Coping with the Weird Weather

BUILDING RESILIENCE INTO OUR CROPPING SYSTEMS

Contact Information

Jerry L. Hatfield

Laboratory Director

National Laboratory for Agriculture and the Environment

1015 N. University Blvd

Ames, Iowa 50011

515-294-5723

515-294-8125 (fax)

jerry.hatfield@ars.usda.gov

Changes in Our Climate

Global mean temperatures will continue to increase throughout the 21st century if CO_2 concentrations continue to increase and under the highest emission scenario would range from 2.6 to 4.8°C.

These temperatures changes will not be uniform across regions with increases over land surfaces being larger than over the oceans.

As the global temperatures increase there will be more hot extremes and fewer cold extremes at both daily and seasonal time scales.

Precipitation will increase with increases in global mean surface temperature and could increase 1 to 3% $°C^{-1}$; however, there will be substantial spatial variation in these changes.

Annual surface evaporation will increase as the temperatures increases; however, over land, evaporation will be linked to precipitation.

Key Messages- 2014 National Climate Assessment

Climate disruptions to agricultural production have increased in the past 40 years and are projected to increase over the next 25 years. By mid-century and beyond, these impacts will be increasingly negative on most crops and livestock.

Many agricultural regions will experience declines in crop and livestock production from increased stress due to weeds, diseases, insect pests, and other climate change induced stresses.

Current loss and degradation of critical agricultural soil and water assets due to increasing extremes in precipitation will continue to challenge both rainfed and irrigated agriculture unless innovative conservation methods are implemented.

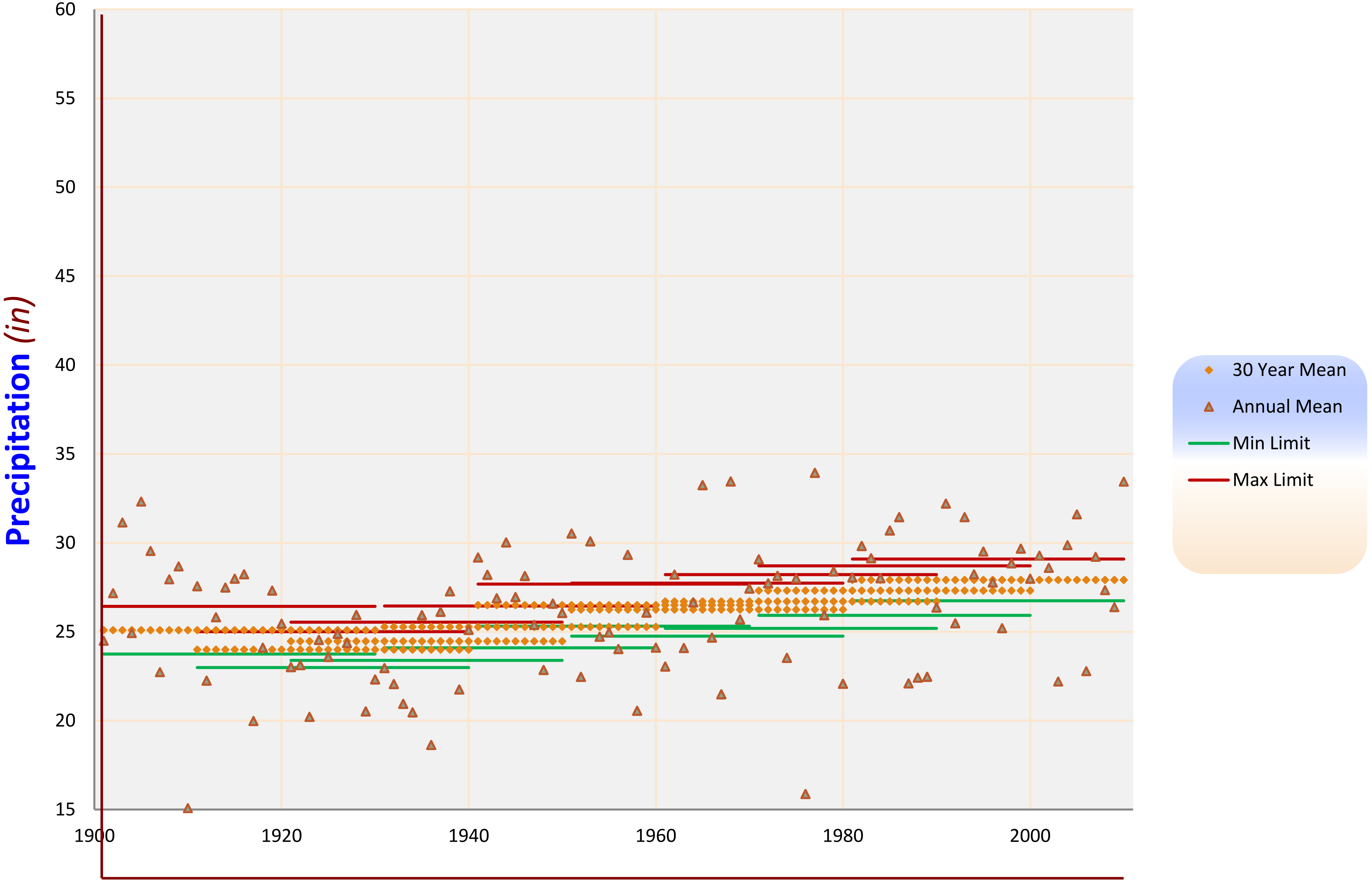
Key Messages- 2014 National Climate Assessment

The rising incidence of weather extremes will have increasingly negative impacts on crop and livestock productivity because critical thresholds are already being exceeded.

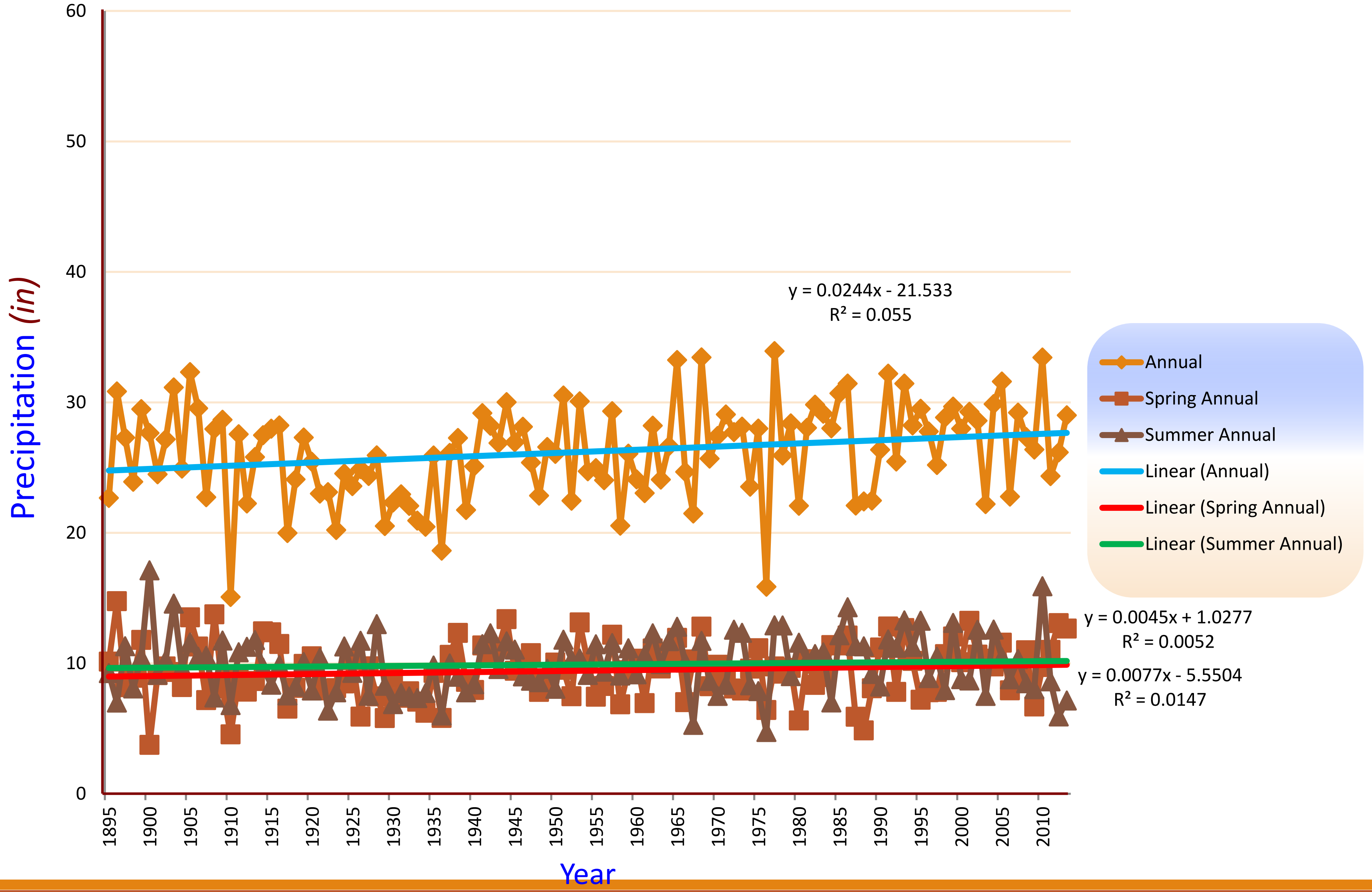
Agriculture has been able to adapt to recent changes in climate; however, increased innovation will be needed to ensure the rate of adaptation of agriculture and the associated socioeconomic system can keep pace with climate change over the next 25 years.

Climate change effects on agriculture will have consequences for food security, both in the U.S. and globally, through changes in crop yields and food prices and effects on food processing, storage, transportation, and retailing. Adaptation measures can help delay and reduce some of these impacts.

