CLIMATE CHANGE AND AGRICULTURE IN THE UNITED STATES

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USDA-ARS

Resilient Agriculture 2014

SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

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Cropping Systems Coordinated Agricultural Project: Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems

IMPACTS OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTIVITY CAN BE OFFSET BY:

- Utilizing improved genetics
- Reducing soil erosion and increasing infiltration
- Improved nutrient management
- Better weather forecasts
- Changing cropping systems

SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

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CLIMATE VS WEATHER

- Climate determines where we grow a crop
- Weather determines how much we produce

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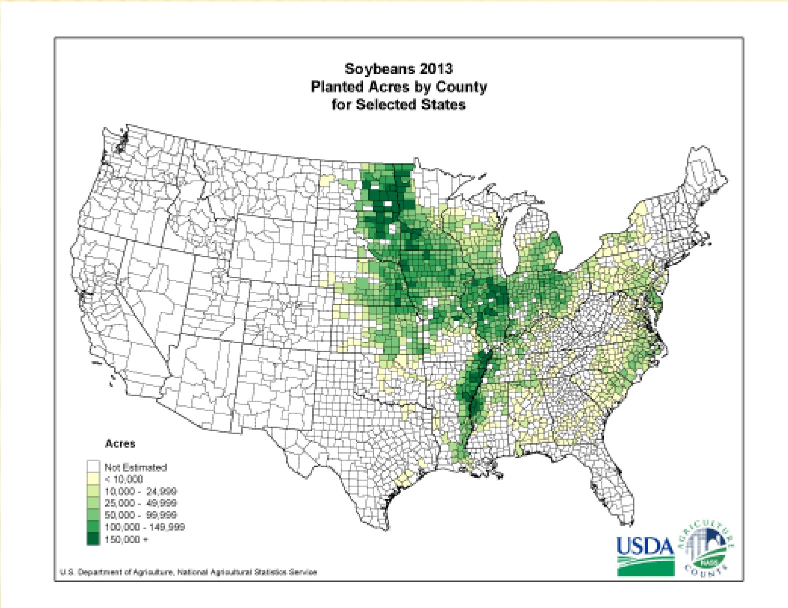
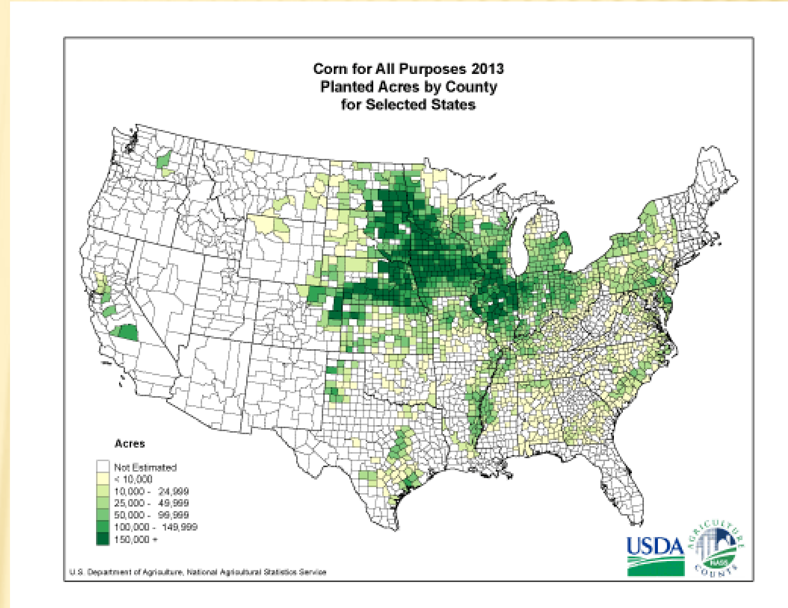
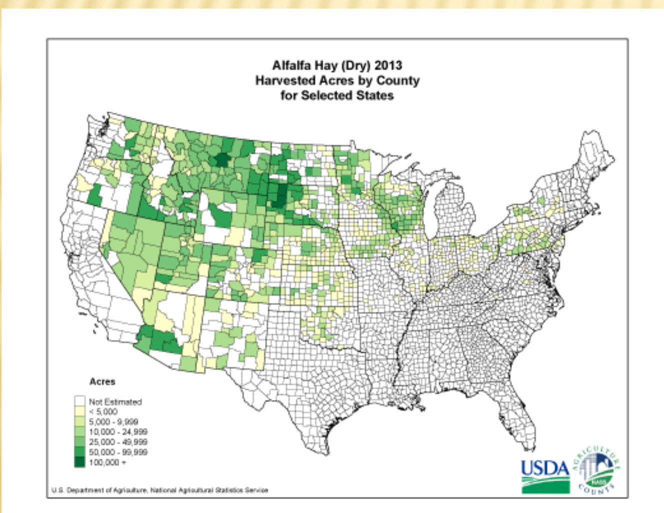
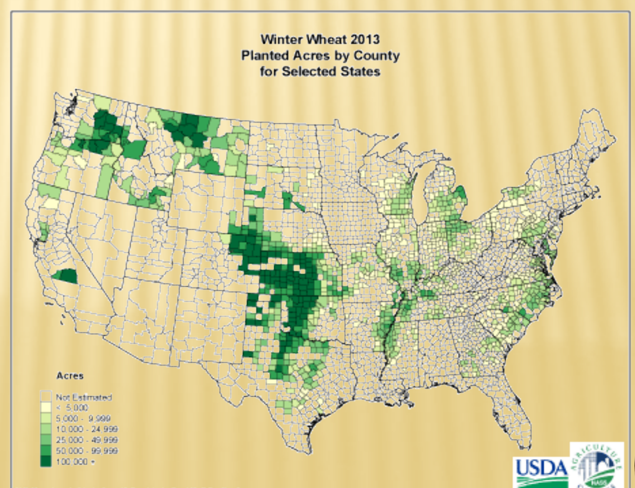
CROP PRODUCTION









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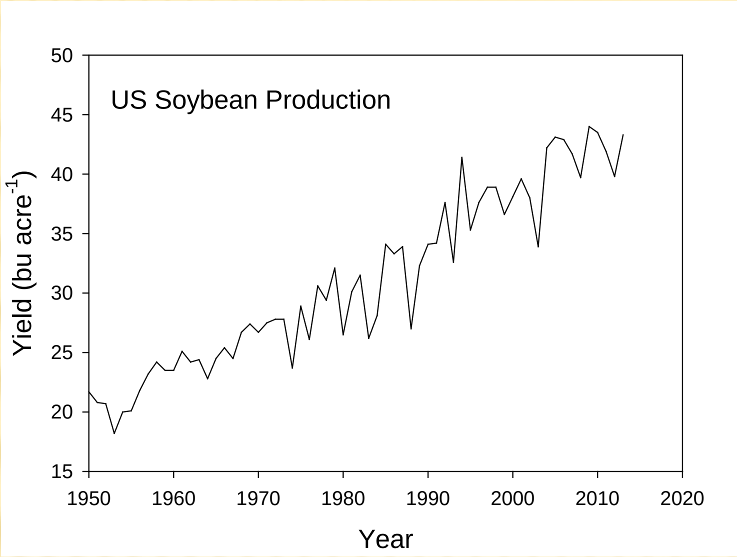
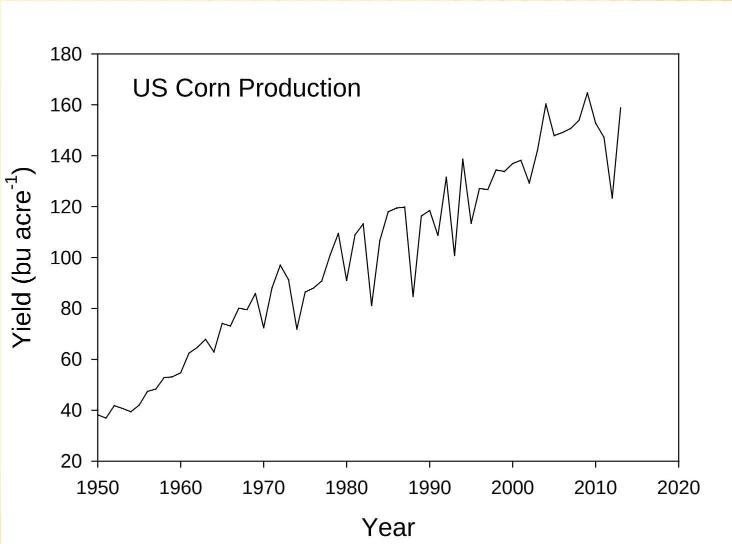
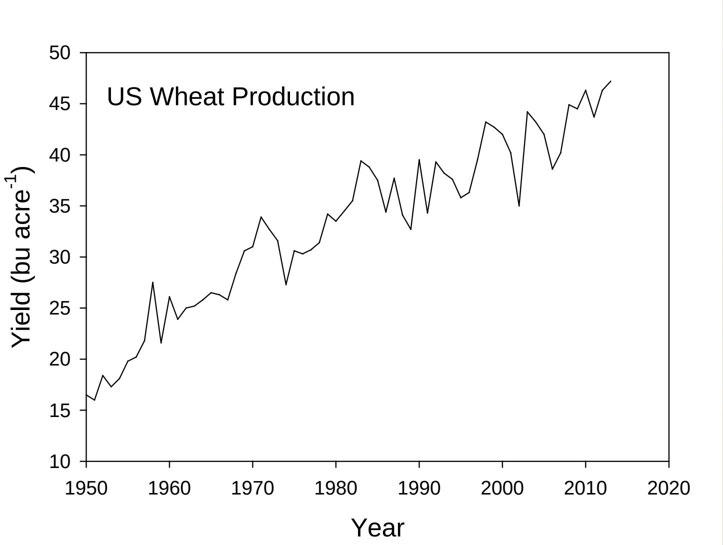
US GRAIN PRODUCTION







