Reducing the impact on production

# HOW SOIL HEALTH CAN MITIGATE THE EFFECTS OF EXTREME WEATHER EVENTS ON FARMS

# CONTACT INFORMATION

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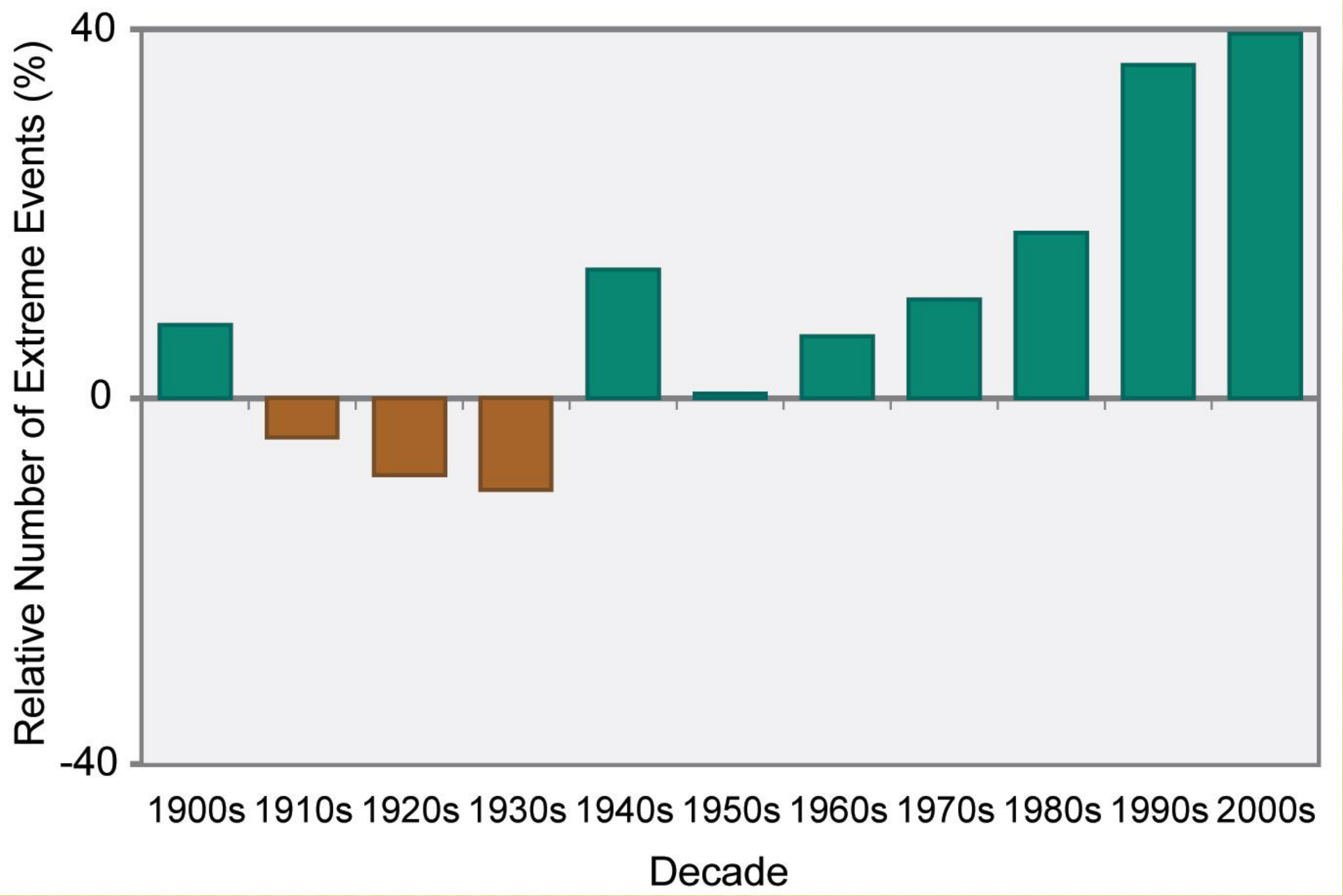
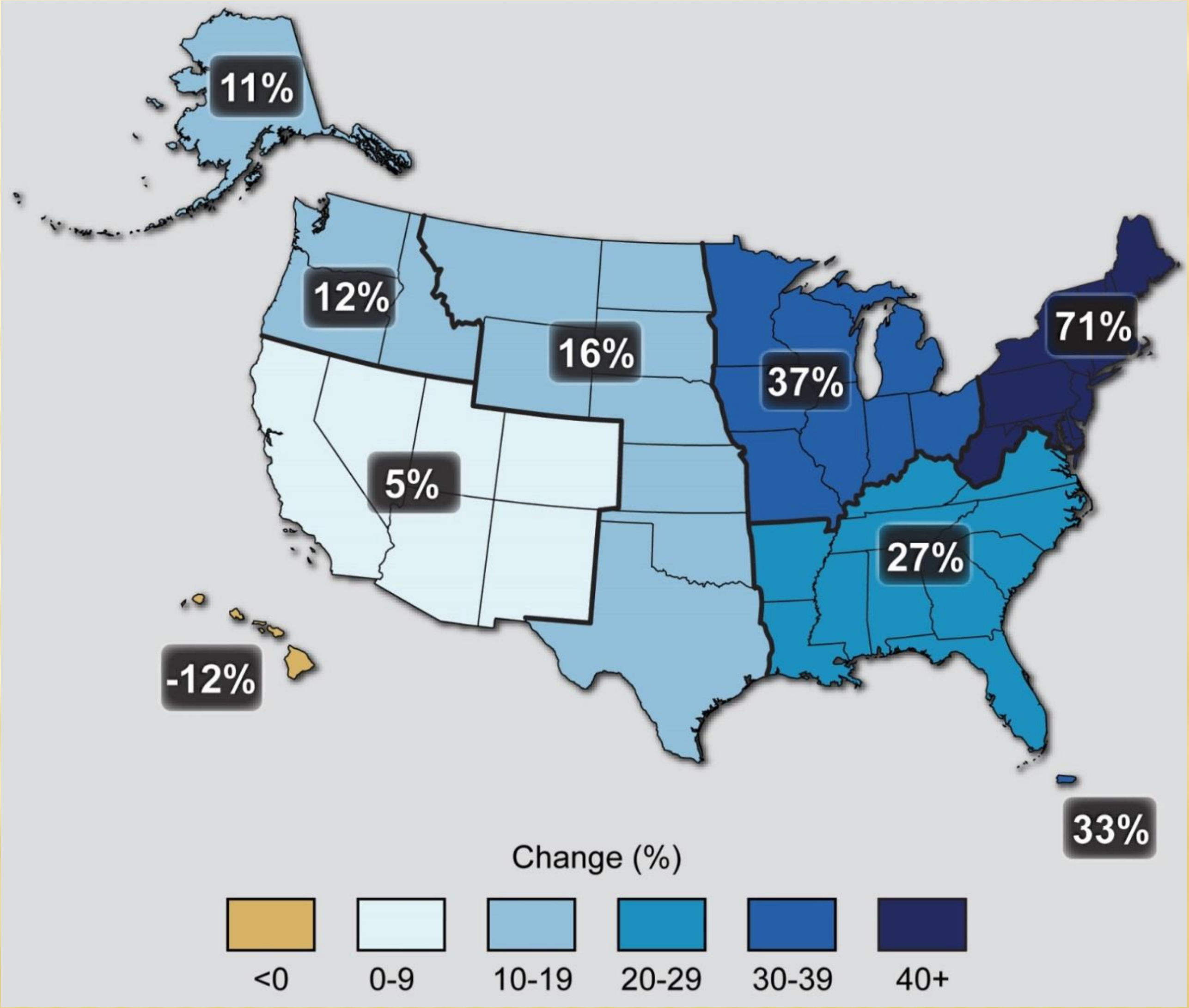
# CLIMATE CHANGE

- Precipitation changes
- Temperature changes
- Moving toward extremes

# OBSERVED U.S. TRENDS IN HEAVY PRECIPITATION



# OBSERVED CHANGE IN VERY HEAVY PRECIPITATION



# EROSION: HOW MUCH IS TOLERABLE

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# THE WIND BLOWS TOO

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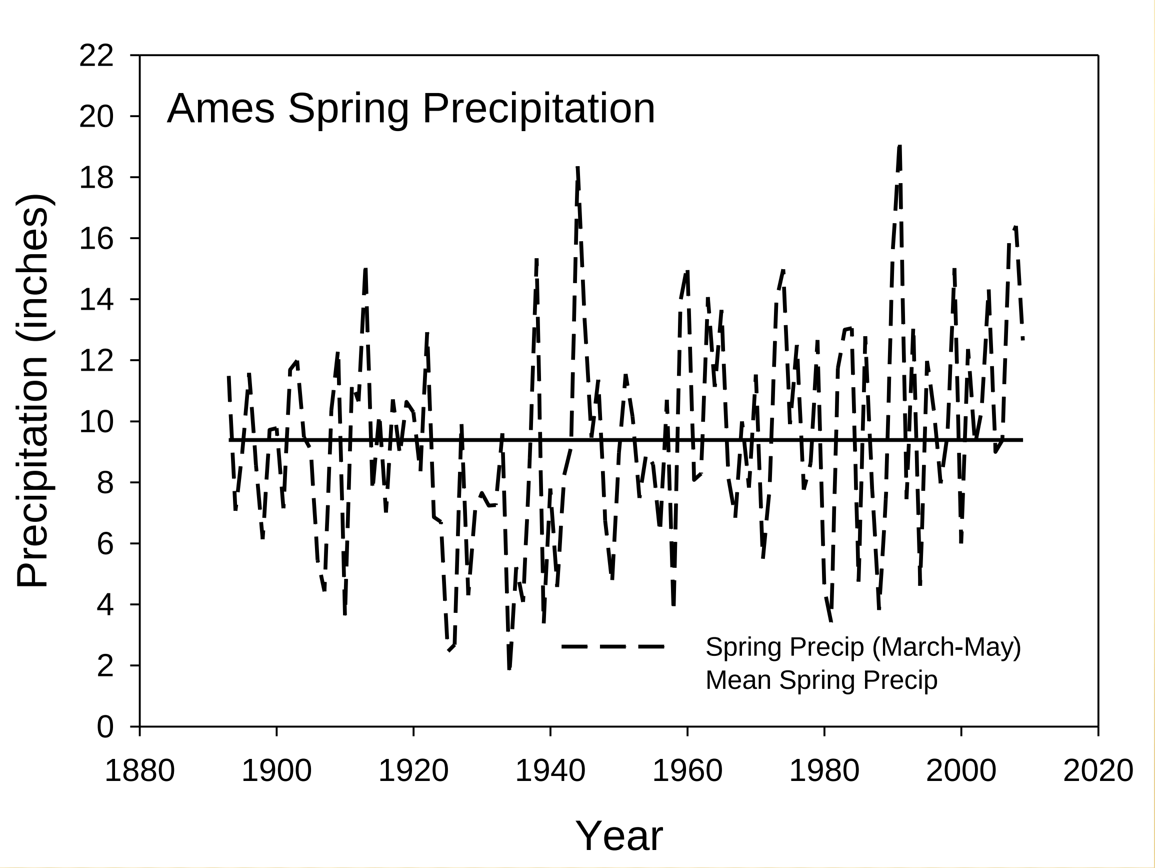
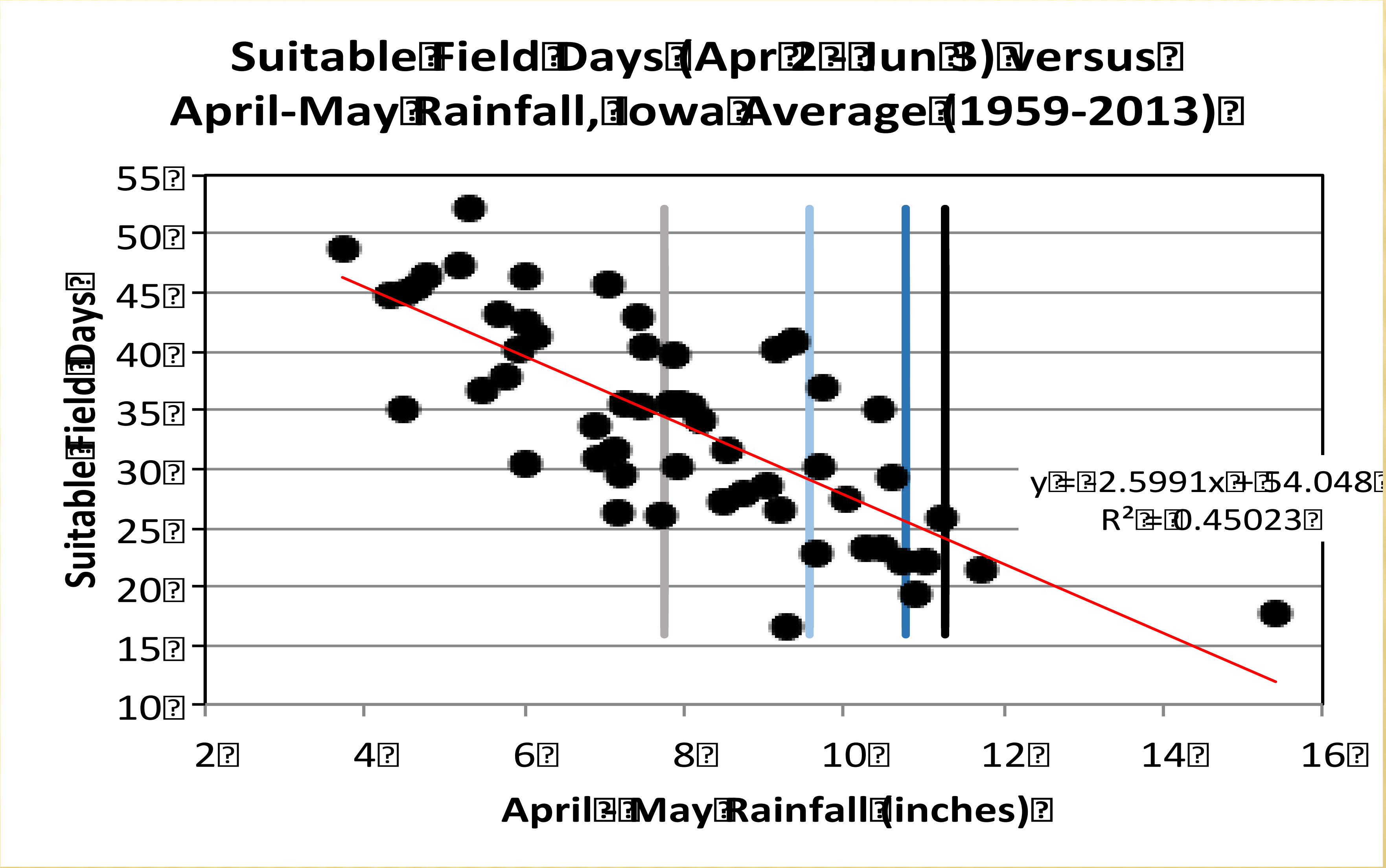
# SPRING PRECIPITATION (AMES)

