

The Carbon Problem

Regenerative Organic Agriculture

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Soil is the Heart of the System



2015 International Year of Soil

REGENERATIVE ORGANIC AGRICULTURE

THE PROBLEM
Too much CO₂ (carbon) in the atmosphere causes climate change. This results in historic weather events—more hurricanes, tornadoes, typhoons, floods, droughts, winter storms and heat waves in magnitudes never seen before.

OUR SOLUTION
A global transition to regenerative organic agriculture, which means working with nature to use photosynthesis and healthy soil biology to draw down greenhouse gases.

Our study, "Regenerative Organic Agriculture & Climate Change" is available at rodaleinstitute.org/regenerative-organic-agriculture-and-climate-change/

Carbon pollution origins

Category	Percentage
Energy supply	26%
Industry	19%
Forestry	17%
Agriculture	14%
Residential & commercial	13%
Transportation	8%
Waste & wastewater	3%

1. Photosynthesis
The process plants use to change carbon dioxide from the atmosphere into carbon based sugars.

2. Nutrient exchange
Carbon-based sugars ooze out of the plant's roots to feed micro-organisms, mostly bacteria and fungi, living in the soil nearby. Microorganisms transform organic matter and soil minerals into nutrients which feed the plant.

3. Capturing carbon
Temporary root sugars and organic materials (e.g. plant debris and compost) are eaten by micro-organisms and converted into more stable materials to store carbon in the soil for decades to centuries.

4. Restoring balance, reversing climate change
Building healthy soil brings carbon levels back into balance, reversing climate change.

Cover crops provide a green cover of photosynthesizing plants that keep the microorganisms thriving and actively storing carbon, rather than leaving the soil bare between growing cash crops.

Compost is organic matter that has decomposed. It is used as a fertilizer and soil amendment, and even as a natural pesticide. Since compost comes from food waste, manure, dead leaves and grass clippings, it also reduces waste sent to landfills.

Rotating crops provides a balanced diet to microorganisms, promoting carbon storage and soil health.

Tillage is a common agricultural practice of breaking up the soil in preparation for planting crops. Microorganisms living in soil are killed by tillage. A no-till approach allows soil to become healthier every year.

**A nation that destroys its soil, destroys itself.
– President Franklin Roosevelt**

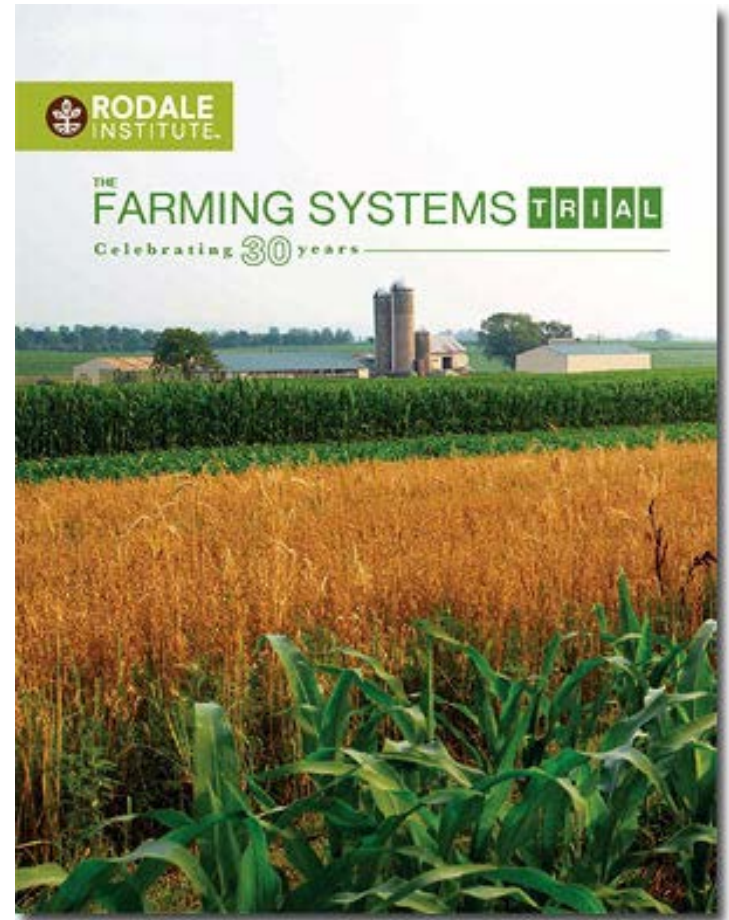
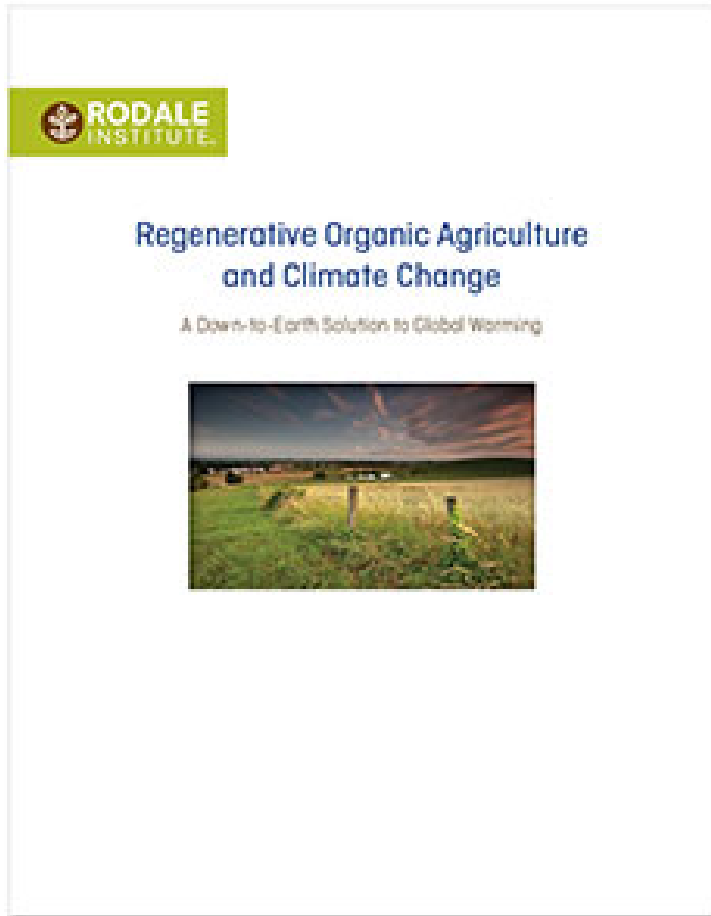


2015 International Year of Soil

- We speak a lot of the importance of sustainable food systems for healthy lives. Well, it starts with soils.
- We need healthy soils to achieve our food security and nutrition goals, to fight climate change and to ensure overall sustainable development.
- The multiple roles of soils often go unnoticed. Soils don't have a voice, and few people speak out for them. They are our silent ally in food production.
- Soils also host at least one quarter of the world's biodiversity. They are key in the carbon cycle. They help us to mitigate and adapt to climate change. They play a role in water management and in improving resilience to floods and droughts.

