Instilling Health into Unhealthy Soils

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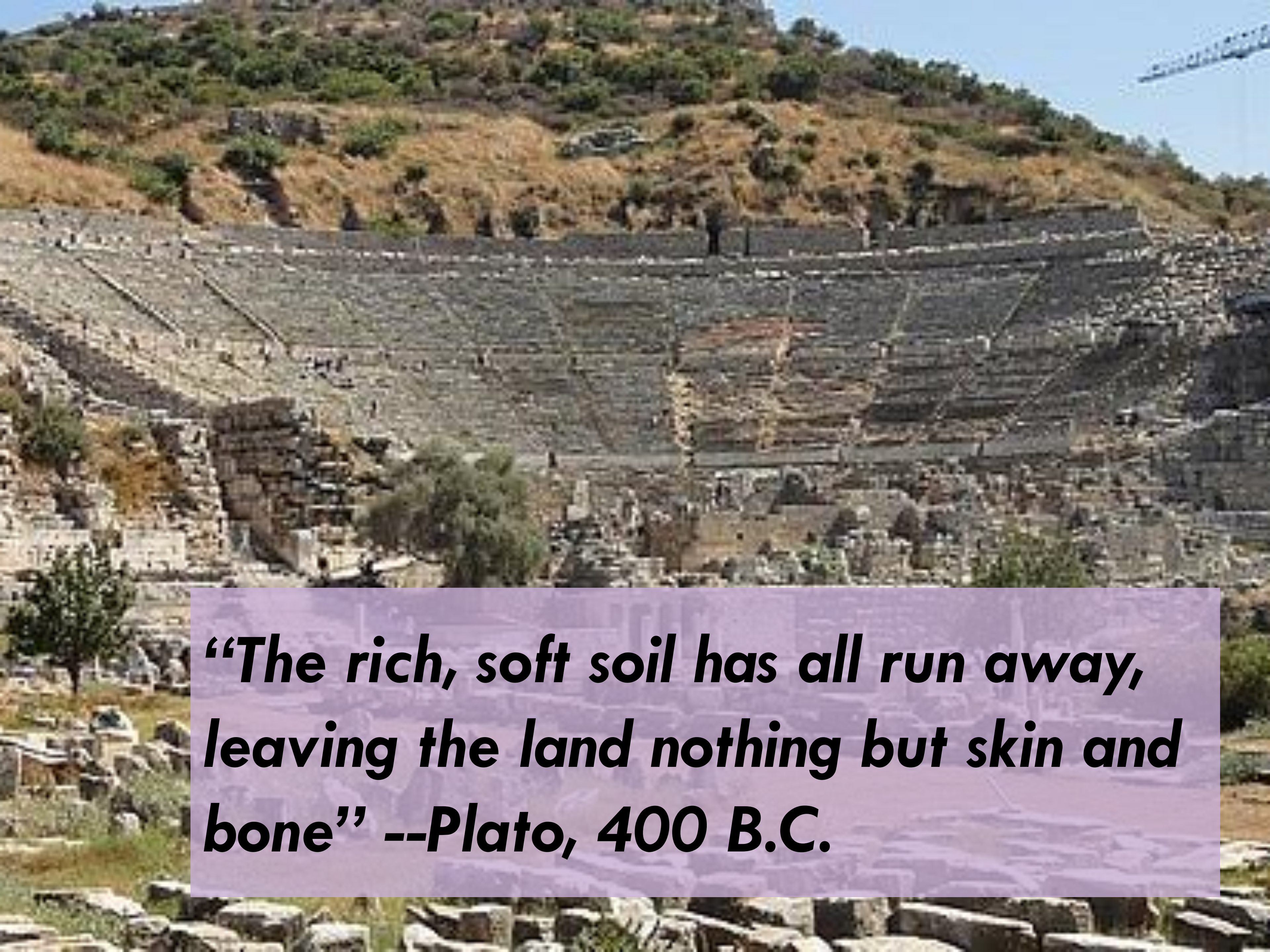
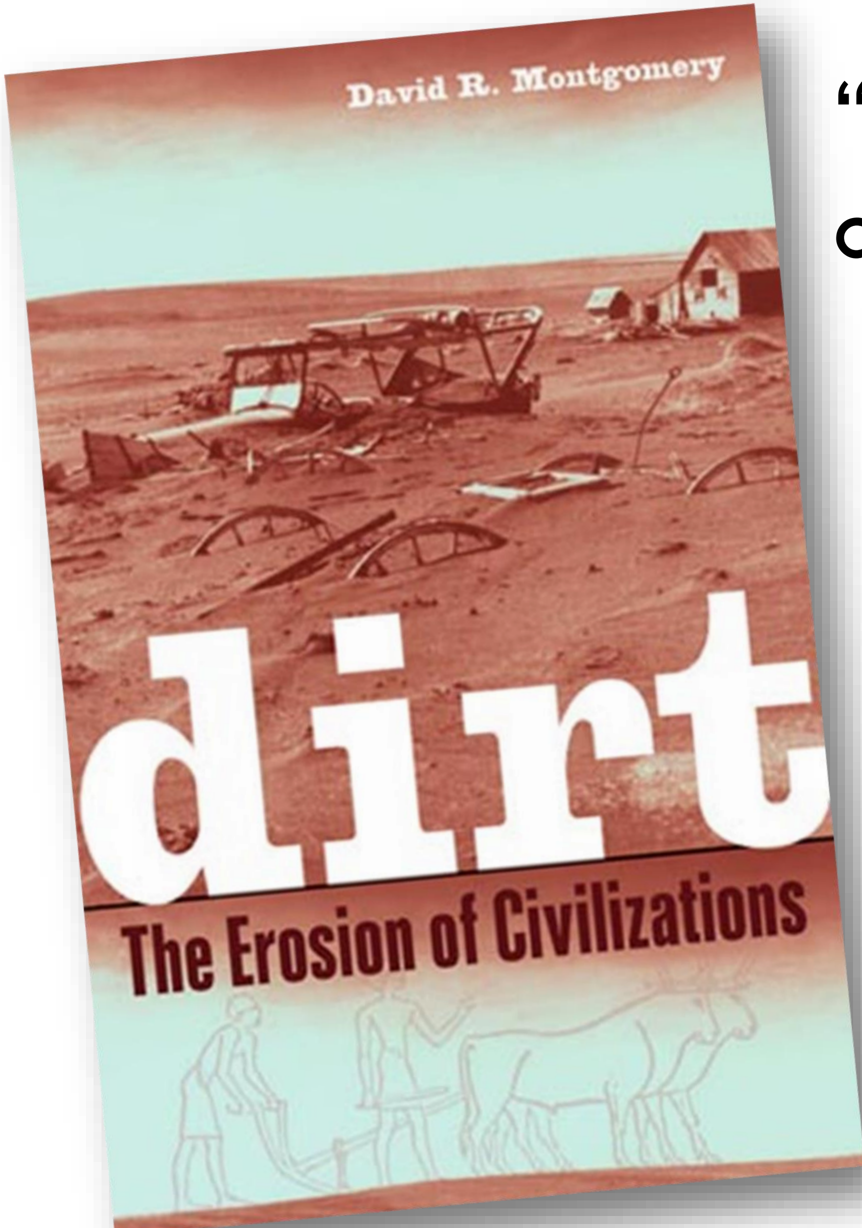
Michigan Chapter of the Soil and Water Conservation Society

Consumables


"The rich, soft soil has all run away, leaving the land nothing but skin and bone" --Plato, 400 B.C.

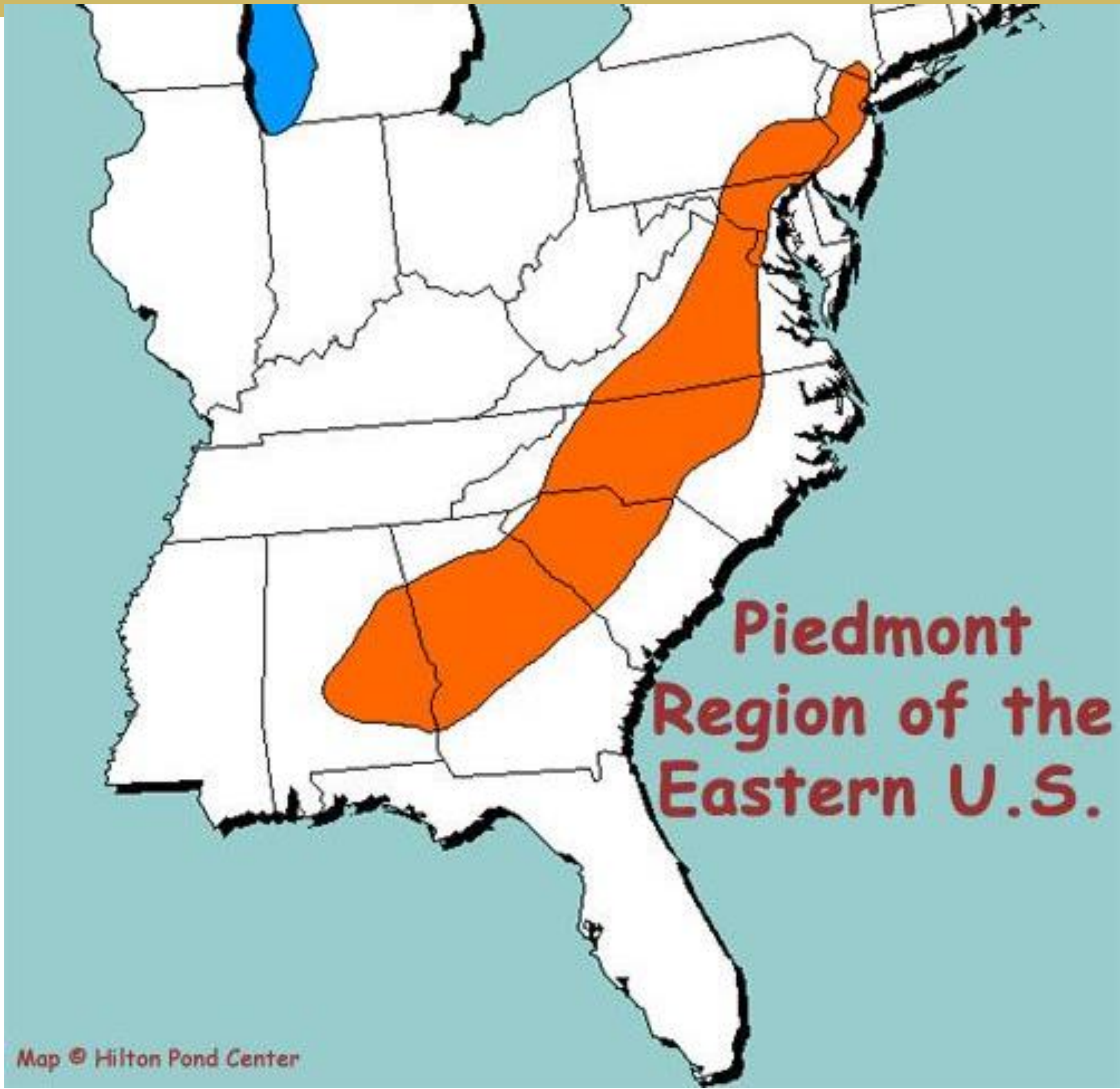


"…. did not so much collapse as consume itself."

How do we get away from treating soil as a consumable?

Recent Times

- U.S. Piedmont used to be a major agricultural region
- Cultivation brought immediate and devastating soil erosion

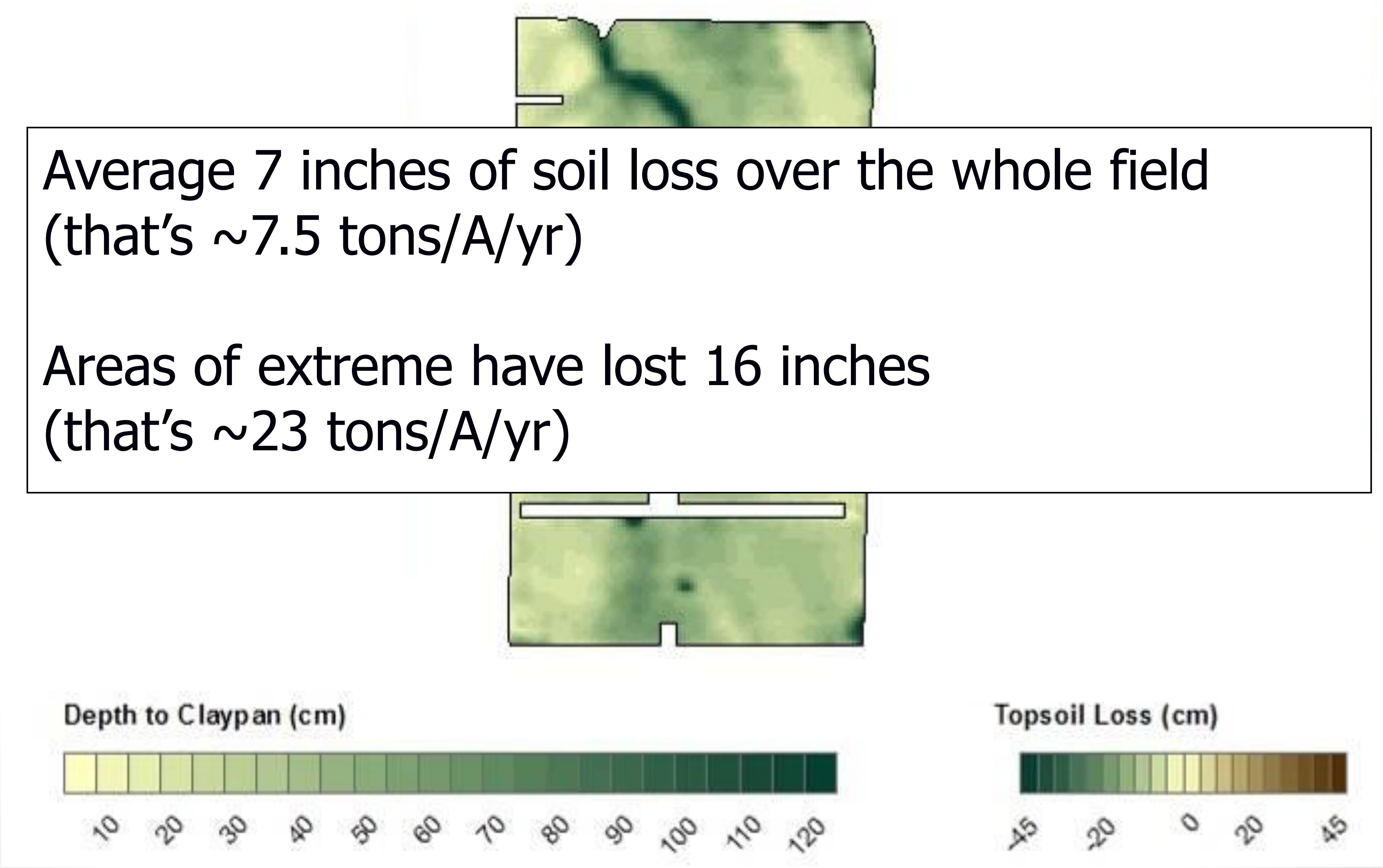


More Recently

- In the U.S. Midwest, extensive flat grasslands were plowed and put into grain production about 100 years ago.