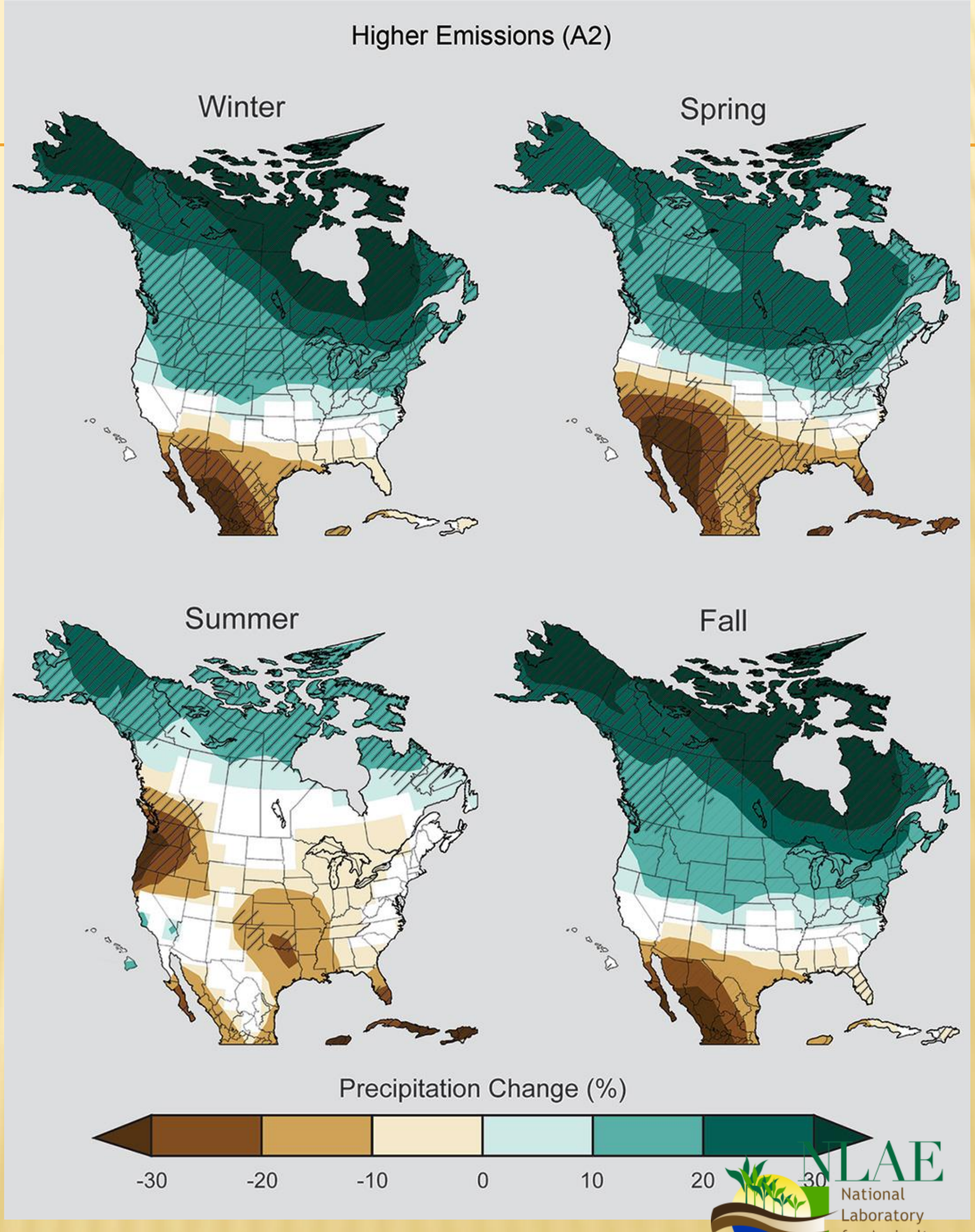



The increase in spring precipitation has decreased the number of workable field days in April through mid-May across Iowa by 3.7 in 1995 to 2010 compared to 1979-1994



Suitable Field Days (Apr 2 - Jun 3) versus
April-May Rainfall, Iowa Average (1959-2013)
Suitable Field Days
55
50
45
40
35
30
25
20
15
10
2
4
6
8
10
12
14
16
April - May Rainfall (inches)
y = -2.5991x + 54.048
R² = 0.45023

# PROJECTED PRECIPITATION CHANGE BY SEASON

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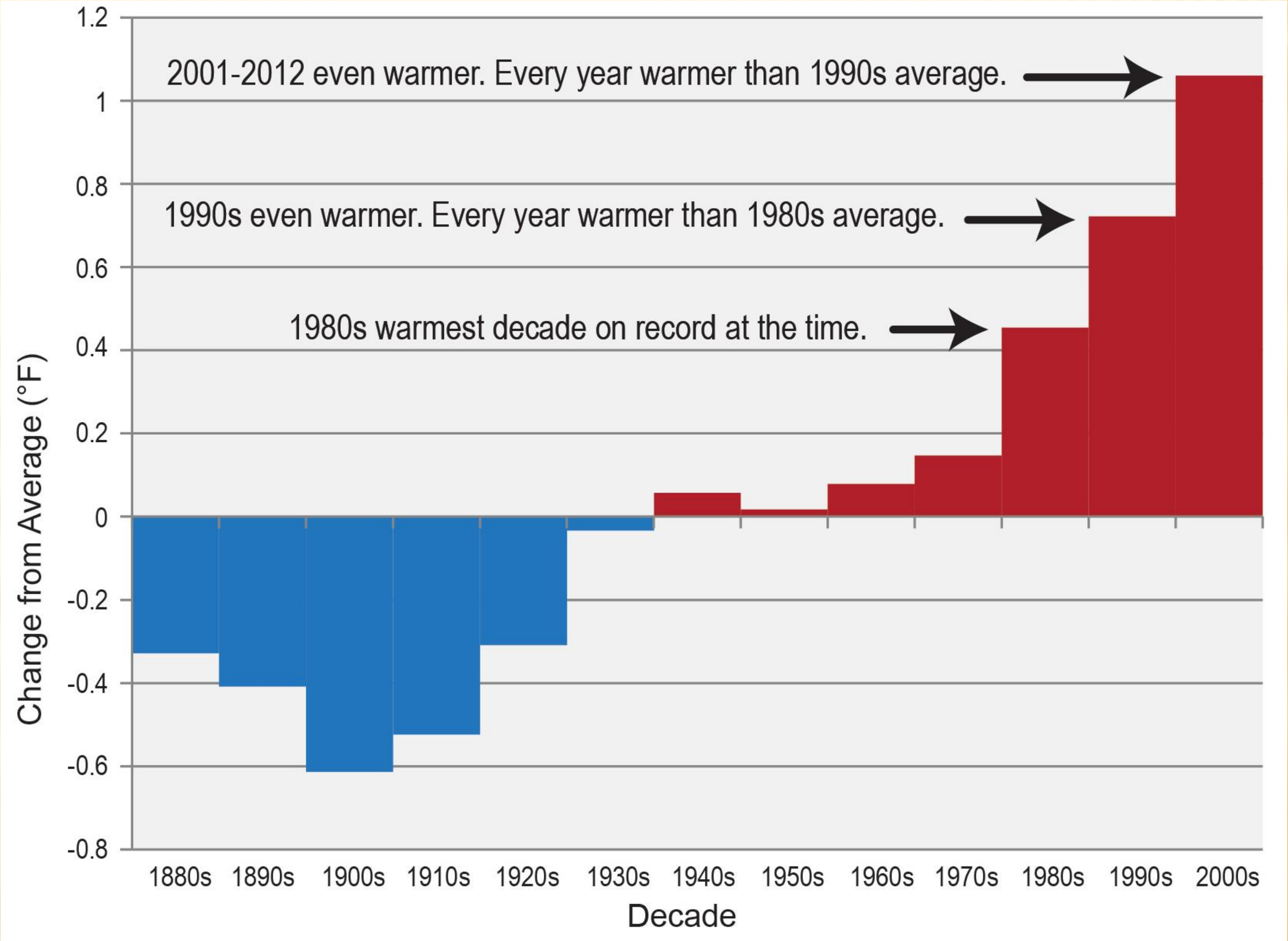
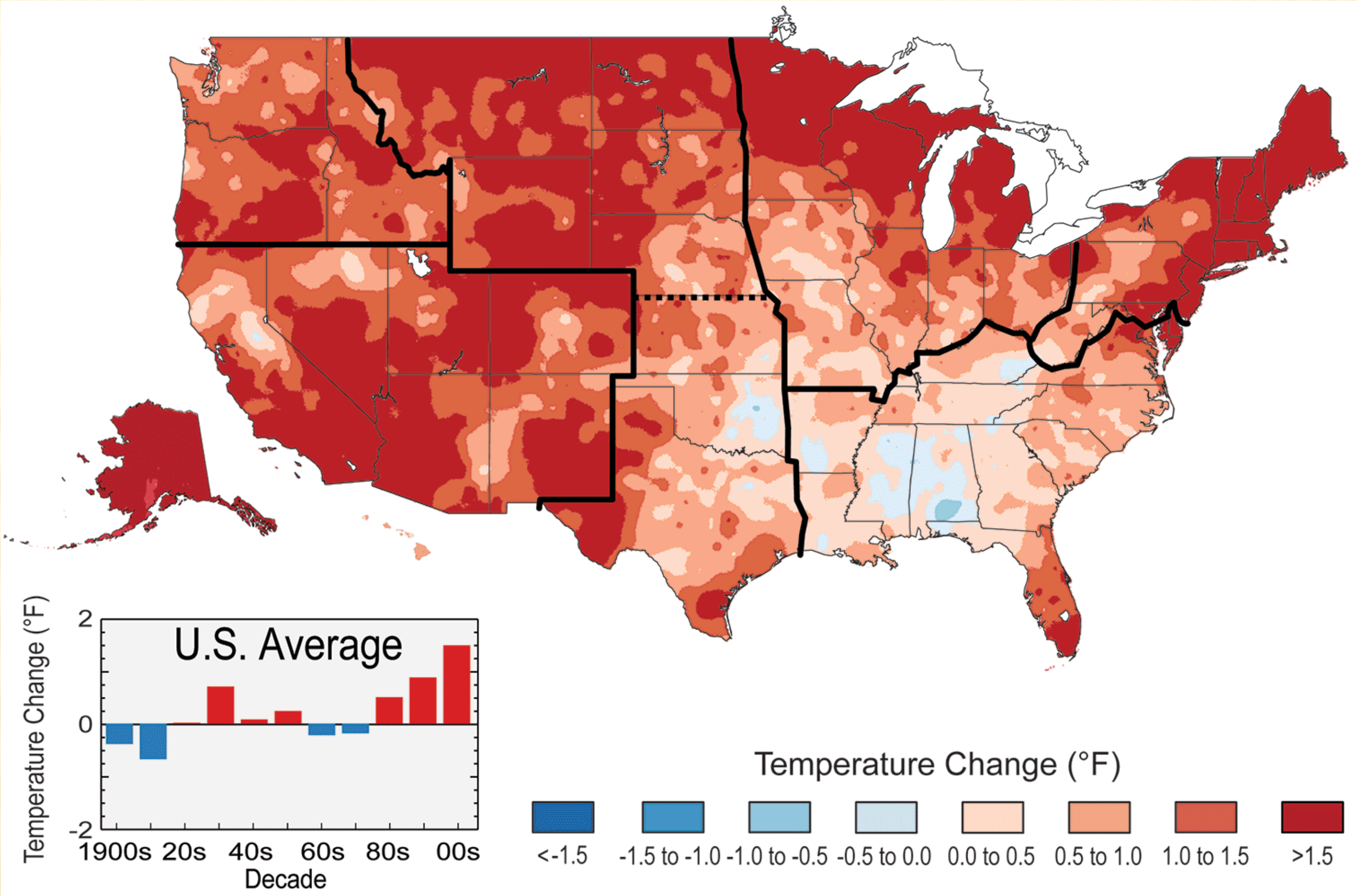
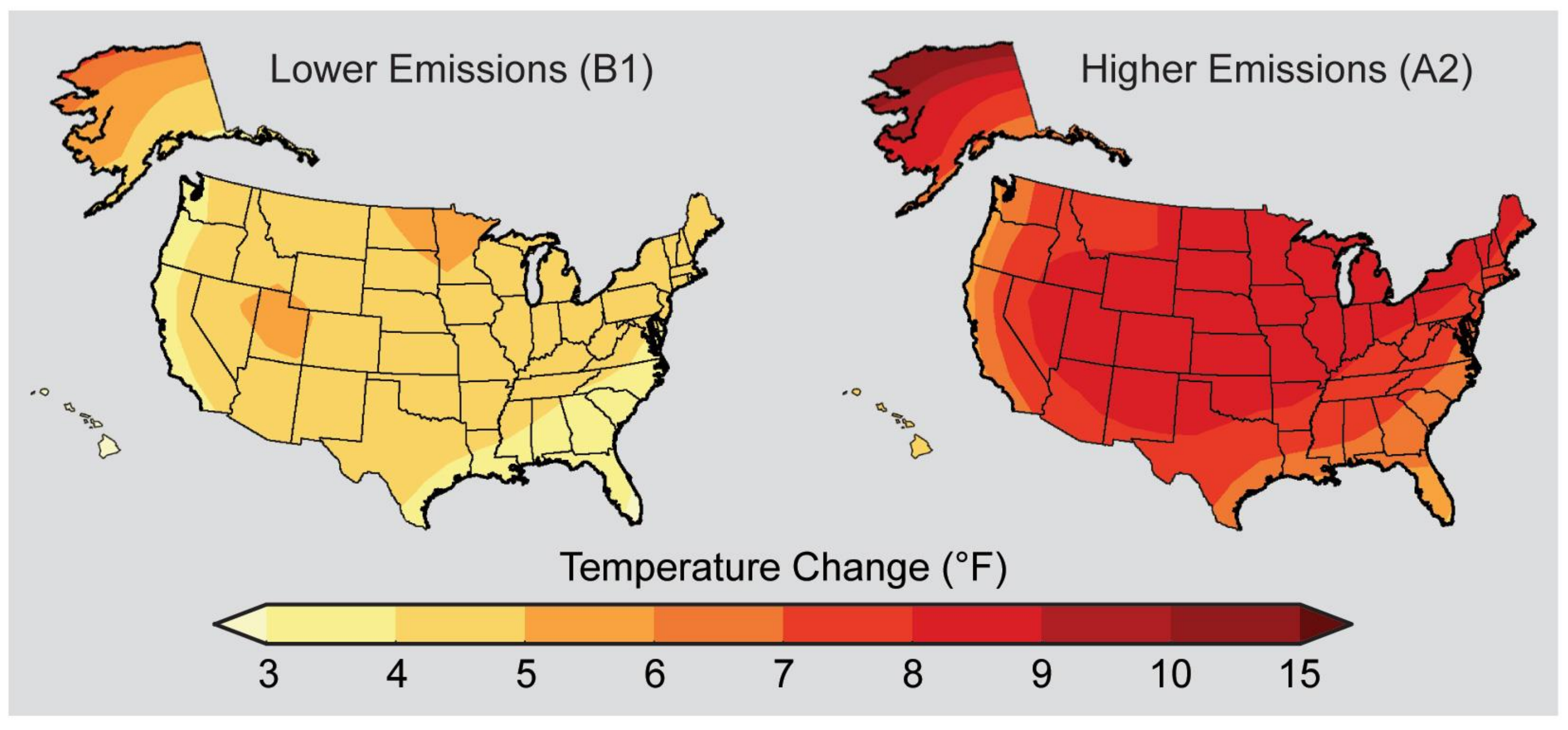
# TEMPERATURE CHANGE BY DECADE