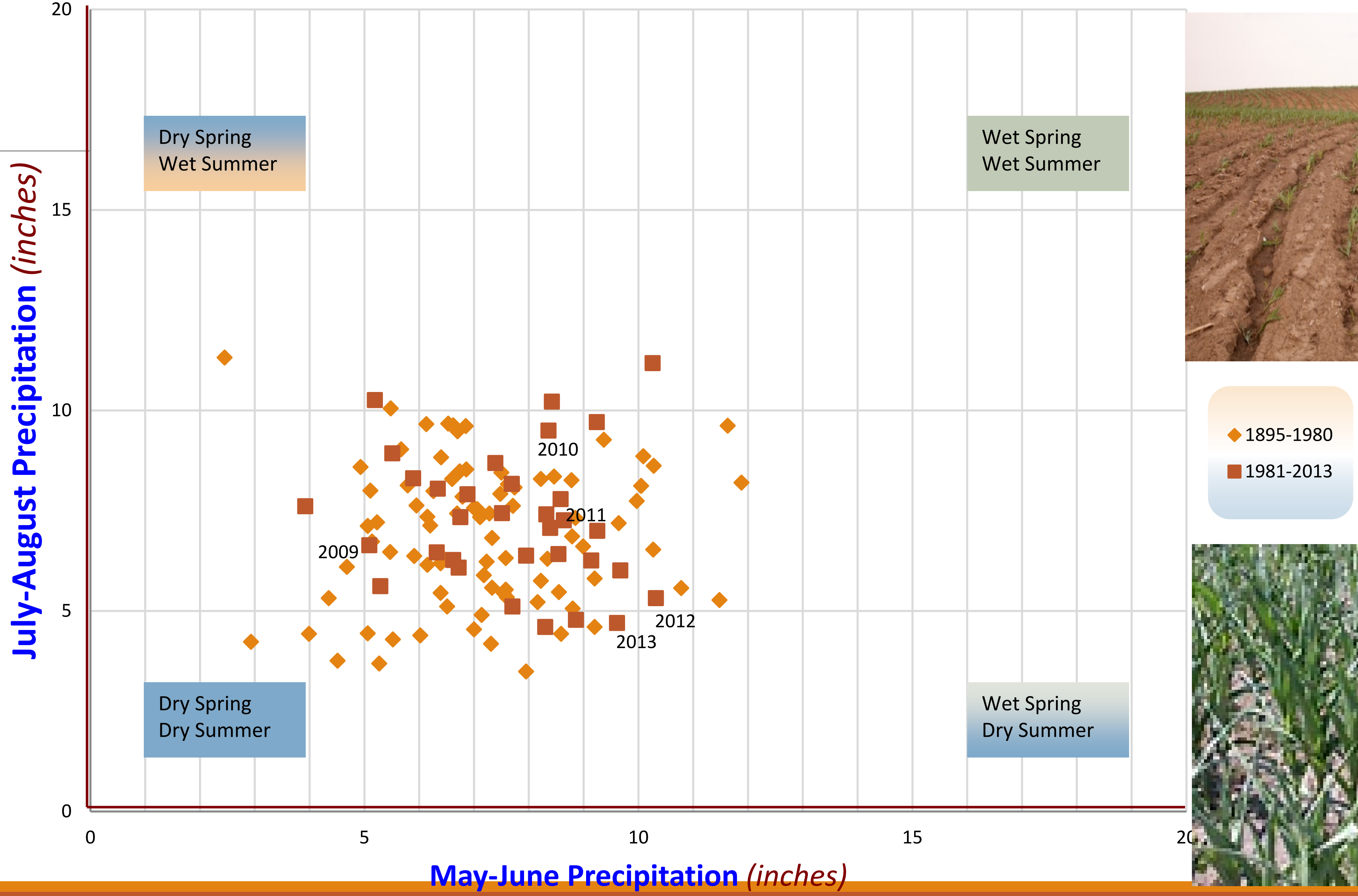
Minnesota Precipitation: 1901-2010



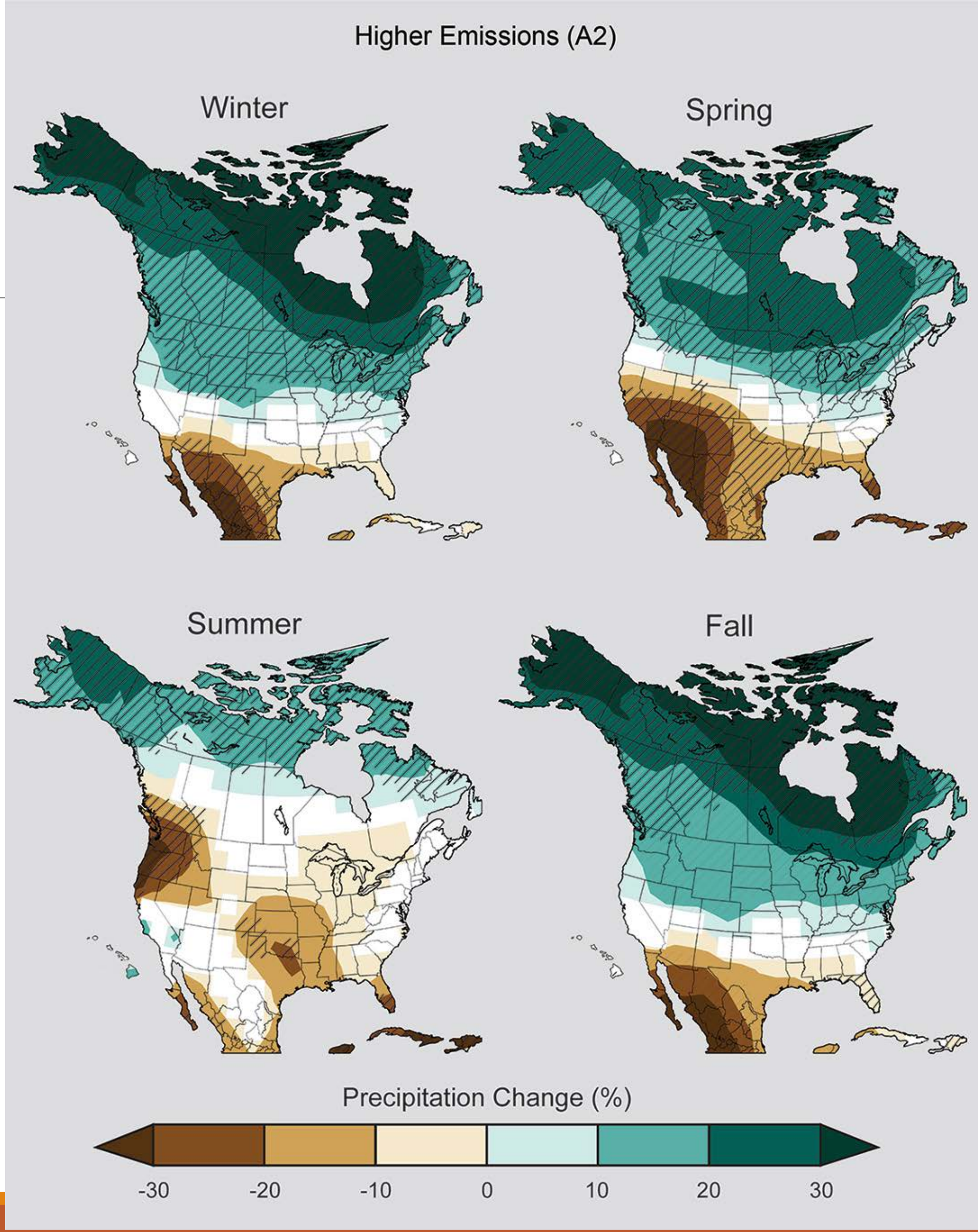
Annual Precipitation- *Minnesota*



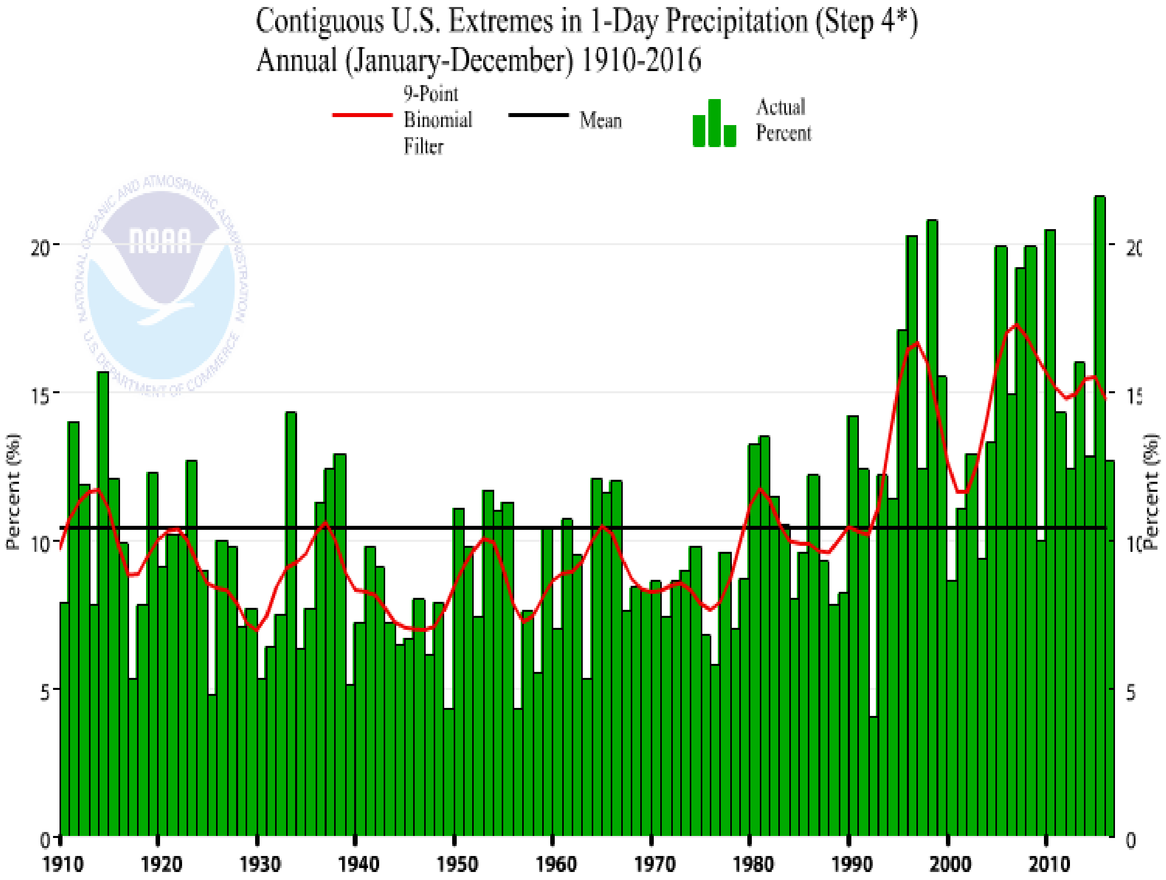
Spring and Summer Rainfall- *Minnesota*

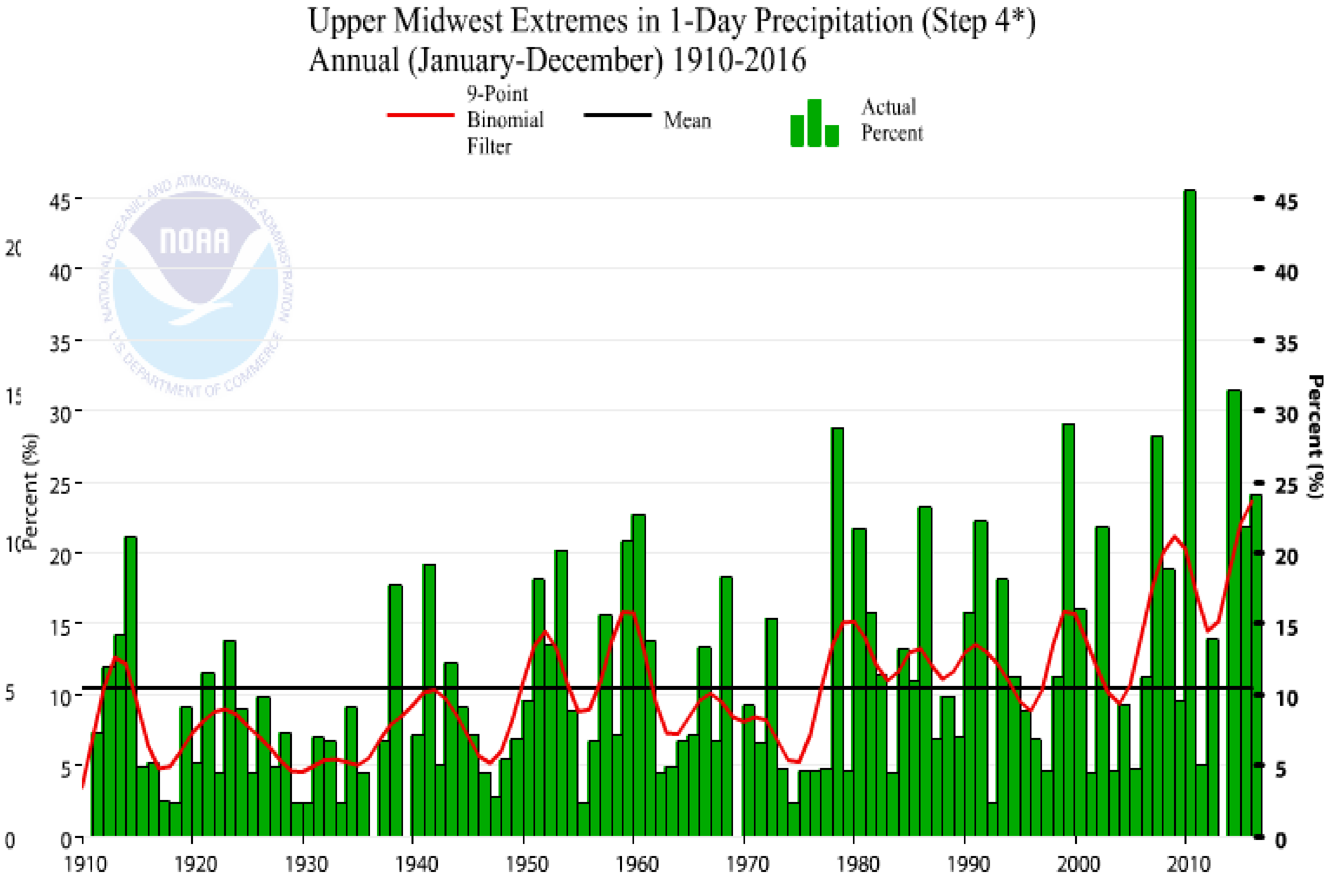


Projected Precipitation Change by Season

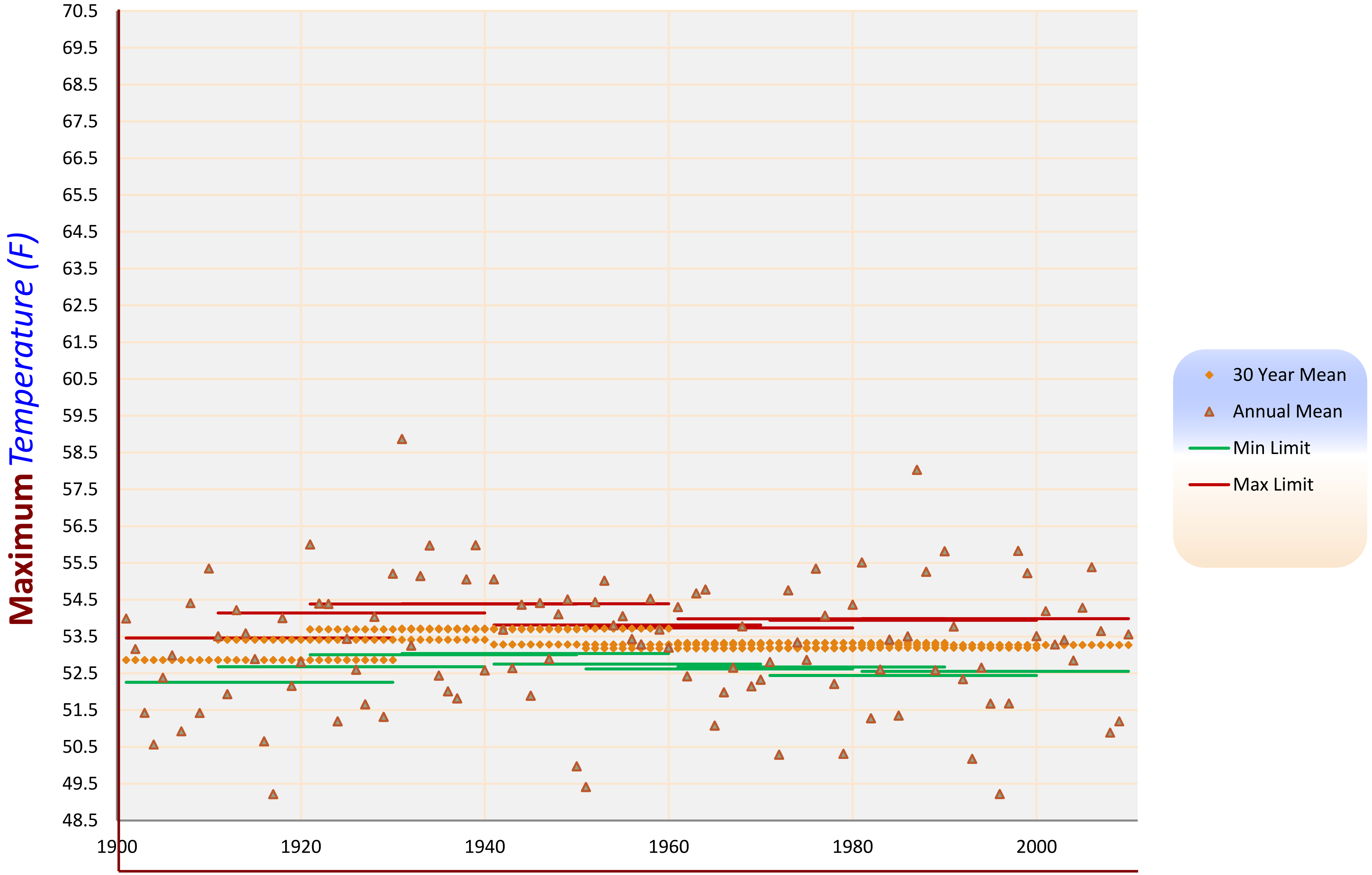


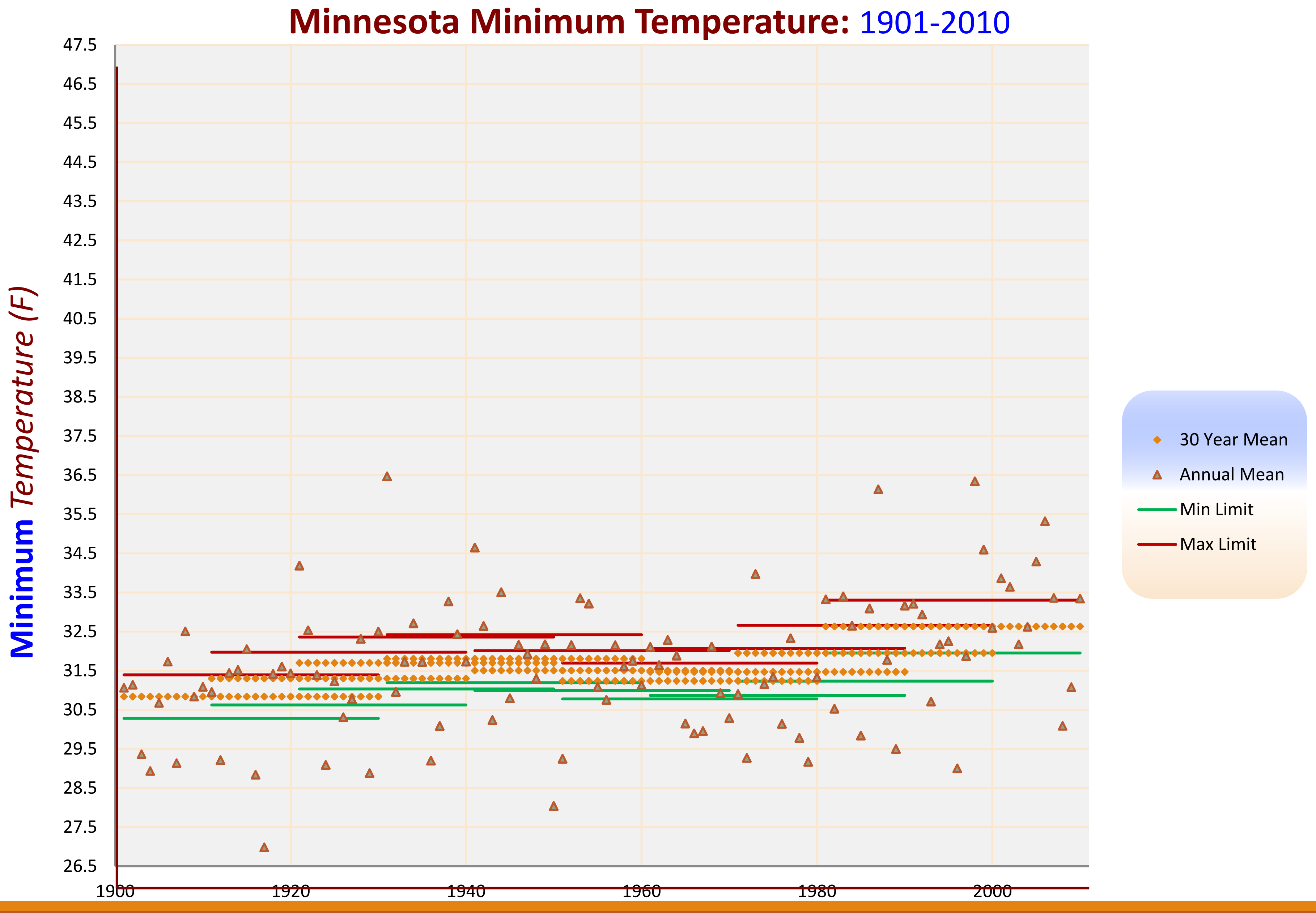
Extreme Precipitation





Minnesota Maximum Temperature: 1901-2010




