BIOMASS POWER FOR RURAL DEVELOPMENT

Quarterly Report for the Period
October 3, 1998 - January 1, 1999

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CHARITON VALLEY
RESOURCE CONSERVATION & DEVELOPMENT, INC.

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Appendix One

*Conference
papers
Removed
for
separate
processing*

Cooper, J., M. Braster, and E. Woolsey 1998. Overview of the Chariton Valley Switchgrass Project: A Part of the Biomass Power for Rural Development Initiative **CONF-981015--1**

Cooper, J. 1998. Policy Considerations for Biomass Commercialization and its Impact on the Chariton Valley Biomass Project **CONF-981015--2**

Pletka, R. , R. Brown, and J. Smeenk 1998. Indirectly Heated Fluidized Bed Biomass Gasification Using a Latent Heat Ballast **CONF-981015--3**

Smeenk, J. and R. Brown 1998. Experience with Atmospheric Fluidized Bed Gasification of Switchgrass **CONF-981015--4**

So, K. and R. Brown 1998. Economic Analysis of Ethanol Production from Switchgrass Using Hybrid Thermal/Biological Processing **CONF-981015--5**

Appendix Two

SWITCHGRASS PRODUCTION IN IOWA: Economic Analysis, Soil Suitability, and Varietal Performance

Appendix Three

Information and Education

Appendix Four

A Progress and Renewable Request Prepared for the Leopold Center for Sustainable Agriculture

Appendix Five

Quarterly Biomass Stakeholders Meeting Minutes

OVERVIEW

This report covers the period of October 2, 1998 to January 1, 1999. Events will be discussed in chronological order where possible, to give the reader a sense of the project flow.

This quarter had a high level of activity for the project partners. Many reports and presentations were written and given. In October, five reports were presented at the BioEnergy 98 Conference in Madison, Wisconsin. In November, a frank and productive meeting was held between representatives of the U.S. Department of Energy the National Renewable Energy Laboratory and project staff and cooperators. In December, two annual reports were prepared and submitted, one to Oak Ridge National Laboratories and the other to the Leopold Center for Sustainable Agriculture. And work continued toward project goals and objectives.

This report includes copies of most presentation and report material in the appendix. Some material was excluded in order to make this document more usable. Any material referenced in papers and presentations, not included, may be obtained directly from the author or by contacting project staff.

Co-firing test protocol and test hardware issues are currently being developed by our utility partner, Alliant Power. We will have a draft plan ready for discussion the end of January and a finalized plan of action ready by April 1, 1999. It is currently anticipated that a turn-key contractor will be retained to handle the installation of the test hardware on site and to oversee the test fire campaign.

A wet fall and a December snow instilled another dose of "Iowa weather reality" into the field work. However, harvest has started and approximately 75 tons of switchgrass is in storage.

Environmental research components continue to move forward and interesting information is beginning to be obtained.

With the FY 1999 funding issue finally behind us, progress toward the co-fire test of 2000 is moving forward quickly.

BIOENERGY 98 CONFERENCE

CONF-981015--

The BioEnergy 98 Conference was held October 4 - 9, 1998, in Madison, Wisconsin. This conference is the premier biomass energy conference of the year in the United States. The following papers were prepared and presented by project staff and cooperators. Copies of these papers are found in (*Appendix One*) at the end of this report.

- Cooper, J., M. Braster, and E. Woolsey 1998. *Overview of the Chariton Valley Switchgrass Project: A Part of the Biomass Power for Rural Development Initiative* CONF-981015--1
- Cooper, J. 1998. *Policy Considerations for Biomass Commercialization and its Impact on the Chariton Valley Biomass Project* CONF-981015--2
- Pletka, R., R. Brown, and J. Smeenk 1998. *Indirectly Heated Fluidized Bed Biomass Gasification Using a Latent Heat Ballast* CONF-981015--3
- Smeenk, J. and R. Brown 1998. *Experience with Atmospheric Fluidized Bed Gasification of Switchgrass* CONF-981015--4
- So, K. and R. Brown 1998. *Economic Analysis of Ethanol Production from Switchgrass Using Hybrid Thermal/Biological Processing* CONF-981015--5

Processed Separately

ENVIRONMENTAL COMPONENT

During this quarter the annual report was prepared for Oak Ridge National Laboratories (ORNL). The report details the project support activities which are sponsored by the Laboratory. Those activities include: Economic, Soils, and Genetic variety work with respect to switchgrass. The research is ongoing and the results should be considered as "preliminary" until final reports are presented. The ORNL annual report, SWITCHGRASS PRODUCTION IN IOWA: Economic Analysis, Soil Suitability, and Varietal Performance, is included at the end of this report in (*Appendix Two*).

