The Sustainability of Harvesting Crop Residues for Energy
Summary of an ARS-DOE Workshop

May 8-9, 2003

Wallace Learning Center
Lewis, Iowa

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CONTENTS

INTRODUCTION

In 1999, the U.S. Department of Agriculture, Agricultural Research Service (ARS), and the U.S. Department of Energy (DOE), determined that understanding the sustainability of collecting corn stover was relevant to both of their missions and jointly planned a project on the implications of removing corn stalks (stover) from production fields. The project, "Implications of Using Corn Stalks as a Biofuel Source," added residue removal experiments to existing ARS corn production studies. It began in September 1999 and included literature reviews and field and laboratory studies designed to last through five growing seasons. By early 2003, a major review of the technical literature was complete, initial results were emerging from the research projects, and participants had begun to identify areas with remaining questions.

In 2000, the DOE's National Renewable Energy Laboratory (NREL) began a life cycle assessment of producing ethanol from corn stover using it as a vehicle fuel. One of the first steps in the assessment was soliciting stakeholder input on goals and scope for the study. Stakeholder input was gathered in May 2000 at a workshop held at the Iowa State University's Wallace Foundation Learning Center. At that time, a promise was made that the stakeholders would be invited to a follow-on meeting to review and discuss results of the project. By early 2003, a preliminary report on the life cycle assessment was complete and ready for such a review.

In May 2003, the ARS and DOE held a second workshop at the Wallace Foundation Learning Center. This workshop was designed to serve two purposes. The first was to provide a forum, promised in 2000, for reviewing and discussing the NREL's life cycle assessment of fuel ethanol from corn stover. The second was to give participants in the USDA-DOE corn residue studies, and others doing related research, an opportunity to present their results to a diverse audience as preparation for soliciting input on the next steps needed to reduce uncertainties about the sustainability of collecting corn stover. This document reports the research needs and priorities identified in the May 2003 workshop.

WORKSHOP OBJECTIVES

The overall objectives of the Workshop on the Sustainability of Harvesting Crop Residues were to review recent research and analysis on the sustainability of collecting crop residues and to develop stakeholder input on the next steps needed to reduce remaining uncertainties. Specific objectives for the two-day meeting included:

- Establish a common understanding of the current status of research and analysis related to the sustainability of collecting crop residues;

- Identify the major areas with remaining R&D questions related to the sustainability of collecting residues;
- Identify specific research needs within each major area; and,
- Establish priorities for specific research needs.

WORKSHOP PROCESS

The scope, objectives, agenda, and attendees for the workshop were developed jointly by DOE and ARS. One decision made early in planning was to focus on corn stover, because of the existing joint corn stover research project and the just-completed corn stover life cycle assessment. Other crop residues would be discussed if they were included in relevant research or analyses. It was decided to hold the meeting in Iowa because the corn stover life cycle analysis covered the state and was based on detailed historical data and computer modeling for Iowa soils. DOE and ARS identified potential participants, including both individuals and groups of stakeholders. The Wallace Foundation Learning Center gave valuable help in identifying specific individuals from the state and region who could represent the desired stakeholder groups. Invitations were sent to 151 individuals. The 25 participants are listed in Appendix B.

The first day of the workshop was spent reviewing the results of recent literature surveys, research, and analyses, including a summary of preliminary observations from an ongoing series of stakeholder input meetings on equipment development needs for residue harvest and handling. Four invited presentations summarized recent reviews and research on the removal of crop residues.

- *Residue Removal: Effects on Soil Quality and Needs for Harvest Guidelines* (Susan Andrews, USDA-Natural Resources Conservation Service). This presentation summarized a white paper recently completed for the USDA Natural Resources Conservation Service.
- *USDA-Office of Energy Policy and New Uses Review of Biomass from Crop Residues: Cost and Supply Estimate*s (Paul Gallagher, Iowa State University). This presentation summarized a report of the same title recently completed for the USDA Office of Energy Policy and New Uses.
- *USDA-Agricultural Research Service Review of Effects of Residue Removal on Crop and Soil Productivity* (Jane Johnson, USDA-Agricultural Research Service). This presentation summarized a recently completed ARS literature review of crop and soil productivity response to corn residue removal that has been submitted for publication in a technical journal.