Minnesota Minimum Temperature: 1901-2010
Minimum Temperature (F)
47.5
46.5
45.5
44.5
43.5
42.5
41.5
40.5
39.5
38.5
37.5
36.5
35.5
34.5
33.5
32.5
31.5
30.5
29.5
28.5
27.5
26.5
1900
1920
1940
1960
1980
2000
30 Year Mean
Annual Mean
Min Limit
Max Limit

Climate trends

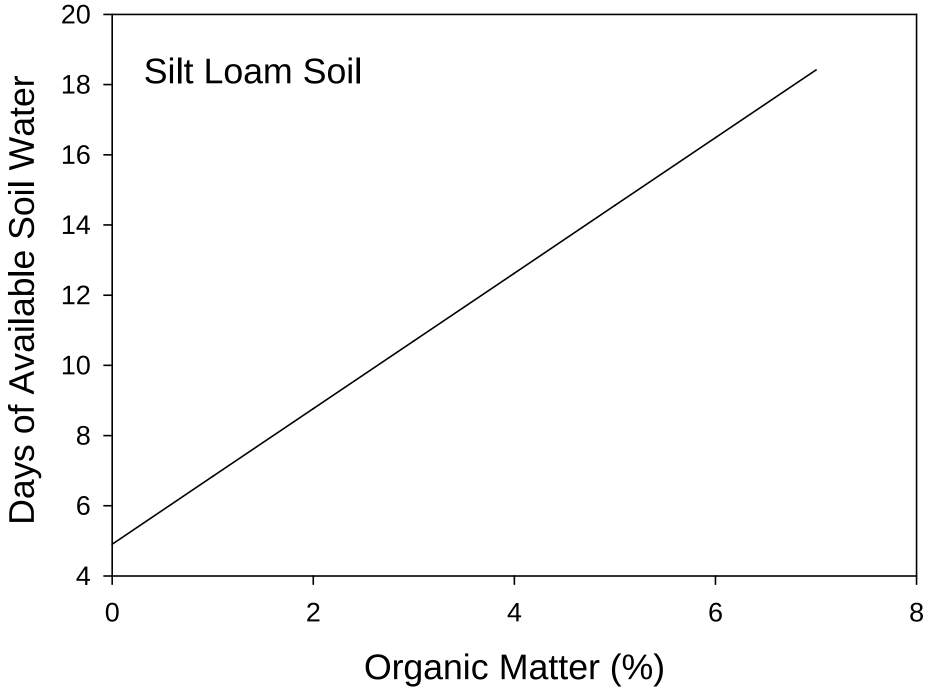
Increasing precipitation

Shift in seasonality with more spring and more variable summer precipitation

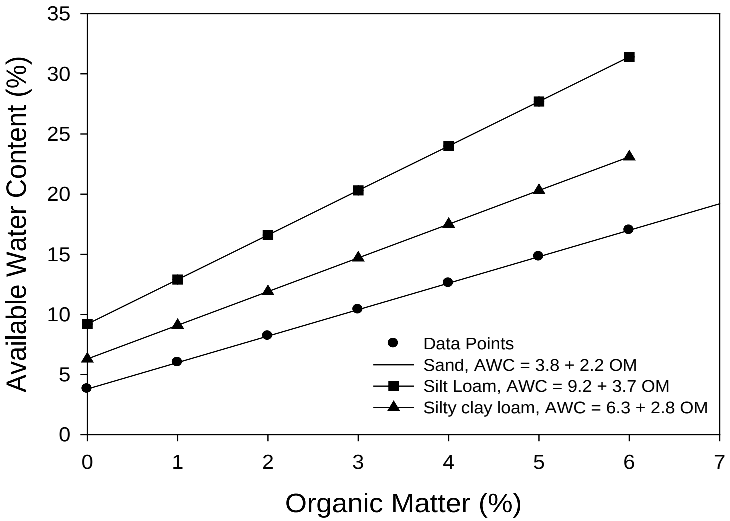
Minimum temperatures are increasing more than maximum

