EXECUTIVE SUMMARY

Analysis of Land Use Change Effects of Soy Biodiesel

National Biodiesel Board

January 14, 2010

The National Biodiesel Board (NBB) continues to appreciate the positive working relationship it has developed with the California Air Resources Board (ARB) and its staff members. We are pleased to note that ARB staff members have been very open to recommendations made with regard to the direct effects models for biodiesel produced from soybean oil, beef tallow, and used cooking oil. This commitment to collaboration and the use of reputable data has, in our view, produced direct effects models that will withstand scientific scrutiny during a peer review process.

While we do have a positive relationship with the ARB and its staff members, and we do largely agree with the results of the agency's direct effects modeling efforts, I would be remiss if I failed to mention our severe disappointment regarding a comment period for the ILUC soy model that is only 30 days in duration, especially in light of the fact that the individual responsible for conducting the GTAP modeling at the University of California, Berkeley (U.C. Berkeley) was wholly unavailable during this time period and thus several key questions regarding assumptions that were used in the model remain unanswered[1]. Certainly this has hindered our experts' ability to provide comprehensive comments and is the chief reason **we are formally requesting an extension to the comment period of not less than 15 days**.

Even taking into account this disadvantage, we believe the noted experts with whom we have contracted for this purpose have provided comments that should aid significantly the efforts of staff at the ARB and U.C. Berkeley in deriving the most accurate results possible from the GTAP model. One concerning aspect of the ARB's GTAP work that our experts have discovered, which should be noted very prominently, is that, while the GTAP model relies consistently on government data when it is available, numerous instances exist in which official government data has been replaced by data from other sources. It is particularly interesting to note that in each of these instances this new data differs not slightly but wildly from the data which has been reported by official governments and the International Panel on Climate Change (IPCC). Additionally, in each and every instance, the data underestimates soy biodiesel's greenhouse gas (GHG) emissions benefit as an alternative to petroleum diesel. In some instances our experts were able to identify the source of the data [e.g. Timothy Searchinger et al (2008); Woods Hole Oceanographic Institution]. In other instances, they were not. Our hope is that all these data, which are inconsistent with highly credible government and international sources, have been identified and can be addressed; but certainly this is an area that would benefit from additional analysis, which could be conducted during the requested 15-day extension.

---

[1] 1. How does the land use modeling take into account the CARB assumption that 80% of the soybean mass is a co-product (soybean meal) and 20% of the mass is the product (soybean oil)? We have replicated CARB's numbers, but have not yet found these factors in the GTAP code.
2. How exactly were soybeans split out from GTAP oilseeds? Can you explain how the model is shocked in regards to soybeans versus vegetable oils?
3. Why is the fraction of the total land converted that is forest higher for the soybean oil shock than for the corn ethanol shock shown in the ISOR (for the same GTAP inputs)?

Finally, I wish to point out that: 1) nearly every recommendation contained in this report is supported by hard data from an objective and highly reputable source; and 2) nearly every instance of constructive analysis is followed by a realistic solution to the stated problem. We hope this approach proves useful to staff at both the ARB and U.C. Berkeley and would be pleased to participate in developing future improvements to the model and these assessments.

Selected recommendations from experts who have reviewed this paper are summarized below.

- **Direct Emission Issues.** Version 3.0 of the direct emissions model changes to using a mass allocation method for determining the emissions associated with soybean oil and soybean meal. The NBB agrees with this change. However, instead of using the precise figures from U.S. Department of Agriculture (USDA) data (81.1/18.9), the ARB uses approximate figures (80/20). This .45 g/MJ discrepancy between the ARB estimate/simplification and actual USDA data has the effect of artificially decreasing soy biodiesel's GHG benefit by 0.4 percent.

- **Glycerin.** The ARB modeling essentially assumes that glycerin, a co-product of biodiesel production used to make cosmetics and pharmaceuticals (among other products), is discarded as waste. This appears to be the case because the model does not include the emissions credit resulting from displacement of petroleum produced glycerin. As such, biodiesel is charged for the carbon emissions related to that co-product (3.7 g/MJ). This is inappropriate because 99 percent of industry participants sell the glycerin that is produced at their facilities, according to a 2009 survey conducted by the NBB. The model's assumption that biodiesel producers do not sell glycerin, a co-product that has a demonstrated value in the marketplace, is counter to both commonsense and NBB survey data. For these reasons, the ARB should provide a co-product credit for glycerin in the model, which would decrease biodiesel's carbon intensity by 3.7 g/MJ, or 3.9 percent.

