Impact of forage mixtures on rumen energetics and performance as assessed by continuous culture

Miriam Snider

Overview

- Introduction
- Materials & Methods
- Results & Discussion
- Conclusions & Moving Forward
- Questions

Introduction

- Lower production costs[1]
- Improved animal health[2]
- Better quality of life – animals and producers[3,4]

- [1] Ford & Musser, 1998
- [2] Washburn et al., 2002
- [3] Jackson-Smith et al., 1996
- [4] Sanderson et al., 2005

Introduction

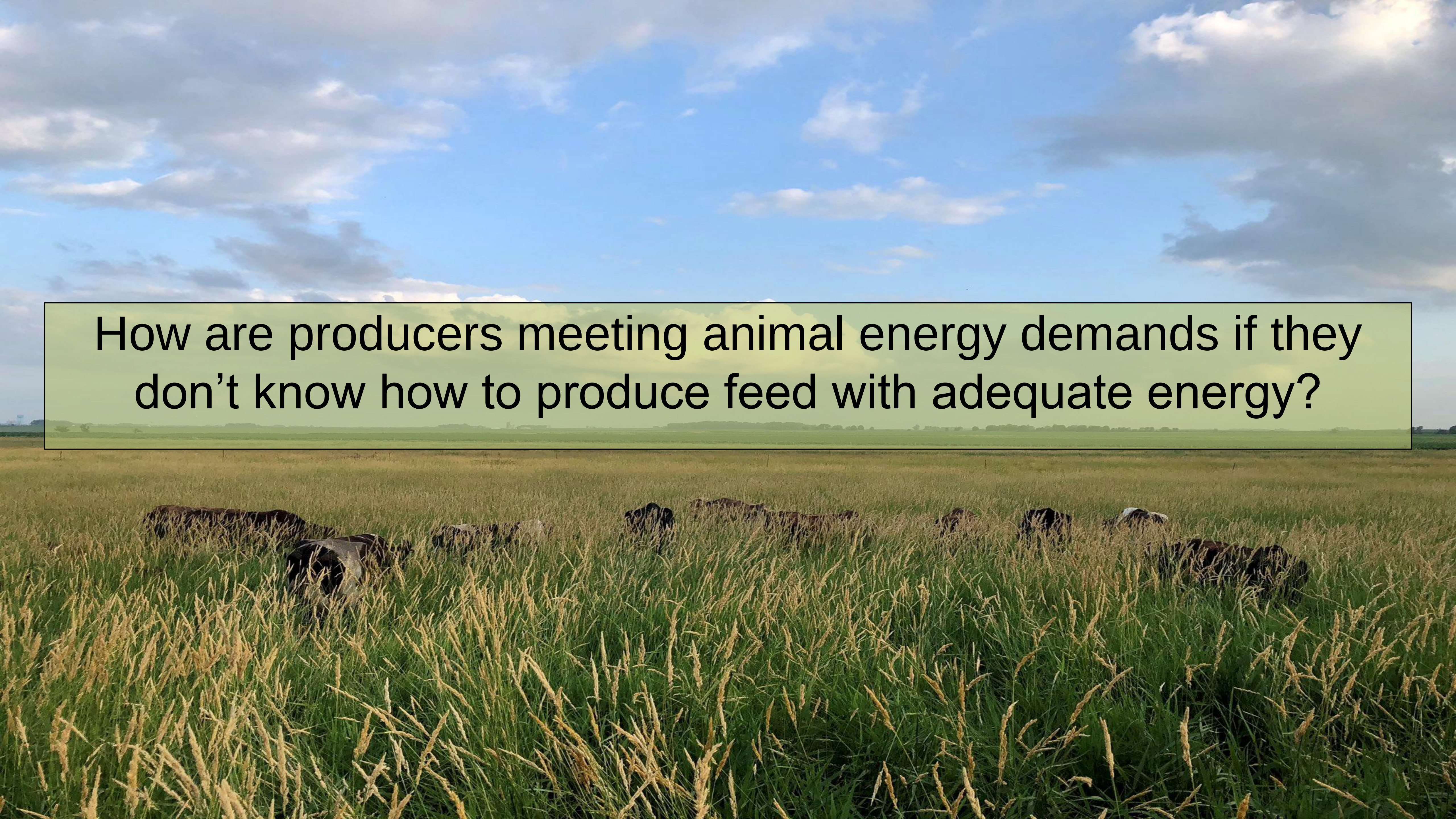
	Very unsatisfied	Unsatisfied	Somewhat unsatisfied	Somewhat satisfied	Satisfied	Very satisfied	At least somewhat satisfied
Pasture quality and yield	0.0%	7.9%	14.7%	46.6%	24.5%	6.1%	77.3%
Stored forage quality	0.0%	6.4%	16.7%	35.3%	32.1%	9.6%	76.9%
Soil fertility and health	0.6%	7.5%	19.4%	40.0%	28.8%	3.8%	72.5%
Stored forage yield	1.9%	7.8%	18.8%	37.7%	29.2%	4.6%	71.4%

