Life Cycle Analysis
Working Group Meeting

June 30, 2008

California Environmental Protection Agency

Air Resources Board

Meeting Agenda

Introductions
Overview of Today's Meeting
Presentation on GTAP Model - Dr. Tom Hertel, Purdue University
ARB Staff Presentation on UCB/Purdue Work in Progress
Update on U.S. EPA Activities - Vince Camobreco, U.S. EPA
Update on Life Cycle Pathway Analyses
Other Presentations
Discussion and Wrap-Up

Overview of Today's Meeting

Workgroup Purpose

- Provide ongoing public opportunity for dialog on issues associated with the development of lifecycle analysis for transportation fuels.
- 6th Meeting of the LCA Workgroup
- Workgroup Objectives
  - Define GHG impact of all fuels
  - Consider direct and indirect impacts of all fuels to the extent that scientifically defensible data/models exist
  - Provide forum for public discussion
  - Educate stakeholders on LCA

Activities Undertaken To Date

- Contracted with UCB/UCD to assist in LCA analysis
- Energy Foundation support of Life Cycle Associates to assist in pathway analysis and stakeholder education
- With CEC support, conducted CA-GREET training seminar and updates on fuel pathway documents
- With DOE support, provided additional GREET seminar conducted by Michael Wang from Argonne Laboratory
- Populated CA-GREET model with the latest data-ongoing
- Released five pathways for review and comment
- Discussed associated issues: e.g. co-products
- Presented introductory material on indirect impacts of biofuels

Purpose of Today's Meeting

- Update stakeholders on work related to land use change analysis
- Educate stakeholders on GTAP and other models that are being used to assess land use change effects
- Provide opportunity to review/comment on analyses
- Continue efforts to ensure that ARB uses defensible science in the evaluation of land use change effects
- Update stakeholders on the status of other life cycle analysis activities, including pathway analyses

Disclaimers!

- ARB staff are presenting the information today to ensure that there is an open dialog on the science
- ARB staff are not endorsing or accepting any information or interim results presented today, but are simply releasing the latest information to facilitate review
- There is much work left before we will be able to quantify land use change effects for regulatory purposes

Next Steps

- Convene additional LCA workgroup and stakeholders meetings to discuss results and design additional analytical approaches
- Run numerous scenario analyses to evaluate critical parameters that affect the results and to assess uncertainty
- Coordinate with U.S. EPA on parallel analyses being conducted pursuant to EISA requirements
- Receive and evaluate public comments

Background - LCA

- The CA-GREET model allows calculation of GHG emissions for fuel pathways
  - For traditional fossil fuels, includes emissions from production, processing, transportation and use
  - For biofuels, includes farming, transportation, processing, biorefining and use

Background - LCA (cont.)

- CA-GREET does not account for land use change
  - Impacts may be relevant for biofuels and traditional fossil fuels
  - Need to conduct analysis for biofuels and fossil fuels (crude, oil sands, etc.)
  - If appropriate and relevant, land use impact can be added exogenously into CA-GREET

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 leads to drilling of new oil wells

How to Assess Land Use Change?

- What are the tools available for assessing such impacts?
- Do the tools provide a reliable quantification?
- If so, how certain are the predictions?
- Can it predict future changes adequately using historic information?
- How does it deal with multiple scenarios/conditions?
- Do the tools capture all relevant global impacts to arrive at a quantifiable value?
- Can tools be validated/calibrated?

Including Land Use Change Value?

Staff considerations for inclusion of land use change calculations in the LCFS regulation

- Has the tool been validated adequately?
- What is the certainty of quantified results?
- What are the technical merits of using the results?
- What is the ability to assess significant factors that cause/mitigate land use change?
- How transparent has the process been?
- Have the results been adequately peer-reviewed?

Tools for Evaluating Land Use Change

Possible models considered:

- 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 (**G**lobal **T**rade **A**nalysis **P**roject from Purdue University)

FAPRI Model

- Ag-sector model
  - Agricultural sector model
  - Models effects of equilibrium between supply and demand for agricultural commodities
  - Captures price effects into land conversions
  - Uses self-created databases (updated yearly)
- Limitations
  - Models only agricultural commodities and ignores products/services outside the agricultural sector
  - Ignores other economic effects outside of agriculture
  - Execution time is long
  - Not publicly available

FASOM Model

- Agricultural-forestry model
  - Models effects in the U.S.
  - Models equilibrium between agricultural and forest land
  - Uses databases created by author
- Limitations
  - Does not include effects outside of U.S.
  - Only models agricultural and forest systems
  - Does not consider other aspects of the economy

GTAP Model

Brings many aspects together into one database

- Models both inside and outside U.S.
- Global coverage: 111 regions
- Sectoral detail: 57 sectors
- Models all sectors of the economy (agricultural and outside agriculture)
- Models International trade: tracks bilateral trade as well as transport margins
- Details Land use by agro-ecological zone

GTAP Model (cont.)