- **Soybean Yield.** According to its report, the ARB chose not to make any type of yield adjustment for soy biodiesel because no yield improvement occurred between the years 2004 and 2007 (Notably, the ARB did include a yield adjustment for corn ethanol). There are a number of problems with this assessment:
    - Two data points (2004 and 2007) is insufficient in terms of analyzing the historical trend of soybean yields, which have increased regularly for 70 years.
    - 2004 represents an inappropriate baseline because it was a very good crop year (excellent weather) and subsequent years were average to below average.
    - Four years is far too short a time span from which to project results to 2020.
    - Forecasts from the major seed companies project yields above 60 bushels per acre by 2020. These reliable forecasts should be part of the estimation of future land use; otherwise the modeling fails to be realistic.
    - Recent data from USDA indicating the average yield in 2009 was 44 bushels per acre is not incorporated in the model. At an absolute minimum, the model should reflect current yields.

Notwithstanding the new data from USDA for 2009, a simple straight-line extrapolation from historical yield data supports a yield of 47 bushels per acre rather than the 42.2 figure the ARB uses. Doing so would reduce the indirect land use change (ILUC) factor by 10.2 percent.

- **Elasticity Assumptions.** The seven scenarios used for soybean biodiesel use exactly the same elasticity values as were used for corn ethanol. It is important to note, however, that soybeans and corn are different crops in many respects and, therefore, should be evaluated independently with respect to elasticity values. Relevant examples include:
  - Soybean yields throughout the world are quite similar, while corn yields in the U.S. are significantly higher than in many other regions. One explanation for this disparity is the fact that soybeans produce their own nitrogen, a key fertilizer that is purchased and applied to corn in the U.S. to maximize yield and perhaps not applied in less developed nations due to cost constraints.
  - While double cropping is not an option for corn in the U.S., soybeans are an excellent candidate for this agricultural practice in the U.S. and Brazil. Data shows that double cropping soybeans is many farmers' first response when prices increase. This effectively boosts the soybean yield without adding planted acres. While the GTAP model does not account for this, Dr. Babcock and Mr. O'Connor both recommend that the issue be addressed by using a crop elasticity of 0.4.

The ARB also assumes that yields will be lower on new lands brought into production as a result of renewable fuels policy. This hypothesis is contradicted by actual data collected by the governments of Brazil and Argentina[2]. Based on this data, Dr. Babcock recommends a value of 1.0 for soybeans for the elasticity of crop yields with respect to area expansion. Mr. O'Connor recommends a value of 0.9 to 1.0. In other words, based on the data, there is no reason to expect a yield loss, and certainly a significant one, on new lands that are planted with soybeans.

With regard to the elasticity of land transformation, the GTAP model results have been developed assuming that the percentage change in pasture land is the same as forest land. However, real-world data shows that pasture lands (and idle lands) are converted at a much higher rate than forest lands, likely because the costs of doing so are immeasurably lower. In his analysis, to reflect this fact, Dr. Babcock points out that GTAP supporting documentation (Ahmed et al, 2008) indicates that different elasticities should be used for each type of land. Using one elasticity value for both types of land overestimates the amount of land that would come from forest and underestimates the amount that would derive from pasture, the effect of which is to artificially increase the carbon intensity of soy biodiesel.

The issues described above are discussed at length in the attached analyses provided by Dr. Babcock and Mr. O'Connor.

[2] Data from the U.S. is unavailable because cropland has not increased in this country for quite some time.

- **Types of Land Converted.** One of the questions we asked ARB staff and Mr. Michael O'Hare from U.C. Berkeley that has, heretofore, gone unanswered is the following:

  "Why is the fraction of the total land converted that is forest higher for the soybean oil shock than for the corn ethanol shock shown in the ISOR (for the same GTAP inputs)?"

