The Role of Agriculture in Mitigating Greenhouse Gas Emissions

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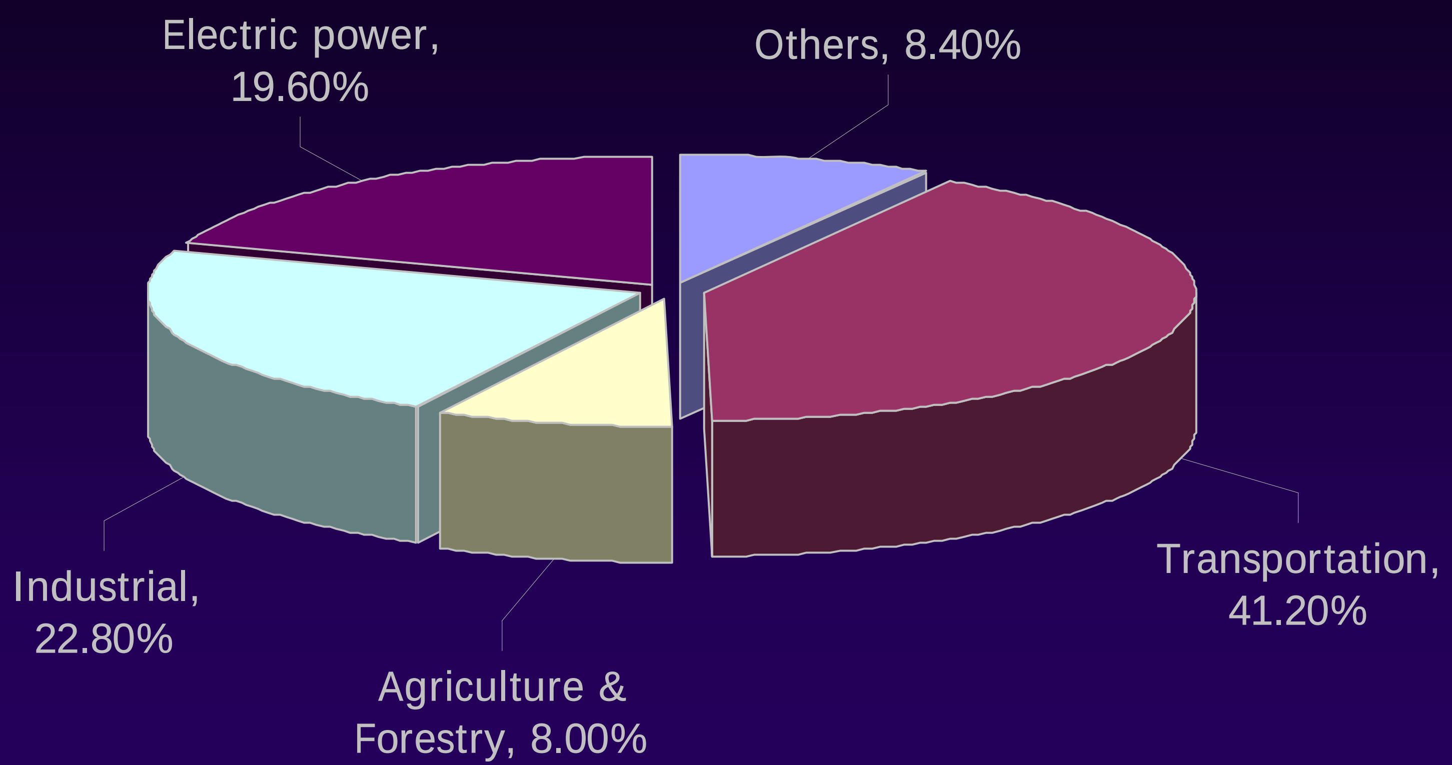
UC DAVIS PLANT SCIENCES

