The Effect of Carbon Reducing Policies on Agricultural Production

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Introduction

- Concerns about climate change have led to efforts to enact policies meant to curb the production of green house gases.
  - Kyoto Protocol
  - Copenhagen Accord
- In the U.S., The American Clean Energy and Security Act of 2009 (H.R 2454) passed in the House of Representatives.
  - Would have established an emissions trading scheme for U.S. industries.
  - Agricultural production would have been exempt.
  - Did not become law.

Introduction

- As the debate about climate change continues similar legislative initiatives will be considered.
- Executive action may also be taken.
  - The Environmental Protection Agency (EPA) claims the right to regulate carbon emissions via the Clean Air Act.
- Agriculture may not always be exempt.

Introduction

- How will carbon reducing policies affect production?
  - Production practices?
  - Crop mix?
  - Regional differences?

- Objectives
  - Develop a model to estimate the effect of carbon policy on production
  - Use the model to predict outcomes for the Texas High Plains

Carbon Emissions in Agriculture

- How do we measure this?
  - Production budgets
  - Carbon Equivalents

Item	Unit	Price	Quantity	Amount
		Dollars		Dollars
INCOME				
cotton lint	lb.	0.54	1000.0000	540.00
cotton seed	ton	200.00	0.7000	140.00
TOTAL INCOME				680.00
DIRECT EXPENSES				
SEED				
seed - cotton	thou	1.10	52.0000	57.20
FERTILIZER				
fert. (P)	lb.	0.50	25.0000	12.50
fert. (N)	lb.	0.50	100.0000	50.00
CUSTOM				
fert appl.	acre	4.50	1.0000	4.50
preplant herb + appl	acre	12.00	1.0000	12.00
post emerg herb + appl	acre	16.00	1.0000	16.00
insect + appl - cotton	appl	12.00	1.0000	12.00
harvaid appl - cot irr	acre	25.00	1.0000	25.00
strip & module - cotto	lb.	0.08	1000.0000	80.00
ginning - cotton	cwt.	3.00	35.7100	107.13
CROP INSURANCE				
cotton - CP	acre	20.00	1.0000	20.00
BOLL WEEVIL ASSESS				
Irrigated	acre	6.00	1.0000	6.00
OPERATOR LABOR				
Implements	hour	10.00	0.7554	7.55
Tractors	hour	10.00	0.8318	8.31
HAND LABOR				
Implements	hour	10.00	0.1908	1.90
IRRIGATION LABOR				
Center Pivot	hour	10.00	0.7680	7.68
DIESEL FUEL				
Tractors	gal	2.25	3.9525	8.89
GASOLINE				
Self-Propelled Eq.	gal	2.00	3.5175	7.03
IRRIGATION FUEL COST				
Center Pivot	ac-in	12.00	12.0000	144.00
REPAIR & MAINTENANCE				
Implements	Acre	9.50	1.0000	9.50
Tractors	Acre	9.71	1.0000	9.71
Self-Propelled Eq.	acre	0.28	1.0000	0.28
Center Pivot	ac-in	2.03	12.0000	24.36
INTEREST ON OP. CAP.	Acre	14.69	1.0000	14.69

Item	Unit	Price	Quantity	Amount
TOTAL DIRECT EXPENSES				646.28
RETURNS ABOVE DIRECT EXPENSES				33.71
FIXED EXPENSES				
Implements	Acre	15.75	1.0000	15.75
Tractors	Acre	14.81	1.0000	14.81
Self-Propelled Eq.	Acre	0.47	1.0000	0.47
Center Pivot	ac-in	33.60	1.0000	33.60
TOTAL FIXED EXPENSES				64.63
TOTAL SPECIFIED EXPENSES				710.92
RETURNS ABOVE TOTAL SPECIFIED EXPENSES				-30.92
ALLOCATED COST ITEMS				
cash rent - cottoni	acre	75.00	1.0000	75.00
RESIDUAL RETURNS				-105.92