- José Graziano da Silva, FAO Director-General

Regenerative Organic Agriculture and Climate Change





Regenerative Organic Agriculture

- **Cover Crops**
- **Crop Rotation**
- **Reduced Tillage**
- **Compost**



Reversing Climate Change

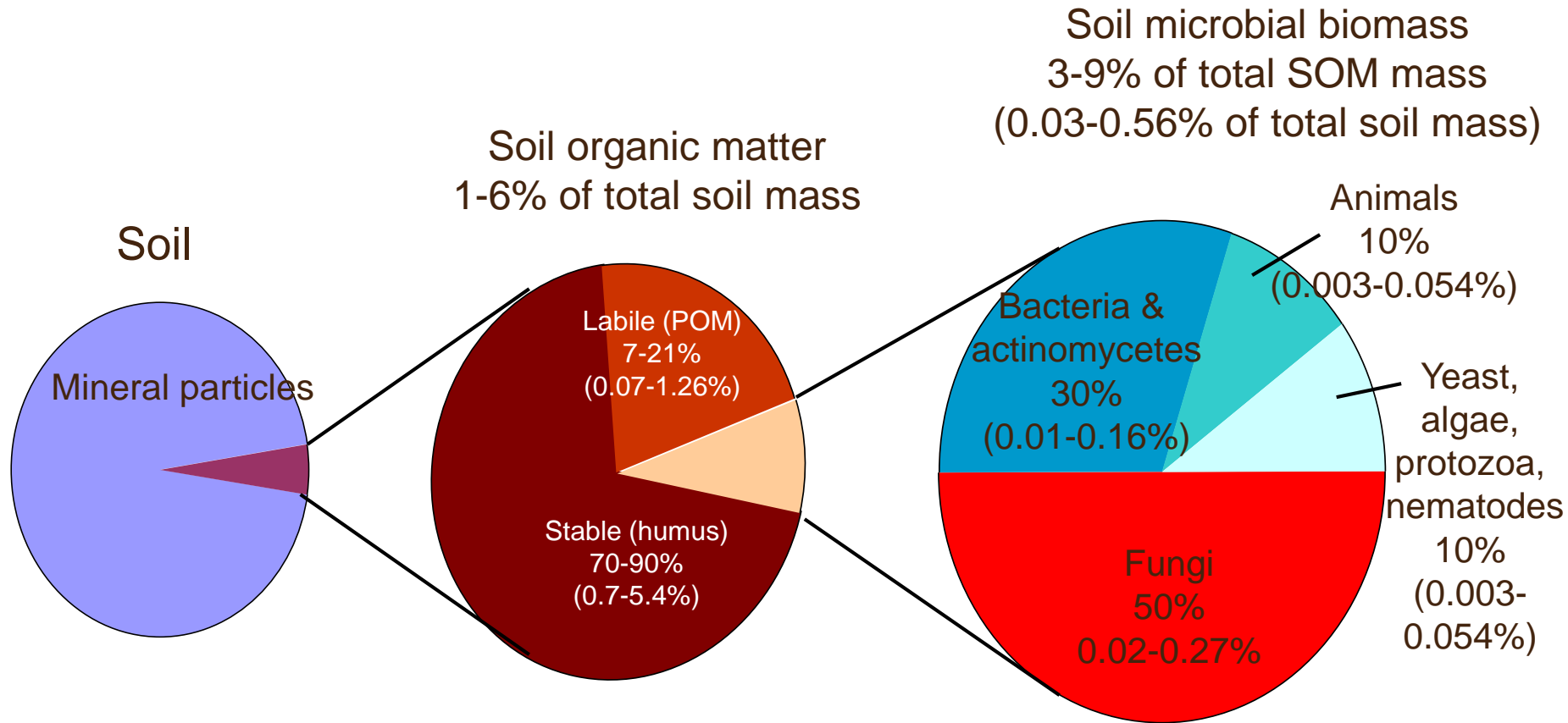
Place	Crop and practices	reported carbon sequestration	Extrapolation to all global cropland
U.S. ²¹	Corn-Vegetable-Wheat Organic, tillage, composted manure, legume cover crop	2.36 Mg C ha ⁻¹ yr ⁻¹	12 Gt CO ₂ yr ⁻¹
Egypt ²²	Peanuts Biodynamic, compost, irrigation	4.10 Mg C ha ⁻¹ yr ⁻¹	21 Gt CO ₂ yr ⁻¹
Iran ²³	Corn No-till, manure, hand-weeding	4.10 Mg C ha ⁻¹ yr ⁻¹	21 Gt CO ₂ yr ⁻¹
Thailand ²⁴	Unreported Crop Organic	6.38 Mg C ha ⁻¹ yr ⁻¹	32 Gt CO ₂ yr ⁻¹
Global ²⁵	Pasture Improved grass species	3.04 Mg C ha ⁻¹ yr ⁻¹	37 Gt CO ₂ yr ⁻¹



Reversing Climate Change

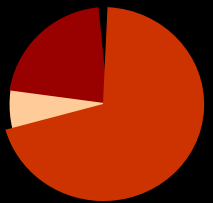
- **Storing Carbon**
- **Reducing Fossil Fuel Use**
 - **Synthetic Inputs**
 - **Tillage**
- **Reducing GHG Emissions from Soil**
 - **Carbon Dioxide**
 - **Methane**
 - **Nitrous Oxide**

Soil Organic Matter Composition



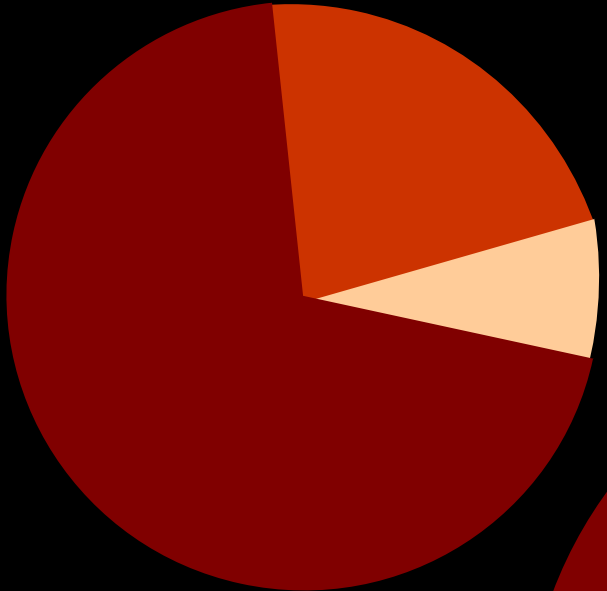
- Modified from Building Soils for Better Crops, Magdoff and van Es, 2000

