Comments of Growth Energy on the Air Resources Board Staff Presentations at a Public Consultation Meeting on the California Low-Carbon Fuel Standard Regulation

These comments respond to the ARB staff's request for comments on the staff's presentations at the March 11, 2014 public consultation meeting on the proposed adoption of a new version of the California low-carbon fuel standard ("LCFS") regulation.[1] These comments address three main subjects: (1) the proposed establishment of two "tiers" for alternative fuel pathways, (2) issues raised by the proposed treatment of electricity in the diesel compliance strategies, and (3) the staff's new analysis of indirect land-use change ("ILUC") emissions factors. The comments on the ILUC emissions factors are contained in an Appendix to these comments, prepared by Air Improvement Resource, Inc.

Before turning to the main subject of these comments, it is important to note that, at present, the staff has not explained fully how it intends to conduct the environmental assessment of the proposed new LCFS regulation. In that assessment, ARB must include a scenario in which the Board would rely on the Advanced Clean Cars regulation, Phase 1 and 2 greenhouse gas ("GHG") regulations for heavy- and medium-duty vehicles, and the federal Renewable Fuel Standard and other existing measures to achieve reductions in GHG emissions from the transportation sectors.

In performing these environmental assessments, ARB must address all reasonable means by which regulated entities could comply with each of the regulatory scenarios considered as well as the secondary consequences of those pathways. For example, if regulated entities might

[1] Growth Energy is among the plaintiffs in the litigation challenging the current version of the LCFS regulation. Because ARB is now contemplating adoption of a new LCFS regulation, Growth Energy is continuing its participation in the rulemaking process while it pursues its federal legal challenge to the currently adopted LCFS regulation.

purchase all the cellulosic ethanol produced in the United States for use in California, the environmental assessment must include not only the impacts associated with the transport of that ethanol to California, but also the transport of ethanol that has been displaced by cellulosic ethanol from California to where it is ultimately consumed.

The environmental assessment must also consider the broader impacts of the regulation, not just the life-cycle GHG emissions that ARB estimates to be associated with the fuels. For example, if ARB believes that LCFS compliance might be achieved in any significant part through increased use of electricity and hydrogen as transportation fuels, then the environmental analysis must also consider the differences in life-cycle GHG emissions associated with the production of vehicles capable of operating on electricity and hydrogen compared to the vehicles that would have otherwise been operating in the state. Similarly, the analysis must consider the life-cycle GHG impacts associated with factors such as the production and installation of refueling infrastructure, as well as the production and disposal of original and replacement batteries used in electric propulsion systems.[2]

In addition, the environmental assessment must avoid "double counting" of potential emissions reductions. Notably, the lifecycle GHG reductions associated with the use of electricity as a transportation fuel have already been claimed in assessing the GHG emissions associated with the vehicle under the Advanced Clean Cars Regulation.

[2] All potential impacts must be identified in the assessment, and measures to mitigate those impacts must be considered. Potential impacts could include those associated with the construction and operation of electricity generation and other fuel production facilities, increases in emissions from marine vessels and port operations associated with biofuel importation, increases in vehicular exhaust or evaporative emissions associated with the use of non-petroleum fuels, effects of higher prices for new vehicles and transportation fuels, and reductions in the effectiveness of other California environmental regulations.

I. Definition of Two Tiers for Alternative Fuel Pathways

There are a number of serious issues associated with the staff's proposed new approach to assigning carbon intensity ("CI") values to alternative fuel pathways. Those issues include the following:

- Penalizing or rewarding of producers of some fuels by assigning production pathway CI values that differ from the actual pathway CI values through the proposed "binning" procedure for "Tier 1" fuel pathways[3] in order to reduce the work load imposed by the LCFS regulation on ARB staff.

- Providing preferential treatment to some fuel production pathways defined by ARB as "Tier 2"[4] by assigning actual pathway CI values to those fuels rather than subjecting them to the "binning" procedure proposed for application to "Tier 1" fuels.

In addition, along with the actions being proposed with respect to creating CA-GREET 2.0 and revising pathway CI values, ARB must carefully reassess all internal ARB-developed fuel pathways to ensure that they are based on the latest available data and have been subjected to the same rigorous review that ARB has applied to pathways approved under the Method 2A/2B process.