- Energy, emissions and climate change mitigation are included
- 6,500 people from >100 countries – contributing data to the model database
- Much more effort put into non-US regions than FAPRI and FASOM
- Publicly available for use (some segments may need subscription)
- Currently being used by U. S. EPA in their analysis

Limitations

- Evaluating even one feedstock still requires complete computational processing

GTAP Model Presentation

ARB Staff Presentation on UCB/Purdue Work in Progress

Scenarios to Be Evaluated

- Biofuel Volumes
  - Corn Ethanol (1.75B to 15B, 13B to 15B, 7B to 15B, 1B to 2.5B)
  - Biodiesel and Renewable Diesel (to be determined)
  - Sugarcane ethanol (to be determined)
- Land Types
  - Pasture land and forest land
  - Other land types (CRP, others)
  - Consider U. S. EPA work

Scenarios to Be Evaluated (cont.)

- Co-products
  - GTAP market based
  - Other approaches
- Yields
  - Price driven
  - Technology driven
  - Other increases in yield

Scenarios to Be Evaluated (cont.)

- Emission Factors
  - Houghton's work
  - Winrock International (from U. S. EPA work)
  - Others
- Impact on food prices
- Fossil Fuels (Crude, Oil sands, etc. for which scenarios will be developed)

Current Work by UC Berkeley

- UCB has contracted with Purdue University to perform GTAP model runs
- First phase of work is for **corn ethanol**
- Current work includes 4 scenarios
- Additional work is for more scenarios, other fuels and biofuels
- Sensitivity analysis will be performed in the future

Initial Scenarios Modeled

- Corn Ethanol volumes
  - 1.75B to 15B gallons
  - 13B to 15B gallons
  - 1.75B to 15B gallons with lower carbon emissions for converted forest and pasture land
  - 1.75B to 15B gallons where land converted in the U. S. is assumed to come from pasture land
- Yield
  - Price driven for all initial scenarios

Initial Scenarios Modeled (cont.)

- Land Types
  - Pasture land and forest land only as land converted
- Co-products
  - GTAP market-based for all scenarios
- Emission Factors
  - Houghton's work for all scenarios

Sequence of Steps in the UCB Analysis

Step 1: GTAP run performed and predicted types of land converted in each region

Step 2: Estimated carbon release/sequestered for each land type

Step 3: Calculated total carbon emissions increase

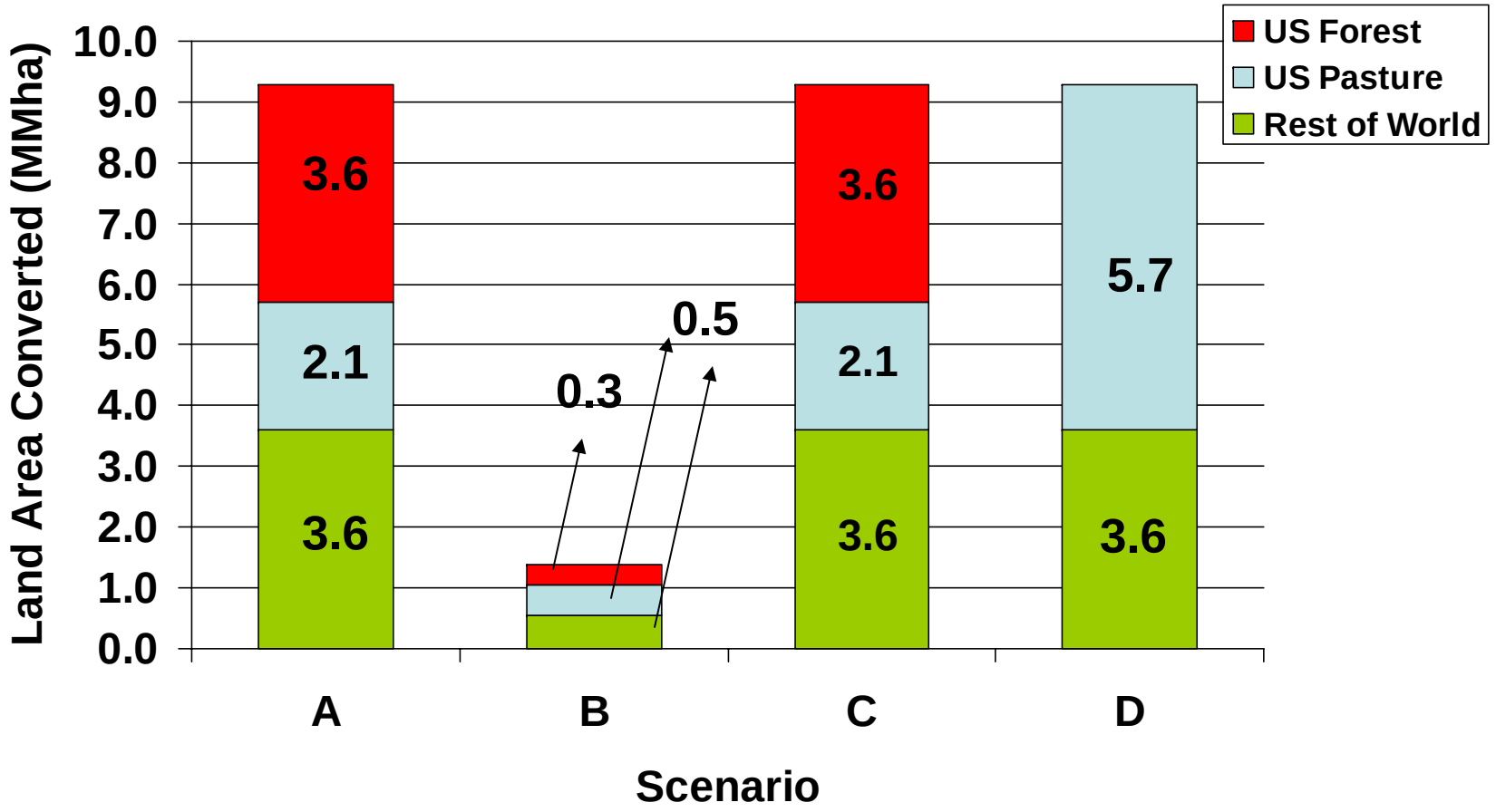
Step 4: Amortized (30 years) and normalized carbon emissions