INFORMATION AND EDUCATION

Information and education activities of the Project are intended to communicate project activities and accomplishments to interested landowners; professionals with public and private organizations; researchers working in the field of renewable resources in general and biomass energy in particular; and the general public.

Information and education activities for this quarter include both the monthly progress activities with some copies of materials developed, (*Appendix Three*) and a copy of the annual report prepared for the Leopold Center for Sustainable Agriculture. (*Appendix Four*). The Leopold Center is a project partner and the primary sponsor of the information and education activities. The Leopold annual report references many prepared documents and assorted presentation materials. Those materials not included are available from the Chariton Valley RC&D office in Centerville, Iowa, 515 437-4376.

QUARTERLY BIOMASS STAKEHOLDERS MEETING

The Energy and Geological Resources Division of the Iowa Department of Natural Resources sponsors a meeting four times a year in order to bring members of the Iowa biomass energy community together to share information. In this quarter the Stakeholders meeting was held on October 21, 1998, in Des Moines Iowa. The notes of that meeting are included in (*Appendix Five*).

GEOGRAPHIC INFORMATION SYSTEM (GIS)

The first phase of the GIS efforts have been completed and a final report with map presentation of materials will be included in the next Quarterly Report.

MEETINGS AND MISCELLANEOUS ACTIVITIES

Antares Meeting: October 23, 1998

Meeting with Ed Gray of The Antares Group and project staff/cooperators. We discussed the Niagara Project and their efforts to value the biomass material and partner contributions. Niagara has identified a "value" to the grid support capabilities of the dispersed generation. We intend to work more closely with our Biomass Power for Rural Development partners in the future.

R.W. Beck Technical Report

We have the "preliminary" Final Report out from R.W. Beck (included in the last quarterly report). Comments are currently being solicited. Comments will be compiled and submitted to R.W. Beck for their consideration and inclusion in their Final Report. This activity will occur in the next quarter.

Harvest Help: November 2, 1998

We currently have interest from John Deere and Vermeer Mfg. in helping us with our fall switchgrass harvest. Both companies are major haying equipment manufacturers in the area and both have worldwide reputations. Their attention to the project gives additional concept support, lends substantial industrial experience and educates both companies on the huge potential of biomass energy crops.

Project management discussed the value of bringing in an outside technical consultant for issues such as feedstock procurement. Mr. Tom Miles, Jr. was the candidate that seemed to offer the most benefits. Mr. Miles was contacted and a meeting was arranged for November 19, 1998, in Des Moines.

The meeting was held as planned. Mr. Miles was briefed on all aspects of the project progress to date. He is currently working with a group of agricultural producers from the Oregon area. This last year they shipped 440,000 tons of straw to Japan. This type of logistical methodology and experience can be very similar to what the Chariton Valley project is likely to require. Mr. Miles was asked to develop a proposed scope of work and funding requirement. This issue will likely be further explored in the next quarter and a formal relationship may be developed.

DOE Meeting Preparation: Nov. 17 - 20, 1998

A meeting was set up with the DOE and NREL to work out project issues concerning cost-share requirements and task/timeline issues. Several days were spent preparing for the meeting. A date was set for November 23 and 24, 1998. The meeting was held in Des Moines, Iowa at the home office of the Farm Bureau.

On November 23 and 24, 1998, an update meeting was held in Des Moines with representatives from the US DOE and NREL. Discussions were centered on Chariton Valley's organizational structure, cost-share issues and task/timeline events. Frank discussions pursued with what seemed to be a very positive conclusion. Compromises were reached on several critical issues. A discussion of the "Test Burn Campaign" determined that we would likely be firing switchgrass over a two month period, as we tested different components of the equipment, and that the actual time spent in and around the boiler would naturally be longer than the period of the actual burn. Action items were discussed and dates set for completion.

