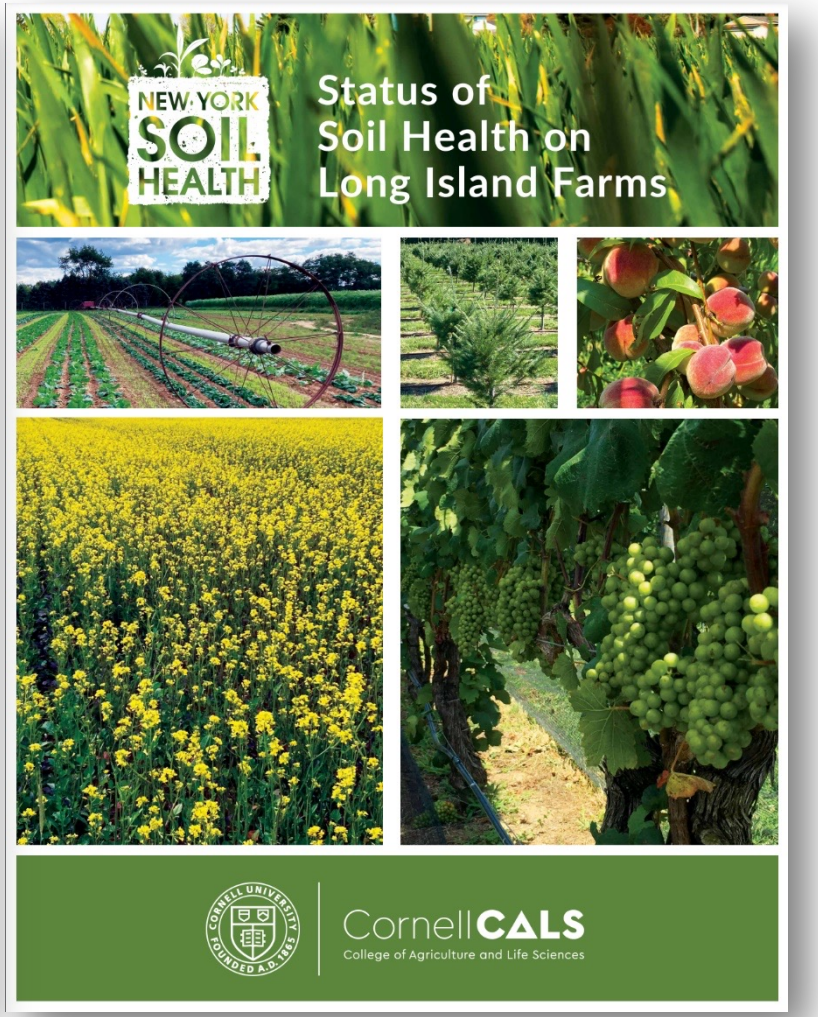
Overall Quality Score: **46** / Medium

Status of Soil Health: New York State and Long Island

- First statewide and regional characterization reports
- Document current status of soil health on farmland statewide and in Suffolk County, Long Island
- Recognize distinct production environments



Amsili et al., 2020

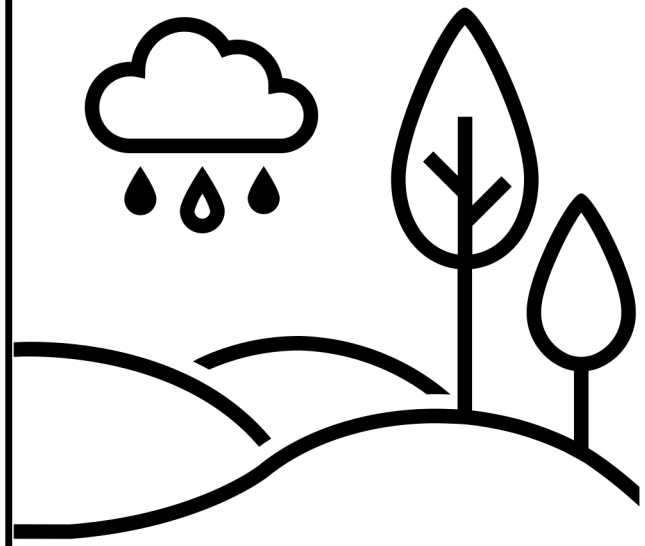


Aller et al., 2022

Factors of Soil Health

Graphics by V. Rubio

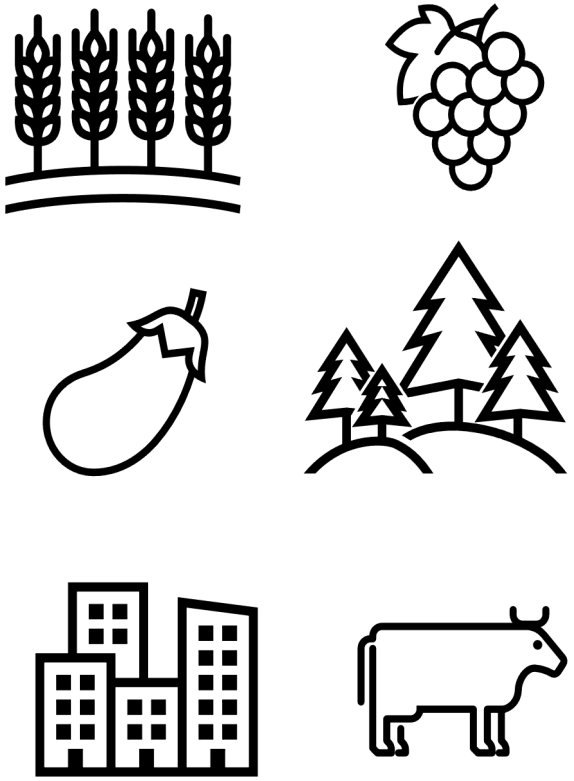
Inherent properties



Parent material (minerals)
climate, biology, relief, and time

No control

Cropping System



Limited control

Management

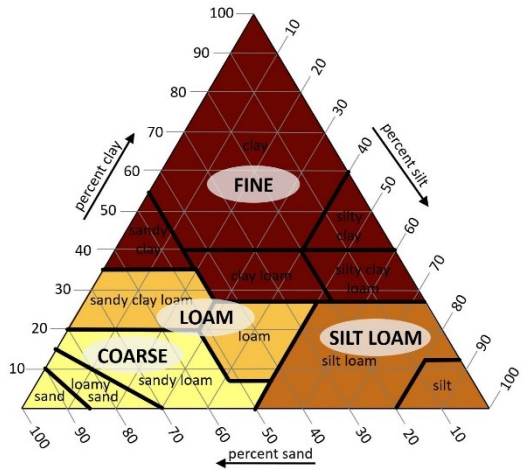
Much control

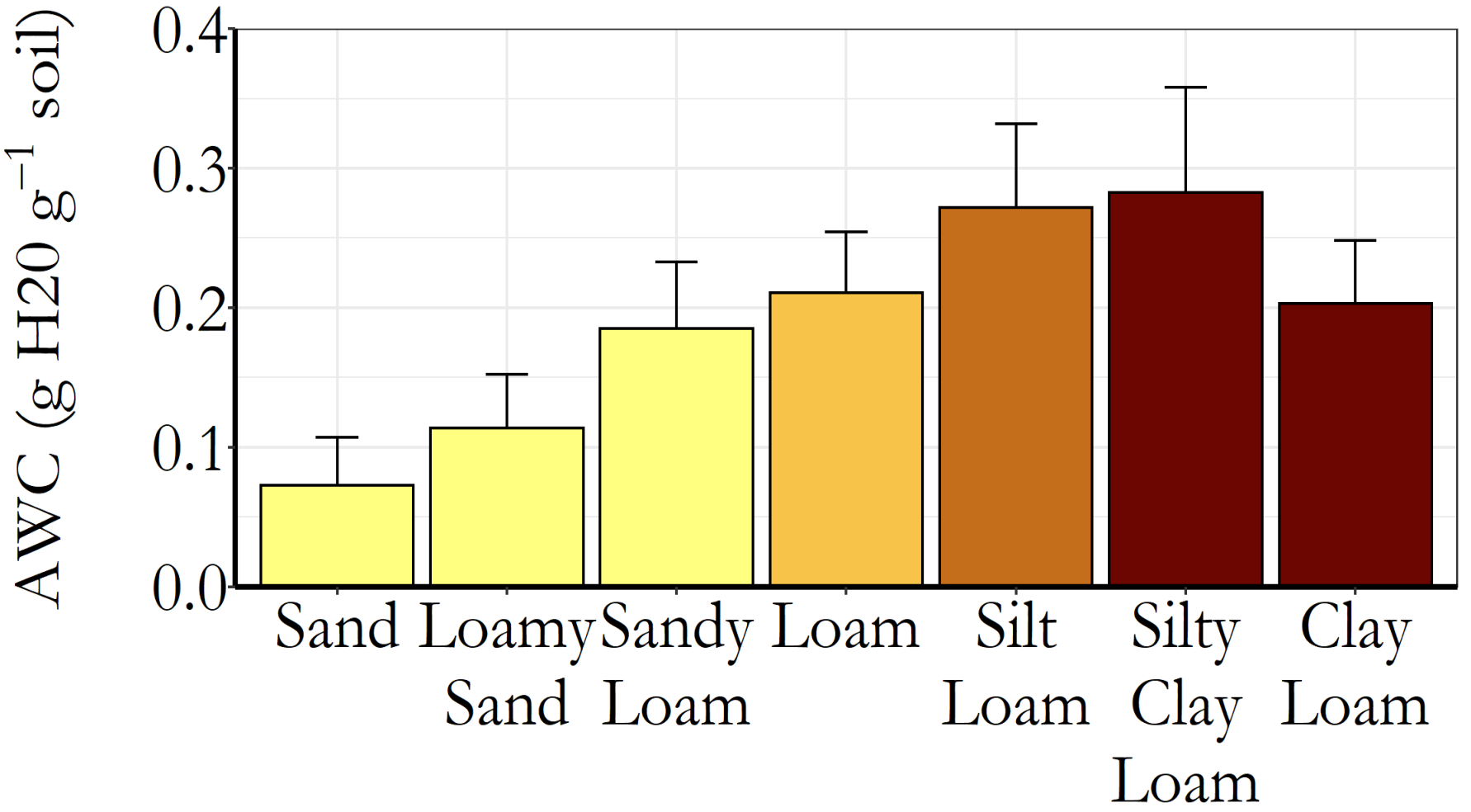
Factors of Soil Health

Inherent Properties - Soil Type

Credit: USDA-NRCS and Richard Stehouwer

Available water capacity by Soil Texture





Soil Biological Indicators by Soil Texture

Finer textured soils store more organic matter, reactive organic carbon, and are more biologically active than coarse textured soils

Texture Class	n	Organic Matter %	Active C /POXC mg/kg	Protein mg/g	Respiration mg CO_2/g
Coarse	407	2.5 c	498 d	7.2 a	0.48 c
Loam	714	3.0 b	548 c	6.5 b	0.59 b
Silt Loam	583	3.7 a	578 b	7.7 a	0.69 a
Fine	46	4.1 a	666 a	7.4 b	0.67 ab

Interpreting Soil Health Data

Comprehensive Assessment of Soil Health

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Overall Quality Score: **46** / Medium

Data Interpretation: SHAPE (Soil Health Assessment Protocol for Evaluation)

