Is a yield slowdown on the horizon? Assessing the relationship between yield and plant population in the U.S corn
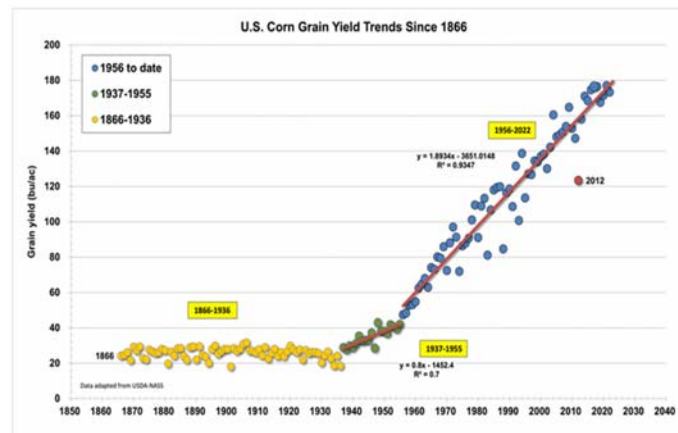
Edward Perry, Kansas State University
Amanda Tian, Kansas State University

U.S. Corn Yield

- Since the advent of commercial hybrids in the 1930s, US corn yields have risen at the rate of nearly **1.9 bu/ac**

- This has been essential for **reducing land use** and keeping **food costs down**

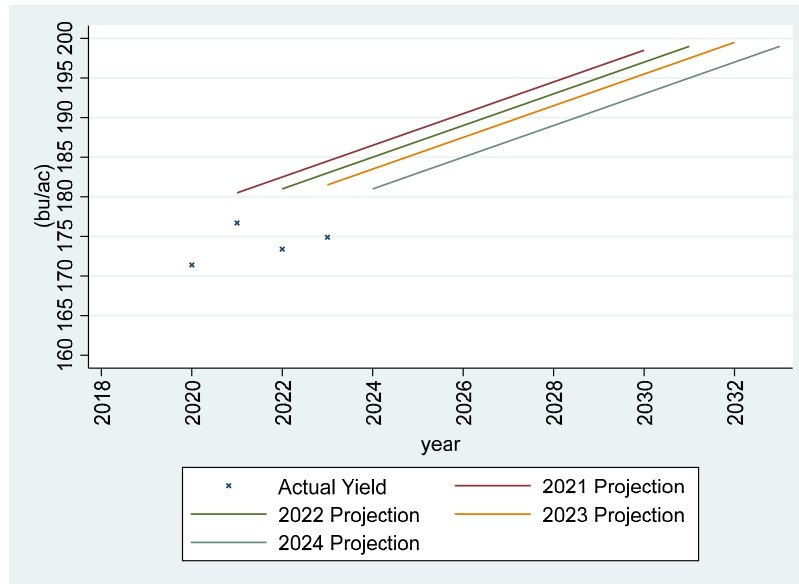- Maintaining this trend is of high importance for ensuring food security in the future
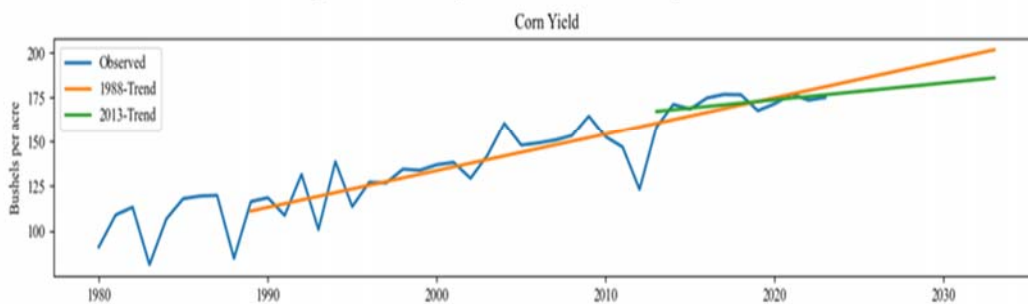
Is there a Yield Slowdown?

