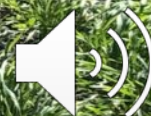


# Can Organic Farms Benefit from Precision Agriculture?

Soils and Crops Conference 2020



Presented by: Sasha Loewen  
PhD student Montana State University  
Department of Land Resources and Environmental Sciences  
Advisor: Bruce Maxwell





# Outline

- Research Problem/Question
- Methods & Preliminary Results
  - A Manitoba Example of On Field Precision Experimentation
- Challenges
- Future





# Research Problem

- Feeding a growing population while maintaining ecosystem services
- Solutions?
  - Organic Agriculture
    - No synthetic fertilizer, no chemicals
    - Low yield
  - Precision Agriculture
    - Reams of unused data

AGRICULTURE

## Sustainable Intensification in Agriculture: Premises and Policies

T. Garnett<sup>1</sup>, M.C. Appleby<sup>2</sup>, A. Balmford<sup>3</sup>, I.J. Bateman<sup>4</sup>, T.G. Benton<sup>5</sup>, P. Bloomer<sup>6</sup>, B. Burlingame<sup>7</sup>, M. Dawkins<sup>1</sup>, L. Dolan<sup>1</sup>, D. Fraser<sup>8</sup>, M. Herrero<sup>9</sup>, I. Hoffmann<sup>7</sup>, P. Smith<sup>10</sup>, P.K. Thornton<sup>11</sup>, C. Toulmin<sup>12</sup>, S.J. Vermeulen<sup>11</sup>, H.C.J. Godfray<sup>1\*</sup>

**nature**  
International journal of science

Letter | Published: 25 April 2012

## Comparing the yields of organic and conventional agriculture

Verena Seufert , Navin Ramankutty & Jonathan A. Foley

## The power of agricultural data

**Science**

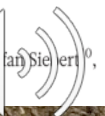
Joshua D. Woodard<sup>1,\*</sup>, Bruce J. Sherrick<sup>2</sup>, Deborah M. Atwood<sup>3</sup>, Robert Blair<sup>4</sup>, Greg Fogel<sup>5</sup>, Nicholas Goeser<sup>6</sup>

+ See all authors and affiliations

Science 26 Oct 2018:  
Vol. 362, Issue 6413, pp. 410-411  
DOI: 10.1126/science.aav5002

## Solutions for a cultivated planet **nature**

Jonathan A. Foley<sup>1</sup>, Navin Ramankutty<sup>2</sup>, Kate A. Brauman<sup>1</sup>, Emily S. Cassidy<sup>1</sup>, James S. Gerber<sup>1</sup>, Matt Johnston<sup>1</sup>, Nathaniel D. Mueller<sup>1</sup>, Christine O'Connell<sup>1</sup>, Deepak K. Ray<sup>1</sup>, Paul C. West<sup>1</sup>, Christian Balzer<sup>3</sup>, Elena M. Bennett<sup>1</sup>, Stephen R. Carpenter<sup>5</sup>, Jason Hill<sup>1,6</sup>, Chad Monfreda<sup>7</sup>, Stephen Polasky<sup>1,8</sup>, Johan Rockström<sup>9</sup>, John Sheehy<sup>10</sup>, David Tilman<sup>1,11</sup> & David P. M. Zaks<sup>12</sup>





# Research Question

- Can we improve yields (and the farmer's bottom line) using PA?
- Apply On Farm Precision Experimentation (OFPE) to answer this question





## Active Data Acquisition

On the Ground  
-soil sample  
-biomass crop  
-biomass weeds

## Passive Data Acquisition

Remote sensing  
-NDVI  
-Elevation

Weather data

As applied map

Yield monitor  
data

Economic data

# On Farm Precision Experimentation

## Analysis

-Linear  
-Non-linear  
-Bayesian updating  
-Random forest

Optimized Net  
Return \$  
Prescription

Input  
prescription map

New information built back into the model





# OFPE - introduction

Sec35mid

Sec35west

Sec1east

Sec1west

Key point of our approach:

Experiments are intended to inform management on the field where conducted, not other fields.



# Applying On Field Precision Experimentation

Precision seeding experiment  
winter wheat

Precision seeding experiment  
spring wheat

Casey Bailey

Bob Quinn (Goodman)

