Why it is important for agriculture

THE SCIENCE OF SOIL HEALTH

CONTACT INFORMATION

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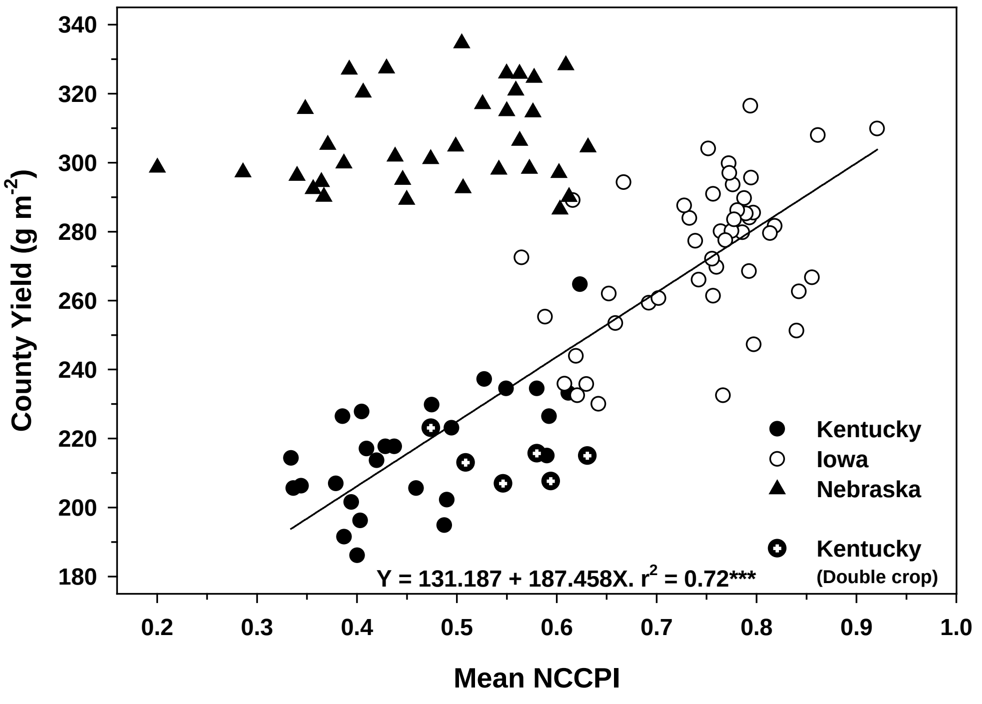
OUTLINE

- Why is soil health important?
- Soil degradation
- Soil enhancement
- How do cover crops fit into the picture
- Future demands of agriculture

WHY IS SOIL HEALTH IMPORTANT?