Temperatures are increasing more in the winter than the summer

Rain into the soil

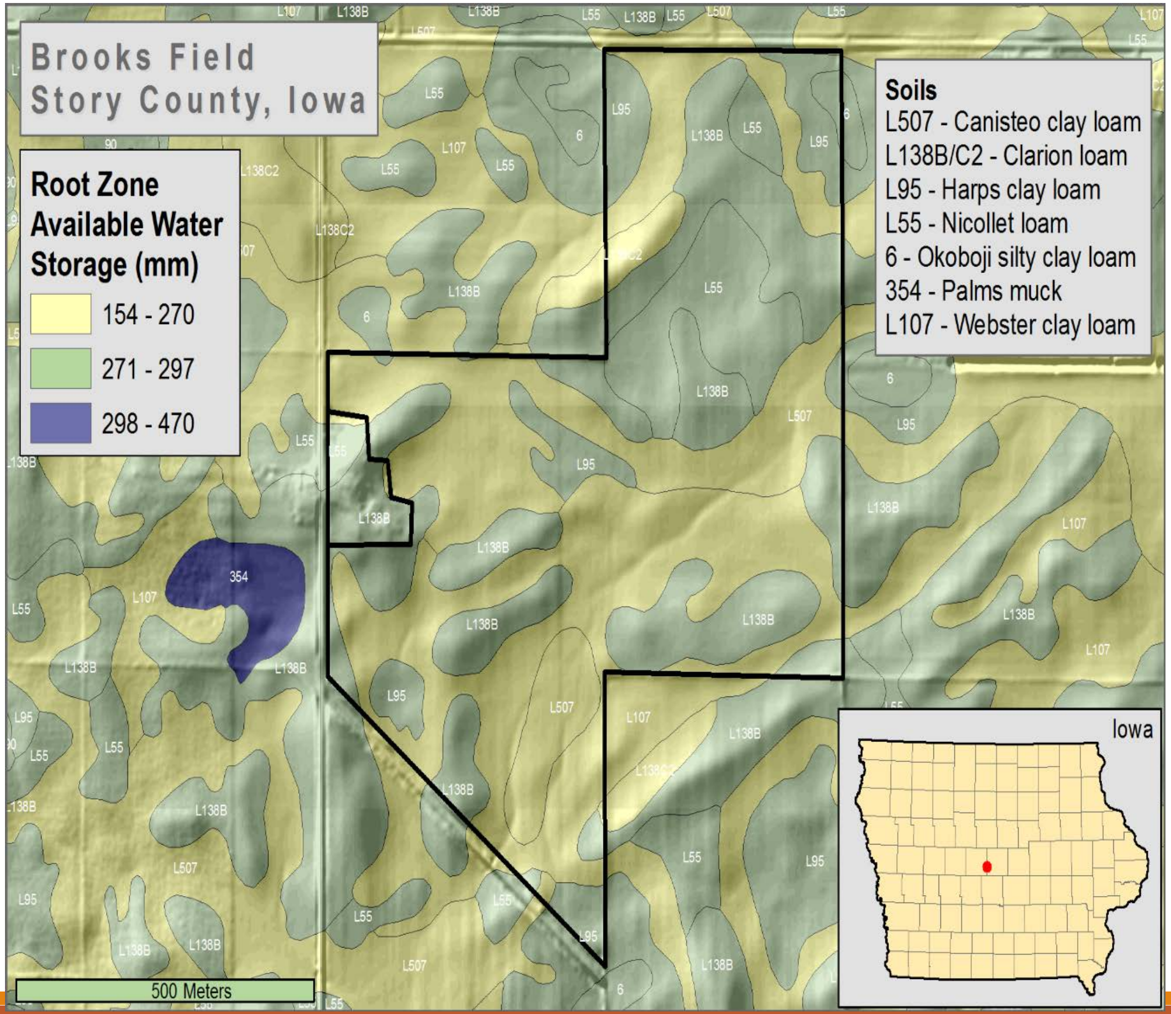


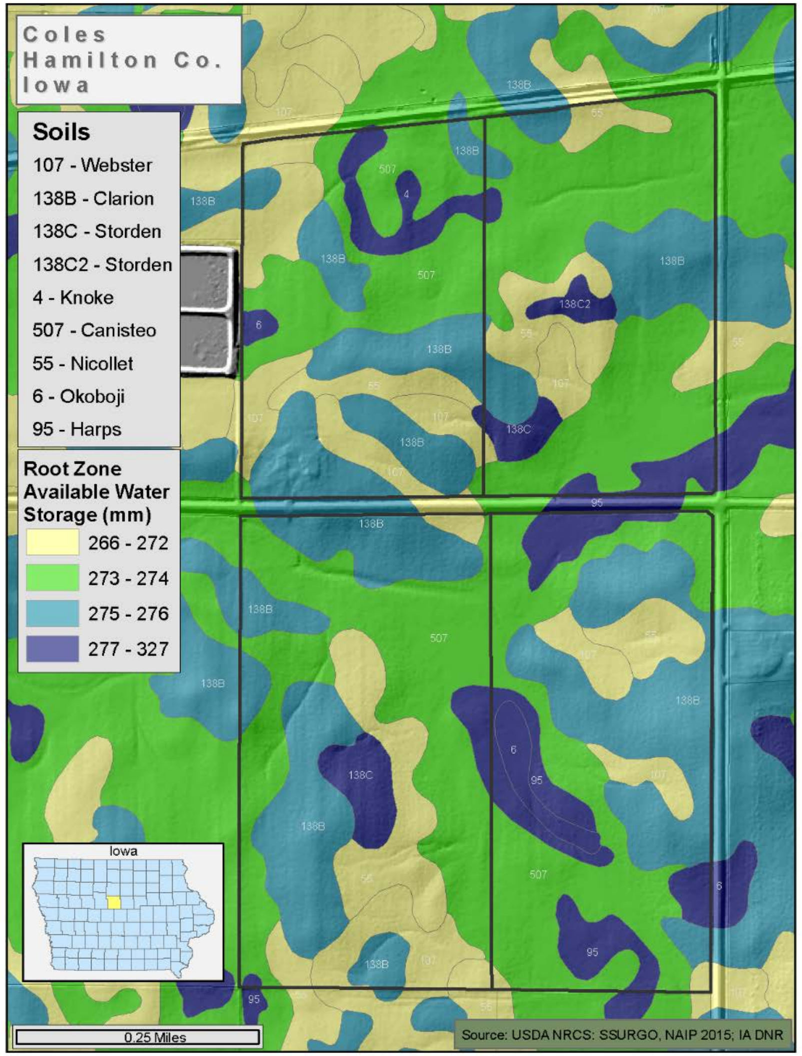
Assuming an average rate of crop water use during the grain-filling period for corn



Hudson, 1994

Variation of Water Holding Capacity within production fields





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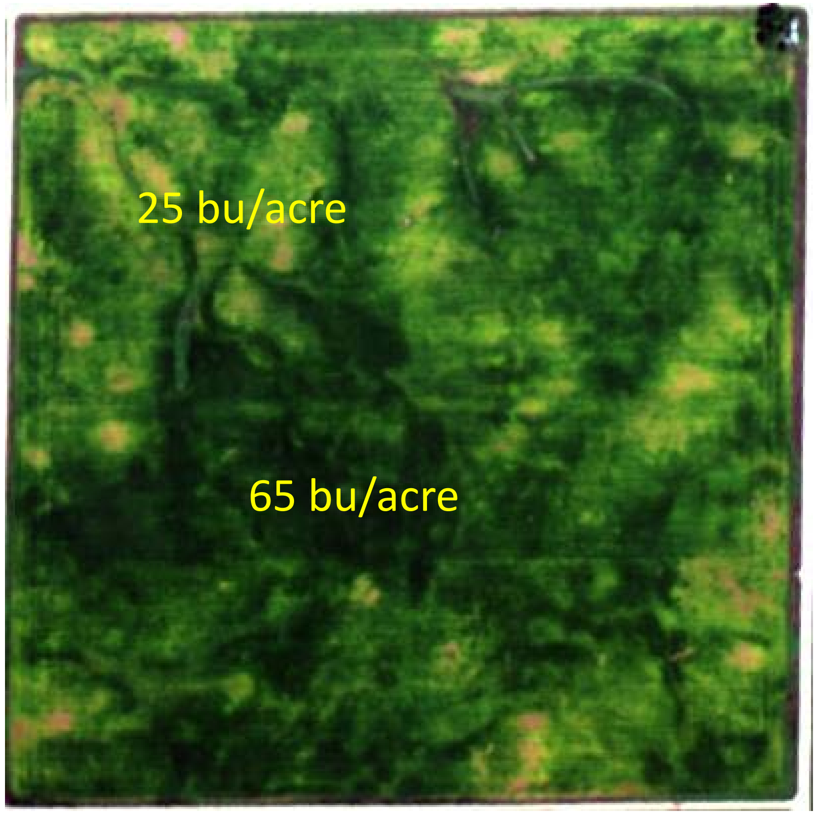
Soybean Production Field

