Economic Analysis of Crop Rotations in the Canadian Prairies

Danny G. Le Roy (University of Lethbridge)
Elwin G. Smith (University of Lethbridge)
Scott Jeffrey (University of Alberta)
Derek Brewin (University of Manitoba)

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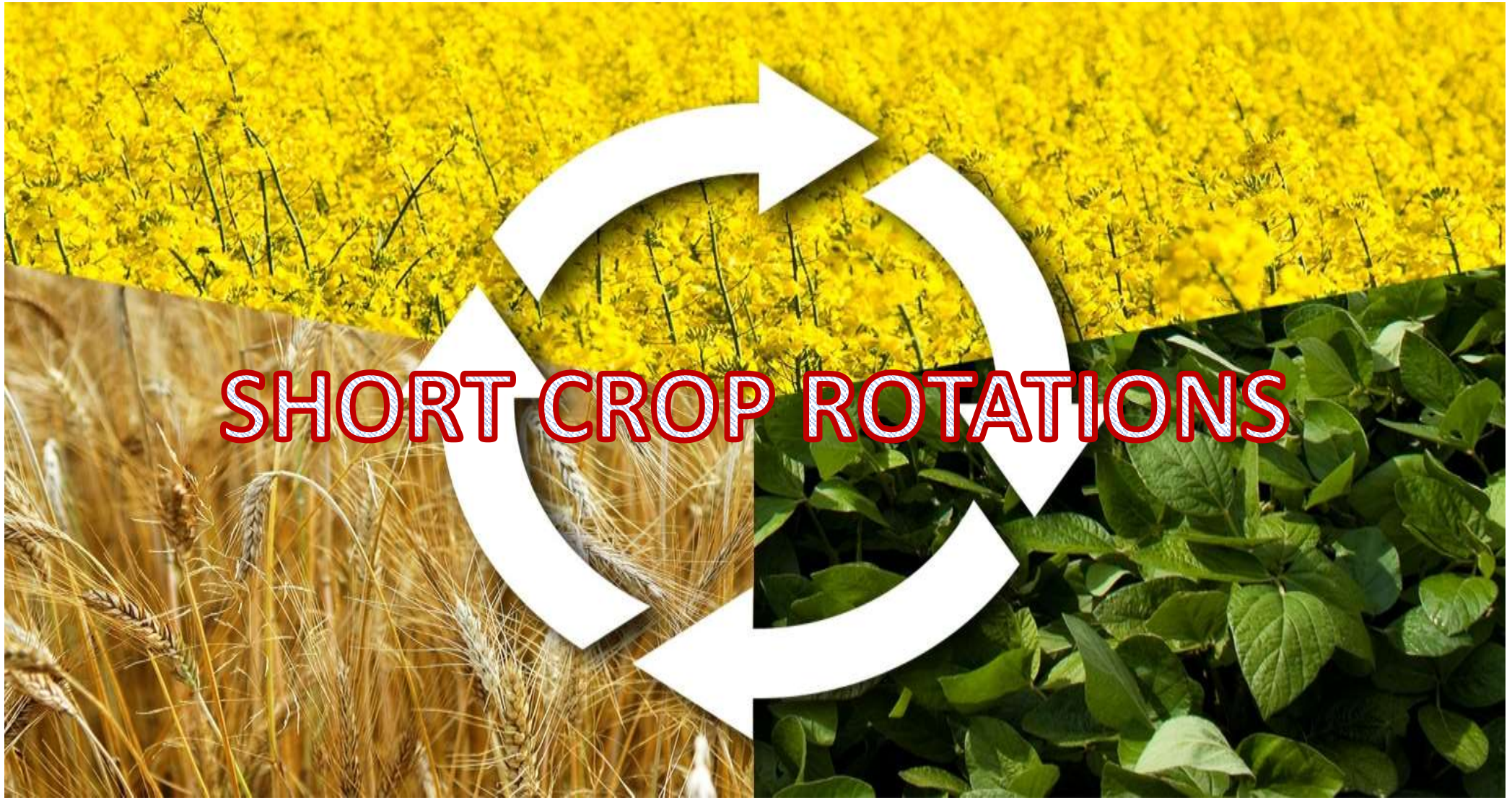
What to grow?

What inputs to use?

