December 21, 2022

Cheryl Laskowski, Chief
Transportation Fuels Branch
California Air Resources Board
1001 I Street
Sacramento, CA 95814

Dear Dr. Laskowski:

The Clean Fuels Alliance America (Clean Fuels)[1] and California Advanced Biofuels Alliance (CABA)[2] appreciate the opportunity to provide comments on the November 9th Low Carbon Fuel Standard (LCFS) workshop to discuss potential changes to the LCFS program. Clean Fuels and CABA have been longtime supporters of the state's overall climate and air quality improvement goals and have collaborated frequently with CARB staff toward achieving those goals. We continue to support California's efforts to decarbonize its economy, especially the transportation sector, with a comprehensive all-of-the-above suite of measures. These comments are also supported by ADM[3], the National Oilseed Processors Association (NOPA)[4] and the American Soybean Association (ASA).[5]

[1] Clean Fuels (formerly the National Biodiesel Board) is the U.S. trade association representing the entire supply chain for biodiesel, renewable diesel, and sustainable aviation fuel. The name change reflects our embrace of all the products Clean Fuels members and the U.S. industry are producing, which include biodiesel, renewable diesel, sustainable aviation fuel, and Bioheat® fuel for thermal space heating. Our membership includes over 100 farmers, producers, marketers, distributors, and technology providers, and many are members of environmental organizations supportive of state and local initiatives to achieve a sustainable energy future.

[2] California Advanced Biofuels Alliance is a not-for-profit trade association promoting the increased use and production of advanced biofuels in California. CABA represents biomass-based diesel (BMBD) feedstock suppliers, producers, distributors, retailers, and fleets on state and federal legislative and regulatory issues.

[3] ADM is a global leader and innovator in biomaterials that develops world-class solutions, such as biodiesel. Starting from the producer in the field, ADM's value chain spans crop origination, processing, manufacturing and delivery of biomaterials.

[4] Founded in 1930, the National Oilseed Processors Association is a national trade organization representing the U.S. soybean, canola, flaxseed, safflower seed and sunflower seed crushing industries. Our members include 13 companies that operate a total of 61 soybean and 5 softseed solvent extraction plants across 22 states and produce meal and oil used in human food, animal feed, fuel and industrial applications. Collectively, our members process 95 percent of all soybeans in the United States.

[5] ASA represents approximately 500,000 American soybean farmers on domestic and international policy issues important to the soybean industry and has 26 affiliated state associations representing 30 soybean-producing states. American soybean growers have long been committed to producing the world's food, feed, fuel, and thousands of other bioproducts in a sustainable and climate-smart way.

Our California member producers and marketers support over 3,900 well-paying jobs in the state and about $960 million in economic activity each year. Further, the biodiesel, renewable diesel, and sustainable aviation fuel supplied to the state by our California and national members are collectively the single largest source of GHG reductions in the LCFS, providing nearly half[6] (44-45%) of the carbon reductions since 2017, more than any other fuel including electricity, and 42% since the start of the LCFS. Our fuels have grown to the point where fully a third (33%) of each gallon on average of diesel fuel consumed in the state in 2021 – and over 44% of the diesel pool in the first half of 2022 – consisted of our industry's low-carbon fuels.[7] Our sustainable replacements for petroleum diesel have been a major factor in driving California's continuing large-scale transformation of transportation from petroleum based toward a carbon neutral system. In short, the LCFS would not be the success it is today, and one the state is looking to export to other jurisdictions, without the key role our diesel replacements have played. More to the point, our liquid petroleum replacement fuels remain the only viable, commercial-scale alternatives for the next several decades to decarbonizing the most difficult-to-electrify sectors: heavy duty on- and off-road, marine, rail, and aviation.

We may have additional comments on other aspects of the staff's presentation in the coming days but wanted to focus our comments in this letter on CARB staff's request for feedback on the three modeling scenarios and the self-adjusting mechanism.

CARB Must Focus On Setting The Right Targets And Updating The Science In This Rulemaking

As reported by the Oil Price Information Service (OPIS) and others, LCFS credit prices have decreased from nearly $200 per credit in 2021 to below $70 per credit in 2022 and have remained there for much of 2022. The precipitous drop in credit prices is due to the LCFS not having sufficiently stringent CI reduction targets in line with the strong fuel producers' response to the LCFS market signal. This is an untenable situation that is substantially harming the billions of dollars in investments our industries and other low carbon fuel producers have made or were planning to make in direct response to the LCFS' market signals. Sustained credit prices at such low levels will result in fewer investments and innovations in low carbon fuels, exactly the kinds of fuels California will need in the years and decades ahead to meet the energy-intensive demands in the most difficult to electrify transportation sectors.

