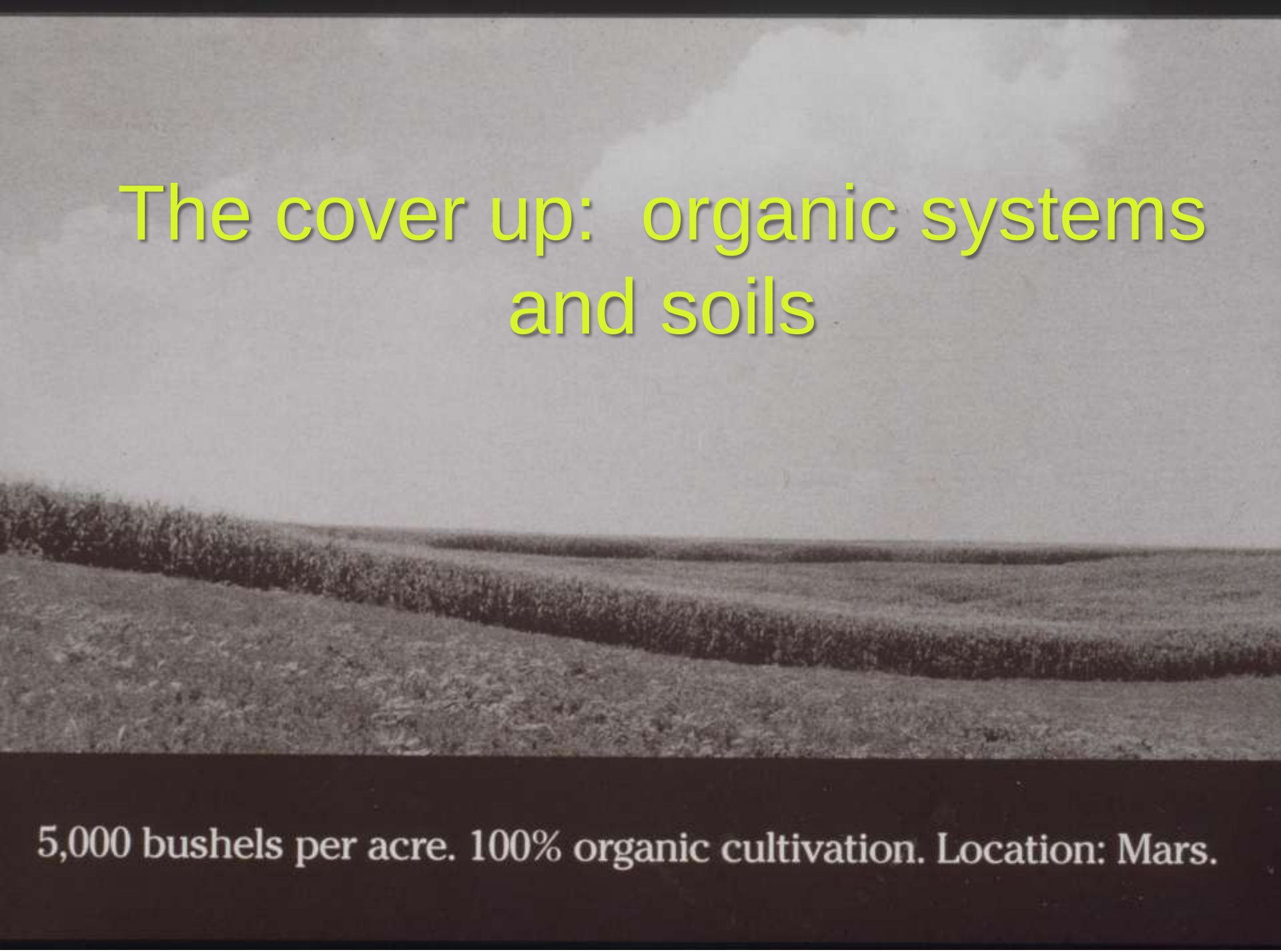
The cover up: organic systems and soils



Michelle Wander
mwander@illinois.edu

Goal is to achieve sustainable agricultural systems

Illustration from National Geographic

Prototype double crop systems for biomass production

- **<u>Winter crop: triticale</u>**
  - Winter soil cover
  - Spring biomass harvest

- **<u>Summer crops:</u>**
- Corn
- Sorghum x sudangrass
- Crotalaria (legume)

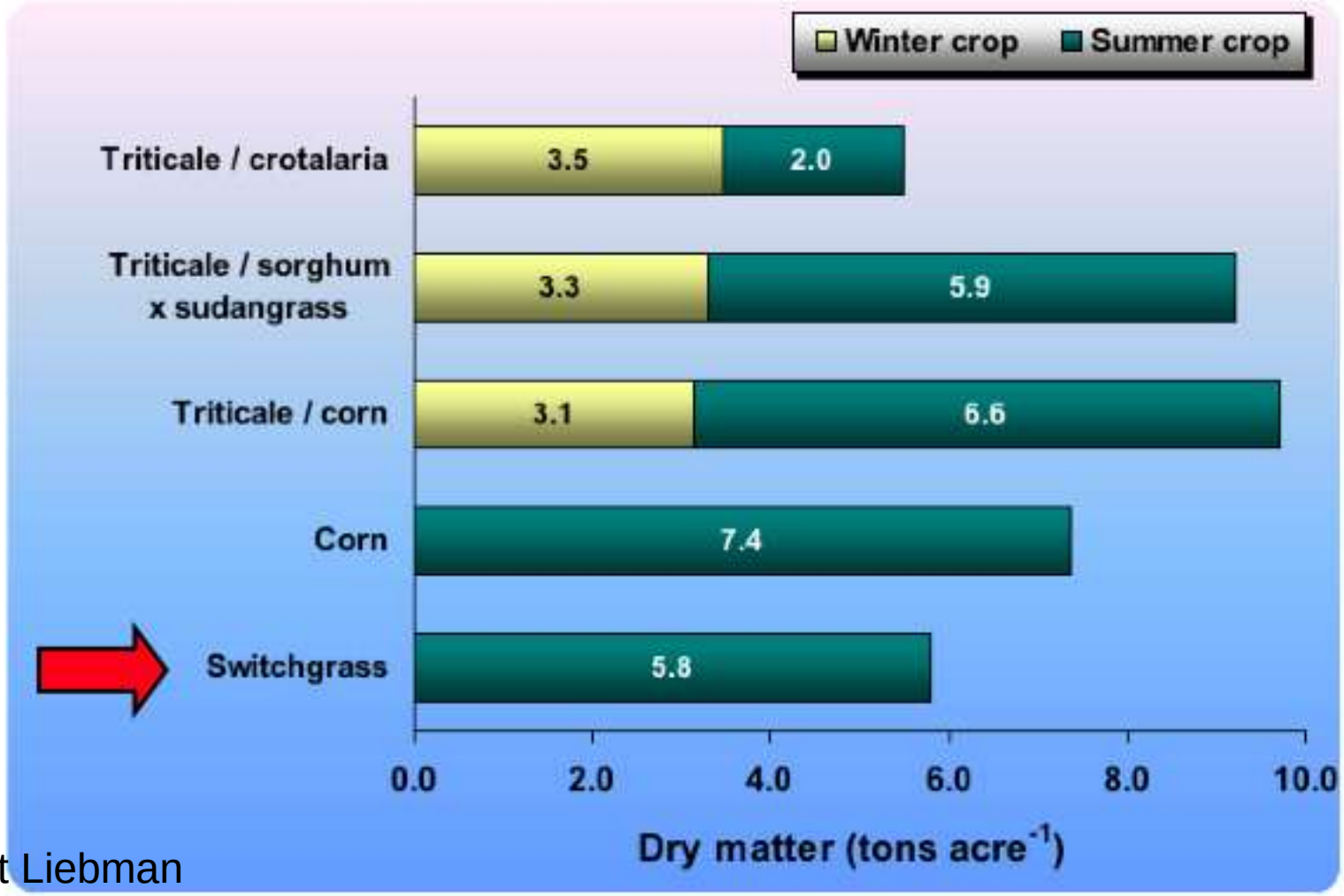
1) Corn

2) Sorgxsudan

3) Crotalaria

Matt Liebman

Two crops can generate more biomass than one



Matt Liebman

Soil Quality: the foundation for organic management

“Humus benefits the soil in three ways: mechanically, as a plant food, and by fundamentally modifying the soil bionomics. Of the three, this last, hitherto largely ignored, is probably the most important".

Lady Eve Balfour- In "The Living Soil" 1943

Organic Fertility

Soil and soil management is the foundation of organic production.

Organic growing systems are soil based, they care for the soil and surrounding ecosystems and provide support for a diversity of species while encouraging nutrient cycling and mitigating soil and nutrient losses.