Early August

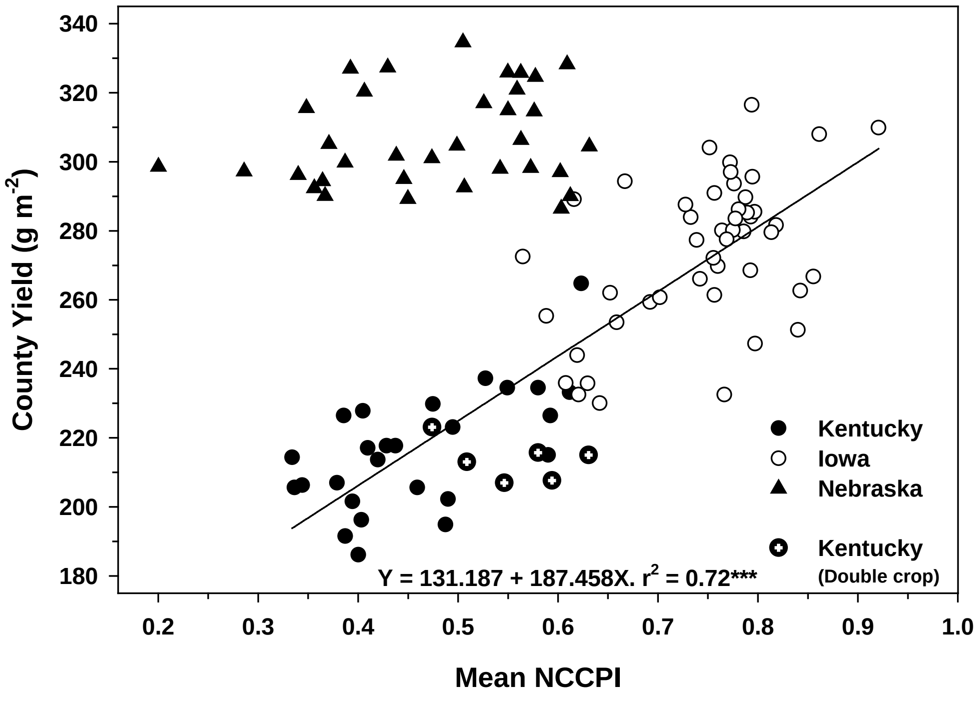
Late August



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

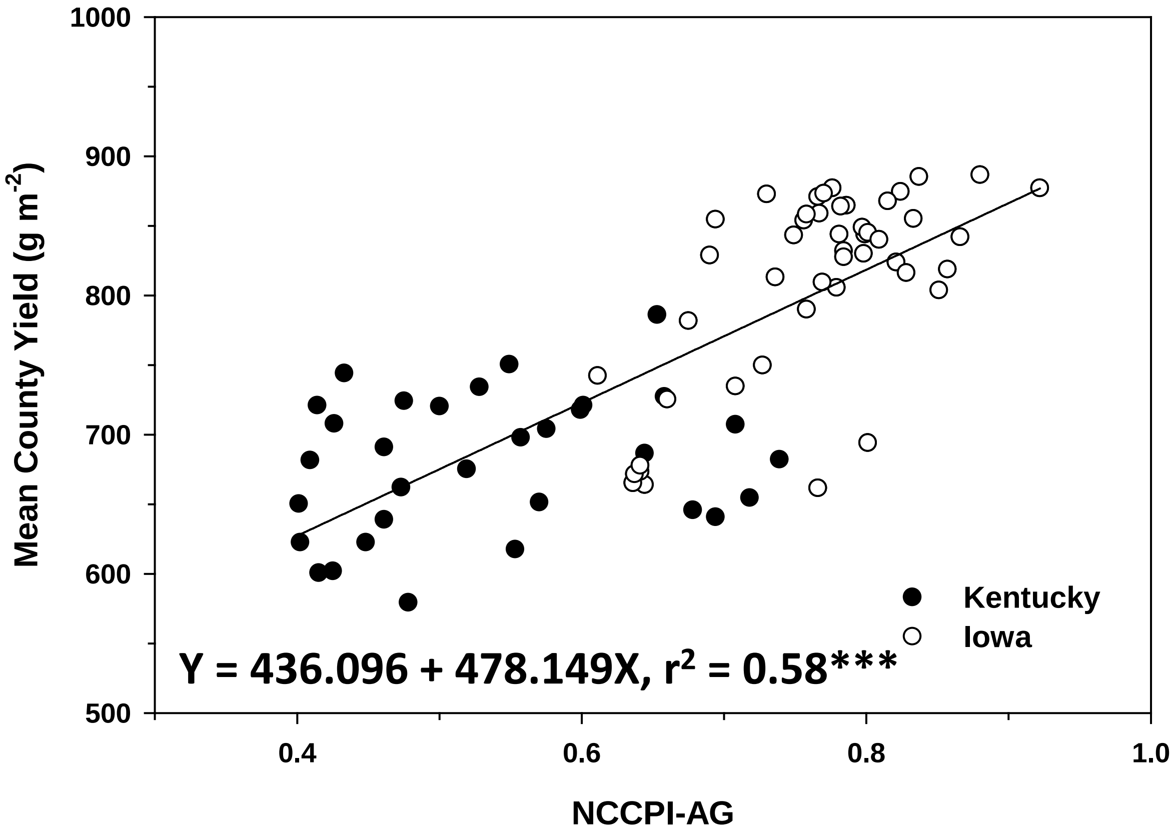
Good Soils = Good Yields

Soybean yields across Iowa, Kentucky, and Nebraska

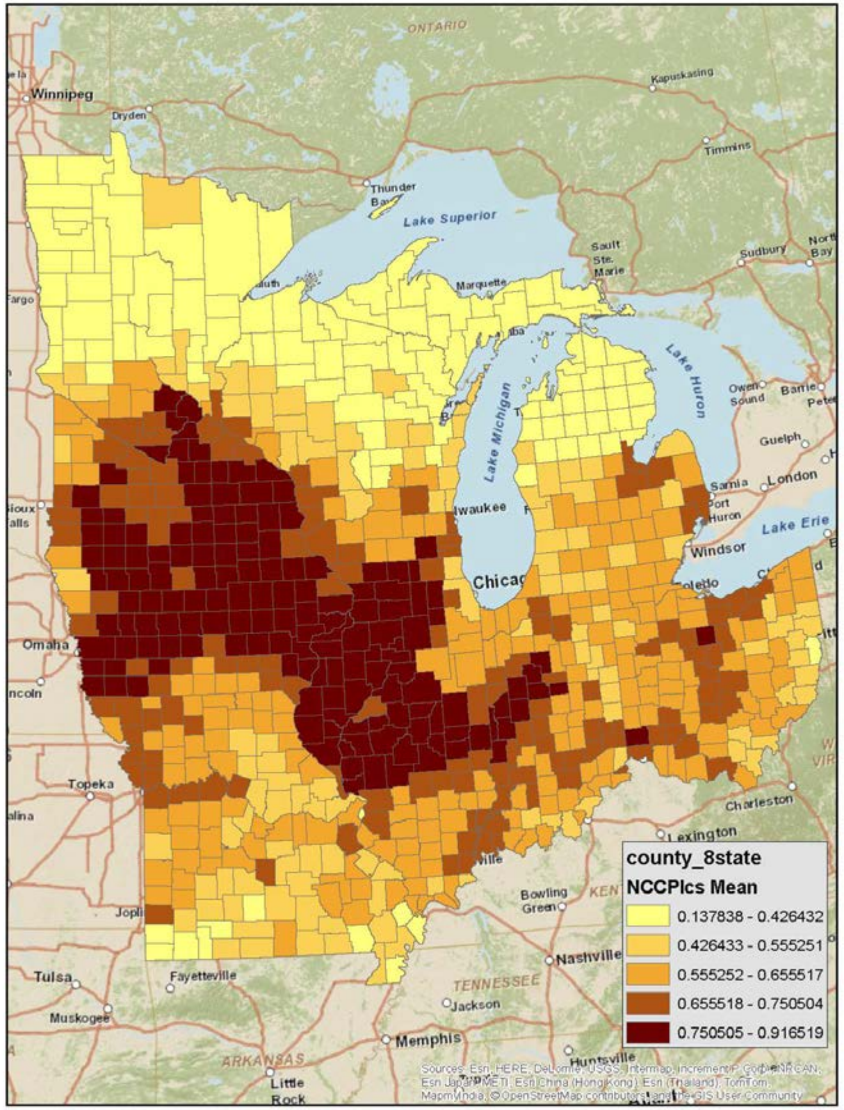


Climate resilience is derived from good soils in rainfed agricultural systems

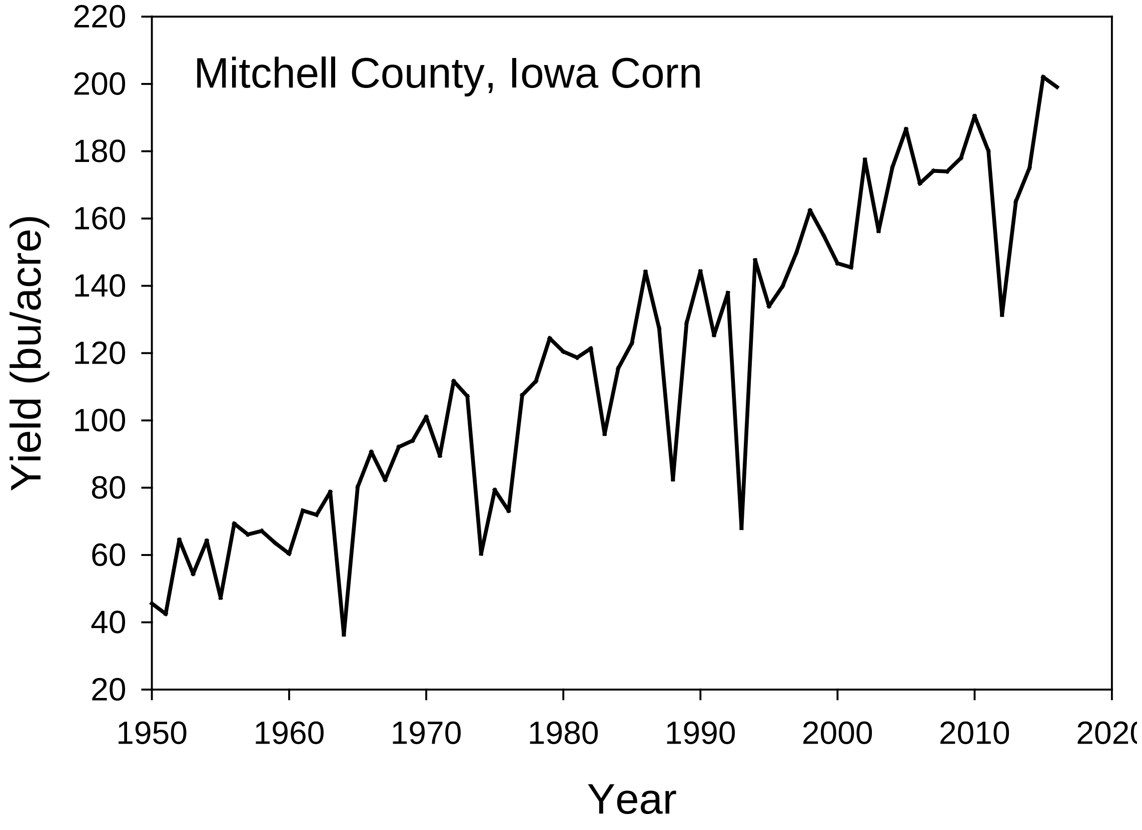
Maize County Yields

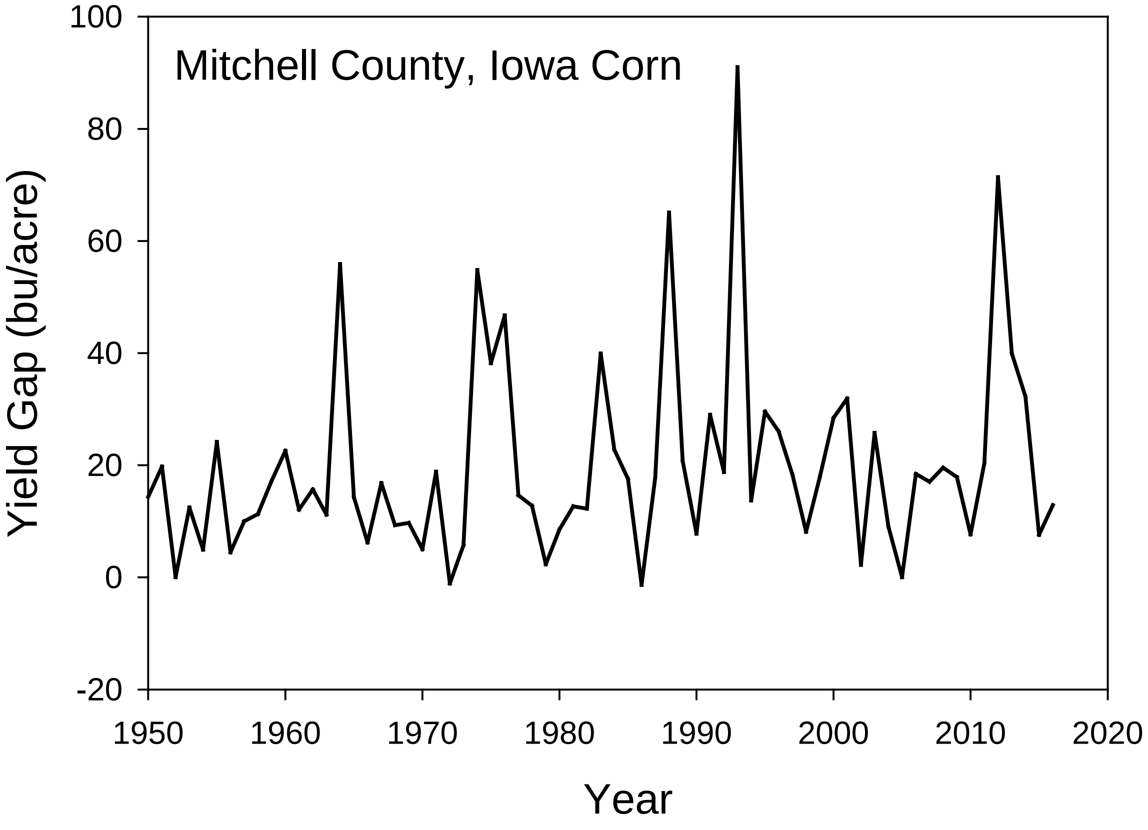


Variation in NCCPI across the Midwest

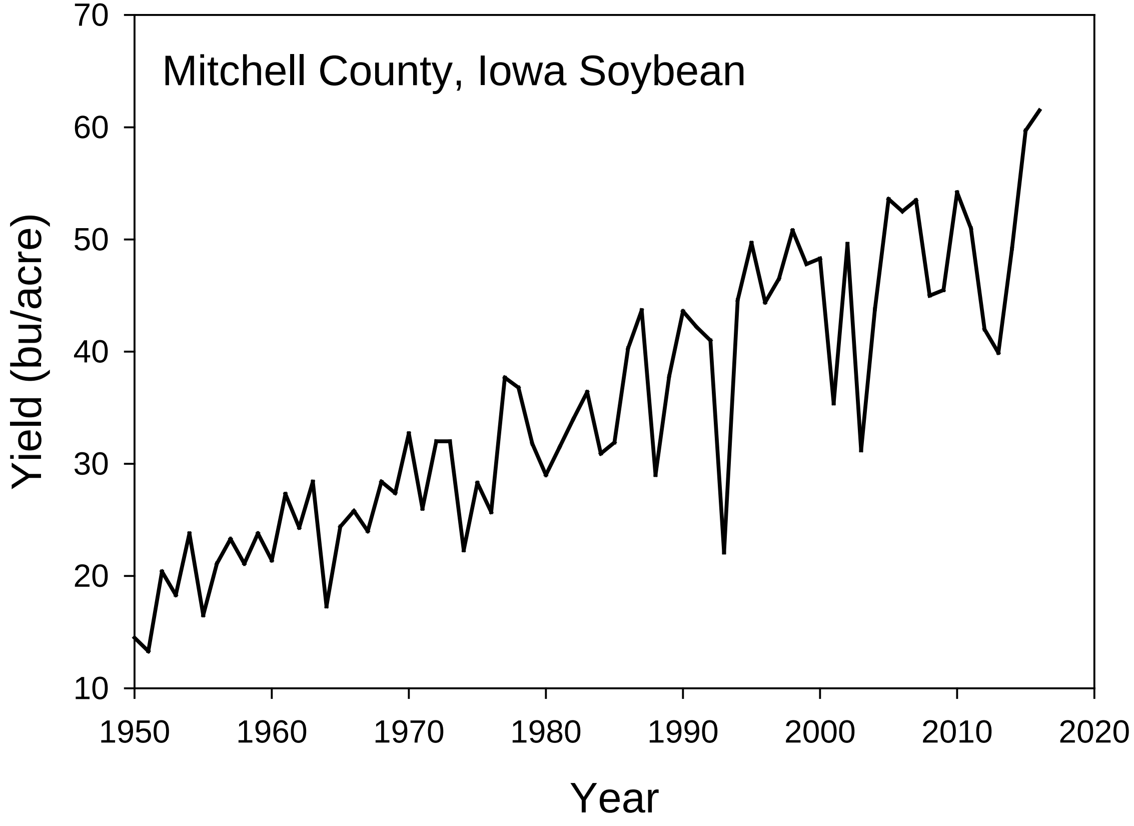


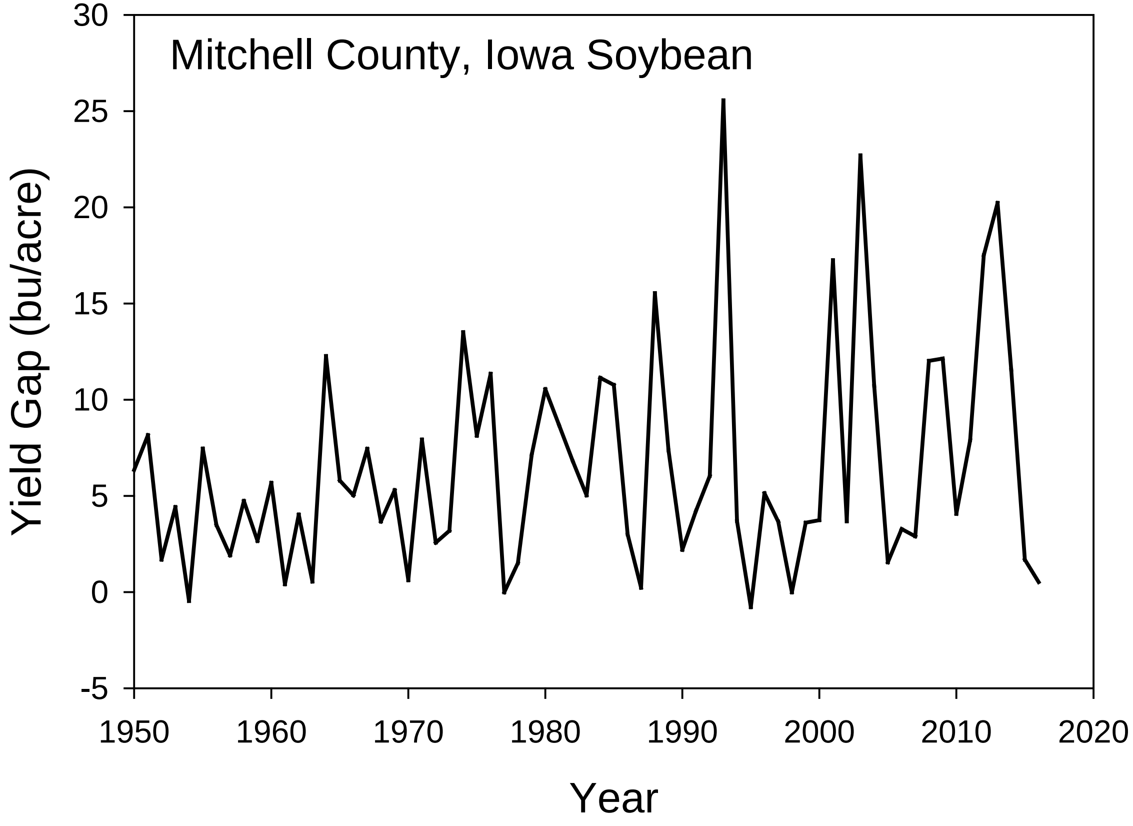
Corn Production – Yield and Yield Gap



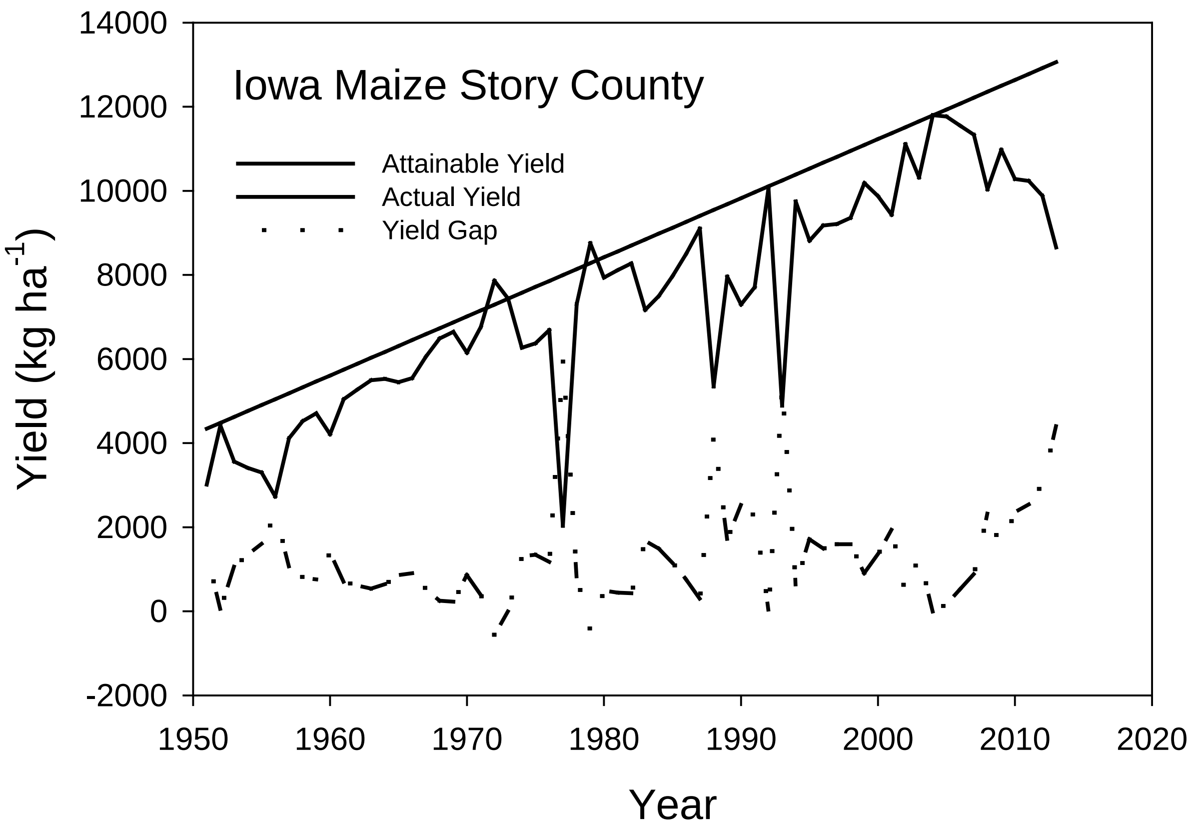


Soybean Production – Yield and Yield Gap

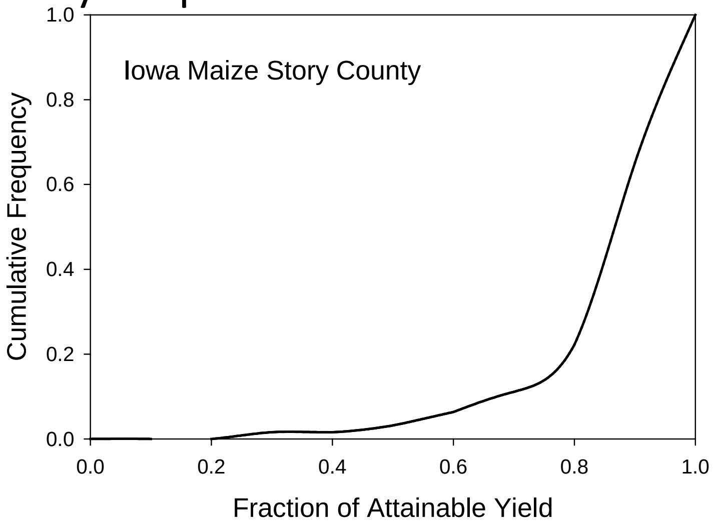




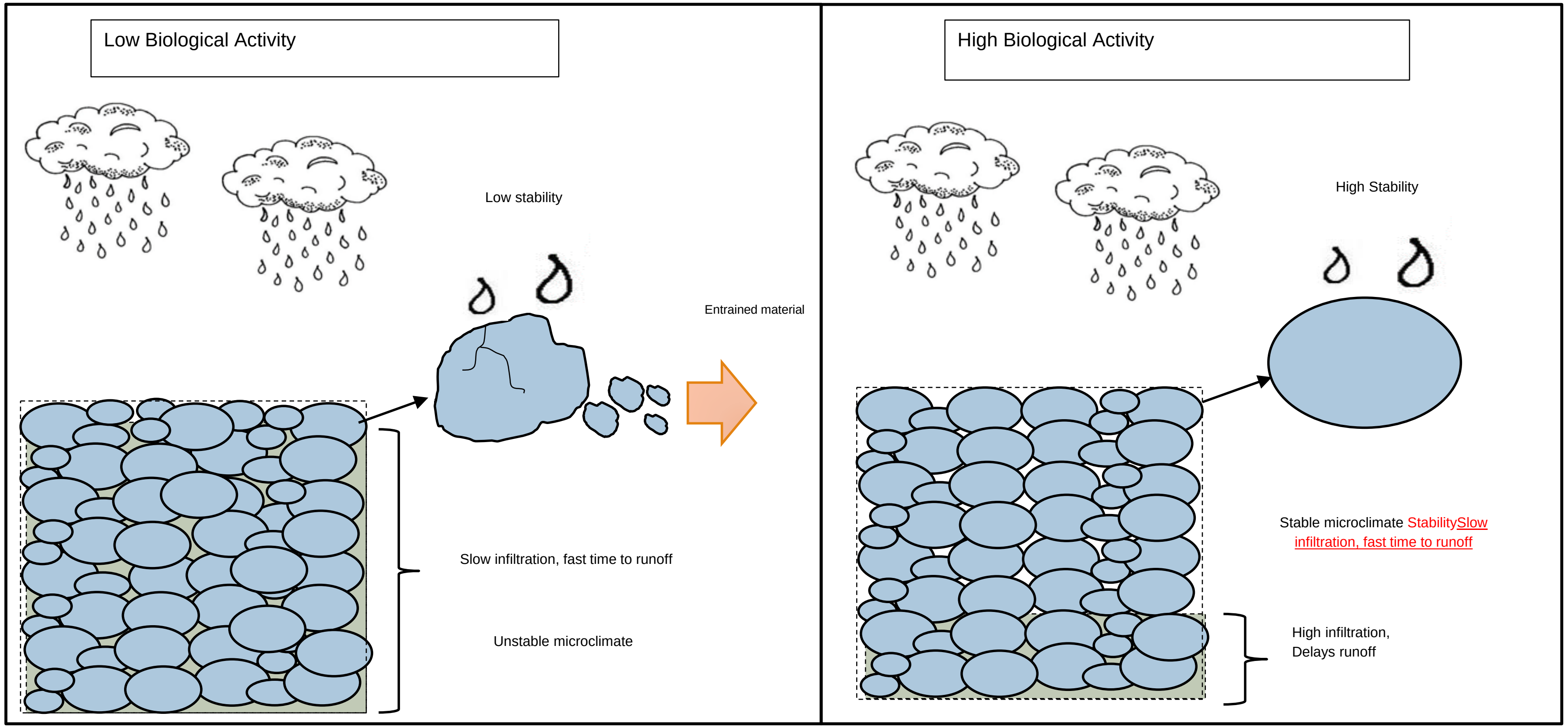
Yield Gaps