Beginning with the binning procedure for Tier 1 fuel pathways, although the details are far from clear, ARB staff has indicated that it will propose CI bins that span a range of gCO2e/MJ values: all fuel pathways falling into a given bin would receive the same CI value, which would be set equal to the midpoint value of the bin. For example, if a given bin spanned the 7 gCO2e/MJ range from 61 to 67 gCO2e/MJ, all fuel pathways assigned to that bin would receive a CI value of 64 gCO2e/MJ. This means that the producer of a fuel with an actual pathway value of 66.9 gCO2e/MJ would be assigned an LCFS CI value of 64 gCO2e/MJ

[3] Tier 1 fuels have been loosely defined to date by ARB as "first-generation fuels, such as starch- and sugar-based ethanol…."

[4] Tier 2 fuels have been loosely defined to date by ARB as "next-generation fuels, such as cellulosic alcohols" as well as fuels produced using "an innovative method…."

(approximately 4% lower than actual) and a credit of 2.9 gCO2e/MJ for each MJ of fuel produced. In contrast, a producer of a fuel with an actual pathway value of 61.1 gCO2e/MJ would be assigned an LCFS CI value of 64 gCO2e/MJ (approximately 5% higher than actual) and a deficit of 2.9 gCO2e/MJ for each MJ of fuel produced. To date, the staff has provided no technical rationale for this approach, and justified it based only on claims that it is necessary to reduce the burden placed on ARB staff to review and approve new CI values.

While the assignment of actual CI values for Tier 2 pathways is technically correct, it is obviously inconsistent with the treatment of Tier 1 pathways and the policy of "fuel neutrality." Furthermore, it clearly discriminates against producers of Tier 1 fuels in favor of producers of Tier 2 fuels. It is also inconsistent with ARB's proposed treatment of CI reductions resulting from the use of "innovative technologies for crude oil production" where the current 1 gCO2e/MJ threshold for receiving credits would be eliminated. It is unclear why ARB staff preferentially values small reductions in the CI of crude oil production, but is willing to assign CI values for Tier 1 fuel pathways that differ from actual CI values by much larger amounts. ARB needs to ensure that the LCFS regulation equitably addresses the CI values assigned to all fuel production pathways. To the extent that ARB finds itself unduly burdened by the regulatory process it has created to assign pathway CI values, it is the responsibility of the agency—not producers of Tier 1 fuels—to find additional resources or identify means to simplify the regulatory process.

The ARB staff is also proposing to create a new version of the CA-GREET model used in determining CI values. According to the staff, the new version will be known as CA-GREET 2.0 and will incorporate updates based on changes that have been made to the GREET model by Argonne National Laboratory since the development of previous version (CA-GREET1.8b), as

well as an updated electricity mix and other changes. As part of this process, ARB must conduct rigorous and objective reviews of all internal ARB-developed fuel pathways similar to those performed for pathways approved under the Method 2A/2B process.

Of particular importance are the pathways internally developed by ARB that apply to California electricity and Brazilian sugarcane ethanol. With respect to California electricity, ARB must ensure that the same level of detail and attention that is being applied to update the electricity mix for the U.S. for use in CA-GREET 2.0 is also applied to the internal pathways used to assign CI values for California electricity. Similarly, ARB must review the CI values that apply to Brazilian sugarcane ethanol based on the existing internal pathways with the same level of scrutiny applied to the Method 2A/2B applications that have been submitted by U.S. producers of corn ethanol. ARB has reviewed and approved scores of pathway Method 2A/2B applications for corn ethanol pathways with CI values lower than those available from the internal ARB pathways. During this process, ARB requires applicants to submit detailed data and documentation substantiating the actual CI values that have been applied to these pathways. In contrast, all of the CI values currently available for Brazilian sugarcane ethanol are based on ARB's internal pathways derived from the limited number of life-cycle analyses available in the technical literature, which are based on limited generic data and have required numerous assumptions. This situation is not going to be remedied by relying on updates to the GREET model made by Argonne since the finalization of CA-GREET 1.8b, given that the most recent update[5] to the Brazilian sugarcane pathways in GREET continues to rely on what appears to be limited data and aggregated data. Further, the basic data do not appear to have been made available to ARB for the same kind of review and scrutiny applied to data from U.S. corn ethanol

[5] "Updated Sugarcane Parameters in GREET1_2012," Second Revision, Han, J., Dunn, J.B., Cai, H., Elgowainy, A., and Wang, M.Q., Argonne National Laboratory, December 2012.

plants or made available to the public at the level of detail required by the Method 2A/2B process. The need for this review is further underscored by the lack of Method2A/2B applications for Brazilian sugarcane ethanol, the absence of which suggests that the CI values assigned by the ARB internal pathways are lower than those that would be assigned based on facility-specific data.

Finally, it is important to note that the staff's proposed binning approach for ethanol is inconsistent with its proposal to provide credit under the LCFS regulations to gasoline refineries with no minimum CI reduction required. The differing treatment of gasoline and ethanol cannot be justified.

