## RSB – ROUNDTABLE ON SUSTAINABLE BIOMATERIALS

# RSB Certification Protocol and Guidance for Harvesting Corn Stover as a Feedstock for Biofuels or Bio-products

Version 1.0

Approved for Certification

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## Contents



## A. Introduction

Corn stover is the above ground plant material that includes the stalks, leaves, husks, cobs and tassels that is generally left in the field after corn (Zea mays L.) grain is harvested. Corn stover makes up approximately half of the dry weight of mature corn plants, with the grain (seed) accounting for the other half (Ertl et al., 2013). Corn stover is composed primarily of carbohydrate polymers (cellulose and hemicellulose) and phenolic polymers (lignin). Other compounds, such as proteins, acids, salts, and minerals, are also present. As stover decomposes it releases nitrogen, phosphorous, potassium, calcium, magnesium, sulfur and other nutrients that subsequently help support the next crop. The stover also provides an important food source for the soil microbial community and is one source (along with roots and root exudates) of the carbon that maintains and builds the soil organic matter (SOM) that influences many soil physical, chemical, and biological properties and processes.

Normally, stover is left on the ground to help protect the soil from wind and water erosion or incorporated through tillage where its breakdown helps sustain soil organic matter and recycle nutrients. Prior to incorporation through tillage, some producers mechanically shred the residue to help increase the rate of decay and enhance its incorporation into the soil.

Traditionally, some corn stover has been harvested and used as animal feed or bedding, but more recently, it has also been identified as a readily available feedstock for production of cellulosic ethanol, advanced biofuels, and other bio-products. Interest in using corn stover for these products has increased as commercial cellulosic ethanol plants have come into operation. However, care must be taken to ensure that the stover is not removed in a manner, or at a rate, that will have a negative impact on soil health and/or the surrounding environment (*i.e.*, water quality, air quality, wildlife habitat, etc.). Many scientific studies (including those listed below) have been completed to help guide decision makers regarding corn stover availability and the implications of removing excessive amounts of stover from farm fields.

### RSB's approach in developing this guidance.

The RSB developed this procedure with a wide range of US stakeholders including, the USDA / NRCS Soil Science Division, the USDA Agricultural Research Service as well as US-based industrial and NGO stakeholders to make sure approaches and tools that are available in the US for soil management are incorporated in this procedure.

## B. The aim of this Guidance

The purpose for this protocol and guidance is to provide decision makers information regarding the practices and the metrics that should be followed by farmers and auditors to ensure that any removal of corn stover for cellulosic biofuel or bioproduct production is done in a way that complies with the RSB Principles & Criteria, specifically with Criterion 8a which states:

> *"Operations shall implement practices to maintain or enhance soil`s physical, chemical, and biological conditions."*

And more specifically Criterion 8.a.1.'s third minimum requirement which states:

> *"The use of agrarian and forestry residual products for feedstock production, including lignocellulosic material, shall not be at the expense of long-term soil stability and organic matter content"*

This procedure is to be used by individual farms or processors and farm groups seeking or operating under RSB certification[1]. It also must be followed by uncertified farms who are supplying stover (agriculture residue) to an RSB-certified downstream processor for use in the production of RSB-certified biofuels or bioproducts.

## C. What this guidance covers (Scope)

This guidance was specifically developed for corn stover harvest in North America.

## D. Background

Soil Health

According to the USDA NRCS (US Department of Agriculture Natural Resources Conservation Service) website, “Soil health, also referred to as soil quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.” In other words, soil health can be defined as the optimum status of the soil's biological, physical and chemical functions. These functions include (1) sustaining biological activity, diversity, and productivity; (2) regulating and partitioning water and solute flow; (3) filtering and buffering, degrading, immobilizing, and detoxifying organic and inorganic materials; (4) storing and cycling nutrients and other elements.

Indicators of Soil Health

The following table has been taken from the USDA/NRCS Guidelines for Soil Quality Assessment, Jan 2001

[1] See more information on the scope of certification and auditing in chapter F

## Table 1: Example of Minimum Data Set of Indicators for Soil Quality

| Indicator | Relationship to Soil Health |
|---|---|
| Soil organic matter | Soil fertility, structure, stability, nutrient retention, soil erosion, and available water capacity |
| PHYSICAL | |
| Soil structure | Retention and transfer of water and nutrients, aeration, habitat for microbes, and soil erosion |
| Depth of soil and rooting | Estimate of crop productivity potential, compaction, and existence of plow pans or similar root restrictive layers |
| Infiltration and bulk density | Water movement, porosity, and workability |
| Water holding capacity | Water storage and availability |
| CHEMICAL | |
| pH | Biological and nutrient availability |
| Electrical conductivity | Plant growth, microbial activity, and salt tolerance |
| Extractable nitrogen (N), phosphorus (P), and potassium (K) | Plant available nutrients and potential for N and P loss |
| BIOLOGICAL | |
| Microbial biomass carbon (C) and N | Microbial Catalytic potential and repository for C and N |
| Potentially mineralizable N | Soil productivity and N supplying potential |
| Soil respiration | |

