COMMENTS OF STEVE BERRY & TIM SEARCHINGER
REGARDING RENEWAL OF LOW CARBON FUEL STANDARD

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We are an economist at Yale University and an environmental scientist at Princeton University and have written papers analyzing the emissions from biofuel use as well as economic land use models. Our shortform CV's are attached. Berry previously served as a consultant for CARB on economic issues related to the analysis of indirect land use change from biofuels. We offer the following comments.

There are compelling reasons to believe that biofuels are contributing significantly to global agricultural land expansion and associated greenhouse gas emissions. There is now a sound satellite study of cropland expansion, which finds that annual crops are expanding at a record rate of roughly 25 million acres per year (Potapov et al. 2021). FAO data would indicate expansion of an additional 2.5 million acres per year of perennial crops. This is net expansion, which is caused by growing global demand for agricultural products, including for biofuels.

According to the same study, global expansion is roughly double, but the roughly 20 million hectares of expansion of arable cropland is offset by roughly 10 million hectares of abandonment. Yet, even with this abandonment, the gross expansion causes additional carbon losses both because it is occurring heavily in carbon-rich lands and because the carbon losses are relatively immediate compared to the carbon gains from regrowing native vegetation. These shifts reflect the fact that agriculture is not only expanding on a net basis but also to some extent shifting, particularly into the tropics, in response to changing economics. These shifts reflect, in part, an outsourcing of agricultural production by countries in the global north, and are indicative of how demand in the global north, including for biofuels, helps to drive expansion and carbon losses in the Global South. (Pendrill et al. 2019) (T. Searchinger et al. 2022).

Oilseeds, which occupy roughly one quarter of global cropland, are major drivers of this expansion including soybeans and oil palm (Weisse and Goldman 2021). Since 2005, when global policy began to drive large increases in biofuels, biodiesel has contributed more than 40% of the increase in global demand for vegetable oil. As discussed in the attached paper regarding the GTAP model, there is strong econometric evidence that prices of vegetable oils and the major grains move in parallel in different parts of the world. This is no surprise. Any simple observation of a chart on global vegetable oil prices for different vegetable oils in different parts of the world shows that their prices move closely in parallel. Global commodity traders ensure this parallel movement as they are engaged in global arbitrage. This means that vegetable oils have high substitutability at the margin. It means that increased demand for vegetable oil anywhere in the world and for any vegetable oil will tend to cause the same price response and therefore lead to similar expansion of vegetable oils. Not surprisingly, cropland will expand most where it is most economical to do so, namely in the Tropics and Neo-tropics. And vegetable oil expansion in the Global North will contribute to this cropland expansion further to replace displaced crops.

We therefore support produced changes to the Low Carbon Fuel Standard that would impose caps on biodiesel production from virgin vegetable oil. As the above discussion indicates, this cap should be extended to all vegetable oils, including corn oil and sunflower oil, as increases in demand for any vegetable oil will cause comparable increases in demand for vegetable oil in general and will therefore elicit very similar market and land responses. There is no reason to exempt corn or sunflower oil from the cap.

More generally, in this rulemaking CARB should commit to an immediate and expeditious reevaluation of the way it estimates the climate costs of using land for biofuels.. When lifecycle analyses such as those used by CARB ignore the emissions of burning biofuels, they are implicitly offsetting these emissions by the carbon removed from the atmosphere by plant growth. This is the climate benefit. But it takes land to grow these plants, and not using this land for other purposes has a climate cost. The evaluation of biofuels is largely based on the valuation of this cost of dedicating the productive capacity of land to biofuel production. Today, indirect land use change estimated by a version of the GTAP is the only way CARB assigns a climate cost to the use of land. There are several reasons this needs prompt evaluation.

First, GTAP lacks an empirical basis, and builds in structural biases that guarantee low ILUC estimates. Many of its predictions are also contradicted by substantial bodies of empirical evidence. In summary:

- GTAP does not work with physical acres but only land revenues, which leads the model to create or destroy large quantities of land. Its economic components estimate a large ILUC, but modelers artificially readjust this estimate by a "hand of God" to conserve land area, which leads to the small ILUC. This kind of readjustment is inherently invalid. If the economic components of the model are correct, then the readjusted results are incorrect. If the economic estimates are physically impossible, then the model is invalid.

- Several invalid model features make it extremely difficult for the model to convert forests. "Unmanaged" forests do not exist in the model although they are the major concern with cropland expansion. The authors also chose a forest area elasticity many times higher than the underlying study they cite, which causes forests to strongly resist conversion or immediately reappear elsewhere if converted in one location.