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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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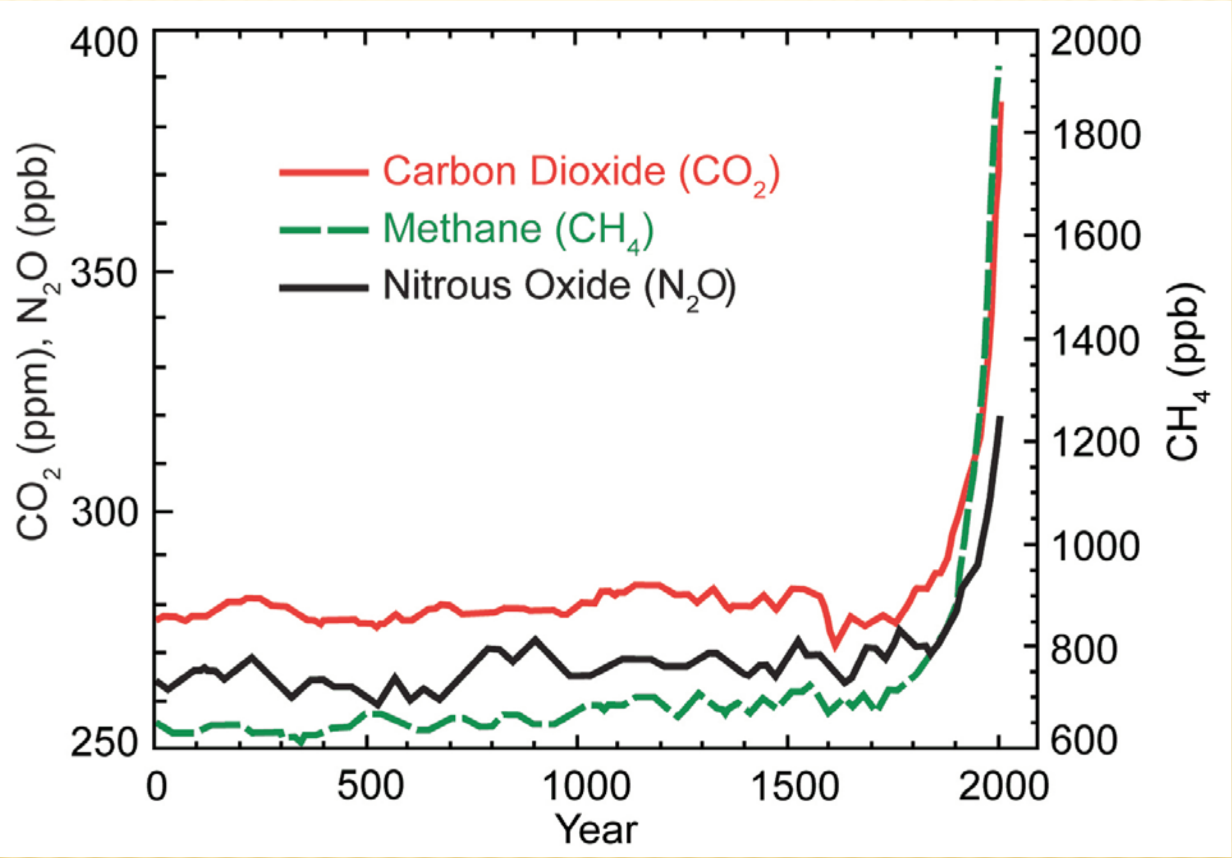
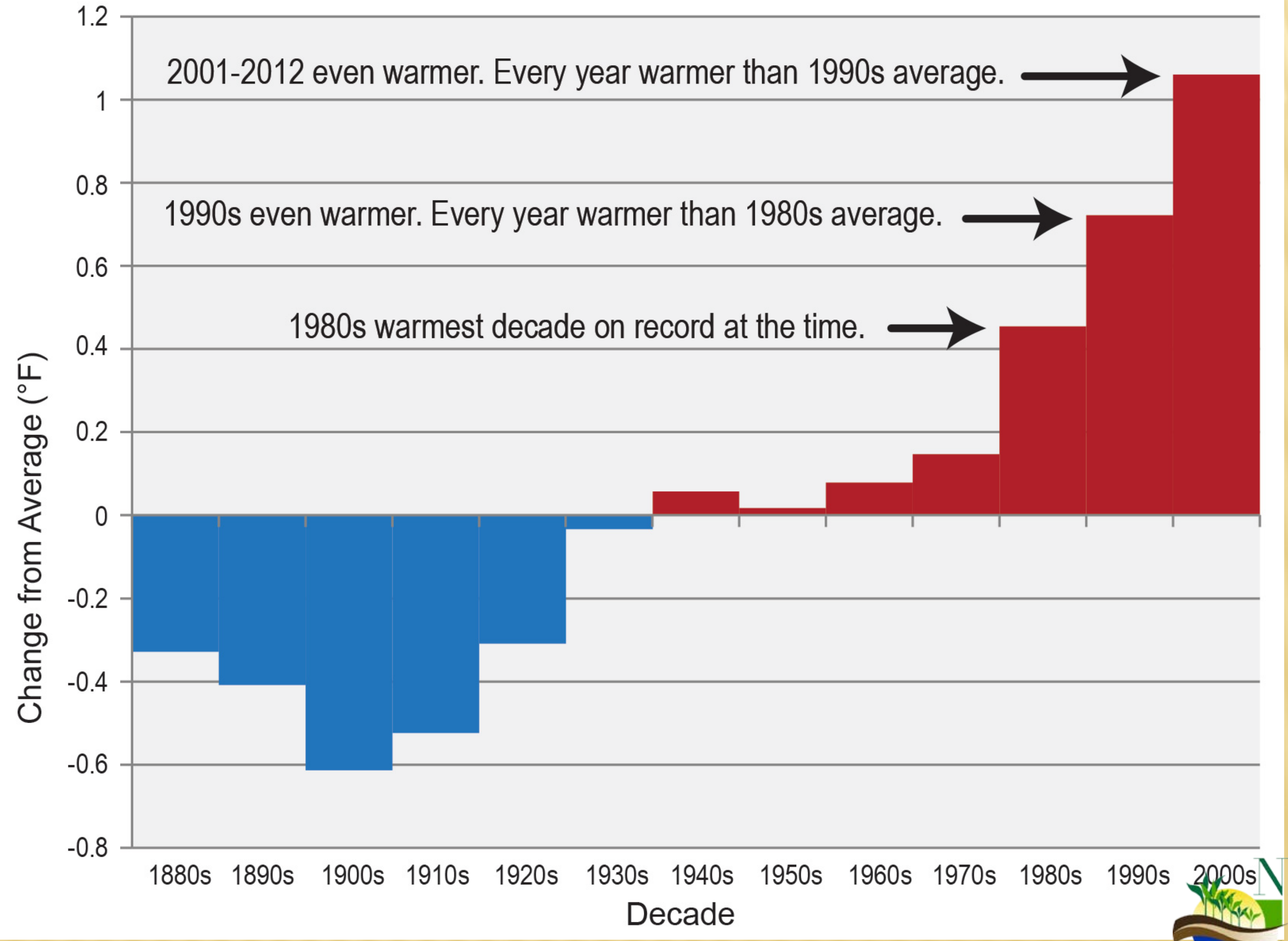
CARBON DIOXIDE INCREASES



TEMPERATURE CHANGE BY DECADE



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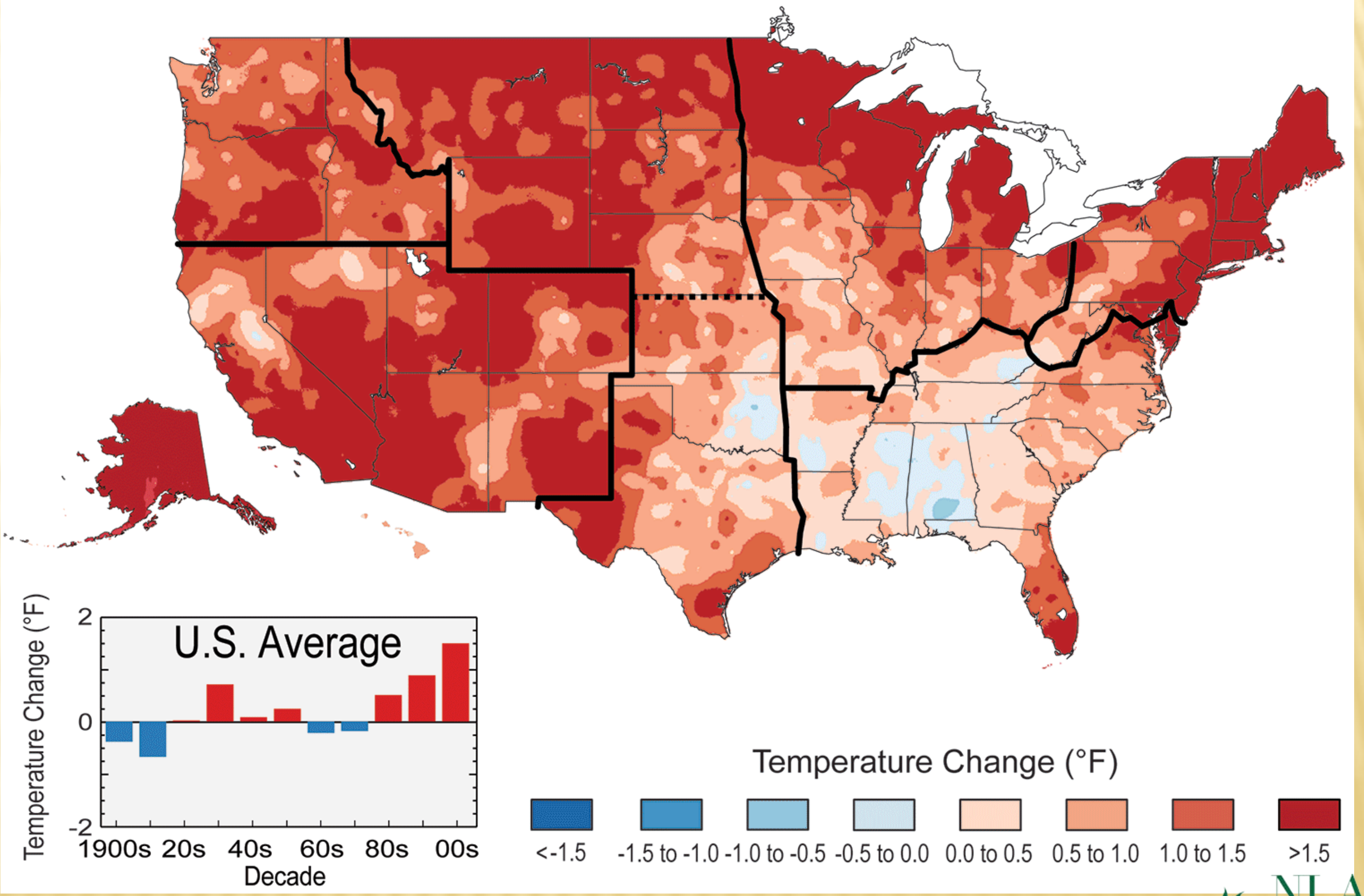
OBSERVED U.S. TEMPERATURE CHANGE