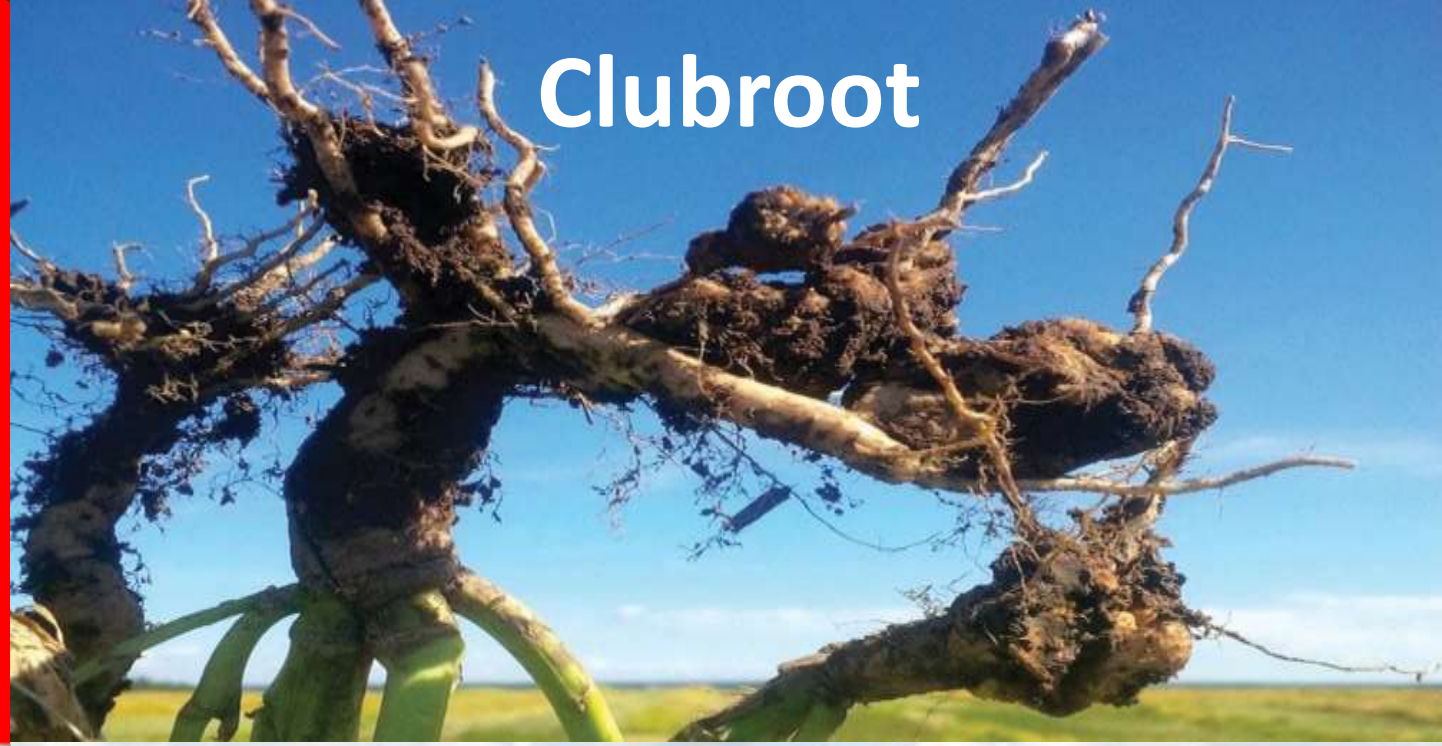
In the context of a crop rotation, where, how much, and how often?

Problematic Situation



Source: aridagriculture.com, http://aridagriculture.com/2018/03/01/crop-rotation-agriculture/


Disease
Herbicide resistance
Pests


Clubroot


Black Leg


Root Rot

The Economic Problem

- <u>The grower's dilemma</u>:

[1] **short rotations with few crops**; higher potential for reduced future productivity, higher costs from plant diseases, and herbicide tolerant weeds.

or

[2] **longer rotations with many crops**; lower potential for reduced future productivity, lower costs from plant diseases, and herbicide tolerant weeds.