We have found that 20% of the yield loss occur 80% of the time due to short term stresses, e.g., we needed an 2 inches but only received 1 inch of rainfall for the week so the plant is under a moderate stress and not fulling its yield potential



Stable Soil Systems



Soil Degradation Spiral

Poor Land Management

Aggregation Degradation

Compaction
& crusting

Water & Wind Erosion

Plant Growth

Soil Biology

Yield

Reduced Soil
Productivity


Soil Aggradation Climb
Visible Outcomes
Improved Water Availabilty
Improved Soil Structure
Improved Nutrient Cycling
Organic Matter Turnover
Biological Activity
Invisible and dynamic process
graphic 3.1

Role of residue on the soil surface

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

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.

Evolution of a continuous no till systems: 4 phases

Initial	Transition	Consolidation	Maintenance
o Rebuild aggregates	❑ Increase soil density	➢ High Crop Residue	✓ High accum. of crop residue
o Low 0M	❑ Start increasing crop residue	➢ High C	✓ Continuous N and C flux
o Low crop residues	❑ Start increasing soil OM	➢ > CEC	✓ Very high C
o Reestablish microbial biomass	❑ Start increasing P	➢ > H2O	✓ > H2O
o > N	❑ Immobilize N >= Minimum	➢ Immobilize N < Min.	✓ High nutrient cycling
		➢ > Nutrient Cycling	✓ Less N & P use
0-5	5-10	10-20	>20

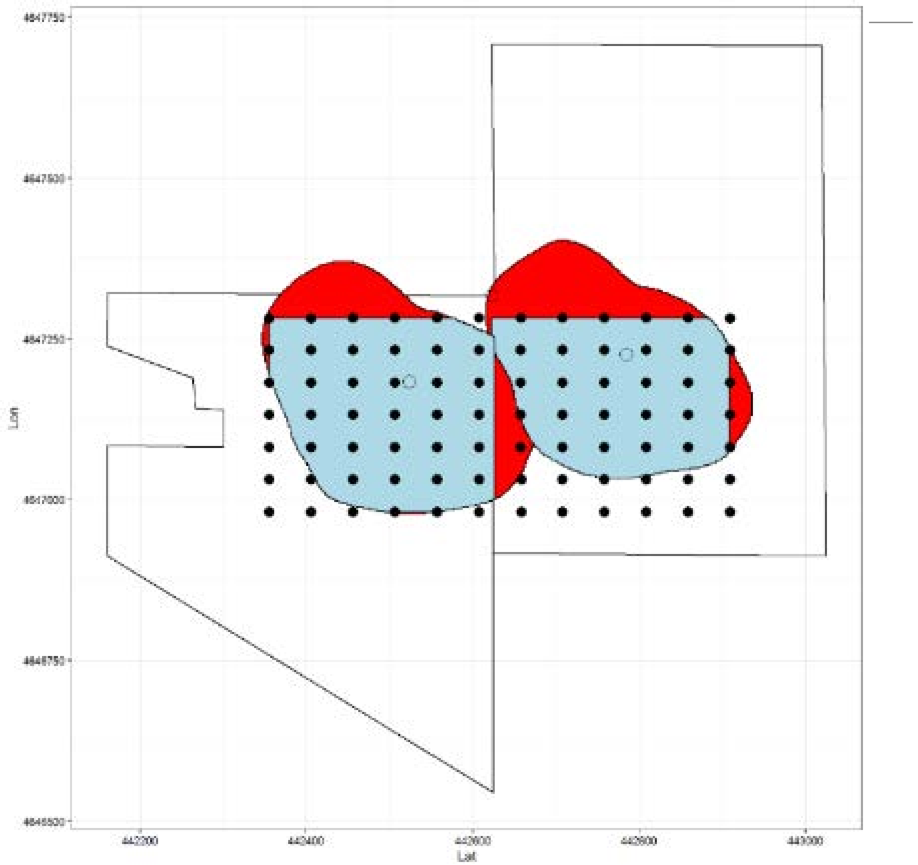
Time (years)

Source: Sa, 2004

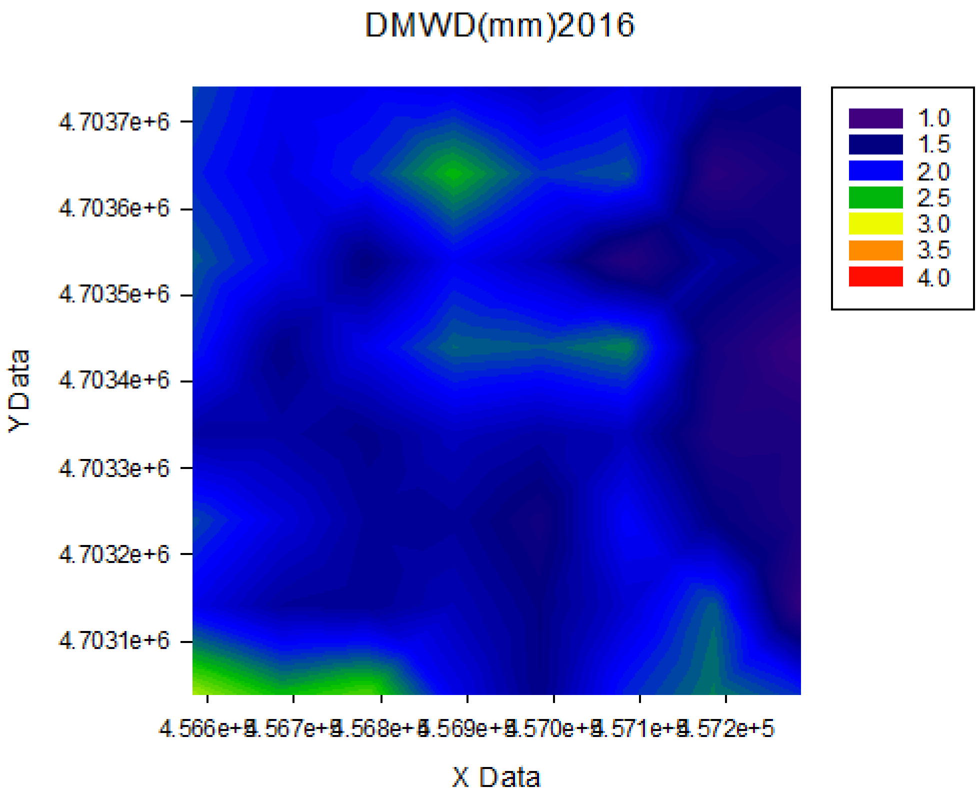
USDA

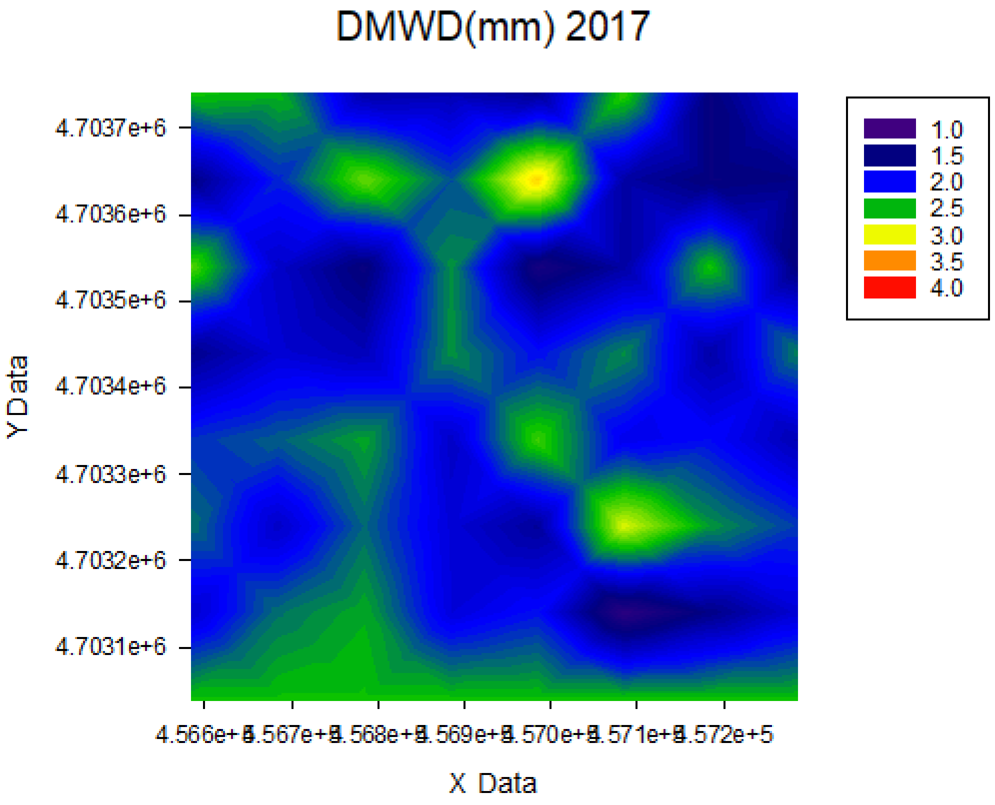
Carbon Balance in Corn-Soybean Fields 2000-2016

Rates **(Mg C ha^{-1} yr^{-1})**	**Field**	**Footprint**
ΔTC	-1.52 ± 0.78	-1.54 ± 0.76
C budget	-1.70 ± 0.01	-1.72 ± 0.02



