Energy Resources Center

Review of John DeCicco et al. Article titled "Carbon balance effects of U.S. biofuel production and use"

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The publication titled "Carbon balance effects of U.S. biofuel production and use" published on August 18 in the journal Climatic Change by John DeCicco et al. expands upon a carbon model titled Annual Basis Carbon (ABC) analysis first introduced by the authors in 2012. The latest article is an application of the methodology at the US geographic scale to asses "carbon that originates in feedstocks and is utilized as fuel, emitted during processing or exits the system in some other material form." An earlier publication released in August 2015 applied the methodology on the local, ethanol plant level. The authors essentially challenge the accuracy of traditional life cycle analysis with their new model. The authors state (page 3):

> "Unlike LCA or other forms of carbon accounting used for climate policy to date, it does not treat biofuels as inherently carbon neutral. Instead, it tallies CO_2 emissions on the basis of chemistry in the specific locations where they occur. ABC accounting reflects the stock-and-flow nature of the carbon cycle, recognizing that changes in the atmospheric stock depend on both inflows and outflows, while LCA focuses only on inflows (GHGs discharged into the atmosphere). It also conforms to a methodology that calls for a consistent system boundary that encompasses both biofuel and fossil fuel pathways "

We have reviewed the publication as well as the supplemental information including the provided spreadsheet with the calculation details. We support the notion that valuable insights can be gained from tracking both carbon inflows and outflows (emissions and uptake) within consistent modeling boundaries. However, in this case the boundaries are set to include largely unrelated agricultural carbon flows.

The ABC analysis starts by assessing "net ecosystem production" (NEP) which is defined by the authors as the portion of the total carbon taken up by vegetation (net primary production, NPP) that becomes material carbon available for local sequestration or other disposition. In the paper the authors describe assessing NEP as the carbon uptake of all major crops over the study horizon (2005-2013). Figure 3 of the publication shows that in 2013, for example, the net ecosystem production amounted to 215.3 Tera gram carbon (TgC). The authors argue that "for a biofuel to provide a net reduction in CO_2 emissions, the production of its feedstock must effect a gain in 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." The study shows that between 2005 and 2013 NEP has increased from 195.5 to 215.3 TgC, a 20 TgC increase but with net gains and reductions along the way (see green line in the below figure which has been reproduced from the supplemental spreadsheet material of the publication).

However, making biofuels production responsible for a net gain in NEP from a large set of complicated crop mix growing decisions only works if the biofuels policy is so significant that there is a clear correlation between biofuels production and crop mix development. 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.

We acknowledge that the RFS2 does contribute to stabilization of corn acres. However, the paper's general approach to assess to what degree ethanol emissions match with changes in NEP is questionable. The paper looks at what is essentially a complex crop mix driven by many variables including weather, global commodity prices, investments in commodities, and export market conditions for diverse crops and posits that a) the resulting change in NEP on US acres is driven by a particular biofuels policy and, on top of that b) the biogenic emissions from the produced biofuels must be below the change in NEP to meet the "additional carbon condition." To illustrate again, the paper for example states that "[NEP] jumped in 2007 due to a better growing season but also because notably more corn was planted that year." However, in 2008 much less corn was planted (78.6 down from 86.5 million acres) despite the fact that growers were knowledgeable about the ramp up in ethanol production from 6.9 to 9.7 billion gallons during that time frame. There are large confounding effects that do not establish direct causality between ethanol production, corn area planted, and NEP.

	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

In a second step the authors assess carbon emissions from end use including those from gasoline, diesel, ethanol, and biodiesel. In 2013, for example, the emissions from ethanol totaled 20.4 TgC. For ethanol additional carbon emissions releases from fermentation at the plant level are included (totaling 10.2 TgC in 2013). End use ethanol fuel emissions and fermentation emissions are added up (together with biodiesel emissions) as "biogenic carbon diverted to fuel." By subtracting biogenic carbon emissions incurred in 2005 from each subsequent year through 2013 emissions the authors then derive the change in biogenic emissions over time (orange line in the figure below from the publication's supporting material). The authors conclude that biofuels production resulted in a 5 TgC gap in 2013 between biofuels emissions and net gain in carbon uptake.[1] However, several carbon pools have been ignored.