The Economic Problem

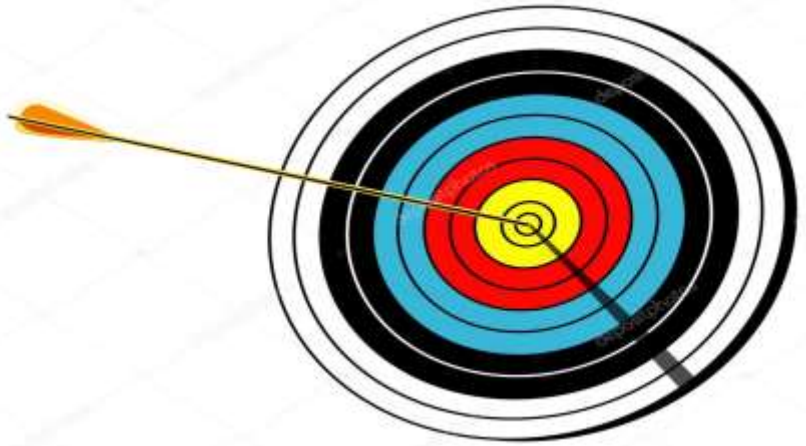
Economic Research Problem

- If growers could identify, delineate and quantify their expected returns from different rotations with varying levels of yield stifling diseases over time,
-

  → ***this would help in their individual decisions of how best to allocate their scarce factors of production.***

- The economic research problem is to generate this information.

Objectives

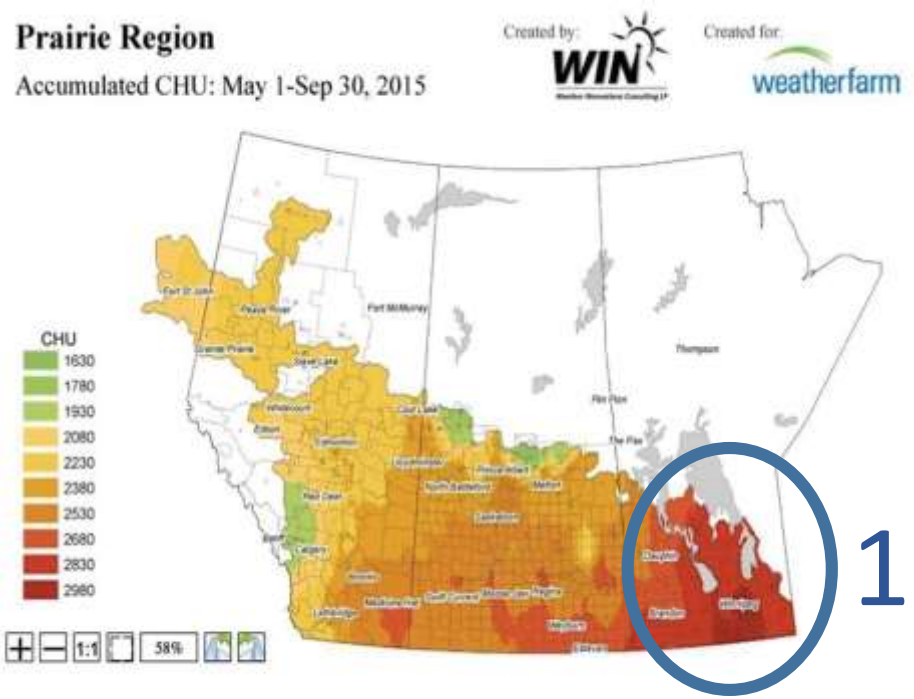


1. To determine the net return and variability (risk) of net returns associated with rotations of different length and diversity.

2. To determine the marginal costs of negative productivity factors associated with reduced diversity in rotations, and

3. To assess the effectiveness of incentive modifying business risk management (BRM) programs on the variability of net returns and diversity in rotations.

Conceptual Framework



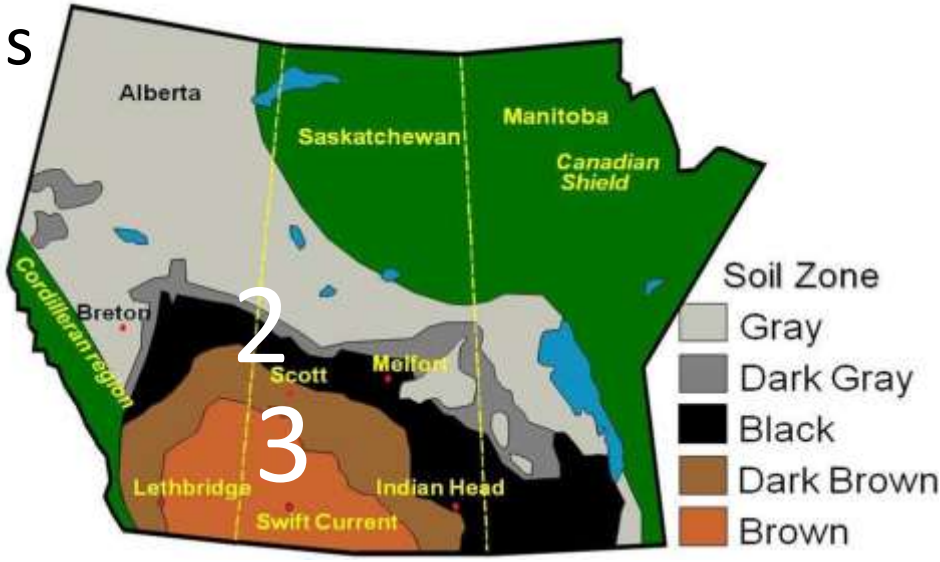
Three regions:

1. **Southern Manitoba:** corn and soybean acres ↑ and canola remains an important crop,

IN AB and SK

2. **Black and Dark Gray soil zones:** canola, field peas and barley (malt and feed) are important.

3. **Brown and Dark Brown soil zones:** pulse crops (peas and lentils) often grown in wheat-based systems.



Region specific crop rotations

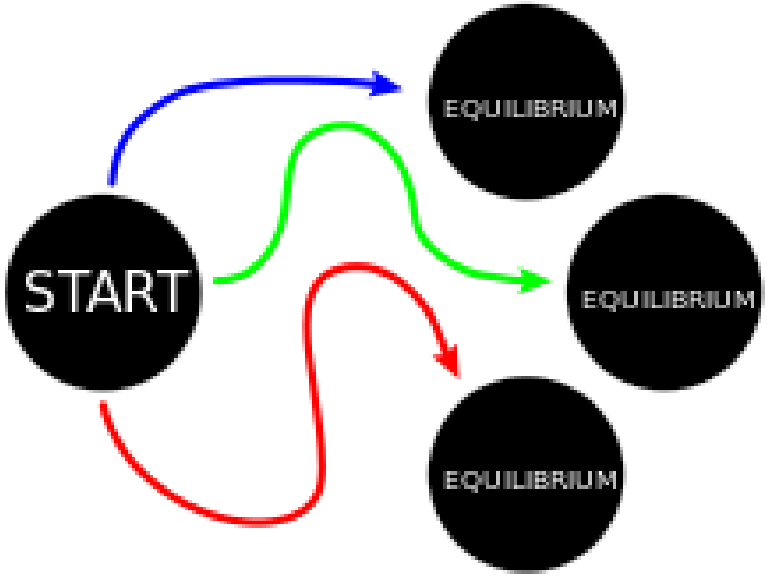
- Practicality vs theory…
- Consider, as an example
  - 11 crops → $(11)^{11}$= **285,311,670,611** possible 11 crop sequence rotations.
  - Most are infeasible (climate & soil type) or inappropriate/nonviable (agronomy).
- Forages? Fallow? Emerging grains (quinoa) or oilseeds (camelina)?

Conceptual Framework

$$Max \quad NPV_j = \sum_t (1+r)^{-t} \left(\sum_{c \in j} P_{ct}\, Y_{ct}(D_c) - \sum_{c \in j} w_{ct}\, X_{ct} - FC_t \right)$$

- *NPV* is net present value
- *j* is the rotation, *c* are the crops in rotation *j*
- *t* is the time period
- *Pc* is the crop price
- *Yc* is output of crop c, dependent on plant disease, *Dc*
- *wc* are prices of factors *Xc*
- *FC* are fixed costs not dependent on the cropping system

Model Relationships



- PHYSICAL
  - Yield (damage): $Y_t = Y_{0t}(1 - D(Z_t))$
  - Disease path: $Z_t = Z_{t-1} + z(PS_{t-1})$

- Previous research on yield damage from:
  - Blackleg (Kutcher et al. 2013; Zhang et al. 2016),
  - Clubroot (Hwang et al. 2014; Strelkov and Hwang 2014; Strelkov et al. 2016)
  - Root rot for pulses (Connor et al. 2013), and
  - Cereal leaf diseases (Turkington et al. 2012)