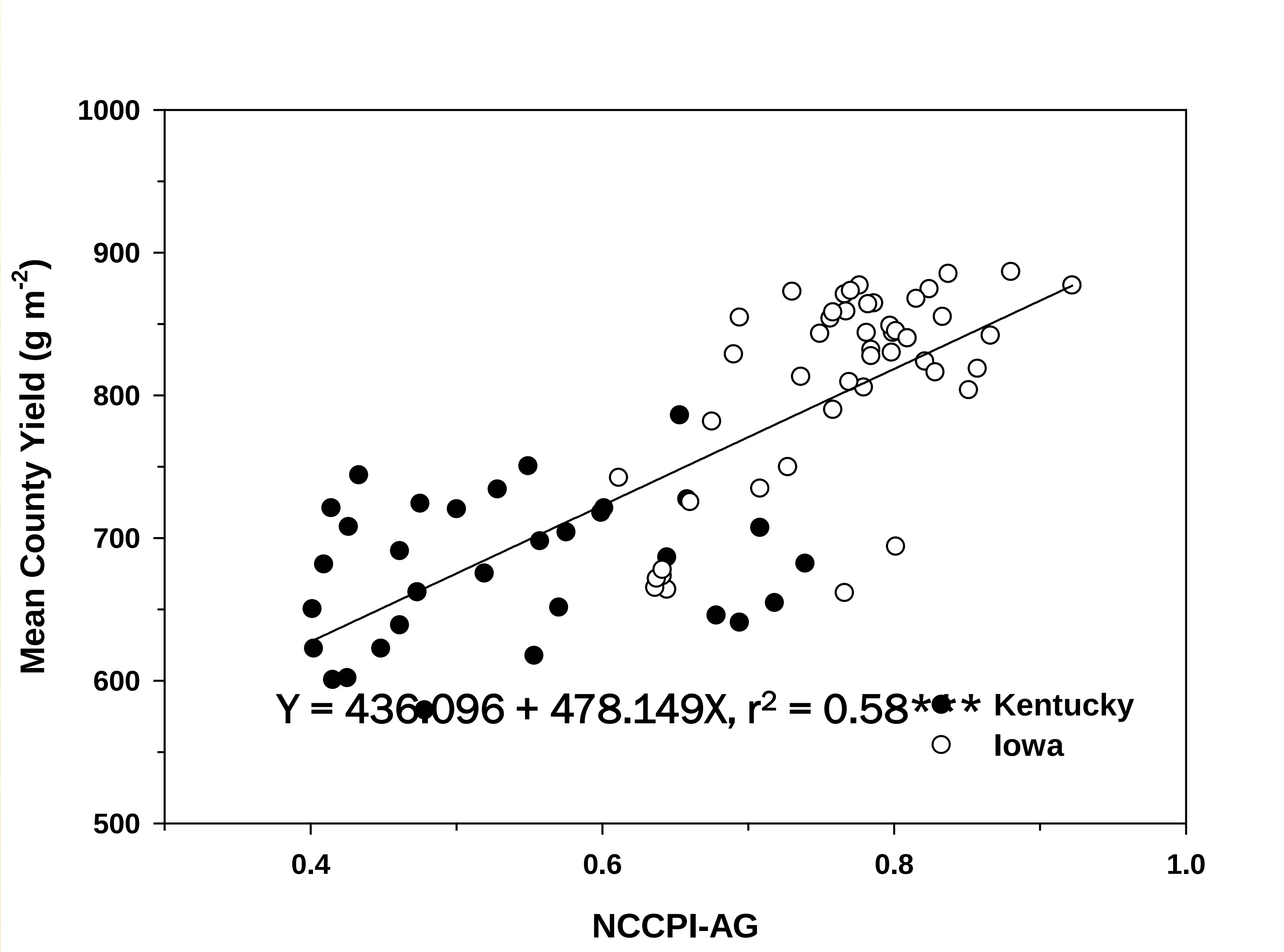
GOOD SOILS = GOOD YIELDS

Soybean yields across Iowa, Kentucky, and Nebraska

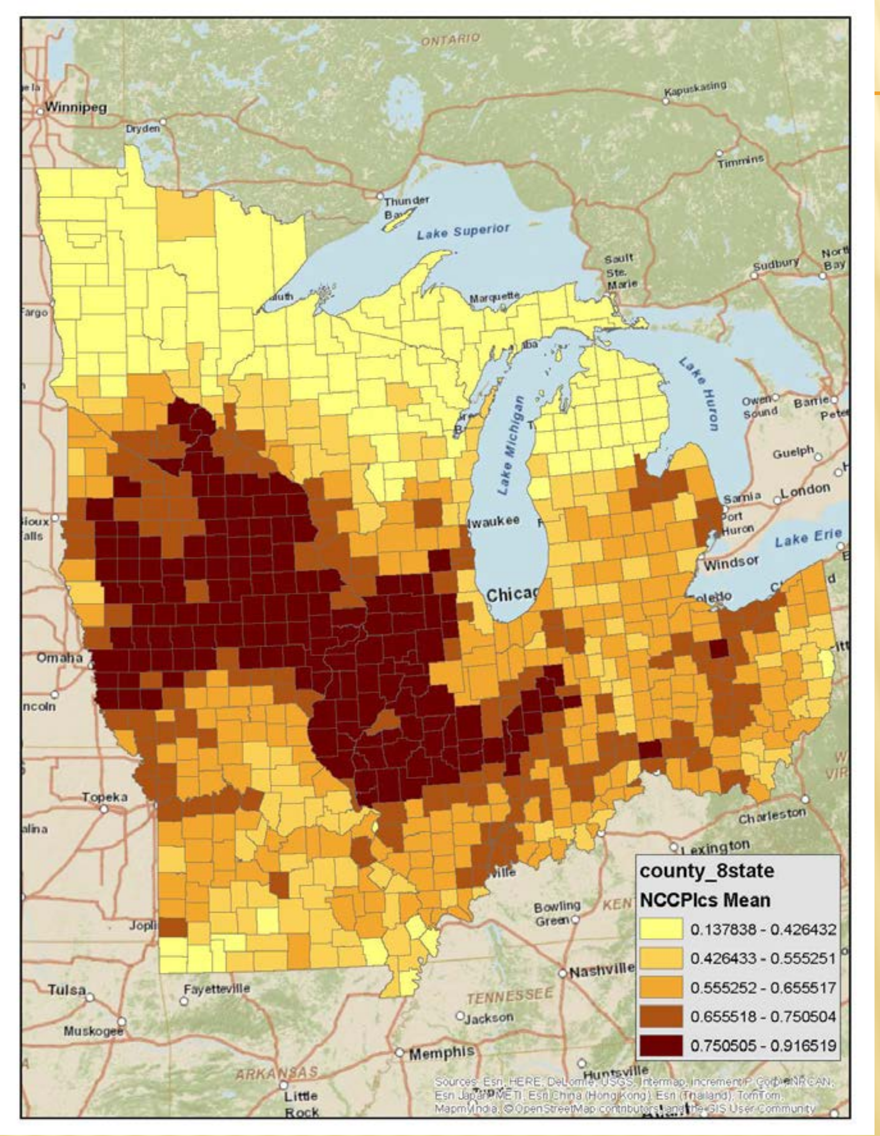


Climate resilience is derived from good soils in rainfed agricultural systems

MAIZE COUNTY YIELDS

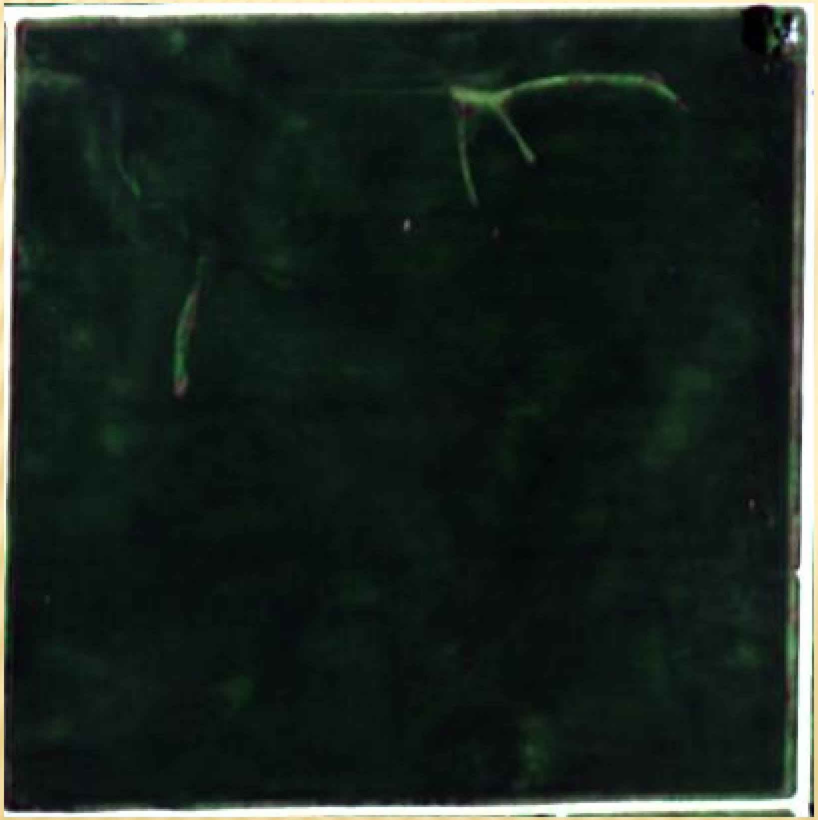


VARIATION IN NCCPI ACROSS THE MIDWEST



SOYBEAN PRODUCTION FIELD

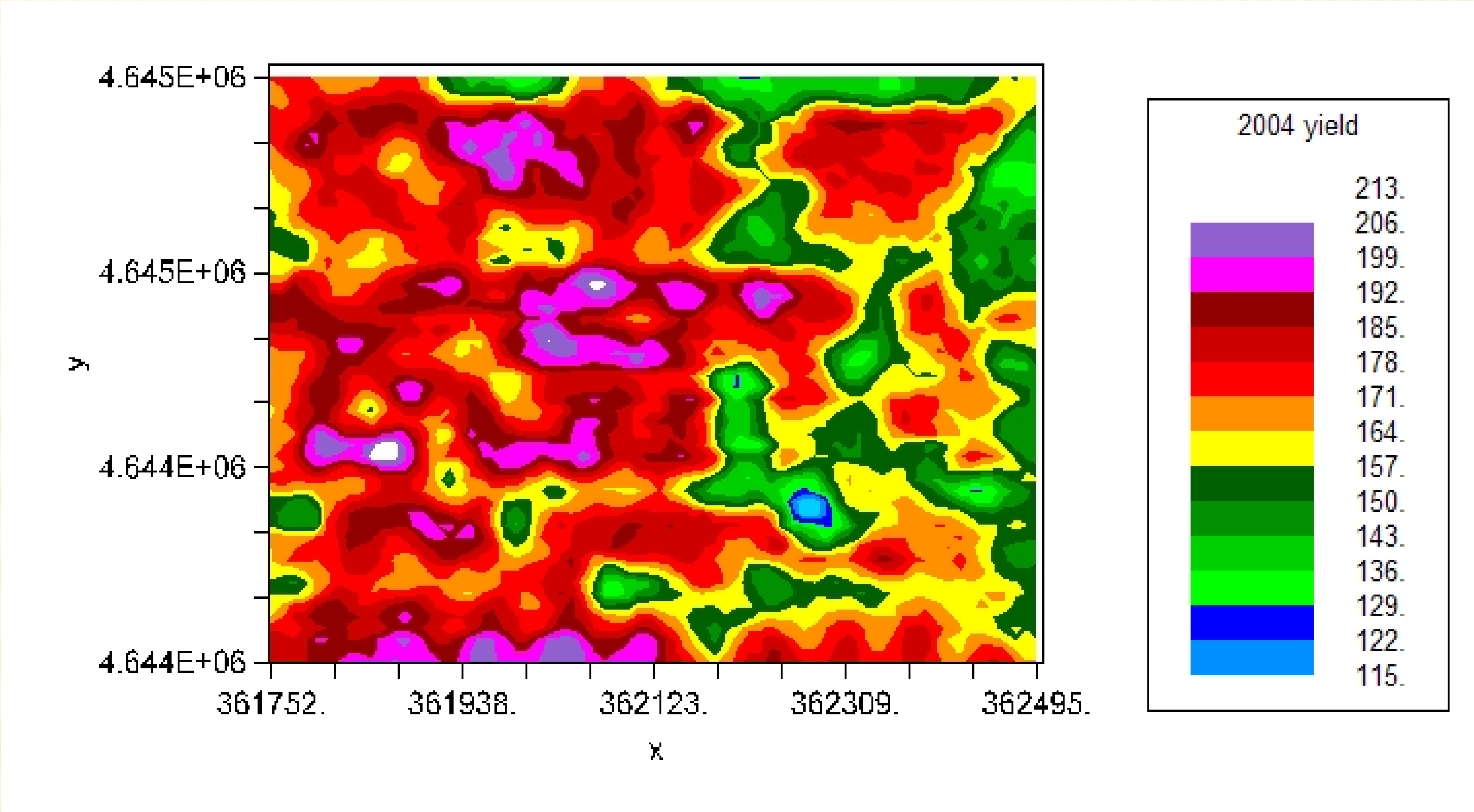
Early August



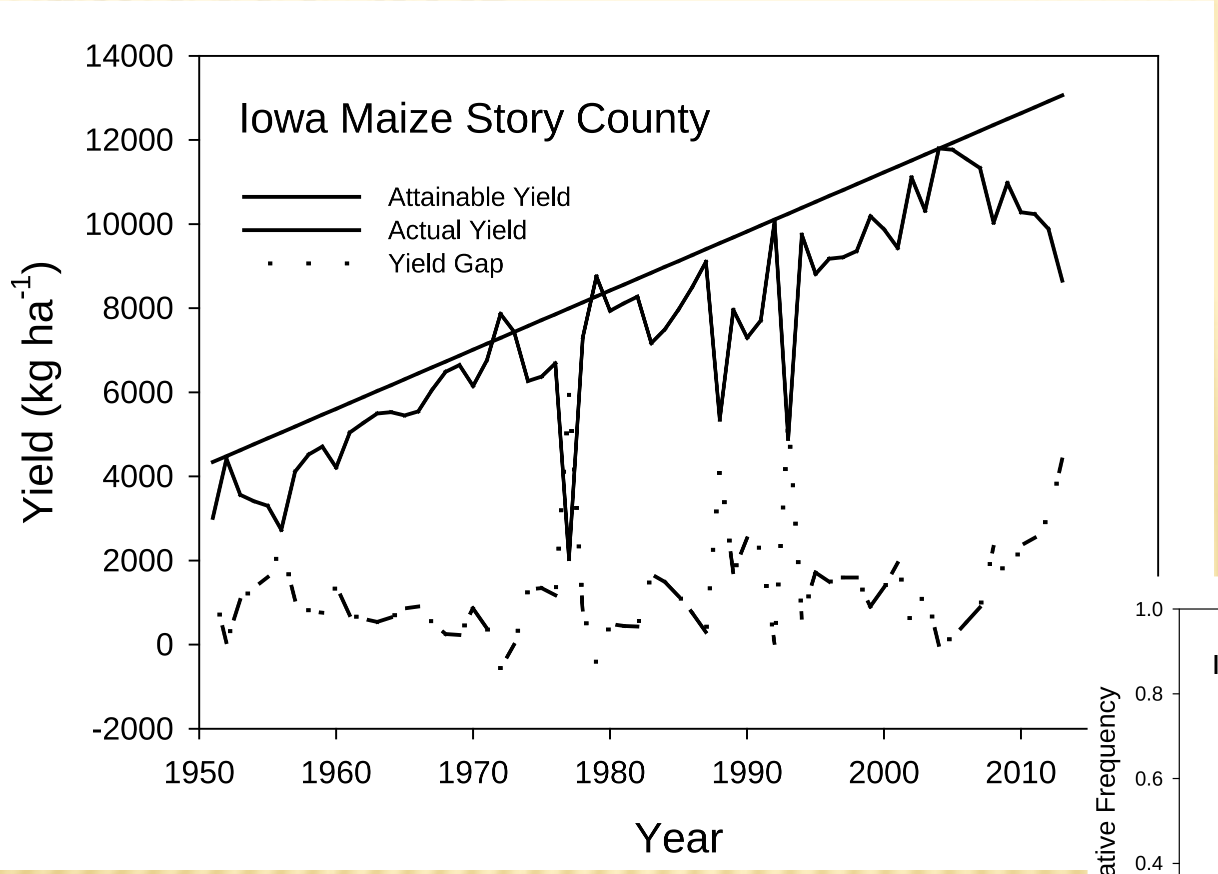
Late August

