Crop Yield Calculations for Estimating Nutrient Application and Projecting Future Demand

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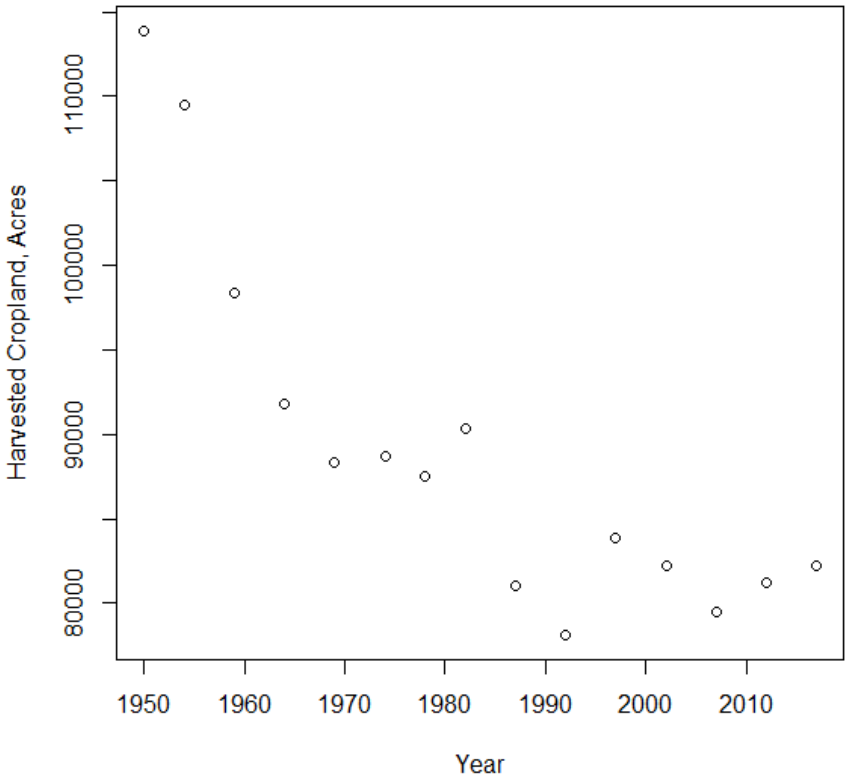
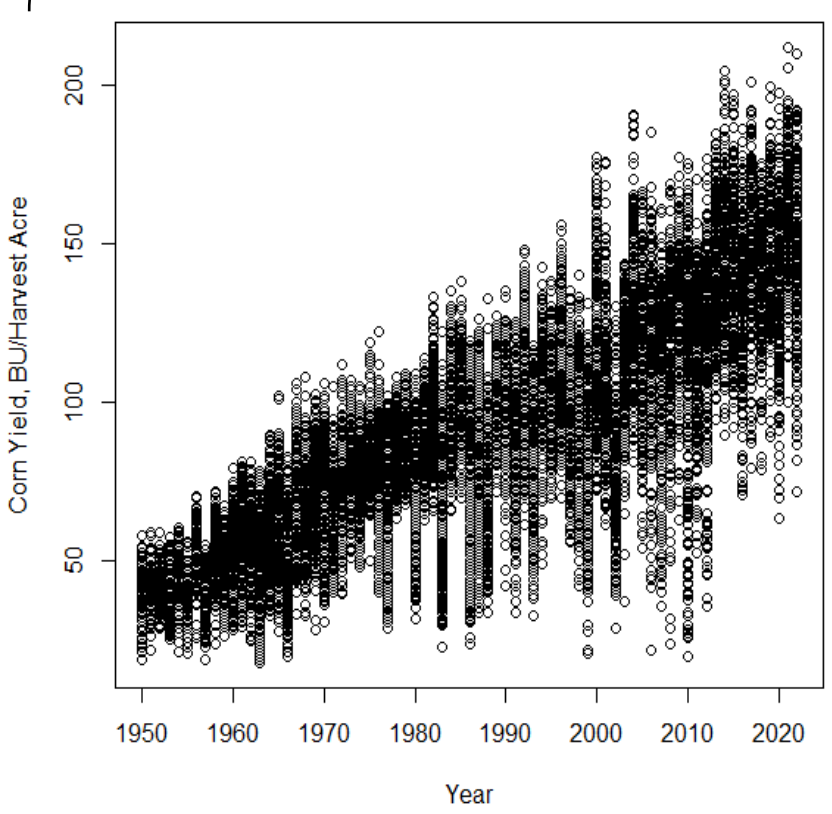
Photo: WILL PARSON/CHESAPEAKE BAY PROGRAM

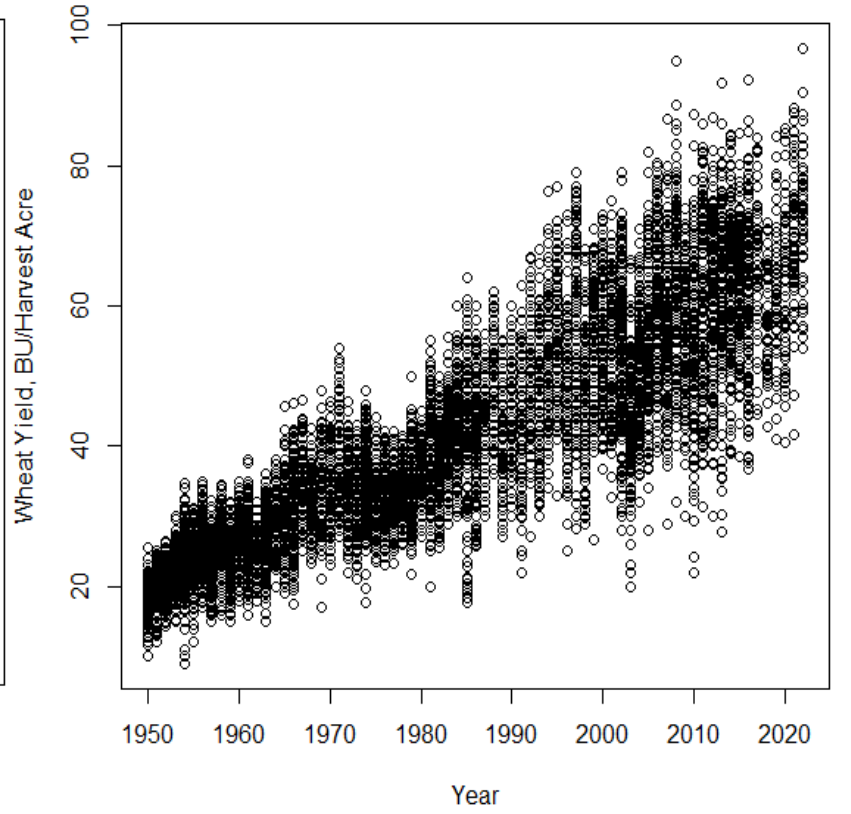
Changing cropland area… AND changing crop yields