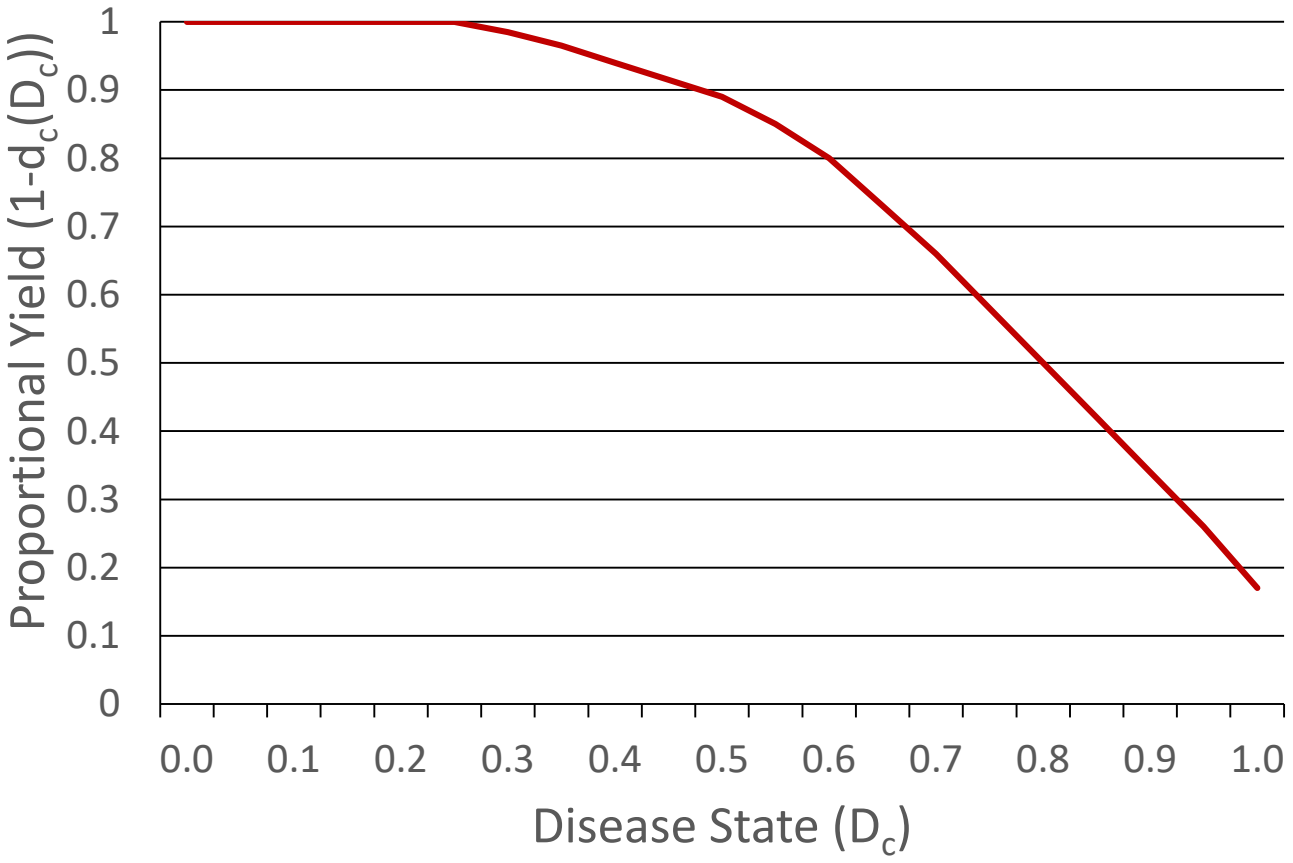
Model Relationships

- RANDOM VARIABLES
  - Random price: $P_{ct} \sim IID\left(\bar{P}_c, \sigma^2_{P_c}\right)$
  - Random disease: $f_c \sim IID\left(\bar{f}_c, \sigma^2_{f_c}\right)$