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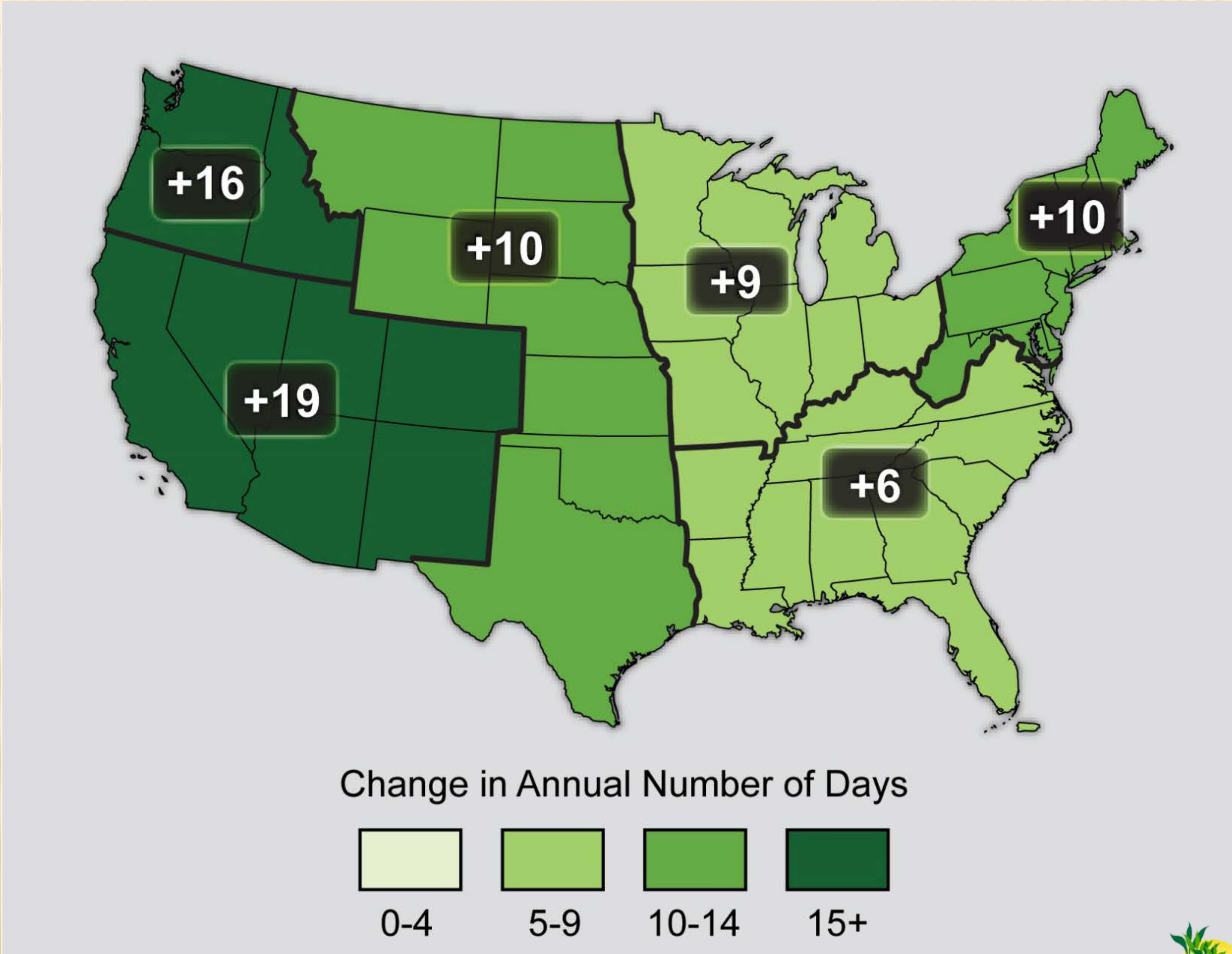
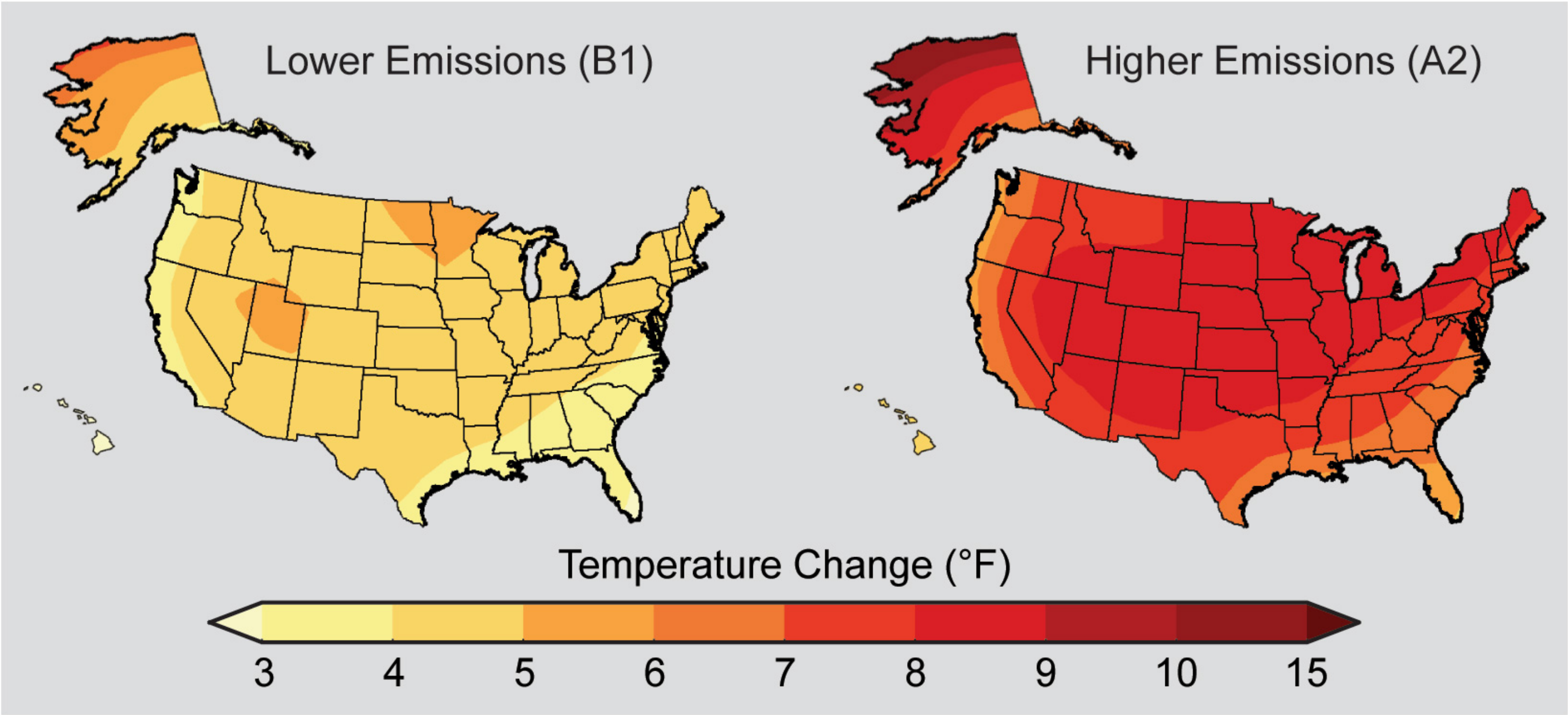
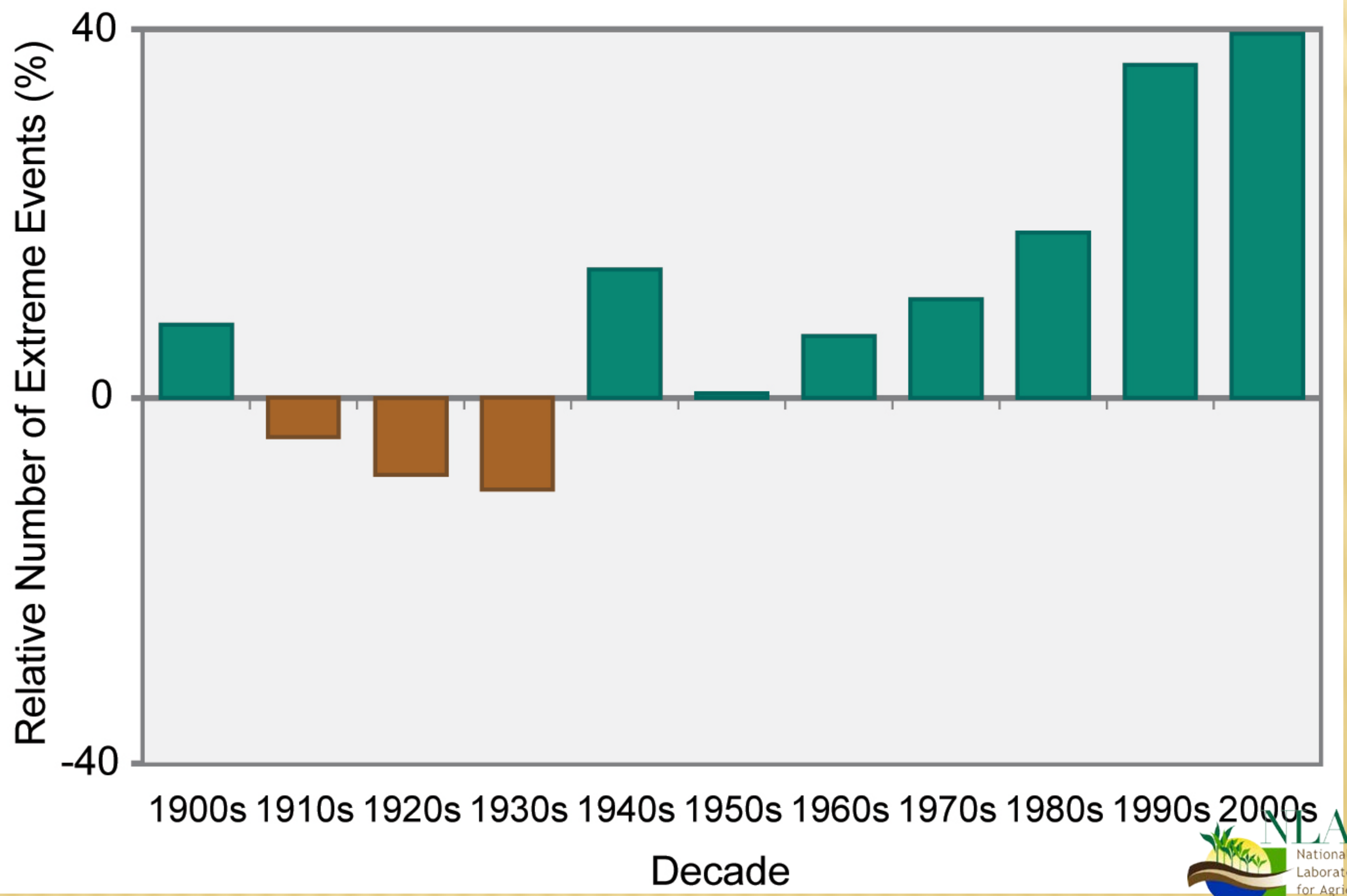
OBSERVED INCREASES IN FROST-FREE SEASON