  For reasons yet to be determined, the individuals at U.C. Berkeley who are working on this project assumed a rate of deforestation for soy biodiesel that is more than twice that of corn ethanol even though the total land use change area in the soy model is less. We have not been able to find an expert who can provide a justification for why this would be the case. Since the carbon loss on forest land is as much as ten times that of pasture land, this assumption has a tremendous impact on the model results and, at a minimum, should be explained. We would hope that the ARB would grant the 15-day comment extension we have requested so this – and the other questions we asked – can be answered.

- **Idle Land.** The fact that the GTAP model is incapable of taking idle lands into account, which comprise more than 30 percent of available agricultural lands worldwide, is a serious shortcoming which no one disputes. Obviously, if land expansion is to occur as a result of renewable fuels policy, it will likely take place on idle land or expiring CRP acres in the U.S. and on set-a-side land in Europe before occurring in forested regions. Far more than the 1.26 million acres of crop land that GTAP indicates are needed to accommodate the California LCFS are available from idle lands. The fact that GTAP ignores these available lands and assumes all needed land comes from forest and pasture creates a massive artificial carbon penalty for soy biodiesel. In the attached analyses, Dr. Babcock and Mr. O'Connor recommend addressing this issue by changing the elasticity of crop yields.

- **Emission Factors for Forest Land.** The ARB assumes that the carbon stored in forests exists permanently. Unfortunately, this is not the case because trees, like all living things, have natural lifecycles and fall victim to death and natural disasters such as fire, disease, pests, and extreme weather. In other words, a portion of the carbon contained in forests is only stored temporarily. These factors, which shorten the life of carbon storage, should be accounted for because at the end of these cycles the carbon contained in the ground biomass decomposes and is recycled into the atmosphere. For these reasons, in a given 30-year time frame, it is likely that only one-third to one-half of the carbon that is removed from land in the first year due to deforestation would have been standing at the end of the time period. Additionally, no allowance has been made for the possibility that some of the wood is converted into wood products. Particularly for developed nations, this should be factored into the analysis as recommended by Mr. O'Connor in his report.

- **U.S. Forest Land.** The carbon inventory of U.S. forest land used by the ARB is based on data from the Woods Hole Oceanographic Institution that was presented by Searchinger et al (2008). This data is less detailed than that which is available from the U.S. Forest Service and it contains carbon values that are more than twice as high as those provided by the Forest Service. Since the methodologies for collecting the data appear to be very similar, it is unclear why these significant discrepancies exist. But since they do exist, we wish to go on record as viewing data collected by the U.S. Forest Service as more appropriate for this purpose than data from the Woods Hole Oceanographic Institution, especially since the GTAP model consistently uses data from government sources when it is available.

  The other major issue with the U.S. analysis is that no offset is provided for the portion of biomass that is stored as harvested wood products. If 40 percent of the above ground biomass was converted to wood products, the emission factor would be reduced by approximately 72 percent. Mr. O'Connor speaks at length about this issue in his analysis.

- **Canadian Forest Land.** In Canada, almost all forest land is government owned and controlled. For this reason, it is extremely unlikely that clear cutting of forests would be allowed for crop production. Therefore, an adjustment to offset biomass used for wood products is merited and recommended.

- **Forest Land in Other Countries.** The emission factors for forest land in the remainder of the world also appear to be overestimated. For example, in the instance of boreal forests, the Intergovernmental Panel on Climate Change (IPCC) reports that the carbon content of above ground biomass for boreal coniferous forests ranges from 10 to 90 t C/ha, and that other types of boreal forest have a maximum of 20 to 50 t C/ha. Despite the fact that the carbon intensities of boreal forests range widely, the ARB has included only one figure for forest carbon intensity. That lone estimate of 90 t C/ha represents the absolute high end of the range of the most carbon intensive boreal forest in IPCC's database. The NBB recommends using a more appropriate mean value for boreal forest. 50 t C/ha would seem more representative of boreal conifer forests while still exceeding the maximum estimated carbon content of the other types of boreal forest described by the IPCC.

- **U.S. Pasture Land.** The assumptions related to pastureland come from Searchinger et al (2008). As in the above case, these figures depart significantly from IPPC default values. Therefore, it is recommended that these figures be amended to reflect international consensus on the issue. The IPCC figures are included in Mr. O'Connor's analysis (Table 3-8).