Ole Norgaard

Precision seeding experiment  
Pea green manure followed by wheat



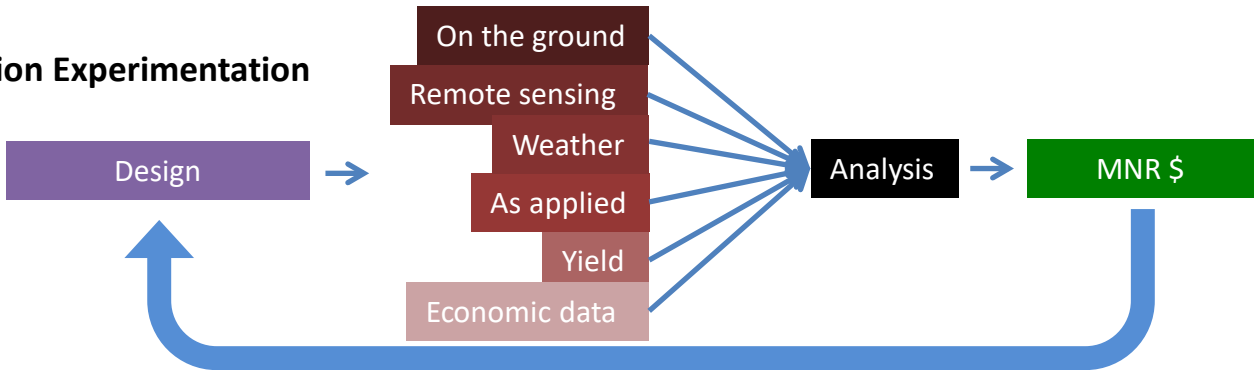
Ty O'Connor

Precision nitrogen experiment  
blood meal on wheat

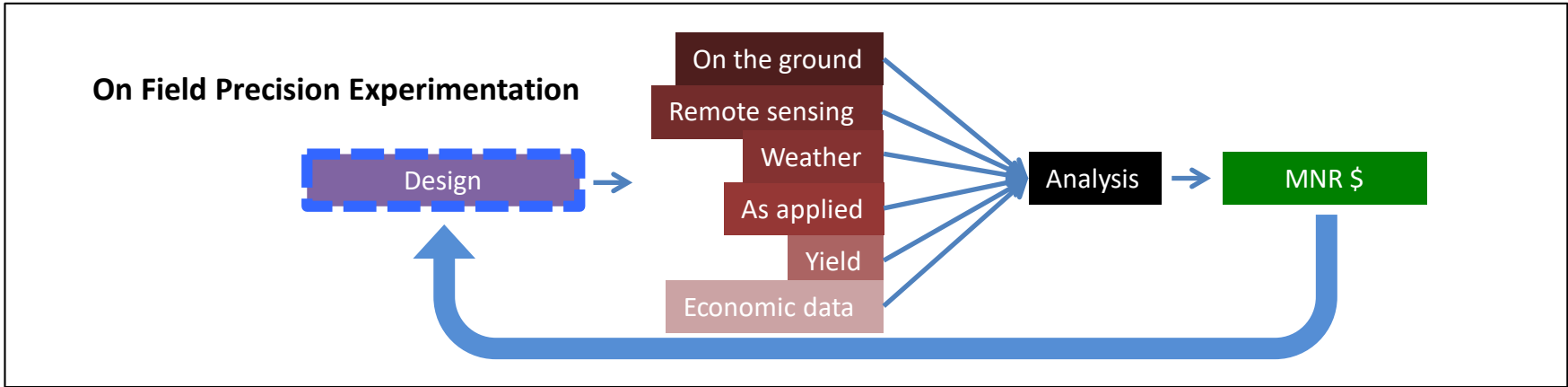
Loewen



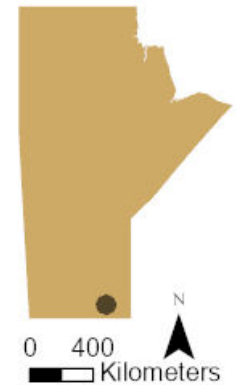
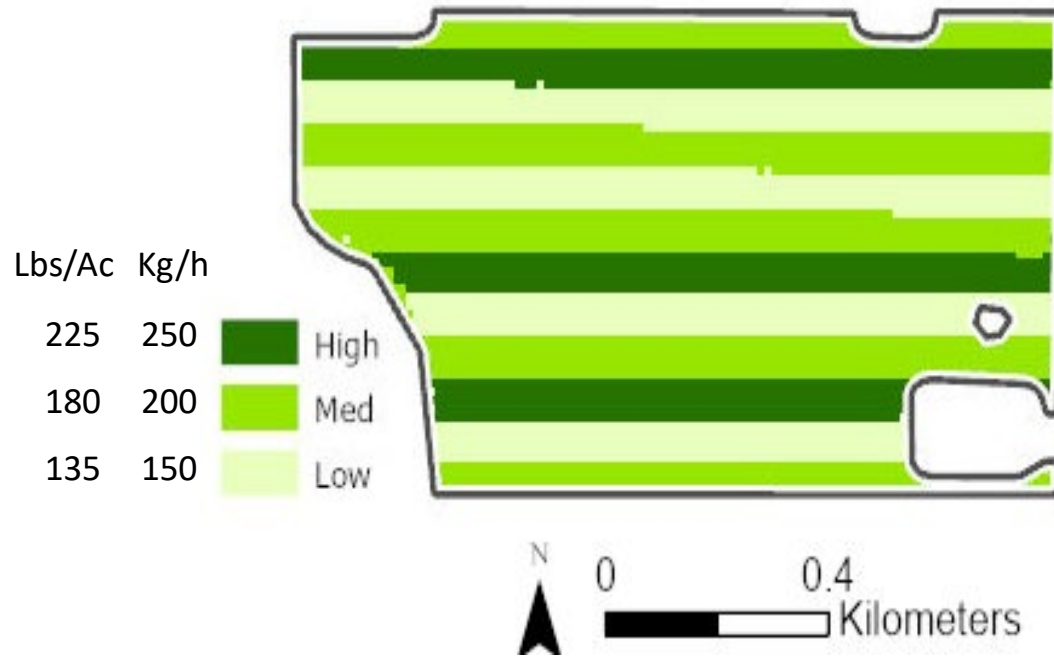
# On Field Precision Experimentation







Variable Rate Spring Wheat, May 15 2019



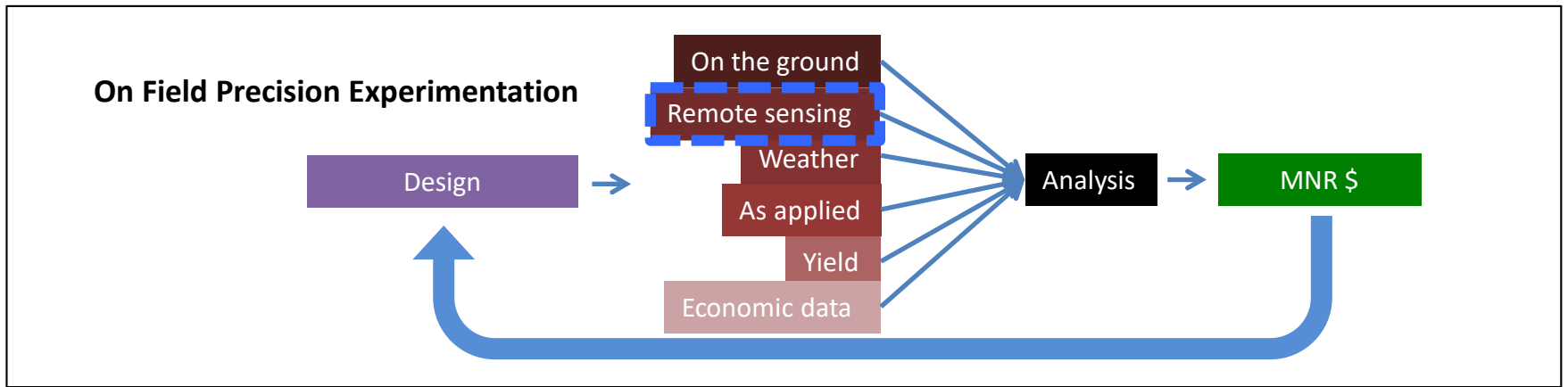
Field size: 71 hectares (175 acres)

Farmer: Sasha Loewen

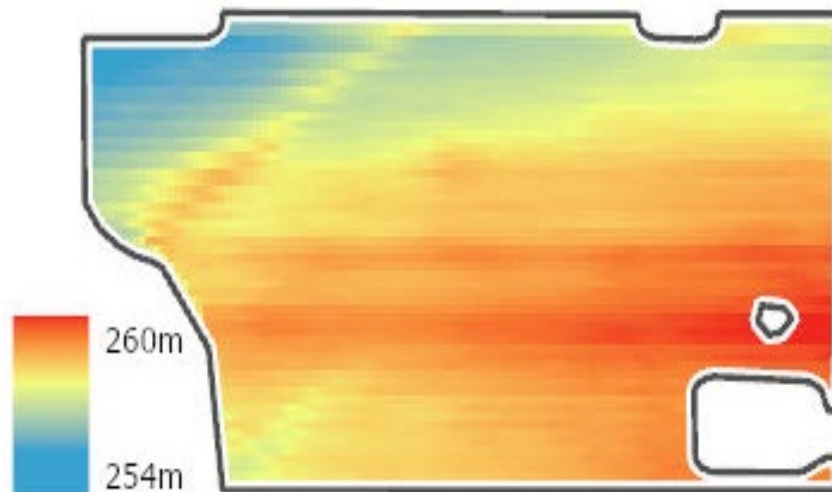
Location: South East Manitoba







Field elevation levels



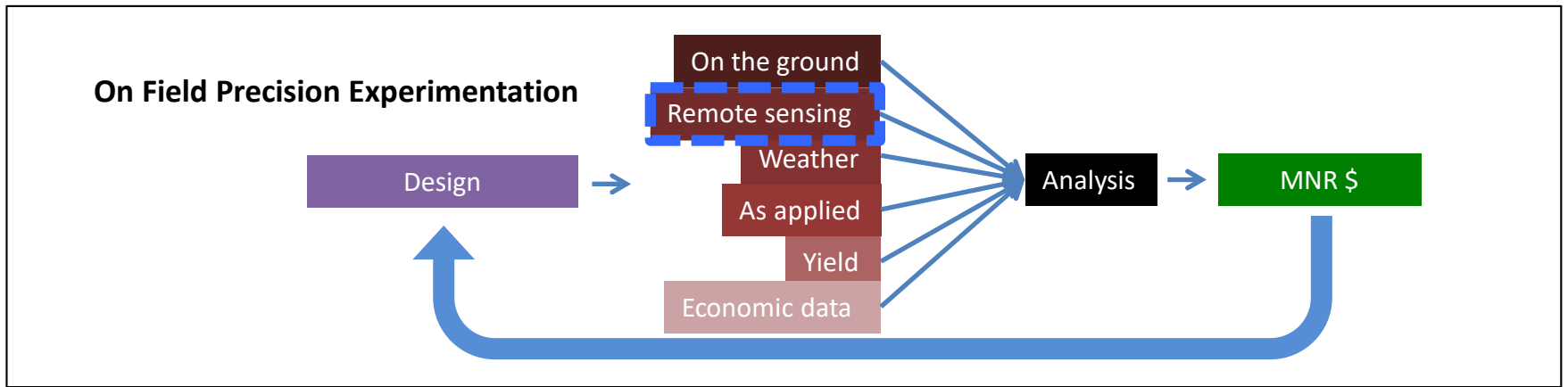
Field size: 71 hectares (175 acres)

Farmer: Sasha Loewen

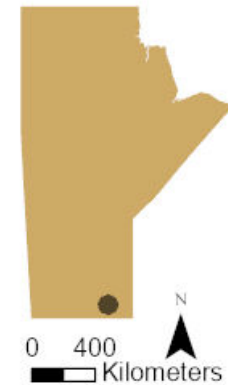
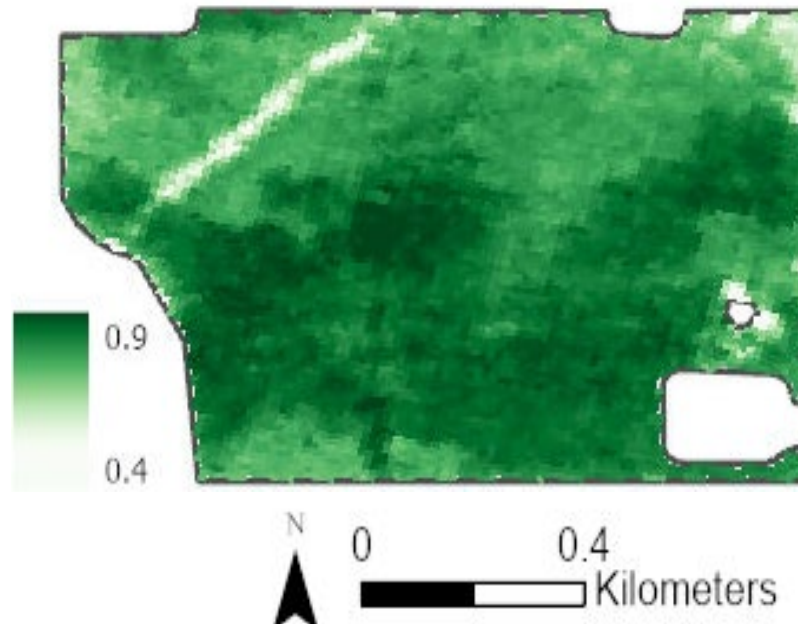
Location: South East Manitoba