Self-reported producer satisfaction of pasture qualities

Introduction

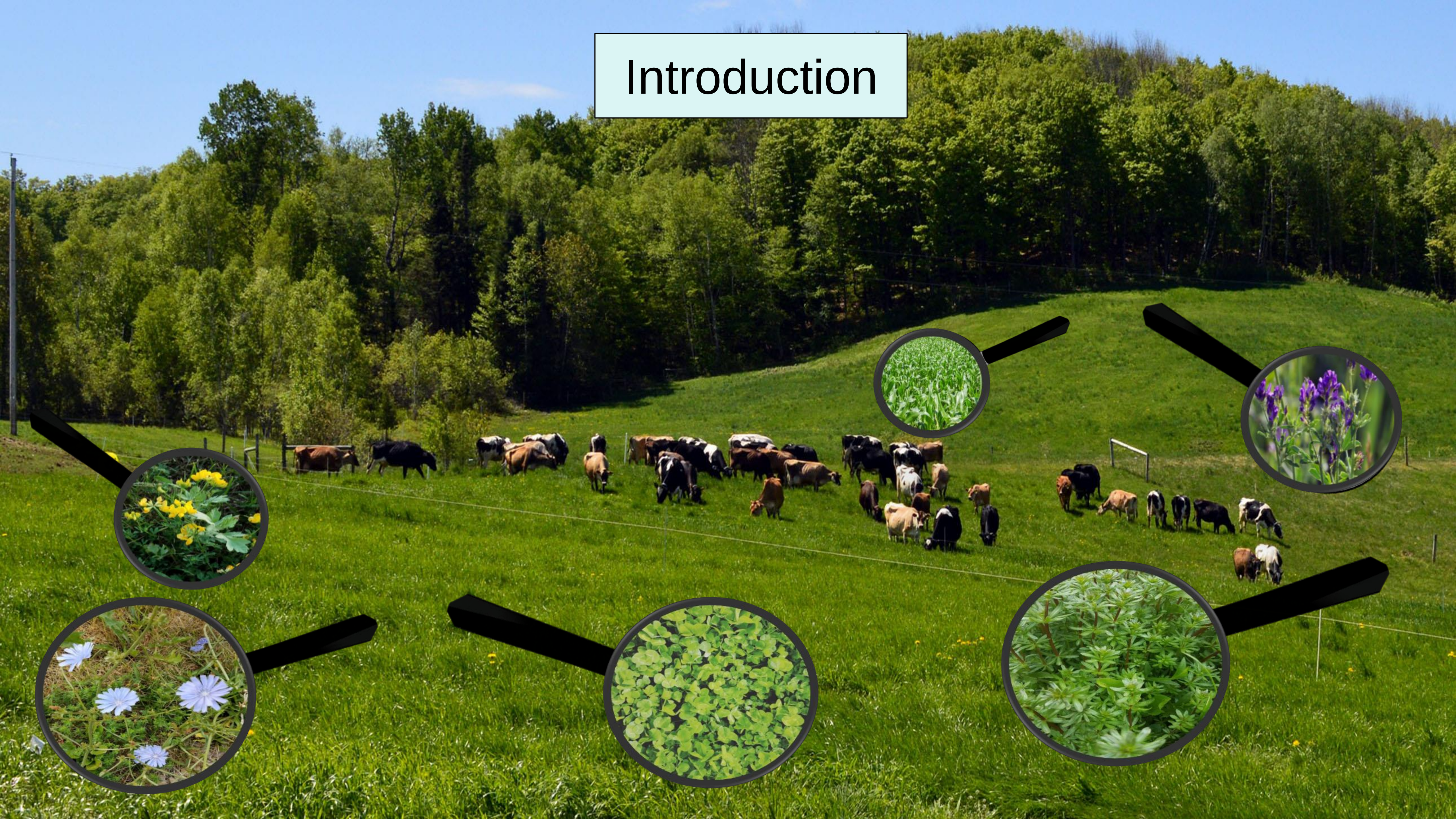
	Very low	Low	Average	High	Very High
Growing higher energy forages	1.3%	15.8%	48.7%	28.5%	5.7%
Improving forage quality	0.0%	6.3%	50.0%	36.7%	6.9%
Understanding forage test results	2.6%	23.1%	44.2%	23.7%	6.4%
Strategies to maximize forage DMI	1.9%	16.5%	47.5%	27.9%	6.3%
Energy requirements for cows	0.6%	6.9%	62.9%	24.5%	5.0%

Self-reported producer knowledge on forage parameters.


How are producers meeting animal energy demands if they don’t know how to produce feed with adequate energy?