II. Treatment of Alternative Fuels in the Baseline.

During the process leading to the adoption of the LCFS regulation in 2009, ARB defined the gasoline baseline as a fuel consisting of 90% CARBOB and 10% ethanol produced using the mid-west average corn ethanol pathway instead of correctly defining it as a pure hydrocarbon fuel. The following passage from the 2009 Final Statement of Reasons explains ARB's reasoning:

> *<u>Comment</u>: … [W]e encourage ARB to revisit its decision to use 2010 E10 as the baseline gasoline. Inclusion of 10% corn ethanol in the baseline gasoline formulation forces corn ethanol to compete against itself, rather than petroleum fuels with higher carbon intensity. … [I]f ARB finds that the carbon intensity of corn ethanol is less than gasoline (due to justifiable adjustments to LUC and GREET analyses), this change in baseline date is not justified or desired, because increasing ethanol content from E5.7 to E10 would actually reduce overall blend carbon intensity.*
>
> *<u>Response</u>: The baseline … includes 10 percent ethanol to reflect the ethanol content in CaRFG that will exist in January 2010. In evaluating the baseline carbon intensity, it was determined that the baseline value was basically the same whether 5.7 percent or 10 percent ethanol was used. Ten percent ethanol was also used because the predictive model in the CaRFG regulations as amended in 2007 requires that increases in evaporative*

> *hydrocarbons from the use of ethanol be mitigated. This can be done by using no ethanol or using more than the current 6 percent ethanol. Due to the Federal requirements to use more ethanol, producers are electing to use this approach. The consideration of the 2010 timeline was based on the Governor's Executive Order and not to satisfy any other requirement.*

The Executive Order (EO) to which the ARB response refers establishes only a 2020 carbon intensity reduction target and nowhere mentions that the target should be linked to a 2010 baseline.[6] The EO undercuts ARB's selection of a 2010 baseline, given that it was issued in 2007, makes reference to the need for the LCFS regulation in light of the 2005 California vehicle fleet, and required the Secretary for Environmental Protection to report to the Governor as early as January 2008 regarding progress being made to achieve the 2020 target. Further, ARB's interpretation of the EO is also contradicted by the 2004 baseline year selected by the University of California in performing the technical and policy analyses[7,8] specified by the EO, and ARB's initial position during the course of the LCFS rulemaking where staff selected 2006 as the baseline year.[9]

The position taken in the 2009 rulemaking is further undercut in light of the improvements to the ILUC value for corn ethanol since 2009. Table 1 presents the CI values for gasoline at different assumed ethanol concentrations, based on the assumptions that the current CARBOB CI value of 99.18 gCO2e/MJ applies and that the reduction in the ILUC value for corn

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[6] Executive Order, S-01-07, 1/18/2007.

[7] Farrell. A.E., and Sperling D., "A Low-Carbon Fuel Standard for California, Part 1: Technical Analysis," August 1, 2007. Available at http://escholarship.org/uc/item/6j67z9w6

[8] Farrell. A.E., and Sperling D., "A Low-Carbon Fuel Standard for California, Part 2: Policy Analysis," August 2, 2007. Available at http://www.escholarship.org/uc/item/8xv635dc

[9] *See* http://www.arb.ca.gov/fuels/lcfs/122007arb_prstn.pdf

under consideration by ARB[10] will result in a CI value for Midwest average ethanol between 89.40 and 79.40 gCO2e/MJ.

Table 1. Effect of Adding Midwest Average Ethanol to Baseline Gasoline		
Ethanol Content (vol%)	Gasoline CI (gCO2e/MJ) and Reduction in CI relative to E0 if Midwest Corn Ethanol CI = 89.40	Gasoline CI (gCO2e/MJ) and Reduction in CI relative to E0 if Midwest Corn Ethanol CI = 79.40
0	99.18 - 0.0%	99.18 – 0.0%
5.7	98.79 - 0.4%	98.40 – 0.8%
10	98.49 - 0.7%	97.79 – 1.4%
15	98.13 - 1.1%	97.06 – 2.1%

As shown in Table 1, the addition of Midwest average ethanol to gasoline does in fact have a substantial impact in reducing CI, with the magnitude of the reduction becoming larger as more ethanol is added.

