The Effect of Climate Change on Crop Production in Ontario & the Economic Viability of Irrigation

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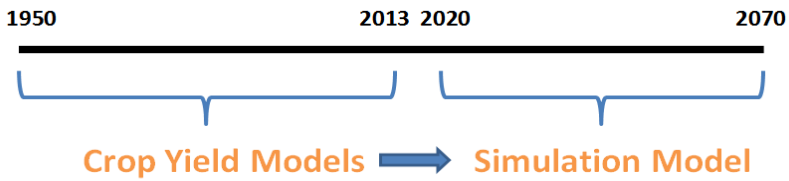
Research Overview

- Background
  - Possibility of increasing water scarcity in rural Ontario
  - *Water Opportunities Act, 2010*
- Objectives
  - To estimate county-level crop yield functions with historical data
  - To develop an economic model of the demand for irrigation water
  - To develop and test the county-level spatial stochastic simulation model for 2020-2070
- Benefit
  - An economic framework to study water use in crop production in Ontario, under alternative climate change scenarios and alternative adaption strategies

Research Methods

- Crop Yield Models (1950-2013)
  - Corn, soybeans, winter wheat, hay
  - Across 29 counties in Ontario
  - Variables: precipitation, degree days, crop price, fertilizer price, groundwater, land quality, technology

- Spatial Stochastic Simulation Model (2020-2070)
  - Monte-Carlo Simulation
  - 4 climate scenarios:
    - 1 base scenario: linear extrapolation of historical trends
    - 3 climate change scenarios
  - 2 adaption strategies:
    - Irrigation
    - Changing county-level cropland areas
  - Including main rivers across county boundaries

