Climate Change in Illinois - Agriculture

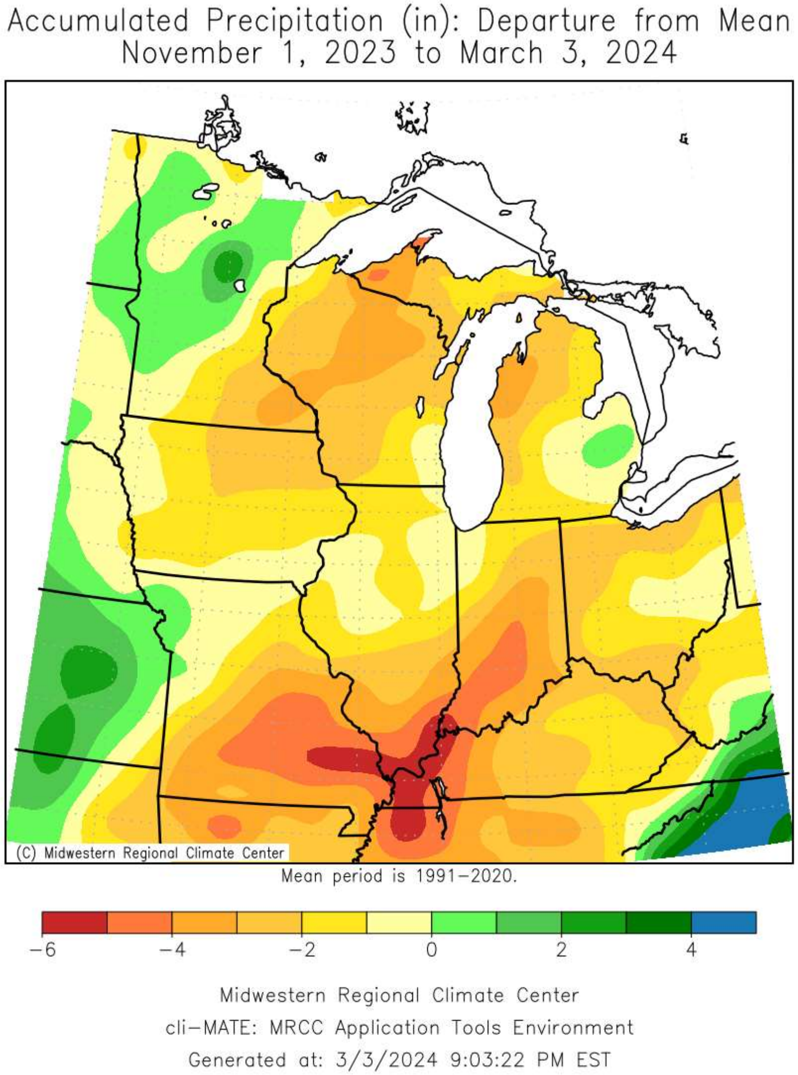
Dr. Jim Angel, former State Climatologist for Illinois

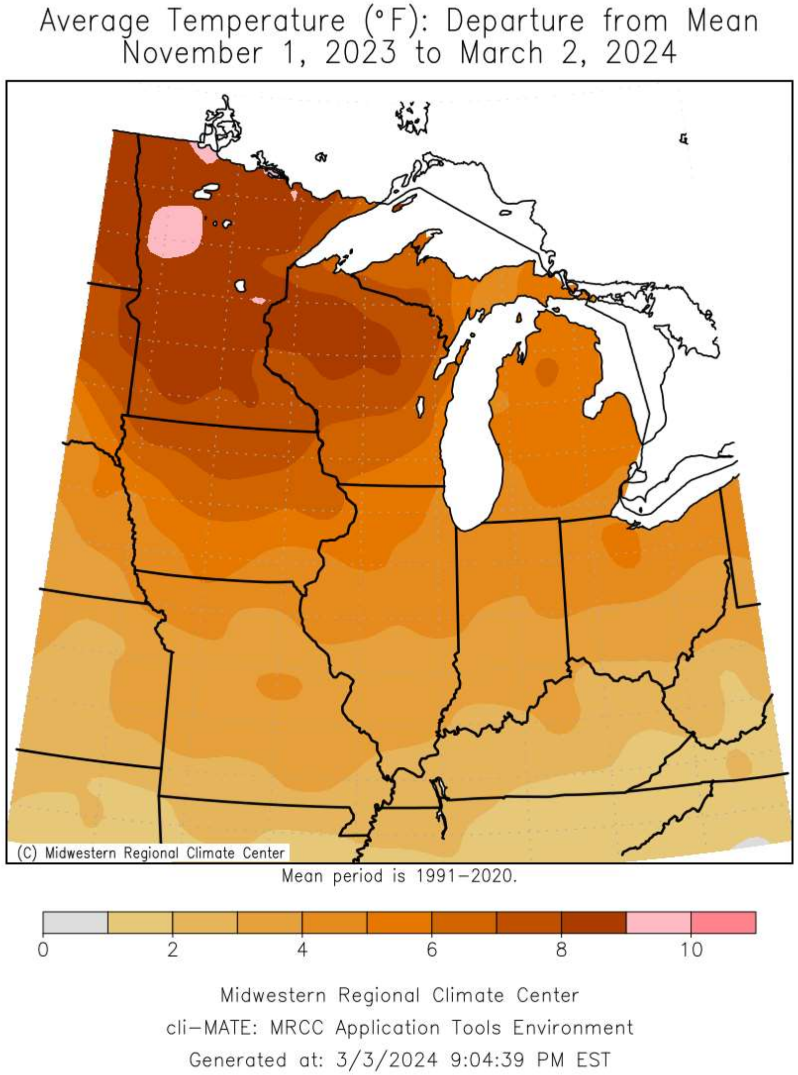
Logistics

- PowerPoint slides will be uploaded to the Box folder and available for anyone
- At around 30 minutes, there will be a pause for questions about <u>material already covered</u>
- At the end of the lecture, there will be plenty of time for additional questions

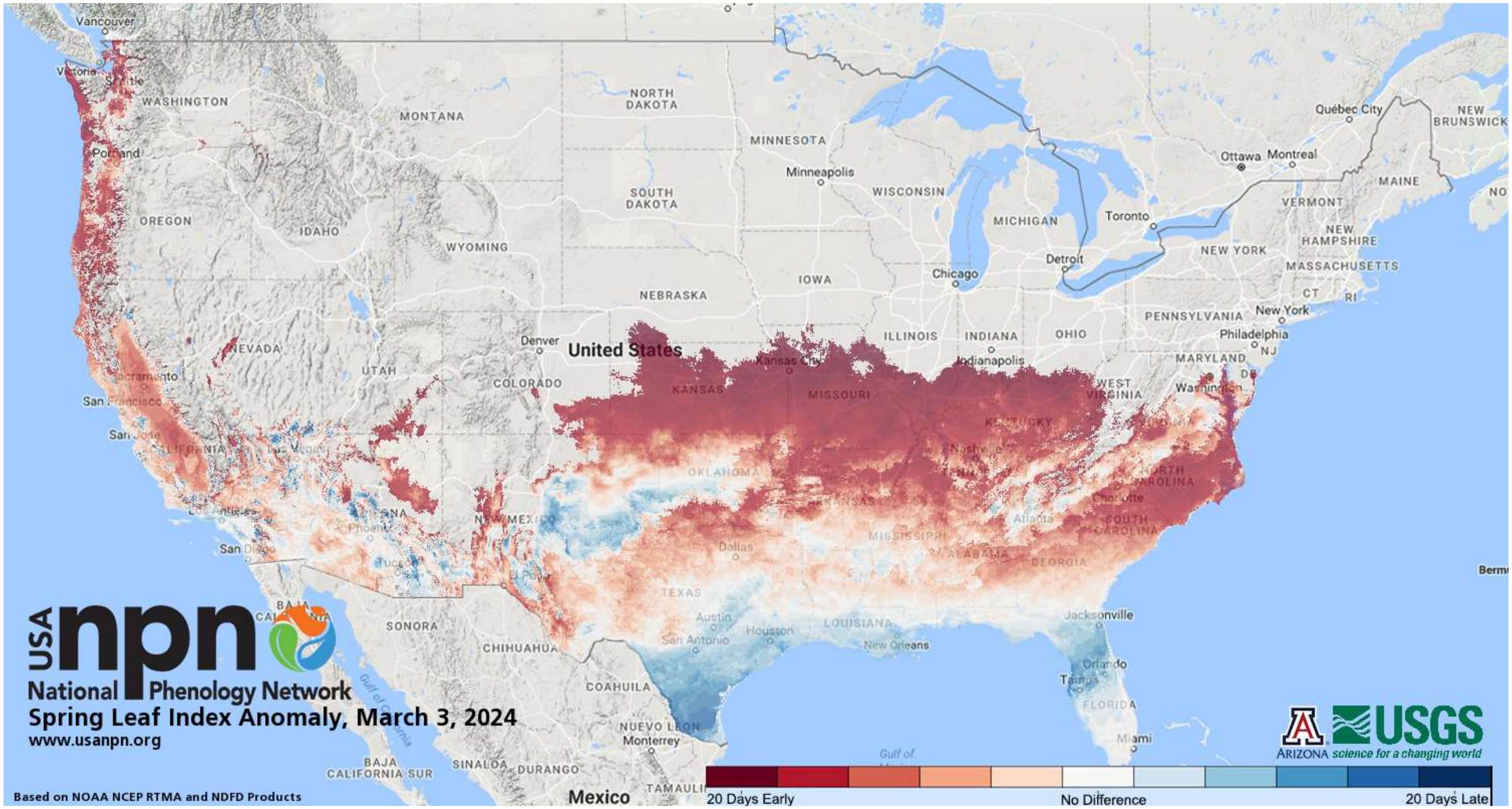
Overview of the course

- The focus will be on Illinois with limited discussion about national issues
  - Week 1: Overview of current trends and future projections for Illinois.
  - Week 2: Impacts on agriculture.
  - Week 3: Impacts on water resources.
  - Week 4: Impacts on health


Accumulated Precipitation (in): Departure from Mean
November 1, 2023 to March 3, 2024
(C) Midwestern Regional Climate Center
Mean period is 1991-2020.
−6
−4
−2
0
2
4
Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 3/3/2024 9:03:22 PM EST

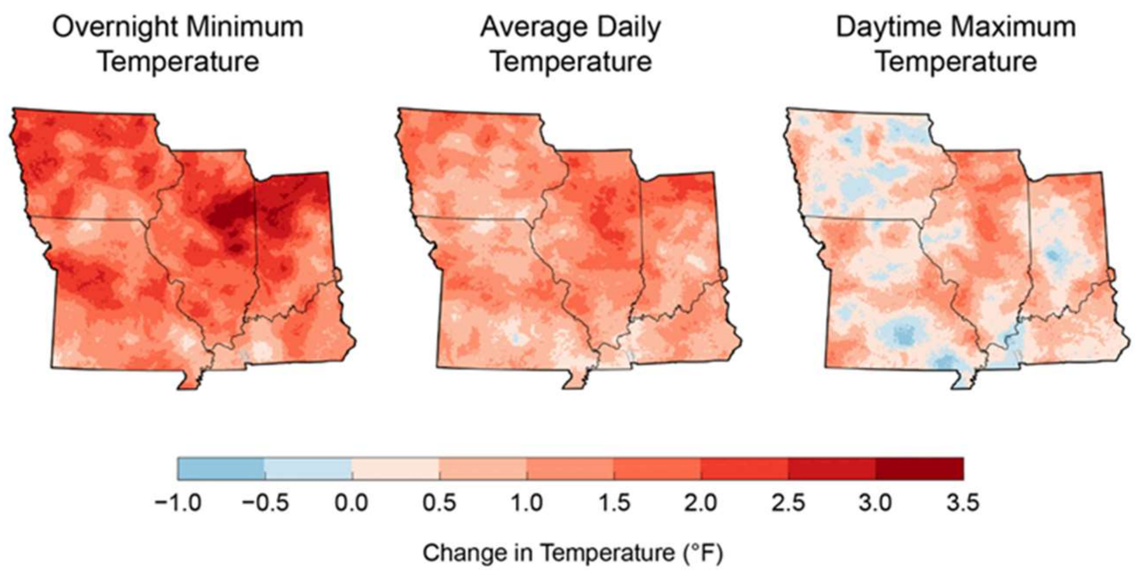

Average Temperature (°F): Departure from Mean
November 1, 2023 to March 2, 2024
(C) Midwestern Regional Climate Center
Mean period is 1991-2020.
0
2
4
6
8
10
Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 3/3/2024 9:04:39 PM EST