IFOAM Norms, 2002

National Organic Program

- Organic food is produced by farmers who emphasize the use of renewable resources and the conservation of soil and water to enhance environmental quality for future generations.
- Organic meat, poultry, eggs, and dairy products come from animals that are given no antibiotics or growth hormones and fed organic feed. Organic food is produced without using most conventional pesticides; fertilizers made with synthetic ingredients or sewage sludge; bioengineering (GMO's); or ionizing radiation.

§ 205.203 Soil fertility and crop nutrient management practice standard.

(a) The producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion.

(b) The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials.

(c) The producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances. Animal and plant materials include:

(1) Raw animal manure, which must be composted unless it is:

(i) Applied to land used for a crop not intended for human consumption;

(ii) Incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles; or

(iii) Incorporated into the soil not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles;

(2) Composted plant and animal materials produced though a process that

(i) established an initial C:N ratio of between 25:1 and 40:1; and

(ii) maintained a temperature of between 131 F and 170 F for 3 days using an in-vessel or static aerated pile system; or

(iii) maintained a temperature of between 131F and 170F for 15 days using a windrow composting system, during which period, the materials must be turned a minimum of five times.

(3) Uncomposted plant materials.

(d) A producer may manage crop nutrients and soil fertility to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances by applying:

(1) A crop nutrient or soil amendment included on the National List of synthetic substances allowed for use in organic crop production;

(2) A mined substance of low solubility;

(3) A mined substance of high solubility, Provided, That, the substance is used in compliance with the conditions established on the National List of nonsynthetic materials prohibited for crop production;

(4) Ash obtained from the burning of a plant or animal material, except as prohibited in paragraph (e) of this section: Provided, That, the material burned has not been treated or combined with a prohibited substance or the ash is not included on the National List of nonsynthetic substances prohibited for use in organic crop production;

(5) A plant or animal material that has been chemically altered by a manufacturing process: Provided, That, the material is included on the National List of synthetic substances allowed for use in organic crop production established in § 205.601.

(e) The producer must not use:

(1) Any fertilizer or composted plant and animal material that contains a synthetic substance not included on the National List of synthetic substances allowed for use in organic crop production;

(2) Sewage sludge (biosolids) as defined in 40 CFR Part 503; and

(3) Burning as a means of disposal for crop residues produced on the operation: Except, That, burning may be used to suppress the spread of disease or to stimulate seed germination.

§ 205.205 Crop rotation practice standard.

- The producer must implement a crop rotation including but not limited to sod, cover crops, green manure crops, and catch crops that provide the following functions that are applicable to the operation:
- (a) Maintain or improve soil organic matter content;
- (b) Provide for pest management in annual and perennial crops;
- (c) Manage deficient or excess plant nutrients; and
- (d) Provide erosion control.

Which cover for which job?

- Prevent erosion
  - improve structure, cover surface
    - buckwheat, cereal rye, manures with grass, composts, reduced tillage
  - increase infiltration
    - rye, barley, reduced tillage
- Enhance water quality
  - increase water holding capacity
    - clovers, rye, manures, reduced tillage
  - reduce leaching
    - rape seed, rye, oats
- Hasten metabolism of contaminants
    - Cereal rye
- Sequester carbon, reduce global warming
- Pest and disease suppression

§ 205.206 Crop pest, weed, and disease management practice standard.

(a) The producer must use management practices to prevent crop pests, weeds, and diseases including but not limited to:

(1) Crop rotation and soil and crop nutrient management practices, as provided for in §§ 205.203 and 205.205;

(2) Sanitation measures to remove disease vectors, weed seeds, and habitat for pest organisms; and

(3) Cultural practices that enhance crop health, including selection of plant species and varieties with regard to suitability to site-specific conditions and resistance to prevalent pests, weeds, and diseases.

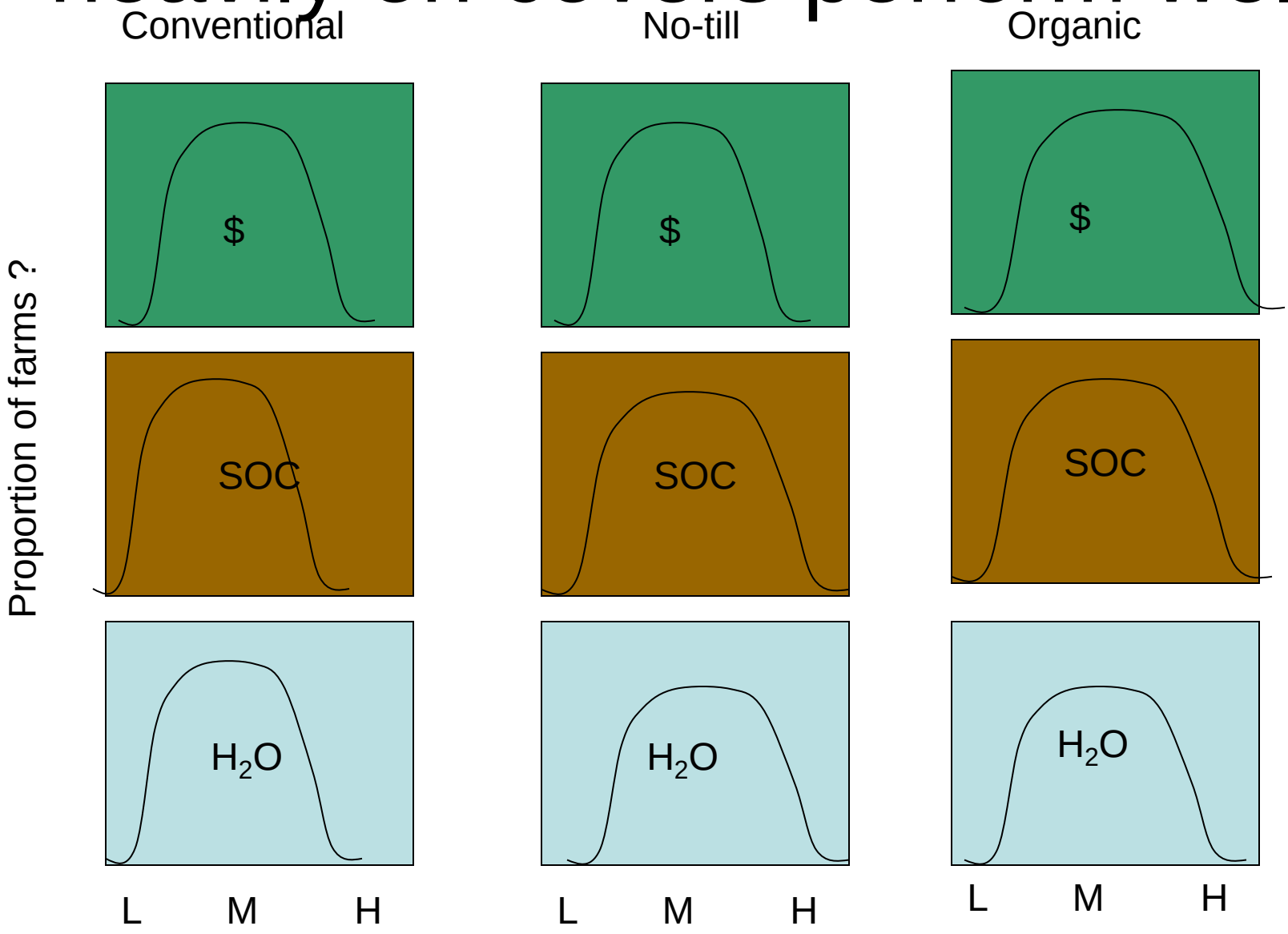
(b) Pest problems …..

(c) Weed problems ….

(d) Disease problems ….

(e) When the practices provided for in paragraphs (a) through (d) of this section are insufficient to prevent or control crop pests, weeds, and diseases, a biological or botanical substance or a substance included on the National List of synthetic substances allowed for use in organic crop production may be applied to prevent, suppress, or control pests, weeds, or diseases: Provided, That, the conditions for using the substance are documented in the organic system plan.

Do organic systems relying heavily on covers perform well?