Conventional



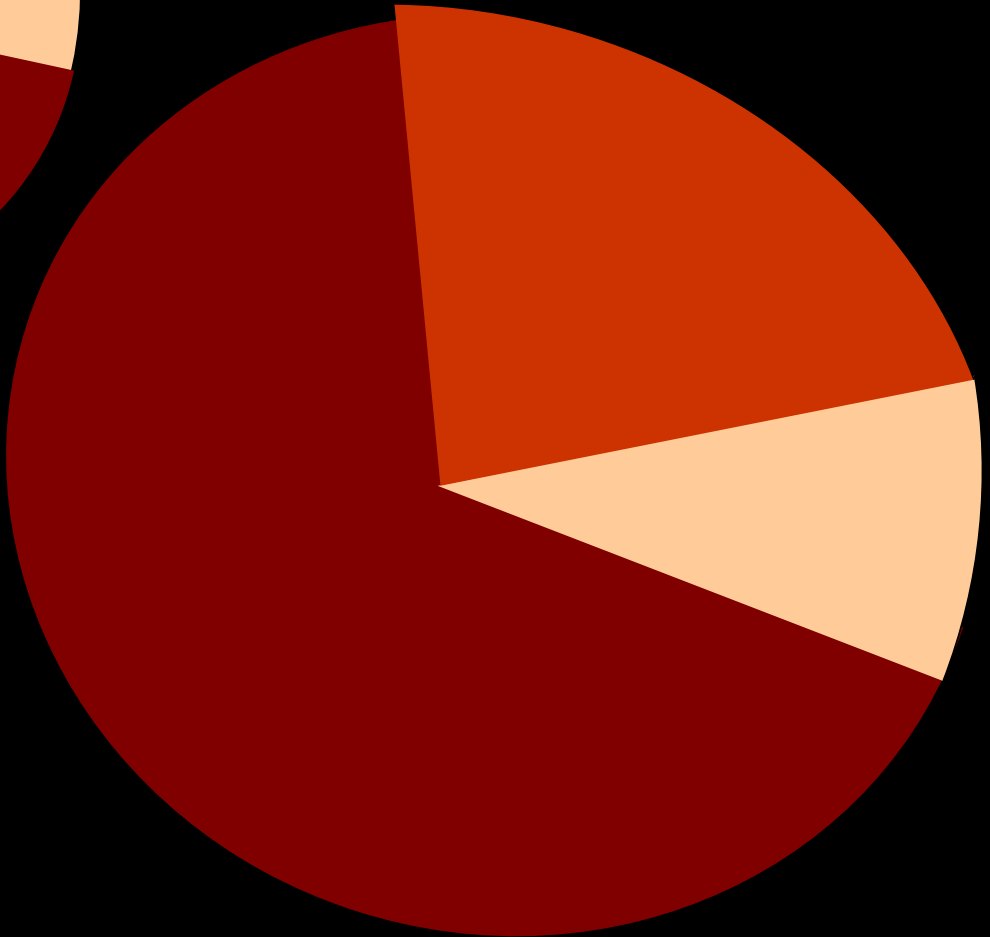
1% SOM

Transitional



3% SOM

Regenerative

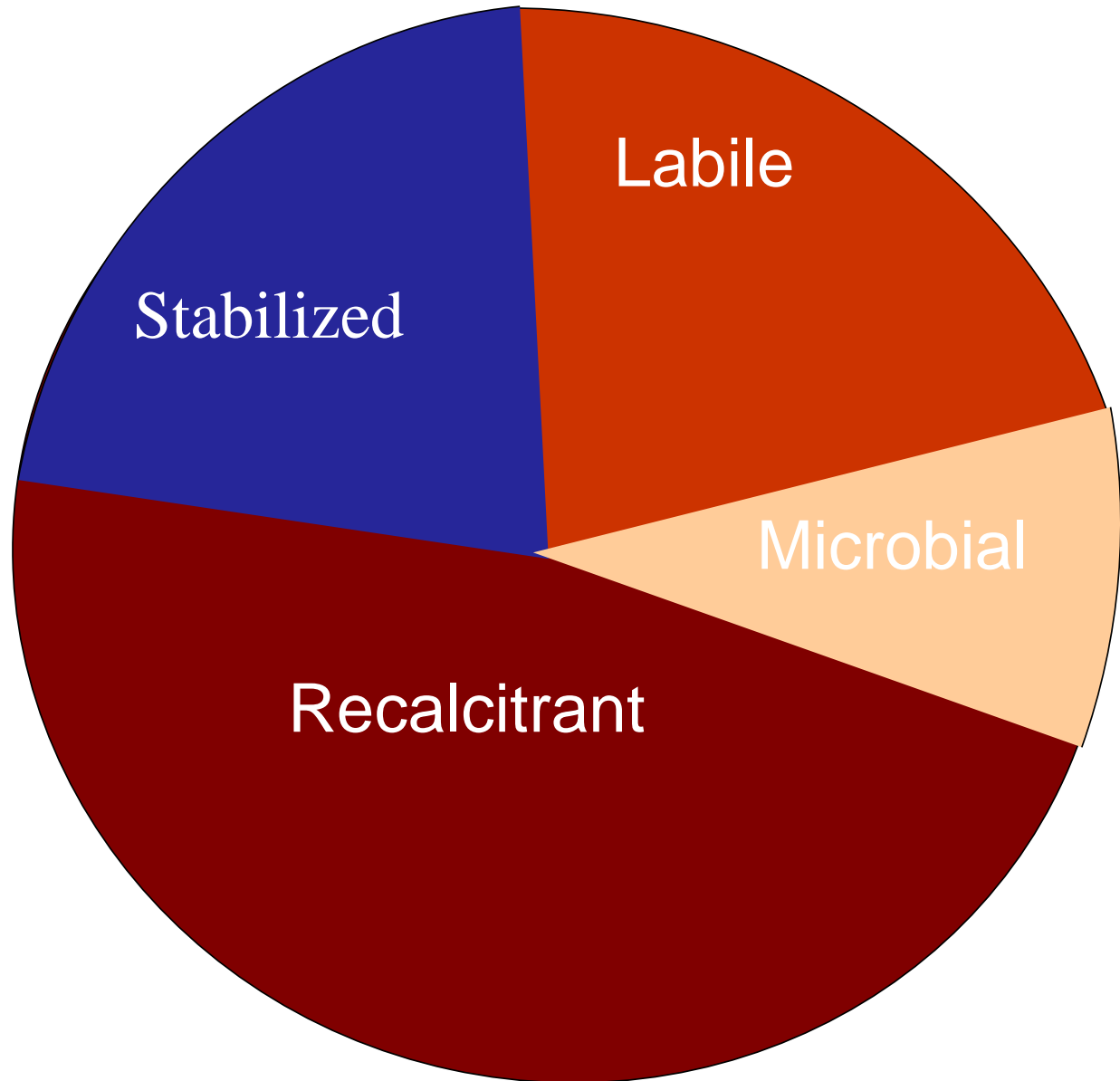


5% SOM

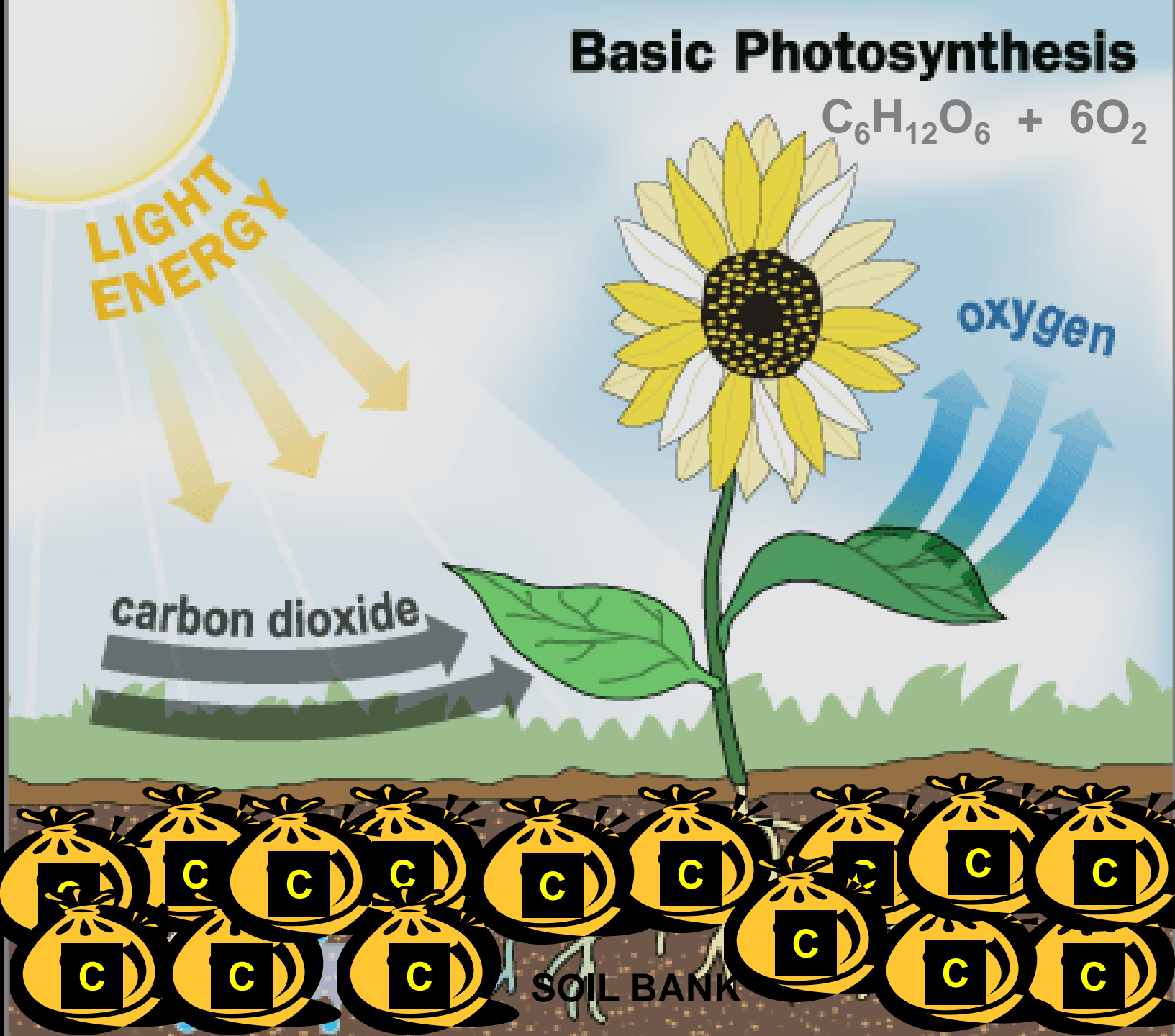
- **Recalcitrant**
- **Labile**
- **Microbial**



Regenerative Organic



Basic Photosynthesis





Why Bank Carbon?

