Using CNCPS models in the field (or barn)

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Overview

Cornell University

University of Minnesota

- **Introduction**
- **Why do we need a model?**
- **Model use on farm:**
  - Key inputs for requirements
  - Key inputs for supply
  - Model performance
- **Quick look to the future of formulation:**
  - Precision feeding and individual cow information

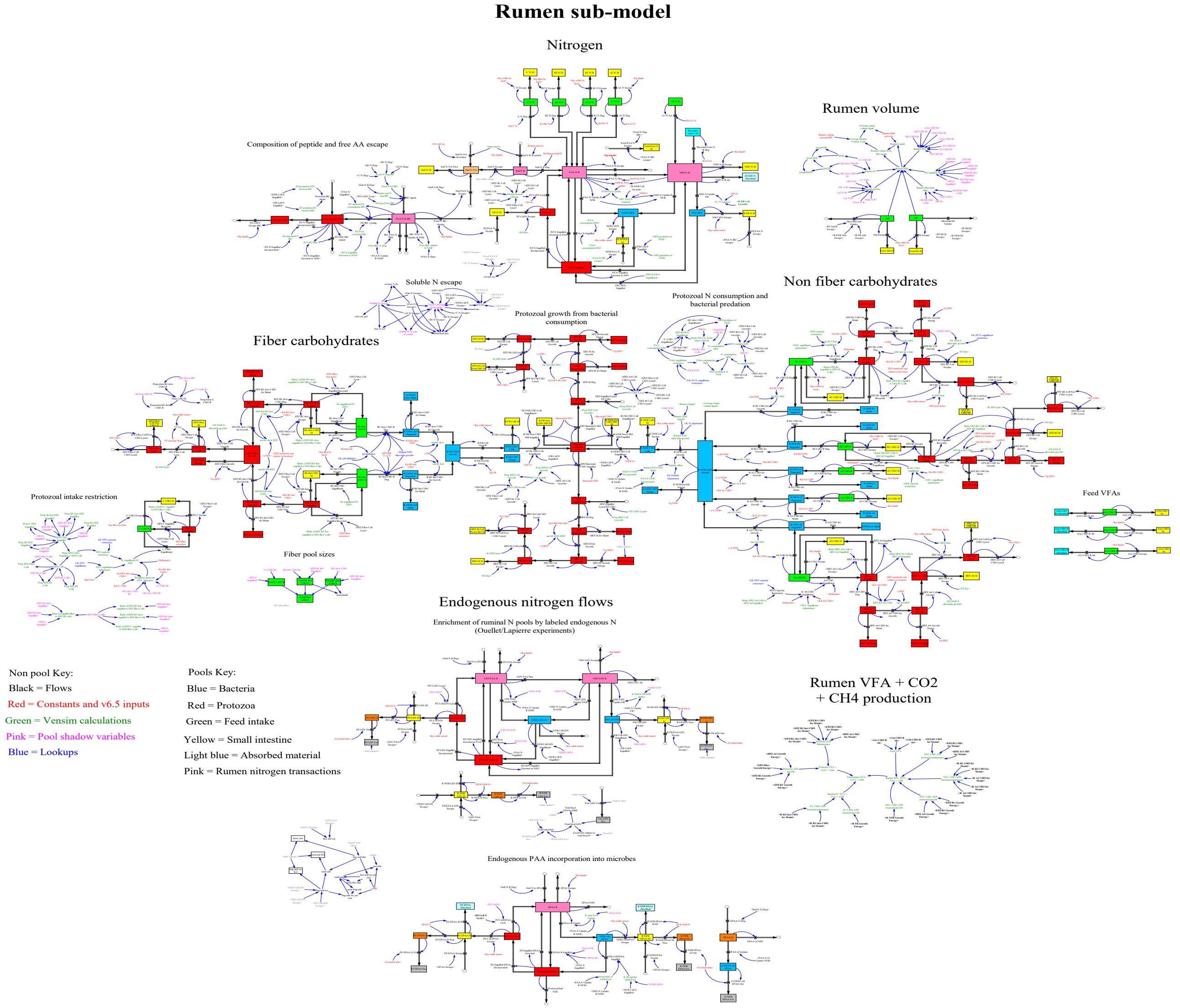
AMTS

Some Questions:

- **Which feed is better at making milk?**
  - **Corn silage or wheat straw?**
  - **Whole corn grain or fine-ground barley?**
  - **Soybean meal or protected soybean meal?**
- **Which feed is less expensive?**
  - **Per ton? Per lb of potential milk?**
- **How do we know these answers?**
  - **Feeding trials, experience, company literature, guessing….**
- **Need to use a feeding system (mathematical model) to predict future performance on hypothetical diets.**

Back to Basics: The ruminant animal

- **Dynamic digestion process**
  - **Heterogenous diets**
  - **Fermentation chamber**
  - **Selective retention of particles**
- **Bacterial fermentation**
  - **Growth and outflow**
  - **Nitrogen cycling**
  - **40-60% of AA from microbes**
- **Multiple physiologic needs**
  - **Maintenance, growth, lactation, pregnancy, reserves gain/loss happening at same time**
- **Need an accounting system!**



Cornell Net Carbohydrate and Protein System

- A mathematical model accounting for supply and requirements
- Focused around energy, protein and amino acid balance

Requirements

- Generally use empirical equations
- Maintenance, pregnancy Lactation, growth, reserves
- Animal characteristics are most important
- Adjustments made for environment and activity

Supply

- Mechanistic equations
- Rumen sub-model (microbes) and intestinal digestibility drive supply
- Feed characteristics are most important
- Diet associated effects are taken into account

Single most important input for requirements:

- **BODY WEIGHT**

- **This holds true for most commercial nutrition models**

- **CNCPS: Used in every section of the model except lactation requirements**

- **Often the most difficult to get, especially for different cattle groups**

- Image: M. Van Amburgh

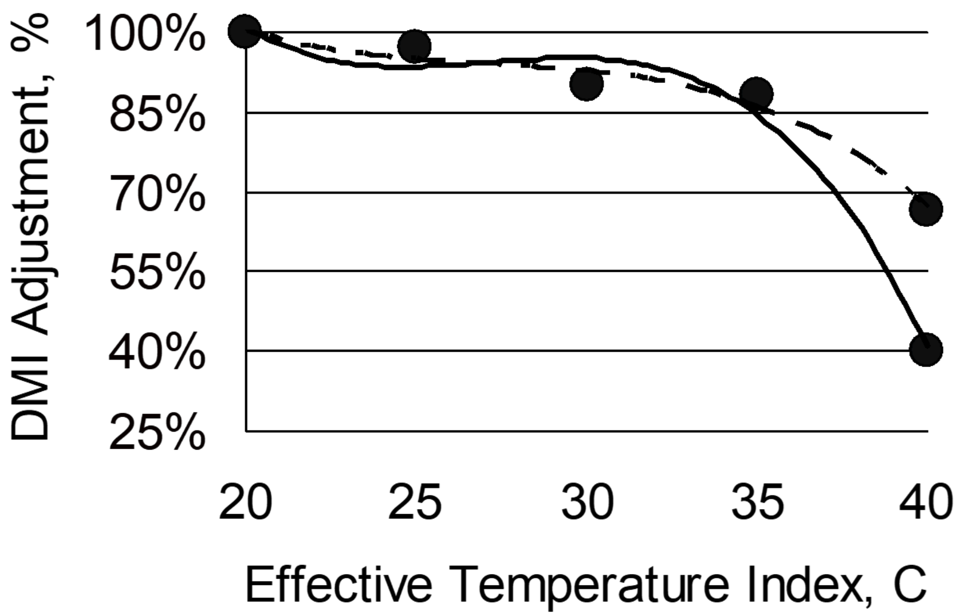
How to get body weights:

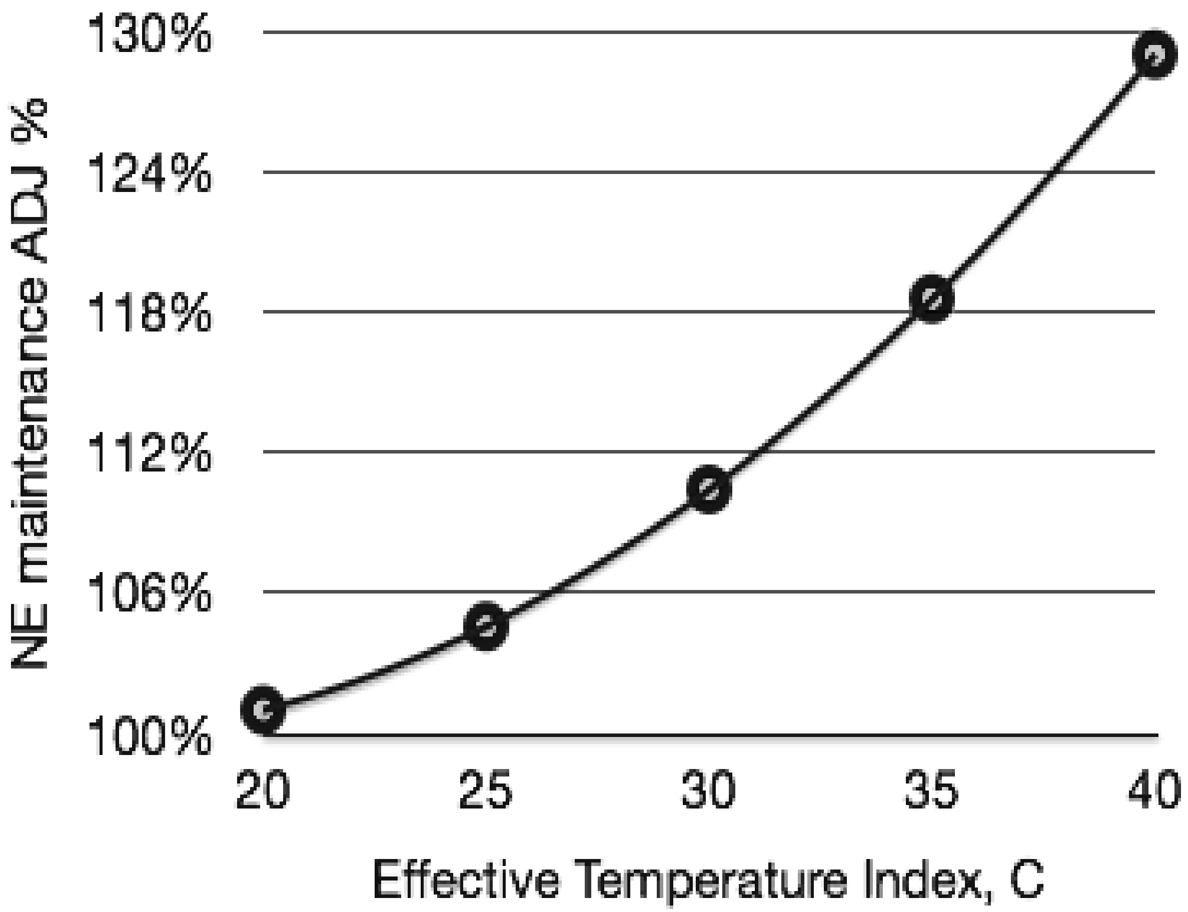
- **Actually weigh the cows:**
  - **Need at least 12 cows, lactation 3 to 6, BCS of 3, healthy, 80-180 DIM.**
  - **Automated systems (robots, scales on farm) are great if maintained, cleaned, and calibrated!**
- **Weigh groups of cows:**
  - **Load cows on trailer and run across truck scales**
- **Avoid using: Marketed cow weights, tape weights, and "eyeball" weights**
  - **Experienced nutritionists off by more than 150 lbs at the Cornell Adv. Nutrition Short Course (2016)**

- Photo: S. Fessenden

BARNS/LOTS -- Environment

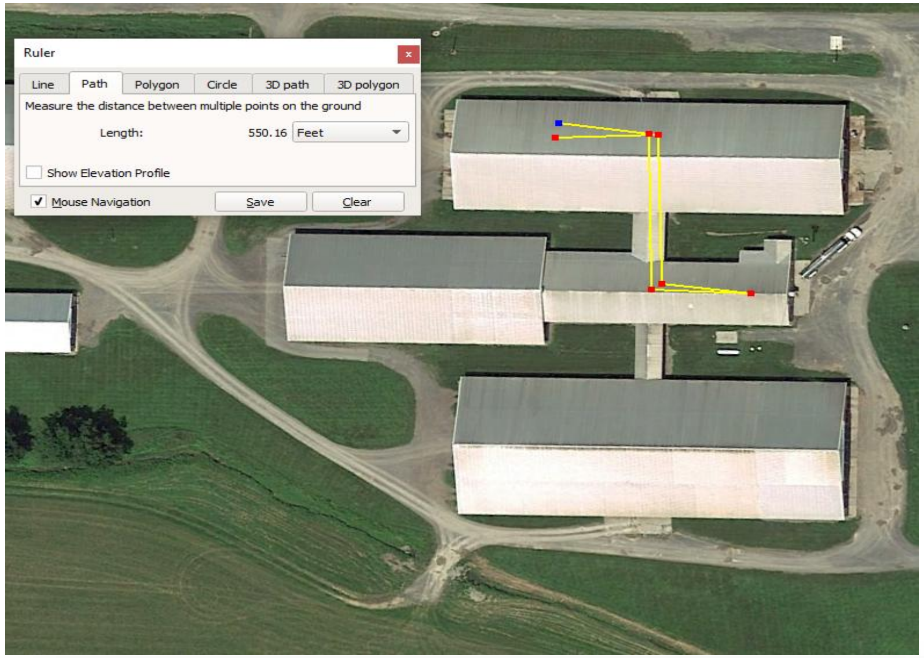
- **Heat Stress**
  - **Increases ME maintenance**
  - **Decreases predicted intake**