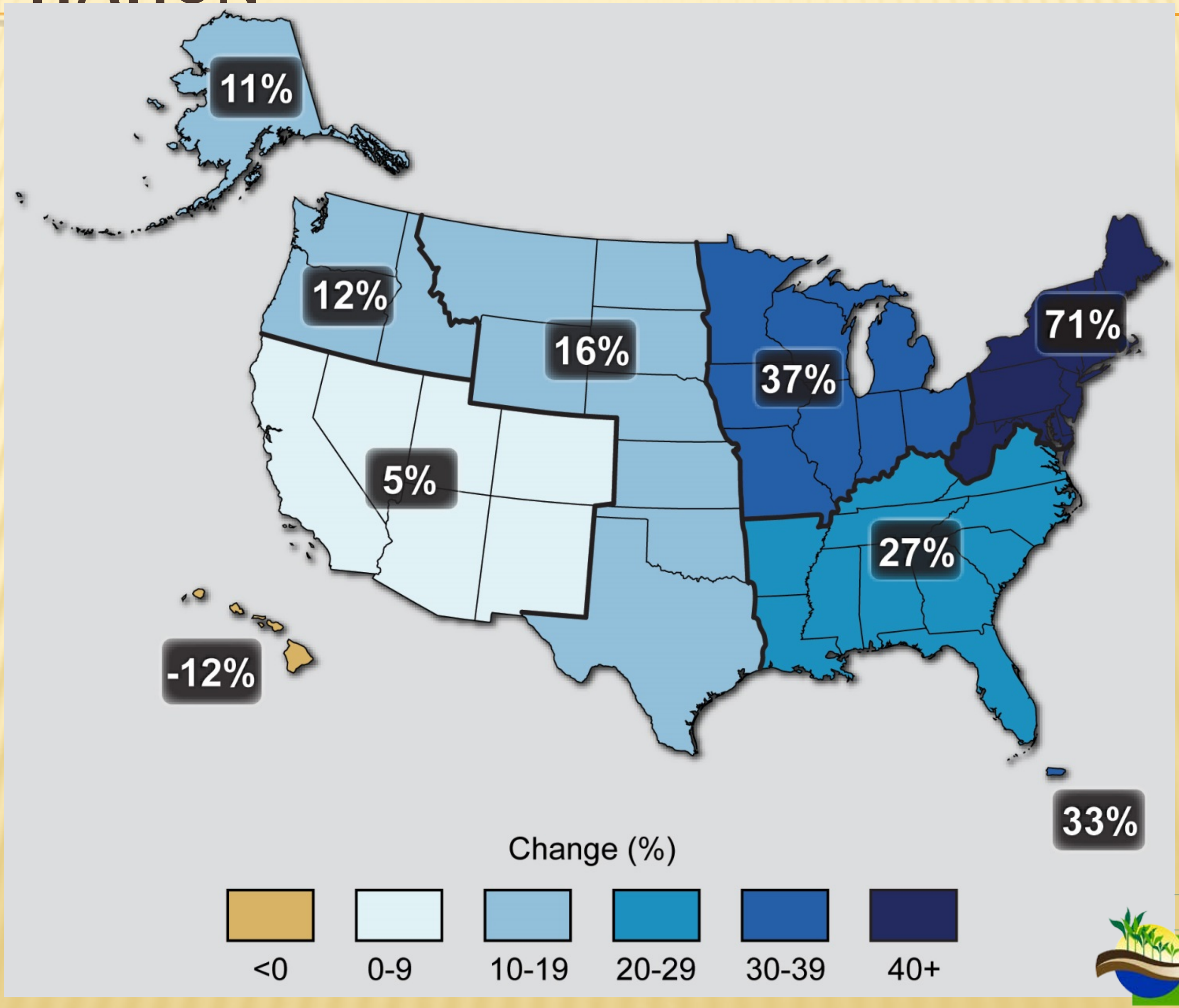
PROJECTED TEMPERATURE CHANGE



OBSERVED U.S. TRENDS IN HEAVY PRECIPITATION



OBSERVED CHANGE IN VERY HEAVY PRECIPITATION



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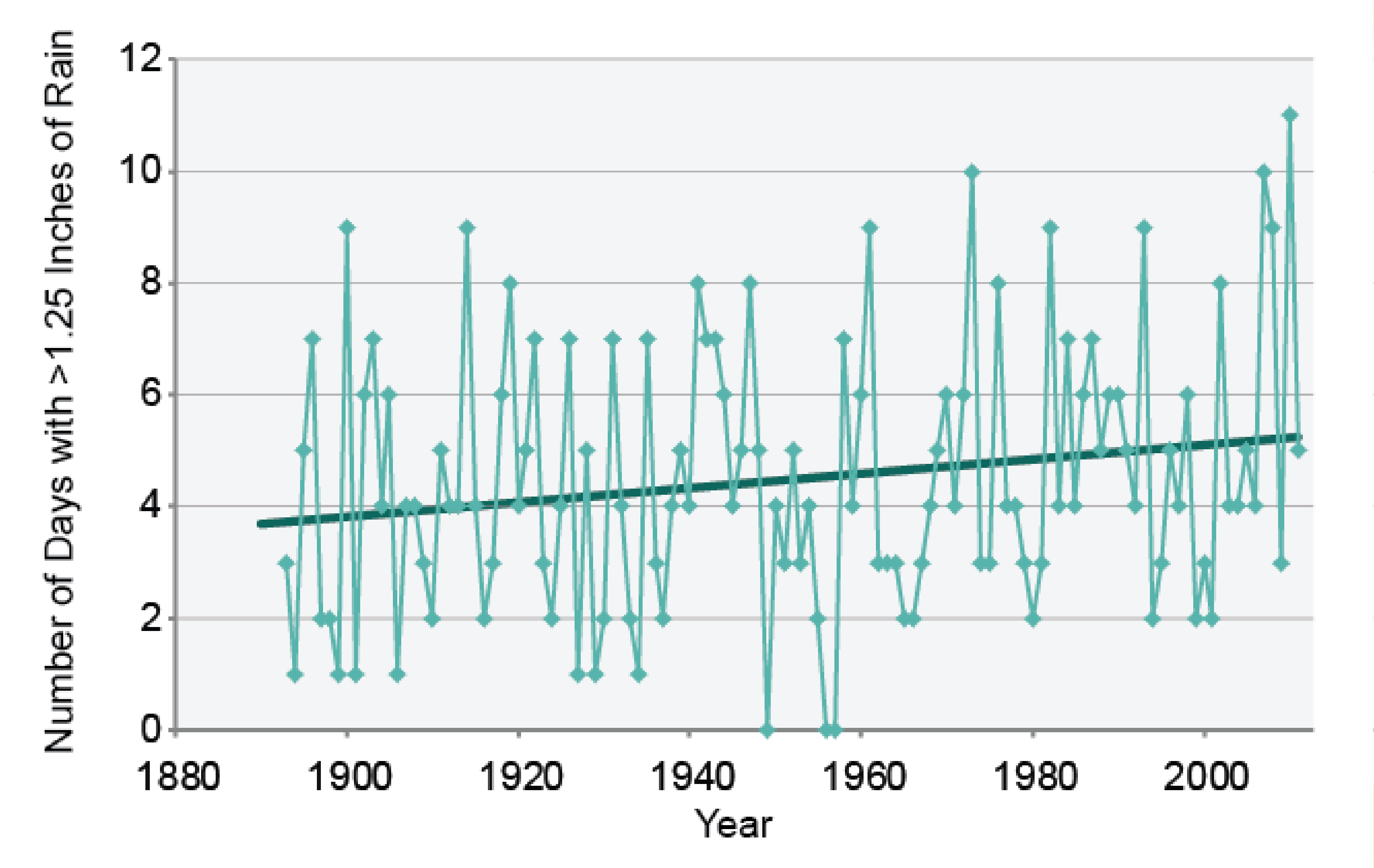
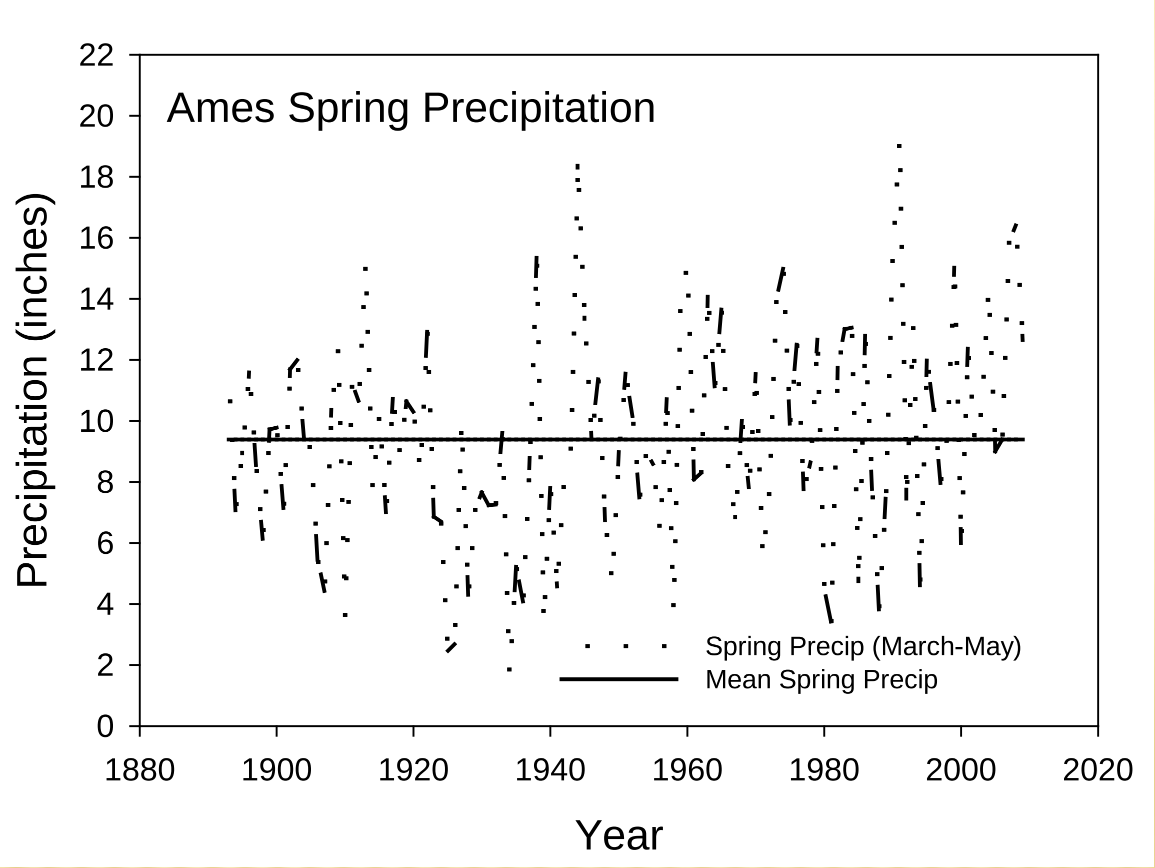
INCREASING HEAVY DOWNPOURS IN IOWA



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

EROSION: HOW MUCH IS TOLERABLE

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THE WIND BLOWS TOO

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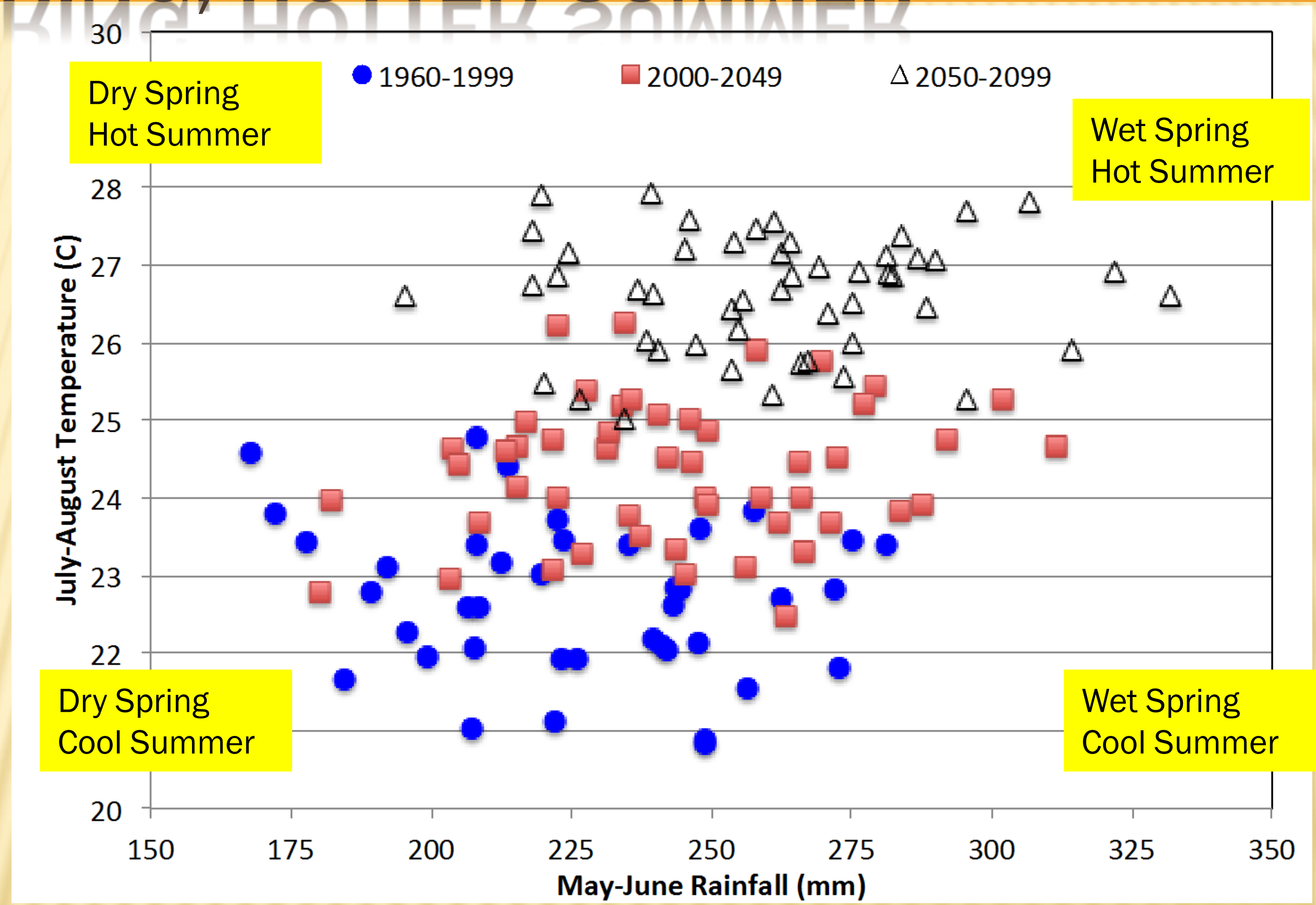
CLIMATE PROJECTION: WETTER SPRING, HOTTER SUMMER

- Iowa climate projection is average May-June rainfall and July-August temperature using 9 downscaled climate scenarios, spanning 3 GCMs and 3 emissions scenarios.
- Training period for downscale method is 1960-1999.



Data Source: Stoner et al. (2013)

QUESTION

- How is agriculture going to cope with the increasing variability in the within season weather and trends toward a warmer climate with shifting seasonality in precipitation?

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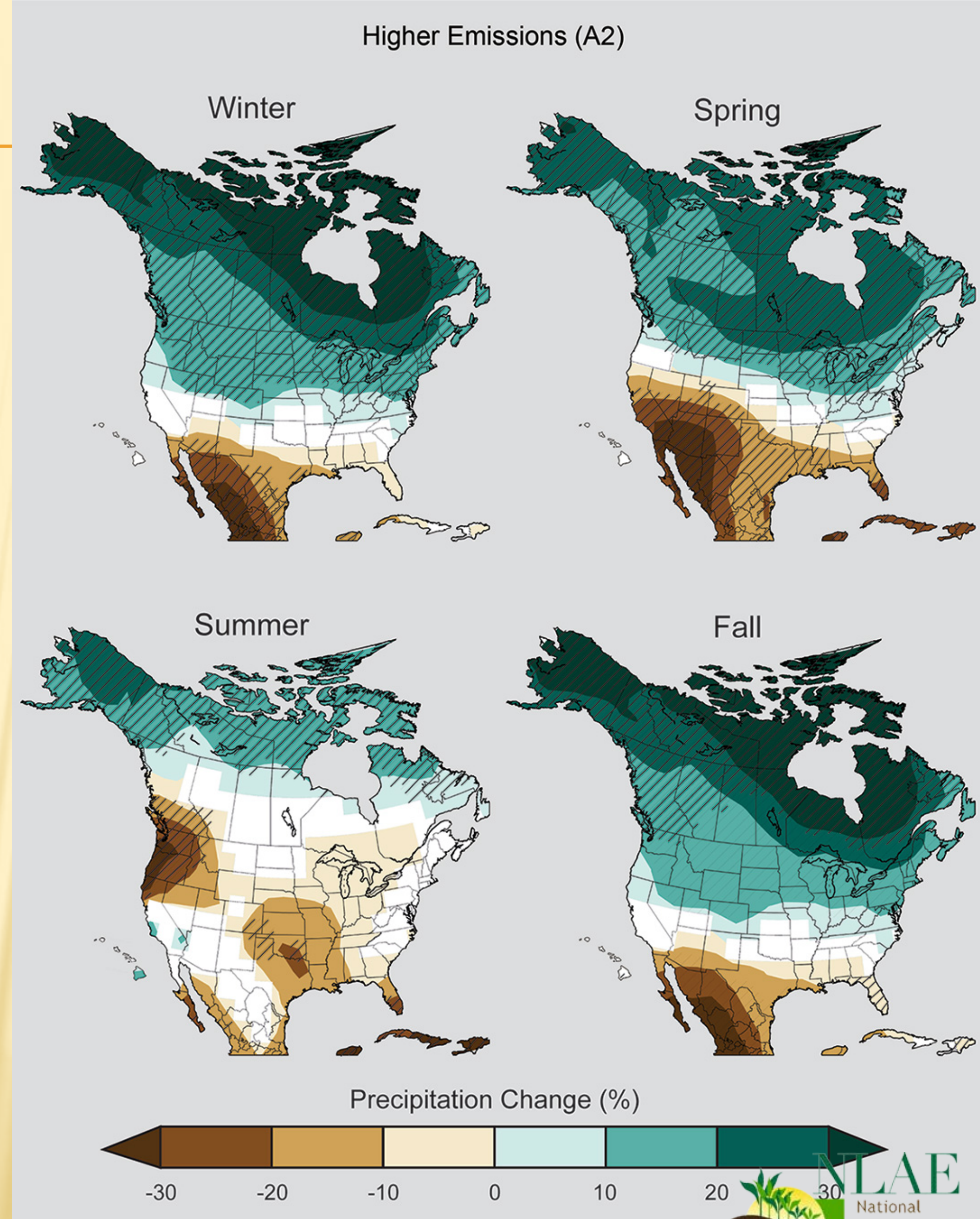
PROJECTED PRECIPITATION CHANGE BY SEASON



