Life Cycle Considerations of Corn Ethanol Production

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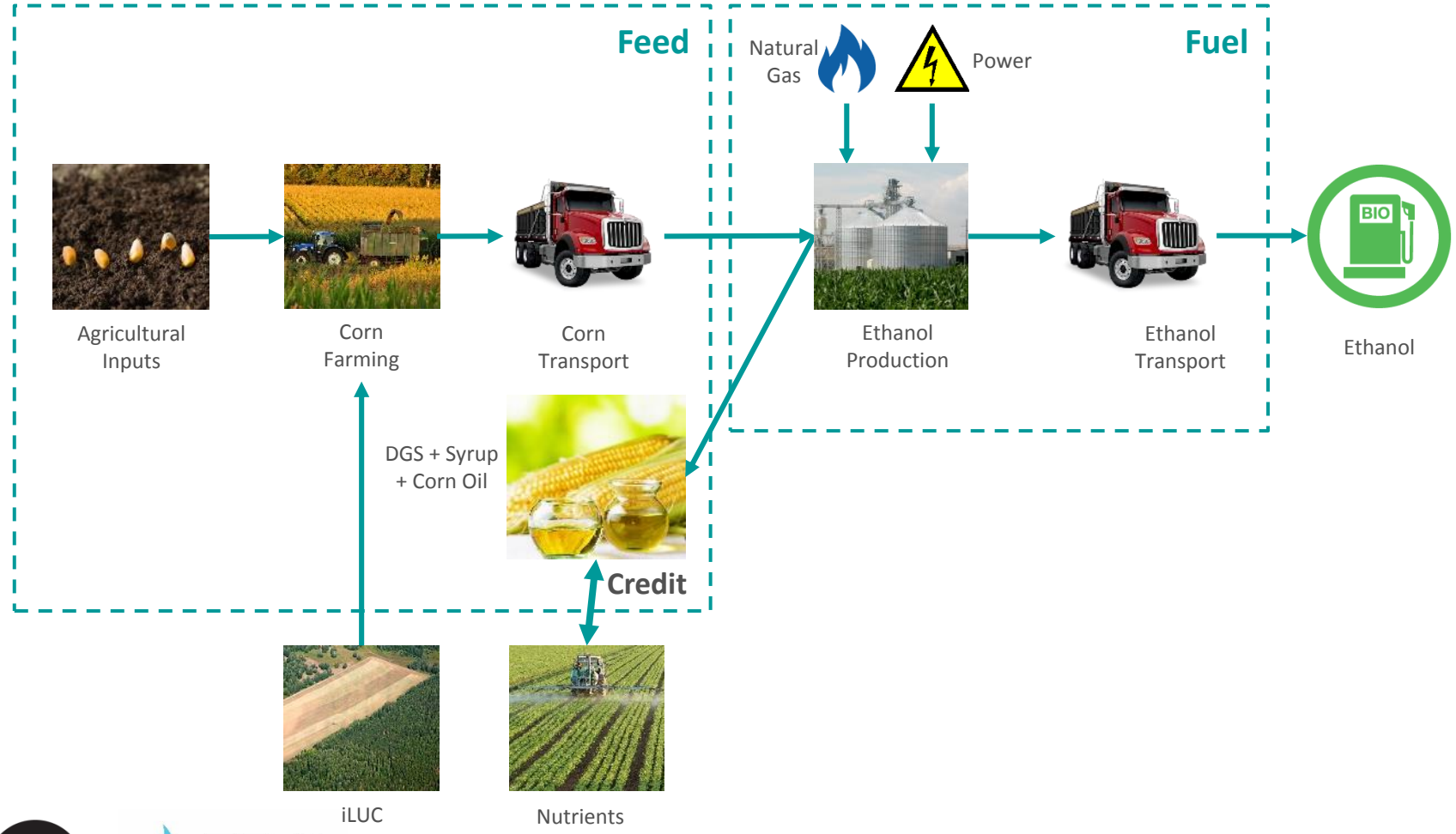
Climate Change:
Greenhouse Gas Life Cycle Assessment