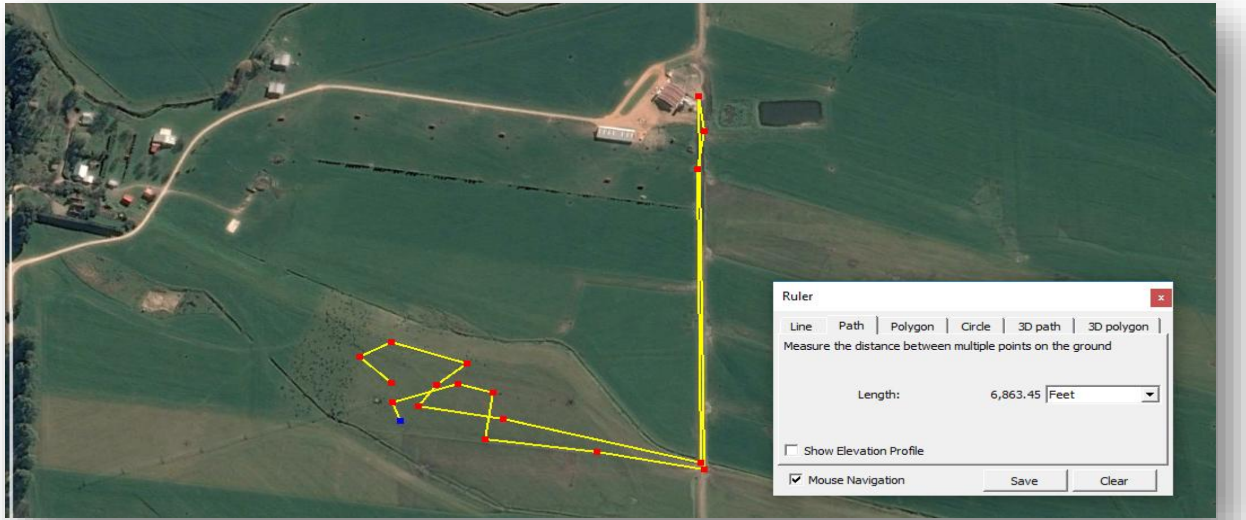


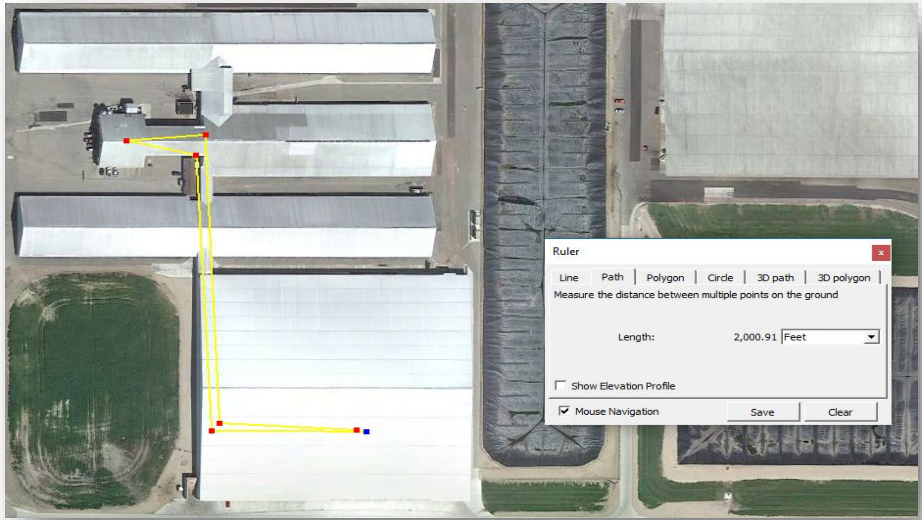


BARNS/LOTS – Activity

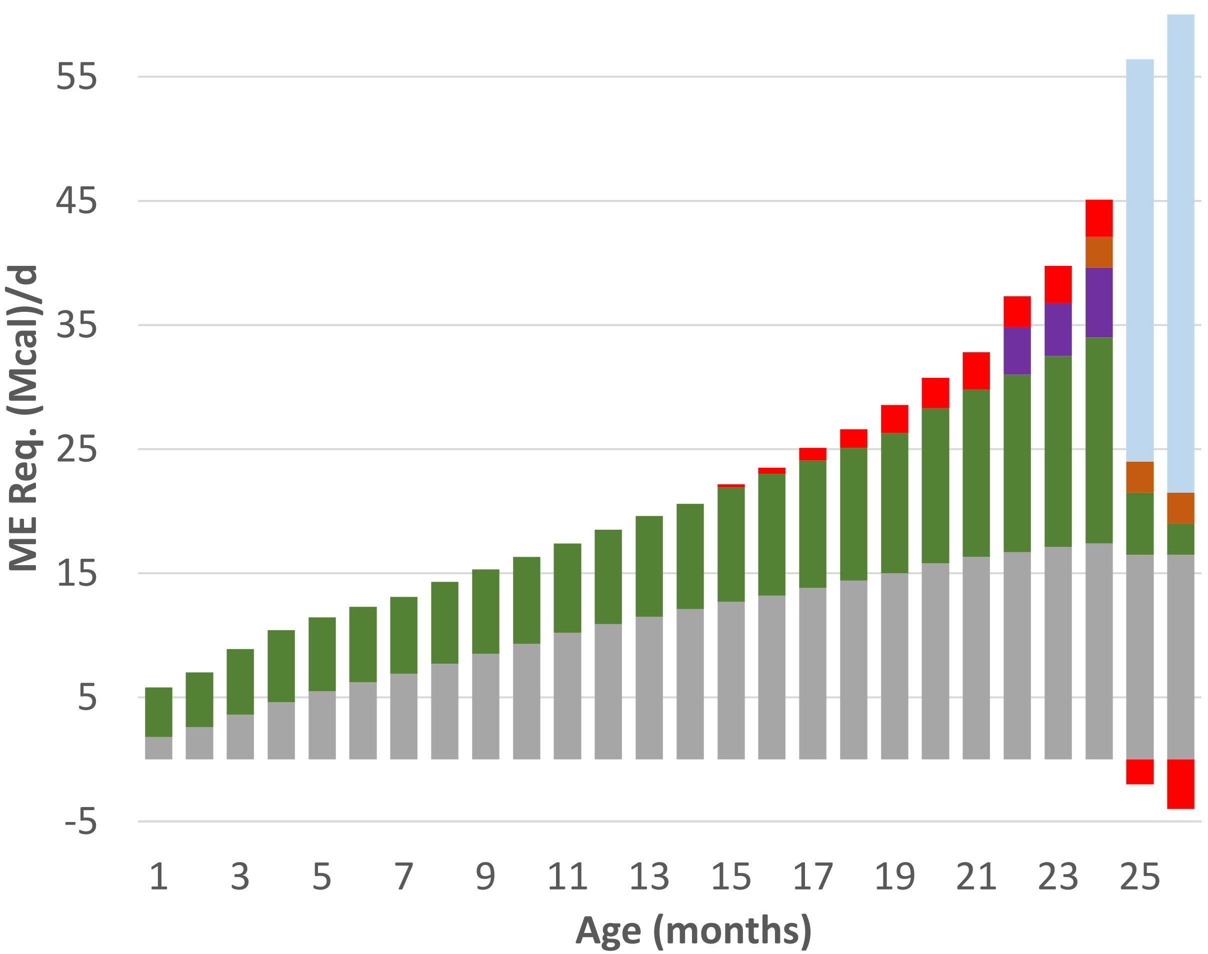
- How far do cows walk?
  - Freestall close parlor (NY)
    - 830 x 3x milking = 2,500 ft
  - Freestall far parlor (MN)
    - 2,000 x 2x milking = 4,000 ft
  - Grazing dairy (S. Island NZ)
    - 6,800 x 2x milking = 13,600 ft!
- Every 1,000 ft is worth 0.33 lbs of milk