Cropland Area



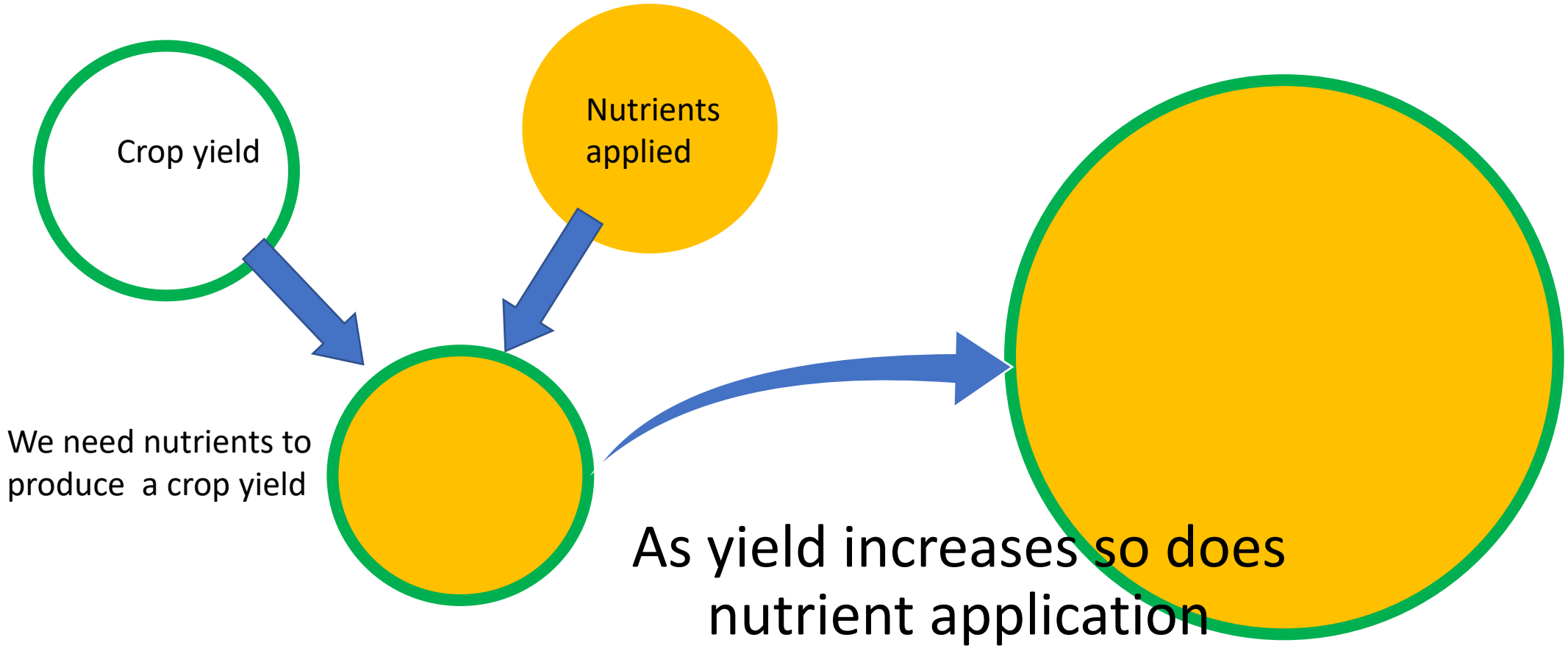
Example CBW County Crop Yields



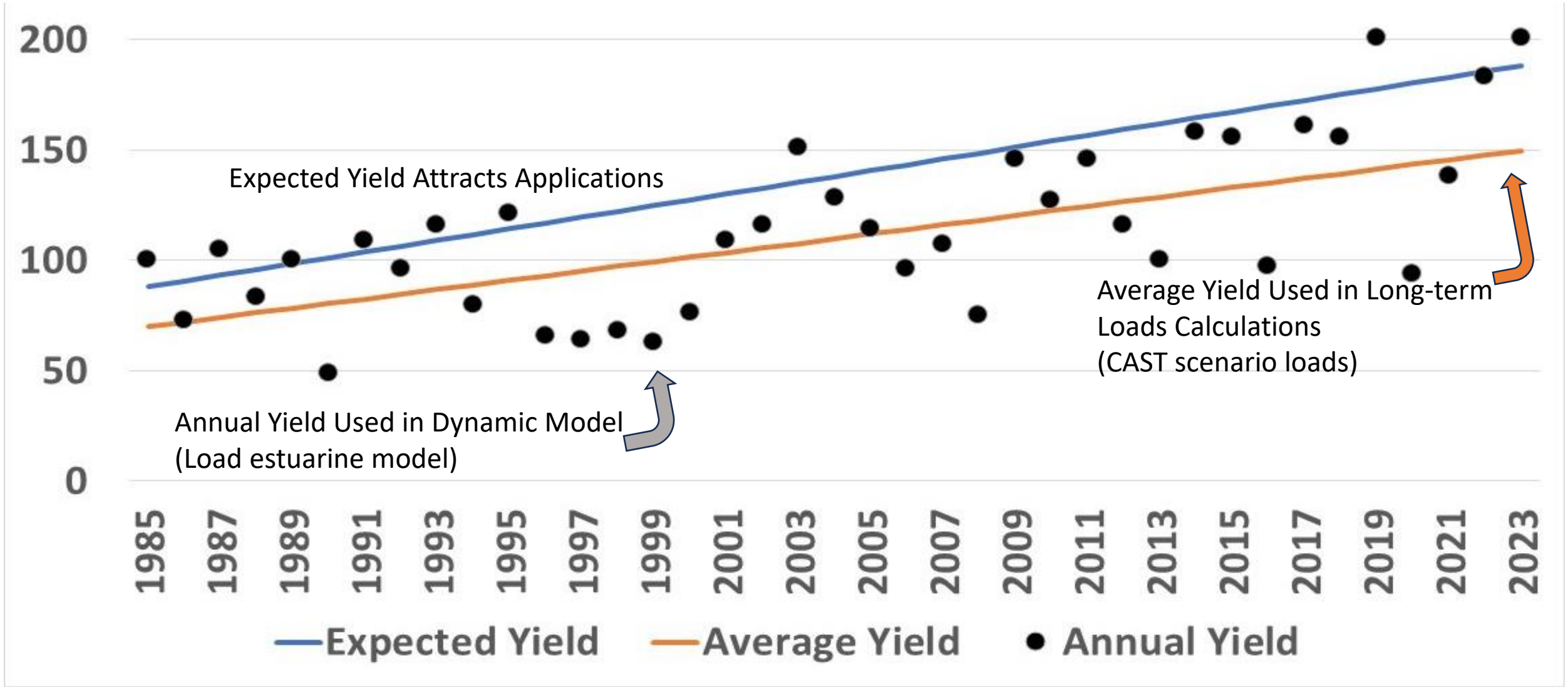


Why crop yields matter