Item	Unit	Quantity	C Equivalent	C Emissions
INCOME				
cotton lint	lb.	1000.0000		
cotton seed	ton	0.7000		
TOTAL INCOME				
DIRECT EXPENSES				
SEED				
seed - cotton	thou	52.0000		
FERTILIZER				
fert. (P)	lb.	25.0000	0.2	5.0000
fert. (N)	lb.	100.0000	1.3	130.0000
CUSTOM				
fert appl.	acre	1.0000		
preplant herb + appl	acre	1.0000		
post emerg herb + appl	acre	1.0000		
insect + appl - cotton	appl	1.0000		
harvaid appl - cot irr	acre	1.0000		
strip & module - cotto	lb.	1000.0000		
ginning - cotton	cwt.	35.7100		
CROP INSURANCE				
cotton - CP	acre	1.0000		
BOLL WEEVIL ASSESS				
Irrigated	acre	1.0000		
OPERATOR LABOR				
Implements	hour	0.7554		
Tractors	hour	0.8318		
HAND LABOR				
Implements	hour	0.1908		
IRRIGATION LABOR				
Center Pivot	hour	0.7680		
DIESEL FUEL				
Tractors	gal	3.9525	7.01	27.7070
GASOLINE				
Self-Propelled Eq.	gal	3.5175	6.48	22.7934
IRRIGATION FUEL COST				
Center Pivot	ac-in	12.0000	30.13	361.5600
REPAIR & MAINTENANCE				
Implements	Acre	1.0000		
Tractors	Acre	1.0000		
Self-Propelled Eq.	acre	1.0000		
Center Pivot	ac-in	12.0000		
INTEREST ON OP. CAP.	Acre	1.0000		

Item	Unit	Quantity	C Equivalent	C Emissions
TOTAL DIRECT EXPENSES				
RETURNS ABOVE DIRECT EXPENSES				
FIXED EXPENSES				
Implements	Acre	1.0000		
Tractors	Acre	1.0000		
Self-Propelled Eq.	Acre	1.0000		
Center Pivot	ac-in	1.0000		
TOTAL FIXED EXPENSES				
TOTAL SPECIFIED EXPENSES				
RETURNS ABOVE TOTAL SPECIFIED EXPENSES				
ALLOCATED COST ITEMS				
cash rent - cottoni	acre	1.0000		
RESIDUAL RETURNS				

Carbon Emissions in Agriculture

Carbon Emissions for Irrigated Cotton

Item	Carbon Equivalent	Carbon Emissions (lbs/acre)	Carbon Emissions (kg/ha)
FERTILIZER			
fert. (P)	0.2	5.0000	5.6043
fert. (N)	1.3	130.0000	145.7107
DIESEL FUEL			
Tractors	7.01	27.7070	31.0555
GASOLINE			
Self-Propelled Eq.	6.48	22.7934	25.5480
IRRIGATION FUEL COST			
Center Pivot	30.13	361.5600	405.2549
TOTAL		**547.0604**	**613.1733**

Model

- Estimated net revenue using a non-linear programming model.
  - Max $NR_i = \Sigma_j (R_j - C_j)$
    - NR_i is net revenue in county i.
    - R_j is the revenue from crop j.
      - Revenue = harvested acres * yield * price
        - Yield is a function that relates water to crop yield
    - C_j is the total cost to produce crop j.
      - Cost = planted acres * specified costs * water cost
  - Constraints
    - Crop yield must at least equal the amount reported for the area.
    - Planted acres cannot exceed the maximum amount reported for the area.