Thus, CARB must be singularly focused on the expeditious adoption of appropriate pre- and post-2030 carbon intensity (CI) reduction targets in the current rulemaking. Because of scientific developments in the past five or more years, CARB should also focus on updating, not replacing, the underlying science that supports the lifecycle assessment (LCA) carbon scoring framework already built into the regulation. Concepts floated in the workshops, such as the self-adjusting CI target mechanism and virgin oil credit caps, serve only to distract from the current rulemaking that should be laser focused on strengthening the weakened LCFS credit market.

[6] Over 46% of the LCFS credits in the first half of 2022. See LCFS Quarterly Data Spreadsheet (dated Oct. 31, 2022).
[7] Ibid.

Other Contributors To Excess Credit Supply Should Be Addressed

As CARB staff correctly noted, the current surplus credit supply situation is, in large part, due to overly generous credit generation provisions for electric forklifts and other fuel sectors. Historically, many of those provisions were established to help foster low carbon fuels or particular vehicle/equipment applications. However, after more than 11 years of implementing the LCFS and with many of those provisions now contributing to the glut of credits, we support staff's efforts to address the excess credit generation where such provisions are no longer needed to serve their original purpose.

Strong Support For 30% CI Target By 2030 With No Virgin-Oil Credit Cap

Regarding the CI targets CARB staff is considering for modeling, we strongly support the 30% CI reduction target by 2030 and appropriate interim and post-2030 targets, with the important caveat that any targets considered by CARB not employ a virgin-oil credit cap. While the Scoping Plan calls for very high carbon reductions across many sectors to achieve carbon neutrality by 2045, we reserve comment on the suggested 90% CI reduction modeling scenario by 2045 pending further analysis of CARB's modeling and underlying assumptions in support of that scenario.

The November 9th workshop continues to float the concept of capping LCFS credits generated from virgin-oil feedstocks with little to no justification besides simply proclaiming a concern that, "in light of expected increase in global production capacity, staff continues to evaluate the need for adjustments to prevent potential deforestation, land conversion, and adverse food supply impacts."[8] Expressing a concern and proceeding to build a fundamental regulatory change around that concern, without providing even minimal scientifically-robust and peer-reviewed justifications, diminishes and calls into question the scientific integrity the LCFS was built upon.

In fact, a recent study from Dr. Jayson Lusk at Purdue University[9] found that increasing the amount of soybean oil consumed by biofuels has almost no impact on the CPI for food at home. Soybean oil costs underly very little of the retail price of food. Soybeans generate about four pounds of soybean meal per pound of oil. This meal is used in animal feed which helps bring down the cost of meat. The net result is almost no change in food costs to consumers.

In addition to the points below, we incorporate by reference the comments we provided in our joint comment letter, dated September 19, 2022, on the virgin oil cap and related issues.

[8] CARB Presentation at slide 28.
[9] https://ag.purdue.edu/cfdas/wp-content/uploads/2022/12/report_soymodel_revised13.pdf

A Virgin-Oil Credit Cap Is An Unjustified, Fundamental Restructuring Of The LCFS Into An Economically Protectionist And Non-Market Based Prescriptive Standard

The virgin-oil cap suggested by staff would turn the market- and science-based LCFS into a prescriptive, non-market-, non-science-based program. It bears repeating that the LCFS has worked successfully for 11 years precisely because it is a market-based, fuel-agnostic program with a robust science-based foundation. CARB should therefore be very mindful not to fundamentally change the LCFS in pursuit of some objective that is neither justified by real world observational data nor warranted by any meaningful documentation provided in any of the workshops held to date.[10]

The proposed cap on credits generated from virgin oil feedstocks affects only one group of stakeholders and one set of fuels: producers of biodiesel, renewable diesel, and sustainable aviation fuel.[11] CARB staff has proposed no similar feedstock-based constraint on credit generation for any other fuel. Without rigorous justification, as noted above and in our prior comments, the cap would single out the fuels providing the single largest contribution of carbon reductions in the LCFS. Our fuels collectively generated 44% of the LCFS reductions over the past five years and over 46% in the first half of 2022, more than electricity (23.6%), renewable natural gas (15.2%), and hydrogen (0.2%) combined, despite the numerous credit-generating advantages those fuels enjoy in the current regulation.[12,13]

Our drop-in fuels provide immediate carbon reductions and air quality benefits in the sectors that will take many years or decades, if ever, to electrify. Since climate change has been described by many as the environmental crisis of this and subsequent generations, it simply defies logic for CARB to propose a cap on feedstocks that can provide significant carbon and air pollutant reductions now and in the many years it will take to electrify the heavy duty sectors. California, and other states, need all the low carbon feedstocks it can use to tackle the climate crisis.

