Practical Soil Health Specialist Training Curriculum

October 22, 2020

Soil Health Prinicples and Functions

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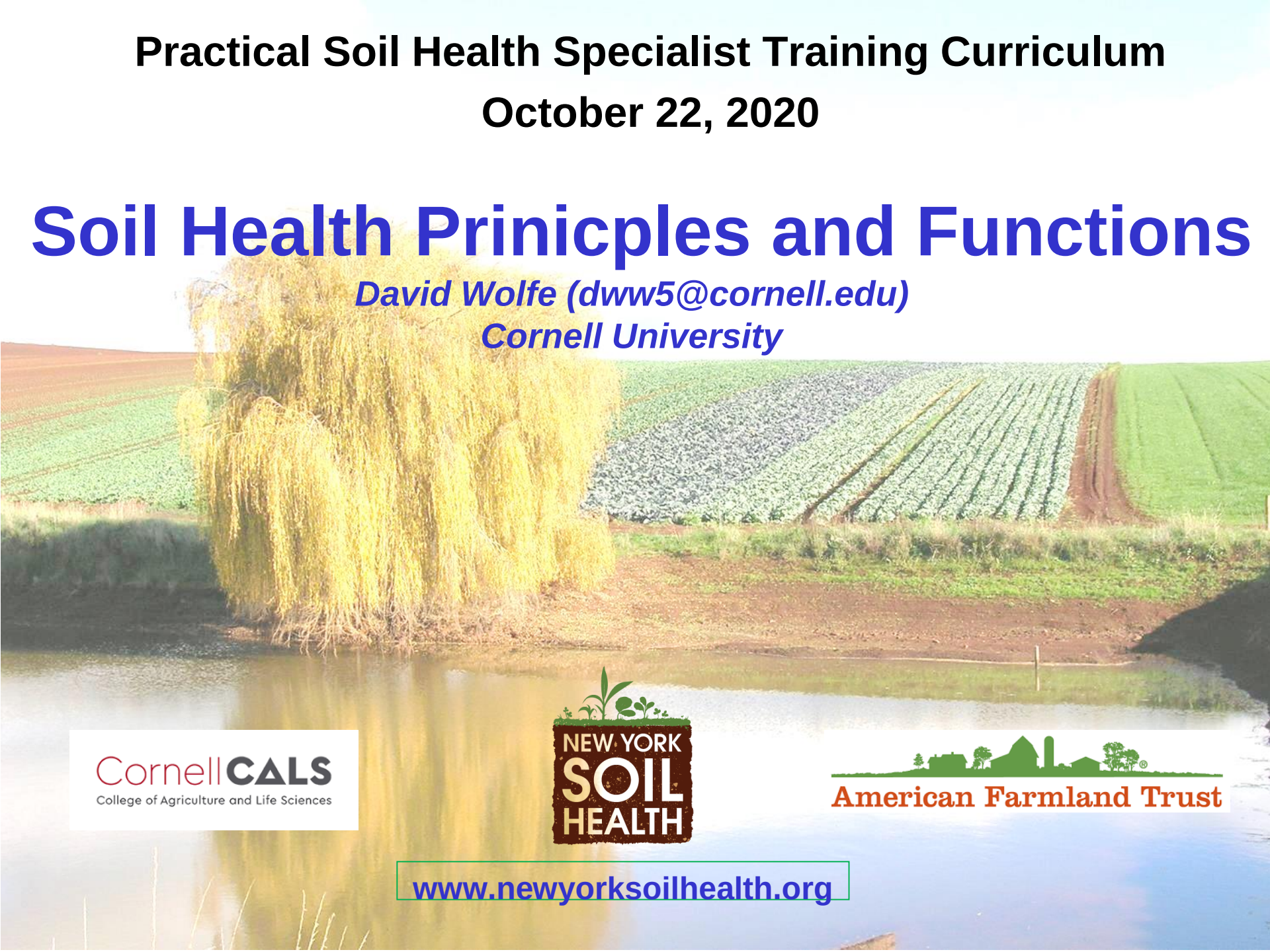
Cornell University



Cornell CALS
College of Agriculture and Life Sciences

NEW YORK SOIL HEALTH

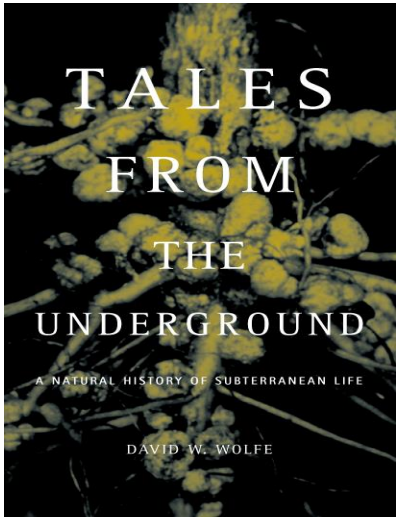
American Farmland Trust

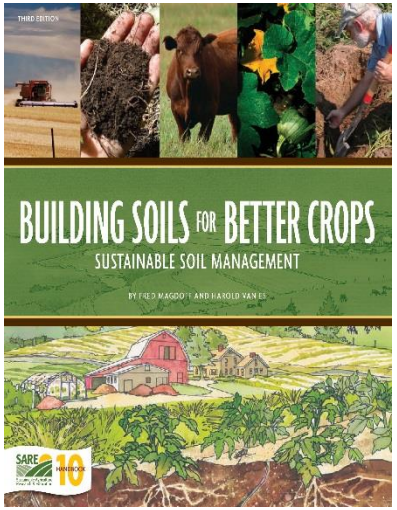
www.newyorksoilhealth.org

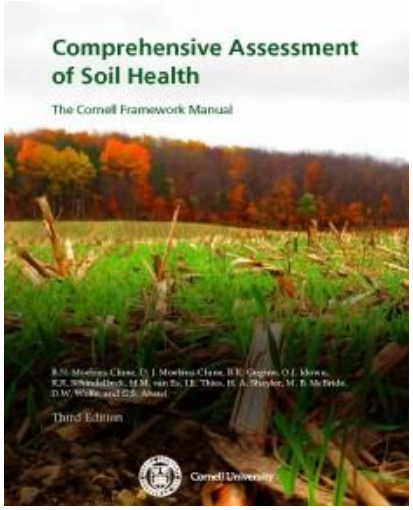
New York Soil Health:

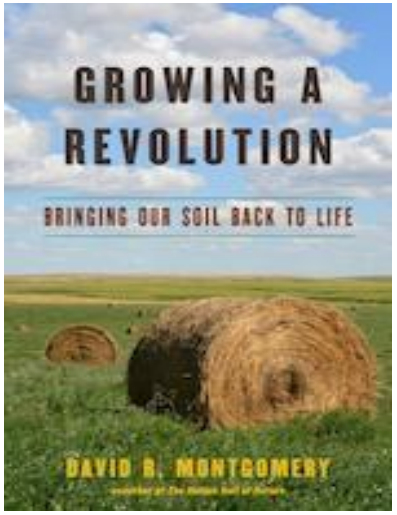
Merging Discovery Science with Farmer Needs and Protection of Natural Resources

- An era of discovery:
  - Amazing biodiversity and abundance beneath our feet
  - Prescription crops and innovative management to build healthy soils
- Farmer motivation and innovation:
  - Healthy soils = resilience and increased profits
- Soil health and the environment:
  - Erosion and water quality;
  - Food security and climate change challenges