- Multiple and damaging large flood events caused severe soil erosion and property damage between 1926-1936. Grain crop yields for many fields actually declined when compared to the previous century (Bennett, 1939).

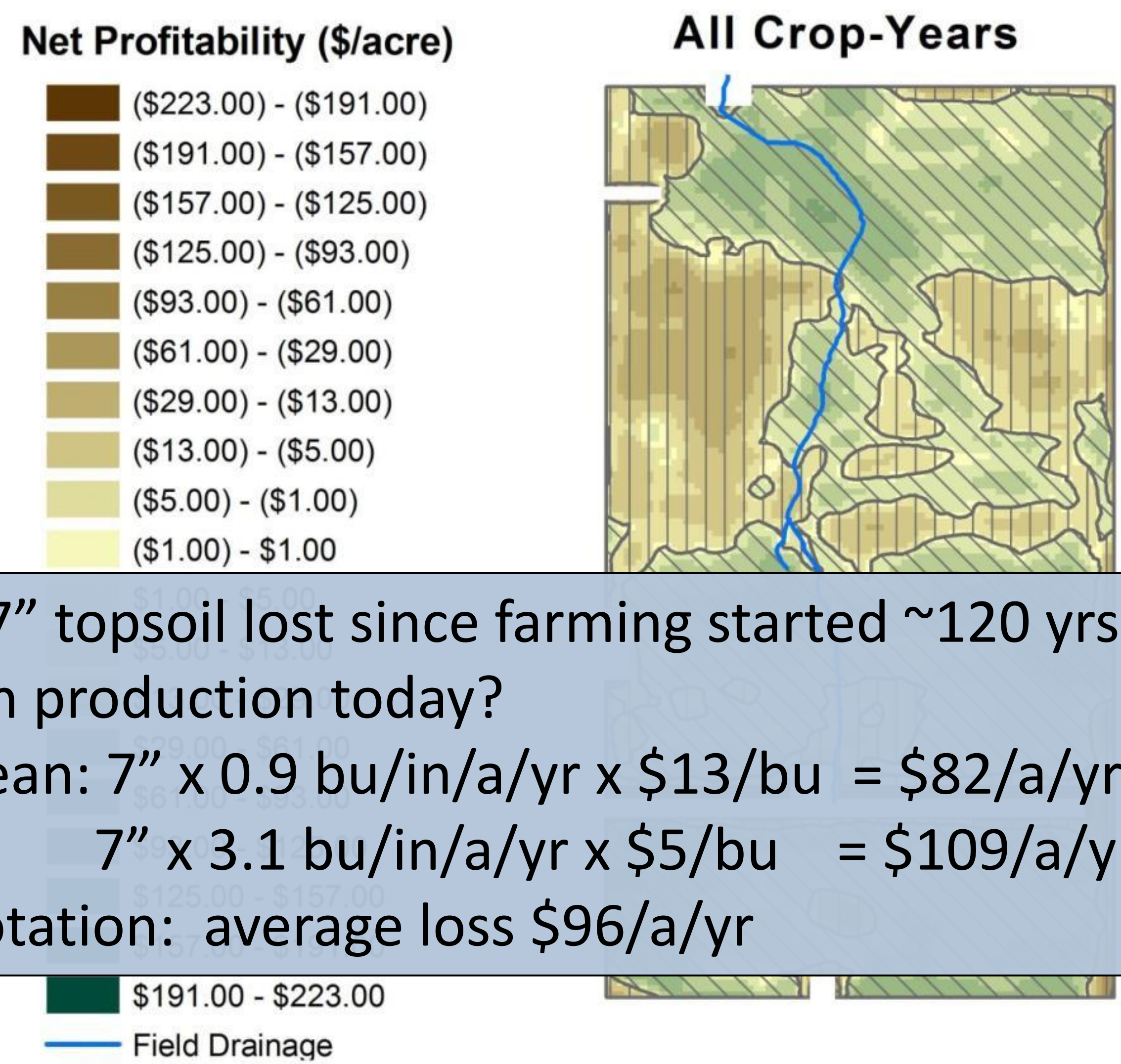
120 Years of Erosion



Average 7 inches of soil loss over the whole field
(that’s ~7.5 tons/A/yr)

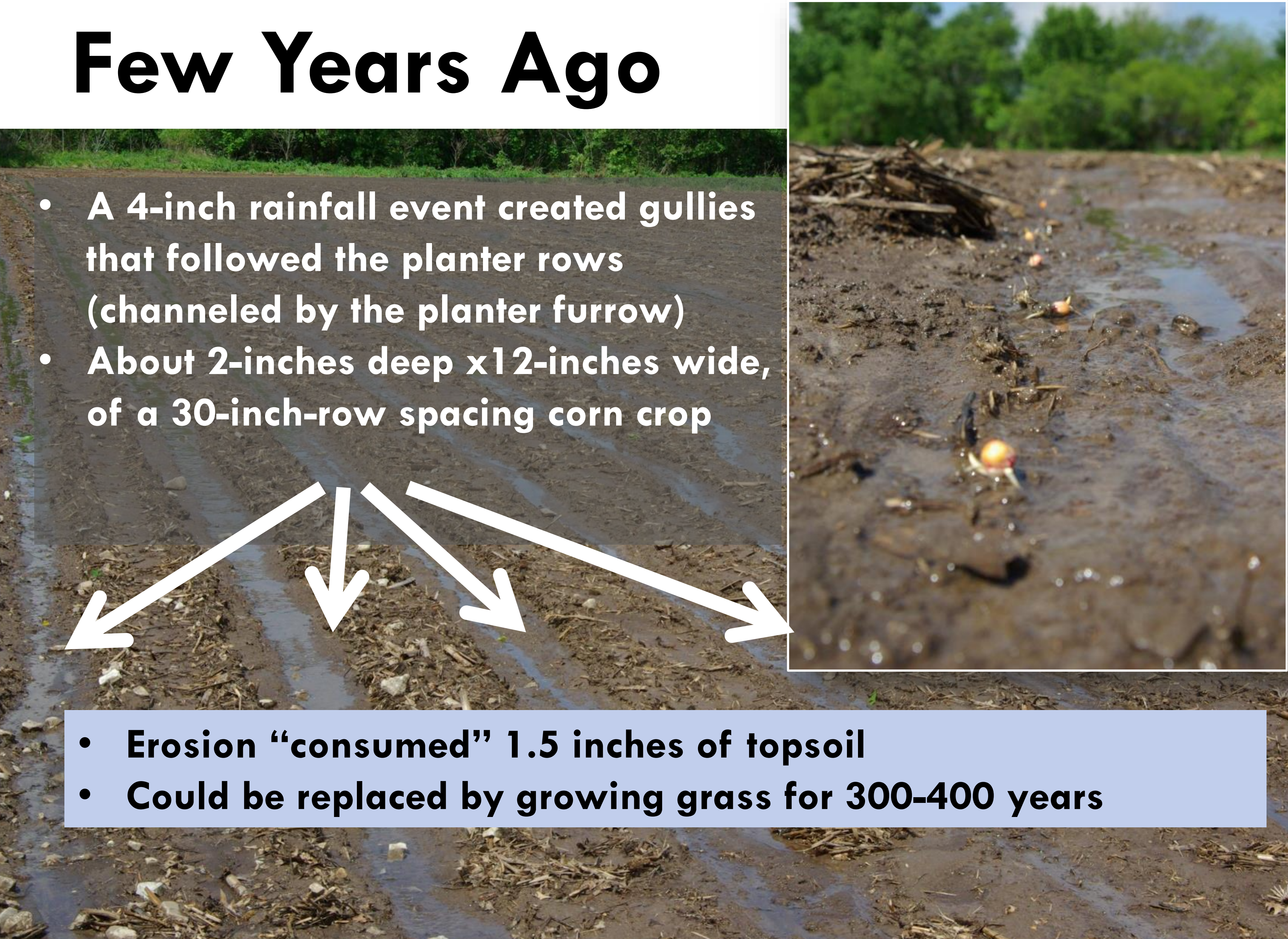
Areas of extreme have lost 16 inches
(that’s ~23 tons/A/yr)

What is the impact of past erosion on productivity?



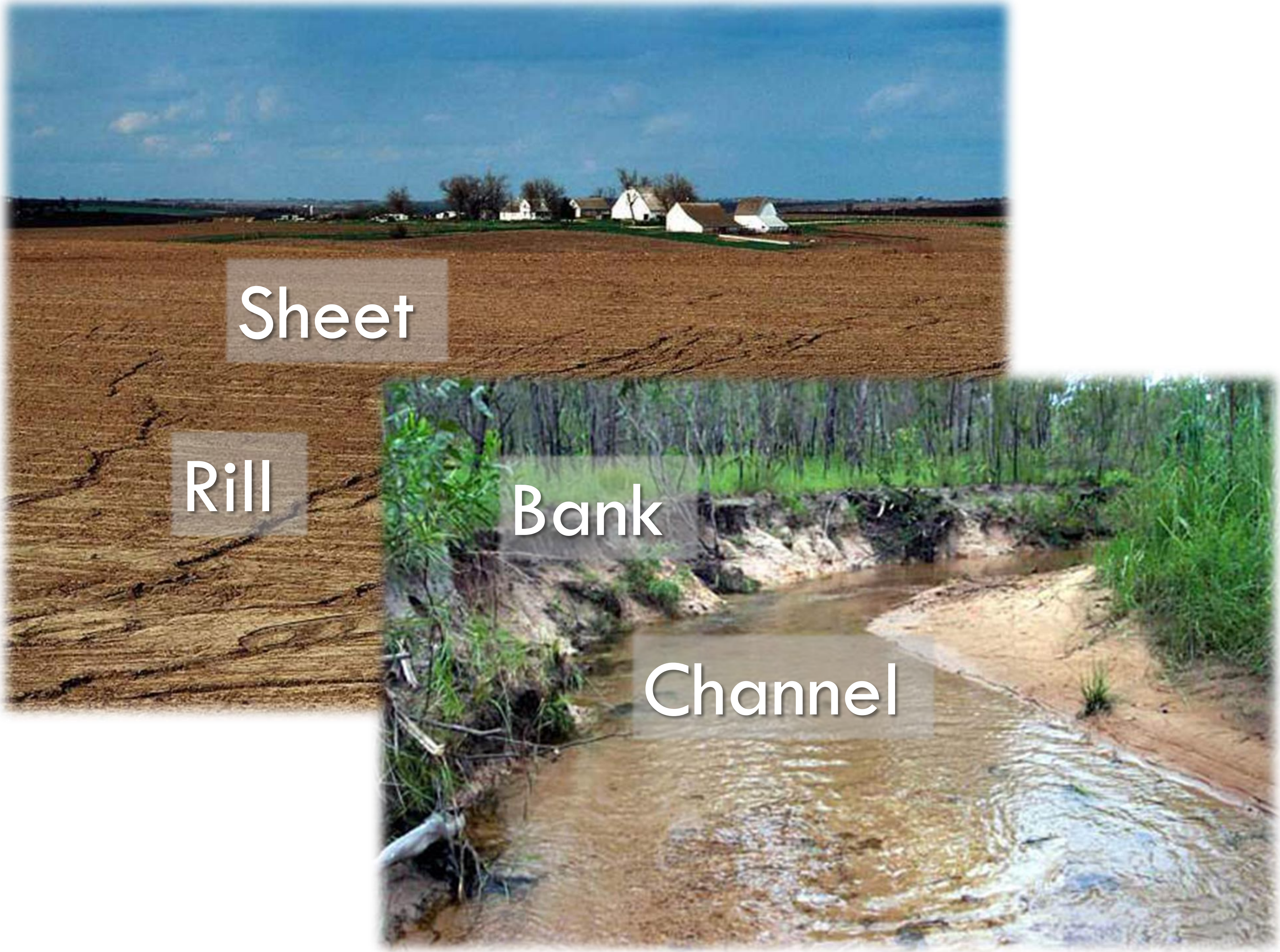
- Average 7” topsoil lost since farming started ~120 yrs ago
- Impact on production today?
  - Soybean: 7” x 0.9 bu/in/a/yr x $13/bu = $82/a/yr
  - Corn: 7” x 3.1 bu/in/a/yr x $5/bu = $109/a/yr
  - C-S rotation: average loss $96/a/yr