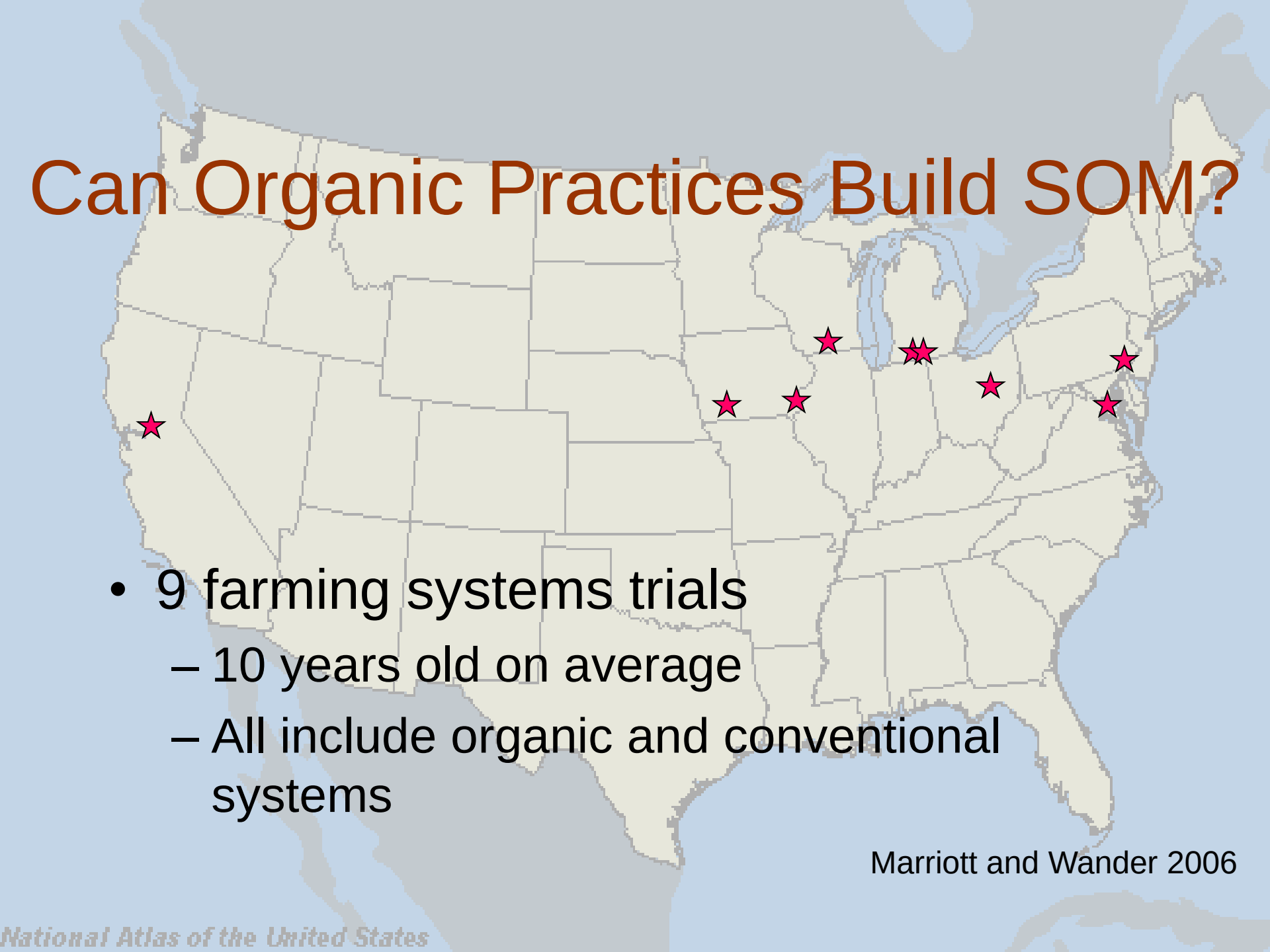


Green vs Brown Manure?

- Conventional
  - Fertility from synthetic fertilizers
  - 8 sites
- Manure-based organic
  - Fertility from compost or manure
  - 7 sites
- Legume-based organic
  - Fertility from N_2 fixing legumes
  - 3 sites

  - Sampled in Spring before heavy feeding crop from plow depth

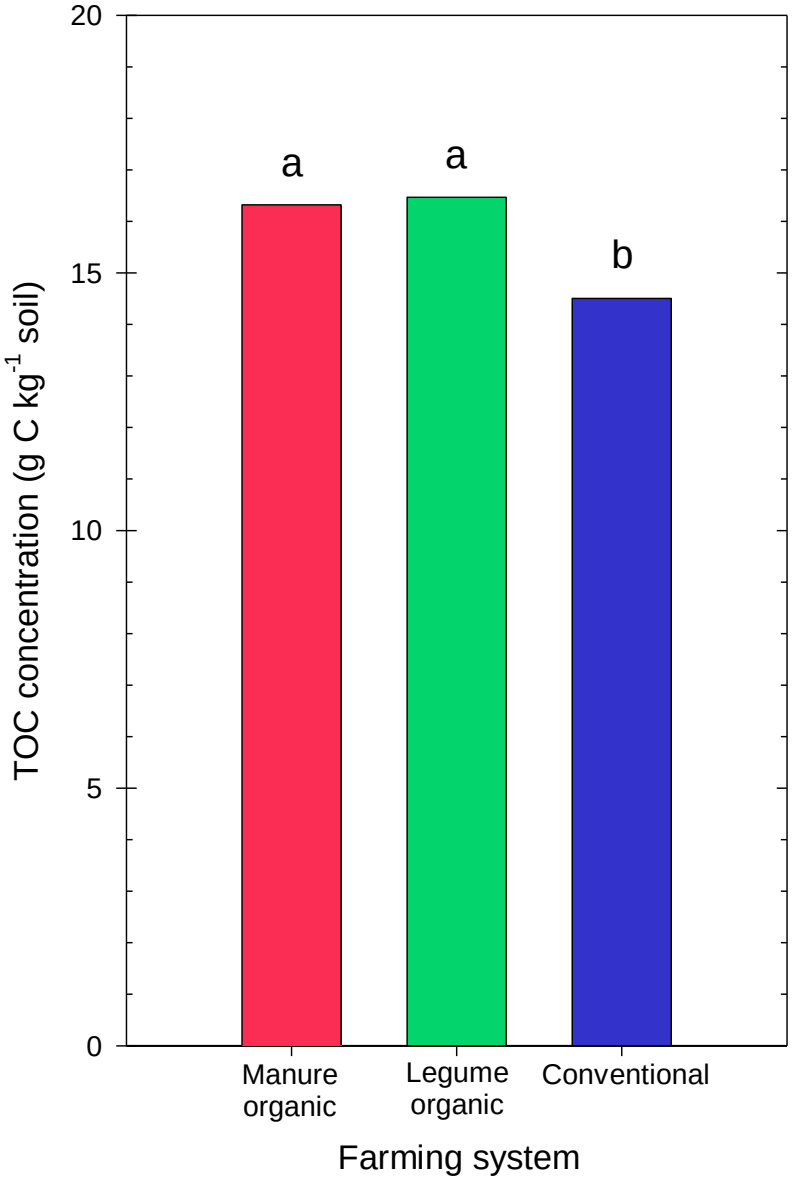
Can Organic Practices Build SOM?

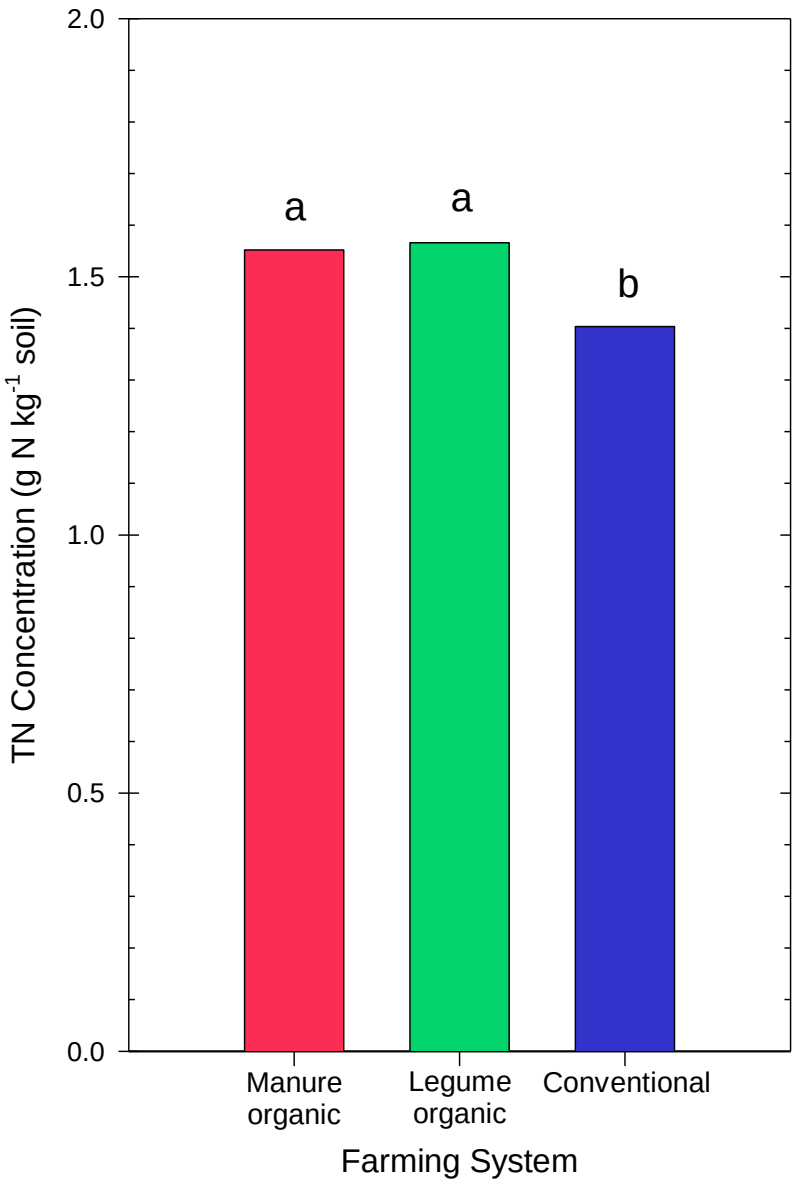


- 9 farming systems trials
  - 10 years old on average
  - All include organic and conventional systems