- *Implications of Using Corn Stalks as a Biofuel Source* (Wally Wilhelm, USDA-Agricultural Research Service). This presentation summarized current results in the ARS-DOE project of the same name.

Three papers covered NREL's life cycle assessment of the production of ethanol from corn stover for use in a flexible fuel vehicle. Because soil carbon was an important factor in the overall carbon balance for the assessment, and because including soil carbon was an innovation in life cycle analysis, two of the papers detailed the soils-based methodologies used to calculate stover resources and stover removal rates.

- *Soils-based Resource Analysis* (Richard Nelson, Kansas State University)
- *Resource Analysis Issues* (Robin Graham, Oak Ridge National Laboratory)
- *Corn Stover Life Cycle* Assessment (John Sheehan, National Renewable Energy Laboratory)

The second day of the workshop was used to identify and set priorities on research and development (R&D) needs. The discussion was initiated with a presentation on research needs identified in a February 2002 workshop for participants in the ARS-DOE project on the implications of removing corn stalks. Those researchers had identified four major areas with questions remaining on the use of corn stover as a biofuel feedstock.

- Production/Management
- Predict amount of stover that can be removed/retained
- Writing exercise (position paper/state-of-art paper)
- Equipment

The participants in this workshop reviewed these areas and, having no additions, agreed to use them, with minor changes in wording, as the categories for identifying specific R&D needs. The potential outcomes from work in each of the R&D categories were identified and discussed. The major areas discussed, and their outcomes, were:

- Area: Production and Management
  Outcome: Sustainable residue harvest can be incorporated into crop management systems
- Area: Analysis and Assessment
  Outcome: Residue availability can be predicted for sites and regions
- Area: Information/Education
  Outcome: All stakeholders have access to current, reliable information on the sustainability of residue removal

- Equipment Outcome: Residues and/or residue components can be harvested and handled efficiently

Then participants were asked to suggest critical R&D activities needed to reach each of these outcomes. The suggestions were discussed and sometimes revised for clarification. Notes were also taken during the discussion to record additional comments that related to the issues being discussed but were not R&D needs. Ten R&D needs were suggested for production/management: eight for analysis and assessment, five for education and information, and three for equipment.

After all suggestions for R&D needs were recorded, participants voted individually on priorities within each category. Participants were directed to indicate only their first, second, and third priorities among the needs listed for each category.

PRIORITIES FOR R&D ACTIVITIES

The discussion on R&D needs opened with one direct question to the workshop participants, "Does anybody think it is impossible to develop sustainable systems for collecting corn residue?" No one expressed the belief that this was an impossible goal, a reaction consistent with the general conclusion of the ARS literature review summary presented earlier in the workshop, that "within limits, corn stover can be harvested to provide a domestic, renewable source of energy." Before moving to the identification of R&D needed to reduce the remaining uncertainties about the limits to stover removal, participants did raise a number of general questions and comments about the role of corn stover relative to other biomass resources, including:

- What is the context (for stover) relative to a long-term vision for biomass?
- What is the full complement of biomass that could be used?
- Farmers will take the risks. Who is making decisions?
- Stover is probably the lowest cost feedstock. If we can succeed, it will be with stover.
- Companies are open to other crops, but will start with corn to show it works.
- Residue is the question, not just corn stover.
- Research on selective harvest and sustainability needs to be done in tandem.
- This is not a waste looking for a place to go.
- We need to better understand the value of residue to the farmer.

Workshop participants were asked to identify their top three priorities for specific R&D activities in each of the four major areas. The individual ratings were marked directly on the sheets used to record the R&D activities as they were suggested. Weighted scores were developed using a score of five points for each top priority rating, three points for each second priority rating, and one point for each third priority rating. The research activities receiving the highest scores in each area are listed below. The complete list of research activities, ratings, and scores for each area follow in Tables 1-4. Additional comments recorded during the discussions are listed in Appendix A.