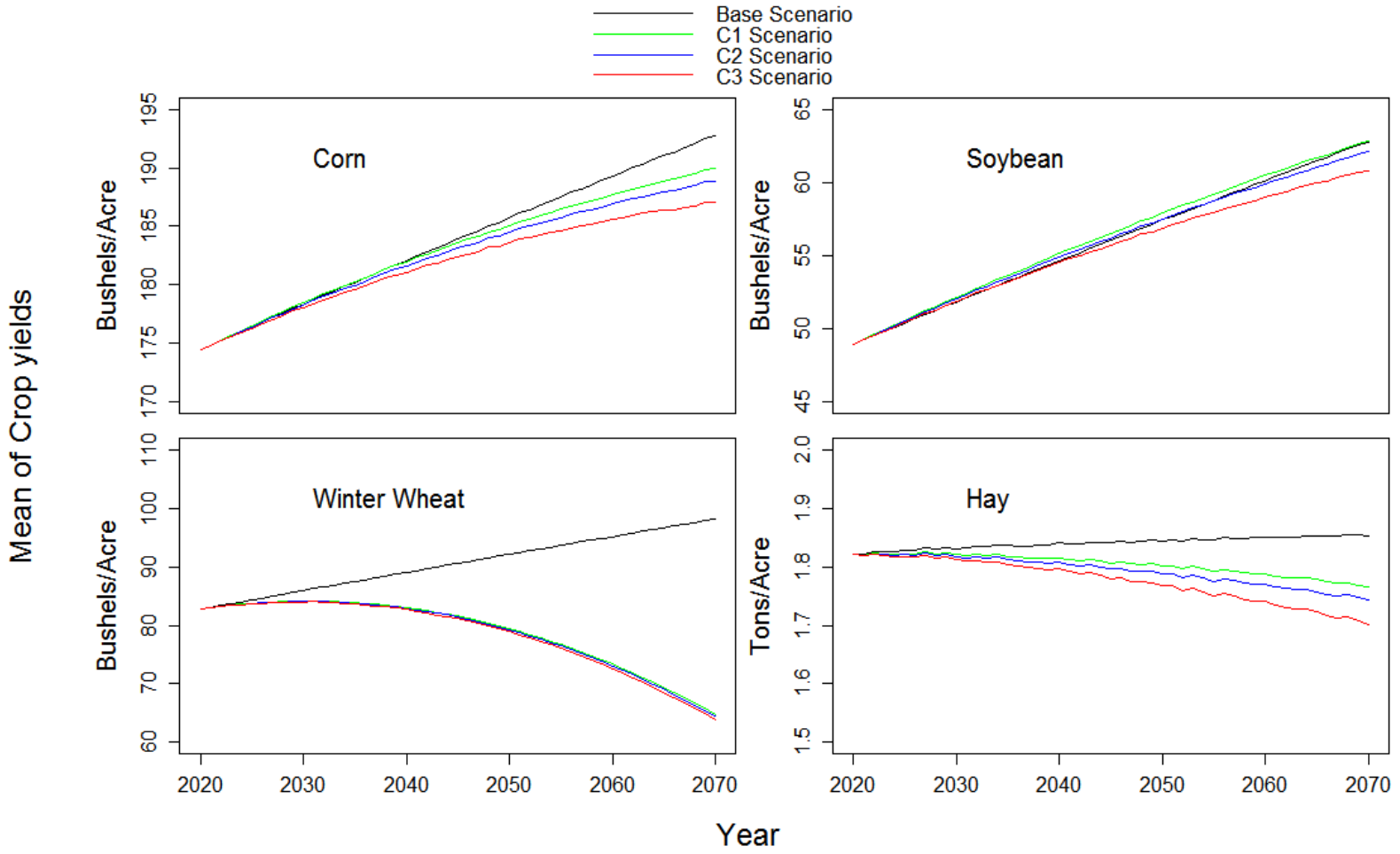


Research Methods

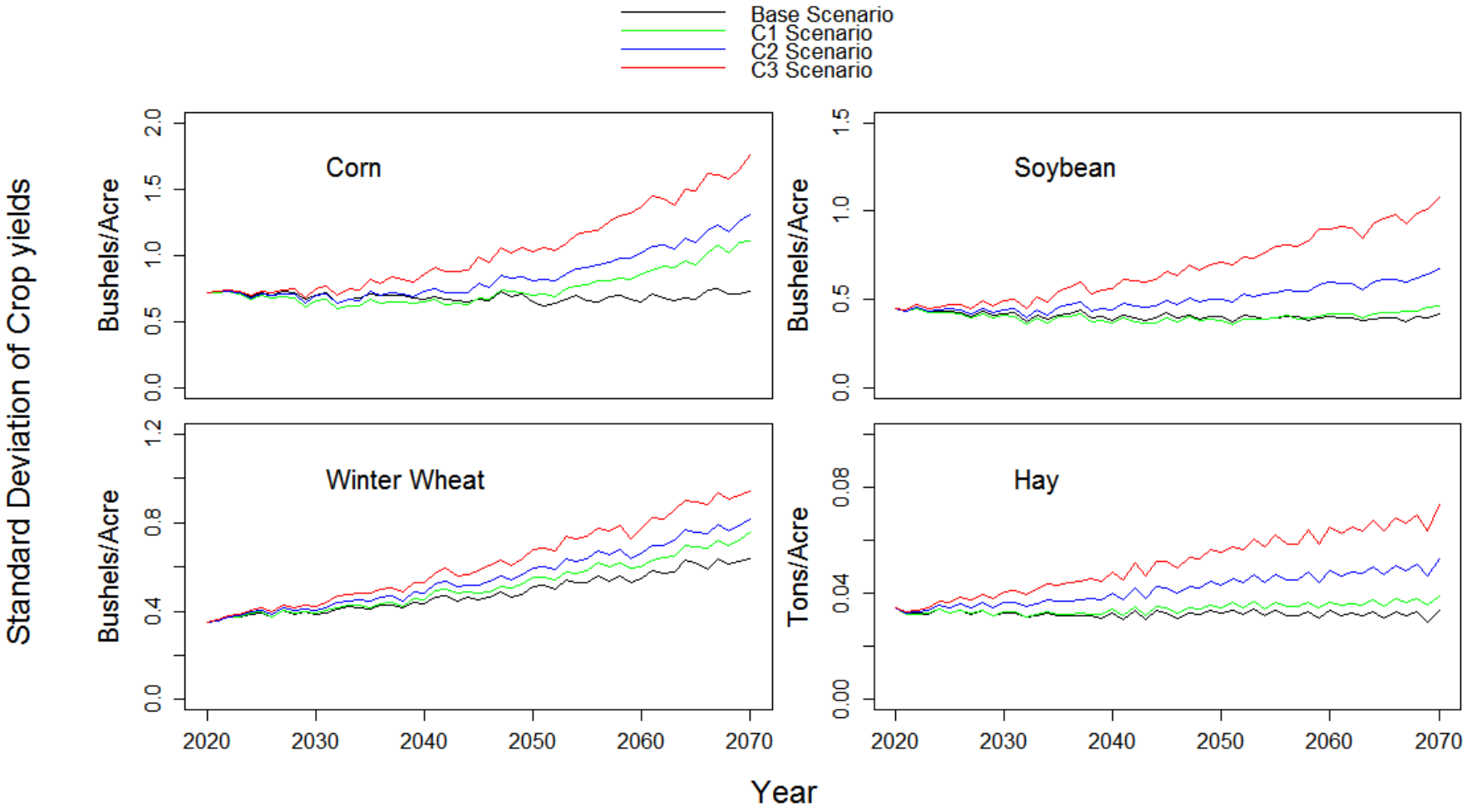
Comparison of Climate Scenarios

- Base scenario
  - Linear extrapolation of county-level historical climate and technology variables, constant real prices
  - Mean and standard deviation
    - Degree days during growing season: increase by 0.20% per year
    - Precipitation during growing season: increase by 0.28% per year
- Climate change scenarios
  - County-level precipitation and temperature variables from composite GCM model with RCP 8.5
  - Variation 1 (C1): Mean and standard deviation of degree days and precipitation during growing season increase by 0.25% per year
  - Variation 2 (C2): standard deviation of precipitation during growing season increases by 1.25% per year
  - Variation 3 (C3): standard deviation of precipitation during growing season increases by 2.5% per year