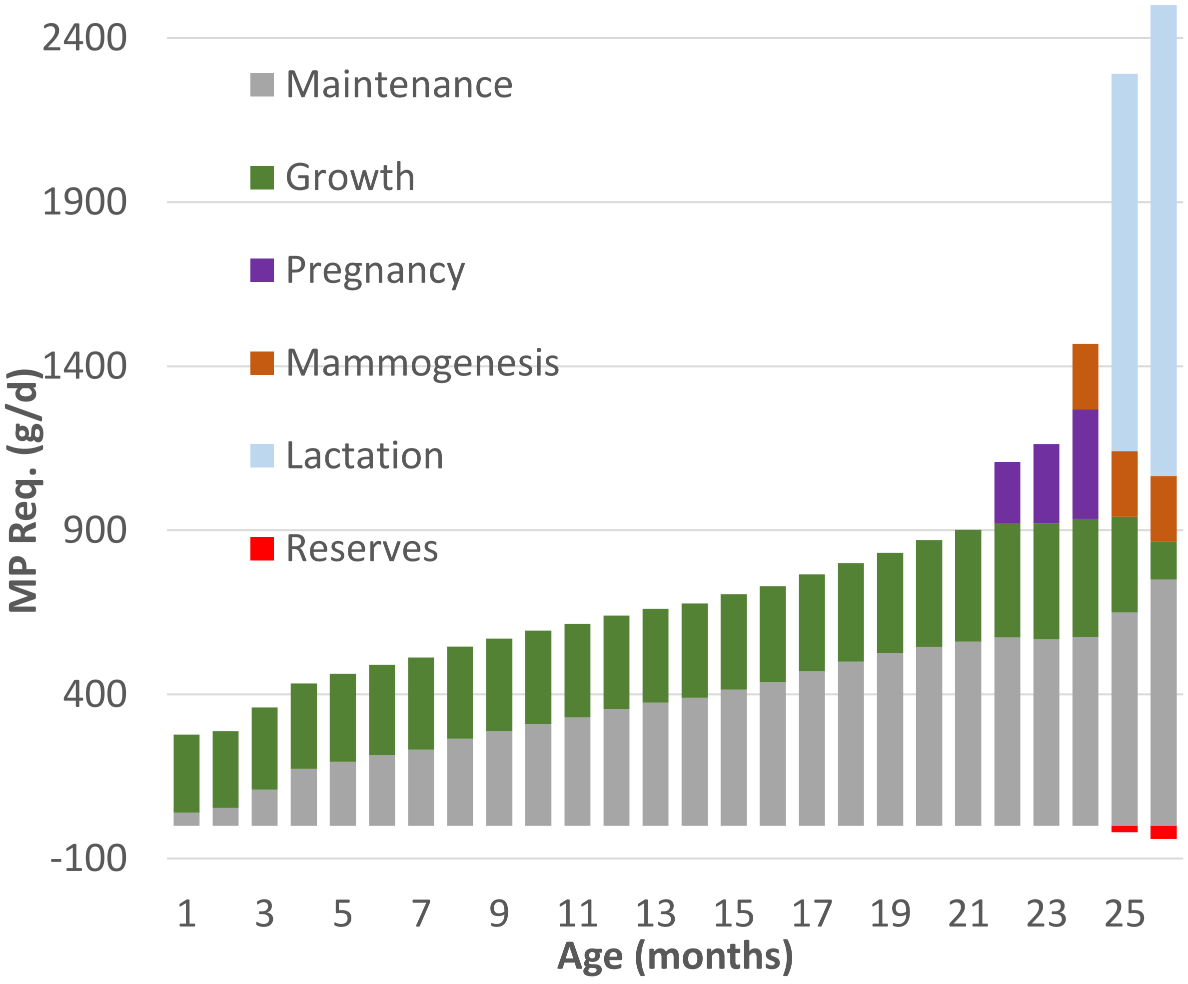




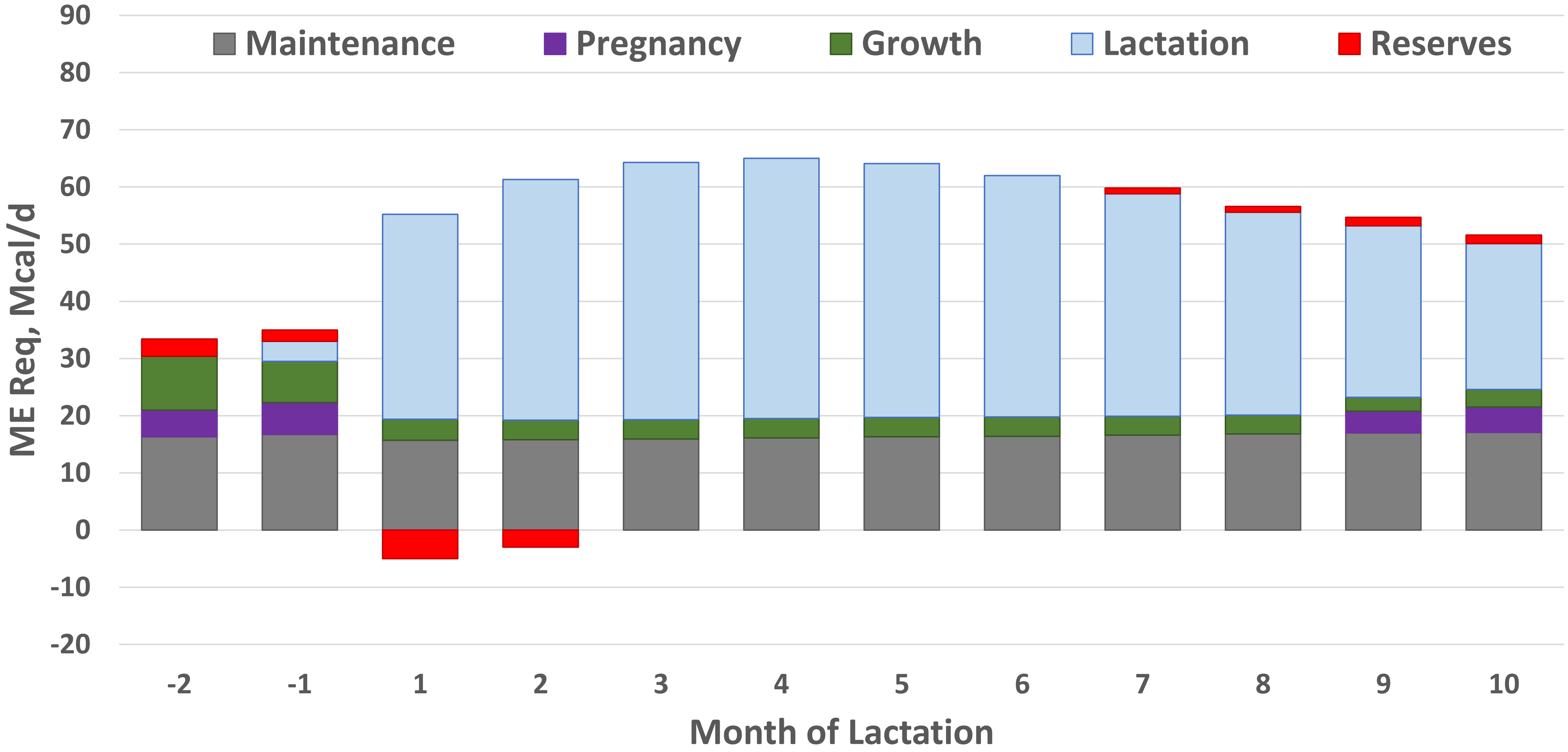


Requirements for ME and MP by month: Heifers



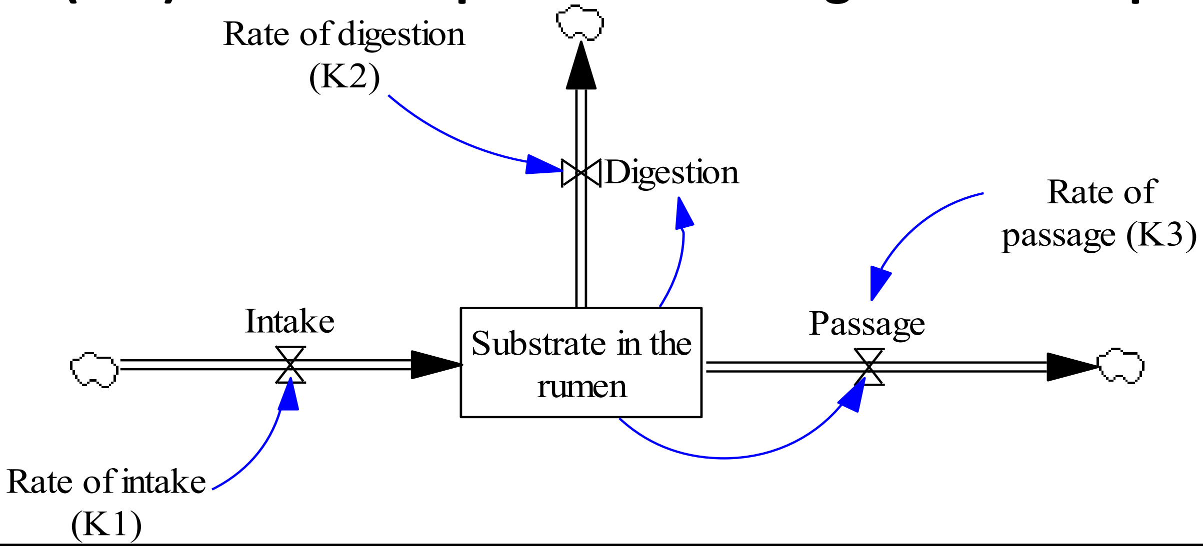


Requirements for Energy –1st Lactation



Determining nutrient supply in the CNCPS

- **Digestibility = kd/(kd+kp)**
  - Rate of degradation (kd): intrinsic to the feed (Protein and Carbohydrate pools in each feed)
  - Rate of passage (kp): intrinsic to the animal (based on intake, weight, stage of lactation)
- Equation used to calculate disappearance of given substrate
  - Microbial growth rate is calculated directly from CHO kd
- Metabolizable Energy (ME): Calculated from digested nutrients (modified TDN system)
- Metabolizable Protein (MP): Microbial protein & undegraded feed protein



Feed analysis: Do we really need all this info?

CORN SILAGE BUNK 6

SAMPLE INFORMATION

Lab ID:	25336 084	Version:	2.0
Crop Year:	2018	Series:	
Feed Type:	CORN SILAGE	Cutting#:	
Package:	NIR Wet Minerals, Cl, S		

NIR ANALYSIS RESULTS

Moisture	62.5
Dry Matter	37.5

PROTEINS	% SP	% CP	% DM
Crude Protein			5.4
Adjusted Protein			
Soluble Protein		53.1	2.9
Ammonia (CPE)	18.8	10.0	0.54
ADF Protein (ADICP)		11.1	0.60
NDF Protein (NDICP)		13.0	0.70
NDR Protein (NDRCP)			
Rumen Degr. Protein		76.6	4.1
Rumen Deg. CP (Strep.G)			

FIBER	%NDFom	NDFom %DM	% NDF	% DM
ADF			60.8	24.3
aNDF		39.5		39.9
NDR (NDF w/o sulfite)				
peNDF				
Crude Fiber				
Lignin			7.70	3.07
NDF Digestibility (12 hr)			33.3	13.3
NDF Digestibility (24 hr)				
NDF Digestibility (30 hr)	54.7	21.6	54.1	21.6
NDF Digestibility (48 hr)				
NDF Digestibility (120 hr)	63.0	24.9	62.4	24.9
NDF Digestibility (240 hr)	65.8	26.0	65.1	25.9
uNDF (30 hr)	45.3	17.9	45.9	18.3
uNDF (120 hr)	37.0	14.6	37.6	15.0
uNDF (240 hr)	34.2	13.5	34.9	13.9

CARBOHYDRATES	% Starch	% NFC	% DM
Silage Acids		10.8	5.5
Ethanol Soluble CHO (Sugar)		3.0	1.5
Water Soluble CHO (Sugar)			3.5
Starch		71.4	36.2
Soluble Fiber		13.6	6.91
Starch Dig. (7 hr, 4 mm)	80.4		
Fatty Acids, Total			2.47
Crude Fat			2.64

MINERALS	
Ash (%DM)	2.11
Calcium (%DM)	**0.17**
Phosphorus (%DM)	**0.18**
Magnesium (%DM)	**0.12**
Potassium (%DM)	**0.64**
Sulfur (%DM)	**0.09**
Sodium (%DM)	**0.01**
Chloride (%DM)	**0.12**
Iron (PPM)	**37**
Manganese (PPM)	**20**
Zinc (PPM)	**20**
Copper (PPM)	**3**
Nitrate Ion (%DM)	
Selenium (PPM)	
Molybdenum (PPM)	

QUALITATIVE	
Total VFA (%DM)	5.47
Lactic Acid (%DM)	3.79
Lactic as % of Total VFA	69
Acetic Acid (%DM)	1.68
Butyric Acid (%DM)	
1, 2 Propanediol (%DM)	
Soil Contamination Probability	Probable low to none
