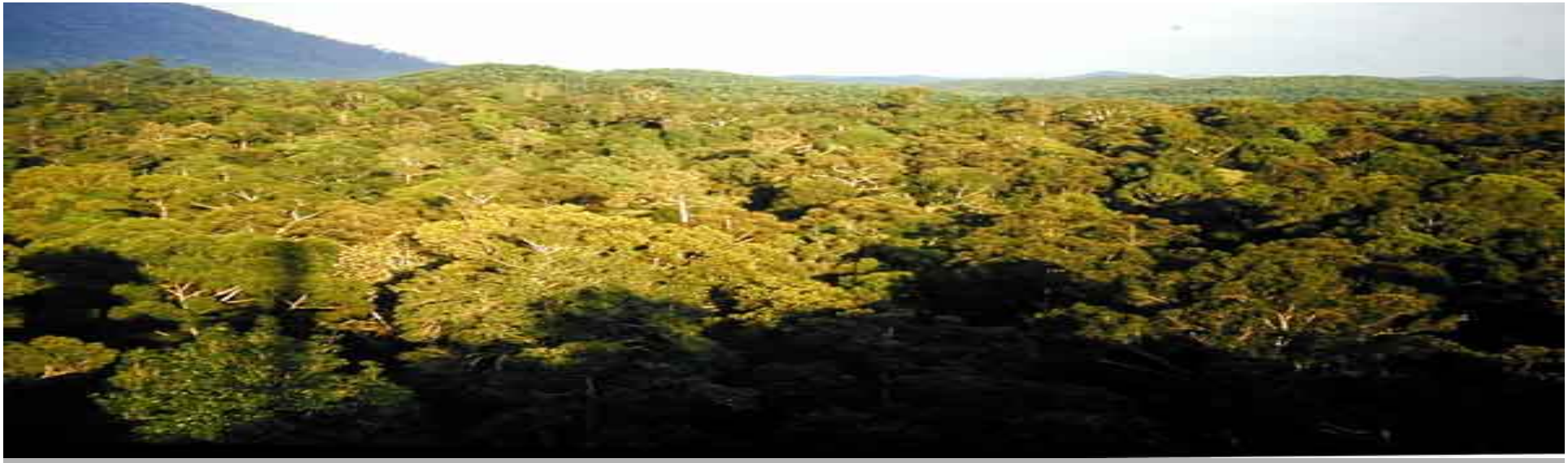

Tropical Deforestation and Biofuels

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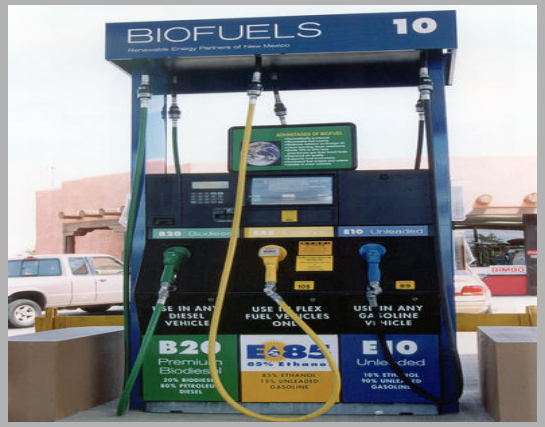
The Lifecycle Carbon Footprint of Biofuels
Miami, FL January 29, 2008

Motivation

- Accurate accounting of GHG benefits of biofuels

If increased demand for liquid biofuels drives land-use changes associated with feedstock production, the GHG profile these fuels will need account for the emissions related to the land-use changes.

- Energy Independence and Security Act of 2007



Act specifies quantity targets for corn ethanol and “advanced biofuels” - which include sugar ethanol and biodiesel. Potentially much of the increase in use of advanced biofuels could come from imports.

US Trade in Ethanol and Biodiesel (in 1,000 Gal.)

