Comments on ARB's September 29th Workshop
On Land Use Change Emissions
Air Improvement Resource, Inc.
October 17, 2014

Introduction

On September 29, 2014 ARB held a workshop on land use change emissions. ARB presented new information on their analysis of LUC emissions for corn ethanol, soybean biodiesel, canola biodiesel, cane ethanol and sorghum ethanol.

We have reviewed the information CARB presented at the workshop and thereafter, and also have obtained the new GTAP model and performed some additional modeling runs. We appreciate the additional time that the staff has provided for us to provide these comments. We will have additional comments later. The comments are presented here are organized into the following sections:

- Irrigated/Rain-Fed Cropland Category
- Land Supply Structure
- ETL11, ETL12, ETL4 and ETL5
- ARB's 30-Scenario Average
- Yield-Price Elasticity
- Cropland Pasture Elasticity
- Corn Ethanol LUC Impacts of our Recommendations

Please add these comments to the page on ARB's website that has been previously established for workshop comments.

Irrigated/Rain-fed Cropland Category

Earlier versions of the GTAP model used an average of irrigated and rain-fed cropland. The expansion of cropland in the model did not differentiate between irrigated or rain-fed areas. Irrigated cropland typically has a higher yield compared to rained cropland in a given Region and AEZ. If cropland expansion occurs on irrigated land, higher yields translate into smaller land requirements. But availability of water for irrigation may limit expansion into irrigated land.

The new version of GTAP developed by Purdue for ARB includes an option to differentiate between irrigated and rainfed cropland. The availability of irrigated land for cropland expansion then can be constrained in certain regions and AEZs, if there is sufficient evidence to constrain expansion of irrigated lands.

ARB used analyses and data from the World Resources Institute (WRI) to determine which regions and AEZs within these regions to constrain expansion into irrigated land.

Figure 1 shows the Regions and AEZs where irrigated land is constrained for the ARB LUC analyses. These regions and AEZs were determined from the WRI reports. [1][2]

Figure 1

GTAP: Water Constrained Regions/AEZs

AEZ →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Region ↓																		
1 USA							1	1	1				1	1				
2 EU27									1									
3 BRAZIL																		
4 CAN							1	1										
5 JAPAN									1			1						
6 CHIHKG							1	1	1	1			1					
7 INDIA	1	1	1				1	1	1	1					1	1		
8 C_C_Amer	1	1					1	1	1	1	1							
9 S_o_Amer	1	1					1	1	1									
10 E_Asia											1							
11 Mala_Indo				1	1													
12 R_SE_Asia																		
13 R_S_Asia	1		1				1	1	1	1			1					
14 Russia																		
15 Oth_CEE_CIS							1	1					1	1				
16 Oth_Europe																		
17 MEAS_NAfr			1	1			1	1	1	1								
18 S_S_AFR								1										
19 Oceania	1							1	1	1	1							

1 indicates water constrained

We reviewed the WRI reports, but were unable to determine how ARB used the information in these reports to identify the regions and AEZs that should have irrigated land constrained. Because we have been unable to locate the technical documentation that would explain how ARB used the WRI reports to draw the conclusions shown in Figure 1, we request that the staff provide the public with that documentation, and then allow at least five business days for comment.

ARB presented little information at the workshop to evaluate the size of this impact on land use emissions. To evaluate the impact of constraining expansion on irrigated land, AIR ran GTAP with and without the irrigation constraint for corn ethanol, using Purdue and ARB's average elasticity inputs. The results are shown in Table 1.

[1] *Aqueduct Global Maps 2.1: Constructing Decision-Relevant Global Water Risk Indictors*, WRI, April 2014.
[2] *A Weighted Aggregation of Spatially Distinct Hyrdrological Indicators*, WRI, December 2013.

Table 1. LUC Impact of Constraining Crop Expansion on Irrigated Land in Some Areas: Corn Ethanol					
Scenario	Ydel	PAEL	ETA	Irrigation Constrained?	LUC (gCO2e/MJ)
Purdue Best Estimates	0.25	0.4/0.2	Baseline	No	14.23
				Yes	13.32
ARB Average	0.19	0.3/0.15	Baseline	No	17.22
				Yes	16.09

For corn ethanol, constraining expansion on irrigated land adds 0.89 g/MJ for the Purdue default case, and by 1.13 g/MJ for the ARB average. ARB must document how the WRI data was used to develop areas on which cropland cannot be expanded, before including this effect for the various biofuel feedstocks.

