Real-World Land Use Change (LUC) Compared to Model Estimates

Contrasting Observed LUC to EPA's GHG Modeling Comparison Exercise (MCE)

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american coalition for ethanol[SM]

EPA released a modeling comparison exercise (MCE) in June 2023, taking inventory of how various models assess the lifecycle greenhouse gas (GHG) emissions biofuels such as corn ethanol. Some of the models used in the comparison, particularly economic models such as the Global Change Analysis Model (GCAM), generate significant and unverifiable indirect emissions which inflate land use change (LUC) for corn ethanol. As noted below, the land use change penalty modeled in GCAM is 31 carbon intensity points.

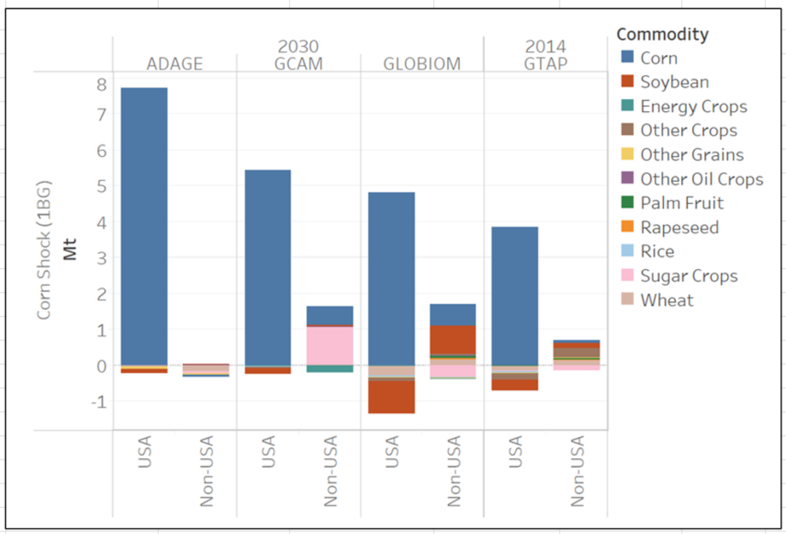
Land Use Change Penalty for Corn Ethanol in the US EPA Modeling Comparison Report:

Model	ADAGE	GCAM	BLOBIOM	GTAP
Kilograms CO2 equivalent GHGs per Million Btus	-1	31	13	6

EPA's MCE concludes by acknowledging it is "important to compare model estimates to historical observations" of real-world land use change. This analysis compares modeled estimates to what has occurred in the real-world and serves to respond to EPA's request for comment on the MCE.

Corn Production – Modeled vs Observed

Figure 6.3-1: Difference in commodity production (million metric tons) in the corn ethanol shock relative to the reference case in 2014 (GTAP) and 2030 (ADAGE, GCAM, GLOBIOM)

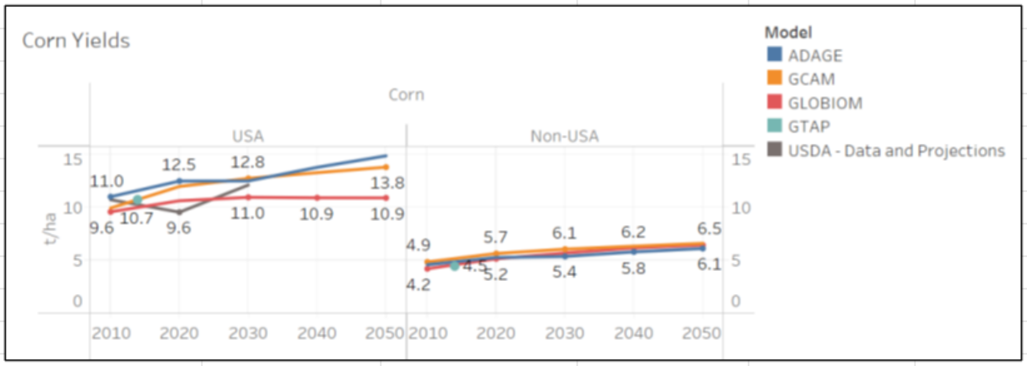


Model	ADAGE	GCAM	GLOBIOM	GTAP
Modeled US Corn Prod. Increase (Million Metric ton/Billion gal. EtOH)	7.9	5.5	4.8	3.9
Bushels corn/MMt	39,375,000	39,375,000	39,375,000	39,375,000
Bu. Corn per 1 BG EtOH Shock	311,062,500	216,562,500	189,000,000	153,562,500
Bu. Corn per 6 BG EtOH Shock	1,866,375,000	1,299,375,000	1,134,000,000	921,375,000
U.S. Corn Prod during 2005-2008 (Bushels) (USDA NASS)	46,724,388,000			
U.S. Corn Prod during 2017-2020 (Bushels) (USDA NASS)	56,681,153,000			
Actual Increase in Corn Prod/year	2,489,191,250			
Actual Increase vs Modeled Increase in Corn Prod/year (bu)	**622,816,250**	**1,189,816,250**	**1,355,191,250**	**1,567,816,250**
Actual Increase vs Modeled Increase in Corn Prod/year (%)	**33.4%**	**91.6%**	**119.5%**	**170.2%**