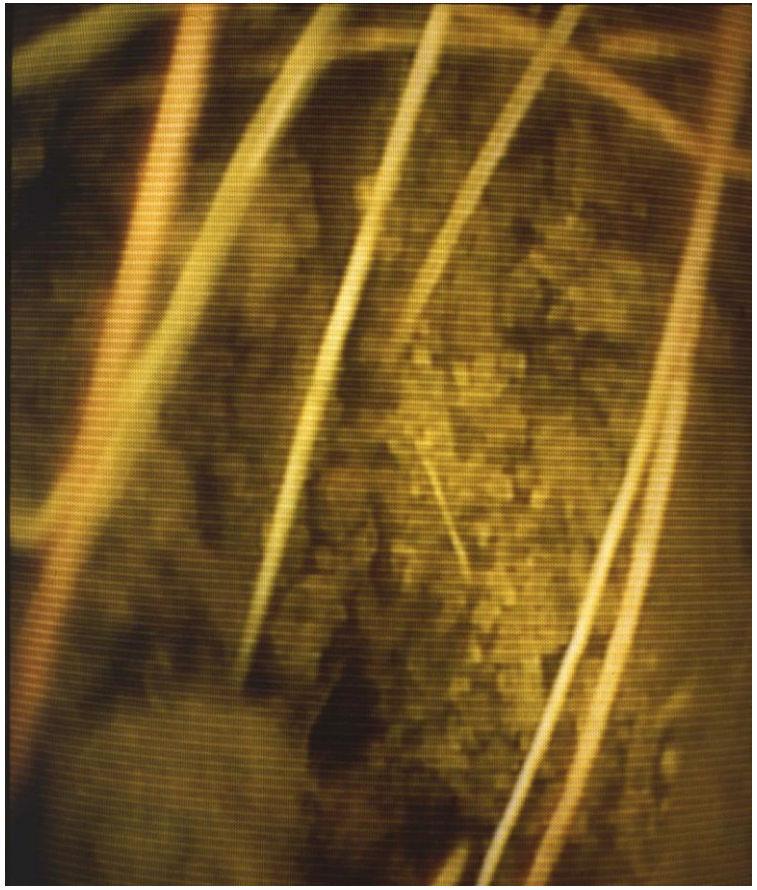








Breakthroughs in Root Biology:
Much More Than Water and Nutrient Uptake



-**Roots exude substances that:**

- inhibit weeds, insects, disease
- attract beneficial microbes
- dissolve plant nutrients in soil

-**Create pathways for water, oxygen, roots to follow**

-**Sequester organic matter (carbon) deep in soil profile**

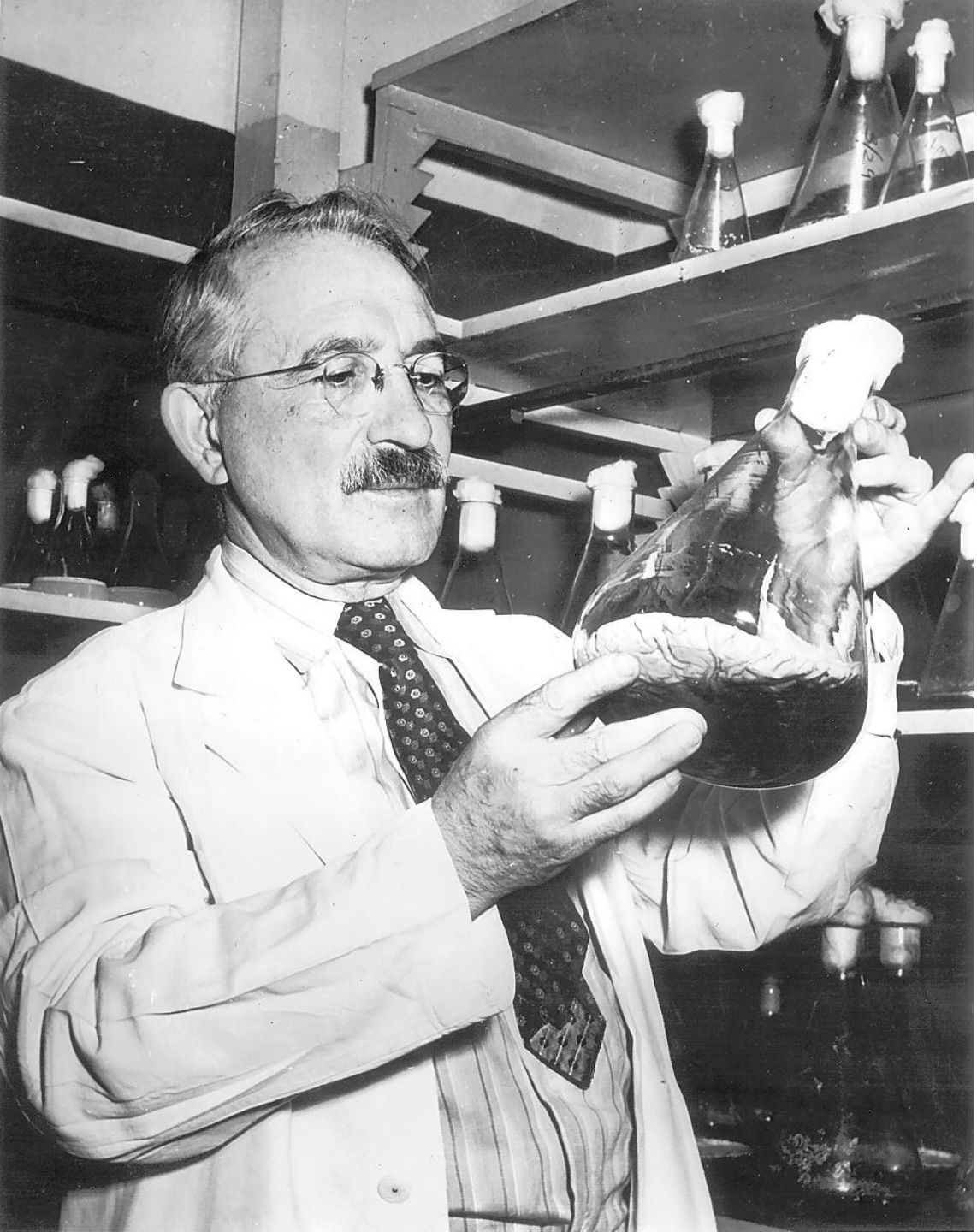
Rhizosphere:
The most dynamic interface on Earth

- a narrow zone of soil, within millimeters, that surrounds plant roots

- hotspot of plant-soil interactions involving microbiota

Source: J. Kao-Kniffin, Cornell

Sudangrass: roots exude allelochemicals that suppress weeds and pathogenic nematodes; roots break through compacted soils; roots pump organic matter (carbon) deep into the soil

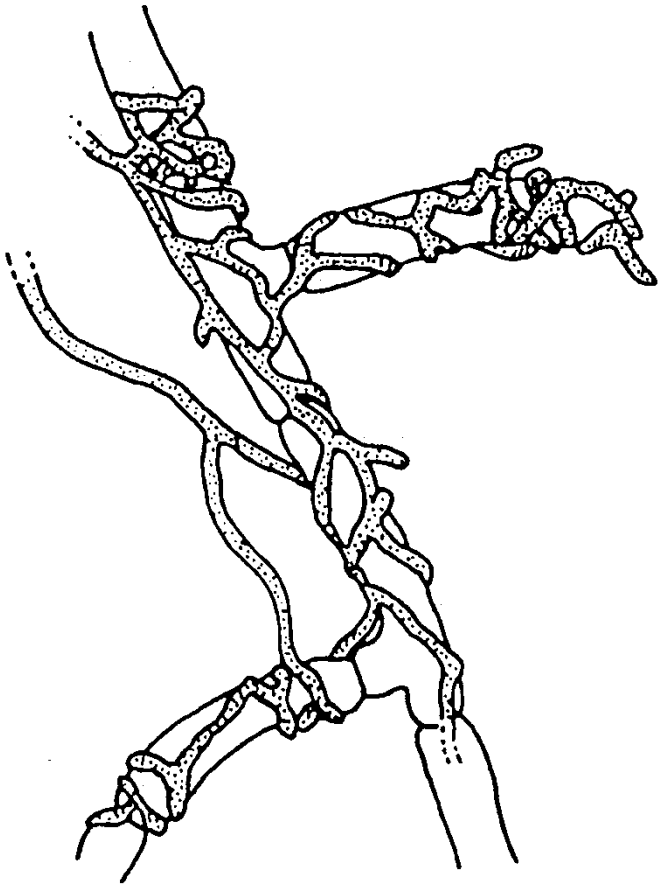


Building Disease-Suppressive Soils

Salman Waksman, a pioneer soil biologist, coined the term “antibiotic”, and discovered Streptomycin in 1943