- The USDA has over-predicted corn yields in the last 5 consecutive years by: 9 bu/ac, 7.1, 3.8, 7.6, and 6.6 bu/ac.
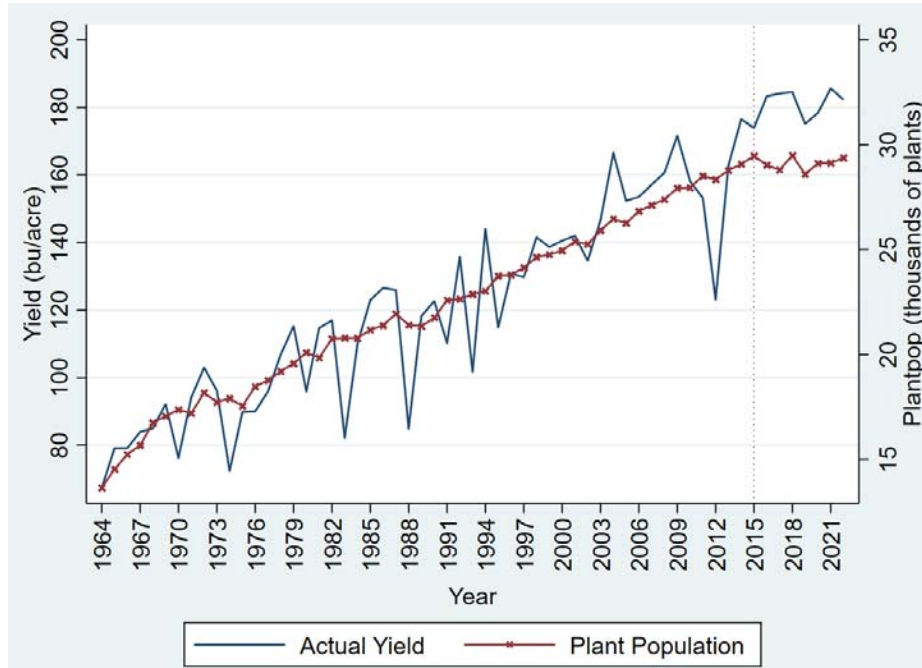
Is there a Yield Slowdown?

- Recent analysis suggests there has been a slowdown in the last 10 years.
  - The trend from 2013 is just 1 bu/acre versus 1.8 bu/acre.
- Why are US corn yields slowing down?

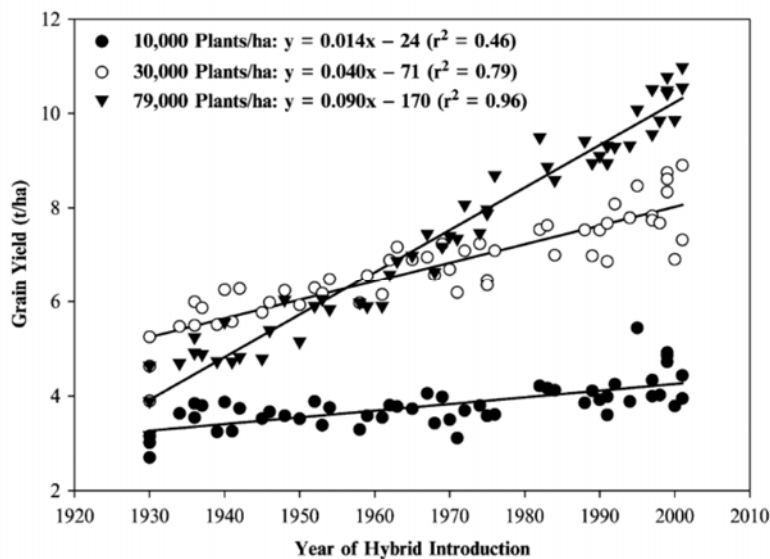Figure 3. Slowing Growth Rates of Crop Yields