NDVI from Sentinel 8 from oat crop 2017



Field size: 71  
hectares (175  
acres)

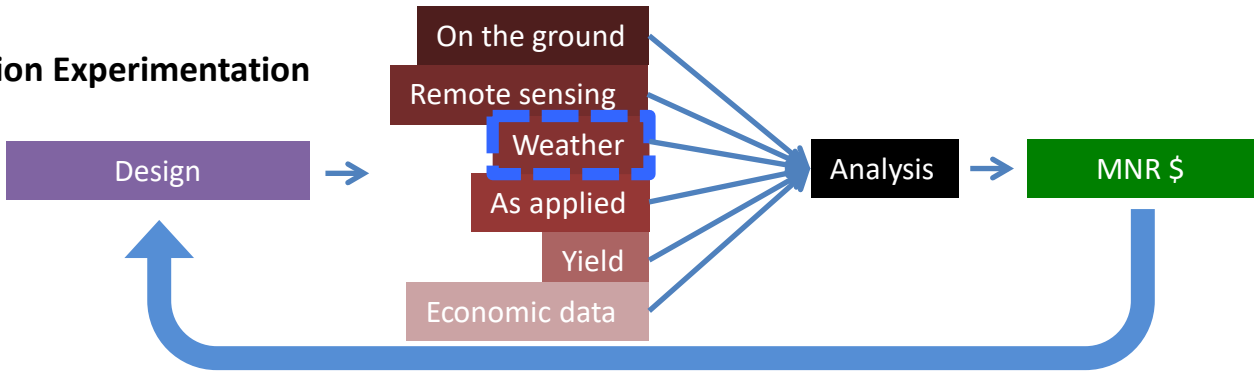
Farmer: Sasha  
Loewen

Location: South  
East Manitoba





# On Field Precision Experimentation

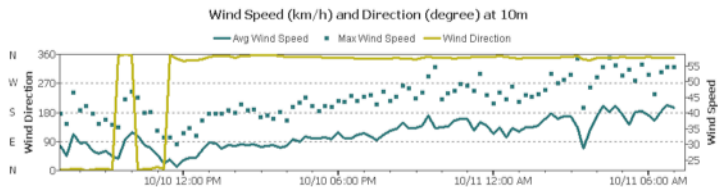
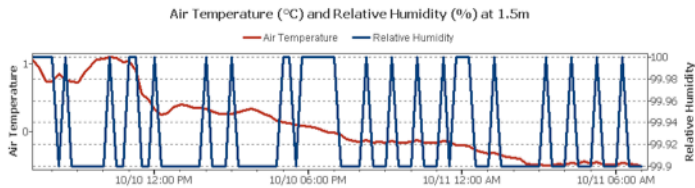


## Weather data from nearby weather stations

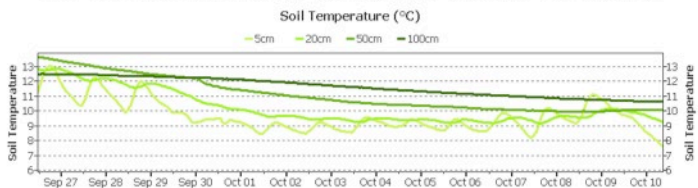
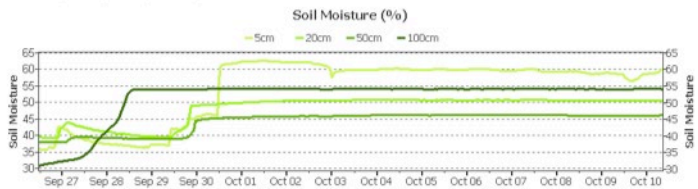
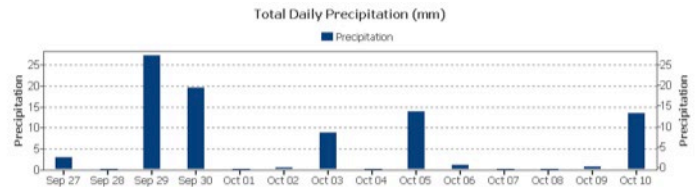
### Steinbach

07:00 AM Friday October 11, 2019  
Eastern Region | 49.5502, -96.6814

<b>Air Temperature</b> -0.5°C	<b>Precipitation</b> 0.2mm Last Hour	<b>2.9mm</b> Since Midnight	<b>Soil Temperature</b> 6°C 5cm	<b>Soil Moisture (VMC)</b> 61% 5cm
<b>Relative Humidity</b> 99.9%	<b>Average Wind Speed and Direction</b> 42km/h N		<b>8°C</b> 20cm	<b>51%</b> 20cm
<b>Dewpoint</b> -0.5°C	<b>Wind Gusts</b> 55km/h		<b>10°C</b> 50cm	<b>46%</b> 50cm
<b>Barometric Pressure</b> 1,005hPa			<b>11°C</b> 100cm	<b>54%</b> 100cm



Total Daily Precipitation (mm)

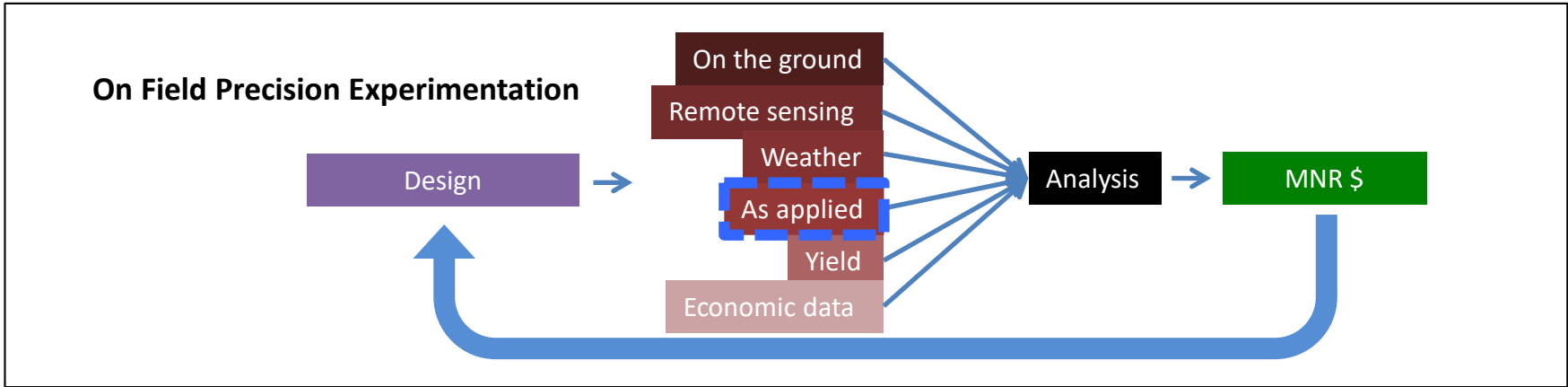


### Yesterday's Summary

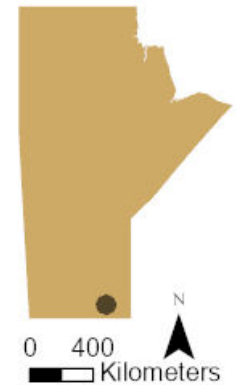
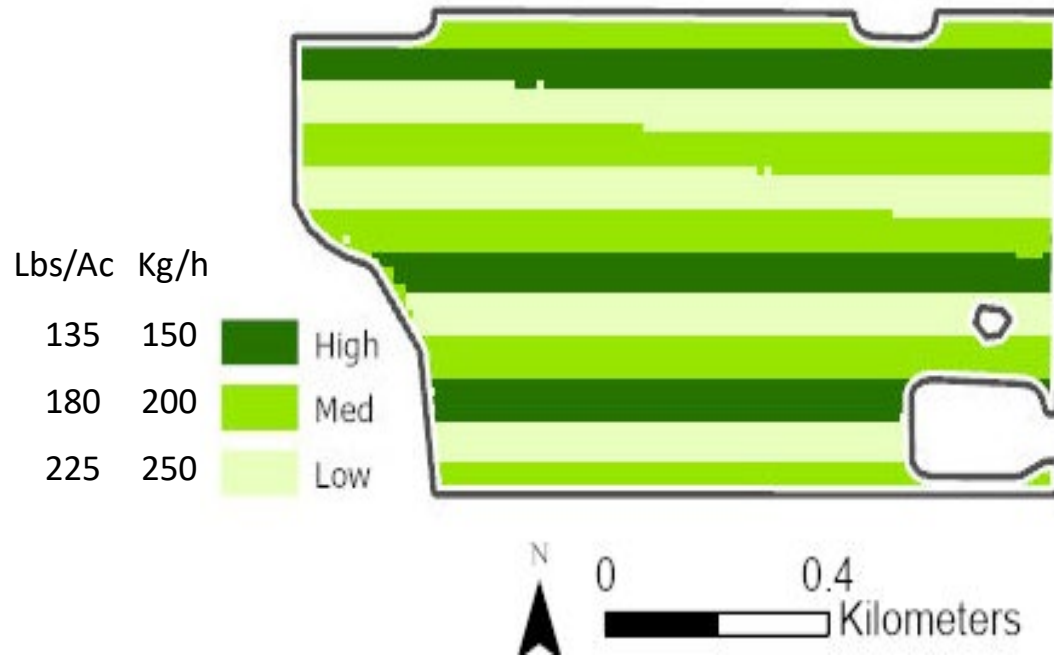
<b>Air Temperature (Min   Avg   Max)</b> 0°C   1°C   2°C	<b>Precipitation</b> 13.5 mm	<b>Evapotranspiration</b> 0.1 mm	<b>Avg Soil Temp (5 20 50 100cm)</b> 7°C   9°C   10°C   11°C
<b>Relative Humidity (Min   Avg   Max)</b> 99%   100%   100%	<b>Wind Speed (Avg   Max)</b> 31 km/h   55 km/h		<b>Avg Soil Moisture (5 20 50 100cm)</b> 60%   51%   46%   54%