ARB's inclusion of ethanol in the gasoline baseline in 2009 failed to acknowledge the reasons why ethanol had come to widespread use in gasoline in California. Those reasons include the oxygenate requirement that was part of the federal Reformulated Gasoline regulation and the federal Renewable Fuel Standard regulation. The inclusion of ethanol in the gasoline baseline penalizes ethanol for having been recognized many years ago to be environmentally beneficial. Rather than penalizing ethanol for its early arrival in the marketplace, ARB should be providing retroactive credits for the GHG reductions that the use of ethanol achieved even before the LCFS regulation took effect. The continued inclusion of Midwest corn ethanol would discriminate against corn ethanol producers by depriving them of credits that they should be

[10] *See* http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/iluc_presentation_031014.pdf

awarded under the LCFS regulation, and prevents those credits from being available to aid regulated entities in complying with the LCFS regulation.

A comparison with the treatment of electricity in diesel-based compliance strategies is instructive. The relevant section of the staff Concept Paper released prior to the March 11 workshop states as follows (emphasis added):

> *The second alternative considered by staff involves modifying the 2010 baseline to include alternative fuel use. In this analysis, staff first determined the fuel use of transit and non-transit natural gas, transit electricity and electric forklifts in 2010. Next the carbon intensity of these fuels was incorporated into the 2010 diesel standard based on each fuel's portion of the total fuel pool (diesel and diesel replacements). A revised diesel standard was determined, and corresponding annual standards calculated, to reflect the revision. Including alternative fuel use in the baseline lowers the 2010 diesel standard by approximately 2 gCO2e/MJ and subsequent standards for 2015-2020 by approximately 1 gCO2e/MJ. This standard adjustment would increase diesel deficits and decrease alternative fuel credits compared to the current program. Staff presented the results of this analysis at a public workshop in April 2013 and thereafter considered stakeholder feedback.* ***Staff chose not to pursue the baseline approach because compliance with the diesel standard would become more difficult with no corresponding benefit to the alternative fuel market.*** *In addition, because these credits would be generated only if regulated parties opt-in to the program and report electricity use, a change to standards based on potential credit generation would be unfair to diesel regulated parties. This recommendation was subsequently presented at a public workshop in May 2013.*

Of course, the same rationale requires that ethanol be excluded from the gasoline baseline. There is certainly no basis to treat Midwest corn ethanol differently than how ARB is proposing to treat electricity. Removing Midwest ethanol from the gasoline baseline would appropriately credit producers, promote competition, and minimize regulatory costs.

Respectfully submitted,

GROWTH ENERGY.

APPENDIX

Comments on ARB's March 11 Workshop on Indirect Land-Use Change Emissions

Prepared by Air Improvement Resource, Inc.

The ARB staff proposes to use two models used to estimate the land use change emissions – the Agri Economic Zone Emission Factor (AEZ-EF) model, and the Global Trade Analysis Project (GTAP). GTAP is a general equilibrium model used to determine land transitions (like pasture to cropland and forest to cropland) in similar agro-economic zones in various regions of the world. The AEZ-EF model is used in conjunction with the GTAP to determine emissions released by the land-use transitions.

We discuss the GTAP model first, followed by the AEZ-EF Model. We then use the ARB-GTAP model and a much more appropriate Purdue GTAP model to estimate the impacts of our recommendations of changes on land use change (LUC) emissions for corn ethanol.

Global Trade Analysis Project (GTAP)

GTAP contains global land pools of cropland, forest, pasture, Conservation Resource Program (CRP) land (in the US), and cropland pasture (in the US and Brazil). The base year for the current model is calendar year 2004. In modeling biofuel increases, the model is "shocked" with the biofuel increase (corn ethanol, for example), and since this requires a significant increase in corn production, the model converts some other cropland to corn production, converts some pasture to crop production, and converts some forest to crop production. The model also contains a price yield elasticity such that when the model is shocked for increased corn ethanol, crop prices increase and yields also increase somewhat on all cropland. Thus, increased production is met through (1) cropland expansion into non-cropland (which creates land use change emissions), and (2) yield increases on existing cropland (no land use change emissions).

There are other ways in which crop production increases in addition to land expansion and yield increases. A 2013 study by Roy and Foley shows there are three other ways crop production increases: (1) using the existing standing cropland area more frequently by multiple cropping, (2) leaving less land fallow, and (3) having fewer crop failures.[1] None of these three ways involves a land use change or land use change emissions. Furthermore, GTAP does not include these three factors: GTAP does not account for double cropping, has no fallow land inventory, and cannot model reduced crop failures. Roy and Foley point out that the influence in these three factors on crop production can be estimated by comparing trends in total harvested area to total cropland.

[1] Ray, D.K., and Foley, J.A., "Increasing global harvest frequency: recent trends and future directions," Environmental Research Letters, 2013, 044041, IOP Publishing.