Density and Yield

Duvick: Density and Yield

- @ 4,000 plants/ac: 45 bu/ac (1930 hybrid) vs 55 bu/ac (2000 hybrid)
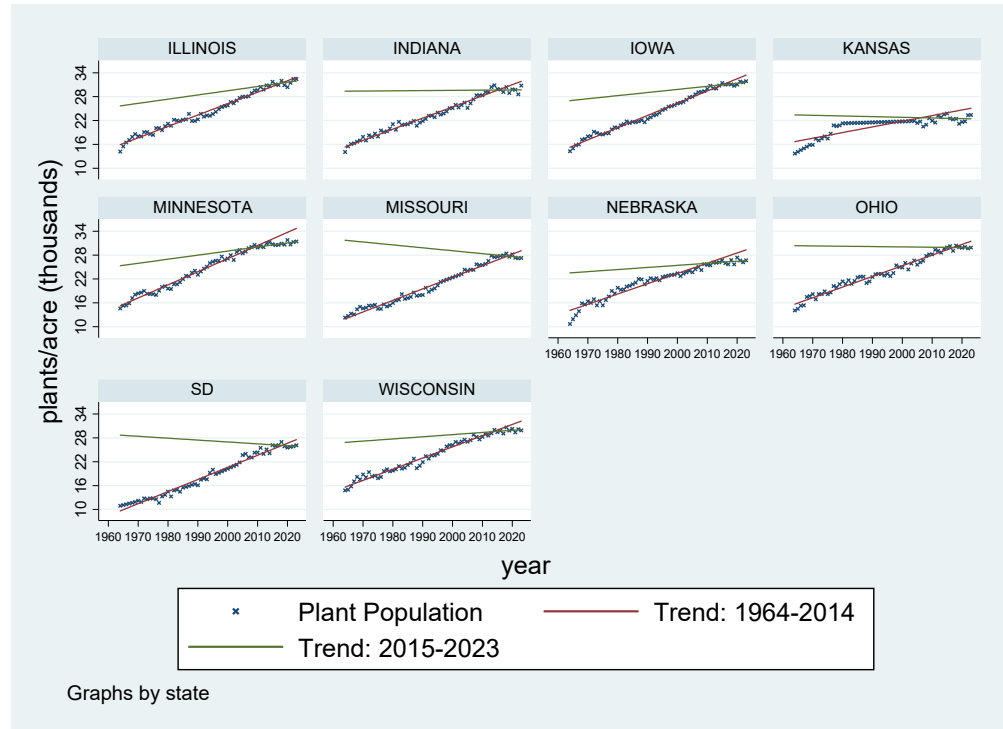- @ 32,000 plants/ac: 60 bu/ac (1930 hybrid) vs 150 bu/ac (2000 hybrid)

Data

- USDA state-level mean plant population data for 10 states from 1964-2023: IA, IL, IN, KS, MO, MN, NE, OH, SD, WI

- 45,607 county-level mean yield observations for 783 counties in these10 states from 1964 to 2023.

- Weather information: Daily minimum and maximum temperature as well as precipitation were collected from the PRISM weather dataset.

