USDA Midwest Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

Re-Carbonizing Row Crop Ag Lands:

Evidence-based management strategies to increase soil carbon and promote financial resilience for farmers.

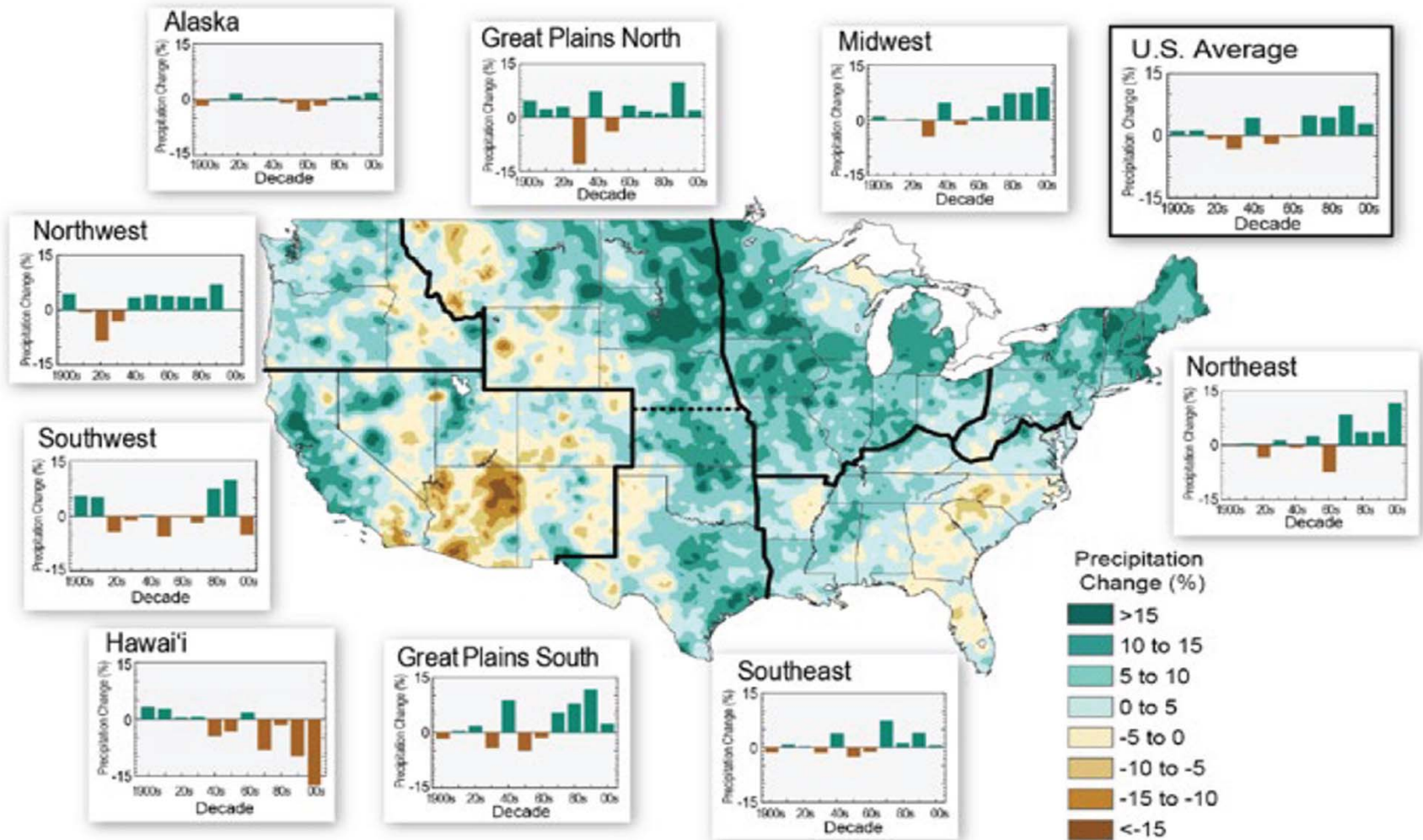**2019 NRCS Midwest Climate Hub Liaison: Justin Mount**

Concepts and Considerations:

➢ View observed and predicted rainfall variability

➢ Establish attributes and functions of productive soils

➢ Explain Soil Condition Index (SCI)

➢ Integrated Erosion Tool (IET) conservation planning workflows
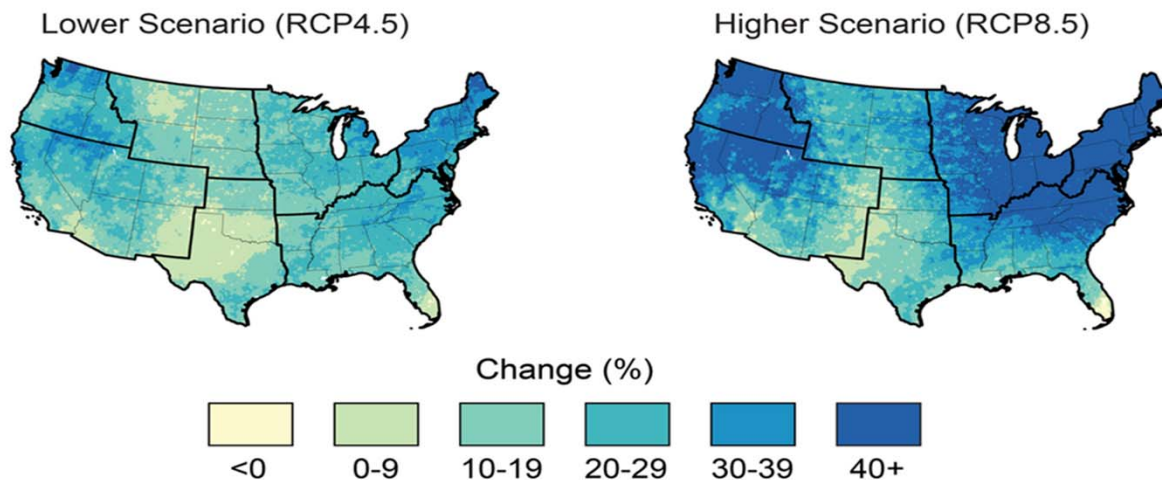
➢ Discuss IET Report and intended use

Observed U.S. Precipitation Change

Observed Change in Total Annual Precipitation Falling in the Heaviest 1% of Events

1901–2016

NA, 22, 35, 38, 42, −2, 24, 18, NA, NA

1958–2016

16, 9, 29, 55, 42, 10, 12, 27, −11, −12
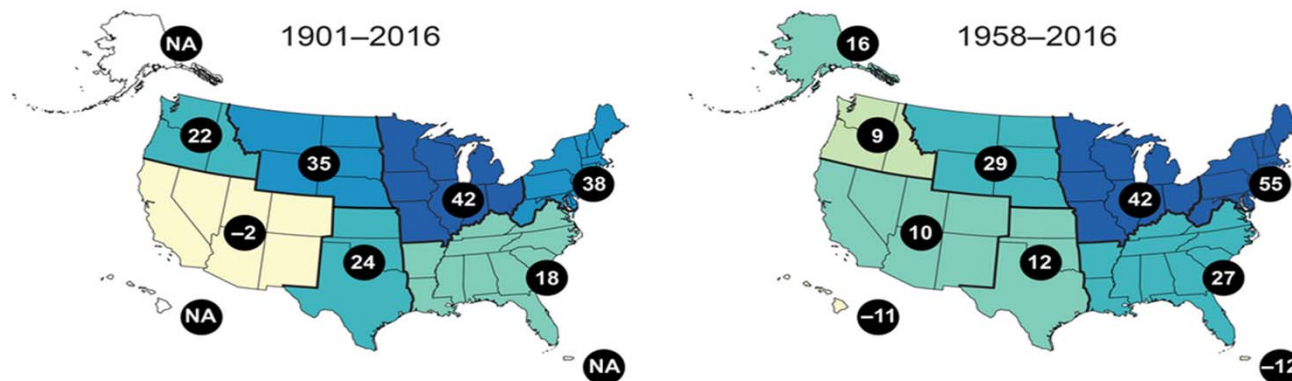
Projected Change in Total Annual Precipitation Falling in the Heaviest 1% of Events by Late 21st Century