Marriott and Wander 2006

Total Organic C and Total N Concentrations

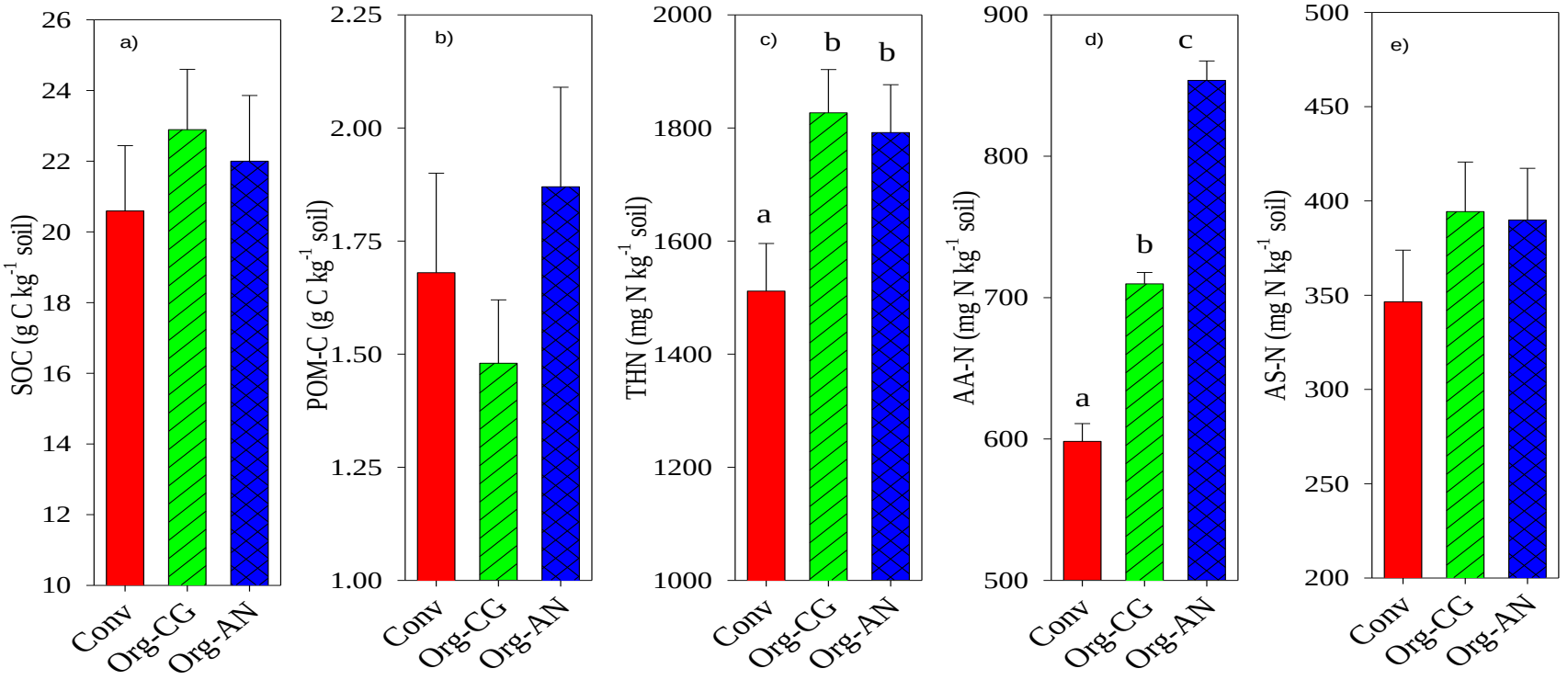




Stepwise multiple regression

Dependent variable†	Model adjusted R^2 value	Partial R^2 values‡ MAT	MAP	% clay	% silt	age
All systems						
SOC	0.788***	0.211	n.s.	**0.514**	**0.086**	n.a.
IL-N	0.789***	0.239	n.s.	**0.450**	**0.123**	n.a.
POM-C	0.398***	n.s.	0.420	n.s.	n.s.	n.a.
Organic systems						
SOC	0.851***	0.222	n.s.	**0.608**	**0.049**	n.s.
IL-N	0.857***	0.231	n.s.	**0.570**	**0.083**	n.s.
POM-C	0.615***	n.s.	n.s.	n.s.	n.s.	**0.639**

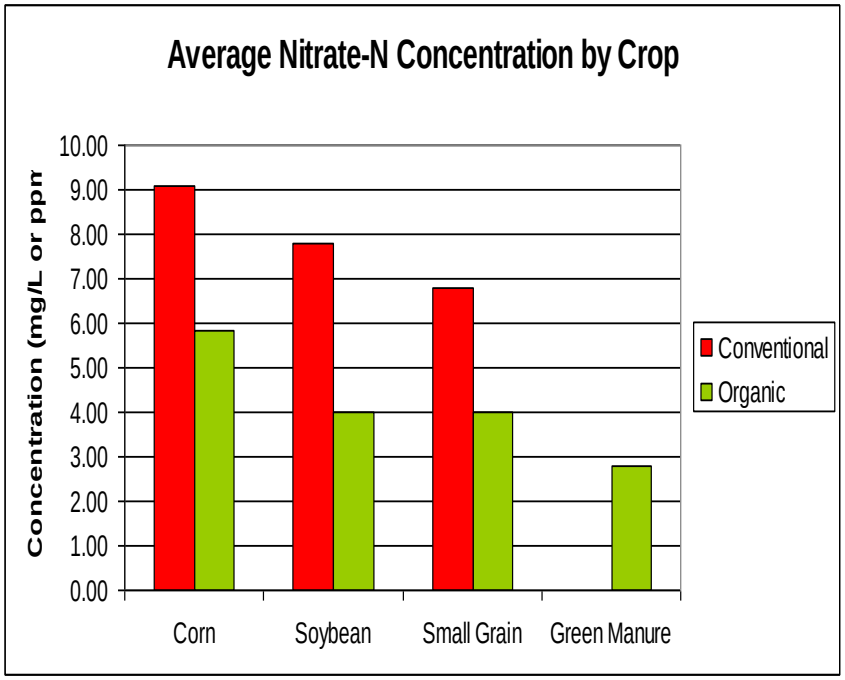
SOM fraction concentrations

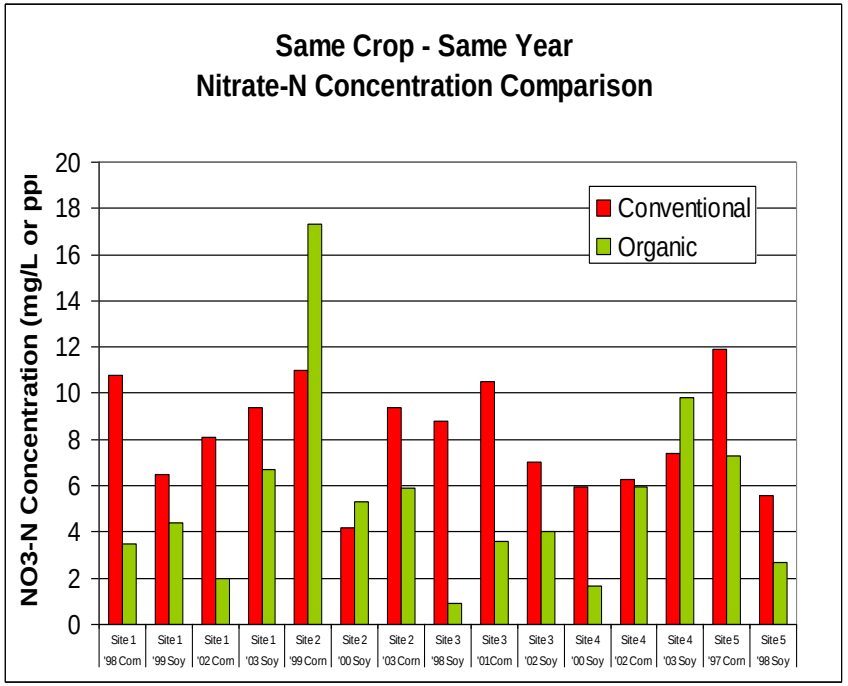


Wander et al. 2007

Source: USDA-NRCS

What about leaching





Greg McIsaac, Organic Agronomy Day 2005

Comparison of Costs

Returns= Revenue – Costs (Price*Yield)

(per acre variable costs, does not include land rent)

	Corn	Soybeans
Conv (IL)	$196	$96
Organic (IL)	$189	$104
Organic (SD)	$185	$145
Organic (KA)	$87/$122	$71/$107

Corinne Alexander, Purdue University, February 1, 2006

Meeting Organic Soil Mgt Goals

- Organic management plan

Verify compliance with NOS

- Soil testing

To determine the proper fertilization for plants to be grown

- Nutrient management plans

Conservation planning tool. “integrates ecological, economic, and production considerations in meeting both the owner's/operator's objectives and the public's natural resource protection needs.”