False Spring

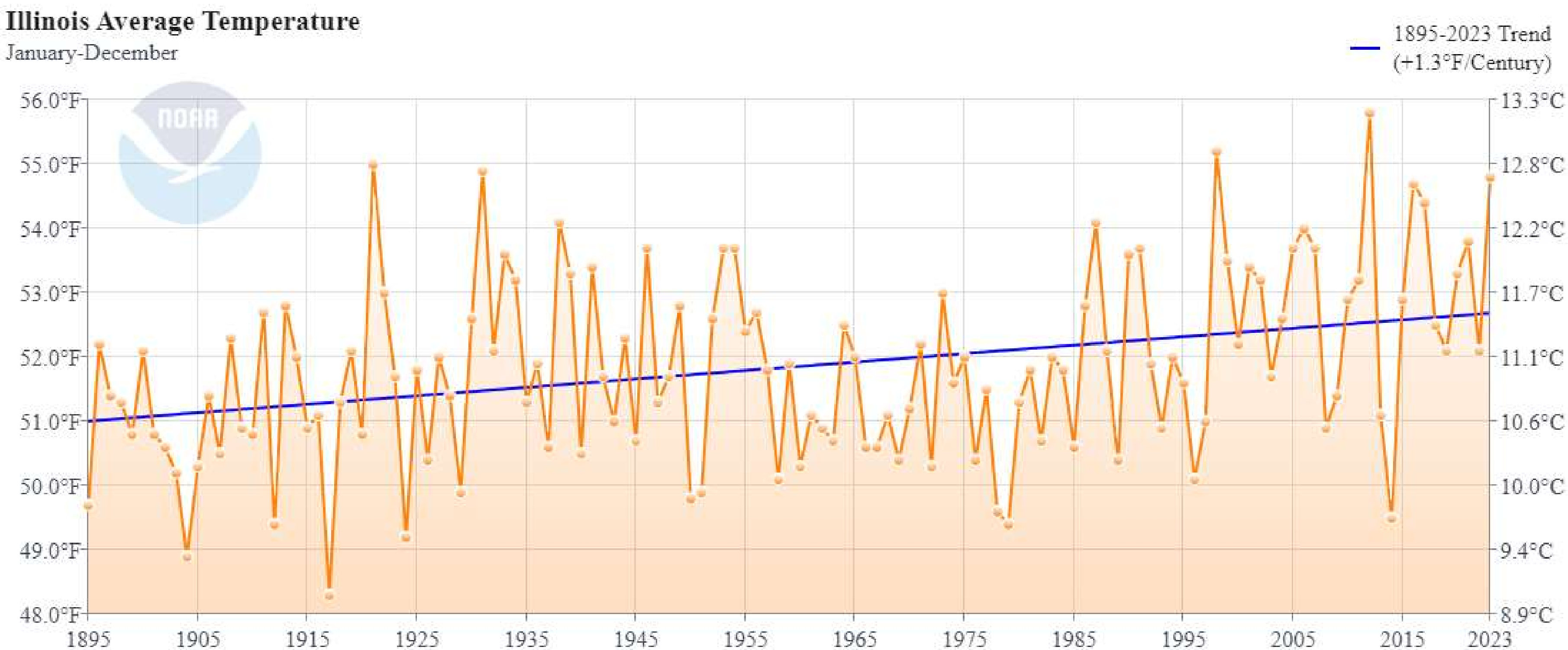


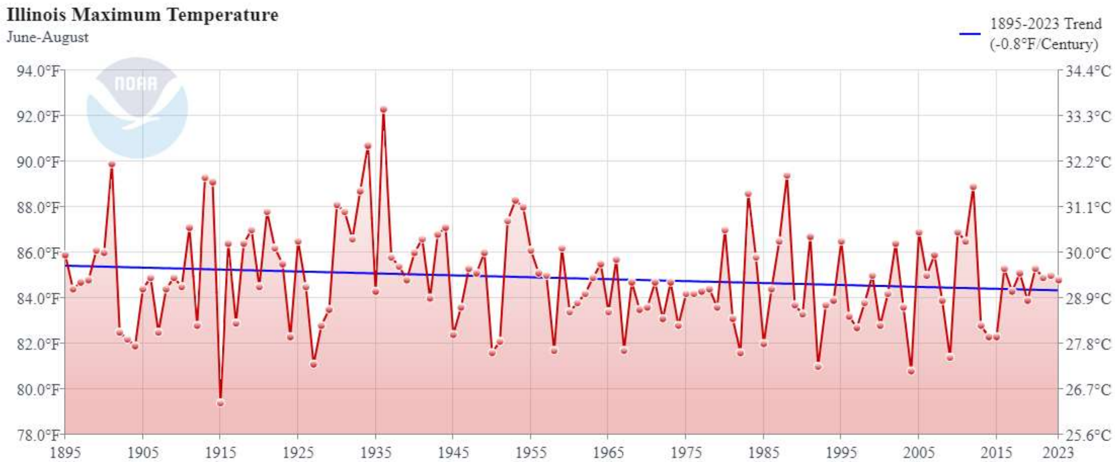
Observed Temperature Changes

Season	Overnight Minimum Temperature	Average Daily Temperature	Daytime Maximum Temperature
Winter	+ 3.0	+ 2.5	+ 2.2
Spring	+ 1.8	+ 1.6	+ 1.4
Summer	+ 1.7	+ 0.5	-0.7
Fall	+ 1.3	+ 0.8	+ 0.4

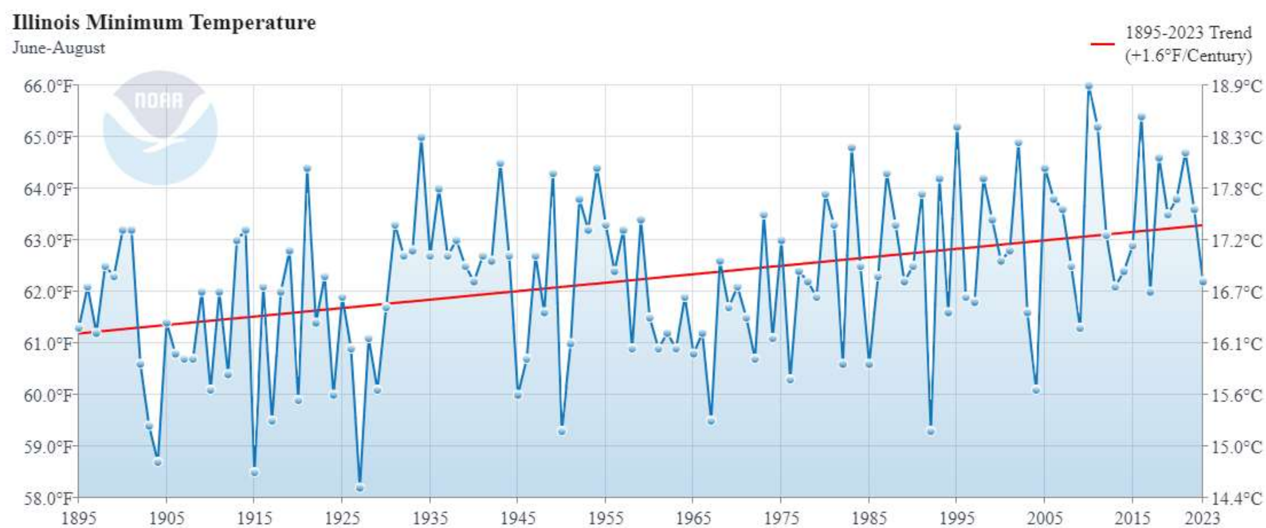


Changes between the early 20th century (1895-1924) and early 21st century (1990-2019)


Illinois Average Temperature
January-December
1895-2023 Trend
(+1.3°F/Century)
56.0°F
55.0°F
54.0°F
53.0°F
52.0°F
51.0°F
50.0°F
49.0°F
48.0°F
13.3°C
12.8°C
12.2°C
11.7°C
11.1°C
10.6°C
10.0°C
9.4°C
8.9°C
1895
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
2015
2023



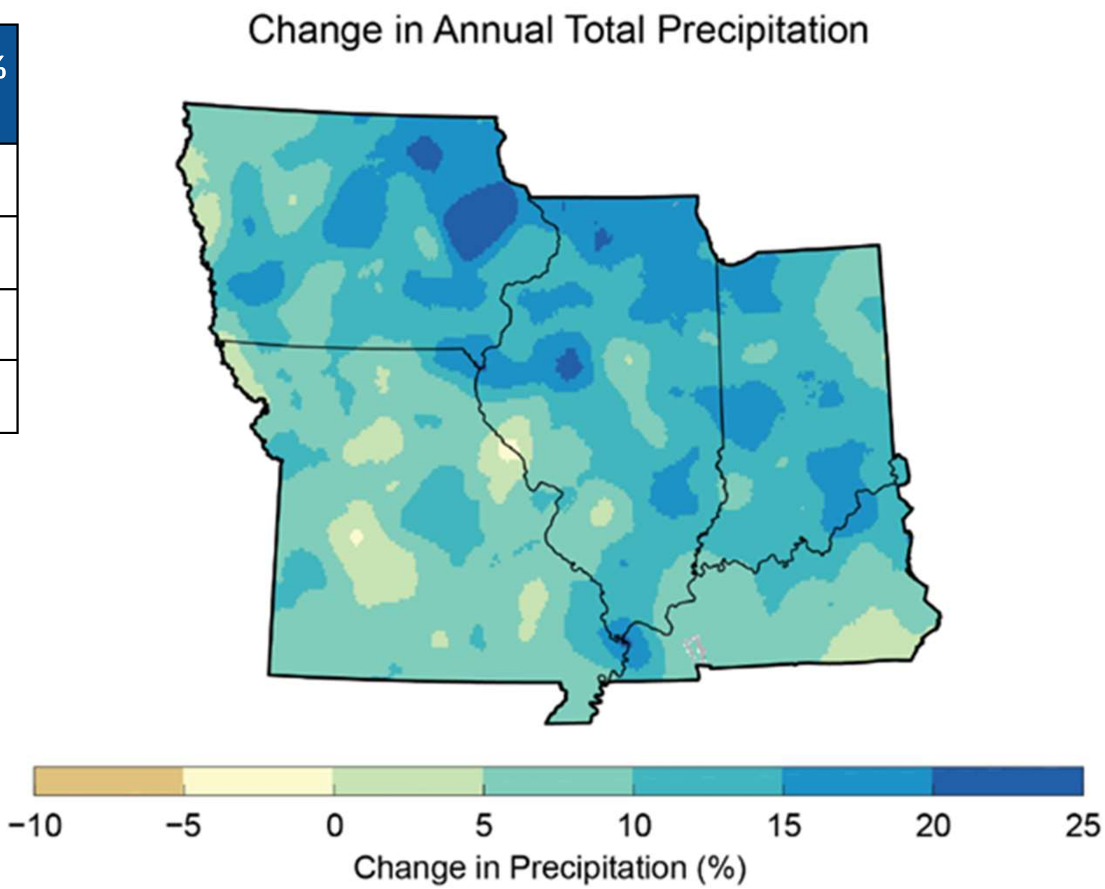
Summer Highs are cooling while Summer Lows are Warming

