BRAZILIAN SUGARCANE INDUSTRY ASSOCIATION
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April 16, 2009

VIA ELECTRONIC MAIL

Mary D. Nichols
Chair, Air Resources Board
Headquarters Building
1001 I Street
Sacramento, CA 95814

Reference: *Proposed Low Carbon Fuel Standard*

Dear Ms. Nichols:

The Brazilian Sugarcane Industry Association (UNICA) welcomes the opportunity to provide specific comments on California's proposed Low Carbon Fuel Standard (LCFS). This letter expands on our previous correspondence[1] regarding lifecycle calculations of sugarcane ethanol and includes a number of specific recommendations concerning the calculations of indirect land use change.

We ask that this letter and all of its references be fully considered by the California Air Resources Board (CARB) and staff prior to approval of the regulation. The letter is structured as follows: (I) Introduction of UNICA as having a direct and significant interest in this rulemaking; (II) Comments and recommended changes to life cycle assessment inputs and assumptions; (III) Comments and recommended changes to land use change calculations; and, (IV) Conclusions.

I. INTRODUCTION

The Brazilian Sugarcane Industry Association (UNICA) is the leading trade association for the sugarcane industry in Brazil, representing nearly two-thirds of all sugarcane production and processing in the country. Our 125 member companies are the top producers of sugar, ethanol, renewable electricity and other sugarcane co-products in Brazil's South-Central region, the heart of the sugarcane industry. Brazil is the world's largest sugarcane-producing country with over half a billion metric tons of cane harvested yearly.

[1] See our letter dated February 10, 2009, available online at http://www.arb.ca.gov/lists/lcfs-lifecycle-ws/65-unica_comments_on_greet-ca_for_sugarcane.pdf. We also note that UNICA representatives have met with CARB staff on various occasions, most recently on April 2, 2009, where we discussed many of these points addressed in this letter.

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Last year, Brazil produced over 31 million tons of sugar and about 26 billion liters (6.8 billion gallons) of ethanol. In addition, the mills generate their own power from the sugarcane biomass. Official government data indicates that sugarcane mills produced approximately 16,000 GWh of electricity (corresponds to about 3% of the country's annual electricity demand) last year.

Thanks to our innovative use of ethanol in transportation and biomass for cogeneration, sugarcane is now the number one source of renewable energy in Brazil, representing 16% of the country's total energy needs according to official government data. Our industry is expanding existing production of renewable plastics and, with the help of innovative companies in California[2] will soon be offering bio-based hydrocarbons that can replace carbon-intensive fossil fuels.

II. LIFE CYCLE ANALYSIS

Our initial assessment of the results of the Greenhouse Gases (GHG), Regulated Emissions, and Energy Use in Transportation model, as modified by CARB, (GREET-CA) suggests that it was carefully done, capturing many of the complexities of our agricultural and industrial operations. This is not surprising given that GREET's designers have worked with Brazilian lifecycle assessment scholars (namely Drs. Joaquim Seabra and Isaias Macedo) to incorporate and harmonize some of the unique characteristics of sugarcane production systems and processing in the original GREET model. However, industry practices continue to evolve, and we believe it is critical that CARB's analysis reflect the current state of the Brazilian sugarcane industry and avoid penalizing those players who have made investments in more efficient and sustainable methods of production since original GREET values were established. In some instances, GREET-CA's default values are far from the norm for current Brazilian agricultural practices.

Lifecycle analysis, by definition, involves a considerable number of variables with complex relationships, and the addition of indirect land use changes (discussed in Section III) only exacerbates these complexities. It has been the recommendation of various stakeholder groups (e.g. Global Bioenergy Partnership, Roundtable on Sustainable Biofuels, etc.) to simplify the analyses by eliminating some aspects that are clearly of smaller impact on the model's output.[3] For example, most Brazilian and international experts do not consider the volatile organic compounds and other pollutants in the GHG calculations, but do include the inputs of energy of equipments and construction. It appears to us that GREET-CA does the very opposite. Reaching a consensus on these approaches would facilitate analyses and comparisons going forward. For simplicity, we have highlighted only the discrepancies that lead to fundamental shifts in model mechanisms of those that have a significant impact on the value of model outputs.

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[2] For example, Emeryville-based Amyris announced last year a partnership with one of UNICA's member companies to produce fuels such as diesel and jet fuel for commercial uses. See http://www.amyris.com for more details. We are aware of similar efforts between a number of other California-based companies and sugarcane mills in Brazil.

[3] See *Sustainable biofuels: Prospects and Challenges*, The Royal Society, January 2008, Policy Document 01/08. Available at http://royalsociety.org/document.asp?id=7366

In this section, our comments address: (A) the changes that should be applied across any sugarcane ethanol pathway based on standard, average practices today; (B) ongoing industry practices improvements that further reduce sugarcane ethanol's carbon intensity; (C) the trends for further improvements based on existing regulations and changes; and, (D) technical and policy recommendations to CARB's sugarcane fuel pathways.

A. Changes for *any* Brazilian Sugarcane Pathway

The following three changes based on current industry practices are requested for any Brazilian sugarcane pathway that CARB considers in the LCFS.

1. Sugarcane Farming. The straw yield figures are above the norm for Brazil's sugarcane industry. Instead of 0.19 dry ton straw per ton of cane, you should use 0.14 dry ton straw per ton of cane.[4] Based on our experience, it appears that the default values for straw yield are possibly based on Hawaiian, not Brazilian, sugarcane averages.

2. Chemical Inputs. The energy values and associated emissions in the production of lime ($CaCO_3$) are said to be 0.6 g CO_2/MJ. However, lime produced in Brazil has significantly lower carbon intensity.[5] As correctly noted in the Staff Report, Brazil's base load electricity (average mix) is currently approximately 83% hydroelectric, though the marginal expansion mix has been mostly natural gas.[6] With this in mind, accurate input values for the production of lime in Brazil are 7 kWh electricity (with grid average mix) per ton of lime (not the mix of products found in some production plants outside Brazil, including calcium oxide) and 2.6 liters of diesel per ton of lime. Consequently, the GREET-CA values should be at most 0.11 g CO_2/MJ in the production. We anticipate that this amount will likely be shown to be lower in the coming months as more in-depth research in Brazil is underway.[7]

3. Sugarcane Transportation. It appears that the energy required for transportation, and consequently the emissions assigned in GREET-CA, are higher than those obtained by our own ground-truthing measurements in Brazil. We believe that the discrepancy may well result from obsolete assumptions related to load performance of the vehicles during feedstock transportation. GREET-CA considers only 17 ton trucks, while a majority of mills

[4] See *Biomass Power Generation: Sugar Cane Bagasse and Trash* edited by Suleiman Hassuani et al; published by United Nations Development Program (UNDP) and Sugarcane Technology Center (CTC) in Brazil, 2005. Available online at http://www.ctcanavieira.com.br/images/stories/Downloads/BRA96G31.PDF

[5] See Hassuani op cit., pg 157. Also, see Macedo, Seabra & Silva in "Greenhouse gases emissions in the production and use of ethanol from sugarcane in Brazil" in *Biomass and Bioenergy* (2008).

[6] Even when considering additional hydroelectric power expansion, emissions calculations should include transmission impacts, direct and indirect land use changes. New hydroelectric power is only available in remote and environmentally sensitive areas of Brazil (e.g. Amazon river basin), which requires very long transmission lines (over 1,000 miles) through high-carbon, high-biodiversity forests. For a recent account of this, see "Doubt, Anger Over Brazil Dams; As Work Begins Along Amazon Tributary, Many Question Human, Environmental Costs" in *The Washington Post* on October 14, 2008. Also, for general background on Brazil's electricity grid see U.S. Department of Energy's Country Analysis Brief, available at http://www.eia.doe.gov/emeu/cabs/Brazil/Full.html

[7] Personal correspondence with Dr. Joaquim Seabra, National Renewable Energy Laboratory, in April 2009.

already operate with trucks with two or three times greater loads.[8] The specific energy consumption values for transportation from the field-to-mill vary according to the type of truck used and distance travelled. The mean distance travelled for field-to-mill is about 12 miles, as GREET-CA correctly assumes. Based on proportion of each type of truck used in field-to-mill transport from latest available data (i.e., 2004), we know that 8% of trucks were 15-ton single wagon, 25% were 28-ton double wagon, and 67% were 45-ton triple wagons. Therefore, based on this 2004 data, we calculate that the energy consumption of sugarcane transport from field to the mill to be approximately 20.4 ml/t.km, or about two-thirds of the consumption of a single wagon truck (i.e., 30.3 ml/t.km). In short, our recommendation would be to use 19,122 BTU/mmBTU instead of 25,722 BTU/mmBTU in Table 3.02.9 of the Staff Report.