- A new monthly spend plan was developed and submitted.
- Alliant will develop a "Test Burn Campaign" after discussion with upper management.
- Comments will be developed for the R.W. Beck "preliminary" Final Report and presented to them for action and inclusion in the Final Report.
- Current plans state that by April 1, 1999 we should have determined the major task and timeline-related issues.

All parties left the meeting feeling positive about the future of the project. The next step is the final determination of the co-fire testing procedure. This is currently being worked on by the utility partner, Alliant Power, and we expect to have draft results by the end of January 1999.

After the review of the co-firing procedure, the details of the cost-share issue will be finalized and preparations for Phase II of the project will begin.

APPENDIX ONE

Conference papers (from
CONF-981015--) processed
separately

APPENDIX TWO

Project Title: Switchgrass Production in Iowa: Economic Analysis, Soil Suitability, and Varietal Performance

Subcontract No: 90X-SY510V

Subcontractor: Chariton Valley Resource Conservation and Development (RC&D), Inc.

Annual Report: October 1, 1997 to December 31, 1998

The Annual Report contents consists of the following:

- A list of project personnel who have the primary responsibilities for completing research tasks.
- A description of the research activities and interim results for the period October 1, 1997 to December 31, 1998
- A description of the research activities planned for the remainder of the project period including budget.
- A description of proposed research activities related to, yet beyond the scope of, current project activities.

Project personnel

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Research activities and interim results for the period October 1, 1997 to December 31, 1998

Background

Marginal soils, widespread throughout southern Iowa, are unsuited to annual row crop--corn and soybean--production. Much of the landscape in southern Iowa is characterized by heavy, wet soils and significant slopes that allow substantial levels of erosion. On-farm integration of biofuel crops with grain and forage crops and livestock may foster the long-term environmental and economic sustainability required for agricultural systems.

Switchgrass has been chosen as the model herbaceous biofuel crop, and its adaptation to Iowa is well known. Profitable use of biomass crops requires sufficient understanding of agronomic aspects of their culture and economic realities of their production. We intend to assess the productive potential of switchgrass across a range of soil types and landscapes, allowing us to more effectively pinpoint locations where it will perform well.

Reed canarygrass represents another potential biofuel crop, a cool-season grass alternative to switchgrass. With its different growth pattern--it is most productive in spring and fall--and tolerance to both wet and droughty soils, reed canarygrass complements switchgrass in a diversified biofuel program. Its strongly rhizomatous growth habit also make it appealing, particularly on soils on which switchgrass, a bunchgrass, does not form thick stands and erosion is a problem.

Research Projects in Brief

- Task I Determine the economic potential of switchgrass as an agronomic crop for bioenergy
 - A. Document on-farm costs and resource commitments for switchgrass production
 - B. Assess regional economic impacts of large-scale switchgrass production
 - C. Quantification of energy consumption for switchgrass production
- Task II Determine the effect of soil variability and environmental quality on switchgrass production
 - A. Evaluate the effects of landscape position, soil properties, and nitrogen fertilizer on switchgrass yield and quality
 - B. Assess soil erosion, soil tilth, and runoff characteristics in switchgrass fields
 - C. Assess the carbon sequestration potential and impacts of switchgrass biomass
- Task III Evaluate and develop switchgrass and reed canarygrass germplasm for bioenergy production and adaptation to Iowa
 - A. Evaluate switchgrass cultivars for yield and biofuel quality
 - B.1. Evaluate harvest management and varietal performance of reed canarygrass for biofuel
 - B.2. Evaluate diverse reed canarygrass germplasm and begin breeding new cultivars for bioenergy uses

Task I Determine the economic potential of switchgrass as an agronomic crop for bioenergy

Work this year has focused on reviewing the literature, collecting farmer data for budget construction, and beginning work with analysis using the agronomic data from Chariton Valley. There are a host of budget estimates published in a variety of sources. Most involve small-scale plots or use economic engineering to arrive at budget estimates. The literature reveals a wide range of cost estimates. The primary reason for this range is the variety of assumptions used. The charge for land appears to be a major factor contributing to the differences in costs. Distance hauled is also a crucial factor in estimating the breakeven price necessary for farmers.