Further, since surplus vegetable oils are produced outside of California, the proposed cap is tantamount to economic protectionism and a potential violation of the Constitution's dormant Commerce Clause. The cap continues to be scientifically unwarranted, especially since we and others have pointed out that the LCFS already has a built-in mechanism for addressing concerns about potential deforestation, land conversion, and adverse food supply impacts.[14] As noted, that built-in mechanism is the indirect/induced land use change (ILUC) modeling framework,

[10] See Clean Fuels and CABA Joint Comments, dated Sept. 19, 2022

[11] Lipids from waste and vegetable oil are the only mature technology for producing commercial-scale sustainable aviation fuel via the hydrotreated esters and fatty acids (HEFA) pathway.

[12] LCFS Quarterly Data Summary Spreadsheet, op cit.

[13] Both electricity and hydrogen can generate advanced credits based on capacity, rather than actual volume of fuel dispensed, and RNG from anaerobic digesters enjoys very low negative CI scores due to "avoided methane" accounting.

[14] See Clean Fuels and CABA Joint Comments, dated Sept. 19, 2022.

and while it needs to be updated, it has served California and the LCFS well since the start of the program in 2011.[15]

Prior Attempts To Constrain Specific Feedstocks Were Addressed Scientifically Through The LCFS' Lifecycle Assessment Framework

As a reminder, CARB previously attempted to restrict or outright ban specific feedstocks from being used in the LCFS' early years, namely high carbon intensity crude oil (HCICO) derived from Canadian oil sands and palm-derived oils from Indonesia and elsewhere. Not only did those attempts raise serious legal concerns that threatened to derail the LCFS program, they ultimately proved to be unwarranted and unnecessary with the establishment and use of the rigorous LCA framework in the current regulation, which assesses carbon intensity from both direct and indirect lifecycle contributions. With the current LCA carbon scoring framework, only a small amount, if any, of those problematic feedstocks are consumed in California[16]. Similarly, CARB does not need to arbitrarily constrain vegetable oil feedstocks since the existing, science-based and peer-reviewed LCA framework (with updates to its datasets and assumptions) already addresses the concerns staff has ostensibly raised to justify the caps.[17]

Fundamental Changes To The LCFS Must Be Vetted Through A Separate Public Process Apart From The Current Rulemaking

Along with the proposed virgin oil cap, the self-adjusting CI target mechanism represents a fundamental change to the LCFS regulation, albeit of a different nature. While an interesting concept, there remains a number of important threshold questions with this concept that should be explored in a separate public vetting process separate from the current rulemaking to avoid distracting CARB from being laser focused on establishing the right targets moving forward. For example, if a self-adjusting (aka "auto ratcheting) mechanism is warranted to accelerate CI targets under specified conditions (e.g., significant LCFS overperformance), wouldn't a self-adjusting mechanism also be warranted to decelerate the targets under specified conditions (e.g., severe underperformance of the LCFS)? We would, of course, not support any mechanism that results in such automatic backsliding, but the possibility of such backsliding that bypasses a formal rulemaking is at least implied by the self-adjusting mechanism. Also, the equations governing the self-adjusting CI targets would seem to produce a spectrum of CI targets, rather than a discrete target, which in turn would exacerbate market uncertainty rather than provide certainty and stability. How does one plan for a CI target that can be one of a number of different targets, depending on which set of conditions is triggered? Further, with only a small number of credit position holders as shown by CARB's own data, how do you design the mechanism to avoid market manipulation and gaming by a few participants?

[15] Ibid.

[16] In fact, there is no approved CARB pathway for legally selling palm oil- or palm fatty acid distillate-derived fuels in California because the LCA provisions would score those fuels above petroleum diesel, effectively limiting sales of such fuels that have been shown to have an adverse effect on deforestation. See Current Fuel Pathways, CARB website (visited 12/19/2022).

[17] Clean Fuels and CABA Joint Comments, Sept. 19, 2022, op cit.