	2004	2005	2006	2007 (Jan-Sept)
US Ethanol Imports				
Brazil	86,184	28,896	429,114	175,560
CBI	56,364	79,044	212,856	180,138
Total US imports	148,764	110,334	680,904	364,056
US Biodiesel Imports				
Malaysia	11,570	6,692	16,591	30,222
Indonesia	0	0	7,669	37,066
Total US Imports	16,538	14,831	52,570	105,338
US Biodiesel Exports				
EU	764	3,914	17,156	152,670
Total US Exports	5,357	8,817	36,123	183,142

Source: ITC Statistics

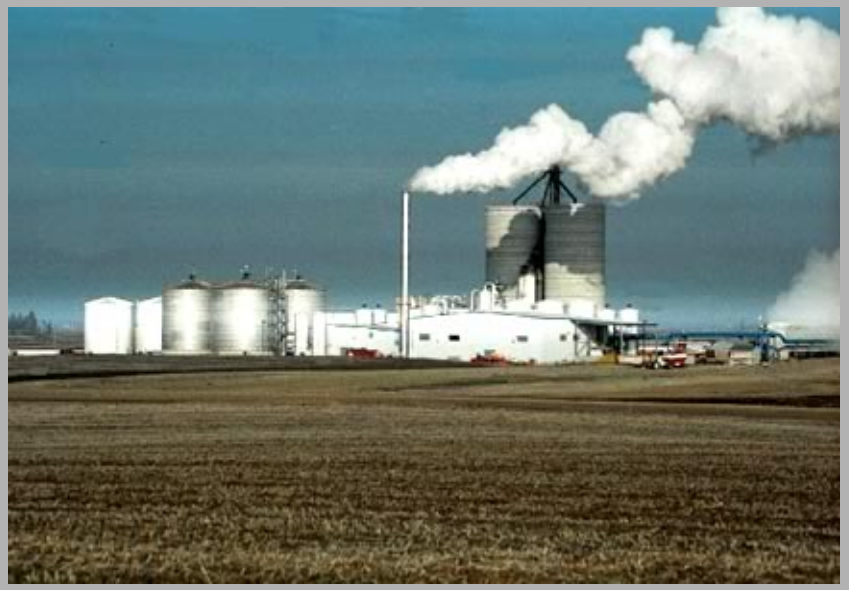
Biofuel Profiles of US and Key Biofuel Trading Partners

Profile: US Corn Ethanol

- Capacity in place:

  110 refineries; 5.5 billion gallons
- Capacity under construction/expansion:

  75 / 8 refineries; 6.1 billion gallons
- 2006 Production: 4.9 billion gallons



Profile: US Biodiesel

- Capacity in place:

  165 refineries; 1.85 billion gallons
- Under construction/expansion:

  80 / 4 refineries; 1.37 billion gallons
- 2006 Production: 250 million gallons

Profile: Malaysia Palm Biodiesel

- Palm oil production (2006): 15.9 million mt

  Exports: 14.7 million mt

- Land Resource:

  Total land area: 32.9 mil. ha

  Forest area: 20.9 mil. ha

  Annual deforestation (FAO):

  Area / Rate: 0.08 mil. ha. / 0.4

  Arable land 7.6 mil. ha (WRI)

  Permanent pasture 0.3 mil. ha (WRI)

Profile: Indonesia Palm Biodiesel

- Palm oil production (2006): 15.9 million mt

  Exports: 12.1 million mt

- Land Resource:

  Total land: 181.2 mil. ha

  Forest area: 88.5 mil. ha

  Annual deforestation (FAO):

  Area / Rate 1.9 mil. ha. / 1.7%

  Arable land 34.4 mil. ha (WRI)

  Permanent pasture 10.9 mil. ha (WRI)

Profile: Brazil Sugar Ethanol

- Capacity in place:
  325 refineries; 5.5 billion gallons
- Capacity under construction:
  48 refineries; 6.1 billion gallons
- 2006 Production: 4.5 billion gallons
- Exports:
  Total: 907.1 mil. gallons
  To USA: 429.1 mil. gallons

Profile: Brazil Sugar Ethanol

- Land Resource:

Total land area	851.5 mil. ha
Forest area	444.7 mil. ha
Annual deforestation (FAO):	
Area / Rate	3.1 mil. ha. / 0.7%
Cultivated land	339.9 mil. ha (FAS)
Sugarcane (total)	7.3 mil. ha
Sugarcane (ethanol)	3.6 mil. ha
Soybeans	21.1 mil. ha
Corn	13.0 mil. ha
Pasture	199.9 mil. ha

Costs-of Production

&

Greenhouse Gas Benefits

Cost-of-Production & GHG Benefits

USA: Ethanol from corn (Skeer and Haq)

- Production costs: $1.90 per gallon
- Competes with crude oil at $75 per barrel
- Lifecycle GHG benefit wrt gasoline: 20-30%

Brazil: Ethanol from sugarcane (Skeer and Haq)