Source of greenhouse gases in CA

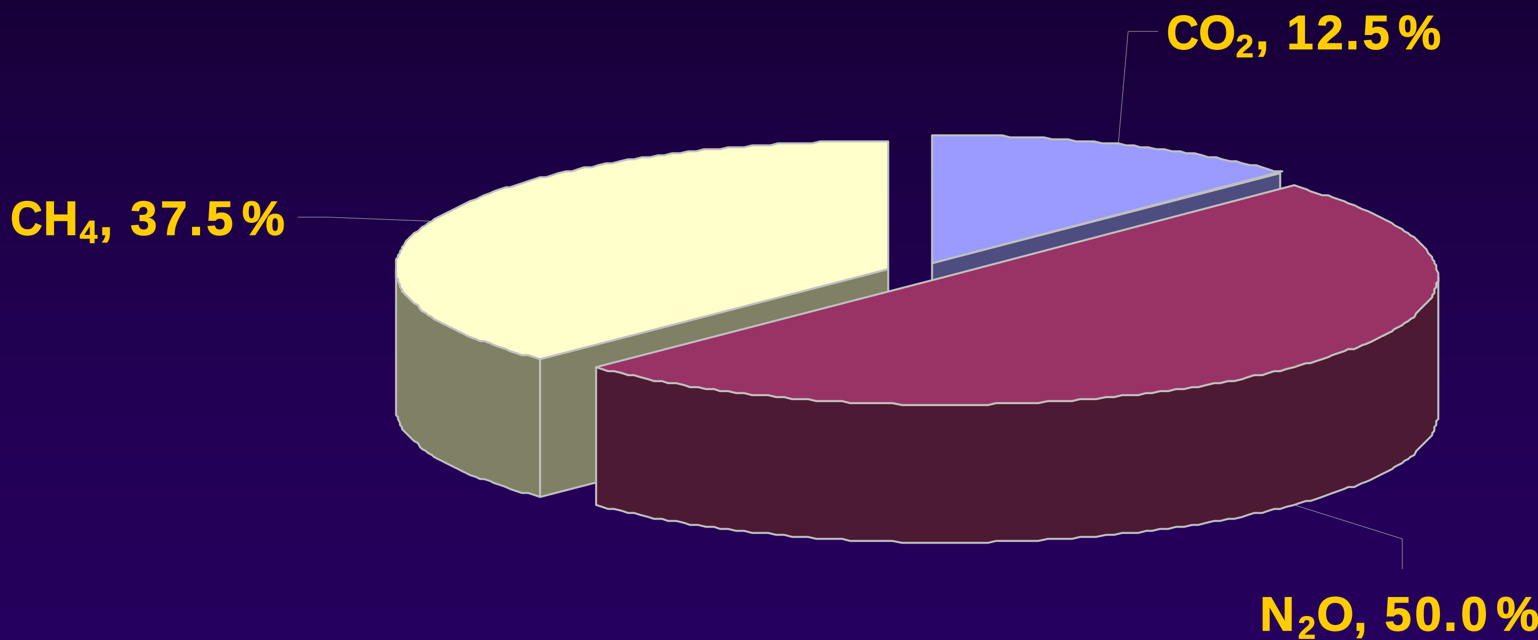


California Energy Commission, 2005

Composition and sources of greenhouse gases by agriculture

Sources: Fossil fuels, biomass burning, soil degradation

Sources: Livestock, manure, anaerobic soils (rice)