Land Supply Structure

The land supply structure in GTAP was revised in 2013 to include four nesting structures instead of two.[3] Prior to 2013, one nest included the substitution of different types of land – forestland, cropland, and pastureland – and a second nest under cropland that included different types of crops. One elasticity – ETL1 – governed the substitution between forestland, cropland, and pastureland, and a second elasticity – ETL2 – governed the substitution between crop types. A significant concern of ARB's Expert Working Group (EWG) was that forestland, cropland, and pastureland were all in the same nest with one elasticity, which meant that forestland is as readily converted to cropland (and vice versa) as pastureland. Clearly this is not the case – the economics of converting forest to crops must be much different than converting pasture to crops.

In 2013, the land supply structure was modified by Purdue such that the first nest includes only forestland and a second category called cropland+pasture. The second nest under cropland+pasture was divided into cropland and pastureland. The third nest under cropland was divided into irrigated and rain-fed. Finally, both irrigated and rain-fed cropland was divided into different crops. The following new elasticities were defined:

- ETL11: substitution at the first level between forest and cropland+pasture
- ETL12: substitution at the second level between cropland and pasture
- ETL2: substitution between irrigated and rain-fed
- ETL4: substitution between crops under irrigated land
- ETL5: substitution between crops under rain-fed land

The new land supply structure allows the use of more disaggregated elasticities of transformation between land types.

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

ARB modeled two approaches in estimating land use emissions – Approach A, which assumes ETL11=ETL12, and Approach B, which provides separate estimates for ETL11 and ETL12. Approach A is essentially the GTAP model prior to the land supply improvements (i.e., only 1 elasticity which governs conversion of forest, crop, and pasture), while Approach B is the GTAP model with the improvements (expanded nesting supply structure). Elasticity values for Approaches A and B are shown in Attachment 1. In both approaches, the ETL2 values are identical; it is only the ETL11 and ETL12 values that are different between the approaches.

ARB did not implement Approach B in its materials presented at the March 11, 2014 workshop, in spite of the fact that GTAP was updated for land supply structure more than a year ago in January 2013. One of Growth Energy's primary comments on the materials ARB supplied at the March 11 workshop was that ARB should utilize a GTAP model with the updated land supply structure with different elasticities of conversion for forest and pasture. (i.e., Approach B). Approach A must be recognized as unrealistic, and not appropriate for use in the new regulation to set the indirect emissions factor for land use change attributed to biofuel expansion. Approach A is *not* an equally technically appropriate alternative to Approach B. Purdue no longer utilizes Approach A – it is simply now an approach that tries to mimic the old GTAP model prior to the significant improvements made in early 2013.

<u>ETL11, ETL12, ET4, ETL5</u>

ARB's ETL11, ETL12, ETL4, and ETL5 values for Approach B were presented in Slide 24 of the September 29 presentation. Based on the information that is currently available, we believe those values are more appropriate than some alternatives.

<u>ARB's 30-Scenario Average LUC Emissions</u>

In the March 11 workshop, ARB modeled 1440 separate scenarios for each biofuel, and averaged the results of these scenarios to estimate LUC for each biofuels. In the September 29 workshop, Staff had reduced this to 30 separate GTAP runs, varying 3 separate input elasticities: the yield price elasticity (YPE, or Ydel), the cropland pasture elasticity (PAEL) for the US and Brazil, and the elasticity of crop yields with respect to area expansion (ETA). There are five values for Ydel, 2 for PAEL, and 3 for ETA (5*3*2 = 30).

Growth Energy has commented previously that the number of runs should be reduced (and they have), and further support doing GTAP runs at varying elasticities, since these can affect the results. (See Attachment 2.) However, we believe that ARB has selected the wrong range of values to use for two of the input elasticities.

It is worth noting that Purdue has "best estimates" for each of these inputs. The ARB input values and Purdue best estimates are shown in Table 2.