B. Improved Low Carbon Industry Practices

In the last few years, there have been significant operational improvements in the Brazilian sugarcane industry.[10] There are at least three inter-related changes that significantly impact carbon intensity calculations, namely:

- Reduction of pre-harvest field burning
- Mechanization of harvest
- Increased cogeneration efficiency

The impact of these practices on the industry's carbon intensity and current increasing adoption rates are discussed below.

GREET-CA presumes all sugarcane in Brazil is burned in the field prior to being manually harvested.[11] Moreover, the model assumes all energy from sugarcane biomass is employed for ethanol production, with no surplus/credit (either in the form of bagasse used as fuel, or excess electricity produced in the cogeneration process). These are incorrect assumptions that do not reflect current industry practices. A growing share of Brazil's sugarcane harvest (approximately 35%) is not burned and is mechanically harvested.[12]

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[8] See CTC report entitled, "Annual Agricultural Reporting for Harvests 98/99, 99/00, 00/01, 01/02, 02/03" [author's translation] for detailed background on ground-truthing in transport practices. For a broader discussion of these and other evolving practices, see *Sugar Cane's Energy*, edited by Isaias Macedo (2005) as well as *Sugarcane Ethanol: Contributions to Climate Change Mitigation and the Environment* edited by Peter Zuurbier and Jos van de Vooren (2008).

[9] For further detail, including formulas used, see page 23, Section A3, "Transport of Sugarcane from Field to Mill" [*author's translation*], of 2004 São Paulo State Government report entitled "Net Greenhouse Gas Emissions in the production and use of ethanol in Brazil" [*author's translation*]. Available online at http://www.unica.com.br/download.asp?mmdCode=76A95628-B539-4637-BEB3-C9C48FB29084

[10] See World Wildlife Fund's "Analysis of the Expansion of Sugarcane's Agro-industrial Complex in Brazil" [author's translation], available online at http://www.wwf.org.br/index.cfm?uNewsID=13760. An English version of the report is available upon request.

[11] See "1.3 GHG Emissions from Straw Burning in Field" on page 22 of GREET-CA.

[12] Though the trend is for all sugarcane is to be mechanically harvested and not all burned cane, there are mills that still burn the sugarcane in the field but harvest it manually.

We believe a generic, single sugarcane pathway may not accurately incorporate these important changes in the way the sugarcane industry has and continues to evolve in Brazil. We note that merely creating separate pathways – one for "using bagasse for electricity production as a co-product" and one for "using mechanized production of sugarcane," as suggested in Table ES-6 of the Staff Report – will miss the mark as it presumes that these processes are mutually exclusive. The reality on the ground today is that mechanization and bagasse for electricity are occurring in significant levels and will only increase due to established regulations in Brazil.[13]

The mechanical harvesting (with no sugarcane field burning) yields a high amount of additional biomass (commonly referred to as "trash" and includes leaves and tops of cane stalks among other parts of the sugarcane plant). Some of this additional biomass is being recovered and transported to the mill for processing and much more is expected in the very near future.[14] This biomass recovery process increases electricity production through cogeneration (or, in the future, additional ethanol production once cellulosic pathways are commercially viable).

As changes in field operations continue, energy efficiency improvements at mills already are adding to the surplus electricity provided to the national grid.[15] In 2007, mills provided about 11,095 GWh, which corresponds to about 22.5 kWh per ton of raw sugarcane crushed.[16] In 2008, the Ministry of Energy indicated that power generation increased to 15.768 GWh.[17] This increased is a result of not only increase sugarcane production but, more importantly, new mills upgrading to high-pressure steam cycle generators that produce at least 70 kWh per ton of cane with bagasse alone.[18] Moreover, more efficient mills are entering into long-term supply contracts with power distribution companies.[19] For instance, the amounts already contracted for 2012 reach 45,180 GWh, which brings power generation to 65 kWh per ton of cane.[20] There will be additional electricity incorporated into the grid by 2012, either through the scheduled government auctions or via open market sales, but those contracts have not yet been signed. Finally, looking ahead, when the additional sugarcane biomass (i.e., "trash") is used for power

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[13] On a personal note, when the CARB Chair visited Brazil in August 2008, she saw these changes – sugarcane mechanizations, cogeneration, and much more – first hand. It is surprising then that the Staff Report failed to account for that.

[14] See Hassuani op cit.

[15] See page 10 in Angelo Gurgel, John M. Reilly, and Sergey Paltsev. "Potential Land Use Implications of a Global Biofuels Industry" *Journal of Agricultural & Food Industrial Organization* 5.2 (2007). Available at: http://works.bepress.com/angelo_gurgel/1

[16] Sugarcane harvest was 493 million tons of sugarcane according to actual production data compiled by UNICA and available at http://www.unica.com.br/dadosCotacao/estatistica/. Data for current power sales is provided by the Brazilian government's Ministry of Mines & Energy and National Electricity Agency, the autonomous regulator, and compiled by the São Paulo Cogeneration Association (COGEN-SP). While all the data is in Portuguese, it is easily accessible online at http://www.aneel.gov.br and http://www.cogensp.com.br.

[17] Personal correspondence between UNICA's Zilmar de Souza and Ministry of Mines & Energy officials.

[18] See "Mitigation of GHG emissions using sugarcane bioethanol" by Isaias C. Macedo and Joaquim E.A. Seabra in *Sugarcane Ethanol: Contributions to Climate Change Mitigation and the Environment* edited by Peter Zuurbier and Jos van de Vooren (2008).

[19] See "Brazil to invest $21.2 billion in cogeneration" in *The Economist Intelligence Unit* (1 December 2008).

[20] See COGEN-SP for additional data and information, http://www.cogensp.com.br/cogensp/workshop/2008/Bioeletricidade_ENASE_01102008.pdf

production, the power generation values will increase to above 100 kWh per ton of cane within the decade (including bagasse and 40% of the straw previously burned in the field).[21]

C. Trends in Industry Adoption of Low Carbon Practices

Mechanization and cogeneration are common industry practices today that we expect to be rapidly adopted across all plants in the coming years.[22] These trends are being driven by the following policy and market pressures:

1. Phase Out of Field Burning. Under current regulations and agreements between the environmental authorities and the sugarcane industry, nearly all the sugarcane in the State of São Paulo will be mechanically harvested by 2014. São Paulo accounts for 60% of all national production and almost 100% of sugarcane exports to the United States. São Paulo state law requires that sugarcane field burning be phased-out by 2021 from areas where mechanical harvesting is possible with existing technology (over 85% of existing sugarcane fields) and by 2031 in areas where this may not be possible (e.g., steep slopes, irregular topography, etc).[23] However, UNICA member companies have entered into an agreement[24] with the São Paulo Environmental Agency to move up the deadlines for sugarcane pre-harvest burning to 2014 and 2017, respectively. The agreement also defines other important actions such as conservation programs and restoration projects for riparian corridors as set-aside land policies.[25]

2. Increasing Restrictions on Burning. Existing plantations that still use manual harvesting in the state of São Paulo must obtain state-issued government permits for the pre-harvest sugarcane field burning. Environmental authorities have set strict contingencies upon which these permits can be suddenly revoked (e.g., if air humidity drops below 30%, cane burning restrictions are applied and if air humidity drops below 20%, all cane burning is suspended).[26] This uncertainty has pushed many producers to mechanical harvesting to eliminate associated operational risk.

3. Expansion only with Mechanization. Since 1986 all new sugarcane plantations and mills are required to submit environmental impact studies prior to construction and operation in

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[21] For further details, please review *Technical-Economic Evaluation for the Full Use Sugarcane Biomass in Brazil*, [author's translation from Portuguese], Joaquim Seabra, Universidade Estadual de Campinas, July 2008.

[22] See Hassuani op cit. Also see Rabobank's report "Power Struggle: The Future Contribution of the Cane Sector to Brazil's Electricity Supply" by Andy Duff and Rodolf Hirsch (November 2007).

[23] See São Paulo State Law 11.241 enacted on 19 September of 2002, which requires the elimination of sugarcane field burning, is available at http://sigam.ambiente.sp.gov.br/Sigam2/Repositorio/24/Documentos/Lei%20Estadual_11241_2002.pdf

[24] See "Protocolo Agro-Ambiental do Setor Sucroalccoleiro Paulista," available in Portuguese at http://www.ambiente.sp.gov.br/cana/protocolo.pdf

[25] See "Environmental Sustainability of Sugarcane Ethanol in Brazil" by Weber Amaral et al. in *Sugarcane Ethanol: Contributions to Climate Change Mitigation and the Environment* edited by Peter Zuurbier and Jos van de Vooren (2008).