These and numerous related questions have not been explored by staff. Accordingly, to the extent CARB believes it is important to explore fundamental changes like a virgin oil cap or self-adjusting mechanism, CARB should establish comprehensive expert working groups (EWG), similar to the two-year EWG process that produced the ILUC modeling framework, to explore these issues comprehensively with experts, academia, fuel producers, and other stakeholders in a public process separate from and subsequent to the current rulemaking.

Incorrect Categorization of Distillers Corn Oil (DCO) and Choice White Grease (CWG)

In addition to the unwarranted cap on virgin oil feedstocks, the CATS modeling proposed by CARB mischaracterizes both DCO and CWG as virgin oil feedstocks[18]. This is completely at odds with best practices and the treatment of these feedstocks as waste oil feedstocks in the current LCFS program.[19] According to the CATS documentation, both DCO and CWG are assumed and characterized for modeling purposes as virgin oil feedstocks without any explanation or supporting references.

Critical Updates Needed For Emission Factors

We very much appreciate CARB staff's prior invitation for feedback on updates to the emission factors used in CARB's lifecycle assessments and continue to reiterate our previous comments on this topic. This is a very timely solicitation, as it recognizes the current data and modeling used in CARB's lifecycle assessments are, for crop-based feedstocks like co-processed soybean and canola oil and non-crop waste oil feedstocks, very outdated and substantially overstate the direct and indirect emission impacts from these important feedstocks for low-carbon biodiesel and renewable diesel. We are deeply concerned that CARB has continued to use ILUC modeling and datasets for soy and canola feedstocks that date back to 2004 and other assumptions/data that date back to 2006. It goes without saying a robust and scientifically-valid LCFS requires a solid and up-to-date scientific basis.

Argonne GREET vs. CA GREET Underlying Assumptions and Data

As an initial matter, we believe the Argonne GREET (adjusted for California conditions and real-world experience gained since 2011) is the most appropriate model to calculate the direct life cycle carbon intensity of alternative transportation fuels. We believe this model is the best choice for several reasons:

1. Is capable of modeling a wide range of traditional and alternative transportation fuels and modes.
2. Argonne's (not CARB's) GREET model is updated annually, incorporating the best available science from a combination of industry surveys, process modeling, and literature reviews.

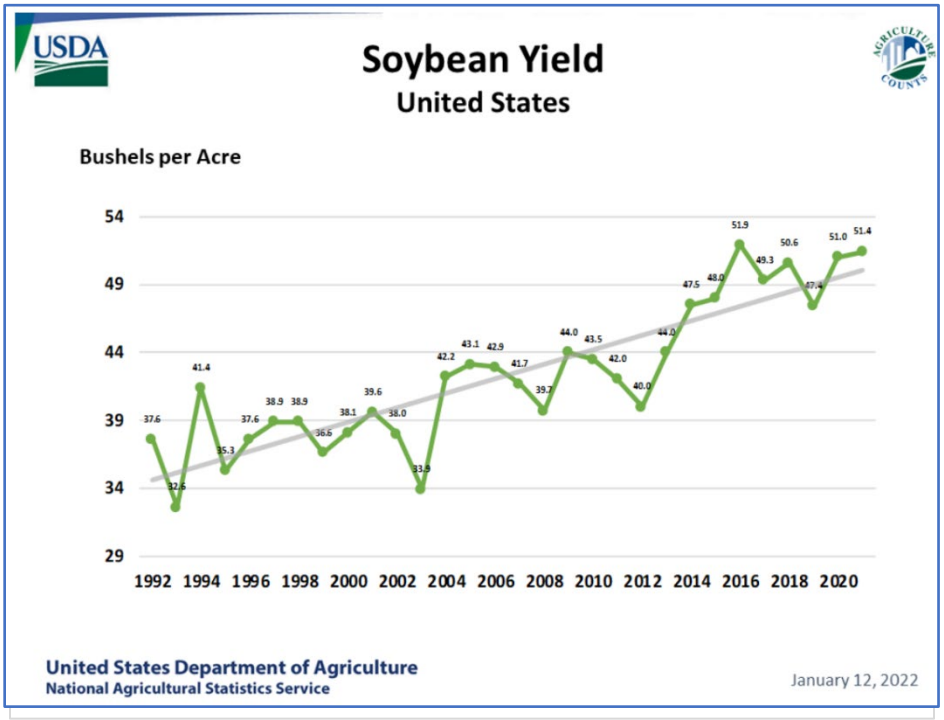
[18] See CATS Model Technical Documentation at 6.
[19] See Current Fuel Pathways spreadsheet showing currently certified fuel pathways (visited Dec. 19, 2022).