Introduction

Introduction



How do we determine forage impacts?

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- **Rumen pH**
  - ↑ pH with ↑ dietary forage
  - Relationship with VFAs
- **VFAs**
  - Acetate, propionate, butyrate
  - 70 A:20 P:10 B ratio
- **Ammonia & microbial protein synthesis**

- **Water soluble carbohydrates**
  - High sugar concentrations = ↑animal performance, improved milk yield, ↑ amino acid flow
  - Increased WSC may improve energetic balance
- **Methane**
  - ↑ WSC = ↓ Methane

Objective

To evaluate rumen energetics and performance metrics using an *in vitro* continuous culture fermenter system receiving different forage mixtures

Hypothesis

More complex forage mixtures will provide energy that is more effectively utilized.

Materials & Methods

Cool-Season Perennials & Legumes

Orchardgrass
Dactylis glomerata

Red Clover
Trifolium pratense

Alfalfa
Medicago sativa

Materials & Methods – Warm-Season Annuals

Sorghum x Sudangrass
Sorghum x drummondii

Pearl Millet
Pennisetum glaucum

Materials & Methods –

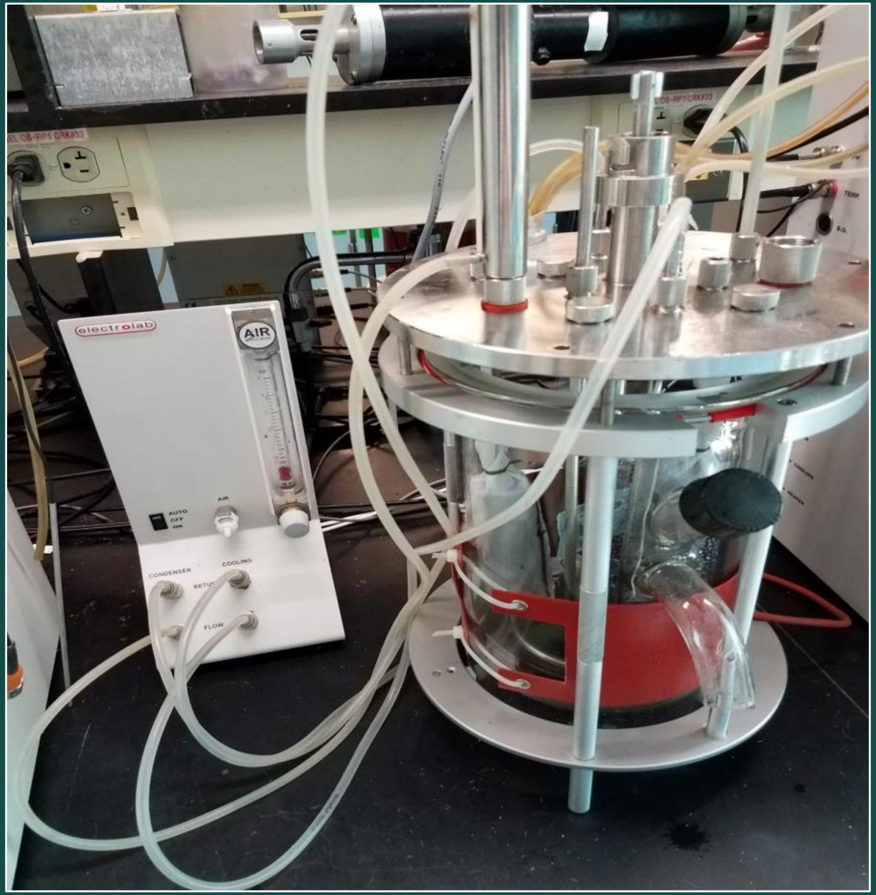
Harvest & Processing

Materials & Methods –

Harvest & Processing

Materials & Methods –

Rumen Fluid Collection & Continuous Culture Operation



Materials & Methods –

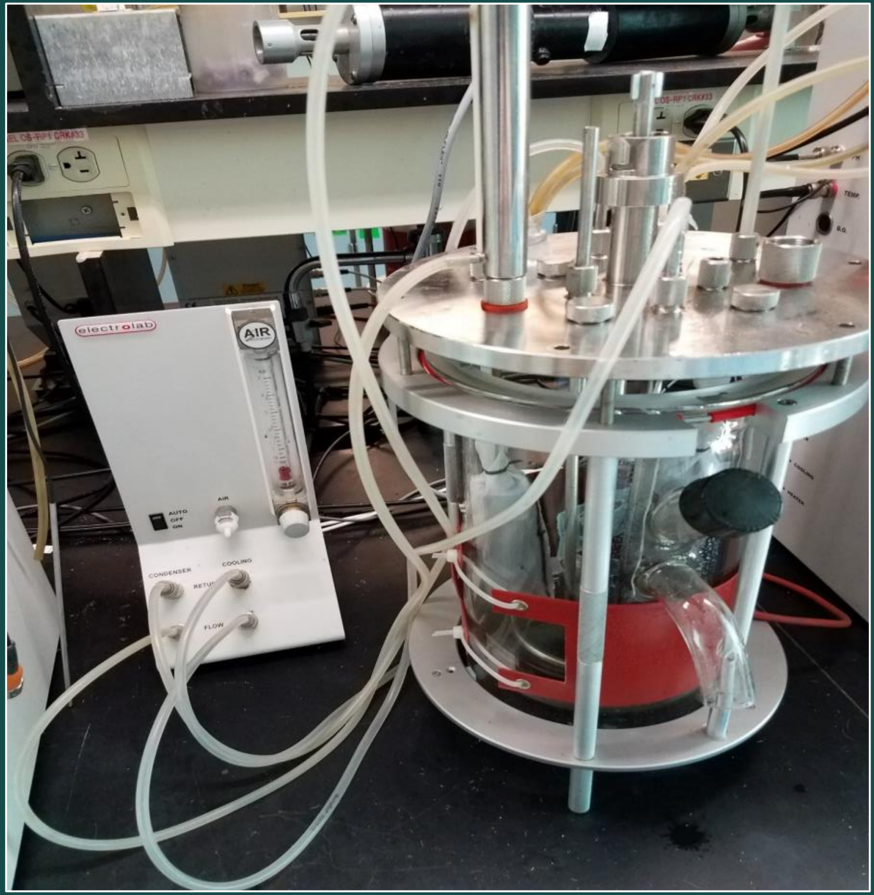
Continuous Culture Operation

- Continuous Culture Fermenter
  - Dual flow
    - Outflow from spout and filters
    - Controlled buffer input and filter output

- Continuously heated & agitated
  - 39ºC
  - 70 rpm; upcycle to 200 rpm

- Constant supply of CO_2
  - Maintain anaerobic environment

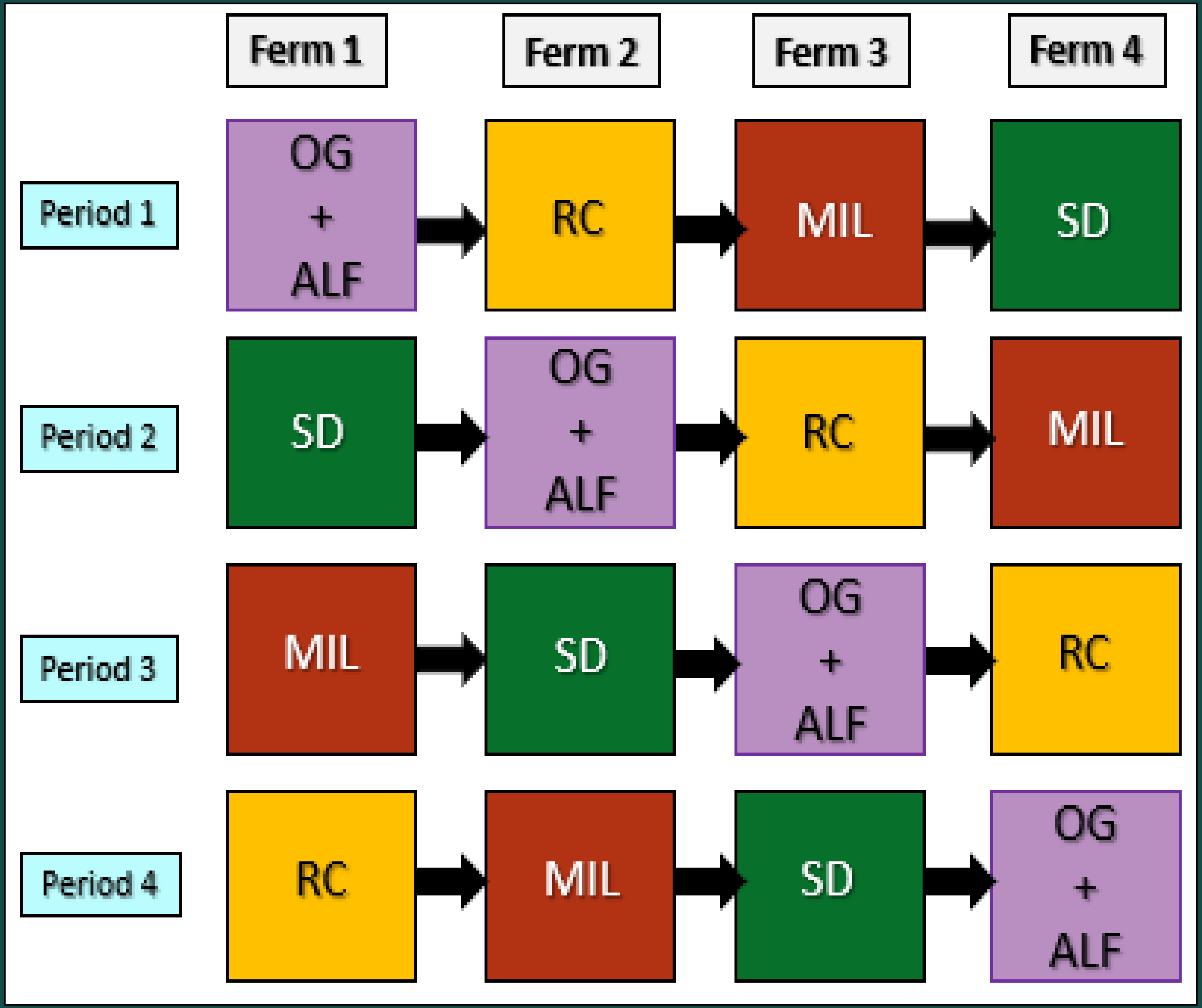
- pH, temperature, and agitation
  - Recorded continuously