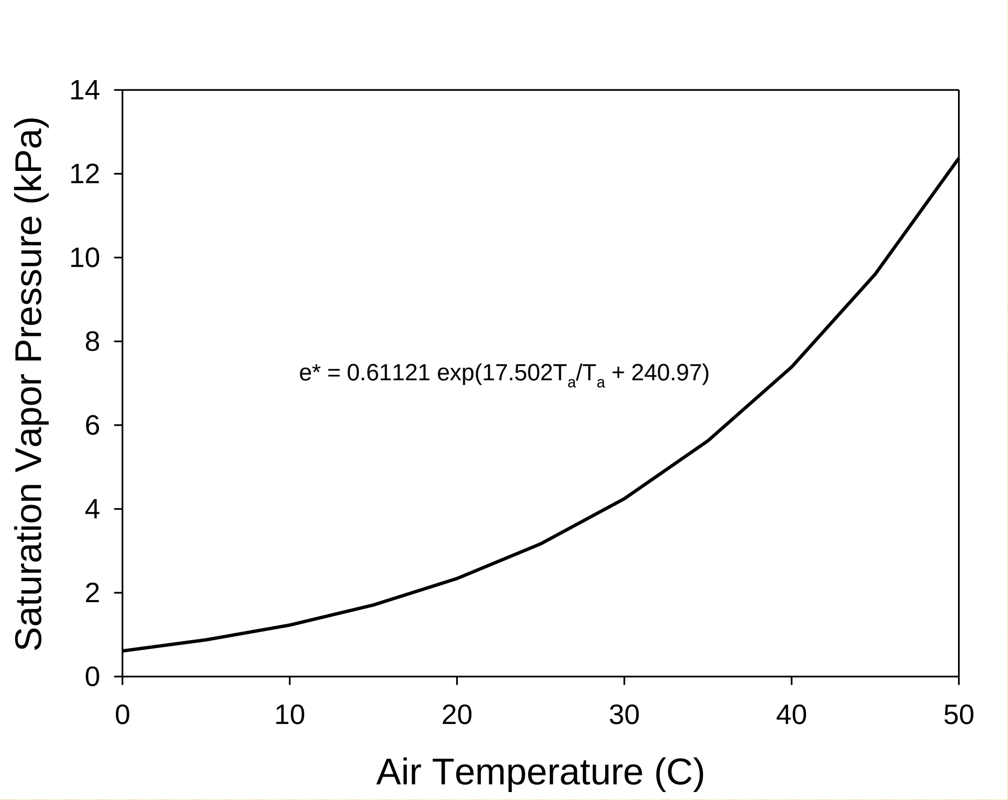
# OBSERVED U.S. TEMPERATURE CHANGE



# PROJECTED TEMPERATURE CHANGE

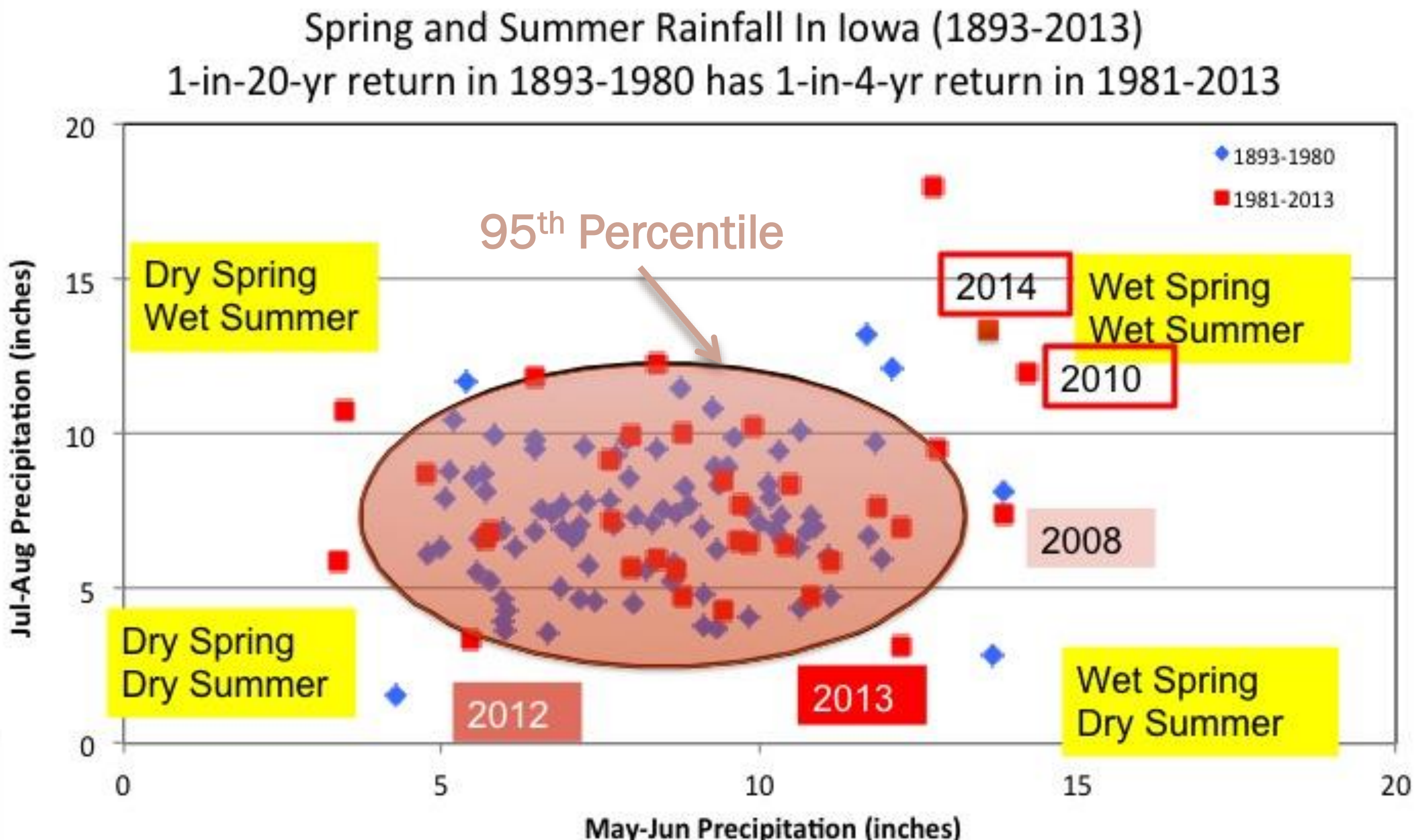


# TEMPERATURE EFFECTS ON EVAPORATION




$$ET = \frac{\rho c_p (T_0 - T_s)}{r_a} + \frac{\rho c_p [e_s(T_0) - e_a]}{\gamma(1 + {}^{r_s}/_{r_a}) r_a}$$

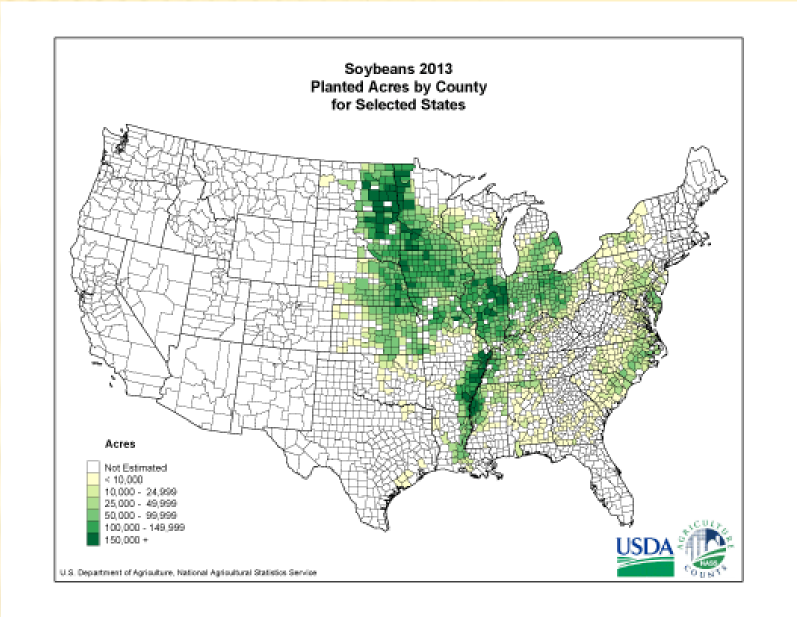
# Weather Trend: Unusual combinations of spring and summer rainfall are occurring more often

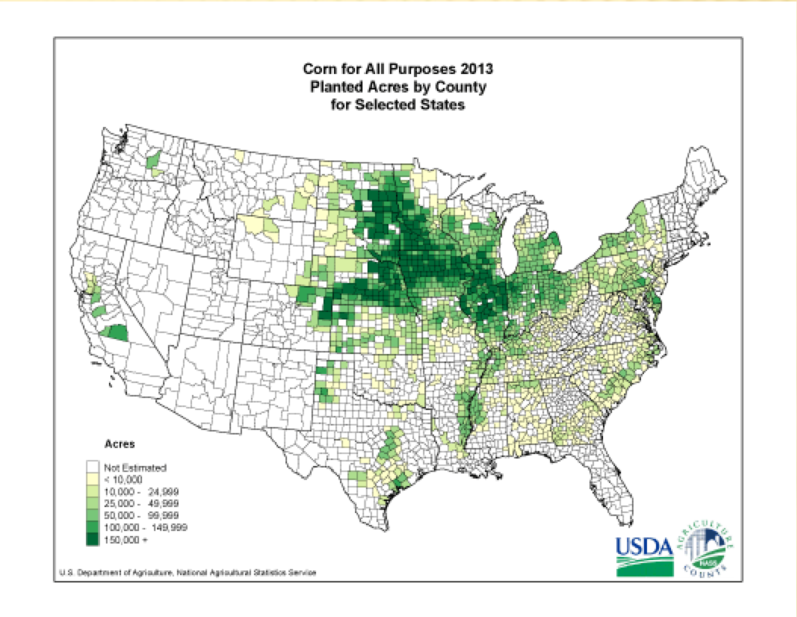


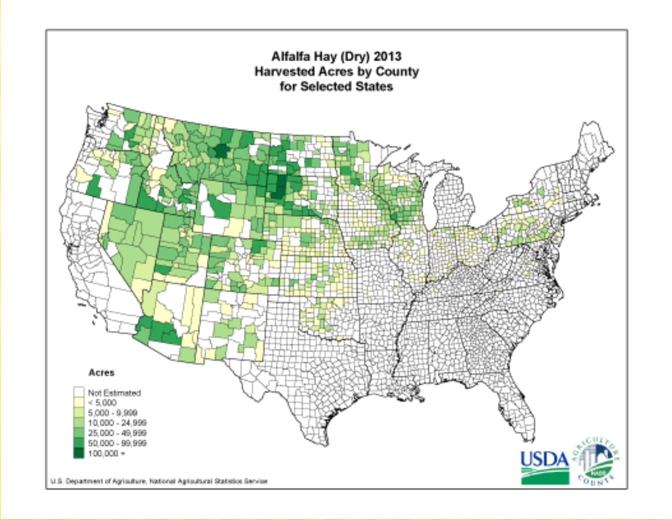

Calculations and plot by C. Anderson

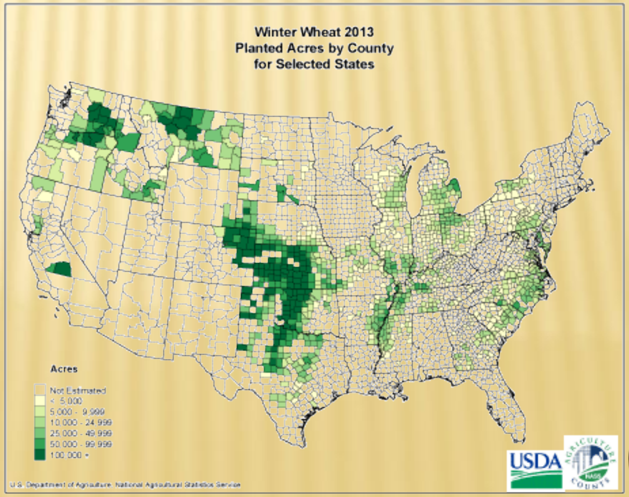
Data Source: State of Iowa Climatologist

