Funding Agricultural Carbon Offset Abatements with Carbon Tax Revenue to Reduce Net Greenhouse Gas Emissions

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INTRODUCTION

- With curtailment of greenhouse gases (GHG) like carbon dioxide, nitrous oxide and methane high on the priority list for slowing climate change several policy options exist:
  - ✓ Cap and trade on emissions where a cap is set by the government and emissions permits are traded in a market to provide least-cost, efficient carbon emissions reduction
  - ✓ Carbon offset programs where reductions from baseline net GHG emissions can be sold either for a zero sum game or for retirement
  - ✓ Carbon taxes on emitting activities, likely levied on fossil fuels
  - ✓ Some hybrid combination of the above
- Assuming a societal demand for a reduction of 5% of GHG emissions this study compares:
  - ✓ **Option A**: 5% emissions reduction via cap and trade including estimates on likely soil carbon sequestration effects
  - ✓ **Option B**: A $15 per ton carbon offset incentive leads to crop pattern changes from a baseline which are sufficient to supply enough carbon permits to retire the same level of emissions targeted in **Option A**
  - ✓ **Option C**: **Option B** plus a carbon tax on off road diesel sufficient to purchase and then retire offsets equivalent to 5% of emissions as calculated in **Option A**
  - ✓ **Option D**: The same carbon tax as in **Option C** without a carbon offset market

- This study analyzes Arkansas row crop agriculture including row crops of rice, soybean, corn, cotton, grain sorghum and wheat, pasture, hay land and pine plantations using 5-year average prices for inputs and commodities for a one-year snapshot of county-level agricultural production.
- Tracked at the county and state level are:
  - ✓ per acre returns to land and management
  - ✓ fuel and irrigation water use
  - ✓ GHG emissions in their carbon equivalents (C.E.) and soil & lumber carbon sequestration
- Table 1 summarizes statistics relevant for the simulation.

Table 1. Estimated Annual Baseline State Statistics Including Acreage, Price, Yield, Expenses, Returns and GHG Emissions, Sequestration and Carbon Footprint on a Carbon Equivalent Basis Using Arkansas, 2006 - 2010 Average Prices.

Commodity	Baseline in 000s of acres	Price	Unit[a]	Avg. Yield	Avg. TSE[b]	Avg. Returns	GHG Emissions	GHG Sequestration	Carbon Footprint[c]
				----------	----------	per acre	per year	----------	----------
Rice	1,521	9.48	cwt	69	$ 472	$ 181	2,193	581	1,600
Cotton		0.57	lb						
Irr	544			1,098	$ 619	$ 8	596	365	224
Non-irrigated	181			895	$ 497	$ 15	459	274	158
Corn	418	3.03	bu	154	$ 378	$ 88	785	1,120	(431)
Soybean		7.34	bu						
Irr	1,659			41	$ 269	$ 29	225	226	(12)
Non-irrigated	903			27	$ 175	$ 24	100	176	(97)
Double cropped	145			33	$ 260	$ (12)	189	167	14
Sorghum		3.05	bu						
Irr	43			105	$ 287	$ 34	518	758	(263)
Non-irrigated	64			70	$ 190	$ 24	387	498	(126)
Wheat	1,019	4.74	bu	52	$ 188	$ 56	446	286	151
Hay	1,434	59.27	ton	2.22	$ 94	$ 38	222	794	(564)
Pasture	3,857	18.50	acre	1	$ 81	$ 19	151	678	(517)
Pine	73	31.17	ton	8.77	$ 10	$ 2	53	2,835	(2,792)

Notes:

[a] Prices are in $/unit. Pasture reflects cash rental rates. Pine is the standing timber price, quantity weighted for pulp, timber and chip and saw.

[b] Total specified expenses include seed, custom work, fertilizer, agricultural chemicals and plastics, fuel, repair and maintenance, operating interest and capital recovery. It excludes taxes, insurance and housing as well as land charges. Hauling, drying and check off charges are included in the prices. Since timber prices are for standing timber, harvesting charges for thinning and final harvest are excluded.

[c] Carbon footprint is quantity weighted across acres in production where as emissions and sequestration are simple averages of per acre GHG emissions and sequestration, respectively. Note that the carbon footprint is emissions less sequestration. Also note that harvest fuel use for carbon footprinting on pine is included.

PROCEDURE

- The scan level Life cycle assessment (LCA) approach implemented here tracks GHG emissions in their C.E. form and sequestration to estimate a net (emissions – sequestration) carbon footprint for the most common production practices for crops, hay, pasture and pine. Note that several production methods are tracked for crops but details are not shown in equation
- Maximize Arkansas net returns above total specified expenses (*NR*) to 13 crop, hay, pasture and pine land use choices in 75 counties as follows:

Maximize $NR = \sum_{i=1}^{75}\sum_{j=1}^{13}\left(p_j \cdot y_{ij} - c_{ij}\right)\cdot x_{ij} + \left(BCF_{ij} - S_{jn}\cdot x_{ij}\right)\cdot p_c$

