Preliminary Assessment of the Economics of Mitigating GHG Emissions from California Farming

April 30, 2013

Hyunok Lee and Daniel A. Sumner

University of California Agricultural Issues Center and UC Davis, Agricultural and Resource Economics

Farming Greenhouse Gas Emissions Inventory in CA (2009) (MMTCO2e)

Livestock			Crops	
Total	**23.2**		**Total**	**8.3**
Enteric Fermentation (EF)	**9.3**		Residue Burning	1.4
Dairy EF	6.6		Nitrogen Fertilizer	5.4
Manure	**10.3**		Rice	0.6
Dairy Manure	9.7		Other	0.9
Dairy Methane	8.5			
Other	**3.6**			

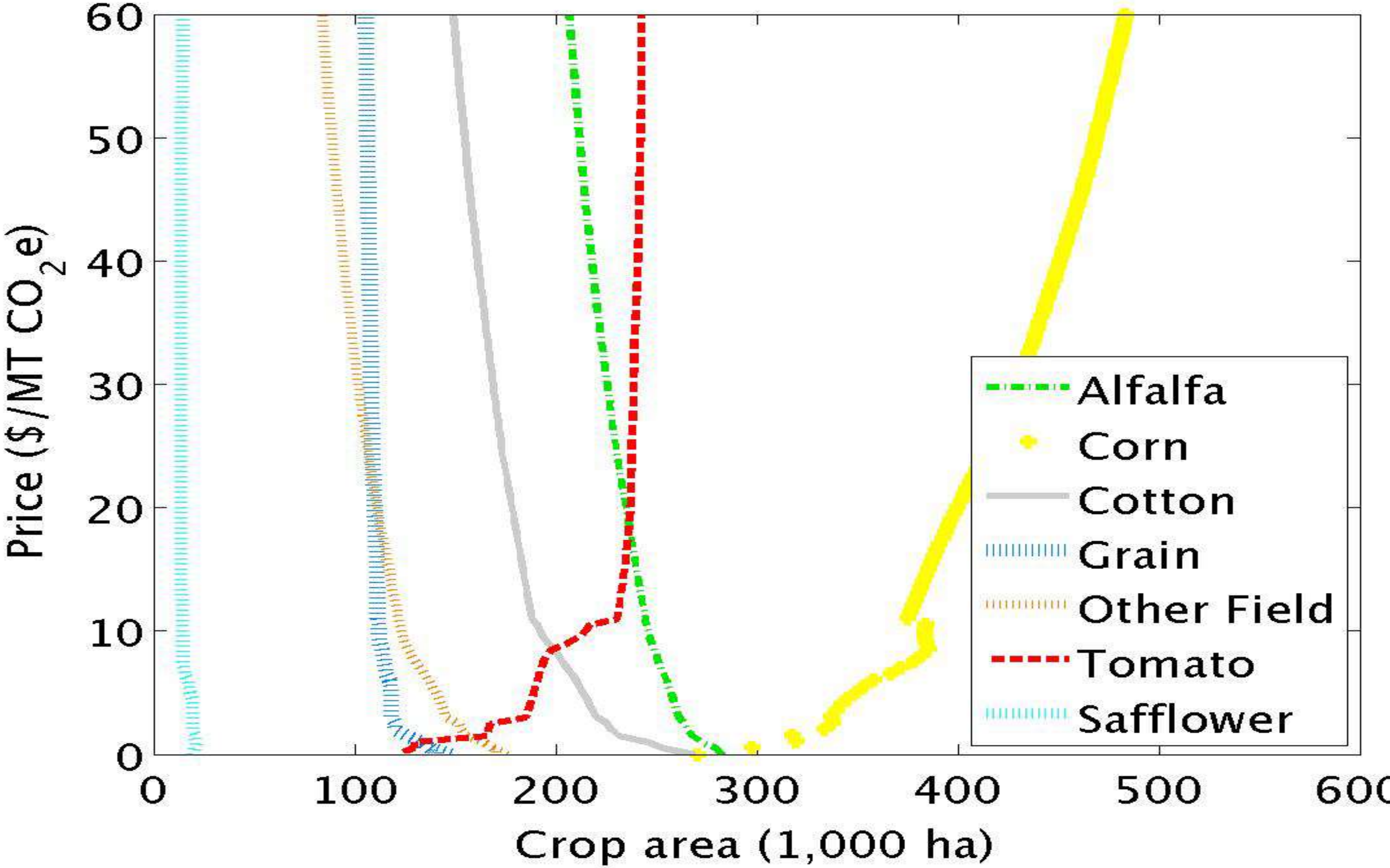
Emission Reduction Under the Carbon Tax: Calibrated Agronomic and Economic Model (Garnache and others)