- Production costs: $0.76 -$1.13 per gallon
- Competes with crude oil at $28 -$50 per barrel
- Lifecycle GHG benefit wrt gasoline: 78 %

Cost-of-Production & GHG Benefits

Malaysia: Biodiesel from palm oil (Skeer and Haq)

- Production costs: $1.44 per gallon
- Competes with crude oil at $42 per barrel
- Lifecycle GHG benefit wrt petroleum diesel: 67.7% (EPA for biodiesel)

Policy Needs Going Forward

1. Develop methodologies/approaches for evaluating the GHG emissions associated with land-use changes for specific units of imported biofuels
2. Improved understanding of how increased US demand for biofuels may drive international land-use changes and how US biofuel policies might be designed to minimize GHG emissions from land-use changes.

Methodologies/approaches:

Backstop Approach: Develop conservative default values for LU emissions by county and biofuel. Allow exporters/importers to provide evidence to support more favorable treatment on a case-by-case basis.

Illustrative Example: Biofuel Crediting System (BCS)

For a unit (say barrel) of a given biofuel from a specific country define:

Total GHG Emissions = Life cycle emissions + LULUCF emissions

BCS Example 1: Replace 1 barrel of gasoline with (sugar) ethanol from Brazil

LCE for gasoline:

1 gallon: 25 lb. CO_2 (GREET)

1 barrel: 0.48 mt CO_2 (1,050 lb)

Total GHG Emissions = (Life cycle + LULUCF) emissions

= 231 lbs + LULUCF emissions

= 0.10 mt + LULUCF emissions

- **Need 3 gallons of ethanol replace 2 gallons of gasoline**
- **63 gallons of sugar ethanol replace 1 barrel of gasoline**
- **Get 1 gal of ethanol from 0.051 mt of sugar cane**
- **Need 3.21 mt sugar cane to get 56 gal of ethanol**

BCS Example 1: Replace 1 barrel of gasoline with (sugar) ethanol from Brazil

Average annual per acre yield of sugar cane = 27.82 mt
Need 0.115 acre to produce 63 gallons of ethanol

GHG emissions from clearing 1 acre of forest: 163.3 mt CO_2
1 barrel of gasoline eq share: 0.10 * 163.3 = 18.8 mt CO_2
Spread out over 25 yrs: 0.75 mt per year

Total GHG Emissions = (Life cycle + LULUCF) emissions
= 0.10 mt + 0.75 mt
= 0.85 mt CO_2

BCS Example 2: Replace 1 barrel of diesel with palm diesel from South East Asia

LCE for 1 gallon of petro diesel: 27.7 lb CO2 (GREET)
LCE for 1 barrel of petro diesel: 0.53 mt CO2 (1,167 lb)

Total GHG Emissions = (Life cycle + LULUCF) emissions
= 376.9 lbs + LULUCF emissions
= 0.17 mt + LULUCF emissions

- **Need 1.2 gal of biodiesel to replace 1 gal of diesel**
- **Need 50.4 gallons of biodiesel replace 1 barrel of diesel**

BCS Example 2: Replace 1 barrel of diesel with palm diesel from South East Asia

Palm diesel yield per acre: 406 - 509 gallon
Need 0.10 acre to produce 50.4 gallons of biodiesel

Emissions from clearing 1 acre of forest: 114.3 mt CO_2
1 barrel of equiv share: 0.10 * 114.3 = 11.4 mt CO_2
Spread out over 25 yrs: 0.46 mt per year

Total GHG Emissions = (Life cycle + LULUCF) emissions
= 0.17 mt + 0.46 mt
= 0.63 mt

2. Improved understanding of US biofuel policies and international land-use changes.

Indonesia: Annual C Loss from Converting Forests to Agriculture (million mt C/yr)