Sources: Fertilizer, crop residues, manure

California Energy Commission, 2005

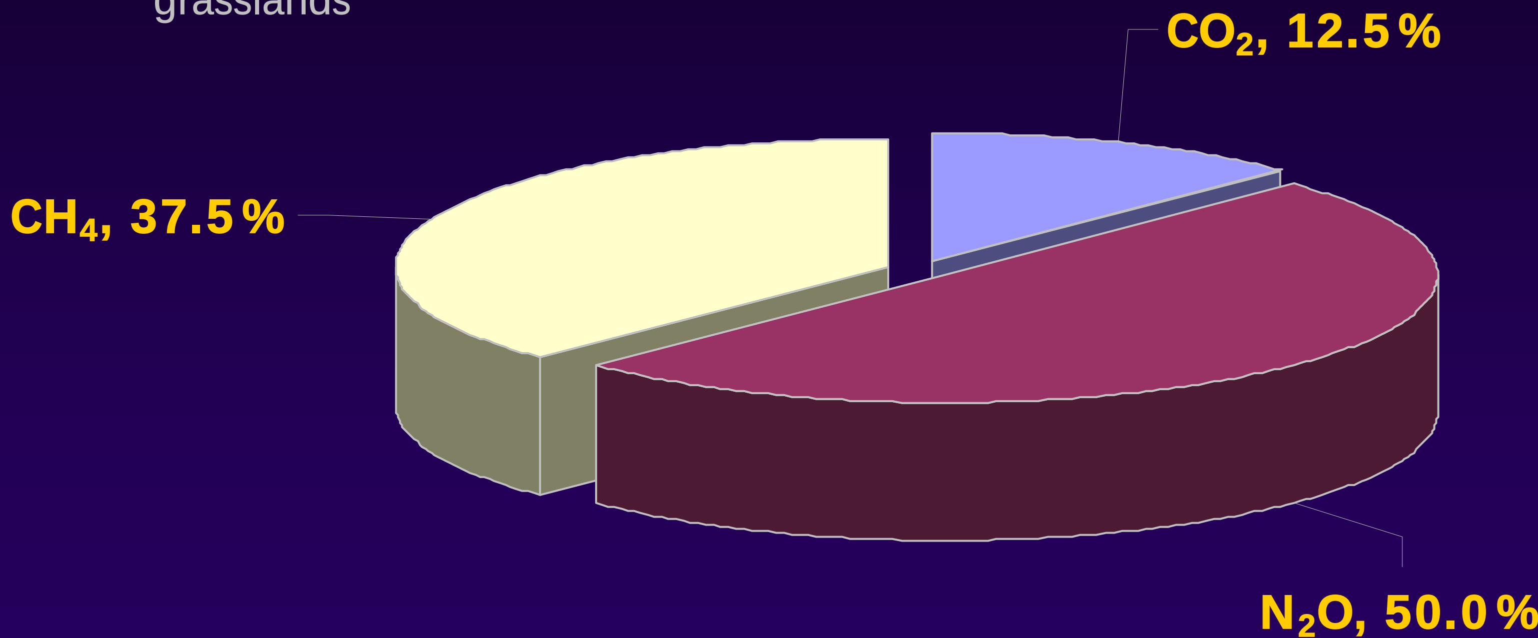
Composition and sinks of greenhouse gases by agriculture

Sources: Livestock, manure, anaerobic soils (rice)

Sinks: Aerobic soils, especially forests and grasslands

Sources: Fossil fuels, biomass burning, soil degradation

Sinks: Buildup soil organic matter and plant biomass



Sources: Fertilizer, crop residues, manure

Sinks: No sinks in soils

California Energy Commission, 2005

Practices for GHG mitigation

- Reduced or zero tillage
- Set-asides/conversions to perennial grass
- Winter cover crops
- More hay in crop rotations
- Higher residue (above- & below-ground) yielding crops
- Manure application and organic cropping
- Reducing fertilizer application rate

Research question:

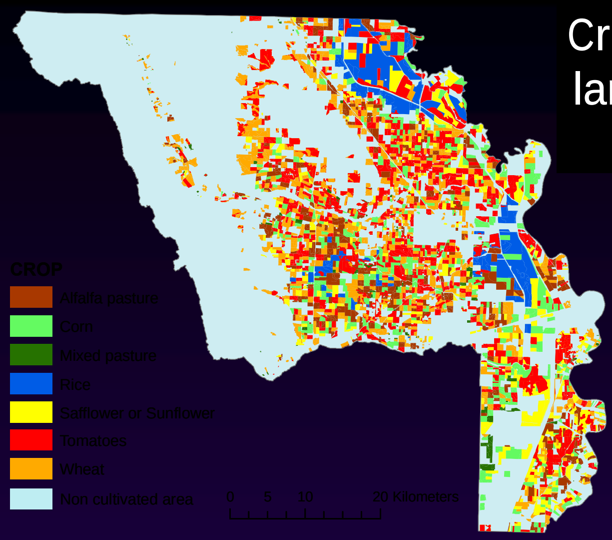
What is the potential for GHG mitigation by agriculture by changing practices for common crops and crop rotations in CA