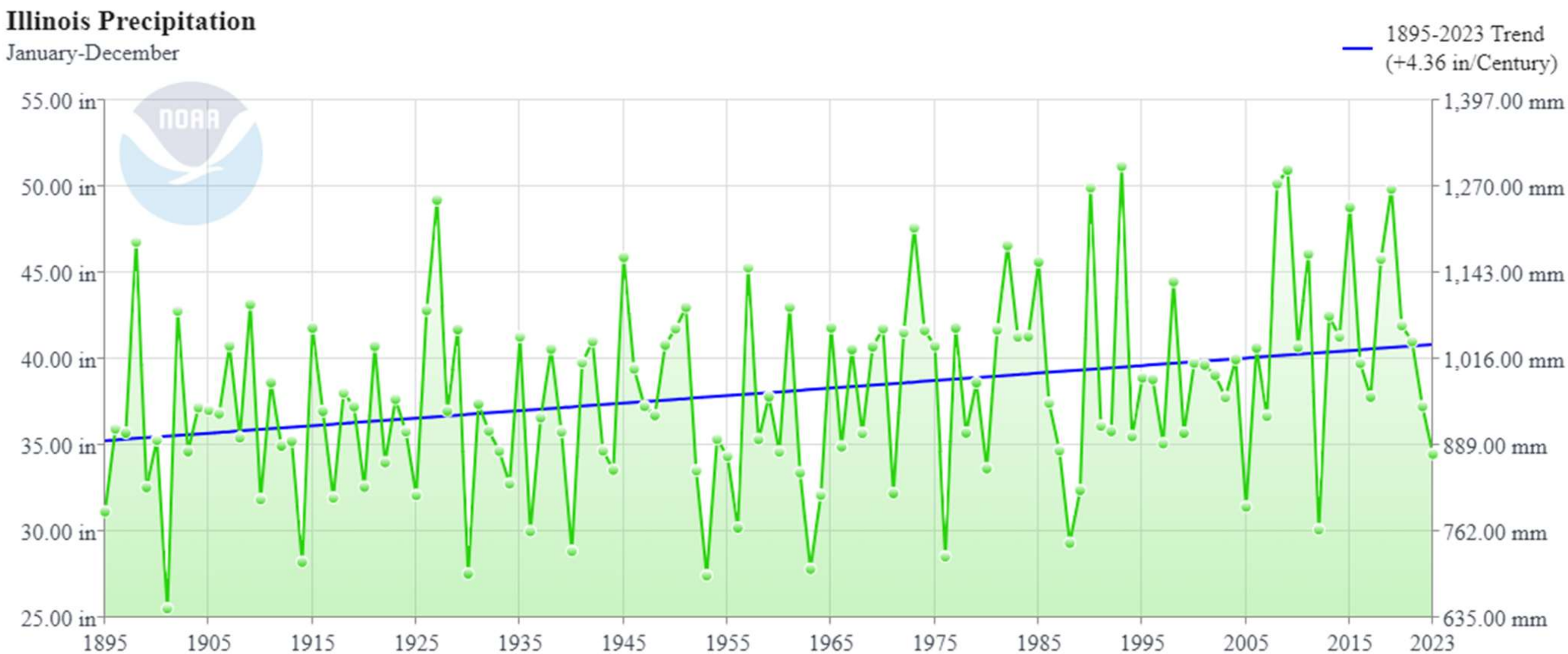


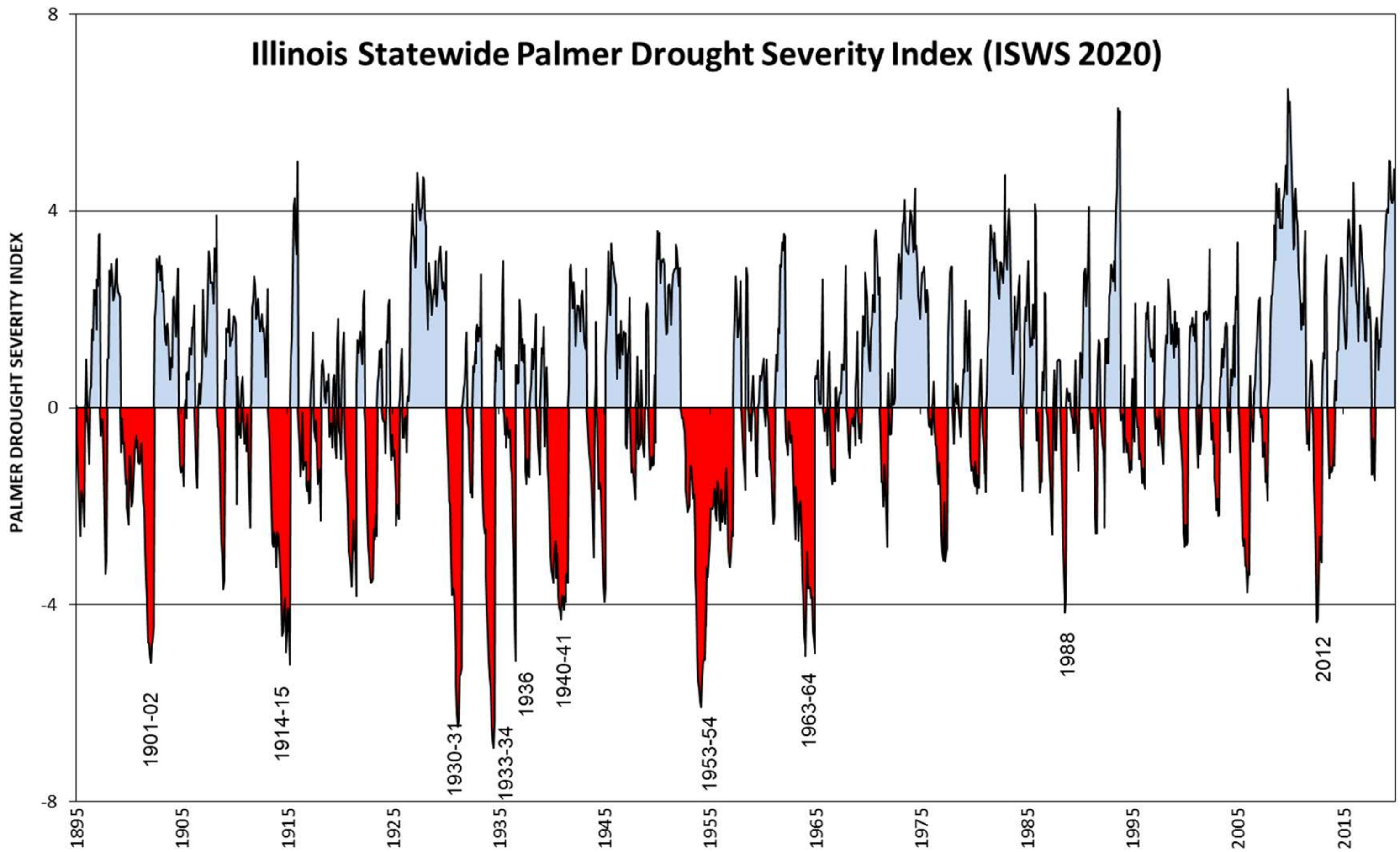
Observed Precipitation Changes

Season	Precipitation (inches)	Precipitation (% Change)
Winter	+0.54	+8.5%
Spring	+1.33	+ 12.5%
Summer	+1.55	+ 14.3%
Fall	+1.33	+ 15.9%

Changes between the early 20th century (1895-1924) and early 21st century (1990-2019)



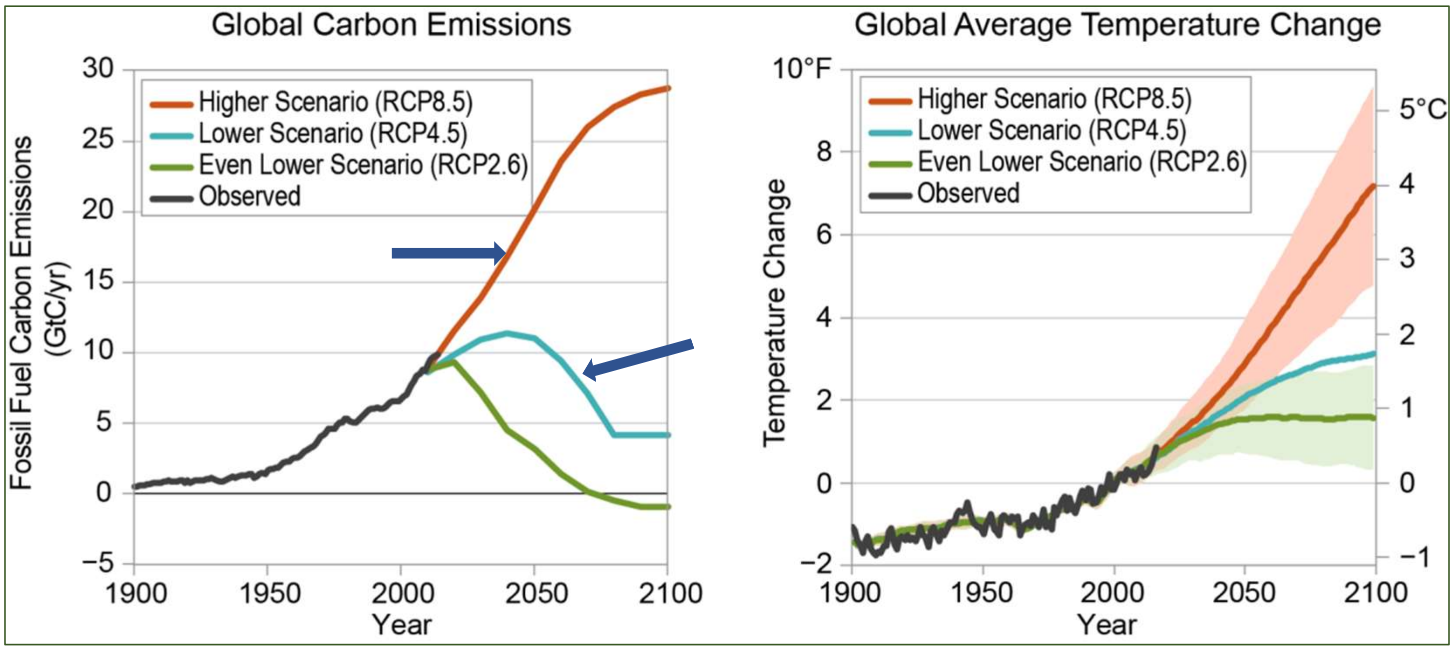

Illinois Precipitation
January-December
1895-2023 Trend
(+4.36 in/Century)
55.00 in
50.00 in
45.00 in
40.00 in
35.00 in
30.00 in
25.00 in
1,397.00 mm
1,270.00 mm
1,143.00 mm
1,016.00 mm
889.00 mm
762.00 mm
635.00 mm
1895
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
2015
2023



Blue means wet; red means dry; noteworthy droughts labeled

Future Projections

- “higher” and “lower” scenarios of global carbon emissions



Source: Hayhoe, K. et al., 2018. Fourth National Climate Assessment.

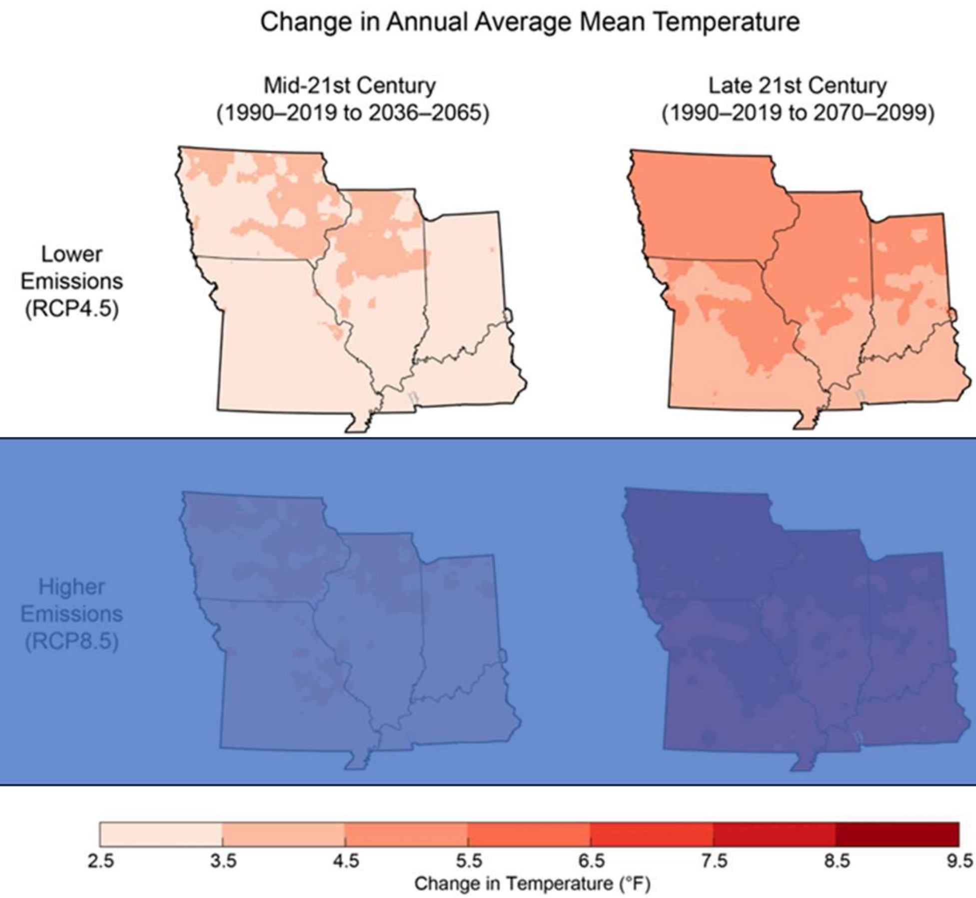
Projected Temperatures

Top panel – lower scenario, mid- to late-century

- 3-4°F warming by mid-century
- 4-5°F warming by late-century

Bottom panel – higher scenario, mid- to late-century

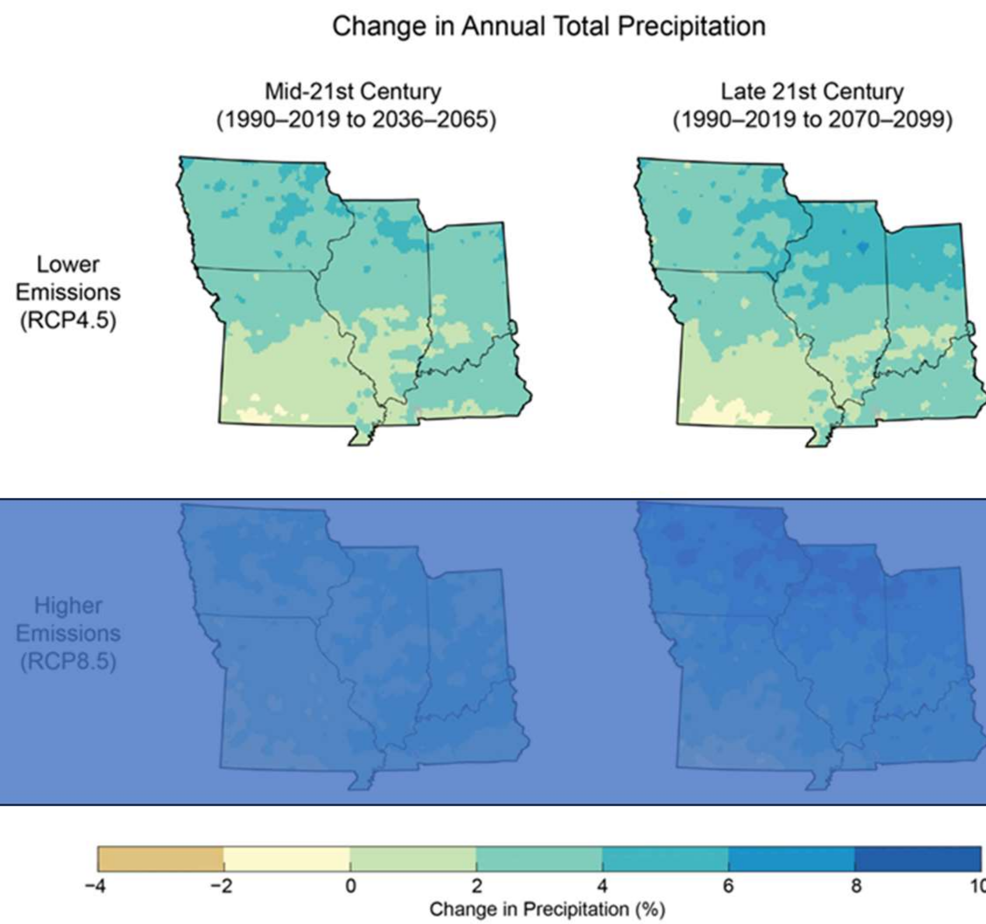
- 4-5°F warming by mid-century
- 8-9°F warming by late-century