# CROP PRODUCTION

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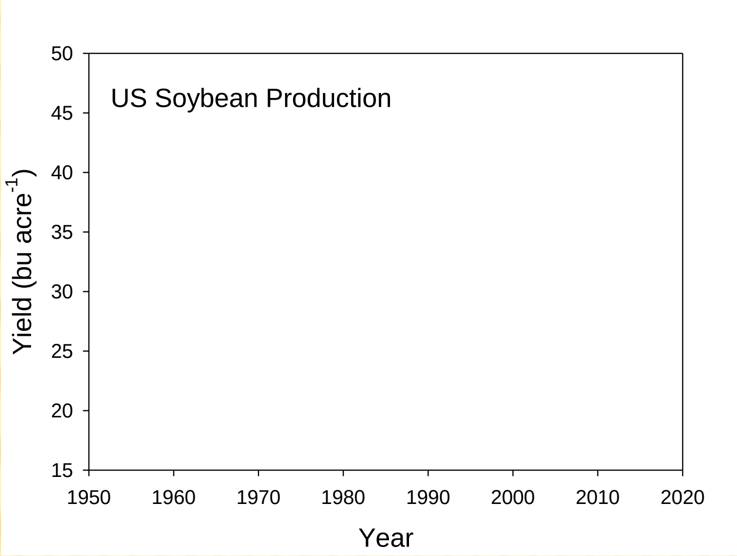
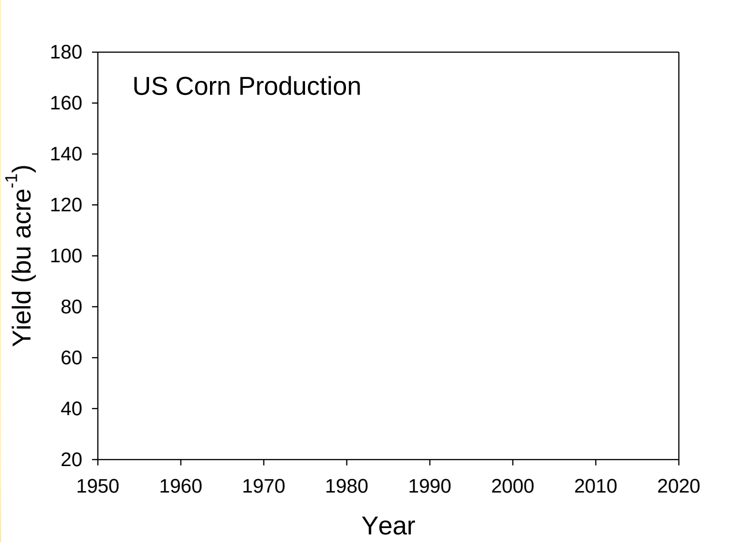
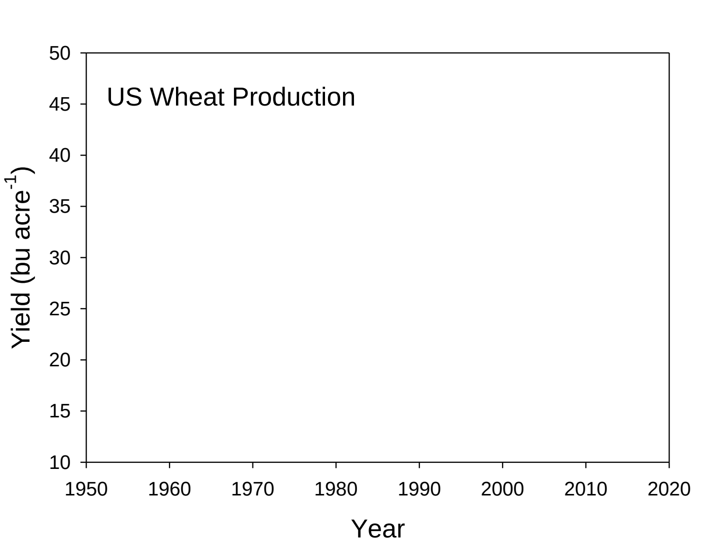
# US GRAIN PRODUCTION

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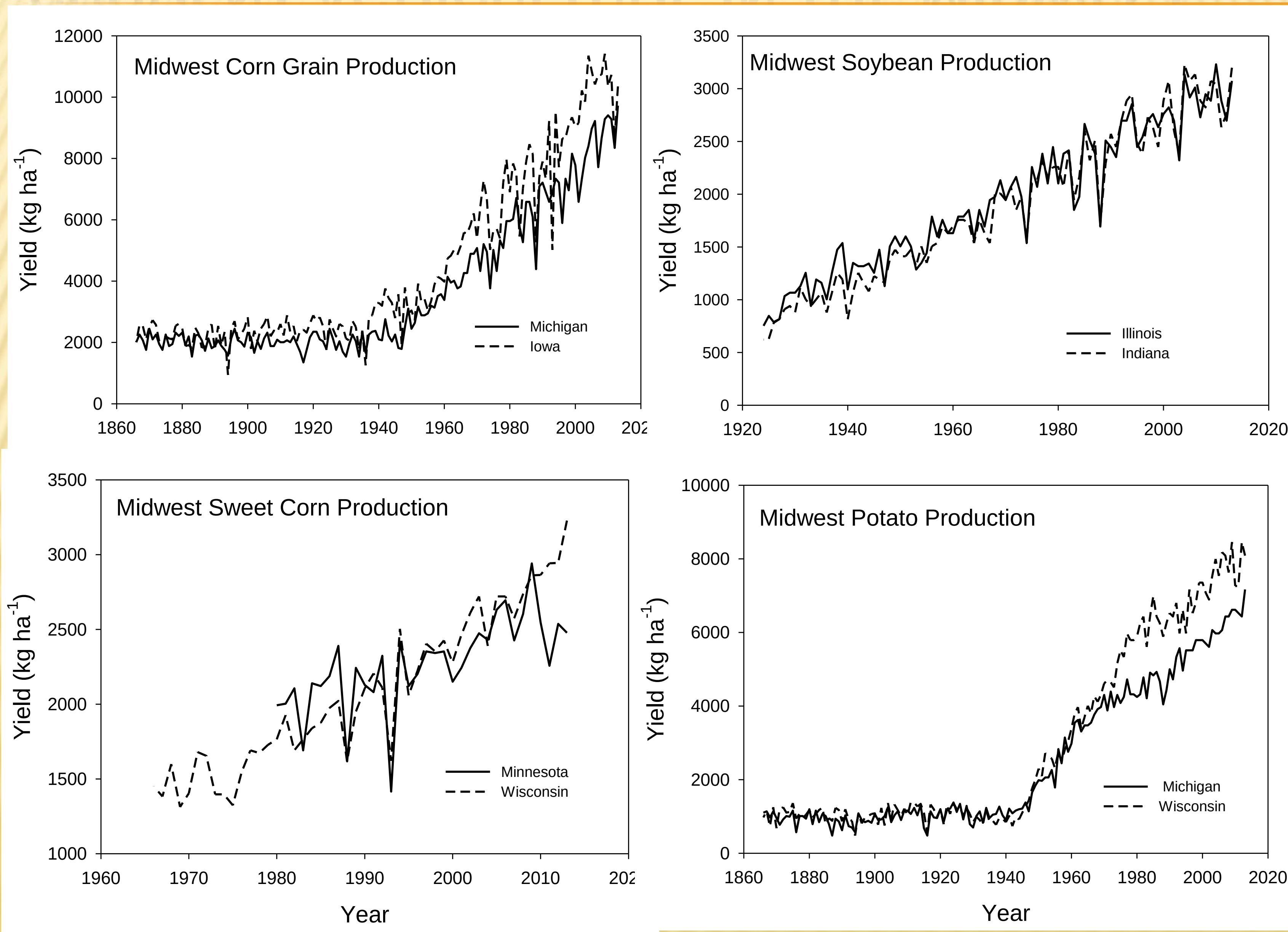
# CURRENT AGRICULTURE IN THE MIDWEST



# CLIMATE FACTORS

- Inputs
  - Temperature
  - Precipitation
  - Solar radiation
  - Carbon dioxide

<u>Direct</u>
Growth
Phenology
Yield

<u>Indirect</u>
Insects
Diseases
Weeds

**Soil is the underlying factor as a resource for nutrients and water**

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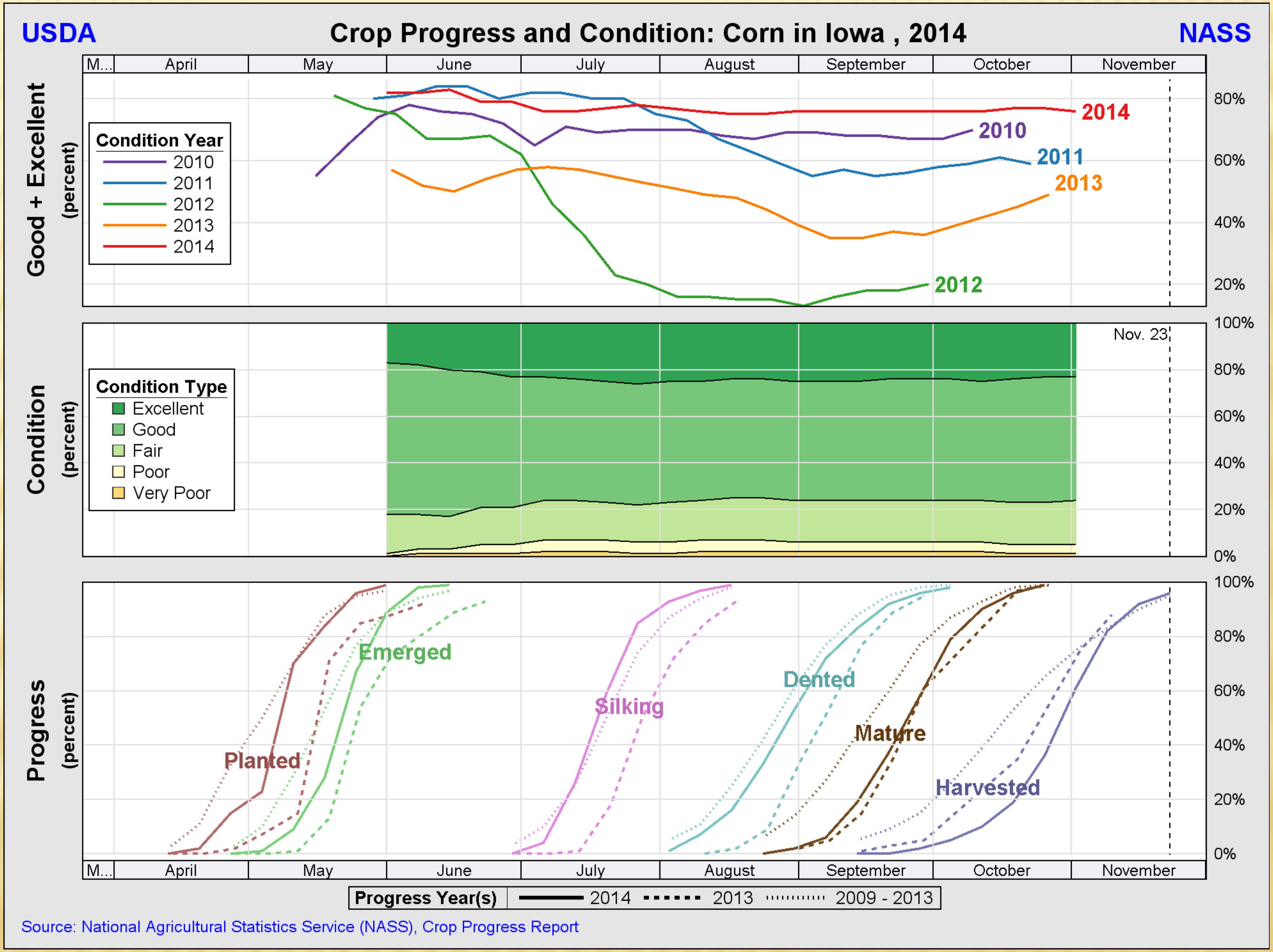
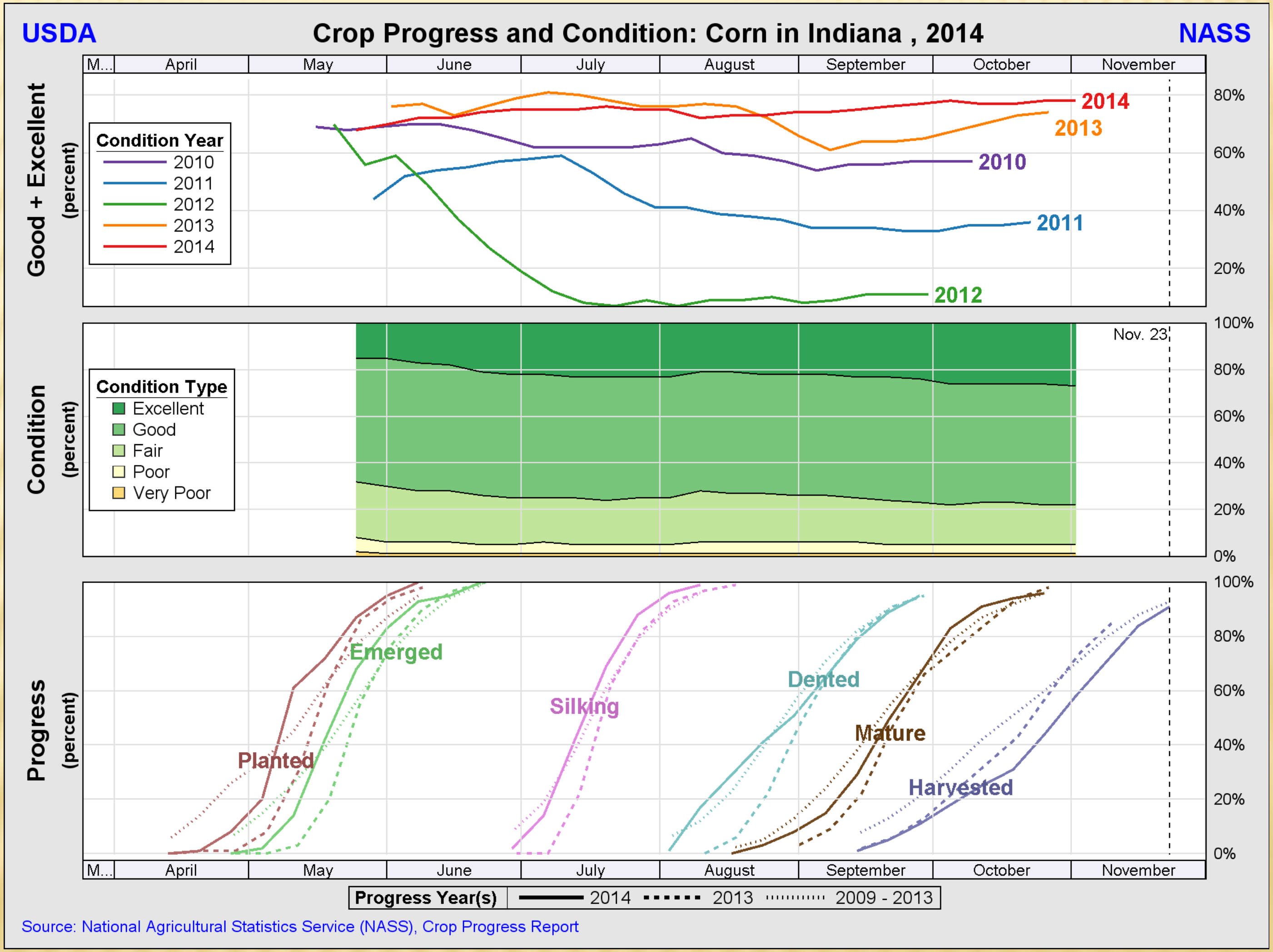
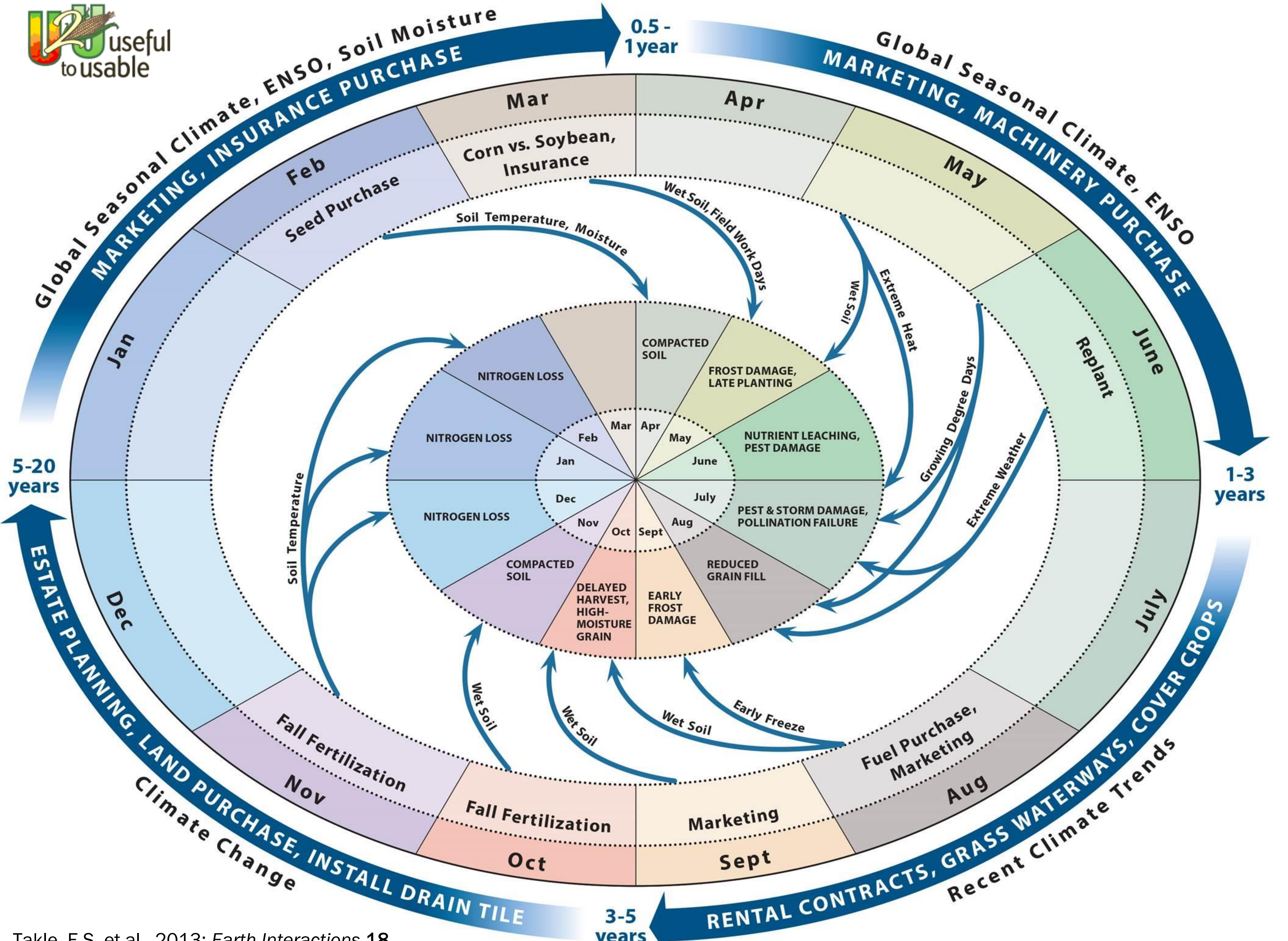
# CROP PROGRESS-IOWA