- When comparing the energy, efficiency and emissions impact of different fuels and vehicle technologies researchers around the world use what is called life cycle models.
  - In the US the dominant and most updated life cycle model is the **GREET** model developed by Argonne National Laboratory.
  - In Canada, the dominant model is **GHGenius**
  - In Europe a common life cycle model is called **Biograce**
- While several different life cycle models exist around the world the basic concept is always the same
- We look at the individual emissions released during the different production stages to make a fuel followed by the emissions incurred during the combustion of this fuel.
- GREET is
  - Updated Yearly
  - Includes detailed land use emissions assessment

UIC ERC ENERGY RESOURCES CENTER Argonne GREET LIFE-CYCLE MODEL

Life Cycle Boundaries of Corn Ethanol Production



Presentation Overview

- Life Cycle Analysis in US, Canada, EU, Japan, etc. has long shown that many agricultural biofuels such as ethanol **result in significant GHG reductions** relative to Gasoline
- Is there merit to recent publications who claim novel scientific insights that this is not the case?
- We have issued public comments to many in response. Let's review…

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Publication 1

"Carbon balance effects of U.S. biofuel production and use"

published on August 18, 2016 in the journal Climatic Change by John DeCicco et al.

Challenge of Traditional Life Cycle Methodology

The authors Question Life Cycle Methodology and assert:

- "Unlike LCA or other forms of carbon accounting used for climate policy to date, [our new model] **does not treat biofuels as inherently carbon neutral.** Instead, it tallies CO2 emissions on the basis of chemistry in the specific locations where they occur. "
- "for a biofuel to provide a net reduction in CO2 emissions, **the production of its feedstock must effect a gain in Net Ecosystem Production NEP […] it is not sufficient for the feedstock to have merely removed carbon from the atmosphere."** The authors further refer to Searchinger's "insight about the need for additional carbon."