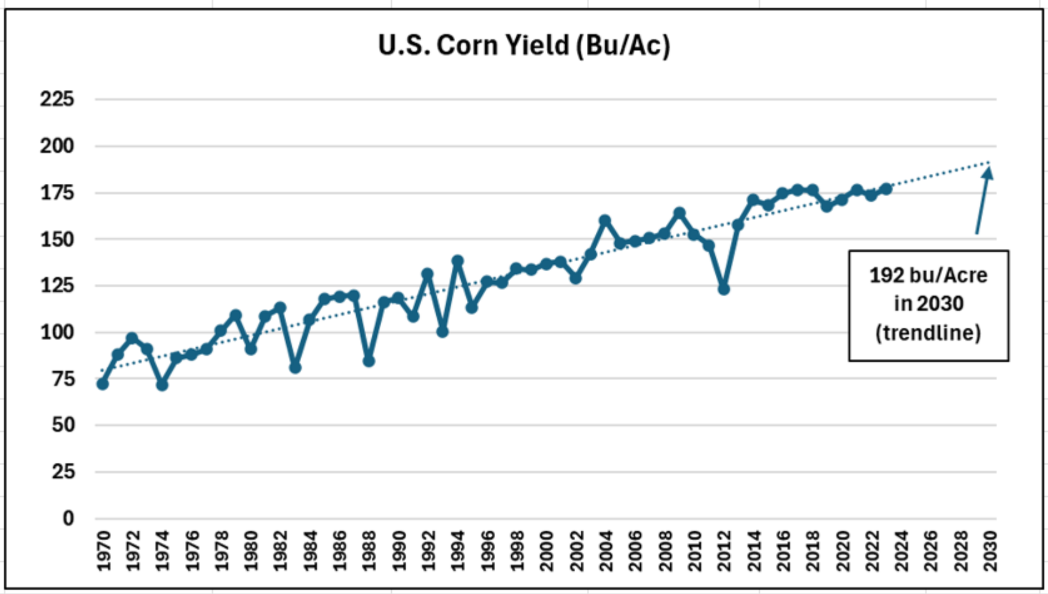
All models used by EPA estimated <u>far less</u> corn production than actual production in recent years. In fact, ADAGE, GCAM and GLOBIOM 2020 projections estimates are lower than actual production today.

Corn Yield – Modeled vs Observed

Figure 5.3-1: Corn yields (tons per hectare) in the reference case



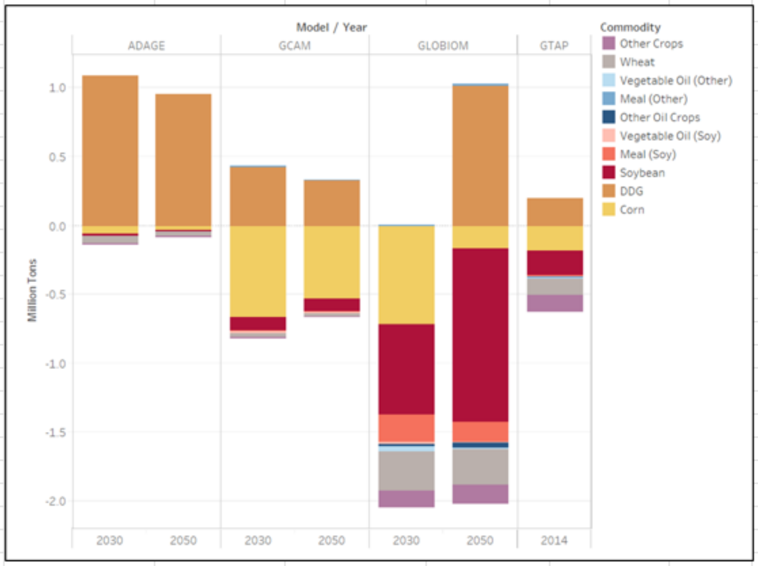
Model	ADAGE	GCAM	GLOBIOM	GTAP (2014)
U.S. Corn Yield, Tons/ha in 2020	12.5	12	10.4	10.7
U.S. Corn Yield, Bu/Acre 2020	**181**	**173**	**150**	**155**
U.S. Corn Yield Tons/ha in 2030	12.7	12.8	11	
U.S. Corn Yield, Bu/Acre 2030	**184**	**185**	**159**	



ADAGE, GCAM and GLOBIOM model estimates are below the 2030 U.S. corn yield trendline. Land use change can be overstated by ignoring or short-changing corn yield.

