Natural Science methods

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IAI-PDS-Transdisciplinary approaches to integrating science and policy for sustainability

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Transdisciplinary approaches

communication

understanding

disciplinary

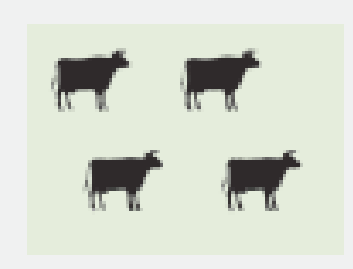
methods,
assumptions,
paradigms

“Our” approach

- Problem or Question
- Hypothesis or possible answer
- Design an experiment
- Collect data, measure variables
- Analyze data (statistics)
- Reject hypothesis (or not)
- Generalization
- Modeling

Example of experiment

- What is the effect of livestock grazing management on animal productivity?



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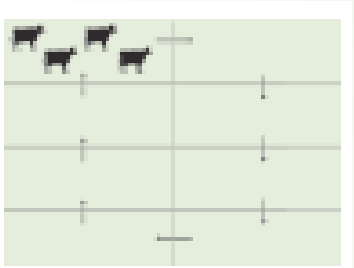


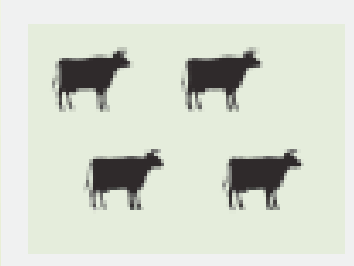
- Hypotheses:
  - Rotational grazing produces more forage than continuous grazing
  - Rotational grazing produces more meat than continuous grazing

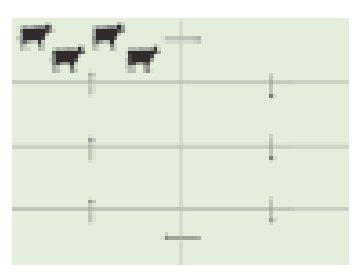
Experimental design

- Treatments (independent variable)
- Response (dependent variable)
- Experimental unit (plot)
- Error (not controlled variables)

Example of experiment

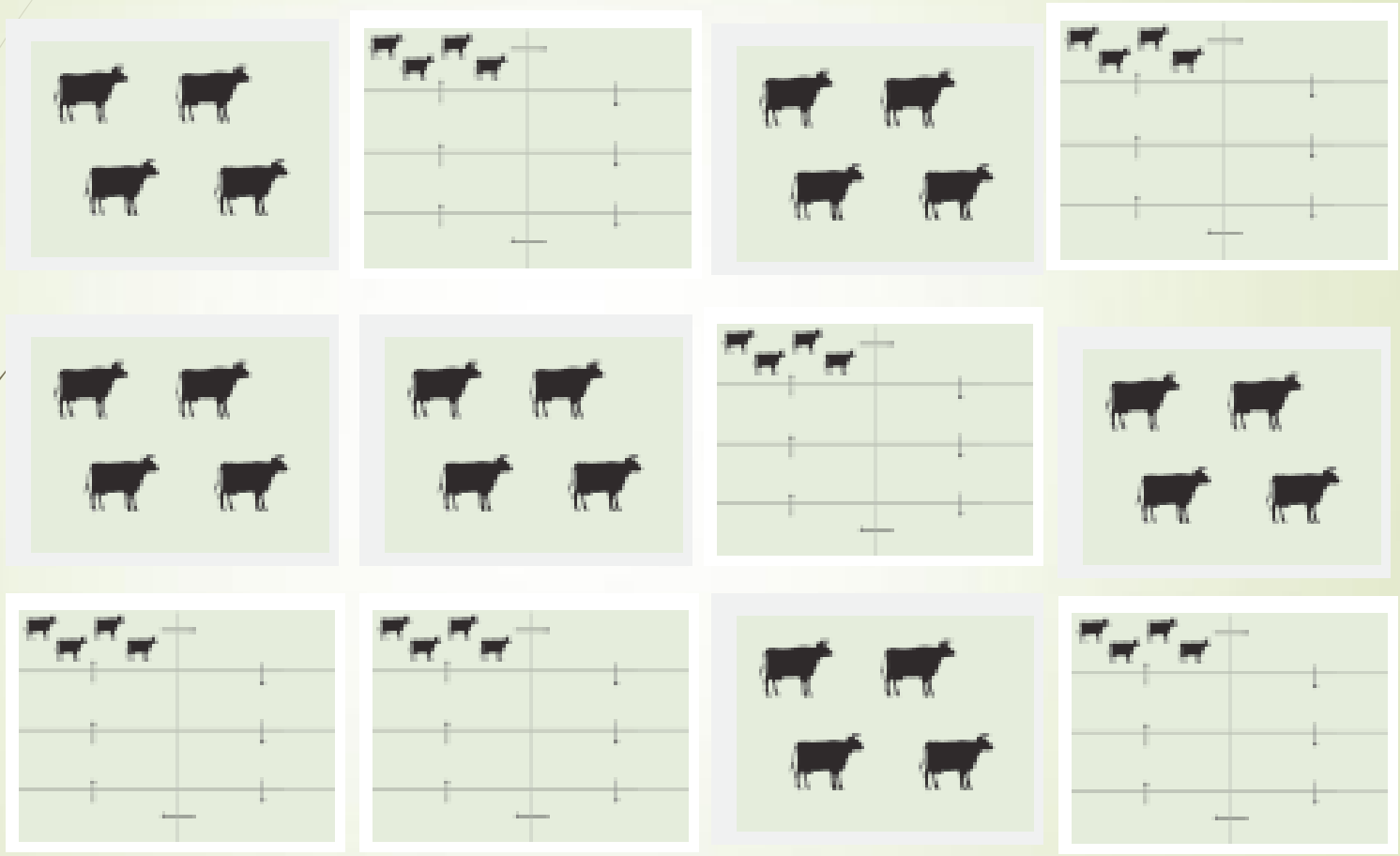
- What is the effect of livestock grazing management on animal productivity?
- Treatments: continuous vs rotational grazing
- Response: animal productivity
- Experimental unit: paddock