= emissions under alternative practices – emissions under conventional practices

Assessing GHG emissions

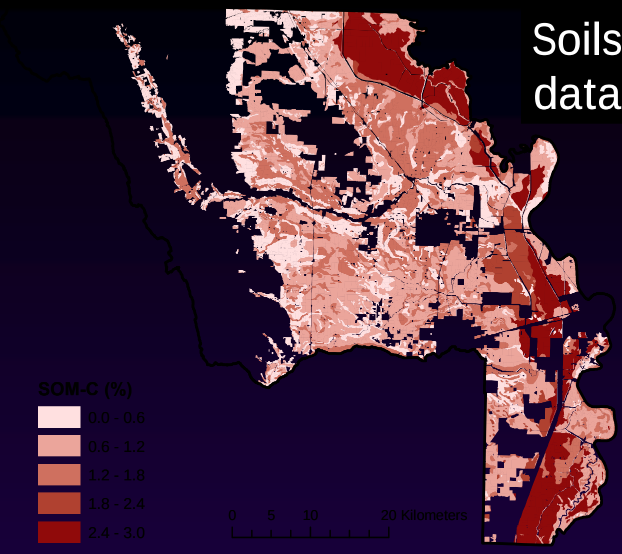
- Integrating measurements with modeling
  - Measurements for calibration and validation of model
  - Modeling for regional extrapolation and prediction in a cost-effective way
  - Measurements to monitor and further validate model
- Integrating remote sensing
  - To assess temporal and spatial variability in crop growth and production

Crop and land-use data



data from 1997, from DWR
(Department of Water Resources)

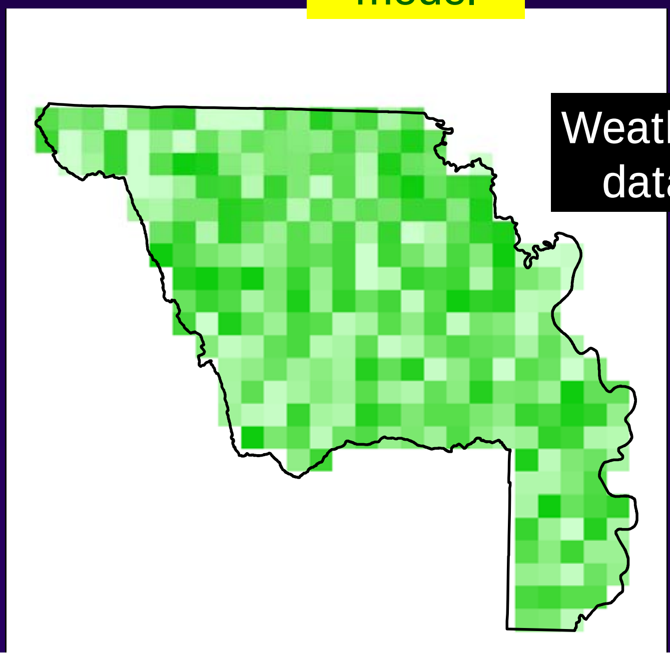
Soils data



from SSURGO (Soil Survey Geographic Database)