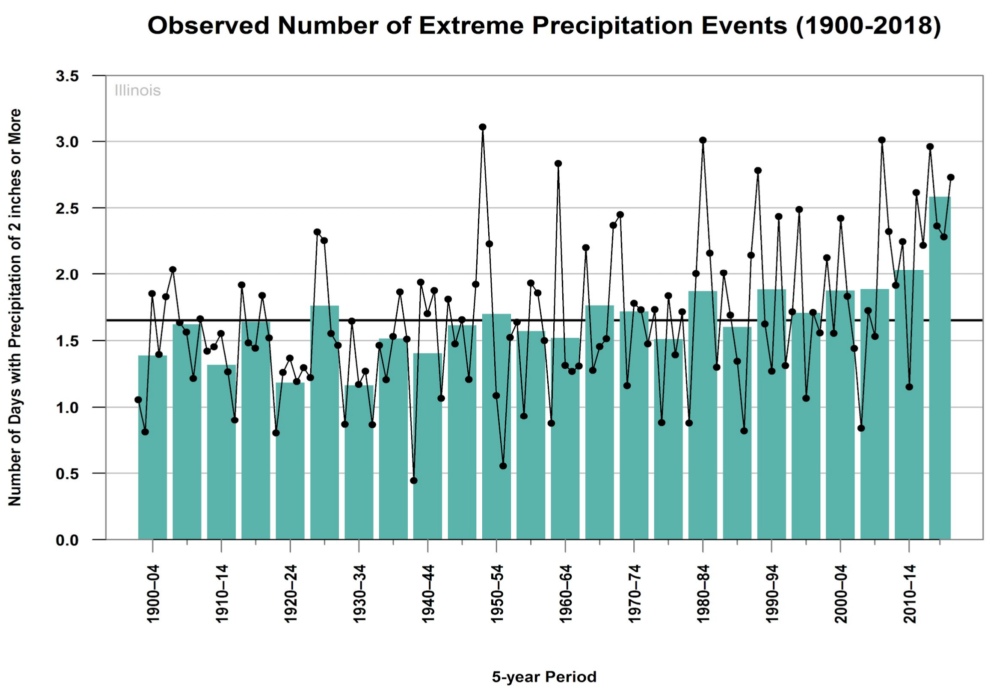
Projected Precipitation

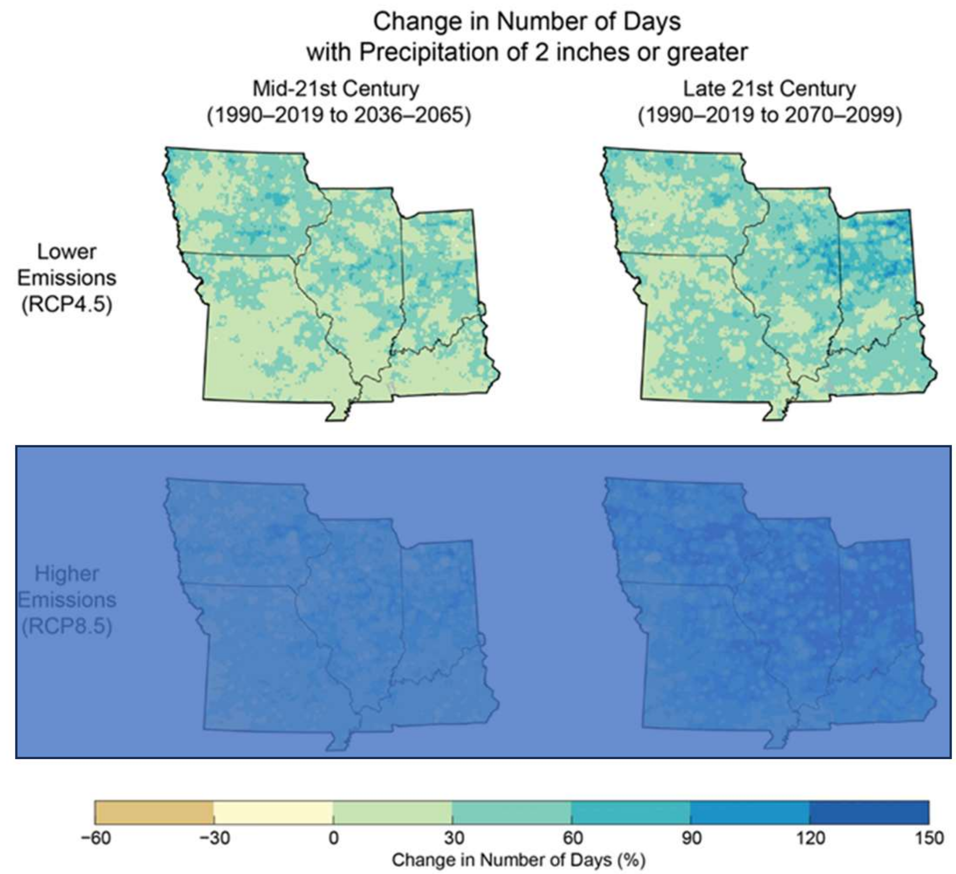
Top panel – lower scenario, mid- to late-century
- 0-4% wetter by mid-century
- 2-6% wetter by late-century

Bottom panel – higher scenario, mid- to late-century
- 3-6% wetter by mid-century
- 4-10% wetter by late-century



Increasing Heavy Rains

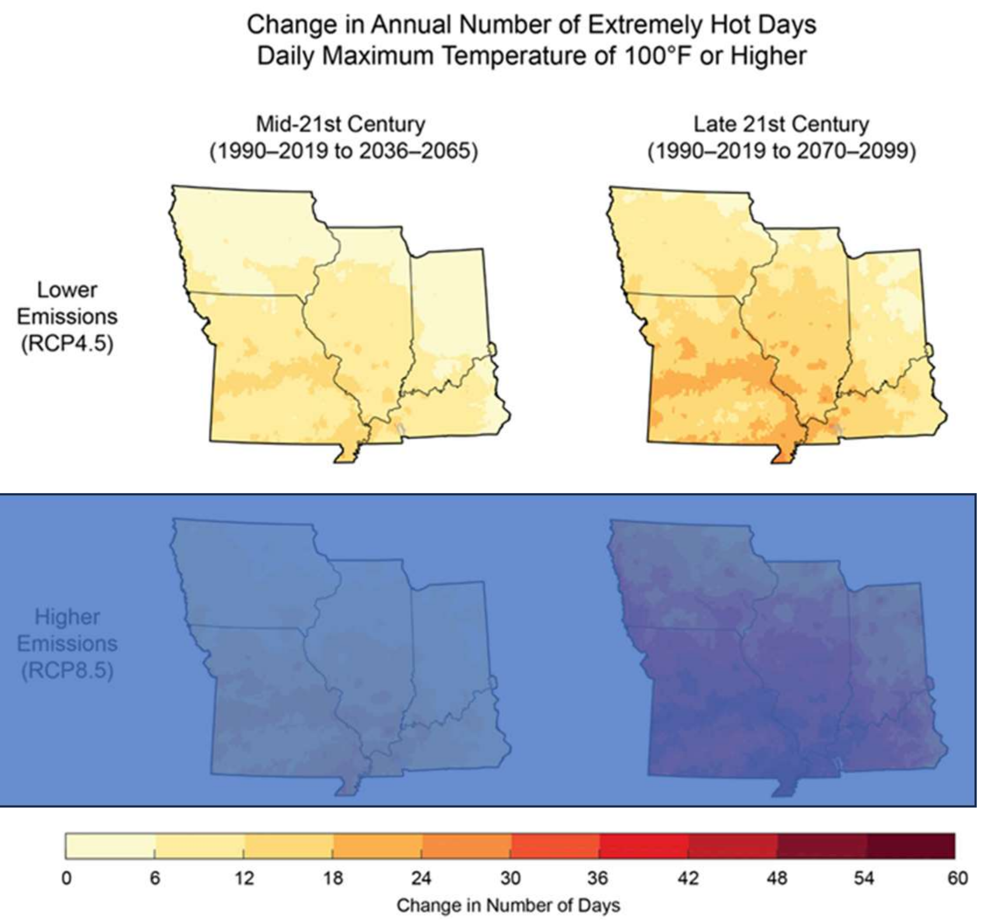




Days of 100°F or Higher

Lower scenario
- 0-12 more days by mid-century
- 6-18 more days by late-century

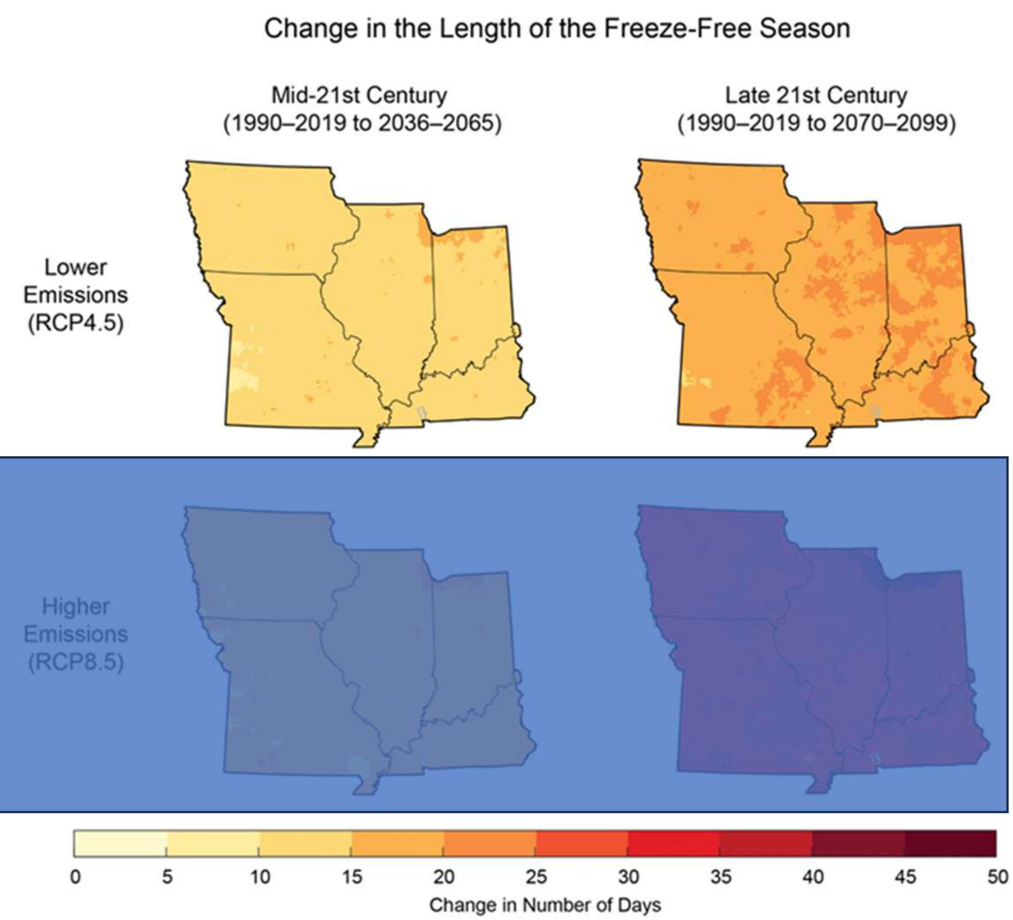
Higher scenario
- 6-18 more days by mid-century
- 18-48 more days by late-century



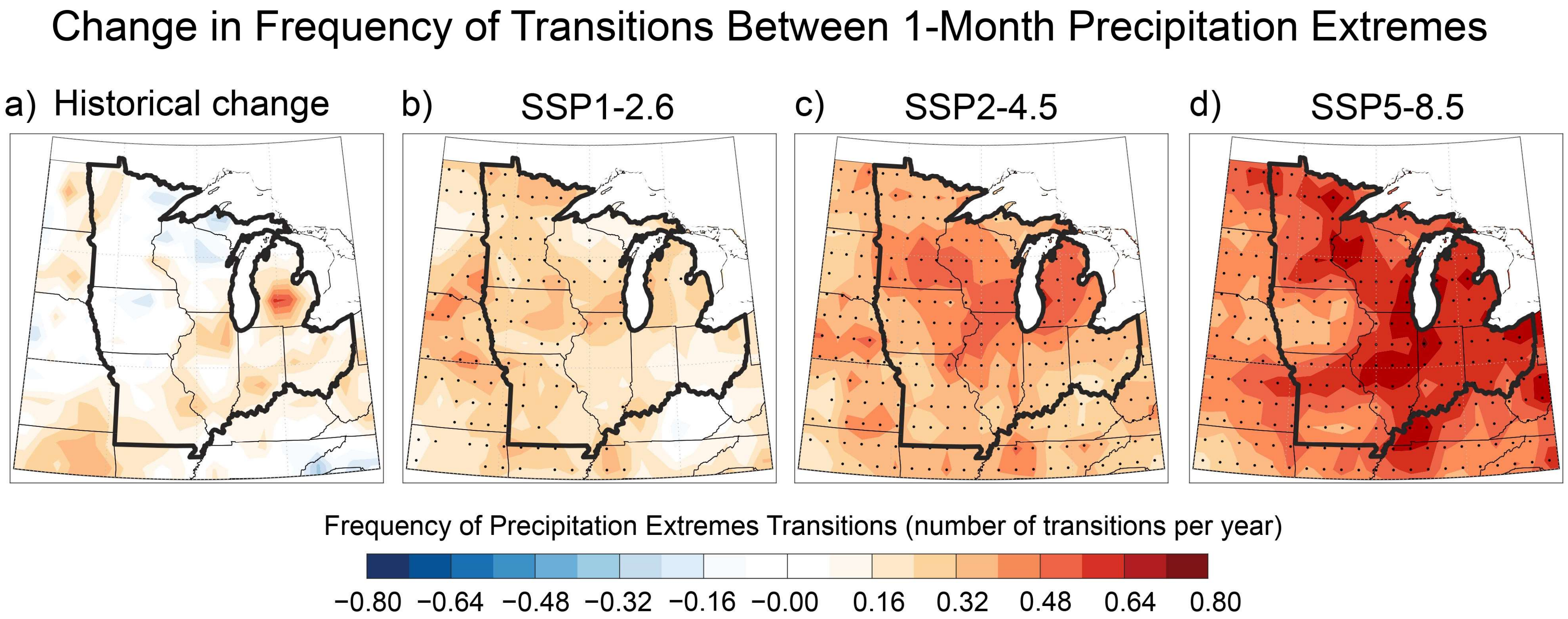
Growing Season Length

Lower scenario
- 10-15 days longer by mid-century
- 15-20 days longer by late-century