Few Years Ago



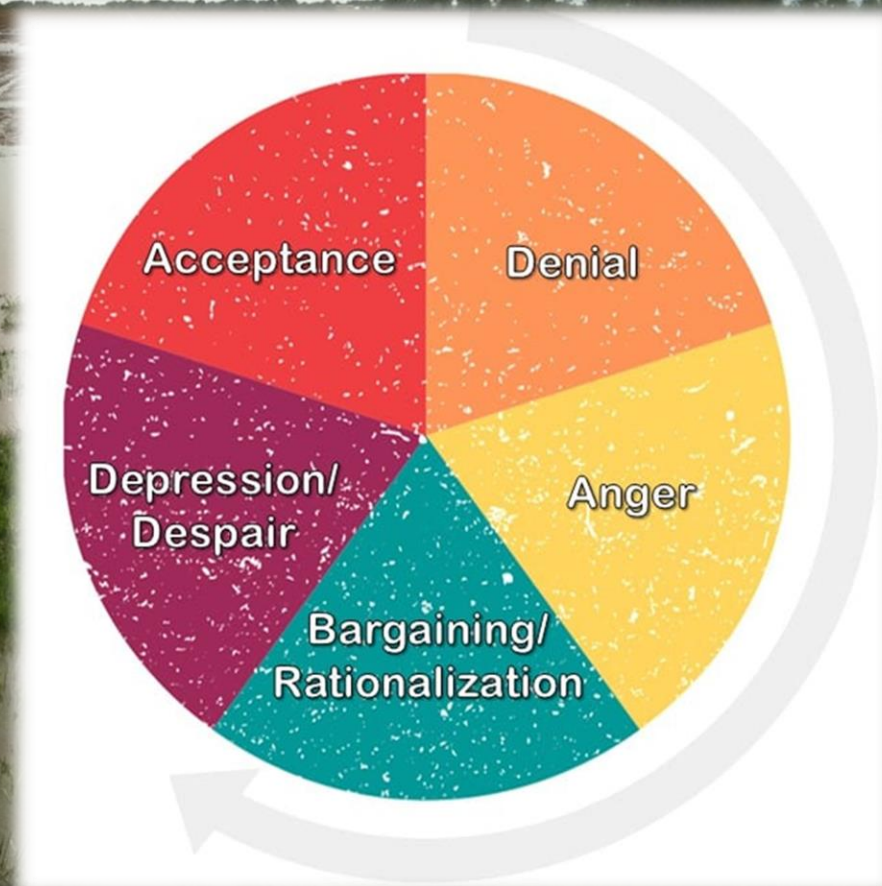
- A 4-inch rainfall event created gullies that followed the planter rows (channeled by the planter furrow)
- About 2-inches deep x12-inches wide, of a 30-inch-row spacing corn crop

- Erosion “consumed” 1.5 inches of topsoil
- Could be replaced by growing grass for 300-400 years

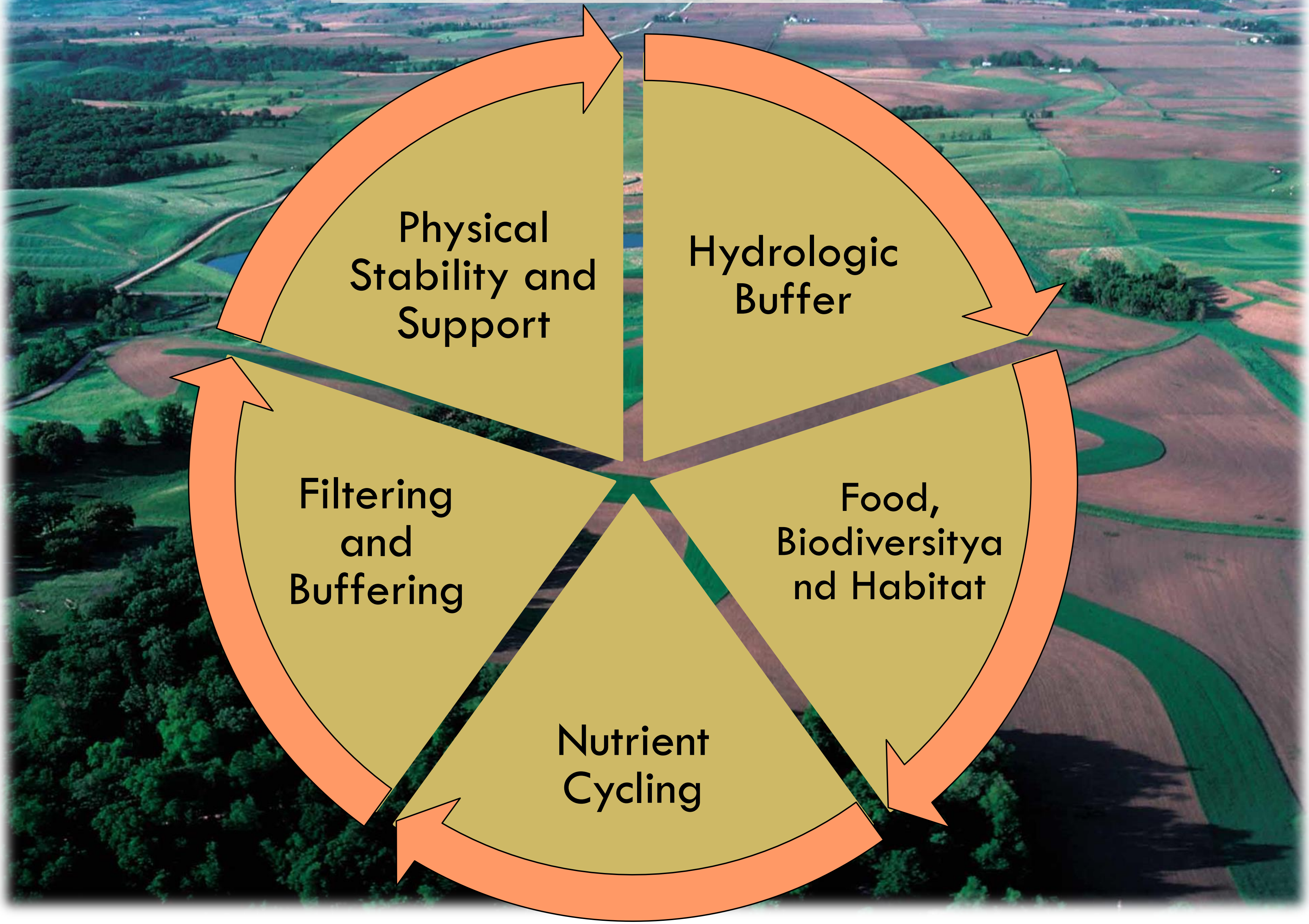

Sheet
Rill
Bank
Channel

"… the slower the emergency, the less motivated we are to do anything about it."