In its assessment of NEP the paper argues that soil carbon effects are small and should be omitted. A large body of literature has been development over the past years that shows the applicability of biophysical soil models to assess soil carbon. These models have in turn supported the development of grower tools such as AgSolver and COMET-FARM which have become valuable resources to ensure sustainable crop production and direct growers in their growing decisions and retailers in their supply chain sourcing efforts.

The CCLUB-GREET model developed by Argonne National Laboratory includes a large database of county-level carbon factors based a surrogate soil carbon model. For mixed cropland going into higher corn rotations the model shows an average soil carbon gain of 0.14 tC per acre per year. For illustration purposes we calculated the gross acres to produce the 2013 ethanol feedstock at the prevailing yield (158 bu/acre) and an ethanol efficiency of 2.8 gallons/bushel resulting in gross acre requirements of 29.9 million acres.[2] If NEP is related to biofuels production as the authors assert then logically many growers would in fact convert to higher corn rotations in which case soil carbon effects from higher corn rotations are applicable. If we apply the CCLUB soil carbon factor to the acres in ethanol feedstock alone then the soil carbon sequestration totals 4.2 TgC (rising to 4.4 TgC in 2015), essentially already closing the gap of 5 TgC shown by the authors in their figure reproduced below. We recognize that soil carbon sequestration effects vary spatially and more refined assessments regarding crop rotation adjustments and soil sequestration are warranted.

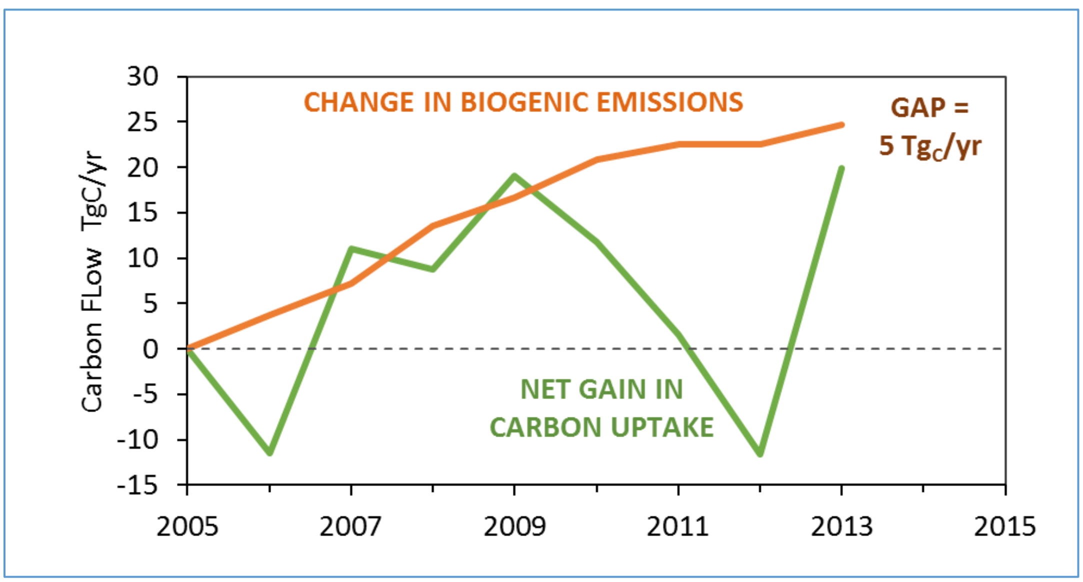

Figure reproduced from DeCicco et al Supplemental Information (Spreadsheet Worksheet "H")

[1] Note that the data and figure below is then rearranged to derive Table 1 and Figure 4 in the main publication
[2] Note that this is gross acreage; net acreage which accounts for DGS animal feed production is lower.

Finally, the paper claims to assess the "CO_2 uptake on cropland" but does not include any adjustments for carbon in crop residues including corn stover. A significant trend over the last 5 years has been corn stover removal for feed and other purposes since stover has become a management issue for growers.

In summary, the ABC methodology fails to establish a correlation between existing biofuels policies and net carbon uptake and it neglects several important carbon pools in its assessment. Further research in this area is required.

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