[26] See São Paulo State Environmental Agency's Resolution SMA 38/08 of May 16, 2008, available online at http://sigam.ambiente.sp.gov.br/sigam2/default.aspx?idPagina=123.

order to obtain required permits.[27] More recently, in order to receive a permit to establish green-field sugarcane mills, the São Paulo state environmental authorities require 100% mechanical harvesting. Other states are in active discussions to follow their lead. Moreover, additional regulations imposed by the state government of São Paulo establishes environmental zoning for the sugarcane industry and progressively stricter requirements for licensing and renewal of existing plantations and mills.[28] Not to be outdone, the federal government has announced that a similar requirement for mechanization will be established nationwide later this year.[29]

4. One-Third Harvest Mechanization Nationwide. The uncertainties caused by the impact of harvest permits, coupled with the aforementioned legislative and regulatory changes, have led to a quicker-than-expected transition to all mechanized, un-burned sugarcane harvest. According to Brazil's Sugarcane Research Center,[30] which works with nearly all sugarcane producers, about 35% of all sugarcane in Brazil is already mechanically harvested, and nearly all of this is not burned in the field. In 2008, about half of the sugarcane fields in the state of Sao Paulo were mechanically harvested. And other states such as Goiás, Mato Grosso do Sul, and Paraná are also implementing mechanical harvest. In fact, the robust pace of mechanization was recently highlighted in a John Deere earnings release that states, "sales are being helped by […] rising demand for sugarcane harvesting equipment."[31]

Any realistic evaluation of carbon emissions from sugarcane farming in Brazil must reflect the strict policies being implemented and action already taken that phase-out of sugarcane burning, increase in mechanical harvest and cogeneration output. Without reasonable allocation of these various aspects, GREET-CA cannot provide realistic carbon intensity values. In fact, the developers of the GREET model recognized this when they wrote, "elimination of open-field burning in sugarcane plantations will result in additional GHG emission reductions by sugarcane ethanol."[32]

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[27] See CONAMA (Brazilian National Council on Environment) first resolution in January 1986, available at http://www.antt.gov.br/legislacao/Regulacao/suerg/Res001-86.pdf. For more info on CONAMA's action regarding sugarcane, see http://www.mma.gov.br/port/conama/index.cfm

[28] See São Paulo State Environmental Agency's resolution SMA-088 of 19 December 2008 as well as resolution SMA-SAA 004, of 18 September 2008, available at http://www.ambiente.sp.gov.br/contAmbientalLegislacaoAmbiental.ph[- 2009 and http://sigam.ambiente.sp.gov.br/sigam2/default.aspx?idPagina=123

[29] See statements by Environment Minister Carlos Minc on this as well as the environmental and economic zoning being prepared by an inter-ministerial group of the Brazilian government and expected to be publicly announced shortly. Available online at http://www.mma.gov.br

[30] See Centro de Tecnologia Canavieira (CTC), accessible online at http://www.ctcanavieira.com.br.

[31] See Deere & Company's second and third quarter of 2008 earnings reports, available online at http://www.deere.com/en_US/ir/financialdata/2008/thirdqtr08.html

[32] See "Life-Cycle Energy Use and Greenhouse Gas Emission Implications of Brazilian Sugarcane Ethanol Simulated with the GREET Model," by Michael Wang et al. in International Sugar Journal (2008), available online at http://www.transportation.anl.gov/pdfs/AF/529.pdf

D. Technical & Policy Recommendations

The table below summarizes the technical implications of actual industry performance today and details how each fuel pathway component will be affected in GREET-CA by these changes. All the proposed changes are based on current production processes, not projection or optimistic best-case scenarios. Recognizing the evolving nature of the technological improvements, a broader structure for how to integrate these and future improvements into sugarcane lifecycle analysis fuel pathways is discussed at the end of this section.

	CARB COMPONENTS FOR SUGARCANE ETHANOL	VALUE (g CO2/MJ)	PROPOSED CHANGES TO EXISTING AND/OR ADDITIONAL PATHWAYS
A	Sugarcane Farming	9.9	(1) Straw Yield should be changed to 0.14 dry ton per ton cane; (2) Cane burning emissions are at most 2.9 g CO_2/MJ under current conditions and are decreasing rapidly; (3) New pathways should be created to credit mechanized and un-burned harvest benefits
B	Agricultural Chemicals	8.7	Energy values in production of lime (CaCO3) should be changed to 0.11 g CO_2/MJ based on average grid mix
C	Sugarcane Transportation	2.0	Total energy in transport from field to plant should be reduced to 19,122 BTU/mmBTU given trucks carry loads larger than 17 tons
D	Ethanol Production	1.9	Emissions from ethanol production should be lowered 1.1 g CO_2/MJ since not all bagasse goes into ethanol production
E	Ethanol Distribution	4.1	No major changes recommended at this point
F	Cogeneration Credit	0	(1) Credits of at least 1.8 to 3.6 g CO_2/MJ, based on low end of emissions scenarios, should be included; (2) Trends and literature confirm that credits will increase to offset other component emissions; (3) New sugarcane ethanol pathways would allow for accurate credits to be given, particularly for incentivizing less carbon intense processes

A. Sugarcane Farming. Depending on various pathways and assumptions CARB decides to pursue, the values for sugarcane farming will vary. Considering the current levels of mechanical harvest (i.e., 35% of all cane) and a revised straw yield figure (14% of the cane), and 90% of actual burning in the burned area, total emissions from burning cane today should drop from 8.2 g CO_2/MJ to approximately 2.9 g CO_2/MJ. That should be the baseline for GREET-CA pathways. However, as noted elsewhere, we recommend that GREET-CA either consider an even lower figure to recognize that the sugarcane ethanol bound for California comes from areas that are already mechanized, or develop separate pathways to capture this carbon benefit.

B. Agricultural Chemicals. The production of Lime ($CaCO_3$) in Brazil is considerably less carbon intensive than GREET-CA suggests. As you noted, recognizing grid average mix and other factors, GREET-CA values for Lime production should be 0.11 g CO_2/MJ.

C. Sugarcane Transportation. Energy required for crop transportation from field to mill is exaggerated in GREET-CA, likely because of higher load performance of the vehicles used in Brazil. GREET-CA should consider trucks with two or three times greater loads, leading to a revised value of 25,722 BTU/mmBTU field to energy consumption.

D. Ethanol Production. As detailed at length above, GREET-CA inaccurately assumes that the electricity generated from bagasse combustion is insufficient to created a surplus.[33] Based on a correct understanding of the use of bagasse, the total GHG emissions for ethanol production should be reduced from 1.9 g CO_2/MJ to 1.1 g CO_2/MJ on average with lower figures likely in the very near future.

E. Transportation and Distribution. We see no significant discrepancy between GREET-CA and our own analysis with regards to transport and distribution.

F. Missing Cogeneration Credit. There are no credits for excess cogeneration electricity from sugarcane biomass. There is an inherent fallacy in any analysis of sugarcane that does not take into consideration the increasing surplus of cogeneration electricity produced at sugarcane mills in Brazil. Though GREET-CA recognizes that sugarcane bagasse is used to produce steam and electricity to power the processing, it does not consider that the mill is generating an increasing surplus of electricity, which is sold into the national grid displacing carbon intense sources of electricity. In other pathways (e.g., Farmed Tree Cellulosic), such credits are given and we see no reasonable basis to deny it within the GREET-CA for sugarcane.[34] Failure to incorporate the anticipated growth in electricity cogeneration not only undermines one of the greatest environmental benefits of the sugarcane pathway, but also creates further discrepancies in the years ahead that could discourage carbon mitigation behavior. Based on the low end of the range of anticipated electricity sales to the grid (i.e. 45,180 GWh already contracted for 2012), a GHG emission reduction credit of 1.8 to 3.6 g CO_2/MJ should be granted under GREET-CA.[35] Looking ahead, sugarcane mills operating with 70 kWh/t will achieve emission credits in the 10-20 g CO_2/MJ range, likely completely offsetting any emissions during production, processing, and transportation. In

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[33] To recap, mechanical harvest yields a significant increase in the amount of biomass (commonly referred to as straw or trash) that comes to the mill, instead of being burned in field. This additional biomass is now added to the existing bagasse (cane biomass remaining after juice extraction) to generate steam and electricity for the mills processes as well as sale of surplus electricity to the national grid. Finally, mills have been replacing older, low-pressure boilers with higher-pressure boilers, therefore obtaining greater efficiencies in power generation. All additional electricity generation is leading to a growing role of cogeneration.

[34] Any denial to accept the surplus energy cogenerated would require at the *very least* a reallocation of the emissions to power the ethanol production, further reducing sugarcane's ethanol overall emission.