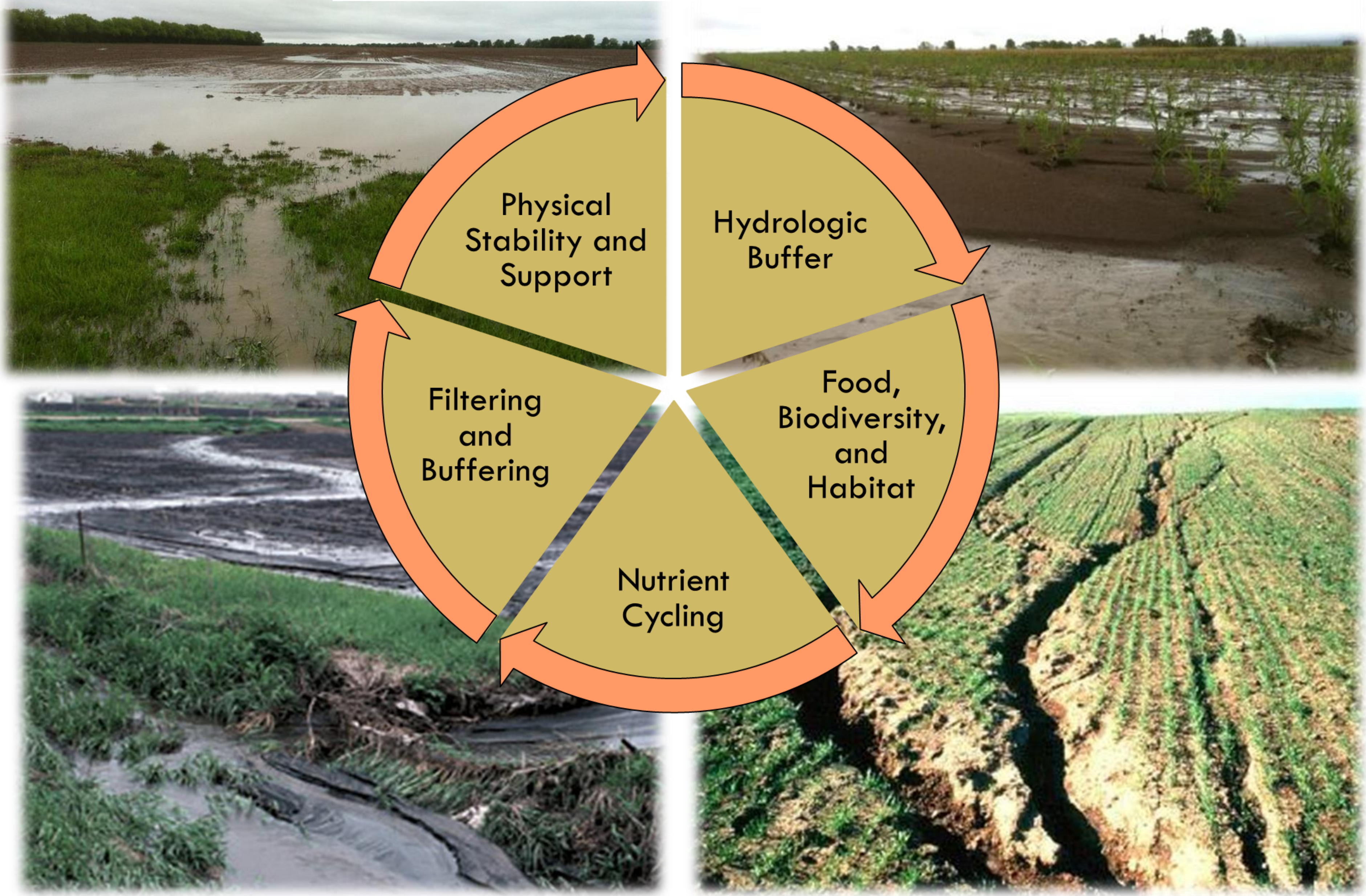
Dirt, David R. Montgomery

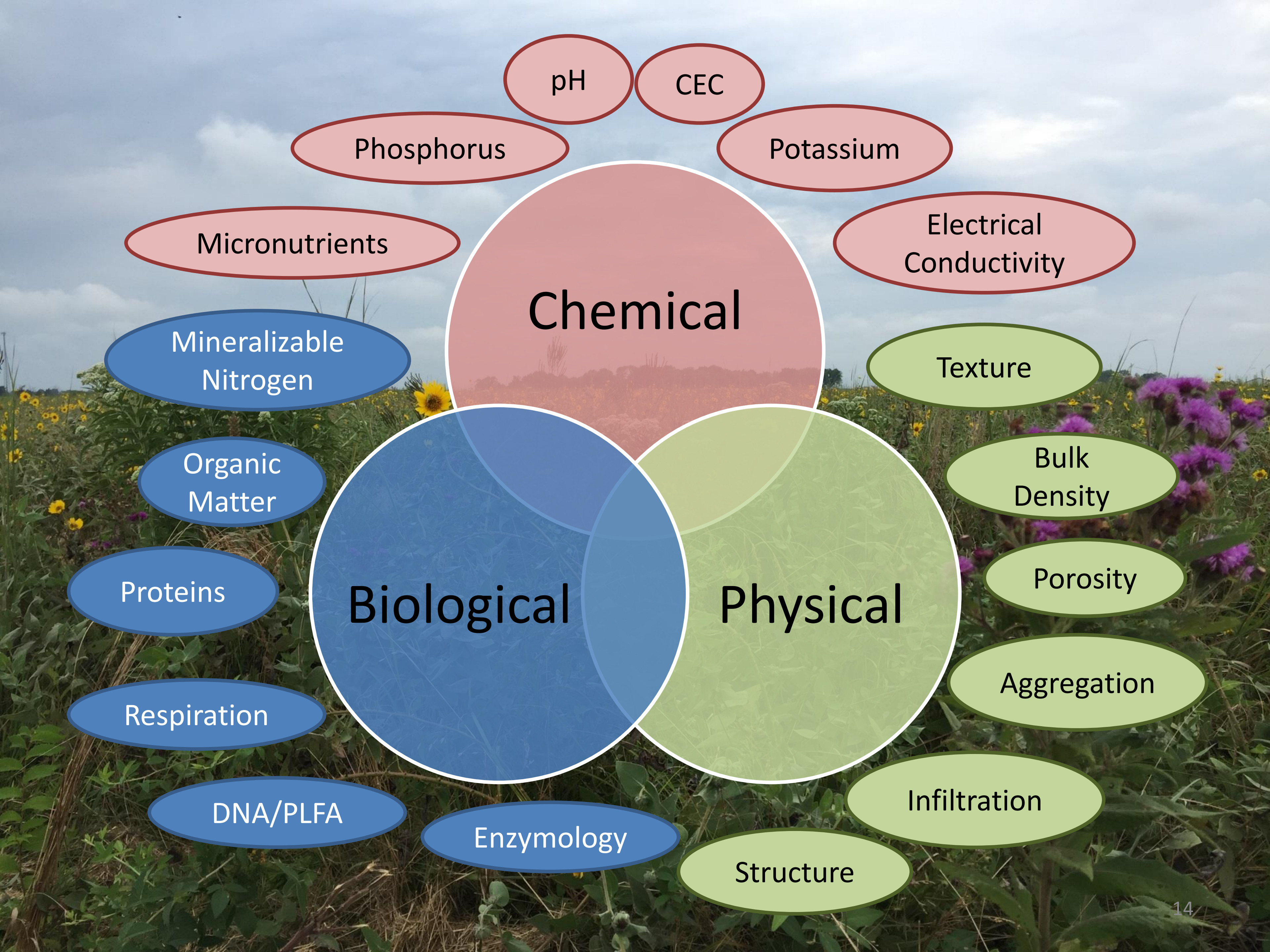


Soil Functions



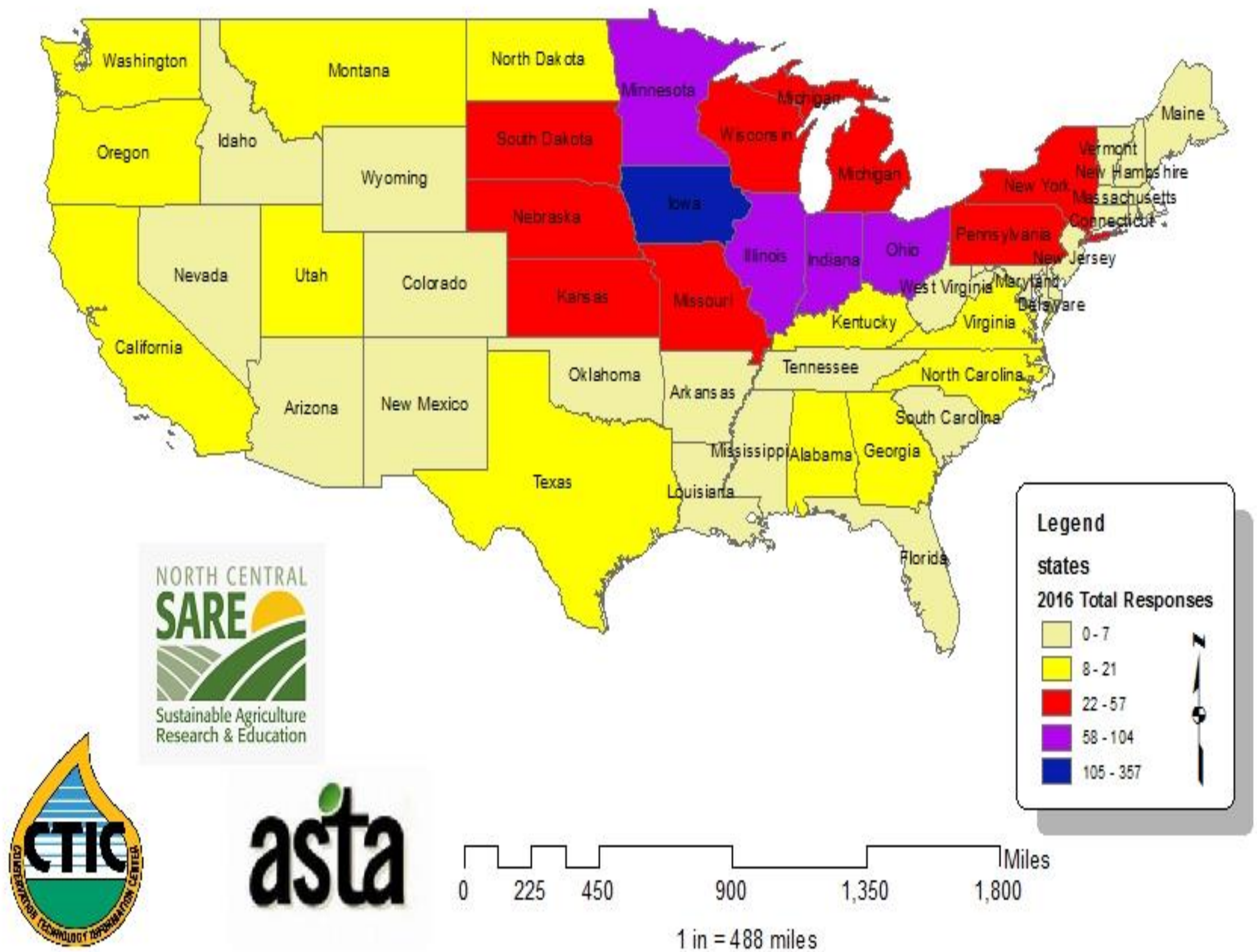
Dysfunctional Soils



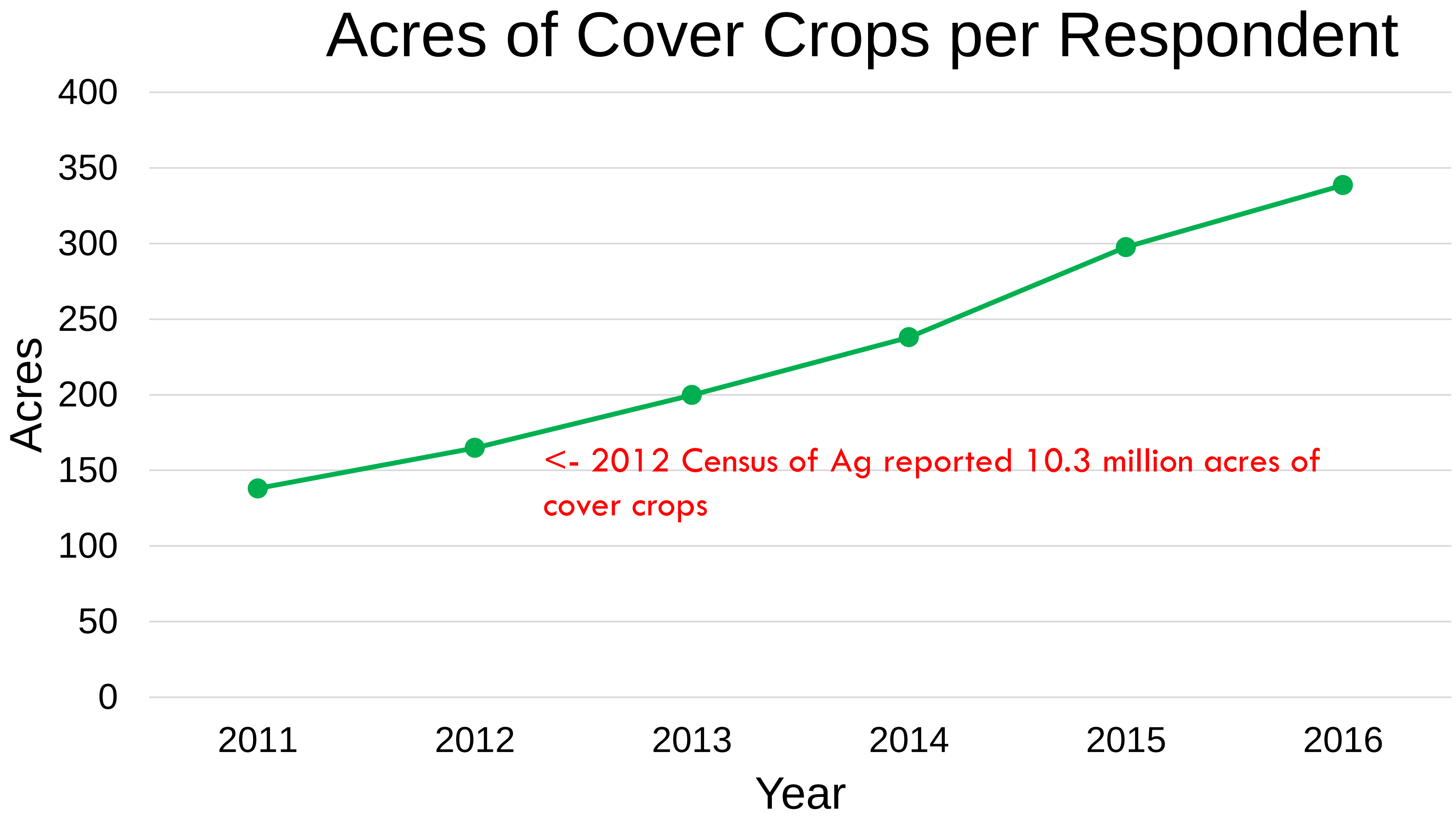

pH
CEC
Phosphorus
Potassium
Micronutrients
Electrical Conductivity
Chemical
Mineralizable Nitrogen
Texture
Organic Matter
Bulk Density
Porosity
Proteins
Biological
Physical
Aggregation
Respiration
Infiltration
DNA/PLFA
Enzymology
Structure

What do we know about soil health and cover crops today that we didn't already know 30 years ago?

2016 Cover Crop Survey Respondents

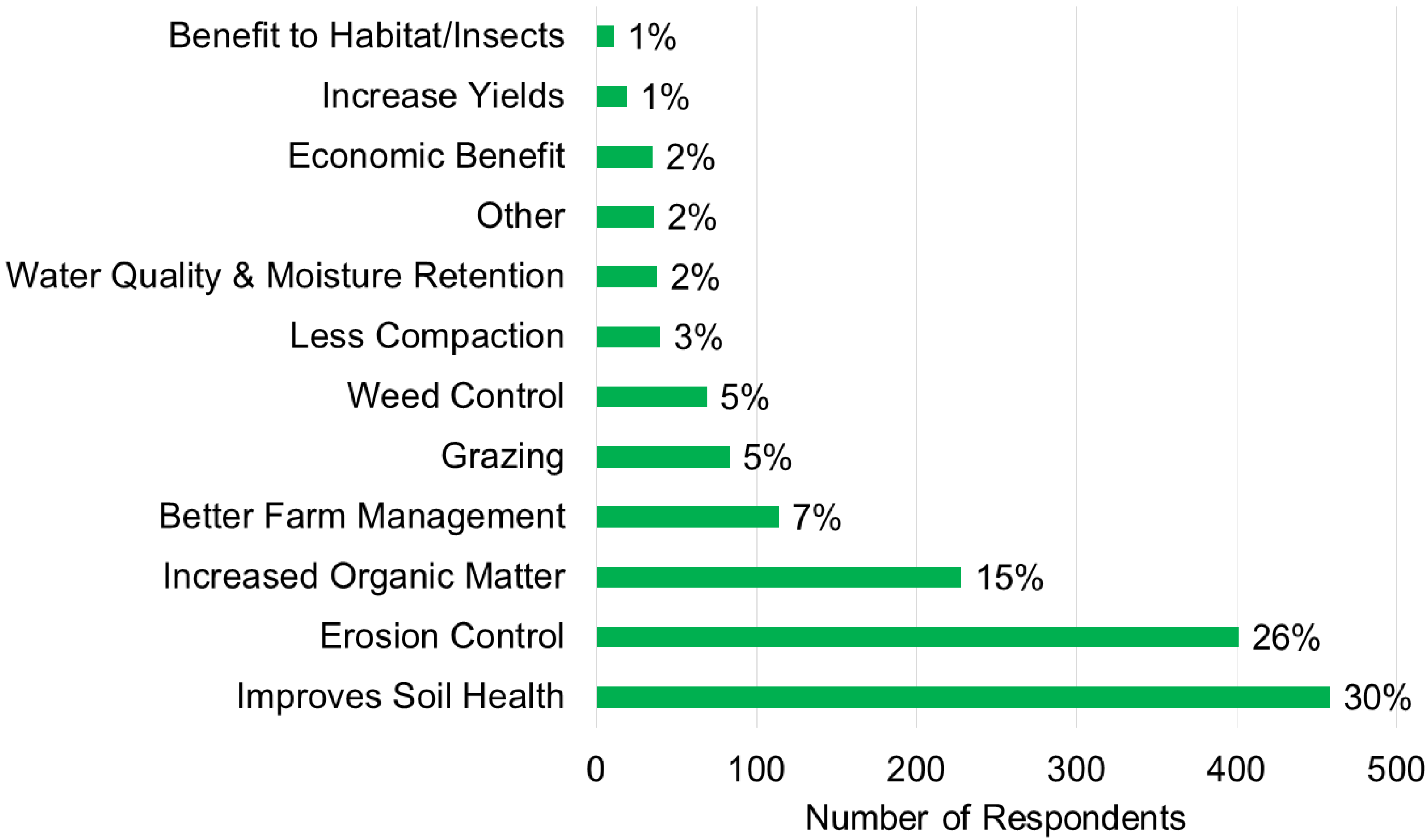


* This map represents only those who indicated their state location in the survey, about two-thirds of all respondents.



Data from 2015-16 SARE/CTIC/ASTA national cover crop survey

What is the single, biggest benefit you receive from using cover crops on your farm?



Yield increase following cover crops?