Calculating Carbon Emissions

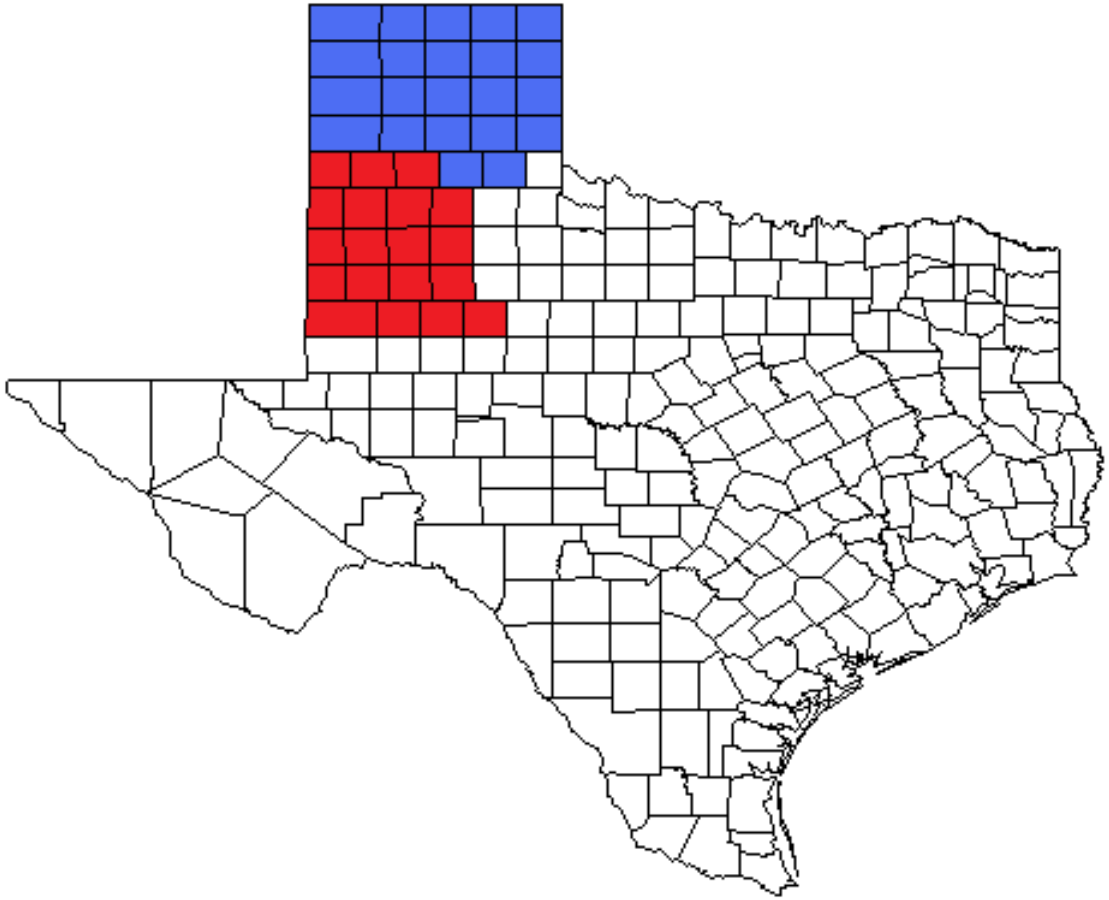
- First separated irrigation emissions from other input emissions
  - Allows water to vary as an input.
- Model estimates number of acres planted & amount of water applied.
- Estimate per acre irrigation emissions using the carbon equivalent, add to the per acre emissions from other inputs, and multiply by the number of acres planted.

Calculating Carbon Emissions– an example

Crop	Acres	Water
Corn	60299.9	21.49
Dry Cotton	39900.0	0.00
Irr. Cotton	93871.8	18.90

Other Input Emissions	Irrigation Emissions	per Acre Emissions	Total Emissions
290.67	647.61	938.28	56,578,230.89
185.50	0.00	185.50	7,401,465.96
185.50	569.43	754.93	70,866,956.83
			134,846,653.68

Study Area- Texas High Plains (THP)



Study Area

- 40 counties total.
  - 5 crops
    - Corn, cotton, peanuts, sorghum, & wheat
  - Two production methods
    - Dryland and irrigated production possible for cotton, sorghum, & wheat.