- Yields and nutrient applications are tied together



*EXAMPLE
DATA ONLY



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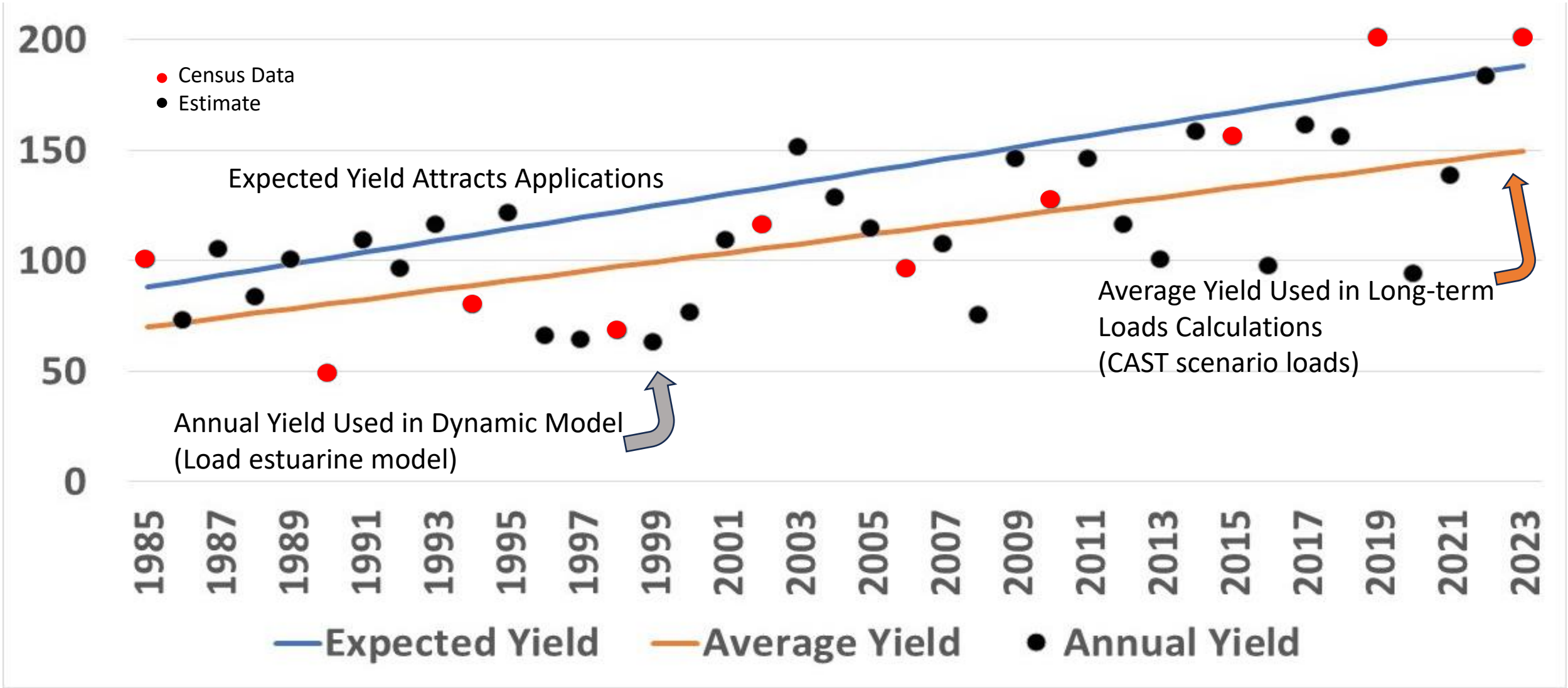
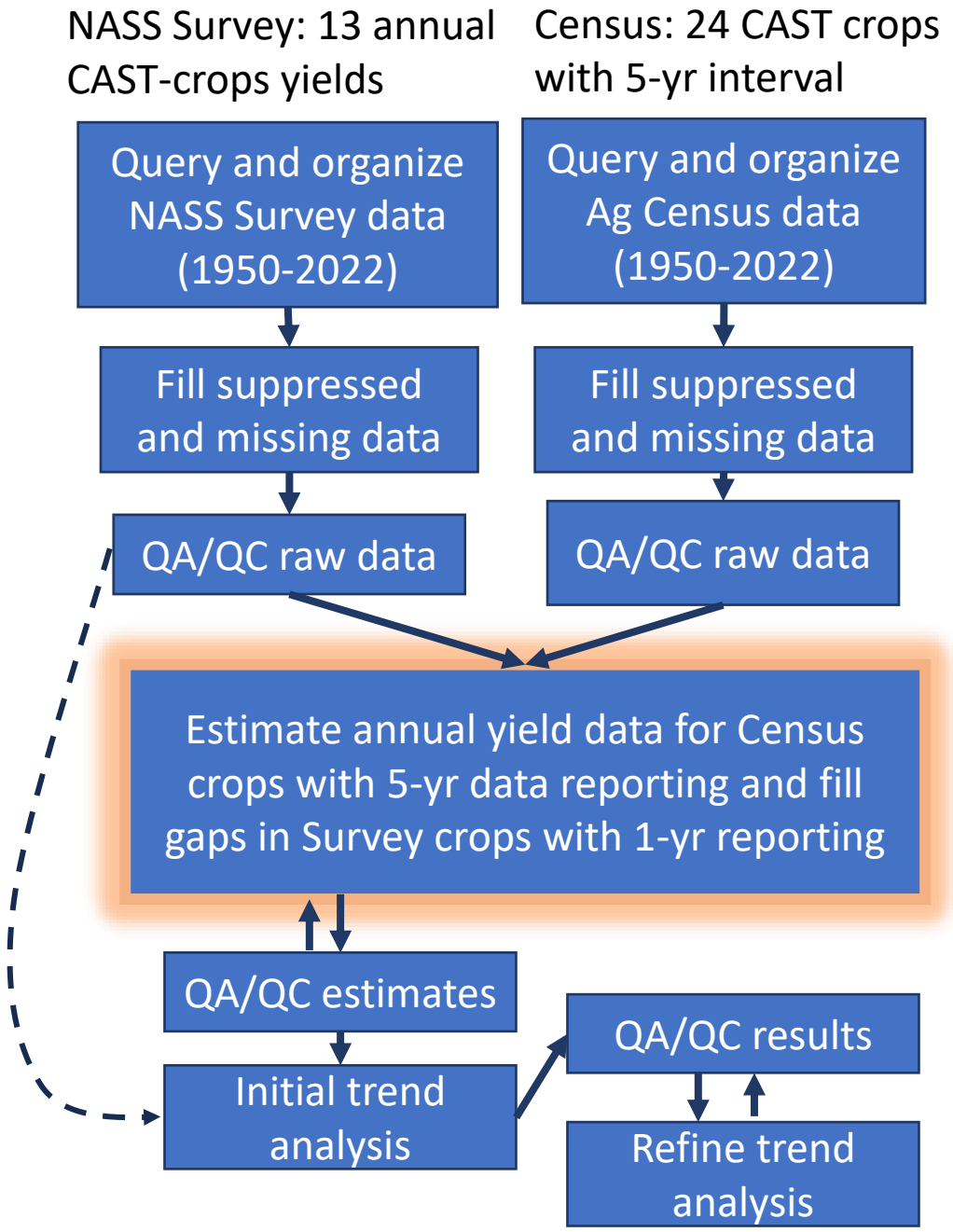