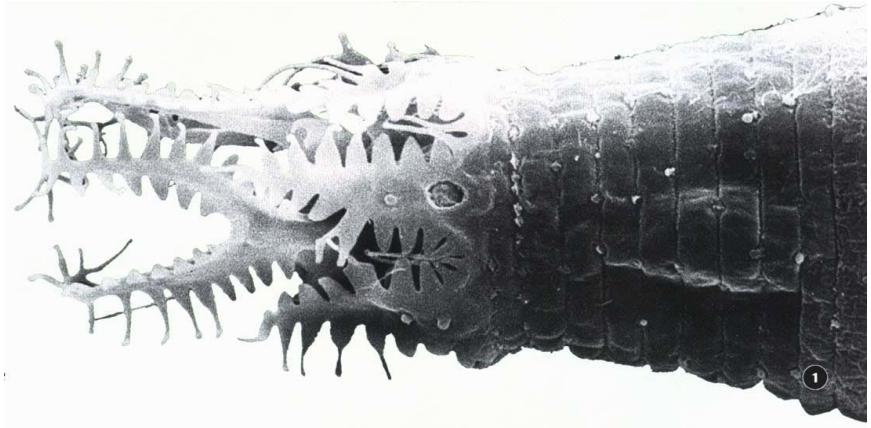
Promoting “natural enemies” of soilborne pathogens

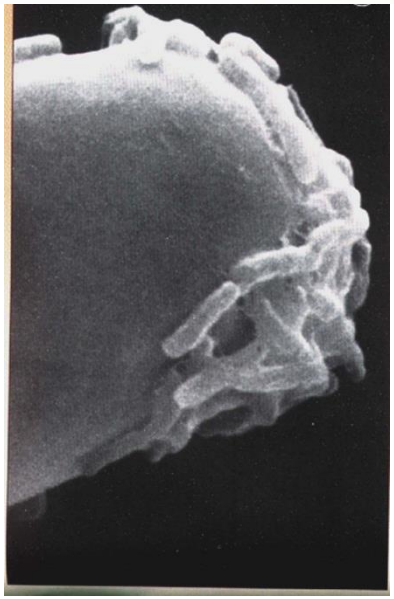
Common *Trichoderma* soil fungus attacking pathogenic *Rhizoctonia* fungus



Healthy soils maintain a diverse community of soil organisms that:

- Suppress plant disease, insect and weed pests;
- Form beneficial symbiotic associations with plant roots;
- Retain and recycle essential plant nutrients;
- Improve soil aggregation for better water infiltration, retention, and drainage;
- Increase grower profits and protect the environment





A Soil Test for the 21st Century:
Cornell's Comprehensive Assessment of Soil Health

http://soilhealth.cals.cornell.edu

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:
Bob Schindelbeck
306 Tower Rd.
Ithaca, NY 14853

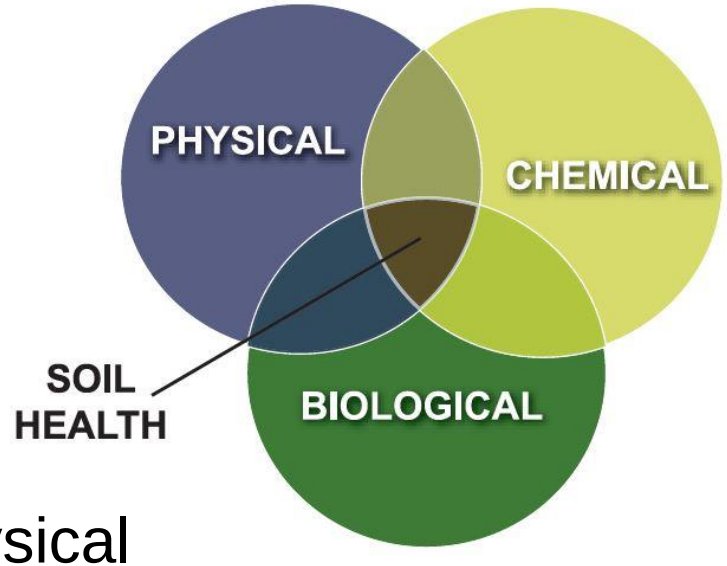
Agricultural Service Provider:
Mr. Bob Consulting
rrs3@cornell.edu

Sample ID:	LL8
Field ID:	Caldwell Field- intensive management
Date Sampled:	03/11/2015
Given Soil Type:	Collamer silt loam
Crops Grown:	WHT/WHT/WHT
Tillage:	7-9 inches

Measured Soil Textural Class: **silt loam**
Sand: **2%** - Silt: **83%** - Clay: **15%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.14	37	
physical	Surface Hardness	260	12	Rooting, Water Transmission
physical	Subsurface Hardness	340	35	
physical	Aggregate Stability	15.7	19	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter	2.5	28	
biological	ACE Soil Protein Index	5.1	25	
biological	Soil Respiration	0.5	40	
biological	Active Carbon	288	12	Energy Source for Soil Biota
chemical	Soil pH	6.5	100	
chemical	Extractable Phosphorus	20.0	100	
chemical	Extractable Potassium	150.6	100	
chemical	Minor Elements Mg: 131.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		100	

Overall Quality Score: **51** / Medium

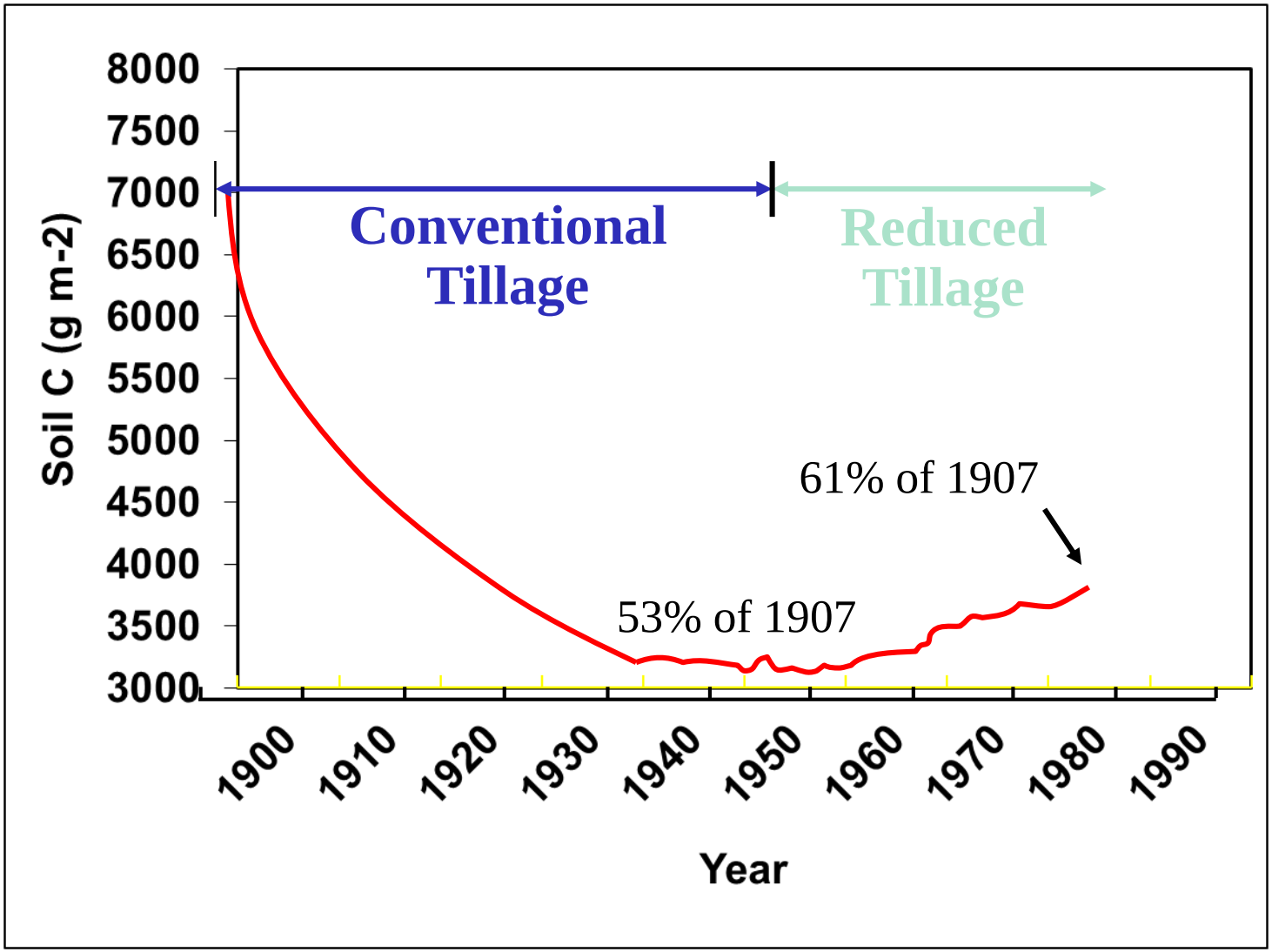


Physical

Biological

Chemical
(std soil test)

