Life Cycle Analysis and Land Use Change Effects

October 16, 2008

California Environmental Protection Agency

Air Resources Board

Meeting Agenda

Introductions
Update on Life Cycle Pathway Analyses
ARB Staff Presentation on LUC Work in Progress
Other Presentations
Discussion and Wrap-Up

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Acknowledgement

- **University of California, Berkeley**
  - Michael O'Hare
  - Andrew Jones
  - Richard Plevin
- **Purdue University**
  - Thomas Hertel
  - Alla Golub

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Summary of LCFS Provisions

- Achieve at least a 10% reduction in carbon intensity by 2020, with interim reductions between 2010 and 2020
- Baseline is carbon intensity of gasoline and diesel fuel
- Requires lifecycle analysis
- Allows compliance with banked, traded, or bought credits; providers of lower carbon transportation fuels earn credits
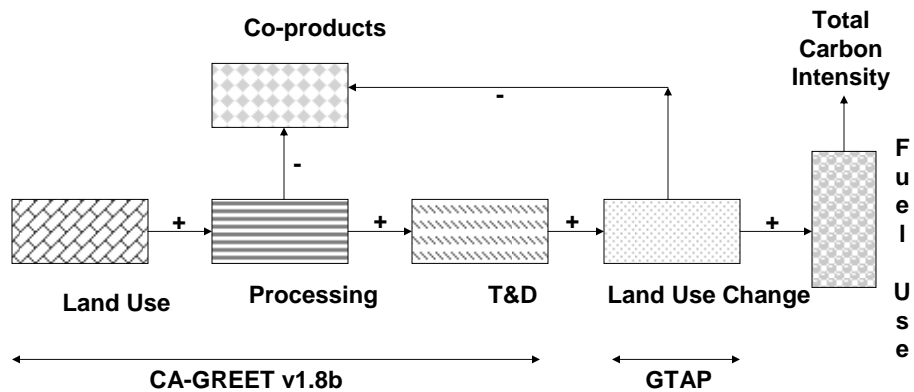
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Past Activities

- Held 6 meetings of the LCA working group to provide ongoing public opportunity for dialog on issues associated with the development of lifecycle analysis for fuels
- Released 8 fuel pathways using CA-GREET
- Presented preliminary land use change analysis methodology using GTAP in June 2008

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Fuel Pathway Life Cycle Carbon Intensity

Co-products

Total Carbon Intensity

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Land Use + Processing + T&D + Land Use Change + Fuel Use

Land Use　　**Processing**　　**T&D**　　**Land Use Change**

CA-GREET v1.8b　　　　　**GTAP**

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Updates to CA-GREET and Fuel Pathway Documents

- Released updated CA-GREET v1.8b

Pathways Released	Pathways to be Released	Expected Release Date
CARBOB	Landfill gas to CNG	10/08
Corn Ethanol	Sugarcane Ethanol (Brazil)	10/08
CaRFG	Cellulosic Ethanol (forest)	11/08
ULSD	Cellulosic Ethanol (farmed trees)	11/08
CNG	LNG (5 sub-pathways)	11/08
Electricity	Renewable Diesel (Soy, Waste, Palm Oil)	12/08
Liquid H2	Other Pathways	??
Soy Biodiesel		

Updates to CA-GREET and Pathway Documents (cont.)

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Ethanol Sub-Pathways to be Released (all corn grown in the Midwest) (all ethanol in Midwest unless specified)	Expected Release date
100% NG Dry Mill DDGS	11/08
100% NG Dry Mill Wet DGS	11/08
Average Wet Mill, Midwest Production	11/08
80% NG 20% Biomass Dry Mill DDGS	11/08
80% NG 20% Biomass Dry Mill Wet DGS	11/08
100% NG Dry Mill DDGS, CA Production	11/08
100% NG Dry Mill Wet DGS, CA Production	11/08
80% NG 20% Biomass Dry Mill DDGS, CA Production	11/08
80% NG 20% Biomass Dry Mill Wet DGS, CA Production	11/08

Future Work Related to Fuel Pathways

- Refine and update CA-GREET v1.8b inputs
- Provide final draft life cycle GHG values for gasoline and diesel
- Develop values for other fuels for various production pathways
- Create additional fuel pathways as appropriate

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What is Land Use Change?