Lower Scenario (RCP4.5)

Higher Scenario (RCP8.5)

Change (%)

<0	0-9	10-19	20-29	30-39	40+

https://nca2018.globalchange.gov/

Summer Precip. data - Iowa

Iowa, Precipitation, June-August

Binomial Filter | 1895-2016 Trend +0.20"/Decade | 1901-2000 Mean: 12.33" | Precip
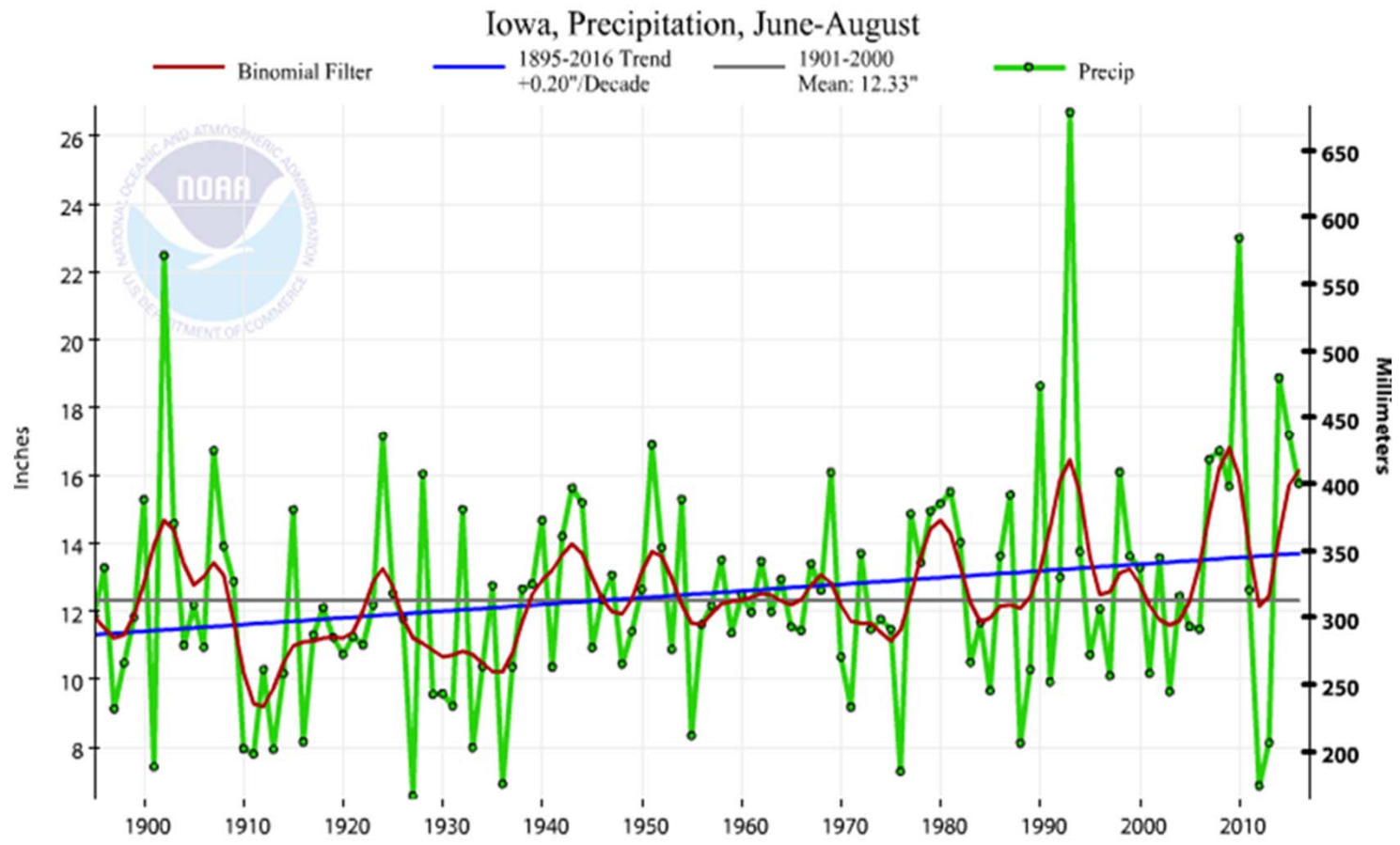
Soil Water Reserves for Crops

Silt Loam Soil

Days of Available Soil Water vs. Organic Matter (%)
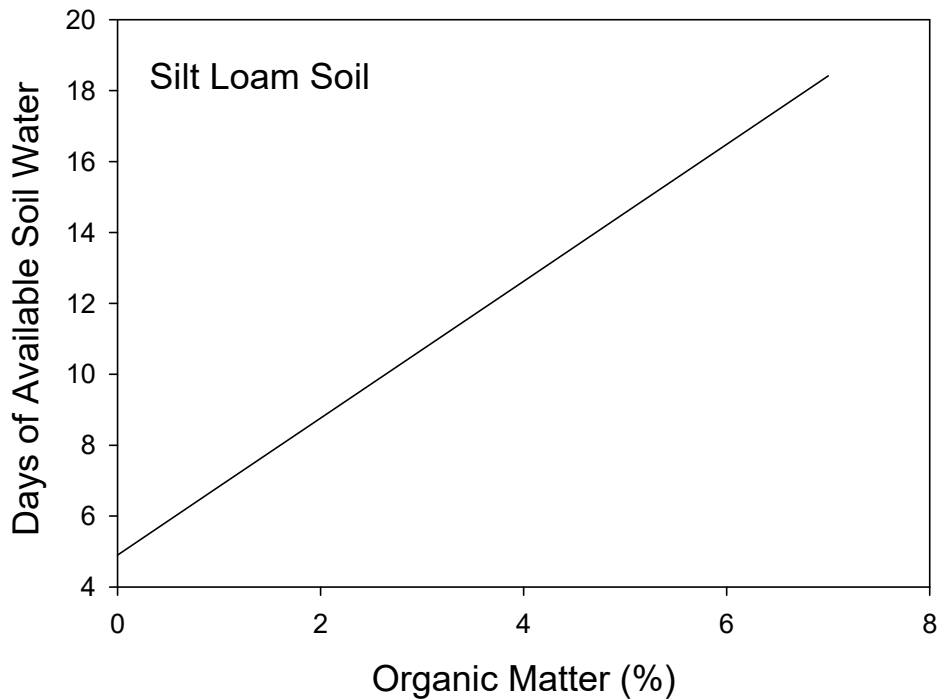
Assuming an average rate of crop water use during the grain-filling period for corn   Hudson, 1994

Available Water Content (%) vs. Organic Matter (%)

