Bioenergy, GHG Mitigation, and the Environment

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Climate Change Policy and Bioenergy

Climate Change Policy- Likely to price GHG emissions through a tax or cap-and-trade system. Bioenergy demand expected to increase as a substitute for fossil fuels, or as a GHG offset source in a cap-and-trade scheme.

Environmental interaction- Expansion in biofuels is likely to have environmental implications including

- Reductions in net GHG emissions relative to fossil fuel usage due to biofuel carbon recycling
- Negative GHG balances from land use change
- Increased irrigation in arid regions
- Increased chemical application, and runoff
- Increased land use and more intense production, leading to higher soil erosion

Objective- To examine economic and environmental implications of expanded biofuels under GHG offset pricing using a U.S. agriculture/forestry sector economic model.

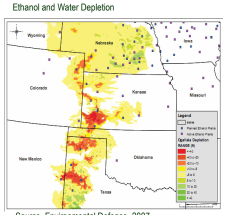
- Model used to develop information on bioenergy production and land use at varying CO_2 prices
    - Output used to assess LUC and environmental impacts of bioenergy expansion due to GHG policy

Environmental Issues

1) Biofuels, Land-Use Change, and Environment

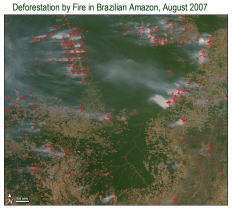
- Biofuels have been found to be an effective means of reducing GHG emissions and contributing to energy independence goals, but have environmental effects.
- Can induce market driven land use change domestically and internationally
- Recent studies indicate that land use change resulting from U.S. biofuel expansion can actually *increase* GHG emissions (Searchinger et al. and Fargione et al. *Science* 2008. Vol. 319. no. 5867)
- Associated intensification of agricultural production likely increases irrigation and application of agricultural chemicals.
- Water quantity and quality are at risk (National Academy of Sciences, 2007; Environmental Defense, 2007)– particularly when non-renewable groundwater is used for irrigation
- It is important to understand the interactions between policies supporting biofuel expansion, and the resulting land use, and soil/water resource impacts

Ethanol and Water Depletion



•Source, Environmental Defense, 2007

Deforestation by Fire in Brazilian Amazon, August 2007



NASA satellite observation

Empirical Modeling Approach

•***Forest and Agricultural Optimization Model with Greenhouse Gases (FASOMGHG)*** is used. FASOMGHG is economic model of the U.S. agricultural and Forestry sectors (McCarl and Scneider, 2001)

1) Used to estimate crop mix across regions, and over time, given various policies.

2) Allows for land-use competition between the sectors

3) Contains comprehensive GHG accounting for virtually all sources of emissions, offsets, and biological carbon sequestration in the two sectors

•Prices all GHG activities, including non-CO_2 emissions

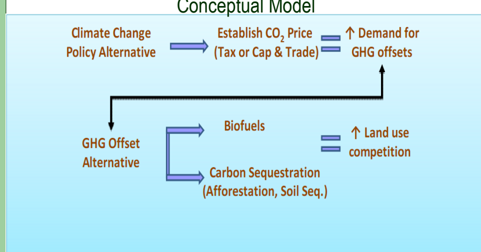
•Life-Cycle GHG accounting information is input and model determines the offset potential for various bioenergy activities. Specifically, offset rates calculated in FASOMGHG are:

Life-Cycle Offset Rates for Bioenergy Activities in FASOMGHG

	Liquid Fuels			Electricity	
Commodity	Crop Ethanol	Cell Ethanol	Biodiesel	5 %	fire100%
Corn	17.2				
Hard Red Winter Wheat	16.1				
Sugarcane	64.9				
Soybean Oil			95.0		
Corn Oil			39.1		
Switch Grass		56.7		86.3	75.1
Corn Cropping Residue		69.8		89.2	80.1
Wheat Cropping Residue		56.4		93.3	87.2
Manure				99.5	96.4
Bagasse		95.7		98.1	96.5
Lignin				91.3	85.8

Why GHG Policy Impacts Land Use Decisions

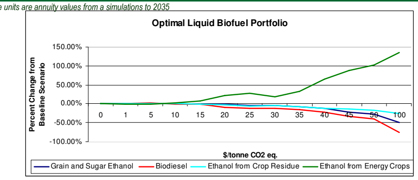
Conceptual Model



Using FASOMGHG, we can evaluate LU decisions contingent on the magnitude of the established CO_2 price