From DeCicco et al. Publication

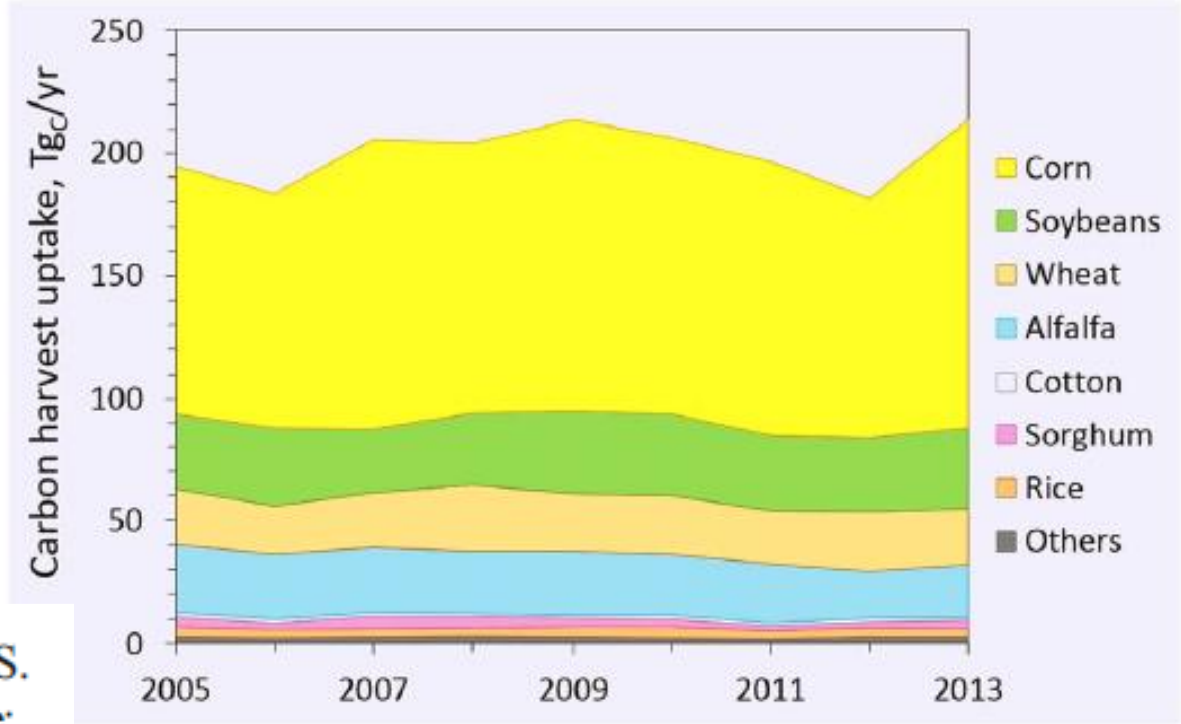

Fig. 3 Carbon uptake on U.S. cropland, 2005–2013. Source: derived from USDA (2015)

Our Comments on this Publication

- We calculated the correlation coefficient between ethanol produced and corn area planted from 2005 through 2016 and found this relationship quite weak.
- In many years corn area plantings went down despite the fact that corn ethanol production increased (2006, 2008, 2009, 2014) in a market environment where growers certainly had direct knowledge that ethanol production was trending up.
- DeCicco does not take soil carbon into account
- Our Comments are Posted at: http://www.erc.uic.edu/assets/pdf/UIC_Review_of_DeCicco_Sept_6sub.pdf

	Corn Area Harvested ('1000 acres)	Ethanol Production (billon gallons)
2005	75,117	4.06
2006	70,648	5.48
2007	86,542	6.89
2008	78,570	9.68
2009	79,490	11.04
2010	81,446	12.86
2011	83,989	12.89
2012	87,375	12.88
2013	87,451	13.22
2014	83,136	14.30
2015	80,749	14.80
2016	86,500	14.80
	Correlation Coeff.	0.6

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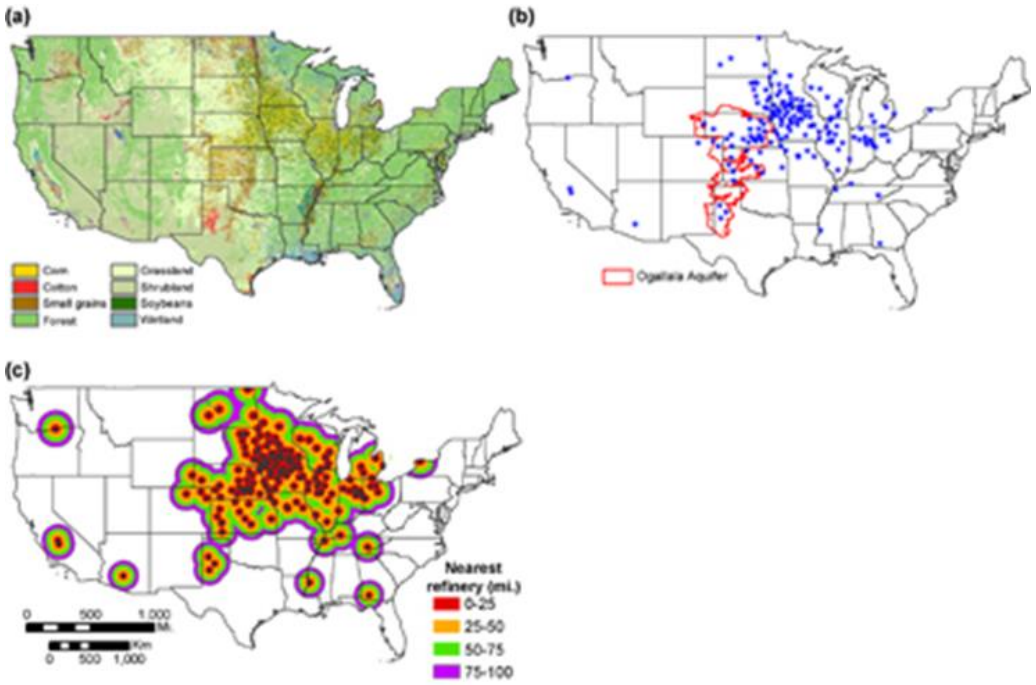
Publication 2

