Agricultural Mitigation Strategies for Animal Management Systems in California

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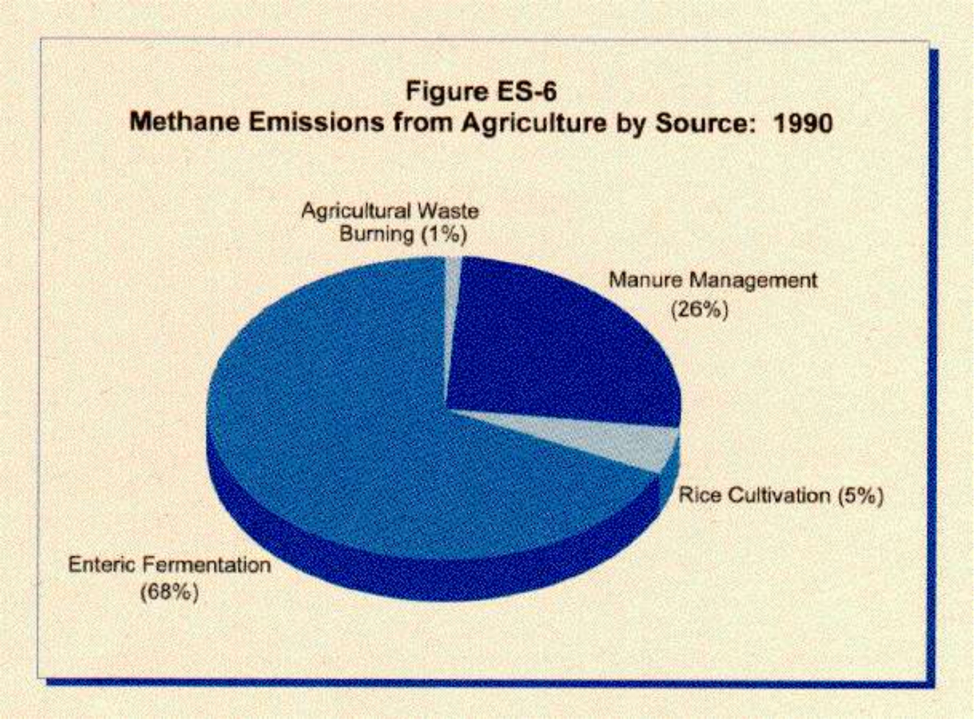
MODELING SUSTAINABLE AGRICULTURE at UC DAVIS

Overview

- Introduction
- Mitigation potential to reduce GHG
- Objective of the current analysis
- Methodology
  - Data collection
  - Statistical analysis
- Results
- Further work

Introduction

- GHG from agriculture
  - Methane
  - Nitrous Oxide
  - Carbon Dioxide
- Sources of emission in animal agriculture
  - Enteric fermentation
  - Manure storage
  - Manure application