Historic Loss of US Soil Carbon



From Lal et al., 1998

Organic Matter (OM) Depletion: A major constraint to soil health

- **OM is "food" for the many beneficial organisms in the soil food web.**
- **Fungal hyphae and sticky substances released by soil biota are essential for aggregate stability**
- **Well aggregated soils buffer plants from short-term drought, flooding, compaction**
- **OM is a source of plant nutrients and also sequesters carbon in the soil**
- **Highly stable humus fraction increases cation exchange capacity and nutrient retention**

Chronic Soil Compaction: Another major constraint to soil health

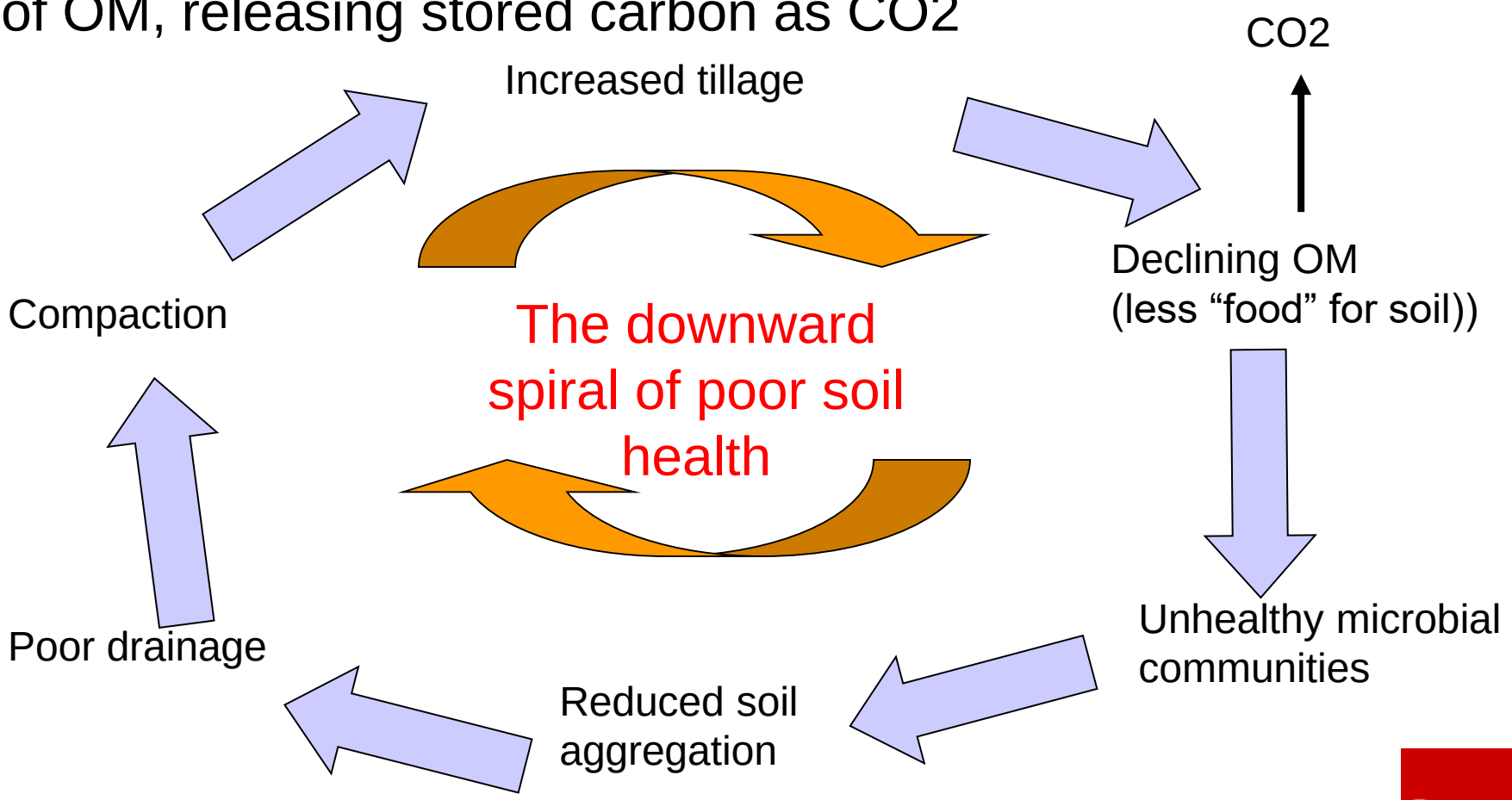
Understands Soil Function !

Does Not Understand Soil Function!

Some tillage equipment leads to plow-pan compaction

Tillage, Soil Health, and Carbon

Tillage oxygenates soil, stimulating microbial decomposition of OM, releasing stored carbon as CO2



Exploring tillage options that minimize soil disturbance

Strip till

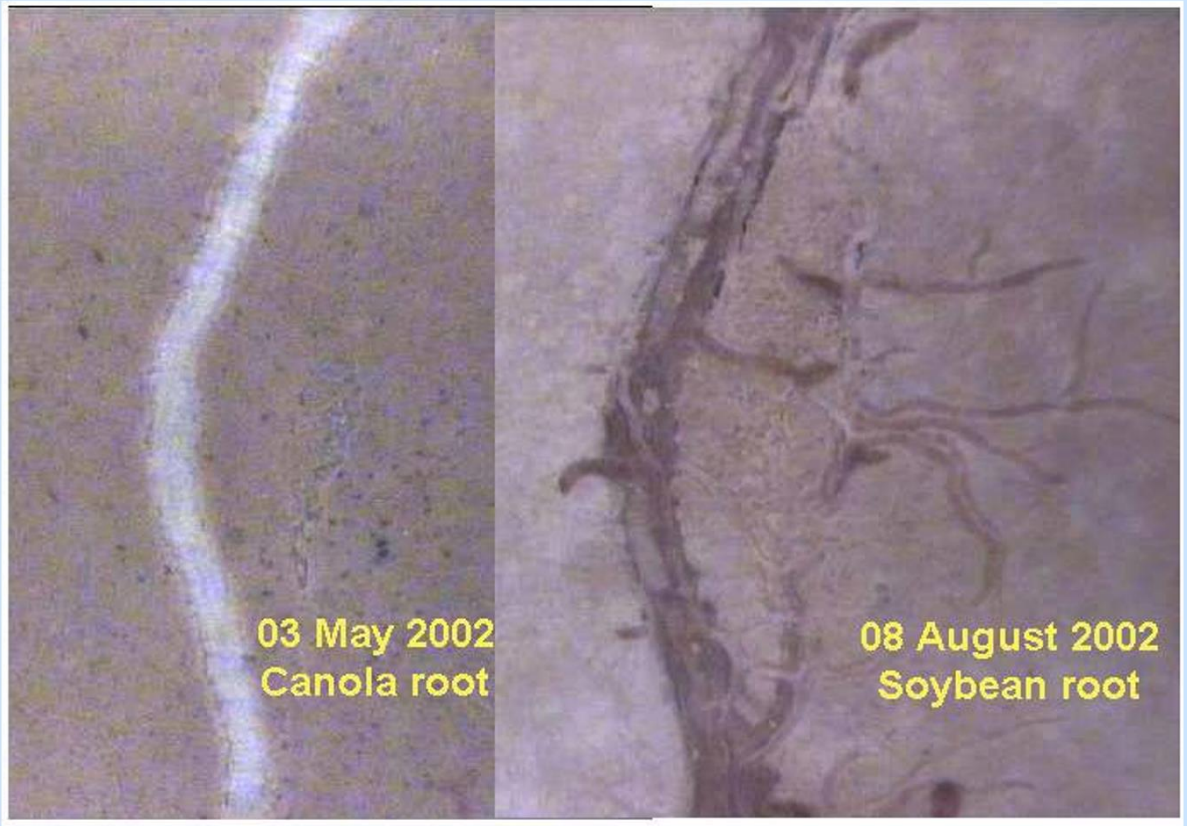
‘Finger’ till

Practices that enhance soil health:

What are barriers for adoption? How long until benefits are realized?

