Recommendations from the Food Consumption Subgroup
ARB Expert Workgroup on Land Use Change

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International food, feed, and fiber (FFF) markets are central to the mechanism of land use change (LUC). The majority of models in current consideration predict reductions in food (and/or feed and fiber) consumption, representing part of the process by which land use change for biofuel production increase is not a hectare-for-hectare displacement of existing area. One of the central policy challenges for ARB in view of this finding is (i) whether and (ii) how FFF effects should be used in Low Carbon Fuel Standard (LCFS) implementation.

The focus of the subgroup has been limited to comparing and evaluating existing estimates of the effect of substituting crop based biofuel for fossil fuel on world food prices and FFF consumption. The development of robust modeling approaches that can be validated against recent empirical data (e.g., the rapid growth of corn ethanol the past 6 years in the United States and the hypothetical impacts on food, fiber, and feed prices) remains an obstacle yet to be overcome. As other subgroups have focused on general reliability and accuracy of economic models used for LUC estimation, our attention has been restricted to how FFF effects are modeled. Because the subgroup has made very little progress in achieving the tasks described in the subgroup work plan, all of the recommendations in this white paper are for future work and research.

The modeling of LUC effects induced by substitution of biofuels for fossil fuels follows classical economic relationships (notwithstanding important uncertainty intrinsic to models of this kind, especially predictive models). Conventional wisdom predicts that when farmland devoted to food, fiber, and feed production is diverted to the production of feedstock for biofuels, supplies of the displaced FFF crops are reduced and/or encroach on other land uses. Supply reductions may cause prices to rise, which in turn stimulates both increased production and reduced FFF demand. Increased production may take the form of increases in crop yields (e.g. price induced yield effect) and increased crop area (e.g. land use change). Reduced demand and/or increased supply may take the form of substitution of livestock feed by biofuel co-products (e.g. distillers grains), reduced direct consumption of crops by humans, as well as reduced consumption of livestock which, in turn, results in reduced demand for feed crops holding caloric nutrition constant.

The magnitude of the calculated LUC estimate is therefore linked to the extent of the dynamic responses that occur in food consumption changes that are predicted by the

model. Larger estimated reductions in food consumption result in smaller estimates for land use change and smaller reported price changes and vice versa.

Recognizing the potential FFF effects in the LCFS presents two problems, one policy-related and the other technical. The first is that the LCFS mechanism in this regard is wholly focused on GHG-intensity of fuels and not non-climate-related effects like nutrition, biodiversity, and the like. The second is that changes in FFF prices cannot be assigned to biofuels or any other potential causative factor (e.g., increased price of oil) on a simple per-unit basis like GHG discharge: a small increment of a biofuel's use causes proportional direct emissions and (to the extent that LUC is linear in biofuel quantity) LUC effects. But the infinitesimal share of food price increase (assuming the overall supply curve for a biofeedstock is locally linear) attributable to a single MJ of it is meaningless even if the price effect of an entire biofuel policy is considerable.

The food consumption subgroup believes that ARB should consider exploring the FFF-biofuel relationship to be understood and quantified to the extent possible, with policy design giving attention to options for including FFF effects in fuel carbon intensity scores or otherwise broadening the LCFS to recognize them. If possible, such additional scoring activity under the LCFS should be based and validated on empirical data sets that address the links between energy and FFF production and consumption. Therefore, the subgroup recommends that ARB perform the following additional work in conjunction with future land use change modeling:

a. <u>Understanding GTAP simulations of the substitution of crop based biofuel for petroleum based fuel</u>: Using the results from GTAP simulations, ARB should attempt to gain a better understanding of how and to what extent the model predicts changes in food consumption. As part of this study, ARB should attempt to determine:
    i. The amount by which GTAP simulations predict that agricultural commodity and petroleum based fuel prices will change.
    ii. The amount by which GTAP simulations predict that non-biofuel agricultural commodity consumption will change.
    iii. Provide, for new GTAP simulations, a decomposition similar to that shown in Hertel 2010, indicating the shares of the reduction from ha/ha displacement resulting from different adjustments including food consumption changes. If possible, refine this to estimate shares of consumption reduction assignable to livestock (diet change away from meat) and other foods like cereals.
    iv. If possible, estimate the extent to which changes in food consumption disproportionately affect low income populations, both suppliers and consumers. Can a prediction be made as to which populations are most affected by agricultural commodity price and consumption changes?
    v. The extent to which feedback from changes in petroleum based fuel prices affects changes in agricultural commodity prices and consumption. For example, the substitution of corn ethanol for

gasoline is expected to exert downward pressure on the price of gasoline. Reduced gasoline prices will have a feedback effect by exerting downward pressure on the cost of producing agricultural commodities (independent of the GHG "rebound effect". Is this feedback properly modeled in GTAP and to what extent does this feedback affect changes in food consumption?

vi. How much of a LUC credit GTAP calculates for global agricultural commodity consumption changes. For example, if food consumption were held constant in GTAP during simulations, what would be the resulting effect on LUC?

b. Model comparison and validation: Compare the results (e.g. agricultural commodity and petroleum based fuel price changes, food consumption changes, etc) from various economic/agricultural models (e.g. GTAP, IMPACT, FAPRI, MIRAGE, others).
   i. Are GTAP model results consistent with those of other models?
   ii. Can model results be validated using empirical data or other means?
   iii. What are the relative uncertainties as a function of the model used?