As applied spring wheat seed rates, May 2019

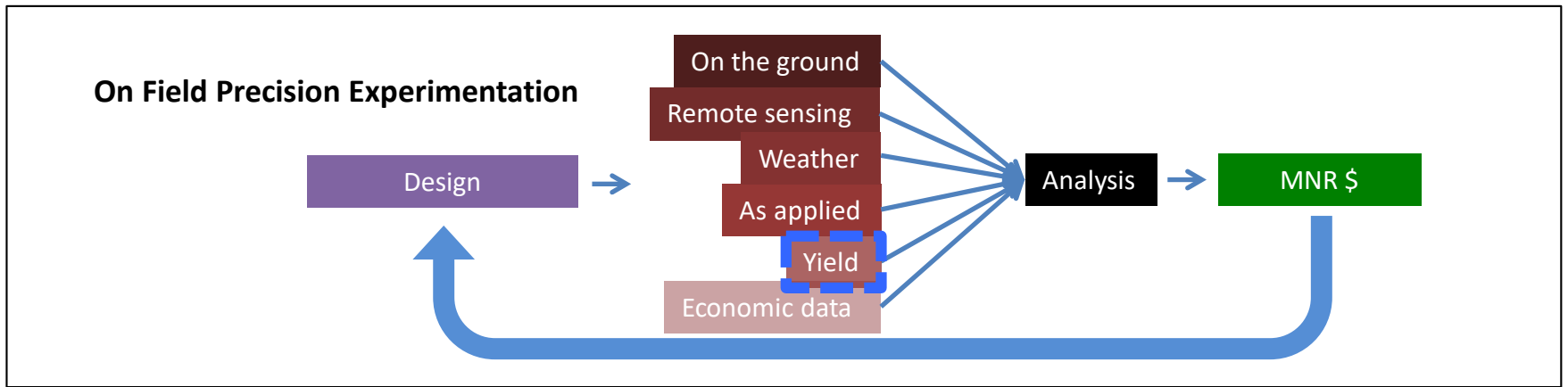


Field size: 71 hectares (175 acres)

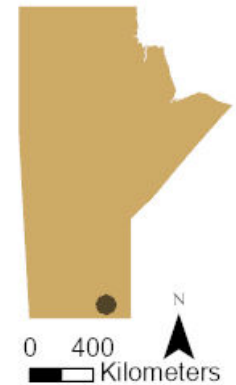
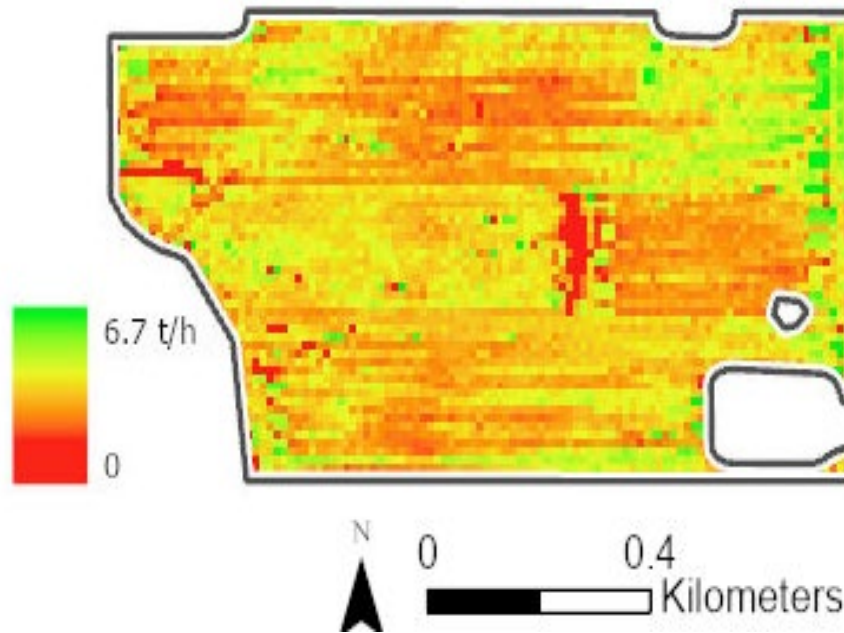
Farmer: Sasha Loewen

Location: South East Manitoba





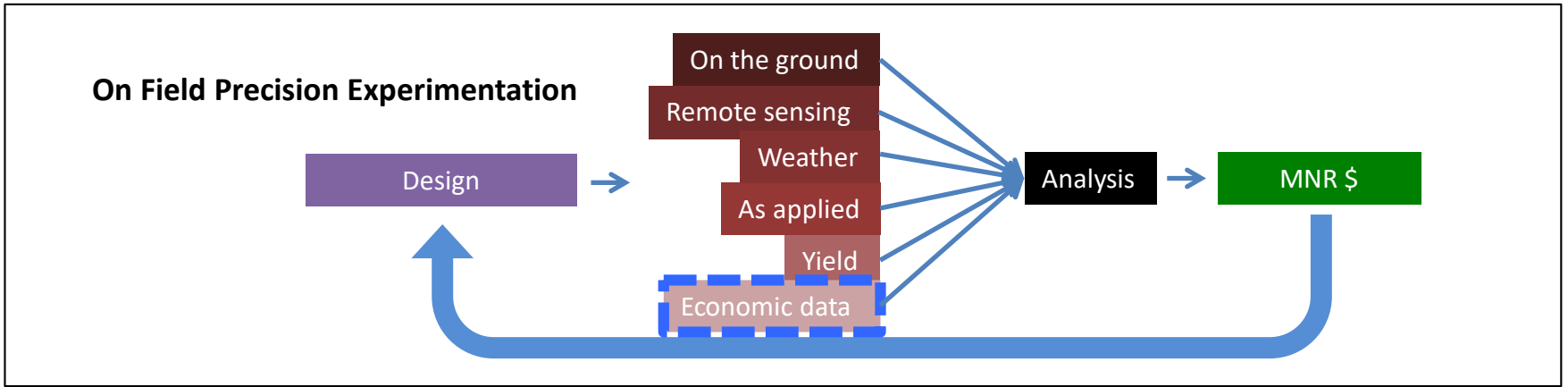
Combine monitor  
 yield results - SE  
 Manitoba field -  
 wheat harvested  
 Aug 15, 2019  
 field average:  
 3.01  
 tonnes/hectare  
 (44.8  
 bushels/acre)