Nitrate Probability	
NIR Statistical Confidence	Excellent prediction potential

ENERGY & INDEX CALCULATIONS	
pH	3.73
TDN (%DM)	73.8
Net Energy Lactation (Mcal/lb)	0.74
Schwab/Shaver NEL (Processed)	0.71
Schwab/Shaver NEL (Unprocessed)	0.66
Net Energy Maintenance (Mcal/lb)	0.75
Net Energy Gain (Mcal/lb)	0.48
NDF Dig. Rate (Kd, %HR, Van Amburgh, Lignin*2.4)	3.43
NDF Dig. Rate (Kd, %HR, uNDF)	4.8
Starch Dig. Rate (Kd, %HR, Mertens)	24.8
Relative Feed Value (RFV)	
Relative Forage Quality (RFQ)	
Milk per Ton (lbs/ton)	3178
Dig. Organic Matter Index (lbs/ton)	
Non Fiber Carbohydrates (%DM)	50.70
Non Structural Carbohydrates (%DM)	37.7
DCAD (meq/100gdm)	7.6
CNCPS / CPM Lignin Factor	5.8
RFC - Fill Index	3.16
Summative Index % (Mass Balance)	98.9

Account No.: 9109 (0)
Sampled By: Samuel Fessenden
Sampled For: SILVER SPIRIT
Lot Name: Corn Silage 2024
Product: Corn Silage 2024 Jul

Test Mode: N3
Feed Type: Whole plant corn
Sub Type: BMR

Moisture	67.63%		
Dry Matter	32.37%		
pH	3.79		
		Dry Basis	**90% Range***
Crude Protein	%DM	8.14	6.43 - 8.77
AD-ICP	%CP	6.27	4.66 - 13.5
ND-ICP w/SS	%CP	10.20	
Protein Sol.	%CP	59.71	35.9 - 69.1
Ammonia-CP	%CP	9.34	0.00 - 11.9
Total Amino Acids	%DM	5.85	5.45 - 7.53
Total Amino Acids	%CP	71.87	71.9 - 89.6
Lysine	%CP	2.46	2.00 - 3.73
Methionine	%CP	1.47	1.18 - 1.88
Isoleucine	%CP	3.07	2.76 - 3.31
Leucine	%CP	7.49	7.91 - 10.4
Histidine	%CP	1.60	1.37 - 2.46
ADF	%DM	26.71	20.6 - 29.6
aNDF	%DM	45.21	33.8 - 47.1
aNDFom	%DM	44.32	32.5 - 44.8
Lignin	%NDFom	5.35	
Lignin (Sulfuric Acid)	%DM	2.37	2.07 - 3.61
NDFD12	%NDFom	32.54	33.8 - 45.3
NDFD 30	%NDFom	60.02	54.3 - 73.8
NDFD 120	%NDFom	73.83	65.6 - 82.7
NDFD240	%NDFom	76.24	70.3 - 85.0
uNDFom12	%DM	29.90	18.7 - 27.5
uNDFom30	%DM	17.72	9.75 - 18.8
uNDFom120	%DM	11.60	6.44 - 13.7
uNDFom240	%DM	10.53	5.60 - 11.7
Sugar (ESC)	%DM	2.28	0.45 - 4.25
Sugar (WSC)	%DM	3.25	1.04 - 5.16
Starch	%DM	29.28	22.4 - 39.6
IVSD7-o	%Starch	72.78	64.3 - 81.9
Fat (EE)	%DM	3.67	2.64 - 4.08
TFA (fat)	%DM	2.32	1.70 - 2.75
16:0 Palmitic	%TFA	17.67	16.0 - 19.2
18:0 Steari			
18:1 Oleic	%TFA	22.41	19.4 - 23.6
18:2 Linoleic	%TFA	49.14	47.6 - 52.0
18:3 Linolenic	%TFA	6.47	4.76 - 9.52
Ash	%DM	4.48	3.23 - 6.05
Calcium	%DM	0.21	0.16 - 0.28
Phosphorus	%DM	0.23	0.21 - 0.27
Magnesium	%DM	0.13	0.11 - 0.21
Potassium	%DM	1.12	0.82 - 1.30
Sulfur	%DM	0.11	0.09 - 0.13
Chloride	%DM	0.20	0.11 - 0.35
Lactic Acid	%DM	3.86	0.00 - 7.83
Acetic Acid	%DM	4.66	0.00 - 5.01
Propionic Acid	%DM	0.49	0.00 - 1.33

*BMR corn silage statistics provided for comparison.