Plant Population by State

Graphs by state
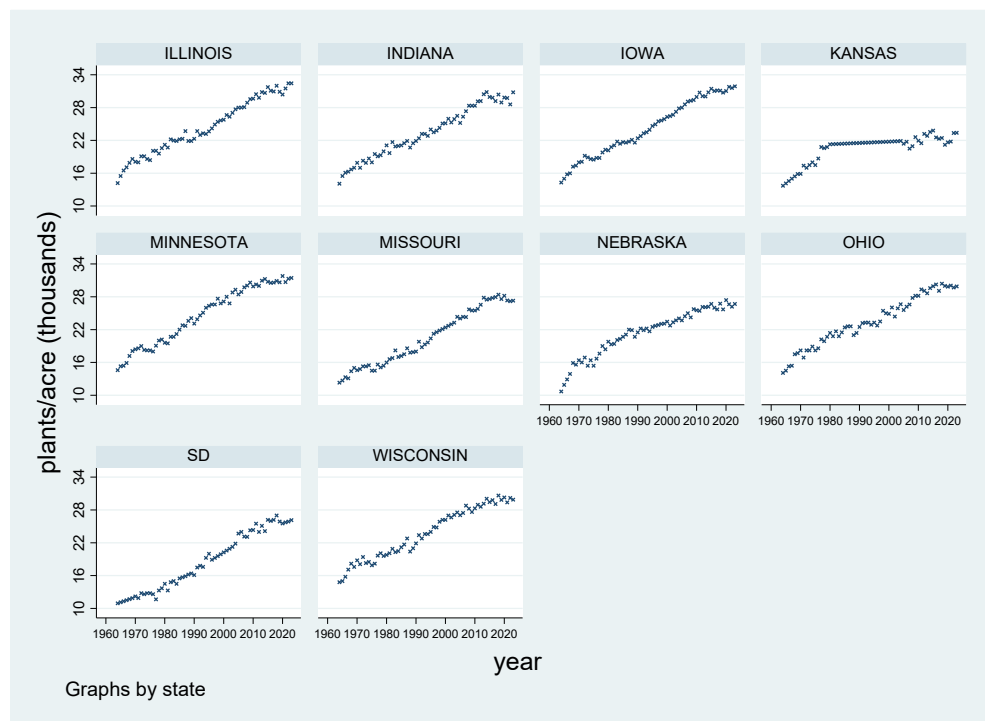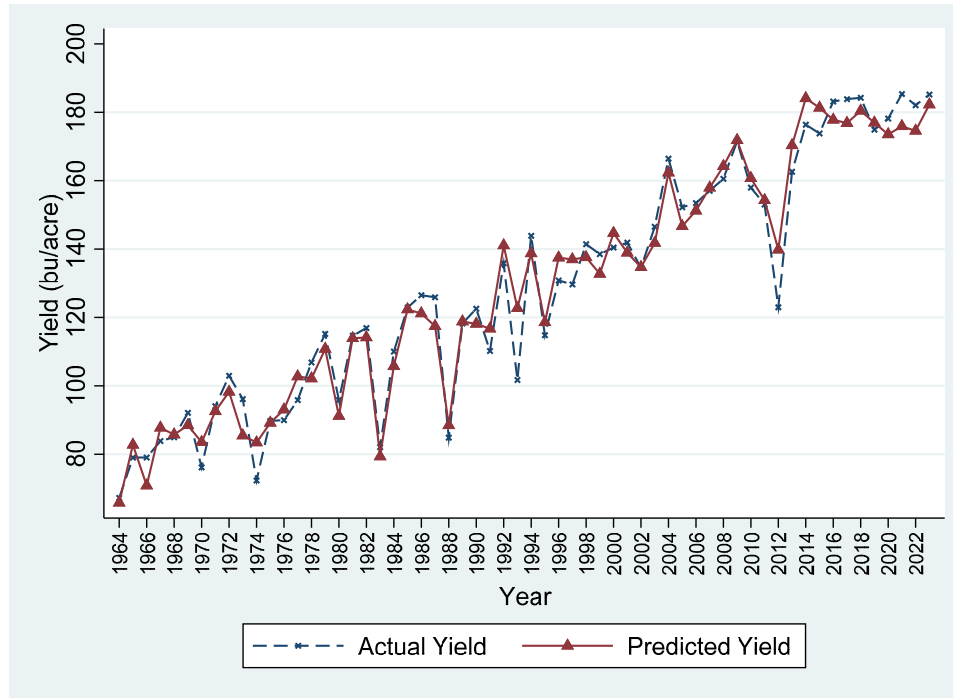
Plant Population: State Trends