"Recent grassland losses are concentrated around U.S. ethanol refineries"
Christopher K Wright, Ben Larson, Tyler J Lark, and Holly K Gibbs; Published 21 March 2017
2017

Publication 2

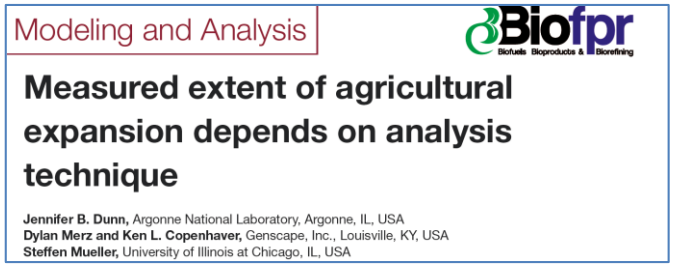
Recent grassland losses are concentrated around U.S. ethanol refineries; Christopher K Wright, Ben Larson, Tyler J Lark, and Holly K Gibbs; Published 21 March 2017 2017

Cropland expansion outpaces agricultural and biofuel policies in the United States; Tyler Lark, J Meghan Salmon and Holly K Gibbs, 2015



Our Comments on this Publication

- Some studies assert that ecologically important, carbon-rich natural lands in the United States are losing ground to agriculture.
- We investigate how quantitative assessments of historical land-use change (LUC) to address this concern differ in their conclusions depending on the data set used in 20 counties in the Prairie Pothole Region using:
  - the Cropland Data Layer,
  - a modified Cropland Data Layer dataset,
  - data from the NAIP Program
  - and in-person ground-truthing.



We find:

- The **Cropland Data Layer analyses overwhelmingly returned the largest amount of LUC with associated error** that limits drawing conclusions from it.
- Analysis with **visual imagery estimated a fraction of this LUC.**
- Clearly, analysis technique drives understanding of the measured extent of LUC; different techniques produce vastly different results that would inform land management policy in strikingly different ways.
- Best practice guidelines are needed.