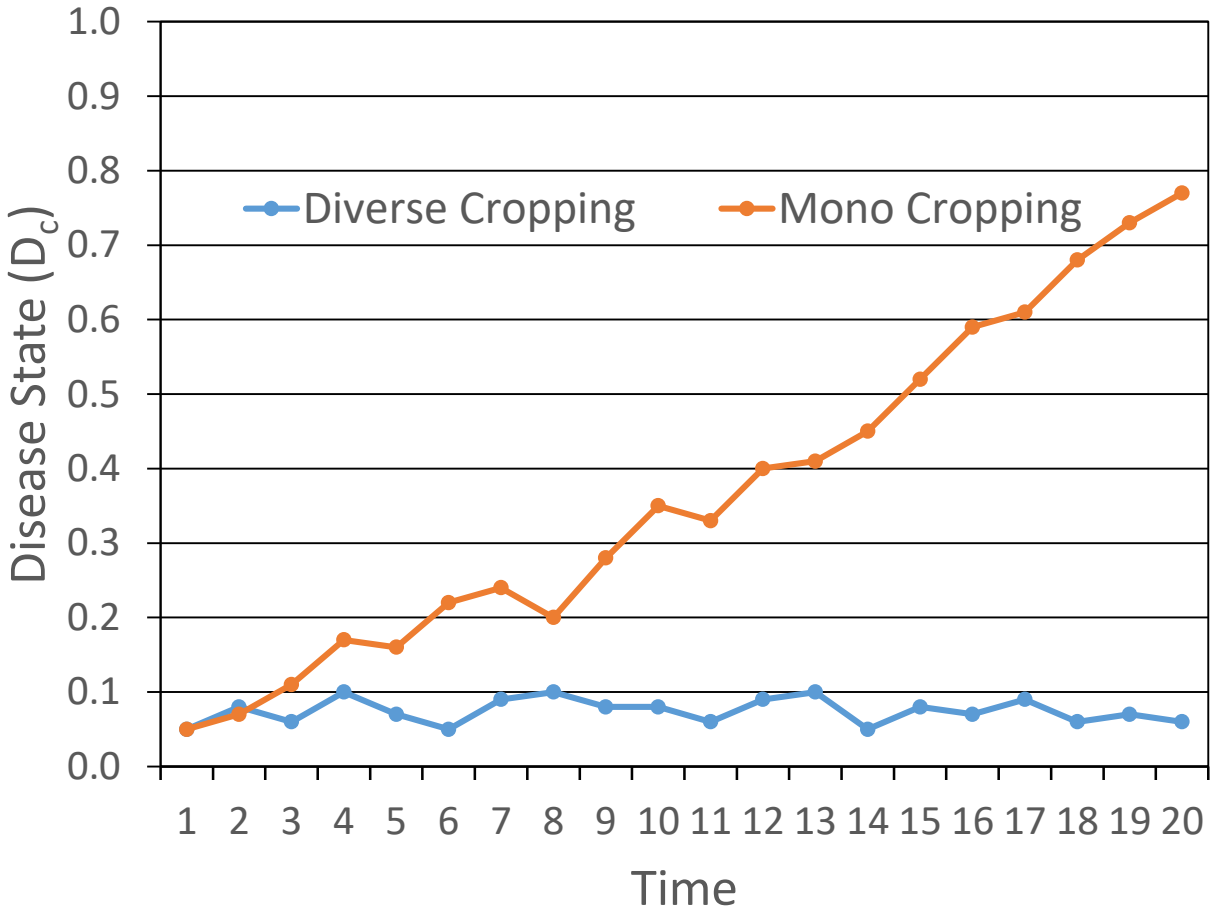
Data and Sources

- Provincial cropping statistics
- Crop area yields from provincial crop insurance agencies
- Crop prices at the farm gate from provincial data
- Crop disease severity from published agronomic studies
- Crop disease impact on yield from published studies
- Agronomist input on plant disease expected for rotations
- Agronomist input on yield impact of disease
- For very uncertain agronomic relationships, utilize sensitivity analyses

Hypothetical Yield Damage Function for a Crop



Hypothetical Disease Paths for a Crop



Anticipated Results

- Key assumptions drive empirical results:

1. Distribution of financial variables
   - Prices (inputs and outputs)

2. Quantification of physical relationships
   - How crop sequencing influences crop yield
   - How damage agents (pests, disease) limits yield potential
   - The use and effectiveness of damage control agents
   - Manifestation of disease over time.

Anticipated Implications

- USEFUL, PRACTICAL decision aid
  - Empirical model that transcends location.
  - User defined exogenous variables to reflect:
    - Financial aspects a particular agribusiness
    - Alternative physical relationships between, rotation, pests and yields
  - Sensitivity analysis
- AND to generate discussion here this afternoon

Funding Organizations

Western Grains Research Foundation

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Alberta Pulse Growers

Prairie Oat Growers Association

Manitoba Pulse Soybean Growers

Sask Wheat Development Commission

Brewing and Malting Barley Research Institute