[35] The range depends on the baseline emissions scenarios for Brazilian electricity. It must be noted that under the recently approved European Commission Directive, cogenerated electricity from sugarcane was given similar carbon credits for ethanol. See http://ec.europa.eu/energy/strategies/2008/2008_01_climate_change_en.htm.

fact, as the Organization for Economic Cooperation and Development (OECD) recently pointed out in a lengthy comparative analysis of biofuels, sugarcane ethanol may soon have negative emissions on a lifecycle basis.[36]

Now, turning to our policy recommendations, UNICA recommends that CARB consider either of the following adjustments to the GREET-CA fuel pathways for sugarcane in order to reflect the variations in agricultural and industrial operations in Brazil's sugarcane industry, as well as to accurately credit carbon-reducing behavior:

- ***Option One***. GREET-CA could assume at least 70% of the sugarcane used for ethanol to be mechanically harvested and not burned in the field.[37] As explained above, the main sugarcane producing area of Brazil reached 50% mechanization in the last harvest and is required to have achieved at least 70% mechanization by 2010. When considering the whole of Brazil, about 35% of all sugarcane is harvested mechanically. The higher figure (from 35% to 70% proposed in this option) more accurately represents the actual source of the sugarcane ethanol that makes it to the United States; or,

- ***Option Two***. Alternative pathways[38] could be developed for mechanically harvested, non-burned sugarcane ethanol and the adoption of more efficient cogeneration technologies described above. While more complex, such a method would have the benefit of not only accurately portraying current specific practices but also proactively encouraging lower carbon intensity sugarcane biofuels production, which is the underlying public policy goal of the LCFS. In separate pathways, credit would be given to mills for non-burning of sugarcane in the field (i.e., avoided emissions), as well as the cogeneration surplus power displacing carbon intense fuels such as natural gas or heavy fuel oil used in marginal power generation in Brazil.

Regardless of the final approach on additional pathways, we strongly urge that CARB adopt verifiable mechanism that ensures best carbon mitigating practices are rewarded on a timely manner so as to ensure quicker adoption. Merely updating the GREET-CA model in hindsight (three years as has been suggested in public hearings) will not be enough to reach the objectives of California's forward-looking climate change policy.

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36 "Ethanol from sugarcane is the pathway where the most consistent results were found. All studies agree on the fact that ethanol from sugar cane can allow greenhouse gas emission reduction of over 70% compared to conventional gasoline. The large majority of reviewed studies converge on an average improvement around 85%. Higher values (also beyond 100%) are possible due to credits for co-products (including electricity) in the sugar cane industry. This reflects the recent trend in Brazilian industry towards more integrated concepts combining the production of ethanol with other non-energy products and selling surplus electricity to the grid." See page 44 of Economic Assessment of Biofuel Support Policies by Organization for Economic Co-operation and Development (2008), available online at http://www.oecd.org/.

37 Another way to implement "Option One" would be to set the percentage as a variable number since it can be easily obtained on an annual basis from public and official sources in Brazil. UNICA would be please to work with CARB to establish this mechanism.

38 As noted above, we believe that the two pathways proposed in Table ES-6 of the Staff Report fail to capture the reality of sugarcane ethanol farming production. Mechanized harvest – with or without burning – and cogeneration cannot be separated, as they are often part of the same pathway. We would be pleased to review sugarcane farming and ethanol production processes with the CARB staff.

III. INDIRECT LAND USE CHANGE[39]

In this section, UNICA presents our assessment of the Staff Report calculations on sugarcane's land use change impact, which relied on the Global Trade Analysis Project (GTAP) from Purdue University.

We echo the various comments from stakeholders – particularly the letter by 111 Ph.D. Scientists – stating that the science used in determining these market-mediated, indirect impacts is quite limited and highly uncertain. In addition, the selective enforcement of indirect land use impacts for biofuels over other fuels included in the LCFS violates the most basic principles of regulatory fairness. A few lines made in the aforementioned letter bear repeating:

> "We are only in the very early stages of assessing and understanding the indirect, market-mediated effects of different fuels. Indirect effects have never been enforced against any product in the world. California should not be setting a wide-reaching carbon regulation based on one set of assumptions with clear omissions relevant to the real world. [...] This proposal creates an asymmetry or bias in a regulation designed to create a level playing field. It violates the fundamental presumption that all fuels in a performance-based standard should be judged the same way (i.e. identical LCA boundaries). Enforcing different compliance metrics against different fuels is the equivalent of picking winners and losers, which is in direct conflict with the ambition of the LCFS."[40]

Moreover, given the tight timeline for CARB implementation of the LCFS, as well as the complexity and uncertainty associated with such modeling exercises,[41] we would like to express our concern about the accuracy of model data assumptions, methodology, and other key factors underlying the GTAP runs made by CARB. We were given 45 days to review and comment on work that CARB took months to develop. By the CARB staff's own admission they have rushed the process and calculations. Our experience with other similar models (e.g., Food and Agricultural Policy Research Institute (FAPRI) model) suggests careful analysis and a deliberative process that considers all factors (i.e., land use dynamics in Brazil in our case) is fundamental to minimize inaccuracies in model outputs.

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[39] UNICA wishes to acknowledge the invaluable input of various scholars in the preparation of this section. Among them are Prof. Angelo Costa Gurgel (University of São Paulo's College of Economics, Business Administration, and Accounting – FEA-RP/USP), André Meloni Nassar (President of the Brazilian Institute for International Trade Negotiations – ICONE), Marcelo Moreira (ICONE), Laura Barcellos Antoniazzi (ICONE), Leila Harfuch (ICONE), Luciane Chiodi (ICONE), and Prof. Weber do Amaral (USP). With their assistance, and that of many other scholars, our comments would not have been possible.

[40] See http://www.arb.ca.gov/lists/lcfs-lifecycle-ws/74-phd_lcfs_final_feb_2009.pdf

[41] A recent workshop organized by Environmental Defense Fund (EDF) and the Energy Biosciences Institute (EBI) with over 120 experts noted the complex uncertainties associated with modeling lifecycle greenhouse gases. The report's summary states, "The rapidly evolving science and policy of GHG reductions involves a dizzying array of sectors and technologies that need to be managed. Fuels lifecycle modeling is a dynamic and rapidly evolving field that is struggling to narrow the many uncertainties regarding the direct and indirect GHG impacts of a rapidly growing variety of biomass feedstocks, production methods, and conversion processes. Indeed, little is known about the GHG impact of a wide range of cropping systems for biomass that might be employed to produce low carbon fuels." See page three of report summary, "Measuring and Modeling the Lifecycle Greenhouse Gas Impacts of Transportation Fuels," EDF & EBI's University of California Berkeley (July 2008), available online at http://www.edf.org/fuels_modeling_workshop.

Recognizing that CARB appears determined to push this regulation despite widespread concerns about the accuracy of its ILUC calculations, we are seeking to address what we see as the most significant miscalculations of CARB's ILUC analysis.

This section is divided into three parts: (A) indirect land use change, (B) carbon intensity calculations, and (C) proposed scenarios. First, we provide comments to improve the GTAP analysis, especially with respect to achieving more a accurate representation of Brazilian agriculture in the model. Then, we present alternative methodologies to calculate carbon emissions as well as emissions factors from Brazil that we believe should be adopted by ARB. Finally, we bring together the results in terms of land use change and carbon intensity according to the alternatives presented in this section.

A. Indirect Land Use Changes

We believe that any attempt to include the impact of market-mediated, indirect land use change (ILUC) in emissions calculations must take into account the "interplay of economic, institutional, technological, cultural and demographic variables" inherent with land use change.[42]

1. Systematic Sensitivity Analysis

The ILUC effects measured by CARB in terms of carbon intensity (gCO_2e/MJ) were estimated using a Computable General Equilibrium (CGE) model, the GTAP model, well known and recognized as a state-of-the-art model in this field. CGE models are usually designed to compare alternative scenarios and its economic results, mostly in terms of welfare changes. In this way, they are suitable to address economic impacts from exogenous changes in some simplified artificial economy, built as a "lab" for simulations.

CGE models give the direction (sign) of changes from the simulated scenarios, identify the best and worst cases and ranking of the results, give an idea about the magnitude or relative scale of the impacts, and allow to track (or explain) the economic reasons leading to the results. Therefore, modelers avoid putting too much weight or credence on the precise numbers produced.