- ● Data Points
- — Sand, AWC = 3.8 + 2.2 OM
- ■ Silt Loam, AWC = 9.2 + 3.7 OM
- ▲ Silty clay loam, AWC = 6.3 + 2.8 OM
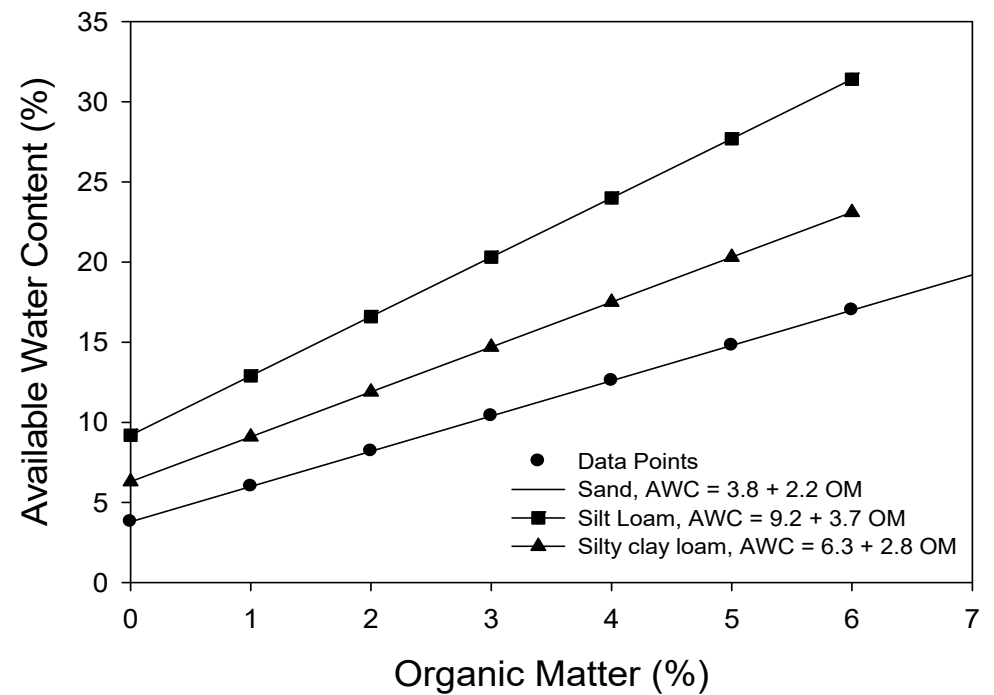
Crop System considerations resulting from intensified and varied precipitation events

- Precipitation variability:
  - ✓ spatially (locality)
  - ✓ temporally > precip intensity in off-season
  - ✓ More weather events resulting in excessive soil loss
- Increased nutrient loss likelihood
  - ✓ Leaching
  - ✓ Runoff
  - ✓ Surface Manure applications moving offsite
  - ✓ Atmospheric release (denitrification)

- Crop protection chemicals:
  - ✓ efficacy adjustments
  - ✓ movement and impacts offsite
- Increased need for drainage (surface and subsurface)
- Field days reduced:
  - ✓ Field pre-plant preparations
  - ✓ Planting
  - ✓ Crop nutrient and protection operations
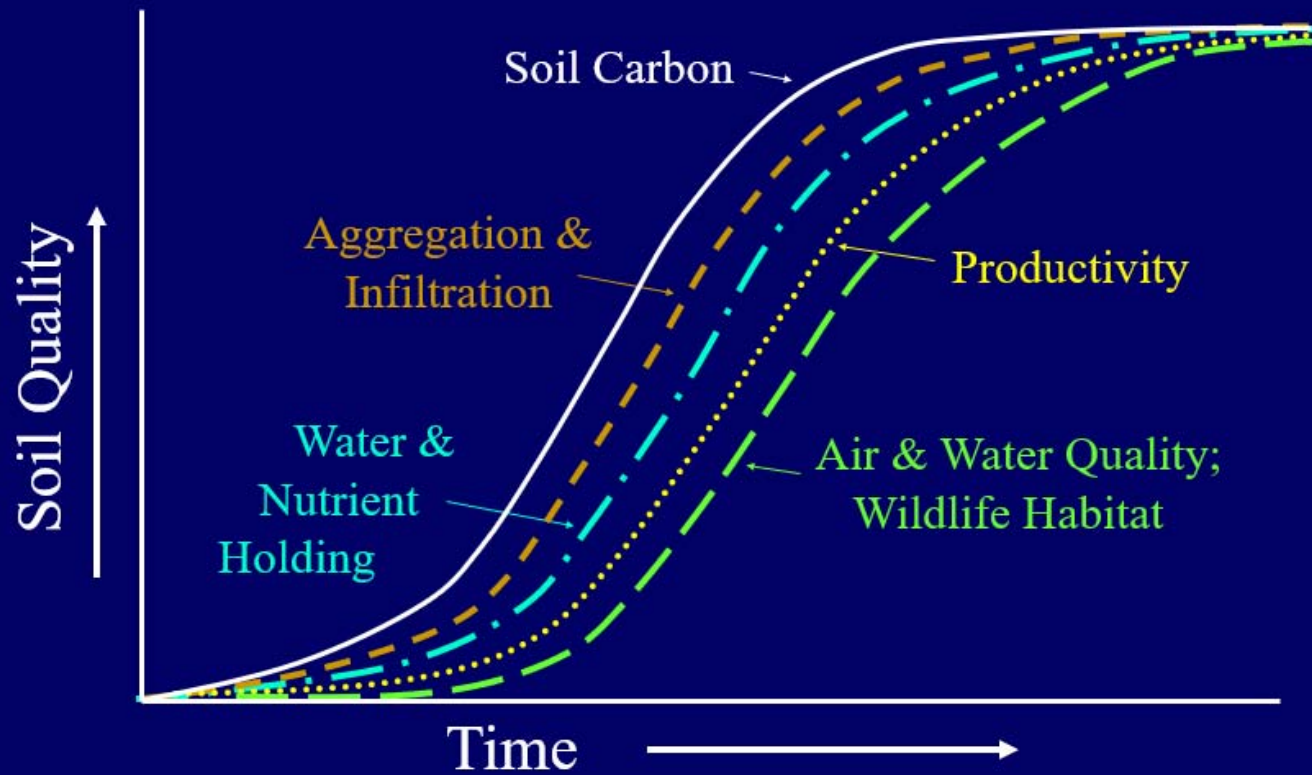 - ✓ Harvest
  - ✓ Cover crop planting

Average Loss of Soil Carbon in Corn Belt (mollisol)