Calculations

NFC	%DM	40.57
NSC	%DM	32.53
NDF kd rate MIR_P1	%/hr	5.46
Starch kd rate MIR_P1T1	%/hr	21.69
Adjusted Crude Protein	%DM	8.14

		ADF	**OARDC**	**MLK 2006 NonProc**
TDN		69.14	71.78	73.50
Nel 3x	Mcal/cwt	71.62	74.48	71.57
Neg	Mcal/cwt	44.33	47.54	50.58
Nem	Mcal/cwt	71.55	75.17	78.62
Milk per ton	lbs/ton			3420
Beef per ton	lbs/ton			

		MLK 2006 Processed	**ISU Beef**	**MLK 2024**
TDN		73.51	67.67	
Nel 3x	Mcal/cwt	71.58		72.46
Neg	Mcal/cwt	50.58	46.16	
Nem	Mcal/cwt	78.62	73.23	
Milk per ton	lbs/ton	3421		2,967
Beef per ton	lbs/ton		267	

CNCPS Feed Fractions

Protein Fractions				Carbohydrate Fractions		
Label	**Lab Measure**	**Relative kd**		**Label**	**Lab Measure**	**Relative kd**
PRT A1	Ammonia	Fast		CHO A1-A3	VFA	Moderate
PRT A2	Sol. True Prot.	Med-Fast		CHO A4	Sugars	Fast
PRT B1	By difference	Moderate		CHO B1	Starch	Med-Fast
PRT B2	NDIP-ADIP	Slow		CHO B2	Sol. Fiber	Moderate
PRT C	ADIP	Undegradable		CHO B3	Digestible NDF	Slow
				CHO C	uNDF	undegradable

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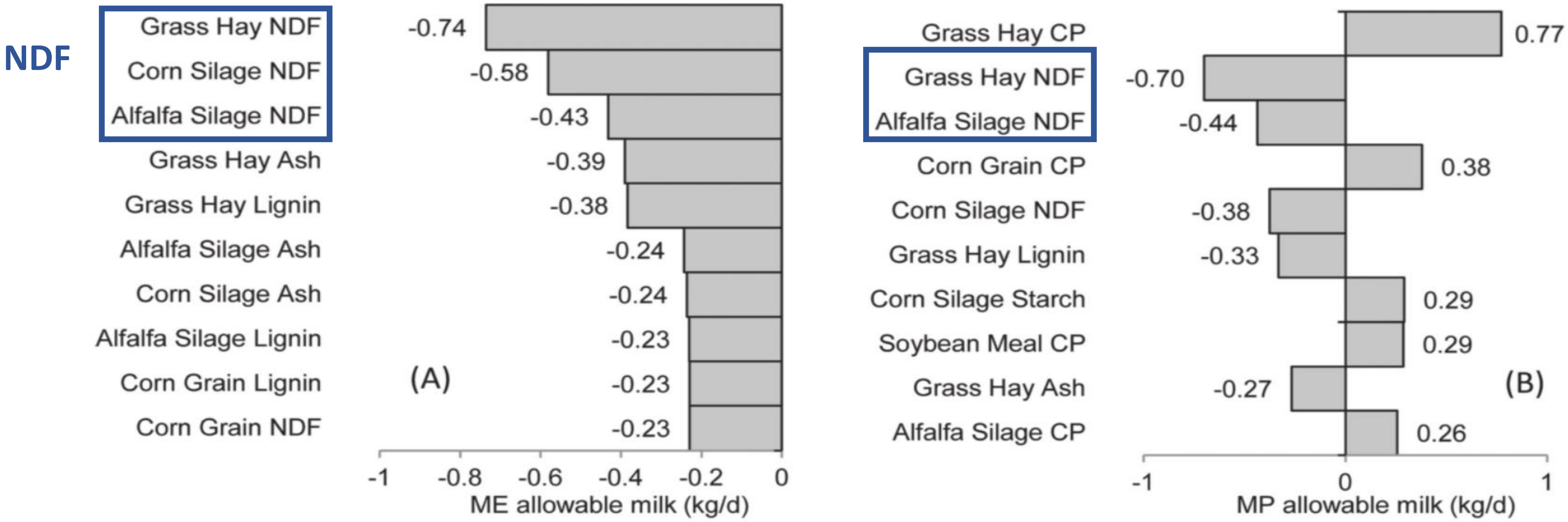
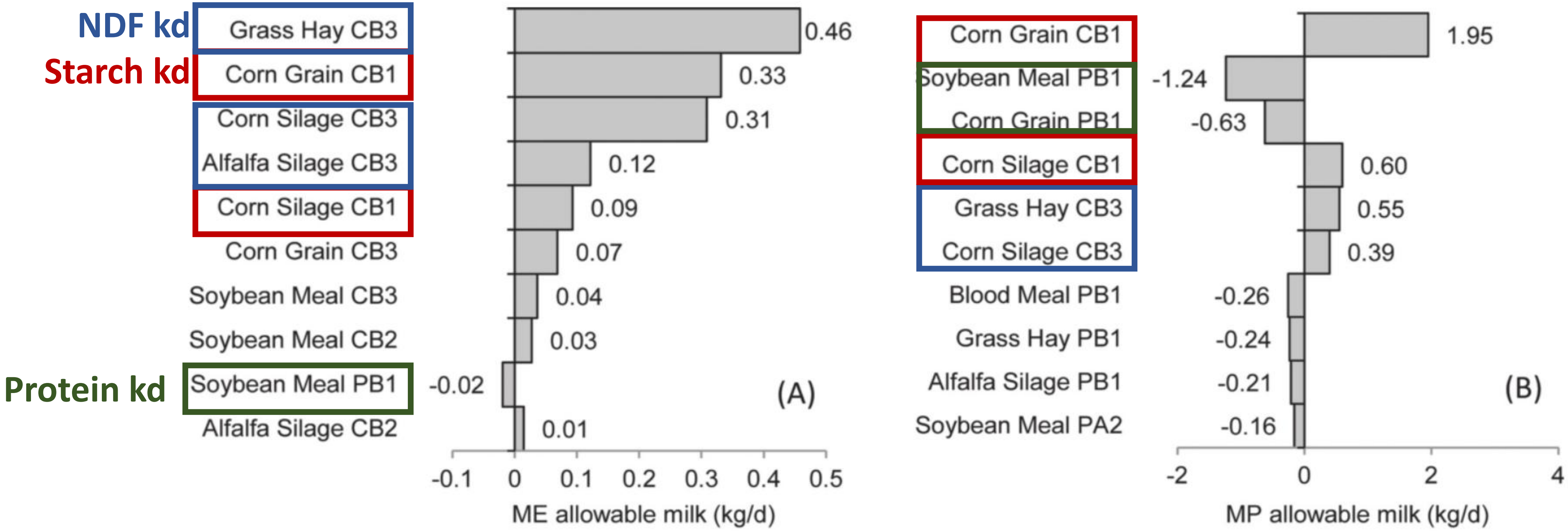
Feed analysis: Composition

