

MEMORANDUM

DATE: June 6, 2009

TO: Larry Schafer, NBB  
Blair Fortner, USSEC

FROM: John M. Urbanchuk

SUBJECT: Review of models used by EPA to estimate indirect land use: RFS2

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**I. EPA used two primary models to estimate the indirect land use changes and implications for domestic and international commodity prices.**

A. Model descriptions

a. FASOM

The Forest and Agricultural Sector Optimization Model (FASOM) is a dynamic, nonlinear programming model of the forest and agricultural sectors in the U.S. The FASOM model initially was developed to evaluate welfare and market impacts of alternative policies for sequestering carbon in trees. FASOM also has been applied to evaluate policy scenarios for a wider range of forest and agricultural commodities.

FASOM is a partial equilibrium agricultural sector model that focuses on *domestic* land competition (e.g. forest vs. pasture converted to crop production) and models major crop commodity prices. The model is being used by EPA in combination with the FAPRI model to establish consistent set of domestic assumptions and forecast agricultural/forestry implications of GHG reduction targets.

FASOM includes a price-endogenous agricultural sector model that simulates production of 36 primary crop and livestock commodities and 39 secondary, or processed, commodities. Crops compete regionally for land, labor, and irrigation water. The cost of these and other inputs are included in the budgets for regional



production variables modeled in FASOM. There are more than 200 production possibilities (budgets) representing agricultural production.

Several major categories of agricultural land use are modeled in FASOM:

- Cropland
- CRP land (constrained at 32 million acres)
- Pastureland (land suitable for livestock pasture calculated based on livestock budgets by region and livestock type).
- Grazing land (rangeland available for livestock grazing divided into public and private grazing by region).
- Forestland (timberland available for timber production)

FASOM adjusts crop yields based on historical growth. Assumed yield increases for corn and soybeans in the EPA study were modified to line up with the most recent USDA long-term projections (through 2017) and then extrapolated through 2022. FASOM does not directly incorporate yield responses to changes in price.

A unique feature of the agricultural sector model in FASOM is the method it uses to prevent unrealistic combinations of crops from entering the optimal solution, a common problem in mathematical programming models. Although the agricultural sector in FASOM is divided into 63 homogenous production regions and 11 market regions, each having available many production possibilities, it often happens that the optimal, unconstrained solution in some regions is represented by one crop budget—complete specialization. In reality, risks associated with weather and the effects of other exogenous and sometimes transient variables on agricultural prices lead to diversification in crop mixes, and such a representation cannot capture the full factor-product substitution possibilities in each area. This is avoided by requiring the crops

in a region to fall within the mix of crops observed in historical cropping records, as reported in the agricultural statistics series. The model is constrained so that for each area, the crop mix falls within one of the mixes observed in the past 20 years.<sup>1</sup>

FASOM assumes that starch and sugar-based ethanol and biodiesel production are mature technologies and have essentially reached technical limits on feedstock conversion. Consequently, FASOM holds ethanol and biodiesel yields constant over time in the model.

b. FAPRI/CARD

FAPRI is a joint effort of Iowa State University's Center for Agricultural and Rural Development (CARD) and the University of Missouri-Columbia. Both the Missouri and ISU teams utilize (and frequently change) the models for policy analysis and to prepare outlooks at the request of Congress and other largely public sector groups. The model used for the EPA analysis is the version maintained at and run by the forecast group at CARD under the direction of Dr. Bruce Babcock.

FAPRI utilizes a set of interrelated supply and demand models to estimate the impacts of changes in policy and economic parameters on prices and production levels of important agricultural commodities in major importing and exporting countries. FAPRI analyses of the impacts of U.S. policy changes on the U.S. agricultural sector are conducted using stochastic models.<sup>2</sup>

The FAPRI model is a non-spatial partial equilibrium agricultural sector model that includes not only domestic land competition but determines net acreage change by

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<sup>1</sup> Adams, Darius M.; Alig, Ralph J.; Callaway, J.M.; McCarl, Bruce A.; Winnett, Steven M. "The forest and agricultural sector optimization model (FASOM): model structure and policy applications". Res. Pap. PNW-RP-495. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 1996.

<sup>2</sup> Simla Tokgoz, Amani Elobeid, Jacinto Fabiosa, Dermot J. Hayes, Bruce A. Babcock, Tun-Hsiang (Edward) Yu, Fengxia Dong, Chad E. Hart, and John C. Beghin. "Emerging Biofuels: Outlook of Effects on U.S. Grain, Oilseed, and Livestock Markets". *FAPRI Staff Report 07-SR 101*. May 2007

country. The model assumes that a decrease in U.S. exports results in increased crop production internationally. Although not all export losses are made up with production – shifts in crops and decrease in demand also occur. The CARD models solve for representative world prices by equating excess supply and demand across countries. Domestic prices for each country are determined through the use of price transmission equations that incorporate exchange rates and other price policy variables such as tariffs, export taxes and domestic support prices.