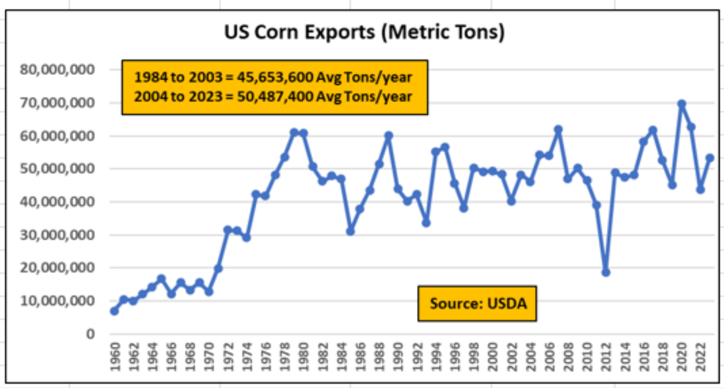
Corn Exports – Modeled vs Observed

Figure 6.4-1: Difference in U.S. net exports of crops and secondary agricultural products (million metric tons) in the corn ethanol shock relative to the reference case in 2030 and 2050 (ADAGE, GCAM, GLOBIOM) and 2014 (GTAP)



	ADAGE	GCAM	GLOBIOM	GTAP
Modeled Change in 2030 Corn Exports/Bgal EtOH (Million Tons)	-0.05	-0.72	-0.74	-0.22
Modeled Change in 2030 Corn Exports/6 Bgal EtOH (ThousandMtons)	-0.30	-4.32	-4.44	-1.32
Modeled Change in 2030 Corn Exports/6 Bgal EtOH (%)	-0.000001%	-0.000009%	-0.00001%	-0.000003%
Actual Change in Corn Exports 1984-2003 vs 2004-2023 (MillionTons)	4,833,800	4,833,800	4,833,800	4,833,800
Actual Change in Corn Exports 1984-2003 vs 2004-2023 (%)	**10.59%**	**10.59%**	**10.59%**	**10.59%**

US Corn Exports (USDA)



All models in EPA's model comparison exercise estimated a small reduction in U.S. corn exports. In reality, corn exports grew 10.6% (1984 to 2003 vs 2004 to 2023)

Land Use – Modeled vs Observed

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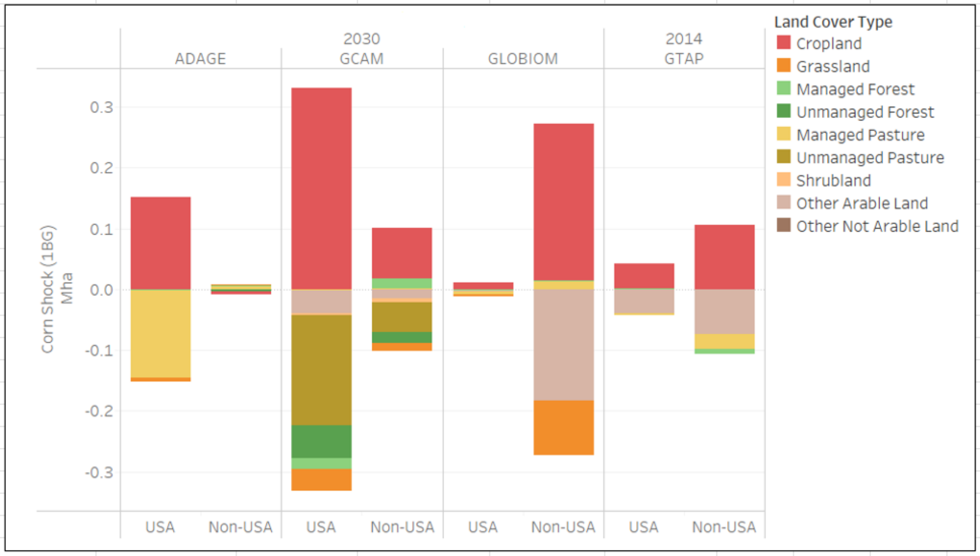
Figure 6.6-2: Difference in land use (million hectares) in the corn ethanol shock to the reference case in 2014 (GTAP) and 2030 (ADAGE, GCAM, GLOBIOM)188