- **Which measurements of <u>composition</u> are most important?**
- **Evaluated ME and MP sensitivity to 1 SD increase in amount of nutrient**



Feed analysis: Digestibility

- Evaluated ME and MP sensitivity to 1 SD increase in kd of nutrient
- Starch digestibility has the single largest effect on predicted milk



External Factor: Particle size

- Photos: S. Fessenden

Starch Particle Size—Field application

- **For the CNCPS: it all relates to CHO B1 kd and ID. Pick the right library feed!**
- **Corn silage**
  - **Poor kernel processing? Use “Unprocessed” out of the library to avoid ME bias post-rumen**
- **High moisture corn (shelled, ear)**
  - **Grind and moisture will be very important.**
  - **Test throughout year. I prefer UW Grain 2.0**
- **Ground corn**
  - **Routine measurement of MPS can help.**
  - **Below 750 micron gets us into the 20%/h range for kd**
  - **Keep an eye on distribution of particle size**

DAIRYLAND
Laboratories, Inc.

Feed Grain	MPS
Fine Ground - Dry Corn	<750
Medium Grind - Dry Corn	750 - 1000
Coarse Ground - Dry Corn	>1000
Whole - Dry Corn	>4000
Fine Ground - High Moisture Corn	<1000
Coarse Grind - High Moisture Corn	1000 - 2500
Rolled - High Moisture Corn	1000 - 2500
Coarse Rolled - High Moisture Corn	>2500
Whole - High Moisture Corn	>4000
Snaplage	750 - 2000

Feed analysis summary

- **Sam's Ranking for the CNCPS**
- **Conditionally important: Parameters like VFA profile, pH, toxins, molds, yeasts, etc...**

Corn Silage	Haycrop
Starch dig. (7h 4mm, or lab kd)	aNDFom
aNDFom	aNDFom dig. (4 time point)
aNDFom dig. (3 time point)	CP
Starch	Ammonia CPE
CP	Sol. Protein
EE	NDICP
Ash	ADICP
VFA	WSC (or ESC)
WSC (or ESC)	Ash
ADICP	EE
NDICP	VFA
Sol. Protein	ADF

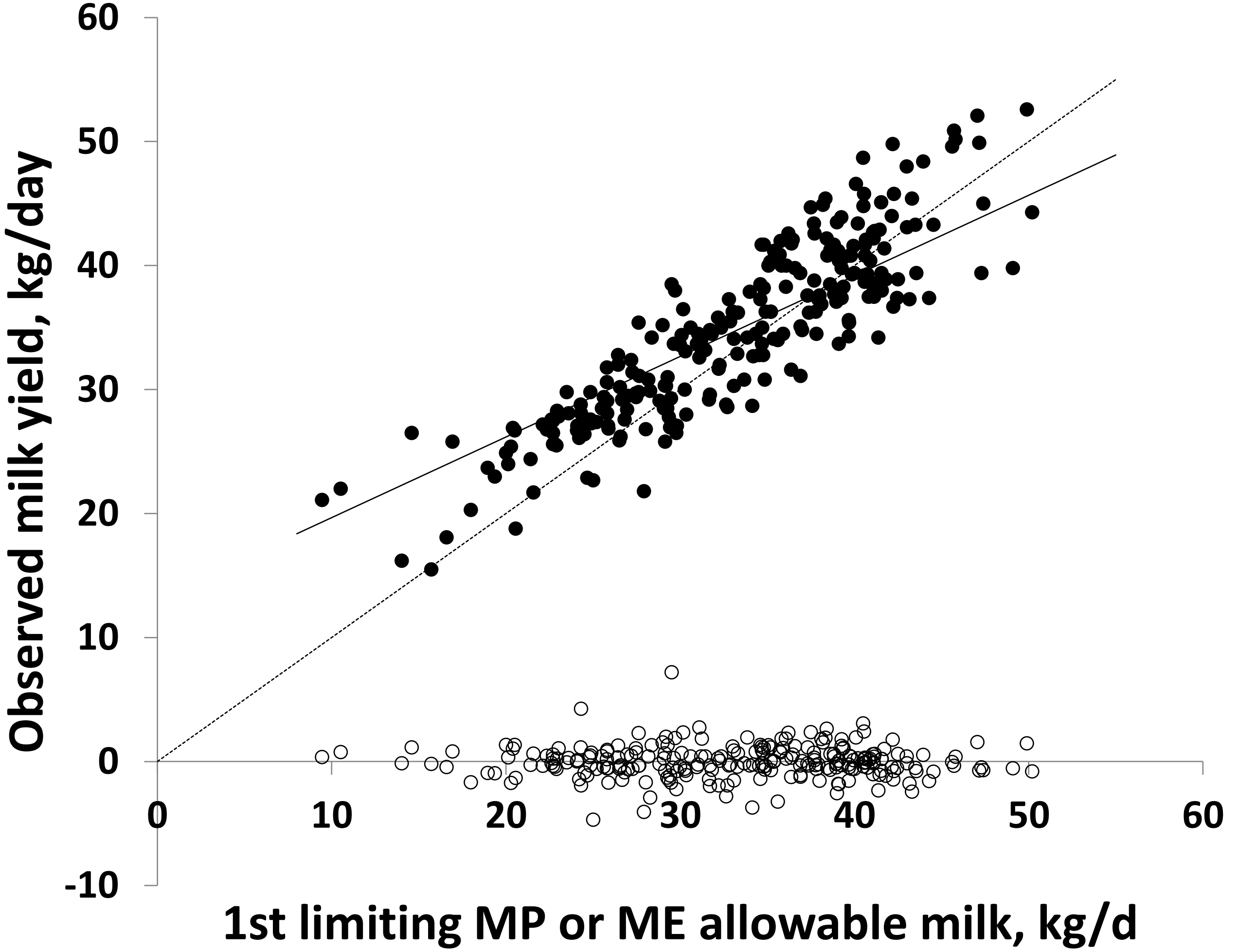
"Model says 105 lb of milk, cows are making 95 lb. Is the model broken?"

My response: Well, was it working? What changed?

TOP 5 things to check:	Typical variation in predicted milk
Is actual dry matter intake measured and entered?	2-6 lb
Are forage dry matters adjusted regularly?	2-6 lb
Is entered starch digestibility realistic?	2-10 lb
Are other forage/feed parameters tested regularly?	1-4 lb
Are cattle inputs entered correctly?	1-3 lb

Use of precise feeding models requires attention to on-farm variation first.