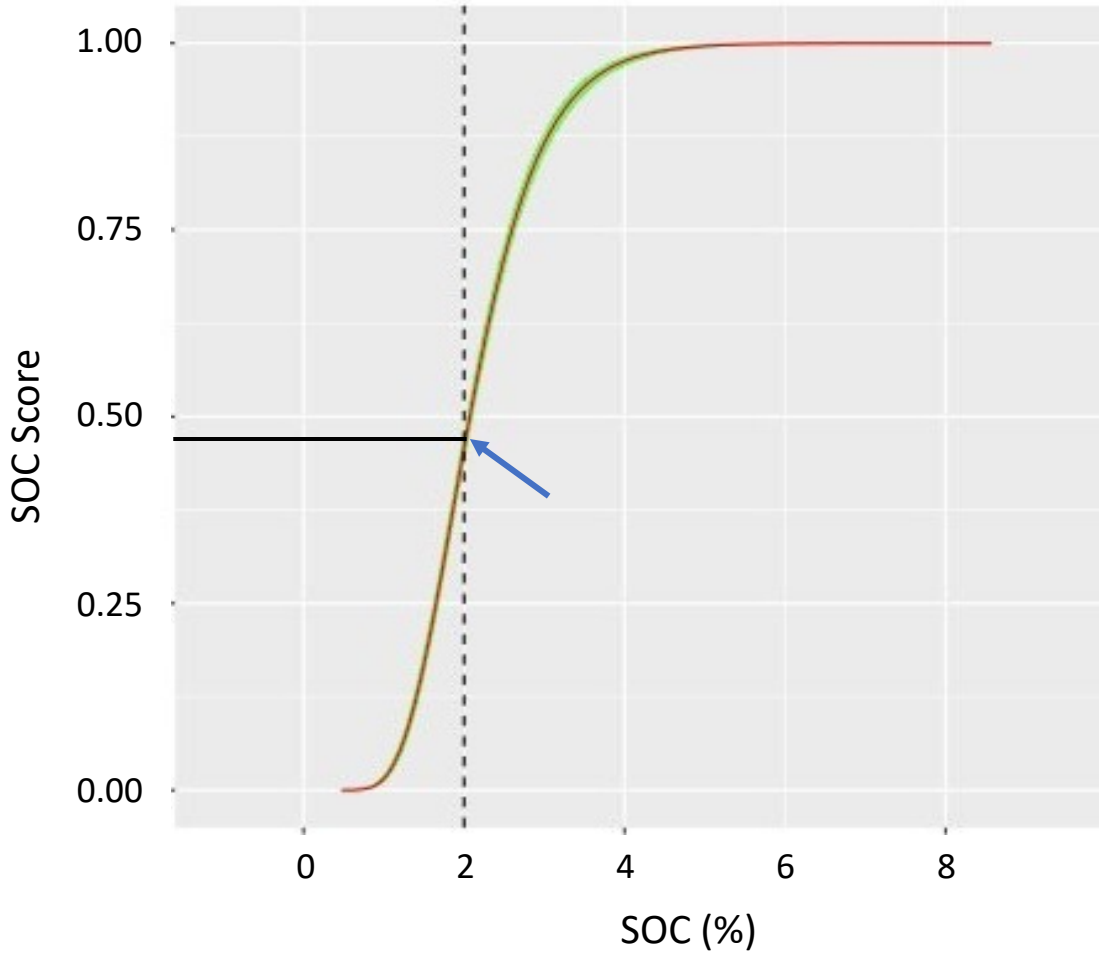
Peer groups; fuzzy, Bayesian modeling

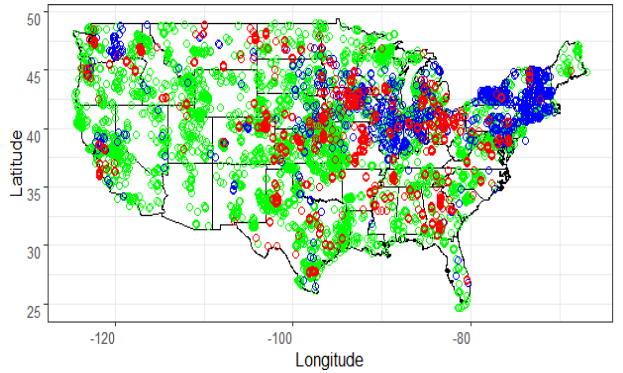
Mollisol - Iowa

Silty clay loam, Endoaquol

Peer group

Texture:	**T3**	Temp:	**10 °C**
Suborder:	**S3**	Precip:	**900 mm**





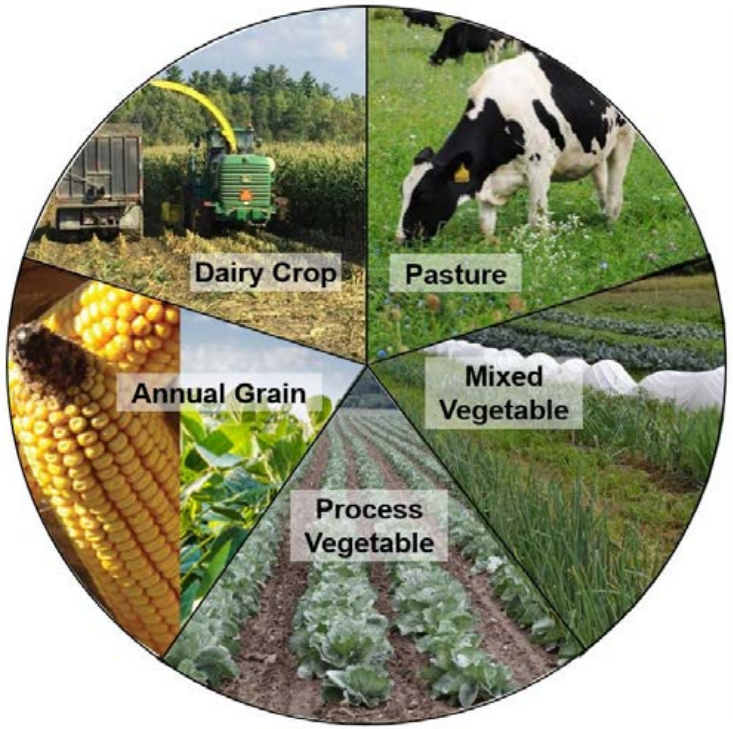
SOC = **2%**

Score = **0.46**

Nunes et al., 2021

Factors of Soil Health

Human - Cropping Systems and Biomass Cycling

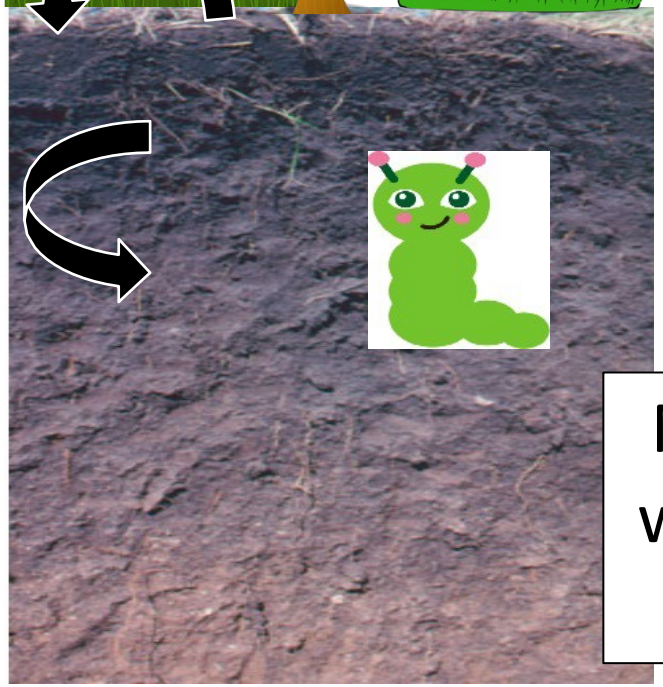


Cropping Systems, Carbon and Nutrient Flows vs.Cycles: Two Extremes Related to Agricultural Specialization

Natural, Crop-Livestock

Returned:
90-100%

high root
turnover



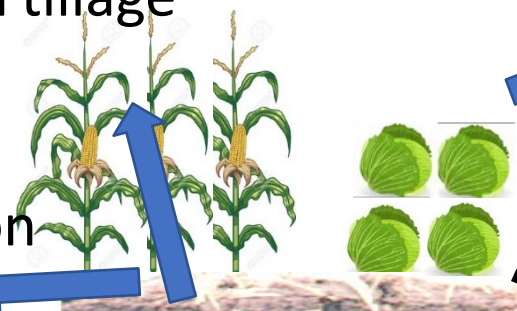
Cash Crops

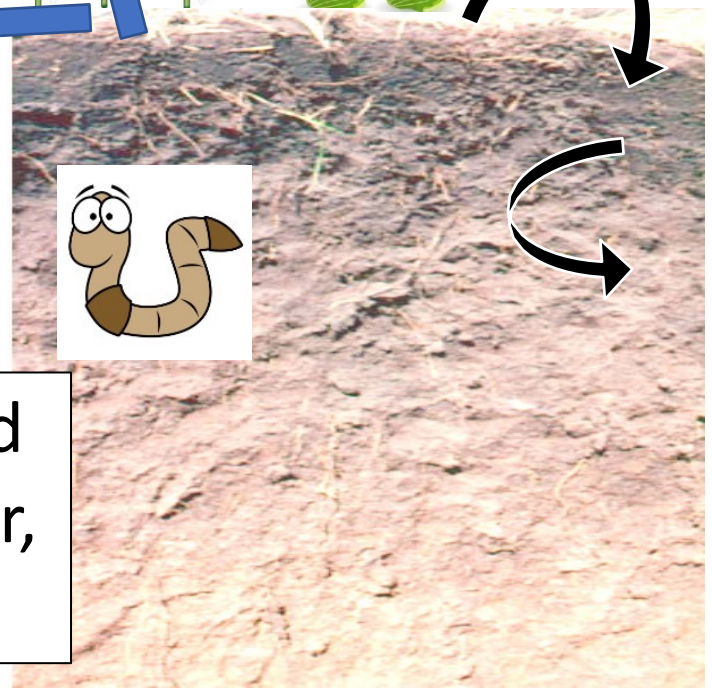
CO_2 loss
from tillage

Harvest:
50-80%

Returned:
20-50%

Erosion





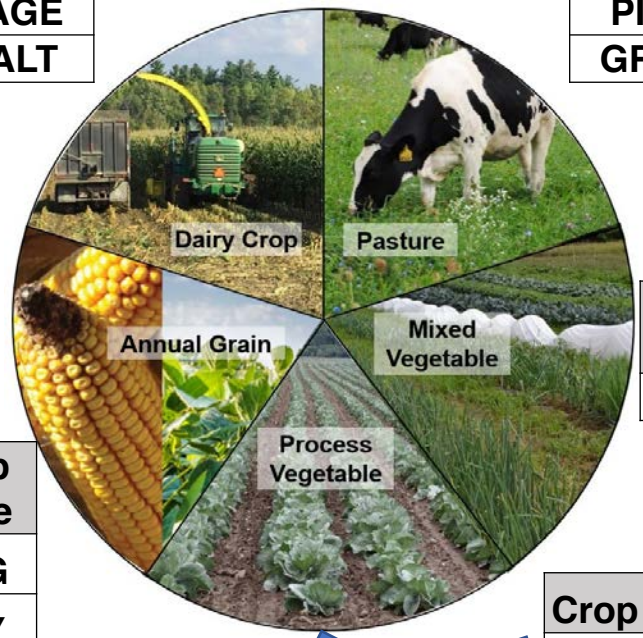
low root
turnover

Nutrients are replaced with synthetic fertilizer, but not carbon

How do Cropping Systems (management) impact soil health?