Planned path for investigation

Goals:

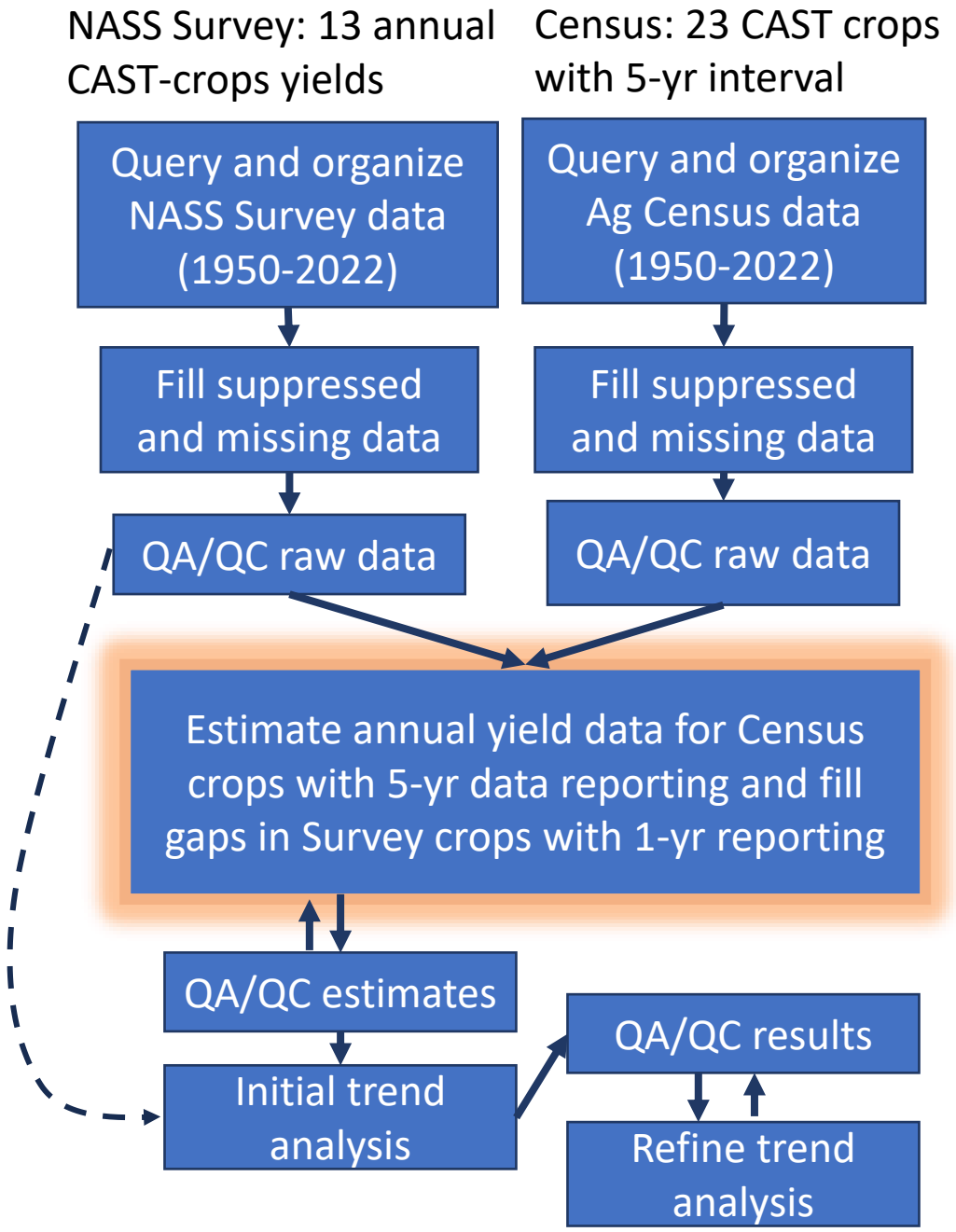
- Estimate farmer yield expectations at the county level which drive the application of nutrients.
- Estimate various yield trends to support several potential scenarios.

Approach: Use trend analysis of long-term annual crop yields.