Two of the most representative budgets for Chariton Valley are shown in Tables I.1 and I.2. The first is from a study near Ames, Iowa and the second is from a study near Chariton, Iowa. The budgets were constructed using plot data. These estimates were part of a doctoral thesis by Park. There are two components necessary for creating a budget estimate for switchgrass. First is the cost of the establishment year and second is for the annual production costs. The two budgets are for both the establishment year and for a typical production year.

Table I.1. Estimated establishment year budget for switchgrass planted at Ames and Chariton, IA.

Item	Unit	Ames			Chariton		
		Price (\$)	Quantity	Amount (\$)	Price (\$)	Quantity	Amount (\$)
DIRECT EXPENSES							
FERTILIZER							
Phosphorus	Lbs	0.25	32	8	0.25	32	8
Potash	Lbs	0.17	94	15.98	0.17	94	15.98
HERBICIDE							
Atrazine 4L	Pt	1.58	2.5	3.95	1.58	2.5	3.95
SEED							
Switchgrass	Lbs	3.5	7.2	25.2	3.5	7.2	25.2
OPERATOR LABOR							
Tractors	Hour	6	1.53	9.18	6	1.53	9.18
FUEL							
Tractors	Gal	0.83	6.62	5.49	0.83	6.62	5.49
REPAIR & MAINTENANCE							
Implements	Acre	8.5	1	8.5	8.5	1	8.5
Tractors	Acre	6.49	1	6.49	6.49	1	6.49
INTEREST ¹ (6.5%)	Acre	3.15	1	3.15	3.13	1	3.13
TRANSPORTATION							
Haul to plant	Ton	4.15	3.62	15.02	4.15	2.59	10.75
TOTAL DIRECT EXPENSES				100.96	96.67		
FIXED EXPENSES							
Implements	Acre	12.05	1	12.05	12.05	1	12.05
Tractors	Acre	11.54	1	11.54	11.54	1	11.54
Land	Acre	115	1	115	80	1	80
TOTAL FIXED EXPENSES				138.59	103.59		
TOTAL EXPENSES				239.55	200.26		
ESTABLISHMENT COST (prorated)				5.63	8.04		

¹ Interest on operating costs.

Nitrogen is a special fertilizer due to its mobility. In switchgrass production it is also special because the N increases yield but it also increases the potential for air pollution when burned. Nitrogen use by the farmers varied considerably. An earlier study by Brown (1994) indicated that the marginal revenue product (using \$40 per ton for switchgrass) would be less than the marginal cost for nitrogen between 125 and 250 pounds of N. Researchers have been working with Dr. Lee Burras at Iowa State University (ISU) and will use the Chariton Valley numbers to refine this estimate for the project area.

Another issue that has been discovered while preparing the budgets is the time to establishment. Several producers have indicated that they were not able to get an adequate establishment in the first year. Obviously, this will have implications for the cost of establishment and for the overall break-even cost of producing switchgrass. Researchers are working with the ISU agronomists to determine how frequently establishment problems may occur and the best approach to include this in the budget estimates.

A final issue in the preparation of the budgets and estimation of the breakeven price for switchgrass involves transportation and storage. The major issue here is who bears the cost. If the farmer bears the cost then the distance to the facility will impact the breakeven price for the producer. For distances less than 75 miles the literature suggests a cost of between \$5 and \$10 per ton.

Researchers met several times with the ISU agronomists. When their yield data is available (first year yields have just been determined), we can begin the economic analysis. Using their yield data and the cost data provided we will be able to estimate the break-even price for switchgrass in the Chariton Valley area.

Based on the literature we have concluded that switchgrass can not be competitive with other sources of energy if only direct costs are counted. However, inclusion of environmental costs make switchgrass much more competitive. One of the major environmental benefits from switchgrass is reduced erosion when compared to a corn/soybean rotation. A study by Hohenstein and Wright (1994) estimate erosion rates of 21.8 mg/ha/yr and 40.9 mg/ha/yr for corn and soybeans, respectively. This is compared to the authors' estimate of 0.2 mg/ha/yr for herbaceous energy crops including switchgrass. The project's environmental quality research (Task II.B.) will help answer this question. In addition to lower erosion rates switchgrass requires less chemical inputs and generally has a lower concentration of heavy metals and ash content when compared to coal. Switchgrass also produces lower sulfur admissions (Laughlin, et al), but may produce negative health impacts in storage from spores and other microorganisms (Weisbrod, et al).