Crop Code
COS
AGT
AGE
ALT

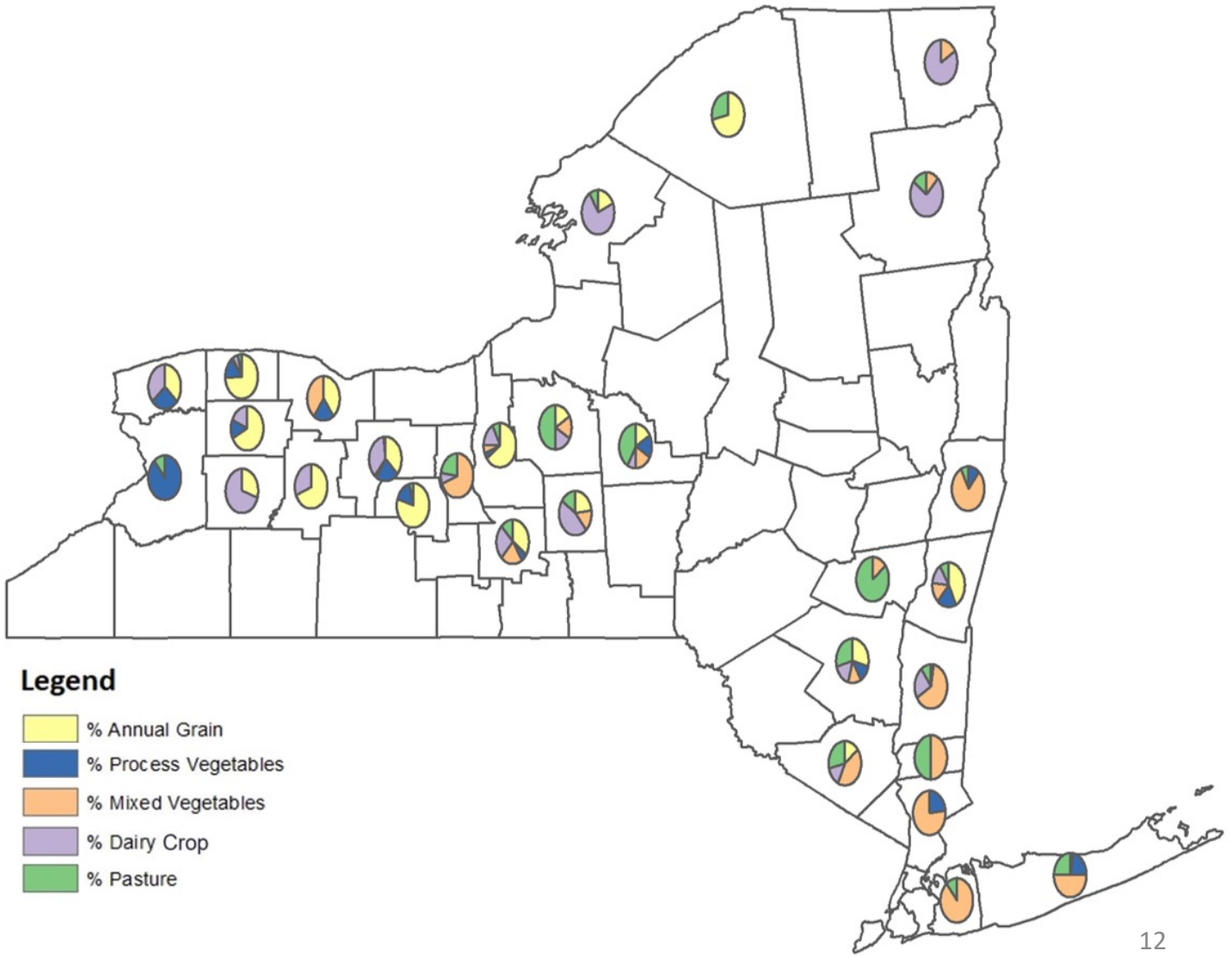
Crop Code
PNT
PIT
PIE
GRE



Crop Code
MIX

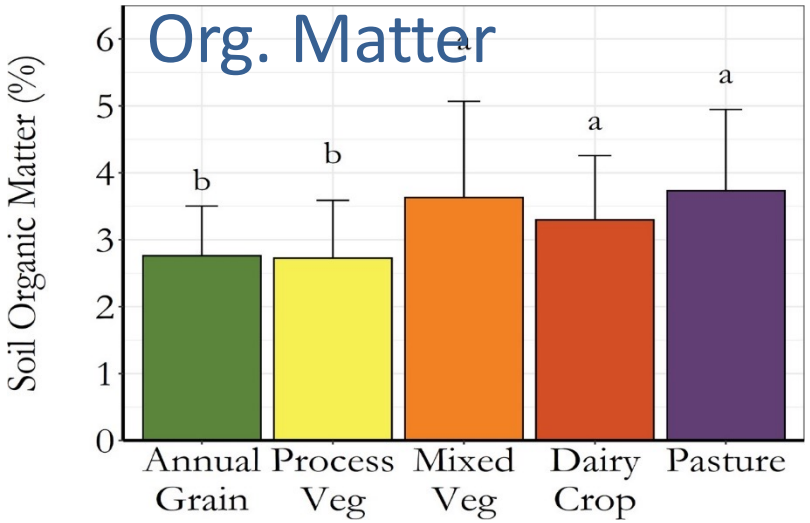
Crop Code
COG
SOY
WHT

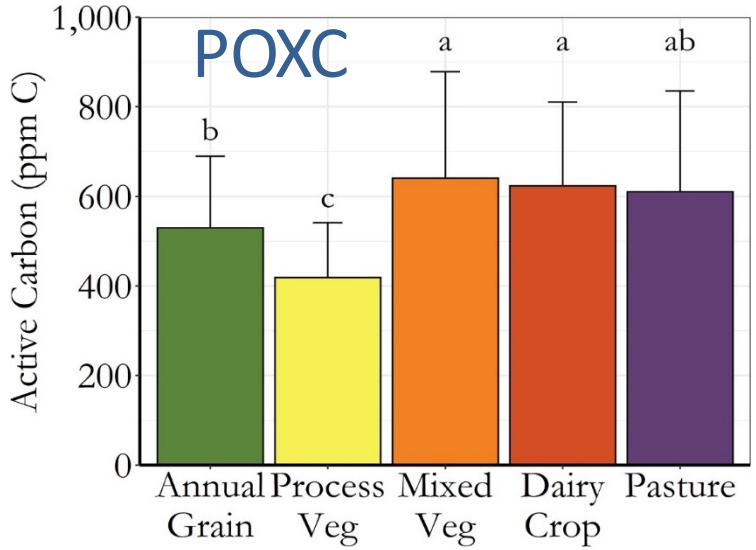
Crop Code
SQW
BNS
BND
SWC
CBP
POT
TOM



Selected Soil Health Indicators by Cropping System – NY

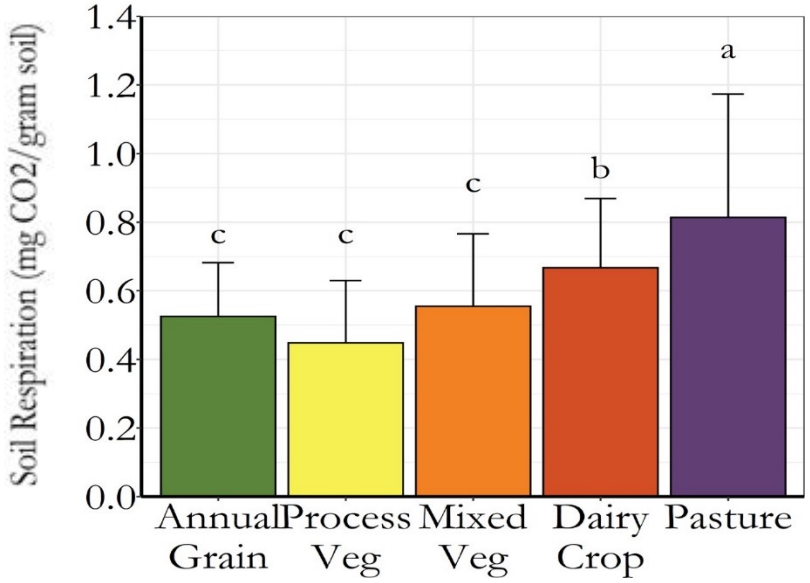
Loam Texture

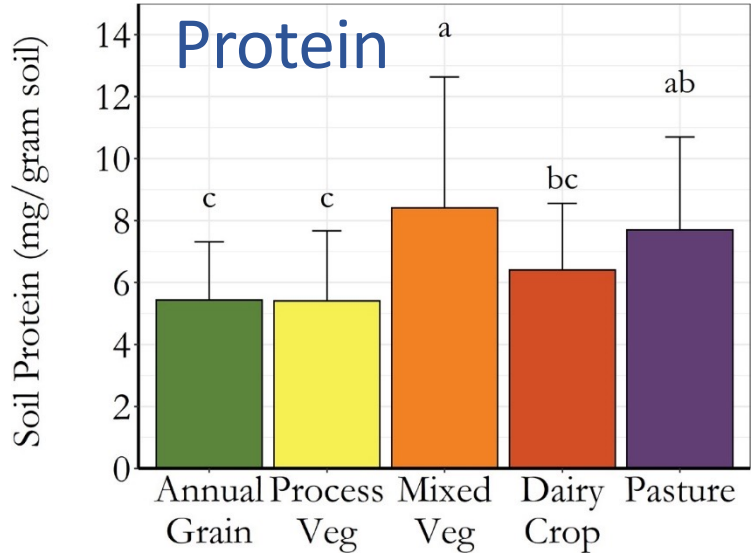


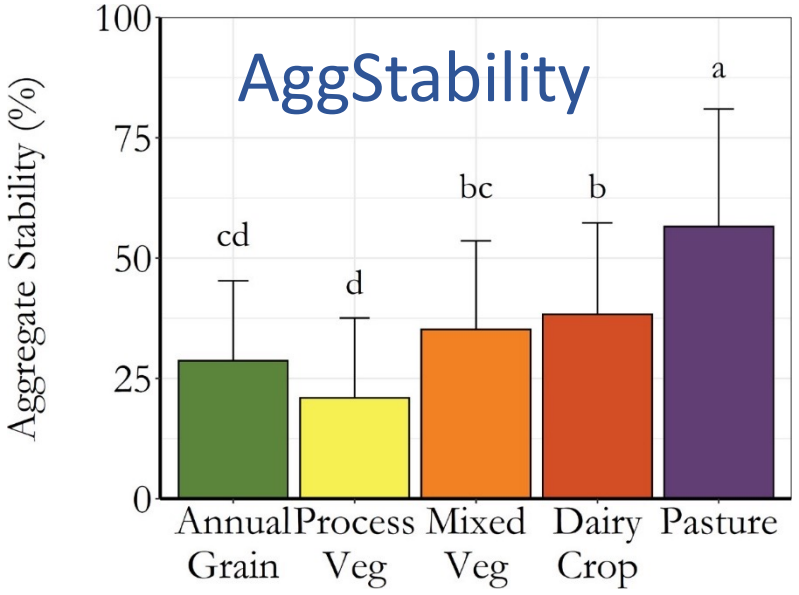


Highest SH levels are in cropping systems with the most C inputs and least disturbance

Amsili et al., 2021







NYS Soil Health and Climate Resiliency Act

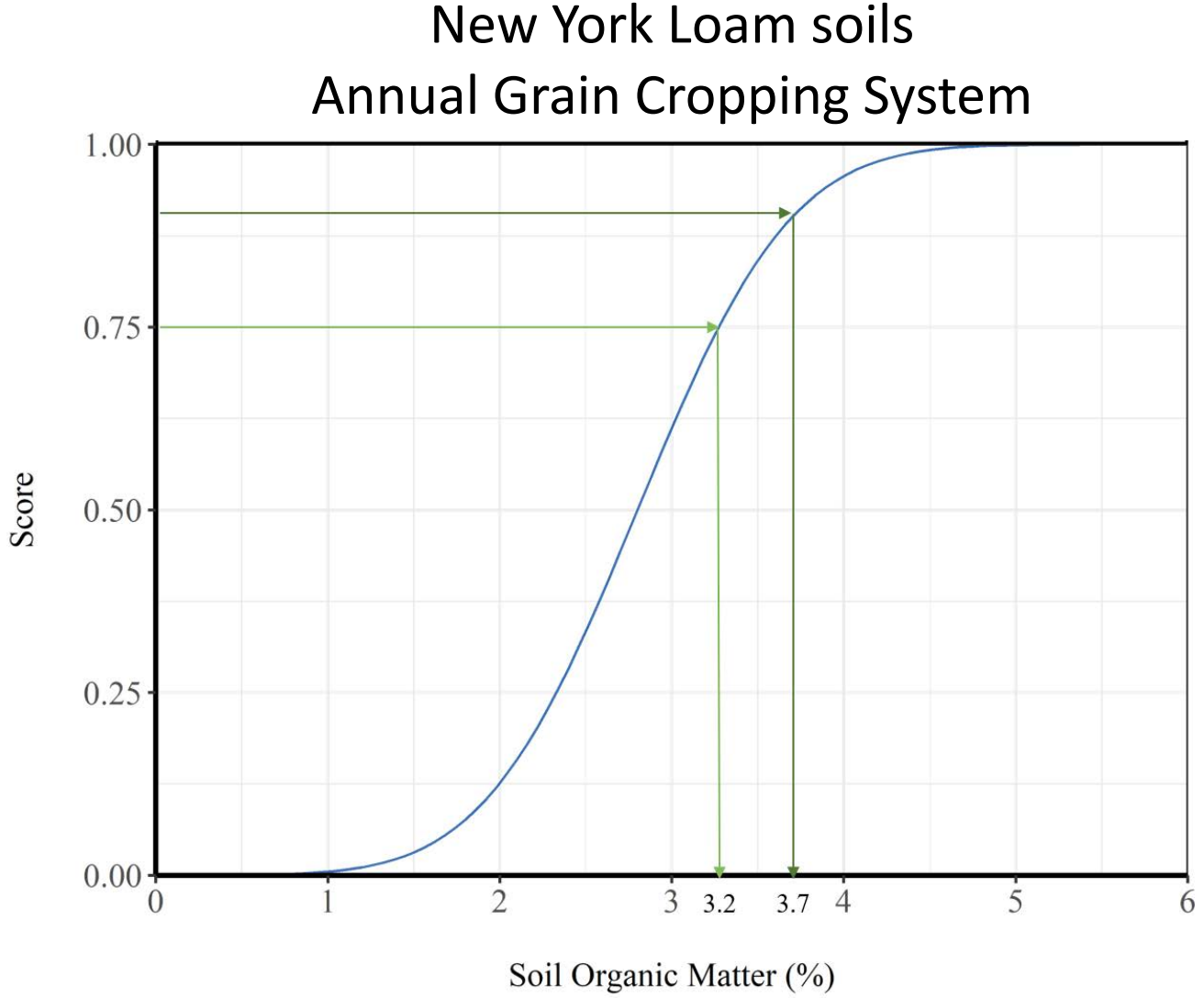
“…

establish appropriate voluntary standards and objectives for soil health

….”