Draft Sustainable Agriculture Standard (SCS-001)

- **6.1.2.6. Agro-Ecosystem Health**
- A listing and description of inputs (including type, application rates and amounts), a description of functional biodiversity, and a description of soil conservation and erosion control practices and procedures.
- **6.1.2.7. Ecosystem Management**
- A description of the effects that the Agricultural Production Operation has had on flora and fauna species and habitats, and any mitigation efforts undertaken to date; a description of existing and planned vegetated buffer zones for watercourses and between areas under cultivation and non-cultivated areas; a list and accompanying maps of any areas of High Ecological Value (HEV),

Soil Quality- Outcomes and Properties (Resource Concerns)

- SQ =f (SQE1, SQE2, SQE3, SQE4, SQE5, SQE6)
  - SQE1 is the food and fiber production,
  - SQE2 the erosivity,
  - SQE3 the ground water quality,
  - SQE4 the surface water quality,
  - SQE5 the air quality
  - SQE6 is the food-quality. Doran and Parkin (1994)
- Descriptive properties- soils, crops, and animals including wildlife. Romig et al. (1994)

“Farm Bill 2007- minimum Standard of Care”

- RUSLE2
- Soil Conditioning Index
- Soil Water Enrollment Tool
- Conservation Management Tool

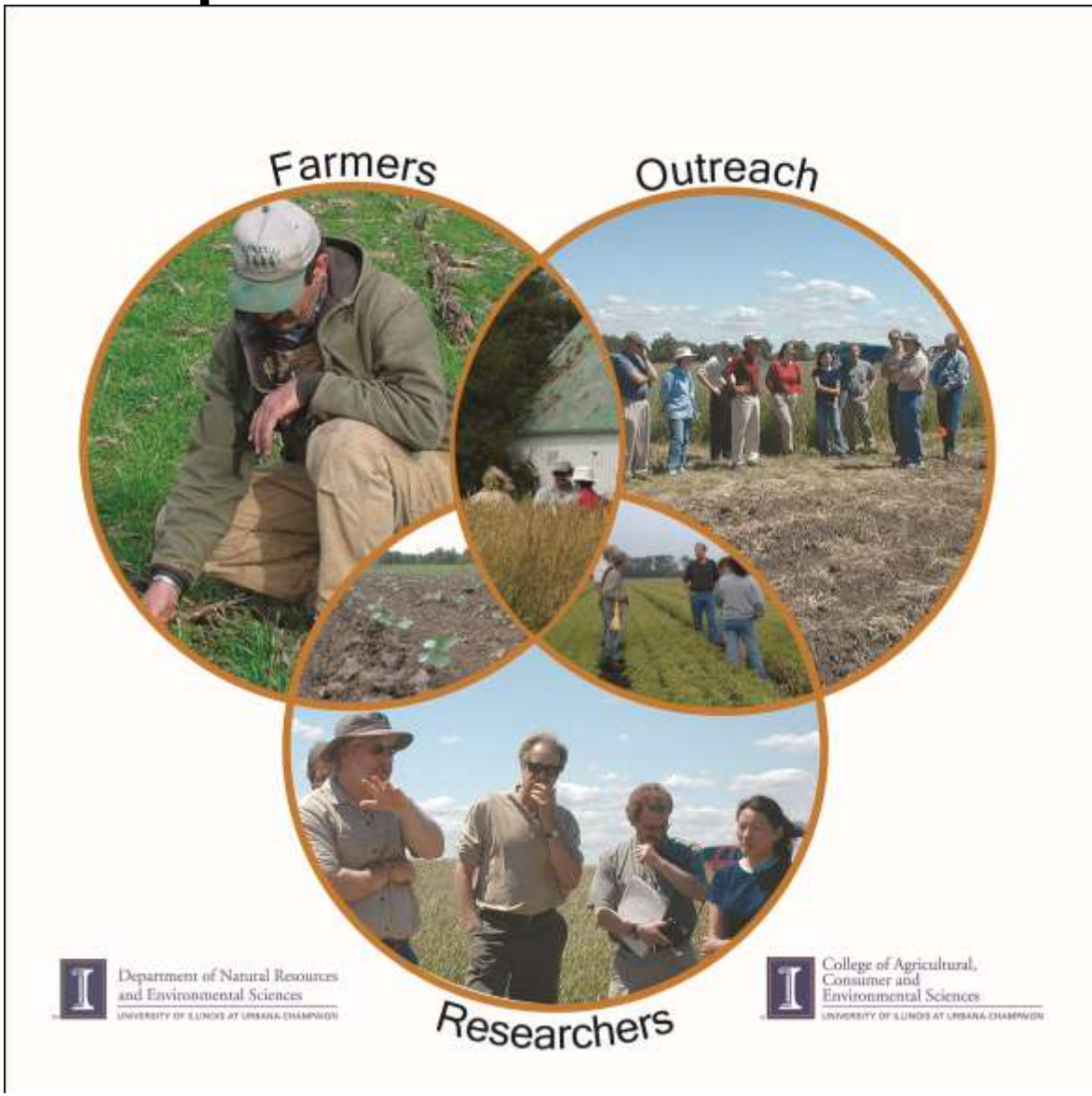
Accounting examples from WORT

C sequestration

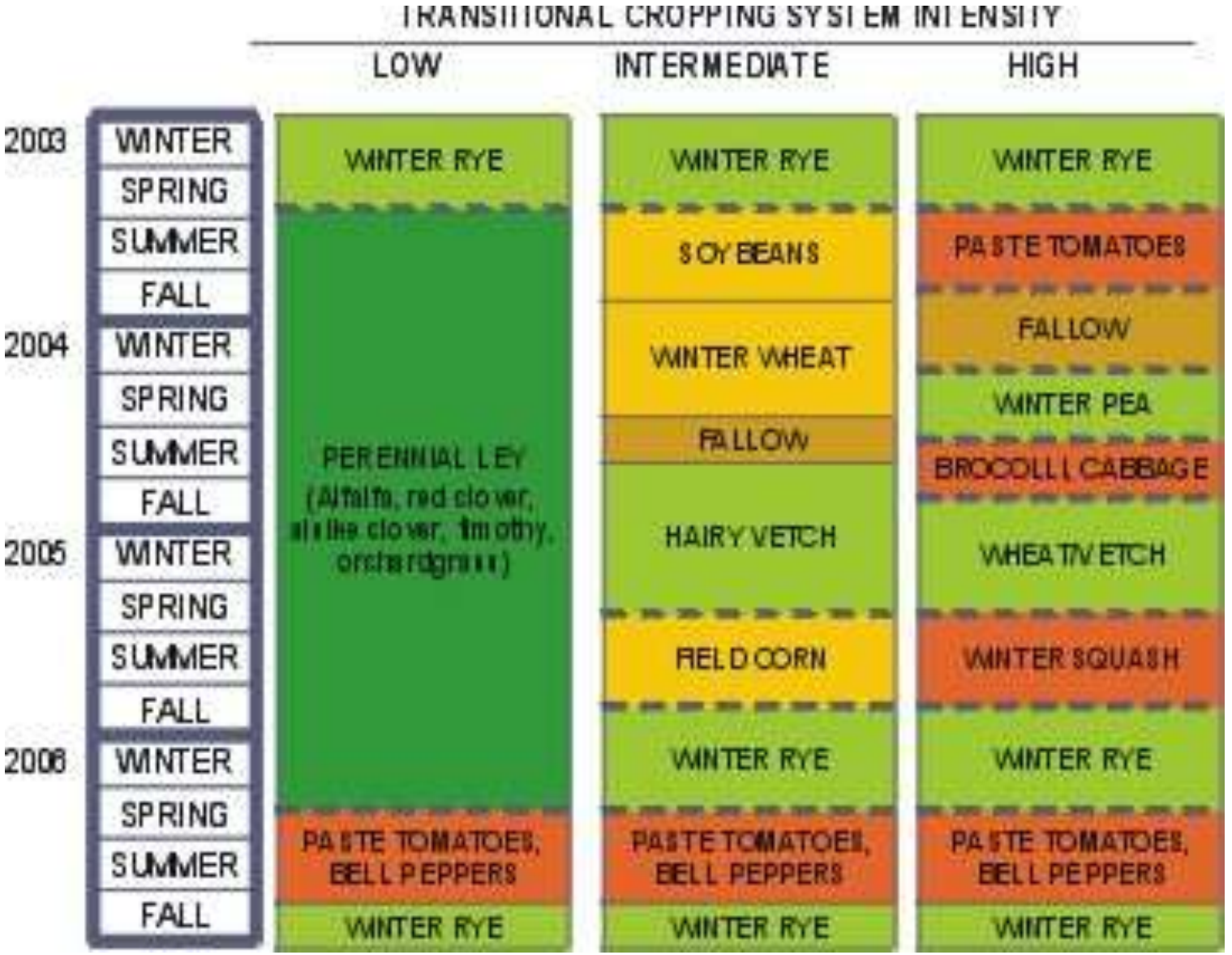
Nutrient budgets

NRCS tools

Life cycle – field to market



Summary of rotations



Spring Soil ‘Benchmark’ (0-15 cm)

Year	SOC	C/N	Bray P	K	pH	Ca	Mg
	%		ppm				
2003	2.21a	11.9a	53a	167a	6.7a	2228a	245a
2006	2.36a	12.7b	61b	261b	6.8b	3062b	321b
p	0.10	0.006	0.03	0.001	0.08	0.001	0.001

ψ SAS Proc Mixed was used to evaluate to the effects of time, transition system and fertility treatment within systems. Means within columns that are not followed by the same letter are considered different.