- Productivity and Management

  1) *Understand the role that different components of the residue can have on sustainability, by crop and by region.*
  2) *Need to reevaluate soil loss tolerance ("T") levels and develop criteria for acceptable soil loss rates.*
  3) *Need to develop management systems that optimize soil, air, water quality, and economic returns.*

- Analysis and Assessment

  1) *Analyze effects of residue collection on erosion and identify production systems that would ensure erosion does not increase with residue collection.*
  2) *Develop a simple tool for estimating the economic and environmental sustainability of residue harvesting, incorporating relevant studies.*
  3) *Set forth a long-term national vision for the development of sustainable biomass resources that shows how residues fit with other potential biomass resources.*

- Information and Education

  1) *Engage grower in planning communication efforts and developing decision tools to ensure the resulting products are relevant and useful.*
  2) *Review the reasons for conflicting information on energy balances for ethanol, including the estimates and assumptions behind the science.*
  3) *Use the web to disseminate information, including information on the energy balance of ethanol.*

- Equipment

    1) *Design cost-effective harvest equipment that reduces the number of passes over the field, separates plant components, and controls the types and amounts of residues left in the field.*
    2) *Develop the capability to control the return of plant components to the field.*
    3) *Incorporate results from environmental and economic analysis into design criteria for crop fractionation.*

The issues discussed in this workshop are relevant to the USDA and the DOE research on bioenergy. The list of priority R&D needs will be used, with other input from stakeholders involved in all stages of agricultural biomass production, in the development of a DOE roadmap for agricultural biomass feedstock supply in the United States.

Table 1. Research and development needs for residue production and management systems

Production and Management R&D Need	Number of Priority#1 Ratings (score=5)	Number of Priority#2 Ratings (score=3)	Number of Priority#3 Ratings (score=1)	Weighted Total	Mean	n
Understand the role that different components of the residue have on sustainability by crop and regions.	3	4	1	28	3.5	8
Need to reevaluate soil loss tolerance ("T") levels and develop criteria for acceptable soil loss rates.	3	3	0	24	4.0	6
Need to develop management systems that optimize soil, air, water quality, and economic returns.	2	1	0	13	4.3	3
Need to develop data on long-term effects by maintaining, for 5 more years, USDA residue removal studies.	1	2	1	12	3.0	4
Understand the potential for breeding crops to enhance residue production to optimize total system economics and sustainability	1	0	1	6	3.0	2
Need to understand genetic variability of plant components (roots, stem, grain, leaves, cobs, etc.) by quantity and chemistry	0	0	6	6	1.0	6
Need to track carbon in the production systems – carbon may in future have direct value for sequestration in soil.	0	0	1	1	1.0	1
Need to design systems that are neutral or positive to grain production	0	0	0	0	0.0	0
Need to link manure management into residue harvesting systems.	0	0	0	0	0.0	0
Need literature review on soil formation rate vs. soil loss tolerance (“T”) levels	0	0	0	0	0.0	0

Table 2. Analysis and assessment research and development needs for harvest and collection of crop residues

Analysis and Assessment R&D Need	Number of Priority#1 Ratings (score=5)	Number of Priority#2 Ratings (score=3)	Number of Priority#3 Ratings (score=1)	Weighted Total	Mean	n
Analyze effects of residue collection on erosion and identify production systems that would ensure erosion does not increase with residue collection	6	0	1	31	4.4	7
Develop a simple tool for estimating the economic and environmental sustainability of residue harvesting, incorporating relevant studies.	4	2	0	26	4.3	6
Set forth a long term national vision for the development of sustainable biomass resources that shows how residues fit with other potential biomass resources	0	6	2	20	2.5	8
Optimize crop production systems that include residue collection in terms of farm income over entire rotation	0	4	2	14	2.3	6
Analyze the potential impacts of hybrids with differing grain-to-residue ratios on the economics and sustainability of crop production system and on the economics and sustainability of ethanol production	1	0	0	5	5.0	1
Develop an analysis system that integrates dynamic modeling and experimental work to enhance fundamental understanding of soil sustainability and sustainable biomass harvesting	0	1	1	4	2.0	2
Develop tools that better follow nutrients in the life cycle	0	0	0	0	0.0	0
Ensure all analysis systems are flexible enough to be applied to other residues, crops, and products	0	0	0	0	0.0	0

Table 3. Information and education needs for harvest and collection of crop residues