Increases\Improves:

1. biological activity – growth and diversity of microflora
2. water infiltration, holding capacity, quality, and efficiency of use
3. soil tilth and structure
4. natural fertility – nutrient cycling and storage and capacity to handle manure
5. cation exchange capacity
6. adsorption of pesticides



Decreases\Reduces:

1. soil erosion
2. soil compaction
3. air pollution

The Farming Systems Trial (FST)



- Established in 1981.
- Three cropping systems are compared.
- 8 replications, 3 crops represented each year in each system
- Plot size: 20 x 300 ft (6 x 91.5 m)
- Lysimeters installed in 4 reps in fall of 1990



Main cropping systems in FST



Organic-manure based

Tilled manure system

No-till manure system (added in 2008)



Organic-legume based

Tilled legume system

No-till legume system (added in 2008)



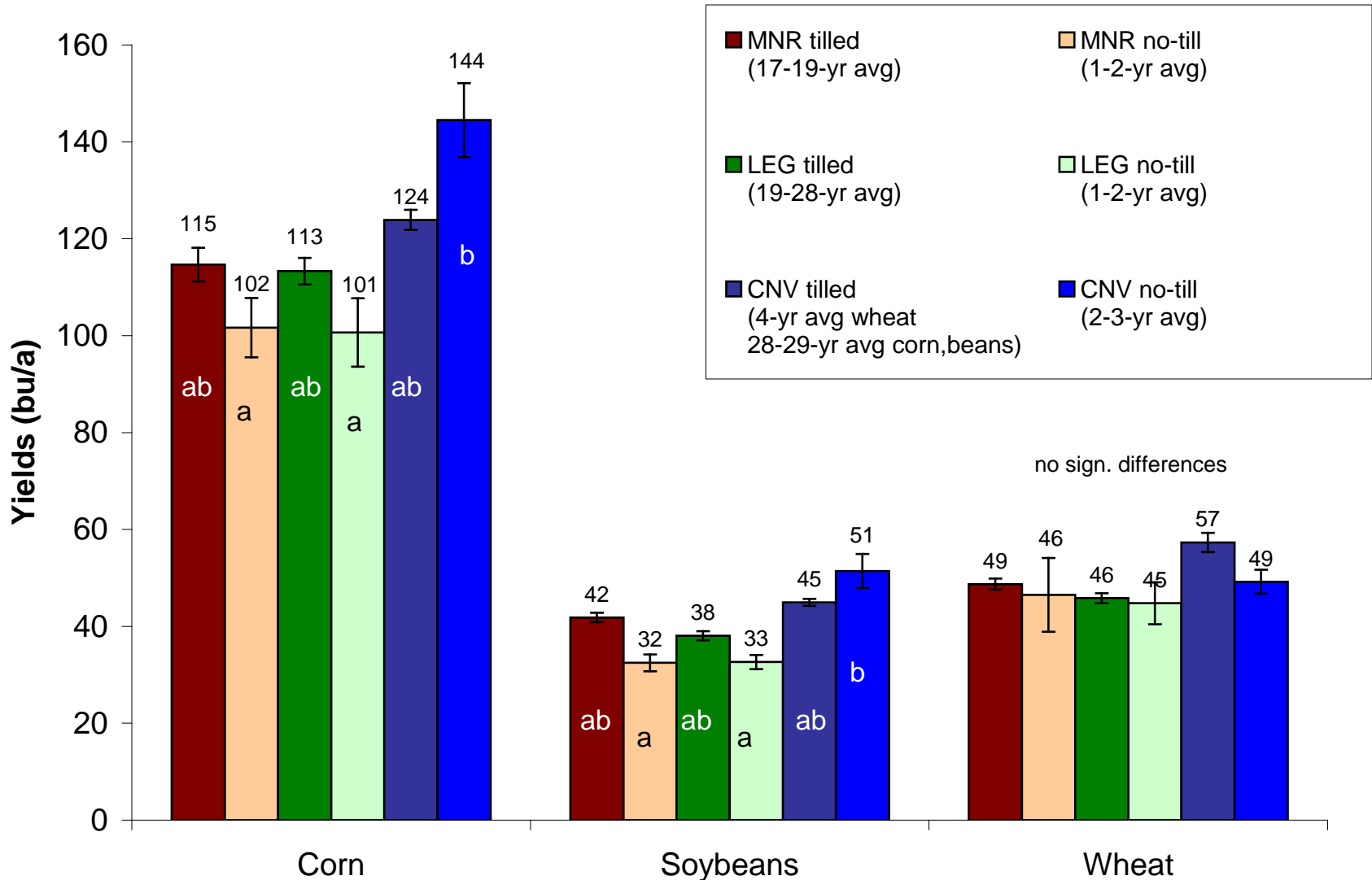
Conventional-chemically based

Tilled conventional system

No-till conventional system (added in 2008)