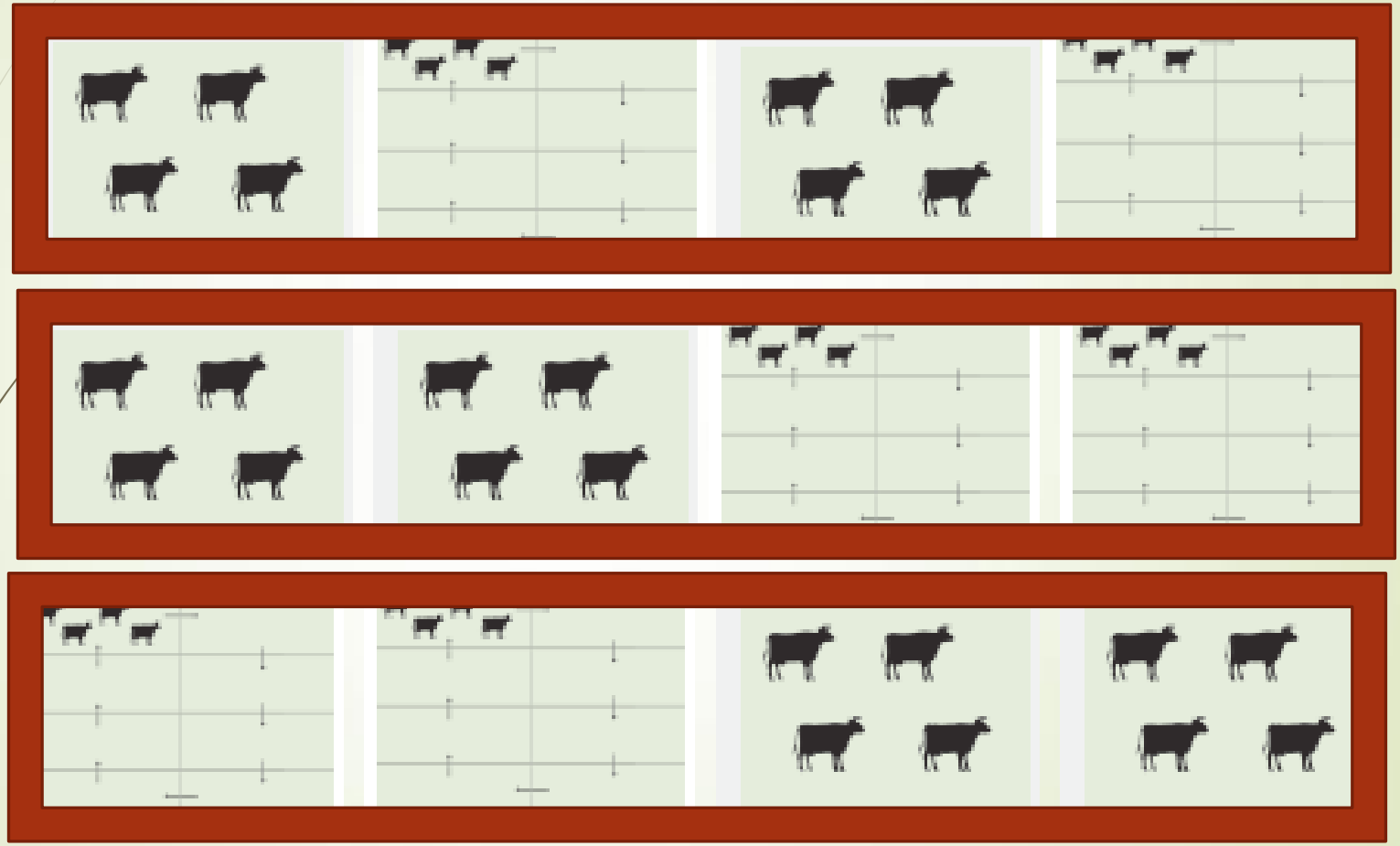


Principle 1: Replication

Principle 2: Randomization



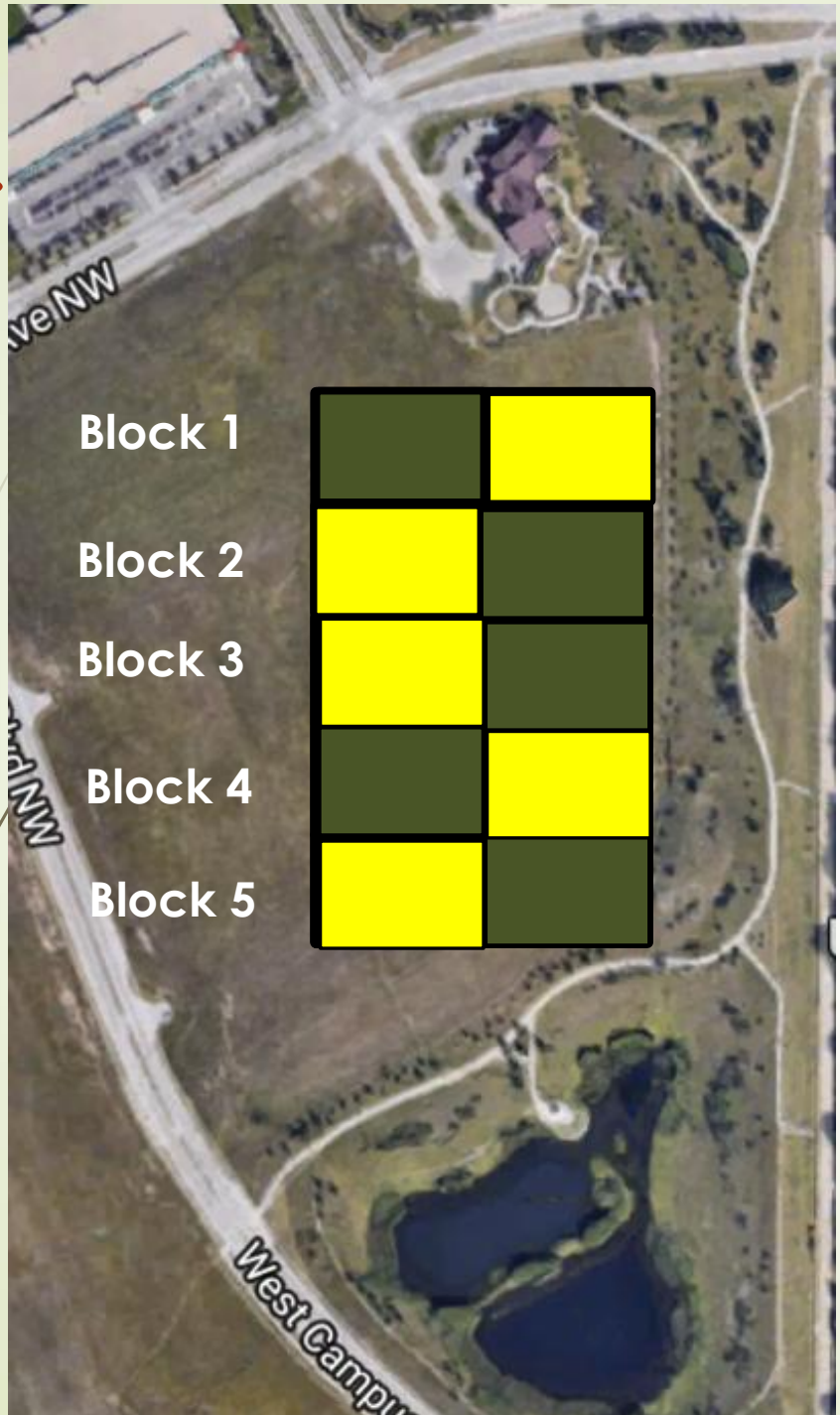
Principle 3: Local control



Principles of experimental design

- By Sir. R. A. Fisher:
  - Replication (measure error)
  - Randomization (independent errors)
  - Local control of variation/blocking (reduce error)

1935



Experimental design

- 2 treatments
- 10 plots
- 5 blocks based on soils and slope of field