Table 2. ARB Input Elasticities Compared to Purdue Best Estimates				
Parameter	Description	ARB Values	ARB Average Value	Purdue Best Estimate
YPE	Yield Price Elasticity	0.05, 0.125, 0.175, 0.25, 0.35	0.19	0.25
PAEL	Cropland pasture elasticity*	0.2/0.1, 0.4/0.2	0.3/0.15	0.4/0.2
ETA**	Elasticity of crop yields with respect to area expansion	Baseline, 80% of baseline, 120% of baseline	Baseline	Baseline

*The first value is for the US, the second for Brazil
** ETA varies by region. The baseline values used by ARB are the same as used by Purdue

For YPE, the ARB range is from 0.05 to 0.35, with an average value of 0.19. The range in the March 11 workshop was from 0.05 to 0.30, so ARB has increased the upper end of this range by 0.05. The average value is lower than the Purdue best estimate of 0.25, and lower values yield to higher land use emissions. For PAEL, ARB selected the ARB best estimate and an estimate one-half of that. The average of the two ETA values for Brazil and the US is lower than the Purdue best estimate. Again, lower values lead to higher land use emissions. Finally for ETA, ARB selected the Purdue best estimate as the central value, and values higher and low than the best estimate. The average of the three is at the Purdue best estimate.

For PAEL, ARB seems to have followed the methodology of selecting values higher than and lower than the Purdue best estimate. This approach makes sense to us. However, for YPE and ETA, ARB selected values rather arbitrarily that yield an average value that is significantly different than the Purdue best estimate. ARB has not presented reasons or a rationale why it did this, so it appears they did this for the sole purpose of increasing the land use emissions of crop-based biofuels. We therefore ask that ARB explain those reasons to the public and allow at least five business days for comment. Because ARB must use the best available scientific information when writing its greenhouse gas regulations, we believe that ARB needs to explain why, if it maintains the current approach, it believes that its approach is scientifically superior and uses the best available scientific data.

We present the impacts of this arbitrary decision making process later in these comments.

<u>Yield Price Elasticity (YPE, also Ydel)</u>

In our comments on the previous workshop, we indicated that GTAP is a medium term model, and that YPE values developed over the very short term were not appropriate -- as previously noted, ARB is required to use the best available scientific information under

the 2006 law that applies here. The values below 0.15 referenced by ARB were short-term values, therefore, ARB should not be using values below 0.15 (i.e., 0.05 and 0.125), as they are not consistent with GTAP's general timeframe.

In addition, in our previous comments we presented information showing that Purdue's best estimate value of 0.25 does not include double-cropping, conversion of fallow land to cropland in the US, Canada and the EU27 regions, and conversion of Conservation Reserve Program (CRP) land in the United States.[4] We presented significant, substantial and compelling evidence on the conversion of fallow land and CRP land in those comments. CRP land is in the GTAP land supplies and could be utilized directly. We pointed out that both double cropping and fallow land conversion could be simulated with higher Ydel values (i.e., values above 0.25).

As indicated in the previous section, ARB used two values below 0.15 – 0.05 and 0.15. We believe these should be dropped from the Ydel analysis since they are not consistent with GTAP. Second, we believe ARB should expand the upper limit of Ydel to 0.50. The values we are recommending are 0.15, 0.2, 0.25 (Purdue best estimate), 0.3, and 0.5. The average of these values is 0.28, which is only 0.03 above the Purdue best estimate, and a reasonable conservative average to reflect a small amount of double cropping and/or fallow land conversion. If the staff does not agree, we ask that it explain why in a manner that we and other interested parties can address in a timely manner, and that the staff can consider before it proposes the new regulation.