Subject to:

$$xmin_{ij} \le x_{ij} \le xmax_{ij}$$
$$iacresmin_i \le \Sigma x_{ij} \le iacresmax_i$$
$$acresmin_i \le \Sigma x_{ij} \le acresmax_i$$

p_j	avg. of July 2005 - 2009 futures prices as of Dec. of previous year
y_{ij}	'05 – '09 average county crop yields
c_{ij}	county and crop specific total specified expenses with fuel and fertilizer prices avg. 2005 – 2009 and all other costs as of 2007
x_{ij}	acres in county i and crop j
BCF_{ij}	is the base carbon foot print without policy changes for each county and crop combination at the above price levels
S_{jn}	is the net carbon foot print per crop linked to yield via harvest index, shoot to root ratio, above and below ground biomass including carbon content and adjusted for tillage and average county soil type
p_c	carbon offset payments for carbon sequestration beyond BCF_{ij}
$xmin/max_{ij}$	historical min. and max. crop acres since 2000
$iacresmin/max_i$	historical min. and max. county irrigated acres
$acresmin/max_i$	historical min. and max. county harvested and pasture acres

- ✓ Pine is restricted to 10% of max. pasture acres and 3.33% of max. crop acres
- ✓ 2006 – 2010 avg. quarterly Arkansas pine stumpage prices were used

- POLICY SCENARIOS
  - ✓ Baseline at commodity and input prices without a carbon policy
  - ✓ For **Option A**, the addition of a state wide constraint on emissions at 95% of the base level resulted in an estimate of 149,455 tons of emissions reductions
  - ✓ For **Option B**, carbon offset prices of $5, $10 and $15 per ton were tested to ensure enough carbon offsets for trade from agricultural sources where available to lead to the same level of targeted emissions reduction as in **Option A** except that producers are either awarded or penalized on their net emissions subject to:
    - $BCF_{ij} > S_{jn} \cdot x_{ij}$ leads to carbon offset receipts
    - $BCF_{ij} < S_{jn} \cdot x_{ij}$ leads to carbon offset charges
  - ✓ For **Option C**, a fuel tax was imposed on fuel in the amount of 1.5 ¢ per gallon. This was sufficient to raise enough revenue for the state to purchase and then retire 149,455 tons of carbon at $15 per ton given 149.75 MM gal of fuel use in the baseline scenario.
  - ✓ **Option D** shows model output with only the added tax on fuel to see if the tax would impact crop patterns.

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Table 2. Estimated Changes in Crop Pattern, Harvested Acres, Fuel, Irrigation and Carbon Footprint under Baseline, Cap and Trade (A), Carbon Offset (B), Carbon Tax (C) as well as Tax and Offset (D) Scenarios.

	Baseline	Cap and Trade (A)	Carbon Offset (B)	Carbon Offset & Tax (C)	Carbon Tax (D)
Acres (in 000s)					
Rice	1,521	1,405	1,509	1,509	1,521
Cotton					
Irr	544	544	544	544	544
Non-irrigated	181	137	170	170	181
Corn	418	457	455	455	418
Soybean					
Irr	1,659	1,770	1,659	1,659	1,659
Non-irrigated	903	937	883	883	903
Double cropped	145	145	145	145	145
Sorghum					
Irr	43	43	40	40	43
Non-irrigated	64	40	55	55	64
Wheat	1,019	866	995	995	1,019
Hay	1,434	1,424	1,432	1,432	1,434
Pasture	3,857	3,857	3,471	3,471	3,857
Pine	73	22	121	121	73
Total Harvested (acres)	8,005	7,789	8,009	8,009	8,005
State Profit ($ MM/yr)	$ 574.67	$ 558.44	$ 576.12	$ 569.66	$ 572.45
Total Fuel (MM gal/yr)	149.75	146.00	149.74	149.74	149.75
Total Water (MM ac-in/yr)	84.03	82.00	84.03	84.03	84.03
GHG (000s of tons)					
Emissions	2,989	2,840	2,960	2,960	2,989
Sequestration	3,276	3,178	3,772	3,772	3,276
Net GHG	(287)	(339)	(811)	(811)	(287)

RESULTS & DISCUSSION

- Policy scenario outcomes are summarized in Table 2.
- **Option A** 's mandated emissions reduction of 149,455 tons leads to:
  - ✓ nearly 100,000 fewer tons of carbon sequestered due to fewer total acres farmed
  - ✓ idled land would sequester some carbon but from a producer income and climate change efficiency perspective this option is sub optimal
- **Option B** results in 524,389 fewer tons of net GHG emissions
  - ✓ while emissions do not decline as much as in **Option A**, sequestration increases
  - ✓ state agricultural returns increase with changes in crop pattern, land use and carbon sequestering crops
  - ✓ net GHG can be bought by polluters and may simply shift emissions elsewhere
- **Option C** yields sufficient fuel tax revenue to buy nearly a third of permits generated at $15 per ton for carbon
  - ✓ farmers offset tax cost with surplus offset permit sales such that net GHG reductions cost less per ton to producers compared to **Option A** and yield greater climate impact
  - ✓ carbon offsets purchased with carbon tax revenue lower net GHG by desired amount without reducing acres farmed as in **Option A**
  - ✓ carbon market has guaranteed buyer at known price level
- **Option D** yields tax revenue without affecting crop pattern both when applied to the baseline and when applied to **Option B**
- For more literature on state level implications of different climate change policies and explanations of procedures for calculating GHG emissions, sequestration and offset revenue or penalties as well as pine as a carbon crop, please see:

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