Higher scenario
- 15-20 days longer by mid-century
- 30-45 days longer by late-century

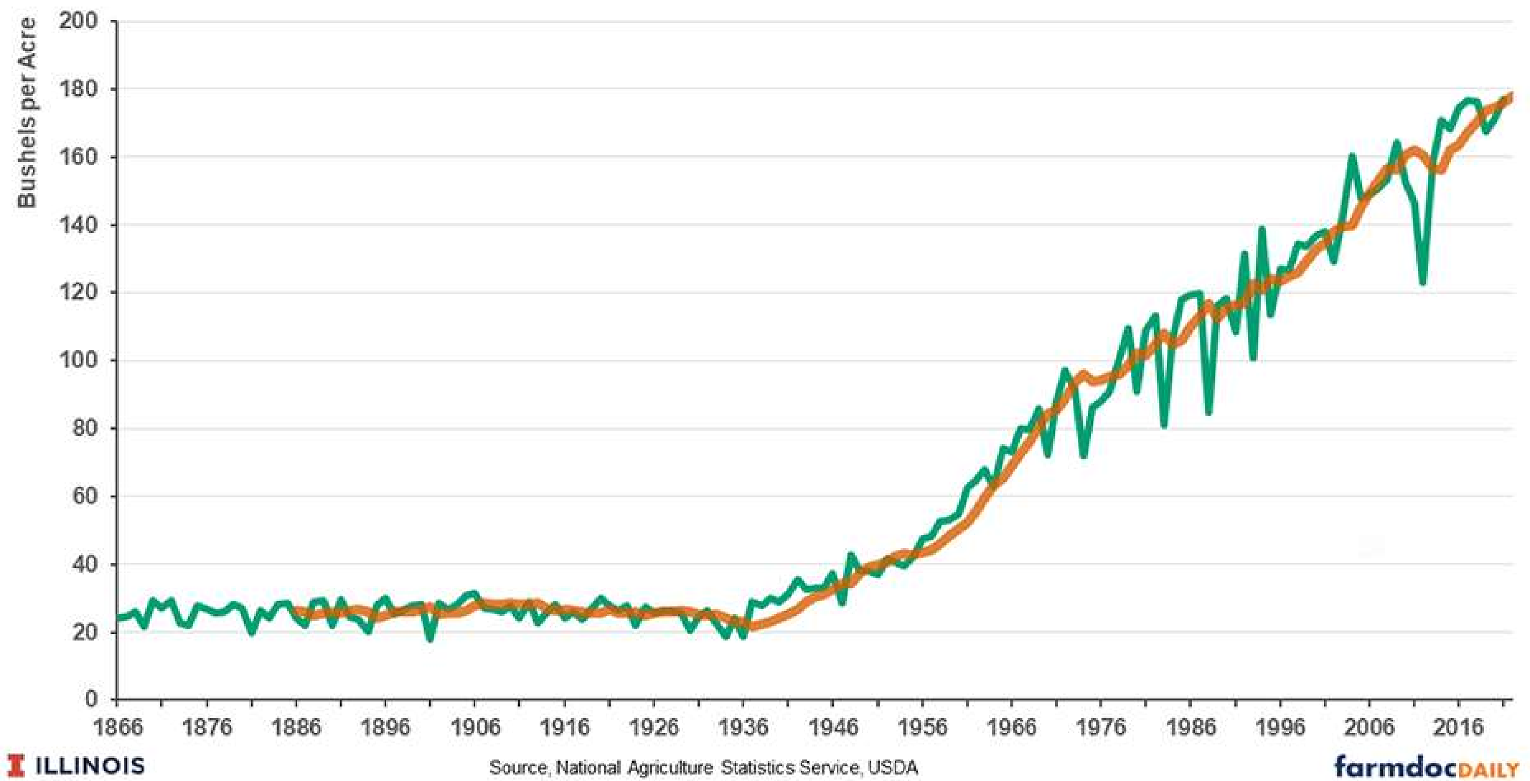


Transition from Wet to Dry to Wet



IMPACTS TO AGRICULTURE

Figure 1. Actual and Trend Yields for Corn, 1886 to 2022



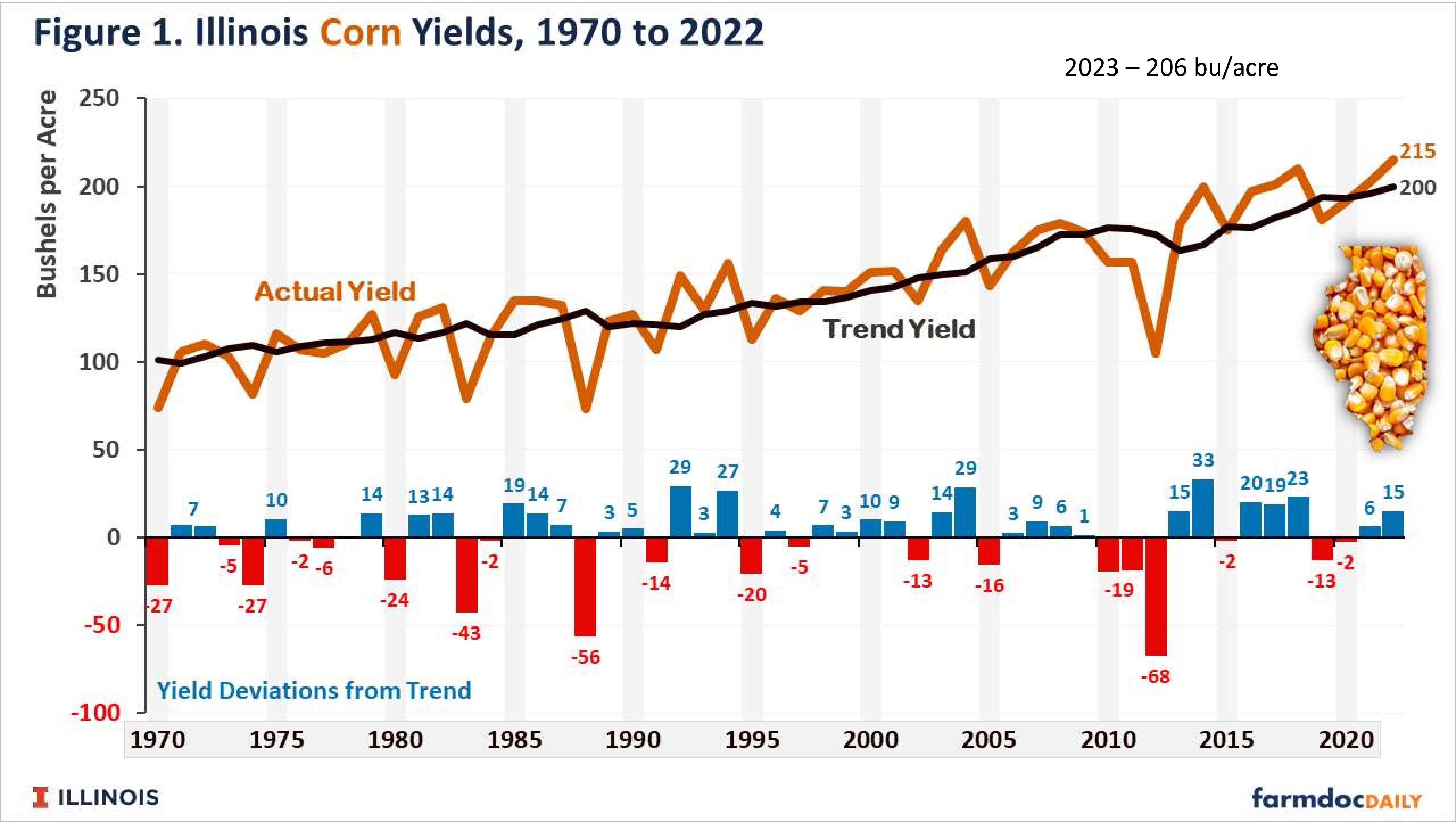


Figure 1. Illinois Corn Yields, 1970 to 2022
2023 – 206 bu/acre
Bushels per Acre
Actual Yield
Trend Yield
215
200
Yield Deviations from Trend
ILLINOIS
farmdocDAILY

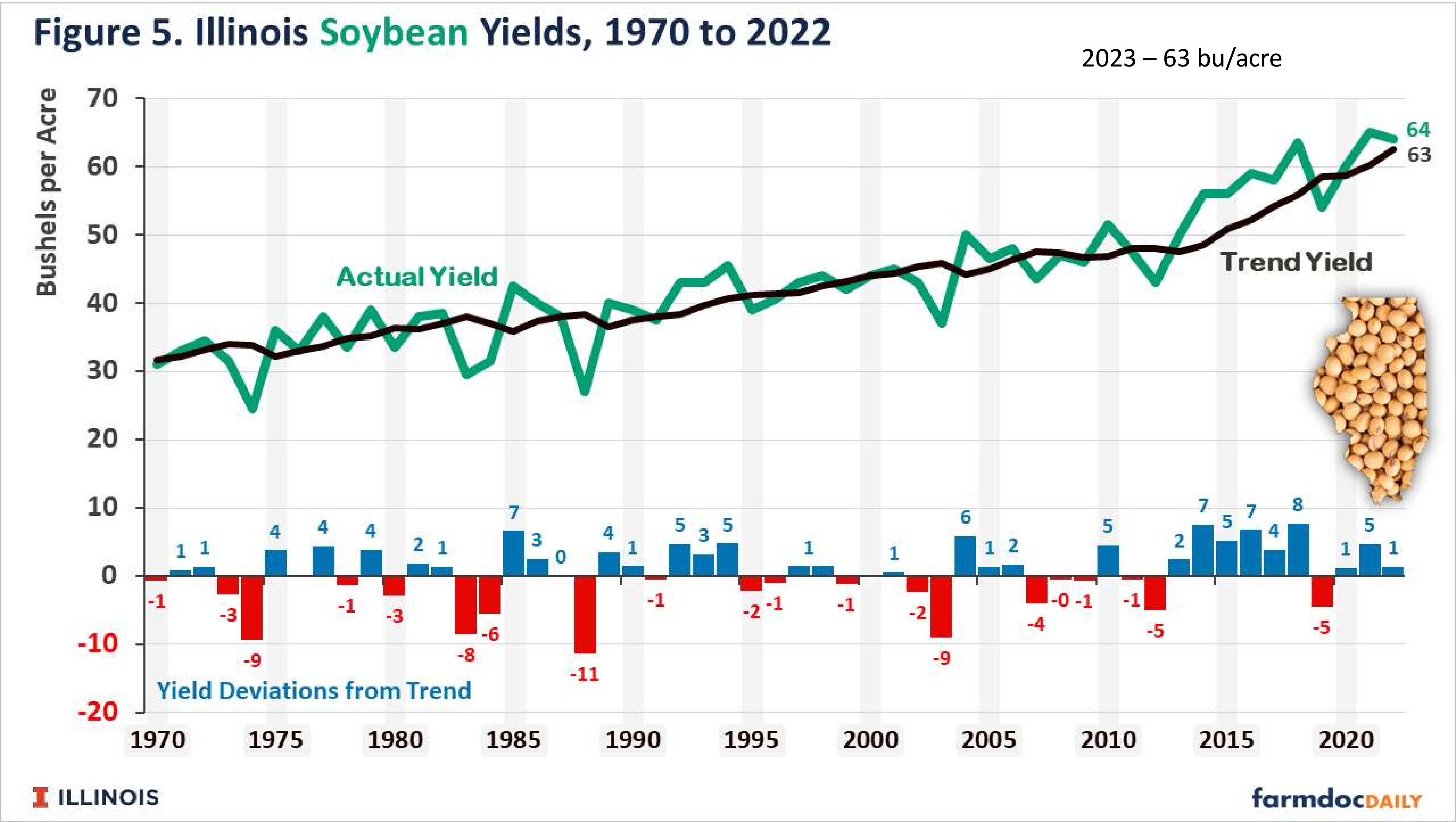
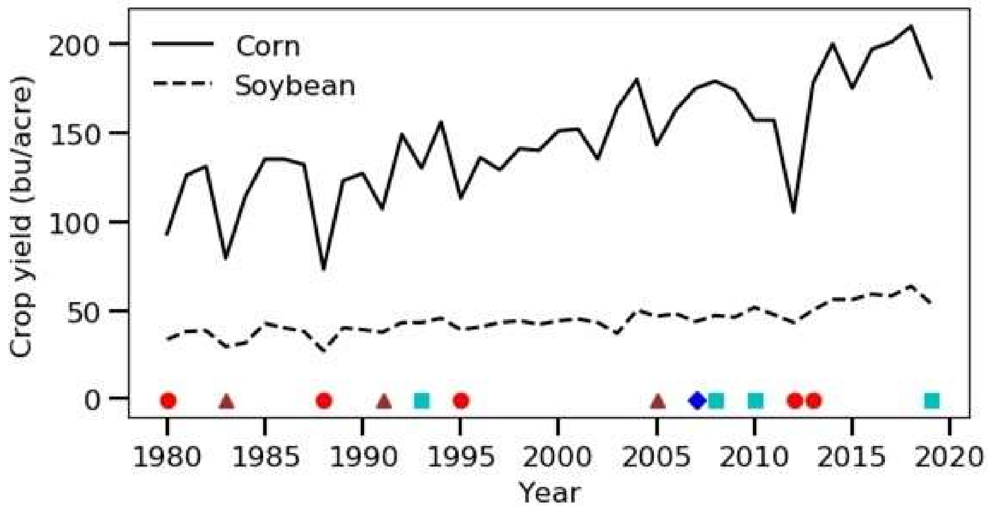