Biofuel Offsets at Selected CO_2 Prices

*Base units are annuity values from a simulations to 2035



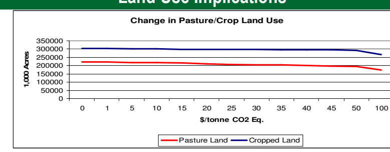
1)The optimal portfolio of liquid biofuels depends on the CO_2 price

- Theoretically "Green" biofuels begin increase at $30/T CO_2 while grain ethanol and biodiesel production decrease
- ***Total biofuel production (annuity) is 19 B Gallon/year.***
    - Energy crops include perennials such as switchgrass

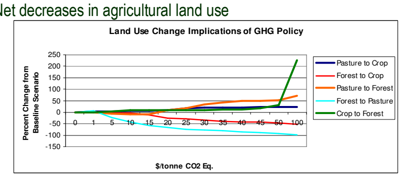
Regional GHG Reduction Potential for Liquid Biofuel and Bioelectricity (1,000,000 T CO2 Eq./ year)				
Selected Regions		$10/T CO2	$30/T CO2	$50/T CO2
Corn Belt	Liquid Biofuel	33.6	34.4	32.1
	Bioelectricity	9.9	46.6	132.3
Great Plains	Liquid Biofuel	29.3	19.2	19.3
	Bioelectricity	10.4	55.7	89.9
Lake States	Liquid Biofuel	18.7	18.6	18.3
	Bioelectricity	2	19.8	20.1

2) Biofuels can provide significant GHG offsets, but higher CO_2 prices make bioelectricity a more economic alternative.

Land Use Implications

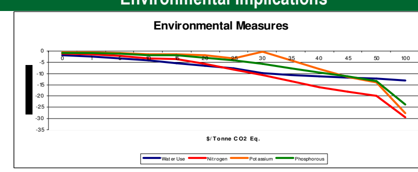


1) Net decreases in agricultural land use



1) Net increases in land converted to forest => forest is more valuable at higher offset prices

Environmental Implications



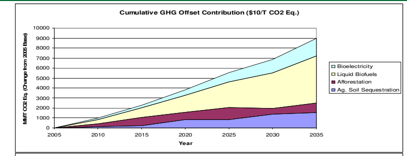
1) CO_2 pricing decreases annual water use and chemical application

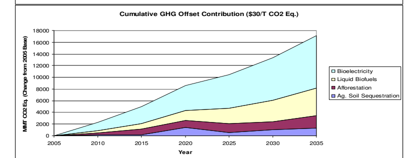
2) This signals a net gain in environmental quality, reducing runoff and groundwater contamination

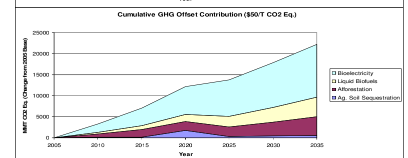
3) Soil erosion, and surface water runoff, and groundwater percolation indicators also all decrease with higher CO_2 prices

Bioelectricity and Afforestation become Dominant GHG Strategies at Higher CO_2 Prices

(Biofuels still play a major role)





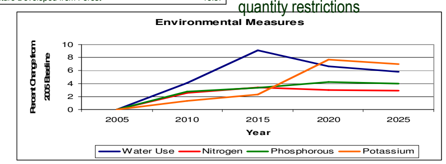


Compared to a Minimum Biofuel Quantity Standard

1) Alternative simulation using the Energy Bill 36 B Gallon mandate without pricing GHG emissions (optimistic approach assuming 16 B Gal. of cellulosic ethanol/ year by 2022)

Cumulative Land Use Change by 2030 (Million Acres)	
Crop Developed from Pasture	6.36
Crop Developed from Forest	14.87
Crop Developed From CRP	9.2
Pasture Developed from Forest	15.87

- Now, land is moving **out** of forest and into agriculture
- Chemical application and irrigation also increase under quantity restrictions



General Conclusions

1)By providing GHG offset credits for biological sequestration, GHG pricing protects land from being converted to agriculture.

2) Targeting GHG emissions can improve environmental quality by reducing GHG emissions, preserving forest and grasslands, decreasing irrigation and chemical application rates

3) GHG pricing is compatible with renewable energy goals as well, and could encourage quicker growth in cellulosic ethanol processing technologies.

4) If implemented in isolation, minimum quantity standards for liquid biofuels could promote inefficient land use change