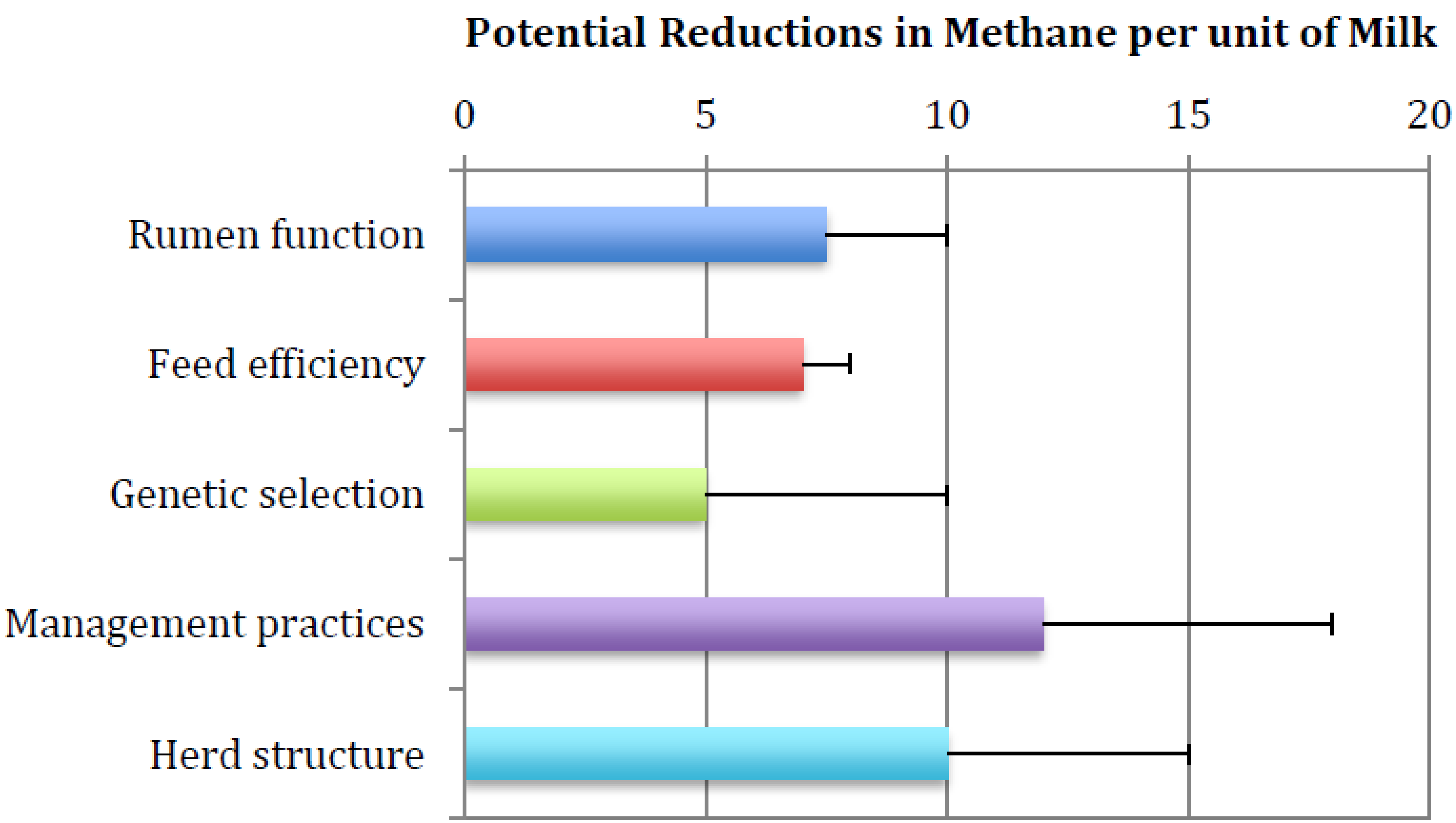


Dairy sector in CA

Cattle by Class as of January 1, 2001-2012										
	Cows That Have Calved			Heifers 500+ Lbs.			Other Cattle			
				Cow Replacements						
Year	Beef	Dairy	All	Beef	Milk	Other Heifers	Calves Under 500 Lbs	Bulls 500+ Lbs.	Steers 500+ Lbs.	All Cattle and Calves
					1,000 Head					
2001	780	1,560	2,340	140	750	170	1,050	70	630	5,150
2002	760	1,620	2,380	135	770	170	1,040	65	640	5,200
2003	740	1,670	2,410	130	790	170	1,070	65	615	5,250
2004	720	1,700	2,420	125	730	170	1,050	65	640	5,200
2005	720	1,740	2,460	130	760	190	1,120	70	670	5,400
2006	680	1,770	2,450	120	790	180	1,200	75	635	5,450
2007	700	1,790	2,490	125	790	170	1,190	70	665	5,500
2008	655	1,835	2,490	110	800	180	1,170	70	630	5,450
2009	620	1,840	2,460	115	780	170	1,060	65	600	5,250
2010	610	1,760	2,370	120	750	210	1,050	70	580	5,150
2011	600	1,750	2,350	110	760	220	1,100	70	590	5,200
2012	620	1,780	2,400	110	800	240	1,100	70	630	5,350

California Department of Food and Agriculture

Mitigation Potential



Dietary Manipulations

- Various dietary mitigation strategies
  - Lipids/fat
  - Starch vs fiber
  - Ionophores (monensin)
- ETAAC (2008) report
  - 16% NRC recommendations
  - 11% specific agents
  - 3% long-term management and breeding

Objective

- Quantify potential reduction in methane emissions from dairy cattle in CA by formulating diets based on:
  - Current practices (1)
  - NRC recommendation
    - Unrestricted (2)
    - Restricted (3)
  - Minimized methane (4)

Methodology

- Data from 40 dairies in CA collected

Diet	Corn Silage	Alfalfa Silage	Oat/Wheat/ Barley Silage	Alf. Hay	Oat/Wheat Hay	Ground Flaked Corn	Barley Grain	Canola	Cotton Seeds	SBM	Soy H.	AH	DDG	Wheat Mill	Grains	Rice Bran	Fat Suppl.	Min & Vit Suppl.
1	19	0	12	18	0	13	5	0	5	6	0	0	8	10	0	0	1	2
2	28	12	0	13	3	24	0	0	9	9	0	0	0	0	0	0	1	3
3	17	0	0	29	0	11	6	6	11	0	0	6	3	3	3	3	1	3
4	36	0	22	8	1	12	0	7	4	0	2	4	0	0	0	0	0	4

		Distribution (percentile)			
	Median	10^{th}	25^{th}	75^{th}	90^{th}
Milk yield, kg/d	32.1	24.9	27.2	35.8	39.0
DMI, kg/d	23.3	20.7	22.5	24.4	25.5

- Feed ingredients converted to chemical composition (according to NRC)

Methane Emission Estimation

- IPCC Tier 2 equation most common
- Not preferred because
  - It does not account for nutrient differences
  - Less precise
  - Assessment of mitigation limited to reduction in cow numbers and feed consumption
- Developed our own model using over 1,000 energy balance records

Methane model

$$\mathbf{y} = \mathbf{X\beta} + \mathbf{Z_1\alpha} + \mathbf{Z_2\xi} + \boldsymbol{\varepsilon},$$

where $\mathbf{y}$ is the vector of n methane records $\mathbf{X}$, $\mathbf{Z_1}$ and $\mathbf{Z_2}$ are design matrices relating element of $\mathbf{y}$ to elements of $\boldsymbol{\beta}$, $\boldsymbol{\alpha}$ and $\boldsymbol{\xi}$ which represent vectors of regression coefficients, animal random regression coefficients, and study random regression coefficients. $\boldsymbol{\varepsilon}$ is the vector of errors

