April 20, 2014

A new study[1] published in *Nature Climate Change* argues that biofuels from corn residue (stover) may be worse for the climate than gasoline. The authors suggest net carbon dioxide (CO_2) emissions associated with the removal of corn residue for biofuels production "are not adequately characterized in biofuel life cycle assessment." To address this perceived deficiency, the authors develop a new model to measure soil organic carbon (SOC) fluxes associated with corn residue removal. They then indiscriminately apply data from the model to a broad geographic area to estimate the greenhouse gas (GHG) emissions impacts of large-scale residue removal. In conclusion, the authors suggest that net CO_2 emissions related to residue removal render the overall GHG performance of cellulosic ethanol from corn residue only slightly better—or even slightly worse—than gasoline.

The study's methodology is fundamentally flawed and its conclusions are highly suspect. Because the results are based on sweeping generalizations, questionable assumptions, and an opaque methodology, stakeholders should exercise extreme caution in interpreting the study's conclusions and consider the broader body of science on the carbon impacts of biofuels from crop residues. We are still reviewing the supplemental material and data, but upon initial review we identified the significant flaws that are enumerated below.

1. **The study assumes unrealistic and inappropriate levels of residue removal, and makes no distinctions with regard to tillage practices.**

For its central scenario, the analysis assumes farmers will harvest 6 metric tonnes (t) of residue per hectare (ha) (2.68 short tons/acre). This means the authors believe *all* farmers would willingly and consistently remove approximately 60-75% of the corn residue from their fields, regardless of their tillage practices, soil types, crop rotations, equipment capabilities, and other location-specific factors. This is an entirely unrealistic assumption that ignores current management practices and disregards the substantial variability in geographic factors affecting sustainable removal rates. Current best practices generally recommend removing no more than 40-50% of the residue in no-till systems, no more than 20-30% in conservation tillage practices, and 0-10% under conventional tillage. Stover removal rates in recent years have typically been in the 10-25% range, although higher rates have been shown to be sustainable under certain conditions. Ultimately, however, *there are no simple "rules of thumb" or "one size fits all" approaches to stover harvest*. Farmers evaluate appropriate stover removal rates based on a wide array of local factors unique to their operations. At a fundamental level, the farmer's livelihood depends on sustaining or improving soil health; growers strive to ensure their most valuable asset (soil) is properly protected and managed.

2. **The authors' argument that soil organic carbon (SOC) fluxes related to stover removal have not been well characterized in previous studies is incorrect.**

Several other models have been used historically to estimate fluxes of carbon among the atmosphere, vegetation, and soil. Among these models, DAYCENT/CENTURY is the most well-known and tested, while other models like EPIC are also commonly used. Numerous experiments using these models have been documented and published in the literature over the past decade or more. Not only does the Liska et al. study make absolutely no attempt to

[1] Liska, A.J. et al. Biofuels from crop residue can reduce soil carbon and increase CO2 emissions. *Nature Climate Change*. Vol. 4. May 2014.

validate its results against those obtained from other established models, but it also fails to discuss model differences. Further, reputable models like DAYCENT have far more calibration points than the new model developed by Liska et al. The authors completely fail to explain why their new model should be viewed as an improvement over existing models and methodologies.

3. **The analysis absurdly suggests SOC loss is perfectly linear with the stover removal rate.**

While the study's primary case was based on an unrealistically high average residue removal rate of 6 t/ha, the authors also examined scenarios where 2 and 4 t/ha of residue is removed (equivalent to roughly 20-40% removal rates). Curiously, the authors suggest that SOC loss was "insensitive to the fraction of residue removed." This assertion is based on the notion that less residue removal will result in fewer CO_2 emissions, but that the energy yield of the residue will also be smaller. Thus, the study incredulously implies that removing 5% of the residue will have the same climate effect per unit of energy as removing 90% of the residue. This finding is in stark contrast to studies that show virtually no change in SOC levels at low residue removal rates, but potentially larger fluxes at high removal rates under certain conditions.

4. **The Liska et al. results are contrary to the findings of other studies; the reasons for divergence are not clearly presented.**

Several other recent studies have examined the carbon impacts of using corn residue for bioenergy, including effects on SOC. Analysis conducted by the University of Illinois and Argonne National Laboratory (using county-level data from the CENTURY model) showed 30% residue removal resulted in no additional direct or indirect carbon emissions. Furthermore, Wilhelm et al. (2007) (which is misleadingly cited by Liska et al. in the first sentence of the paper) show certain levels of corn stover *can* be removed without decreasing SOC. Finally, initial results from research at South Dakota State University (SDSU) showed that SOC levels remained constant from 2008-2012 in a harvest system with relatively high residue removal rates. The SDSU research used 13C isotopic source tracking to quantify the mineralization of SOC as well as to determine how much new plant carbon (PCR) was incorporated into the SOC. These are just three examples of recent research efforts that produced findings that starkly contrast Liska et al. The authors make no attempt to dispute the results of any of these recent studies.

5. **The authors assume "no mitigation action is taken" to prevent SOC losses or replace lost C.**

Even though the authors admit that "[s]oil CO_2 emissions from residue removal…can be mitigated by a number of factors and management options," they fail to include any of these mitigation practices in their scenario analyses. In fact, in its discussion of overall GHG impacts associated with residue-derived ethanol, the study apparently fails to include the emissions benefits related to the use of the lignin fraction for process energy production. Most, if not all, cellulosic biofuel projects under way or in planning stages will make use of lignin for power generation. While other mitigating factors (including no-till cover crops, improved management practices, animal manure application, rotation with forage crops, etc.) are mentioned, none figure into the authors' calculations of overall GHG impacts.

Bottom Line*: The new paper by Liska et al. is based on flawed assumptions as well as unclear methods and data. It contradicts the findings of other recent research without robust explanation for the divergence. Ultimately, the paper should be seen for what it truly is—a gratuitous attempt to grab headlines and further scandalize the debate over renewable fuels.*