Treatments & Experimental Design

DM basis (131 g)

- **50% OG: 50% ALF**
- **25% OG: 25% ALF: 50% RC**
- **25% OG: 25% ALF: 50% MIL**
- **25% OG: 25% ALF: 50% SD**



Treatments & Experimental Design

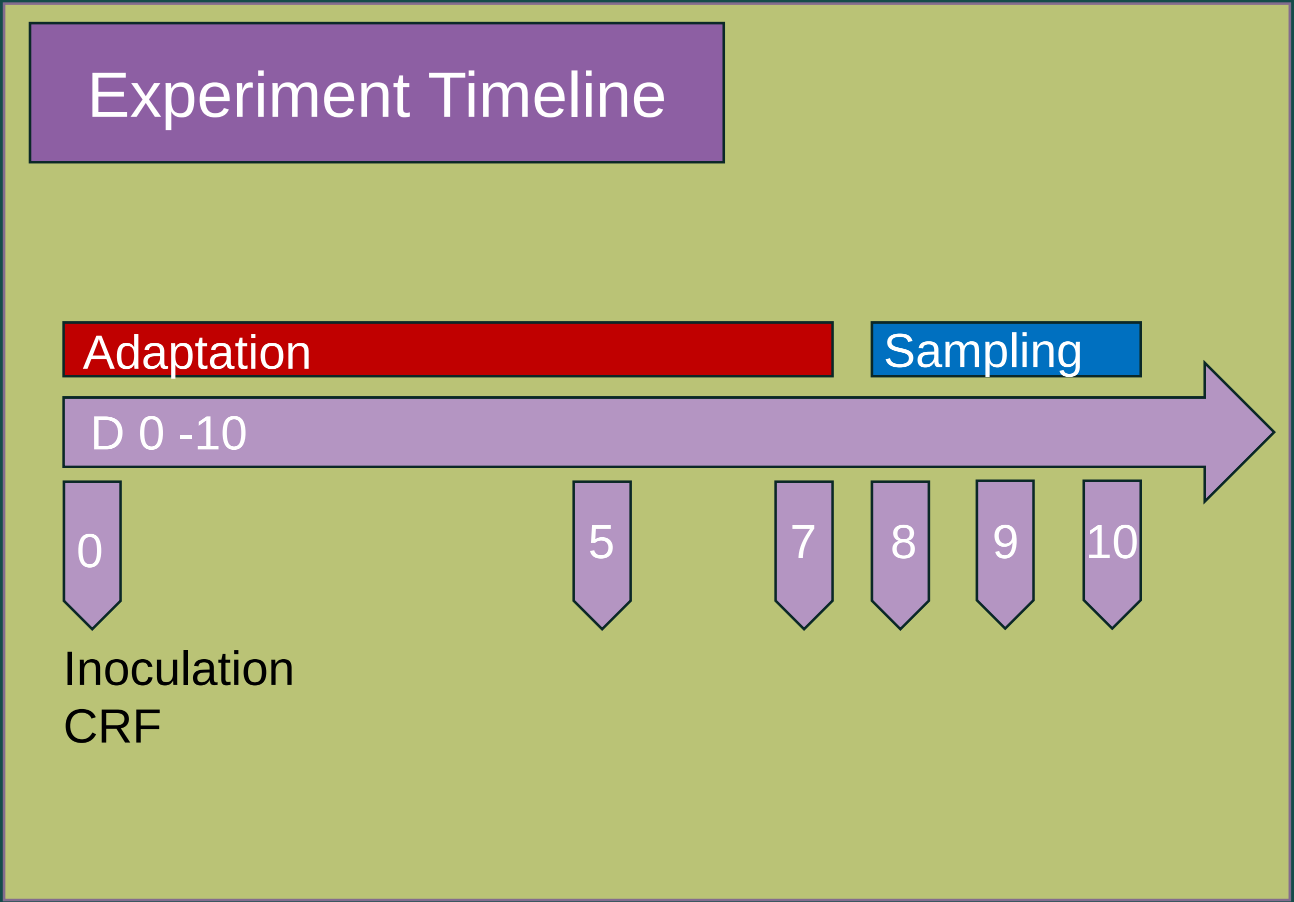
To mimic grazing intake patterns[5]:

- 33% DM at:
  - 0600 h
  - 1800 h
- 17% DM at:
  - 0720 h
  - 1920 h

	Ferm 1	Ferm 2	Ferm 3	Ferm 4
Period 1	OG + ALF	RC	MIL	SD
Period 2	SD	OG + ALF	RC	MIL
Period 3	MIL	SD	OG + ALF	RC
Period 4	RC	MIL	SD	OG + ALF

[5]Gregorini et al., 2010

Materials & Methods –Sampling



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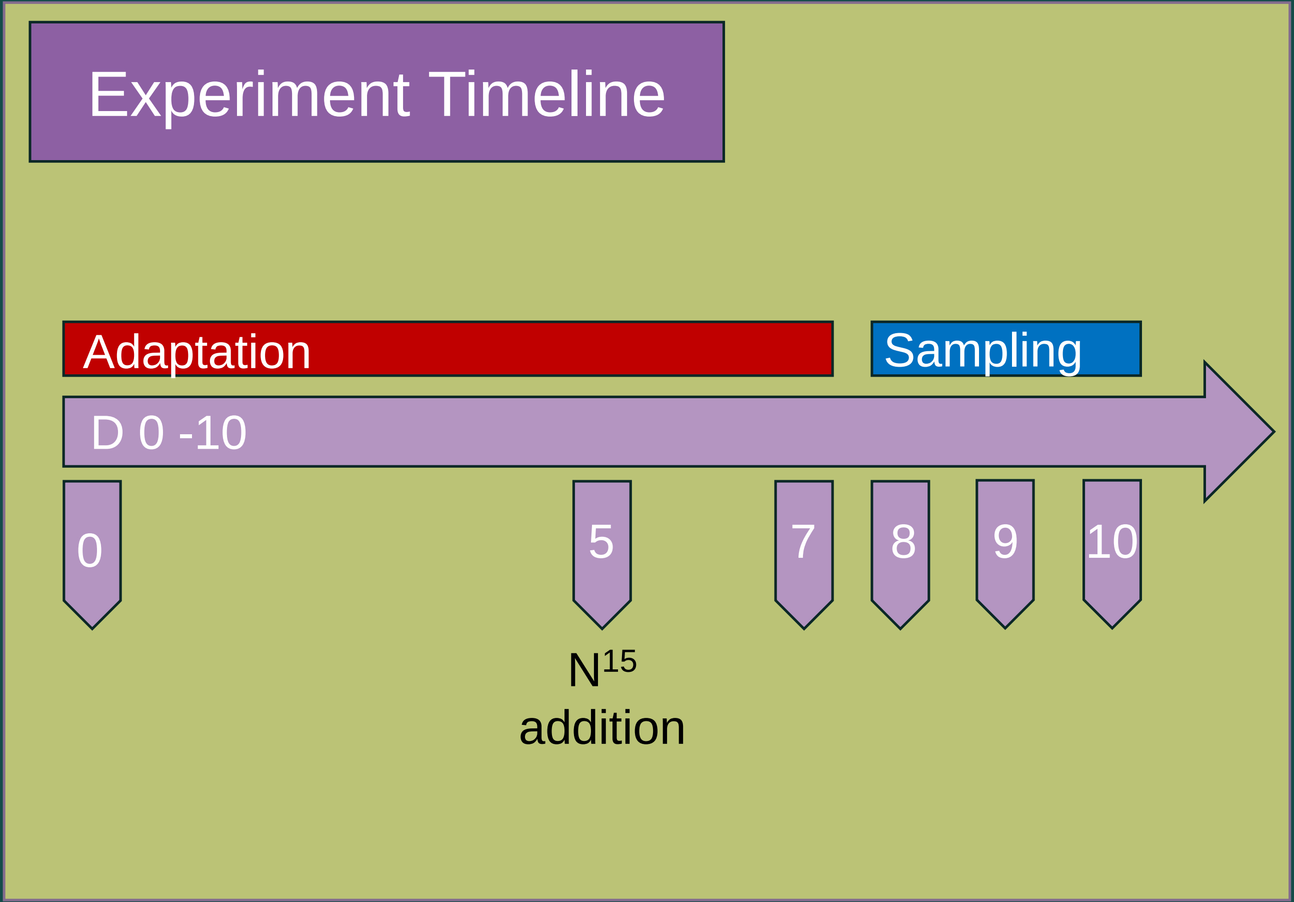