- Reduce tillage
- Maximize vegetative cover:
  - Fall-winter cover crops, including legumes
  - semi-perennial and/or perennial cropping systems
- Direct additions of organic matter and carbon:
  - compost and mulches
  - manure
  - biochar

Cover crops and rotation crops to remediate chronic soil compaction



Source: Ray Weil, Univ of MD

Below-ground rhizotron photos

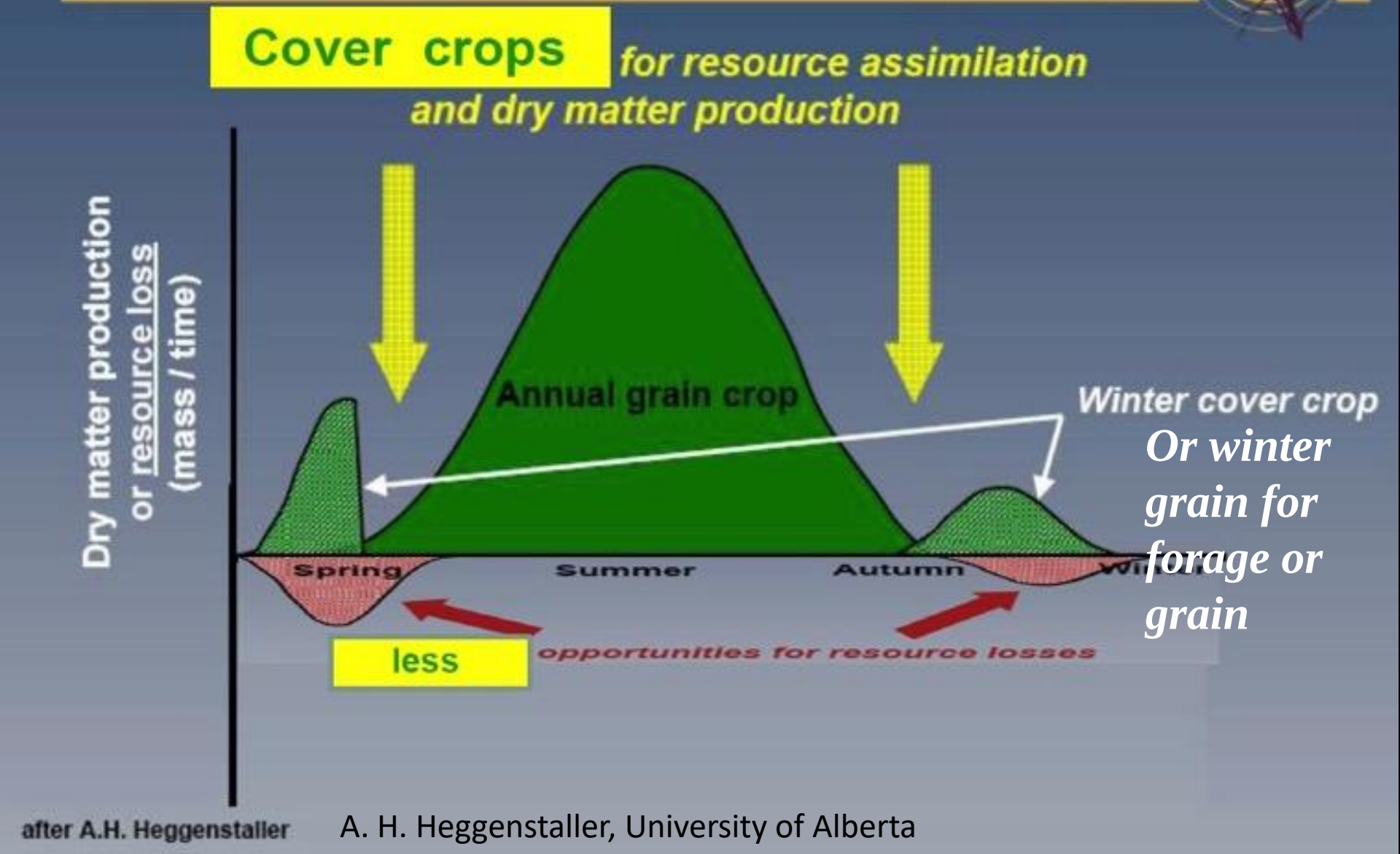
Tillage Radish

Many cover crops and cover crop mixes being explored by growers

(See Cornell cover crops decision tool: http://covercrop.org)

	Legumes	Brassicas	Grasses
Winter-hardy	Red Clover 	Canola 	Cereal Rye 
Winterkilled	 Austrian Winter Pea	 Forage Radish	 Oats

Biomass Production
Annual Cropping Systems



Or winter grain for forage or grain

A. H. Heggenstaller, University of Alberta

Addressing Barriers: Establishing and terminating fall/winter cover crops into cash crop systems

Field experimentation by farmers and researchers

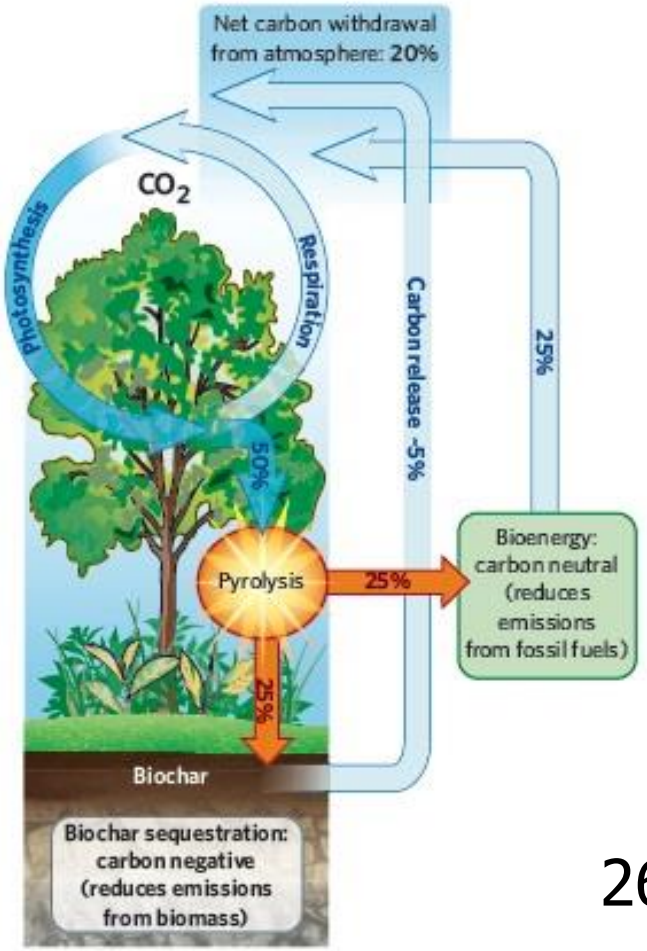
Composts and other soil amendments

for improving soil health

Biochar:

Capturing energy from biomass or waste through pyrolysis,

and creating stable charcoal that is stable in soils and benefits soil structure and function.