> *The growth in annually harvested cropland and standing cropland has been changing in recent decades. Analyzing the 177 crops traced by FAO since 1961 shows that the amount of annually harvested land has increased much faster than the reported total standing cropland on the globe. While standing cropland has increased at the rate of 3.5 mha/year, the annually harvested land increased at a much faster rate of 5.5 mha/yr.*

The difference in the above growth rates – 2.0 mha/year – is due to the three factors mentioned earlier, which have no land use emissions impact. The authors also examine the potential for the increase in harvested area to continue to increase faster than standing cropland in the future, and find that these trends should continue.

It is difficult to incorporate these factors into the current GTAP model, because these factors require a dynamic GTAP model, and the current model is a static model.[2] However, the analysis of these trends can be used to inform the ranges of input elasticities for the current static GTAP model used by ARB, particularly the price-yield elasticity. Increasing the price-yield elasticity in GTAP increases crop production without a land use impact. Thus, the Ray/Foley study argues for a relatively high price-yield elasticity range. ARB, however, has selected a very low price-yield elasticity range. This is discussed in more detail in the next section.

Review of ARB's GTAP Modeling

Price-Yield Elasticity Range

GTAP includes a price-yield elasticity of 0.25 as a default. This level is in part based on extensive research by the GTAP modeling community.[3] The Expert Working Group also recommended this value. The EWG also recommended higher values for regions with significant double cropping, since GTAP does not explicitly include double cropping. GTAP researchers have also pointed out GTAP is a medium-term model, with projections being applicable in the 5-10 year timeframe. ARB appears to concur with this timeframe for GTAP, because ARB describes the model as a "Current" model, meaning that its estimates are applicable to the 2013/2014 timeframe, even though its primary data is for 2004.[4]

ARB, however, performed sensitivity analyses using price-yield elasticity values from 0.05-0.30 (20%-120% of the default value). ARB's selection of the lower end of the range came from a variety of price-yield studies that were very short term (1-2 years) in nature, and were clearly not appropriate for the GTAP timeframe. All studies on data less than about 4 years should not even be considered in establishing the range of this

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[2] Purdue is continuing to develop a dynamic GTAP model for these and other reasons.

[3] Keeney and Hertel, "Yield Response to Prices: Implications for Policy Modeling," Working Paper #08-13, August 2008, Department of Agricultural Economics, Purdue University.

[4] See page 57 of the ARB March 11 Workshop Briefing, iluc_presentation_handouts_031014.pdf.

parameter to use in modeling. Furthermore, ARB did not consider the analysis by Ray and Foley in determining the range of price-yield values to use.

ARB performed sensitivity analyses on several other parameters. Most of these values were in the range of 80%-120% of the GTAP default level, for example, ARB performed sensitivity modeling of the ETA parameter at the baseline (default), 80% of the baseline, and 120% of the baseline. We support performing sensitivity modeling at different price-yield levels, but the range should be at least 80%-120% of the Purdue baseline value of 0.25, or 0.20 to 0.30. However, even this range is not nearly high enough to properly reflect the increase in crop production that has occurred without land use changes reflected by the Ray and Foley analysis referenced earlier.

ETL1 and ETL2 Values

ARB updated the land transformation elasticities (ETL1 and ETL2) in GTAP prior to estimating land use changes. ETL1 governs the transformations between forest, crops, and pasture, and ETL2 governs the transformations between various crops.
ARB appears to have used some, but not all, ETL1 and ETL2 values from a 2013 Applied Science paper by Taheripour and Tyner. [5] In the Applied Sciences paper, Taheripour and Tyner indicate

> *We tune the regional land transformation elasticities based on actual historical observations on changes in land cover and distribution of cropland among alternative crops during the past two decades. To accomplish this task we use published data on cropland use around the world by the Food and Agriculture Organization (FAO) of the United Nations over the period 1990-2010.*

The differences in ETL1 and ETL2 values between the Applied Sciences paper and ARB are shown in Table 1 below.

Table 1. Differences in ETL1 and ETL2 Values Between ARB and Purdue

Region	Purdue – Applied Sciences 2013		ARB	
	ETL1	ETL2	ETL1	ETL2
Brazil	-0.30	-0.50	-0.20	-0.75
S_O_Amer	-0.30	-0.25	-0.10	-0.50
R_S_Asia	-0.10	-0.25	-0.10	-0.75
Russia	-0.20	-0.75	-0.02	-0.75
S_S_Afr	-0.30	-0.50	-0.30	-0.25

[5] Taheripour and Tyner, "Biofuels and Land Use Change: Applying Recent Evidence to Model Estimates," Applied Sciences, 2013, 3, 14-38.