Preliminary analysis of NRCS Tools: SWET & SCI compared with SOC in the Windsor Organic Transition Experiment

	SWET		SCI		Measured SOC (%)	
Treatment	Score/Eligible?		Score/Eligible?		Yr 3 µ & (stdev)	
VEG	44	**no**	-0.46	**no**	2.45	(0.72)
VEG + manure	52	**no**	0.86	yes	2.36	(0.80)
VEG + compost	52	**no**	2.80	yes	2.39	(0.63)
ROW	64	yes	-0.12	**no**	2.17	(0.41)
ROW + manure	72	yes	1.60	yes	2.28	(0.58)
ROW + compost	72	yes	3.60	yes	2.37	(0.40)
LEY	101	yes	0.98	yes	2.50	(0.31)
LEY + manure	109	yes	2.40	yes	2.55	(0.38)
LEY + compost	109	yes	3.70	yes	2.24	(0.63)

Andrews, Widman and Wander, 2007

Nutrient balance sheet WORT field budget		N *kg ac*	P *kg ac*	K *kg ac*
Veg	Leg	48.86	-9.95	-70.43
	Manure	172.88	39.75	5.18
	Compost	220.67	140.74	32.98
	Mean	***147.47***	***90.70***	***20.36***
Row	Leg	-45.48	-15.04	-28.89
	Manure	0.93	23.54	29.15
	Compost	52.81	130.97	91.77
	Mean	***2.75***	***80.00***	***68.23***
Ley	Leg	323.31	-11.15	-16.96
	Manure	455.92	39.38	60.97
	Compost	503.72	140.37	88.77
	Mean	***427.65***	***90.05***	***75.38***
harvested	***Mean***	***345.92***	***82.08***	***67.41***


Inputs
Marketing
Carbon foot print?
On farm operations
Transportation and storage

In Field Energy Use; RUSLE2; 2003 thru 2007

Mgt		Equiv diesel fuel use	Energy Use BTU/AC	Fuel Cost $/Ac
Veg	Compost	39	5400000	116.9
	Manure	39	5400000	116.9
	Cover crop	36	5000000	107.6
Row crop	Compost	41	5700000	124.3
	Manure	41	5700000	124.3
	Cover crop	38	5200000	113.3
Pasture	No harvest	28	3900000	84.68
	With harvest	51	7000000	152

Andrews, Wander and Widman

4 year balance for GWI

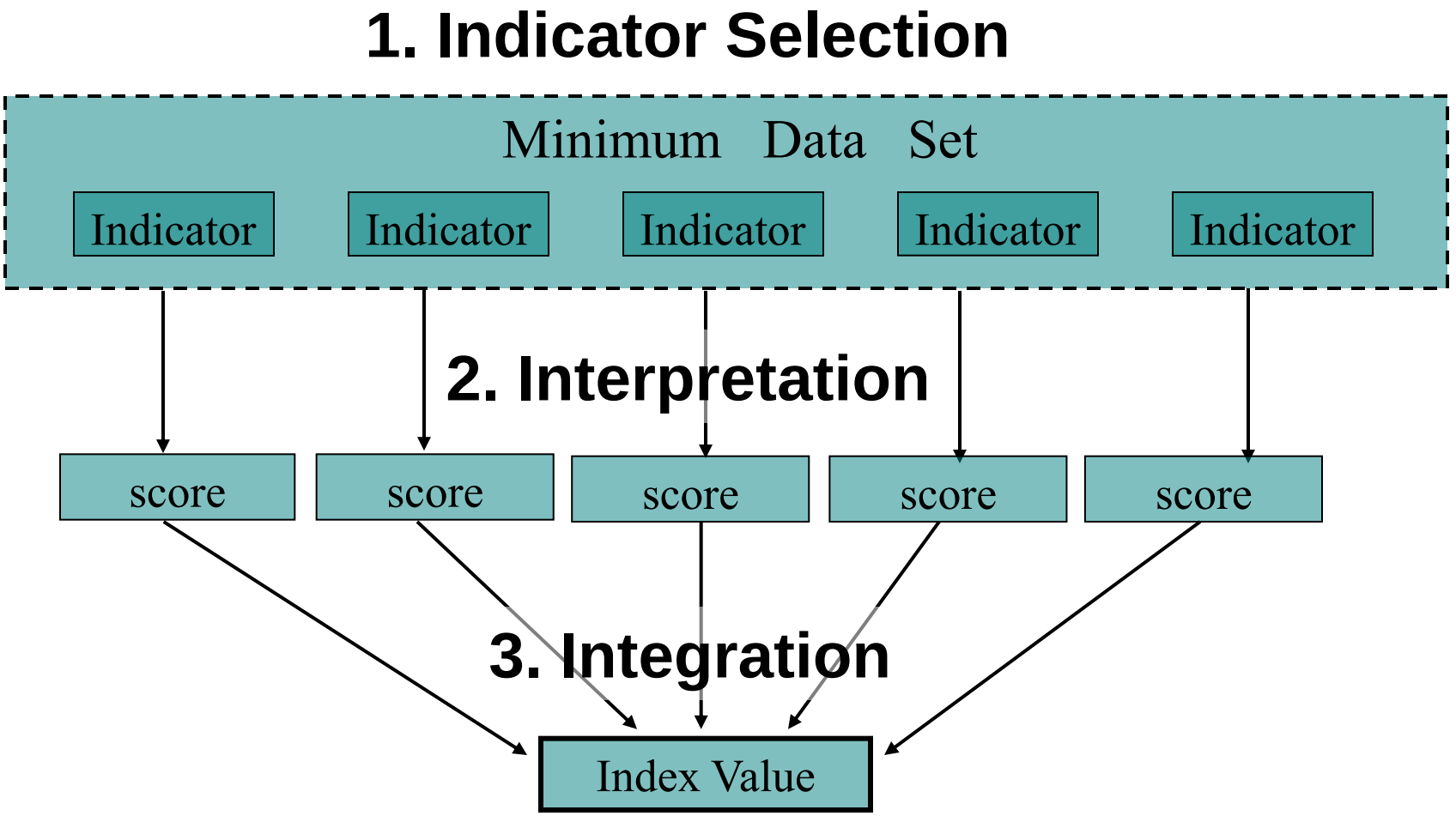
	Soil Seq	Denit	Energy	Balance
			Tons CO_2 per acre	
	A	B	C	D
VEG	8.4	1.94	8.0	-1.54
VEG + M	8.4	2.47	8.2	-2.27
VEG + C	8.4	2.66	8.2	-2.46

A= mean soil sequestration in Vegetable system
B=estimated based on denitrification from soil
C=LCA with GREET boundaries
D= A-(B+C)

The Conservation Stewardship Program (CSP)