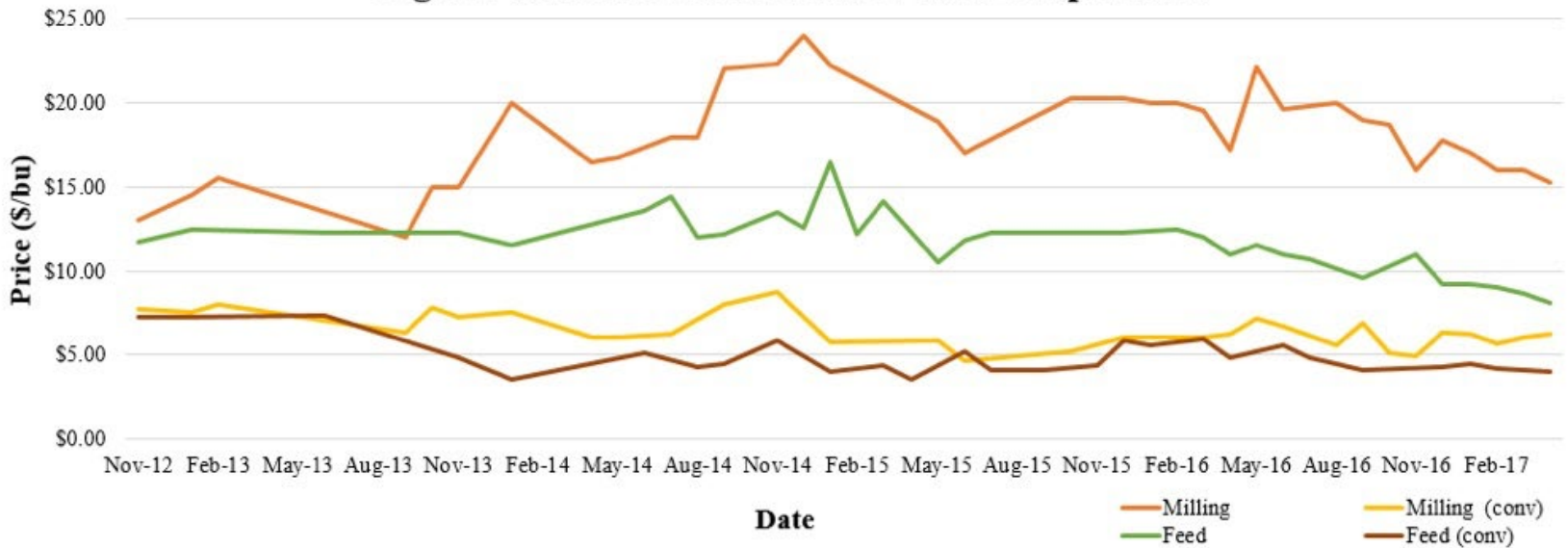
Field size: 71  
 hectares (175  
 acres)  
 Farmer: Sasha  
 Loewen  
 Location: South  
 East Manitoba







**Organic Wheat Prices: November 2012 to April 2017**



<https://organicbiz.ca/organic-grain-price-trends-over-time/>



# On Field Precision Experimentation

Design



On the ground

Remote sensing

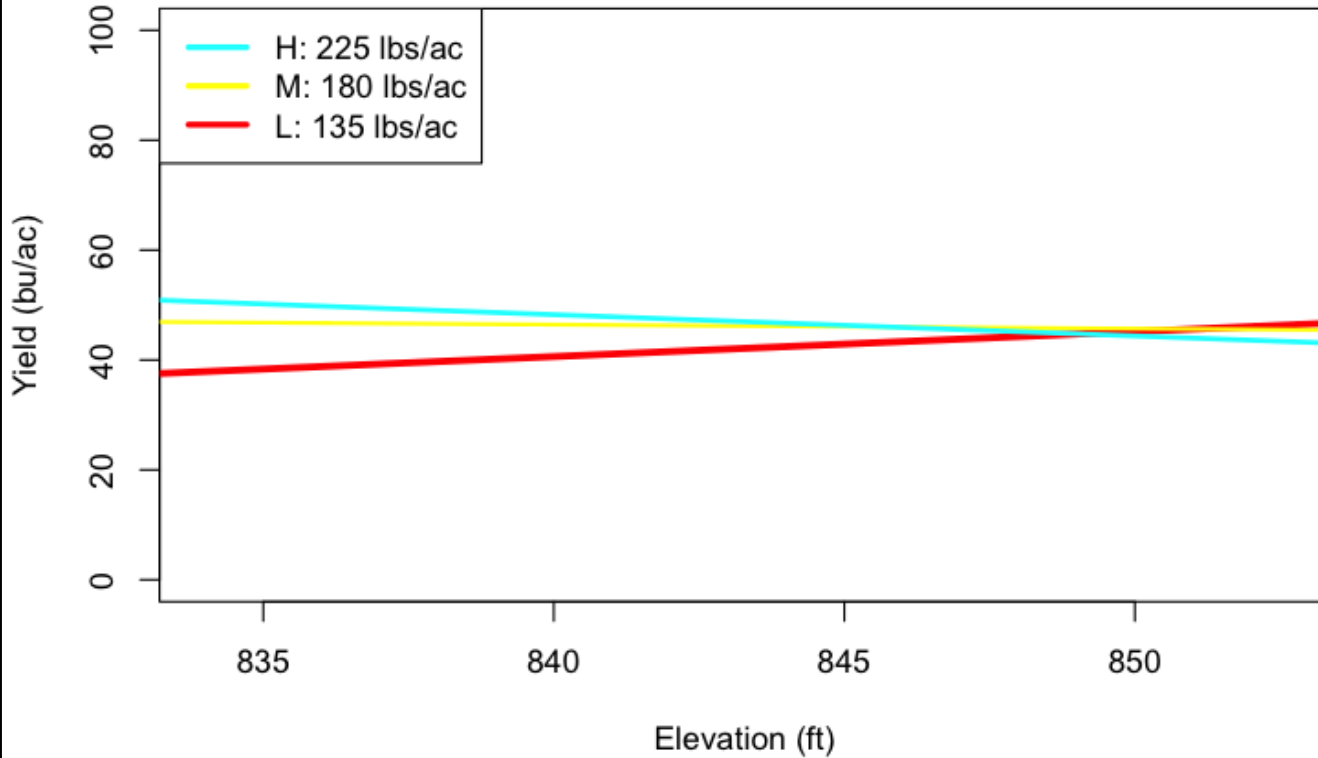
Weather

As applied

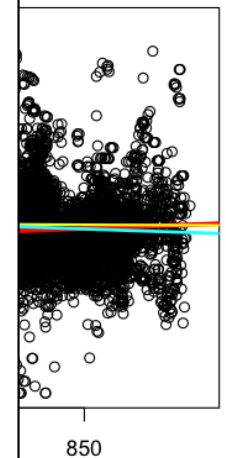
Analysis

MNR \$

## Yield as a function of three seeding rates and field elevation



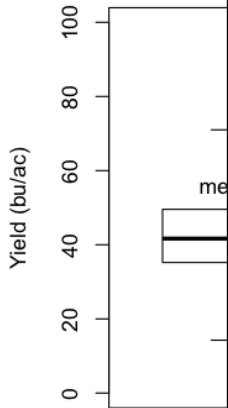
field elevation



0.0001

Med rate yield =  $108.5 - 0.074 \cdot \text{elevation}$ , p-value < 0.0001

High rate yield =  $374.5 - 0.388 \cdot \text{elevation}$ , p-value < 0.0001



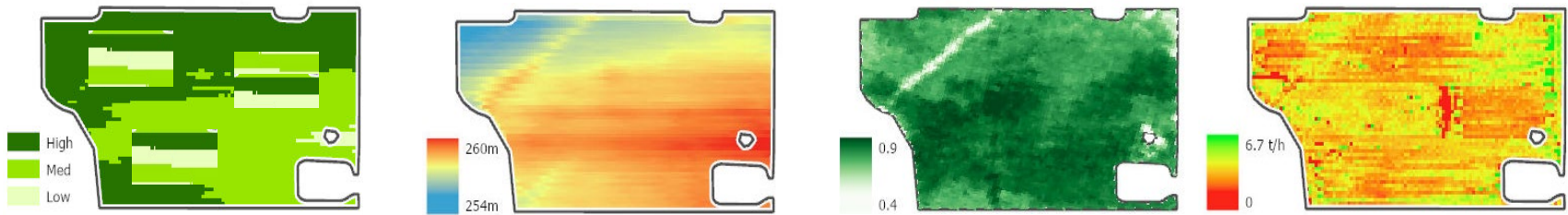
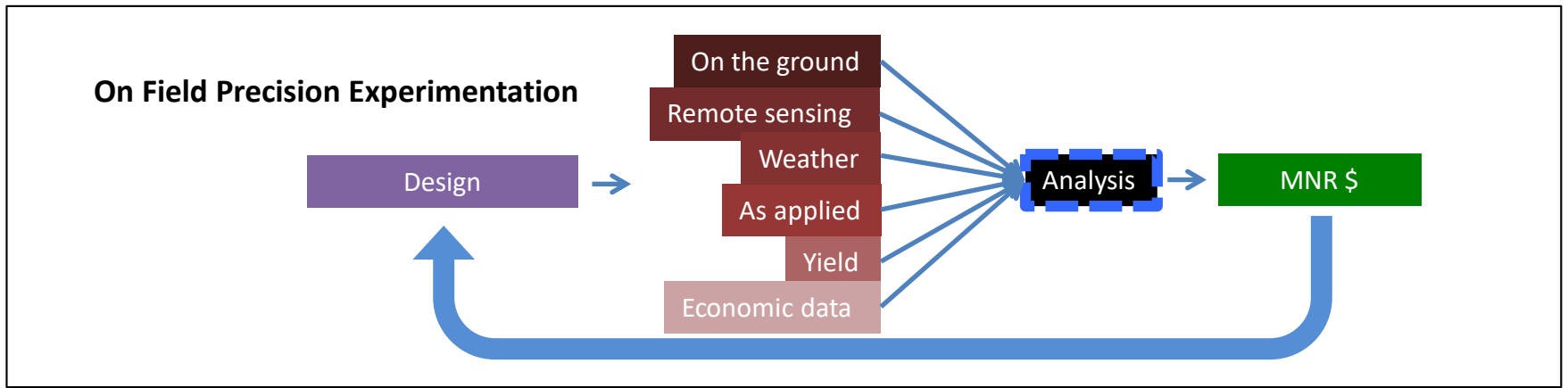
Tukey multiple comparison

