Dear ARB,

I would like to comment on the ARB’s “Applicable Operating Conditions” for the Poet-DSM corn stover ethanol pathway. The ARB states that: *“2. Corn stover removal rates from farms around the Project Liberty Plant shall not exceed 50 percent. The corn stover removal rates shall also be contingent upon future research results identifying sustainable crop residue removal rates.”*

 Crops that produce large root masses and large amounts of stover provide valuable biomass carbon that greatly aid soil organic carbon stocks. Modern high yield corn is one of the very few annual crops that produce enough unharvested carbon rich biomass to build SOC stocks and this reduces atmospheric CO2. However, removal of corn crop stover will reduce the magnitude of the SOC increase, and this should be accounted for in Life Cycle Analysis of GHG emissions from corn grain ethanol and or corn stover ethanol.

 There is much scientific agreement of the effect corn has on SOC stocks. Soil Carbon Models such as CENTURY and USDA NRCS RUSLE2 SCI estimate this effect **(1,2)**. These models are calibrated with thousands of actual measurements of soil carbon from fields **(3)**. Recent research on the effect of stover removal from corn fields on SOC stocks quantify a decrease in atmospheric CO2 sequestration in soil **(4,5)**.

 Relatively small increases or decreases in soil carbon stocks result in large decreases or increases in the carbon intensity of corn grain and stover ethanol. For example, Clay et al. (2014) **(4)**, found SOC stocks increased 2.65 Mg SOC (9.7 Mg CO2) per hectare over five years from corn fields when all the stover remained on the field, and .153 Mg SOC (.56 Mg CO2) per hectare when 60% of the stover was removed **(6)**. Assuming corn grain yields of 185 bu./acre (5 year avg. in study), and 2.75 gallons of ethanol are produced from each bushel, this means there were SOC gains equivalent to 19.2 grams CO2 eq./Mj/year when no stover was removed and 1.1 grams CO2 eq./Mj/year when 60% of the stover was removed. This represents a large reduction in the carbon intensity of the ethanol made from corn grain. In this five year study, corn stover ethanol with 60% removal rates was still sustainable from a SOC stocks standpoint, but corn production with no stover removal provided significant soil health and environmental service by sequestering atmospheric CO2 in soil.

 Halvorson and Stewart (2015) **(5)** found that corn increased SOC stocks 6.8 Mg SOC (24.9 Mg CO2) per hectare over seven years when no stover was removed, and lost 2.4 Mg SOC (8.8 Mg CO2) per hectare when 66% of the stover was removed **(7)**. Average seven year corn yields in this study were 143 bu./acre and if we again assume 2.75 gallons ethanol per bushel, SOC gains were equivalent to 45 grams CO2 eq./Mj/year when no stover was removed and there was a loss of SOC equivalent to 16 grams CO2 eq/Mj/year when 66% of the stover was removed. Soil carbon models predict a similar impact on LCA GHGs, and soil health/sustainability from corn with and without stover removal.

 Current CO2 prices in excess of $100 per Mg in the California LCFS market provide a powerful incentive to remove corn stover that is normally retained on corn fields. I urge you to consider and adjust the carbon intensity of corn grain ethanol pathways to reflect the positive impact retained stover has on climate change. Not doing so will incentivize reductions in soil health and sustainability, and result in higher atmospheric CO2.

Respectfully,

Ron Alverson

Corn Producer, Wentworth, S.D.

**Sources:**

**(1)** **CENTURY Soil Carbon Model**

<http://www.nrel.colostate.edu/projects/century5/reference/html/Century/submodel-som.htm>

 <https://greet.es.anl.gov/publication-cclub-land-management>



**(2)** **USDA NRCS RUSLE2 Model**

<http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/ia/technical/?cid=nrcs142p2_008161>

**(3)** **USDA NRCS RUSLE2 SCI explanation:**

(PPT)[National Science and Technology Consortium - Natural ...](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_019353.ppt)

*www.nrcs.usda.gov/.../nrcs143\_0...*

Natural Resources Conservation Service

**Using the Soil Conditioning Index to Assess Management Effects on Soil Carbon**. USDA Natural Resources Conservation Service. Soil Quality National ...