Figure 5. Illinois Soybean Yields, 1970 to 2022
2023 – 63 bu/acre
Bushels per Acre
70
60
50
40
30
20
10
0
-10
-20
Actual Yield
Trend Yield
64
63
Yield Deviations from Trend
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
ILLINOIS
farmdocDAILY

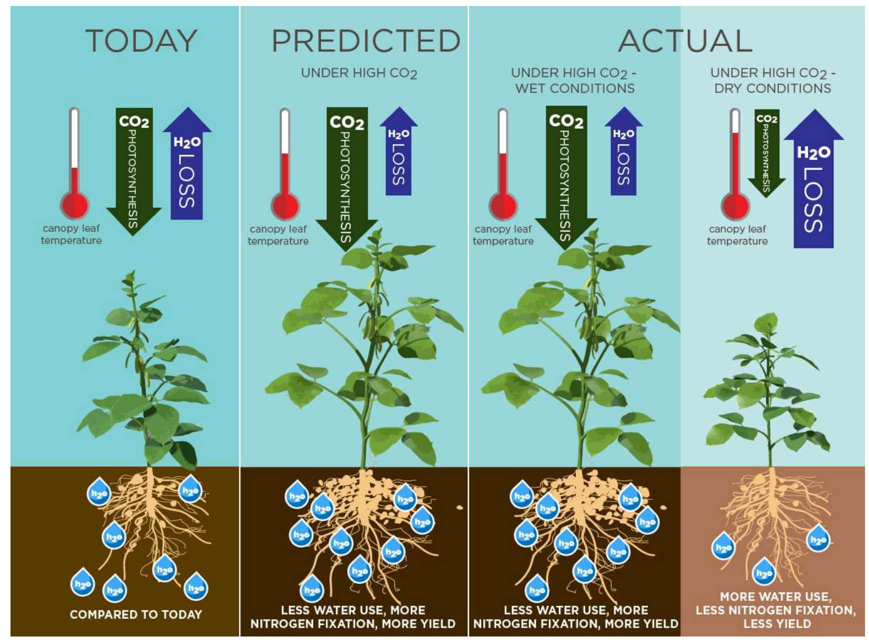
Impacts to Agriculture




© Adobe stock


© Adobe stock

Severe heat combined with drought has had largest historical impact on yields



© Julie McMahon

Soybeans benefit from CO_2 fertilization effect, but after mid-century heat/drought to have negative impact

Impacts to Agriculture

© Aaron Hager

Weeds, pests and diseases impact crops & livestock

Expected to increase due to warmer winters, increased spring rainfall, higher temperatures

Increased pest/disease resistance may exacerbate climate change risks and increase management costs

Livestock

Increased heat stress expected with a

40-55 day increase in days over 86°F per yr

Reduced forage quality

Impacts to Agriculture

Specialty crops – Fruits & Vegetables

Plant Hardiness zones will shift northward:

- Expanding opportunities to grow peaches and nectarines
- Allowing bramble crops not possible today (boysenberry, loganberry, jujube)
- Possibly hurting important traditional crops pumpkins, tomatoes and apples

Likely changes in required chilling hours (35°F and 50°F) likely to mean some cultivars of nut and fruit species can no longer be grown in the South

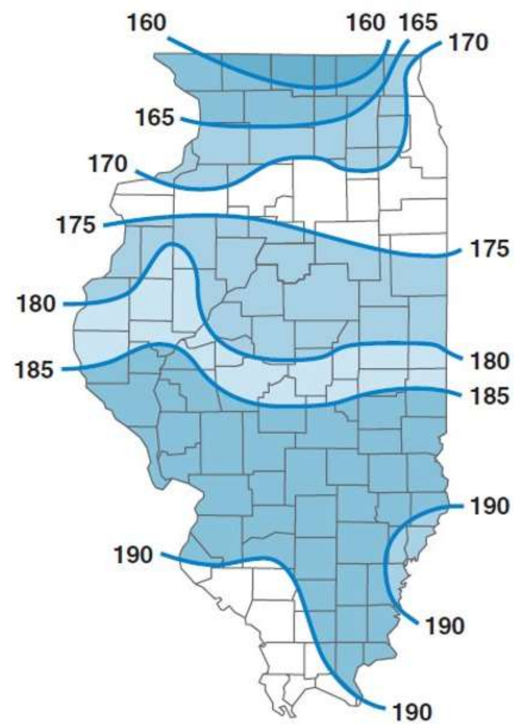
Extreme heat likely to impact farm labor *and* agritourism (u-pick, farm stands)

© Marius Ciocirlan

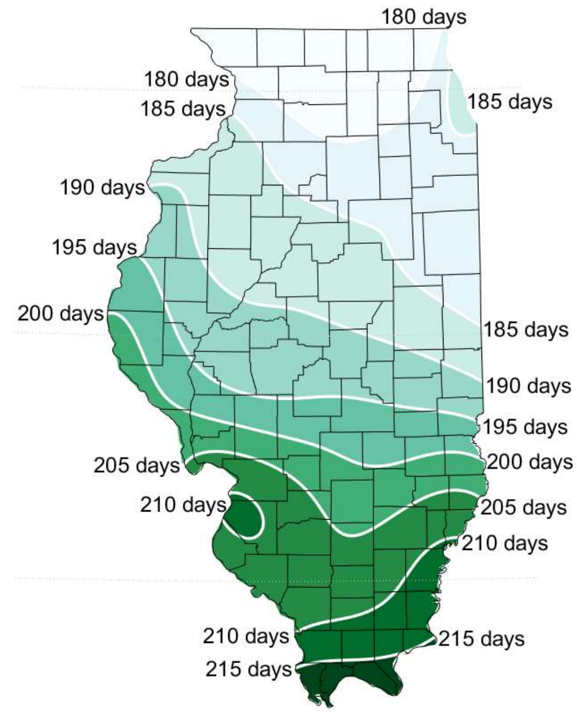
Longer Growing Season

- New 30-year average growing season is **10 to 25 days longer** than 1971-2000 average
- Models project growing season length will increase by another **8 to 12 days** by 2050
- **Impacts**
- Lessens issues from delayed planting, emergence, etc. (e.g., 2019)
- Increased weed and insect pressure

1971 – 2000 Average

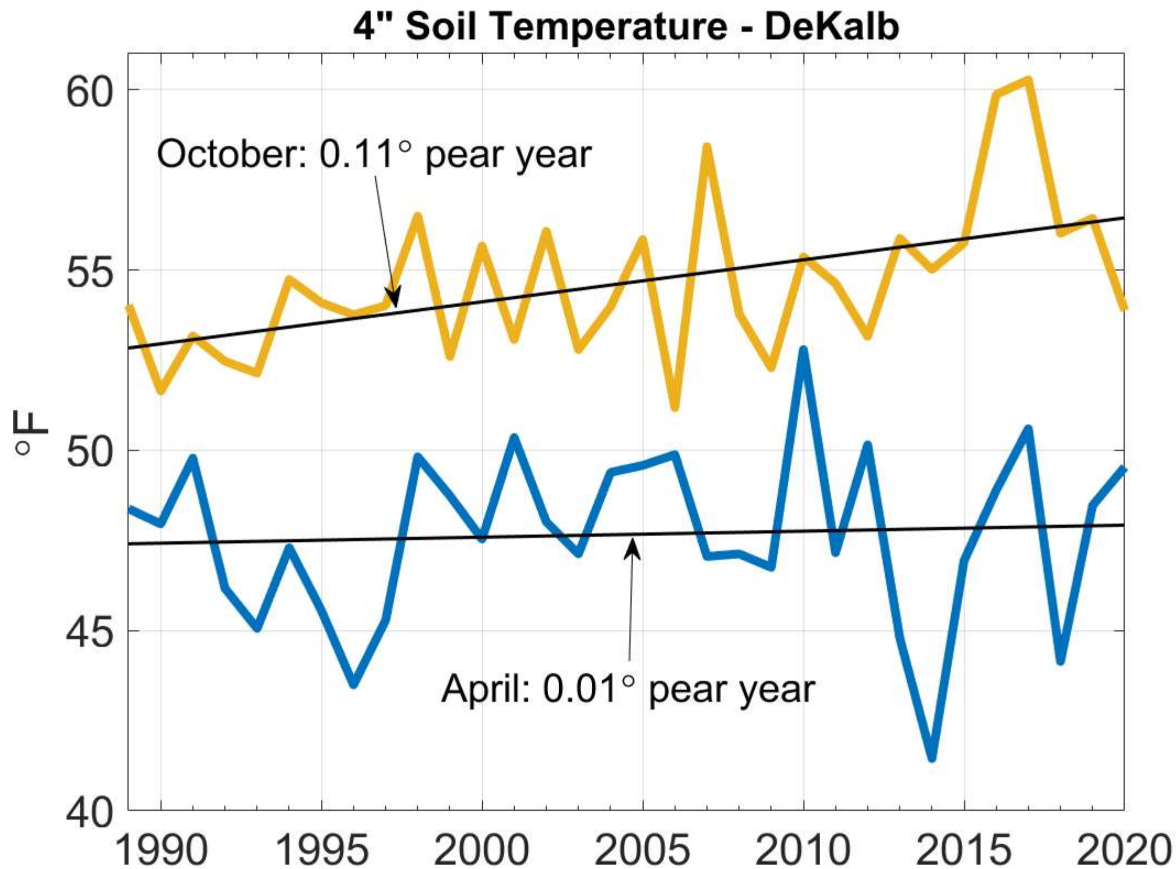


1991 – 2020 Average



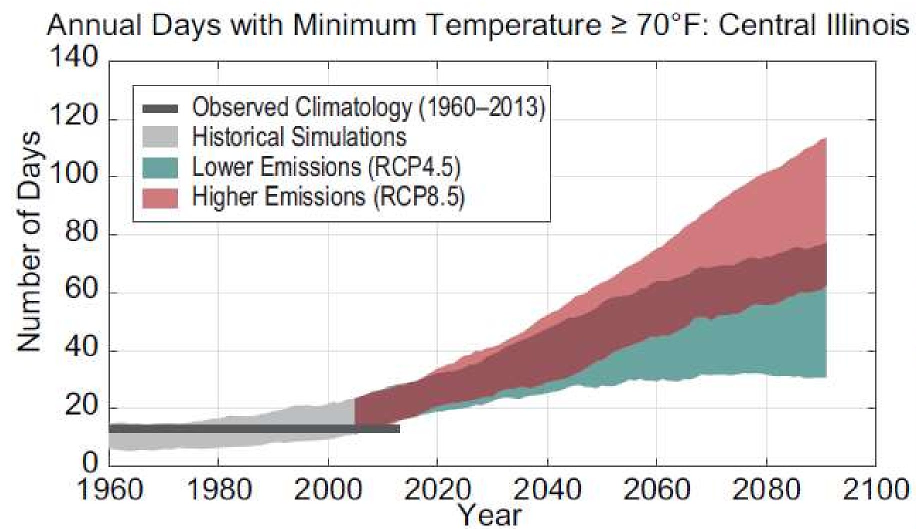
Soil Temperature Change

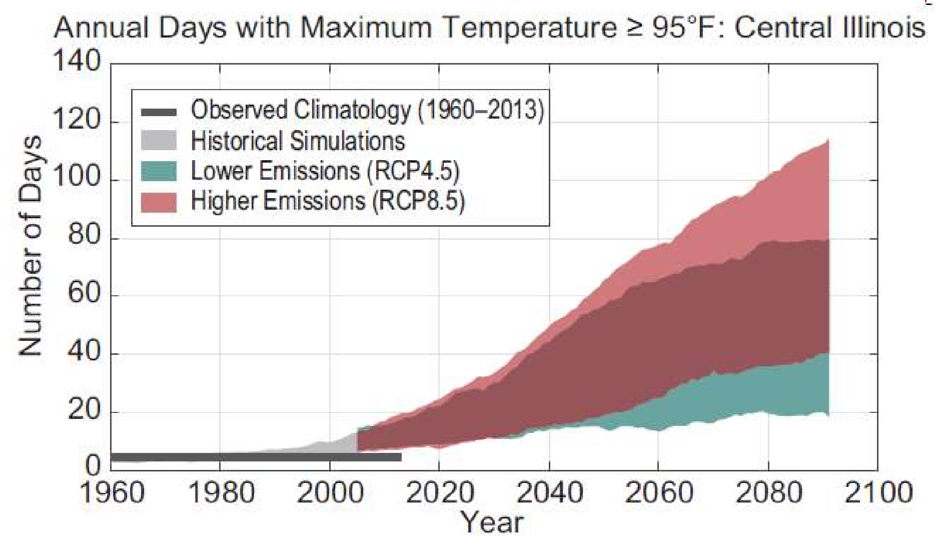
- Fall soil temps have increased over the last 30-years, much more than spring
- **Impacts:**
- Extension of warm soils in the fall reduces window of opportunity for fall fertilizer application (e.g., 2021)
- Lack of spring soil warming has not facilitated earlier planting