3. The model is constructed in a fairly consistent manner, ensuring that related biofuel systems (i.e. corn ethanol and corn oil biodiesel) are estimated in a consistent fashion. By contrast, CARB's adaptation has introduced double counting (double debits) for certain pathways.

A critical issue with wholesale continuation of CA-GREET is the vintage of the data included. It is critical to note while California adopted and modified the 2016 version of GREET, crucial data sources in that model were already several years old at the time. For example, the 2016 version of CA-GREET relies on 2012 agricultural data for soybean processing. This data, which is now a decade old, fails to account for the continued and significant improvements in efficiency on the farm related to better genetics and higher yields, precision agriculture, and general efficiency. Utilizing the older data overestimates the energy associated with producing soybeans by over 30%.

Energy Per Bushel of Soybeans		
Input	**CA-GREET 2016**	**GREET 2021**
Diesel (Btu)	13,696.64	9,352.51
Gasoline (Btu)	3,061.02	2,064.69
Natural Gas (Btu)	984.20	176.45
LPG (Btu)	765.48	662.03
Electricity (Btu)	935.21	1,468.05
Total Energy Usage (Btu)	**19,442.56**	**13,723.73**

Inputs Per Bushel of Soybeans		
Input	**CA-GREET 2016**	**GREET 2021**
Nitrogen (grams)	44.13	43.73
P_2O_5 (grams)	180.45	207.81
K_2O (grams)	289.01	329.56
$CaCO_3$ (grams)	-	-
Herbicide (grams)	17.34	19.43
Pesticide (grams)	0.34	0.28



Source: USDA – National Agricultural Statistics Service – Charts and Maps – Soybeans: Yield by

The outdated data is not only relevant to the soybean oil to biodiesel and renewable diesel pathway, but other major pathways such as animal fat rendering have been updated and corrected[20] since the 2016 CA-GREET model was adopted by CARB. To date, CARB has not adopted these new figures, even though they are well established in the literature and CARB staff has approved several domestic and foreign producer-specific Tier 2 applications which are documenting rendering energy which meets or exceeds survey results contained within GREET 2021.

Energy Per LB of Tallow Rendered		
Input	**CA-GREET 2016**	**GREET 2021**
Residual oil (Btu)	1,055.56	-
Natural gas (Btu)	1,611.11	1,052.45
Electricity (Btu)	444.44	306.86
Total Energy Usage (Btu)	**3,111.11**	**1,359.31**

Critical Updates Needed For More Robust Indirect Land Use Change (ILUC) Assessments

As CARB seeks further incentives to encourage innovation, competition, and more sustainable production while discouraging less sustainable actions, we recommend the following three options for CARB staff to consider:

1. **Develop Country- or Regional-Specific Land Use Change Factors**

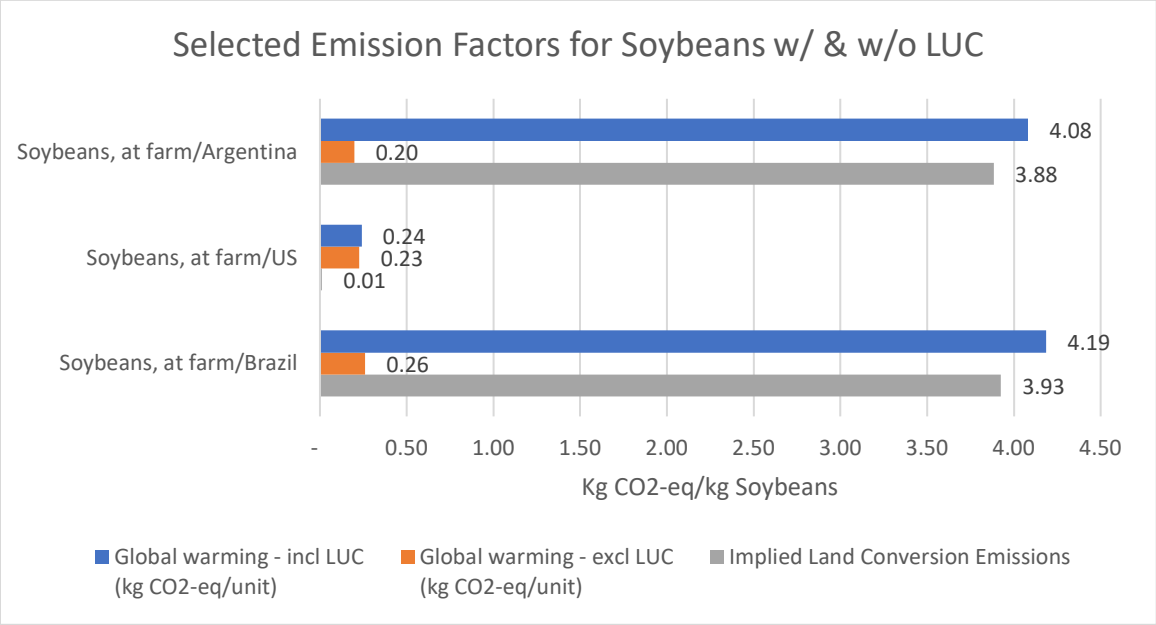
CARB could draw on the approach established by Canadian jurisdictions such as British Columbia which have prominently incorporated country specific direct land use change into their estimates for major regions or certain crops. This is based on observed changes in land cover type in major growing regions for a specific crop. For example, although British Columbia's Low Carbon Fuel Requirements has no explicit indirect land use change, the LCA for feedstock such as southeast Asian palm oil -- which have historically been grown on high carbon stock land that is converted -- is directly penalized in the model. This results in a carbon intensity for palm oil biodiesel approaching or exceeding that of diesel fuel. This is consistent with the ILUC value for palm oil.