The CARD U.S. model is divided into nine production regions and includes behavioral equations for principal by-products (HFCS, ethanol, corn oil, biodiesel)

Changes in area planted to crops are based on yields in different countries but the model does not reflect price induced yield changes or changes in area that reflect marginal yields. CARD assumes the net increase in all crop acres results in land being converted into agriculture with associated land use change GHG impacts.

The CARD model assumes that existing agricultural and trade policy variables will remain unchanged in the projection period. As is the case with FASOM, the CARD holds ethanol yields constant at 2.71 gal/bu for dry mills and 2.5 gal/bu for wet mills). CARD does not model cellulosic ethanol.

The CARD models do not include price induced yield changes from intensification of agricultural practices. They also make no differentiation in yields on marginal land brought into production and land already in production. CARD claims that these two assumptions cancel each other out.

The CARD model was designed to produce a 10-year projection. The model was “forced” to produce a projection through 2022.

## Strengths and weaknesses

### **c. FASOM**

#### i. Strengths

1. Long-term forecast horizon
2. Commodity coverage (includes forestry)
3. Geographic coverage of domestic production regions

#### ii. Weaknesses

1. Does not include effects outside of U.S.
2. FASOM models only agricultural and forest systems and ignores broader economic implications.
3. It is interesting to note that while FASOM contains a forestry component, EPA states that the model does not model biofuels from MSW or forestry sector feedstocks.
4. FASOM does not model land use and agricultural sector changes outside of the U.S.
5. Transparency. Model is not publically available.
6. No account is made for technological progress in ethanol yields that will reduce the amount of feedstock required.

**d. CARD**

i. Strengths

1. Well regarded model used for policy analysis at Congressional request.
2. Well maintained model and database.
3. Solid staff of analysts.
4. Large model of domestic and international agriculture covers most major commodities in most countries.

ii. Weaknesses

1. CARD models only agricultural commodities and ignores products/services outside the agricultural sector.
2. The model system essentially ignores other economic effects outside of agriculture
3. Model is very large and cumbersome. The model is complex and requires significant staff time to run. Execution time for model results is long.
4. CARD does not model cellulosic feedstocks. This may affect land allocation amongst conventional grain and oilseed crops (e.g. corn and soybeans).
5. Neither FASOM or FAPRI model potential biofuel feedstocks such as corn oil used for biodiesel or MSW. It is unclear how these models treat white and yellow grease.

6. No account is made for technological progress in ethanol yields that will reduce the amount of feedstock required.
7. Transparency. Model is not publically available.

B. How the models are used

- a. EPA uses the AEO 2007 as the base for comparison. It is unclear what the control case projection is for either FASOM or CARD.
- b. EPA used FASOM for domestic agricultural impacts and land use changes and CARD primarily for international impacts.
  - i. EPA admits that using two separate models provides inherent challenges in reconciling results.
    1. For example each model produces different commodity price impacts with CARD producing larger impacts. To the extent that these price changes determine world prices and that relative prices the allocation of land among commodities in foreign producers, this could lead to inconsistent land use changes. The bias would likely be on greater area shifts outside of the U.S.
  - ii. EPA provided a summary of the major assumptions used in the analysis these need to be reviewed carefully. A major assumption to review is crop yields both domestically and for other major producers.
  - iii. The agricultural sector models for countries important for biodiesel, notably Malaysia, Indonesia, Brazil, Nigeria to ensure that the impact of price shifts on land use changes is reasonable.

- c. EPA provides no information about how the two model teams coordinated with each other and EPA staff. Forecasting is as much an art as a science. The model is a tool and the results reflect the experience and expertise of the modeler.
  - i. What adjustments were made to the models and what forecast procedure was utilized?
  - ii. What changes were required to force a projection beyond the normal 10-year horizon? Who provided the macroeconomic assumptions and how were they determined?
  - iii. Can the scenario analysis be replicated?
  - iv. Who at EPA consolidated the output of the two models and made decisions regarding conflicts? What basis was used for this?

## C. Macroeconomic impacts

- a. It is unclear how EPA estimated the macroeconomic impacts of changes in agricultural sector performance.
  - i. Specifically who did the analysis and what model was used. At one point EPA mentioned that ORNL was tasked with this and that the EPA NEMS (National Energy Modeling System) was used to analyze the impacts on petroleum imports.
- b. EPA indicated that a thorough macroeconomic impact assessment of RFS2 rules will be done before the final rulemaking.
  - i. Who will do this?
  - ii. What model will be used?



- iii. How will the commodity and agricultural price, output, and trade impacts from FASOM and CARD factor into this analysis?
- iv. Will we have the opportunity to review and comment on these results before the final rule is published?