Production Environment Soil Health (PESH) Goals

- Development of soil health goals by soil type, cropping system, and region (**production environment**)
- → define goals as the 75th or 90th percentile (e.g. NY-Loam-Annual Grain)



PESH Goals by Cropping System – New York

(Q75 Basis, Loam Texture)

Cropping System	n	SOM %	Predicted SOC %	POXC mg/kg	Protein mg/g	Resp mg CO_2/g	WAS %	AWC g H_20/g	PR15 psi	PR45 psi
					Loam					
Annual Grain	209	3.2	2.0	651	5.9	0.61	34.5	0.22	100	230
Processing Veg	48	3.0	1.8	507	6.0	0.47	25.7	0.22	100	230
Dairy Crop	133	3.6	2.3	688	7.4	0.72	38.9	0.22	100	230
Mixed Veg	90	4.6	2.9	784	10.1	0.67	44.5	0.24	100	230
Orchard	67	3.2	2.1	601	7.4	0.58	41.9	0.22	100	230
Pasture	46	4.6	2.9	712	9.0	1.05	74.5	0.24	100	230
All	593	3.5	2.2	666	7.2	0.66	39.8	0.23	100	230

Amsili et al., 2022

Regional PESH Goals by Cropping System in NY

Silt Loam Texture

- Regionalization of PESH goals was necessary for: Long Island, NY vs. the Rest of NY

	NYS w/o Long Island			Long Island		
Cropping System	**n**	**SOM**	**Q75 SOM**	**n**	**SOM**	**Q75 SOM**
		%	%		%	%
Annual Grain	79	3.6	4.2	-	-	-
Processing Veg	21	3.5	4.2	13	2.9	3.5
Dairy Crop	52	3.9	4.4	-	-	-
Mixed Veg	58	4.3	5.0	38	2.6	3.0
Orchard	48	3.7	4.5	25	2.8	3.1
Pasture	62	5.2	5.9	20	3.2	3.6

Explanation: Coarser textured soils and 3.3 °C warmer climate than the rest of NYS are likely causes of these differences.

Amsili et al., 2022

Extension and Outreach

Applications of the CASH Test

Soil Health Benchmarking

Comprehensive Assessment of Soil Health

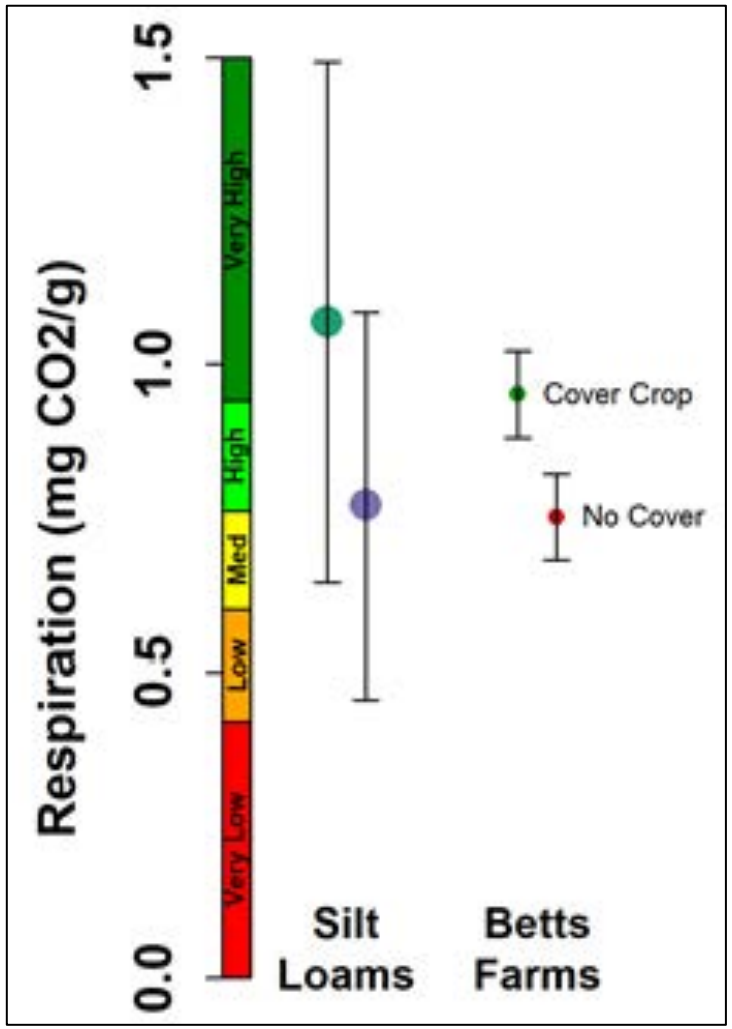
From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. http://soilhealth.cals.cornell.edu

Measured Soil Textural Class: **silt loam**

Sand: **28%** - Silt: **54%** - Clay: **28%**

Group	Indicator	Value	Rating	Constraints
physical	Predicted Available Water Capacity	0.25	91	
physical	Surface Hardness	260	12	Rooting, Water Transmission
physical	Subsurface Hardness	350	32	
physical	Aggregate Stability	31.9	43	
biological	Organic Matter Soil Organic Carbon: 2.67 / Total Carbon: 2.69 / Total Nitrogen: 0.19	4.5	71	
biological	Predicted Soil Protein	5.50	37	
biological	Soil Respiration	0.5	40	
biological	Active Carbon	449	26	
chemical	Soil pH	6.3	100	
chemical	Extractable Phosphorus	2.6	74	
chemical	Extractable Potassium	146.3	100	
chemical	Additional Nutrients Ca: 1362.5 / Mg: 299.7 / S: 10.5 Al: 65.8 / B: 0.15 / Cu: 0.28 Fe: 8.7 / Mn: 4.8 / Zn: 0.3		100	

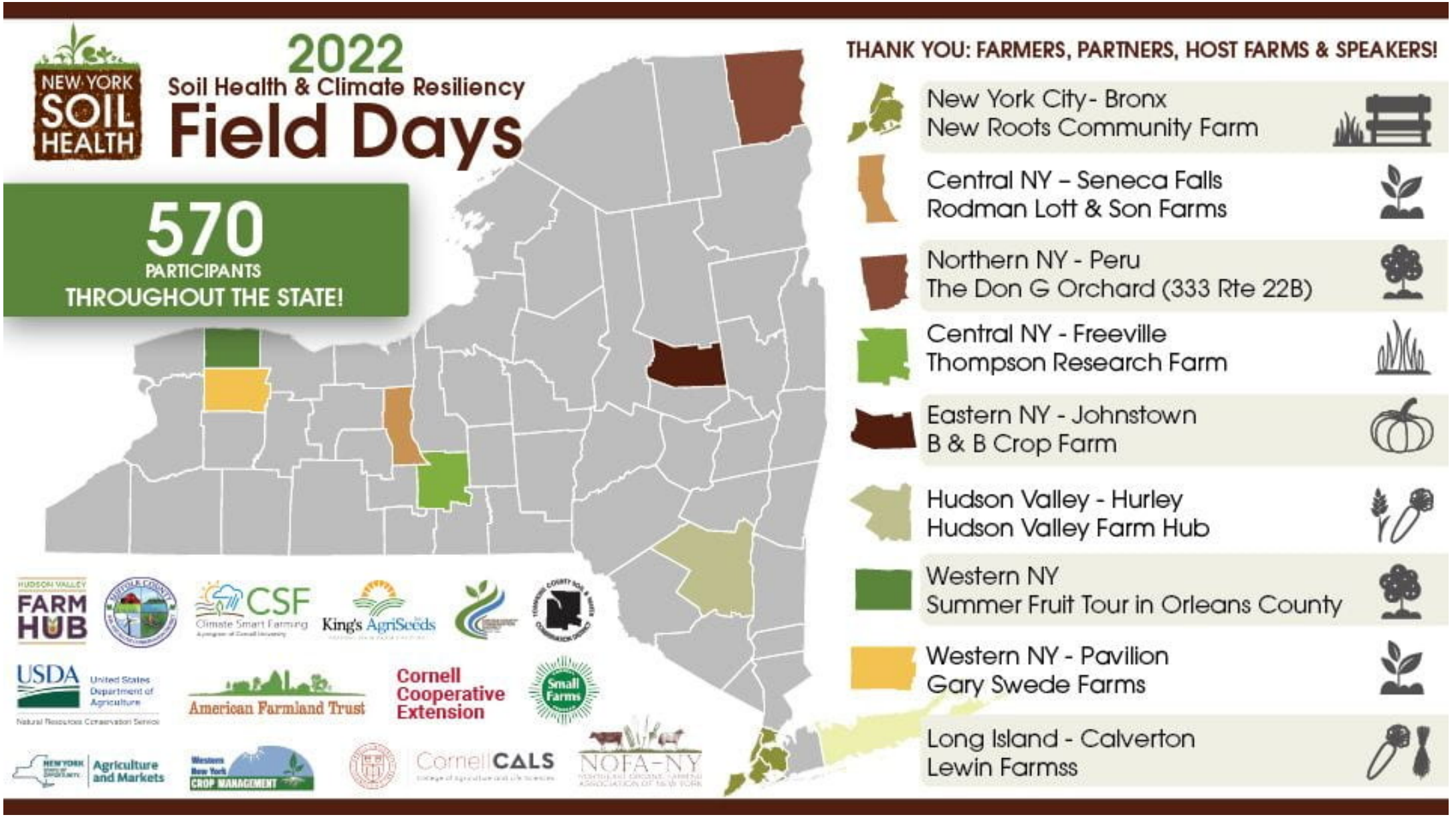
Overall Quality Score: **61** / High



Coordinate the New York Soil Health Alliance

- NYSH Working Group → NYSH Alliance (2022)
- Individuals and organizations from across NYS interested and/or working on soil health
- Meet biannually in different locations across NYS to share updates, coordinate activities, and facilitate collaboration on projects and programs

Soil Health and Climate Resiliency Field Day Series 2022




FORAGE RAPE

NYSH mini-grants 2022

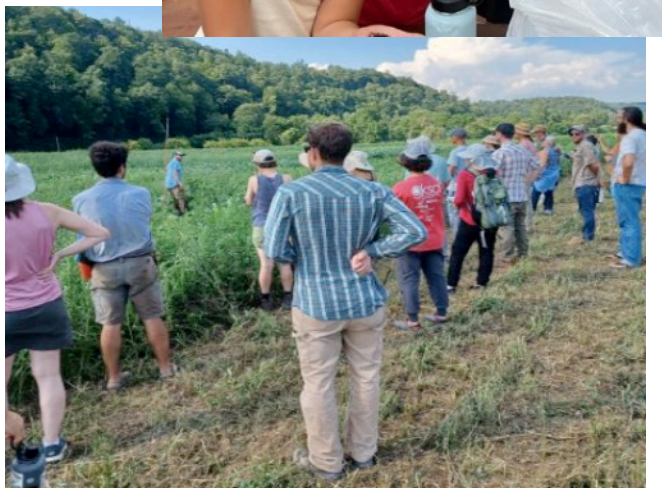
- First year offering mini-grants
  - Up to $3,000 for projects
  - Up to $500 for travel
- Project grants were to support research, extension, or outreach activities with a soil health component
- Travel grants for travel and attendance at a soil health related workshop, field day, event, etc., within NYS.
- Received over 60 applications
- Supported 11 organizations across 10 counties

Awarded Project Grants (organization – project title, county, award amount)

1. Cameron Community Ministries – *'From the Ground Up: Healthy Soil for Healthy Living,'* Monroe – $2000
2. CCE Vegetable Program – *'Cover Crops & Soil Health,'* Erie – $500
3. West Haven Farm – *'Juntos Aprendemos: Un Día de Campo en Español para la Comunidad Latina,'* Tompkins – $2000
4. CCE Capital Area Agriculture & Horticulture Program – *'Soil health field days for cut flower production,'* Albany – $1500
5. CCE Chautauqua – *'4H Special Interest Programming,'* Chautauqua – $1000
6. Farm School NYC – *'Studying Safe Soils with FSNYC,'* Kings (NYC) – $2250
7. CCE Oneida – *'Urban Farm Learning Lab at Union Station: Exploring Soil Health in Urban Growing,'* Oneida – $770

Awarded Travel Grants (organization – event title, county, award amount)

1. Agricultural Stewardship Association, Inc. – *'Soil Health Workshop for Livestock and Crop Farmers,'* Washington – $500
2. Farm School NYC – *'Community Work & Learn day at Soul Fire Farm,'* Kings (NYC) – $500
3. MaWu Lisa Temple – *'Healthy soils in Siuslaw Model Forest,'* Ulster – $500
4. King of Glory Farms – *'Organic no-till workshop,'* Sullivan – $500



Advanced Trainings in SH & Sustainable Soil Management

- 220 participates → Dec. 2021 Course
- Will be offered again February - March 2023. Registration coming soon!