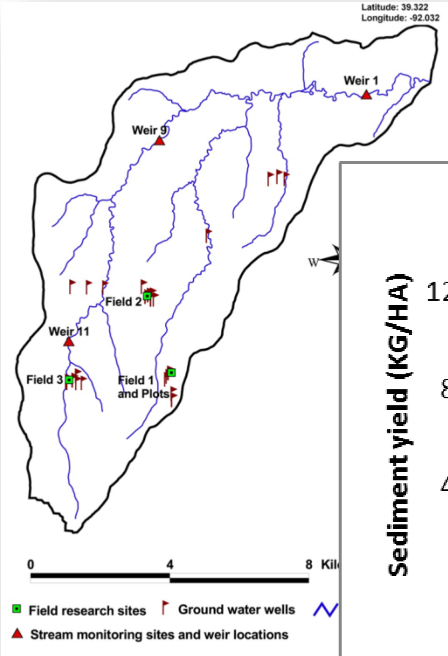
Crop Year	Corn	Soybeans
2012	9.6%	11.6%
2013	3.1%	4.3%
2014	2.1%	4.2%
2015	1.9%	2.8%

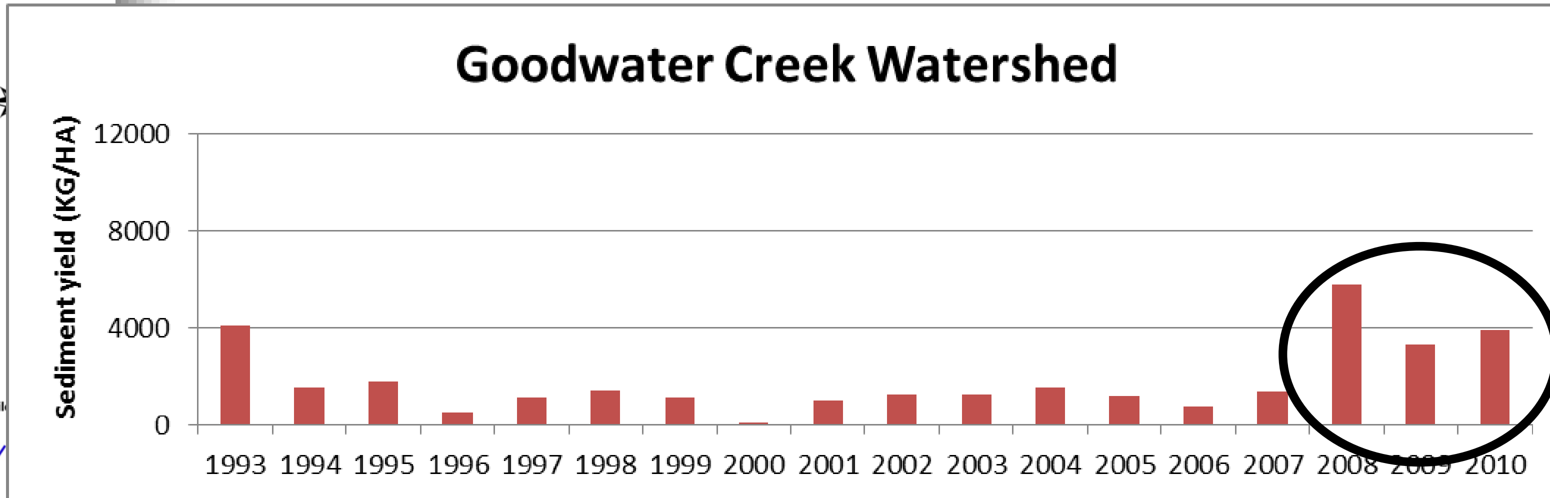
Data provided from farmers in the SARE/CTIC national cover crop survey.
Differences are statistically significant based on analysis by Purdue University.

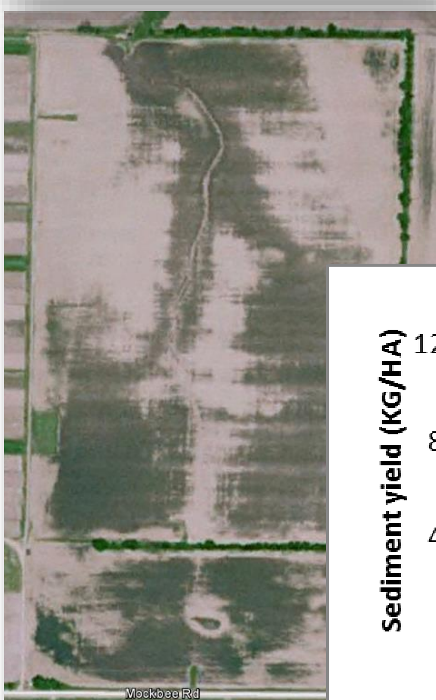
Summary of Typical Positive Impacts Attributed to Cover Crops

1. Greatly reduced erosion
2. Increased soil organic matter
3. Recycle nutrients
4. Fix N with legumes
5. Enhanced infiltration
6. Enhanced aeration with improved soil structure/aggregation
7. Preventive of soil compaction
8. Reduced evaporation potential

Sediment Loss

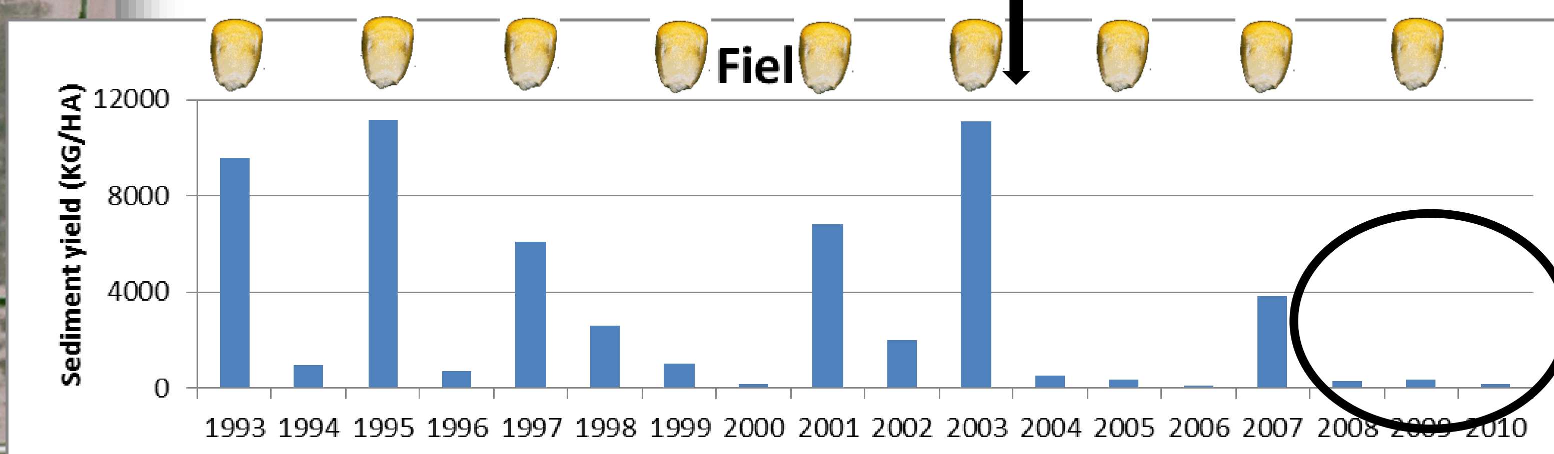




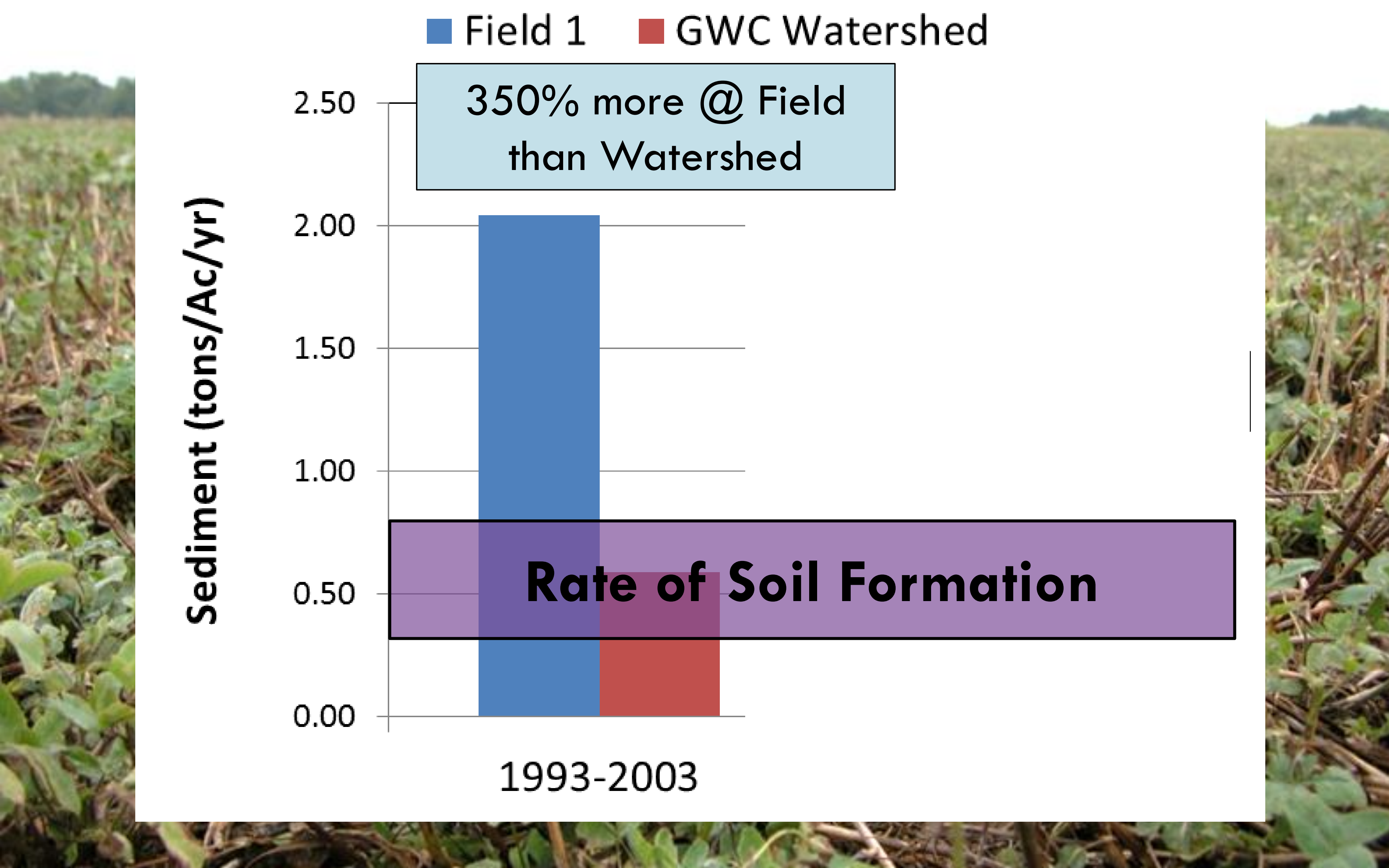


Conventional

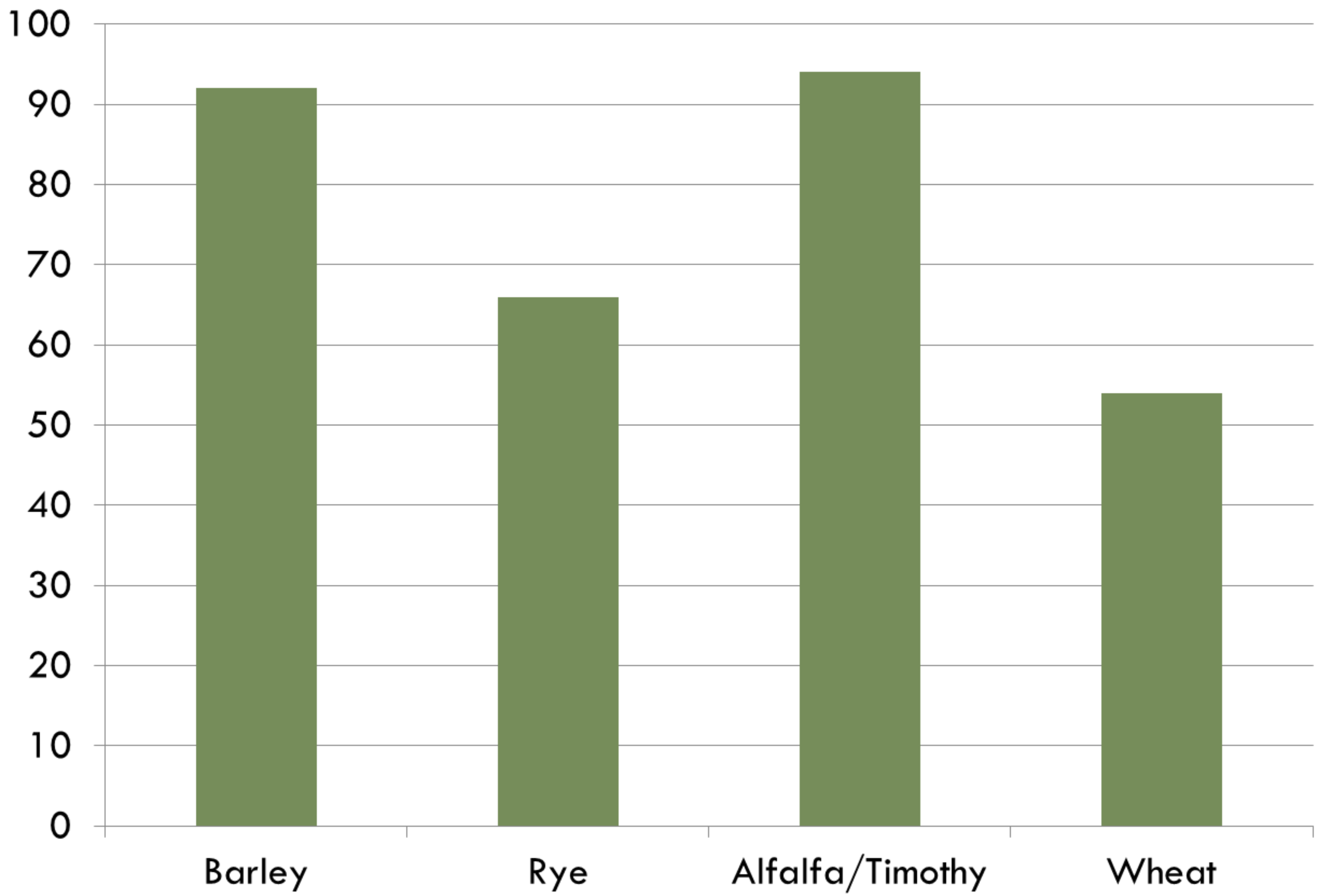
PAS with No-till and CC



Average Annual Sediment Loss



Percent Reduction in Phosphorus in Runoff
(summary of studies; Sharpley and Smith; 1991)



