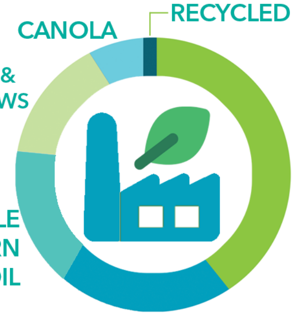
ENVIRONMENTAL BENEFITS OF **BIODIESEL**

GREENHOUSE GASES REDUCED 50% TO 86% WITH BIODIESEL COMPARED TO PETROLEUM DIESEL.

RFS2: All renewable fuels meet minimum GHG reductions.



U. S. Biodiesel Sources

More forests. more food. more efficient crops like soybeans.

CO_2 Emissions studies consider everything about feedstock & production along with impact on other markets.

BIODIESEL, THE RENEWABLE/LOW CARBON OPTION FOR AMERICA...NOW.

Environmental Benefits of Biodiesel & the Renewable Fuel Standard

Biodiesel significantly reduces Greenhouse Gas (GHG) emissions compared to petroleum. The most comprehensive, accurate and up-to-date lifecycle analysis of U.S. biodiesel produced from soybean oil concludes that GHG emissions are reduced 66-72% relative to average U.S. petroleum.[1] This is consistent with published reports summarized in the table below.

RFS2 Protections

Renewable Fuel Standard (RFS2) requires all renewable fuels to meet minimum GHG reduction threshold compared to petroleum.[11]

GHG calculations must include international indirect land use change. [12]

All renewable fuel must certify that feedstock came from land that was already managed in agricultural production before 2008. No land conversion is allowed.

EPA has determined that palm oil does not meet the minimum GHG requirement to participate.

Palm Oil Use

Virtually zero palm oil biodiesel has been used in the U.S. since implementation of the RFS2.13

Globally, palm oil does participate in renewable fuels policies in Asia, South America, Canada and the European Union's *Renewable Energy Directive* (RED).

The United States consumes less than 3% of global palm oil production.[14] U.S. consumption of palm is primarily in manufactured food products. This use has increased since 2003 as partially hydrogentated soybean oil has been steadily removed from food processing due to health concerns stemming from trans fats.[15] This has resulted in a decline in the use of soybean oil-for-food manufacturing of 1.496 million metric tons.[16] The physical consistency of palm oil is most closely substitutable for the thickened, partially hydrogenated soybean oil in processed food that rely on physical consistency. In those uses, palm oil use has increased by 1.039 million tons since 2003.[17] For deep fried foods, much of the partially hydrogenated soybean oil has been replaced by canola, corn oil and other North American vegetable oils. These substitutes are generally more expensive than soybean oil, illustrating that changes in food formulation are not driven solely by low cost. The physical attributes of the oil are dominant in many applications.

Indirect Linkages Between Palm Oil and U.S. Soybean Oil

The U.S. exported over 12 million tons of soybean oil in 2017.[18]

U.S. soybean oil exports have risen 69% since enactment of the RFS.

Since 2003, soybean oil use for biodiesel has increased by 1.01 million tons.

Since passage of the RFS, U.S. soybean oil exports have grown by more than 5 million tons.[19]

Total veg oil consumption for food in the U.S. has also grown by 1.245 million tons since 2003. These increases in exports, increases in food consumption and increases in biodiesel

Authoring Agency	Year Published	Carbon Intensity (g/MJ)	GHG reduction compared to baseline petroleum
Argonne National Lab.	2017	26.40	66-72%[2] *
California Air Resources Board	2015	51.83	50%[3] *
U.S. Department of Agriculture	2012	21.20	76%[4] *
California Air Resources Board	2011	83.25	12%[5] *
Argonne National Lab.	2011		73-90%[6]
U.S. Environmental Protection Agency	2010	38.60	57%[7] *
Argonne National Lab.	2008		66-94%[8]
U.S. Environmental Protection Agency	2008	70.00	22%[9] *
National Renewable Energy Lab.	1998		78%[10]

*indicates indirect emissions from palm oil deforestation and peat oxidation. These are included as a penalty to the soy biodiesel pathway.

production all result from increased U.S. production of fats and oils as byproducts of protein production.

Even though the U.S. has been supplying more veg oil to export markets in years following enactment of the RFS, econometric modeling has been developed as a more precise tool to quantify the impact of biodiesel separate from other influencing factors. The U. S. Environmental Protection Agency (USEPA) replicated the modeling reported by Searchinger, *et. al*. in 2008. USEPA concluded that international land use change might occur as a result of increased biofuel usage in the US. However, EPA's numerical assessment of these emissions was much lower than reported by Searchinger.

The California Air Resources Board (CARB) independently created a different set of models to address questions about indirect land use change (ILUC). CARB appointed a diverse expert workgroup to evaluate and make recommendations on key and sometimes controversial aspects of ILUC modeling.[20] CARB's lengthy and transparent process adopted initial findings in 2012 and updated those in 2015. The model used by CARB quantifies the substitution between different vegetable oils based on price and predicts how much palm oil production might increase in response to increased soybean oil prices from the US. These models also identify which regions of the world might experience a change in production of palm oil or other oilseed crops.