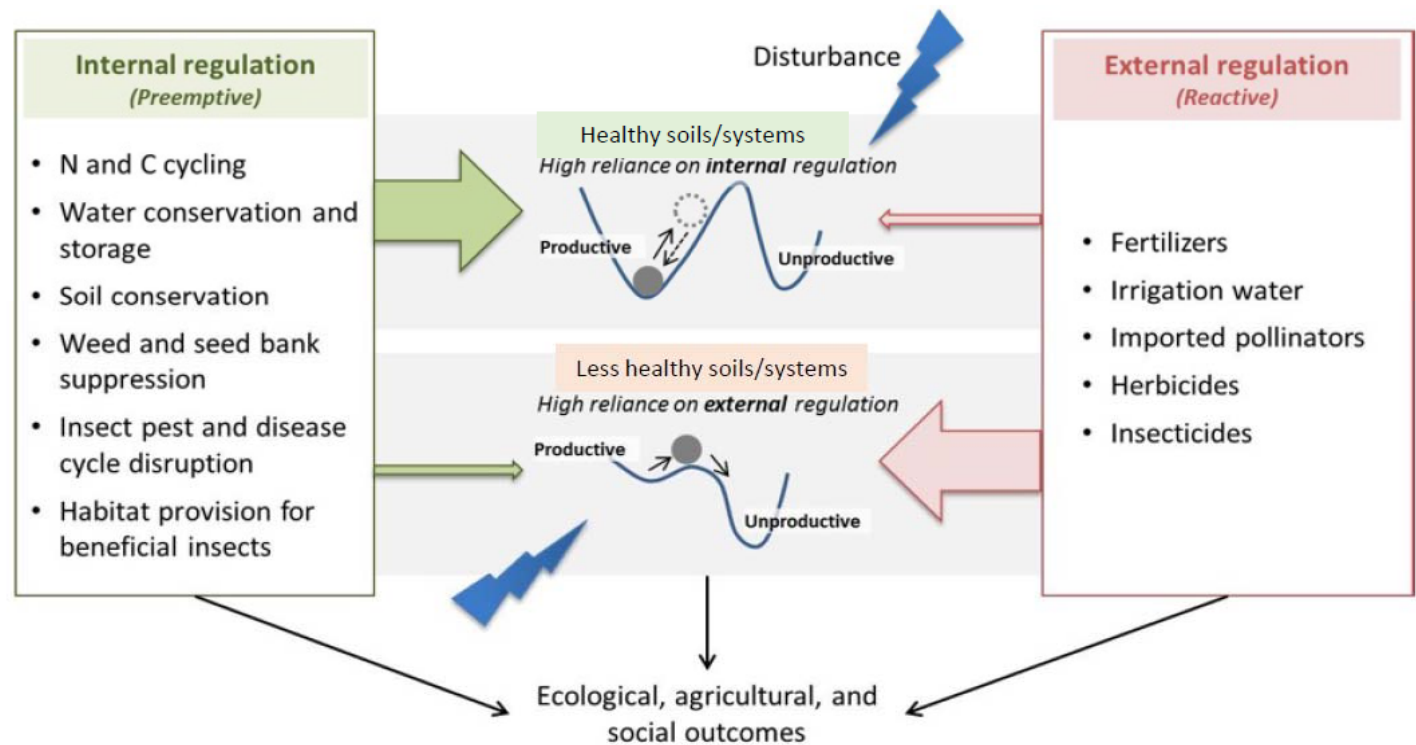Conventional Tillage

Reduced Tillage

61% of 1907

53% of 1907

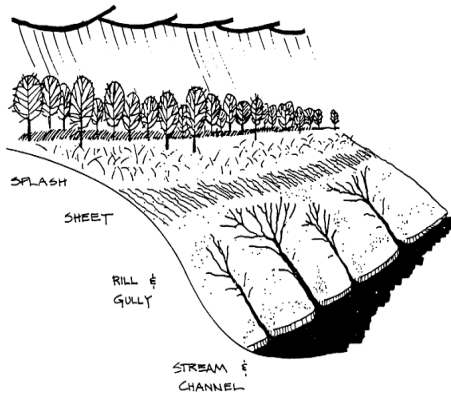Soil C (g m-2)

Year
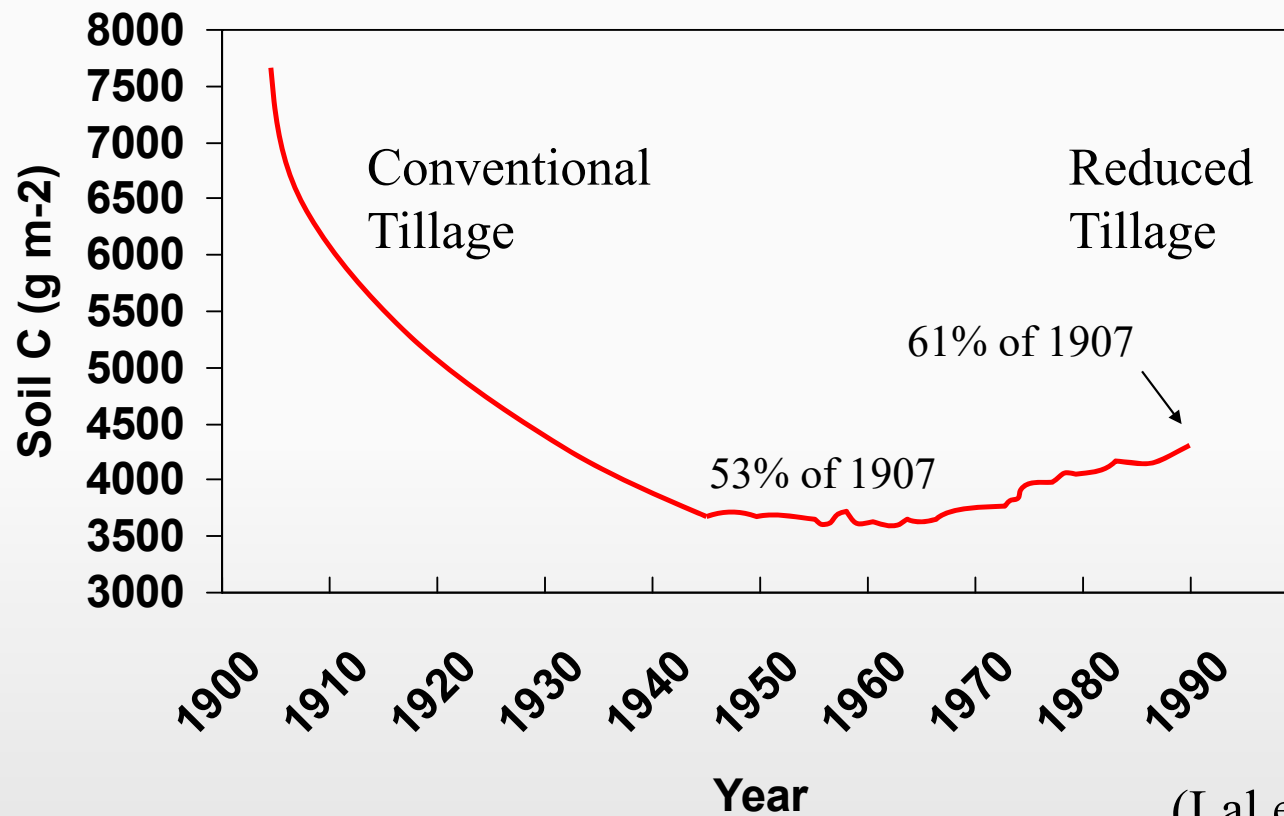
(Lal et al., 1998)

Healthy soils have a major role to play
helping boost the internal regulatory mechanisms of a system

Why should farmers and conservationists be concerned with re-carbonizing annual row crop lands?

Internal regulation
(Preemptive)

- N and C cycling
- Water conservation and storage
- Soil conservation
- Weed and seed bank suppression
- Insect pest and disease cycle disruption
- Habitat provision for beneficial insects

Disturbance

Healthy soils/systems
High reliance on internal regulation

Productive   Unproductive

Less healthy soils/systems
High reliance on external regulation

Productive   Unproductive

External regulation
(Reactive)

- Fertilizers
- Irrigation water
- Imported pollinators
- Herbicides
- Insecticides