# CROP PROGRESS-INDIANA

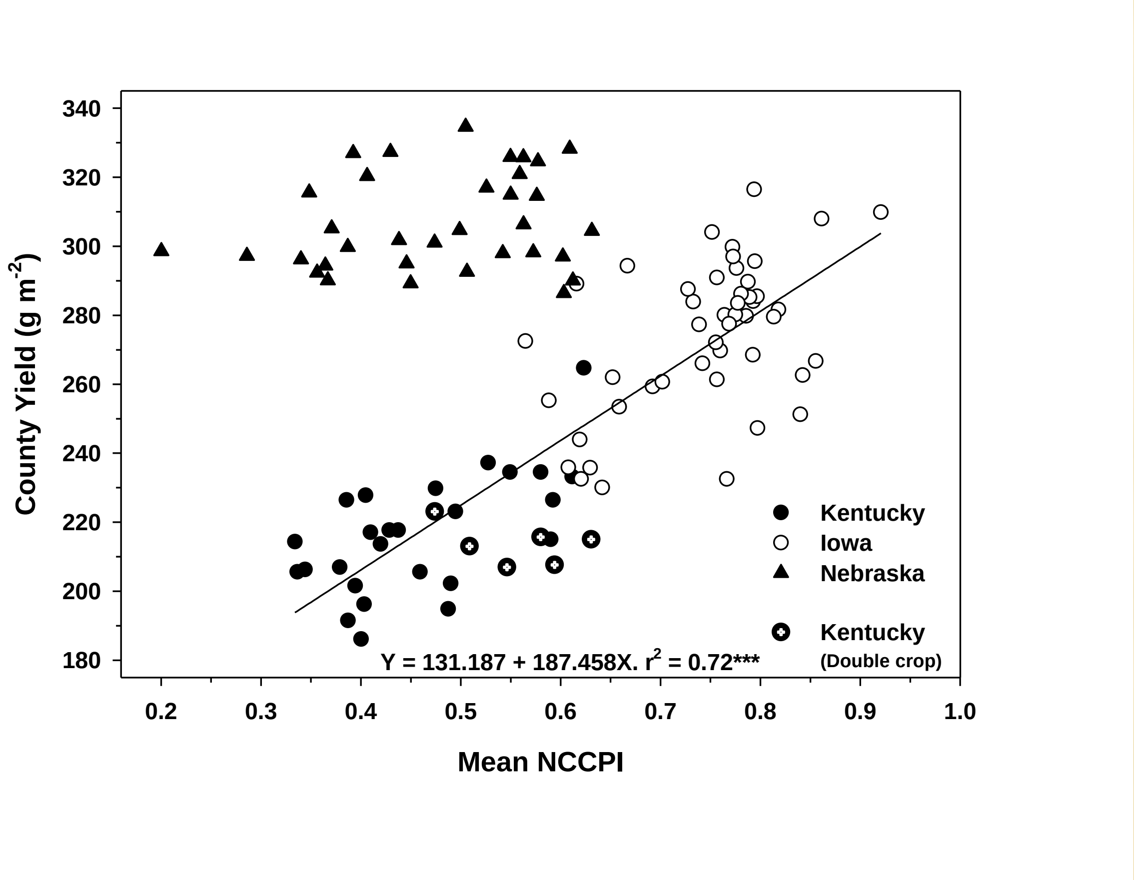




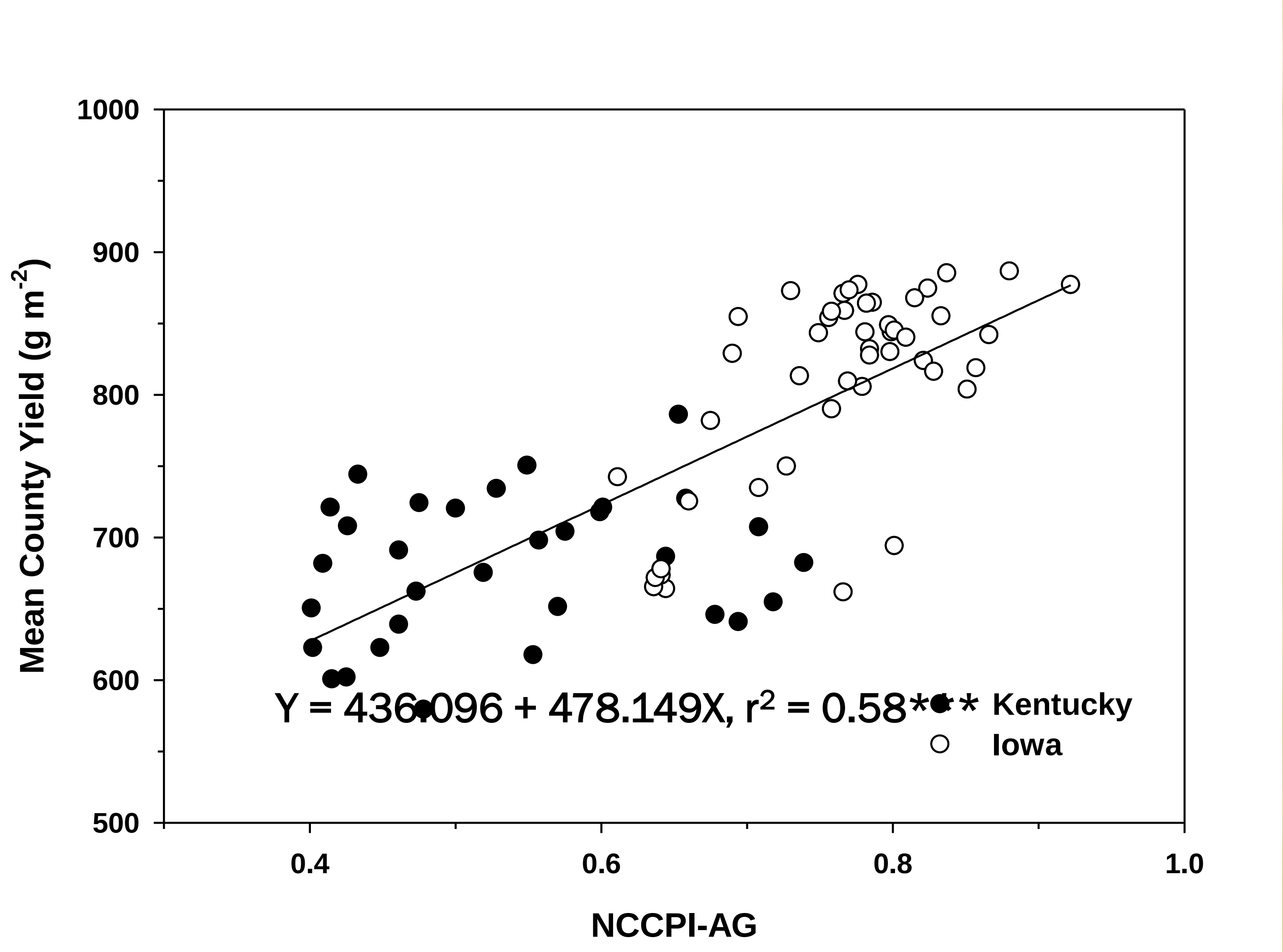

Takle, E S, et al., 2013: *Earth Interactions* **18**,

# GOOD SOILS = GOOD YIELDS

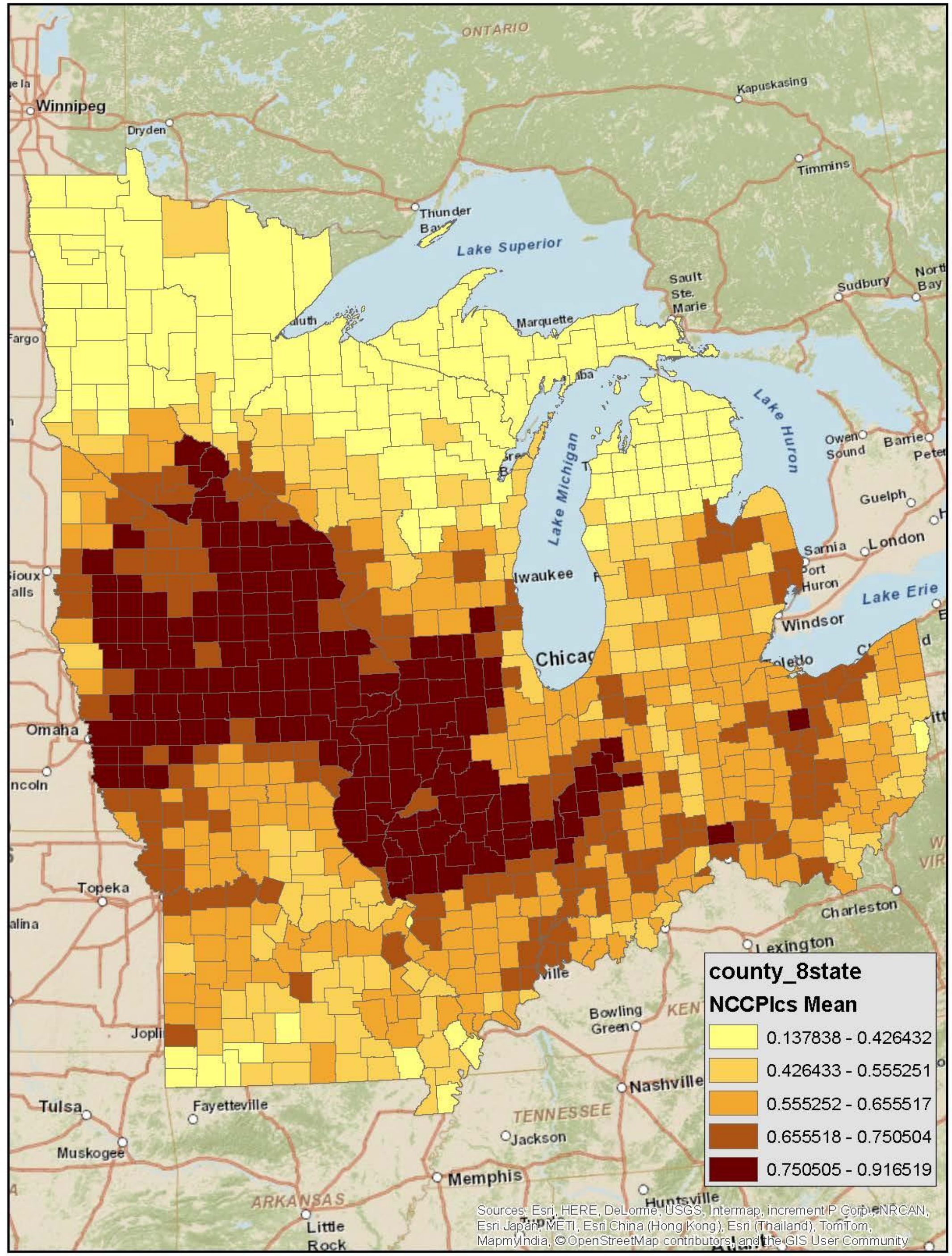
Soybean yields across Iowa, Kentucky, and Nebraska



# MAIZE COUNTY YIELDS

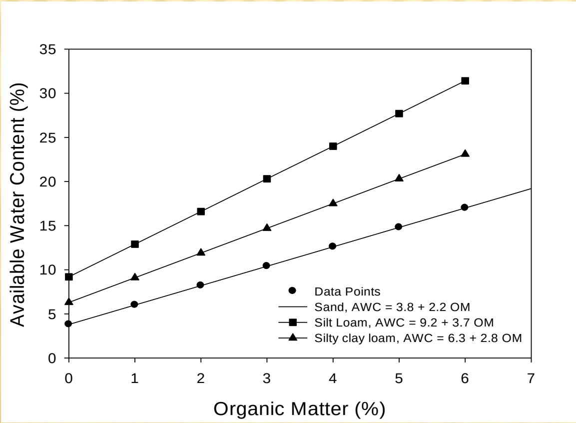


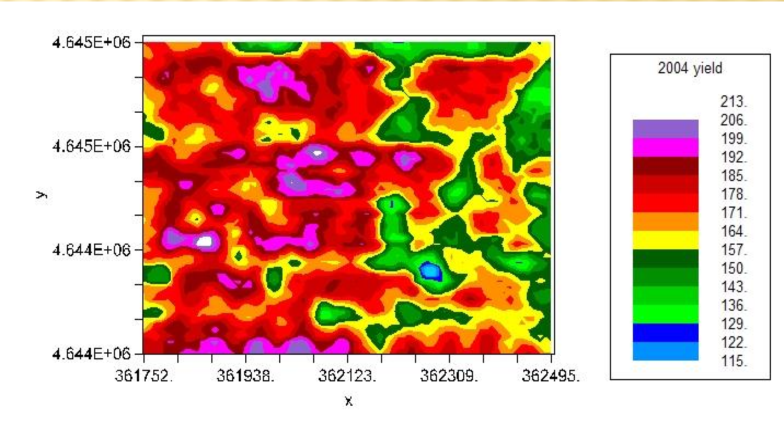
# NCCPI ACROSS THE MIDWEST

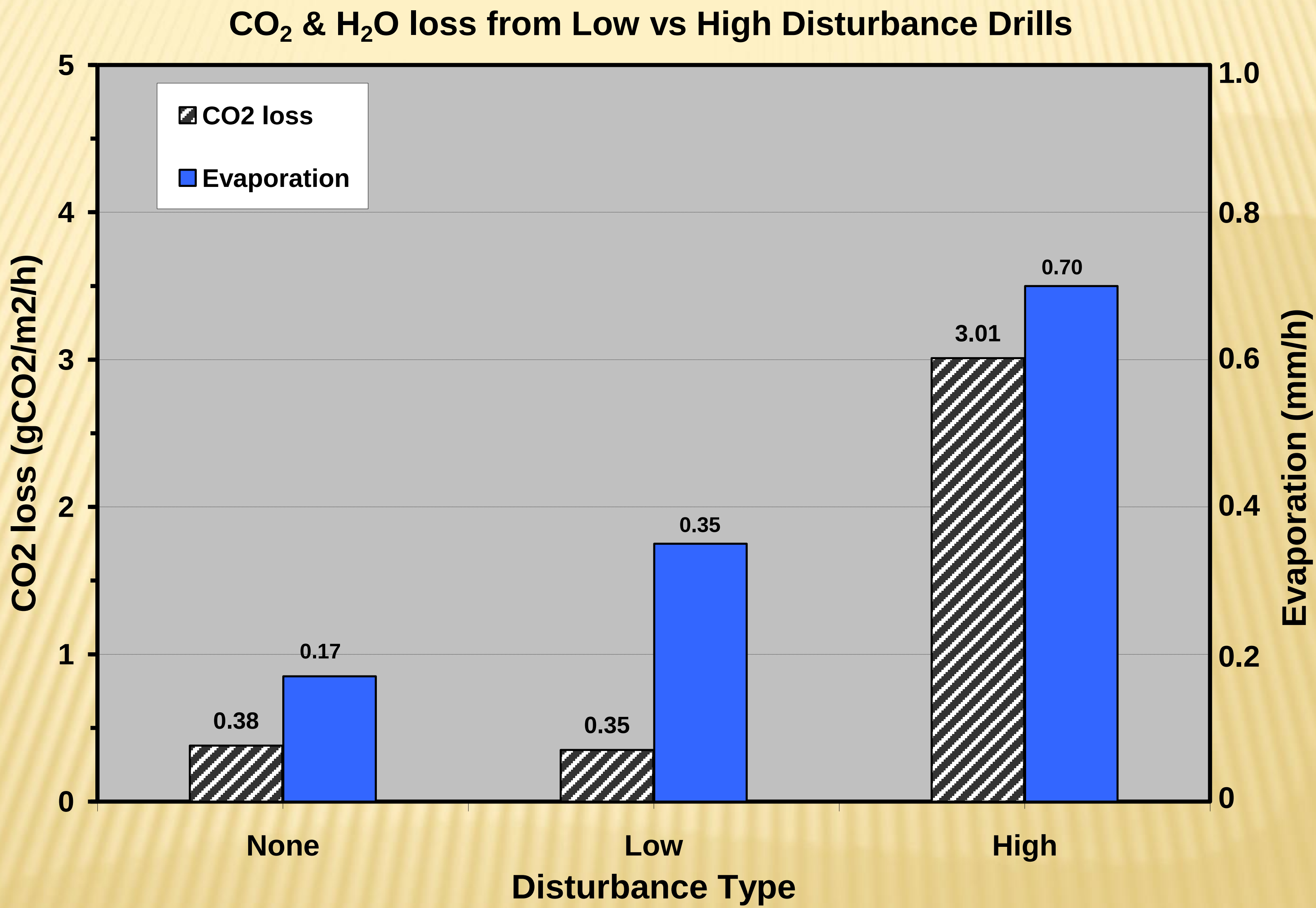


# OBSERVATIONS

- Tillage increases the soil water evaporation rate
- Differences among soils within a field which is related to organic matter content and soil water holding capacity
- Water use patterns within a field cause "drought" stress to occur in every year

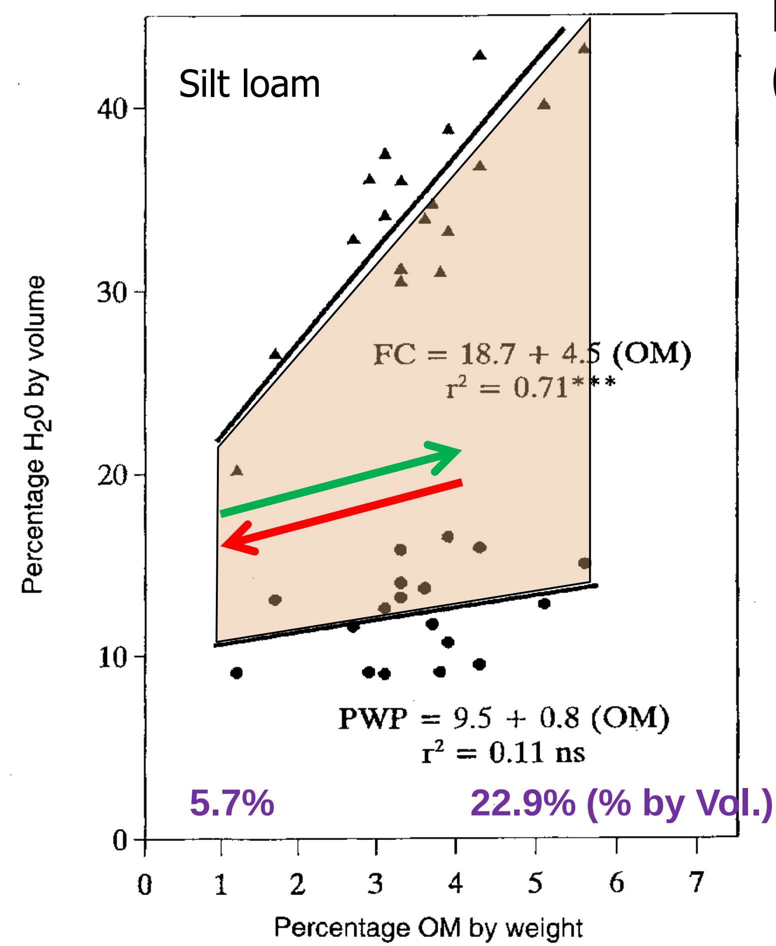




CO2 & H2O loss from Low vs High Disturbance Drills
CO2 loss
Evaporation
CO2 loss (gCO2/m2/h)
Evaporation (mm/h)
0
1
2
3
4
5
0
0.2
0.4
0.6
0.8
1.0