Model	ADAGE	GCAM	GLOBIOM	GTAP
Modeled Increase in U.S. Cropland (Million Ha/Bgal	0.15	0.33	0.28	0.105
Billion Gallons EtOH Shock	6	6	6	6
Modeled Increase in U.S. Cropland (Million Ha/6 Bgal	0.9	1.98	1.68	0.63
Modeled Increase in U.S. Cropland (Million **Acres per 6** Bgal	**2.22**	**4.89**	**4.15**	**1.56**

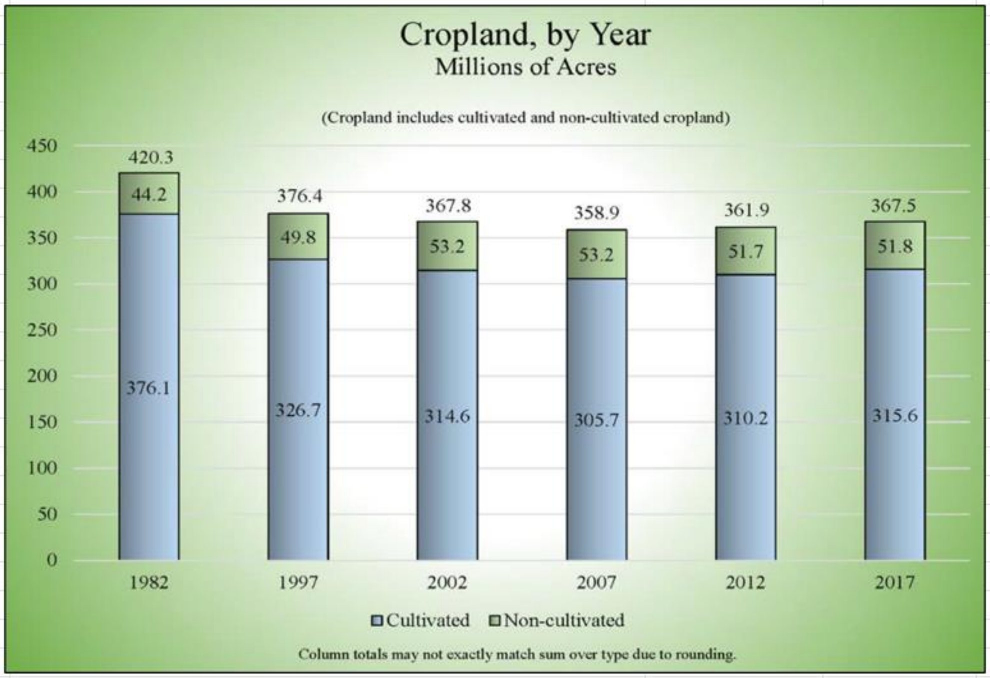
EPA's model comparison exercised assumed a 6-billion-gallon ethanol "shock" would expand U.S. cropland by a range of 1.56 million acres to 4.89 million acres