Diff

Comparison	p-value
med-low	0.0000
high-low	0.0000
high-med	0.0002

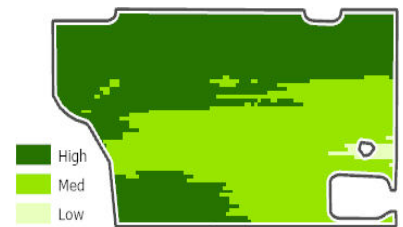




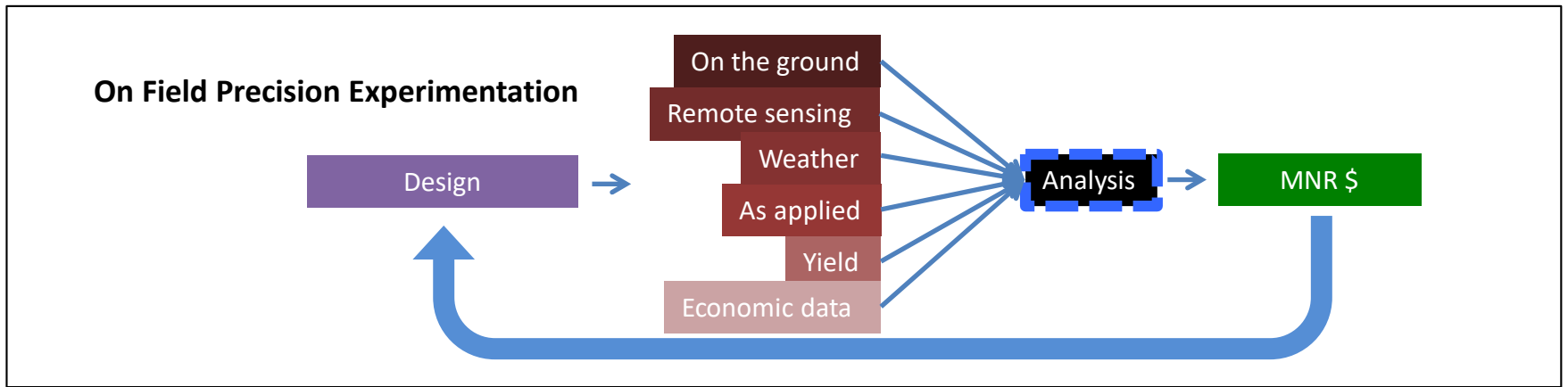


MLR:

$$\text{Seed Rate} * \text{Elevation} + \text{NDVI} = \text{Yield}$$

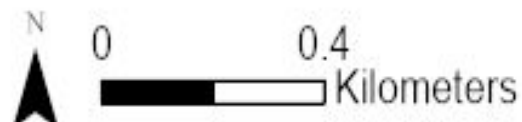


Optimize seeding rate for max net yield

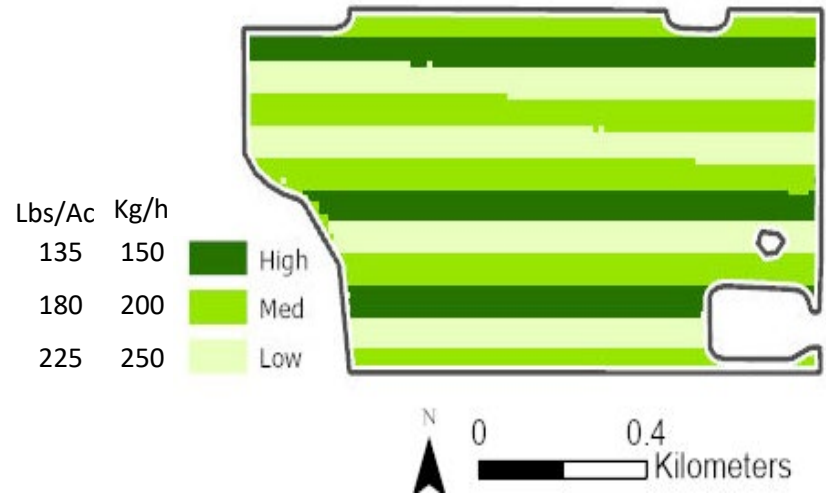
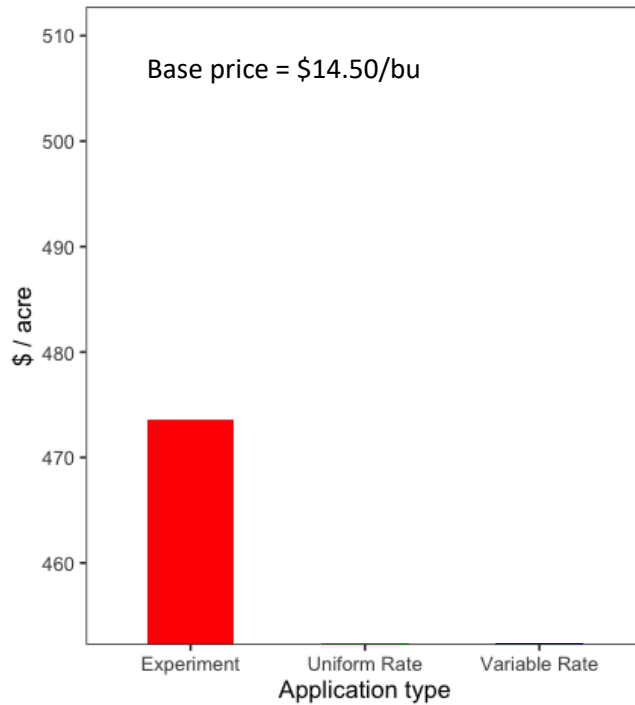
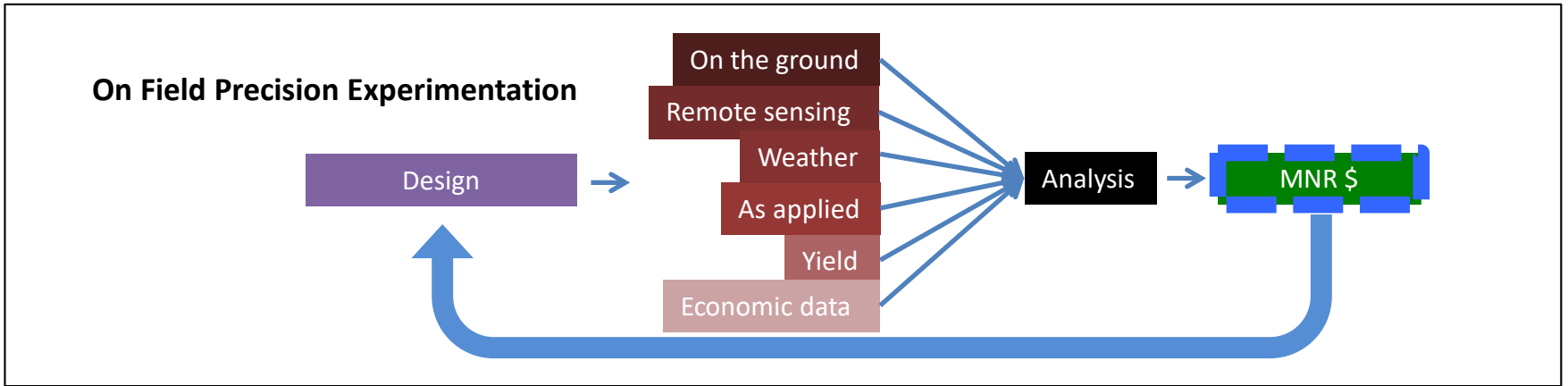