- Treatments randomly assigned to plots in each block (Completely randomized block design)

Collect data

Plot	Block	Treatment	Forage kg/ha	Meat kg/ha
1	1	Continuous	1200	50
2	1	Rotational	2000	100
3	2	Rotational	1800	70
4	2	Continuous	1300	60
5	3	Rotational	2200	90
6	3	Continuous	1400	80
7	4	Continuous	1000	60
8	4	Rotational	2100	80
9	5	Rotational	1900	60
10	5	Continuous	1100	70

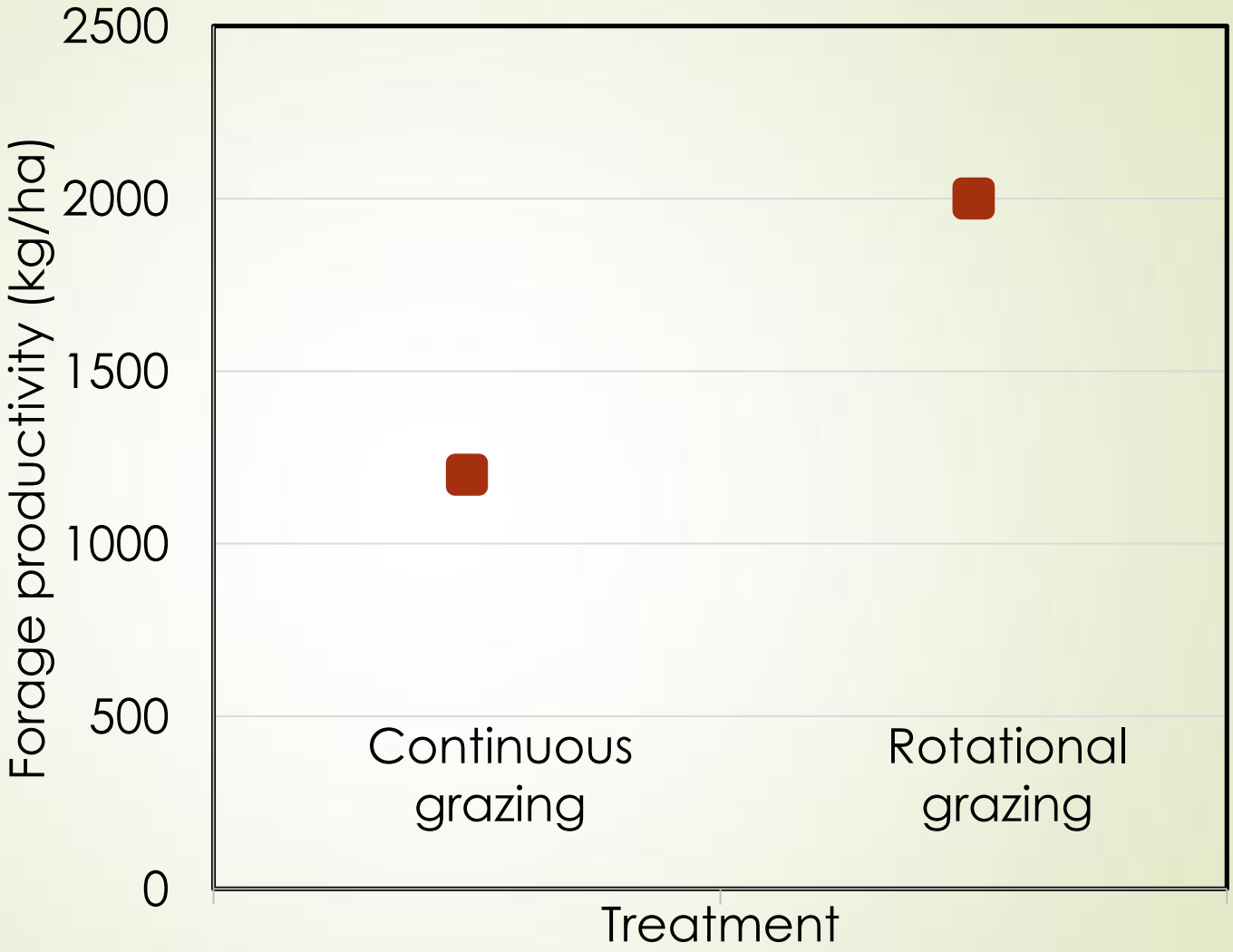
Analyze data (Statistics)