Ecological, agricultural, and social outcomes

Peterson et al_2019_Agricultural systems

IET models both **Wind** and **Water** induced erosion

Potential Total Wind Erosion Index

Potential Sheet and Rill Erosion Index

Wind
Suspension
Saltation
Creep
Saltation

Sheet
Rills
Gullies

SPLASH
SHEET
RILL &
GULLY
STREAM &
CHANNEL
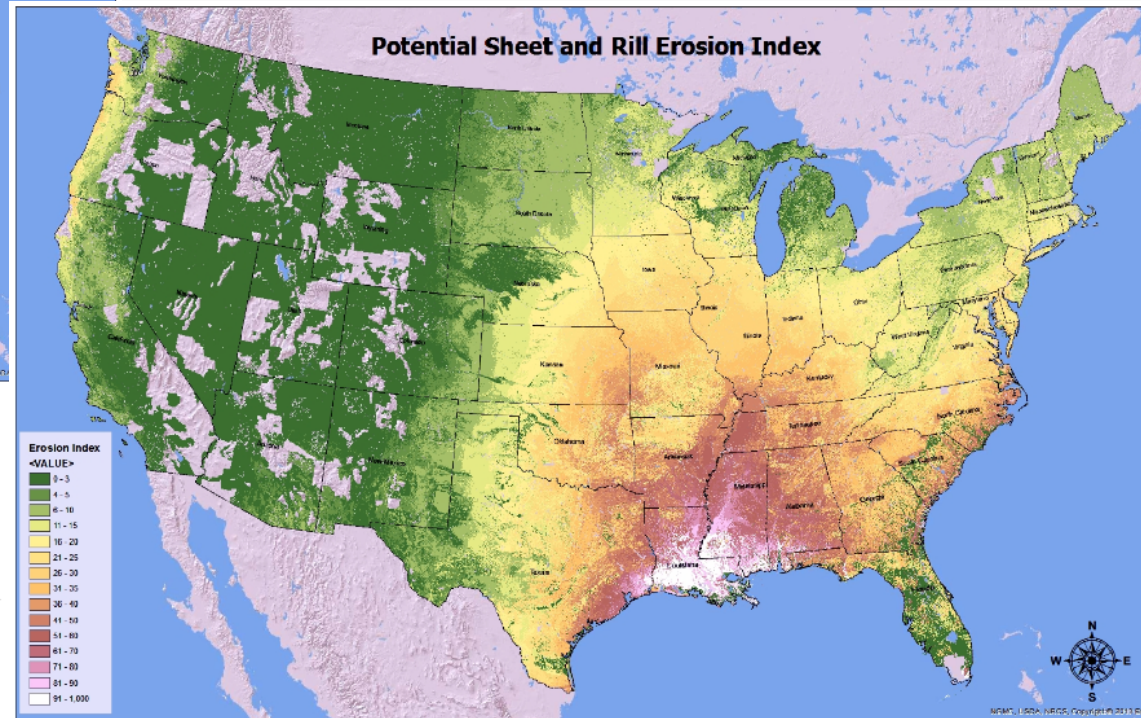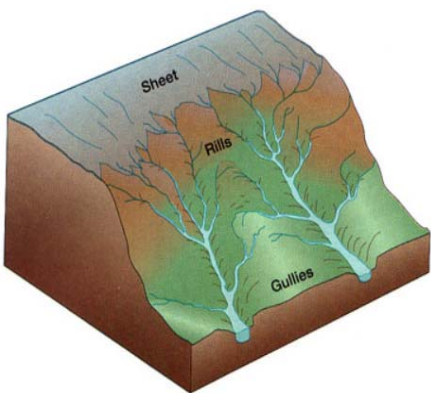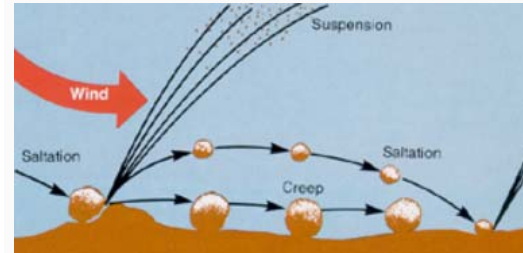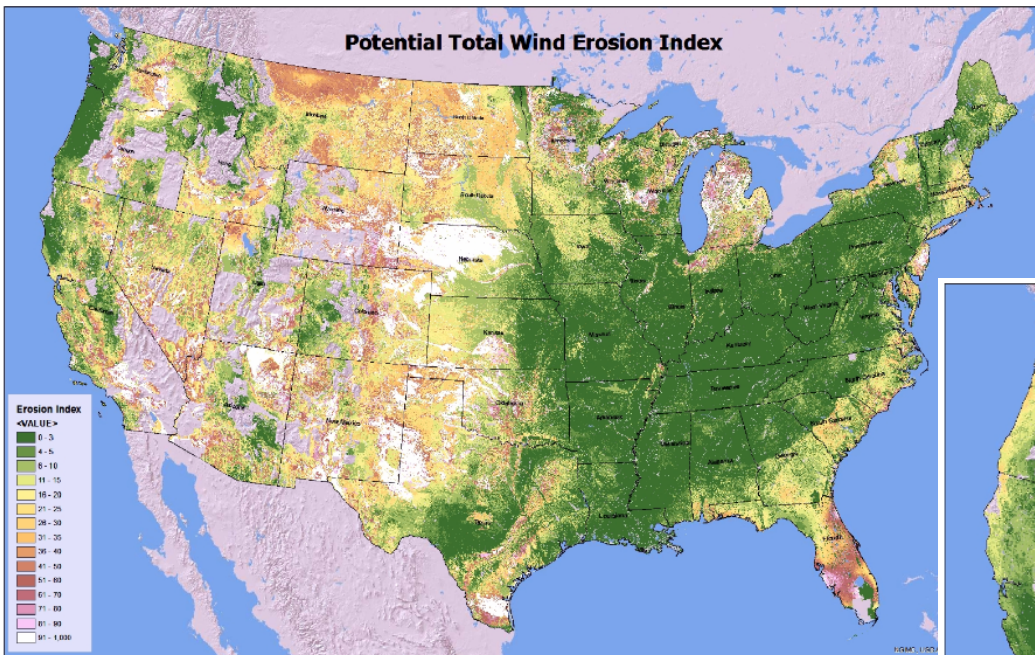
1:12,000,000

Integrated Erosion Tool (IET)

IET is a digital map-based interface designed to supply site specific and crop management data to current NRCS crop system models.
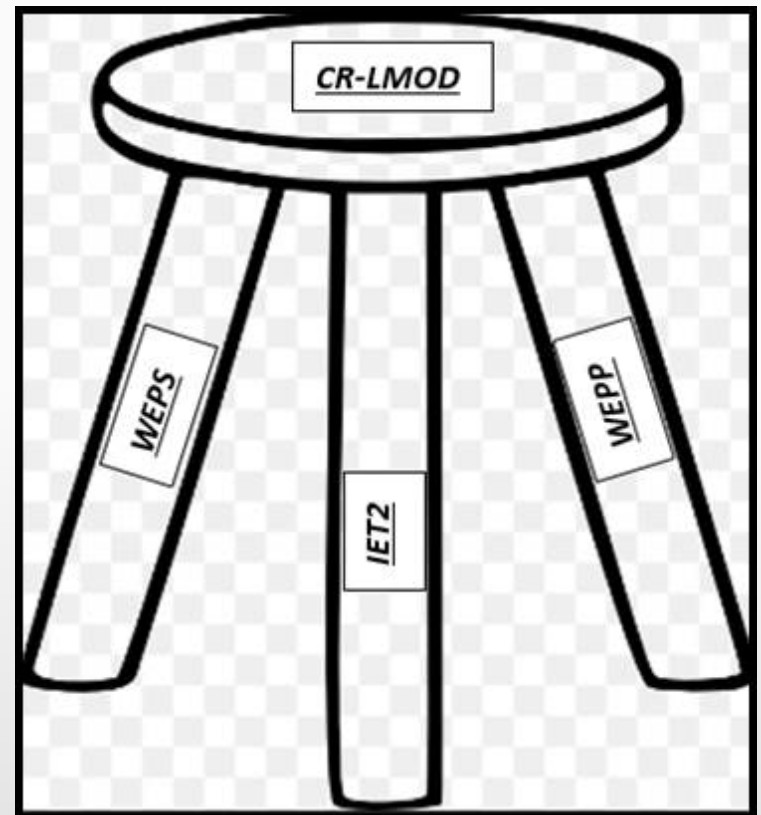
WEPP = **W**ater **E**rosion **P**rediction **P**roject