Original Design

New, more complex design

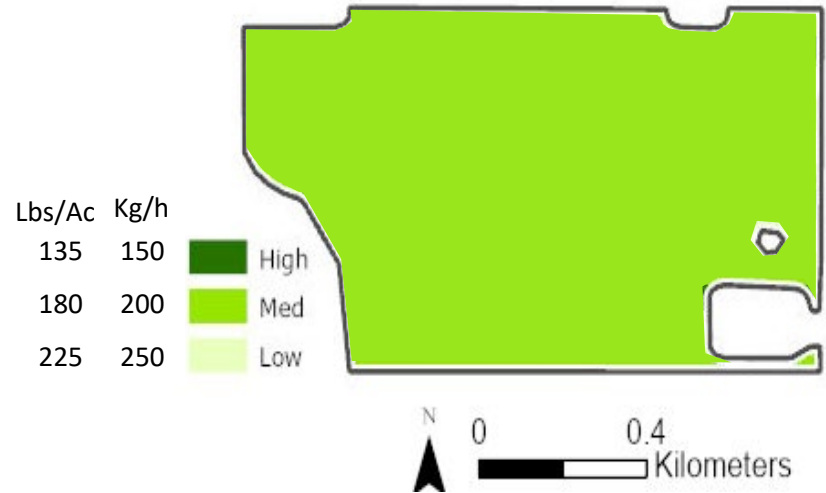
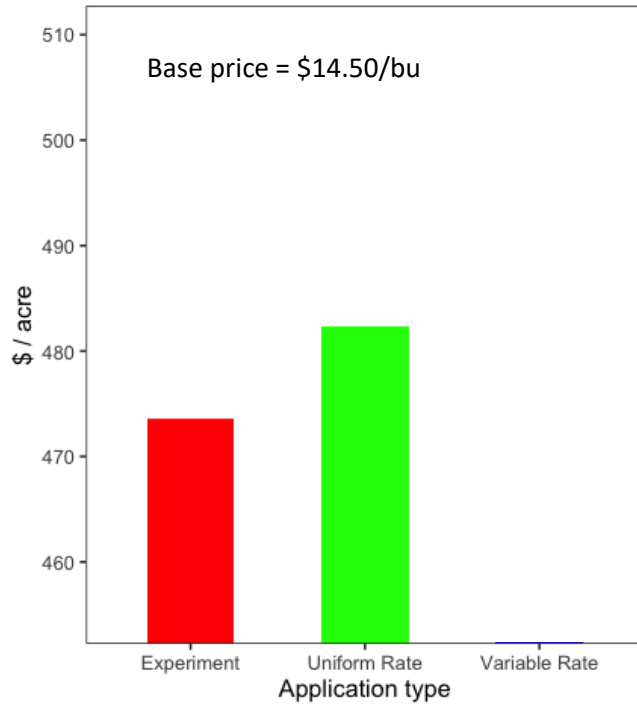
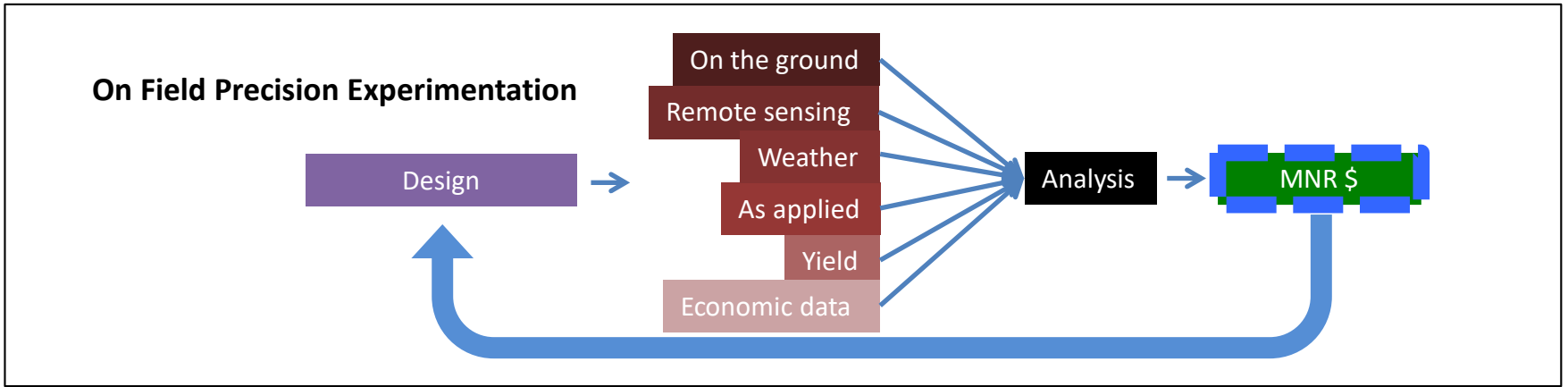






Cost and benefit of OFPE from Manitoba test site in net return per acre

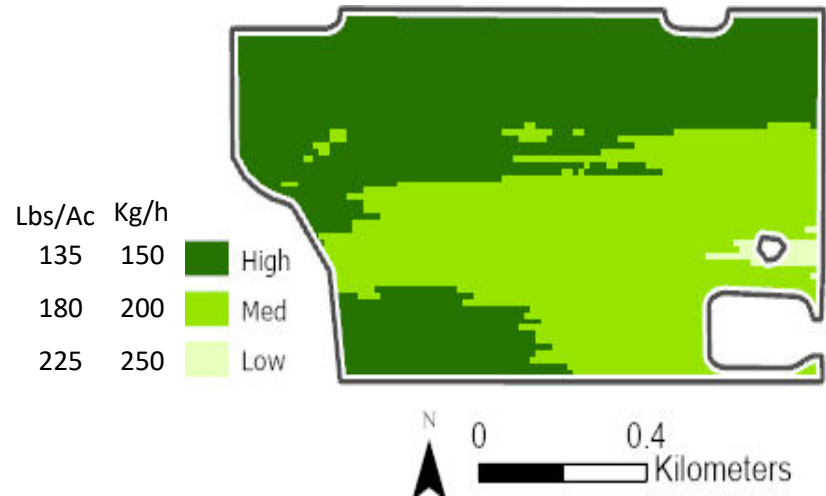
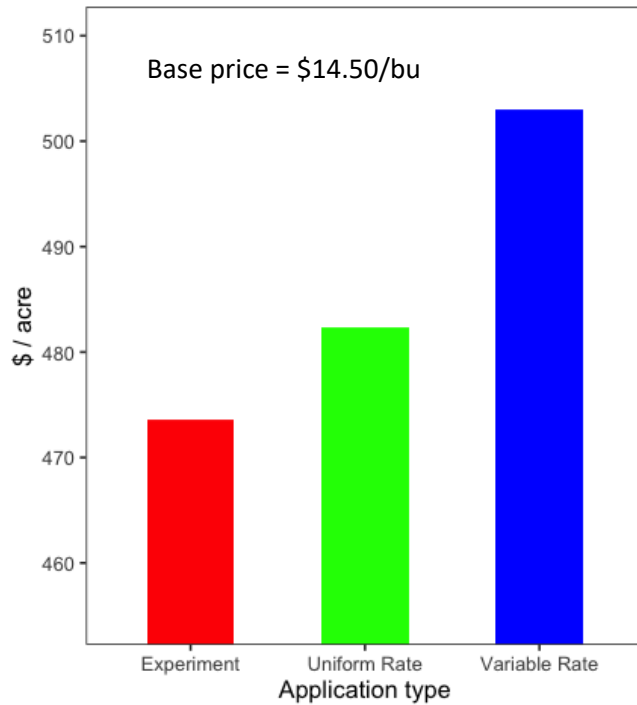
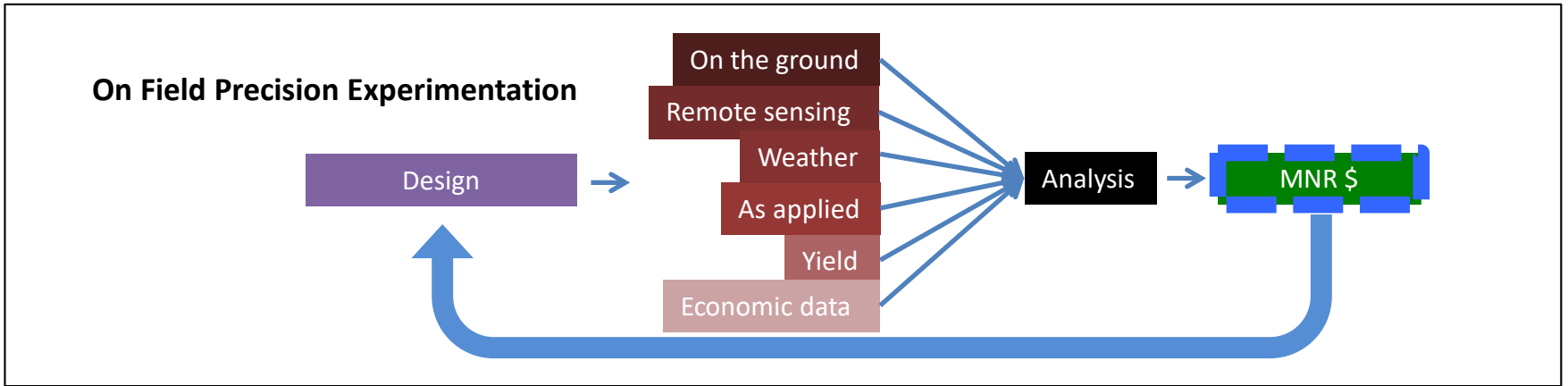




Cost and benefit of OFPE from Manitoba test site in net return per acre







Cost and benefit of OFPE from Manitoba test site in net return per acre





# Unique Organic Challenges

- Fertility
  - Green manure plowdowns





# Unique Organic Challenges

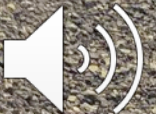
- Fertility
  - Green manure plowdowns
- Weeds
  - Map perennials





# Unique Organic Challenges


- Fertility
  - Green manure plowdowns
- Weeds
  - Map perennials
- Organic farmers skeptical of tech
  - Is PA worth it?