DAYCENT ⟷ Regional model

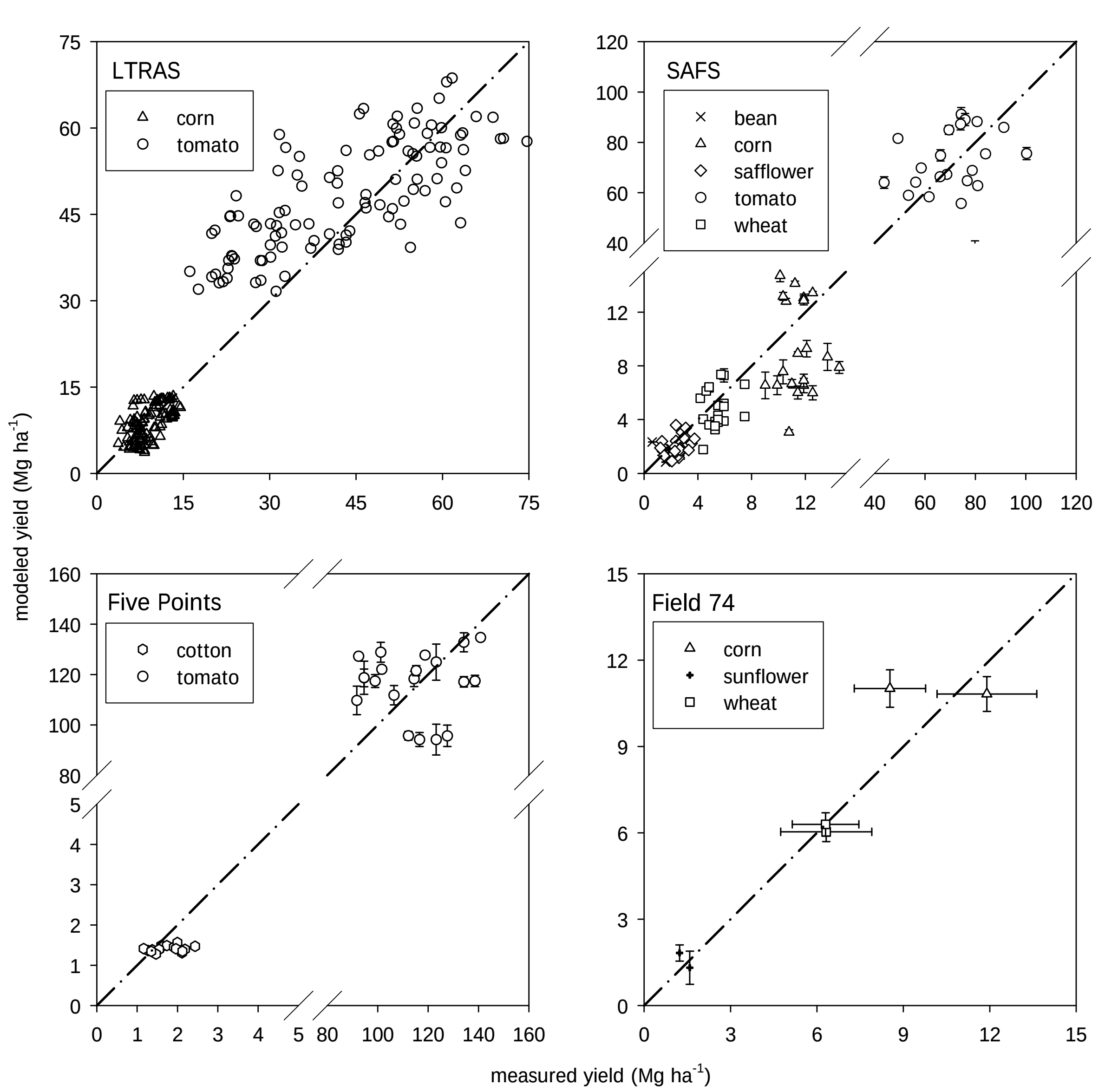
Weather data



3 x 3 km grid from DAYMET
(University of Montana)

Validation: yields (Site)

Site level



Validation: yield and soil C (Site)

		LTRAS	SAFS	Five Points	Field 74
		prediction of yield			
variation explained by model (%)		86	92	94	92
partitioning of the MSD	non-unity slope (%)	13	4	3	5
	lack of correlation (%)	74	96	96	91
	square bias (%)	13	0	1	4
		prediction of soil organic carbon			
variation explained by model (%)		69	83	87	6
partitioning of the MSD	non-unity slope (%)	24	21	63	28
	lack of correlation (%)	70	56	31	45
	square bias (%)	6	23	6	27

Results (Site)

Site	Treatment or property	ΔSOC kg C ha^{-1} yr^{-1}	N_2O kg N ha^{-1} yr^{-1}	CH_4 kg C ha^{-1} yr^{-1}	GWP kg CO_2-eq ha^{-1} yr^{-1}
LTRAS	Standard tillage	95 ± 46[c]	3.18 ± 0.10	-1.52 ± 0.02	1081 ± 192
	Standard tillage and cover cropping	315 ± 46	2.60 ± 0.10	-1.44 ± 0.02	9 ± 192
	Standard tillage and organic	1324 ± 46	3.02 ± 0.10	-1.49 ± 0.02	-3496 ± 192
	Proportion of variation due to seasonal differences[d]	*74%*	*37%*	*46%*	*72%*
	Conservation tillage	47 ± 87	3.01 ± 0.18	-1.51 ± 0.05	1182 ± 391
	Conservation tillage and cover cropping	321 ± 87	2.21 ± 0.18	-1.46 ± 0.05	-192 ± 391
	Conservation tillage and organic	1279 ± 87	2.98 ± 0.18	-1.49 ± 0.05	-3349 ± 391
	Proportion of variation due to seasonal differences	*65%*	*53%*	*68%*	*61%*

Results (Site)