Methane (GE/d) = -0.32 (0.318) + 0.19 (0.008) DMI (kg/d) – 0.05 (0.046) EE (%) + 0.038 (0.007) NDF (%)

Linear Programing model

- Investigated changes in methane emissions for all scenarios

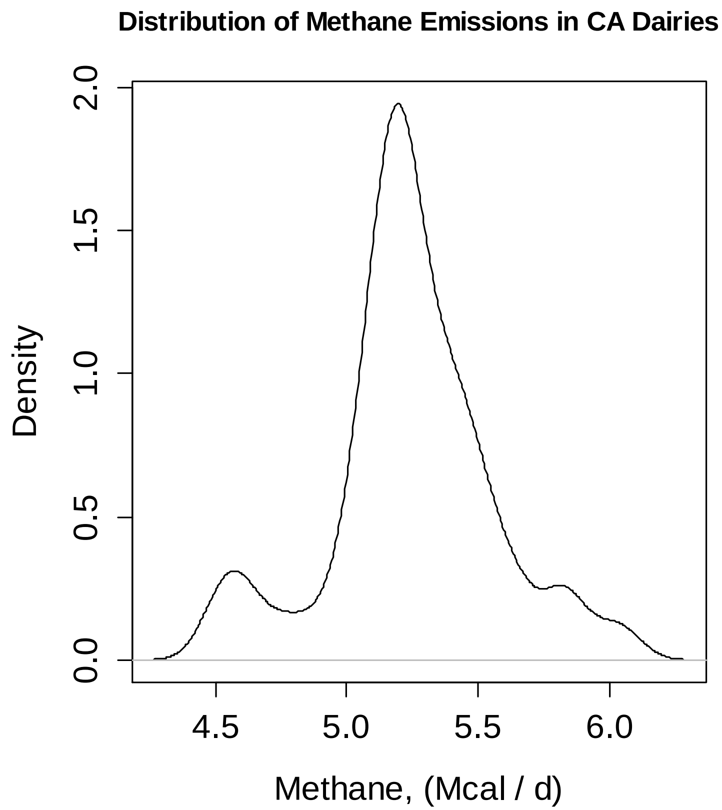
$$min(\mathbf{c}^T\mathbf{x}), \text{ subject to } \mathbf{Ax}\ \{\leq, =, \geq\}\ \mathbf{b},$$

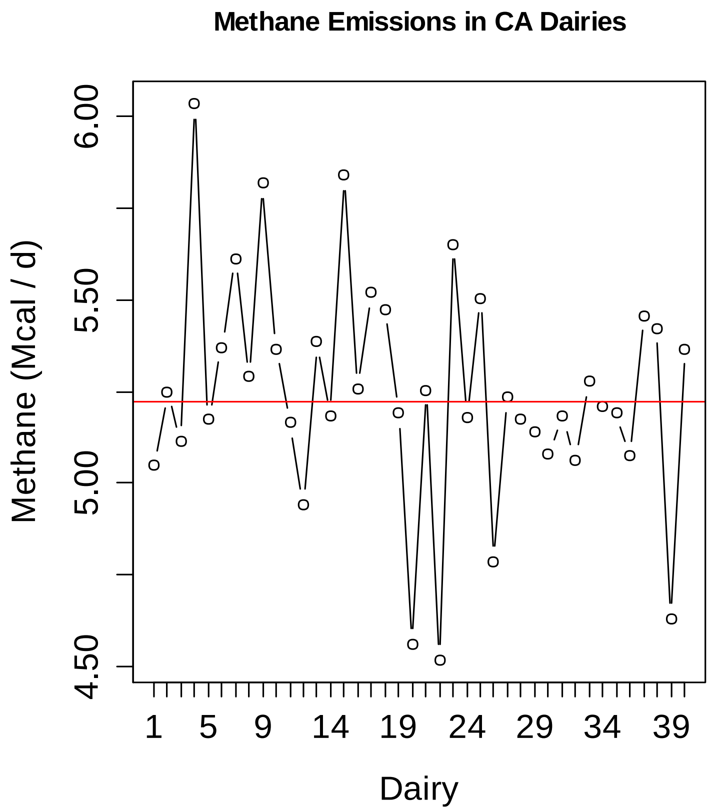
- where **c** is the vector of objective function coefficients (e.g. cost), **x** is the vector of decision variables (feed), **A** is the matrix of constraints coefficients and **b** is the vector of constraints right hand sides (requirements).