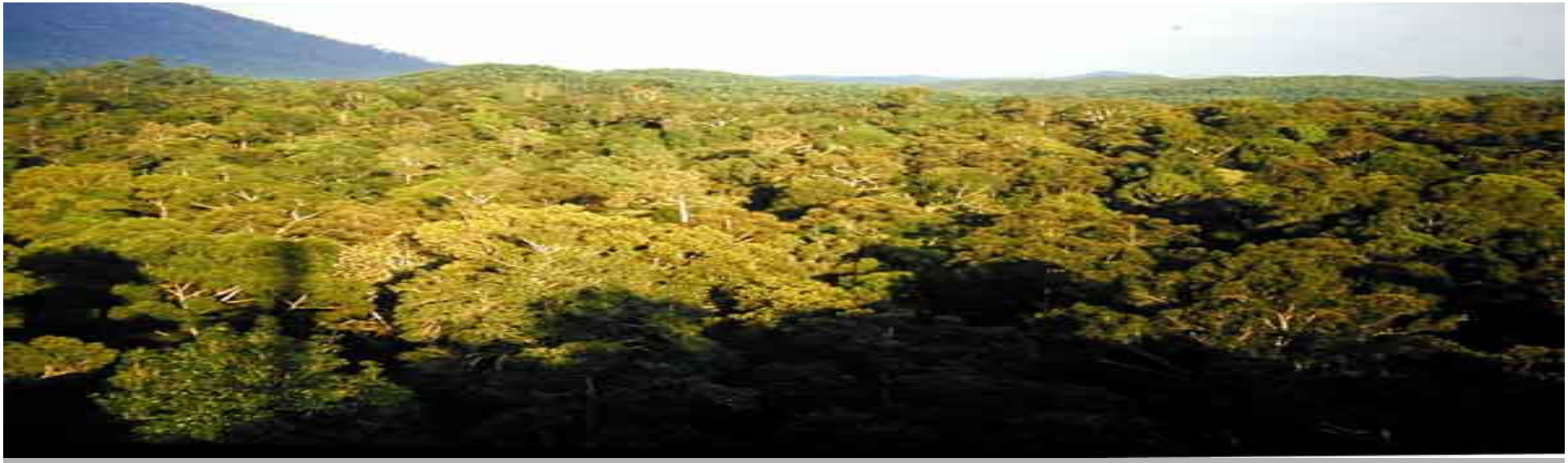
Year	Total	Productive	Degraded	Other Trop.
Baseline Agricultural Land Rents				
2005	149.6	42.3	8.2	99.0
2015	111.8	19.8	3.1	88.9
2025	84.1	9.7	1.6	72.8
5% Increase in Agricultural Land Rents				
2005	155.5	44.6	8.5	102.3
2015	114.0	20.7	3.5	89.9
2025	84.9	10.1	1.8	73.0
2005	176.4	51.3	9.7	115.4
2015	121.9	25.0	4.1	92.8
2025	87.3	11.4	2.1	73.9

Malaysia: Annual C Loss from Converting Forests to Agriculture (million mt C/yr)

Year	Total	Productive	Degraded	Other Trop.
Baseline Agricultural Land Rents				
2005	46.3	5.4	1.3	39.6
2015	38.5	3.4	0.5	34.6
2025	29.4	1.7	0.3	27.5
5% Increase in Agricultural Land Rents				
2005	47.5	5.8	1.4	40.4
2015	39.2	3.5	0.5	35.1
2025	29.5	1.7	0.3	27.5
25% Increase in Agricultural Land Rents				
2005	52.5	7.4	1.6	43.5
2015	41.9	4.2	0.7	37.0
2025	29.9	2.1	0.4	27.5

Brazil: Annual C Loss from Converting Forests to Agriculture (million mt C/yr)

	Total	Non Tropical (South & East)		Amazon: Not Deep in Basin		Amazon: Deep in Basin		Other Tropical (North & East)	
Year		mg	unmg	mg	unmg	mg	unmg	mg	unmg
Baseline Agricultural Land Rents									
2005	254.4	1.7	7.2	15.2	143.4	3.9	81.0	0.0	2.0
2015	191.1	1.2	1.3	5.2	122.2	0.9	58.1	0.0	2.0
2025	164.4	1.0	0.1	2.8	110.7	0.4	48.1	0.0	1.3
5 % Increase in Agricultural Land Rents									
2005	256.3	1.8	7.4	15.9	144.0	4.1	81.1	0.0	2.0
2015	191.8	1.3	1.4	5.5	122.7	1.0	58.1	0.0	2.0
2025	164.8	1.0	0.1	3.0	110.9	0.4	48.0	0.0	1.3
25% Increase in Agricultural Land Rents									
2005	264.4	2.2	7.8	18.9	147.0	4.8	81.7	0.0	2.0
2015	195.3	1.5	1.5	6.5	124.7	1.1	58.0	0.0	2.0
2025	167.1	1.2	0.2	3.6	112.4	0.5	47.9	0.0	1.3



Thank you