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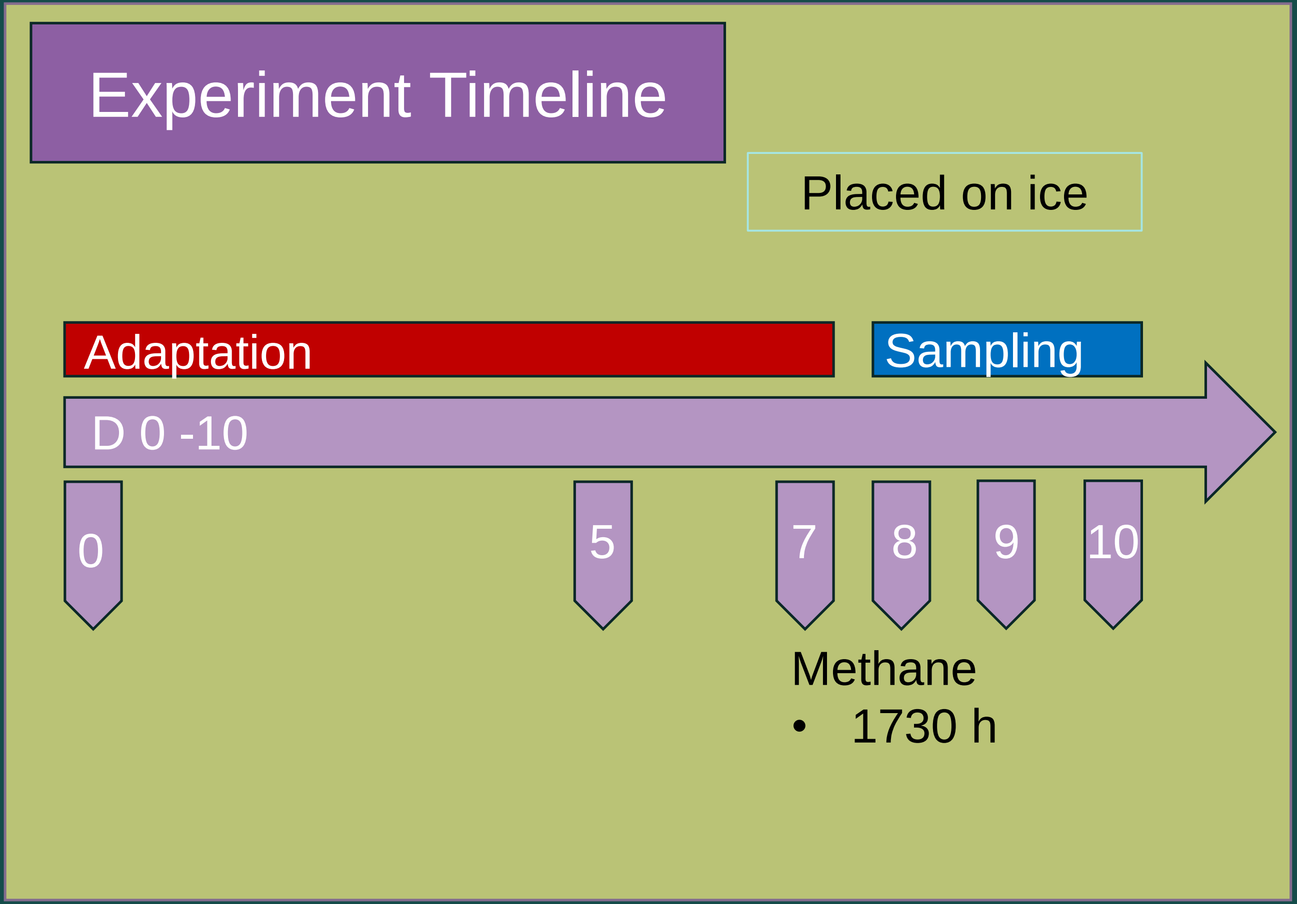