**(4)** **Tillage and Corn Residue Harvesting Impact Surface and Subsurface Carbon Sequestration** David E. Clay,\* Graig Reicks, C. Gregg Carlson, Janet Moriles-Miller, James J. Stone, and Sharon A. Clay (2014)

 https://dl.sciencesocieties.org/publications/jeq/pdfs/44/3/803

**(5)** **Stover Removal Affects No-Till Irrigated Corn Yields, Soil C and N**

 Ardell D. Halvorson\* and Catherine E. Stewart

http://www.ars.usda.gov/research/publications/Publications.htm?seq\_no\_115=314250

**(6)** **Clay et al. (2014), Summary paragraphs from paper:**

In South Dakota, agriculture contributed to a 42% SOC loss

between the 1880s and 1937 and a 60% loss between the 1880s

and 1985 (Clay et al., 2012, 2014). Since 1985, tillage changes and

increasing corn yields resulted in a 24% increase in SOC levels and

34, 23, and 20% decreases in wind, sheet, and rill erosion in South

Dakota, Nebraska, and North Dakota, respectively (NRCS, 2007).

As expected, tillage increased SOC loss and the associated *k*SOC rate

constants. Extensive residue harvesting could threaten these recent

improvements. After 5 yr, adopting no-till management, returning

surface residues, or increasing the yield potential increased the

opportunity to sequester C (= PCRincorp − SOClost). For example, in

the combined 0- to 15- and 15- to 30-cm soil zones, (i) 0.153 (3.38

− 3.227) and 2.65 (5.34 − 2.62) Mg SOC ha−1 were sequestered

in the 60 and 0% residue removal treatments, respectively; (ii)

2.51 (4.86 − 2.35) and 0.36 (3.89 − 3.53) Mg SOC ha−1 were

sequestered in the no-till and chisel plow treatments, respectively,

and (iii) 1.16 (4.36 − 3.2) and 1.65 (4.34 − 2.69) Mg SOC ha−1

were sequestered in the moderate and high yield zone treatments,

respectively. In addition, (i) in the 0- to 15-cm depth, SOClost was

less in the high yield zone (1.49 Mg ha−1) than the moderate yield

zone (2.19 Mg ha−1), (ii) in the 15- to 30-cm depth, SOClost was

higher in the 60% residue removal (1.377 Mg ha−1) than the 0%

removal (0.82 Mg ha−1) treatments, and (iii) the chisel plow–60%

residue removal treatment did not provide 30% residue soil cover

after planting. These findings show that surface residue harvesting

has profound impacts on C turnover and surface soil coverage.

**(7)** **Halvorson and Stewart (2015), Abstract from Paper:**

Corn (*Zea mays* L.) stover removal can increase yields under no-till (NT) in climates

 where cold spring soil temperatures delay emergence and plant growth. The study objective was to evaluate partial stover removal (PR) effects on irrigated NT corn grain and stover yields, N uptake, and changes in soil organic C (SOC) and total soil N (TSN) compared to full stover retained (FR) under three N treatments for 7 yr on a clay loam soil. Stover removal (average 66%) increased early spring soil temperatures and enhanced early plant development compared to FR. Grain and stover yields increased with increasing N rate, as did plant N and C uptake, but varied with stover treatment. Averaged over N rate, grain yields were greater with PR than FR, but stover yields were lower with PR than FR. The C:N ratio of stover declined with increasing N rate. Nitrogen fertilization did not significantly influence SOC and TSN stocks after 7 yr.

Averaged over N rates, PR (partial stover removal) decreased SOC 2.4 Mg SOC ha-1, but FR (full stover retention) increased SOC 6.8 Mg SOC ha-1 in 0-30 cm soil depth. TSN stocks increased significantly with FR (1176 kg N ha-1 ) but not with PR (70 kg N ha-1 ). These results suggest that continued, long-term residue removal will negate any initial yield benefits from more rapid early spring plant development. Partial stover removal as a cellulosic feedstock at the levels we used for ethanol production would negatively impact soil quality under irrigated, NT corn production in Colorado.