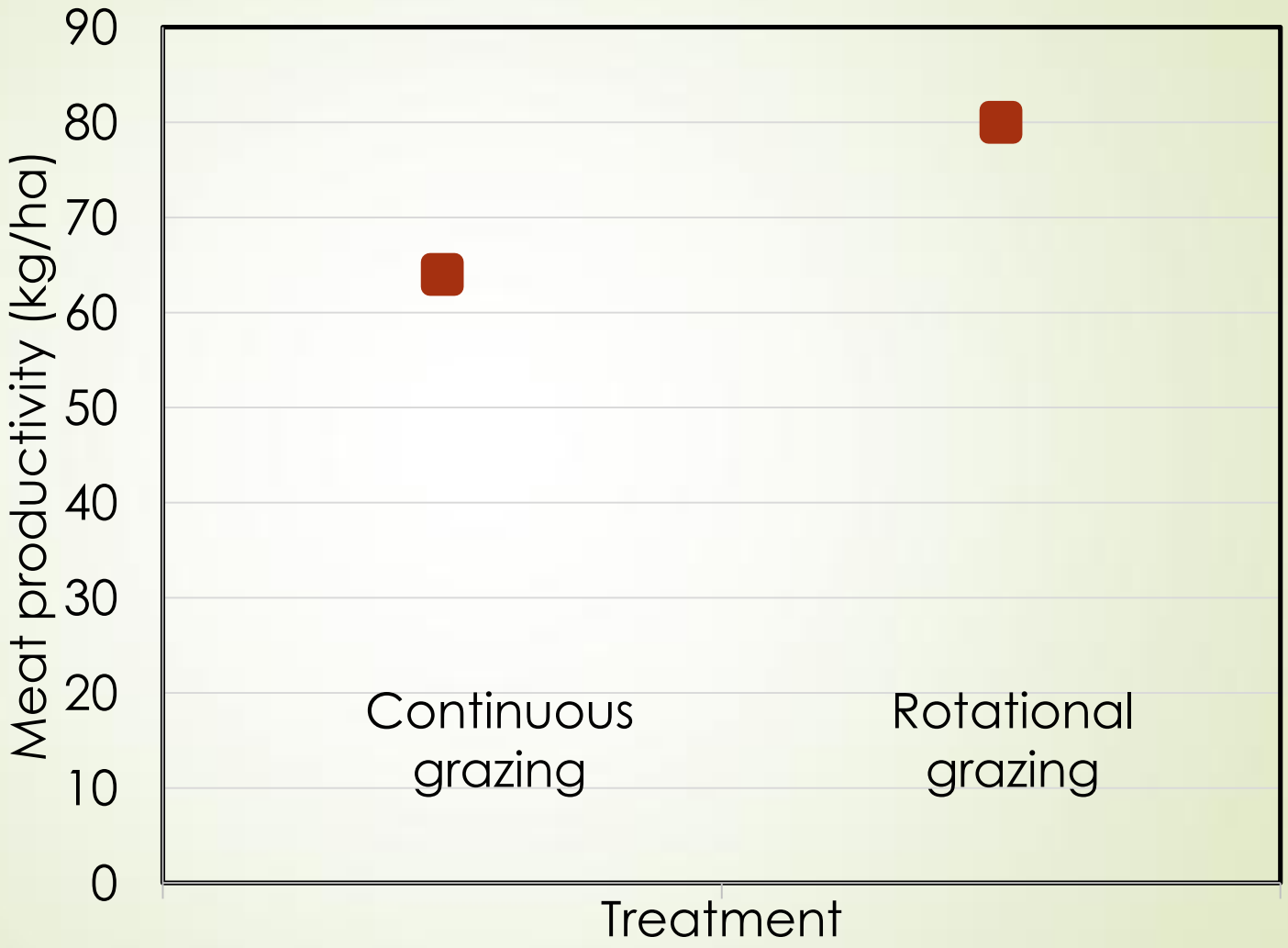
	Forage (kg/ha)		Meat (kg/ha)	
	Continuous	Rotational	Continuous	Rotational
Mean	1200	2000	64	80
Minimum	1000	1800	50	60
Maximum	1400	2200	80	100
St. Deviation	158	158	11	16