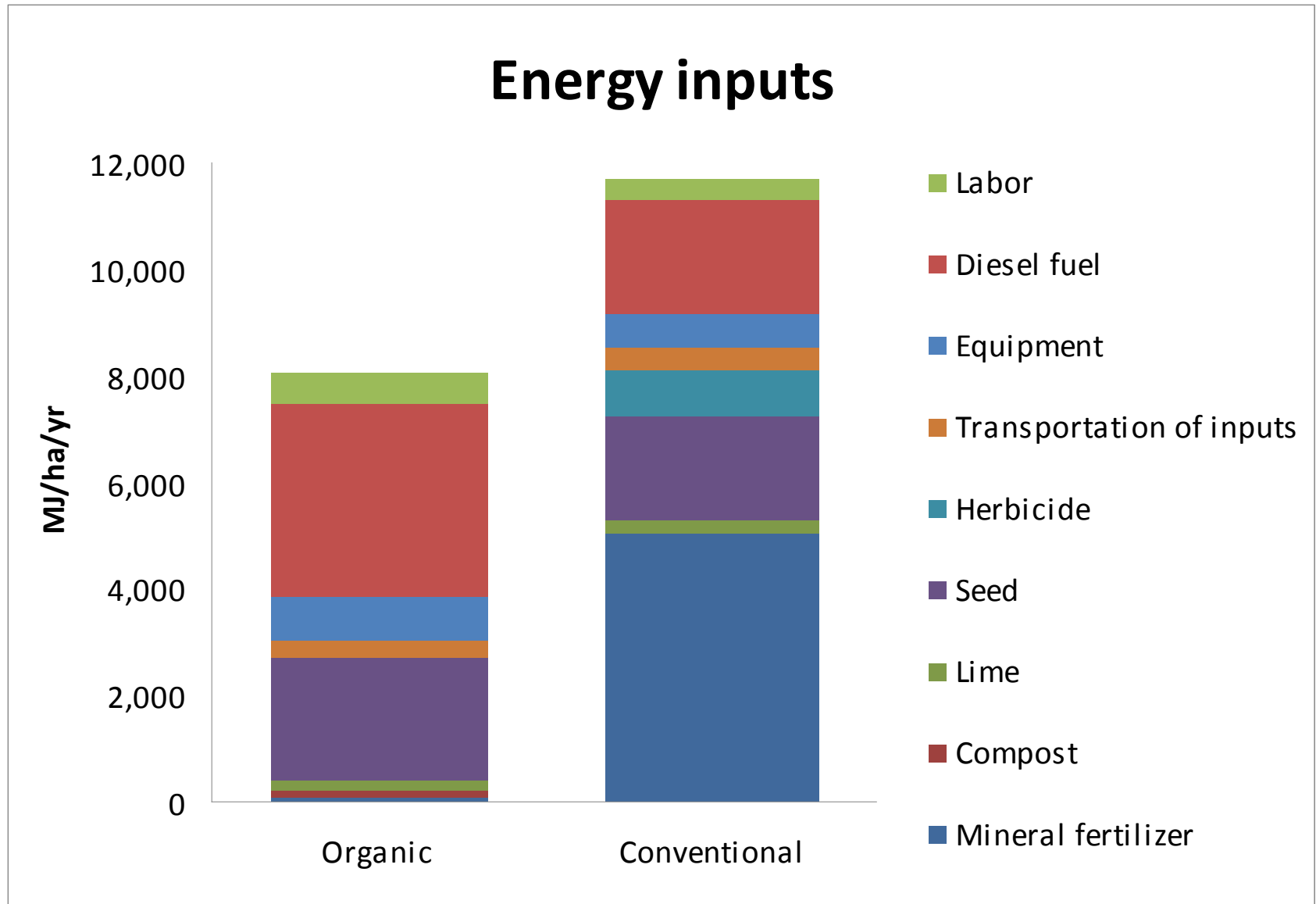


FST long-term grain yields 1981-2010



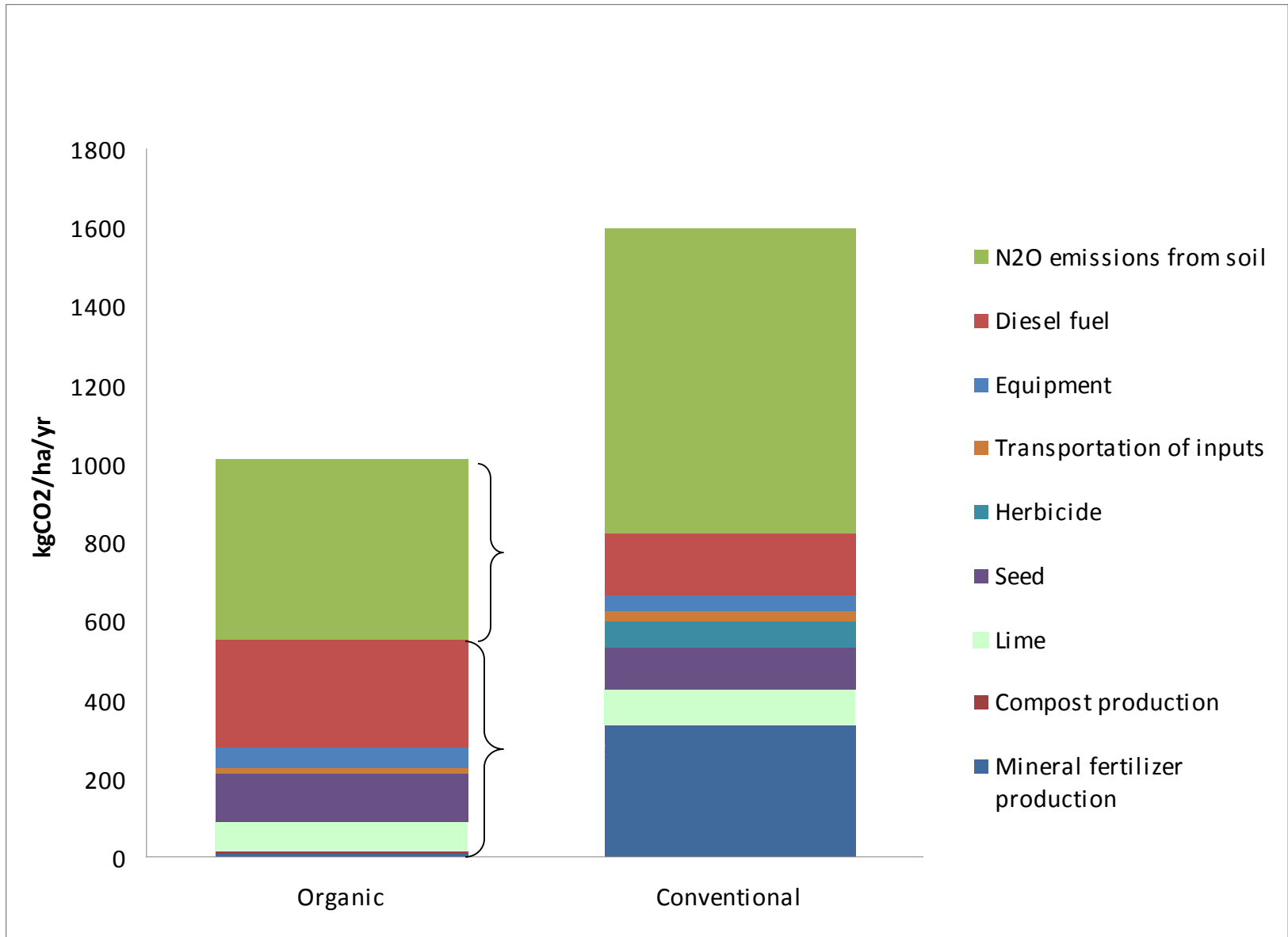


FST Energy Analysis





FST Greenhouse Gas Emissions





FST Soil Results



- Higher percentages of water stable aggregates
- Higher carbon levels
- Higher levels of glomalin
- Potentially more arbuscular mycorrhizal (AM) fungi



FST Soil Results

Soil carbon and soil nitrogen increased significantly in the organic systems, but not in the conventional system

	Organic		Conventional	
	1981	2010	1981	2010
Soil C	2.0%	2.4-2.5%	2.0%	no change
Soil N	0.31%	0.35-0.37%	0.31%	no change

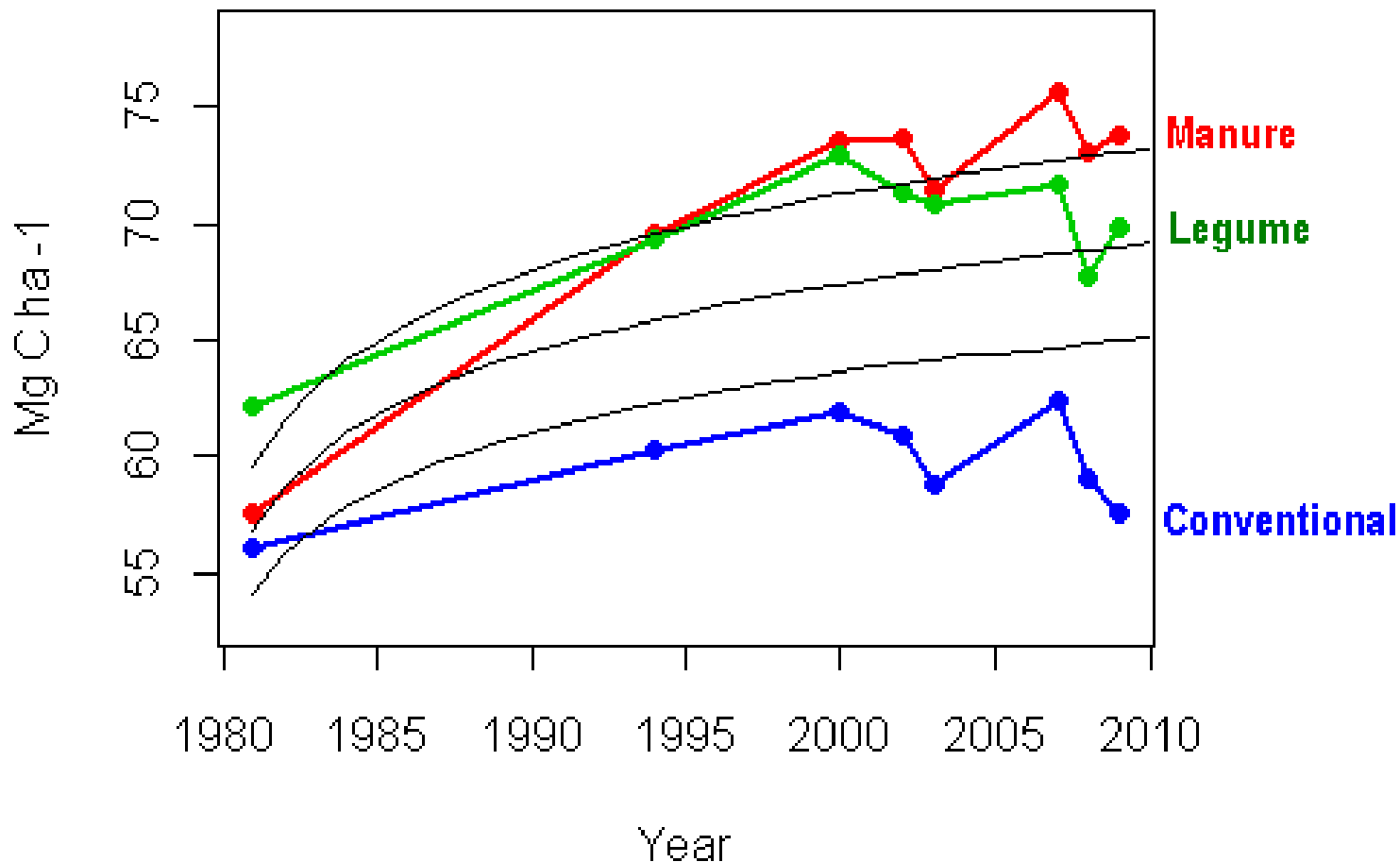
Soil carbon increases were greatest in the first 13 years of the trial. Carbon continued to build in both organic systems during the second half (after 1994), but at a slower rate.