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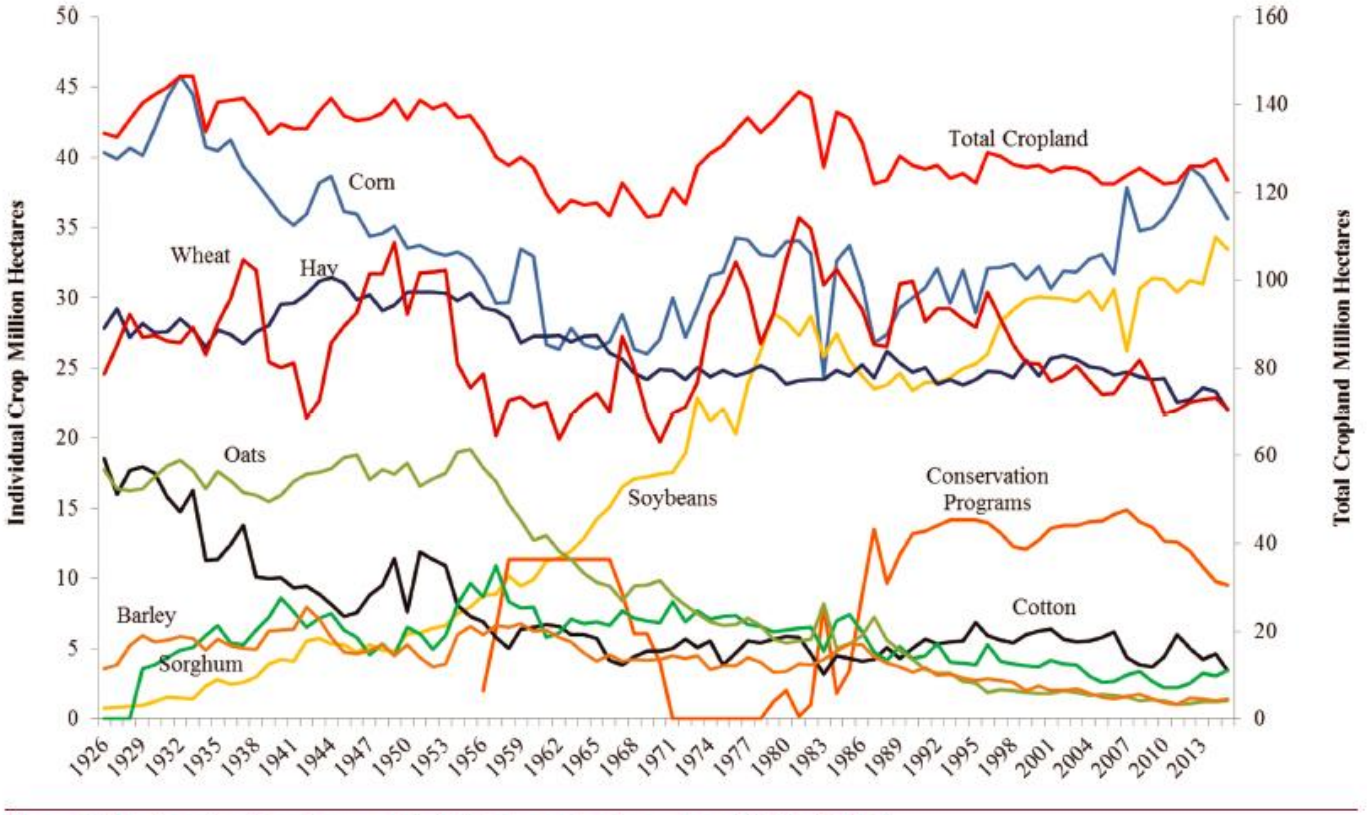
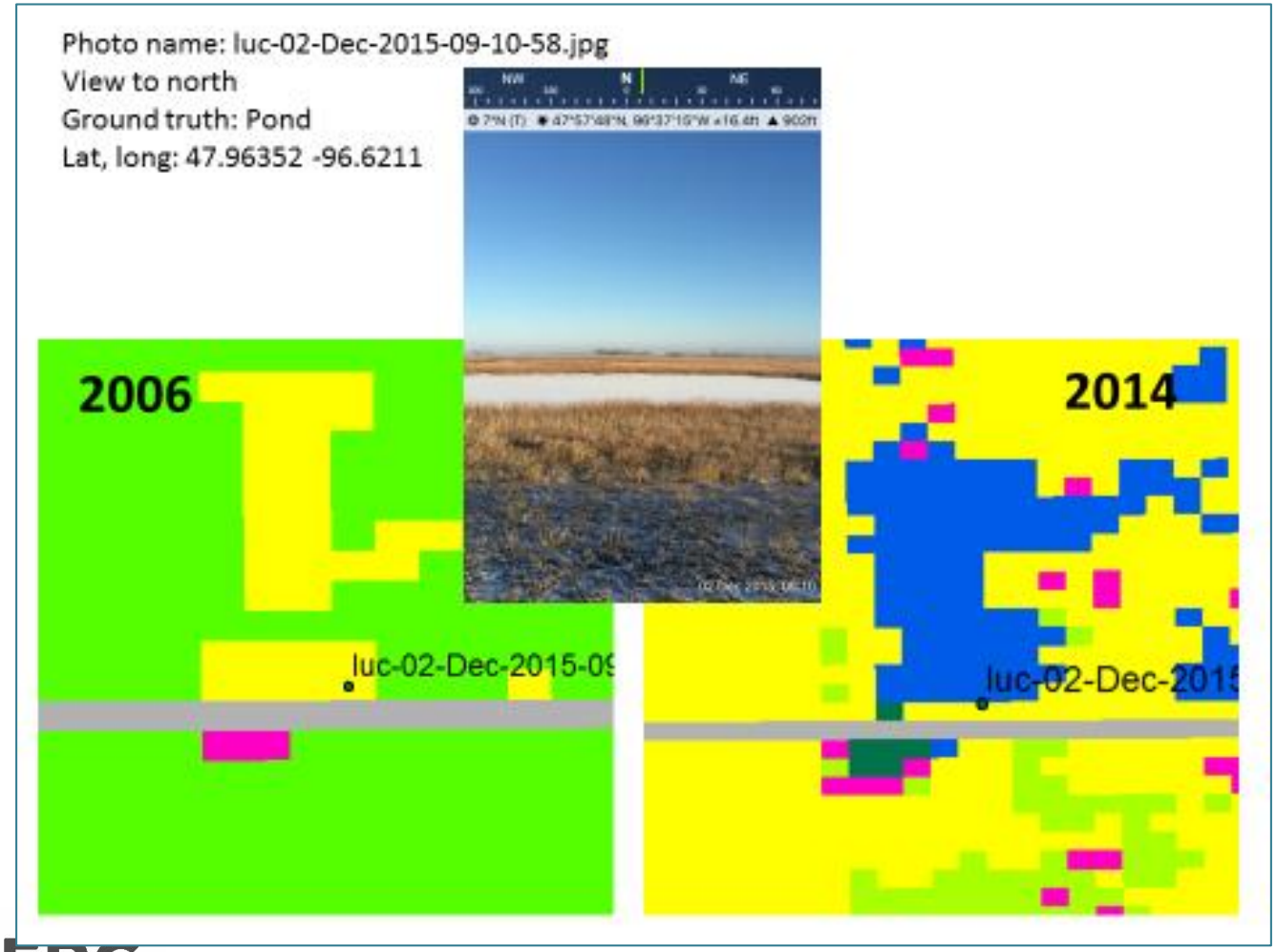
Our Comments on this Publication