0.38
0.17
0.35
0.35
3.01
0.70
None
Low
High
Disturbance Type

# Organic Matter Effects on Available Water Capacity




**Data from Soil Survey Investigation Reports (surface horizons only)**

- Sands: FL (n = 20)
- Silt loams: IA, WI, MN, KS (n = 18)
- Silty clay loams: IA, WI, MN, KS (n = 21)

**Sands** AWC = 3.8 + 2.2 (OM)
$r^2 = 0.79$

**Silt loams** AWC = 9.2 + 3.7(OM)
$r^2 = 0.58$

**Silty clay loams** AWC = 6.3 + 2.8 (OM)
$r^2 = 0.76$

**OM increase from 1% to 4.5% AWC doubles!**


Hudson, B. D. 1994. Soil organic matter and available water capacity. J. Soil Water Conserv. 49(2):189-194.

# EVAPOTRANSPIRATION

ET = Soil water evaporation + Plant transpiration

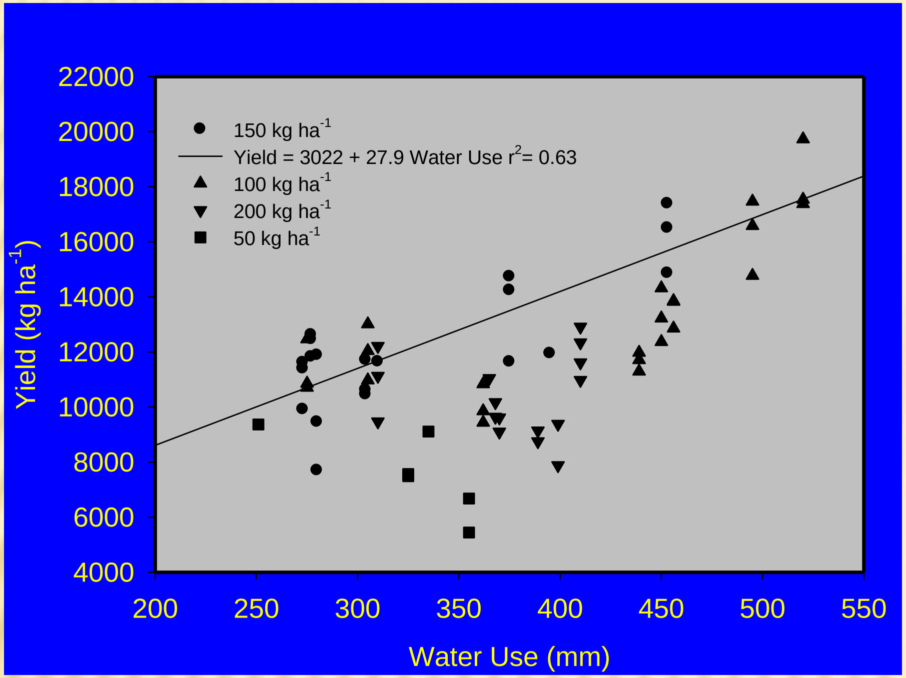
Components of ET

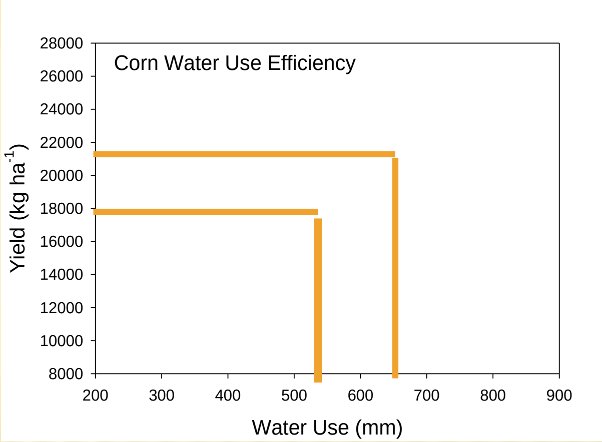
| Energy Input<br><br>(Net radiation) | Water Vapor Gradient<br>f (temp, vapor pressure) | Windspeed Gradient | Soil Water Availability |
|---|---|---|---|