Additionally, if CARB staff is interested in crafting a policy which rewards the sustainability leaders and incentivizes laggards, rather than painting everyone with an unduly broad brush, we recommend you consider using the data from Blonk[21], more commonly known as Agri footprint. Blonk utilizes highly respected data including UN FAO statistics and IPCC calculation rules[22] and follows PAS2050-1[23] to develop country and crop specific emission factors.

[20] Argonne GREET Publication : Updates on the Energy Consumption of the Beef Tallow Rendering Process and the Ratio of Synthetic Fertilizer Nitrogen Supplementing Removed Crop Residue Nitrogen in GREET (anl.gov)
[21] Blonk Sustainability | Agri-footprint
[22] Agri-footprint 5.0 (amazonaws.com)
[23] bsi.shop (bsigroup.com)

Critically, for voluntary markets and corporate emission reductions pledges, PAS2050-1 is accepted by the World Resources Institute a global leader in GHG reduction efforts and the founder of GHG Protocol and the Science Based Targets Initiative. Applying a standard accepted by WRI will help drive consistency between major regulatory markets like the LCFS program and global voluntary reporting of carbon emissions.

Illustrated below using the Blonk data, the sharp contrast in emission factors becomes apparent for soybeans from markets like the United States and two selected markets in South America. Utilizing more granular and transparent information such as what is outlined below would help the LCFS program reward leaders for highly sustainable practices and encourage laggards to improve. Without clear differentiation between growing regions which is masked by a one-size fits all ILUC penalty, the market will continue to operate in a highly inefficient manner, broadly judging all agricultural commodities of the same type by the least sustainable producer.



2. Simplify the Process by Utilizing One Model

If CARB determines country-specific emission factors, such as those from Blonk, do not meet the state statutory or regulatory requirements, we encourage CARB staff to take the simplest approach by using the Argonne National Lab's most recent version of GREET, including their land use change emission estimates modeled in the CCLUB module. This would remove a significant burden for CARB staff by eliminating the need to maintain its own unique GREET model and indirect land use change scores. Additionally, it is critical to note that the CCLUB module contained within GREET, which is used to estimate land use change values, is based on results from the GTAP modeling. GTAP was the model used by California years ago to conduct its estimates of indirect land use change.

3. Rely On an Updated Version of GTAP

Finally, if CARB determines the use Argonne's CCLUB model is impractical, necessitating the need to use a discrete land use change model, we implore CARB to use the most recent version of GTAP, not simply implement the values CARB calculated in 2015. A strict adherence to consistency is neither logical nor warranted; indeed, simply continuing the state's use of the older GTAP results effectively guarantees California's program will be based on flawed and outdated science.