Total Cropland has not increased in a long time



CDL vs. NAIP vs. Groundtruthing



Land Use Change Assessment with Different Methods

Table 1. Comparison of results from this study (2006 to 2014), Lark *et al.*[4] (2015) (2008-2012), Reitsma *et al.*[15] (2016) (2006-2012) (thousand ha).

	Forest to Cropland				Wetland to Cropland				Wetland and Forest to Cropland	
	This Study			Lark et al.	This Study			Lark et al.	Reitsma et al.	
	NAIP[a]	CDL	Mod-ified CDL	CDL[b]	NAIP	CDL	Mod-ified CDL	CDL[b]	CDL	NAIP
MN[c]	1.7	249	0.02	5.6	0	38	0	10	NA	NA
ND	0.83	222	13	0.44	0.01	25	0	7.4	NA	NA
SD	1.2	94	2.3	0.47	0	47	0	5.1	416	336

[a]Includes forest and grassland that was converted to cropland.
[b]Lark *et al.*[4] describe their modifications to the CDL in the supporting information to their paper. We attempted to replicate this approach, reporting results as 'modified CDL'.
[c]We used 2013 NAIP imagery because 2014 imagery was not available at the time of analysis.

Using the Cropland Data Layer or the Modified Cropland Data Layer (with aggregated classes) produces significantly higher land use change than NAIP and ground truthing

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Publication 3

"Critical Zone services as environmental assessment criteria in intensively managed landscapes"

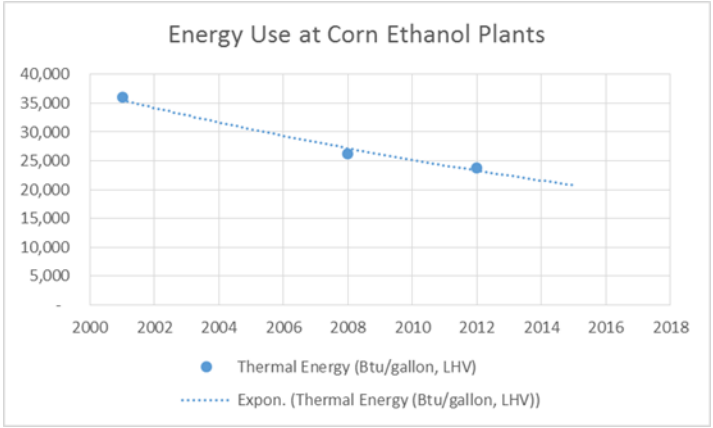
Richardson, M., and P. Kumar (2017),

Earth's Future, 4, oi:10.1002/2016EF000517.