- Although the model has thousands of economic parameters, only a handful are based on any cited reference, none instrumented, and are then incorrectly applied to other products and in other regions. In addition, *every* elasticity is altered, often greatly, by a formula based on its share of a category of expenditure. That contradicts any underlying estimates, which are not based on expenditure shares. It also leads to bizarre results. For example, biofuels for fuel somehow lead to price decreases for electricity, which somehow lead to *less* electricity consumption.

- Without empirical basis, the model is programmed to prevent international land use change, which is where agricultural expansion occurs. It does so by using arbitrary assumptions to constrain trade in agricultural products. The resulting predictions are provably wrong because this leads the model to predict large price differences for crops in different parts of the world, which do not occur in reality. Because global prices of grains and vegetable oils are highly linked, changes in demand will have global effects leading to heavy cropland expansion in the Tropics, where it is cheapest.

Because CARB's emissions estimates are dependent on GTAP, it lacks an empirical basis for encouraging their use. Faced with this evidence, an argument can be made that CARB should immediately stop incentives for at a minimum crop-based biofuels. At a minimum, CARB should undertake a quick review.

Second, as also discussed in the attached paper, the ILUC estimates generated by GTAP are only around 10% of the average carbon losses from vegetation and soils that have occurred to generate the cropland used to produce the quantity of corn used in corn ethanol or the quantities of vegetable oil used in any form of biodiesel or renewable diesel.(Timothy D. Searchinger et al. 2018). (These calculations adjust generously for by-products and co-products.) In other words, if the additional corn or vegetable oil used for biofuels is replaced on the average type of land used to generate these products globally and at the average global yields, the land use emissions will be roughly ten times the ILUC estimates used by CARB. If the ILUC emissions are even around 20% of this average, the emissions reductions estimated by CARB will disappear. In the absence of compelling economic evidence that the sources of supply will be overwhelmingly lower than the global average land use source to the present date, these biofuels cannot credibly be viewed to lower emissions.

Third, even if the GTAP model were correct, the resulting policy is morally indefensible. As revealed even in the publication by the GTAP authors (Hertel et al. 2010), but also shown separately in (T.D. Searchinger et al. 2015), the ILUC number for ethanol is much lower because GTAP estimates much of the food diverted to biofuels is not replaced due to higher crop prices. As shown in the latter paper, the literal physical source of the emissions reduction is people and livestock around the world eat less carbon and therefore emit less carbon dioxide in their respiration. Global food prices primarily affect consumption by the global poor. California's implicit policy, by using GTAP, is therefore to obtain greenhouse gas reductions by increasing global food prices so that the global poor consumed less. This is an indefensible position.

Finally, the use of economic models to estimate ILUC does not actually estimate the true climate costs of devoting land to biofuels. In effect, the ILUC estimate seeks to ask what are the climate effects if California enacts expensive policies to make greater use of land for biofuels but there are no policies in the world to use land to achieve climate benefits in any other way. The true costs reflect the lost opportunity to use land in other ways to benefit the climate. These are the opportunity costs, and in economic terms, opportunity costs are costs, and that principle applies equally to climate effects as money or use of any other asset.

Land is an extremely valuable asset, with fixed global quantity, for the climate. The world needs both more food and more carbon storage. The proper measure in evaluating the costs of diverting land from food production is the quantity of carbon that could reasonably be saved by continuing that food production. And even if that food production were treated as surplus, the appropriate measure would be the quantity of carbon that could be removed from the atmosphere by reforesting "surplus" cropland. As discussed in the GTAP paper and in (T. D. Searchinger, Beringer, and Strong 2017), these alternative uses of land are vastly more valuable than using land for biofuels, even cellulosic biofuels. The best uses of U.S. corn land for climate purposes are to produce corn, but even if they were established in forest, they would reduce carbon for decades far more than biofuels. And the world faces challenges even of siting solar power. On three quarters of the world's land, solar power will generate more than 100 times the useable energy, and when used to transport cars in electric engines, will generate more than 300 times the motion. On low productivity land, the ratio extends into the thousands. Overall, the world has no substitute for the use of well-watered land for food, forests and other carbon-rich native habitats. But the world has far more efficient alternatives for the generation of energy.

The academic literature has been moving broadly to recognize that the climate uses of land must be evaluated using some form of opportunity cost (see list in Appendix A). CARB should do so as well. And once it does so, it will conclude that the dedication of the productive capacity of land to produce biofuels is a poor use of land and has adverse effects on the climate.

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