Identification of these potential environmental consequences is the first step in providing a complete economic analysis of switchgrass. The budget preparation is necessary to determine breakeven costs but the societal costs and benefits need to be figured for a true social optimization. One of the more obvious means of having society help defray the lost revenue from switchgrass biomass production is through an amended Conservation Reserve Program (CRP). Of the four main counties in the Chariton Valley area, the percent of cropland in CRP ranges from a high in Lucas County of 24.9 percent to a low in Appanoose County of 12.7 percent. The payment rates are all in the mid to upper \$60 per acre range. A modified CRP could be used to provide an economic incentive to farmers that will encourage the switchgrass production necessary to support a biomass energy industry.

Work was initiated to estimate the regional economic impacts associated with the conversion of land to switchgrass production for biomass. A portion of this work consisted of identifying and examining alternative models available for this type of analysis. The model that has been selected is the regional impact assessment model originally proposed by the Economics Department at ISU for use in the project. The decision to apply the ISU regional impact assessment model is based primarily on the researchers' familiarity with this model as well as the great deal of similarity between the model and others examined.

Meetings have been conducted with ISU researchers with expertise in applying the ISU regional impact assessment model. During these meeting, researchers reviewed data and assumption required by the model for use in the project. As a result, a database of socio-economic information related to the Chariton Valley area that will be required by the model is being developed. In addition, researchers are working with other project participants to develop the assumptions required by the model. These assumptions such items as projections regarding the extent of land that may be converted to switchgrass biomass production and information related to current uses of land that would most likely be converted to switchgrass production.

Analysis of the expected changes in energy consumption associated with the production of switchgrass for biomass will depend in a large part of completion of estimated switchgrass budgets, i.e., identify and quantify inputs and operations. Researchers have been working with the USDA Iowa Agricultural Statistics Service to collect information regarding current corn and soybean cropping practices. Information collected includes machinery use and agricultural chemical application. This data will provide a basis for a comparison of the energy consumption between alternative land uses, i.e., corn and soybean production, and switchgrass in the Chariton Valley area.

Task II Determine the effect of soil variability and environmental quality on switchgrass production

A. Evaluate the effects of landscape position, soil properties, and nitrogen fertilizer on switchgrass yield and quality

Methods

Plant materials:	Mature, established switchgrass fields; primarily 'Cave-In-Rock'
Harvest treatments:	November after killing frost--cut and bale whole plots. Sub-sampling July 1, August 15, October 1, (January 1, weather permitting), March 1 using 1 m ² quadrat
Plot locations:	Lucas County, near Derby; Wayne County, near Millerton (added in 1998)
Experimental design:	Randomized complete block design, six replications at Derby, five reps at Millerton (The replications are split across two fields in each location, which are owned and managed by the same farmer and which are adjacent to each other. We have not observed a "field" effect.)
Plot size:	200' x 100' to 400' depending on slope length; summit, backslope, and swale in each plot
Nitrogen treatments:	Within each plot, four treatments: 0, 50, 100, and 200 lb N/Ac., 50' wide through plot
Soil testing:	'A' horizons sampled at five points along each the landscape for each N level 30 1-m cores were taken across all plots and will be analyzed in 1999

Results

Plant traits

March 1998 Harvest

Sampling was done in March 1998 on the Derby plots (the Millerton plots were not added until spring 1998) and fiber and chemical constituents were analyzed. No sampling had been done on these plots the previous fall or over winter. Results are shown in Table II.1. (Samples from 1998 growing season are currently being analyzed.)

Table II.1. Dry matter, fiber, and mineral constituents in *over-wintered* biomass harvested in March 1998 at Derby.