Lehamann J. 2007. Nature 447:143-144

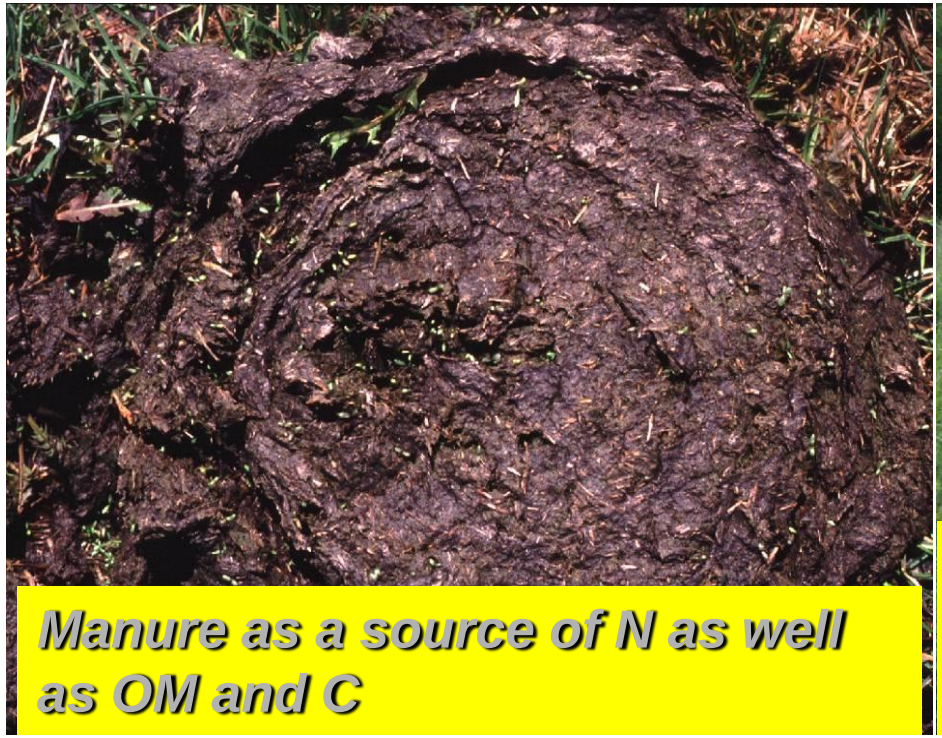
Soil Health and "win-win" solutions:

Low-cost resilience to weather extremes while reducing the carbon footprint of agriculture

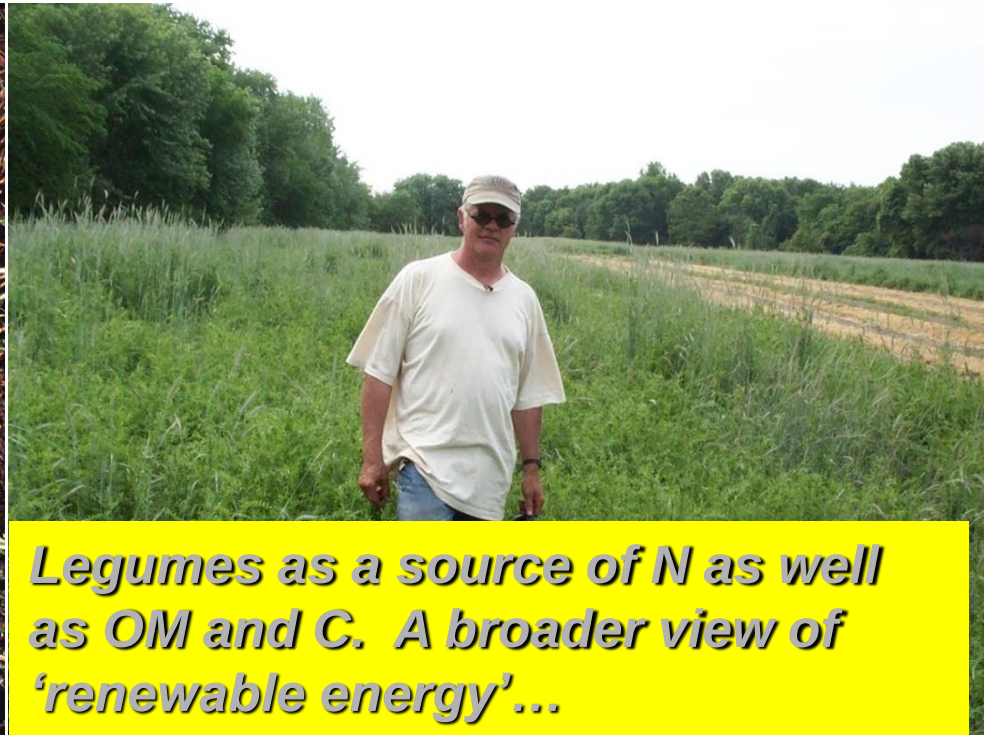
Building soil organic matter (reducing tillage; winter cover crops; using manure, composts, biochar; more perennial crops):

- Adaptation: increases resilience to drought, flooding, erosion
- Mitigation: stores carbon in the soil that otherwise would be in the air as CO_2

Organic N sources avoid the "carbon footprint" of synthetic N fertilizers



Manure as a source of N as well as OM and C

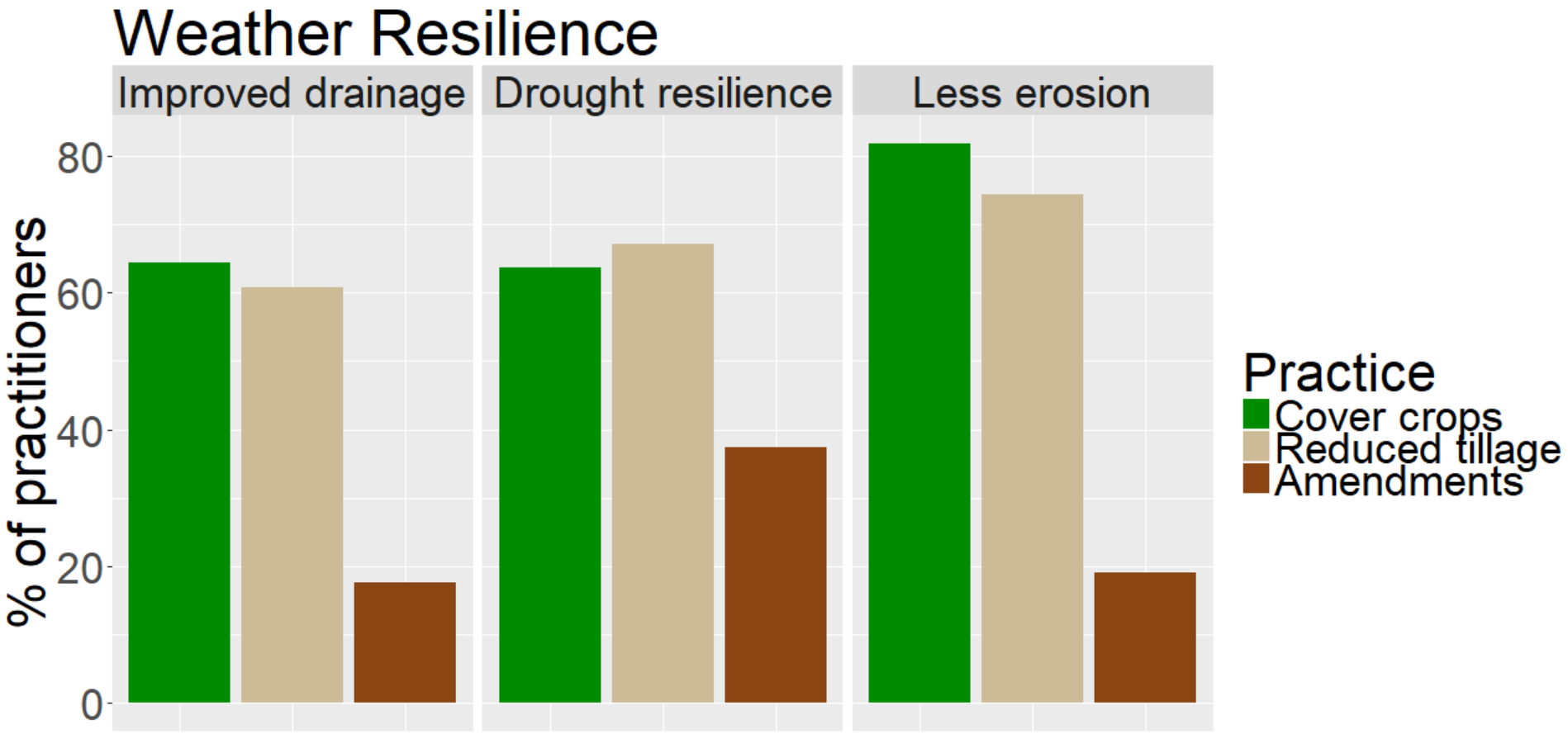


Legumes as a source of N as well as OM and C. A broader view of 'renewable energy'…