Cropland Pasture Elasticity (PAEL)

ARB used the Purdue best estimate (0.4/0.2) and one-half of the best estimate (0.2/0.1). There is no information given on why ARB used one-half of the Purdue best estimate without also using something above the Purdue best estimate, for example, 0.6/0.3. The purpose of sensitivity analysis is determine how the model inputs affect the results. Using a sensitivity analysis on only the "low" side of the Purdue best estimate skews the land use values higher, and is not consistent with scientific norms or the requirement to use the best available scientific information. We recommend running three PAEL values, where one is the Purdue best estimate and the other two are higher and lower than the Purdue best estimate. If the staff does not agree with that recommendation, we ask that it fully explain why it is not doing so, in time for the public to comment

Corn Ethanol LUC Impacts of our Recommendations for Elasticity Inputs

The time allowed by the staff to prepare these comments did not permit us to run all of CARB's 30 cases to establish a baseline, but instead, we ran the average of the elasticity

[4] Double cropping refers to the practice of growing two crops on the same land in the same season. For example, often corn or soybeans are grown after winter wheat on the same land in the US. In Brazil, because the growing season is longer, often corn is grown after soybeans. The Conservation Reserve Program is a cost-share and rental payment program under the United States Department of Agriculture (USDA), and is administered by the USDA Farm Service Agency (FSA). The CRP encourages farmers to convert erodible cropland or other environmentally sensitive acreage to vegetative cover.

inputs, and the high and low. Results are shown in Table 3 compared to ARB's results of the 30 runs. As shown in Table 3, values generated by us are lower than ARB's values. The reasons for this are not clear. Our program files have been provided to the staff for these cases for review. For now, we have also constrained expansion on irrigated land, even though we have not had a chance to review the method ARB used to incorporate data and information from the two WRI reports.

Table 3. ARB Average, Low and High LUC Emissions for Corn Ethanol (Approach B with Irrigation Constrained)

Case	Ydel	PAEL	ETA	AIR LUC gCO2e/MJ	ARB LUC gCO2e/MJ
Average of ARB Inputs	0.19	0.3/0.15	Baseline	17.22	21.6
ARB "High"	0.05	0.2/0.1	80% of Baseline	34.49	37.0
ARB "Low"	0.35	0.4/0.2	120% of Baseline	9.68	11.5

Basically, we are recommending that ARB use the Purdue best estimates for elasticity inputs, except for Ydel, which we believe should average about 0.28 or so to reflect some double-cropping which typically takes place in Brazil and also in the US and other areas, and also conversion of some fallow land in the US, Canada, and the EU27, at a minimum. We have estimated emissions by utilizing average input parameters, instead of making 45 runs; but acknowledge that it would be more precise to perform the 45 runs and determine average emissions, since some of the effects are likely not to be linear.[5] Results are shown in Table 4.

Table 4. ARB Average and Recommended Values for Corn Ethanol (Approach B with Irrigation Constrained)

Case	Ydel	PAEL	ETA	LUC (gCO2e/MJ)
Average of ARB Inputs	0.19	0.3/0.15	Baseline	17.22
Purdue Best Estimate	0.25	0.4/0.2	Baseline	14.23
AIR Recommended*	0.28	0.4/0.2	Baseline	13.23

* We recommend performing the 45 runs and determining the average emissions, which may differ from 13.23 g/MJ.

The LUC with the Purdue best estimate inputs is 14.23 gCO2e/MJ. Our recommendation results in LUC emissions of 13.23 gCO2e/MJ, based on these inputs. Here again, we would like to know if the staff agrees with this recommendation, and, if not, we request

[5] 45 = 5 Ydel values (0.15, 0.2, 0.25, 0.3, 0.5), 3 PAEL values (0.2/0.1, 0.4/0.2, 0.6/0.3), and 3 ETA values (baseline, 80%, 120%).

an explanation why it does not agree in time for us to provide further input, that the staff can consider as it develops the new regulatory proposal.

Attachment 1

Approach A: ETL11 = ETL12

GTAP Region	ETL11	ETL12	ETL2	GTAP Region	ETL11	ETL12	ETL2
USA	-0.02	-0.02	-0.75	R_SE_Asia	-0.3	-0.3	-0.50
EU27	-0.02	-0.02	-0.75	R_S_Asia	-0.1	-0.1	-0.75
BRAZIL	-0.2	-0.2	-0.75	Russia	-0.02	-0.02	-0.75
CANADA	-0.02	-0.02	-0.25	Oth_CEE_CIS	-0.02	-0.02	-0.75
JAPAN	-0.2	-0.2	-0.50	Oth_Europe	-0.02	-0.02	-0.25
CHIHK	-0.2	-0.2	-0.25	MEAS_NAfr	-0.02	-0.02	-0.25
INDIA	-0.1	-0.1	-0.25	S_S_AFR	-0.3	-0.3	-0.25
C_C_Amer	-0.02	-0.02	-0.25	Oceania	-0.02	-0.02	-0.25
S_o_Amer	-0.1	-0.1	-0.50				
E_Asia	-0.2	-0.2	-0.50				
Mala_Indo	-0.3	-0.3	-0.25				