Objective

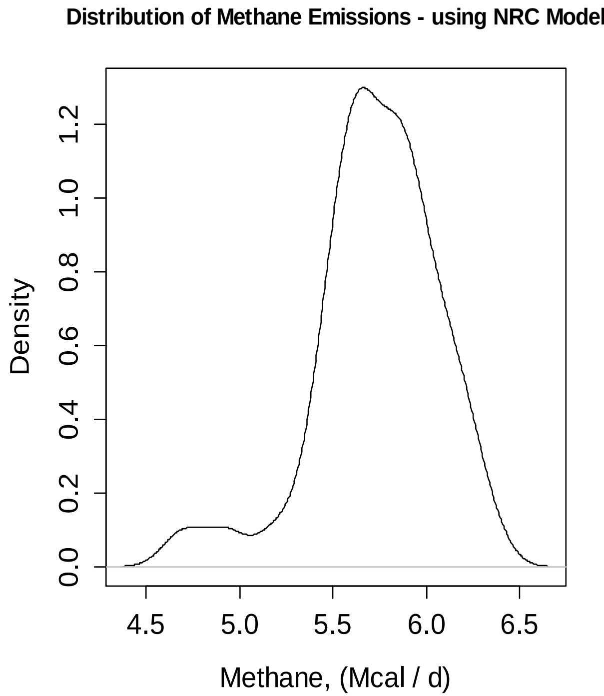
- Quantify potential reduction in methane emissions from dairy cattle in CA by formulating diets based on:
  - Current practices (least cost formulation)
  - NRC recommendation (least cost)
    - Unrestricted
    - Restricted (practical)
  - Minimized methane (least emission)