- **Canadian Pasture Land.** The ARB uses a soil carbon content estimate for grassland in Canada of 189 t C/ha. The value reported by Environment Canada is only 75 t C/ha – less than half of that which the ARB is using in its version of GTAP. It is recommended that the ARB adopt the figure reported by Environment Canada.

- **GTAP Deficiencies.** Others have commented extensively on the deficiencies inherent in the GTAP model and its level of appropriateness for the task in which it is currently being employed by the ARB. While the NBB generally agrees with many of these comments, it is quite clear that the ARB intends to utilize the GTAP model rather than adopt a more complicated approach as is being utilized by the U.S. Environmental Protection Agency. Therefore, in an effort to use the limited time we have been provided for analysis as constructively as possible, our comments are focused on how the GTAP model can be improved. That said, several issues experts have observed with regard to the GTAP model and the version being used by the ARB/U.C. Berkeley are noted below.

  - Minor Price Increases Drive Major Land Expansion. The ARB GTAP modeling concludes that the low carbon fuel standard (LCFS) policy would increase the price of soybeans by 1.44 percent. The model indicates that this minor increase – less than the price change on many trading days – causes an additional 1.26 million acres of crop land to be brought into production. Put simply: the data does not support this level of expansion.

  - Volume of Soy Biodiesel Input to GTAP Model. The ARB attempted to model the indirect land use changes from one billion gallons of soy biodiesel, assuming an initial volume of 250 million gallons and shocking the model for 750 million gallons of additional biodiesel demand. This overestimates the amount of soy biodiesel that would be required to meet the California LCFS.

    When calculating demand for biodiesel, it is important to consider that the fuel is produced from many different feedstocks, including waste feedstocks such as used cooking oil, animal fats, and inedible corn oil which comprise nearly 40 percent of the market, according to the U.S. Census Bureau. It would appear that the ARB did not take this fact into account when determining the volume of soy biodiesel that should be modeled.

  - Little Relationship Between Biodiesel Volume & Land Expansion. The ARB and U.C. Berkeley ran the GTAP model for an alternate shock of 450 million gallons (versus 750 million gallons). This 40 percent reduction in biodiesel demand resulted in a mere 5 percent decrease in land use change emissions. This lack of sensitivity to biodiesel volume means: a) the GTAP model is not functioning properly; or b) the indirect land use change hypothesis is largely invalid, or at least is not triggered until biodiesel demand exceeds what would be required to meet the California LCFS.

    The sensitivity analysis presented by ARB/U.C. Berkeley, and confirmed by our experts, shows that the land use change predictions from GTAP are far more sensitive to the data and assumptions made by the modelers than by varying the volume of biodiesel within the model. In fact, under certain scenarios, the model concludes that land use change emissions actually decrease as biodiesel volumes increase. This phenomenon is likely caused, in part, by GTAP's inability to consider idle farm land and soybean double cropping. Both Dr. Babcock and Mr. O'Connor recommend a way to address this issue in their reports.

- **Concluding Remarks.** If adopted, the recommendations made by Dr. Babcock and Mr. O'Connor would increase soy biodiesel's greenhouse gas benefit substantially. These results are summarized in Mr. O'Connor's analysis. Once again, it should be noted that nearly every recommendation that has been put forth is supported by official government or IPCC data. Because we are exceedingly confident in the objectivity and credibility of the reports drafted by Dr. Babcock and Mr. O'Connor, we would fully support enlisting their papers in an independent peer review process if the ARB views this as beneficial.

  Finally, while we have a great deal of confidence in both the accuracy of the recommendations contained in the reports we have submitted and the ARB staff's interest in review them, we have significantly less confidence with regard to the time frame in which all of this is occurring. Specifically, we are concerned that the GTAP modeling for soy biodiesel is being rushed to a speedy conclusion that will not allow for a meaningful level of interaction between the experts we have asked to review this work and staff at the ARB and U.C. Berkeley. As a point in fact, the individual conducting the modeling at U.C. Berkeley has not been available by telephone, email, or personal meeting since the report was released. Certainly this is not an ideal situation or characteristic of a public process managed by the ARB. While we are confident the ARB will address this in a way that results in a productive and fair process, it does merit mentioning as well as a reiteration of our request for a 15-day comment extension and belief that 30 days or more would be most appropriate and beneficial.