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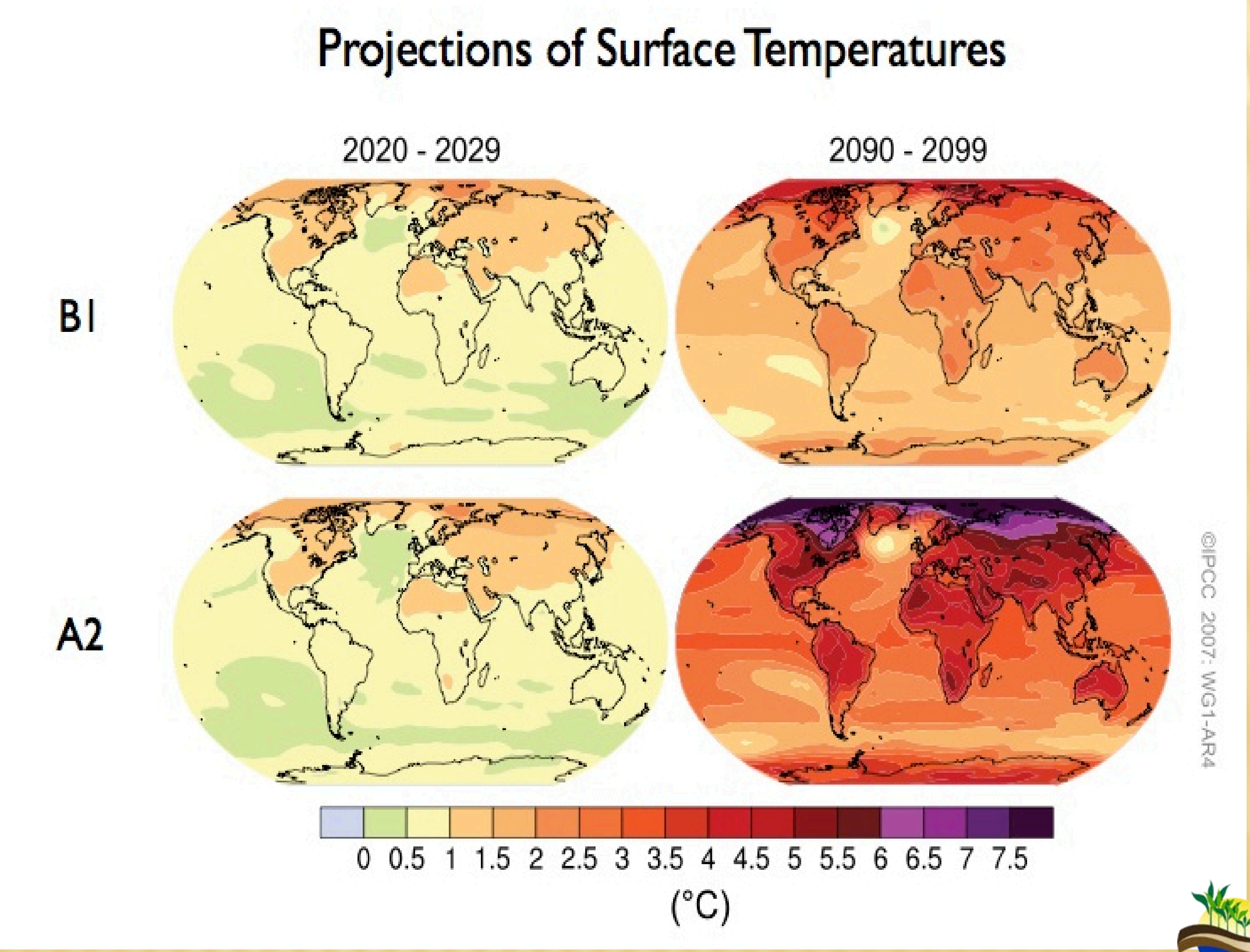
TEMPERATURE CHANGES



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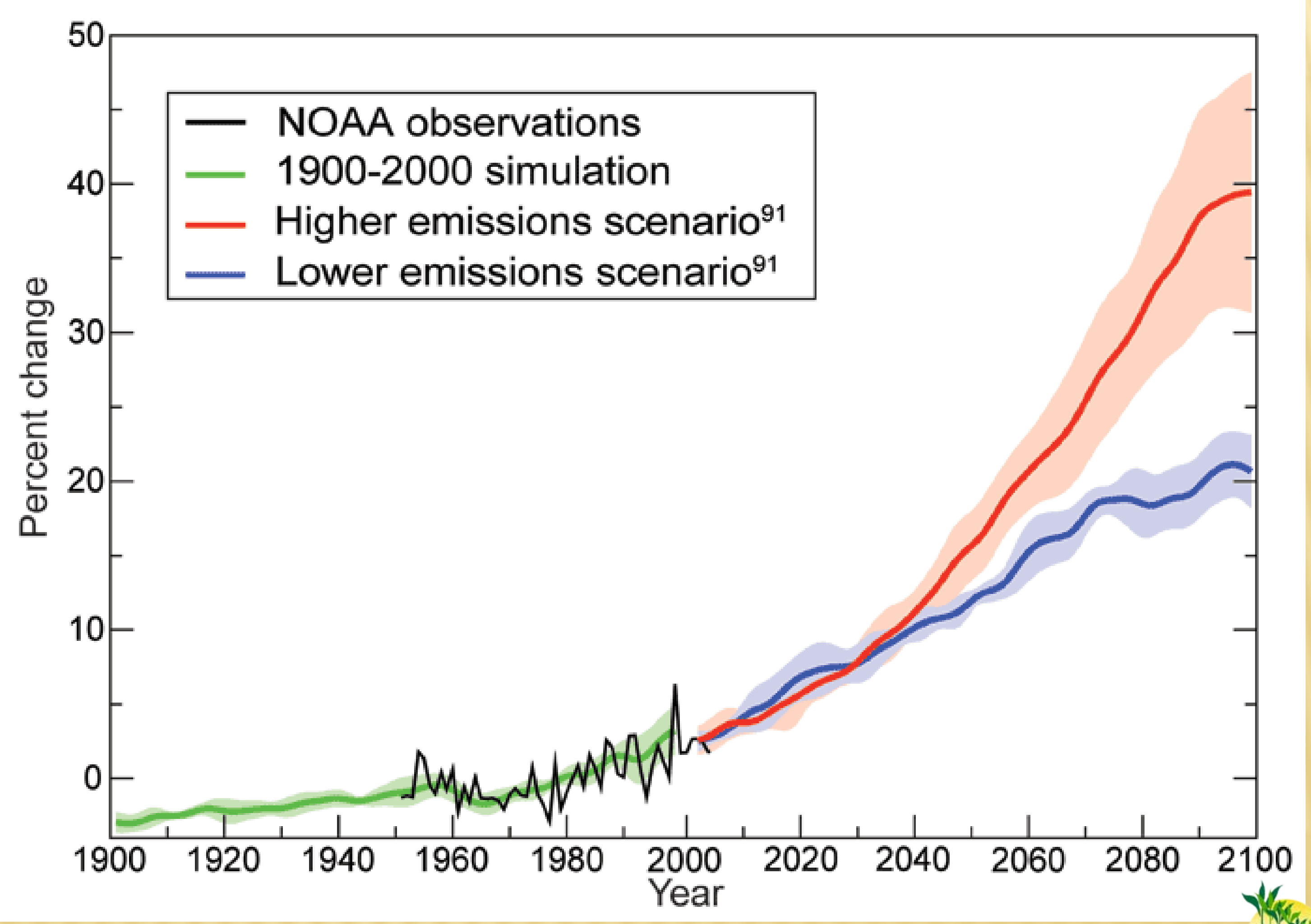
NIGHTTIME TEMPERATURES



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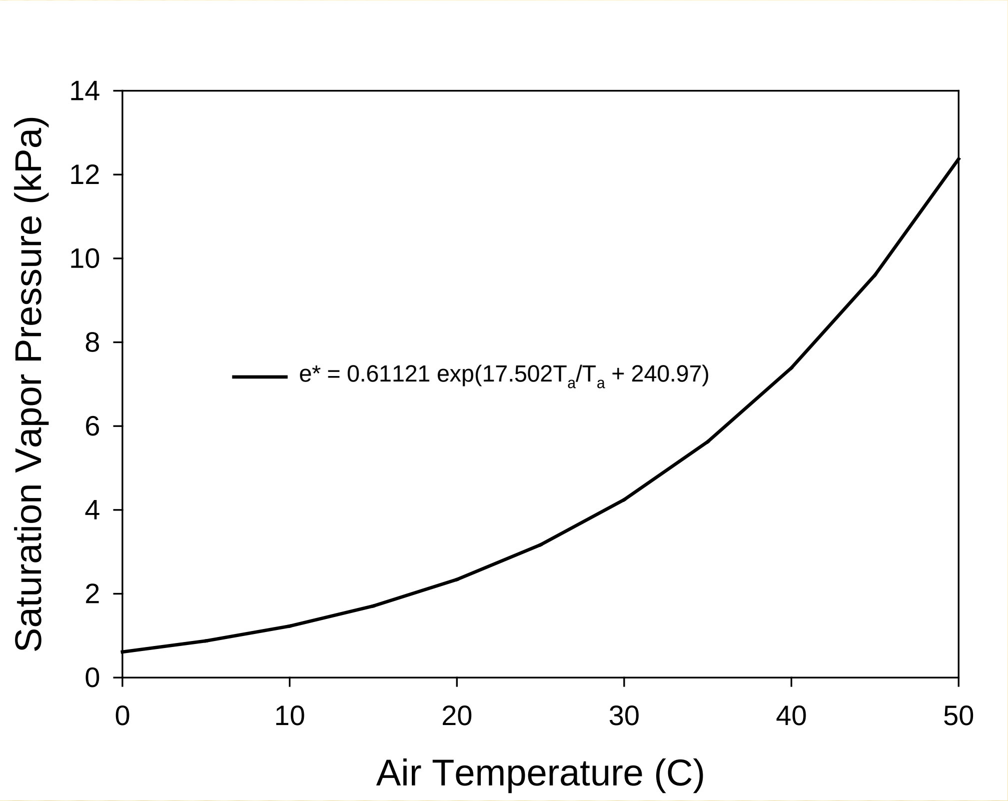
TEMPERATURE EFFECTS ON EVAPORATION



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

WHAT DOES ALL OF THIS MEAN TO THE PRODUCER?