CARB developed the AEZ-EF (Agroecological Zone-Emission Factor) model to quantify the GHG emissions of land use change in specific regions. CARB's AEZ-EF model uses a factor of 95 t CO_2e/ha/year for peat oxidation related to the most problematic land conversion in Indonesia.[21] CARB's emission factor is 56% higher than the 61 t CO_2e/ha/yr emission factor used in the European GLOBIOM model. While 55 t CO_2e/ha/yr might be reasonable for pristine peat swamp forest, 35.6 t CO_2e/ha/yr would be more accurate for secondary forests most likely converted to palm oil production after prior disturbance, such as for logging.[22]

CARB adopted an assumption that one third of new palm plantations will be converted from pristine peat swamp forests. This assumption was adopted from estimates created by the European Commissions' Joint Research Center.[23] More recent data suggests that actual conversion rates are more like 13% in Malaysia and 22% in Indonesia.[24]

Thorough quantification of the above factors shows that U.S. biodiesel policy has very little impact on global palm oil production. Nevertheless, because estimated emissions from converting pristine peat swap forests are so high, those conservative penalties translate to a reduction in the GHG benefit of biodiesel.

In CARB's most recently adopted regulations, soy biodiesel is penalized with a 29.1 g CO_2e/Mj penalty resulting from induced land use changes in Indonesia and elsewhere. Purdue University has continued to update the GTAP model and more recently suggests that penalty should be reduced to 18.3 g CO_2e/MJ.[25], [26] In any case, the concerns about GHG emissions from palm oil production have been thoroughly and repeatedly quantified in lifecycle analysis, and biodiesel produced from U.S. feedstocks exceeds 50% GHG reduction compared to baseline petroleum.

Consensus & Controversy over Indirect Land Usage Change

Real world data shows that global forested area has increased by 19 million acres since 2004.[27] Global farm land has decreased by 60 million acres since 2004.[28] U.S. farmland has shrunk by more than 23 million acres since 2007. We are growing more forests today, because we are farming less land. Farmers are feeding more people using less land, because they are planting more efficient crops like soybeans. Soy produces more protein per acre than any other crop. If biodiesel deserves blame for increasing soybean production, then biodiesel deserves credit for the increase of forested area resulting from these trends.

Notwithstanding the actual trends in net forest growth, the GHG studies cited above represent the most transparent, and reproducible predictions that have been published on biodiesel's impact on net GHG emissions and land management. They prove that biodiesel deserves a place in the RFS and other climate policies.

- The Coordinating Research Council (CRC) has organized biennial workshops on lifecycle analysis for fuel alternatives. USEPA, CARB, and several leading environmental organizations have participated on the organizing committees which works diligently to invite diverse and qualified experts for presentation and debate on the data needs and methodologies for quantifying lifecycle impacts of alternative fuels. In 2013, the consensus summary from this diverse group of experts included the following conclusions: "Considerable progress has been made during the past two years (since the previous workshop) in lifecycle carbon analysis (LCA) of transportation fuels. Significant updates have been made to several of the models and underlying databases that are used in these assessments, resulting in a higher degree of confidence in model outcomes."
- "Considerable improvements appear to be happening in the area of ILUC assessment. Greater spatial resolution now exists (in some locations) with respect to feedstocks, land types, crop productivities, and land conversion options. Overall, it appears that the extent of land use change to support biofuels policies is not as large as was thought a few years ago, although this remains an area of high uncertainty."

In 2015, the consensus summary included the following conclusions:

- "On-going improvements in model structure and underlying databases appear to be reducing the large disparity among results that previously existed for similar fuel pathways and have increased overall confidence in LCA results."
- "The issue of indirect land use change (ILUC) remains controversial—both in principle and in application. Recent revisions to ILUC models have reduced the estimated ILUC effect on the carbon intensity (CI) of some biofuels"

In 2017, the consensus summary included the following conclusions:

- "There is general consensus in the U.S. that our understanding of ILUC has improved dramatically over the past decade. This has been driven both by improved observational methodologies—such as remote sensing—and by improved databases. During recent years of biofuel expansion, there has been less agricultural extensification and more intensification than was represented in previously-used models. Proper distinction between intensification and extensification is necessary for reliable assessment of ILUC and its impact on the CI of biofuels. The practice of double-cropping is now recognized as an important factor that has significant spatial variability and must be handled correctly when assessing ILUC. However, a lack of reliable data on planted crop areas and double cropping is an ongoing impediment to such modeling."
- "Most commercial biofuel feedstocks in the U.S. are co-produced with protein for livestock feed. The role of protein demand should not be underestimated when evaluating trends on the agricultural landscape."[29]

The Union of Concerned Scientists (UCSUSA) has provided leadership to the CRC workshops as well participating on CARB's LCFS Expert Workgroup[30]. UCSUSA's Jeremy Martin weighed in publicly when CARB revised its ILUC in 2015. Martin said,

"The headline 7 years ago—that crop-based biofuels are far worse than fossil fuels—no longer holds. Both the studies and the world have changed. Agricultural markets are more flexible, deforestation has fallen in some key areas (Brazil in particular) and biofuels production is getting more efficient. The overall result is that biofuels are getting cleaner over time, and most biofuels are cleaner than gasoline."[31]

Endnotes

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