	Dry Matter g/m ²	NDF	ADF	ADL	N	CP	Cl	P	S
		-----% of DM-----					-----ppm-----		
Derby mean	448	79.4	49.1	8.8	0.45	2.8	210	200	51
By nitrogen level									
0	389	78.4	47.9	8.3	0.43	2.7	188	174	56
50	446	80.4	49.8	8.9	0.44	2.7	259	198	57
100	459	79.5	49.5	9.0	0.46	2.9	216	213	44
200	<u>500</u>	<u>79.2</u>	<u>49.1</u>	<u>8.9</u>	<u>0.47</u>	<u>3.0</u>	<u>176</u>	<u>213</u>	<u>45</u>
LSD (5%)	103 (6%)	ns	ns	ns	ns	ns	ns	ns	ns
By landscape position									
Backslope	413	78.8	48.8	8.7	0.45	2.8	269	237	52
Summit	452	79.5	49.2	8.7	0.44	2.7	227	227	53
Swale	<u>480</u>	<u>79.8</u>	<u>49.1</u>	<u>8.9</u>	<u>0.47</u>	<u>2.9</u>	<u>134</u>	<u>135</u>	<u>47</u>
LSD (5%)	ns	ns	ns	ns	ns	ns	54	40	ns
Interactions									
N level x Landscape	ns	ns	ns	ns	ns	ns	ns	ns	ns

Dry Matter Yield: Nitrogen, applied in 1997, increased yields of over-wintered biomass. The backslopes tend to have lower yield than either summits or swales, though our sampling procedures (1 m²) are not precise enough to statistically discriminate among landscape positions (the main purpose of these samples is quality analysis). However, this trend correlates with visual observations and with data collected in summer and fall 1998 (Tables II.2 and II.3). Extrapolating yields from a square meter quadrat is risky, but these yields are roughly 1.5 to 2 T/Ac.

Fiber and chemical constituents: Fibers (NDF = hemicellulose; ADF = cellulose and lignin; ADL = lignin) were not influenced by either N level or landscape position in over-wintered material. These data suggest that adding N does not reduce the concentrations of lignin or other desirable burning constituents. Nitrogen and crude protein (CP) were likewise invariable in this material. Minerals did not significantly vary with N level, though a trend to study further is the increase in P and decrease in inorganic S with increasing N fertilization. Cl content does not appear to be associated with N. Landscape did influence Cl and P concentrations, with significantly lower levels present in plant material collected in swales. All these analyses will be conducted on material collected in November 1998, March 1998, and November 1999 to confirm these findings.

Summer and Fall 1998 Harvests

Dry matter yield trends can be observed from the *sub-sample* (1 m²) yields collected in July, August, and September 1998. The sub-sample yields indicate that the two locations have similar yield potential. Nitrogen application increased yields, as expected. A trend for the summit and swale to produce more dry matter than the backslope is congruent with our observations of numerous switchgrass stands. Slopes in some plots are not severe and probably contribute a higher yield than is common in many of the more erosive fields in southern Iowa. Essentially no interactions among factors were identified. Although we attempted to take sub-samples at specific points within each plot, they probably do not fully represent vagaries in stand density since we needed to sample some material for subsequent chemical analysis. The sub-samples were used to determine leaf/stem ratios (Table II.3), maturity, and fiber/mineral constituents. No consistent differences in maturity were noted over N levels or landscape positions (data not shown). Fiber/mineral analysis will be conducted this winter.

Table II.2. Dry matter yield at two locations, four nitrogen levels, and three landscape positions based on sub-samples during 1998.

	July	Aug -----g/m ² -----	Sept
Overall mean	140	483	503
Location			
Lucas	139	475	487
Wayne	141	492	518
Pr>F	ns	ns	ns
Nitrogen level			
0	138	385	409
50	119	425	441
100	151	508	568
200	151	615	593
LSD (5%)	21	90	85
Landscape position			
Backslope	142	473	490
Summit	147	500	505
Swale	131	476	513
LSD (5%)	ns	ns	ns
Interactions			
Loc x N level	ns	ns	ns
Loc x Land	ns	ns	0.03
N level x Land	ns	ns	ns

Agronomic results and *field-level* dry matter yields from the 1998 growing season are summarized in Table II.3. The two locations only differed for leaf/stem ratio in July and lodging in November. Importantly, dry matter yield was not different between the locations, averaged over all landscape positions and N levels. Total biomass was harvested in November 1998 with conventional farm machinery and the able assistance of John Sellers. Bales were tagged, GPS coordinates taken for each bale, and bales weighed individually. Yields represent the sum of all bales for a given plot. Analysis by N level averaged across locations showed that increasing levels of N application increased height, leaf/stem ratio in July, lodging, and dry matter yields. Yields were low, averaging just over 1 T/Ac at each location. Nitrogen increased yields, though an economic analysis needs to be conducted to determine the economic threshold. Leaf/stem ratios, particularly later in the season, were not affected by N application rate. This result, together with the fiber and mineral results in Table II.1 indicate that N application may not seriously impact the quality of the biofuel feedstock.