- Begin to consider all aspects of the crop production system as an integrated set of components
- Utilize the following examples as guides

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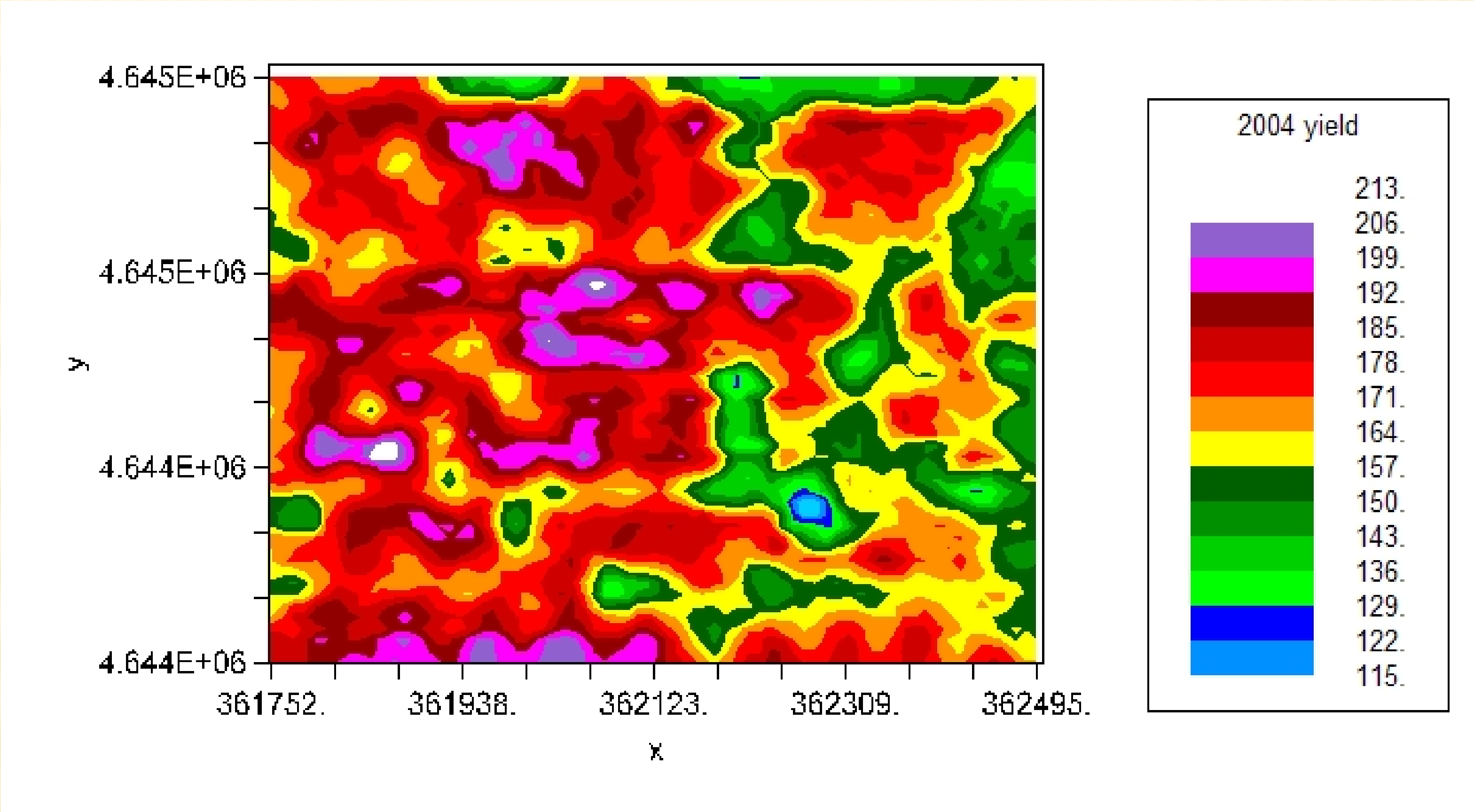
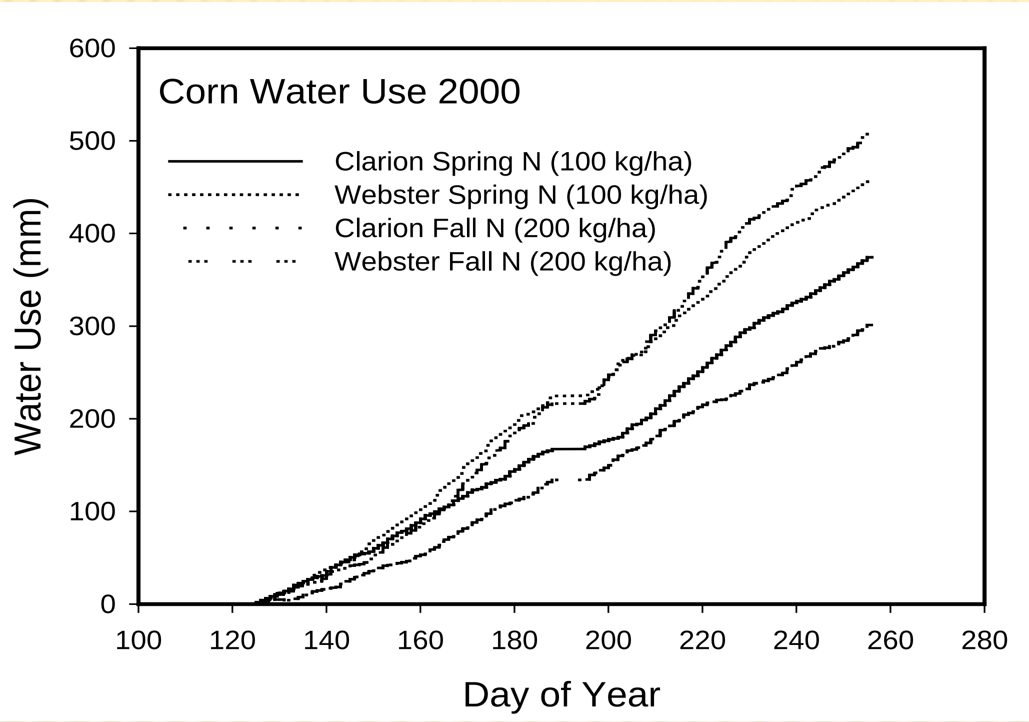
CROP YIELD VARIATION



SOIL WATER USE RATES



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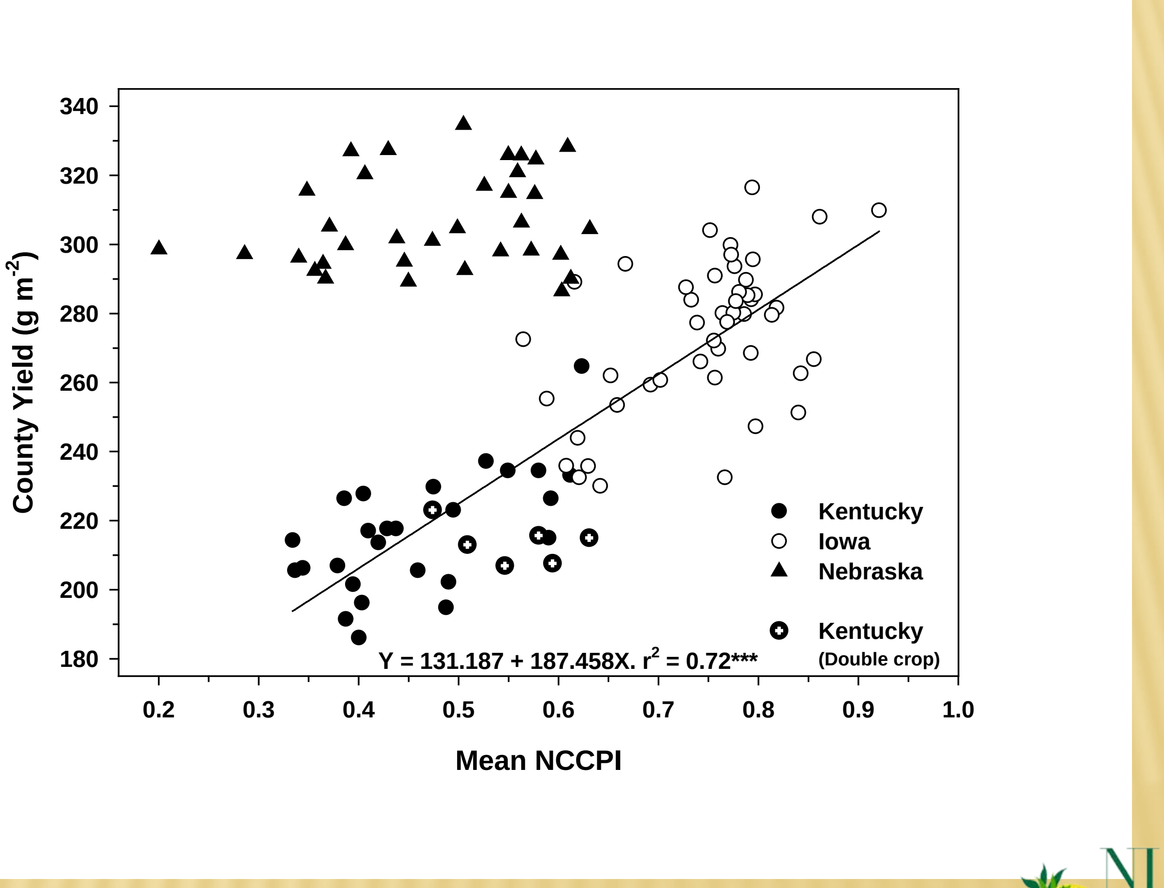
GOOD SOILS = GOOD YIELDS

Soybean yields across Iowa, Kentucky, and Nebraska



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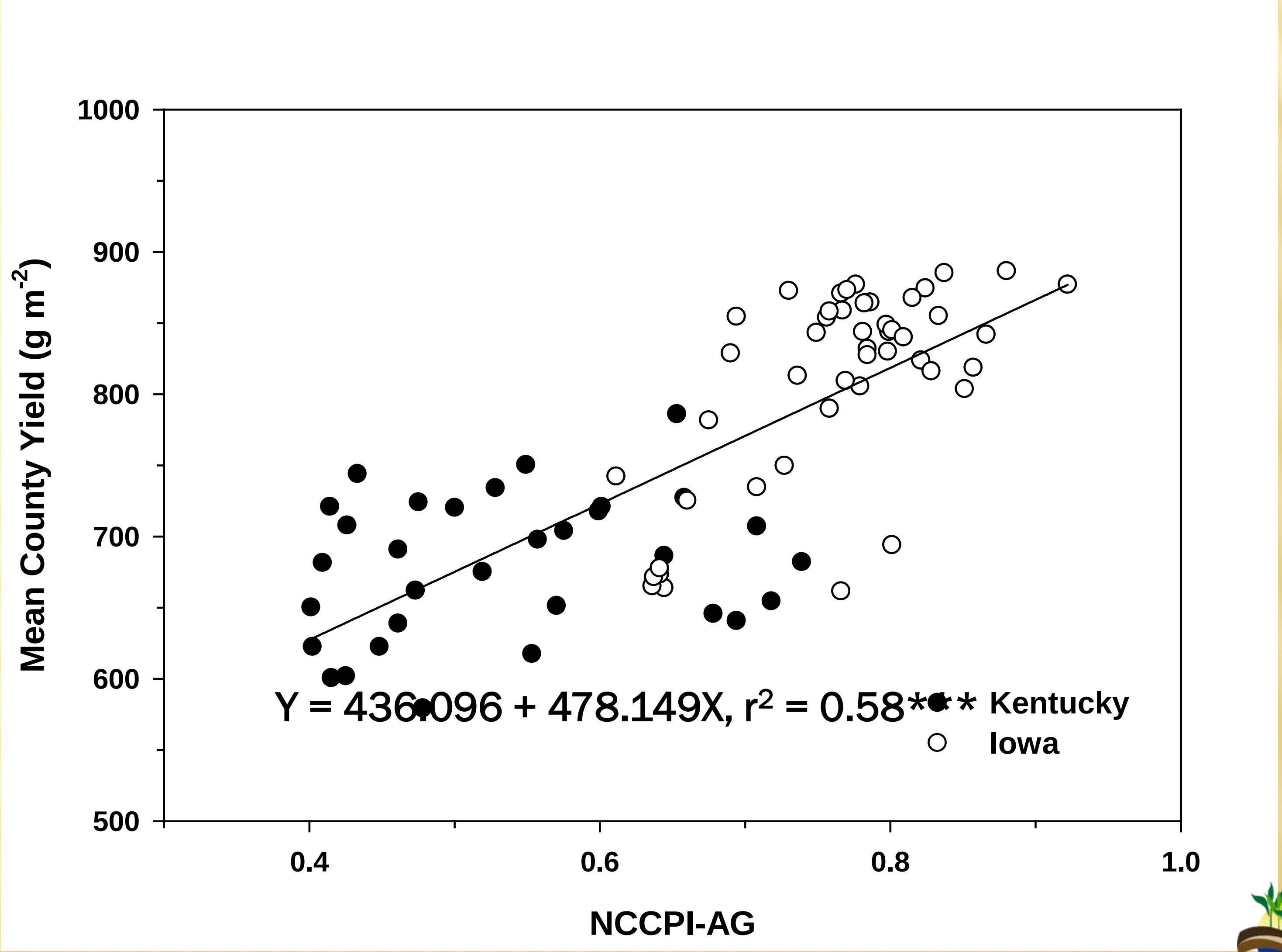
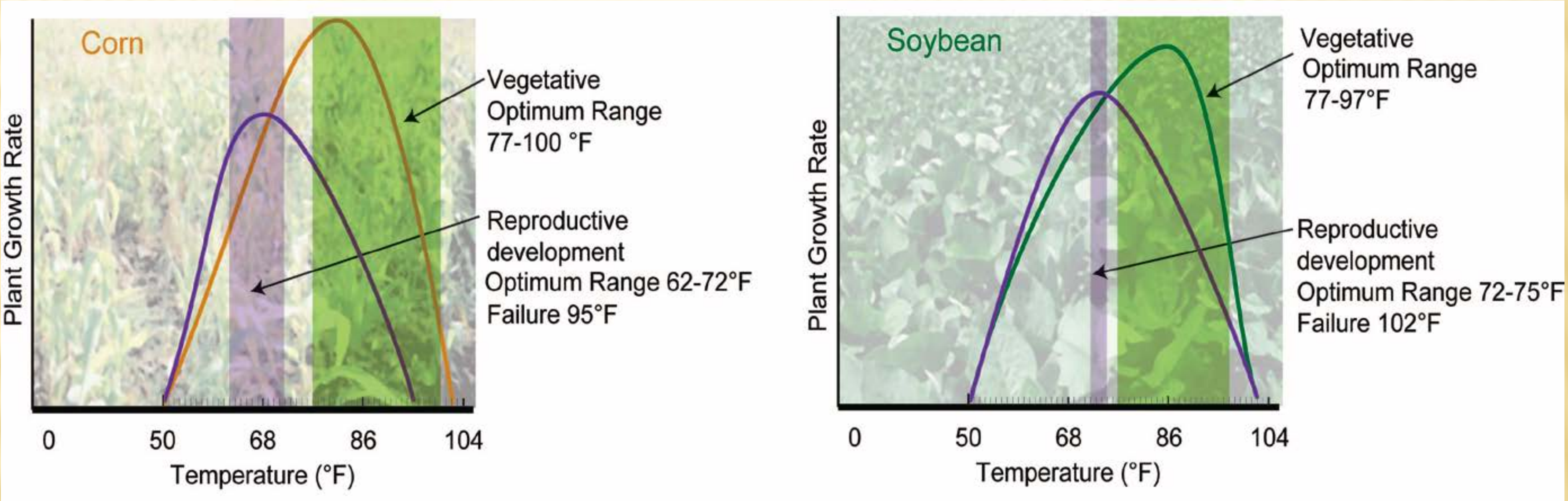
MAIZE COUNTY YIELDS