Crop data collection

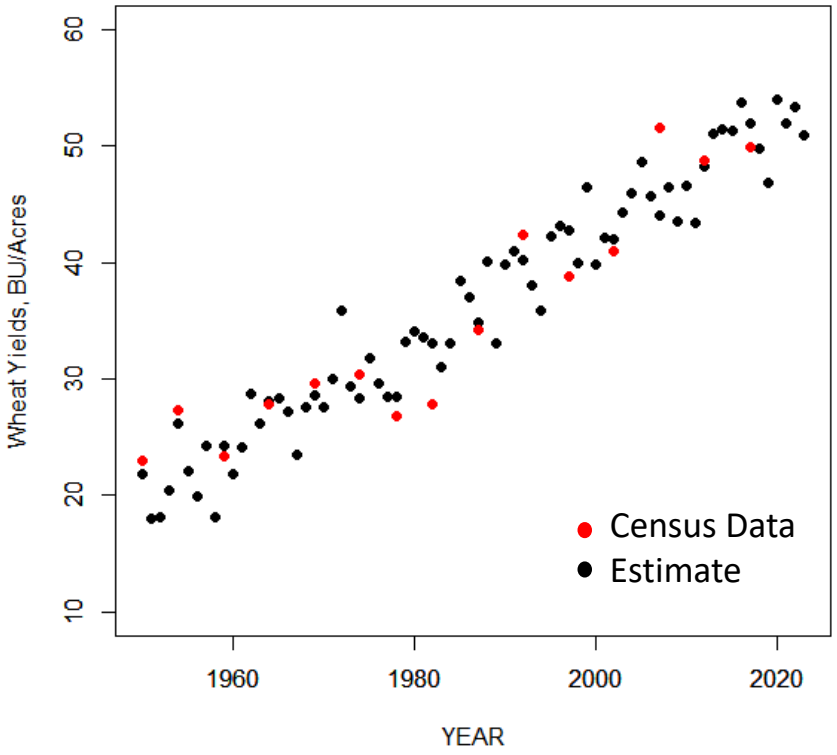
- 94 CAST-crops with both a potential yield and N-application
  - Excludes pasture, fallow, unmanaged or wild covers
- "Complete" data for 23 of these CAST-crops
  - Complete = data spanning >85% of period 1950-2017
  - **91% of crop land area, 95% of N applied to crop land**
- Partial data for an additional 40 crops
  - Partial = partial spatial range, partial time range, state-level only
  - 2.2% of crop land area, 3% of N applied to crop land
- No yield data for 31 crops
  - 6% of crop land area, 2% of N applied to crop land

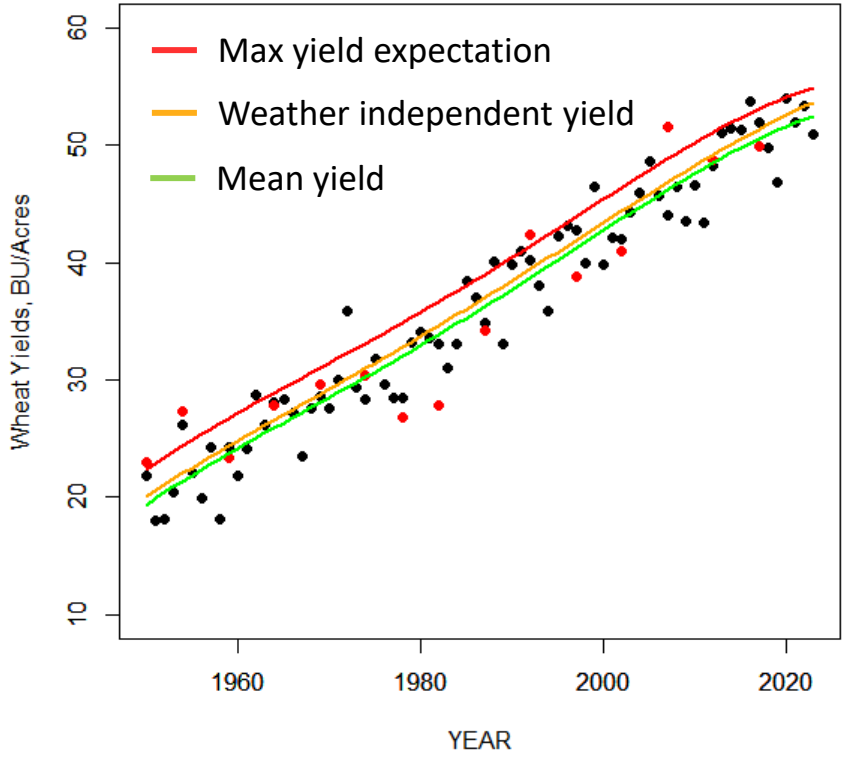


Statistical modeling method for estimating annual yields

multivariate linear models, bootstrapped (LOO)

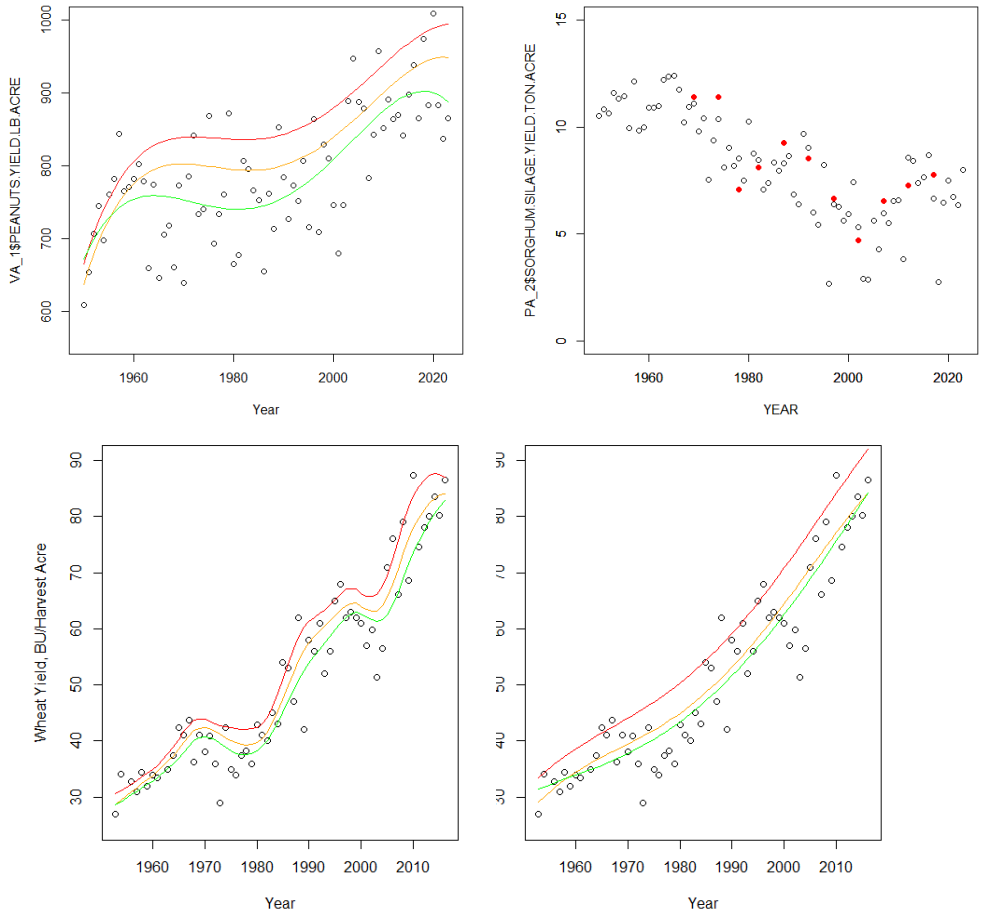
$$Yield_{\text{crop i, growth region j}} \sim f(\text{time, weather, climate, Survey crop yields, economics})$$