WEPS = **W**ind **E**rosion **P**rediction **S**ystem

CR LMOD = **C**onservation **R**esources **L**and **M**anagement **O**perations **D**atabase

Soil Conditioning Index (SCI) formula is:

$$(\underline{OM} \times 0.4) + (\underline{FO} \times 0.4) + (\underline{ER} \times 0.2) = SCI$$

- **<u>OM</u> accounts for <u>o</u>rganic <u>m</u>aterial returned to and grown in the soil as a function of biomass produced**

- **<u>FO</u> represents <u>f</u>ield <u>o</u>peration effects**

- **<u>ER</u> is the sorting and removal of surface soil material by sheet, rill and/or wind <u>er</u>osion**

Rotation Soil Conditioning Index (SCI):	1.1
SCI Organic Matter (OM) Factor:	1.7
SCI Field Operation (FO) Factor:	0.9
SCI Erosion (ER) Factor:	0.7

Soil Conditioning Index (SCI)

Organic Matter:
Biomass and residue additions:
- ✓ Plant roots
- ✓ Crop residue
- ✓ Manure
- ✓ Mulch

Biomass and residue removals:
- ✓ Grain removal
- ✓ Silage production
- ✓ Baling
- ✓ Grazing
- ✓ Burning

Field Operations:
- ✓ Ground / Arial
- ✓ Inversion tillage
- ✓ Horizontal tillage
- ✓ Vertical tillage
- ✓ Planting operations
- ✓ Nutrient applications
- ✓ Row Cultivation
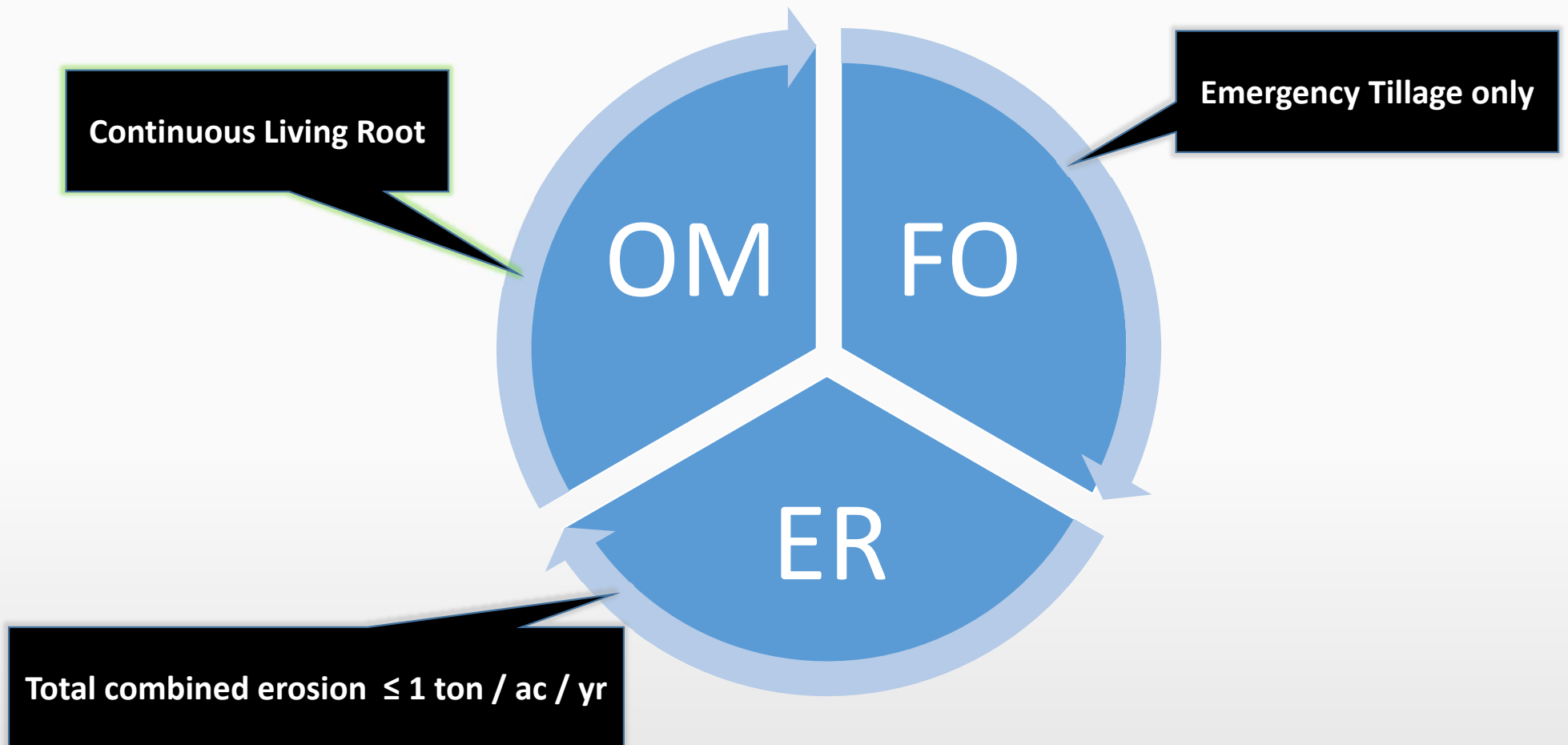- ✓ Land leveling
- ✓ Etc…

Water-induced erosion:
- ✓ Sheet erosion
- ✓ Rill erosion

Wind-induced erosion:
- ✓ Saltation,
- ✓ Creep (wind)

Monitor fields for Ephemeral and Gully Erosion.

Soil Conditioning Index (SCI) – crop management goals

Continuous Living Root

Emergency Tillage only

Total combined erosion ≤ 1 ton / ac / yr

OM   FO

ER

IET directly assesses seven NRCS resource concerns:

- ✓ Water-induced Erosion – *sheet & rill*
- ✓ Wind-induced Erosion – *saltation, suspension and creep*
- ✓ Soil Quality – *organic matter depletion*
- ✓ Water Quality & Quantity – *sediment delivery, runoff, evaporation, transpiration*
- ✓ Energy – *field operations*
- ✓ Air Quality – *particulate matter, objectionable odors, greenhouse gas precursors*
- ✓ Wildlife - Habitat – *surface residue, stem height*

Integrated Erosion Tool (IET)

◯ **Anyone with ArcMap is able to use IET**

◯ **Working towards deploying a publicly available and secure web interface for IET**

**Purposes of IET :**

Identify site factors:
- Soil
- Slope steepness
- Slope length
- Aspect
- Field shape and orientation (wind erosion)
- Barriers (wind erosion)

Document crop system management:
- Sequence and timing of field operations and crops grown
- Residue additions
- Yield for each crop
- Alternative System formulation and evaluation
- Planned system identified

Digital map informs user of sensitive areas.