Extreme Heat

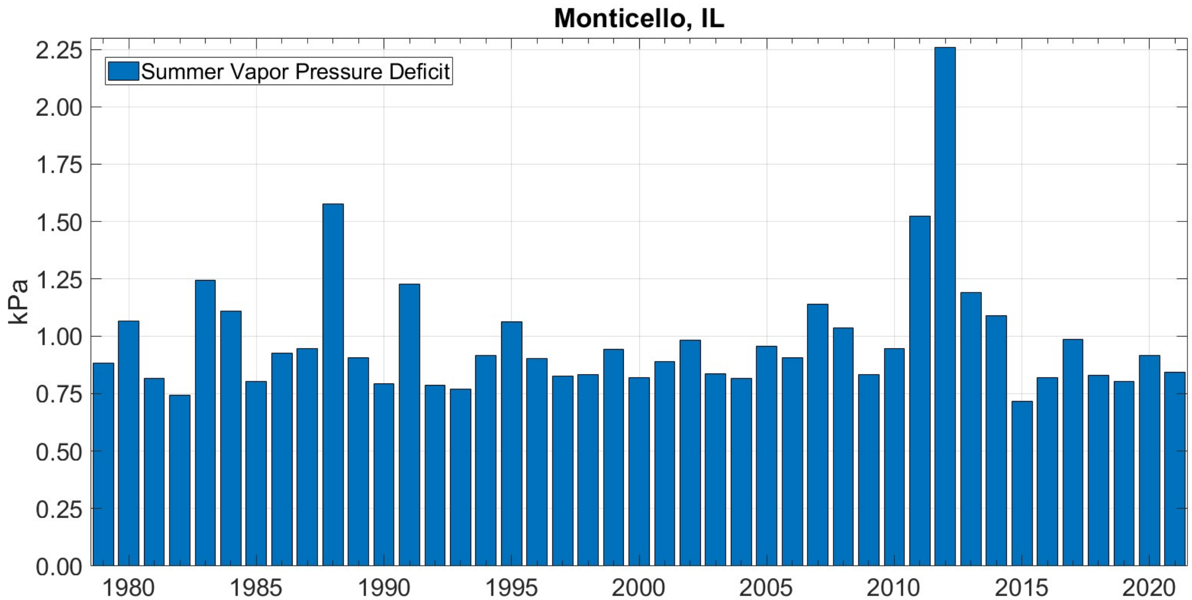
- Observed and projected increased frequency of hot days (> 95°F) and warm nights (> 70°F)
- Evaporation and evaporative demand increase with temperature
- **Impacts**
- Risk of extreme heat/demand stress on crops during silking, reproduction, grain fill
- Worsens disease, insect, weed stress (e.g., 2021)
- Extreme heat exposure issues for farmers and farm workers



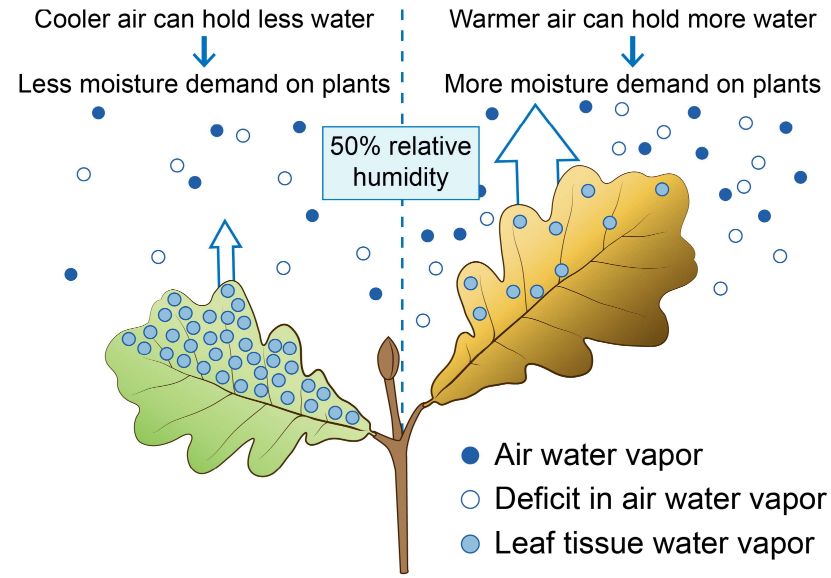


Flash Drought

- More summer rainfall variability + higher temps = more hot dry spells
- **Impacts**
- Crop stress from high evaporative demand & depleted soil moisture
- Drought stress made worse by poor soil health & water holding capacity

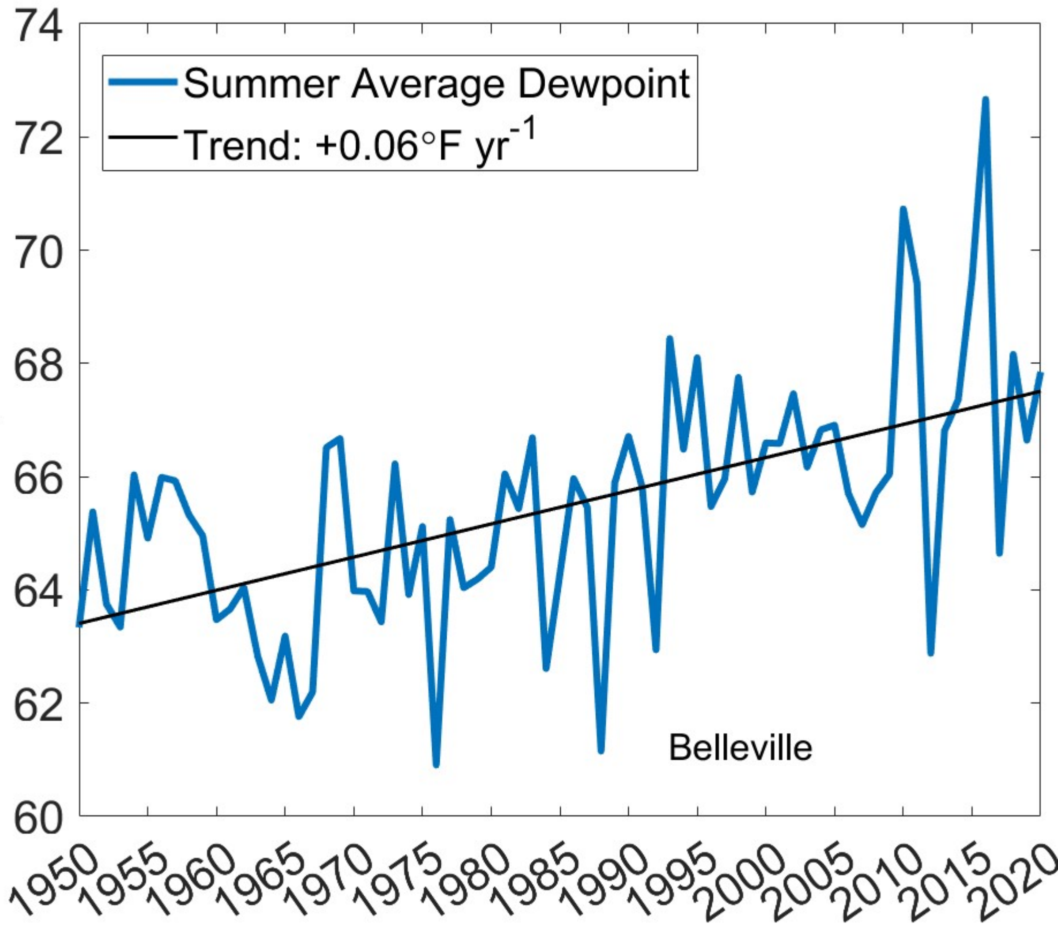


2022 Crop management conferences



A More Humid Growing Season

- Summers have become more humid
- **Impacts**
- Welcoming environment for insect and weed pests, and fungal disease (e.g., 2021)
- Humidity can also offset negative impacts of drought (e.g., 2021)

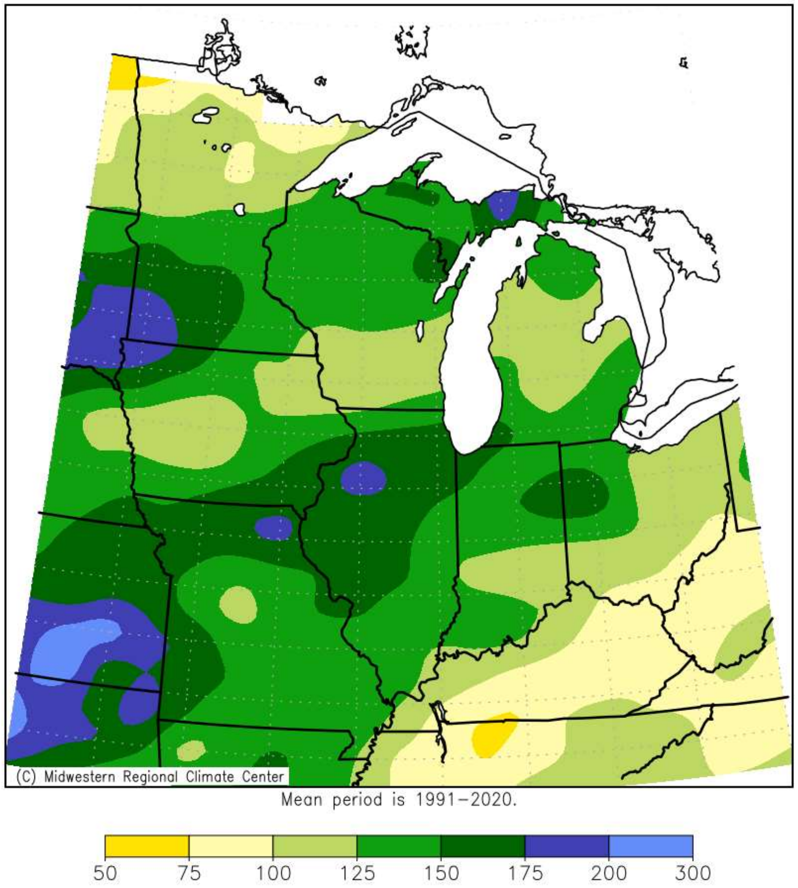


Wetter Springs

- Models expect springs like 2019 to become much more frequent in the future – 1-in-5 years by 2080
- **Impacts**
- Spring fieldwork delays due to excessively wet soils, despite an expanded growing season (e.g., 2019)

Bureau County, June 2019. Source: Reuters

2019 Total Spring Precipitation (% Normal)



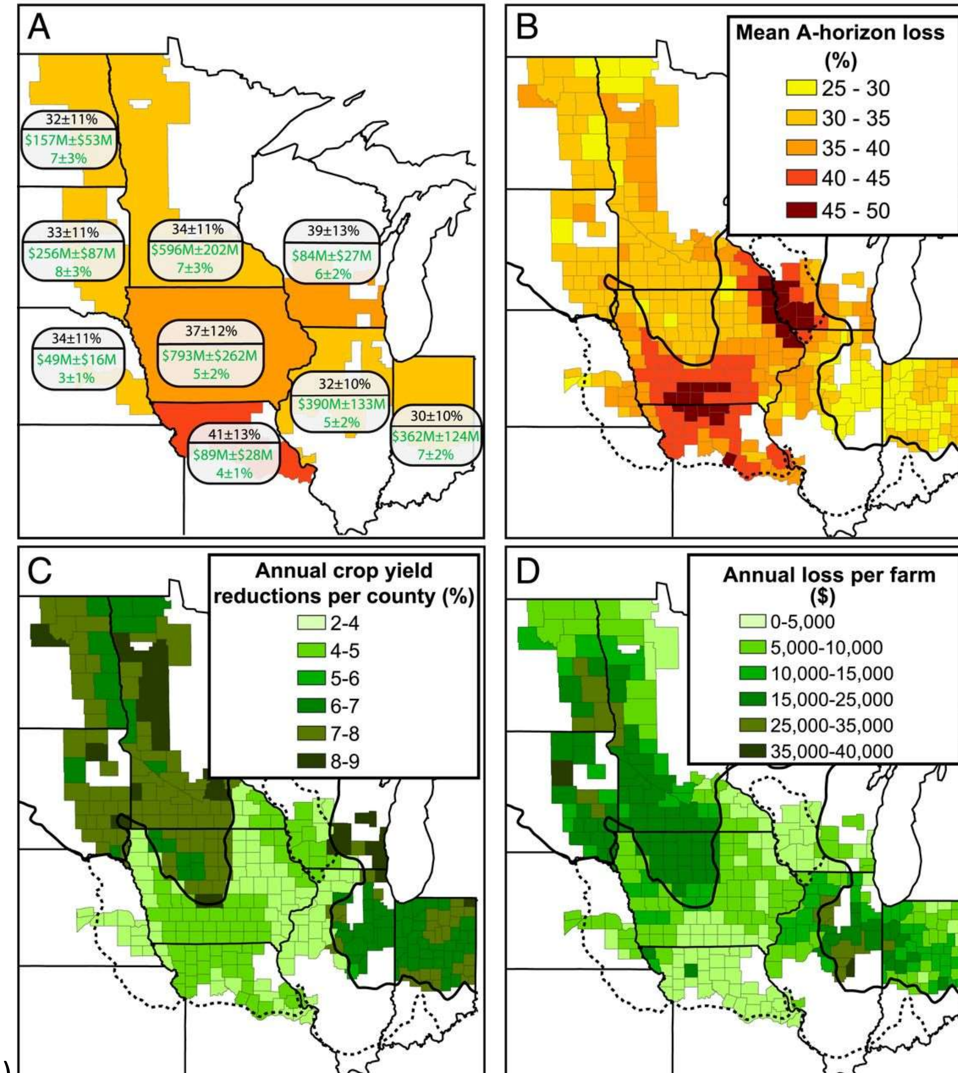
Intense Precipitation

- Heavy rainfall is becoming more frequent, especially in spring and summer
- Likelihood of 2”+ has increased 40% in the last 50 years
- **Impacts**
- Crop inundation and standing water (e.g., 2019, 2020, 2021)
- Soil erosion
- Nutrient runoff
- Soil compaction, delayed planting/harvest