The choice of an interval of results is a widely recognized method to use the model results, and central numbers are used merely to simplify the explanation about results and conclusions from the modeling exercise. Given the uncertainty or even lack of scientific knowledge about many parameters used in the model, an extensive sensitivity analysis is always recommended when using numbers from CGE models to policy implementation, as discussed and applied in Morgan

[42] B.L. Turner II, Eric F. Lambin, Anette Reenberg, The emergence of land change science for global environmental change and sustainability, PNAS vol. 104, no. 52 (Dec. 26, 2007).

and Henrion (1990)[43], Webster et al. (2003)[44], DeVuyst and Preckel (1997)[45] and Pearson and Arndt (2000)[46].

In this way, we believe that the single carbon intensity number generated from the GTAP implementation of only five scenarios (for sugarcane ethanol) or seven scenarios (for corn ethanol) is scientifically weak and a legally questionable method to represent the complexity and broad possible pathways related to land use changes from any kind of biofuel expansion.

We strongly urge CARB that prior to implementation of this regulation a Systematic Sensitivity Analysis[47] should be applied on the analysis, considering the possible range and probability distribution functions of key parameters. Given our team of scholars and researchers, and also our partnership with Brazilian research institutions, we are able to offer some help to CARB in setting up and implementing, or even performing, such systematic sensitivity analysis for sugarcane ethanol.

2. Size of the Shock

CGE models are used to perform analysis of policy instruments (e.g., taxes and subsidies), technological changes, and changes in resources supply. It is uncommon to find in the CGE literature demand shocks, as implemented by CARB. That said, we were even more surprised to see that CARB chose such large demand shocks.

The basis for the choice of the size of the sugarcane ethanol shock (2 billions of gallons) is not explained in the Staff Report or during public hearings. Such an exaggerated shock in terms of the potential of production being exported from Brazil in the next decade is not justified by recent trends and available analysis. Total Brazilian ethanol exports have expanded by less than 850 million gallons from 2001 to 2007, according to the Ministry of Mines and Energy.[48] A shock of 2 billion gallons represents about an increase in ethanol demand from Brazil of about 55 percent! As evidence that the size of the shock fundamentally alters results, when we ran the GTAP model used by CARB with a slightly smaller shock (increase ethanol demand from Brazil in 1.5 billion of gallons), we observed smaller land use changes and smaller ILUC carbon intensity numbers (Table 1).

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[43] Morgan, M.G., and M. Henrion, 1990. Uncertainty : a guide to dealing with uncertainty in quantitative risk and policy analysis. Cambridge University Press, Cambridge.

[44] Webster M., C. Forest, J. Reilly, M. Babiker, D. Kicklighter, M. Mayer, R. Prinn, M. Sarofim, A. Sokolov, P. Stone, C. Wang, 2003. *Climatic Change* 61(3): 295-320.

[45] DeVuyst, E.A., P. V. Preckel, 1997. Sensitivity analysis revisited: A quadrature-based approach. *Journal of Policy Modeling* 19(2):175-185.

[46] Pearson, K., C. Arndt, 2000. Implementing Systematic Sensitivity Analysis Using GEMPACK. GTAP Techinical paper 3, Center for Global Trade Analysis, Purdue University, Indiana.

[47] Additional information on "Systematic Sensitivity Analysis" can be obtained from Implementing Systematic Sensitivity Analysis Using GEMPACK (2000) by Pearson, Ken and Channing Arndt, GTAP Technical Paper No. 03.

[48] Official data for ethanol supply and demand balance in Brazil is available online at http://www.mme.gov.br/site/menu/select_main_menu_item.do?channelId=1432&pageId=17036.

Table 1: GTAP modeling results for sugarcane ethanol land use change with alternative shock sizes (Scenario A)

Shock size	2 billions gallons	1.5 billion gallons
Total land converted (million ha)	1.28	0.92
Forest land (million ha)	0.43	0.31
Pasture land (million ha)	0.85	0.61
Brazil land converted (million ha)	0.89	0.64
Brazil forest land (million ha)	0.30	0.22
Brazil pasture land (million ha)	0.59	0.42
ILUC carbon intensity (gCO2e/MJ)	*56.7*	*50.6*

Sources: CARB documentation and author's calculation (GTAP outputs available at http://www.iconebrasil.org.br/).
Note: CO2 emissions were calculated using emission factors from the array EMISSCTR. The amount of forestry and pastureland displaced was multiplied by the emission factors of the mentioned array. Forest gained and crops were not taken into consideration.

In short, as the size of the shock really matters in terms of ILUC, **we strongly recommend that CARB use a more realistic projection of the increase in the demand of sugarcane ethanol from Brazil, taking into consideration aspects such as the total production capacity in place and the investments to expand the production. And, as noted above, CARB should perform systematic sensitivity analysis of the alternative shock sizes, given the uncertainty about the incremental capacity in the next decades.** We again can help to project the increase in production capacity in Brazil and also to implement the shocks in GTAP.

3. Cattle Intensification

The usefulness and desirability of an economic model resides in its capacity of representing reality using the simplest possible representation of the phenomena under study (approach, theory, equations, relationships). There is strong evidence of cattle intensification occurring the same time as the expansion of sugarcane, oilseeds, coarse grains, and commercial forests taking place in Brazil since 2001. In the last decade or so, comparing data from the 1996 and 2006 Agricultural Censuses presented in Table 2, it can be observed that pasture land has decreased and cattle herd have increased. Following the same trend, beef production and exports have also increased despite the reduction in pasture land. Also, a recent study has shown that most of the sugarcane expansion is occurring on old pasture land, although the crop is also expanding over agriculture land (Nassar et al., 2008)[49].

[49] Nassar, A.M., Rudorff, B. F. T., Antoniazzi, L. B., Aguiar, D. A., Bacchi, M. R. P. and Adami, M, 2008. Prospects of the Sugarcane Expansion in Brazil: Impacts on Direct and Indirect Land Use Changes. In: Sugarcane Ethanol: Contributions to Climate Change Mitigation and the Environment. Zuurbier, P, Vooren, J (eds). Wageningen: Wageningen Academic Publishers.

Table 2: Brazilian Agriculture Census: Pasture Area, Cattle Herd and Pasture Productivity by Regions

	1996			2006		
	Pasture Area (ha)	Cattle Herd (heads)	Stocking Rate (heads/ha)	Pasture Area (ha)	Cattle Herd (heads)	Stocking Rate (heads/ha)
Brazil	177,700,469	153,058,275	0.86	172,333,073	169,900,049	0.99
Region North	24,386,622	17,276,621	0.71	32,630,532	31,233,724	0.96
Region Northeast	32,076,340	22,841,728	0.71	32,648,537	26,033,105	0.80
Region Southeast	37,777,049	35,953,897	0.95	32,071,529	34,994,252	1.09
Region South	20,696,546	26,219,533	1.27	18,145,573	23,888,591	1.32
Region Center-West	62,763,912	50,766,496	0.81	56,836,902	53,750,377	0.95

Source: IBGE, Agricultural Census, available at http://www.sidra.ibge.gov.br/bda/pesquisas/ca/default.asp?o=2&i=P
(Preliminary data for 2006)

As can be seen in Table 2, the higher number of animals per unit of land (stocking rate index) demonstrates that pasture yields are being improved. Higher stocking rate and higher beef production suggests that pasture yields tend to grow when more pasture land is released for crops and other uses, which means that pasture yields respond strongly to cattle price changes. The low level of pasture intensification reinforces argument that there is still considerable room for even greater improvements on pasture intensification in Brazil. In other words, this data suggests that pasture intensification is elastic to price. An empirical analysis of the pasture yield (measured by the stocking rate index) response to prices is presented in Table 3. According to ICONE's calculations, pasture yield price elasticity in Brazil is 0.6, much higher than the crop yield elasticities used in the GTAP scenarios presented in the CARB Staff Report.

Table 3: Result for Pasture Yield with respect to Real Prices, in logarithm [50]

	Coefficient (1)	t-Statistic	Probability
Real Price (2)	0.60	8.83	0.000000
Dummy for High Yield (3)	0.64	12.62	0.000000
Constant	-2.26	-9.46	0.000000
R-squared	0.92		
Adjusted R-squared	0.90		
Number of Observations	28		

Notes: (1) Using Pesquisa Pecuaria Municipal (PPM) for cattle herd and pasture area from Agricultural Census (1996 and 2006), both from IBGE.; (2) Real prices for 1996 and 2006 for 14 Brazilian Regions. (3) Dummy variable for regions that had yield higher than one in 1996.
Source: ICONE, underlying data and regressions available at http://www.iconebrasil.org.br or upon request.