Notice towns and large water bodies.
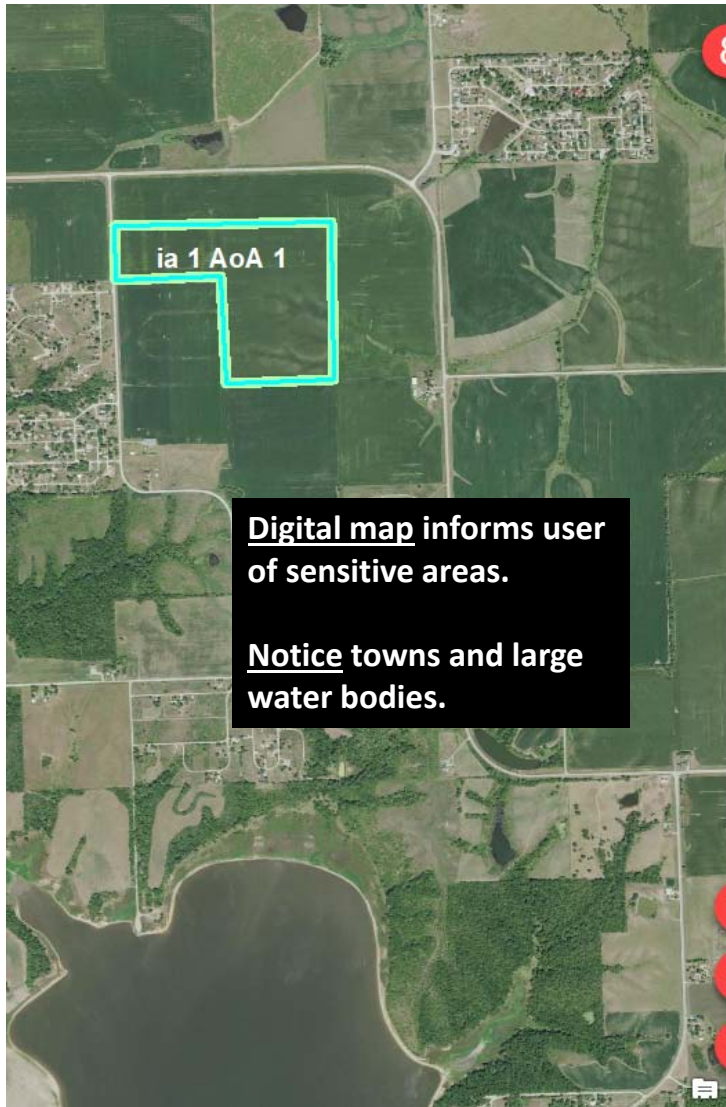
Integrated Erosion Toolkit

File   Options   Help   ia 1:AoA 1

⊘ **Soil / Climate**

This step assigns representative soil components in order to supply parameters for calculating water and wind erosion, ⓘ and when needed assigns a climate location for water erosion

Field Size (acres 120.2

Water Erosion:

MU (% AoA)	% AoA	K factor
364B	Grundy silty clay loam, 2 t ⌄	22.63	0.32

Soil Component		Rock Cover (%)
Grundy Tvalue = 5	⌄	0

Wind Erosion:

MU (%AoA)	% AoA	% Sand
362	Haig silty clay loam, 0 to 2 ⌄	61.46	8

Soil Component		Rock Cover (%)
Haig Tvalue = 5	⌄	0

Climate Location:

State
IA

County
Monroe County, Iowa

Lat / Long

② ⊘ Slope / Practice
③ ⊘ Region / Barriers
④ ⊘ Crops / Operations
⑤ ⊘ Run Simulation
⑥ ⊘ Analyze Results
⑦ ⊘ Planning Summary

IET Workflow:
Area of Analysis has been identified on digital map.

1. **Select correct soil.**
2. **Identify slope length and slope steepness.**
3. **Select field shape and set orientation.**
4. **Define timing of field operations and crop yields.**
5. **Run model simulations.**
6. **Analyze graphs (as needed)**
7. **Print planning summary**
8. **Create IET Report.**

Conservation Conversation
Engage Farmer with IET outputs to demonstrate crop system benefits of strongly positive SCI values.
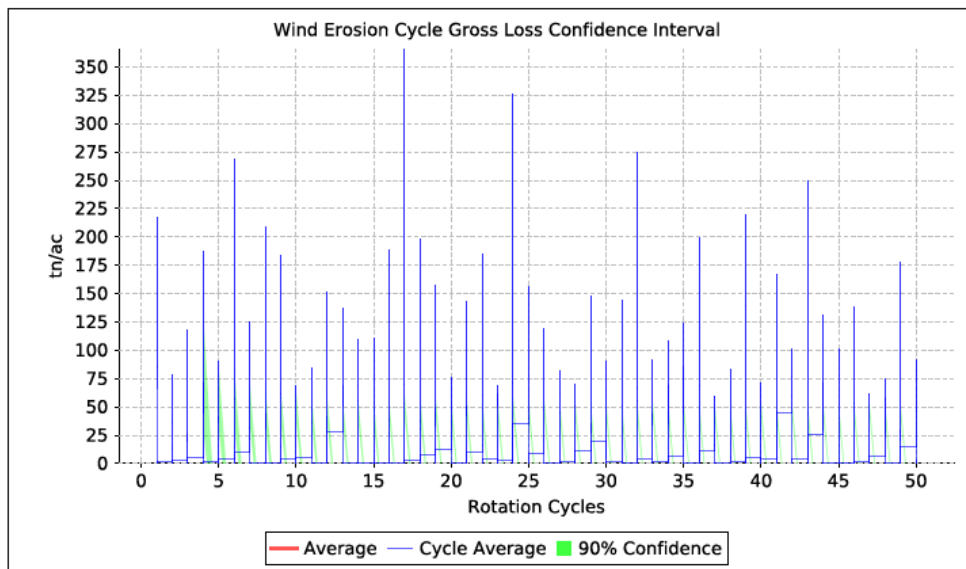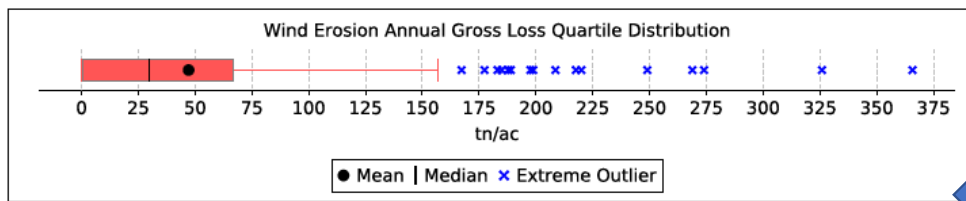
Date	Interval End	Operation	Crop	Residue	Residue (lb/ac)	Yield	Yield Unit	Row / Ridge Dir
05-10-20	☐	Sprayer, pre-emergence ⌄ ⓘ		weed residue; 0-3 mo ⌄	50			0
05-11-20	☐	Cultivator, field 6-12 in sweep ⌄ ⓘ						0
05-12-20	☐	Planter, double disk opnr ⌄ ⓘ	Soybean, grain ⌄ ⓘ			70	bu/ac	0
06-07-20	☐	Sprayer, post emergence ⌄ ⓘ		weed residue; 0-3 mo ⌄	50			0
08-01-20	☐	Sprayer, post emerge, insecti⌄ ⓘ						0
10-15-20	☑	Harvest, killing crop 20pct sta ⌄ ⓘ						0
11-01-20	☐	Fert applic. surface broadcast ⌄ ⓘ						0
04-15-21	☐	Coulter caddy, fluted coulters ⌄ ⓘ						0
05-01-21	☐	Sprayer, pre-emergence ⌄ ⓘ						0
05-01-21	☐	Planter, double disk opnr ⌄ ⓘ	Corn, grain, seed ⌄ ⓘ			220	bu/ac	0
06-02-21	☐	Fert applic. side-dress, liquid ⌄ ⓘ						0
06-07-21	☐	Sprayer, post emergence ⌄ ⓘ						
10-10-21	☑	Harvest, killing crop 50pct sta ⌄ ⓘ						
10-15-21	☐	Fert. applic. anhyd knife 30 in ⌄ ⓘ						
10-16-21	☐	Chisel plow, coulter, st. pts., c ⌄ ⓘ						
11-01-21	☐	Fert applic. surface broadcast ⌄ ⓘ						
04-15-22	☐	Cultivator, field 6-12 in sweep ⌄ ⓘ						
05-01-22	☐	Sprayer, post emergence, fert ⌄ ⓘ						
05-05-22	☐	Planter, double disk opnr ⌄ ⓘ	Corn, grain, seed ⌄ ⓘ			205	bu/ac	0
06-02-22	☐	Fert applic. side-dress, liquid ⌄ ⓘ						0
06-07-22	☐	Sprayer, post emergence ⌄ ⓘ		weed residue; 0-3 mo ⌄	50			0

Crop System Management Editor.
Ability to model over 100 crops.