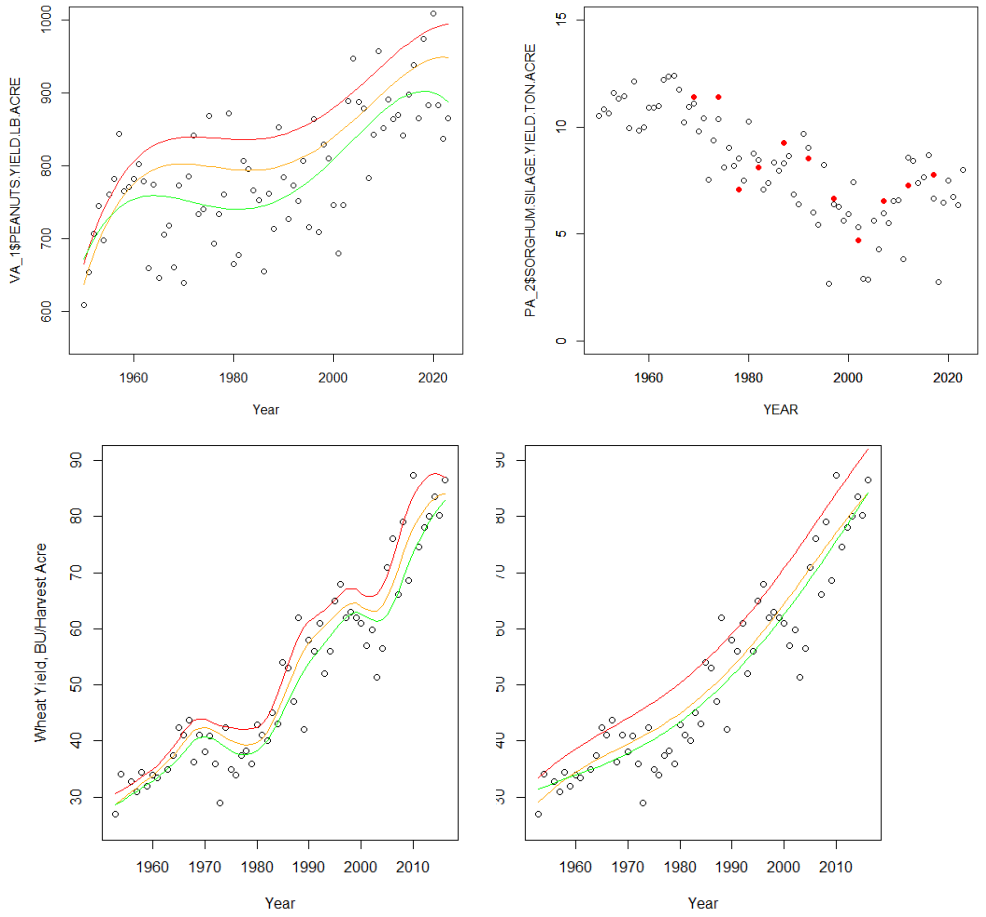
Generating a suite of metrics to describe the yield estimates and trend analyses

- Generating thousands of these plots
- We need a way to iterate without visually inspecting all of the generated data
- A suite of metrics to quickly assess the changes to numerical methods and flag issue to bring to the working group
  - “Smoothness”
  - Change metrics
  - Fit