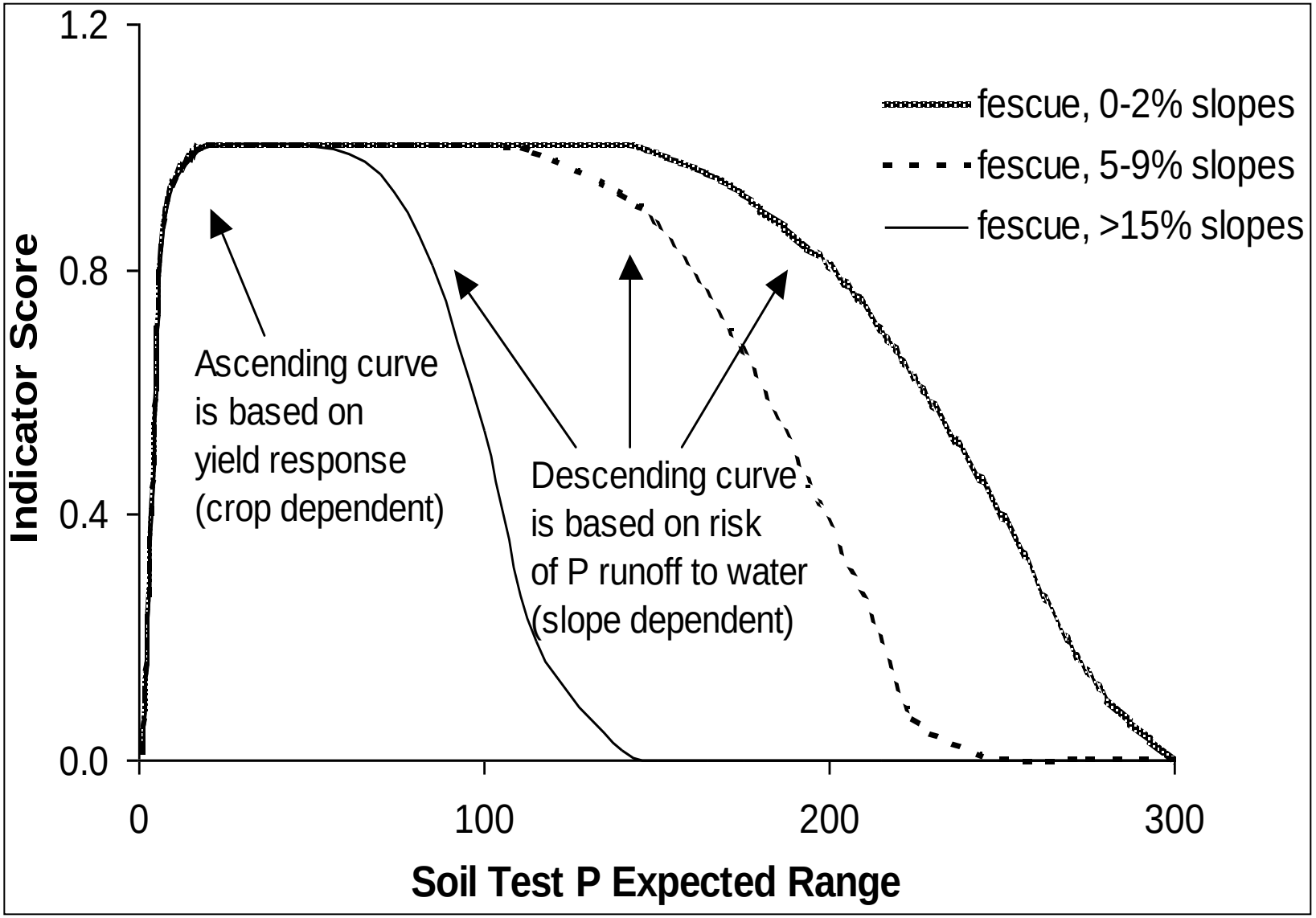
- is a voluntary conservation program that encourages producers to address resource concerns in a comprehensive manner by:
  - Undertaking additional conservation activities; and
  - Improving, maintaining, and managing existing conservation activities.

Soil Management Assessment Framework (SMAF)