Data Sources

- Extension Service
  - Crop budgets for 2008 – 2010
- National Agricultural Statistics Service
  - Planted Acres for 2000-2009
  - Harvested Acres for 2000-2009
  - Historic Yields for 2000-2009
- Previous Studies
  - Yield functions
- University of Arkansas
  - Carbon equivalents

Study Method

- Created a “representative farm” for each county
  - Took data from several existing sources to create each farm.
- Ran the model three times for each county.
  - 1st run had no carbon constraint.
  - 2nd run constrained carbon to 95% of current estimated emissions.
  - 3rd run constrained carbon to 85% of current estimated emissions.

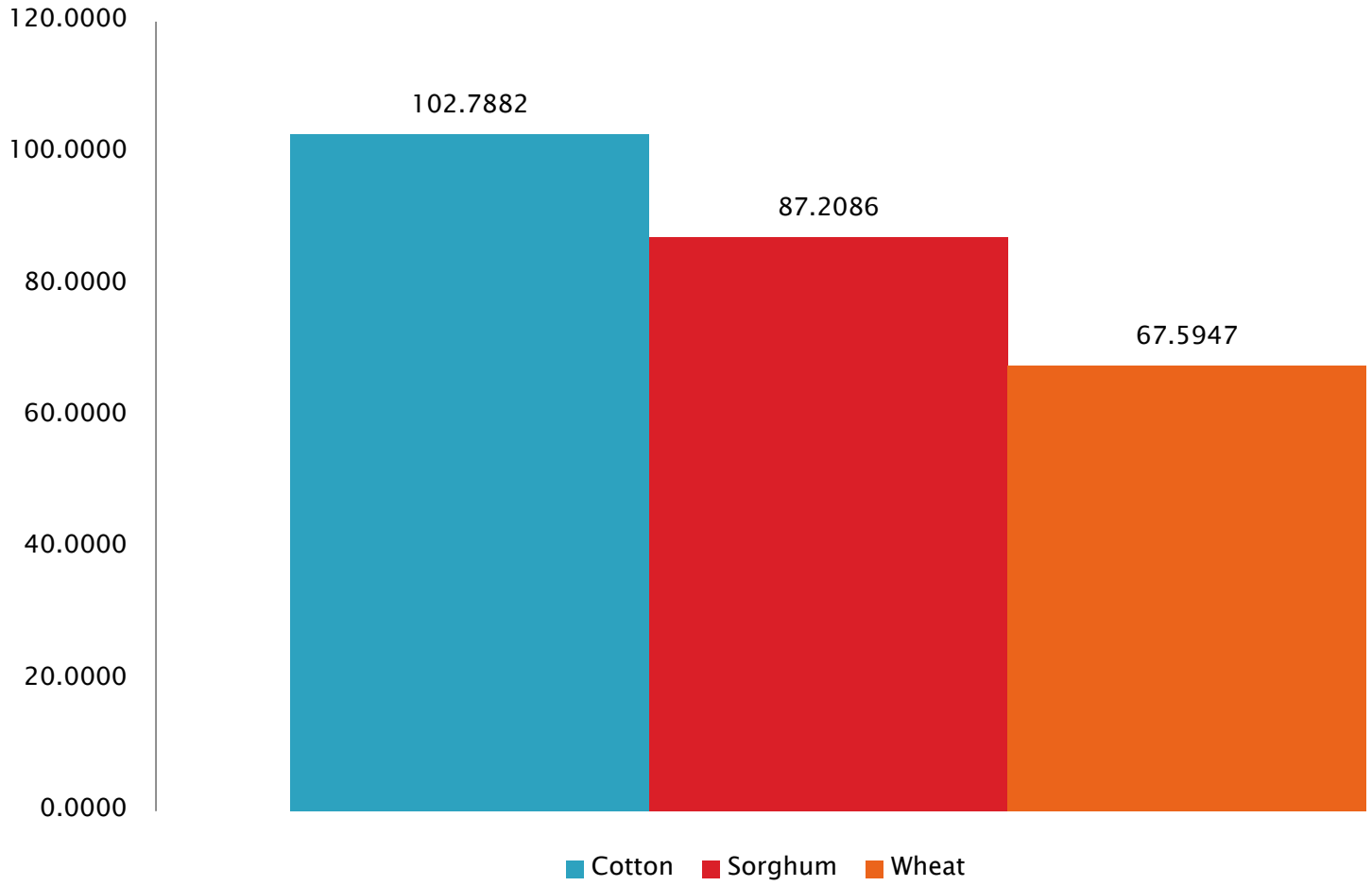
The Carbon Constraint

- For each county, multiplied emissions by acreage for every crop.
  - Emissions were estimated from the production budget.
  - Used average acreage reported by NASS.