- **Synthetic N fertilizers are <u>energy-intensive to produce</u>**
- **But <u>all</u> N fertilizers (including manure and other organic sources) give off <u>nitrous oxide</u> (N_2O), a potent greenhouse gas, as they degrade in soils**
- **Additional incentive for efficient N management**

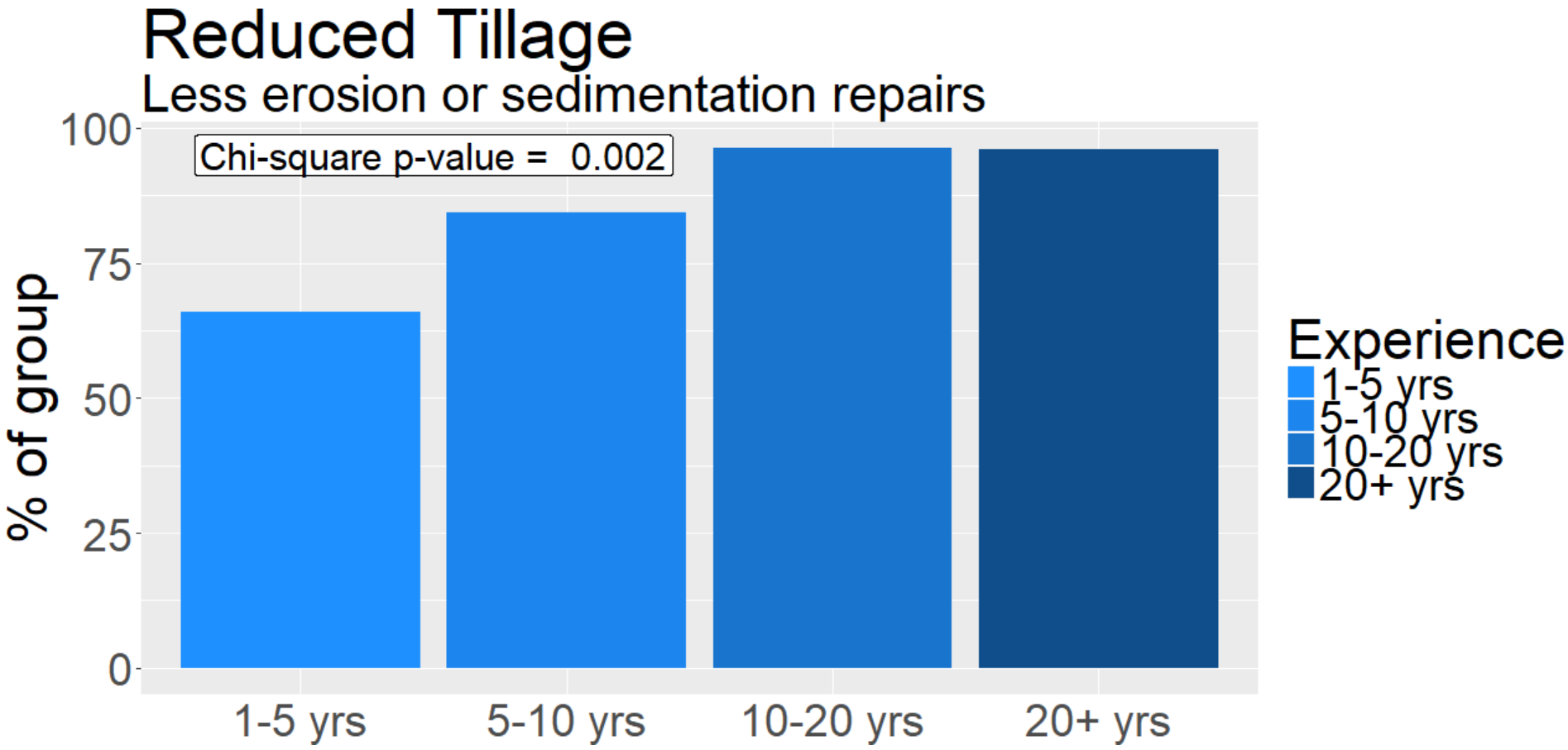
NY Farmer Soil Health Survey (n=182)

Economic and Environmental Costs and Benefits



Mason C and D Wolfe. Nov/Dec 2018. *What's Cropping Up?* 28(5): 79-89.
https://scs.cals.cornell.edu/extension-outreach/whats-cropping-up/

How long does it take to see specific benefits?



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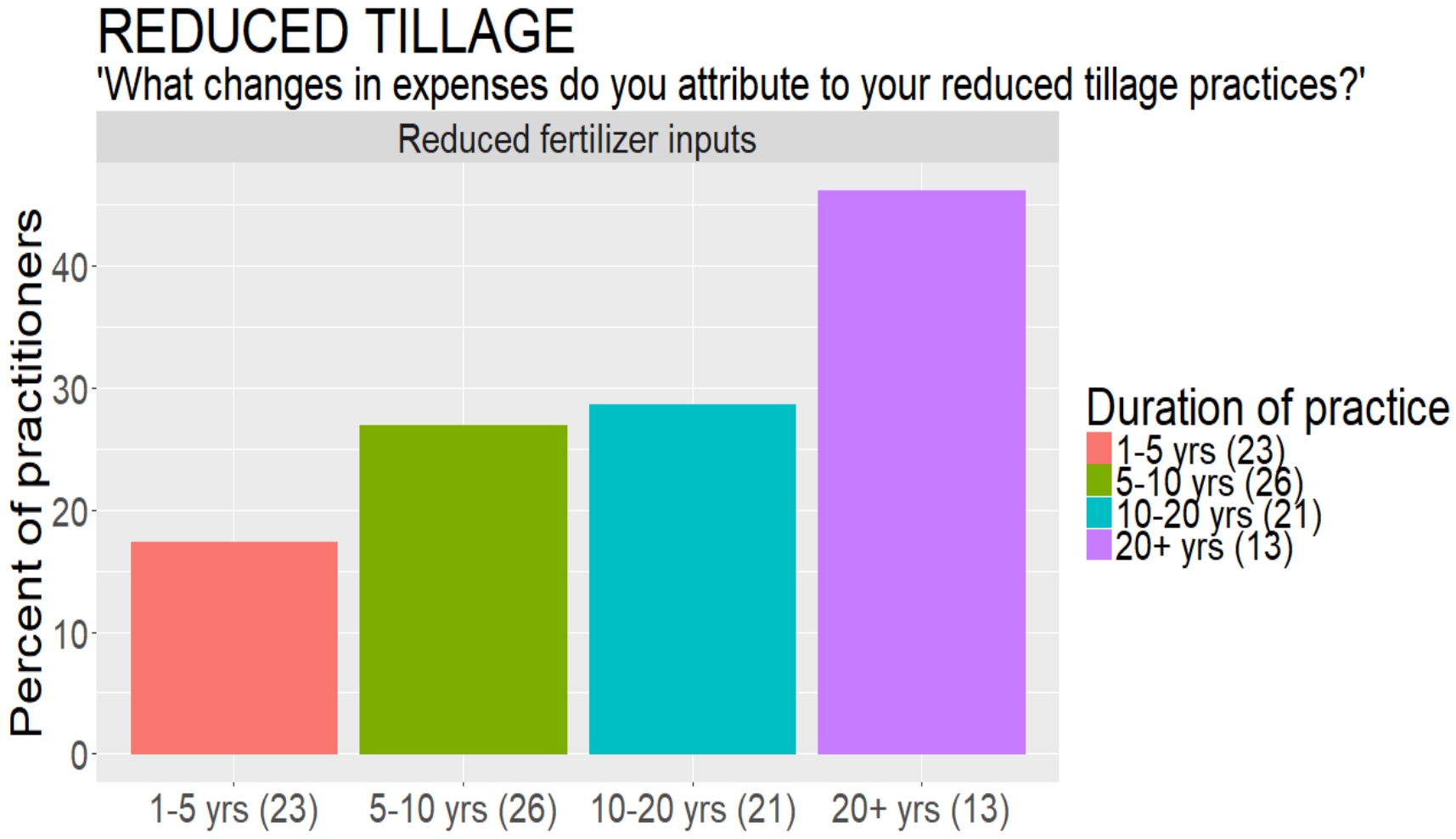