Mean of Simulated Crop Yields



Standard Deviation of Simulated Crop Yields

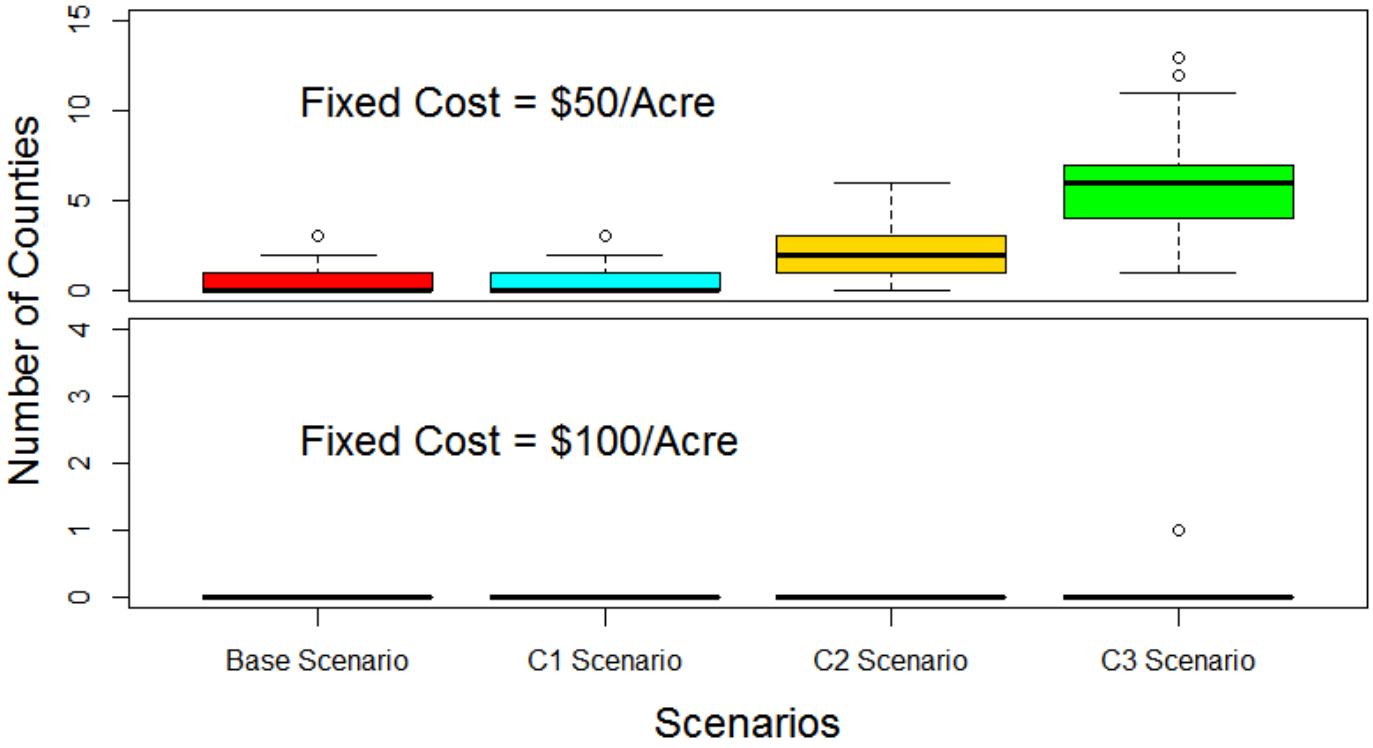


Simulated Crop Revenues

Scenarios	Revenue (Millions) Total		
	2020	2070	Increase %
Base Scenario	3685	4270	15.88%
Variation 1 (C1)	3685	4067	10.37%
Variation 2 (C2)	3685	4029	9.34%
Variation 3 (C3)	3685	3965	7.59%

Revenue = Yield * Crop Price * Cropland Area

Number of Counties Where Irrigation for Corn Would be Profitable



Currently, the fixed cost of irrigation is $700-$800 per acre

Research Impact

Main Findings

- Corn, soybean, winter wheat yields increased at an increasing rate between 1950 and 2013
- Historical trends and climate modeling both anticipate wetter & warmer climate in Ontario
- Winter wheat appears to be the most vulnerable crop with respect to climate change
- Irrigation for corn is economic attractive only when the fixed cost is as low as $50 per acre
- If irrigation is applied, in some circumstance, low water flow restrictions become a binding constraint

Take-Home Message

- We have developed and tested an economic framework can be used to study adaptation strategies to climate change for crop production in Ontario

Recommendation

- We are proposing additional research to use this framework to study the economics of irrigation and tile drainage as adaptation strategies

Discussion Topic

How can agricultural producers adapt their farm practices?

- Need to understand if anything could be done to reduce the vulnerability of winter wheat
- Additional work is needed on the economics of irrigation and drainage
- If irrigation is applied, building on-farm water storage infrastructure would mitigate water scarcity in July

Summary

- We have developed and tested an bio-economic spatial model could be used to study water use and adaptation strategies in crop production in Ontario
- Features of the framework
  - Four crops
  - County-level
  - Historical yield, physical, price and climate data 1950-2013
  - Projection for 2020-2070
  - Incorporate a climate modeling output at the county level
  - Outputs of crop yields, production level, revenues, irrigation amount, frequency of irrigation, economic viability of using irrigation, and frequency of facing water scarcity
  - Stochastic simulation model (Monte-Carlo simulation)
  - Estimate irrigation water demand in an economic method rather than a engineering method
  - Capable to be used in other relevant research

Research Projects

OMAFRA / UofG Partnership – Agriculture and Rural Policy

- **UofG2013-1552 Spatial Stochastic Modeling of Water Use Efficiency in Ontario Agriculture**

Thank You

Appendix

Simulated Crop Revenues
with Reallocating Cropland Area

Scenarios	Revenue (Millions) in 2070		
	0%	Corn +5% & Soybean +5% Winter Wheat Land Area	Difference (Δ)
Base Scenario	4270	4295	25
Variation 1 (C1)	4067	4106	39
Variation 2 (C2)	4029	4069	40
Variation 3(C3)	3965	4004	39

Revenue = Yield * Crop Price * Cropland Area