It is not clear why ARB departed from the ETL1 and ETL2 values developed by Purdue, and what analysis or data ARB based these values on. An explanation of this should be provided for review, or ARB should use the tuned ETL1 and ETL2 values that were developed by Taheripour and Tyner.

Model Nesting Structure

The Applied Science paper referenced above also included another major improvement in GTAP. According to the paper

> *The GTAP-BIO model puts three types of land cover items (forest, pasture, and cropland) into one nest an implicitly assumes that the economic costs of converting one hectare of forest to cropland is similar to the economic cost of converting one hectare of pasture land to cropland and vice versa. <u>This set up another key deficiency of the GTAP-BIO model.</u> Including cropland, forest, and pastureland in the same nest could cause systematic bias in land conversion processes among land cover types due to biofuel production. In general this is not the case and often the opportunity costs of converting forest to cropland is higher than the economic cost of converting pastureland to cropland.* (emphasis added)

The Expert Working group studying elasticity parameters in GTAP identified this nesting structure as a key deficiency in the model and recommended using a revised nesting structure, such as the one developed by Taheripor and Tyner in the Applied Science paper. The fact that forest is more costly to convert to crops than pasture almost needs no explanation. However, Taheripor and Tyner point out that

> *Gugel et al have shown that in general pastureland rent is higher than forest land rent, and both of these land rents are smaller than cropland rent across the world except in a few places. This means that the net costs of converting pastureland to crop production should be less than the net costs of converting forest to cropland. Putting forest, pasture, and cropland in the same nest ignores this important fact.*

Taheripour and Tyner altered the land cover component of the land supply tree to have forest and pasture land in two different nests. They also developed new ETl1 and ETL2 values, tuning these to historical land use changes. They split the ETL1 into an ETL1 for pasture and an ETL1 for forest (i.e., $ETL1_f$, and $ETL1_p$). They made the ETL_f only 20% higher than ETL_p. Then they re-evaluated global land use impacts due to the USA ethanol program using the improved model tuned with actual observations. They showed that, compared to the old model

> *The new model projects: (1) less expansion in global cropland, (2) lower share for the USA economy in global cropland expansion, (3) and lower forest share in global cropland expansion.*

To show how important these changes were, the authors modeled the US ethanol program, estimating land transitions. With the new ETL1 and ETL2 values, predicted global net forest conversions were reduced from 303,000 ha to 241,000 ha. When the forest/pasture nesting changes were made, however, predicted global net forest conversions dropped from 241,000 ha to 75,000 ha. Forest conversions are the factor that drives 75% of LUC emissions in estimating LUC emissions of biofuels.

ARB did not include the model nesting structure changes implemented by Taheripour and Tyner, and recommended by the Expert Working Group, even though this revised model was available to ARB in early 2013. ARB should include this critical change in the GTAP model.

Additional Cropland/Pasture Areas in Canada and EU27

GTAP has been updated to include cropland/pasture in the USA and Brazil (ARB used the model with these additions). Other regions of the world, such as Canada and the EU27 (and probably many other regions of the world) also have a significant amount of cropland/pasture and idle land. These land areas should be added to GTAP.

Conservation Resource Program Impacts

The GTAP model includes the ability to include CRP land in the land inventory for the US. There has been a significant amount of land converted to production from CRP land in the last seven years. Table 2 shows data from the Conservation Resource Program. [6] These data show over 10 million acres of CRP land have gone back into production. These are not US forest acres that have gone into production. Over the period from 2007-2011, CRP acreage in wetlands and buffers increased. Clearly, GTAP should be run to access CRP land in the US prior to converting forests or even cropland/pasture.

Table 2. CRP Land Enrolled

Year	Area (million acres)
2007	36.8
2008	34.6
2009	33.8
2010	31.3
2011	31.1
2012	27.1
2013	25.6

[6] "Annual Summary And Enrollment Statistics," FY2011 for 2007-2011, and December 30 Reports for 2012 and 2013, http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns-css.

AEZ-EF Model

Use of Carbon Data on Accessible and Inaccessible Forests to Determine Emissions from Forest Conversion

The AEZ-EF report indicates

> *The carbon data used in AEZ-EF have been aggregated to GTAP-BIO boundaries, but they include both accessible and inaccessible forests, as well as grasslands other than those used for livestock grazing, and thus represent broader resources than those represented in GTAP-BIO.*

It is not clear why ARB is including inaccessible forests in developing forest carbon stocks. If forests are inaccessible, then it is highly unlikely they would be converted to pasture or cropland. ARB should instead develop forest carbon from accessible or commercial forests. Detailed carbon data on public, private, and other forests is utilized by EPA in estimating its annual GHG inventories.[7] The carbon in private forests (most likely of forests to be converted to pasture/cropland) is much lower than public or other forests.