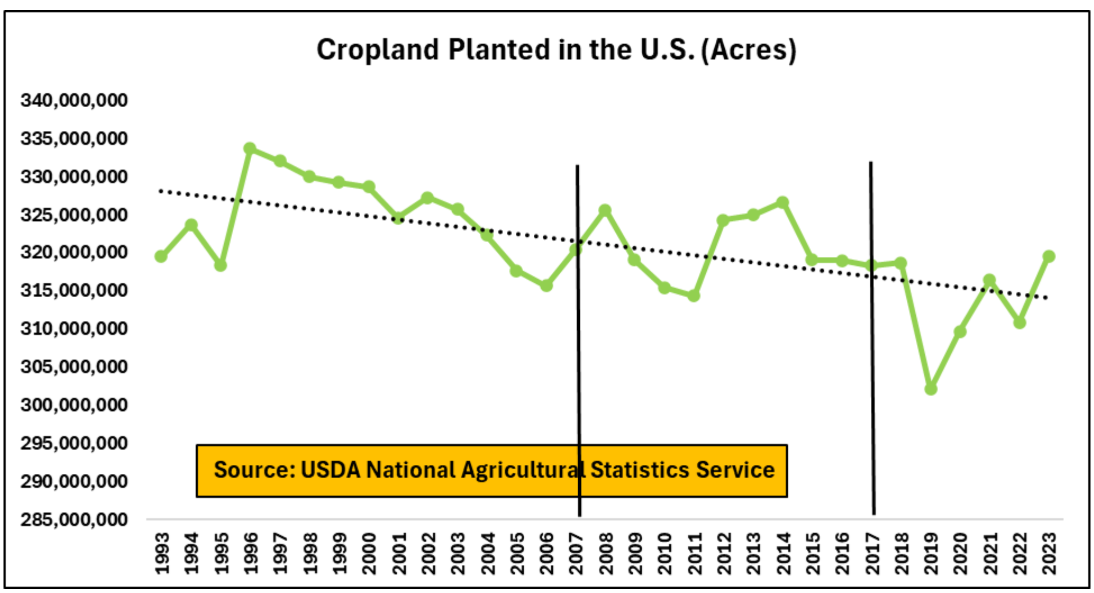
Land Use Change - Observed

USDA 2017 National Resources Inventory Report - https://www.nrcs.usda.gov/nri

Cropland

Cropland acreage increased by about 5.6 million acres from 2012 to 2017. It had steadily declined since the NRI began in 1982 up until 2007 (25 years). Since 2007, it has increased every year. The increase since 2012 was a little less than 1.6 percent from 362 to 367 million acres. **Most of the gain (80%) came from land coming out of the Conservation Reserve Program with some pasture and rangeland converting to cropland**, counterbalanced to some degree by losses of cropland to development and other rural land.





USDA's 2017 National Resource Inventory Report indicates an 8.6 million acre increase in cultivated and uncultivated cropland from 2007 to 2017. USDA NASS indicates a 2 million acre decline of planted cropland from 2007 to 2017.

Important Considerations: How much cropland expansion should be attributed to the RFS? What types of land conversion are taking place?

What portion of the USDA NRI cropland expansion of 8.6 million acres should be attributed to the Renewable Fuel Standard (RFS)?

As EPA has noted, many factors have impacted ethanol production and consumption in the United States historically, including higher prices of oil and gasoline, the replacement of methyl tert-butyl ether (MTBE) in RFG areas, the RFS program, the Volumetric Ethanol Excise Tax Credit (VEETC), the octane value of ethanol, state programs, and air emission standards.

EPA's Third Triennial Report to Congress on the RFS program estimates about 20 percent of cropland expansion should be attributed to the RFS program.

External Review Draft – Do not quote, cite, or distribute.

Table 6.11. Comparison of estimated changes in cropland with changes in cropland attributable to the RFS Program.

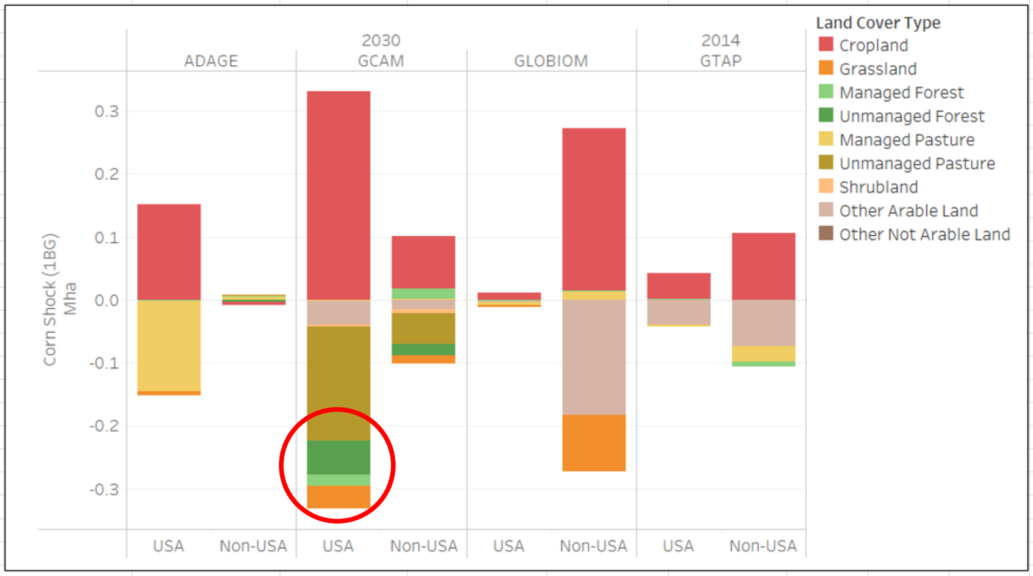
Measure	2008–2016	2007–2017
Total Converted Acreage (millions of acres)	10.09	8.63
Reference	Lark et al. (2020)	NRI (2020)
Total Converted Acreage Estimated to be Attributable to the RFS Program (millions of acres)	0–1.9	0–1.9
Percent of Converted Acreage Estimated to be Attributable to RFS Program	0–19%	0–22%
Acreage Estimated Attributable to the RFS Program as a Percent of Total Cropland in 2017[a]	0–0.5%	0–0.5%

[a] This assumes 367,483,300 acres of total cropland in 2017 from the NRI (Brown-Hruska et al., 2018).