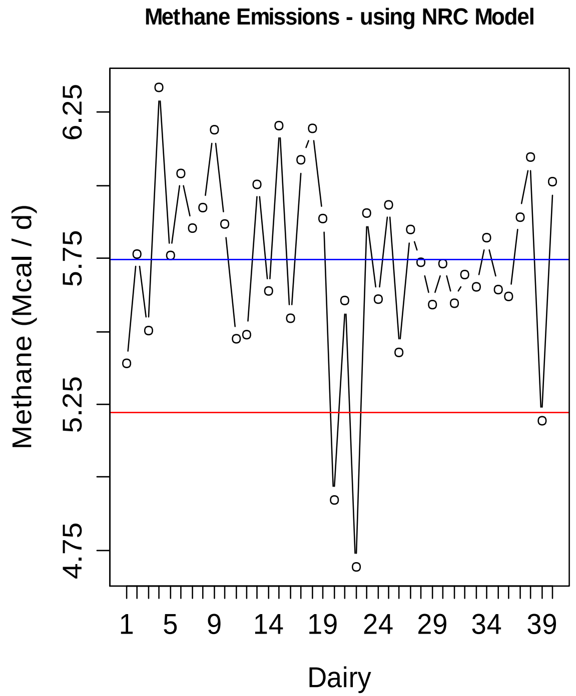
Results – Scenario 1





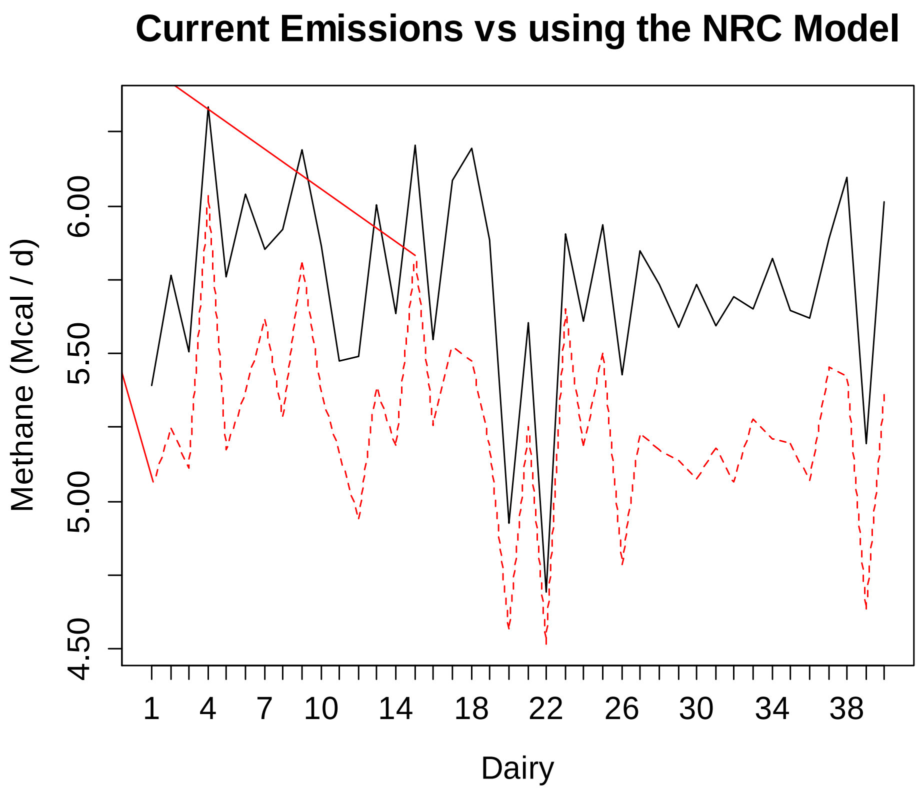
Results – Scenario 2





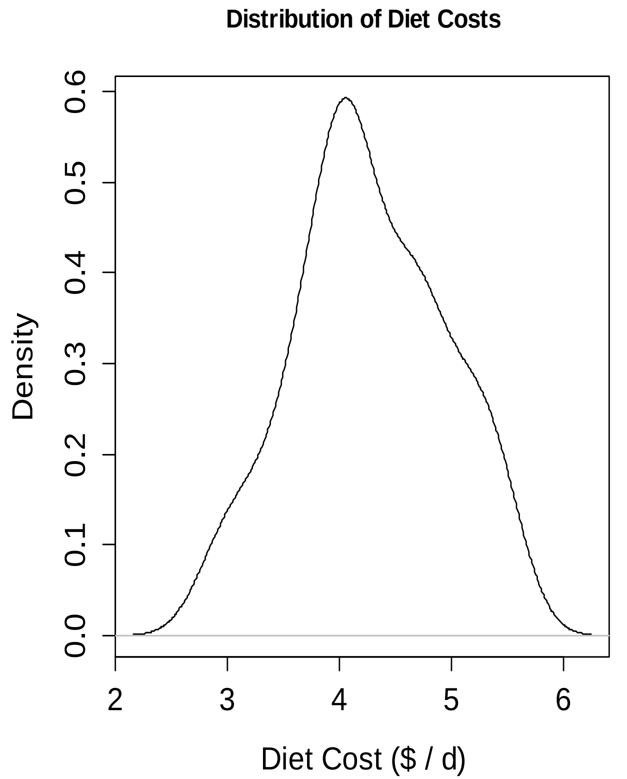
- Using the NRC recommendations with no restrictions caused an increase in total methane emissions of 9.23%
- diets were not practical. E.g. (% DM) 11 % soybean meal, 34% tomatoes, 50% grass silage, and 5% whey.

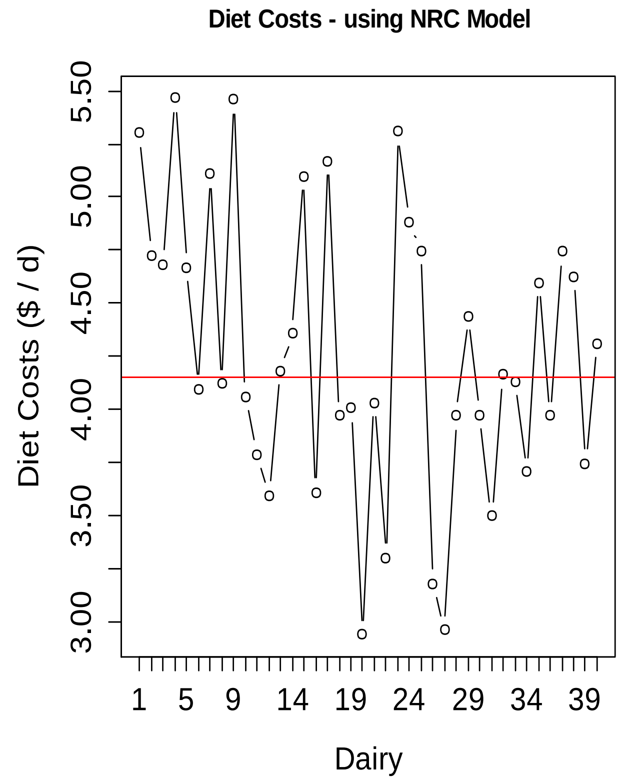
Results – Scenario 1 vs 2



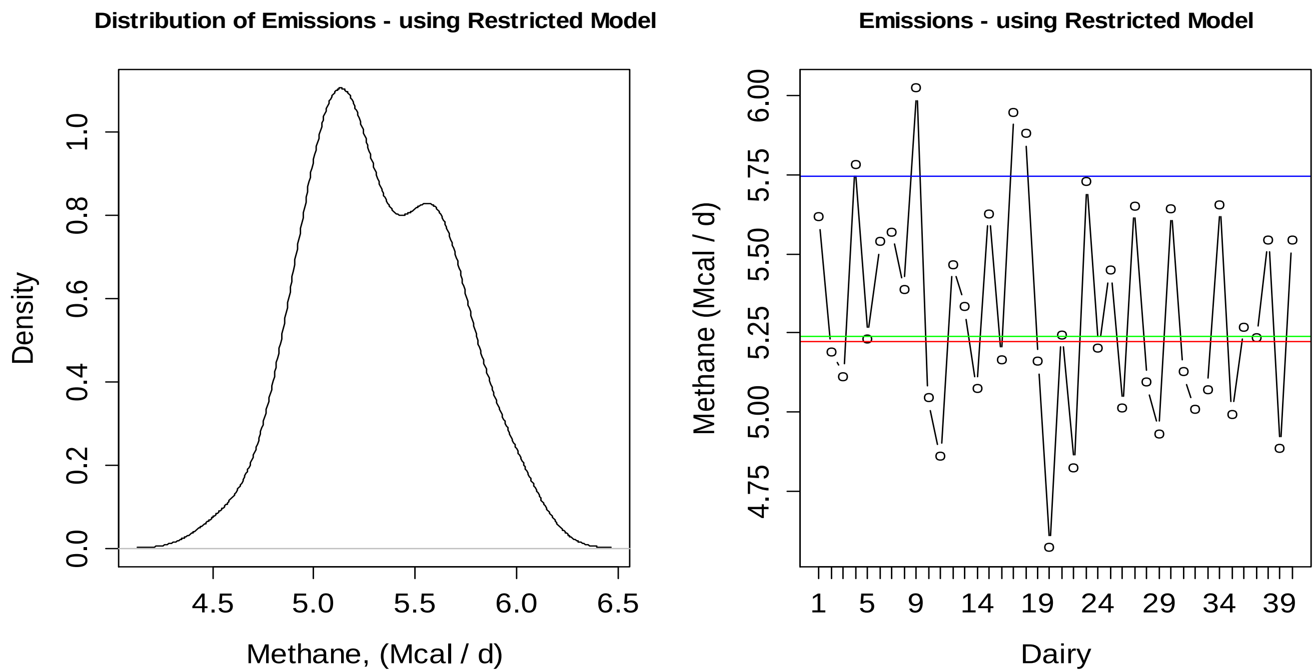
Comparison of predicted current emissions in 40 CA dairies (red dotted line) compared to NRC based diets (black solid line)