- NYSH Specialist Trainings
  - 1st cohort (2018-2020)
  - 2nd cohort (2020-2021)
  - ~ 45 graduates
  - Future → urban or perennial fruit focused training

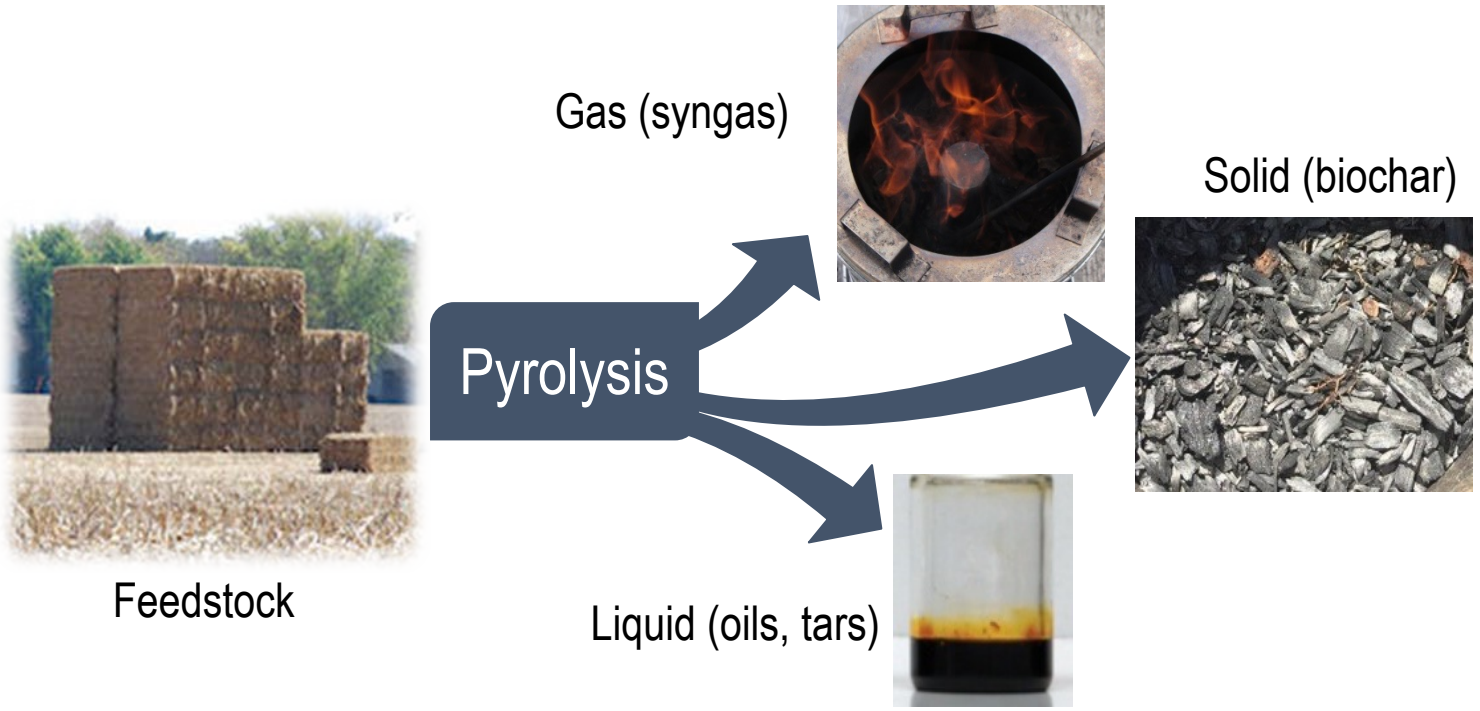
Collaborative research and extension initiatives

- **On-farm research in orchards and vineyards**
  - Vineyards – both *vinifera* and concord (*Jennifer Russo, Alice Wise, Justine Vanden Heuvel)
  - Orchards – more sampling needed, connecting management practices to SH indicators, evaluating if current indicators are all relevant for tree fruit (*Mike Basedow, Janet Van Zoeren, Mario Sazo, Greg Peck)

- **Support urban soil health applied research/extension activities** (*Jonathan Russell-Anelli, Perl Egendorf, Sam Anderson, Yolanda Gonzalez, Hannah Shayler, and Jenny Kao-Kniffin)
  - Portable XRF (heavy metal screening)

- **Soil suitability for biochar use in NYS** (*Johannes Lehmann, Dominic Woolf)
  - Identify farmland that is most suitable for biochar applications

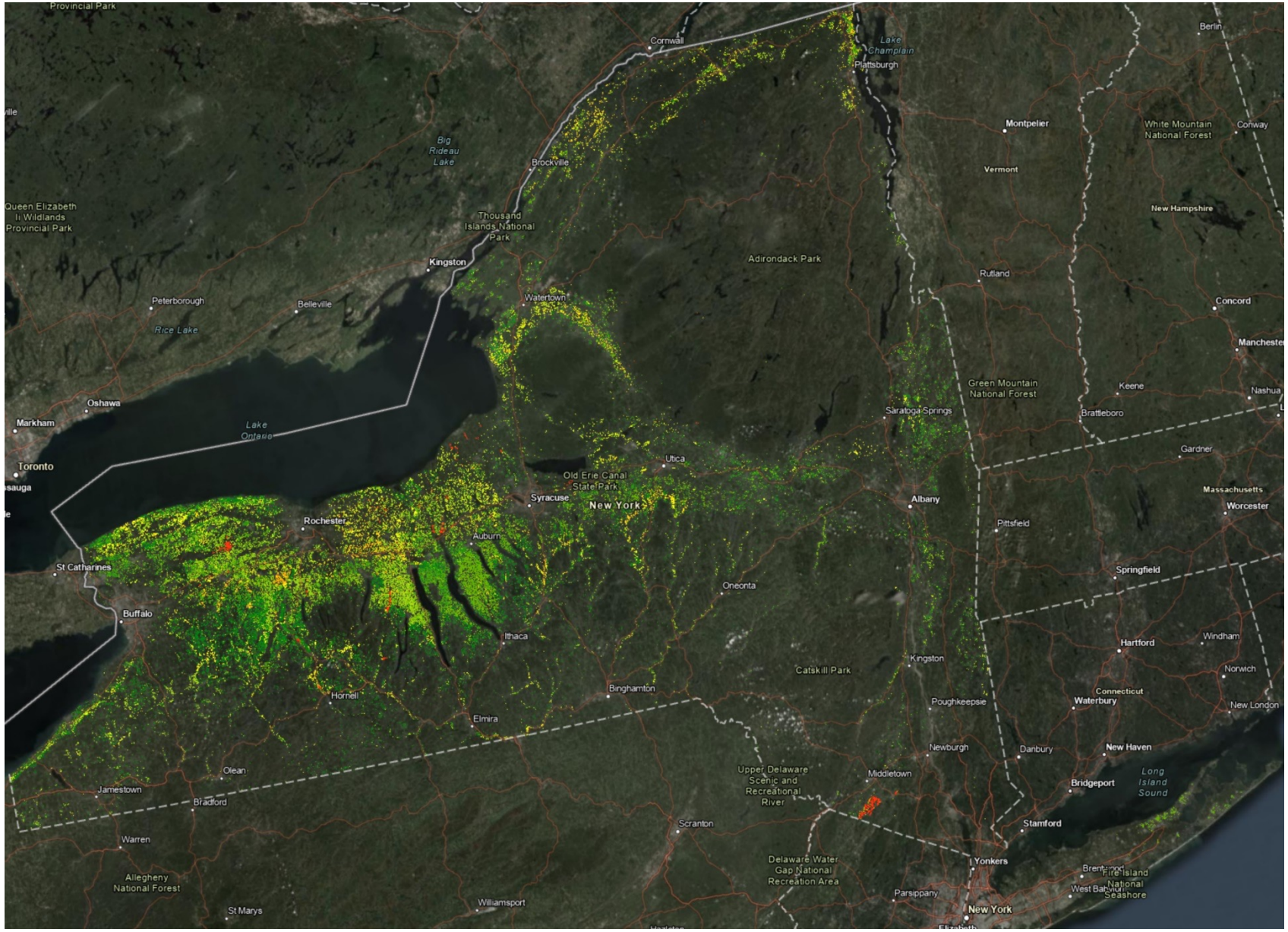
Biochar: increasing awareness and understanding



- Charcoal like material produced from organic waste materials
- Long-lasting soil amendment
- Improves soil health
- Carbon sequestration technology

Pyrolysis - the thermochemical decomposition of biomass at high temperatures in the absence of oxygen

Suitability of biochar for application to NYS croplands

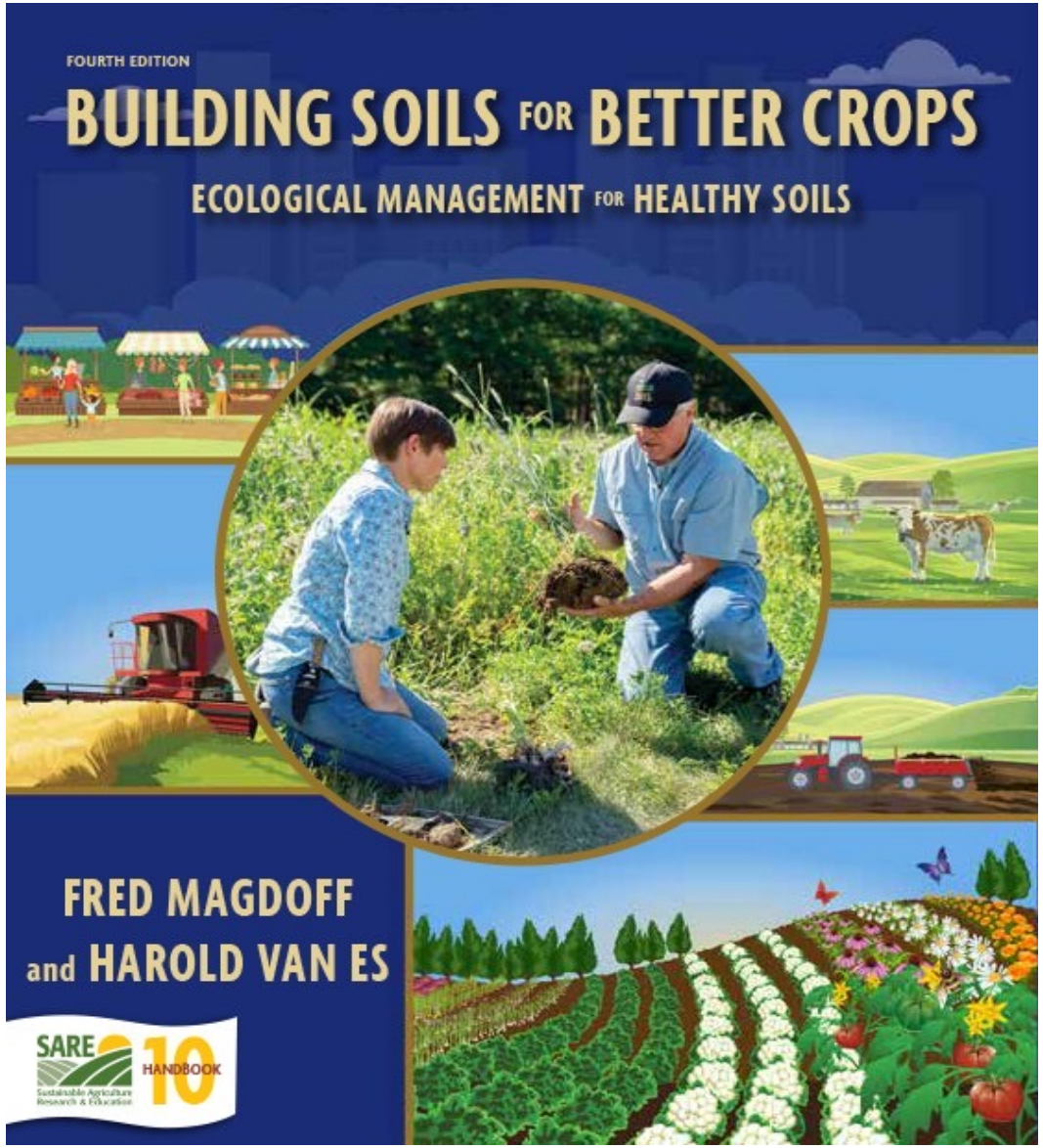


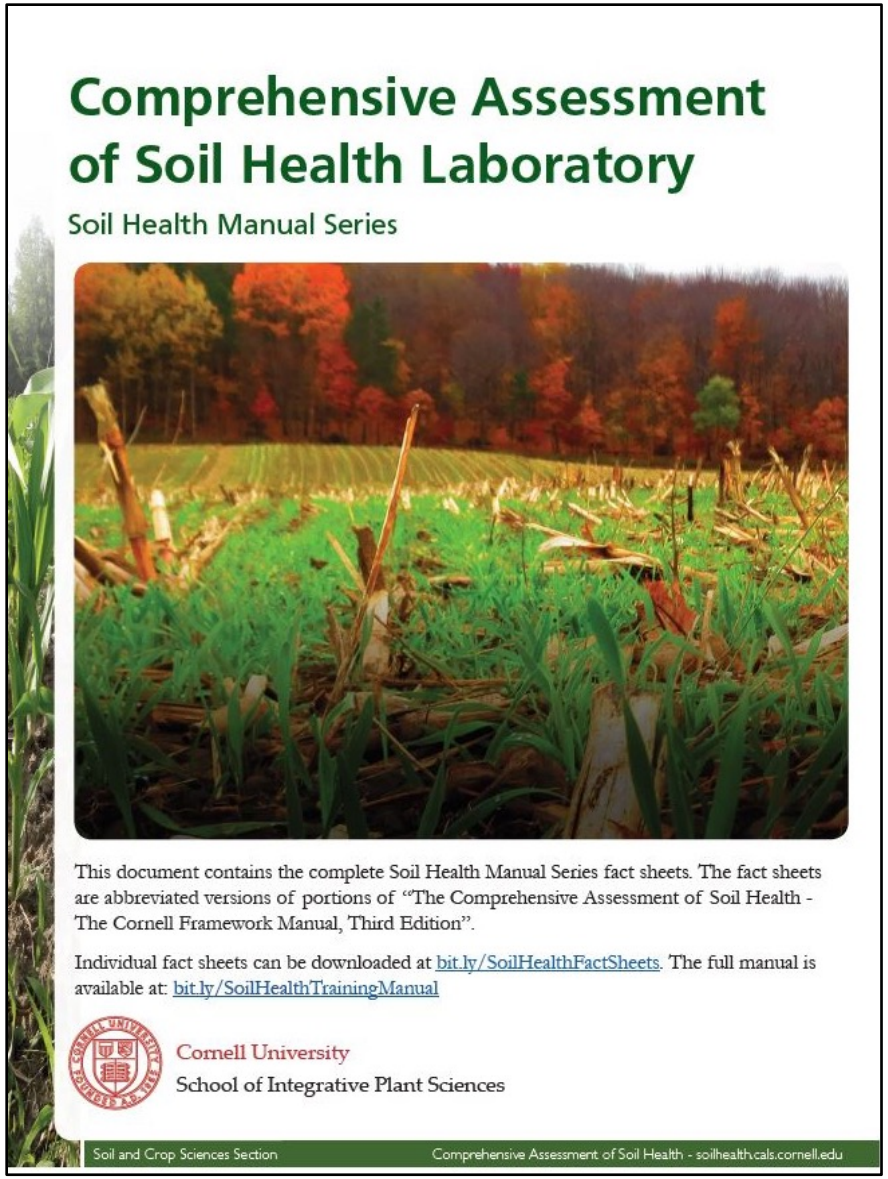
Potential for a positive yield increase

- 20% - 45%
- 45% - 55%
- 55% - 65%
- 65% - 70%
- 70% - 75%
- 75% - 85%
- 85% - 95%