Such phenomena — high response of pasture yields to prices changes — must be captured by the GTAP model. However, the results from GTAP about land use changes due to the increase in sugarcane ethanol production show a strong decrease in pasture land associated to strong reduction in forest land. Given our knowledge about the dynamics of agriculture in Brazil, CARB results suggest that the pasture land is being replaced by sugarcane and other crops, and that pasture land is advancing onto forest areas. This anomaly in CARB results may be due to the small elasticity of crop yields with respect to area expansion, which requires significantly more

[50] We can provide any information regarding the results presented in Table 3 for CARB, as well as the data and the regressions used to estimate the parameters.

pasture area to place a new sugarcane plantation or recover the displaced production of other crops by sugarcane. We will address our concerns about this elasticity below, but first we believe CARB must address how livestock production incorporated into the model.

Another modeling issue that is generating very low intensification is related to the representation of the livestock production technology in the model. One aspect of such technology is the possibility of imperfect substitution among several primary factors and inputs, as described in Birur et al. (2008).[51] The model assumes a low elasticity of substitution (0.2) among all primary factors (natural resources, land, labor, and a capital-energy composite factor) in all regions of the model. If we look at the reality on the ground and compare the technology of livestock production in Brazil and the United States, we will observe a much more intensified process in United States and a very extensive use of land in Brazil. In terms of modeling, it would imply somewhat higher elasticity of substitution among primary factors in Brazil than in United States. As an experiment, in Table 4, we have implemented the GTAP model used by CARB with a higher value (0.4) for this elasticity in Brazil than in other regions (0.2), and have seen substantial differences in the results, with higher use and intensification of pasture land in Brazil and less deforestation. The 0.6 pasture yield elasticity presented before reinforces the argument that the elasticity of substitution for pasture should be higher in Brazil.

Table 4: GTAP modeling results for sugarcane ethanol land use change with alternative elasticity of substitution among primary factors in livestock production, Scenario A

Elasticity of Substitution among primary factors in livestock production	0.2 everywhere	0.2 everywhere but 0.4 in Brazil
Total land converted (million ha)	1.28	1.33
Forest land (million ha)	0.43	0.20
Pasture land (million ha)	0.85	1.13
Brazil land converted (million ha)	0.89	0.95
Brazil forest land (million ha)	0.30	0.08
Brazil pasture land (million ha)	0.59	0.88
ILUC carbon intensity (gCO2e/MJ)	56.7	39.3

Note: CO2 emissions were calculated using emission factors from the array EMISSCTR. The amount of forestry and pastureland displaced was multiplied by the emission factors of the mentioned array. Forest gained and crops were not taken into consideration.
Sources: CARB documentation and author's calculation (GTAP outputs available at http://www.iconebrasil.org.br/).

In sum, we strongly believe that the GTAP model used by **CARB should take into consideration the higher elasticities of substitution among primary factors in the livestock production sector in Brazil, where livestock intensification is potentially high and is occurring in practice.** We will be working on estimating such elasticity and implementing the GTAP model with such higher elasticity.

[51] Birur, D.K., T.W. Hertel and W.E. Tyner, 2008. "Impact of Biofuel Production on World Agricultural Markets: A Computable General Equilibrium Analysis." GTAP Working Paper No. 53, Center for Global Trade Analysis. Purdue University, West Lafayette, IN. Available at: https://www.gtap.agecon.purdue.edu/resources/download/4034.pdf

4. Elasticities and Scenarios

As our experts discussed with CARB staff recently, the combination of different elasticities in alternative scenarios has concerned us greatly. When we compare CARB scenarios across alternative biofuels feedstock, it is clear that the choice of elasticities was inconsistent, if not haphazard, as was also the number of scenarios implemented. As example, the central value of the elasticity of crop yield was 0.4 in the case of the seven corn scenarios, but it was only 0.25 for all sugarcane ethanol and soybean biodiesel scenarios. As this elasticity is applied to all crops, there is little justification to applying higher numbers in corn scenarios than in other feedstock scenarios.

CARB staff has explained to us that the uneven application of elasticities was not on purpose but a result of having spent too much time trying various corn scenarios. As a consequence, the staff informed us, the modelers generated more runs and were able to figure out that the 0.25 for crop yield elasticity was a "better" value to assume. From a modeling testing and calibration perspective, it is easy to understand the pressure and various runs. Nevertheless, there remains no credible explanation as to why the "better" choice about elasticities was not applied in the same way across alternative biofuels feedstock scenarios. Uneven application of the model parameters yields results that should not be used.

As a result, **we strongly urge CARB staff and experts to run the same number of scenarios and same combination of elasticities for all biomass sources** to be able to achieve a fair and balanced process.

5. Elasticity of Crop Yields with Respect to Area Expansion

Crop Yields with Respect to Area Expansion expresses the yields that will be realized from newly converted lands relative to yields on acreage previously devoted to that crop. On page IV-20 of the Staff Report, it is asserted that: "…because almost all of the land that is well-suited to crop production has already been converted to agricultural uses, yields on newly converted lands are almost always lower than corresponding yields on existing crop lands."

The fact that almost all of the land well suited to crop production has already been converted can be true in the United States and the European Union. But, in many other parts of the world, as in Latin America, and particularly Brazil, there is considerable, potentially well-suited agricultural area for crop expansion. Some studies have shown this potential in terms of land available to agriculture or biomass production, as Chou et al. (1977)[52], Edmonds and Reilly (1985)[53] and Bot et al. (2000)[54] show us. Such research suggests that the elasticity of crop yields with respect to area expansion is *potentially larger* in those regions with *larger land availability*.

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[52] Chou, M., D. P. Harmon Jr., H. Kahn, and S. H. Wittwer, 1977. *World Food Prospects and Agricultural Potential*. New York: Praeger, 316 p.
[53] Edmonds, J. A., and J. Reilly, 1985. *Global Energy: Assessing the Future*. New York: Oxford University Press.
[54] Bot, A. J., F. O. Nachtergaele and A. Young, 2000. *Land Resource Potential and Constraints at Regional and Country Levels*. Rome: Food and Agriculture Organization of the United Nations, World Soil Resources Report 90.

More importantly, the GTAP model is highly sensitive to the value of this elasticity since the indirect land use change carbon intensity can change more than 75% when this elasticity varies from 0.25 to 0.75. We note that CARB staff chose values ranging from 0.5 to 0.75 (except one scenario for sugarcane ethanol in which 0.8 was used for Brazil) to be used in the GTAP model runs though there is no detailed explanation as to the basis of such decision. In fact, from a microeconomic perspective, we would hardly expect investments in new areas if the yield of the new crop would be half of the traditional area, as assumed with an elasticity of 0.5 proposed by CARB staff.

Empirical data in Brazil shows that the crop yield elasticity with respect to area expansion should be around 0.9-0.95, rather than in the range of 0.5 to 0.75. The analysis of the empirical data is presented in Table 5, but first we outline the steps that were used to prepare the data:

a. Considering the time horizon from 2001 to 2007, the 558 IBGE microregions were divided in new and traditional areas according to the growth in planted area for crops and allocated area for pastures. The 10 percent largest growth microregions were considered new areas and the remaining microregions the traditional areas.

b. Yields for new and traditional areas are compared to the corresponding year. For example, in 2007 the sugarcane yield in the new areas was 83.4 tons per hectare, while in the traditional areas it was 64.8 tons per hectare.

c. The measure that represents the yield elasticity with respect to the area expansion is presented in the last column of Table 5 ("2007-2001"). The values in this column are the ratio of the relation between 2007 and 2001 yields (new and traditional). Intuitively, in the case of sugarcane, this value suggests that a hectare in the new area of the crop has a yield that is 95 percent of the yield in the traditional area, if the increment would have taken place in the traditional area.

Table 5: Yield Elasticity with Respect to Area Expansion: Estimates for Brazil
(tons per ha for crops and animals per ha for pasture)

	2001			2007			2007-2001
Activities[1]	Yield New Areas	Yield Traditional Areas	New/ Traditional Areas	Yield New Areas	Yield Traditional Areas	New/ Traditional Areas	New Area/Traditional Area[2]
Sugarcane	76.68	56.86	1.35	83.38	64.78	1.29	0.95
Soybean	2.77	2.59	1.07	2.84	2.75	1.03	0.97
Corn	3.46	3.17	1.09	3.70	3.74	0.99	0.91
Rice	3.42	3.09	0.91	3.80	3.79	1.00	1.11
Pasture [3]	0.76	0.95	0.81	1.34	1.12	1.20	1.48

Sources: (1) Considering 10% of the 558 IBGE microregions that had the largest area increase between 2001 and 2007 (based on Pesquisa Agricola Municipal – IBGE data); (2) Yield relation for new areas with respect to traditional ones due to expansion between 2001and 2007. This measure is the equivalent of the crop yield elasticity with respect to area expansion; (3) Pasture yield is the ratio between cattle herd (based on Pesquisa Pecuaria Municipal – IBGE data) and pasture area (based on Brazil's Agricultural Census) for the years 1996 and 2006. The expansion was calculated based on the increase on cattle herd from 2001 to 2006.