Results– Scenario 2 (costs)



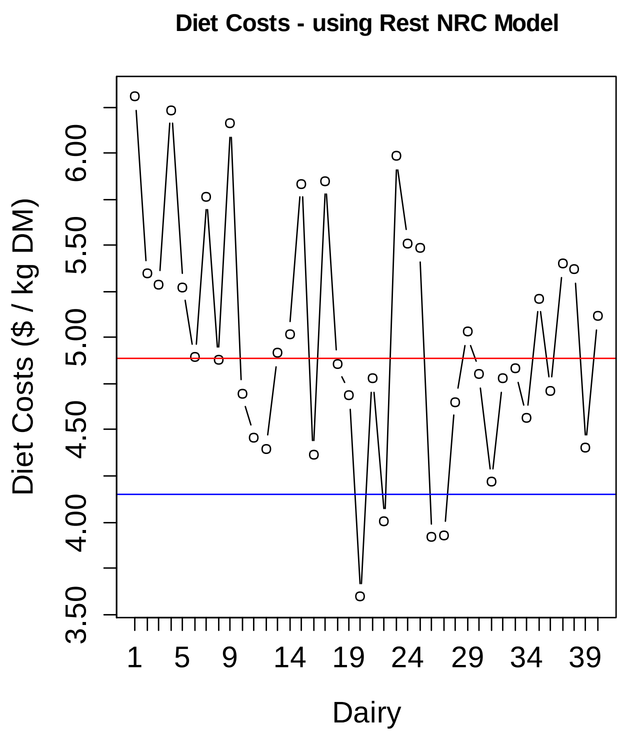


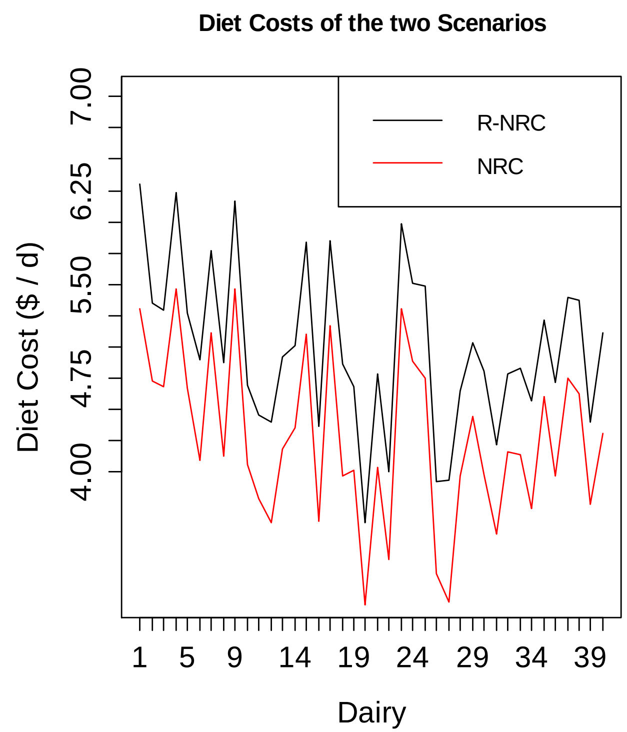
Results – Scenario 3



- Using the NRC recommendations with restrictions caused an increase in total methane emissions of 1.24% compared to current
- Diets were practical. E.g. (% DM) 20% corn silage, 10% DDG, 40% grass silage, 3% molasses, 3% rice bran, 12% soybean meal, 10% tomatoes, 1% whey, 1% mineral supplement