Summary - Initial Scenarios Modeled

	Scenario A	Scenario B	Scenario C	Scenario D
Ethanol Volume	1.75 to 15B	13B to 15B	1.75B to 15B	1.75B to 15B
Type of Land	Forest and pasture	Forest and pasture	Same land as A but lower carbon emissions from converted land	All U. S land change from pasture land

Note: For all scenarios, processing for carbon emissions is done outside of the GTAP model.

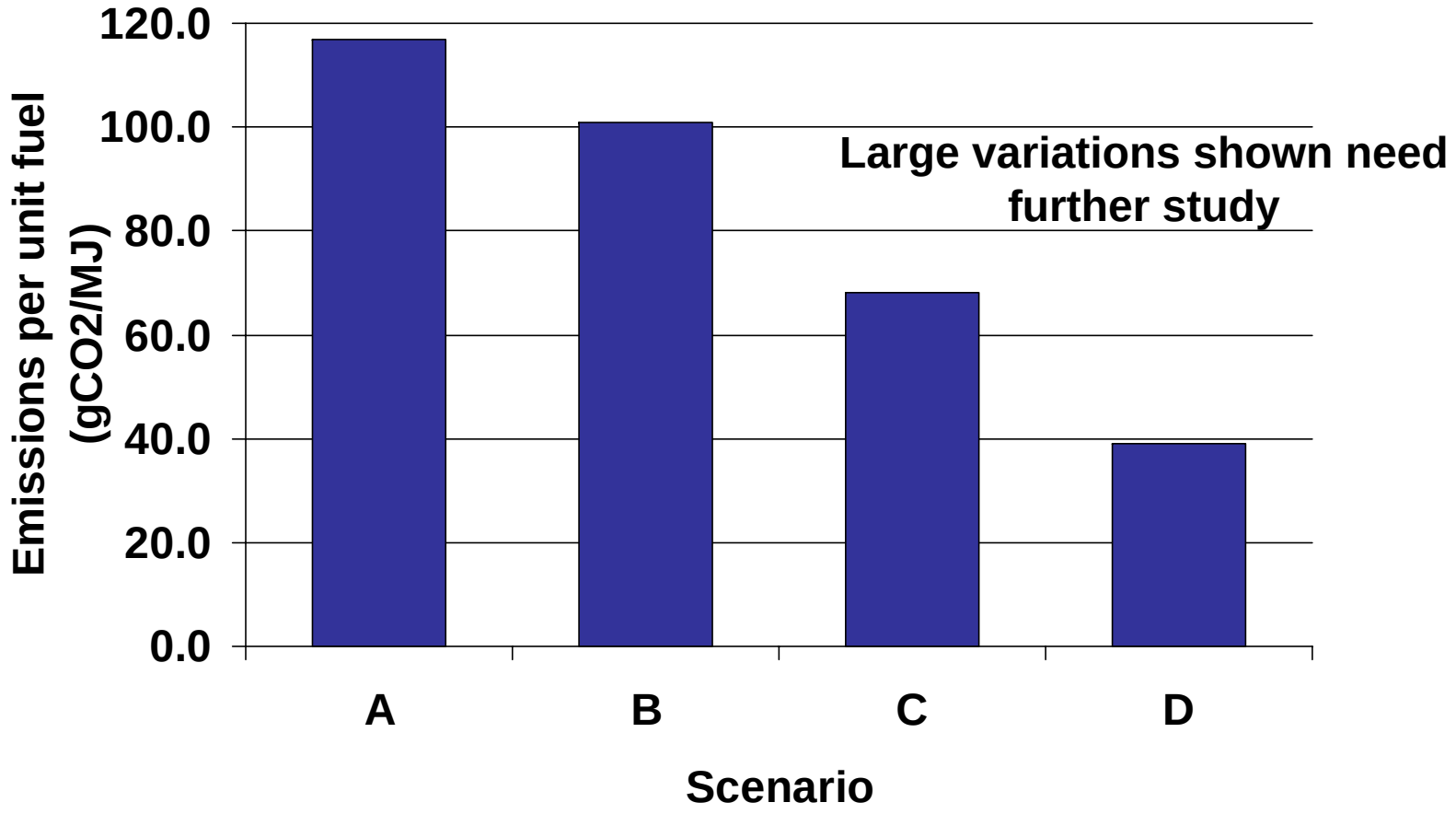
Scenarios Run by UCB/Purdue



Comparison of Scenarios

- The difference in total land converted for scenario B is due to the different volumes of ethanol:
  - Volume for A, C and D is 13.25 B gallons (increase modeled)
  - Volume for B is 2B gallons (increase modeled)

Scenarios Run by UCB/Purdue (cont.)



Sensitivity of the GTAP Model

- The results shown in the previous slide are illustrative of the sensitivities of the GTAP model to different assumptions
- The model results are sensitive to land conversion types, emission factors, yield, and other factors

Comparison of Scenarios (cont.)

- The difference in carbon emissions for the 4 scenarios is primarily due to the varying amounts of forest and pasture land being converted:
  - Scenario A is default forest and pasture land converted (emissions factor associated with land converted are 529 and 117 $MgCO_2$/ha respectively)
  - Scenario B is also default converted land

    (land type converted is different from scenario A)
  - Scenario C is same amount of land converted as scenario A but with lower carbon emissions (carbon emissions of 215 and 109 $MgCO_2$/ha for forest and pasture land respectively)
  - Scenario D is where land in the U. S is assumed to come from pastureland and rest of world land mix is the same as scenario A

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

Future Work

- Complete scenarios listed earlier