We note that although there is no pasture yield elasticity with respect to area expansion, we also calculated that measure to show that new areas of pasture, as it is the case for crops, produce the same as the traditional areas.

In short, based on this analysis, **we recommend that CARB run all scenarios for Brazilian sugarcane ethanol using 0.90 crop yield elasticity with respect to area expansion, in order to avoid overestimations of land conversion for Brazil.**

6. Adjustments for sugarcane yield

The Staff Report suggests that the GTAP results on sugarcane land use change were updated to reflect the 8.2 percent increase in Brazilian sugarcane yields observed between 2001 and the average for the 2006-2008 time period. However, the physical yield of the sugarcane *plant* is not the only source of yield gains in the production of sugarcane ethanol. The yield gain in Total Recoverable Sugars (TRS) should also be taken into account. According to the Ministry of Agriculture, Livestock and Supply (2007)[55], the TRS per ton of sugarcane was 138.7 in 2001 and 149.47 in 2006 — an increase of 8.3 percent. (We note that this result would be even higher if official data for 2007 and 2008 were already available.)

TRS is a measure of the energy content of the sugarcane.[56] Higher TRS are obtained over time due to different improvements in sugarcane production, such as better varieties and harvesting period. TRS is converted into sugar or ethanol using technical factors. According to CONAB,[57] the following factors are used for ethanol:

1 liter of anhydrous ethanol	⇒	1.7651 kg of TRS
1 liter of hydrous ethanol	⇒	1.6913 kg of TRS
1 kg of sugar	⇒	1.0495 kg of TRS

Using those factors, the average ethanol production per hectare for 2001 was 5,457 liters [(69.44 x 138.7)/1.7651] while for 2006-2008 the average increased to 6,365 liters [(75.13 x 149.47)/1.7651]. In other words, including the yield gains in TRS, the ethanol yield has increased by 16.6 percent (6,362/5,457 = 1.166). Consequently, **we recommend CARB adjust sugarcane land use change to reflect the total gains in yield, which is 16.6 percent,** rather than 8.2 percent.[58]

[55] See table 5 of the following study: Ministério da Agricultura, Pecuária e Abastecimento. 2007. Balanço Nacional da Cana-de-Açúcar e Agroenergia. Edição Especial de Lançamento (available at www.feagri.unicamp.br/energia/bal_nac_cana_agroenergia_2007.pdf).

[56] Technical explanation about TRS can be obtained in the following publication: Macedo, I. C (organizer). 2007. Sugar Cane's Energy: Twelve Studies on Brazilian Sugar Cane Agribusiness and its Sustainability. Berlendis & Vertecchia and UNICA – União da Agroindústria Canavieira do Estado de São Paulo. São Paulo (available at http://english.unica.com.br/multimedia/publicacao/). See also SEABRA, J. E. A. Análise de opções tecnológicas para uso integral da biomassa no setor de canade-açúcar e suas implicações. Campinas: Universidade Estadual de Campinas, Faculdade de Engenharia Mecânica, 2008 (PhD Thesis).

[57] See page 45 of the following study: Companhia Nacional de Abastecimento (CONAB). 2008. Perfil do Setor de Açúcar e do Álcool no Brasil. Brasília (available at http://www.conab.gov.br/conabweb/download/safra/perfil.pdf).

[58] When we presented this argument in a meeting with ARB, it was raised a question about reduction in bagasse production based on the argument of a mass conservation. The argument was that if more energy is extracted from a tone of sugarcane, it

B. Carbon Intensity Calculations

In addition to the improvements in the GTAP assumptions and parameters described above, it is necessary to adjust the carbon emissions factor for each type of land use change. The comments below are an attempt to improve the carbon intensity calculations for sugarcane ethanol scenarios. We suggest three main target areas for optimizing the model outcomes.

1. Carbon Data for Latin America Used as Default Value for Brazil

Considering that most of the land use change due to sugarcane expansion takes place in Brazil (62% as an average of the 5 scenarios), it is essential that emission factors values used for Brazil are accurate. However, the emission factors (as CO2 equivalent) used in the CARB analysis came from the Woods Hole data, which considers Latin America (a region twice the size of Brazil) as whole. This approximation results in higher values than the ones observed in Brazil, where considerable more research on carbon stocks is available.

Peer reviewed data for Brazilian ecosystems are compared with Woods Hole default values, as well as data for pastureland carbon stocks, in Tables 6 and 7. Data from Amaral at al. (2008)[59] indicate total carbon stocks in different natural vegetation range from 71.5 Mg C/ ha for Cerrado (typical savannah) to 271.0 Mg C/ha for tropical forest. The same study indicates total carbon stocks in pastureland range from 42.0 Mg C/ha in degraded pastures to 58.5 Mg C/ha in managed pasture.

Table 6: Carbon stocks in different land uses, considering both above and below content, in Mg C per hectare

Land use	Above	Below	Total
Tropical evergreen forest	200	98	298
Tropical seasonal forest	140	98	238
Tropical open forest	55	69	124
Temperate evergreen forest	168	134	302
Temperate seasonal forest	100	134	234
Grassland	10	42	52
Desert	6	58	64

Source: Woods Hole (http://www.arb.ca.gov/fuels/lcfs/ef_tables.xls)

should expected that less bagasse is produced and then less bagasse should be taken into account in the co-generation. The reality is that the amount of bagasse informed for the cogeneration in the GREET analysis is based on current numbers, which means that it is the bagasse production with higher TRS. If the TRS would not have grown from 2001 to 2006, more bagasse would be available for cogeneration. See out comments in Section II under sugarcane farming.

[59] Amaral, W. A. N.; Marinho, J. P.; Tarasanthy, R.; Beber, A.; Giuliani, E. "Environmental sustainability of sugarcane ethanol in Brazil." In: Sugarcene ethanol: contribution to climate change mitigation and the environment. Zuurbier, P; Vooren, J. van de (eds). Wageningen: Wageningen Academic Publishers, 2008.

Table 7: Carbon stocks in different land uses, considering both above and below content, in Mg C per hectare

Land use	Above	Below	Total
Tropical forest	200	71	271
Cerradão - Woody Savannah	33.5	53	86.5
Cerrado - Typical Savannah	25.5	46	71.5
Campo Limpo - Grassland Savannah	8.4	72	80.4
Managed Pasture	6.5	52	58.5
Degraded Pasture	1.3	41	42.3

Source: Amaral et al. (2008)

Given the availability of peer reviewed data for carbon stocks in Brazil, we recommend that CARB adopt the data in Table 7 in its emissions values.

2. Forest Lost and Gained

It is not clear how the carbon factors for forest gained were considered in CARB calculations. Such coefficients should be multiplied by the area of forest increasing in some GTAP regions to estimate the amount of carbon being sequestered, since land use changes from pasture to forest would imply a net carbon uptake. However, the carbon coefficients in the model ("GTAP array EMISSCTR") do not include carbon factors related to forest gained and then, the carbon emissions being calculated by GTAP do not account for the model results about reforestation. ***We recommend that forest gained be considered as carbon uptake.***

3. Crops Carbon Emission Factors

The current CARB assumption does not consider any carbon uptake from crops, even though there is ample literature on crop carbon uptake from above and below ground biomass. Unless CARB can provide evidence as to why a crop's carbon update should not be considered in the modeling, we believe CARB must either (a) use crop-specific default values for crops that show significant area variation or (b) use default values for the most impacting crop on land use changes (i.e., sugarcane).

Sugarcane expansion scenarios should use the carbon content specific to this crop because most of the crop variation is related to sugarcane. Considering the most conservative estimate for sugarcane uptake, which considers just the below ground soil content, carbon stock would be an average of 49.25 Mg C/ha (IPCC, 2006).[60] But we note that IPCC does not recommend the use of general default values when country specific data are available, as it is the case of Brazil. In fact there is a vast and well-documented of literature on carbon uptake from sugarcane (Cerri, 1986[61]; Macedo, 2008[62]).

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[60] IPCC, 2006. Guidelines for National Greenhouse Gas Inventories, prepared by the National Greenhouse gas Inventories Programme. In: H. S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe (eds.) Japan: IGES.

[61] Cerri, C. C., 1986. *Dinâmica da Materia Orgânica do Solo no Agroecossistema Cana-de-Açucar*. Tese (livre-docencia). Escola Superior de Agricultura "Luiz de Queiroz", Piracicaba, SP, Brasil.