- Summed across all crops in the county. Used 95% and 85% of this amount for the constraint on the second and third runs of the model.

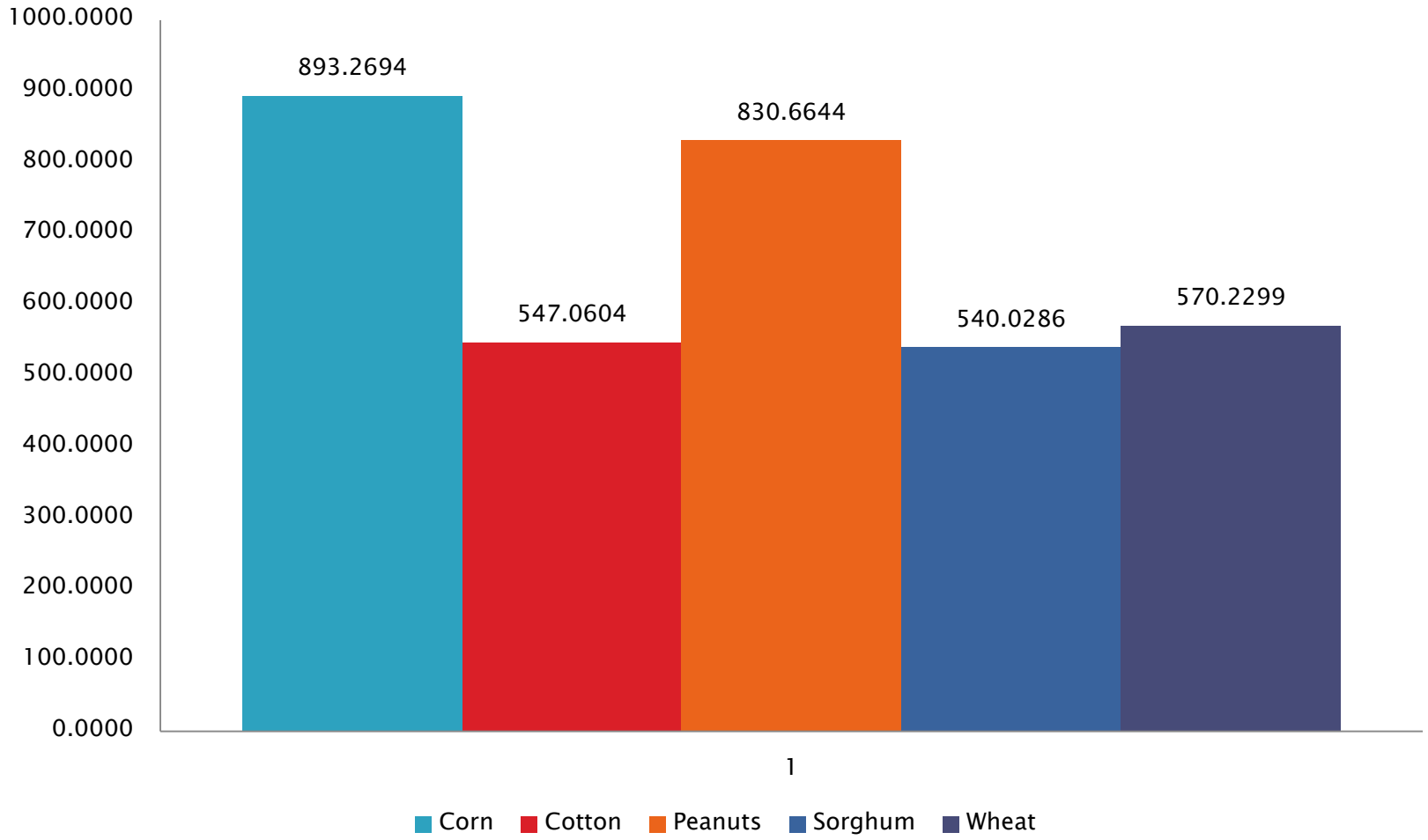
THP Carbon Emissions

- Dryland Crops



THP Carbon Emissions

- Irrigated Crops



Results

- A typical county