Comments on this Publication

From the Publication

- "Although it does not lose energy, the refinery barely yields positive total net energy. At around 3 MJ/m^2,the total net energy for ethanol production demonstrates how this process is merely a transfer of mechanical and chemical energy associated with the refinery inputs, mainly natural gas and coal, to potential chemical energy stored in ethanol"
- "We base the U.S. LCA on *Ethanol Today*, a comprehensive dataset available for corn-based ethanol production, which synthesizes and consolidates six different corn-based ethanol LCA studies into one data set simulating today's production system and GHG emissions."



Our Comment:

- The cited *Ethanol Today* paper by Farrell et al. was written ***in 2006 before the build-up of the modern dry grind ethanol industry***. Since that paper is in itself a synthesis of datasets the underlying references are even older. Below, we have reproduced the energy balances from the Farrell paper.

Our Comments are Posted at:
http://www.erc.uic.edu/assets/pdf/mueller_comments_on_richardson_et_al32..pdf

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Publication 4

Subnational mobility and consumption-based environmental accounting of US corn in animal protein and ethanol supply chains.

Smith TM et al, September 2017

"Corn production, and its associated inputs, is a relatively large source of greenhouse gas emissions and uses significant amounts of water and land, thus contributing to climate change, fossil fuel depletion, local air pollutants, and local water scarcity."

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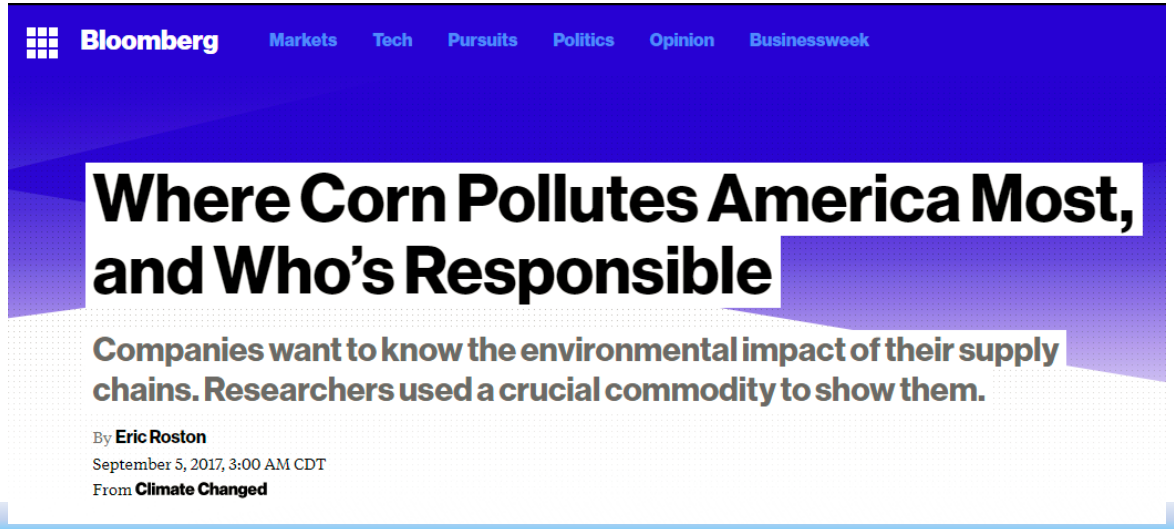
Our Comments on this Publication

- Mueller counter comments quoted in Bloomberg: "[Mueller] criticized the new study for **using 2012 as its base year, a time when devastating drought reduced corn yields to 122 bushels an acre,** which is equivalent to 1995 levels, or roughly 28 percent below 2016."
- "Mueller said that newer data would have been more appropriate, and is concerned with recent examples of outdated data use in research."


Bloomberg Markets Tech Pursuits Politics Opinion Businessweek

Where Corn Pollutes America Most, and Who's Responsible

Companies want to know the environmental impact of their supply chains. Researchers used a crucial commodity to show them.