The conventional system has shown a loss in carbon in more recent years.



Long-term soil carbon data

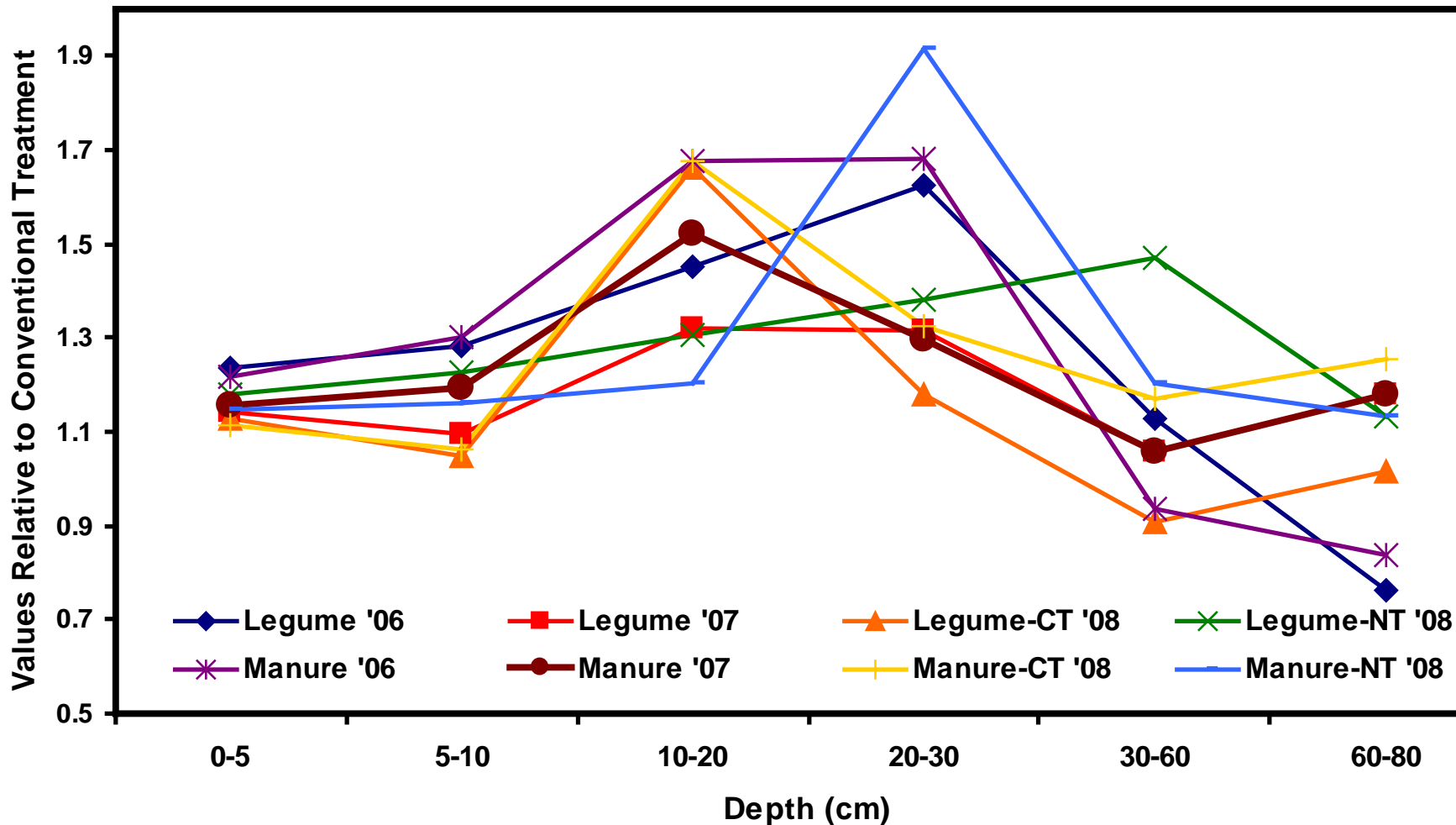
FST Average Soil Carbon Level



- Carbon changes in FST systems are shown in colors and potential model curves in black.
- Dots represent actual years with carbon data (archival samples will assist in refining rate of change estimates for missing years).

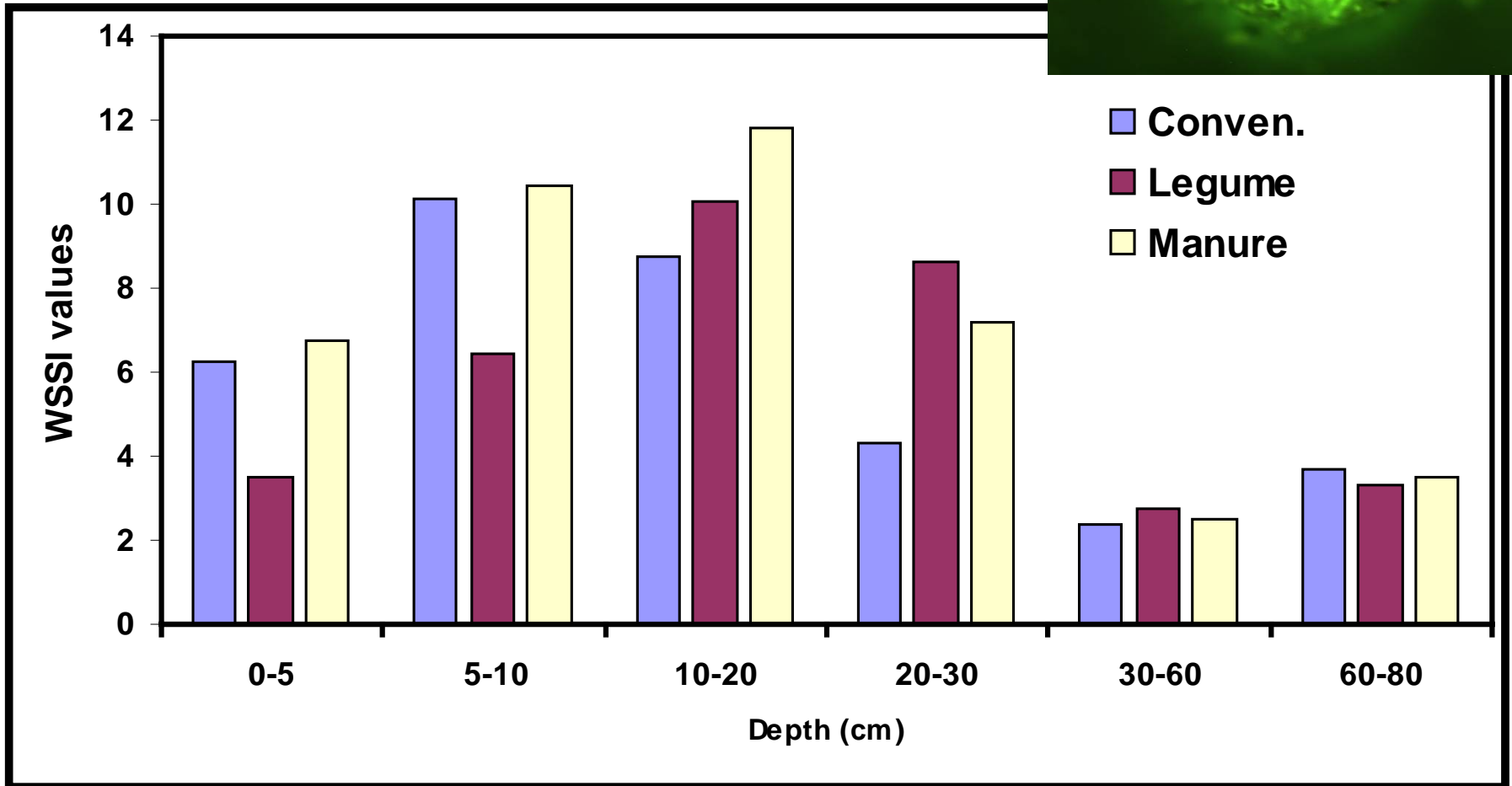
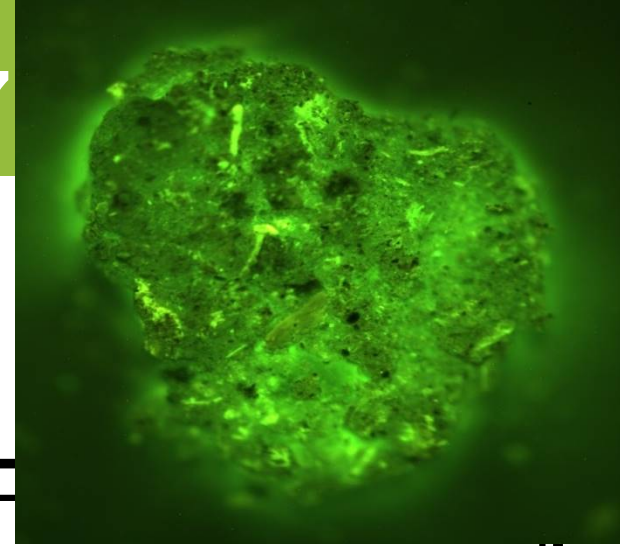


