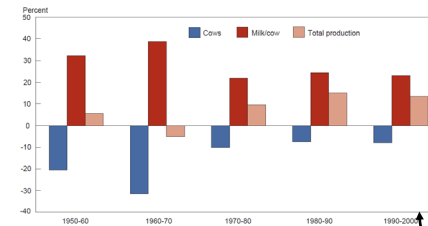


# Modeling the Nutrition-Environment Nexus

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## The Changing Dairy Landscape

10-Year changes in average cow numbers, production per cow, and total production, 1950-2000



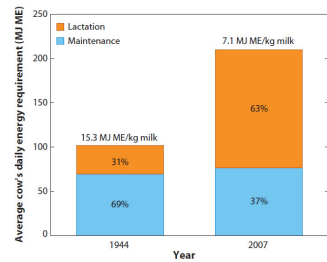
(Blaney, 2004, ERS)

Clean Water Act, 1972  
CAFO Defined, 1976

NMP Requirement, 2003

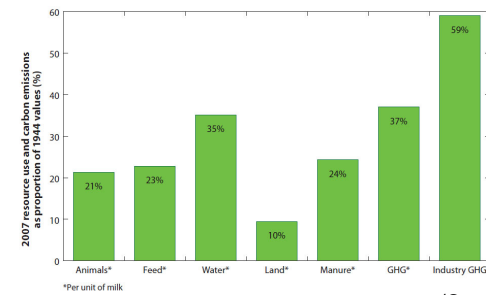
## Models in the Changing Dairy Landscape

- ▶ Nutrition Models
  - ▶ CNCPS
  - ▶ NRC
- ▶ Genetic Selection Models



(Capper and Bauman, 2013)

## Progress towards Environmental Goals

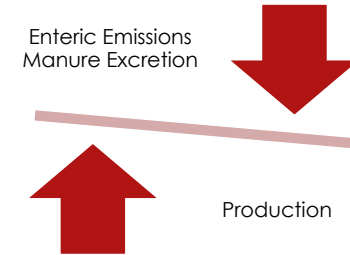


(Capper and Bauman, 2013)

“Achieving the higher level of productivity needed—itself a formidable task—will not be sustainable without innovative solutions to challenges posed by shortages of arable land and water, the degradation of ecosystems, and the negative impacts of climate change.”

Science Breakthroughs to Advance Food and Agricultural Research by 2030.  
National Academies of Science, Engineering, and Medicine (2018)

## Multi-Objective Nutrition Modeling

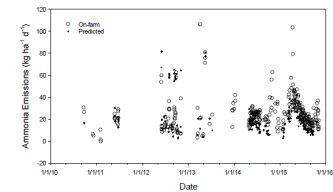


What's  
happening on  
the rest of the  
farm?



## Beyond the Barn

➤ Manure  
Management



$$\text{NH}_3 = -34.7 + 0.098(\text{TKN}) + 3.38(\text{Wind}) + 0.492(T_m)$$

$$\text{NH}_3 = -78.3 + 0.112(\text{TAN}) + 3.19(\text{Wind}) + 0.437(T_m) + 7.45(\text{pH})$$

(Leytem et al., 2018)

## Beyond the Barn

- Manure Management
- Crop production



**SWAT** Soil & Water Assessment Tool

What's missing?

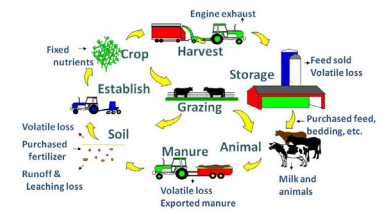


## NAS Report

- **Breakthrough 1:** A systems approach to understand *the nature of interactions* among the different elements of the food and agricultural system can be leveraged to increase overall system efficiency, resilience, and sustainability.
- **Breakthrough 3:** The application and integration of data sciences, software tools, and *systems models* will enable advanced analytics for managing the food and agricultural system.

## Beyond the Barn

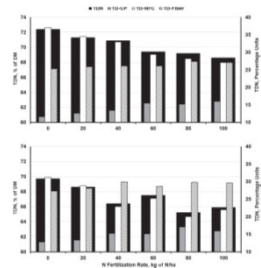
- Manure Management
- Crop production
- Whole Farm Models



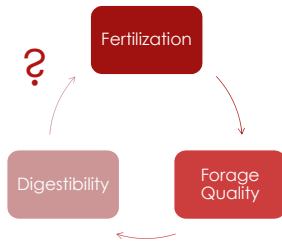
IFSM   SIMS(Dairy)   DairyMod   Comet Farm

## Missing connections

Fertilizer Impact on Digestibility

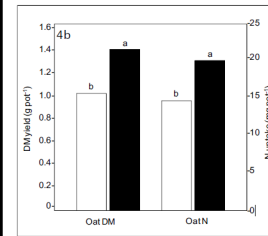


(Coblentz et al., 2017)

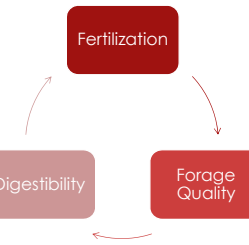


## Missing connections

Manure Impact on Yields



■ High CP diet  
□ Low CP diet

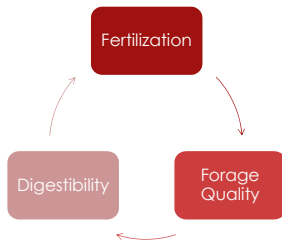


(Powell and Broderick, 2011)

## Missing connections

Manure Impact on Yields

Manure N from:	AS	CS	CG	SBM
CS DM (kg/m <sup>2</sup> )	1.95	2.04	2.10	2.20
CS N uptake (g/m <sup>2</sup> )	12.0	19.1	19.1	18.8
NUE (g Corn N/ kg Manure N)	274 <sup>ab</sup>	250 <sup>b</sup>	285 <sup>ab</sup>	327 <sup>a</sup>

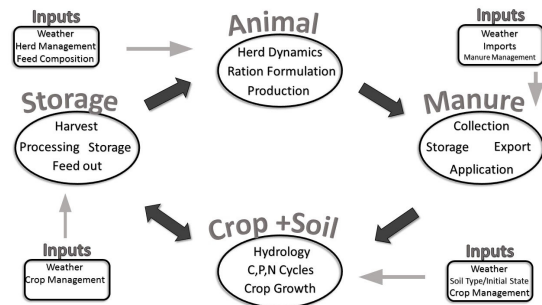


(Powell et al., 2017)

## Questions for Farm Systems Models

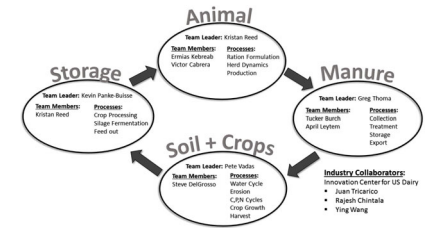
- ▶ How does herd nutrition affect nutrient fate in crop uptake and crop quality?
- ▶ Does reduction in enteric methane shift emissions to manure or soil?
- ▶ How do crop system choices affect whole farm nutrient efficiency?
- ▶ How does dairy nutrition affect soil health parameters and overall farm productivity?

## Ruminant Farm Systems Model (RuFaS)



## Model Objectives

- ▶ Simulates N, P, and C cycling
- ▶ Estimates:
  - ▶ Production
  - ▶ GHG production
  - ▶ Energy and water use
  - ▶ N and P losses
- ▶ Account for weather and soil types
- ▶ Respond to common management practices and cropping systems
- ▶ Reflect current state of knowledge



Thank you for your attention...

Questions?

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