By Eric Roston
September 5, 2017, 3:00 AM CDT
From Climate Changed

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Publication 5

"Navigating the maize. A critical review of the report 'A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol"

Report commissioned from Cerulogy by the Clean Air Task Force and National Wildlife Federation.

Author: Dr Chris Malins

July 2017

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Malins is Critical of USDA/ICF Report – What does USDA/ICF Report State?

- USDA/ICF report, titled "A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol," finds that greenhouse gas (GHG) emissions associated with producing corn-based ethanol in the United States are about 43 percent lower than gasoline
- "GHG profile of corn ethanol will be almost 50 percent lower than gasoline in 2022 if current trends in corn yields, process fuel switching, and improvements in trucking fuel efficiency continue.
- On-farm conservation practices, such as reduced tillage, cover crops, and nitrogen management, are estimated to improve the GHG balance of corn ethanol by about 14 percent.

Analysis cites repeatedly:
J. Dunn, Z. Qin, S. Mueller, H-Y. Kwon, M. Wander, M. Wang ; Carbon Calculator for Land Use Change from Biofuels Production (CCLUB) Manual; October 07, 2016; https://greet.es.anl.gov/publication-cclub-manual

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Publication 5

Malins states on Page 24:

> "The ICF report characterizes the CCLUB model as reflecting more accurate carbon stock factors" than factors used in the original ILUC modeling for the Low Carbon Fuel Standard, but in fact the **CCLUB has been criticized for methodological problems and questionable use of data**."
>
> "A report by the International Council on Clean Transportation (Searle & **Malins, 2016**) assessed the basis of soil carbon emissions factors within the CCLUB model […] The review concludes of the underlying data (Qin, Dunn, Kwon, Mueller, & Wander, 2016) that, "we do not believe that this meta-analysis adequately supports an assumption that the conversion of generic cropland to corn will increase soil carbon."
>
> "It further concludes that, **"The scientific literature points towards a consensus that continuous corn cultivation does not significantly affect soil carbon stocks over time, and there is not sufficient evidence to compare soil carbon under corn with that under other annual food crops."**

Our Comment: The author (Malins) is citing Himself as the criticizing source and refers to scientific literature consensus that is not supported by providing citations:

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Publication 5

Referring to the lack to incorporate a Remote Sensing Study into the USDA/ICF report the Malins states (Page 27):

> "A similar dataset was analyzed by Wright, Larson, Lark, & Gibbs (2017) with a particular focus on geographical correspondences between ethanol refineries and land use changes. **This study found with high statistical significance that proximity to refineries was a predictor of likelihood of land conversion to cropland […]**
>
> **The ICF report makes no mention of any of these studies** linking recent grassland and wetland losses to greater ethanol production, which have resulted in greater GHG emissions and losses of biodiversity."

Our Comment: We have shown in our peer reviewed publication that the referenced study asserting land use conversions around bio refineries suffers from potential errors.


Modeling and Analysis

Biofpr

Measured extent of agricultural expansion depends on analysis technique

Jennifer B. Dunn, Argonne National Laboratory, Argonne, IL, USA
Dylan Merz and Ken L. Copenhaver, Genscape, Inc., Louisville, KY, USA
Steffen Mueller, University of Illinois at Chicago, IL, USA

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Summary

- A series of recent papers assert new insights into life cycle modeling of biofuels, with claims of reduced sustainability
- Problems arise when:
  - **Researchers try to supplant established life cycle methodologies with simplified concepts**
  - Updated Life Cycle Data is replaced with **outdated data sets**
  - Studies are based on **outlier base years**
  - Studies incorrectly attempt to overcome **classification errors of satellite data** which are….
  - …..then cited in subsequent publications to further the criticism (against the USDA GHG Study)
- We have clarified/refuted some of these studies with peer reviewed publications, publicly posted comments, answering of press calls.
- Life Cycle Models worldwide iterate around GHG reductions from biofuels produced from many agricultural feedstocks

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