Conversion of new or existing land brought on by increased demand for a commodity (e.g. biofuel). This effect is at a different location.

Examples include:

- native grasslands converted to soybean farming due to increased demand arising from soybean cultivation being replaced by corn cultivation
- increased demand for fossil fuels likely to lead to land use change from Oil Sands

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No Land Use Change Effects?

A biofuel will likely have no Land Use Change when it:

- is not derived from crops;
- is derived from cover crops, or similar types;
- is derived from crops grown on land not supporting other crop growth

Tools for Evaluating Land Use Change

Possible models considered:

- GTAP (**G**lobal **T**rade **A**nalysis **P**roject from Purdue University)
- FAPRI (Model developed by the **F**ood and **A**gricultural **P**olicy **R**esearch **I**nstitute at Iowa State University)
- FASOM (**F**orest and **A**gricultural **S**ector **O**ptimization **M**odel from Texas A&M University)

GTAP Model

Computable General Equilibrium model
- – Model addresses worldwide impacts of agricultural policies
- – Models both inside and outside U.S. with 111 global regions and 57 sectors;
- – Models all sectors of the economy (agricultural and outside agriculture) and international trade: tracks bilateral trade;
- – Details land use by 18 agro-ecological zone
- – Publicly available for use (some segments may need subscription)

Limitations
- – Evaluating even one feedstock still requires complete computational processing

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FAPRI Model

- Computable General Equilibrium model; ag-sector model
  - – Model addresses worldwide agricultural sector impacts of U.S. policy
  - – Models effects of equilibrium between supply and demand for agricultural commodities
  - – Captures price effects into land conversions
  - – Uses self-created databases (updated yearly)
- Limitations
  - – Does not include other economic effects outside of agriculture

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FASOM Model

- Agricultural-forestry optimization model
  - Model addresses only U.S. impacts of U.S. agricultural policies
  - Models effects in the U.S.
  - Models equilibrium between agricultural and forest land
- Limitations
  - Does not include effects outside of U.S.
  - Only models agricultural and forest systems
  - Does not consider other aspects of the economy

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GTAP Model Chosen
for Preliminary Analysis

- UCB/Purdue developed land use module for GTAP

- GTAP run with multiple inputs

- Data are preliminary and subject to change

- Staff seeking comments on approach and inputs

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Inputs into GTAP

Input Factor	Value
Baseline Year	2001
Target Year	2015
Initial Volume	1.75B Gallons
Final Volume	15B Gallons
Corn Yield Elasticity	Discussed under Sensitivity
Elasticity of Harvested Acreage Response	Discussed under Sensitivity
Elasticity of Land Transformation across Cropland, Pasture and Forestry	Discussed under Sensitivity
Elasticity of Crop Yields with Respect to Area Expansion	Discussed under Sensitivity
Trade Elasticity	Discussed under Sensitivity

Sequence of Steps in Estimating Preliminary GHG Impacts

Step 1: Perform GTAP run to predict types of land converted in each region

Step 2: Use estimated carbon release/sequestered for each land type using Woods Hole data and calculate total GHG carbon emissions increase

Step 3: Annualize total GHG emissions over 30 years

Note: Other approaches under evaluation, including other time periods and net present value approach

Draft Land Change Resulting from Increased U.S. Production of Corn-ETOH

Description	Middle estimate (million ha)	Range of estimates (million ha)
Land converted in USA	**1.6**	**1 to 4.8**
Forest land converted	**0.5**	
Pasture land converted	**1.1**	
Land converted in total world wide	**4.2**	**2.3 to 14.6**
Forest land converted	**0.8**	
Pasture land converted	**3.4**	