Wood Used to Produce Energy

In the new AEZ-EF model, for forest converted to cropland or pasture, ARB is now accounting for carbon stored in hardwood products (HWP). The storage rates are different for different regions, and are based on a 2012 study by Earles, Yeh, and Skog. The HWP fraction ranges between 2-36%.

In addition to accounting for carbon stored in HWP, ARB should also account for wood mass that is used for fuel during forest clearing. Wood that is burned to produce energy (for a sawmill, for example) is replacing fossil-fueled energy, and is renewable. ARB does not count CO_2 emissions from facilities that use waste wood to produce energy for fuel production (ARB does, however, count non-CO_2 GHG emissions, which is appropriate). Heath et al estimate that 35% of carbon from forest clearing is used for energy.[8] In the US, Canada, and the EU27, ARB should not count the CO_2 from wood used to produce energy.

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[7] USDA Forest Service (2010a), Forest Inventory and Analysis National Program:User Information. U.S. Department of Agriculture Forest Service. Washington, DC. Available online at http://fia.fs.fed.us/tools-data/docs/default.asp.

[8] L. Heath, R. Birdsey, C. Row, and A. Plantinga. "1996 carbon pools and flux in U.S. forest products," Forest Ecosystems, Forest Management, and the Global Carbon Cycle, M. Apps and D. Price, eds. NATO ASI Series I:Global Environment Changes, Volume 40, Springer-Verlag, ppg 271-278.

CCLUB Model

ARB should consider using the CCLUB (Carbon Calculator for Land Use Change from Biofuels Production) model for estimating emissions.[9] Like AEZ-EF, the model was designed to be integrated with GTAP. It has several advantages over AEZ-EF. First, instead of using the Harmonized World Database (HWD) for soil, it uses the CENTURY model, which contains much more specific information on soil carbon for the US than the HWD, on a county-by-county basis. Second, it uses county-by-county carbon data from forest ecosystems for the US from the Carbon Online Estimator (COLE) database, developed by Van Deusen and Heath in 2010 and 2013.[10,11] Third, it allows the user to input HWP fractions, and fourth, it does not count CO_2 from the forest wood used to produce energy. For areas outside of the US, it utilizes Winrock emissions.

ARB has conducted uncertainty analysis of its land use estimates using only AEZ-EF and GTAP. Using the CCLUB model with GTAP to estimate land use change emissions would also provide more information on the uncertainty of ARB's estimates.

Updated LUC Modeling

AIR downloaded ARB's GTAP model and the AEZ-EF model to determine the impacts of some of our suggestions. ARB ran the models under 1440 different input conditions, for 5 different biofuel shocks, and determined the average emissions for each of the 1440 runs (a total of 7200 runs). The results are shown in Table 3.

Table 3. ARB Average Land Use Results, March 11 Workshop

Biofuel	LUC Emissions (gCO2e/MJ)
Corn Ethanol	23.2
Sugarcane Ethanol	26.5
Soy Biodiesel	30.2
Canola Biodiesel	41.6
Sorghum Ethanol	17.5

[9] Dunn, J., Mueller, S, Kwon, H.Y., Wander, M., Wang, M., "Carbon Calculator for Land Use Change from Biofuels Production (CCLUB)," Argonne National Laboratory, ANL/ESD/13-8, September 2013.

[10] Van Duesen, P., and Heath, L., 2010. "Weighted Analysis Methods for Mapped Plot Forest Inventory Data: Tables, regressions, maps and graphs." Forest Ecol. Manage. 260:1607-1612.

[11] Van Duesen, P. and Heath, L. 2013. COLE web applications suite. NCASI and USDA Forest Service, Northern Research Station. Available at http://www.ncasi2.org/COLE/

In this analysis we test the impact of five factors that should be changed in the ARB modeling:

- ARB's ETL1 and ETL2 values
- Model Nesting Structure and additional tuned ETL1 values
- Price-Yield Range
- Include US CRP conversions
- Include CCLUB emissions

It is clearly impractical for us to run the model 1440 times to test the impact of these five~~3~~ items. However, it is possible to test the impact with a representative model run. To create the representative model run, we first estimated the average of the ARB inputs. Next, we ran the model with a corn ethanol shock to determine the LUC emissions. Finally, we changed the price yield elasticity, until the model run gave the same answer as corn ethanol in Table 3. The average model inputs are shown in Table 4.