Yield variability in a field comes from soils inability to supply water during grain-filling

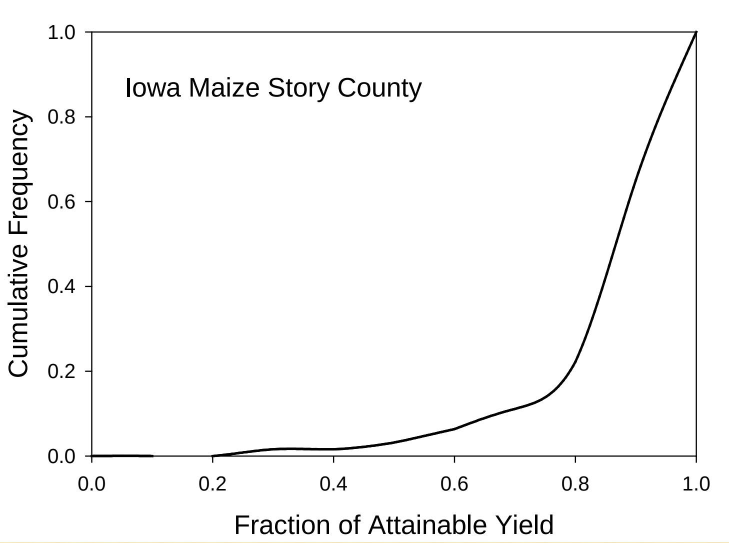
CROP YIELD VARIATION



YIELD GAPS

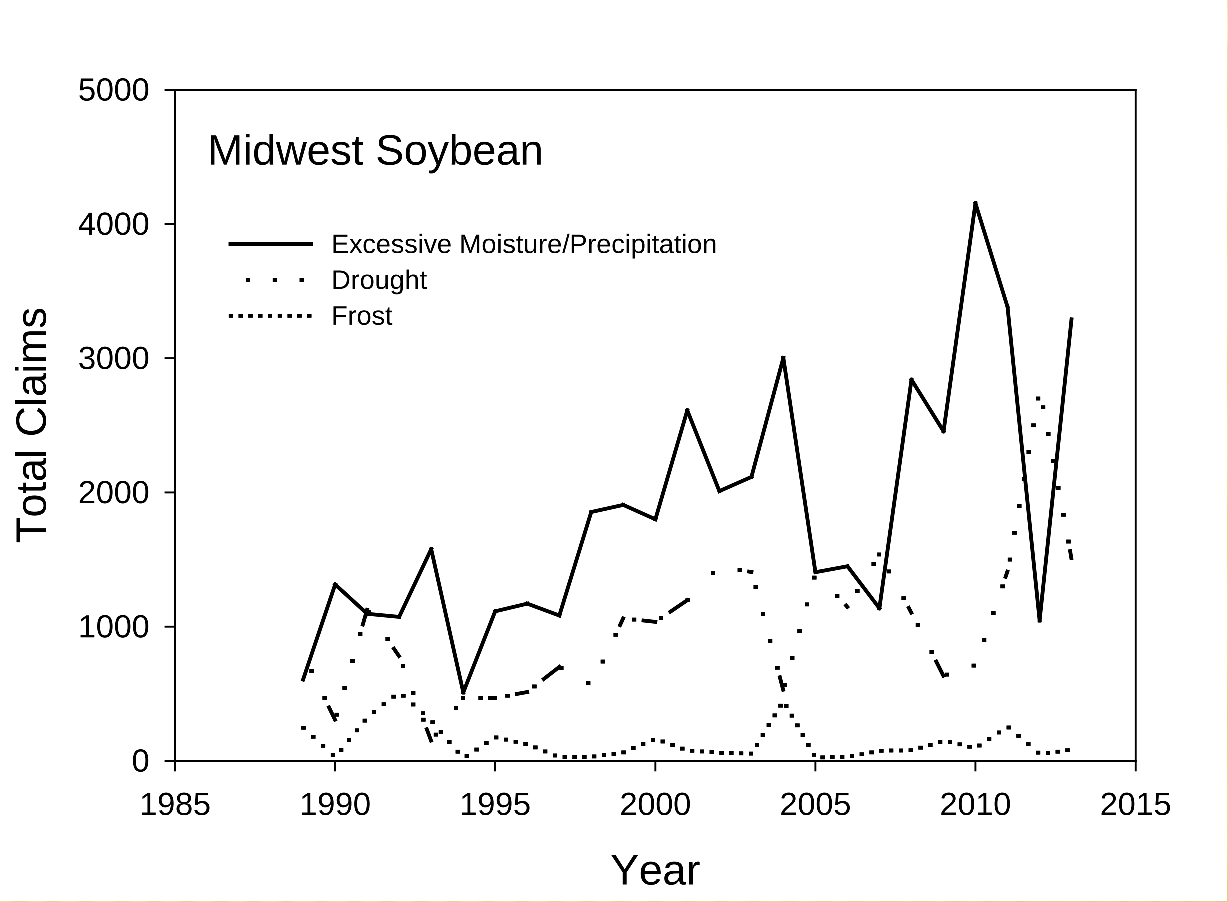


Iowa Maize Story County
Attainable Yield
Actual Yield
Yield Gap
Yield (kg ha-1)
14000
12000
10000
8000
6000
4000
2000
0
-2000
1950
1960
1970
1980
1990
2000
2010
Year



Iowa Maize Story County
Cumulative Frequency
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Fraction of Attainable Yield