- Considers GHG emission reduction in Central Valley field crop system with an imposition of carbon tax, \$20/MT CO_2e
- Seven crops, covering 3.2 million acres and emitting 4.4 million MMT CO_2e
- GHG emissions are reduced by optimally adjusting, land, water, fertilizer, and tillage (crop mix, practices, and inputs), until marg. cost of abatement=carbon tax
- Based on the Daycent model, economic model is calibrated to the agronomic yield response model
- Preliminary results show that under a \$20 carbon tax, up to 60% of GHG emissions are abated
- More detailed and revised results are coming

Changes in Total GHG Emissions and Crop Mix Induced by Carbon Tax

	Emissions MMtCO2e		Land (Mil ha)	
	Baseline	$20/tCO2e	Baseline	$20/tCO2e
alfalfa	0.89	0.67	0.28	0.25
corn	0.52	0.01	0.27	0.38
cotton	1.35	0.89	0.27	0.19
grain	-0.04	-0.03	0.15	0.11
other field	0.80	0.43	0.18	0.12
safflower	0.02	-0.01	0.02	0.01
tomato	0.82	0.45	0.12	0.21
Total	4.35	2.40	1.29	1.29

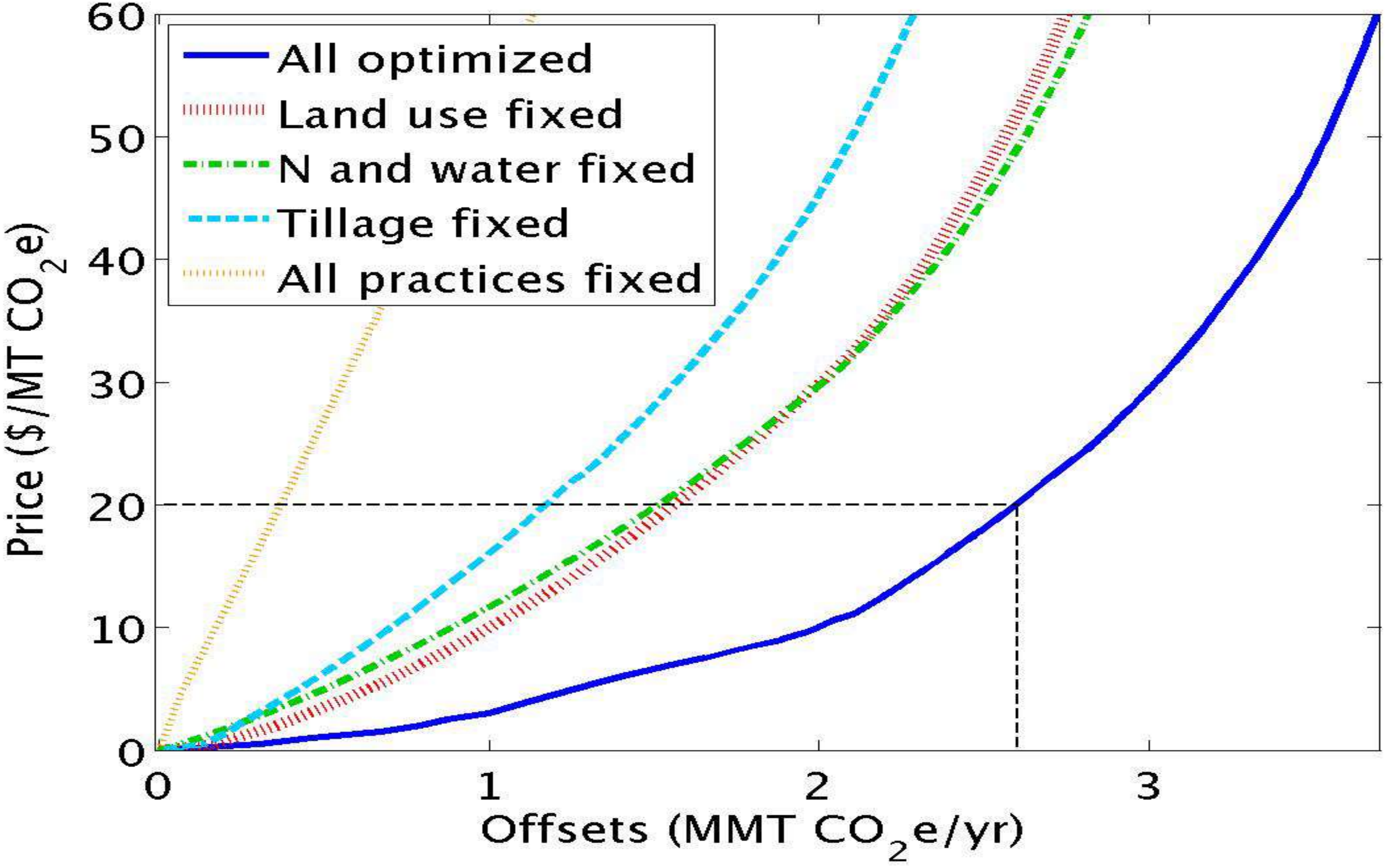
Crop Mix Changes Induced by Alternative Carbon Taxes