Lubbock County Net Revenue and Acreage

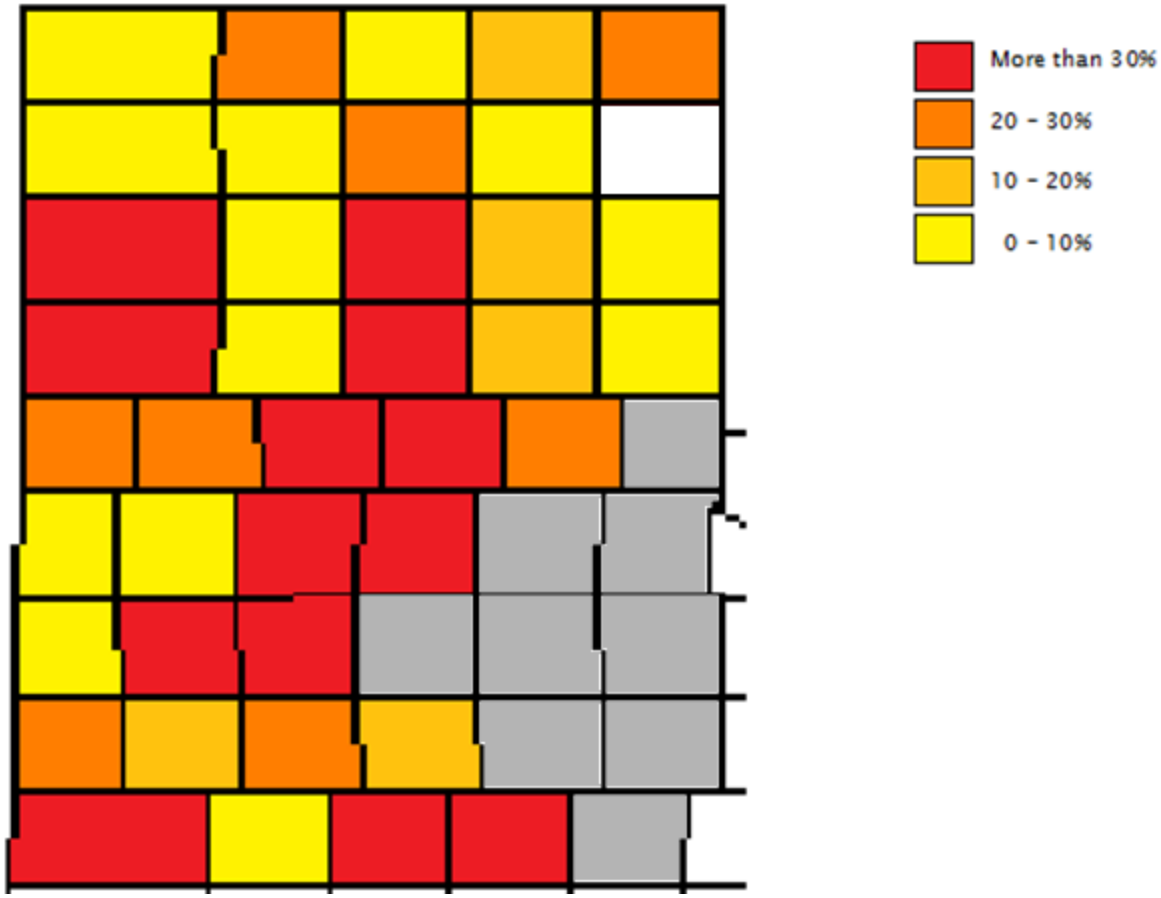
	Net Revenues	Dry Cotton	Irr. Cotton	Irr. Sorghum	Irr. Wheat
Baseline	$ 71,394,791.57	109100.0	206300.0	42800.0	9600.0
95%	$ 40,956,264.03	109100.0	109240.9	42787.9	9520.6
85%	$ 37,273,110.44	106958.5	106958.5	42799.9	9600.0