SOYBEAN: SPECIFIC CLAIMS



SOIL DEGRADATION SPIRAL

Poor Land Management

Aggregation Degradation

Compaction
& crusting

Water & Wind Erosion

Plant Growth

Soil Biology

Yield

Reduced Soil
Productivity

Susceptible to extremes

Negative responses to
weather variation

Hatfield, 1999

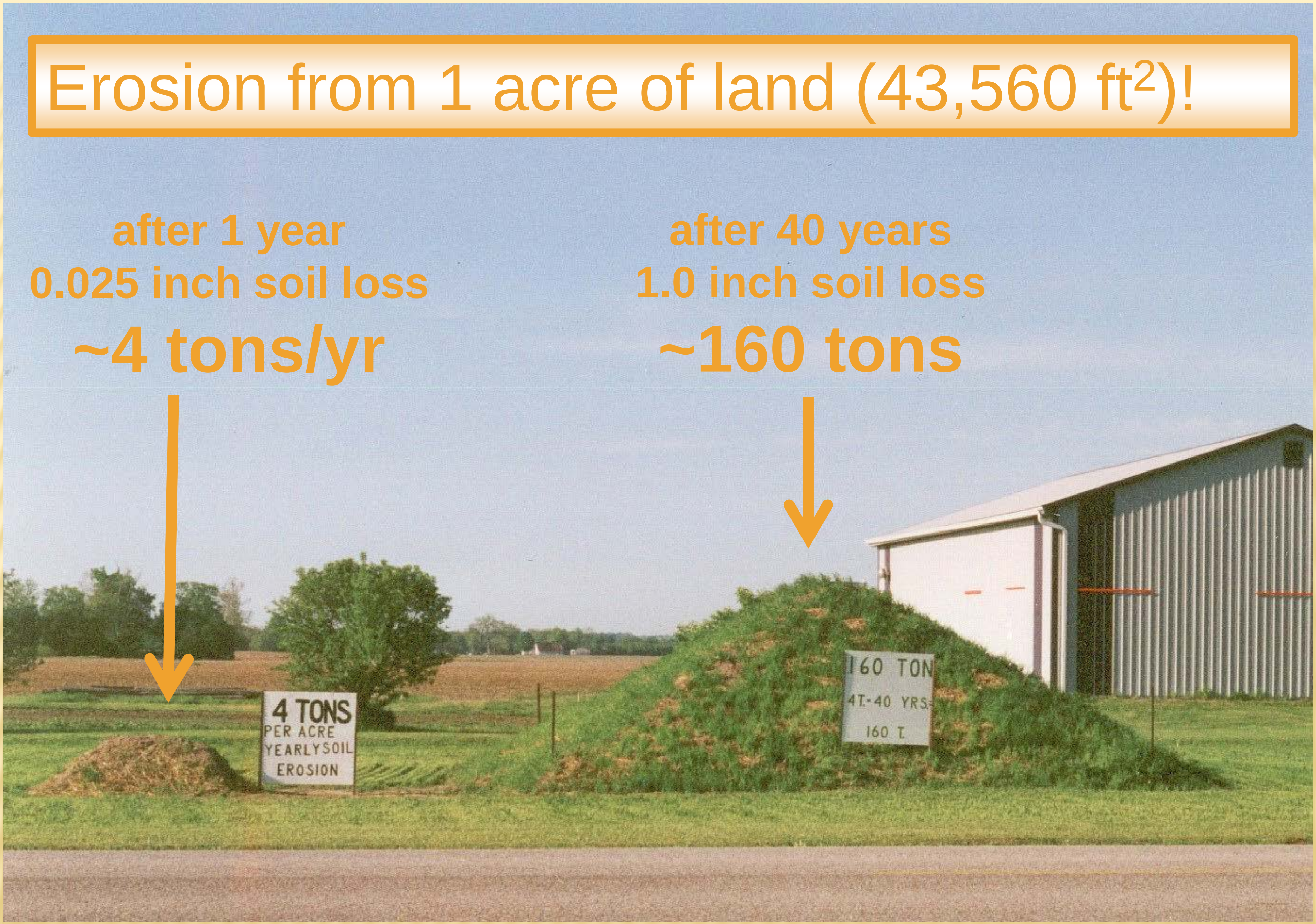
EROSION: HOW MUCH IS TOLERABLE?

NLAE
National Laboratory for Agriculture and the Environment

Erosion from 1 acre of land (43,560 ft^2)!