CNCPS predicted vs. actual milk



- **Range of 10 to 50 kg/d**
- **Error of ± 1.6 kg/d (4%)**
- **Overpredicts at low production**
- **Underpredicts at high production**
- **On farm use should expect slightly lower error (± 1 kg)**
  - **Better feed characterization**
  - **Better animal input**

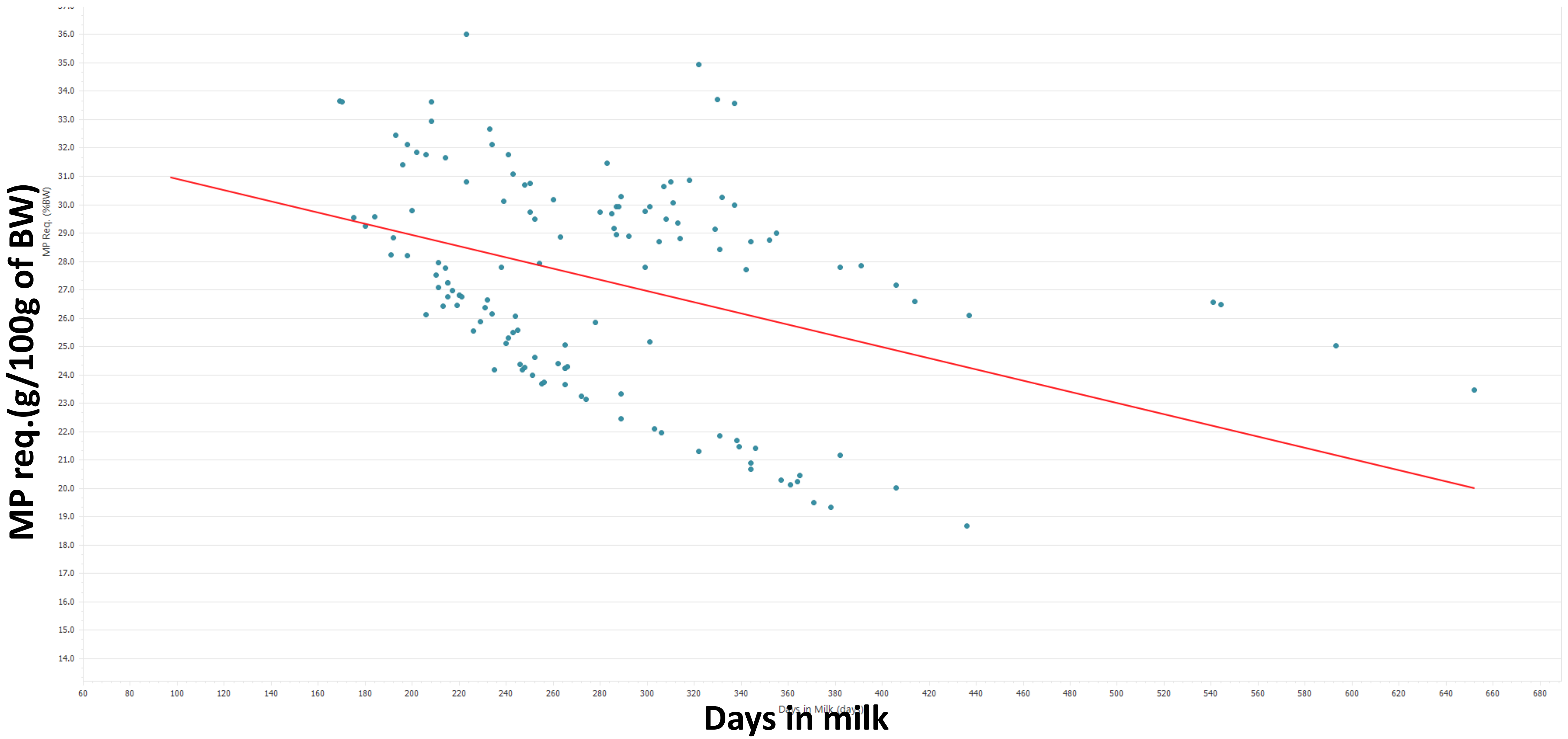
- Van Amburgh et al. (2015)

A note on precition feeding

- **Technology now allows for real-time collection of milk production (including components), body weight, even BCS.**
- **Sensor and data modeling techniques(AI) can help ‘fill in the blanks’ where data may be lacking (individual intake)**
- **Ration balancing based on group averages is leaving information on the table.**

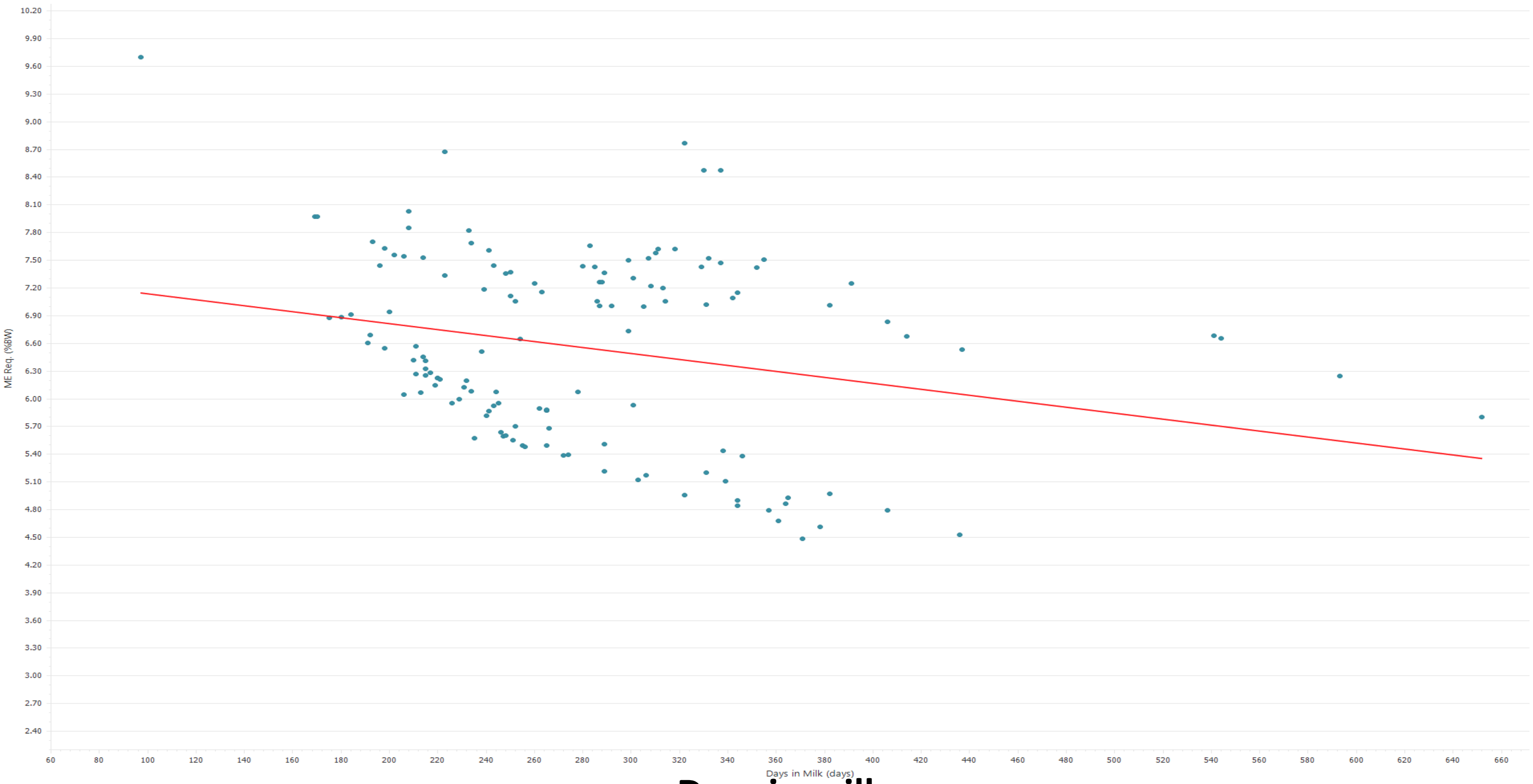
- Photo: Cornell Animal Sci. Dept.

MP req. (g/ 100g) BW by days in milk



ME req. (Mcal/100g BW) by days in milk

ME req. (Mcal/100g of BW)



Days in milk

Summary

- **Successful CNCPS implementation requires a high level of attention to inputs and control of on-farm variation**
- **Technology use alone does not mean 'precision feeding':**

- Photos: S. Fessenden

Thank you!
Questions?