(Adapted from: Doran et al, 1996, Larson and Pierce, 1994, and Seybold et al, 1997)

Studies show that the key soil health indicators that should be monitored when removing stover are:

1. Soil Erosion
2. Soil Organic Matter (SOM)
    a. Particulate Organic Matter (POM)
3. Soil Organic Carbon (SOC) or Total Organic Carbon (TOC)
4. Nutrient balance (N-P-K levels and soil pH)
5. Soil compaction

Total soil organic carbon (SOC) may take several years to show a change. Additionally, it is difficult to sample soil in a manner that reliably indicates small changes in SOC. However, a number of tests can be done to baseline SOC levels and indicate significant changes in soil carbon relatively quickly:

- Permanganate oxidation test
    - doesn't work for all soils
    - easily performed by commercial labs

- Particulate Organic Matter (POM) test
    - best indicator of change in total carbon
    - may not be available at commercial laboratories
- Soil enzyme Beta glucosidase test
    - also a good indicator of change in total carbon
    - normally need 'fresh' soils kept cool at field moisture and tested within 10 days
    - can be done on dried soil
    - may be able to use equipment found in typical soil test labs

<u>Key considerations when removing stover:</u>

- Select fields with the least amount of slope to reduce erosion potential
- Select fields or field segments with the highest yield potential as they will produce the most stover
- Give priority to fields that will be going back into corn the following year since even with some removal, they will generally have a sufficient amount of stover to protect and sustain the soil resource
- Account for nutrients removed with the stover (primarily N, P, and K) through an appropriate nutrient management plan that accounts for all inputs including manure, cover crops, and inorganic fertilizer.

- Reduce tillage intensity following stover harvest to leave more residue on surface to minimize runoff and erosion and to sustain soil organic matter levels
- Remove only the amount of stover which will not adversely affect the level of erosion protection and maintenance of soil organic matter levels (typically no more than 30 percent of the stover, or 2.5-5.0 metric tons per hectare (1-2 US tons/acre))
- Account for the full costs of harvesting corn stover (e.g. what additional nutrients might need to be added to the soil if stover is harvested, will stover harvest result in additional wheel traffic and create unwanted soil compaction)
- If at all possible, plant a cover crop before grain harvest so that the soil has better protection from wind and water erosion. In many northern locations, spring oats will winter-kill and thus avoid the need for additional herbicide.

## E. Minimum Requirements for Biomass Producers

1. Removal rate

The operator shall conduct a site-specific assessment by using the NRCS Soil Conditioning Index (SCI) or equivalent. The rating of the SCI shall be a positive value, indicating that the system is predicted to have increasing soil organic matter. Removal rates shall be assessed site specific or for a uniform region (i.e. uniform in terms of the parameters of the SCI).

> The Soil Conditioning Index (SCI) is a tool that can predict the consequences of agricultural practices on soil organic matter. The SCI has three main components: 1) Organic Matter – accounts for the amount of organic material returned to the soil 2) Field Operations – accounts for the effect of field operators 3) Erosion – accounts for the effect of removal of surface soil by erosion processes.
>
> The SCI gives an overall rating on these components. If the rating is a negative value, the system is predicted to have declining soil organic matter. If the rating is a positive value, the system is predicted to have increasing soil organic matter.

2. Preventing Erosion

A site-specific assessment shall be conducted to ensure that the erosion is below the tolerable level (i.e. USDA ARS ‘t’ values) for soil loss by using the Revised Universal Soil Loss Equation 2 (RUSLE 2) or equivalent.

2.1. One or more of the following shall also be met to reduce erosion on fields where corn stover is harvested:

2.1.1. Use of “no-till” or “minimum-till” tillage practices

2.1.2. Use of cover crops

3. Nutrient Management Plan

3.1. The operator shall have a nutrient management plan in place that accounts for nutrients removed with the stover (primarily N, P, and K) and all inputs including manure, cover crops, and inorganic fertilizer.

3.2. The nutrient management plan shall ensure that the soil nutrient balance is maintained and nitrate pollution is reduced.

4. Measurements

4.1. Regular basic soil analysis (N-P-K, pH,) shall be completed on fields where corn stover is harvested (baseline analysis in the first year and based on a 3-years testing cycle afterwards). In the case of significant deviations from the results expected as part of the nutrient management plan, the reasons for the deviation shall be assessed and the nutrient management plan shall be adapted accordingly. In this case, the soil analysis shall be done based on an annual testing cycles.