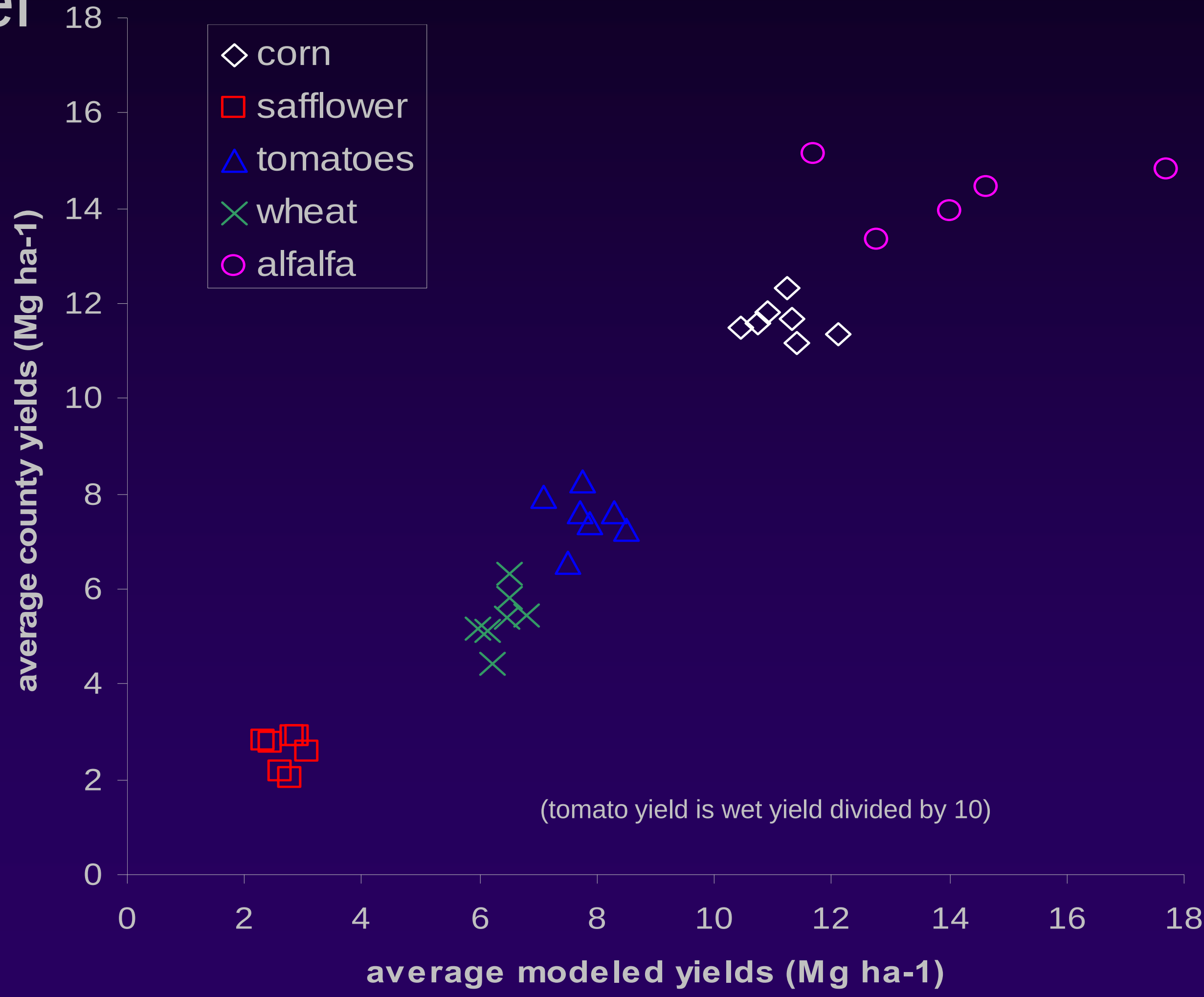
SAFS	Conventional 4-year rotation	407 ± 77	2.21 ± 0.08	-1.62 ± 0.02	-515 ± 292
	Conventional 2-year rotation	436 ± 78	1.54 ± 0.08	-1.44 ± 0.02	-925 ± 298
	Cover cropping	999 ± 77	1.70 ± 0.08	-1.63 ± 0.02	-2921 ± 292
	Proportion of variation due to seasonal differences	*94%*	*80%*	*89%*	*96%*
WSREC	Standard tillage	-90 ± 38	3.44 ± 0.10	-2.00 ± 0.02	1866 ± 147
	Standard tillage and cover cropping	677 ± 38	4.01 ± 0.10	-1.93 ± 0.02	-675 ± 147
	Conservation tillage	-9 ± 38	3.26 ± 0.10	-1.99 ± 0.02	1487 ± 147
	Conservation tillage and cover cropping	729 ± 38	3.79 ± 0.10	-1.94 ± 0.02	-969 ± 147
	Proportion of variation due to seasonal differences	*91%*	*82%*	*38%*	*92%*
Field 74	Standard tillage	128 ± 20	2.62 ± 0.08	-1.54 ± 0.04	700 ± 87
	Conservation tillage	256 ± 20	2.43 ± 0.08	-1.33 ± 0.04	150 ± 87
	Proportion of variation due to seasonal differences	*51%*	*49%*	*19%*	*43%*