after 1 year
0.025 inch soil loss
~4 tons/yr

after 40 years
1.0 inch soil loss
~160 tons

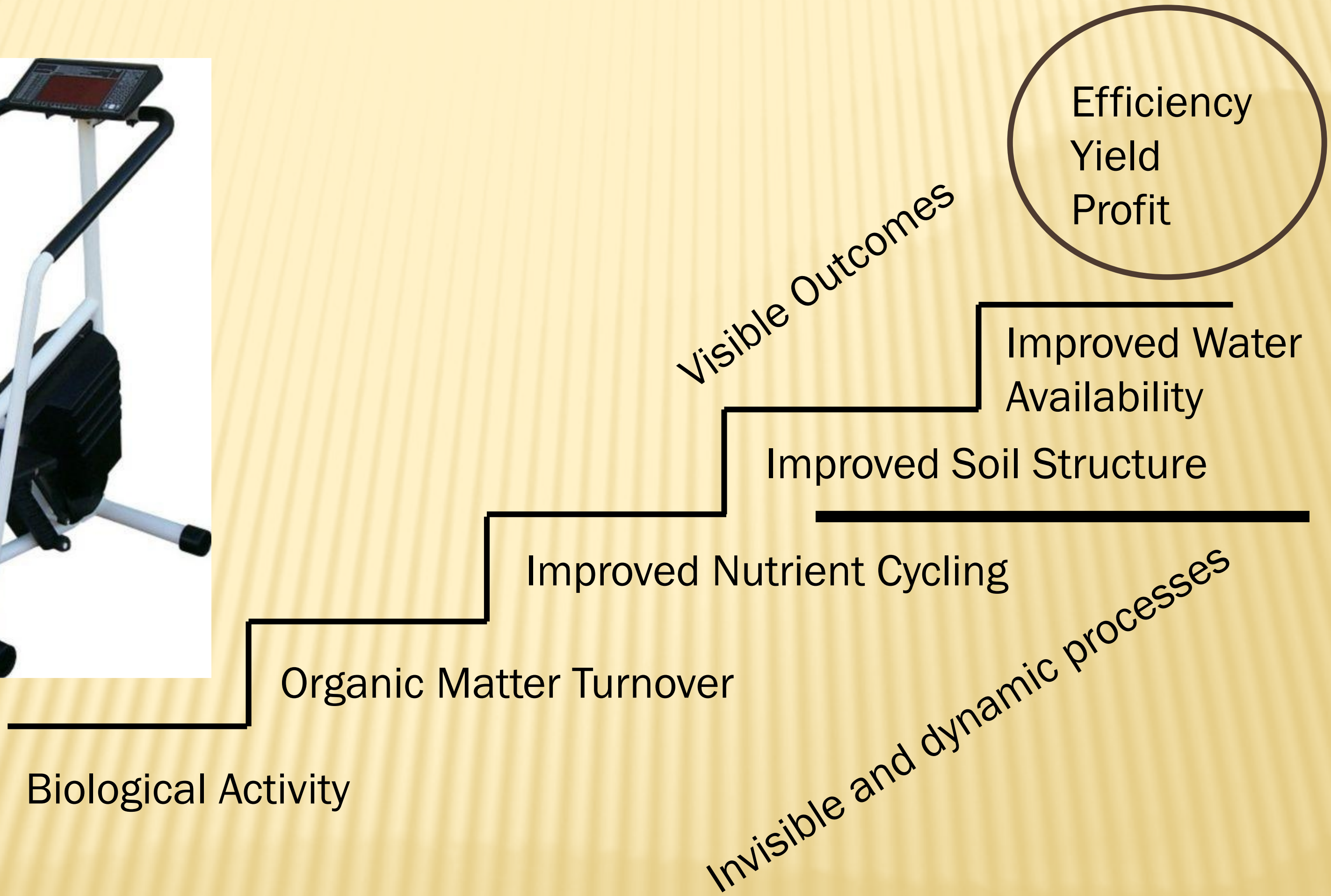


Credit: Roger Wolfe, Baltimore, OH

THE WIND BLOWS TOO

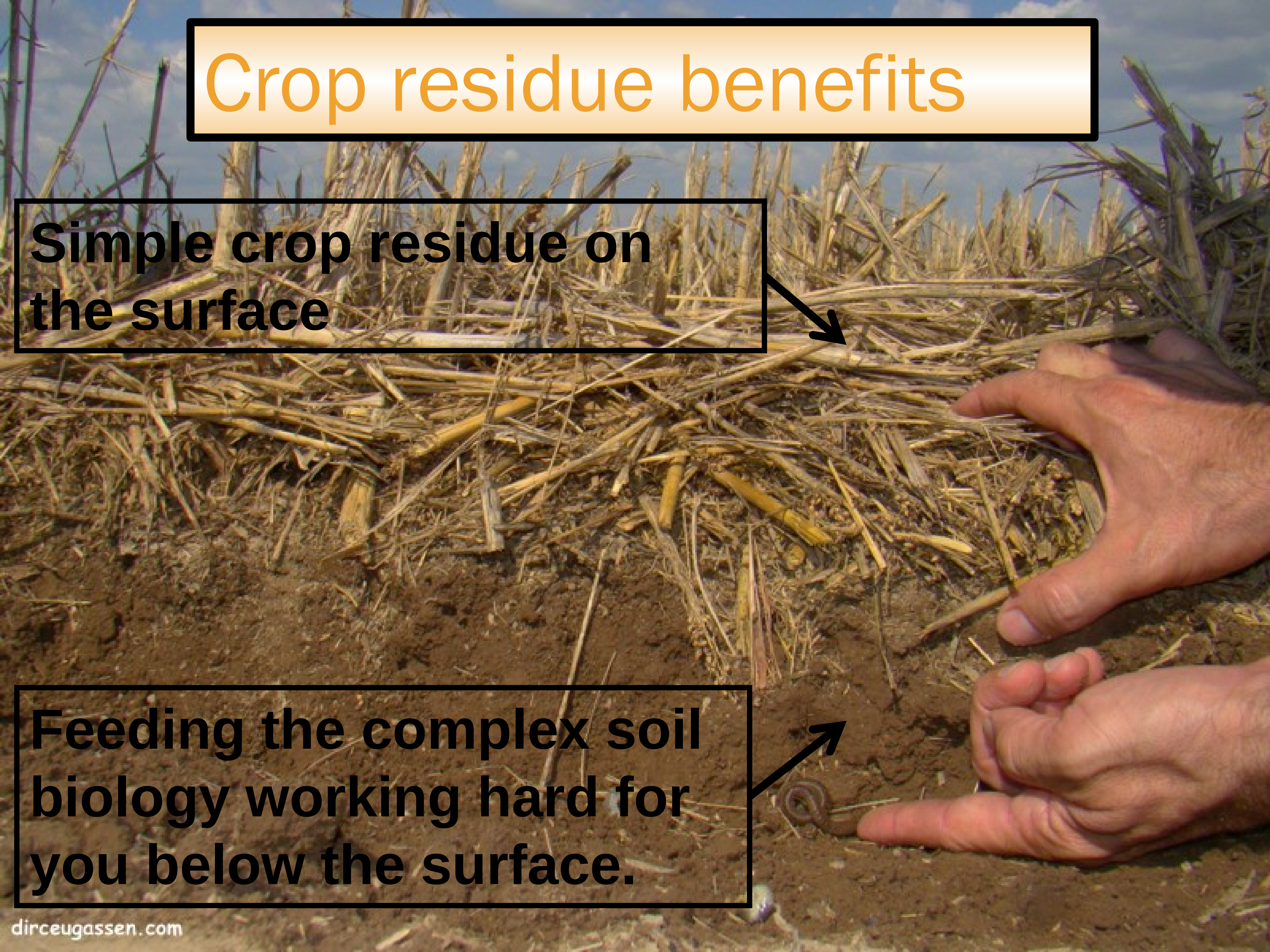
National Laboratory for Agriculture and the Environment

SOIL AGGRADATION CLIMB



We build soil through biological activity not by physical or chemical manipulation

Hatfield, 2004


Crop residue benefits
Simple crop residue on the surface
Feeding the complex soil biology working hard for you below the surface.
dirceugassen.com

“Passive protective blanket”

“Active protective blanket”

The “living soil”, a biological system.

Mammals - gophers, moles, mice, groundhogs

Earthworms - night crawlers, garden worms

Insects and mollusks - ants, beetles, centipedes, snails, slugs

Microfauna - nematodes, protozoa, rotifers≈

Microflora - fungi, yeast, molds, mychorhiza

Actinomycetes - smaller than fungi, act like bacteria

Bacteria - autotrophs, heterotrophs, rhizobia, nitrobacter

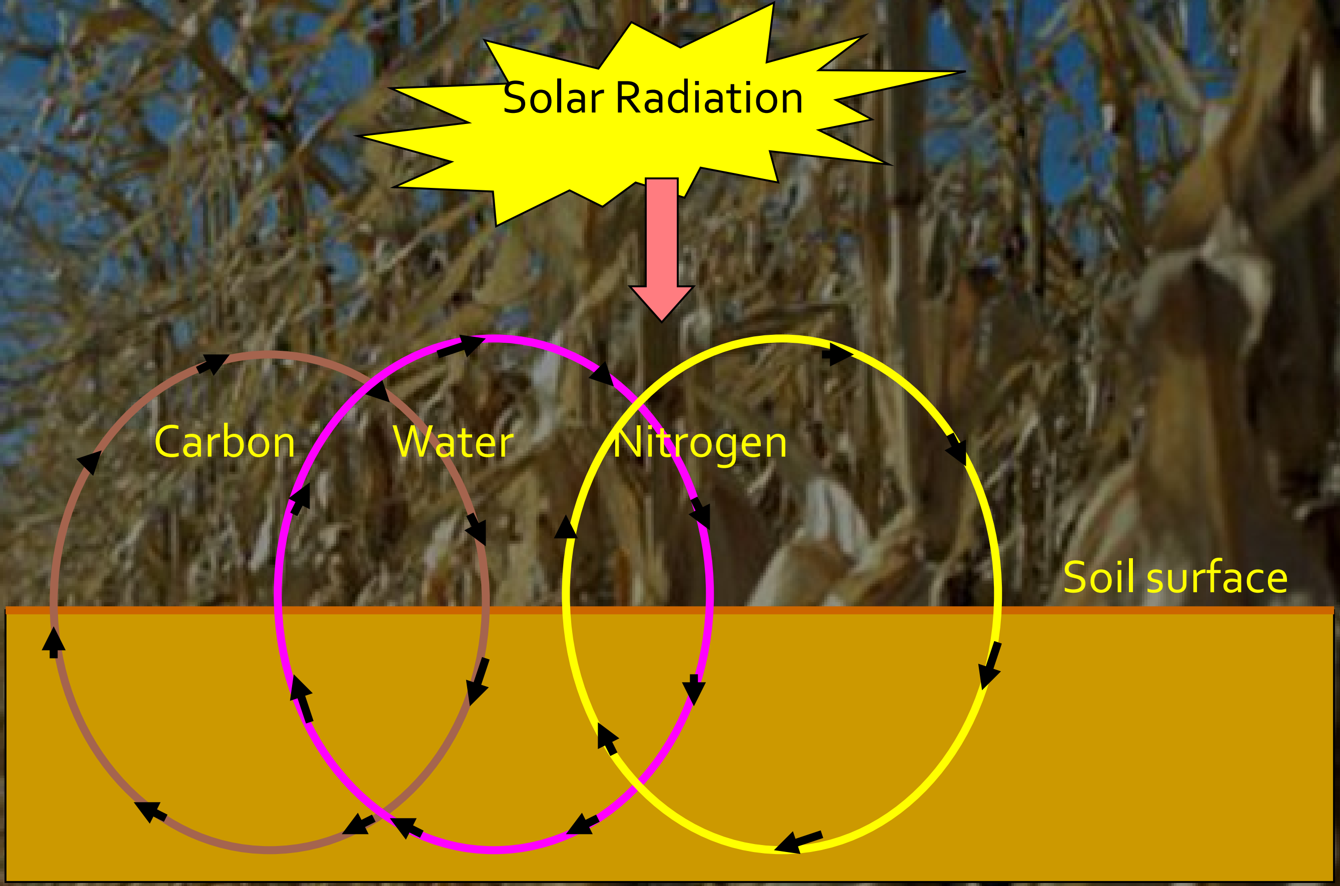
Algae - green, blue-green

≈

Earthworms, insects and rodents are “nature’s plow” and the most visible components of the “living soil” team. They work in tandem with other soil fauna, soil microorganisms and fungi to contribute to aeration and nutrient cycling as part of a “soil factory” team effort.

RESIDUE AND COVER CROPS

- Stabilize the microclimate of the upper soil surface
- Provide a food source for microbes
- Source of nutrients to be recycled



Key Processes

Carbon	Water	Nitrogen
Photosynthesis	Precipitation	N Fixation
Respiration	Evaporation	Mineralization
Org Matter decomp	Infiltration	Denitrification
Plant decomposition	Runoff	Plant decomposition
	Percolation	

Cycles interact over time and space with different rates

USDA United States Department of Agriculture

Agricultural Research Service

National Soil Tilth Laboratory

Evolution of a continuous no till systems: 4 phases

Initial

- Rebuild aggregates
- Low 0M
- Low crop residues
- Reestablish microbial biomass
- > N

0-5

Transition

- Increase soil density
- Start increasing crop residue
- Start increasing soil OM
- Start increasing P
- Immobilize N >= Minimum

5-10

Consolidation

- High Crop Residue
- High C
- > CEC
- > H2O
- Immobilize N < Min.
- > Nutrient Cycling