Lubbock County Water Use

Baseline	4,914,970.76	0.00	19.52	18.18	11.49
95%	2,202,894.02	0.00	15.74	8.72	5.89
85%	1,809,657.47	0.00	14.20	4.85	3.57

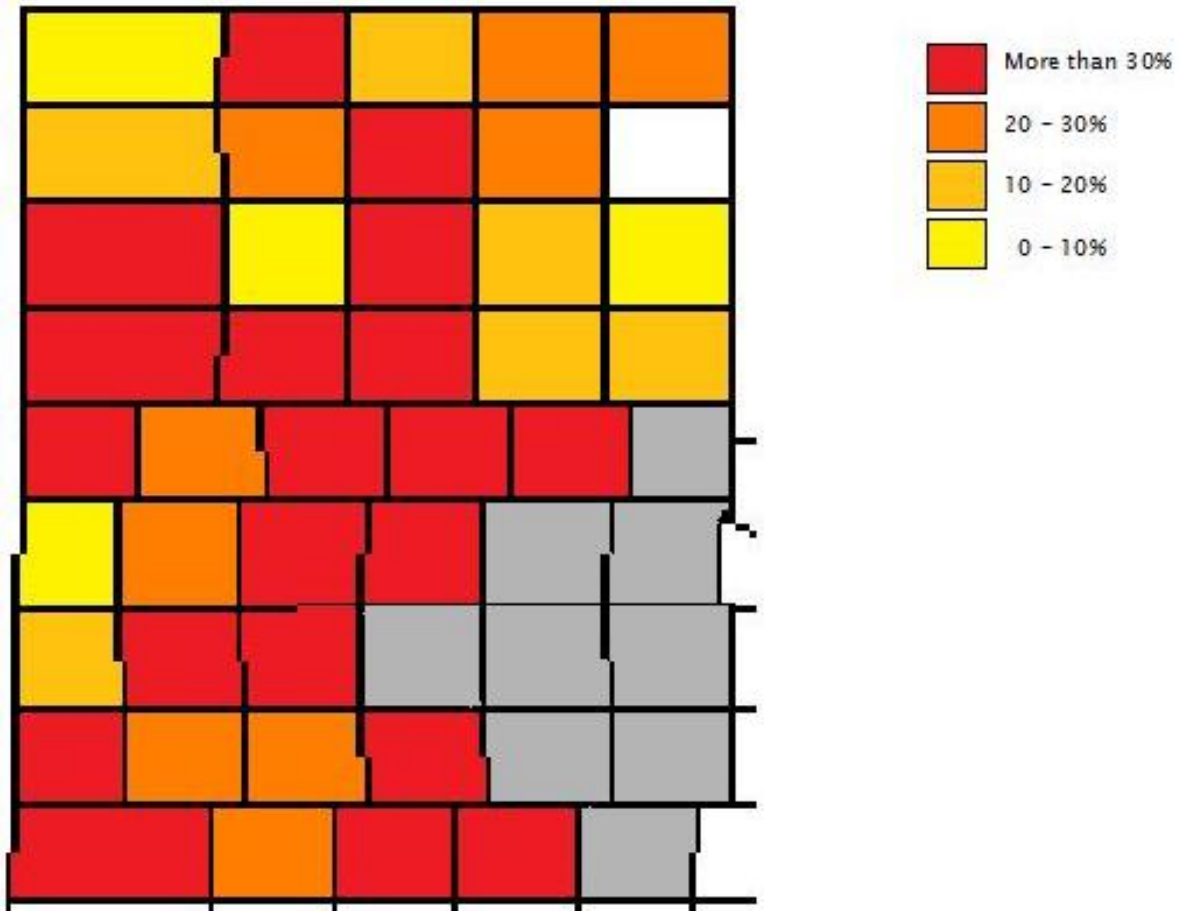
Results

Percent change in net revenue when carbon is constrained to 95% of the baseline



Results

Percent change in net revenue when carbon is constrained to 85% of the baseline



Results

Changes in net revenue and water use

Regional Change in Net Revenue

	Baseline	95% Constraint	85% Constraint
Texas High Plains	$ 1,273,964,348	$ 880,148,639	$ 777,073,011
Northern High Plains	$ 396,361,273	$ 314,260,938	$ 281,369,849
Southern High Plains	$ 877,603,074	$ 565,887,700	$ 495,703,162

Regional Water Use

	Baseline	95% Constraint	85% Constraint
Texas High Plains	80,298,596	50,364,535	42,909,096
Northern High Plains	26,756,814	19,198,342	16,192,607
Southern High Plains	53,541,782	31,166,193	26,716,488

Results

Changes in cropping patterns

Change in Irrigated Cropping Patterns

	Corn	Irr. Cotton	Peanuts	Irr. Sorghum	Irr. Wheat
Baseline	896,494	1,943,360	158,700	724,155	1,222,678
95%	868,524	1,370,856	125,552	727,751	1,065,454
85%	792,839	1,279,155	154,584	710,329	1,072,691

Change in Dryland Cropping Patterns

	Dry Cotton	Dry Sorghum	Dry Wheat
Baseline	1,404,217	1,140,493	1,404,826
95%	1,231,684	1,153,865	1,416,992
85%	1,078,101	1,210,007	1,371,455

What happens if the cotton price changes?

Lubbock County Net Revenue and Acreage

	Net Revenues	Dry Cotton	Irr. Cotton	Irr. Sorghum	Irr. Wheat
Baseline	$120,827,268	109,100.0	206,300.0	42,800.0	9,600.0