Summary of Typical Positive Impacts Attributed to Cover Crops

1. Greatly reduced erosion
2. **Increased soil organic matter**

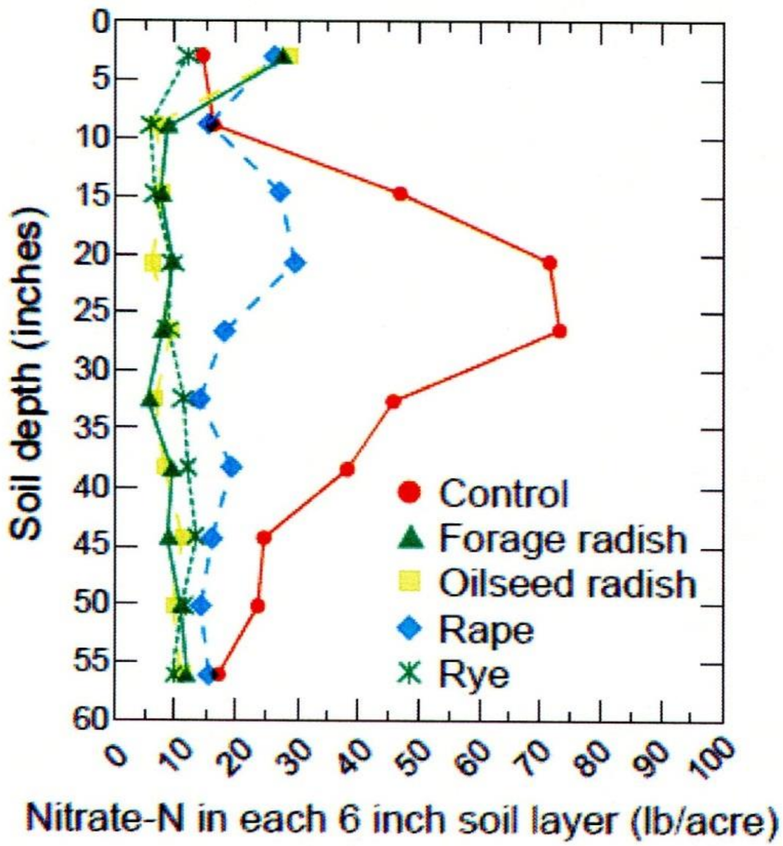
Role of Organic Matter on Nutrients

- Organic matter is a reservoir of nutrients that can be released to the soil.
- Each percent of organic matter in the soil releases ~20 to 30 pounds of N, ~4 to 6 pounds of P_2O_5, and ~2 to 3 pounds of sulfur per year.
- The nutrient release occurs predominantly in the spring and summer, so summer crops benefit more from organic-matter mineralization than winter crops.

Summary of Typical Positive Impacts Attributed to Cover Crops

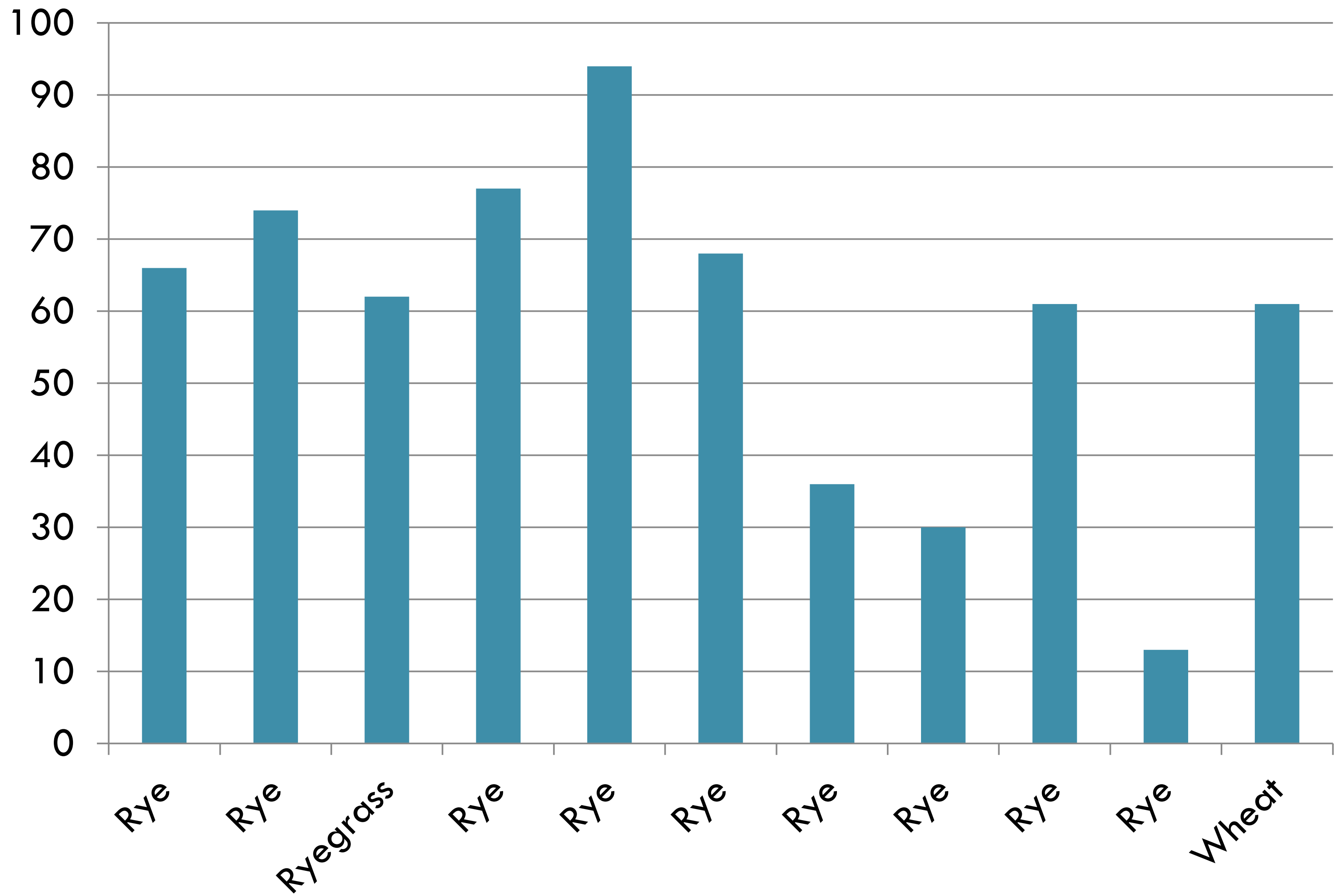
1. Greatly reduced erosion
2. Increased soil organic matter
3. **Recycle nutrients**

Radish and Rye Capture Nitrate-N in the Soil Profile



Forage radish and other cover crops clean up nitrate from a sandy soil profile by mid-November. Control soil had no cover crop, only winter weeds. (Data from Dean and Weil, 2009)

Percent Reduction in Nitrate Leaching (summary of studies; Meisinger et al., 1991)



Cost to Remediate Nitrate Losses

(Gulf Hypoxia and Local Water Quality Concerns Workshop, 2005)

Practice	Range of N removed (lb N /acre)	Cost ($ per lb of N)
Constructed Wetlands	?	> $2.00
Controlled Drainage	Up to 30%	$1.40 - $2.00
Buffers and Filter Strips	10- 20	$0.60 – $0.40
Conservation Tillage	10-20	$0.38 - $1.11
Cover Crops	20 - 45	$0.57-$1.42

COVER CROPS EFFECTS ON NUTRIENT CYCLING AND FERTILIZER RECOMMENDATIONS

- "Cover Crops: Grow your own fertilizer"
- "Cut fertilizer costs" with cover crops
- "Cover crops help farmers produce own fertilizer"

Summary of Typical Positive Impacts Attributed to Cover Crops

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2. Increased soil organic matter
3. Recycle nutrients
4. **Fix N with legumes**

Chart 2 **PERFORMANCE AND ROLES**

LEGUMES

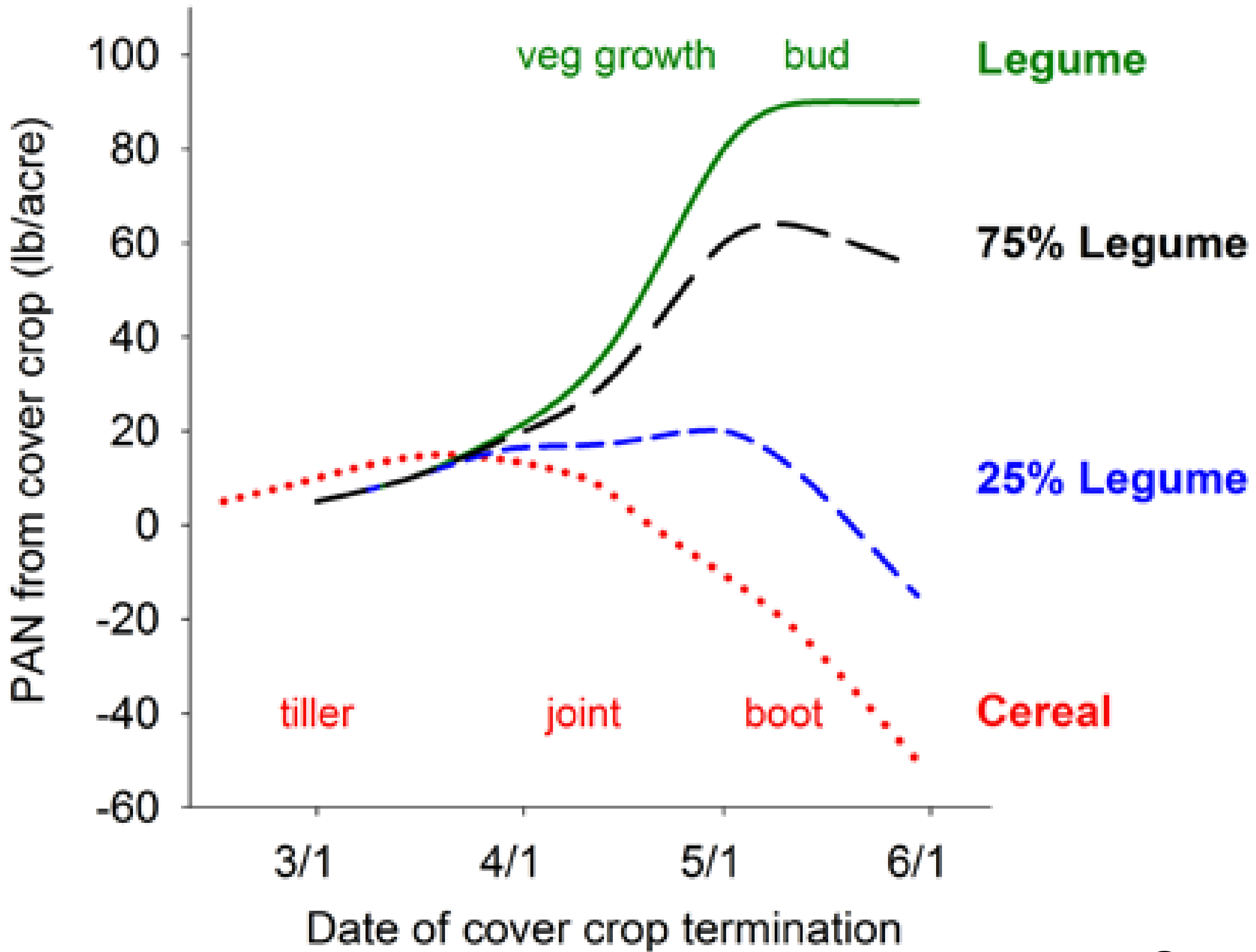
Species	Legume N Source	Total N (lb./A)[1]	Dry Matter (lb./A/yr.)	N Scavenger[2]	Soil Builder[3]	Erosion Fighter[4]	Weed Fighter	Good Grazing[5]	Quick Growth
Berseem clover *p. 118*	Excellent	75–220	6,000–10,000	Very Good	Very Good	Very Good	Excellent	Excellent	Excellent
Cowpeas *p. 125*	Excellent	100–150	2,500–4,500	Fair	Good	Excellent	Excellent	Good	Very Good
Crimson clover *p. 130*	Very Good	70–130	3,500–5,500	Good	Very Good	Very Good	Very Good	Excellent	Good
Field peas *p. 135*	Excellent	90–150	4,000–5,000	Fair	Good	Very Good	Good	Very Good	Very Good
Hairy vetch *p. 142*	Excellent	90–200	2,300–5,000	Fair	Very Good	Good	Good	Good	Fair
Medics *p. 152*	Good	50–120	1,500–4,000	Fair	Good	Good	Very Good	Very Good	Excellent
Red clover *p. 159*	Very Good	70–150	2,000–5,000	Good	Very Good	Good	Very Good	Excellent	Fair
Subterranean clovers *p. 164*	Excellent	75–200	3,000–8,500	Fair	Very Good	Very Good	Excellent	Very Good	Good
Sweetclovers *p. 171*	Excellent	90–170	3,000–5,000	Fair	Excellent	Very Good	Very Good	Very Good	Good
White clover *p. 179*	Excellent	80–200	2,000–6,000	Fair	Good	Very Good	Very Good	Excellent	Fair
Woollypod vetch *p. 185*	Excellent	100–250	4,000–8,000	Good	Excellent	Good	Excellent	Good	Very Good

[1]**Total N**—Total N from all plant. Grasses not considered N source. [2]**N Scavenger**—Ability to take up/store excess nitrogen. [3]**Soil Builder**—Organic matter yield and soil structure improvement. [4]**Erosion Fighter**—Soil-holding ability of roots and total plant. [5]**Good Grazing**—Production, nutritional quality and palatability. Feeding pure legumes can cause bloat.