If 20% of cropland expansion should be attributed to the RFS (U.S. EPA Third Triennial Report draft), the USDA NRI data indicate 1.9 million additional cropland acres are due to the RFS.

What Land Types in the U.S. were Converted to Cropland

Figure 6.6-2: Difference in land use (million hectares) in the corn ethanol shock to the reference case in 2014 (GTAP) and 2030 (ADAGE, GCAM, GLOBIOM)188

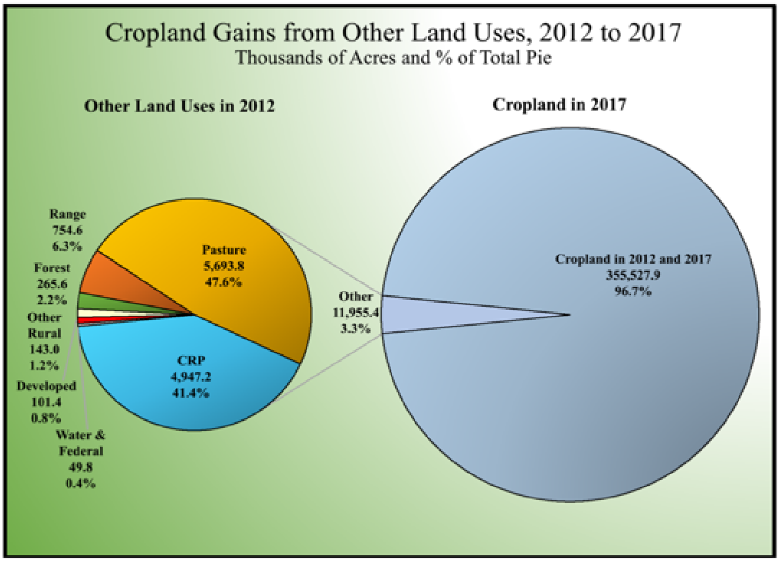


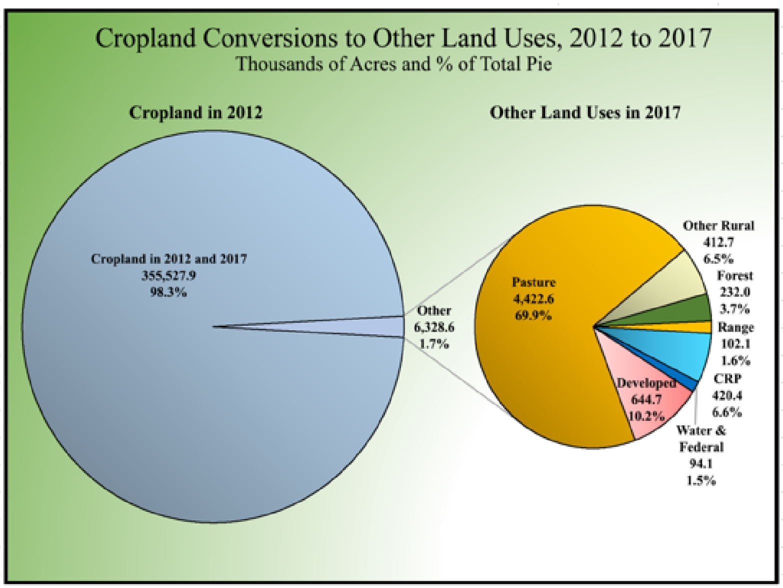
	ADAGE	GCAM	GLOBIOM	GTAP
Modeled U.S. **Forest** conversions to Cropland (Million Ha/Bgal)	0	0.077	0	0
Modeled U.S. Forest conversions to Cropland (Million Ha/6 Bgal)	0	0.462	0	0
Modeled U.S. Forest conversions to Cropland (Million Ac/6 Bgal)	**0**	**1.142**	**0**	**0**
Modeled U.S. Forest conversions to Cropland (Million Ac/6 Bgal) (% of total Cropland)		**0.32%**		

GCAM is the only model in EPA's model comparison exercise that predicted significant (1.14 million acres per 6 billion gallons ethanol shock) forest to cropland conversions

How do GCAM forest to cropland conversions compare to the real-world observations of USDA's National Resource Inventory (NRI)?