Aller and Dookohaki, unpublished

Soil Health Publications





Cover Crop Poster

Cornell CALS
College of Agriculture and Life Sciences

Roots: an exploration of cover crops belowground

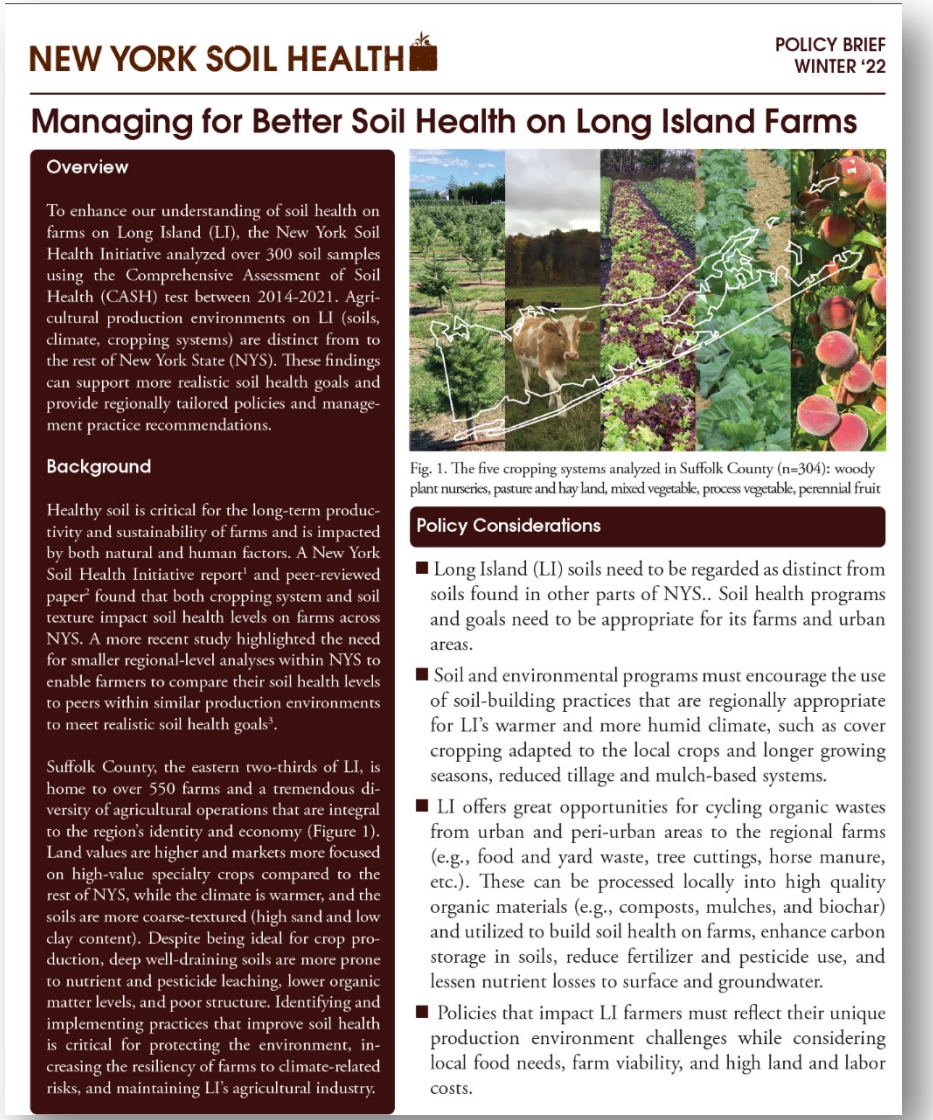
NEW YORK SOIL HEALTH

Project credit: Joseph Amsili, Jenn Thomas-Murphy, Sandra Wayman, Matt Ryan

NYSH Policy Briefs

Quarterly briefs beginning winter 2022

- Targeted at non-technical audiences and decision makers
- Highlights from research and outreach efforts
- Considerations for policy decisions
- Published on NY Soil Health website



NEW YORK SOIL HEALTH

POLICY BRIEF
WINTER '22

Managing for Better Soil Health on Long Island Farms

Overview

To enhance our understanding of soil health on farms on Long Island (LI), the New York Soil Health Initiative analyzed over 300 soil samples using the Comprehensive Assessment of Soil Health (CASH) test between 2014-2021. Agricultural production environments on LI (soils, climate, cropping systems) are distinct from to the rest of New York State (NYS). These findings can support more realistic soil health goals and provide regionally tailored policies and management practice recommendations.

Background

Healthy soil is critical for the long-term productivity and sustainability of farms and is impacted by both natural and human factors. A New York Soil Health Initiative report[1] and peer-reviewed paper[2] found that both cropping system and soil texture impact soil health levels on farms across NYS. A more recent study highlighted the need for smaller regional-level analyses within NYS to enable farmers to compare their soil health levels to peers within similar production environments to meet realistic soil health goals[3].

Suffolk County, the eastern two-thirds of LI, is home to over 550 farms and a tremendous diversity of agricultural operations that are integral to the region's identity and economy (Figure 1). Land values are higher and markets more focused on high-value specialty crops compared to the rest of NYS, while the climate is warmer, and the soils are more coarse-textured (high sand and low clay content). Despite being ideal for crop production, deep well-draining soils are more prone to nutrient and pesticide leaching, lower organic matter levels, and poor structure. Identifying and implementing practices that improve soil health is critical for protecting the environment, increasing the resiliency of farms to climate-related risks, and maintaining LI's agricultural industry.

Fig. 1. The five cropping systems analyzed in Suffolk County (n=304): woody plant nurseries, pasture and hay land, mixed vegetable, process vegetable, perennial fruit

Policy Considerations

- Long Island (LI) soils need to be regarded as distinct from soils found in other parts of NYS.. Soil health programs and goals need to be appropriate for its farms and urban areas.
- Soil and environmental programs must encourage the use of soil-building practices that are regionally appropriate for LI's warmer and more humid climate, such as cover cropping adapted to the local crops and longer growing seasons, reduced tillage and mulch-based systems.
- LI offers great opportunities for cycling organic wastes from urban and peri-urban areas to the regional farms (e.g., food and yard waste, tree cuttings, horse manure, etc.). These can be processed locally into high quality organic materials (e.g., composts, mulches, and biochar) and utilized to build soil health on farms, enhance carbon storage in soils, reduce fertilizer and pesticide use, and lessen nutrient losses to surface and groundwater.
- Policies that impact LI farmers must reflect their unique production environment challenges while considering local food needs, farm viability, and high land and labor costs.

Insights Into Soil Health Indicators and Farming Practices

Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. http://soilhealth.cals.cornell.edu

Grower:
Innovative Grower

Agricultural Service Provider:
Lorie Ames
lames@wnycma.com

Sample ID: UUU24
Field ID:
Date Sampled: 05/13/2020
Given Soil Type: OnC
Crops Grown: COG/SOY/RYG
Tillage: no till
Coordinates: Latitude:
Longitude:

Measured Soil Textural Class: **loam**

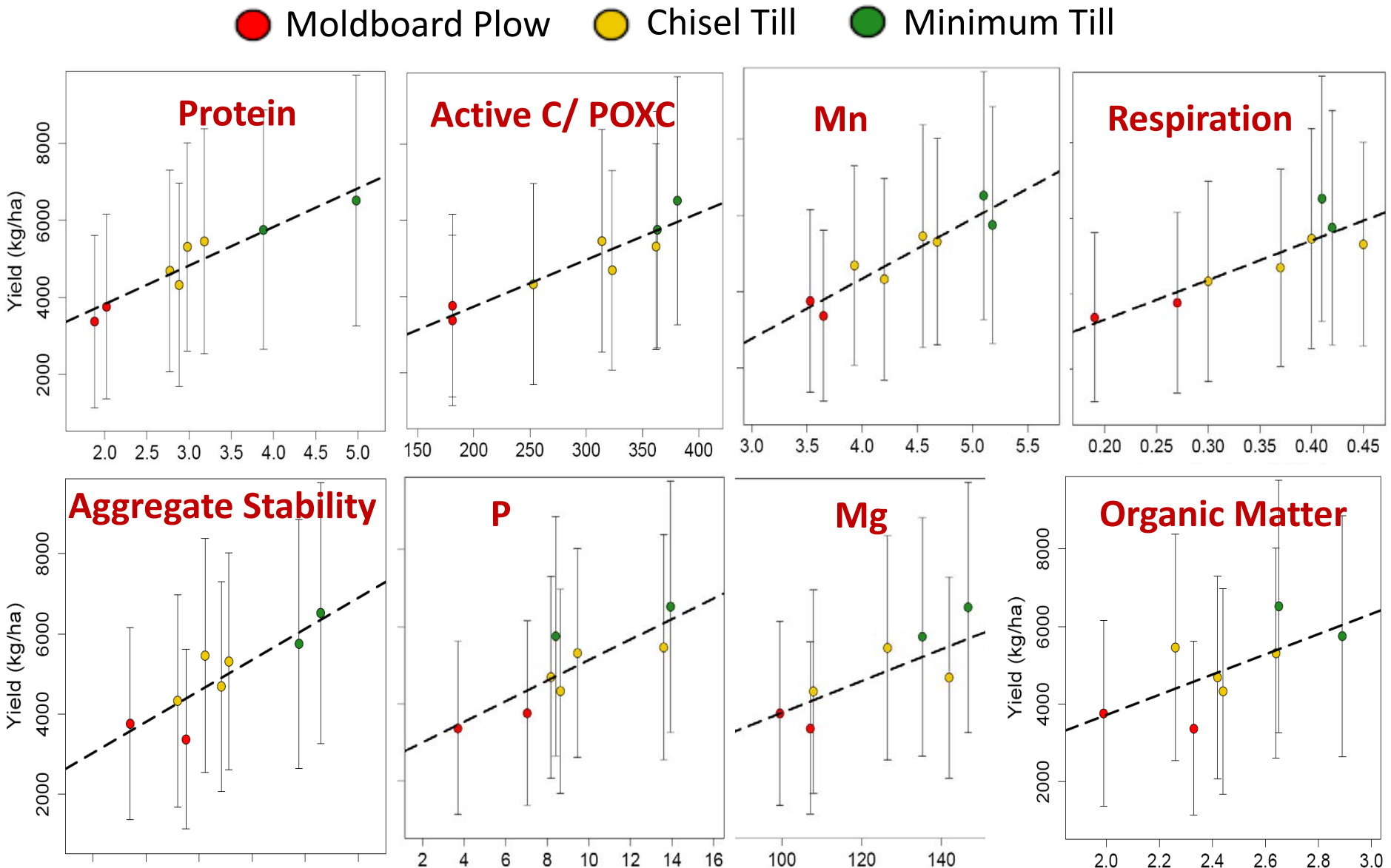
Sand: **49%** - Silt: **38%** - Clay: **12%**