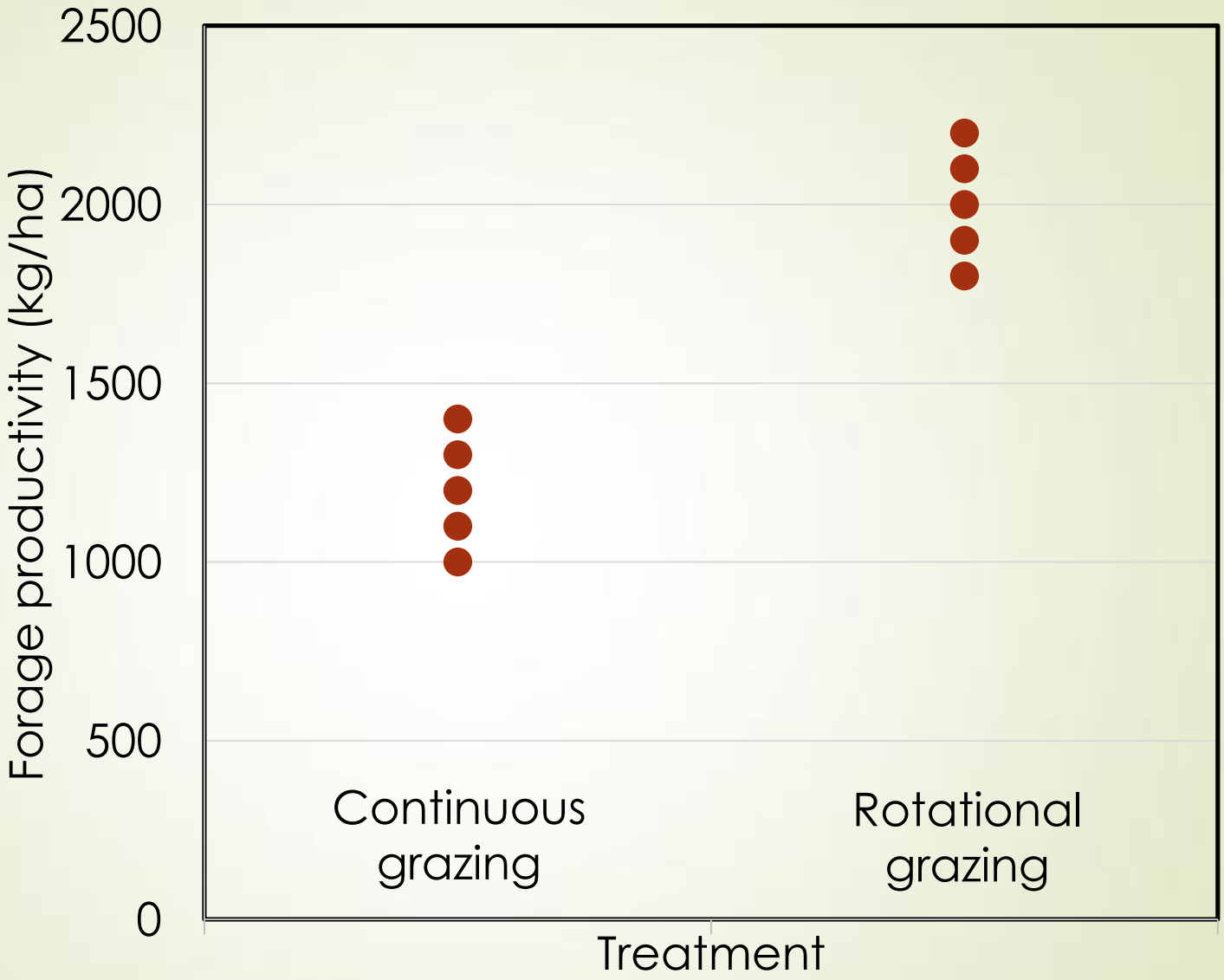
Are there differences between treatments?

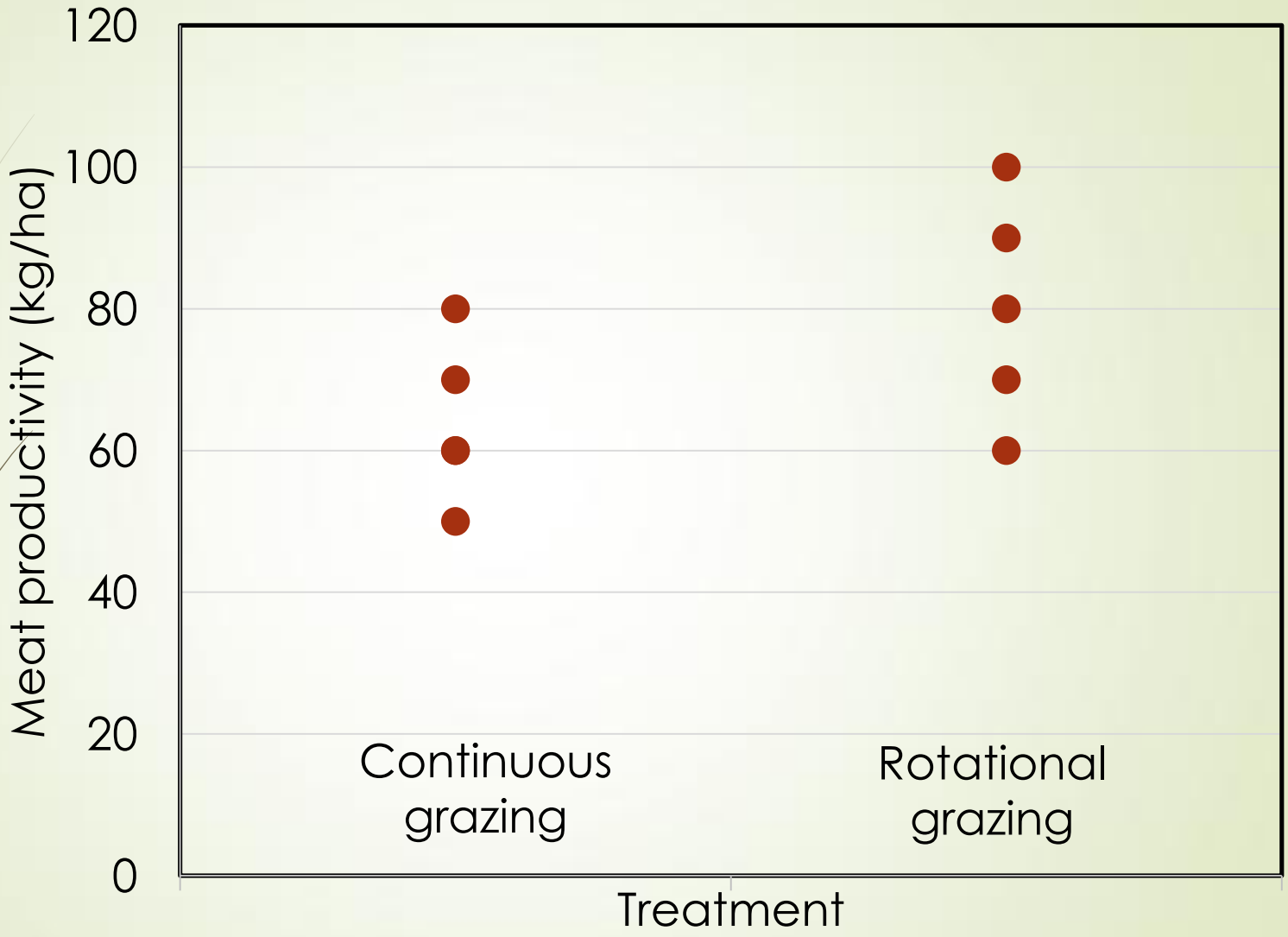
Statistical Analysis

- ANOVA: Analysis of Variance
- How much is the variability due to the treatments?
- How much is the variability due to error?
- Is the variability due to treatments large enough to be considered significant?