USDA National Resource Inventory Report 2017	
Forest to Cropland (2012 to 2017) (Million Acres)	0.266
Cropland to Forest (2012 to 2017) (Million Acres)	0.232
USDA NRI Net Forest to Cropland (2012 to 2017) (Million Acres)	**0.034**
USDA NRI Increase in Cropland from Forest (2012 to 2017)	**0.009%**





<u>GCAM's modeled forest to cropland conversions are 34 times higher than the historical observations from USDA's 2017 NRI</u>. GCAM was the only model to predict significant forest to cropland conversions. It is very expensive to convert forest to cropland and such conversion results in substantial CO_2 emissions.

Since 2012 cropland acreage increased by about 1.6 percent from 326 million to 367 million acres

Most of the gain (80 percent) is the result of land exiting the Conservation Reserve Program (CRP).

How much soil organic carbon (SOC) is lost after conversion of CRP to cropland? USDA addressed this question with a 2022 report based on the Rapid Carbon Assessment (RaCA) Project.

Surface soil organic carbon sequestration under post agricultural grasslands offset by net loss at depth

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Abstract Post agricultural grasslands are thought to accumulate soil organic carbon (SOC) after cultivation cessation. The Conservation Reserve Program (CRP) in the U.S. is a wide-scale, covering approximately 8.9 Mha as of 2020, example of row-crop to grassland conversion. To date, changes in SOC stock in CRP lands have mostly been evaluated at local scales and focused on the surface 20–30 cm of the soil profile. Thus, we lack knowledge of SOC dynamics in CRP lands on a continental scale, especially in the subsurface soil, after agricultural cessation. The Rapid Carbon Assessment (RaCA) project is the most recent effort by the United States Department of Agriculture (USDA) to systematically quantify C stock in the 0–100 cm soil profile across the conterminous US. Here we analyzed data from RaCA to evaluate the SOC stocks of both surface and subsurface soil of the CRP on a continental scale. We found there was no difference in SOC stock between croplands and CRP lands when comparing the 0–100 cm soil profiles, which indicates that the C sequestration in CRP lands is insignificant overall. We did find that CRP lands have higher SOC stocks in the surface soil (0–5 cm). However, such higher SOC levels in surface (0–5 cm) soil were offset by the lower SOC stock in the subsurface (30–100 cm) of the CRP. We also found that CRP lands in humid and warm regions may have net soil C sequestration because they have much more SOC in the surface as compared with croplands in the same regions. Whether the lower SOC in the subsurface of CRP lands is caused by legacy effects or is a result of C losses needs to be verified by long-term repeated sampling in both surface and subsurface soil. This analysis highlights the importance of examining C dynamics in subsurface soil after agricultural cessation to accurately measure and improve C sequestration rates in CRP lands.