DeWitt County, June 2021

Soil Erosion

- New estimates suggest 30 – 50% of A-horizon has been lost in the Midwest since 1800s
- Estimated annual crop losses related to soil erosion range from \$10,000 to \$40,000 per farm in Illinois
- Soil health degrades with erosion, economic losses difficult to quantify



Thaler *et al.* (2021)

Nutrient Runoff

- Intense precipitation yields more runoff
- Less nutrients for cash crop
- 2015-19 nitrate load statewide was 13% greater than 1980-96 baseline loads
- Larger increases in TP likely related to increased river flow + increased tile drainage

Prairie Strips in CRP de Kok-Mercado and Katrina Ruff

Sources: Zhou et al. 2012, Helmers et al. 2012, Hernandez-Santana et al. 2013, Iqbal et al. 2014, Mitchell et al. 2014, Zhou et al. 2014

Flumes at Neal Smith credit Jose Gutierrez

Quick Stats

- In a corn-soybean rotation with 10% coverage
  - 37% reduction in runoff
  - 95% reduction in sediment loss
  - 70% reduction in nitrogen loss
- Practices just accepted for USDA Conservation Reserve Program

Illinois ag community: We need more conservation money

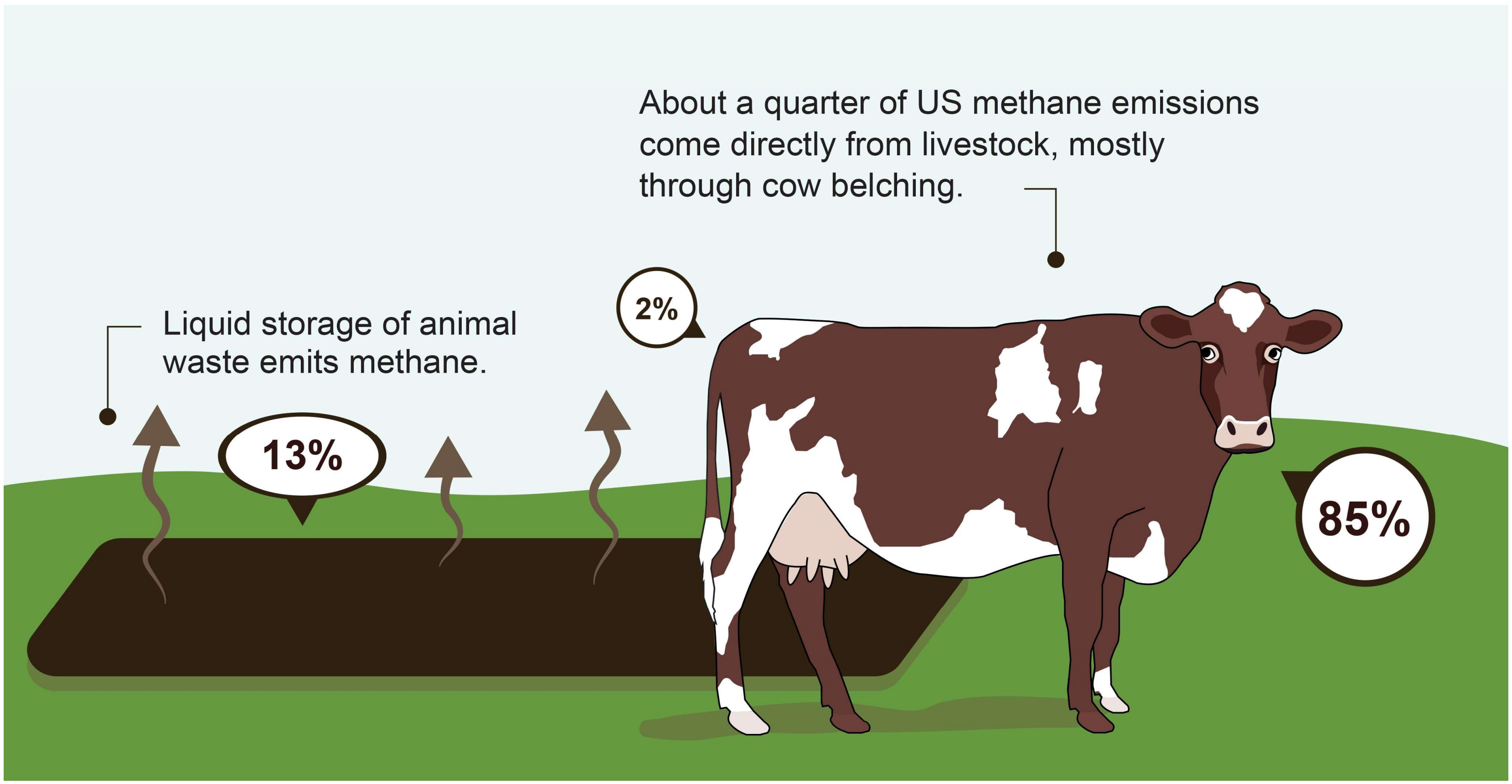
State ag leaders want to see the Fall Covers for Spring Savings program expanded to half a million acres, as Illinois lags behind its neighbors in cover crop adoption.

Holly Spangler
February 23, 2024

2 Min Read

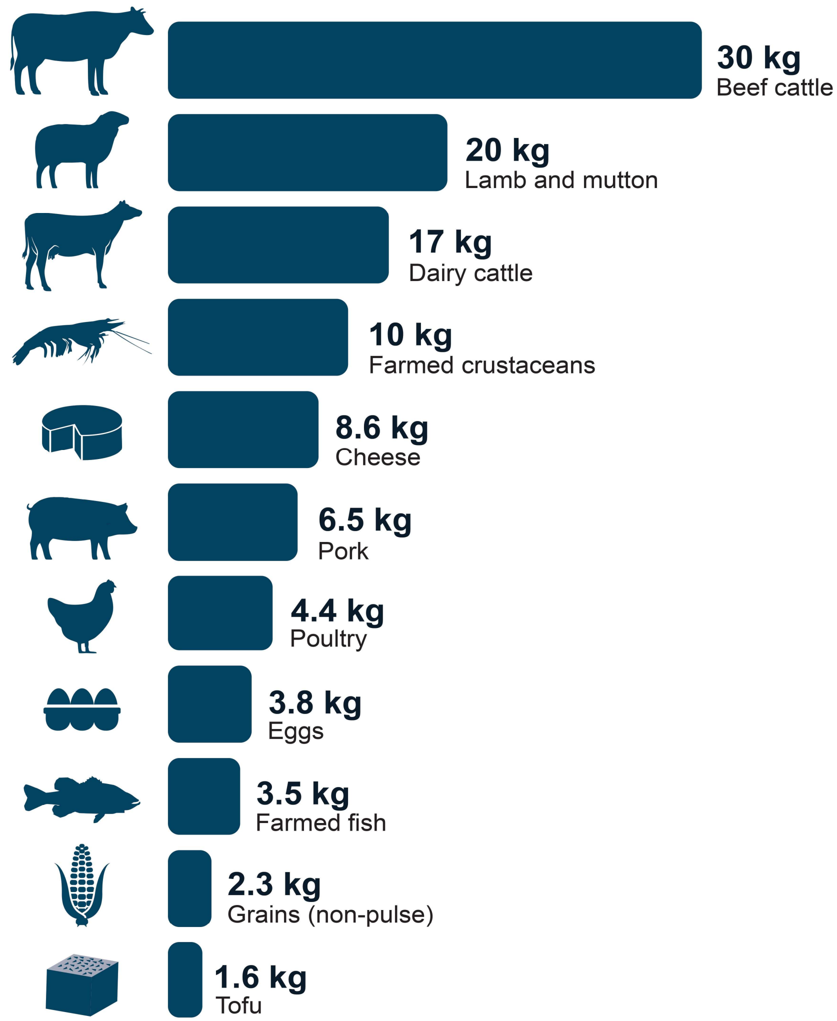
COVERED: Illinois farmers trail their neighbors in cover crop adoption. University of Illinois ag economist Jonathan Coppess recently noted that Illinois has just 4% of its acres in cover crops, compared to nearly 10% in Wisconsin. HOLLY SPANGLER

Cattle-Based Methane Emissions



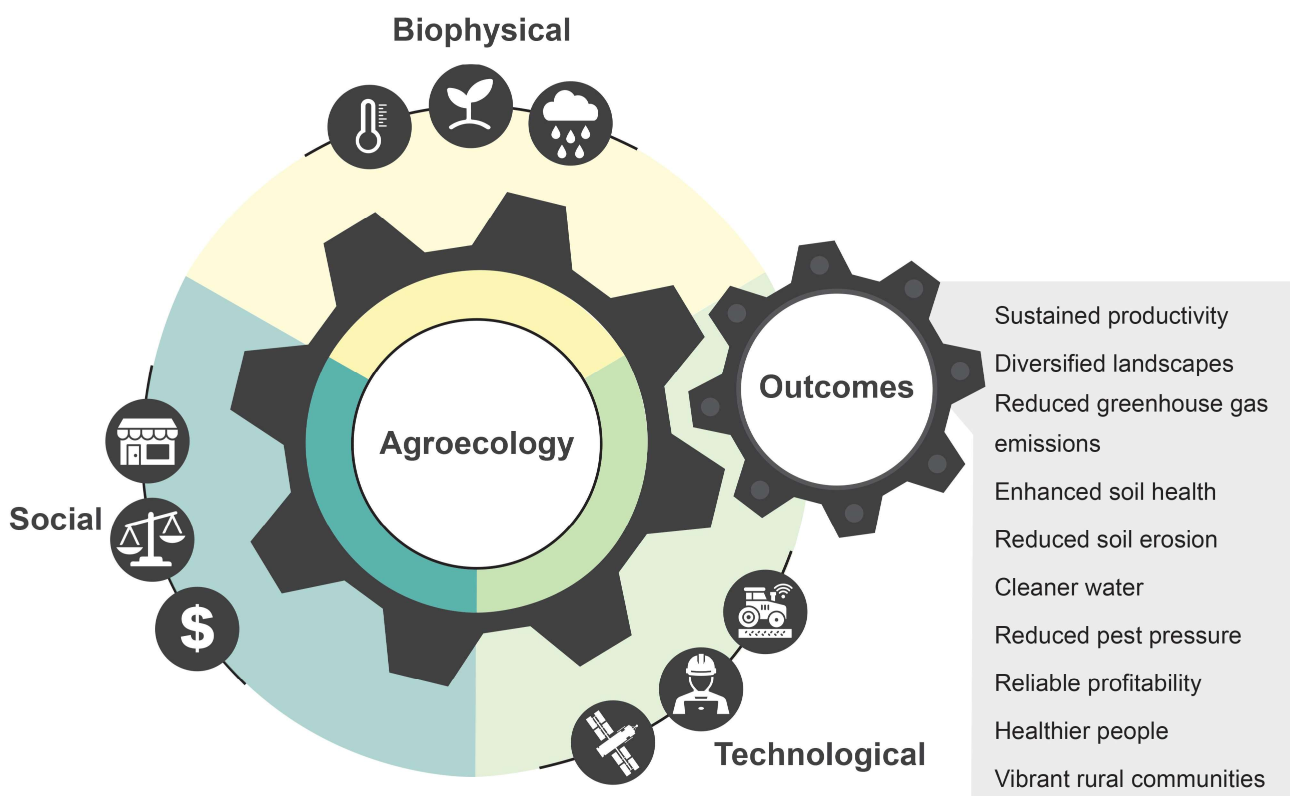
Greenhouse Gas Emissions from Protein Production

Shown as kilogram (kg) CO_2 equivalent per 100 grams of protein



Final Thoughts – Challenges and Opportunities

Agroecology Approaches and Outcomes



Thank you

Jim Angel: jimangel@illinois.edu