4.2. SOC analysis shall be carried out as a baseline analysis and on a 5-year interval on selected representative fields by using one of the above fast carbon pools (permanganate oxidizable C, POM etc.)

4.3. If the SOC analysis deviates significantly from the modelling through the Soil Conditioning index, the reasons for the deviations shall be assessed and practices adapted accordingly.

## F. Auditing

1. Certification Scope

1.1. The scope of certification can either cover

- one individual farm, or
- multiple farms organized under the umbrella of the participating operator.

The participating operator may be one of the individual farm operators, a trader or a processing operator.

1.2. If an individual farm is certified, all necessary documents and records have to be provided by the individual farm operator. If the certification scope consists of multiple farms, the participating operator shall have the complete description of all entities in the scope of certification, contracts to ensure compliance with this procedure and all necessary management plans in place to comply with this procedure.

Please see the RSB Standard for Participating Operators for more information (RSB-STD-30-001)

1.3. Auditing shall be carried out in accordance with the RSB Procedure Requirements for Certification Bodies and Auditors RSB-PRO-70-001 including audits of a representative sample on the farm level.

1.4. Auditors shall assess the following documents and records for verifying compliance:

1.4.1. Initial audit

- Initial baseline soil analysis (N-P-K, pH, SOC)
- Nutrient application rates, nutrient management plan, verification of input parameters

- Initial corn yields (from current or previous year)
- Corn stover management plan, removal rates (based on modelling), verification of SCI input parameters
- Erosion assessment: Determining max. slopes (based on modelling), planning of erosion prevention practices
- Maps showing where stover will be removed, land and soil characteristics, corn yield maps

1.4.2. Annual audits

- Annual records of measurements (frequency as defined in the minimum requirements) and measures in case of deviations
- Documentation showing corn yields, calculation of corn stover removal, volumes of corn stover harvested/delivered from each field in line with management plan.
- Check that stover was not taken from fields with higher slope than determined
- Nutrient application according to nutrient management plan

## G. Additional Guidance

1. Estimating corn stover yield to determine how much can be removed

As a general rule, the amount of dry stover produced is about the same as the amount of grain produced when expressed on a dry weight basis (not the yield at 15% water content). This is commonly expressed in a ratio called the harvest index.[2]

Harvest index is defined as the weight of grain divided by the total weight of above ground biomass (stover plus grain).

Harvest index = tons of dry grain / (tons dry stover + tons dry grain)

Using a 50% rule of thumb: the maximum amount of stover that can be harvested

= corn yield (mt/ha) minus 7.4,
or
= corn yield (US tons/acre) minus 3.0 [3]

Using the above rule of thumb, if a field is not producing at least 7.4 mt/ha (3.0 US tons/acre) of corn yield, then no stover shall be removed.[4]

2. Erosion Assessment Resources

Erosion trends are more difficult to quantify. The following aggregate stability test may be done by the biomass producer each year.

Most available modeling database/software is not very user-friendly for farmers. However, these models have been incorporated into the AgSolver Sustainable Residue Calculator described below.

- Aggregate stability test (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=stelprdb1237387)
- Modeling software: USLE database, RUSLE2, WEPP, WEQ (modeling software, not for farmers)
- A Methodology of a Visual Soil - Field Assessment Tool: ftp://ftp.fao.org/agl/agll/lada/vsfast_methodology.pdf

AgSolver - Sustainable Residue Calculator

[3] Use alternatively the site specific removal rate value
[4] Use alternatively the site specific removal rate value

http://agsolver.com/agronomic_decision_services
https://www.youtube.com/watch?v=QWV5QfX8W8c

The Sustainable Residue Calculator is a stover management tool offered by a private company that can be offered to farmers to help them identify areas of the farm where stover can sustainably be harvested, as well as management practices that should be used to preserve soil health.

Outputs from the analysis would include stover removal rates, soil erosion levels, quantified carbon trends, CO2 gas flux, etc. The output could potentially be used as evidence for an audit that the farmer is harvesting stover sustainably. See paper by David Muth in bibliography - Muth Jr., D. J., McCorkle, D. S., Koch, J. B. and K. M. Bryden. Modeling Sustainable Agricultural Residue Removal at the Subfield Scale. Agronomy, Soils & Environmental Quality 104, 970-981. (2012).