Soil carbon data compared to conventional





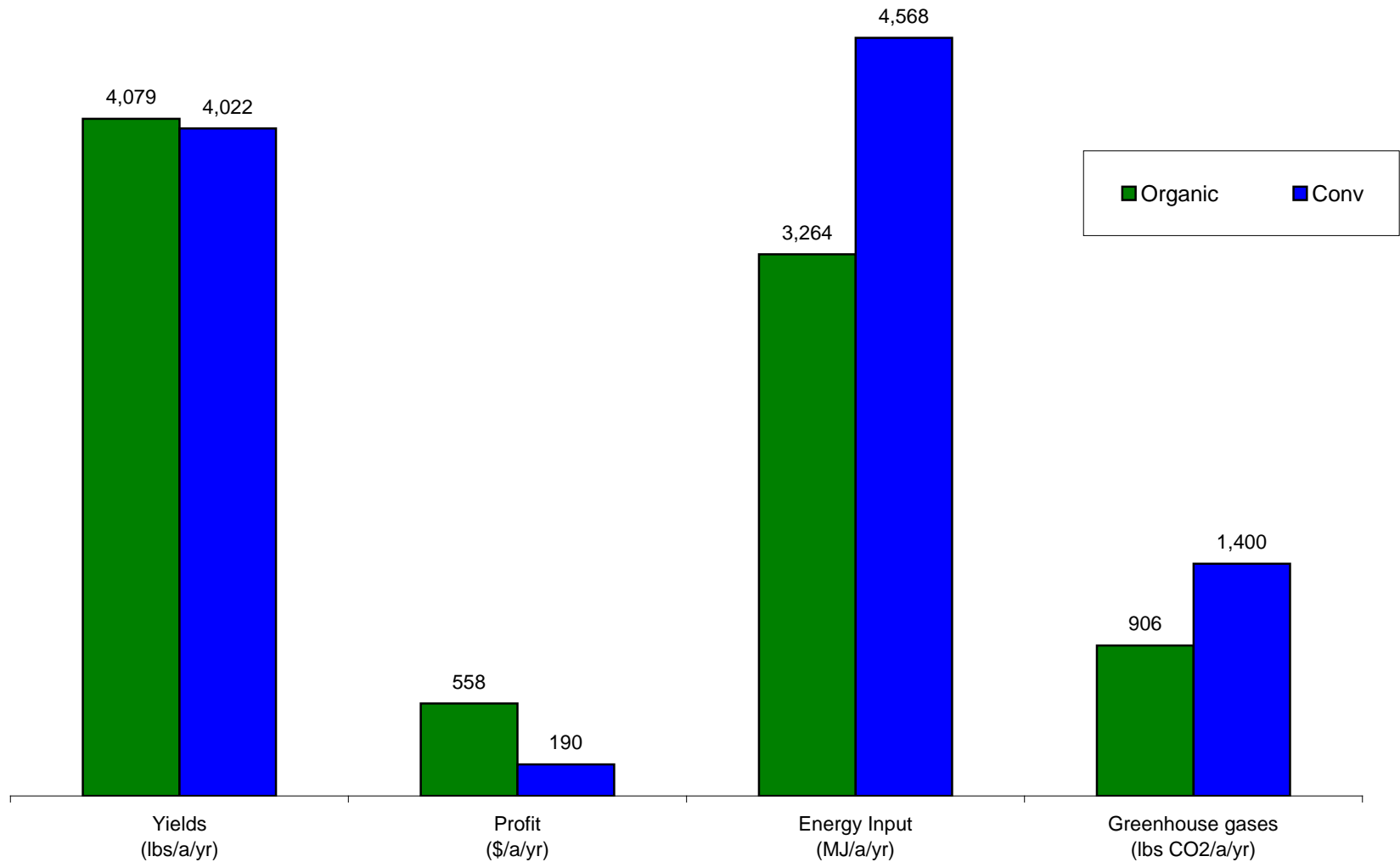
Aggregate Stability 2007





FST Summary

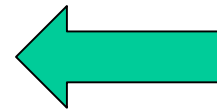
Comparison of FST organic and conventional systems



Yields = grain and forage yields combined



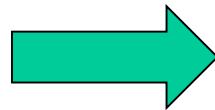
Impacts of Those Changes On Water Management



Conventional Soil
Wheat After Rain



Organic Soil
Wheat After Rain



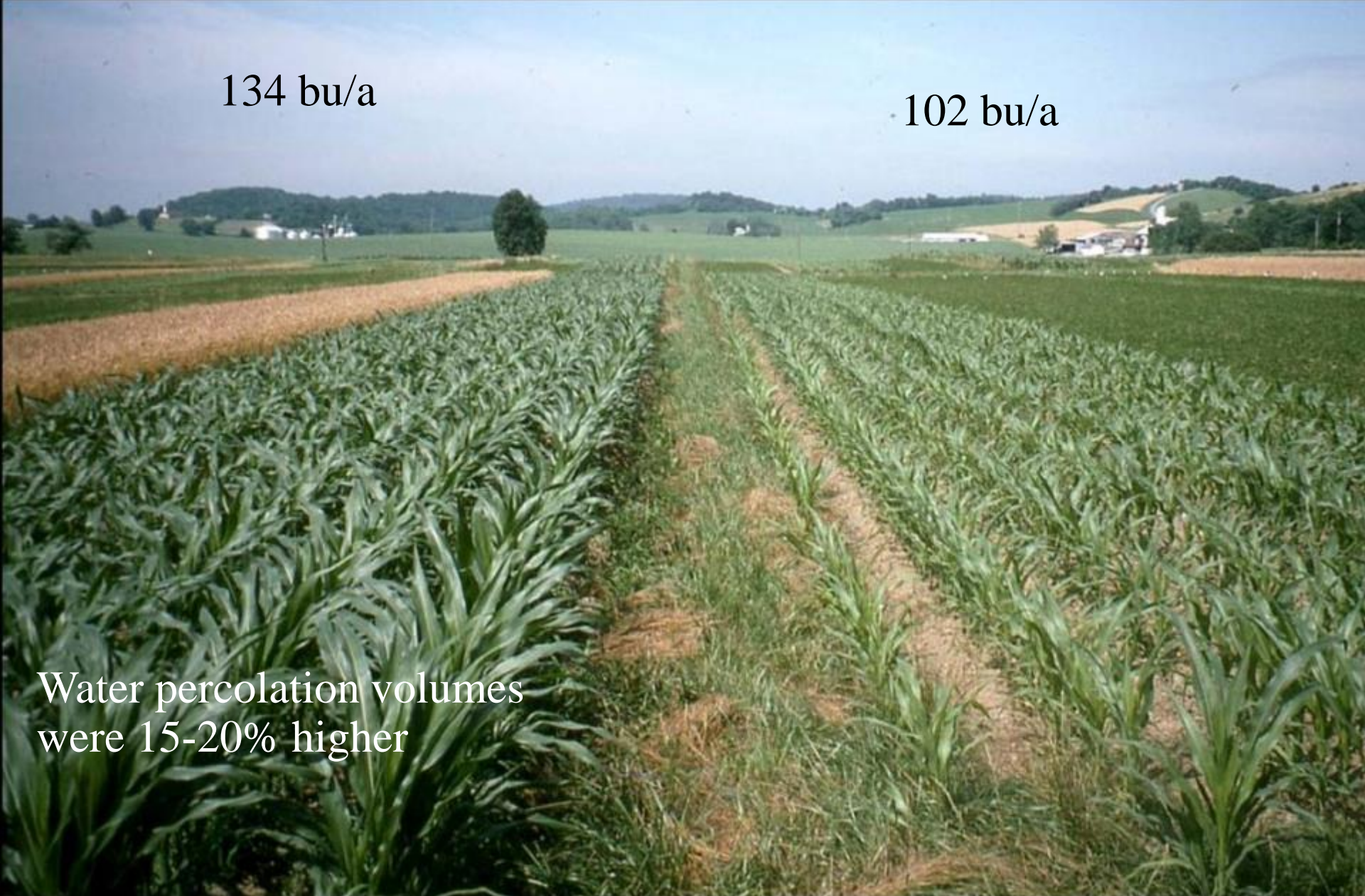


Organic (left) and conventional (right) corn during the 1995 drought – six weeks after planting