Results (Site)

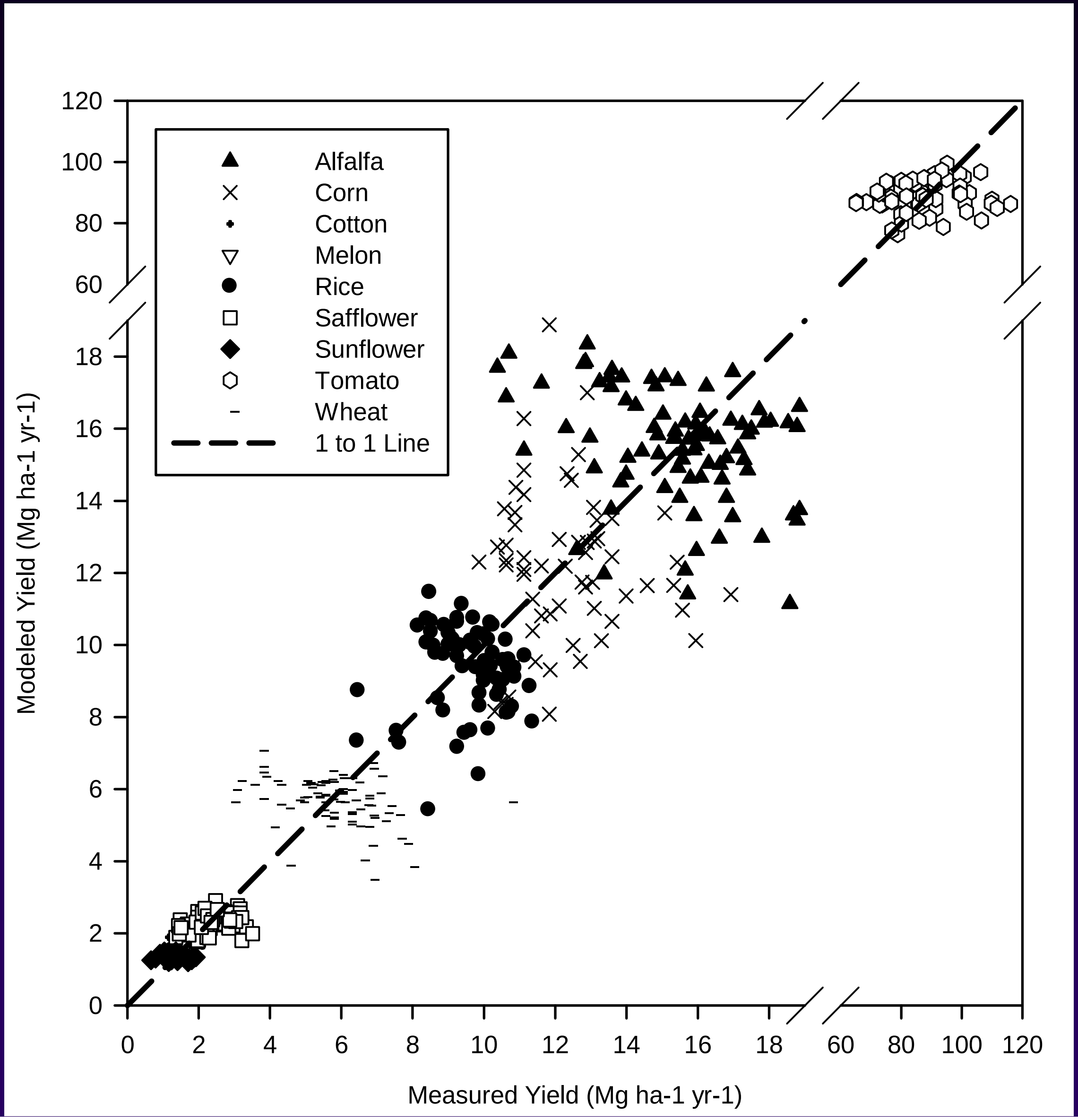
Site	Effect of treatment	ΔSOC[a] kg C ha^{-1} yr^{-1}	ΔN_2O[b] kg N ha^{-1} yr^{-1}	ΔCH_4[b] kg C ha^{-1} yr^{-1}	ΔGWP[b] kg CO_2-eq ha^{-1} yr^{-1}	Contribution of ΔN2O to ΔGWP
LTRAS	Conservation tillage	36 ± 31	-0.07 ± 0.08	0.00 ± 0.01	-168 ± 131	20%
	Cover cropping[c]	220 ± 65	-0.58 ± 0.14	0.09 ± 0.03	-1072 ± 272	25%
	Manure application[c]	1229 ± 65	-0.16 ± 0.14	0.04 ± 0.03	-4577 ± 272	2%
SAFS	Cover cropping	577 ± 21	-0.18 ± 0.02	-0.10 ± 0.01	-2201 ± 82	4%
WSREC	Conservation tillage	66 ± 10	-0.20 ± 0.03	0.00 ± 0.01	-336 ± 47	28%
	Cover cropping	752 ± 10	0.55 ± 0.03	0.06 ± 0.01	-2499 ± 47	-10%
Field 74	Conservation tillage	128 ± 28	-0.19 ± 0.11	0.20 ± 0.05	-550 ± 123	16%