Approach B: Separate ETL11 and ETL12

GTAP Region	ETL11	ETL12	ETL2	GTAP Region	ETL11	ETL12	ETL2
USA	-0.0182	-0.0218	-0.75	R_SE_Asia	-0.2727	-0.3273	-0.50
EU27	-0.0182	-0.0218	-0.75	R_S_Asia	-0.0909	-0.1091	-0.75
BRAZIL	-0.1905	-0.2095	-0.75	Russia	-0.0182	-0.0218	-0.75
CANADA	-0.0182	-0.0218	-0.25	Oth_CEE_CIS	-0.0182	-0.0218	-0.75
JAPAN	-0.1818	-0.2182	-0.50	Oth_Europe	-0.0182	-0.0218	-0.25
CHIHK	-0.1818	-0.2182	-0.25	MEAS_NAfr	-0.0182	-0.0218	-0.25
INDIA	-0.0909	-0.1091	-0.25	S_S_AFR	-0.2727	-0.3273	-0.25
C_C_Amer	-0.0182	-0.0218	-0.25	Oceania	-0.0182	-0.0218	-0.25
S_o_Amer	-0.0909	-0.1091	-0.50				
E_Asia	-0.1818	-0.2182	-0.50				
Mala_Indo	-0.2727	-0.3273	-0.25				

Attachment 2

Comments on ARB's March 11 Workshop on
The Low Carbon Fuel Standard
Air Improvement Resource, Inc.
April 6, 2013

These comments are primarily on the workshop presentations provided by CARB, and some of the documentation provided by CARB on the AEZ-EF model shortly after the workshop. The following comments focus on Land Use Change and Facility Registration components of the LCFS.

Land use Change Emissions

There are 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.

<u>Global Trade Analysis Project (GTAP)</u>

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.

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.[6] None of these 3 ways involves a land use change, or land use change emissions. Furthermore, GTAP does not include these 3 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 3 factors on crop production can be estimated by comparing trends in total harvested area to total cropland.

> 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 3 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.[7] 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 CARB'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. [8] 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

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[6] Ray, D.K., and Foley, J.A., *Increasing global harvest frequency: recent trends and future directions,* Environmental Research Letters, (2013), 044041, IOP Publishing.
[7] Purdue is continuing to develop a dynamic GTAP model for these and other reasons.
[8] Keeney and Hertel, "Yield Response to Prices: Implications for Policy Modeling", Working Paper #08-13, August 2008, Department of Agricultural Economics, Purdue University.

model, with projections being applicable in the 5-10 year timeframe. CARB appears to concur with this timeframe for GTAP, because CARB 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.[9]

CARB, however, performed sensitivity analyses using price-yield elasticity values from 0.05-0.30 (20%-120% of the default value). CARB'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 parameter to use in modeling. Furthermore, CARB did not consider the analysis by Ray and Foley in determining the range of price-yield values to use.

CARB 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, CARB 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, however, 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 Ray and Foley analysis referenced earlier.

ETL1 and ETL2 Values

CARB 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. CARB appears to have used some, but not all, ETL1 and ETL2 values from a 2013 Applied Science paper by Taheripour and Tyner. [10] 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.

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[9] See page 57 of the CARB March 11 Workshop Briefing, iluc_presentation_handouts_031014.pdf.

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

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

Table 1. Differences in ETL1 and ETL2 Values Between CARB and Purdue				
Region	Purdue – Applied Sciences 2013		CARB	
	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

It is not clear why CARB chose different ETL1 and ETL2 values than Purdue, and what analysis or data CARB based these values on. An explanation of this should be provided for review, or CARB should use the 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. This set up another key deficiency of the GTAP-BIO model. 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.

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.

Taheripour and Tyner altered the land cover component of the land supply tree to have forest and pasture land in two different nests. 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.