Table 4. Average ARB GTAP Inputs

Input Parameter	Average Value
Price Yield (Ydel)	0.175
PAEL, US	0.3250
PAEL, Brazil	0.1875
ETA	ARB Baseline
ETL1, ETL2	ARB Baseline

When we ran the case in Table 4, we obtained corn ethanol emissions of 19.87 gCO2e/MJ. We then reduced the price yield elasticity from 0.175 to 0.1263, and obtained emissions of 23.21 gCO2e/MJ, which is the same as ARB's corn ethanol estimate. This is our single run that generally represents ARB's 1440 cases (i.e., the AIR "Representative" case).

- To test ARB's ETL1 and ETL2 values, we inputted Purdue's ETL1 and ETL2 values into ARB's GTAP model, and estimated LUC emissions.

- To test the model nesting structure change, we used the GTAP model provided by Purdue for work by AIR and others for the European Biodiesel Board (EBB), which is the same as the Purdue Applied Science Model, but with additional changes for the European Union such as disaggregated oilseeds, and

disaggregated coarse grains.[12] All other inputs were the same as the ARB inputs for ARB's model, including price-yield at 0.1263.

- To test the price-yield value, using the EBB GTAP model with the above ARB inputs, we increased the price-yield value to the Purdue default value of 0.25.

- To test the CRP impact, we activated the CRP code in the EBB-GTAP model.

- To test the CCLUB emissions impact we turned off the CRP activation and used CCLUB emissions instead of AEZ-EF.

The impact of the five changes on LUC emissions for the corn ethanol shock are shown in Table 5. The changes are all cumulative except for the last change (CCLUB), which includes the first three changes but does not convert CRP in the US.

Table 5. Impacts of Changes in GTAP Modeling (Corn Ethanol Shock in the US)

Scenario	Model	Emissions	LUC Emissions (gCO2e/MJ)
AIR "Representative" Case (ARB model, Price-yield = 0.1263)	ARB-GTAP	AEZ-EF	23.21
Change ETL1 and ETL2 parameters to Purdue "tuned" values from Applied Science 2013	ARB-GTAP	AEZ-EF	21.03
Implement Purdue GTAP Nesting Structure with Tuned Forest and Pasture ETL1 Elasticities, from Applied Science 2013	EBB-GTAP*	AEZ-EF	18.65
Use Purdue Default Price-Yield Value	EBB-GTAP	AEZ-EF	12.84
Include CRP Land Conversions	EBB-GTAP	AEZ-EF	11.97
Use CCLUB Emissions Instead of AEZ-EF Emissions (w/o CRP Conversion)	EBB-GTAP	CCLUB	6.84

* Same model as Purdue model used in 2013 Applied Science paper, but with disaggregation of coarse grains and oilseeds in EU27.

[12] Air Improvement Resource, (S&T)[2] Consultants, Steffen Mueller, UIC, "Land Use Change Greenhouse Gas Emissions of European Biofuel Policies Utilizing the Global Trade Analysis Project (GTAP) Model," August 30, 2013, for European Biodiesel Board.

Utilizing the ETL1 and ETL2 values from the Applied Science paper reduces emissions from 23.21 to 21.03 g/MJ. Implementing the improved nesting structure reduces emissions further to 18.65 g/MJ. With more reasonable but still very conservative price-yield value of 0.25, emissions are reduced to 12.84 g/MJ. If CRP land is included in conversions, emissions are reduced to about 12 g/MJ. If CCLUB emissions are used instead of AEZ-EF, emissions are just under 7 g/MJ.

ARB is planning on incorporating irrigation changes in GTAP. We support this effort if done in a reasonable manner. ARB is also planning on incorporating "inaccessible" forest in GTAP. We do not support this effort, since inaccessible forest would not be converted to crops or pasture. It is somewhat ironic that ARB wants to include "inaccessible" forest, but is putting no effort into including extremely accessible cropland/pasture in Canada, the EU27, and other regions.

Summary

Overall, ARB's currently analysis of LUC for biofuels in the US has improved from earlier 2009 estimates, but clearly is using modeling inputs that are wrong (price-yield range and ETL1/ETL2 values) and have been proven to be inappropriate, and is also not using certain critical updates to GTAP (i.e., the updated nesting structure) that have been available for awhile. If the ARB analysis were updated appropriately, LUC emissions for corn ethanol would be in the 8-12 g/MJ range. There would be corresponding changes in the LUC emissions of other biofuels as well.