Education and Information R&D Need	**Number of Priority#1 Ratings (score=5)**	**Number of Priority#2 Ratings (score=3)**	**Number of Priority#3 Ratings (score=1)**	**Weighted Total**		**n**
Engage growers in planning communication efforts and in development of decision tools to ensure the resulting products are relevant and useful	9	0	1	46	4.6	10
Review the reasons for conflicting information on energy balances for ethanol, including the estimates and assumptions behind the science	1	4	3	20	2.5	8
Use the web to disseminate information, including information on the energy balance of ethanol	1	2	5	16	2	8
Create information products tailored to specific stakeholder groups (growers, policymakers, environmental organizations, city dwellers, etc.)	0	4	0	12	3	4
Develop accessible information for growers that synthesizes current understanding of the sustainability of harvesting residues	0	0	1	1	1	1

Table 4. Equipment research and development needs for harvesting crop residues

Equipment R&D Need	Number of Priority#1 Ratings (score=5)	Number of Priority#2 Ratings (score=3)	Number of Priority#3 Ratings (score=1)	Weighted Total		n
Design cost-effective harvest equipment that reduces the number of passes over field, separates plant components, and controls the types and amounts of residues left in the field	5	4	2	39	3.5	11
Develop the capability to control the return of plant components to the field	3	3	1	25	3.6	7
Incorporate results from environmental and economic analysis into design criteria for crop fractionation	3	2	2	23	3.3	7

APPENDIX A: ADDITIONAL COMMENTS RECORDED DURING R&D NEEDS DISCUSSIONS

- Sustainability is truly a whole plant optimization.
- Historical data (on grain-to-residue ratios) will be difficult to find.
- Ecologists and agricultural scientists think very differently.
- Breeders respond to what their customers require.
- Situation could change if soil carbon credits become an economic incentive.
- Choice is:
    - Carbon recycling *vs.* carbon storing
    - Sustainable harvest of residues *vs.* payment for storing carbon
- To reach producers, information needs to be in farm magazines and science magazines.
- What can states do for renewable resources?
- How do you do a business plan (for residues) with no market?
- Residue is not a large part of the energy solution for this country.
- Residue is a good starting point as long as we understand where we are going.
- Remember that soil is a renewable resource.
- What is a sustainable mix in the long term?

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APPENDIX C: WORKSHOP AGENDA

USDA-DOE Workshop on Sustainability of Harvesting Crop Residues for Energy
May 8-9, 2003, Lewis, Iowa

Agenda

May 8

8:00 a.m.	Shuttle from Ameristar Hotel/Casino	
9:00 a.m.	Welcome – USDA	Wally Wilhelm, USDA-ARS, Lincoln, Nebraska
9:15 a.m.	Welcome – DOE	Tom Foust, Idaho National Engineering and Environmental Laboratory
9:35 a.m.	Introduction	Janet Cushman, Oak Ridge National Laboratory
9:45 a.m.	Residue Removal: Effects on Soil Quality and Needs for Harvest Guidelines	Susan Andrews, USDA-NRCS, Soil Quality Institute
10:15 a.m.	Break	
10:45 a.m.	USDA-OEPNU Review of Residue Cost and Supply Estimates	Paul Gallagher, Iowa State University
11:30 a.m.	USDA-ARS Review of Effects of Residue Removal on Crop and Soil Productivity	Jane Johnson, USDA-ARS
12:00 p.m.	Lunch – buffet on site	
1:00 p.m.	Implications of Using Corn Stalks as a Biofuel	Wally Wilhelm, USDA-ARS, Lincoln, Nebraska
1:30 p.m.	Soils-based Resource Analysis	Richard Nelson, Kansas State University
2:15 p.m.	Resource Analysis Issues	Robin Graham, Oak Ridge National Laboratory
3:00 p.m.	Break	
3:30 p.m.	Stover Life Cycle Assessment	John Sheehan, National Renewable Energy Laboratory
5:30 p.m.	Shuttle to Ameristar Hotel/Casino	

APPENDIX C: WORKSHOP AGENDA (PAGE 2)

May 9

8:00 a.m.	Shuttle from Ameristar Hotel/Casino	
9:15 a.m.	Introduction to planning session	Janet Cushman
9:30 a.m.	Summary of discussions on remaining questions at ARS Omaha meeting	Wally Wilhelm
9:45 a.m.	Identification of major issues and critical activities	
10:45 a.m.	Break	
12:00 p.m.	Lunch – buffet on site	
1:00 p.m.	Shuttle to Ameristar Hotel/Casino and Omaha airport	