2500
2000
1500
1000
500
0
Forage productivity (kg/ha)
Continuous grazing
Rotational grazing
Treatment


90
80
70
60
50
40
30
20
10
0
Meat productivity (kg/ha)
Continuous grazing
Rotational grazing
Treatment


2500
2000
1500
1000
500
0
Forage productivity (kg/ha)
Continuous grazing
Rotational grazing
Treatment


120
100
80
60
40
20
0
Meat productivity (kg/ha)
Continuous grazing
Rotational grazing
Treatment

Analyze data (Statistics)

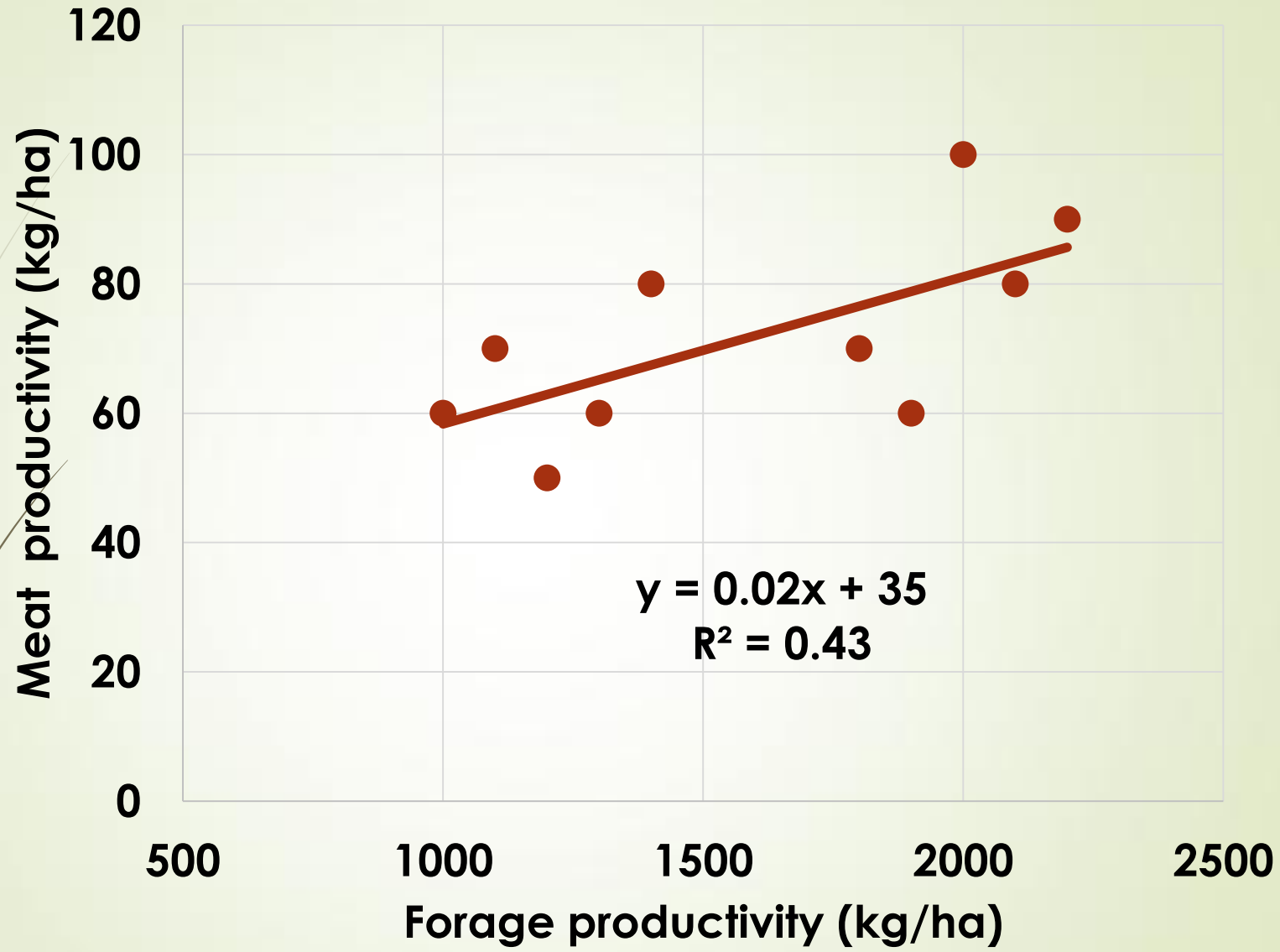
	Forage (kg/ha)		Animal (kg/ha)	
	Continuous	Rotational	Continuous	Rotational
Mean	1200	2000	64	80
St. Deviation	b	a	A	A

Hypotheses:

- Rotational grazing produces more forage than continuous grazing – YES
- Rotational grazing produces more meat than continuous grazing – NO

Analysis: are two variables associated?

- Correlation: linear association between 2 variables
- Regression: equation that describes the change in one variable due to another one
- Linear equation vs other models


120
100
80
60
40
20
0
Meat productivity (kg/ha)
y = 0.02x + 35
R² = 0.43
500
1000
1500
2000
2500
Forage productivity (kg/ha)

Epistemology

- Empiricism
- Positivism
- Cause-effect relationships
- Reductionist / Analytical: breaking reality in pieces
- Repeatability (always happens the same)
- Objectivity (anyone gets same results)
- Hypothesis: a guide meant to be rejected
- Paradigms (Kuhn)
- Modeling (integration)
- Emergent properties? Interactions?

Thank you!

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GPS Project: Grasslands + People + Sustainability

- Funding: Roundtable for Sustainable Calgary

- Grasslands are cool, threatened, forgotten, etc.
- People in Calgary care about sustainability, etc.
- Livestock management may be a key driver for sustainability

GPS Project: Grasslands + People + Sustainability

- Goal: To improve sustainability of livestock systems in grasslands, through scientific knowledge and policy recommendations

- Our research question is: What makes livestock systems sustainable in Calgary?