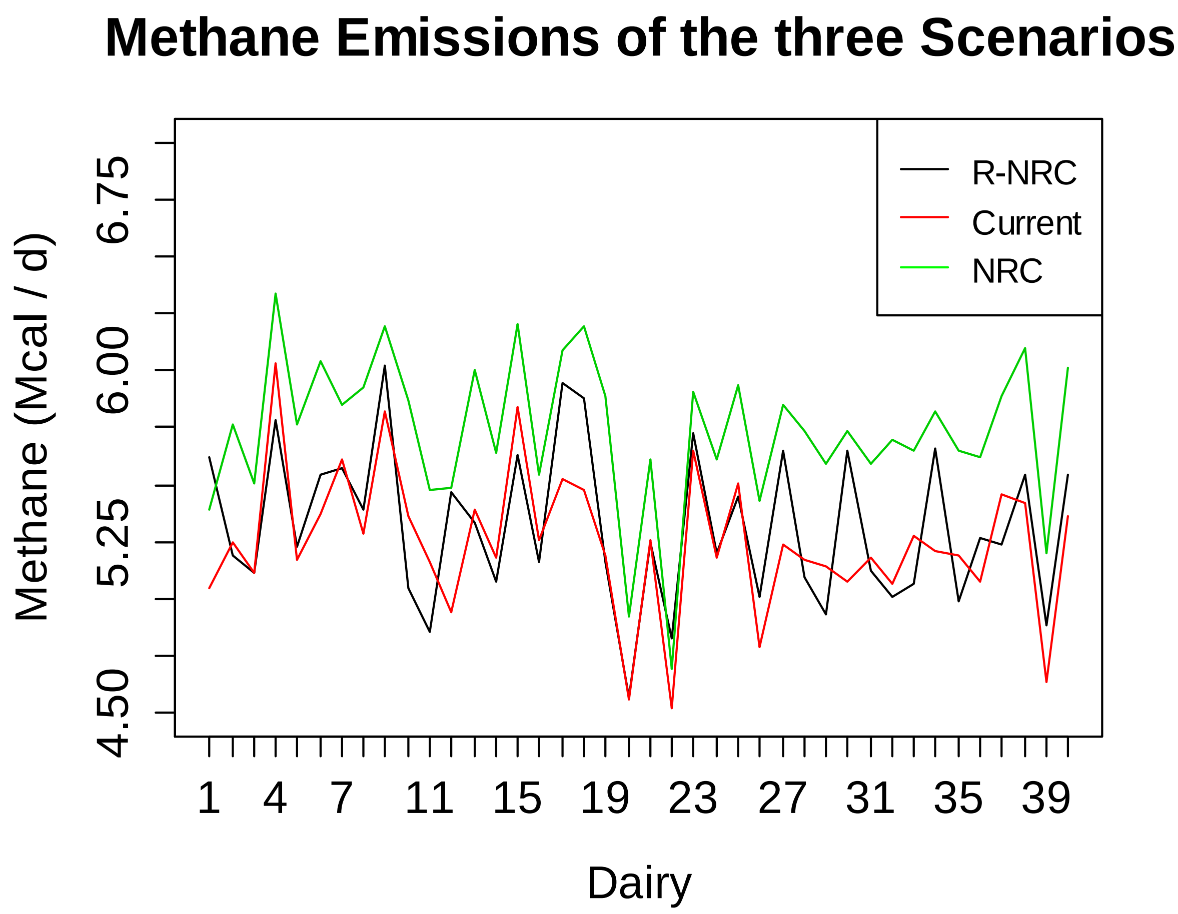
Results – Scenario 2 vs 3 (costs)