We believe it is inappropriate and inconsistent with state policy goals to use data, methods and results -- which in some cases are well over a decade old -- in a climate-progressive policy which is claimed to be based on the "best available science." Before continuing to use the antiquated results from the 2015 CARB ILUC modeling exercise, we strongly encourage you to look at the literature which has been published relating to GTAP since then.[24,25] Since the concerns underlining the suggestion to cap vegetable oil feedstocks are based largely on claims of extreme substitution between the various crop oils, it behooves CARB to evaluate critically the recent peer-reviewed GTAP publication, which directly questions the elasticity of these substitutions.[26]

Accordingly, we recommend adopting the latest ILUC values for soy and canola from recent work by Argonne and Purdue, which would substantially decrease the current ILUC value in the LCFS (in the case of soy biodiesel, up to about 90% less than CARB originally estimated at the 2009 rulemaking). This would better reflect real world observations showing that ILUC estimates for our crop feedstocks were severely exaggerated in the earlier rulemakings (which, to be fair, were based on the data and assumptions available to staff at the time). It is time to update the ILUC values for soy and canola to reflect the learnings and scientific developments occurring over the past decade.

<u>Critical Updates To Direct CI Factors Based On Real-World Experiences In California And Correction Of Existing Errors</u>

In addition to using an updated GTAP-BIO and AEZ-EF, we strongly encourage CARB staff to use updated direct CI inputs that reflect both real-world experience in California as well as errors that have been identified and acknowledged by CARB staff but have not yet been corrected in the LCFS. Using updated direct CI values, inputs, and assumptions will help ensure that the LCFS reflects the most robust and current science available. The specific updates are shown in Attachment 1.[27]

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[24] The increasing global environmental consequences of a weakening US–China crop trade relationship | Nature Food

[25] Land | Free Full-Text | Dynamic Amazonia: The EU-Mercosur Trade Agreement and Deforestation (mdpi.com)

[26] US biofuel production and policy: implications for land use changes in Malaysia and Indonesia | Biotechnology for Biofuels and Bioproducts | Full Text (biomedcentral.com)

[27] Clean Fuels comments submitted to CARB in response to public workshop to consider potential changes to the LCFS regulation, https://www.arb.ca.gov/lists/com-attach/120-lcfs-wkshp-oct20-ws-WjQCZgBjUV0FYFM8.pdf, accessed April 8, 2022.

Conclusion

We strongly support a more stringent set of pre- and post-2030 CI reduction targets, in particular the 30% modeling target using no virgin oil cap. We remain deeply concerned with and are strongly opposed to any CI reduction targets premised on a cap on vegetable oil feedstocks as being unwarranted, not based in sound science, chilling of ongoing and future investments, and counterproductive to California's climate and carbon neutrality objectives. Instead of pursuing this line of inquiry further and introducing more uncertainty into the LCFS market, we strongly encourage CARB to focus on adopting more stringent CI targets and updating the science, datasets, and assumptions underpinning the existing LCA framework as expeditiously as possible in the upcoming rulemaking. We also encourage CARB staff to reduce or eliminate those overly generous credit provisions that have outlived their usefulness.

Finally, we would like to endorse and incorporate by reference the comments filed by ADM and other members of Clean Fuels and CABA, as well as those submitted by NOPA.

Thank you for your consideration of these comments. We look forward to continuing our strong collaboration with CARB and staff.

Sincerely,

Floyd Vergara, Esq., P.E.
Director of State Governmental Affairs
Clean Fuels Alliance America