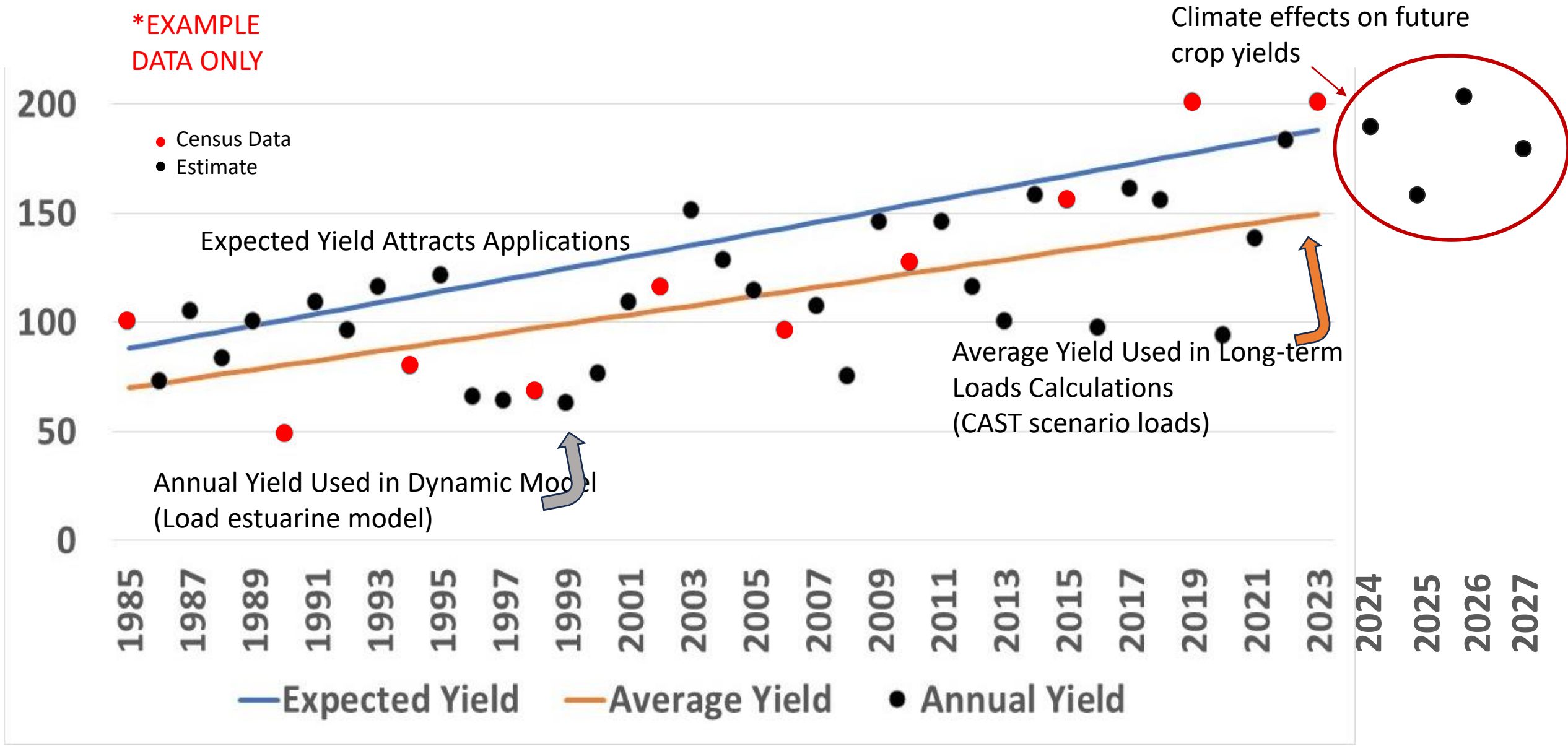


Generating a suite of metrics to describe the yield estimates and trend analyses

- Smoothness and change metrics
  - Lag-one autocorrelation
  - Coefficient of variation of the change between timesteps
  - “Anomaly detection”-variation greater than one standard deviation in a timestep
  - Deviation from smoothing line
  - Directional symmetry – is the value consistently increasing or decreasing and how does the trend compare to the data?
- Fit
  - Adjusted R^2, least absolute residual, CI%



Estimate the effects of climate change on future yields



Relative effect of climate parameters on crop yields

Year - represents the technological and genetic effect on yields

Winter Precip. - October to March precipitation

GDD – Growing Degree Days

GS Precip. – Growing season (April-September) precipitation

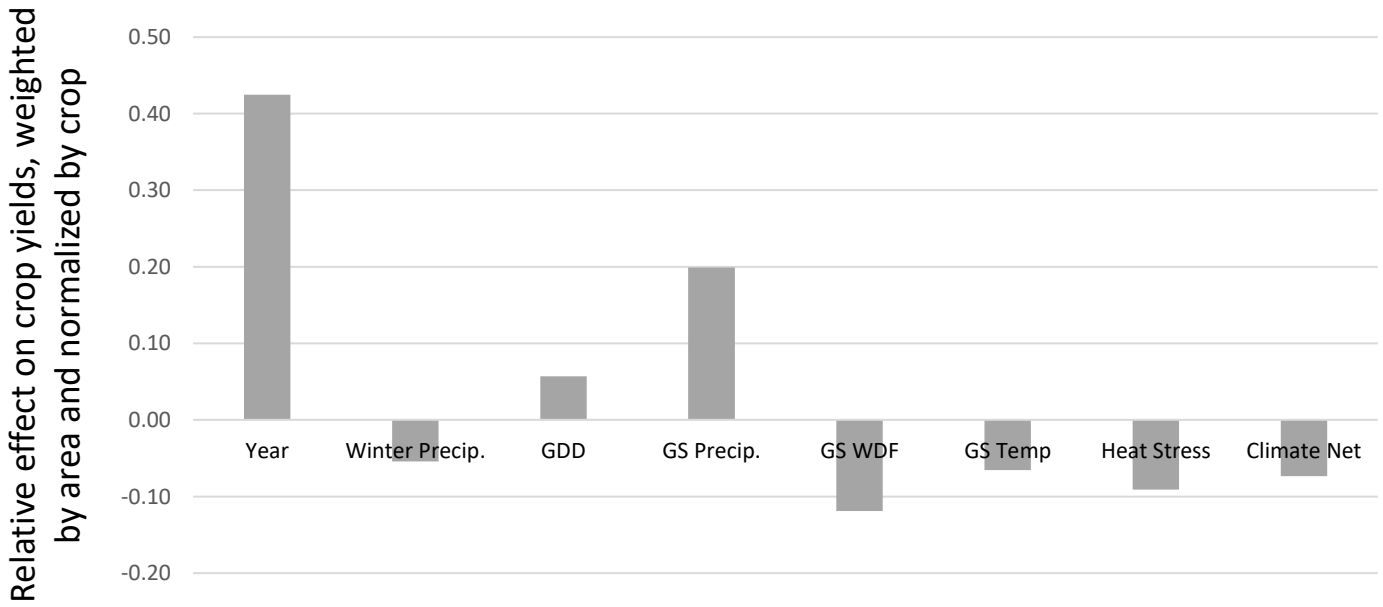
GS WDF – Growing season wet day frequency

GS Temp – Average growing season temperature

Heat Stress – Number of 5 consecutive days exceeding 86 degrees, April - July

Climate Net – The net effect of all climate related metrics on crop yields

Crop	Year	Winter Precip.	GDD	GS Precip.	GS WDF	GS Temp	Heat Stress	Climate Net	R2
Corn for grain	0.59	-0.10	0.14	0.24	-0.15	-0.16	-0.14	-0.17	0.77
Corn, silage	0.29		0.17	0.12	-0.11	-0.11	-0.11	-0.05	0.42
Wheat	0.71		0.02	0.14	-0.13		-0.07	-0.03	0.88
Barley	0.57		0.01	0.19	-0.18		-0.07	-0.05	0.66
Soybeans	0.49	-0.13		0.36	-0.13		-0.10	0.00	0.73
Cotton	0.44	0.90	0.82	-0.89			-0.48	0.35	0.81
Hay, small grain	0.21		0.05	0.17	-0.16			0.06	0.67
Hay, alfalfa	0.13	-0.02		0.12		-0.12		-0.02	0.44
Hay, other	0.30			0.11	-0.13	-0.03	-0.0666	-0.11	0.85
Sorghum				0.44		0.24	-0.36	0.32	0.72
All, N weighted	0.54	-0.06	0.13	0.21	-0.15	-0.13	-0.13	-0.13	
All, area weighted	0.42	-0.05	0.06	0.20	-0.12	-0.07	-0.09	-0.07	