95%	$68,668,970	109,100.0	109,100.1	42,799.9	9,600.0
85%	$64,445,585	107,412.4	107,895.8	42,367.7	9,122.7

Lubbock County Water Use

	Total for County	Per Acre of Cotton	Per Acre of Sorghum	Per Acre of Wheat
Baseline	5,236,894.33	21.08	18.18	11.49
95%	2,203,405.47	17.17	5.65	4.04
85%	1,815,312.64	15.88	1.54	1.60

What happens if the cotton price changes?

Comparison of Lubbock County Acreage at Different Cotton Prices

	Baseline	95% Constraint	85% Constraint
Dry Cotton			
$0.72	109,100.0	109,100.0	106,958.5
$0.92	109,100.0	109,100.0	107,412.4
Irr. Cotton			
$0.72	206,300.0	109,240.9	106,958.5
$0.92	206,300.0	109,100.1	107,895.8
Irr. Sorghum			
$0.72	42,800.0	42,787.9	42,799.9
$0.92	42,800.0	42,799.9	42,367.7
Irr. Wheat			
$0.72	9,600.0	9,520.6	9,600.0
$0.92	9,600.0	9,600.0	9,122.7

What happens if the cotton price changes?

Comparison of Lubbock County Water use at Different Cotton Prices

	Baseline	95% Constraint	85% Constraint
Irr. Cotton			
$0.72	19.52	15.74	14.20
$0.92	21.08	17.17	15.88
Irr. Sorghum			
$0.72	18.18	8.72	4.85
$0.92	18.18	5.65	1.54
Irr. Wheat			
$0.72	11.49	5.89	3.57
$0.92	11.49	4.04	1.60

Conclusions

- Results indicate that carbon management and water conservation policies are one and the same.
  - Important for regions where water is scarce and irrigation is essential to the production process
  - Implies that carbon management would favor production methods that use less water for irrigation.
- Commodity price matters.

Further Research

- Including different production practices
- Different soil types
- Including sequestration