Materials & Methods –Sampling

Experiment Timeline

Placed on ice

Adaptation

Sampling

D 0 -10

0

5

7

8

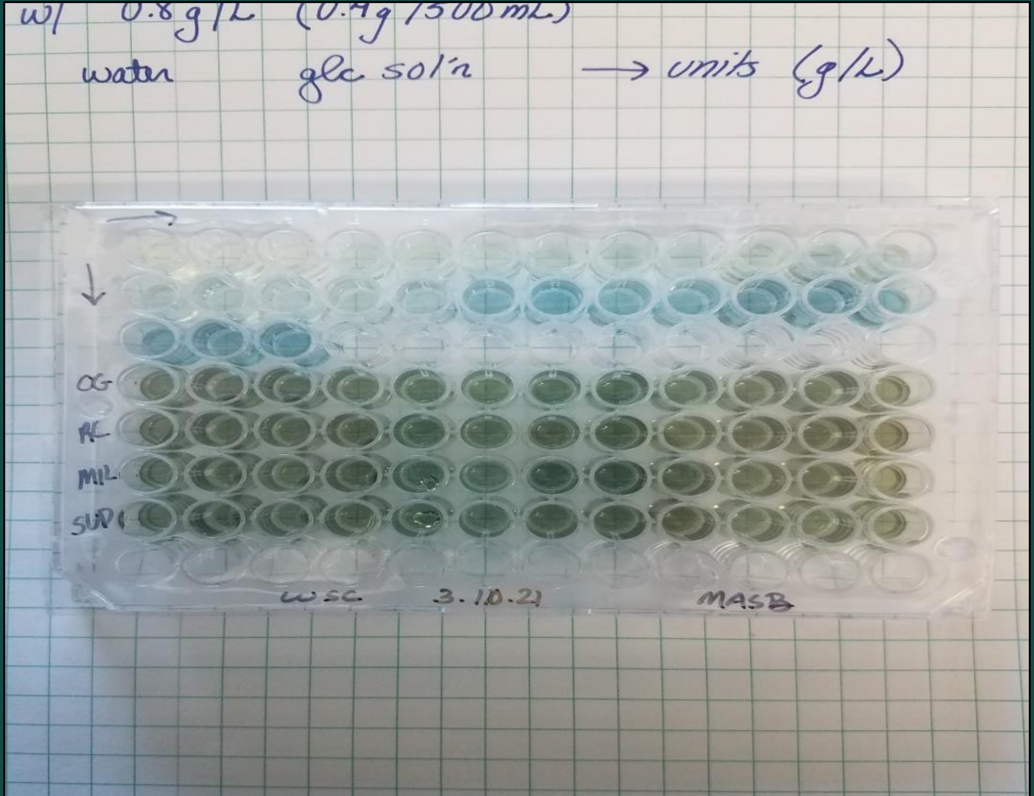
9

10

Methane, VFAs
N^{15}, NAN, Ammonia
Proteomics
PPO , DM

Materials & Methods –Analysis

- **VFAs**
  - Analyzed by Miner Institute (Chazy, NY)
  - Mass spectrometry
- **Methane**
  - Converted from ppm basis to mg/dL
- **pH**
  - Measured continuously every min for 10 d
- **WSC**
  - Anthrone- sulfuric acid colorimetric assay
- **Statistical analysis**
  - PROC MIXED procedure
  - SAS 9.4



Anthrone-Sulfuric Acid WSC Assay

Results & Discussion – VFAs

	Treatment[1]					*P* – value[2]		
	OG-ALF	RC	MIL	SD	SEM	Treatment	Period	Treatment x Period
Total VFA, m*M*	38.6	35.0	30.4	35.2	1.63	0.08	0.14	0.48
Individual VFA, mol/ 100 mol								
Acetate (A)	73.6	73.4	72.9	72.8	0.16	0.22	<0.0001	0.07
Propionate (P)	16.3	16.3	16.9	16.6	1.13	0.52	0.0003	0.41
Butyrate (B)	6.87	7.02	6.70	7.06	0.09	0.32	0.06	0.51
Isobutyrate	0.89	0.85	0.95	0.97	0.02	0.13	0.64	0.03
Valerate (V)	1.30	1.38	1.36	1.44	0.03	0.06	0.19	0.02
Isovalerate	1.02	1.01	1.16	1.112	0.03	0.15	0.38	0.05
A:P	4.56	4.57	4.43	4.41	0.04	0.49	<0.0001	0.31
A+B:P	4.99	5.00	4.83	4.84	0.05	0.46	0.0002	0.36

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Maximum	7.14	7.24	7.05	7.10	0.04	0.51	0.0021	0.63
CH_4								
mg/dL	50.8	21.2	6.2	6.9	3.52	<0.0001	<0.0001	<0.0001
WSC								
g/kg DM	1.36	1.57	2.74	1.71	0.09	<0.0001	<0.0001	0.001

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Conclusions

- Diverse forage mixtures may improve and inclusion of warm-season annuals may provide benefits relating to ruminant nutrition and energetic capture

- Furthermore, inclusion of warm-season annuals may improve energetic capture by mitigating methane production.

Moving Forward

CURRENT

- Awaiting analysis
  - Feed & DM samples
  - N^{15} , Ammonia, NAN
- Statistical analysis
  - Proteomic data
  - PPO

FUTURE WORK

- Potential 6 x 6 Continuous Culture Study
  - Combination of 6+ forages
    - Further diversification
  - Evaluation of rumen energetic capture

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- Borderview Research Farm Staff
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Questions or
Comments?