TEMPERATURE RESPONSES



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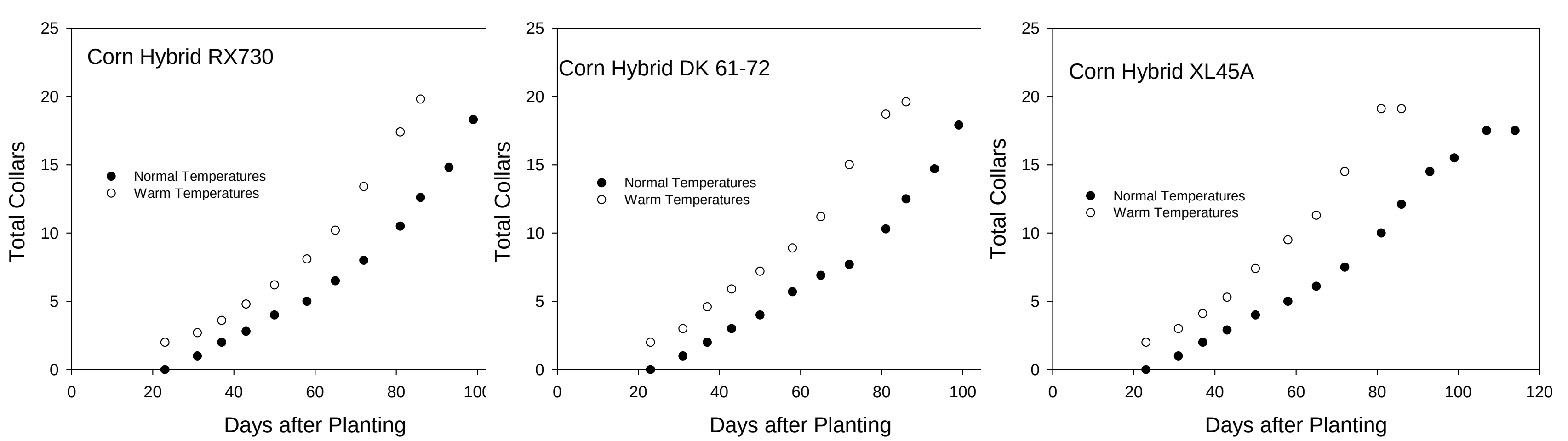
TEMPERATURE EFFECTS ON CORN PHENOLOGY



0 116 bu/A   34 206 bu/A   34 218 bu/A

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

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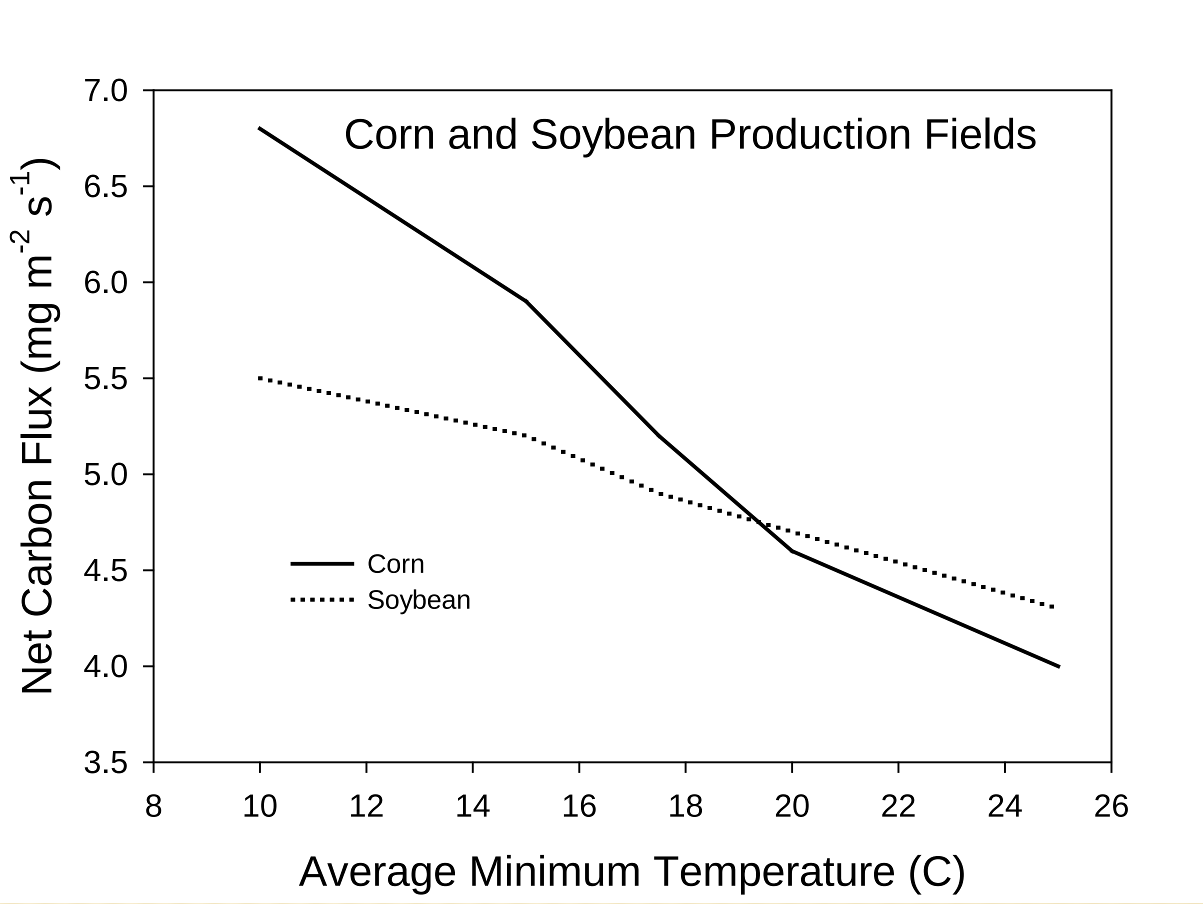
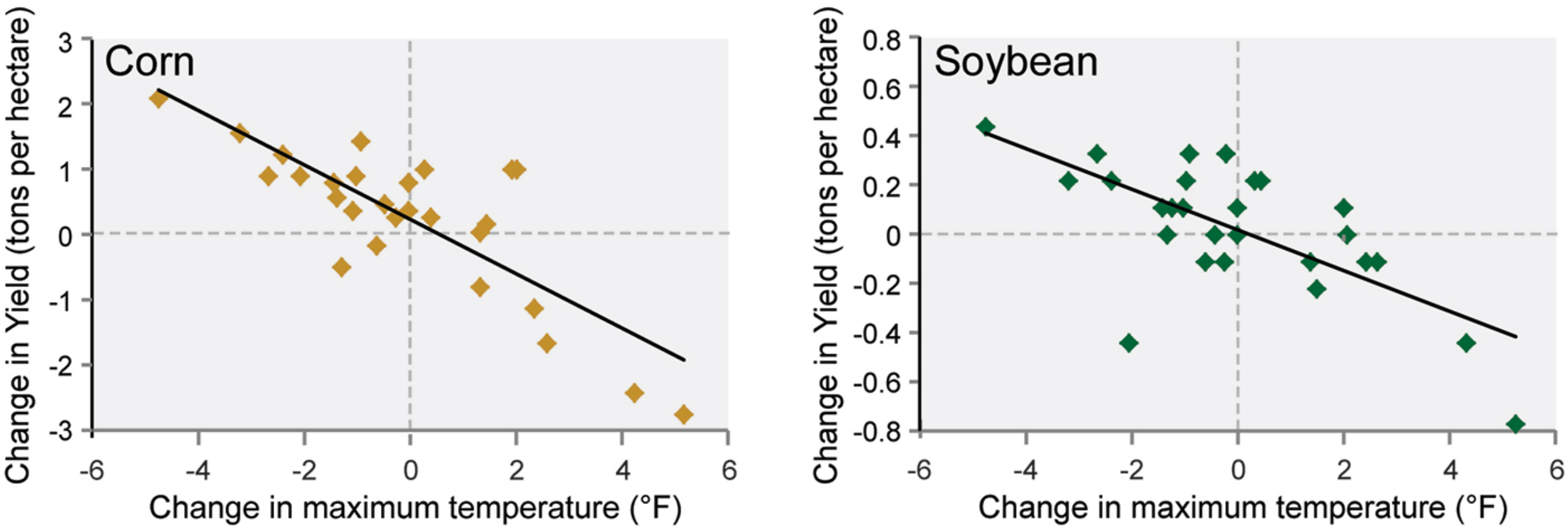
IMPACT OF WARM NIGHTS ON CORN AND SOYBEAN PRODUCTIVITY



CROP YIELDS DECLINE UNDER HIGHER TEMPERATURES



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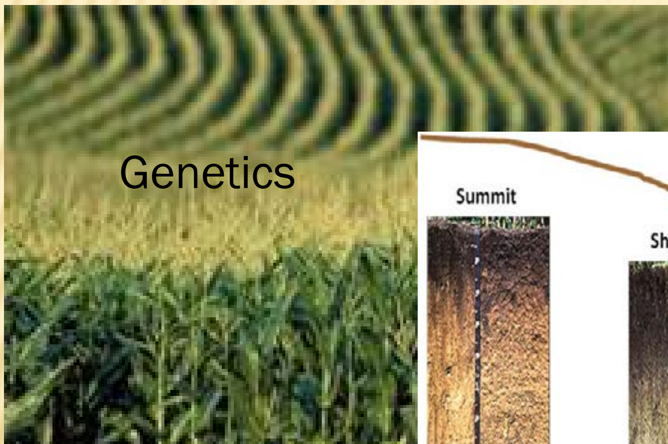
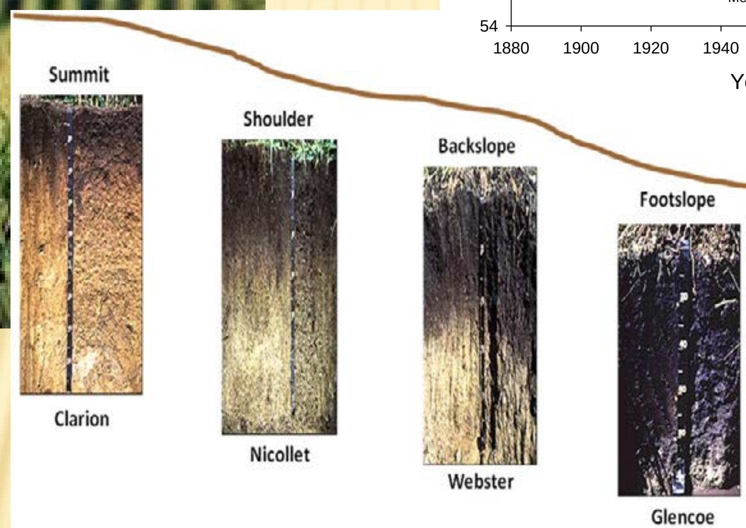
APPLICATION OF THESE RESULTS

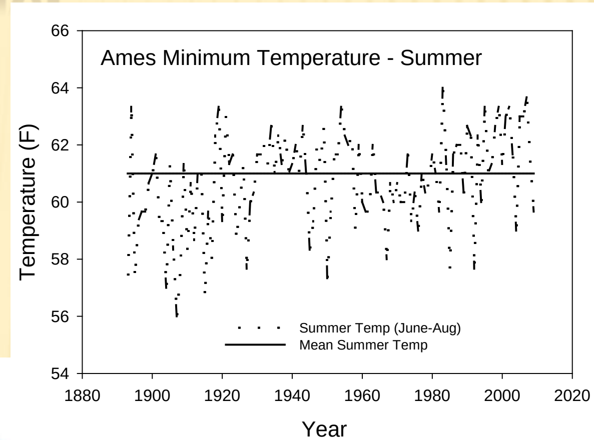
- Producers will not deal with a single climate factor, exposed to all factors, temperature, precipitation, carbon dioxide, solar radiation
- What is in the producers control?
- Concept that we must begin the process of understanding agriculture systems as the interactions of genetics, environment and management.