○=Poor; ◔=Fair; ◑=Good; ◕=Very Good; ●=Excellent

Managing Cover Crops Profitably, SARE

Cover Crop and Kill Date on Plant Available Nitrogen



Source: D. Sullivan.

Soil Quality

Soil Management Assessment Framework (SMAF)

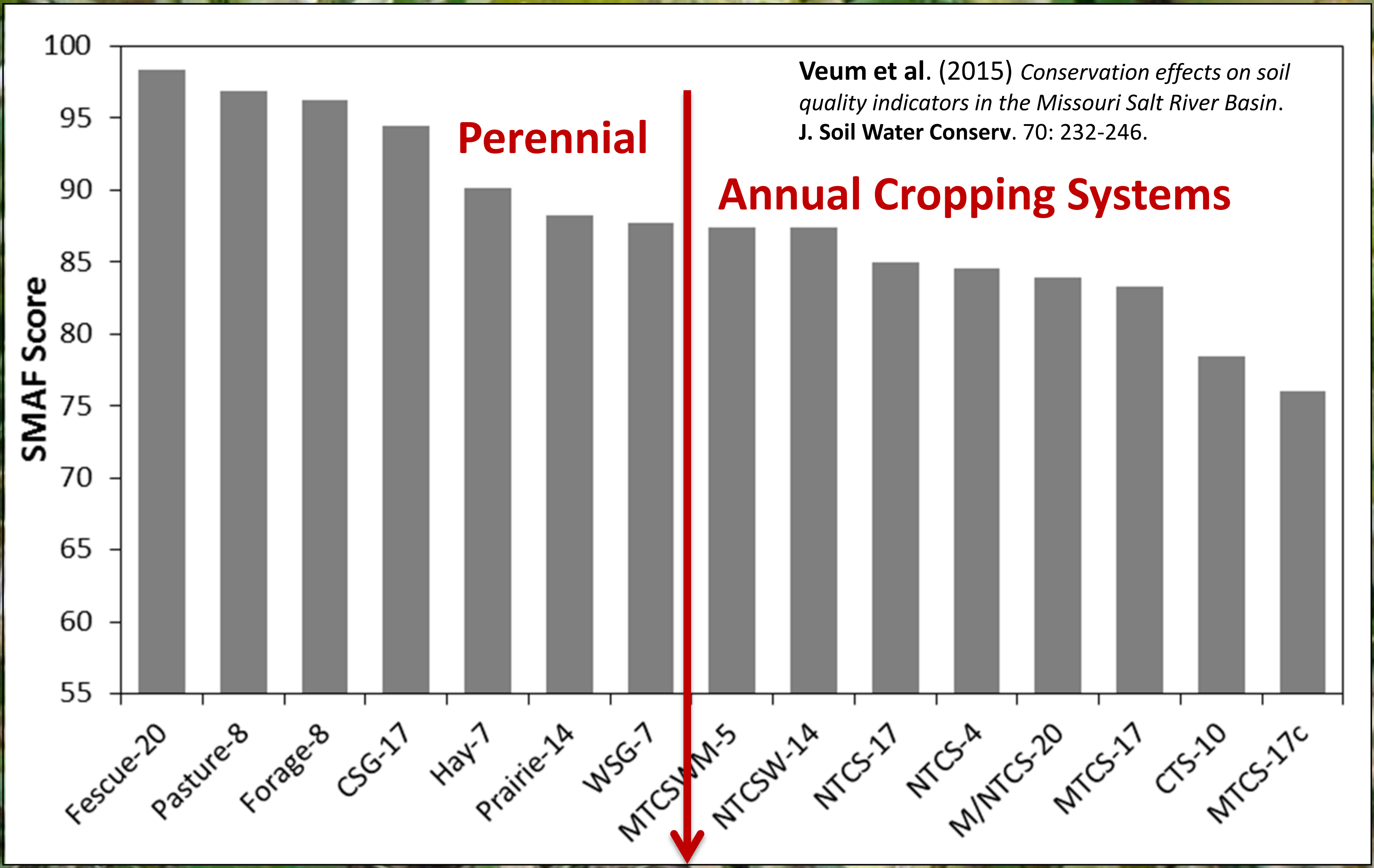
Physical Score
- bulk density
- water-filled pore space
- water-stable aggregates

Biological Score
- organic C
- B-glucosidase
- microbial C
- mineralizable N

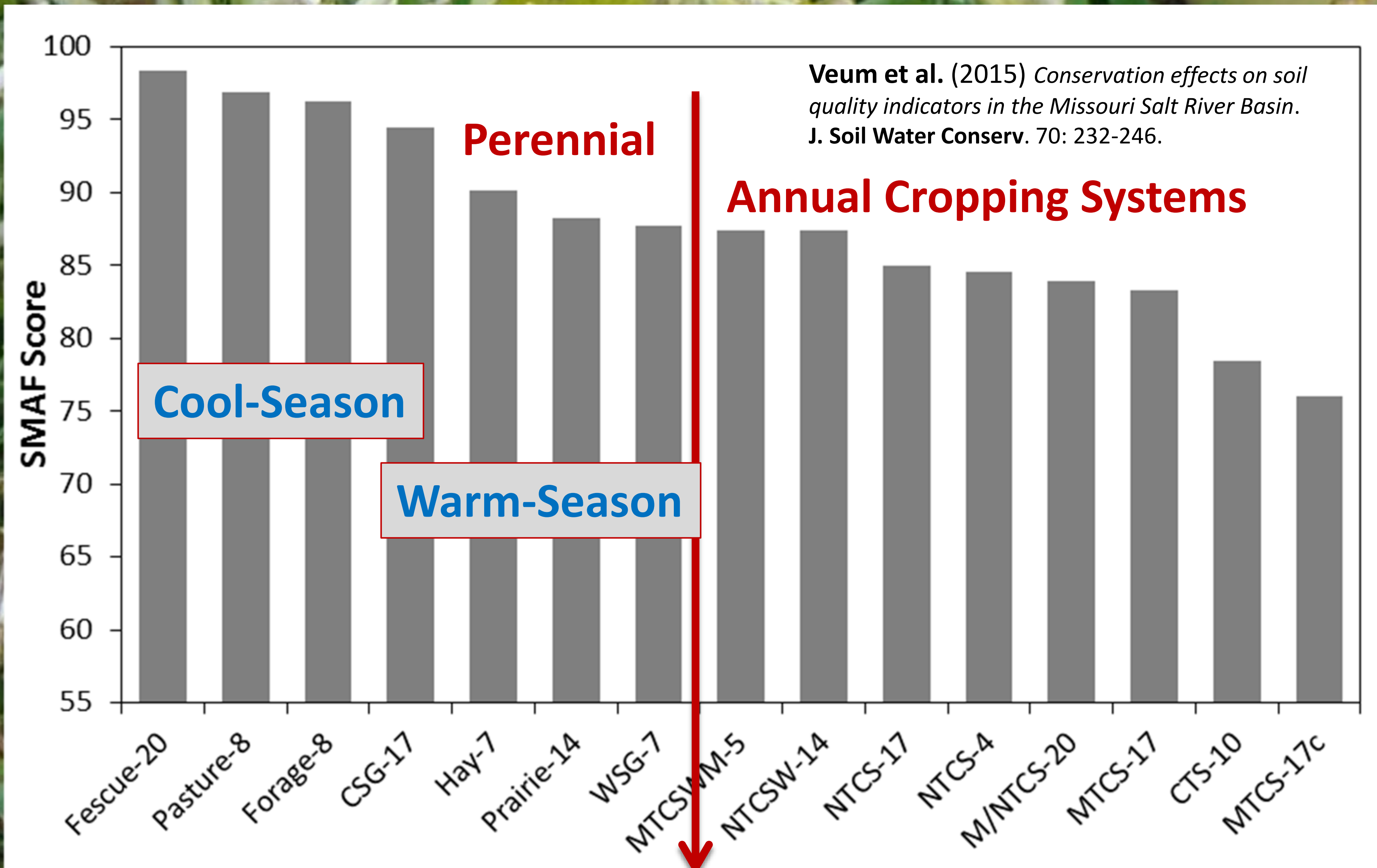
Chemical Score
- pH
- electrical conductivity