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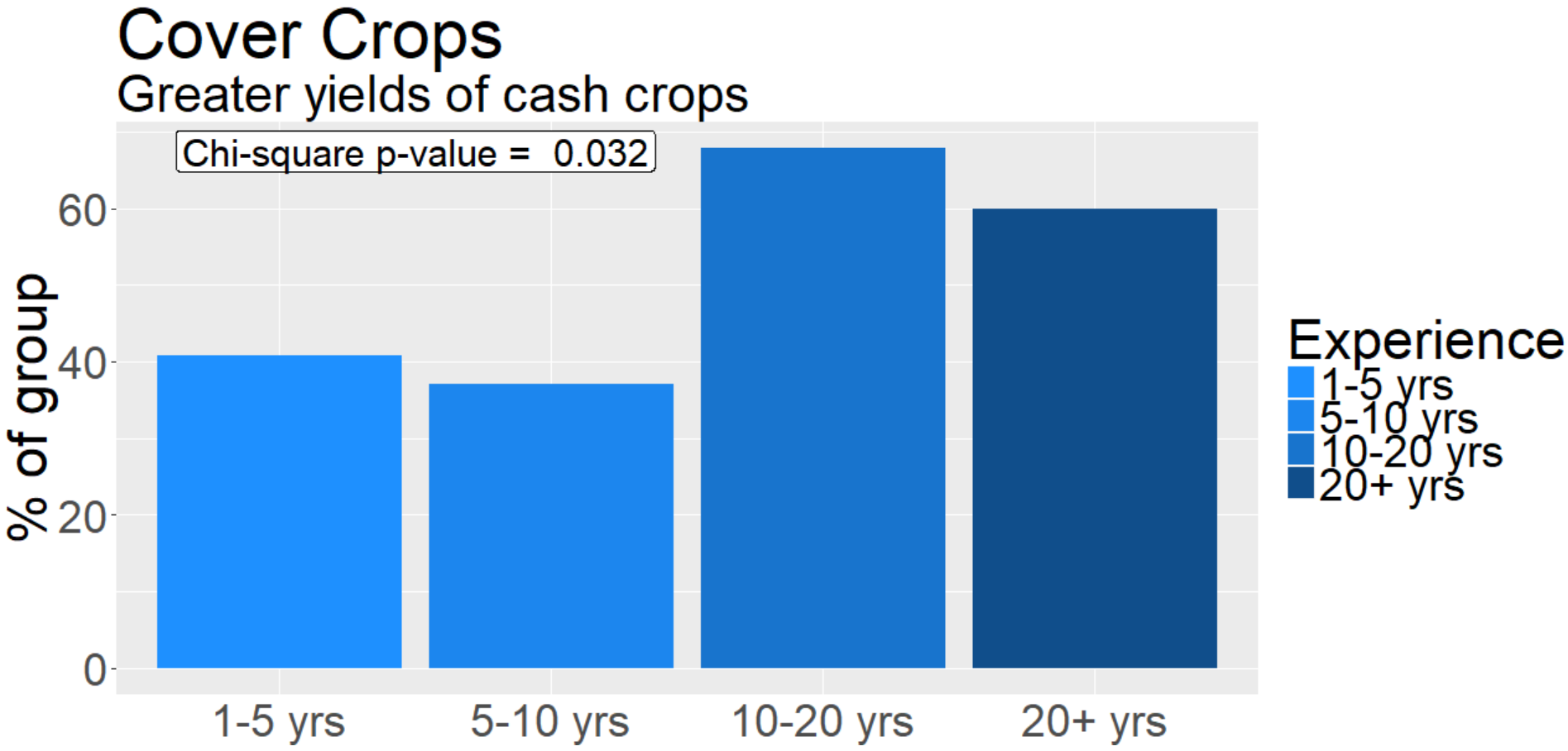

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Cover crops can have flooding and erosion benefits in year 1
When combined with reduced tillage, benefits increase

- Runoff from two different cropland managements in close proximity and on similar soils after 1” of rainfall in 30 minutes.

- Fall conventional tillage without cover crop

Spring strip tillage with multispecies cover crop

Photos by Dan Wallace, USDA/NRCS, GA

New York Has Been at the Forefront of the Soil Health Movement For More Than 20 Years

Where Do We Go From Here?

What Are the Priorities for Research, Outreach, Policy?


NEW YORK
SOIL
HEALTH
Welcome
to the
SUMMIT
newyorksoilhealth.org
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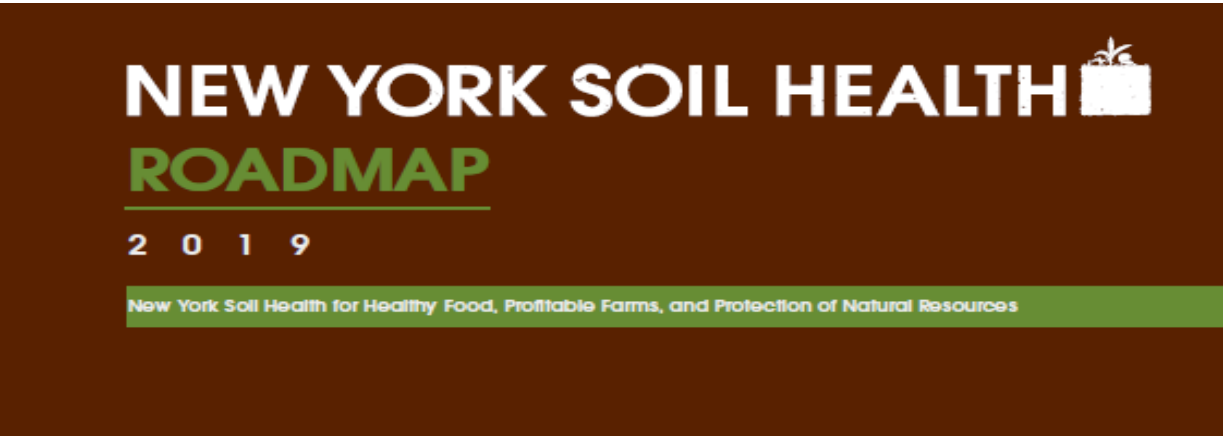
Input on the "Soil Health Roadmap" at first NY Soil Health Summit



NEW YORK SOIL HEALTH

www.newyorksoilhealth.org

- **Introduction/Background**
  - Defining, measuring, improving soil health
  - On- and Off-Farm costs and benefits
  - Relevant on-going regional, national efforts
  - Unique challenges and opportunities for NY
- **Vision**
- **Goals (and Policy, Research, Outreach Priorities for each)**
  - A stakeholder framework for collaboration, communication, priority-setting
  - Steps to overcome barriers to adoption
  - Integrate soil health with climate change policy, research, and outreach
  - Integrate soil health with water quality and nutrient management policy, research, and outreach