- Transdisciplinary team:
  - Social scientists,
  - Natural scientists,
  - Local citizens and
  - policy makers

Interviews – Social Science

- 6 general public
- 2 environmentalists
- 2 policy makers
- 2 ranchers

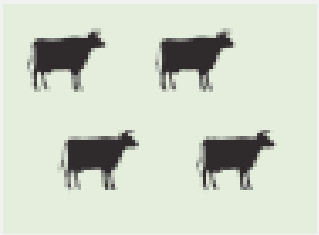
- 5 groups of 4 participants
- One pair per group interviews general public, the other pair interviews stakeholders
- Each pair is doing 6 interviews of 10 minutes
- Each group makes 12 interviews

Agronomic experiment - Natural Science

- University of Calgary Bear Field Research Station
- Compare 2 livestock grazing management strategies:
  - Current system: continuous grazing
  - Alternative system: rotational grazing

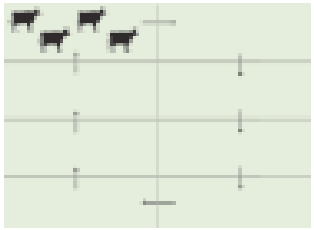
CONTINUOUS GRAZING*

- one pasture system
- livestock have unrestricted access throughout the grazing season
- livestock do not move out of the field for most, if not all, of the grazing season



INTENSIVE ROTATIONAL GRAZING

- many pastures, usually eight or more, sometimes referred to as paddocks
- livestock are moved frequently based on forage growth and utilization
- multiple passes through each paddock possible