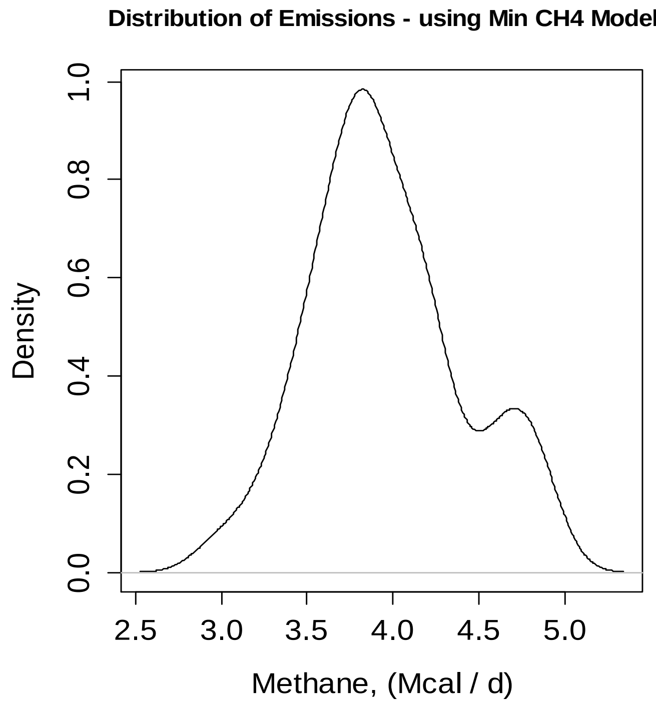


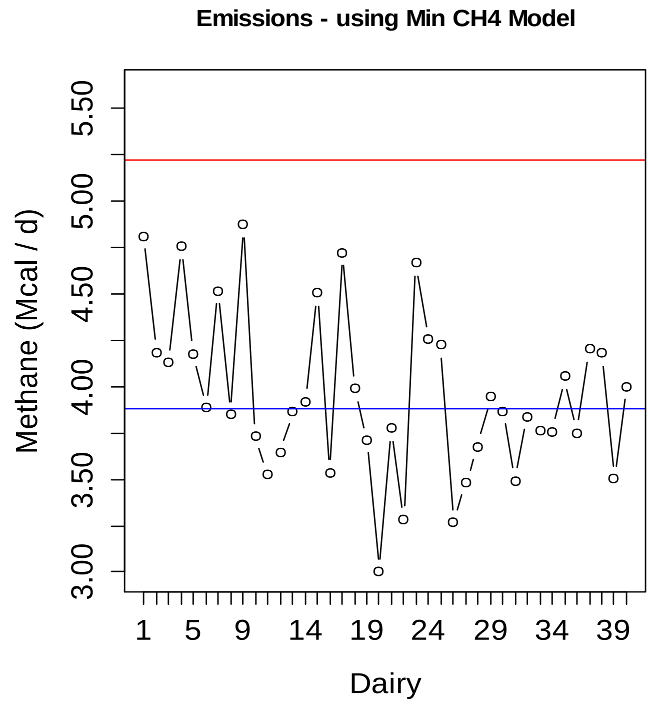
- Using the NRC recommendations with restrictions caused an increase in diet costs of about 16% compared to no restrictions

Results – Scenario 1 vs 2 vs 3



Results – Scenario 4

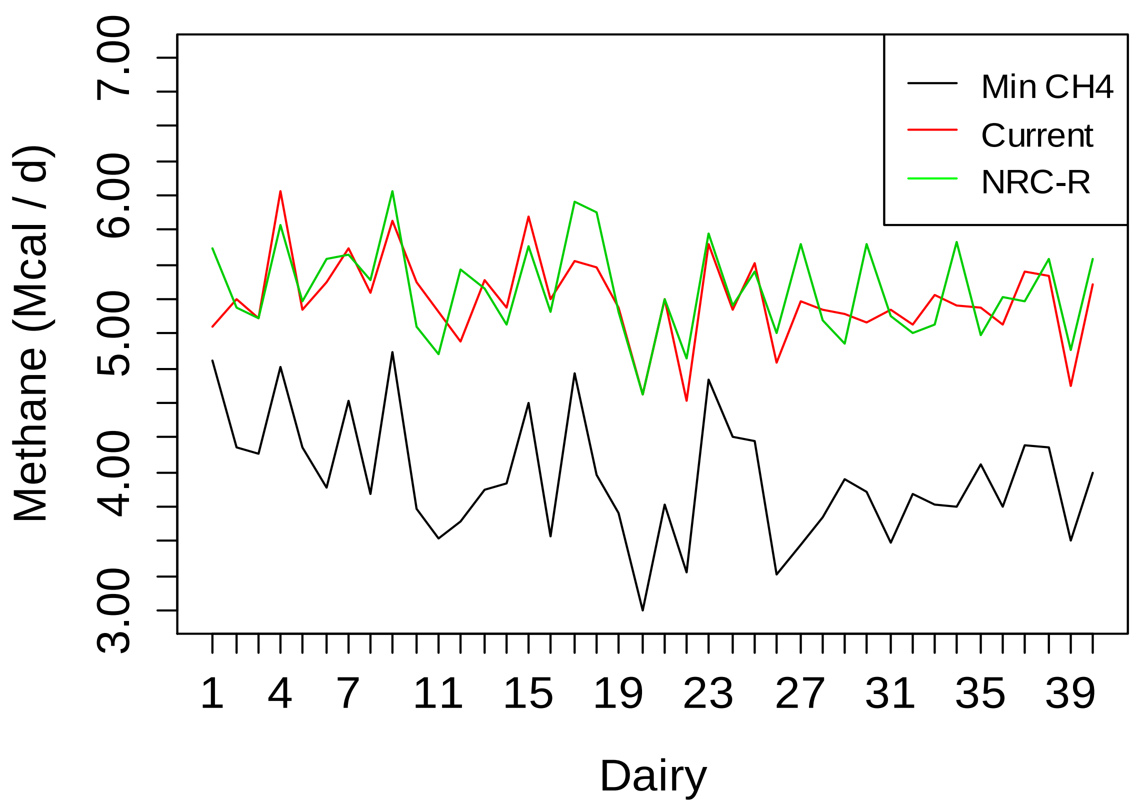




- Using the minimized methane model with restrictions caused an decrease in total methane emissions of **24%** compared to current
- Diets were practical. E.g. (% DM) 40 % alfalfa silage, 8% bakery waste, 9% canola, 26% ground flaked corn, 15% soybean meal, 1% whey, 1% mineral supplement

Results– Scenario 1 vs 3 vs 4

Methane Emissions of the three Scenarios



Results– Scenario 3 vs 4 (costs)

- Diets formulated to minimize methane emissions increased costs by an average of 49%

Further Work

- Multi-criteria LP to reduce methane AND cost
  - – Cap and trade?
  - – Shadow prices
- Specific agents (monensin)
  - – Include recent work (in press, JDS)
- Estimate costs of current diets
- Suggestions welcome


THANK
YOU
GRACIAS
ARIGATO
SHUKURIA
TASHAKKUR ATU
SUKSAMA
GRAZIE
MEHRBANI
BIYAN
SHUKRIA
DANKSCHEEN
JUSPAXAR
BOLZIN
MERCI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