Emissions by Crop baseline and with a $20 Carbon Tax

Emissions in ($MTCO_2e$/ha)			
Crop	Baseline/ha	Optimized/ha with tax	Change %
Alfalfa	3.1	2.7	13
Corn	1.9	0	100
Cotton	5	4.6	8
Wheat	-0.3	-0.3	0
Sunflower	4.6	3.5	24
Proc. Tomatoes	6.7	2.1	69
Safflower	0.9	-0.6	167

Offset Supply Curve under Alternative Scenarios



Break-even Price for Dairy Methane Digesters (Based on analysis of ICF)

- Calculates the min payment/MTCO_2e that induces a dairy farm to install methane digester and considers alternative technologies, regions, current manure handing and herd size
- Uses present value formulation with an option of on-farm use of electricity generation
- Huge economies of scale in capital costs for new digesters
- Within each digester system, GHG reductions from digester are constant per animal

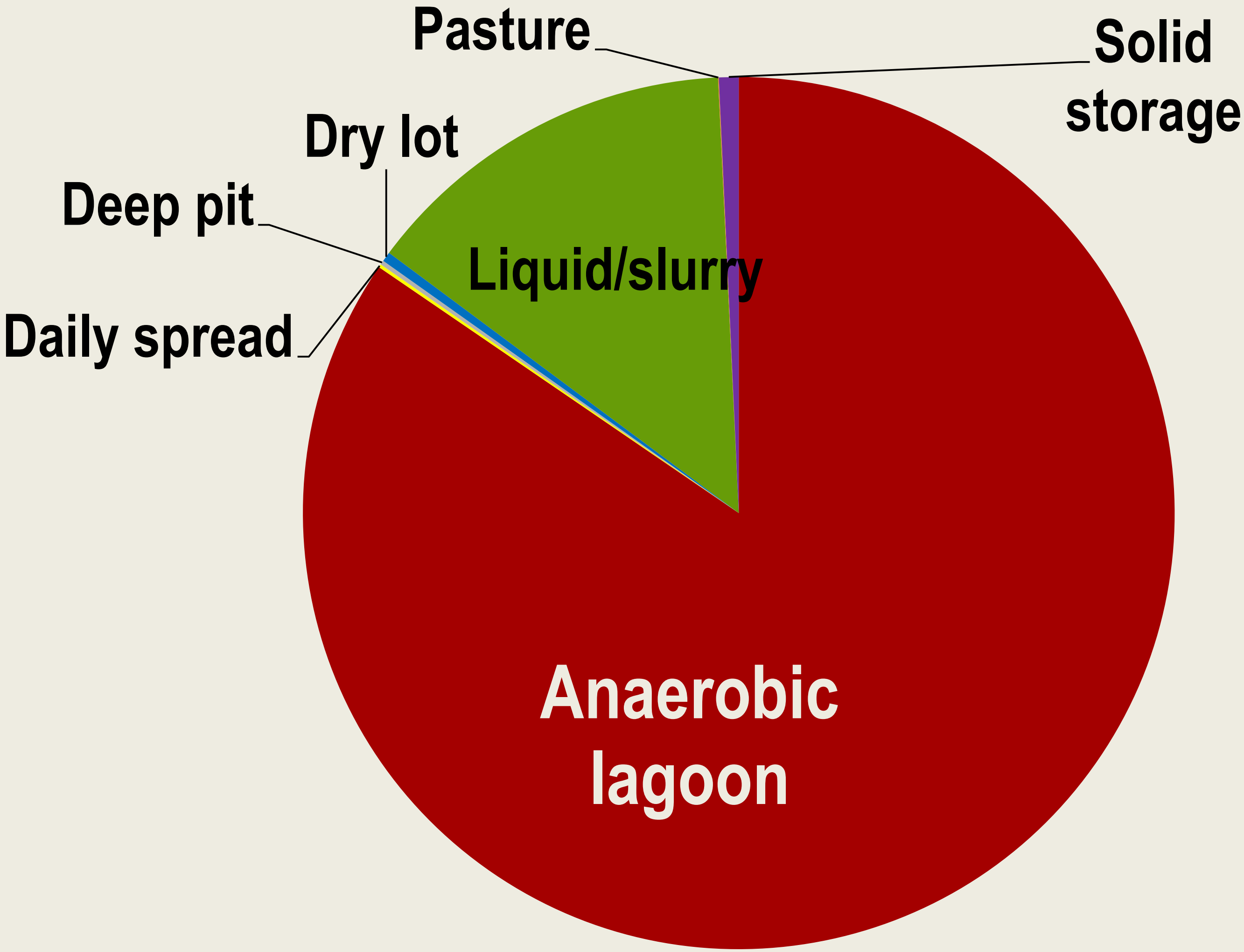
Capital Costs and Outputs of Anaerobic Digester System for 2,000 Cows and Heifers (ICF data and calculations)