Rebecca Baskins
Executive Director
California Advanced Biofuels Alliance

Attachment 1

Post-2015 Updates to Indirect and Direct Carbon Intensity Values and Parameters

DIRECT/ INDIRECT EMISSIONS	MODEL	FEED STOCK	UPDATE NEEDED	CURRENT VALUE/CI	UPDATED VALUE/CI	REFERENCE/COMMENTS
DIRECT	CA-GREET	Tallow	Rendering Energy	3944 BTU/lb. This is about **18 g/MJ**	2211 BTU/lb. This is about **10 g/MJ** (GREET 2019)	Chen, R., Qin, Z., Han, J., Wang, M., Taheripour, F., Tyner, W., O'Connor, D. and Duffield, J., 2018. Life cycle energy and greenhouse gas emission effects of biodiesel in the United States with induced land use change impacts. Bioresource Technology, 251, pp.249-258. https://www.sciencedirect.com/science/article/pii/S0960852417321648/pdfft?md5=768c9ac49614fbb7252d0ff821fa3ea9&pid=1-s2.0-S0960852417321648-main.pdf Updates on the Energy Consumption of the Beef Tallow Rendering Process and the Ratio of Synthetic Fertilizer Nitrogen Supplementing Removed Crop Residue Nitrogen in GREET. https://greet.es.anl.gov/files/beef_tallow_update_2017
DIRECT	CA-GREET	Uncooked UCO	Rendering Energy	1073 BTU/lb This is about **5.3 g/MJ**	300 BTU/lb This is about **2 g/MJ**	A new pathway with a default values is recommended for this feedstock. A number of renderers have supplied ARB with data on energy use for uncooked UCO rendering operations and these are conservative values. This would restore one of the default pathways that was present in the original regulations.
DIRECT	CA-GREET	Hydrogen	Energy Density	290 BTU/lb	274 BTU/lb	The current value is at 32F whereas the standard for measurement is 60F. CARB has accepted this change but only in approved Tier 2 applications.
DIRECT	CA-GREET	Hydrogen	Carbon Intensity	106,907 g/mm BTU	105,612 g/mm BTU	CARB has also accepted this change. Existing value includes 150 miles of hydrogen pipeline transportation, which is not applicable in most cases.
DIRECT	CA-GREET	Corn Oil	Extraction CI	**13.27 g/MJ**	**10.46 g/MJ**	2.81 g/MJ for corn oil extraction is improperly double-counted as both an ethanol debit and a biodiesel feedstock debit.

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DIRECT/ INDIRECT EMISSIONS	MODEL	FEEDSTOCK	UPDATE NEEDED	CURRENT VALUE/CI	UPDATED VALUE/CI	REFERENCE/COMMENTS
INDIRECT	GTAP-BIO	Soy	Various, as shown below	**29.1 g/MJ**	**17.5 g/MJ**	
			Using model parameters recommended by GTAP developers	**29.1** → 22.4		Follow-On Study of Transportation Fuel Life Cycle Analysis: Review of Current CARB & EPA Estimates of Land Use Change Impacts http://crcsite.wpengine.com/wp-content/uploads/2019/05/E-88-3b-Final-Report-2016-08-23_v2.pdf
			Updating to 2017 GTAP model (includes intensification changes) and 2011 data base.	22.4 → 18.3		Taheripour, F., Cui, H. and Tyner, W.E., 2017. An Exploration of agricultural land use change at the intensive and extensive margins: implications for biofuels induced land use change. Bioenergy and Land Use Change, pp.19-37. https://doi.org/10.1002/9781119297376.ch2 Taheripour, F., Zhao, X. and Tyner, W.E., 2017. The impact of considering land intensification and updated data on biofuels land use change and emissions estimates. *Biotechnology for biofuels*, *10*(1), p.191. https://biotechnologyforbiofuels.biomedcentral.com/track/pdf/10.1186/s13068-017-0877-y
			Including feed-land substitution in GTAP	18.3 → **17.5**		Taheripour, F. and Tyner, W.E., 2020. US biofuel production and policy: implications for land use changes in Malaysia and Indonesia. *Biotechnology for Biofuels*, *13*(1), p.11. https://link.springer.com/content/pdf/10.1186/s13068-020-1650-1.pdf

DIRECT/ INDIRECT EMISSIONS	MODEL	FEEDSTOCK	UPDATE NEEDED	CURRENT VALUE/CI	UPDATED VALUE/CI	REFERENCE/COMMENTS
INDIRECT	GTAP-BIO	Canola	Various, as shown below	**14.5 g/MJ**	**11.7 g/MJ**	
			Using model parameters recommended by GTAP developers	**14.5**		Follow-On Study of Transportation Fuel Life Cycle Analysis: Review of Current CARB & EPA Estimates of Land Use Change Impacts http://crcsite.wpengine.com/wp-content/uploads/2019/05/E-88-3b-Final-Report-2016-08-23_v2.pdf
			Updating to 2017 GTAP model (includes intensification changes) and 2011 data base.			Taheripour, F., Cui, H. and Tyner, W.E., 2017. An Exploration of agricultural land use change at the intensive and extensive margins: implications for biofuels induced land use change. Bioenergy and Land Use Change, pp.19-37. https://doi.org/10.1002/9781119297376.ch2 Taheripour, F., Zhao, X. and Tyner, W.E., 2017. The impact of considering land intensification and updated data on biofuels land use change and emissions estimates. *Biotechnology for biofuels*, *10*(1), p.191. https://biotechnologyforbiofuels.biomedcentral.com/track/pdf/10.1186/s13068-017-0877-y
			Including feed-land substitution in GTAP		**11.7**	Results have not been published for US canola biodiesel shock but similar percentage reductions can be expected for canola as were found for soy oil