CONCEPT OF G X E X M



Genetics





Environment

Management

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FOUNDATION OF CLIMATE RESILIENCE FOR AGRICULTURE IS BASED ON:

- Soil and soil water availability
- Yield variation within fields and among years is due to soil water availability which exaggerates the temperature effect.
- Soil water increases the ability of the crop to utilize nutrients

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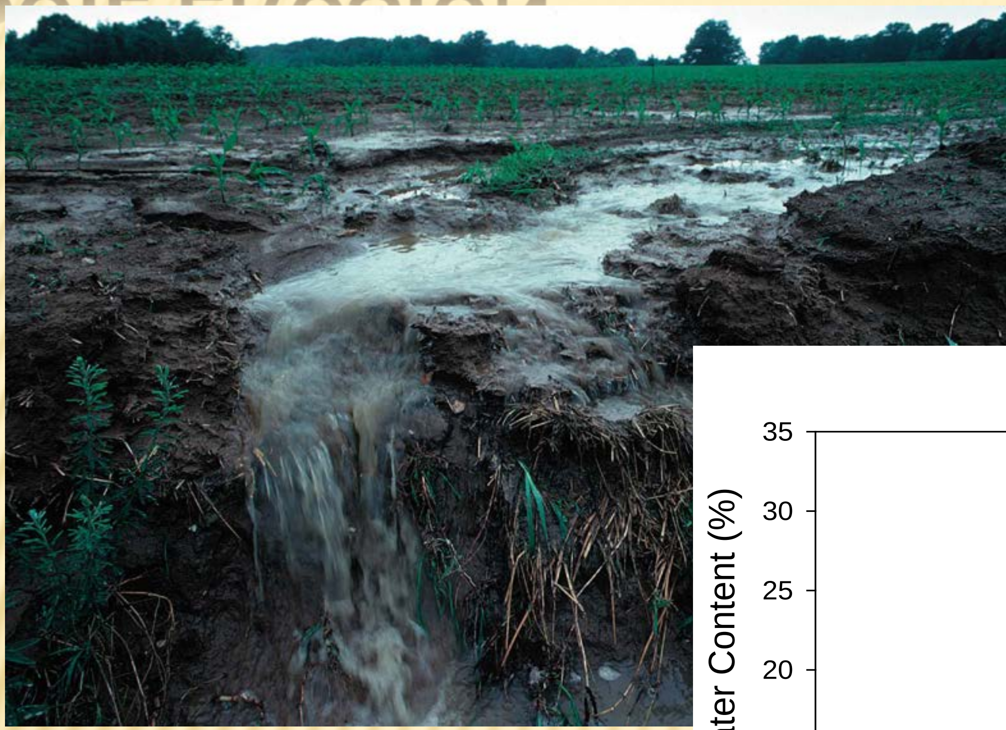
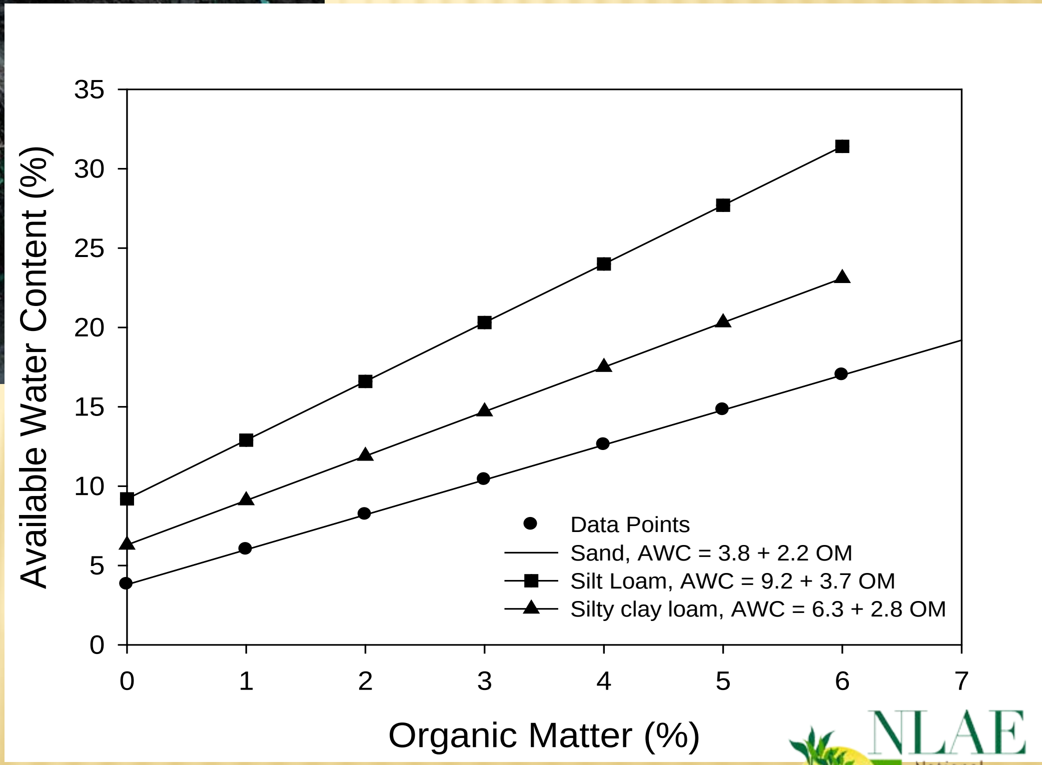
SOIL EROSION





Degrading the soil resource decreases the water holding capacity

Hudson, 1994

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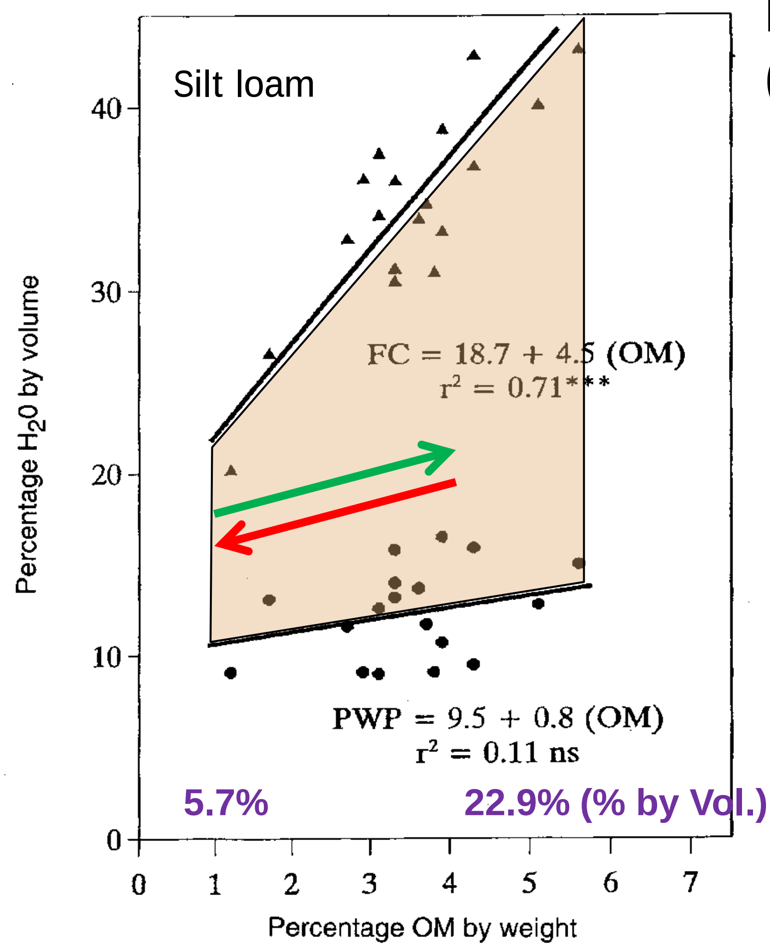
Organic Matter Effects on Available Water Capacity



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.

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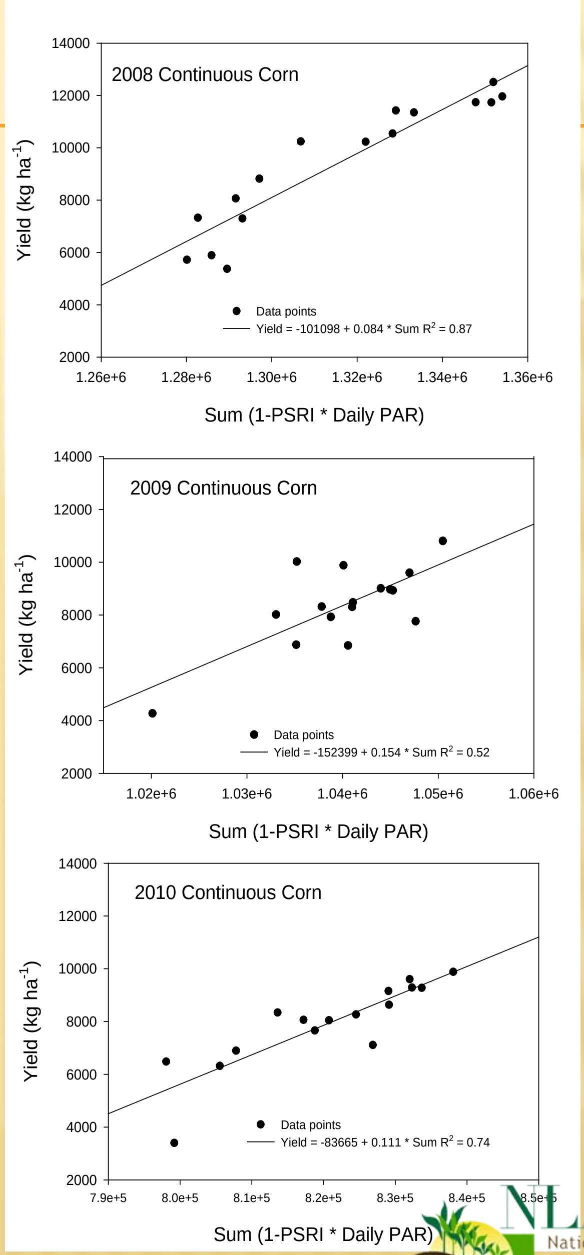
SENESCENCE INDEX

The longer we can maintain green leaf area during the grain-filling period the higher the yield



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CONSERVATION AGRICULTURE BENEFITS

- Short-term
  - Reduce soil water evaporation
  - Increase infiltration of rainfall or irrigation events
  - Reduce the overall of evapotranspiration rate if plants are grown in standing stubble
- Long-term
  - Increase the soil water holding capacity through improved organic matter content
  - Increase water availability to the crop
  - Increase rooting depth

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CLIMATE RESILIENCE

- Will have to rely on capturing, storing, and making available maximum amount of soil water to the crop during the growing season
- Implement cropping system which increase the organic matter content of the soil and reduce erosion under the shifting precipitation patterns

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CLIMATE FACTORS

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

Direct
  Growth
  Phenology
  Yield

Indirect
  Insects
  Diseases
  Weeds

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

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GOOD NEWS

- You can't control the weather but you can manage the soil and management inputs to increase climate resilience
- Aggressive soil management to improve organic matter (soil water storage and infiltration rates) will pay dividends in improved yield stability and water and nutrient use efficiency

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IMPROVED SOIL MANAGEMENT PRACTICES COULD BE IMPLEMENTED ON MY FARM BY:

- Decreasing tillage
- Increasing the retention of crop residue
- Adding cover crops to provide for more ground cover and residue
- Changing a crop rotation to diversify crops
- I am not convinced any of these can work on my farm