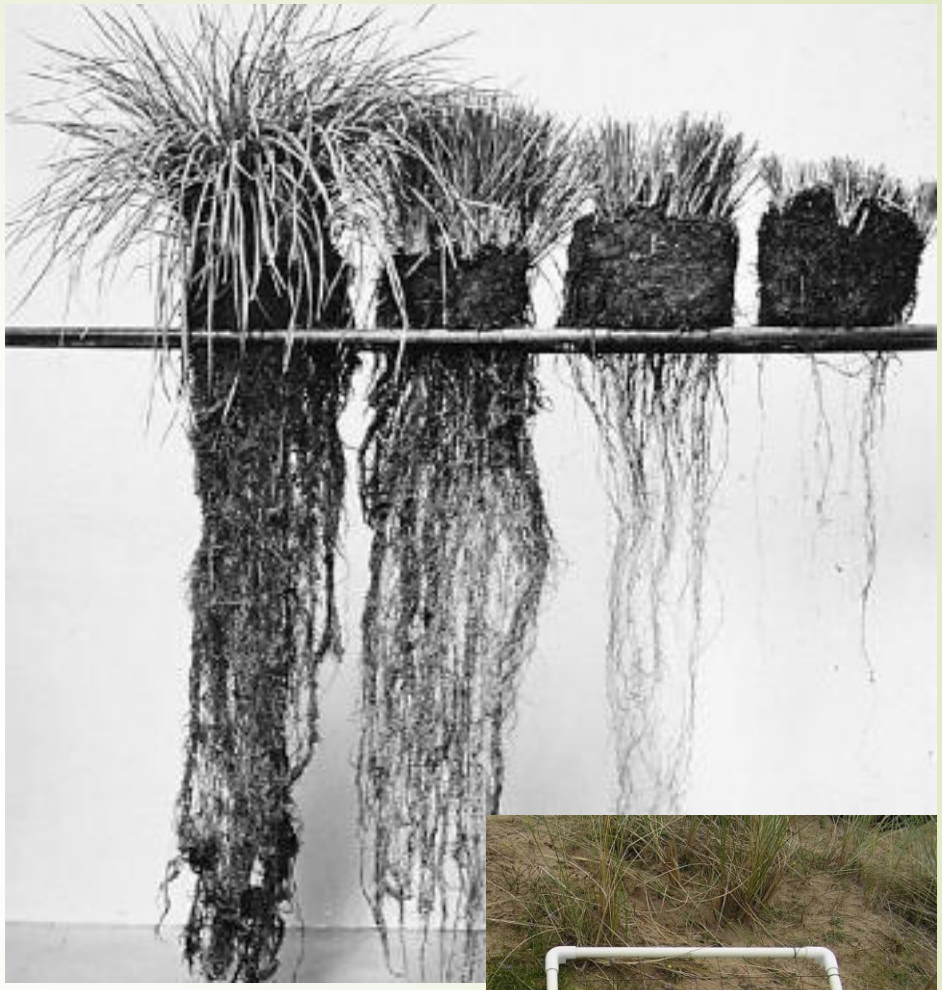


Variables

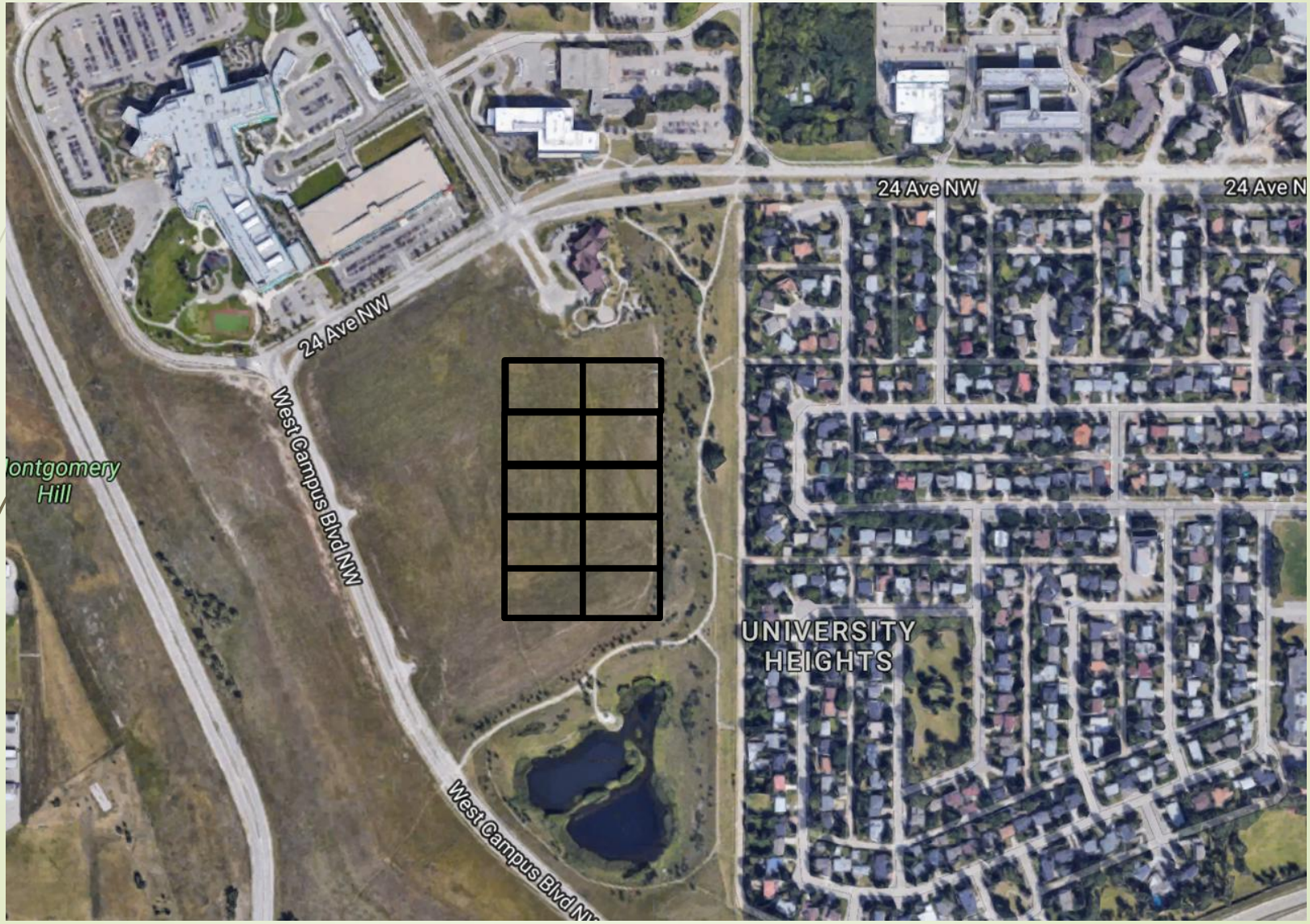
- Animal productivity (kg/ha)
- Forage productivity (kg/ha)

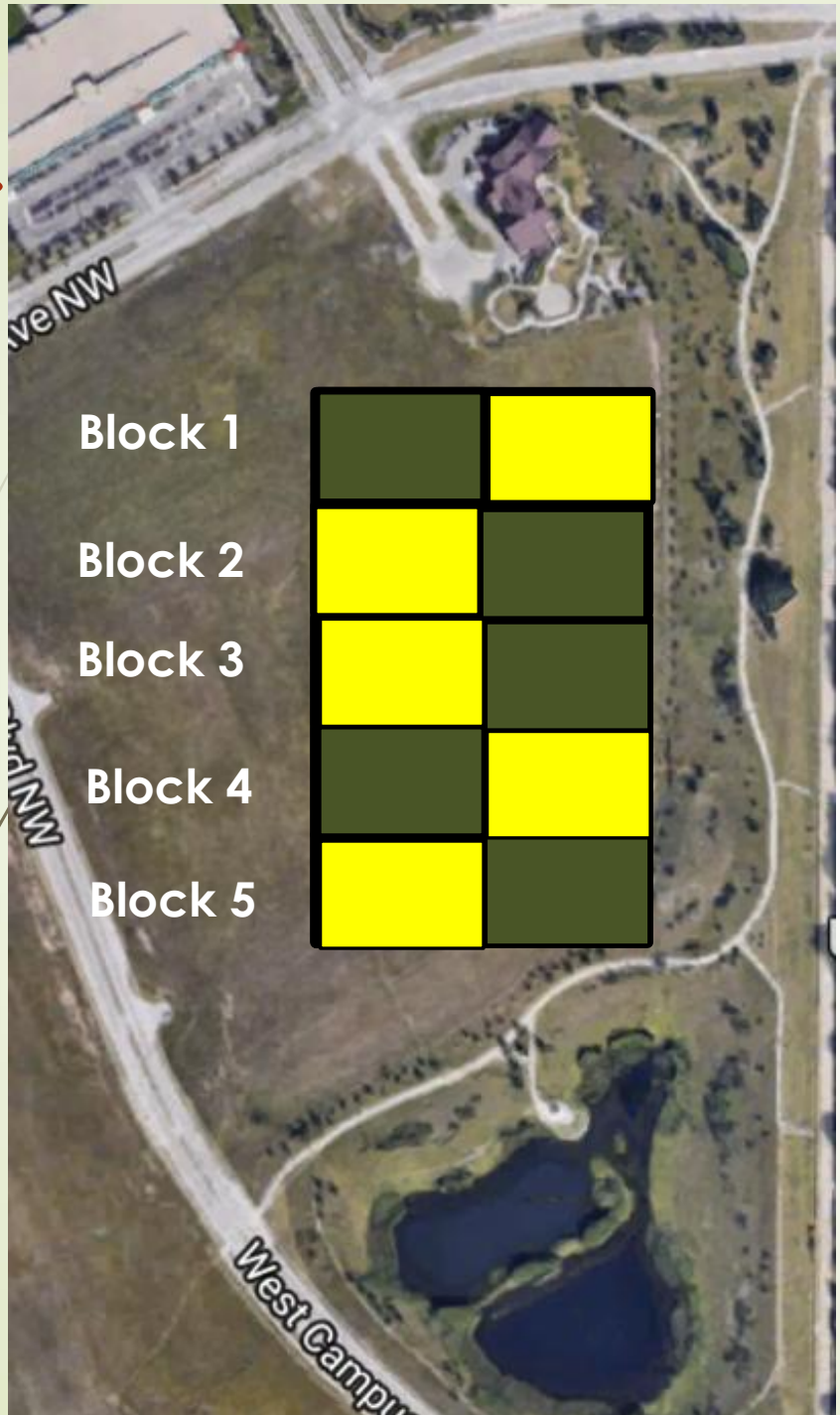
- Forage height (cm)
- Plant species richness
- Soil cover (%)
- Weed cover (%)
- Soil organic matter (%)

- Each team of 4 people will measure each variable in 2 plots



Experimental site





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