10-20

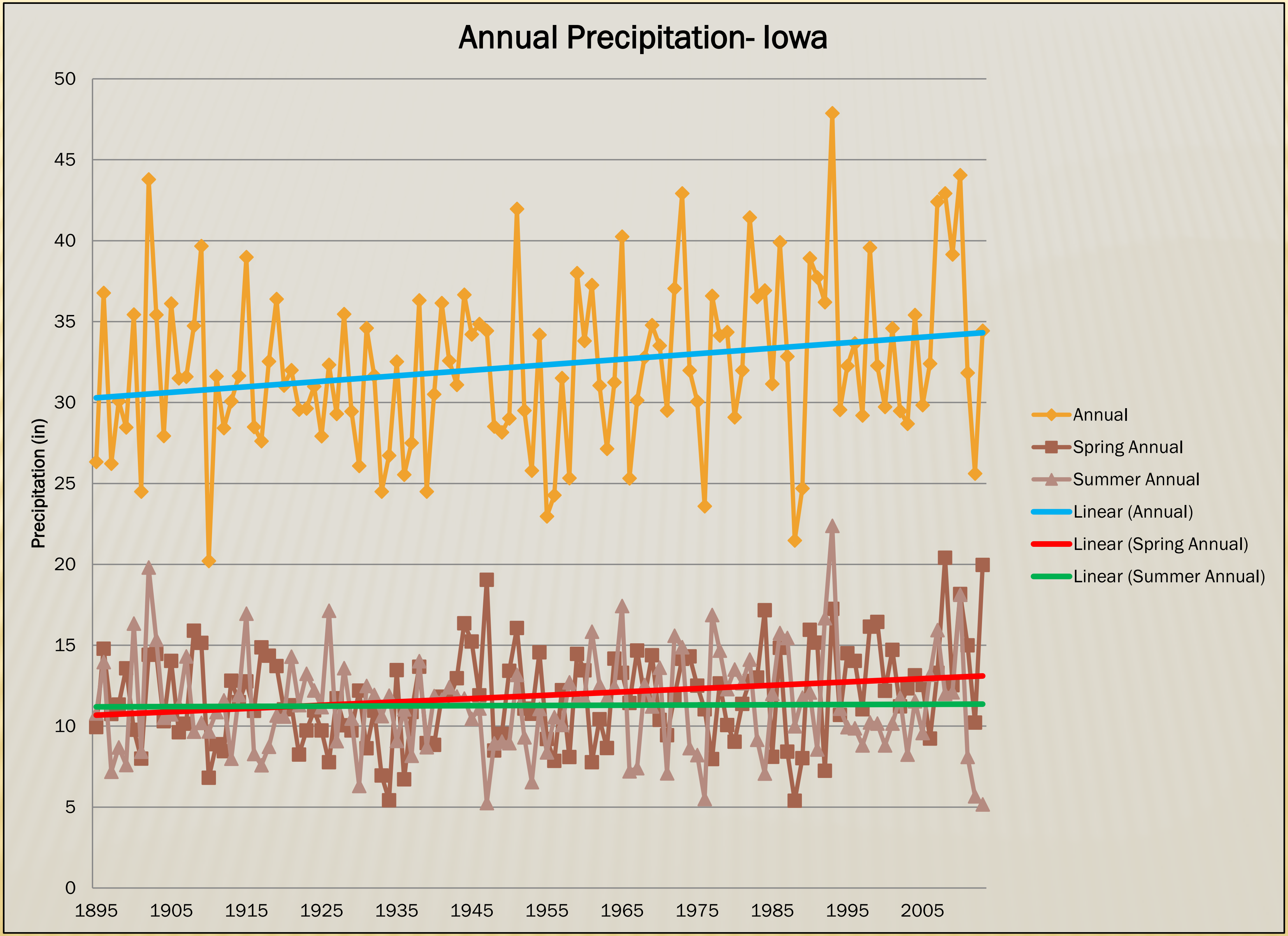
Maintenance

- High accum. of crop residue
- Continuous N and C flux
- Very high C
- > H2O
- High nutrient cycling
- Less N & P use

>20

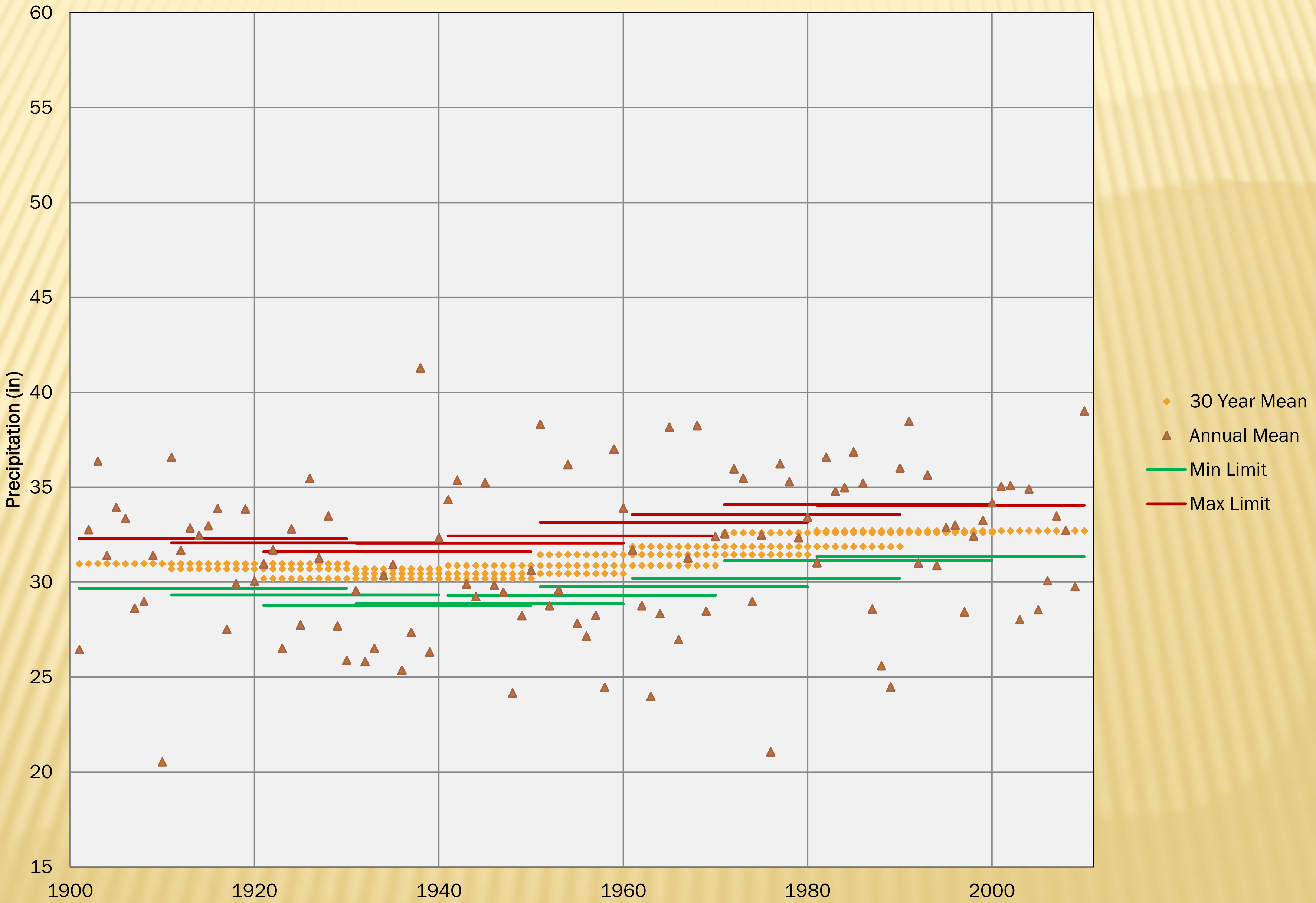
Time (years)