* For details, refer to document on land use change posted on LCFS website

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Input Variables

- **Corn Yield Elasticity**
  - Expresses the relationship between price and yields as corn yields (amount of corn produced per acre) varies with corn price
- **Elasticity of Harvested Acreage Response**
  - Expresses the maximum extent to which the number of acres devoted to a crop will change in response to an increase in the cost of land
- **Elasticity of Land Transformation across Cropland, Pasture, and Forestry**
  - Functions similarly as the elasticity of harvested acreage response parameter and expresses the land use conversions between alternative uses
- **Elasticity of Crop Yields with Respect to Area Expansion**
  - Expresses the yields that will be realized from newly converted lands relative to yields on acreage previously devoted to that crop
- **Trade Elasticity**
  - Express the extent to which the importer will respond to a price increase from a given exporter by switching to a different exporter for the more expensive commodity
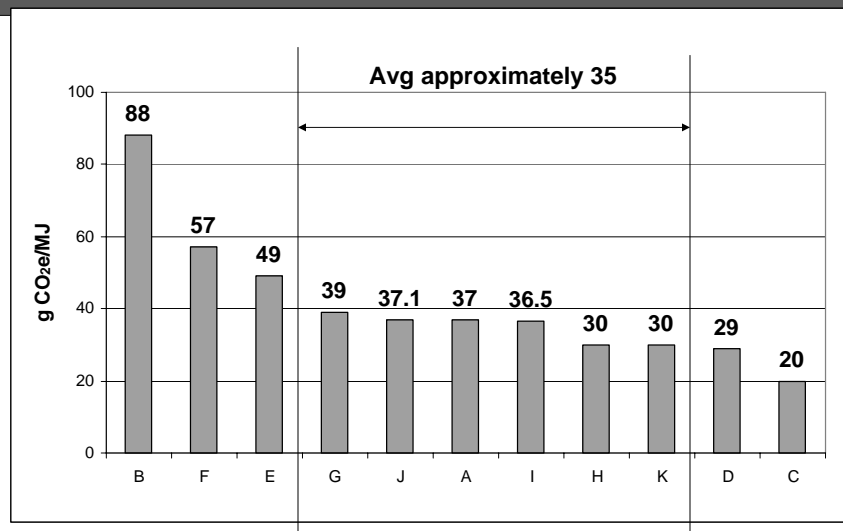
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Sensitivity Analysis Results

Input Variable	Input Variable Ranges		Output Variable Ranges (gCO2/MJ)		
	Low Value	High Value	From Low Input Value	From High Input Value	
Corn Yield Elasticity	0.1	0.6	57	29	
Elasticity of Harvested Acreage Response	0.5	0.5	Was not subjected to sensitivity analysis		
Elasticity of Land Transformation across Cropland, Pasture and Forestry	0.1	0.3	30	39	
Elasticity of Crop Yields with Respect to Area Expansion	0.25	0.75	88	20	
Trade Elasticity	1 Std. Dev. Below Central	1 Std. Dev. Above Central	37.1	36.5	

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Draft Land Use Change Results

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Draft Land Use Change Results (cont.)

- Land Use Change – range between 20 and 88 gCO_2e/MJ
- Majority of values between 29 and 40 gCO_2e/MJ
- Average of these ~ 35 gCO_2e/MJ
- This is current number staff used in scenario work
- Will be modified based on future work

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Issues to be Addressed in Estimating GHG Impacts

- Evaluate predictions of land conversions
  - Domestic vs. international
  - Forest vs. pastureland

- Carbon factors
  - Woods Hole vs. Winrock

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Issues to be Addressed in Estimating GHG Impacts (cont.)

- Time treatment of emissions
  - Time factor of 20, 30,or 100 years
  - Net present value with discount approach

Work in Progress

- Evaluating yield elasticity (technology driven)
- Evaluating implications of potential CRP land conversion
- Evaluating integration of co-products results as part of GTAP and GREET analysis
- Complete uncertainty evaluation
- Compare with U.S. EPA analysis

Work in Progress (cont.)

- Evaluating LUC for
  - Biodiesel
  - Sugarcane ethanol
  - Cellulosic ethanol
  - Others
  - Determining if LUC effects are significant for any other fuels regulated by the LCFS
- Conduct peer review

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Timelines (tentative)

- Update GTAP results (November 2008)

- Conduct peer review of GTAP results (Dec 2008)

- Update CA-GREET (Oct-Dec 2008)

- Propose values for use in LCFS (Jan. 2008)

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Availability of Materials Related to this Analysis

- GTAP model and associated material from:
  - www.gtap.agecon.purdue.edu\
- Spreadsheet used external to model:
  - www.arb.ca.gov\fuels\lcfs
- All material related to present work
  - www.arb.ca.gov\fuels\lcfs

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Questions/Comments

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