Table 8: Carbon stocks in different crops, considering both above and below content, in Mg C per hectare

	Below[(1)]		**Above[(2)]**	TOTAL[(3)]
	LAC	HAC	Vegetation	
Maize	31.0	42.0	3.9	40.4
Soybean	31.0	42.0	1.8	38.3
Cotton	23.0	31.0	2.2	29.2
Sugarcane[(4)]	41.5	57	17.4	66.65
Average	*31.63*	*43.00*	*6.33*	*43.64*

Sources: (1): IPCC, 2006. Guidelines for national greenhouse gas inventories, prepared by the National Greenhouse gas Inventories Programme. In: H. S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe (eds.) Japan: IGES; (2): Macedo, I. C.; Seabra, J. E. A., 2008. Mitigation of GHG emissions using sugarcane bioethanol. In: Sugarcane ethanol: contribution to climate change mitigation and the environment. Zuurbier, P; Vooren, J. van de (eds). Wageningen: Wageningen Academic Publishers.; (3): it was considered the average of LAC and HAC values; (4): the average of burned and unburned sugarcane was considered.

In conclusion, regardless of the alternative used, **carbon emission factor for crops should represent a net carbon uptake when it replaces pasture. Furthermore, both above and below ground carbon must be considered, as was done in the other land use estimations.**

C. Proposed Scenarios for CARB's ILUC Calculations

This section presents a set of alternative scenarios combining the suggestions discussed in the previous parts of this Section on ILUC. The scenarios presented below are divided in two groups:

(i) Table 9 shows the results of land use change and carbon intensity resulting from changes made in the parameters of the GTAP (shock size, elasticity of substitution among primary factors in livestock production, elasticity with respect to area expansion, adjustments for sugarcane yields) that are proposed above; and

(ii) Table 10 depicts the results in terms of carbon intensity departing from the land use change scenario presented in Table 9 and makes the necessary adjustments in carbon uptake from forest gained and from crops expansion.

The results presented in Table 9 are based on a shock size of 1.5 billion gallon, on an elasticity of substitution among primary factors in livestock production of 0.4 for Brazil and 0.2 in other countries, on a crop yield elasticity with respect to area expansion of 0.9 and on an adjustment for sugarcane and TRS yields of 16.66%. **The carbon intensity for that scenario, accounting only for the emissions associated with forestry and pastures conversion, is 25.3 gCO2e/MJ, about half of the values proposed in Table IV-12 of the proposed regulation.**

[62] Macedo, I. C.; Seabra, J. E. A., 2008. Mitigation of GHG emissions using sugarcane bioethanol. In: *Sugarcane ethanol: contribution to climate change mitigation and the environment*. Zuurbier, P; Vooren, J. van de (eds). Wageningen: Wageningen Academic Publishers.

Table 9: GTAP Modeling Results for Sugarcane Ethanol Land Use Change with Alternative Scenarios

1.	Shock size	*1.5 billion gallons*
2.	Elasticity of substitution among primary factors in livestock production	*0.2 everywhere but 0.4 in Brazil*
3.	Crop yield elasticity w/ area expansion	*0.9*
4.	Adjustment for sugarcane and TRS yields	*16.66%*
	Total land converted (million ha)	0.60
	Forest land (million ha)	0.01
	Pasture land (million ha)	0.59
	Brazil land converted (million ha)	0.35
	Brazil forest land (million ha)	-0.07
	Brazil pasture land (million ha)	0.42
	ILUC carbon intensity (gCO2e/MJ)	**25.3**

Source: CARB documentation and author's calculation (GTAP outputs available upon request).
Note: *CO2 emissions were calculated using emission factors from the array EMISSCTR. The amount of forestry and pastureland displaced was multiplied by the emission factors of the mentioned array. Forest gained and crops were not taken into consideration.*

Departing from the scenario drawn in Table 9, a set of three calculations for carbon intensity are presented in Table 10. The underlying principles of all of them are the same: forest gained and crops expansion should be taken into account as a carbon uptake, following the comments above. In the case of forest gained, there is no difference in the calculations as the emission factors obtained in the array EMISSCTR were multiplied by the forest gained and accounted as a carbon uptake.

The different alternatives rely on crops calculations. In *Alternative 2*, the increase in crop area is multiplied by 18 $MgCO_2e$/ha cited in the file "ef_tables.xls, sheet GTAP EFs." However, as argued in the previous section, those factors do not represent the carbon uptake associated to sugarcane, oilseeds and coarse grains. Even with very low emission factors for crops, it can be observed that the sugarcane carbon emission is strongly reduced (12.4 gCO_2e/MJ) in comparison with the departing scenario (25.3 gCO_2e/MJ).

More reliable carbon emissions for sugarcane in Brazil are used in *Alternative 3*. The emission factor of this alternative is 66.65 MgC/ha (244MgCO2e/ha), as presented in Table 8. Both C in vegetation and below ground were taken into account in this factor. In that alternative, carbon emissions became positive, confirming that sugarcane is uptaking carbon, rather than emitting.

Alternative 4 is based on an average of above and below carbon emissions factors of the crops presented in Table 8 (43.64 MgC/ha), without differentiating sugarcane in Brazil as was the case in Alternative 3. Negative emissions were also obtained in that alternative.

Although Tables 6 and 7 clearly show that carbon emissions factors used in Woods Hole for Latin America overstates emissions in Brazil, because emission factors for Brazilian ecosystems are lower, we decided not to change emissions factors for forests and pasture lands in the alternative scenarios presented in this section. However, it is worth mentioning that more precise (specific data already available in peer-review literature) carbon emissions factors should be used for Brazil, given that the majority of the sugarcane land use change is taking place, for all scenarios, in Brazil.

Table 10: Carbon Intensity Using Land Use Change from Table 9 and Alternative Scenarios for Carbon Uptake

Alternative Scenarios	ILUC carbon intensity (gCO_2e/MJ)
1. Departing Scenario (Table 9)	25.3
2. Departing Scenario + Carbon Uptake of Forest Gained (array EMISSCTR) + Carbon Uptake of Crops from GTAP Efs-ef_tables.xls (18Mg CO2e/ha)	12.4
3. Departing Scenario + Carbon Uptake of Forest Gained (array EMISSCTR) + Carbon Uptake of Crops Rest of World from GTAP Efs-ef_tables.xls (18Mg CO2e/ha) + Carbon Uptake for Sugarcane Brazil from Table 8 (244Mg CO2e/ha).	-9.4
4. Departing Scenario + Carbon Uptake Forest Gained (array EMISSCTR) + Carbon Uptake Crops from Table 8 (160Mg CO2e/ha)	-10.7

Source: Author's Calculations available upon request

The large variations in the values presented in Table 10 makes clear that both for land use change and for carbon intensity calculations results are hihgly sensitive to criteria and parameters used. Not only changes in GTAP parameters lead to strong reductions in land converted as a result of sugarcane expansion, but also the inclusion of the carbon uptake in forest gained and crops expansion may revert carbon emissions to carbon uptake.

Given that Brazilian agriculture dynamics are a significant determinant in land use and that the analysis above — done with support of the leading agricultural economists in Brazil — runs counter to CARB's preliminary results, **we strongly urge CARB to revisit the methodologies used in the land use change modeling carefully**.

With respect to GTAP analysis, the revision should focus on improvements to better represent the complex dynamics of the Brazilian agriculture. With respect to carbon intensity calculations, CARB should revise all carbon emission factors using specific, credible values for Brazilian ecosystems as well as carbon credits resulting from forest gained and crops area expansion. Once those improvements are implemented, we fully expect that CARB would conclude that Brazilian sugarcane ILUC is marginal, as we endeavored to demonstrate in this document.

IV. CONCLUSION

We commend CARB for its assessment of the lifecycle emissions associated with the production of sugarcane ethanol. However, we believe the analysis assessment requires a comprehensive update with more accurate and realistic data from current experience and anticipated trends in Brazil.

As for GREET-CA modeling, perhaps no other issue deserves greater attention than the credits resulting from the combination of reduced field burning, increased mechanization, and improved boiler efficiency, which were absent in CARB's analysis.

As for estimates of indirect land use changes based on GTAP modeling, while we strenuously disagree with the assertions that ILUC can be accurately calculated at this moment, we believe a number of critical elements are absent from the Staff Report analysis, particularly an explanation of the assumptions made, supporting evidence for elasticities used, and understanding of land and cattle dynamics in Brazil.

It is imperative that these land use issues be properly addressed in order to have a robust and meaningful calculation of the carbon intensity of biofuels. Without a doubt an ILUC penalty of 46 g CO_2/MJ for sugarcane ethanol has no scientific basis. As evidenced by the level of analysis of this letter, there may well be carbon credits generated in sugarcane production if the model is reasonably calibrated.

We hope this letter will contribute to improving the development of the LCFS in California and remain at your disposal to answer any questions you or your colleagues may have.

Sincerely,

Marcos S. Jank
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