134 bu/a

102 bu/a

Water percolation volumes were 15-20% higher



FST 2015

Organic Corn



Conventional Corn





FST 2015 – Nutrient Stress in Conventional Corn





Production budgets for corn

	Organic Tilled	Organic No-till	Conv Tilled	Conv No-till
	vetch+ corn	vetch+ corn	corn	vetch+ corn
Expenses				
fertilizer	0.00	0.00	118.04	90.44
herbicide	0.00	0.00	108.19	144.56
seeds	139.40	139.40	88.15	148.35
custom haul	30.00	30.00	30.00	30.00
labor	39.35	18.61	15.78	16.14
fuel	47.60	23.96	23.76	20.67
repair & maintenance	17.56	10.35	8.42	8.97
interest on op.capital	6.35	4.54	11.50	13.50
fixed expenses	52.02	30.98	27.31	27.46
Total Expenses (\$/acre)	332	258	431	500
Profit (\$/acre) *				
@ 100 bu/a yield	504	578	-16	-85
@ 150 bu/a yield	922	996	191	122
@ 200 bu/a yield	1,340	1,414	399	330
Break-even price (\$/bu)				
@ 100 bu/acre	3.32	2.58	4.31	5.00
@ 150 bu/acre	2.22	1.72	2.87	3.33
@ 200 bu/acre	1.66	1.29	2.16	2.50

These production budgets were calculated using the free on-line Mississippi State Budget Generator (MSBG), developed by the Department of Agricultural Economics at Mississippi State University, (<http://www.agecon.msstate.edu/what/farm/generator/>). When available, input and price data were taken directly from data collected at the Rodale Institute (2008-2010), otherwise default values from the Budget Generator were used.

* The 3-year average price for organic corn was \$8.36/bu, for conventional corn \$4.15/bu.



Soil Health Principles

- 1. MINIMIZE SOIL DISTURBANCE – reduce tillage; use cover crops, compost, and mulch; manage livestock – Keeping not Adding Carbon**
- 2. ENERGIZE WITH DIVERSITY – diversify and lengthen rotation; use cover crops and compost – Adding and Diversifying Carbon**
- 3. KEEP THE SOIL COVERED – reduce tillage; retain residue; use cover crops, compost, and mulch – Keeping, Adding, and Diversifying Carbon**
- 4. MAXIMIZE LIVING ROOTS – choose crops carefully; use cover crops; manage livestock – Adding, Keeping, and Diversifying Carbon**
- 5. INSERT LIVESTOCK – manage animals for soil – Adding, Keeping, and Diversifying Carbon**



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Our Work

Rodale Institute - Our Work - Organic No-Till



Organic No-Till

Overview

No-till farming techniques have gained great popularity over the past two decades as growers seek new ways to protect and conserve their soil and save time and money. No-till production allows farmers to save all three because it reduces or eliminates the need to till fields for planting or weed cultivation. However, while these practices can effectively meet farmers' soil conservation and work reduction goals, they rely on herbicides for weed control, and as such, cannot be directly adopted for use in organic production systems.

The question has been how to make the benefits of no-till accessible to organic farmers and how to free conventional farmers from the expensive and toxic chemicals. Organic no-till is based on sound biological principles and mechanical covercrop kill, making it possible to reduce and even eliminate tillage.

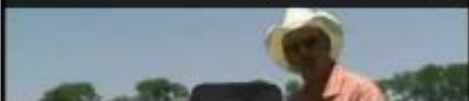
Rodale Institute researchers have been identifying and refining organic no-till or reduced-till techniques that can meet farmers' needs to improve soil and reduce labor while using tools other than herbicides to manage weeds. In organic systems, one of the best tools to manage weeds is cover crops, and this has proven to be true for organic no-till systems as well.

One of the key elements of our organic no-till research is a front-mounted covercrop roller that knocks down a woodchipping mat that can be planted through all in one quick pass.

Build your own: [Get the No-till Roller Crimper Plans](#)

Watch the video: Farm director Jeff Moyer talks about the ins and outs of our roller crimper.

No-Till Roller Crimper



Explore this

[Overview](#)

[Current Projects](#)

[Reports and Publications](#)

[DIP DEEP](#)

Did you know

Rodale Institute's Jeff Moyer, literally an organic no-till, is a clear and concise tour of organic no-till soil biology to provide a system laid out in the best aspects of the requirement regulations. For want to refine the conventional farmland, Organic is indispensable.

[LEARN MORE](#)

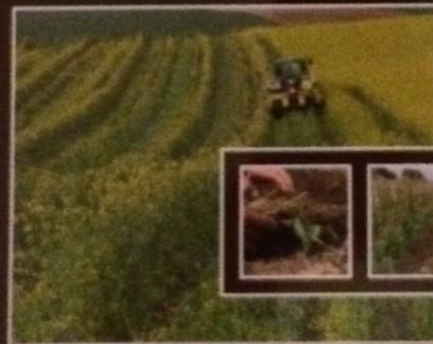
ORGANIC NO-TILL FARMING



ADVANCING NO-TILL AGRICULTURE

► CROPS, SOIL, EQUIPMENT

JEFF MOYER



The BROWN REVOLUTION

Recognize proper soil management as the most ecologically and economically sustainable form of agriculture.

Provide food, fiber, and fuel

Provide nutrients

Protect the soil

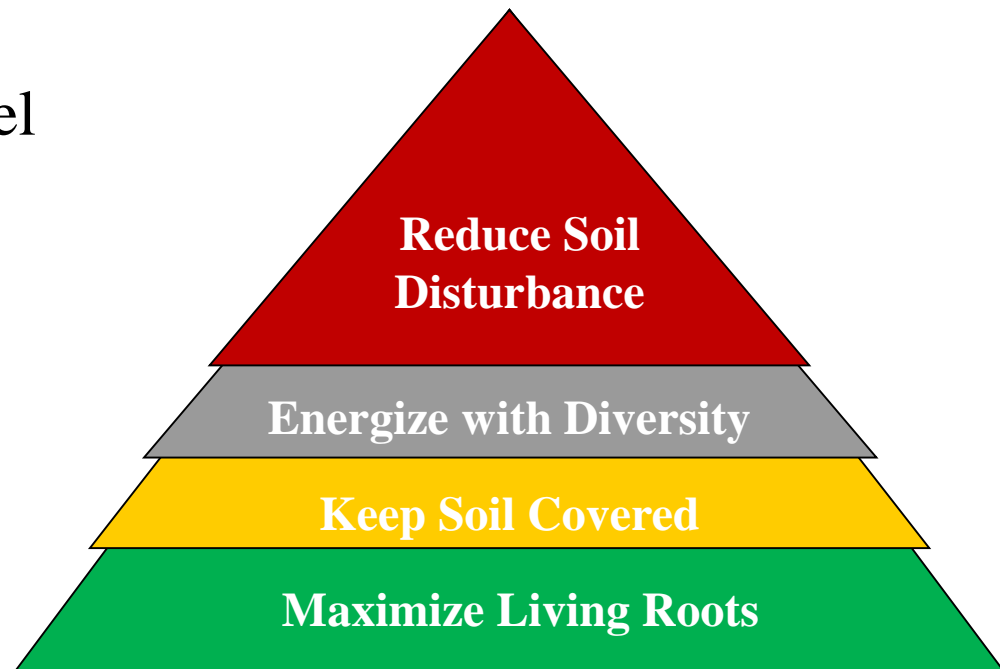
Consistency

Resiliency

Moisture to roots

Maximize efficiency

Make money





Thank You!

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Regenerative Organic Agriculture and Climate Change

http://rodaleinstitute.org/assets/RegenOrgAgricultureAndClimateChange_20141001.pdf