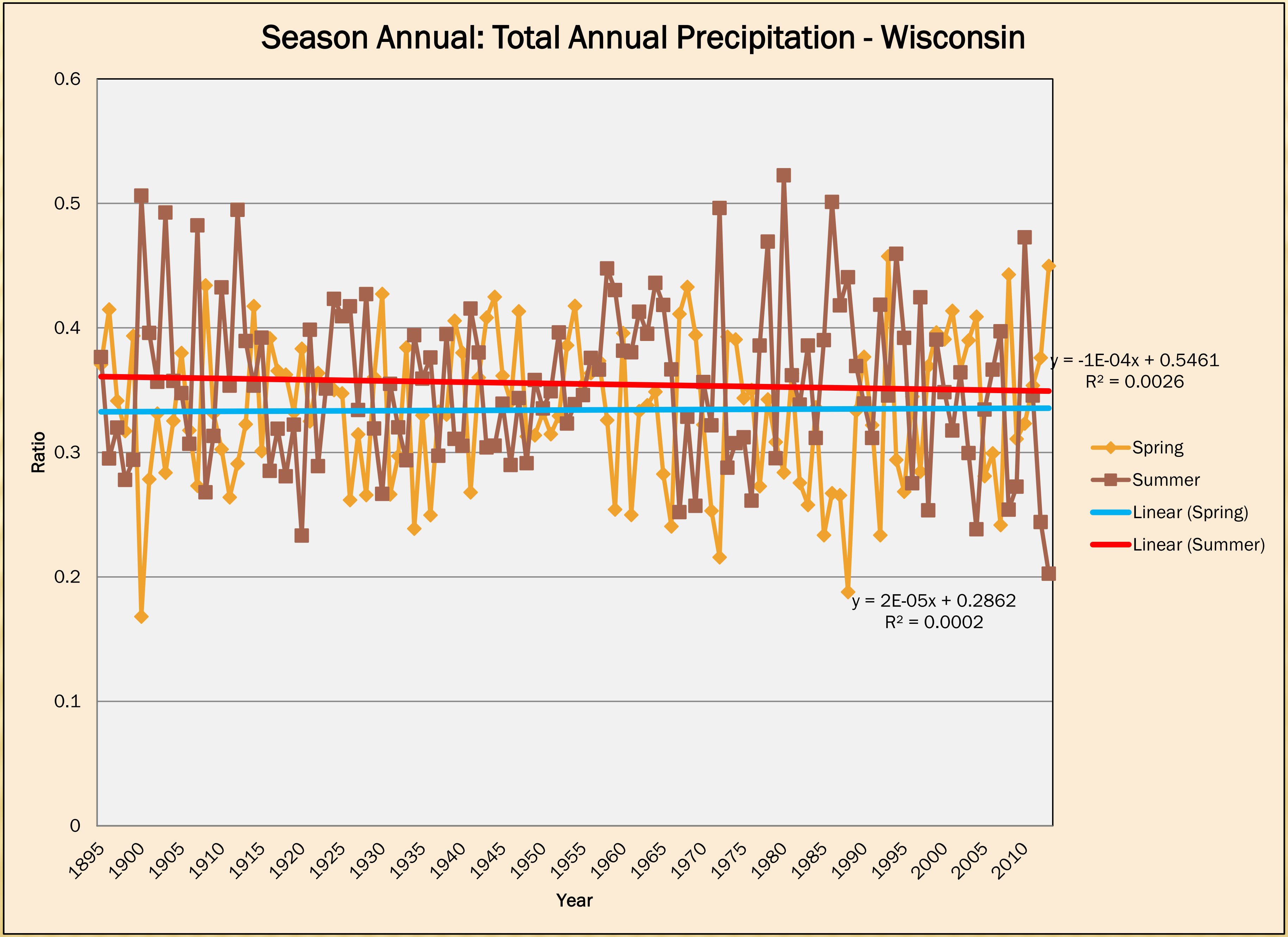
Source: Sa, 2004

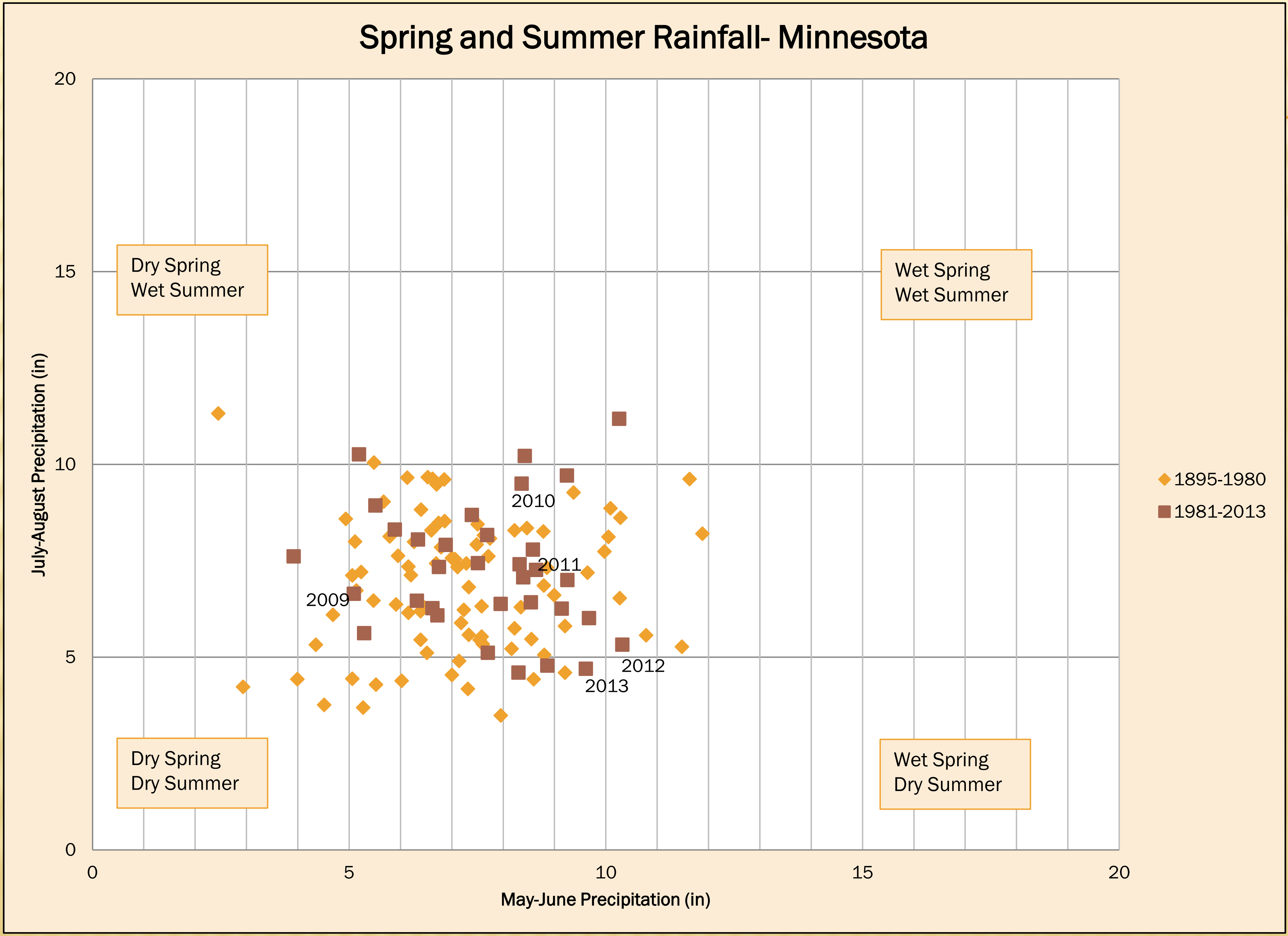


Annual Precipitation- Iowa
Precipitation (in)
50
45
40
35
30
25
20
15
10
5
0
1895
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
Annual
Spring Annual
Summer Annual
Linear (Annual)
Linear (Spring Annual)
Linear (Summer Annual)