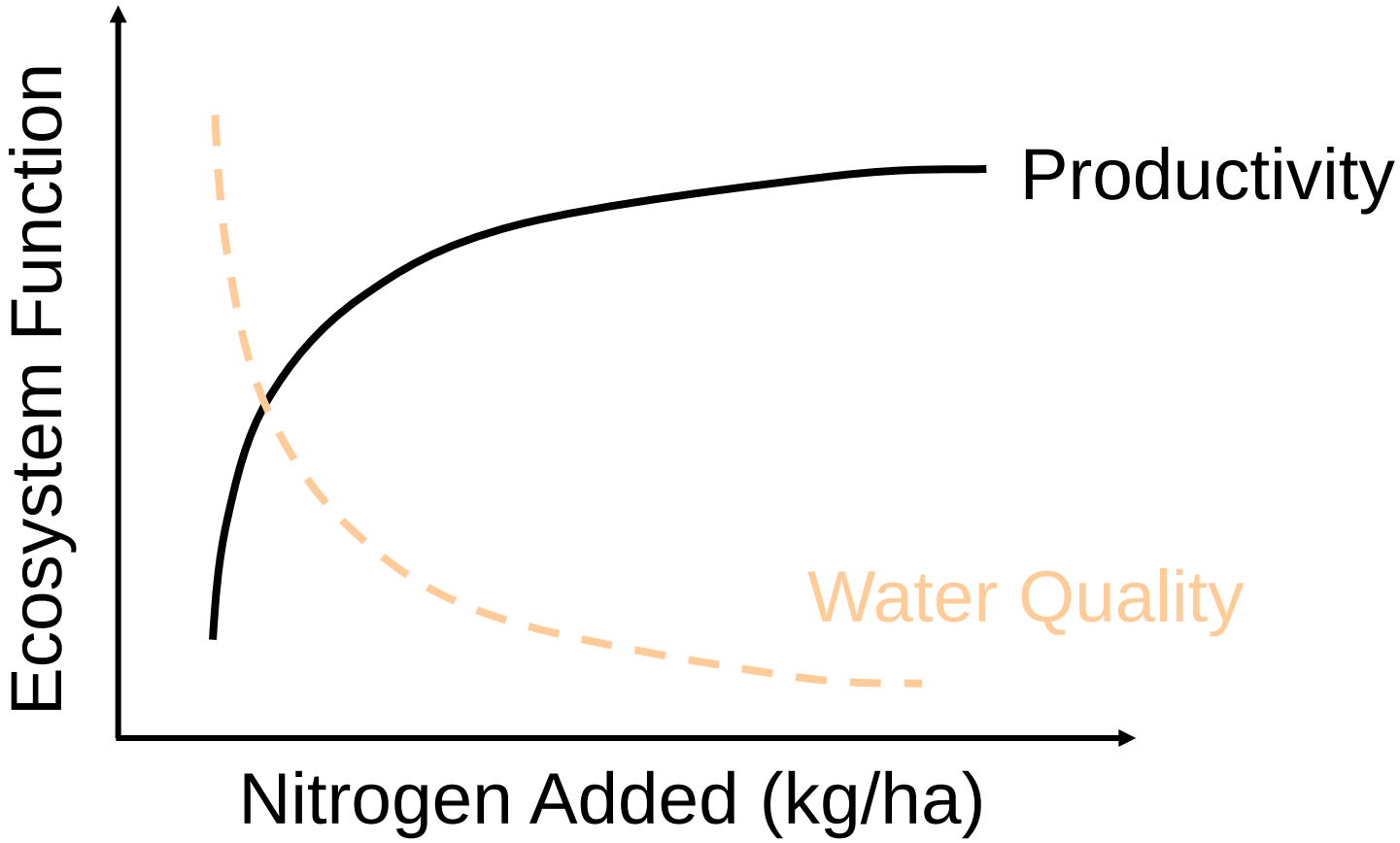


- Andrews et al., 2002; 2004

Test P Interpretation



Multiple Functions



- after DeFries et al., 2002

2008 Farm Bill recognizes organic practices

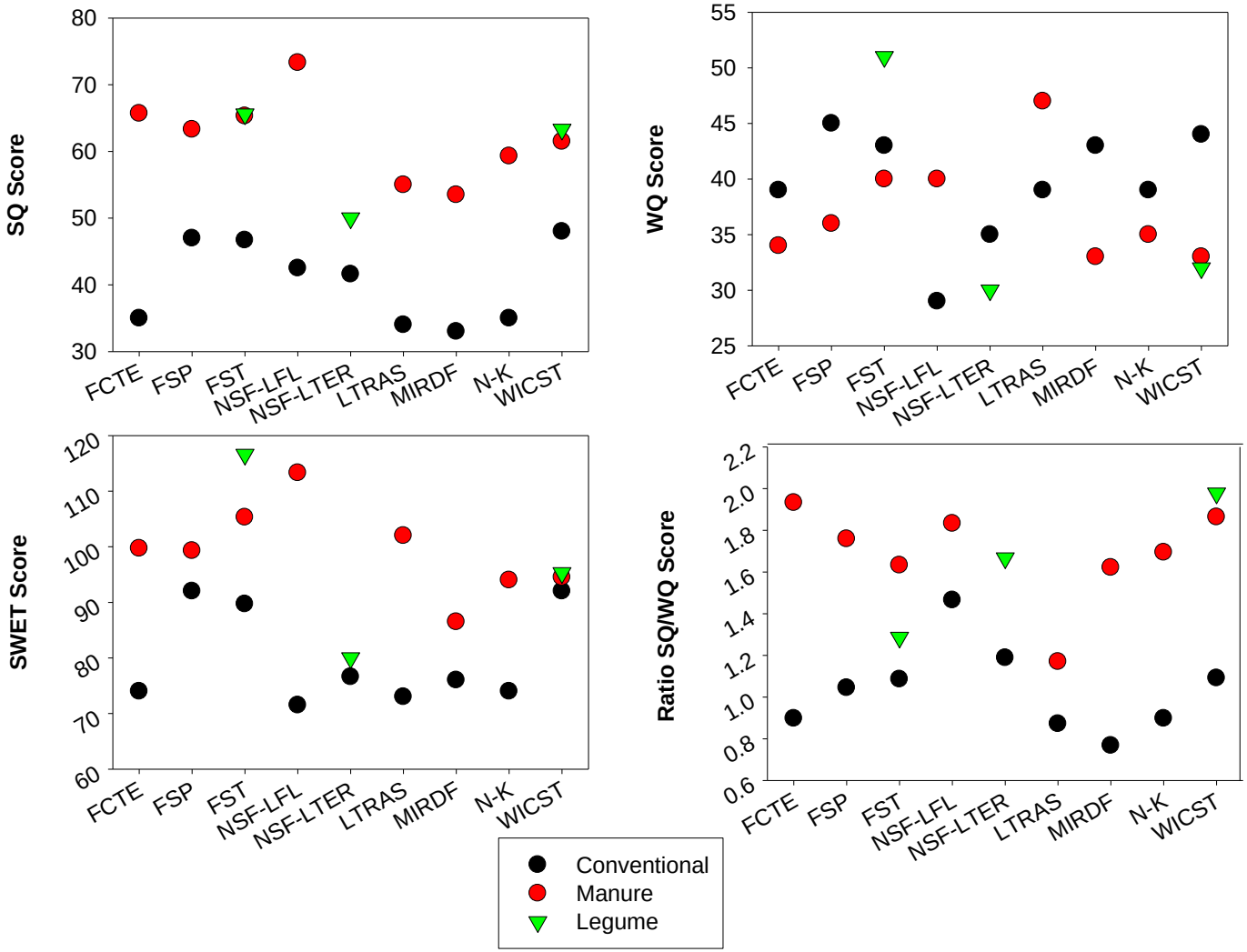
- Required NRCS to establish a transparent process that would allow producers to undergo organic transition while in a CSP contract
- CSP requires the use of Conservation Enhancements that provide additional environmental benefit(s)

NRCS enrollment tools

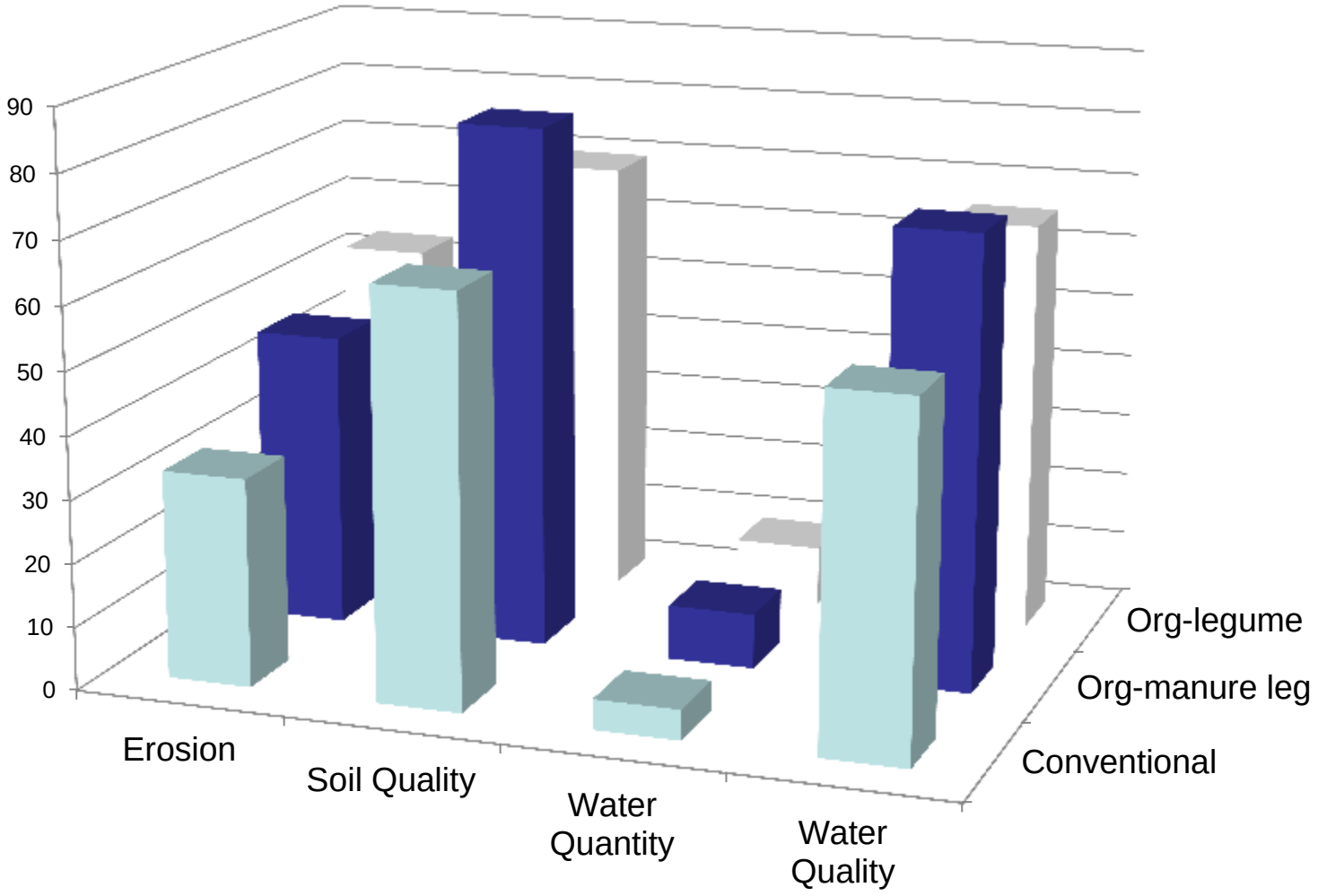
under development

#		Enter number/ Check here for					
	Pass - Not a Resource Concern		NA	NA	NA	NA	NA
	Minimum Score YES or NO		NO	NO	NO	NO	NO
	Total Score		0	0	0	0	0
	How long is the rotation? (Enter the Number of Years)	0					
2	Soil Conditioning Index is positive (If yes, stop here, you pass for soil quality.)	☐	0	0	0	0	0
3	On how many years of the crop rotation is a moldboard plow, chisel plow or annual raised beds used?	0	0	0	0	0	0
4	How many crops (per rotation) receive fall tillage?	0	0	0	0	0	0
5	Is controlled traffic (tram lines) used; OR are soil moisture conditions monitored to minimize compaction.	☐	0	0	0	0	0
6	How many crops are grown during the rotation from each group listed below. (See comment boxes for full listings.)						
a	a) Enter the number of years this occurs during your rotation: summer fallow, idle fields or harvested sod	0	0	0	0	0	0
b	b) Enter the number of years any of these crops are grown during your rotation: Horticultural crops, dry beans, annual herbs, flowers (cut and seed)	0	0	0	0	0	0
c	c) Enter the number of years any of these crops are grown during your rotation: Corn silage, Cotton, Soybeans, Sorghum hay, Peanuts, Root crops (non-hort), Pineapples, Tobacco	0	0	0	0	0	0
d	d) Enter the number of years any of these crops are grown during your rotation: Corn grain,popcorn, Sorghum, Small grains, Tree crops, Perennial herbs, Berries	0	0	0	0	0	0
e	e) Enter the number of years any of these crops are grown during your rotation: Grass, Pasture, Hay, CRP	0	0	0	0	0	0
	How many years are annual crops established using no-till or with at least 30% residue						

Soil and Water Quality, Field Practices



Conservation Stewardship Program Ranking (CSPR) Tool



Covers- not just another silver bullet