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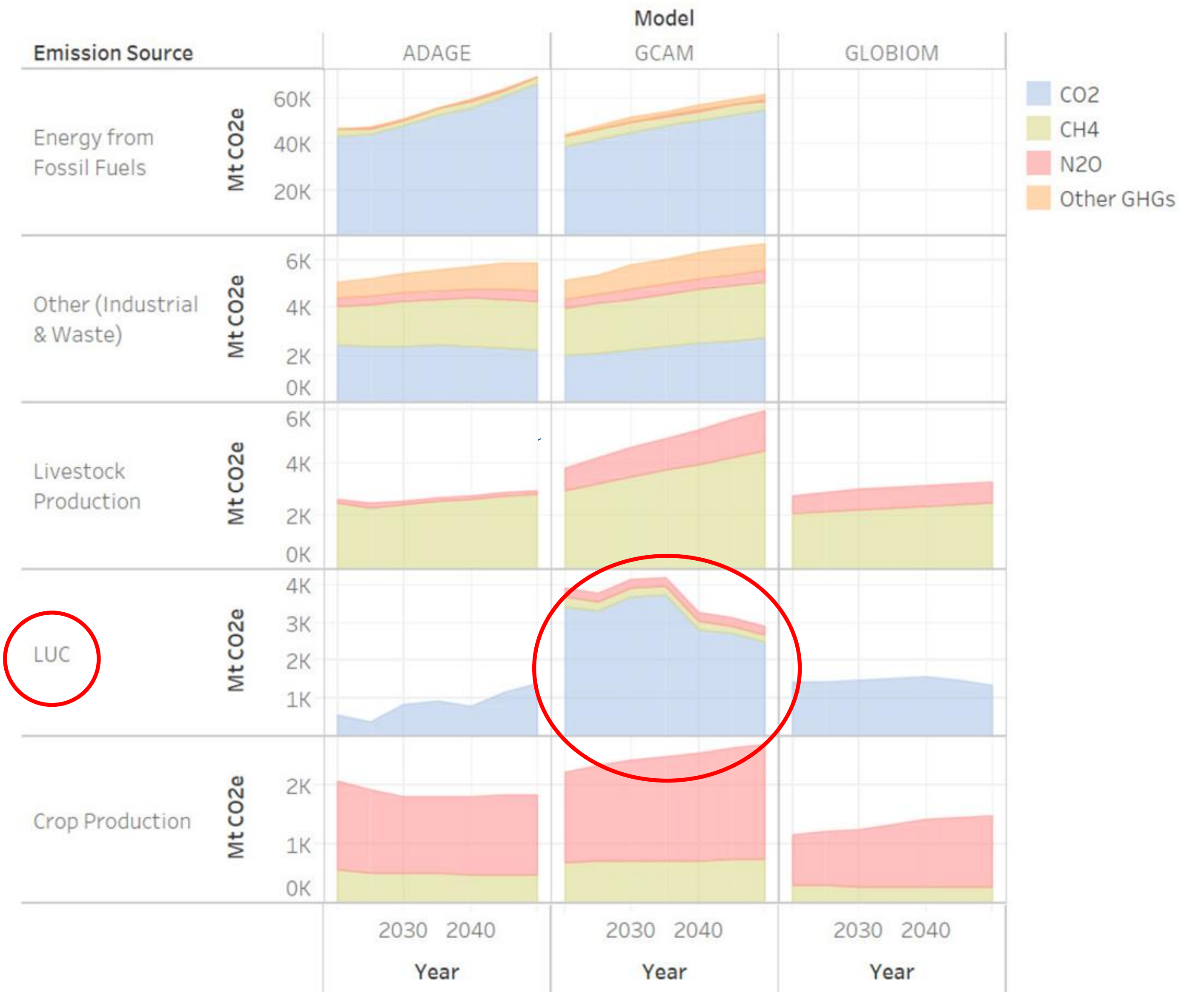
The USDA RaCA found very little SOC had accrued in CRP lands, no more than in adjacent croplands, so it is likely that little SOC is lost following conversion of CRP back to cropland. The Colorado State University National Resource Ecology Laboratory CENTURY/Daycent SOC modeling indicates croplands are accruing SOC (U.S. EPA GHG Inventory), thus, CRP and cropland SOC accrual may be similar. The Michigan State University Cropland GHG Calculator estimates similar SOC accrual as does the CENTURY/Daycent Model. http://carboncalculator.kbs.msu.edu/

Additional LUC Estimates in the EPA Modeling Comparison Report

Figure 5.5-1: Global greenhouse gas emissions in ADAGE, GCAM, and GLOBIOM in the reference case[176]



GCAM's estimated forest conversions to cropland likely inflated the LUC penalty

Figure 6.7-1: Difference in global greenhouse gas emissions in the corn ethanol shock relative to the reference case[189]

GCAM's inflated LUC modeling is the outlier based on EPA's modeling comparison assessment.

Conclusions:

This analysis shows economic modeling is not a reliable tool for estimating land use change (LUC) when compared to historical observations of real-world land use change.

It would undermine scientific integrity for the Interagency Working Group to force unreliable economic LUC penalties into the GREET model modified for SAF under the 40B tax credit.

In fact, use of GREET, with the Carbon Calculator for Land Use and Land Management Change from Biofuels Production (CCLUB) model and application of Global Trade Analysis Project (GTAP), have and continue to be the most closely aligned to observed, real-world land use change from ethanol production. The IWG must acknowledge GREET has proven to be more accurate for estimating LUC.

In October of 2022, the International Energy Agency (IEA) Bioenergy Task Force published a report titled "Towards an Improved Assessment of Indirect Land-Use Change." According to the IRA report, traditional LUC modeling, described as the ***"Trade and Market Response Narrative,"*** has failed to accurately predict RFS spurred corn ethanol land use change. When an alternative modeling approach is used, described as the ***"Internal Adjustment Response Narrative,"*** a negligible LUC impact is predicted, similar to the observed land use changes we have shared in this analysis. It would be informative for the IWG to review the IEA report, particularly EPA as the Agency considers next steps to assess and update GHG modeling for crop-based biofuels. Here is a link to IEA Bioenergy Task Force publication:

https://task43.ieabioenergy.com/wp-content/uploads/sites/11/2022/10/IEA-Bioenergy-iLUC-report_Final.pdf

Finally, if corn yields continue to increase along trendline, corn ethanol production can similarly increase with no additional land requirements. It is likely that corn and soybean crops will dominate world agriculture because they produce far more crude protein and calories per unit of land, water, and fertilizer nutrients than other grain crops.

This analysis should also serve to help respond to EPA's request for comment with respect to the modeling comparison exercise (MCE).