**Other Soil Testing Resources**

USDA/NRCS Soil Quality Indicator Sheets:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=stelprdb1237387

Soil Conditioning Index (SCI) -
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ia/newsroom/factsheets/?cid=nrcs142p2_008548

A Methodology of a Visual Soil - Field Assessment Tool:
ftp://ftp.fao.org/agl/agll/lada/vsfast_methodology.pdf

Estimating Corn and Soybean Residue Cover:

https://www.extension.purdue.edu/extmedia/AY/AY-269-W.pdf

## Bibliography

Andrews, S. 2006. Crop residue removal for biomass energy production: Effects on soils and recommendations. Available at http://soils.usda.gov/sqi/files/AgForum_Residue_White_Paper.pdf. USDA NRCS.

- *Periodic Monitoring and Assessment. Regardless of the specific residue removal practice chosen, fields should be carefully monitored for visual signs of erosion or crusting. Periodic checks of SOC as part of a fertility testing regime are also recommended. Removal rates should be adjusted in response to adverse changes: if erosion increases or SOC decreases, removal rates must be reduced to maintain soil quality.*

Ertl, W. Sustainable Corn Stover Harvest: A Publication of the Iowa Corn Promotion Board (2013)

- This review addresses the issues related to corn stover harvest beginning with background information about corn stover's composition, abundance and availability. Considerations for determining sustainable stover removal rates. Other key points to consider regarding stover harvest.

Friedman, D., Hubbs, M., Tugel, A., Seybold, C., Sucik, M. Guidelines for Soil Quality Assessment in Conservation Planning. USDA/NRCS (2001)

- This guidance document outlines indicators for assessing soil health.

Johnson, J.M.F., R.R. Allmaras, D.C. Reicosky (2006) Estimating source carbon from crop residues, roots and rhizodeposits using the national grain-yield database. Agron J 98:622-636

Marshall, L. and Z. Sugg. 2009. Corn Stover for Ethanol Production: Potential and Pitfalls. WRI Policy Note, Energy Biofuels (4). Available online at [http://www.wri.org/publication/corn-stover-ethanol-production](http://www.wri.org/publication/corn-stover-ethanol-production)

- This paper raises multiple environmental and economic concerns, and some potential mitigation approaches, regarding the use of corn stover for bio-fuel production

Muth Jr., D. J., Bryden, K. M., and R. G. Nelson. Sustainable Agricultural Residue Removal for bioenergy: A Spatially Comprehensive US National Assessment. Applied Energy (2013)

Muth Jr., D. J., McCorkle, D. S., Koch, J. B. and K. M. Bryden. Modeling Sustainable Agricultural Residue Removal at the Subfield Scale. Agronomy, Soils & Environmental Quality 104, 970-981. (2012). This analysis provides the background for the development of computational tools for managing sustainable corn stover removal (see AgSolver - Sustainable Residue Calculator above).

Wilhelm, W. W., Hess, J. R., Karlen, D. L., Johnson, J. M. F., Muth, D. J., Baker, J. M., Gollany, H. T., Novak, J.M., Stott, D. E. and G. E. Varvel. Balancing Limiting Factors and Economic Drivers for Sustainable Midwestern US Agricultural Residue Feedstock Supplies. Industrial

Biotechnology 6, 271-287 (2010).

- This review examines six agronomic factors that collectively define many of the limits and opportunities for harvesting crop residue for biofuel feedstock in the Midwestern United States. The limiting factors include soil organic carbon, wind and water erosion, plant nutrient balance, soil water and temperature dynamics, soil compaction, and off-site environmental impacts.

Wilhelm, W. W., Johnson, J. M. F., Hatfield, J. L., Voorhees, W. B. and Linden D. R. Crop and Soil Productivity Response to Corn Residue Removal: A Literature Review. Agronomy Journal 96, 1-17. (2004).

Wilhelm, W. W., Johnson, J., Karlen, D., Lightle, D. Corn Stover to Sustain Soil Organic Carbon Further Constrains Biomass Supply. Agronomy Journal, Vol. 99 November-December (2007).

- Identifies estimated ranges of corn stover residue needed to remain on field to sustain soil organic carbon: 2.3 tons stover/acre under no-till or minimum-till regime; 3.3 tons stover/acre under high tillage regime.
- Soil organic carbon retains and recycles nutrients, improves soil structure, enhances water exchange characteristics and aeration, and sustains microbial life within the soil. Sparling et al. (2006) reported that crop yield and the value of environmental services (C and N sequestration) were greater for soils with greater SOC. Limited research has shown that removing stover reduces grain and stover yield of subsequent crops and further lowers soil organic matter levels (Wilhelm et al., 1986). Highlights the critical role stover plays in preventing erosion and maintaining or replenishing SOC.

USDA/USDOE. 2005. Biomass as a Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. Report No. DOE/GO-102995-2135. Available online at [http://www.osti.gov/bridge](http://www.osti.gov/bridge).