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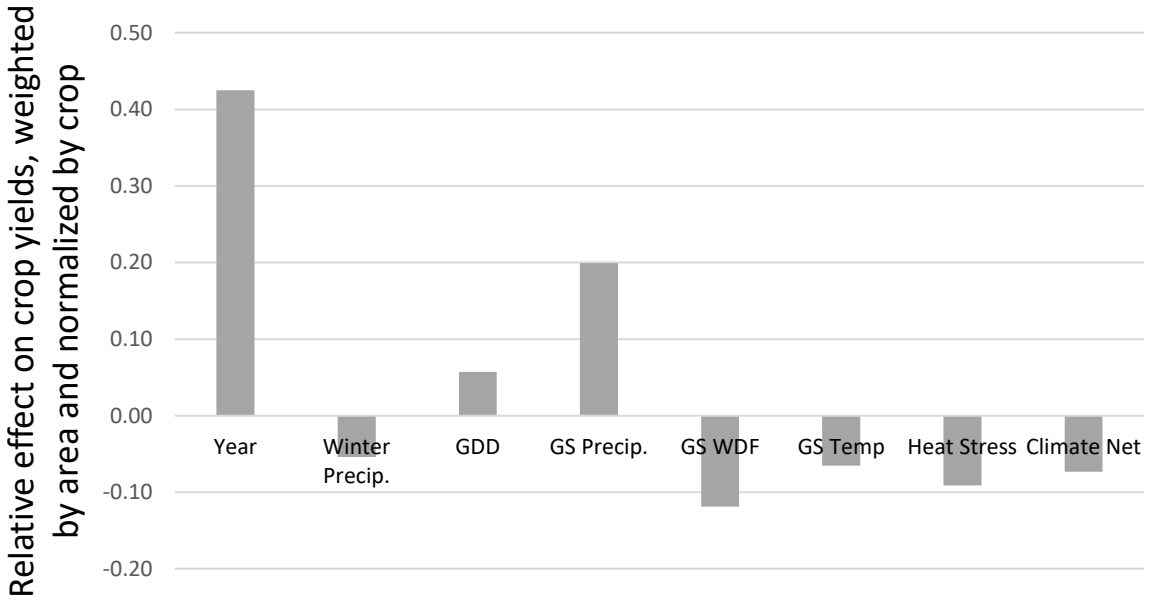

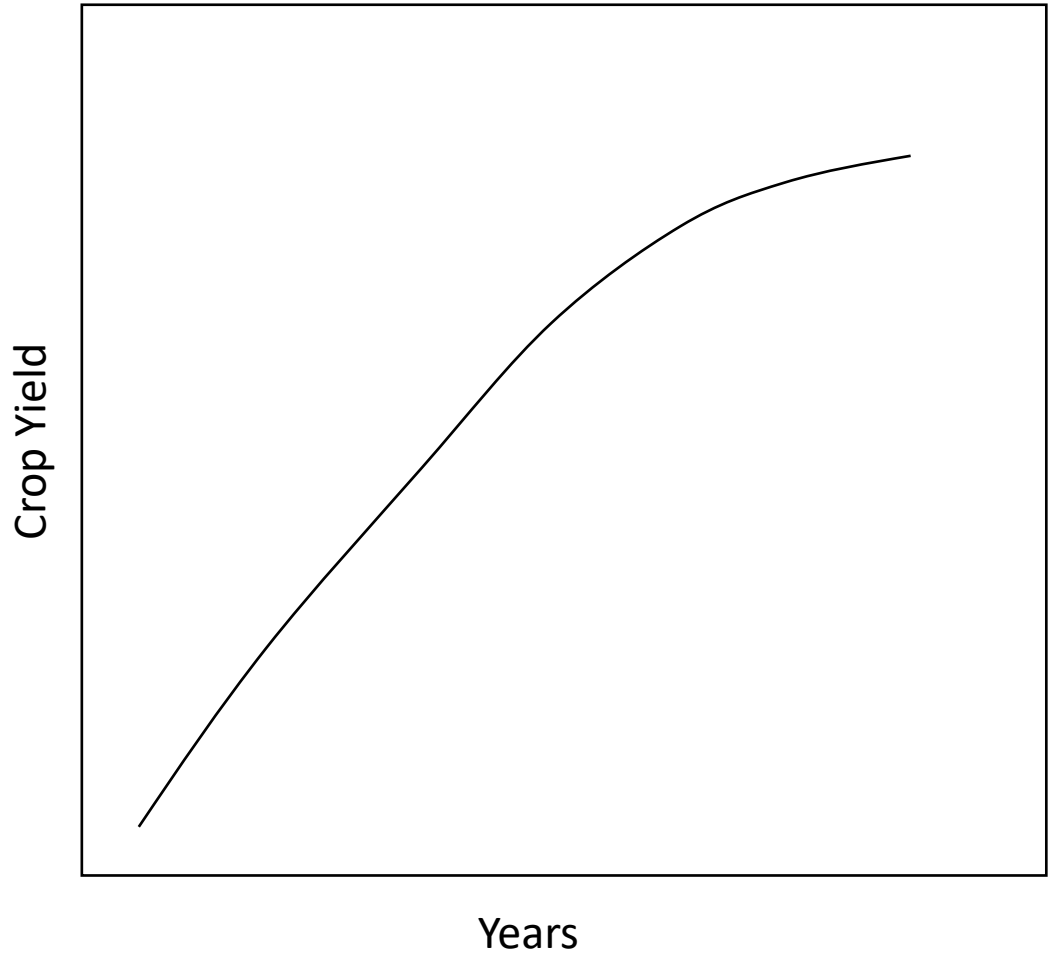

Moving forward

- Finalize crop yield methods for the AMT
- Sensitivities (nutrient load sensitivity to input and land use)
  - July quarterly

Questions?