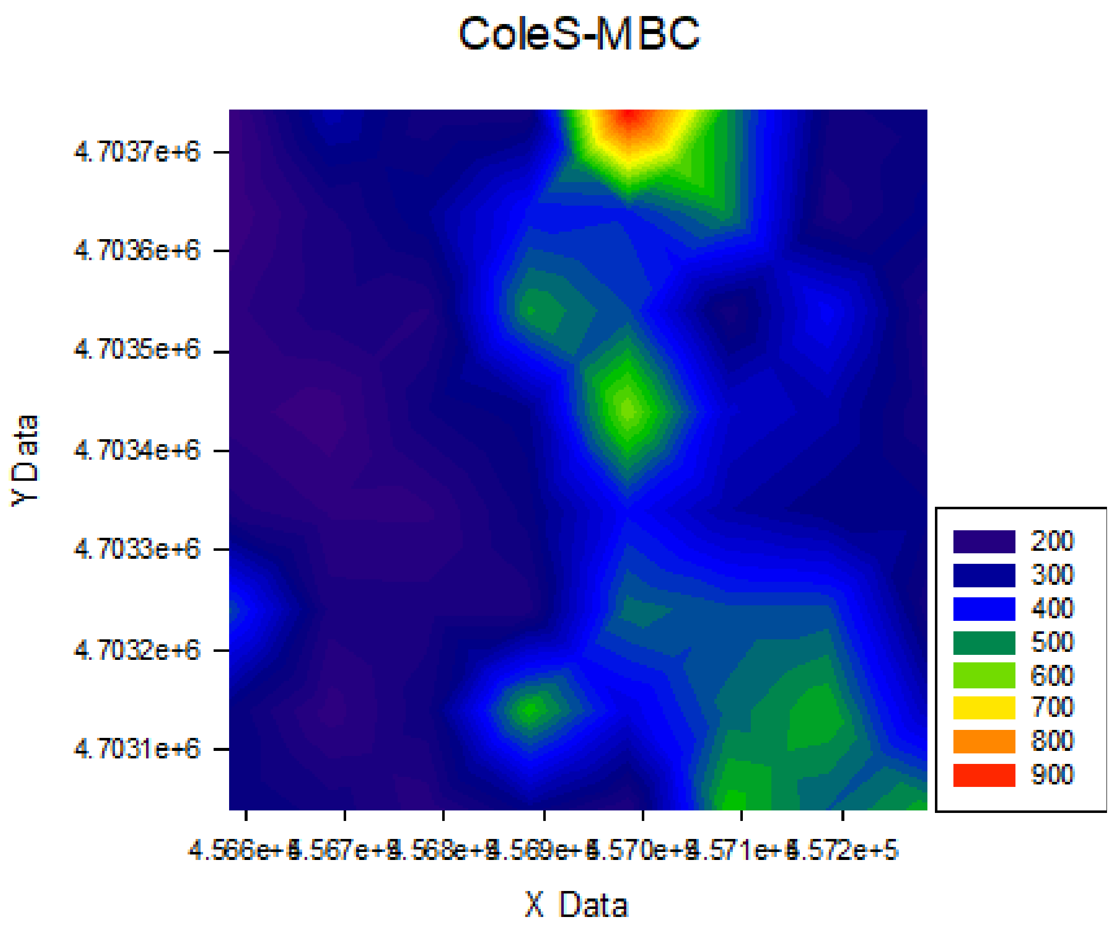
Spatial variation- dry mean weight diameter

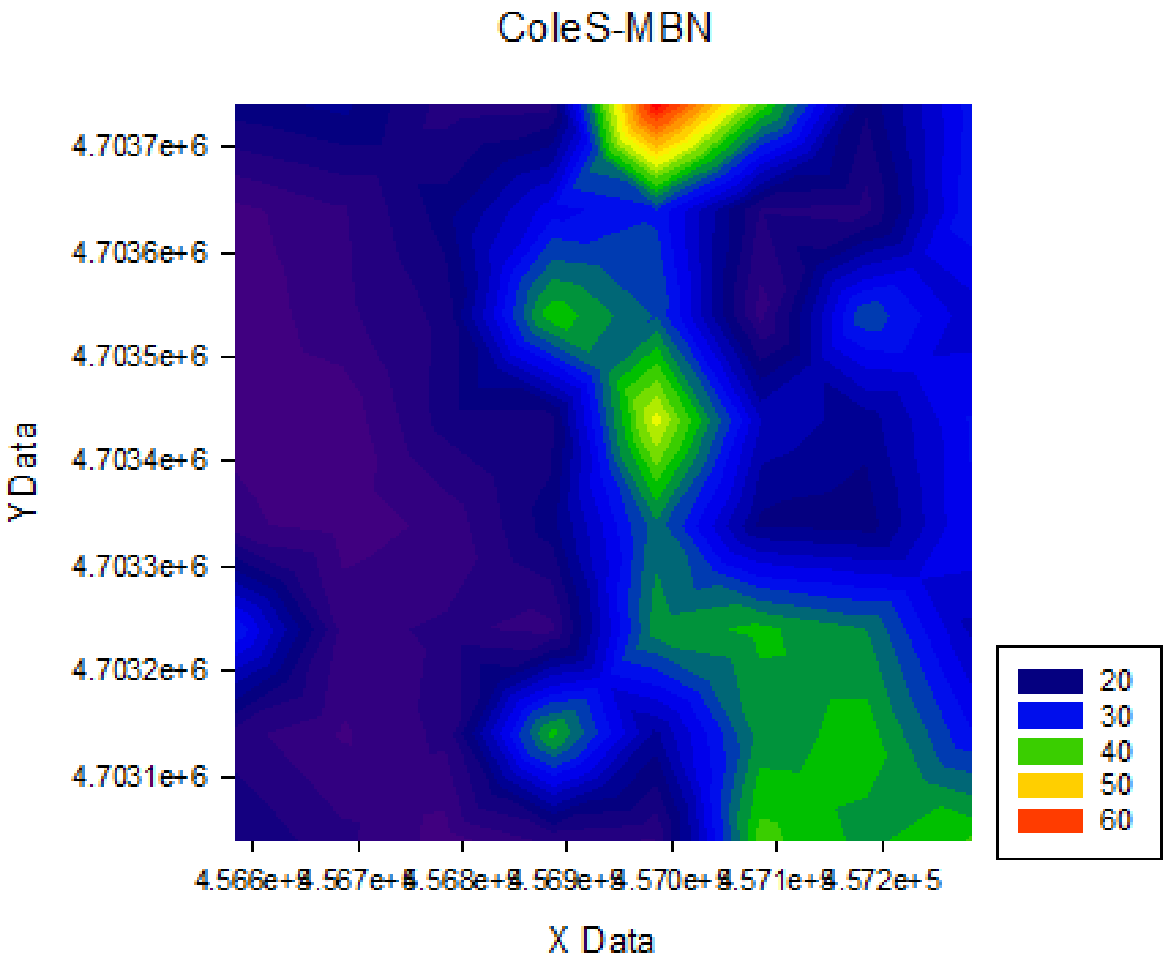




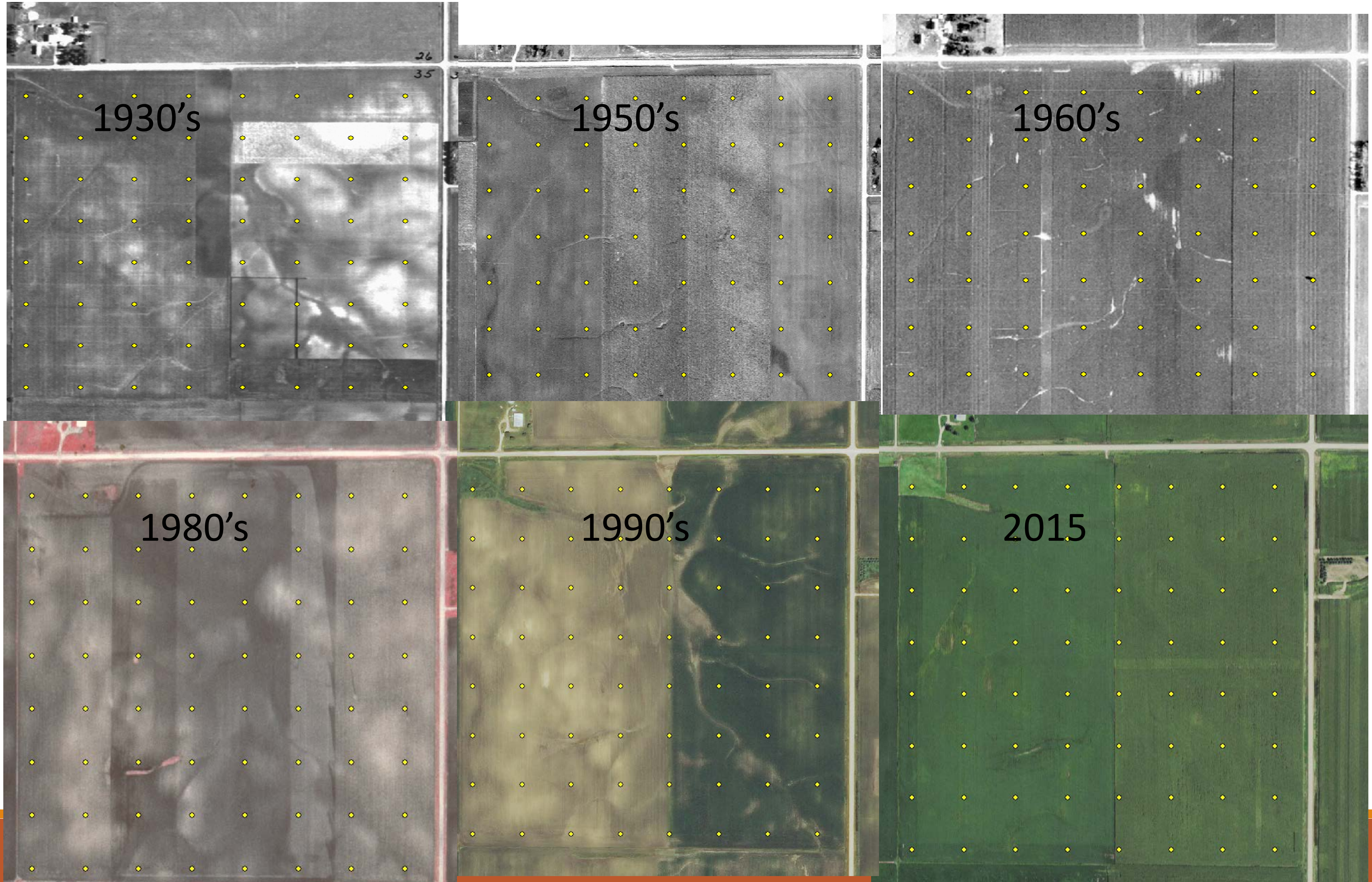
Sampling in 2016 was prior to implementing cover crop and no-till, change in the upper 15 cm in the 2017 samples

Spatial variation – Microbial biomass





History of the Coles South Field



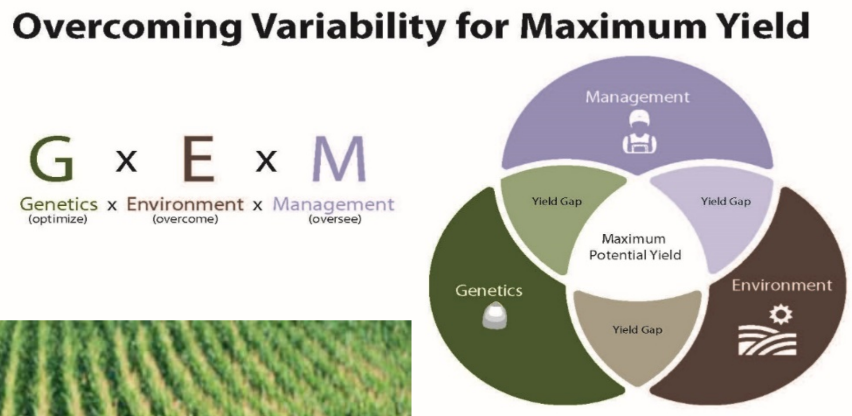
What do we know

Our weather is becoming more variable

Efficient crop production is dependent upon good weather and a good soil

We can manage the soil to increase climate resilience by increasing water availability and nutrient cycling

Enhancement is soil is only possible by enhancing and maintaining the soil biological system



Overcoming Variability for Maximum Yield
G x E x M
Genetics (optimize) x Environment (overcome) x Management (oversee)
Management
Yield Gap
Yield Gap
Maximum Potential Yield
Genetics
Environment
Yield Gap