Crop Year STIR Information

Number	Crop Name	STIR	Start Date	End Date
1	Corn, grain, seed	128	5/26/2018	10/20/2020
2	Soybean, grain	7	10/21/2020	10/10/2021
3	Wheat, winter, grain	46	10/11/2021	7/1/2022
4	Alfalfa, hay	117	7/2/2022	5/25/2023

Annual Segment Statistics for 100 years

Segment	Model Output	Mean	Median	Standard Deviation	Coef. Of Variation	Min	Max
Hillslope	Precipitation	41	41	6.4	0.2	27	63
Hillslope	Soil Loss	9.5	8.3	6.8	0.7	0.05	42
Hillslope	Sediment delivery	1.4	1.2	1	0.7	0.007	6.3
1	Irrigation	0	0	0	0	0	0
1	Runoff	7.5	7.1	3.4	0.5	1.2	20
1	Plant Transpiration	17	17	3.7	0.2	11	23
1	Soil Evaporation	13	13	2	0.1	8.3	18

Wind Erosion Annual Gross Loss Quartile Distribution

● Mean | Median ✕ Extreme Outlier

Wind Erosion Cycle Gross Loss Confidence Interval

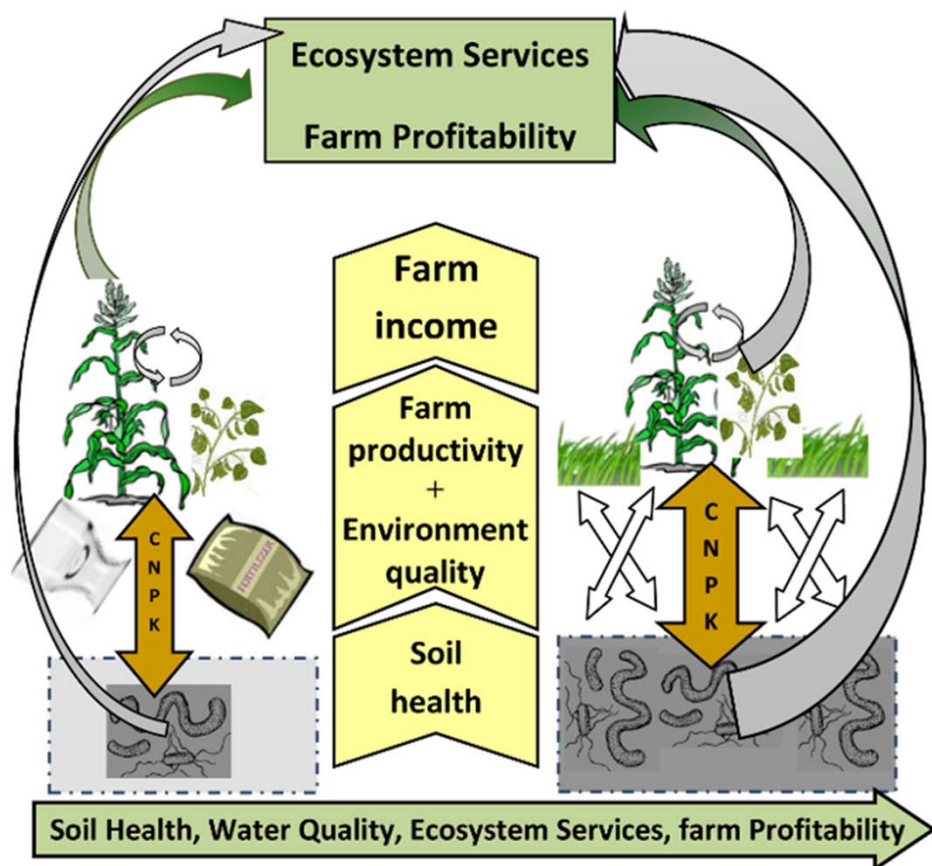— Average — Cycle Average ▮ 90% Confidence

IET Outputs

Rotation Soil Conditioning Index (SCI): 1.1

SCI Organic Matter (OM) Factor: 1.7

SCI Field Operation (FO) Factor: 0.9

SCI Erosion (ER) Factor: 0.7

Annual Soil Tillage Intensity Rating (STIR): 11

Air Particulates (PM10): 0 ton / ac / yr

Average Annual Fuel Use: 4 gal / ac / yr

Primary takeaways for SCI plus IET use and results interpretation:

✓ Quickly document crop systems for a defined location.

✓ Lower STIR = > SCI = more soil carbon > farm profit potential.

✓ Lower total erosion > SCI = better field conditions more often.

✓ More OM additions results in an improving SCI trend.

✓ Providing living roots throughout the entire year equates to better soil health

✓ SCI drives foundational soil health and solidifies a base for soil and enhance its production potential.

✓ IET model results are field specific and affected by interrelationships between multiple factors and variables.

✓ At this time, IET is <u>unable</u> to account for ephemeral and gully erosion

Economic incentives and financial resiliency benefits will encourage annual row crops farmers to prioritize increasing soil carbon.

Short term

Financial assistance provided by 2018 Farmbill programs such as:
- EQIP = Environmental Quality Incentives Program
- CSP = Conservation Stewardship Program
- RCPP = Regional Conservation Partnership Program

Long term

- ✓ Reduced crop yield variability
- ✓ Increased in plant available water
- ✓ Soil rewetting ability is magnified to capture more water during intense rainfall events
- ✓ Cleaner and fewer runoff events – healthy soil absorbs and cleans water
- ✓ Improved cycling of primary, secondary and micro nutrients
- ✓ More days open for ground engaging field activities
- ✓ Greater financial resiliency and profit stability
- ✓ Carbon Market(s), existing and emerging, participation more lucrative

IET & SCI – application to Climate Hubs

✓ IET models and creates reports for scores of annual and perennial cash crop systems.

✓ IET can be used by the public (requires ArcMap 10.3 or 10.5).

✓ Business Goal = Deploy a publicly available and secure web interface for IET.

- How much is SCI, as a foundational soil metric, a part of Climate Hub discussions?
- MCH will use IET to explain SCI to promote engagement with Certified Crop Advisors (CCAs) by offering Continuing Education Units (CEUs).
- Accelerate adoption of cover crops through technology transfer, include Ag Retailers and frontline agronomists.
- Promote the value of soil carbon (SCI) as a financial resiliency toolset for crop farmers.

❖ Is this SCI & IET presentation able to support your Climate Hub outreach efforts?

- ❑ **Comments**
- ❑ **Observations**
- ❑ **Questions**
- ❑ **Suggestions**
- ❑ **Constructive feedback**

Provide Continuous Living Roots

Minimize Disturbance

Maximize Biodiversity

Maximize Soil Cover

Image by CCSI, 2014