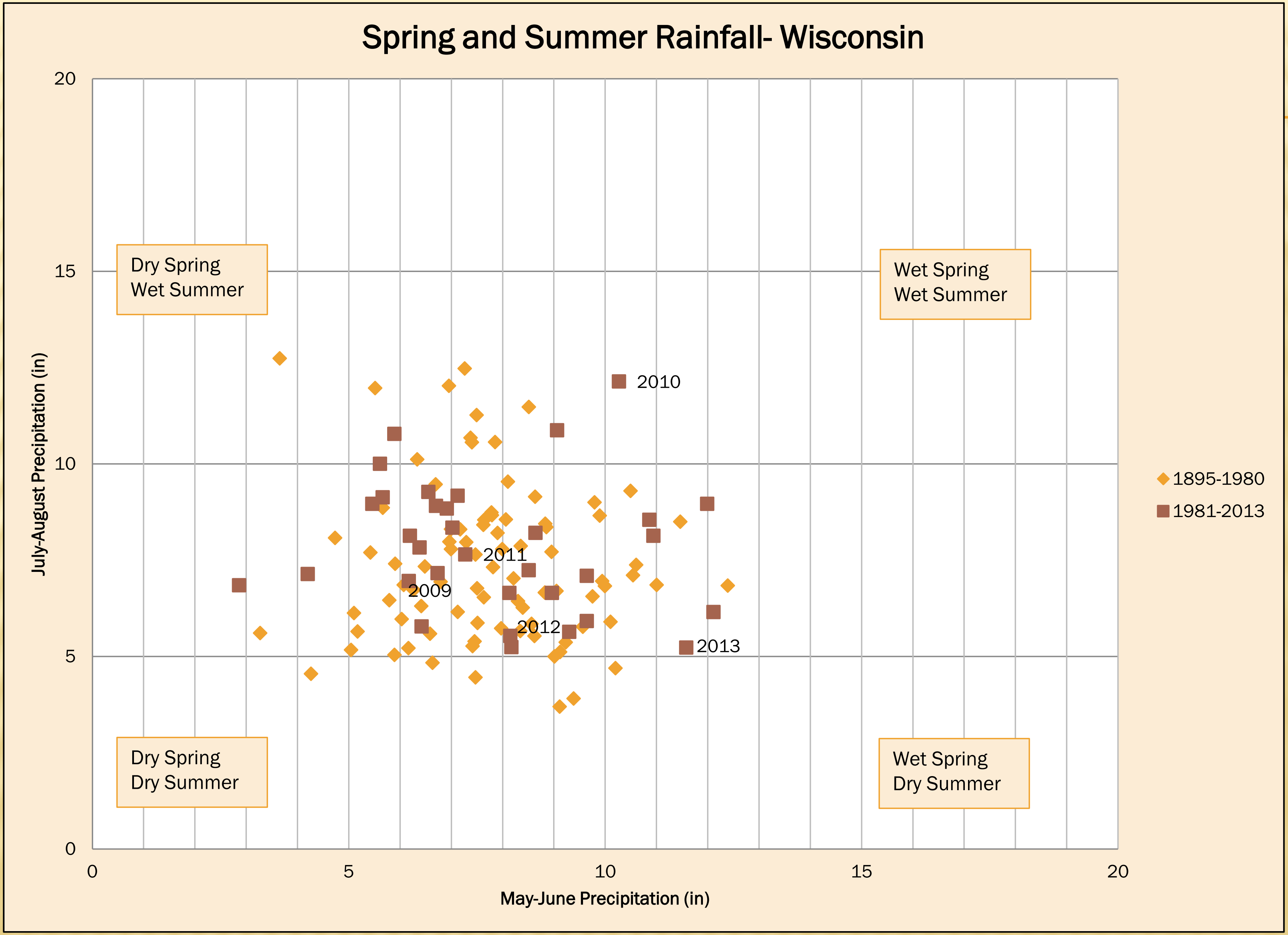
Wisconsin Precipitation: 1901-2010




Season Annual: Total Annual Precipitation - Wisconsin
Ratio
Year
0.6
0.5
0.4
0.3
0.2
0.1
0
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
y = -1E-04x + 0.5461
R² = 0.0026
y = 2E-05x + 0.2862
R² = 0.0002
Spring
Summer
Linear (Spring)
Linear (Summer)

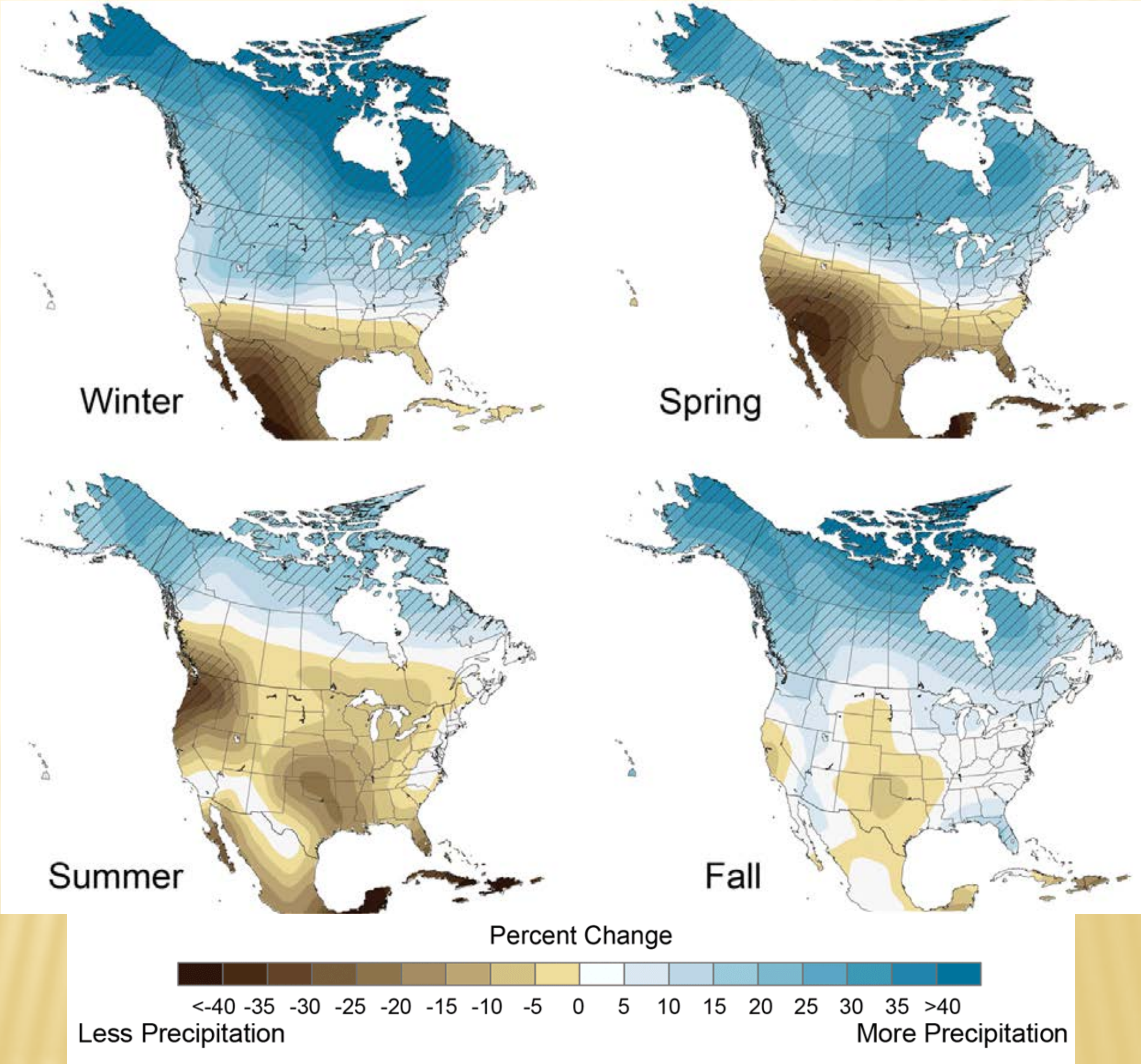


Spring and Summer Rainfall- Minnesota
Dry Spring
Wet Summer
Wet Spring
Wet Summer
Dry Spring
Dry Summer
Wet Spring
Dry Summer
2009
2010
2011
2012
2013
July-August Precipitation (in)
May-June Precipitation (in)
0
5
10
15
20
1895-1980
1981-2013


Spring and Summer Rainfall- Wisconsin
Dry Spring
Wet Summer
Wet Spring
Wet Summer
Dry Spring
Dry Summer
Wet Spring
Dry Summer
2010
2011
2009
2012
2013
1895-1980
1981-2013
July-August Precipitation (in)
May-June Precipitation (in)
0
5
10
15
20

PROJECTED CHANGE IN N. AMERICAN PRECIPITATION

BY 2080-2090



SCIENCE OF SOIL HEALTH

- Assume we change soil health without considering that we need to use soil biology as the first step
- Recognize that biology is linked to all of attributes we consider as soil health

HOW DO COVER CROPS FIT INTO THE PICTURE

RYE AFTER CORN SILAGE

EXPERIENCES WITH COVER CROPS

- Nitrate concentration changes in the Raccoon River watershed are related to the removal of small grains and hay from the cropping system (Hatfield et al. 2009, JSWC, 64:190-199)
- On a large scale, the principles of effective cover crops affect water quality and strategically placed within a watershed would have positive results on water quality

CENTRAL IOWA CORN-SOYBEAN SYSTEMS

- Rye and oat cover crops are used after soybean to protect the soil surface.
- Little is understood about the water use rates from these crops over the winter and early spring.
- Measured the water use rates from rye, oats, and bare soil environments.

RESULTS

- Daily soil water evaporation rates were considerable for all surfaces from Oct 16 through April 5
- In 1994-1995, there was no differences in the in the seasonal water use among the three ground covers
- In 1996-1997, the bare soil had the highest cumulative water use over the rye by 3.5 inches and oats by 1.6 inches

BENEFITS OF USING COVER CROPS

- Reduced erosion
- Reduced nitrate leaching
- Reduced phosphorus losses
- Increased soil organic matter
- Improved weed control
- Support and maintain soil organisms
- Improve soil structure – especially no-till
- Grazing and forage potential
- Recycling manure nutrients

COVER CROPS AND NO-TILL
SOIL STRUCTURE AND HEALTH

FUTURE DEMANDS OF AGRICULTURE

CLIMATE SMART AGRICULTURE
INTEGRATE ADAPTATION WITH MITIGATION

- Building soil organic matter, such as by minimum/conservation tillage; Note: Soil OM is third largest carbon pool on earth;
- Integrated nutrient management practices, such as green manures, planting of legumes, livestock manure.
- Increase water and nitrate use efficiency, irrigation, water harvesting;
- Improve livestock management practices, grassland management, land restoration, and apply agro forestry.

BETTER SOIL AND WATER MANAGEMENT PRACTICES ARE KEY

CHALLENGES

- Enhance the soil resource through soil health to increase water availability to the crop
- Increase the biological activity in the soil to increase organic matter cycling and nutrient cycling through a stable microclimate at the soil surface
- Protect the soil against the extremes in climate