# Conclusion and Moving Forward

- Other inputs (manure?)
- Integrate satellite data, NDVI, Soil Moisture Active Passive (SMAP), Enhanced Vegetation Index (EVI)
- Develop complete program that can integrate weather, variable prices, to make predictions for ideal seed rates (build from conventional model)



### On-Farm Precision Experimentation Data Analysis and Simulation

Developed by the Agroecology Laboratory for the On-Farm Precision Experiments Project (OFPE) - Montana State University  
Please contact Paul Hegedus or Bruce Maxwell for citing product. Copyright Montana State University. Updated 2019/01/31.



This application allows the user to select a farmer and field to query available field-specific data for analysis and simulating net-return (NR) and as-applied (nitrogen or seeding rate) application outcomes from various N-management strategies under user selected predicted weather scenarios in the upcoming year. The OFPE database is queried for fields that are available for analysis from which the user can select one or multiple. For each field specified, the database is queried and the user selects the year or years to use to fit yield or protein models as a function of variable N-application rates and other open source covariates. This application allows the user to specify the characterization of crop response from the observed N-rates and other variables. Additionally, the user is able to run a simulation that randomly selects from economic data gathered for the past 16 years to compare the average net-returns (NR) per acre and total as-applied rates for a site-specific optimized as-applied rate approach (SSOPT), a full-field optimized uniform as-applied rate (FFOPT), the farmer selected uniform as-applied rate (FS), zero rates across the field (N0SR0), and the net-return with zero nitrogen applied and organic prices received (Org). The user can select what they think the upcoming climate will be to compare N-management outcomes under their predicted weather scenario.

Database Connection	Select Field Specific Inputs	Select Data	Select years for each field and response variable from which to get data.
<b>Port Number</b> <input type="text" value="5432"/>	<b>Field size in acres.</b> <input type="text" value="427"/>	<b>Select farmer to get data from.</b> <input type="text" value="broyles"/>	<input type="button" value="Select Years"/>
<b>Host</b> <input type="text" value="127.0.0.1"/>	<b>Cost for applying site-specific technology per acre.</b> <input type="text" value="4"/>	<b>Select response variables to use for optimization.</b> <input type="button" value="Yield Protein"/>	<b>Select years to get yield from sec1east</b> <input type="text" value="2019 2017"/>
<b>User</b> <input type="text" value="postgres"/>	<b>Fixed costs per acre.</b> <input type="text" value="71.31"/>	<b>Select field(s) to analyze and simulate field-specific responses.</b> <input type="text" value="secteast sectwest"/>	<b>Select years to get protein from sec1east</b> <input type="text" value="2019 2017"/>
<b>Password</b> <input type="text" value="Ph210220"/>	<b>Farmer selected uniform rate (lbs/ac) that would be applied if no experiment was performed.</b> <input type="text" value="70"/>	<b>Select the experimental variable to optimize rates on, based on maximizing the response variable(s).</b> <input type="text" value="As-Applied Nitrogen"/>	<b>Select years to get yield from sec1west</b> <input type="text" value="2019 2016"/>
<b>Database Name</b> <input type="text" value="OFPE"/>	<b>Maximum as-applied rate (lbs/ac) to simulate responses up to.</b> <input type="text" value="150"/>	<b>Select function to use.</b> <input type="text" value="Non-Linear Logistic"/>	<b>Select years to get protein from sec1west</b> <input type="text" value="2019 2016"/>
<input type="button" value="Connect to Database"/>			<input type="button" value="Gather Data"/>

Gather the selected data from the database for analysis and simulation.





Thank you!

Advisor – Bruce Maxwell

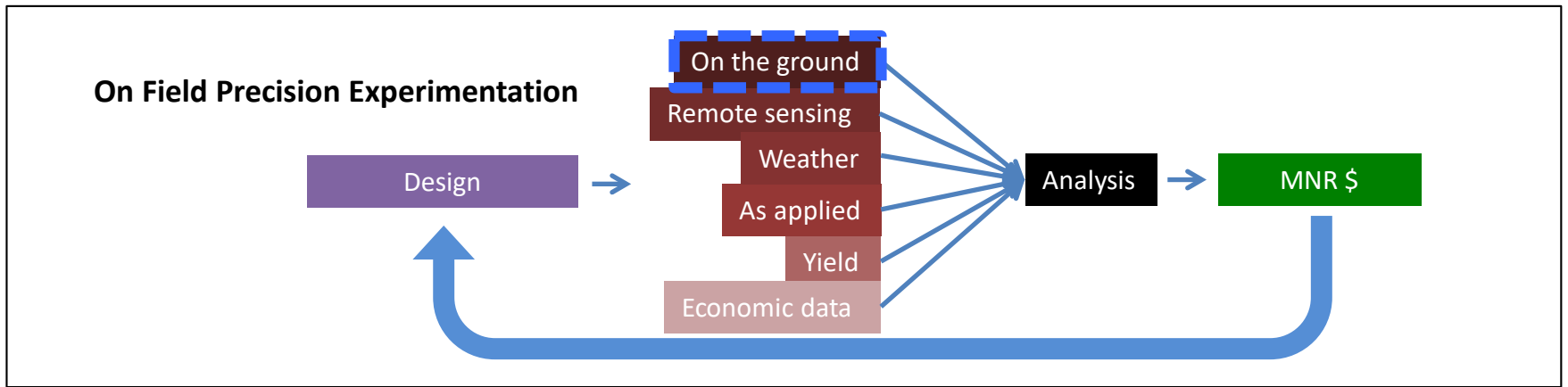
Lab mates – Hannah Duff, Paul Hegedus, Tommy Bass,  
Braedon Lineman, Lexi Emeny, Madison Boone

Farmers: Bob Quinn, Ole Norgaard, Casey Bailey, Ty  
OConnor, Roy Loewen

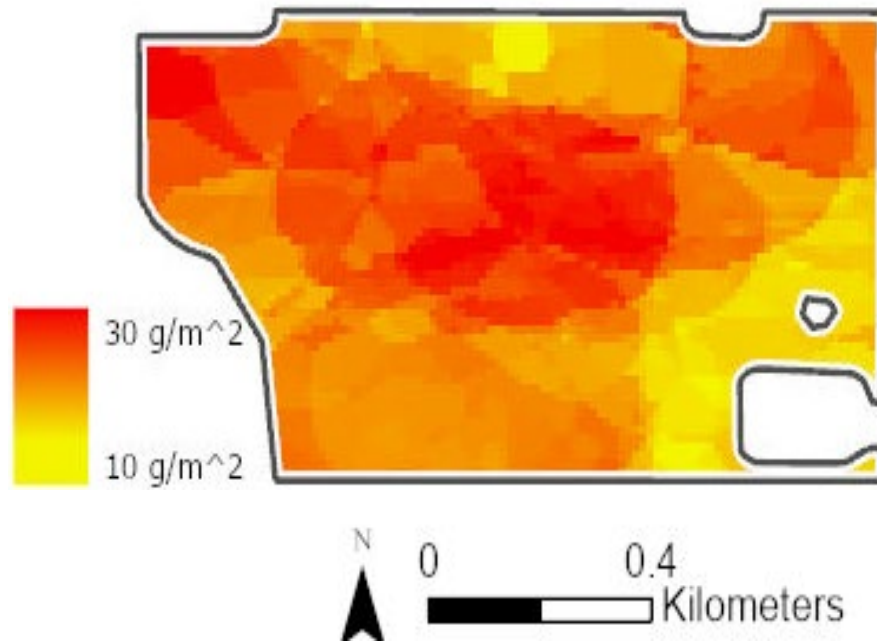
Funding: Western SARE, Montana Academy of Sciences

Questions?





Estimated weed densities, June 15, 2019



Field size: 71  
hectares (175  
acres)

Farmer: Sasha  
Loewen

Location: South  
East Manitoba





# OFPE - introduction

- Farmer driven as far as possible
- Experiments field scale
- Conventional machinery
- Analysis provides insight to treatment effect and causes of variation

(adapted from Cook et al., 2018)