- Explore different sources for C data that works with the AEZ specific predictions of GTAP - currently we only distinguish between forest and grassland conversion by trade region, not AEZ
- Conduct sensitivity analyses:
  - Volume, amortization timelines, prices and subsidies, varying elasticity, land types, etc.
- Develop validation protocols for GTAP model
- Evaluate robustness of model and methodology

Future Work (cont.)

- Evaluate additional models or tools and compare with GTAP results
- Assess uncertainty estimates
- Compare with U.S. EPA models and scenarios
- Conduct peer review
- Evaluate appropriateness of inclusion in the low carbon fuel regulation

U.S. EPA Presentation

Update on
Life Cycle Pathway Analyses

CA-GREET Pathway Updates

- CA-GREET Pathways posted
  - CARBOB, Ethanol, CaRFG, ULSD, CNG, Electricity
- Future Pathways to be posted
  - H_2, Biodiesel (July 15, 2008)
  - Ethanol (sugarcane), Biomethane, GTL, LNG, Renewable Diesel (July 30, 2008)
  - CTL (August 2008)
  - Canadian Oil Sands (September 2008)*

* In consultation with University of Alberta in Calgary, Canada

Update of CA-GREET Model

- Migrating from CA-GREET v98 to CA-GREET v1.8b
- We are developing a companion user interface to use with the new CA-GREET model
- Will include changes based on new information and stakeholder comments
- New draft CA-GREET model and companion user interface expected to be posted on 07/15/08

Timelines (tentative)

- GTAP results (mid-August 2008)
- Land Use Change Impacts (Sept. 2008)
- Peer review of GTAP results (Sept.-Oct. 2008)
- CA-GREET updates (July-Sept. 2008)
- Stakeholder comments/suggestions for Land Use Change (current work) requested by July 15, 2008

Other Presentations

Questions/Comments

- John Courtis at 916-323-2661 or via e-mail at jcourtis@arb.ca.gov
- Dean Simeroth at 916-322-6020 or via e-mail at dsimerot@arb.ca.gov