↑ Rate-limitation

Potential ET (how much could evaporate) vs Actual ET (how much does)

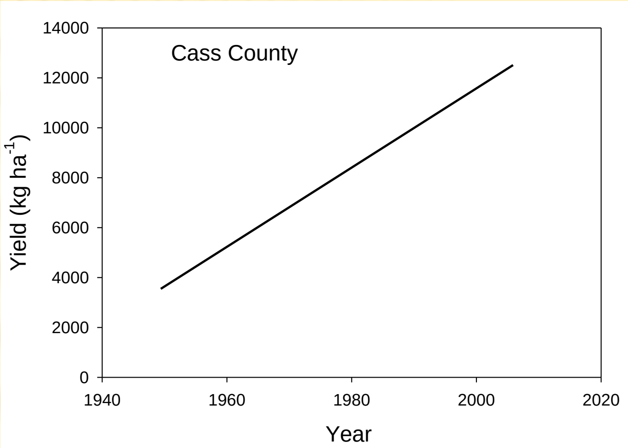
# WATER USE EFFICIENCY-REALITY

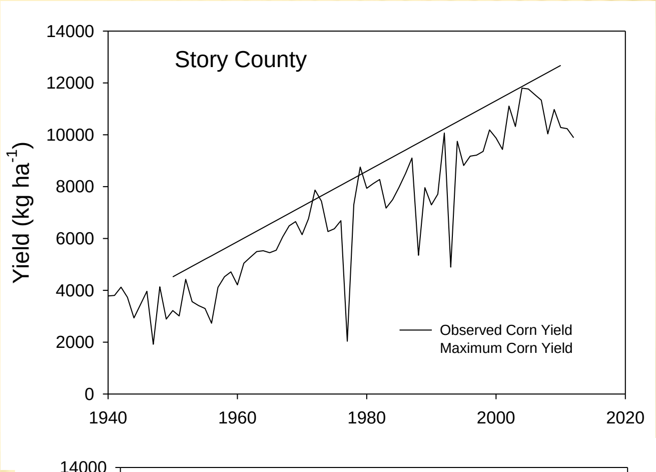


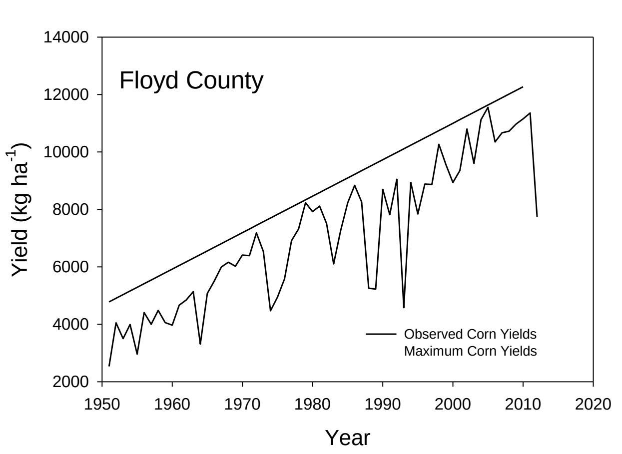



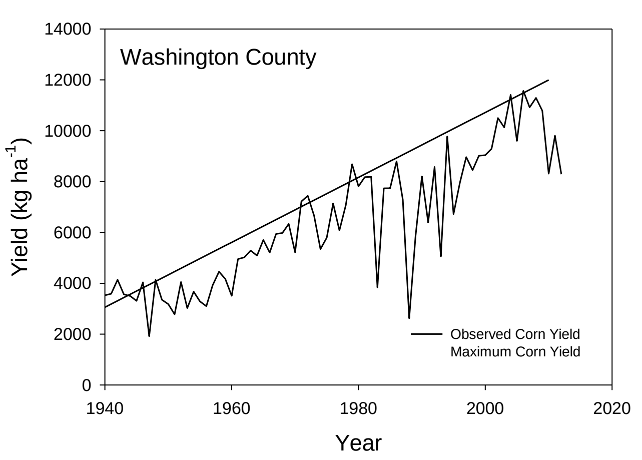

Water deficit
need 5 inches more water to grow 300 bu corn

# IOWA COUNTY YIELDS

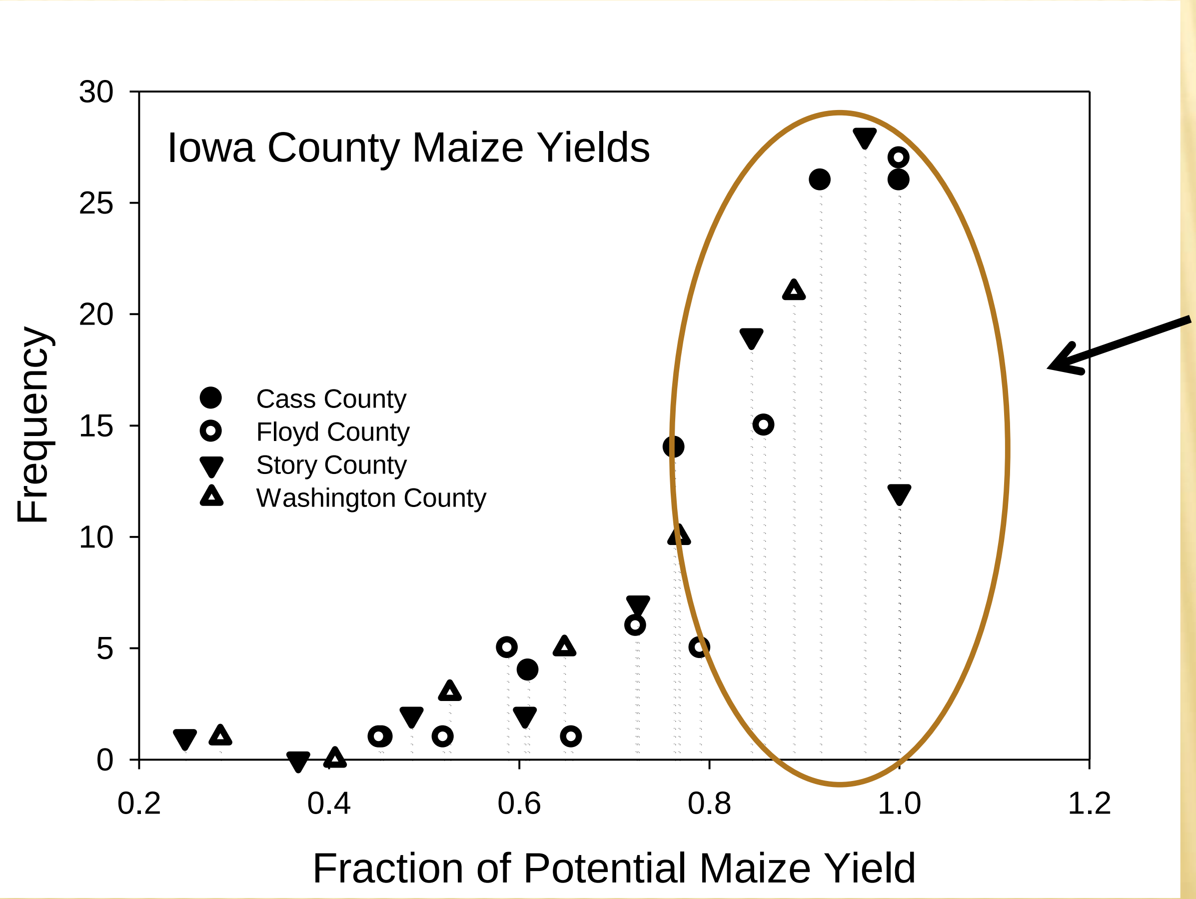


# VARIATION IN YIELDS



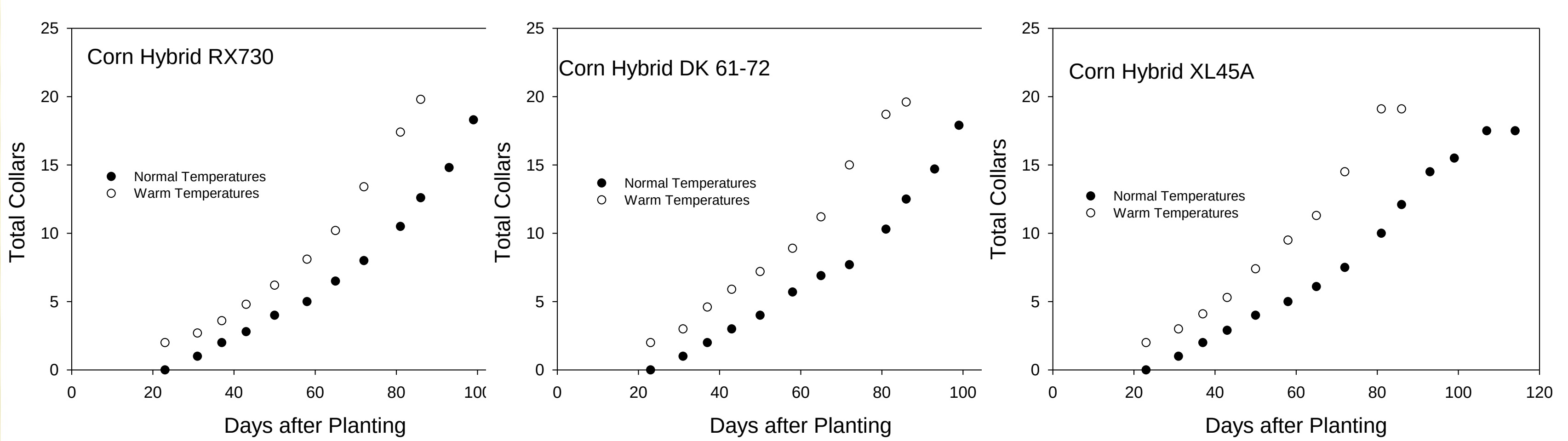

20% of the yield loss occurs 80% of the time due to water availability

The majority of the yield losses due to the weather are short-term stresses

# FEEDBACKS BETWEEN TEMPERATURE EXTREMES AND CROP WATER USE

- Depends upon the soil water status and the root exploration of the crop
- Extreme temperatures increase atmospheric demand and lead to short-term water stress even in well-watered or saturated soils
- Magnitude of the effect depends upon the prior soil water conditions and rooting depth

# TEMPERATURE EFFECTS ON CORN PHENOLOGY




2139 13700 0 7323 2168 12962 kg ha$^{-1}$

Rhizotron study with warm chamber 4C warmer than normal chamber with simulation of Ames IA temperature patterns.

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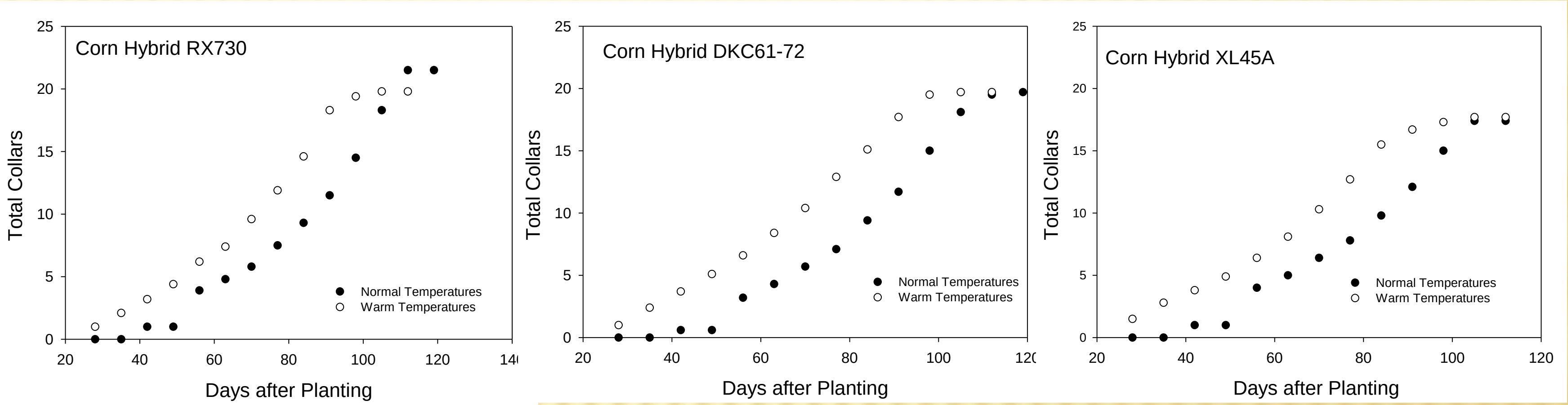
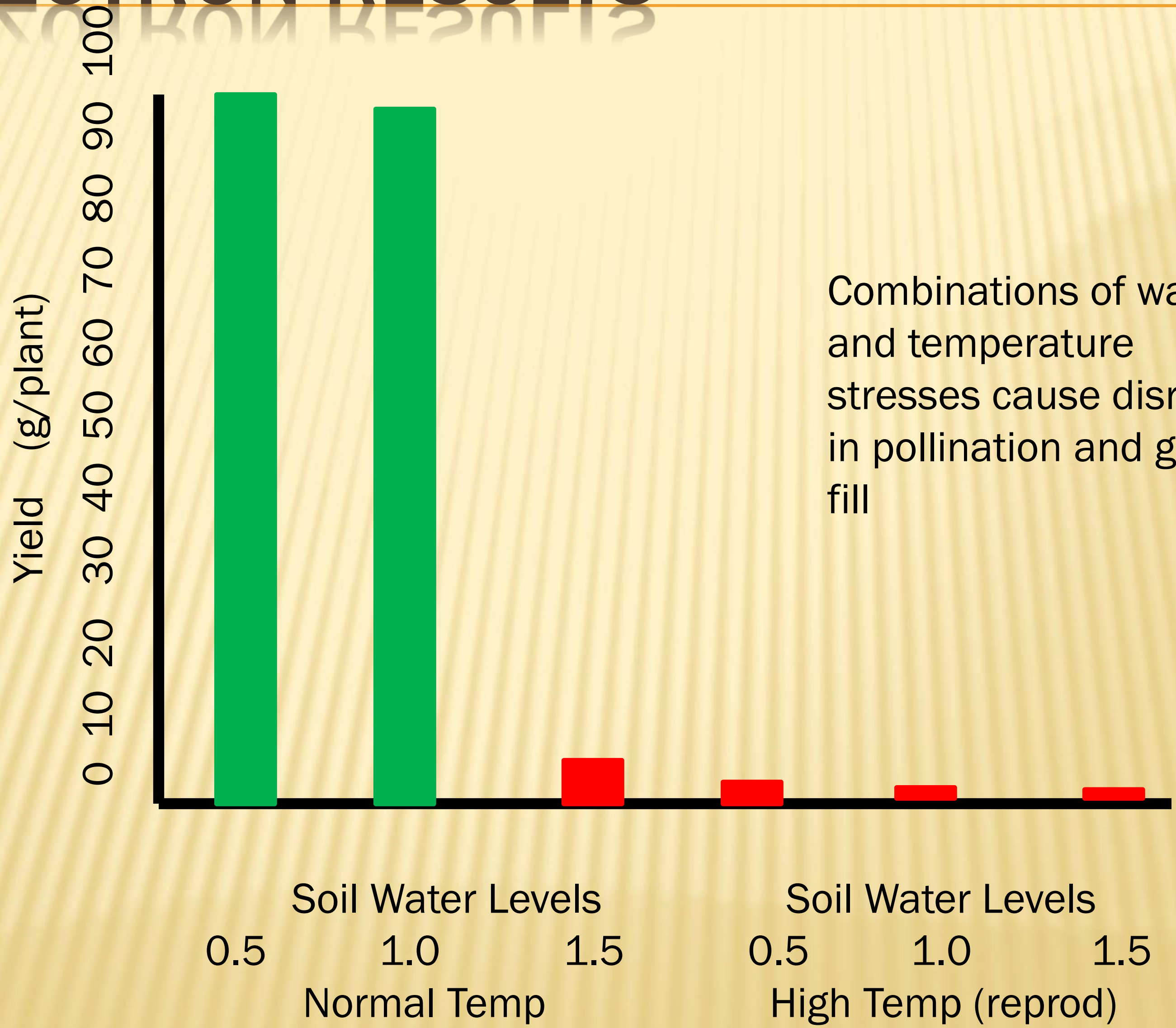
# TEMPERATURE EFFECTS ON CORN PHENOLOGY