Validation: yields (Regional)

Regional level



Validation: yields (Regional)



Results (regional)

Tillage	Fertilizer	Cover crop	GWP (Mg CO_2-eq ha^{-1} yr^{-1})	? SOC (kg C ha^{-1} yr^{-1})	N_2O (kg N ha^{-1} yr^{-1})
			Sacramento Valley		
convent.	mineral, 75%	no	-0.89 ± 0.76	-2 ± 16	-1.92 ± 1.59
conserv.	mineral	no	-0.68 ± 0.36	103 ± 34	-0.64 ± 0.56
convent.	mineral	yes	-1.36 ± 0.89	310 ± 180	-0.48 ± 0.94
conserv.	mineral	yes	-1.37 ± 0.88	312 ± 178	-0.48 ± 0.94
convent.	Organic	no	-1.16 ± 0.78	158 ± 63	-1.23 ± 1.51
conserv.	Organic	no	-1.94 ± 1.03	288 ± 88	-1.89 ± 1.86
convent.	Organic	yes	-2.60 ± 1.87	405 ± 212	-2.38 ± 2.81
conserv.	Organic	yes	-3.29 ± 2.07	532 ± 246	-2.86 ± 2.98
			San Joaquin Valley		
convent.	mineral, 75%	no	-0.61 ± 0.58	-4 ± 14	-1.33 ± 1.24
conserv.	mineral	no	-0.57 ± 0.33	81 ± 35	-0.59 ± 0.55
convent.	mineral	yes	-1.35 ± 1.07	284 ± 170	-0.66 ± 1.36
conserv.	mineral	yes	-1.38 ± 1.08	287 ± 169	-0.68 ± 1.39
convent.	Organic	no	-0.49 ± 0.89	154 ± 54	0.16 ± 1.96
conserv.	Organic	no	-1.14 ± 0.90	255 ± 79	-0.43 ± 1.82
convent.	Organic	yes	-1.87 ± 1.41	395 ± 203	-0.89 ± 2.41
conserv.	Organic	yes	-2.45 ± 1.52	498 ± 235	-1.32 ± 2.41

3 concerns around C-sequestration

- Permanence
  - They have to be secured over the long run
- Additionality
  - Carbon stocks with project activities compared to carbon stocks without project activities
- Leakage
  - Potential negative C flows due to the project (on land outside of the project) must be addressed
    - Migration of people who were farming on the land to other places and clearing forest somewhere else

Future needs

- Get a handle on nitrous oxide
- Including perennial systems (vineyards/orchards)
  - Targeted measures integrated with modeling
  - Remote sensing integrated with modeling
- Monitoring
- Decision support tool for stakeholders
  - COMET-VR

THANKS!