	Covered Lagoon Digester	Complete-mix Digester	Plug Flow Digester
Capital Costs ($ mil)	1.05	1	1.35
Methane Mitigated (Thousand MTC02e)	6.9	8.2	8.2
Electricity Generated (mil KWh)	1.34	1.6	1.6
On-farm Electricity Usage (Mil KWh)	0.8-1.1	0.8-1.1	0.8-1.1

Break-even Price for Dairy Methane Control Adoption (ICF data and calculations)

Status	Head of Cows		
	5,000	1,000	600
Existing Anaerobic Lagoon	**($/MT$CO_2$e)**		
Covered Lagoon	5	7	8
Complete-Mix Digester	7	14	20
Covered Lagoon Digester w/ Electricity Generation	2	17	30
Covered Lagoon Digester w/Flaring	15	29	41
Existing Liquid/Slurry	**($/MT$CO_2$e)**		
Covered Lagoon	15	23	25
Complete-Mix Digester	32	62	87
Plug-Flow Digester	32	85	129

CH_4 Emissions from California Dairy Manure Management by Manure Treatment Method in 2009 (source: ARB)



Current Status of Dairy Digesters

- Currently there are 157 dairy digesters (including 10 in CA) operating in the US.

- Of 157 digesters, 50 are complete mix, 15 are covered lagoon (7 in CA), 20 are horizontal plug flow, and 57 mixed plug flow.

- Of 157 digesters, 96 were built during 2006-2010. Prior to 2006 there were 38, and 17 in 2011 and 7 in 2012.

- 85% of digesters are located in the East or Midwest (6 in WA, 10 in CA, 5 in ID, 1 in each of SD, MT, GA)

Number of Dairy Methane Digesters by Year of Operation in Major Dairy States

	2012	2011	2010	2009	2008	2007	2006	2005	2004	pre2004	total
CA				1	4				5		10
WI	2	1	4	4	3	4	3	4	2	1	28
ID		1	1	1	2						5
NY	1	2	3	7	3	2	2	1	1	2	24
PA		4	1	1	1	3	6			2	18
TX					1					2	3
MN			1		4	1				2	8
MI						2	1				3
NM											0
WA		1	1	1	1		1	1			6
VT		3	2	2	1	2	1	1		1	13

Basic economics of digesters

- According to our reading of the ICF cost and returns data and analysis, digesters would seem to be easily profitable for most California dairy farms, given their scale of operation.
- But very few California dairies have invested and all look to incentive subsidies.
- So why the disconnect? Farm operators make big investments when economic conditions suggest it. The Basic ICF data look sound.
- Something else: other regulations, policy uncertainty, uncertainty about the long term feasibility of Central Valley dairies, or what?

Final Remarks

We have focused here on the field crop mix and methane digesters on dairy farms.

Other mitigation options either seem less promising or we have not yet evaluated any available studies.

Shifts from annual crops to tree and vine crops, potential tools for rice methane emissions, and the use of better water management for more crops may all be promising.

But, we also need much more careful evaluation of the studies now available and a thorough assessment of the applicability of the methods and results.