Group	Indicator	Value	Rating	Constraints
physical	Predicted Available Water Capacity	0.21	78	
physical	Surface Hardness	193	36	
physical	Subsurface Hardness	293	52	
physical	Aggregate Stability	10.4	12	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter Total Carbon: 1.68 / Total Nitrogen: 0.14	2.3	20	
biological	ACE Soil Protein Index	4.8	30	
biological	Soil Respiration	0.5	40	
biological	Active Carbon	628	75	
chemical	Soil pH	6.9	100	
chemical	Extractable Phosphorus	19.0	100	
chemical	Extractable Potassium	154.4	100	
chemical	Minor Elements Mg: 137.1 / Fe: 1.5 / Mn: 5.2 / Zn: 0.6		100	

Overall Quality Score: **62** / High

Soil Health Indicators Related to Average Corn Yields

Long-Term Tillage Studies



Labile forms of C and N are most related to yield

Ranked by R^2 value

Protein:	0.88
ActiveC/POXC:	0.85
Mn:	0.85
Respiration:	0.75
AggStab:	0.71
P:	0.66
Mg:	0.56
OrgMatter:	0.37

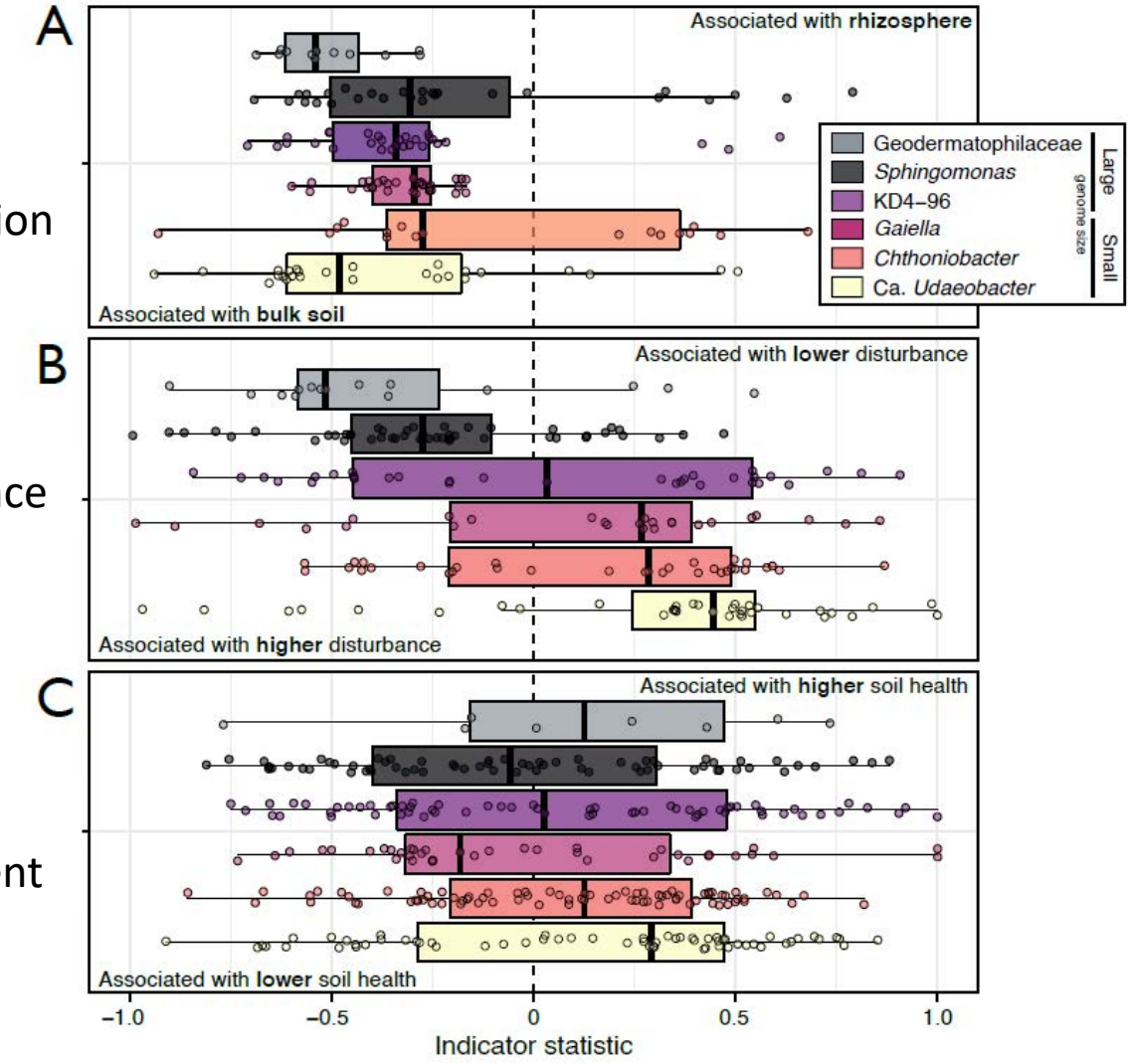
van Es and Karlen, 2019;
Data source: Roper et al., 2017.

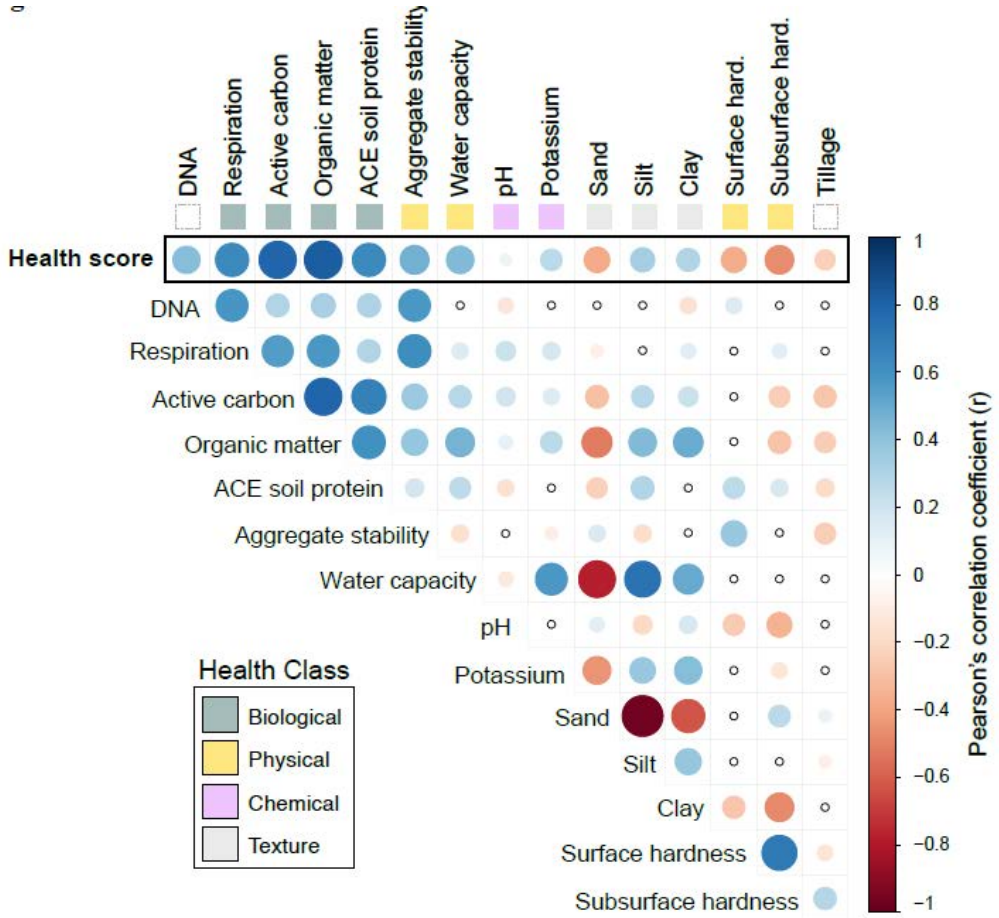
Ecological Insights on Soil Health: Microbiome Data

Plant association

Disturbance

Crop management

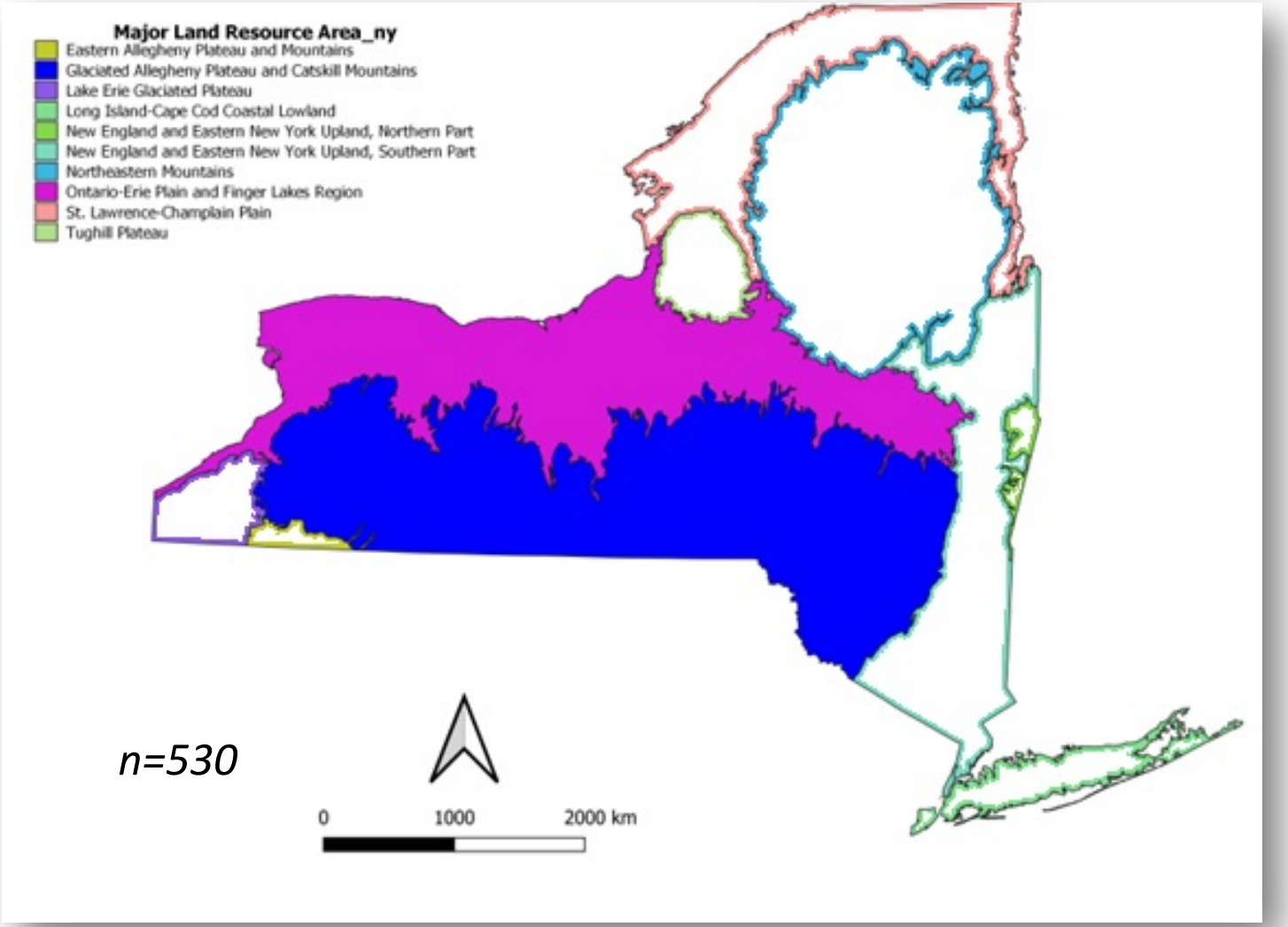




Wilhelm et al., 2022

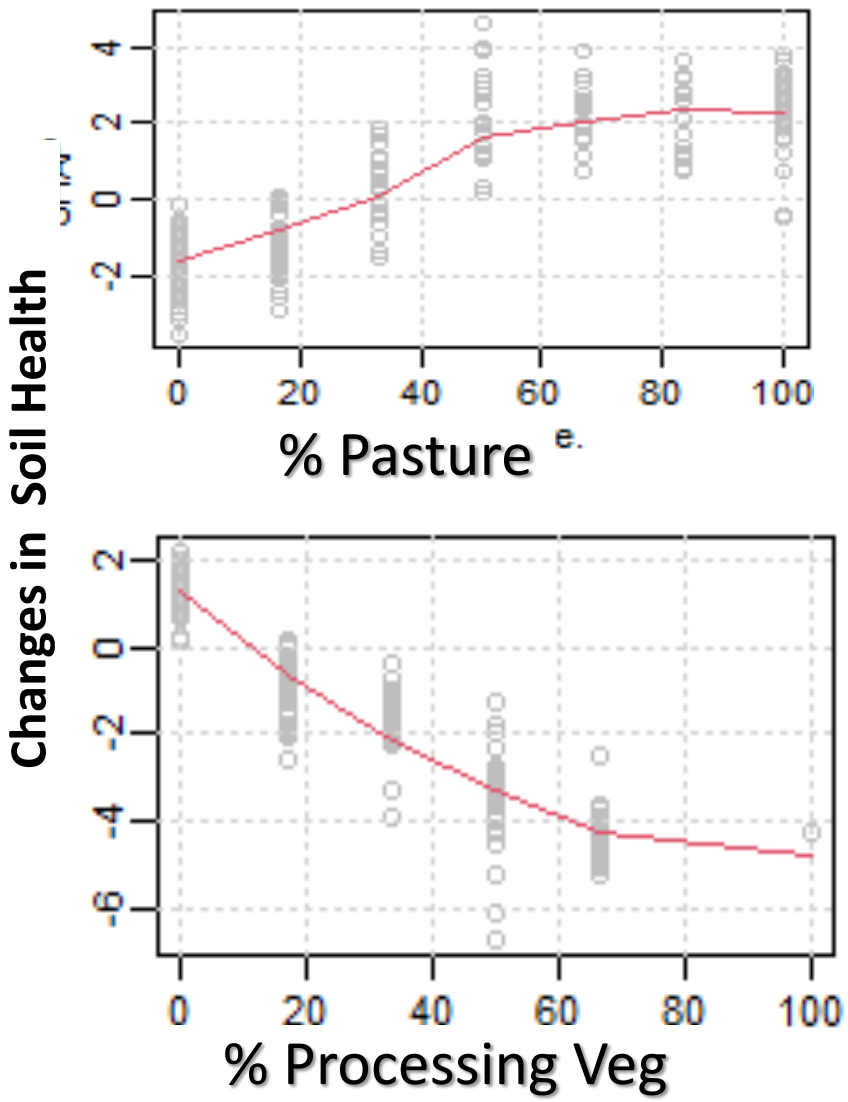
SPATIAL ASSESSMENT SOIL HEALTH INDICATORS IN NEW YORK:
Disentangling the role of anthropogenic management