599 4711 342 3053 0 4197 kg $ha^{-1}$

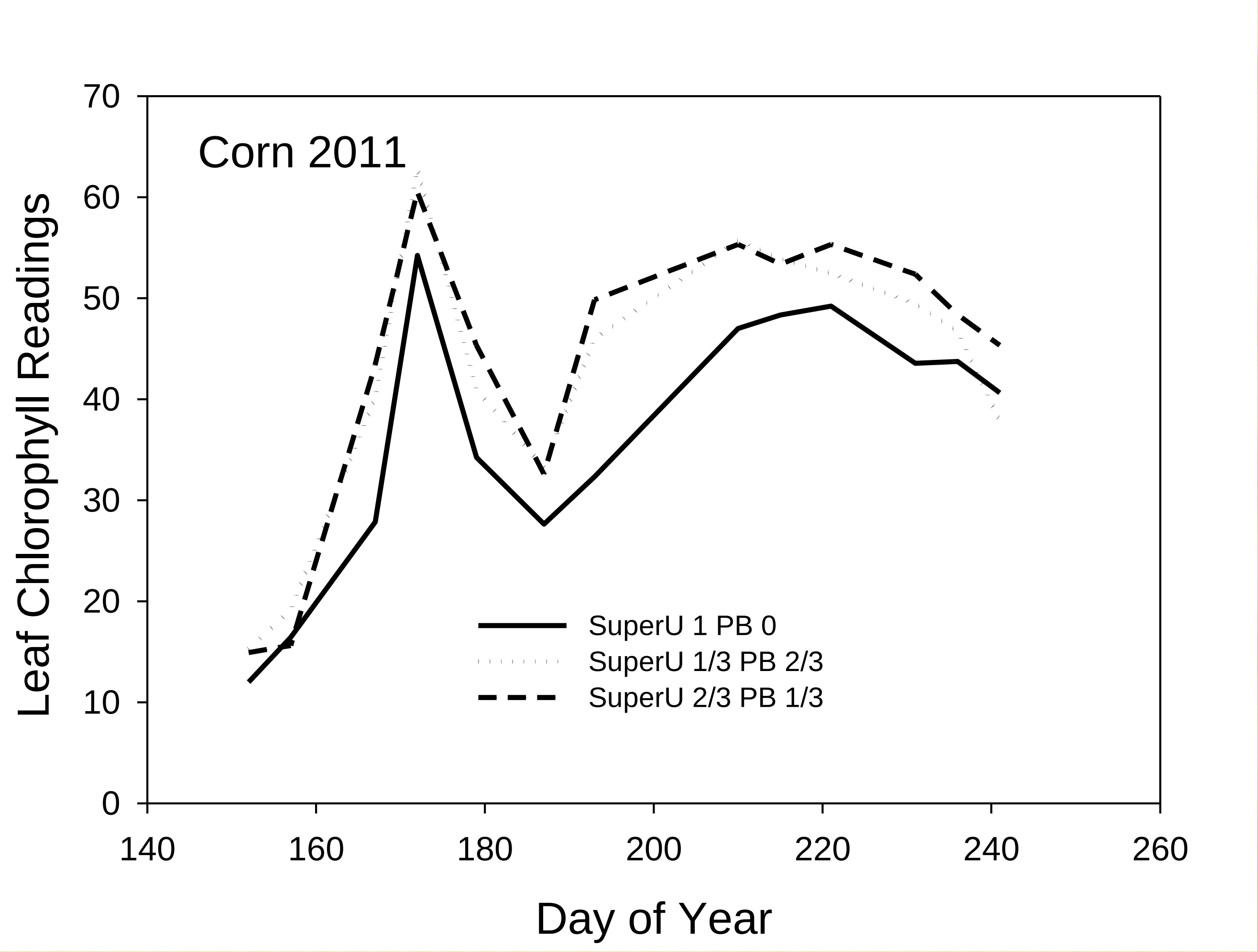
Rhizotron study with warm chamber 4C warmer than normal chamber with simulation of Ames IA temperature patterns.

# RHIZOTRON RESULTS

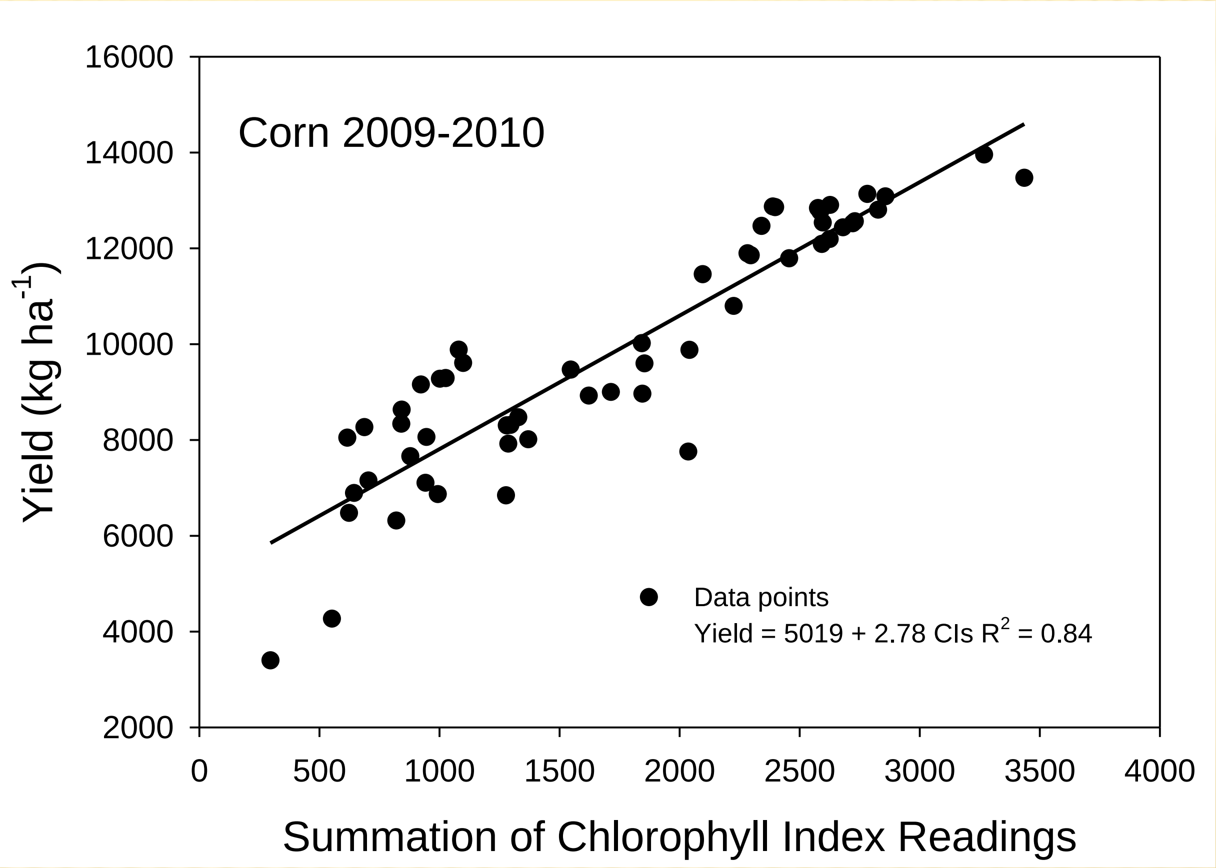



Combinations of water and temperature stresses cause disruption in pollination and grain-fill

# LEAF CHLOROPHYLL 2011



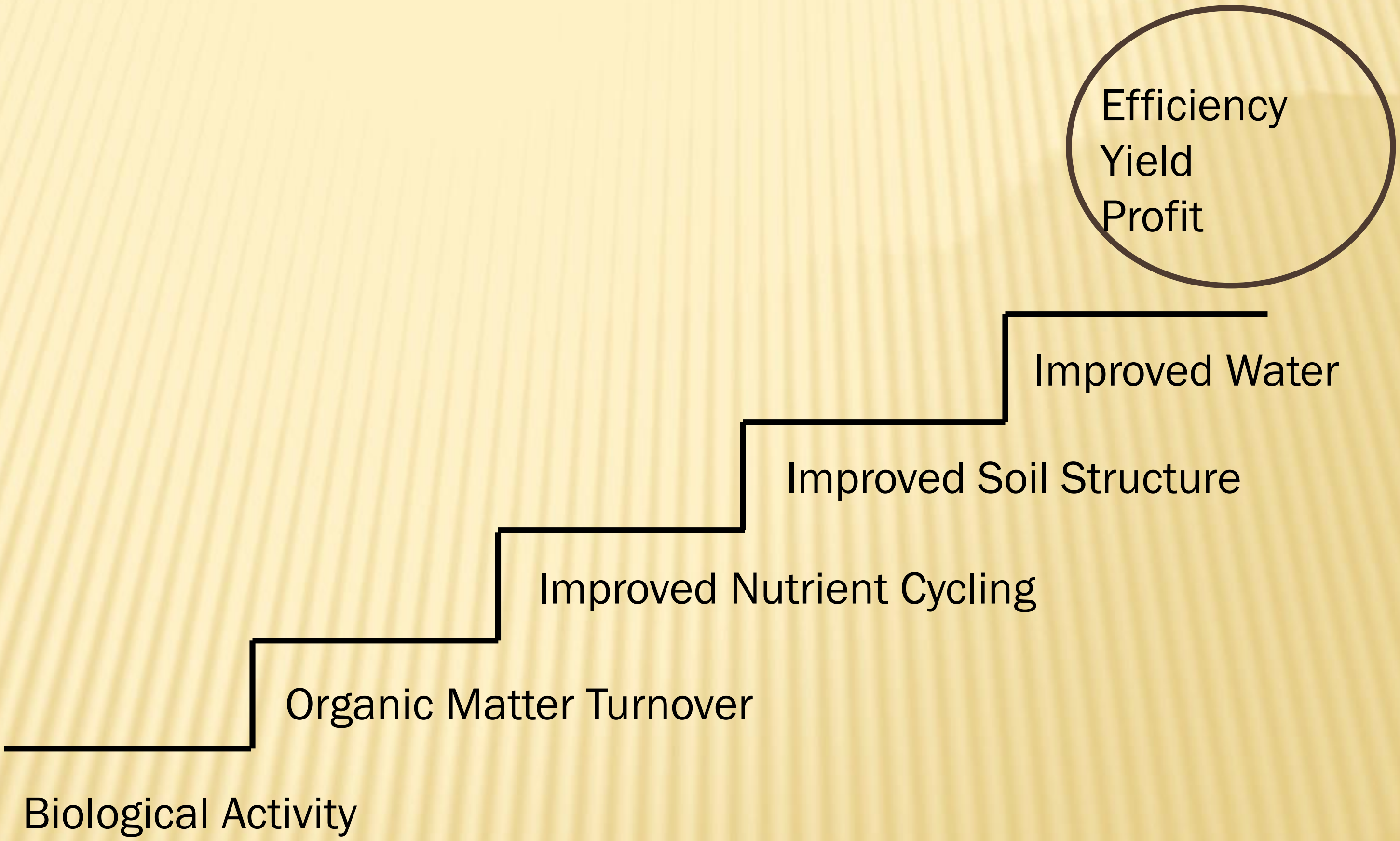
# CHLOROPHYLL SUMMATION INDEX



"Passive protective blanket"


"Active protective blanket"

# SOIL AGGRADATION CLIMB



# SOIL HEALTH FACTORS

- Water holding capacity
- Aggregate stability (infiltration)
- Rooting depth
- Nutrient cycling and nutrient availability
- Gas exchange between the soil and the atmosphere (oxygen and carbon dioxide)
- Residue cover (living or dead)
- Reduced tillage