CARB 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 CARB in early 2013. CARB 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 US and Brazil (CARB 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. [11] These data show over 10 million acres of CRP land have gone back into production. These are not 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.

[11] "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.

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

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 CARB 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. CARB 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.[12] 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

[12] 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.

In the new AEZ-EF model, for forest converted to cropland or pasture, CARB 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, CARB 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. CARB does not count CO2 emissions from facilities that use waste wood to produce energy for fuel production (CARB does, however, count non-CO2 GHG emissions, which is appropriate). Heath et al estimate that 35% of carbon from forest clearing is used for energy.[13] In the US, Canada, and the EU27, CARB should not count the CO2 from wood used to produce energy.

CCLUB Model

CARB should consider using the (Carbon Calculator for Land Use Change from Biofuels Production (CCLUB) model for estimating emissions.[14] 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. [15,16] Third, it allows the user to input HWP fractions, and fourth, it does not count CO2 from the forest wood used to produce energy. For areas outside of the US, it utilizes Winrock emissions.

CARB 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

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[13] 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.

[14] 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.

[15] 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.

[16] 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/

emissions would also provide more information on the uncertainty of CARB'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 did not supply example run results for any particular biofuel shock. 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 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

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

- ARB's ETL1 and ETL2 values
- Model Nesting Structure
- Price-Yield Range

It is clearly impractical for us to run the model 1440 times to test the impact of these 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 21.66 gCO2e/MJ. We then reduced the price yield elasticity from 0.175 to 0.1507, and obtained emissions of 23.22 gCO2e/MJ, which is the same as ARB's corn ethanol estimate. This is our single run that generally represents CARB's 1440 cases.

The impact of the 3 changes on LUC emissions for the corn ethanol shock are shown in Table 5.

Table 5. Impacts of Changes in GTAP Modeling	
Scenario	LUC Emissions (gCO2e/MJ)
AIR "Representative" Case	23.22
Change ETL1 and ETL2 parameters to Purdue "tuned" values	21.20
Implement Purdue GTAP Nesting Structure	19.00
Use Purdue Default Price-Yield Range	14.63
Include CRP Land Conversions	13.75

Table 5 shows likely emissions of 13.75 g CO2e/MJ instead of 23.22 gCO2e/MJ if these changes are implemented and the various runs are repeated. The emissions would be even lower if the model were modified to more properly reflect (1) the Ray and Foley analysis that a major part of crop production has increased without a land use change, and (2) the ARB analysis properly accounted for wood from forest that is used for fuel and replaces fossil fuel during forest clearing.

2.0 Fuel Pathways and Producer Facility Registration

Growth Energy supports the streamlining of the application process for biofuel production facilities, however, Growth Energy does not support limiting the pathways a facility can apply for, nor does Growth Energy support implementation of CI "bins" that facilities must use when registering the facilities. These changes would both severely limit continued innovation in biofuel facilities.

At the workshop, CARB envisioned bins of either 5, 7, or 9 CI values, with all facilities falling in a bin range getting the same, midpoint value of the bin. For a 7 CI bin case, for example, facilities falling in a bin from 61-67 would all be assigned a value of 64, whether their CI is 61.1 or 66.9. Furthermore, a facility with an actual CI of 65 (assigned value of 64) would not be able to obtain a lower CI value unless it reduced its actual CI to the upper part of the next bin range, or 60.9 (a difference of 4.1 CI). A facility at 61.1, however, with an assigned value of 64 would be able to get into the next lowest bin by reducing its CI to the same value of 60.9, a difference of only 0.2 CI. Clearly, if we are understanding CARB's bin approach correctly, it appears to have significant problems, no matter how the bins are designed.

A second major concern we have with the bin approach is that it is not at all consistent with what ARB is proposing for refineries producing gasoline and diesel. CARB's GHG Emission Reductions for Refineries proposal indicates that CARB is willing to provide credit under the LCFS regulations to refineries, with no minimum CI reduction required. In other words, a refinery that has a project to reduce its CI by 0.1 CI would receive consideration. But under the binning approach for biorefineries above, there is a much higher minimum threshold for consideration of a lower bin. Thus, gasoline/diesel refineries receive special treatment that biofuel facilities do not.