Samples with GPS coordinates submitted between 2014-2022



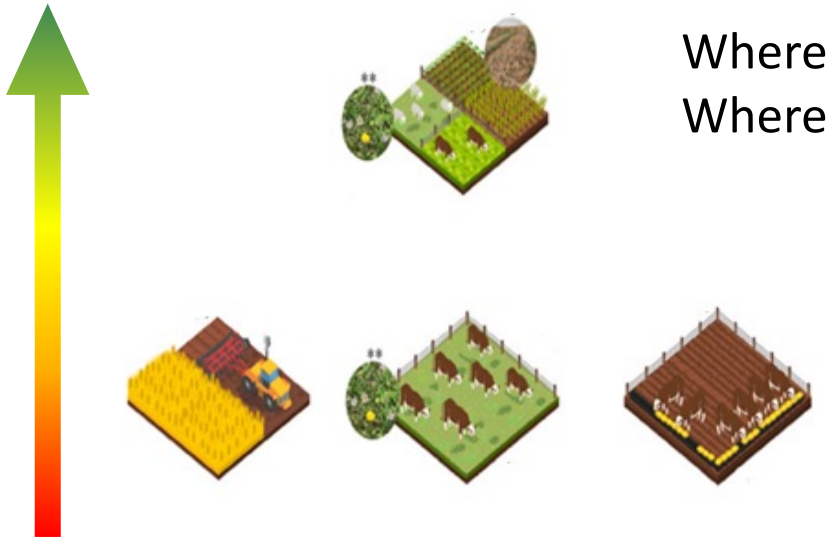
Understanding the effects of cropping system factors

Composite SH Indicator



Objectives

- Spatially assess soil health and carbon/nutrient cycling
- Explore opportunities for regional management strategies and carbon/nutrient exchange



Where are farms with surplus?
Where are farms with deficits?

Adapted from Carvalho et al, 2020

NYS Soil Health and Climate Resiliency Act

…PROMOTE SCIENTIFIC UNDERSTANDING OF SOIL HEALTH AND **CARBON SEQUESTRATION** WITH VARIOUS FARMING PRACTICES…

…AND PRECISE APPLICATION OF ADDED **NUTRIENTS** TO ACHIEVE NITROUS OXIDE EMISSIONS REDUCTION…

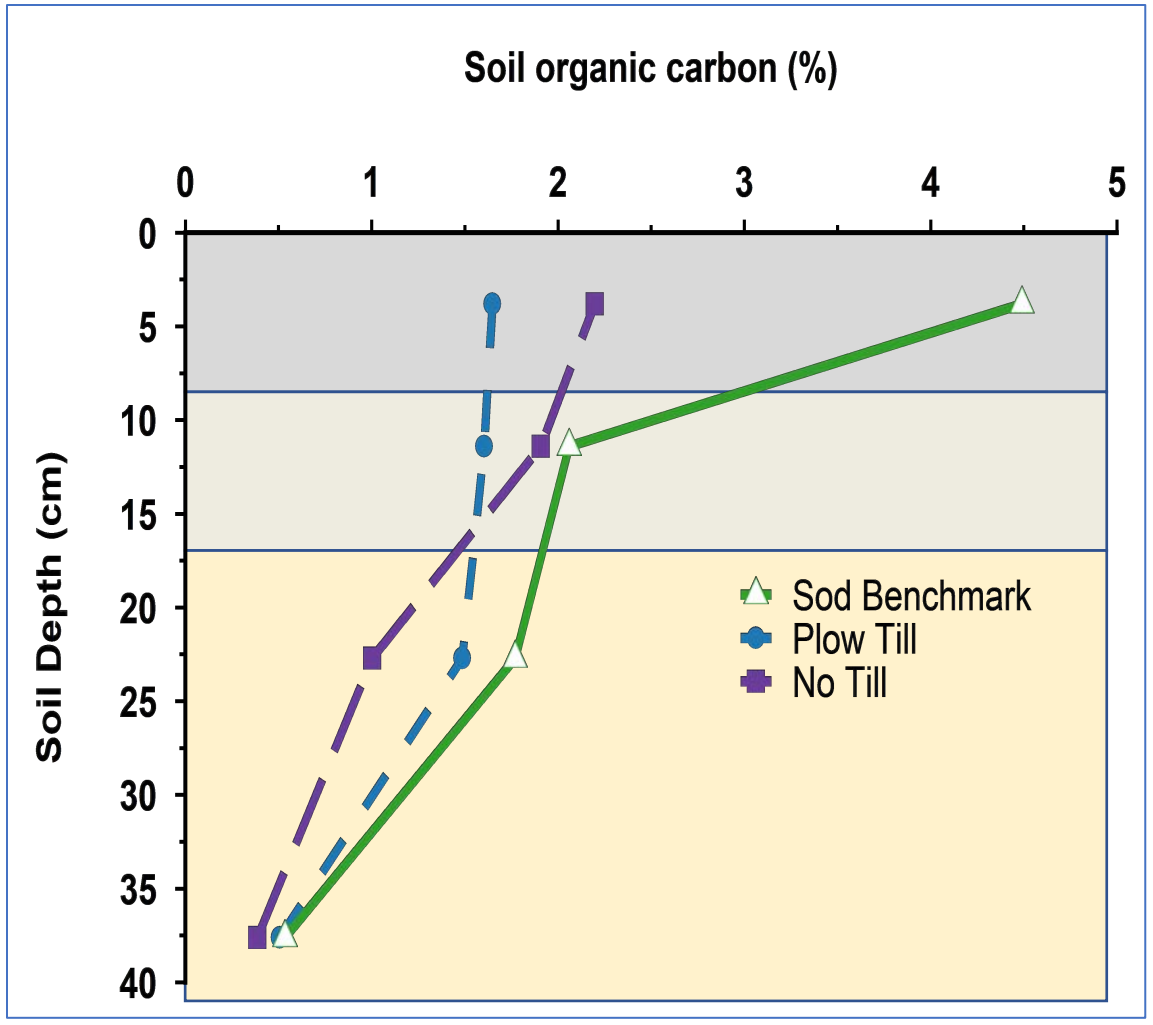
Quantifying effects of tillage, cropping system, and cover crops on soil organic carbon

Sites:

- Musgrave Research Farm
- Willsboro Research Farm

Preliminary Results:

- No-Till leads to higher SOC and soil health at the surface than Plow-Till, but not necessarily overall greater SOC sequestration.
- Biomass inputs (e.g., grain vs. silage) influence benefits of tillage system



New Initiative: Strategic Tillage and Amendment Management

No-till corn silage:
Compaction & poor manure injection

Strip tillage:
Flexible soil management tool

Cold season field management:
Improved soil health and reduced nutrient and GHG losses

Nitrogen Management in Multi-Objective Cropping Environments:
Soil Health, Carbon Storage, Water Quality, Energy

Innovation in cropping systems requires updated nutrient recommendations:

- More diverse and perennialized rotations
- Conservation practices (tillage, crop residue management)
- Cover cropping
- Improved crop genetics and higher yields
- Diverse organic inputs
- Variable timing, placement, and new fertilizer technologies

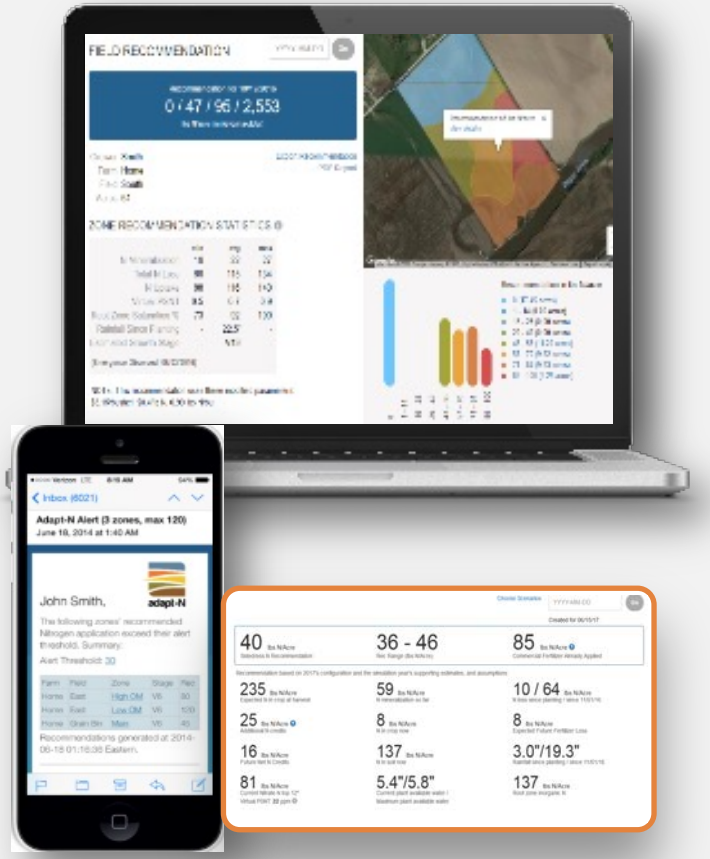
ALL PRACTICES INTERACT WITH SOIL AND WEATHER

Photos: J. Amsili; B. Wavrin

Optimum Nitrogen Rate

AVAILABLE:

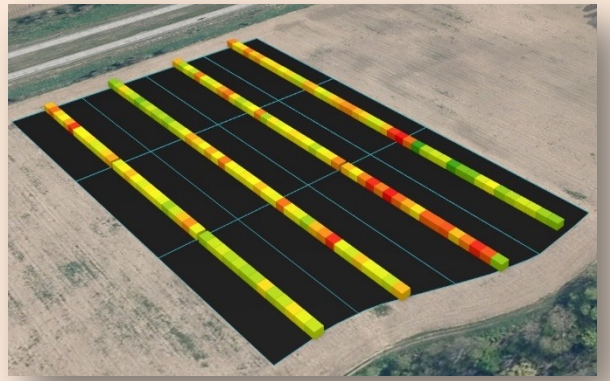
MODEL USING WEATHER, SOIL AND CROP MANAGEMENT DATA

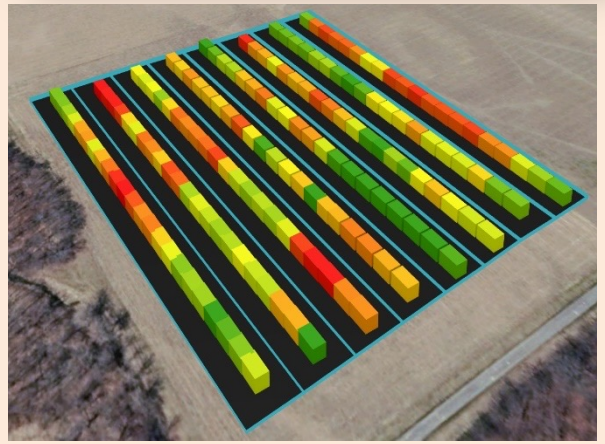


NEW:

IN-FIELD SENSING

NITROGEN OPTIMIZATION





Summary Points

Soil health is a function of inherent, cropping, and management factors

Biomass cycling and tillage are important factors for soil health

R&E activities to support NYS Soil Health and Climate Resiliency Act

New soil health initiatives: urban areas, perennial fruits

Soil health related to C storage and greenhouse gas emissions

Soil health integration into 4R nutrient management