Nutrient Score
- extractable P
- extractable K

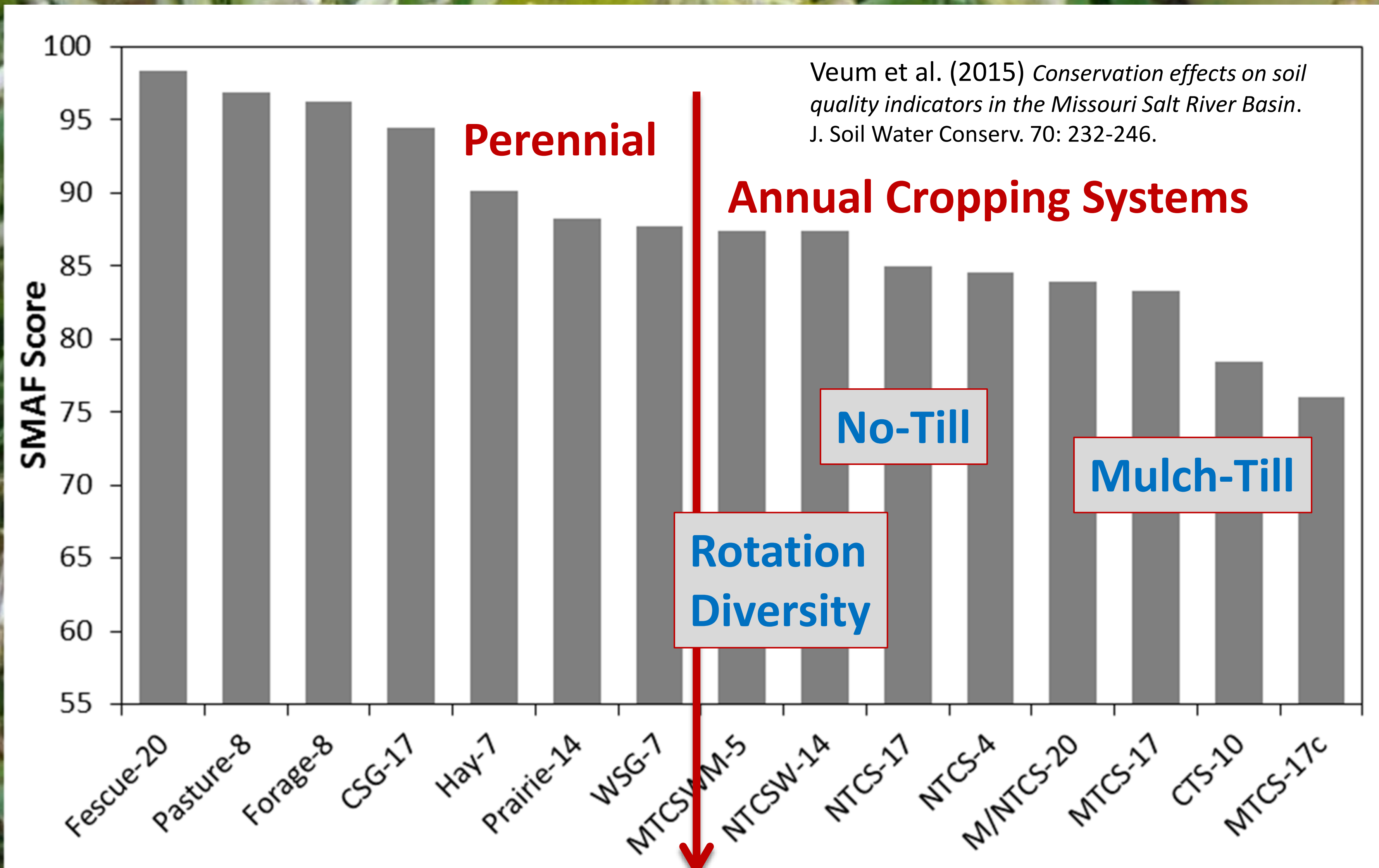
Centralia 2008 SMAF Scores



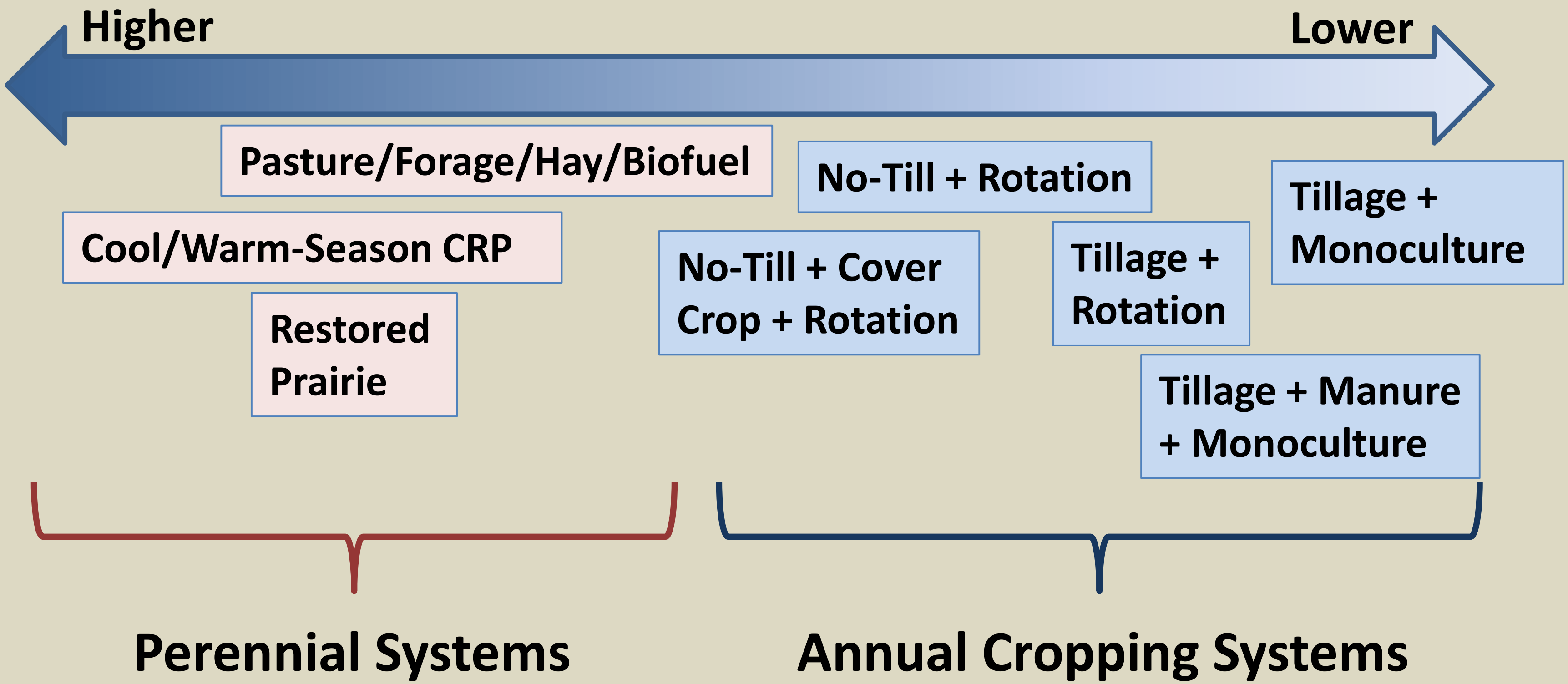
Centralia 2008 SMAF Scores



Centralia 2008 SMAF Scores



Agricultural Continuum of Soil Health



Veum KS, Goyne KW, Kremer RJ, Miles RJ, Sudduth KA (2014) Biological indicators of soil quality and soil organic matter characteristics in an agricultural management continuum. **Biogeochemistry**

Veum KS, Kremer RJ, Sudduth KA, Kitchen NR, Lerch RN, Baffaut C, Stott DE, Karlen DL, Sadler EJ (2015) Conservation effects on soil quality indicators in the Missouri Salt River Basin. **J. Soil Water Conserv.**

SMAF Total Score (0-5 cm)

P

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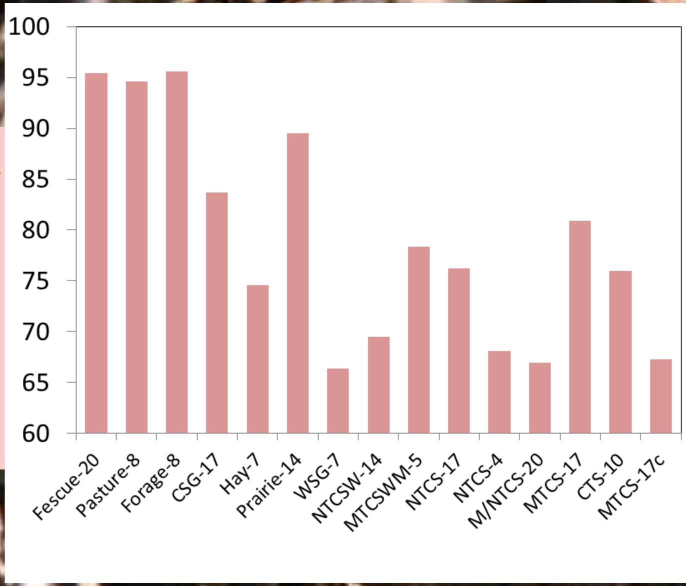

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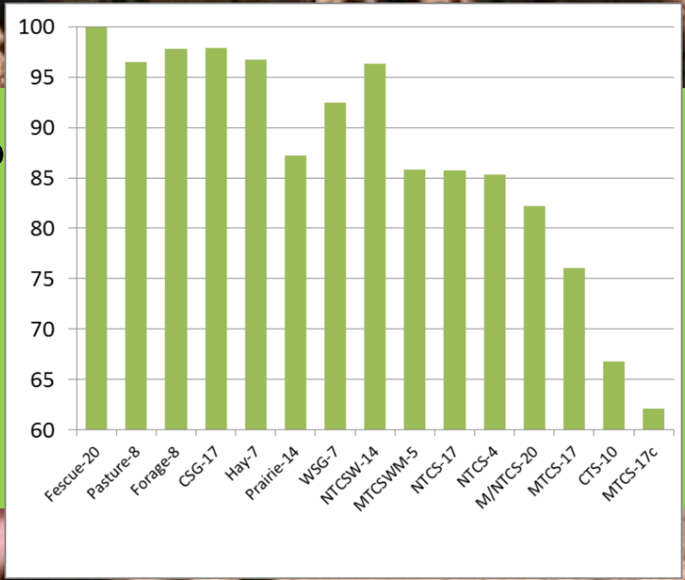

C

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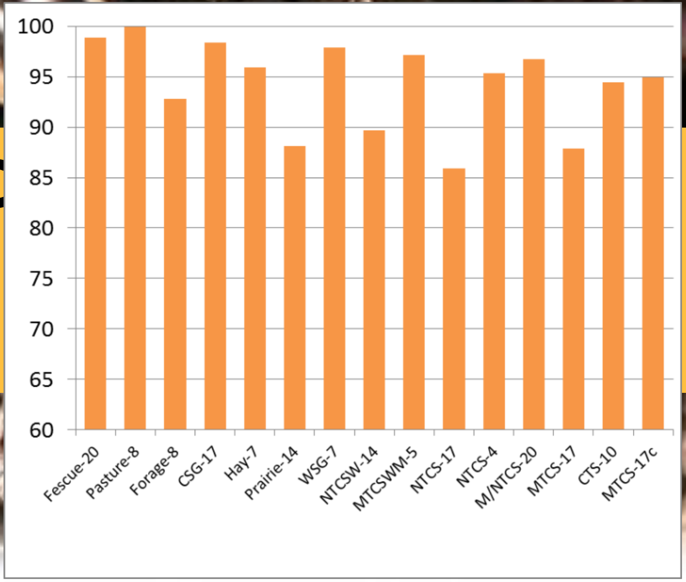

N

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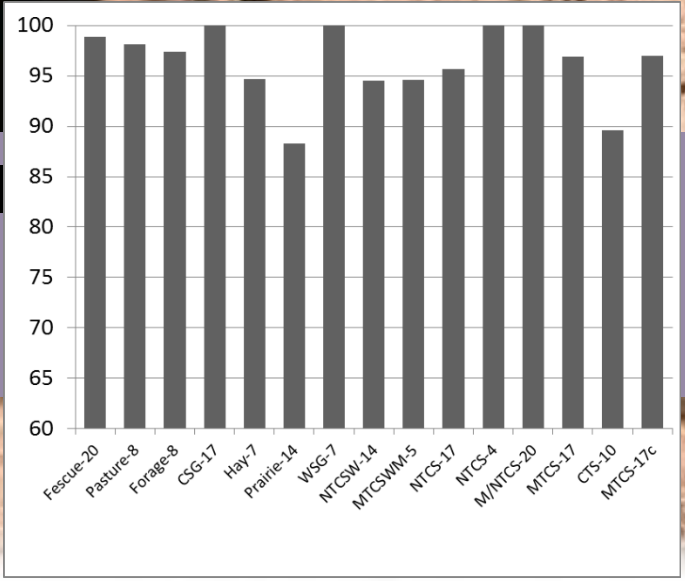


"While the chemistry (and physics) of the soil system provides the context. . . it is the ***soil biota*** which is ***adaptive*** to changes in environmental circumstances"

-Kibblewhite et al. 2008

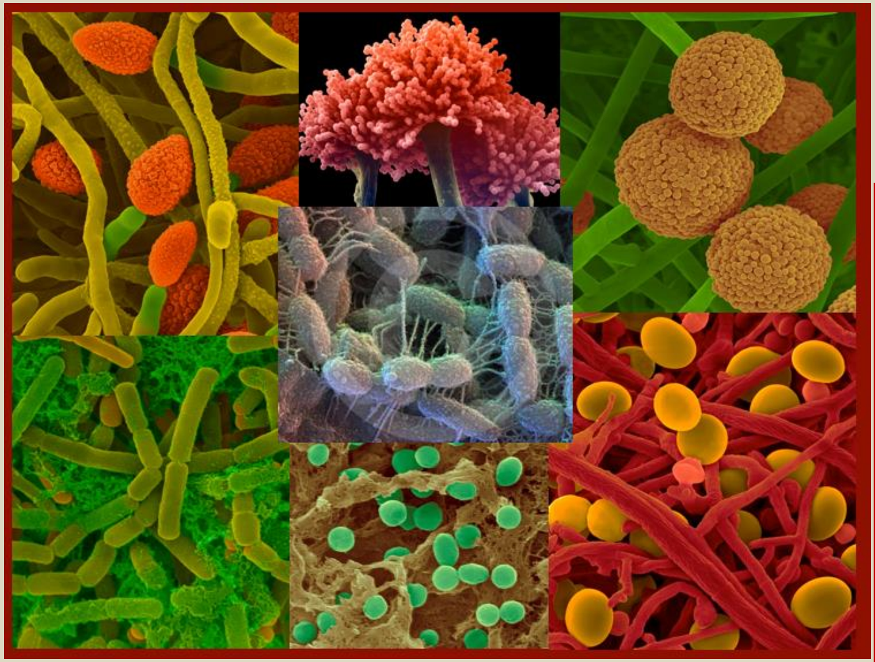


Image: piremongolia.wordpress.com

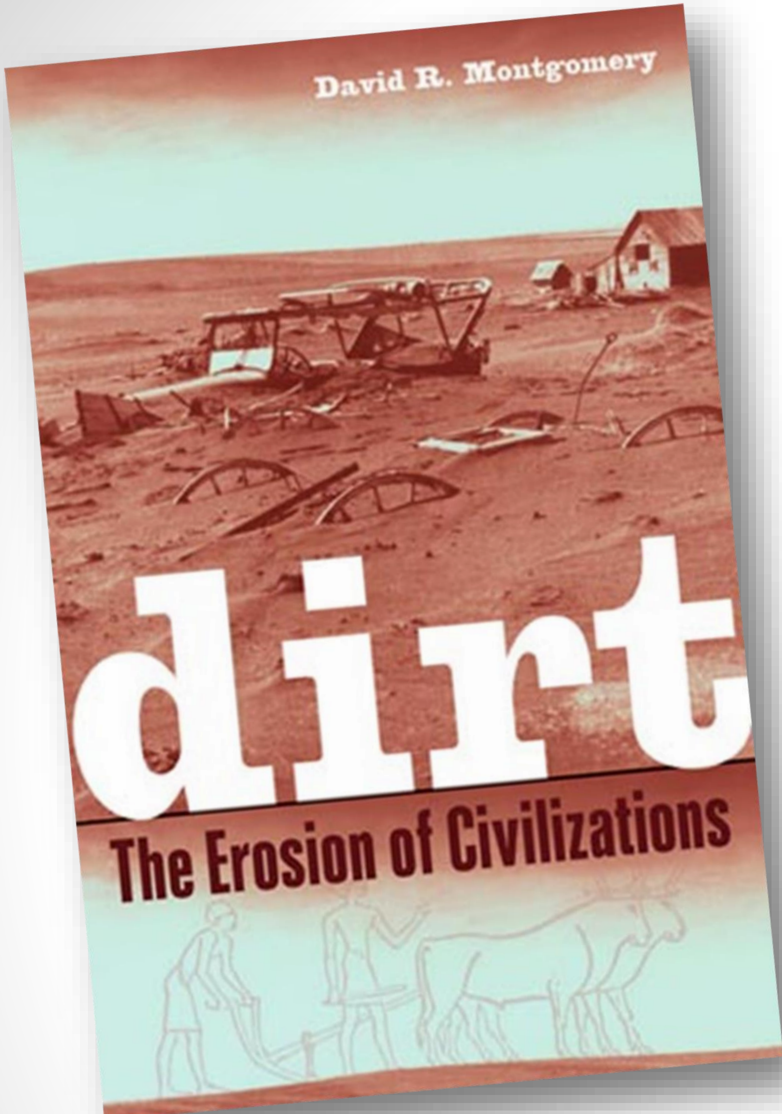
Image: eusoils.jrc.ec.europa.eu

What risks are associated with cover crops?

Downside Risks	Opportunity Costs
Planted when time and labor is limited	Reduce soil erosion, nutrient loss, and increase residue cover
Addition costs (planting and killing)	Increased water infiltration
Reduced or increased soil moisture effects depending on weather or management	Increased soil organic carbon
Difficult to incorporate cover crops with tillage	Improved soil physical properties/reduced soil compaction and improved field trafficability
May increase disease risks	Recycle nutrients, fix nitrogen with legumes
May increase insect pests	Improve weed control, beneficial insects, disease suppression
Allelopathic effects	Wildlife habitat and landscape aesthetics

CAN I NOT AFFORD TO DO COVER CROPS?

(short- and long-term cost and benefits)



"How might we rethink the conventional wisdom of conventional agriculture to find a way to work with nature?"

Stop "trying to make soil *adapt* to our technology."

Use innovation and technology to *adapt* to how we manage soils.

Questions…..