Graphs by state

Predicting Future Corn Yields

- Given that plant populations seem to have plateaued in many areas, what does this imply for future corn yields?
- We create a **model** that predicts corn yields based on historical information.
- Model: $yield = f(plant\ population, temp, precip, GE, etc.)$
- We then use this model to predict corn yields in the future (2024-2033). For this, we need predictions for weather and plant population for 2024-2033.
  - **Weather**: we assume predicted precip and temp are what was observed from 2000-2023
  - **Plant Population**: we consider two scenarios.
    - 1. Prediction based on trend from 2014-2023
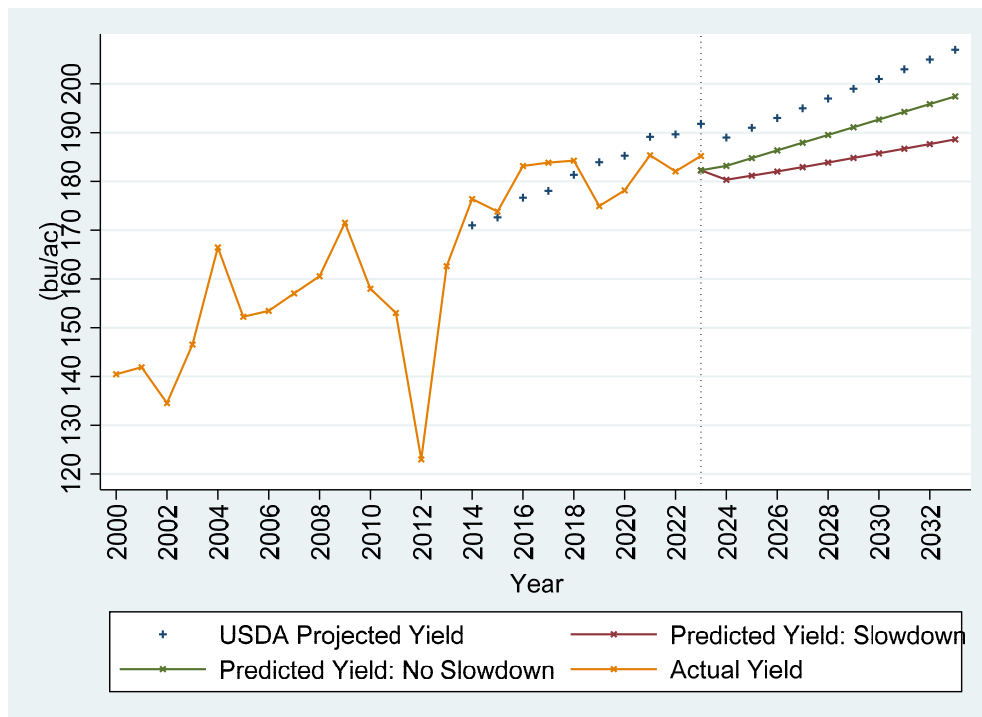   - 2. Prediction based on trend from 1964-2023
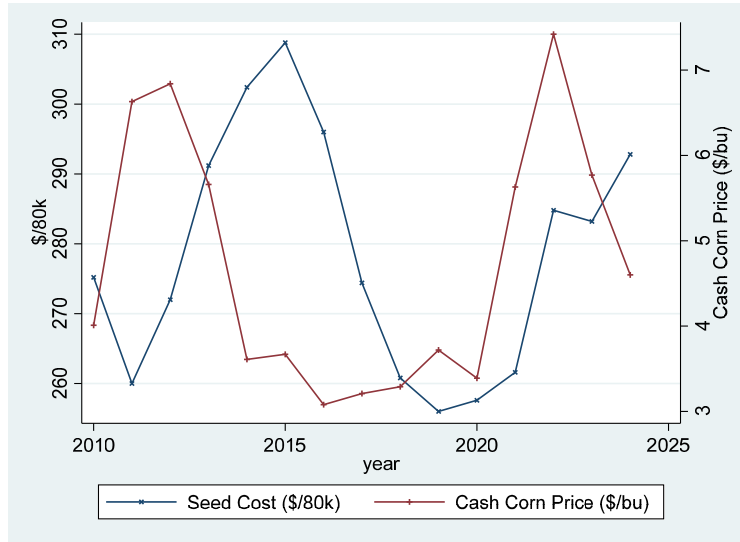
Model Prediction: 1964-2023

Model Predictions: 2024-2033

Iowa Seed and Corn Prices

- Can changes in input and output prices explain that slowdown in population and yields?
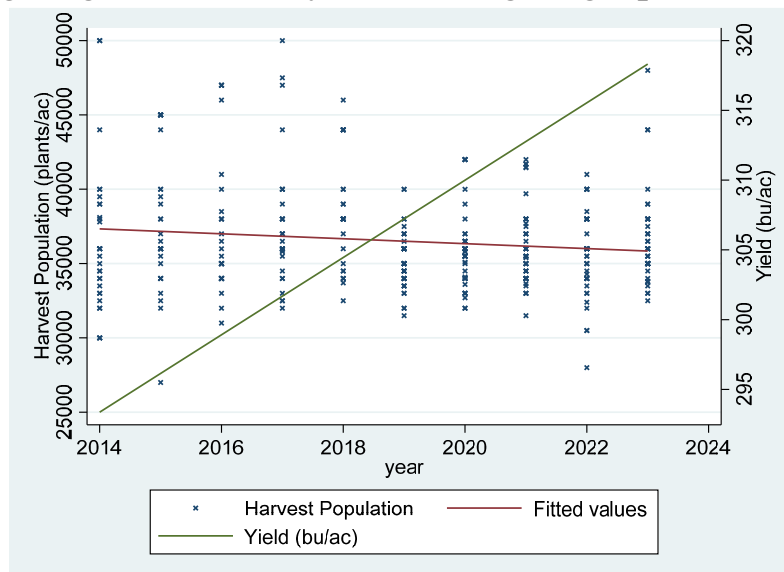- No clear trend…

National Corn Yield Contest

- What about populations used in yield contests?
- Also going down, **but** yields still going up.

Conclusions/Caveats

- Plant population growth has slowed down, plateauing in 2014 in many areas
- Projected yields based on future population predictions show a yield slowdown
  - Significantly below USDA predictions
- Where will yield growth come from?
  - If no longer through increasing populations, is this sustainable?
  - Can plant pop have a resurgence?
- Plant pop is essential for a predicting yield and USDA should be using it for future predictions