For no trait did we identify a location x nitrogen level interaction, indicating that N effects are similar across these two sites. The yield of the 50 lb N/Ac plots may be overestimated. One replication at Derby lies near a limestone-based gravel road, and the 50 lb N/Ac treatment is adjacent to the road. This plot also has higher pH than other plots, biasing the mean in Table II.4. Thus, the increase in yield from applied N may be more closely linear than these data suggest. The "road effect" we observed suggests we should further examine pH effects on yield.

Table II.3. Height, leaf/stem ratios, lodging percentage, and dry matter yield from fertility plots during 1998.

	Height (cm)			Leaf/Stem Ratio (DM basis)			Lodging (%) Nov.98	Yield (kg/ha) Nov. 98
	July	Aug	Sept	July	Aug	Sept		
Overall Mean	72	114	121	0.73	0.50	0.34	10.5	2626
By Location								
Lucas (Derby)	68	112	118	0.68	0.49	0.35	15.6	2837
Wayne (Millerton)	<u>75</u>	<u>116</u>	<u>124</u>	<u>0.78</u>	<u>0.52</u>	<u>0.33</u>	<u>5.4</u>	<u>2415</u>
Prob. level	ns	ns	ns	0.0001	ns	ns	0.06	ns
By Nitrogen Level								
0	64	106	113	0.69	0.51	0.34	4.0	2077
50	70	111	117	0.71	0.47	0.33	6.8	2502
100	74	116	123	0.78	0.55	0.36	12.8	2701
200	<u>79</u>	<u>123</u>	<u>129</u>	<u>0.76</u>	<u>0.49</u>	<u>0.32</u>	<u>18.3</u>	<u>3226</u>
LSD (5%)	4.6	6	6.1	0.046	ns	ns	5.9	499
Interactions								
LocxNit	ns	ns	ns	ns	ns	ns	ns	ns

Soil properties

The two fields at the Derby site are in the SE 1/4 section 21 and the SW 1/4 section 22, T71N and R22W, respectively, about nine miles southwest of Chariton. The fields have two main soils: Grundy (fine-silty, mixed, mesic Aquic Argiudoll) and Haig (fine-silty, mixed, mesic Typic Argiaquoll) although additional soils are shown on the soil maps. The Grundy and Haig soils are highly productive soils, especially with regard to the Chariton River watershed. Detailed evaluation of the soils at Millerton are currently underway.

Analysis of the Derby site has been conducted on soil samples collected in 1997 (Table II.4). The depth of the 'A' horizon is not different among the levels of nitrogen as expected but does differ by landscape position, with a significantly thinner topsoil in the backslope than in either the summit or swale. For these plots, little evidence for topsoil accumulation in the swale was noted. Nitrate nitrogen increased with added N and was substantially higher in plots receiving 200 lb/Ac ammonium nitrate-N. A trend toward higher nitrate-N in swales was noted. Organic carbon tended to be lower in swales than summits or backslopes. Little variation in phosphorus content was noted, though a trend toward higher P at the summits and swales may be present. Variation in pH was limited.

Discussion

Biomass yield and composition is variable within the fields in the Chariton Valley that we are studying--and these fields have less soil variability than many fields located in the watershed. The best predictor of yield appears to be N fertilizer rates. Yield increases proportionally to rate of N applied, but harvest may be more difficult with high N applications due to excessive lodging. Likewise, the differential N uptake efficiency across the landscape indicates off-site impacts of high N levels may be problematic, either due to nitrate leaching or overland flow from summits and backslopes. We found yields of 1 to 2 T/Ac in both large and small experimental plots in southern Iowa. Because the Derby plots are on Grundy and Haig soils, some of the more highly productive soils of the Chariton Valley, large-scale field yields likely will be less than 2 T/Ac.

Table II.4: Soil properties at the Derby site.

	'A' Horizon Depth (cm)	Nitrate N	Organic C	P (mg/kg)	pH
Overall Mean	19.2	0.78	4.66	22.6	6.12
By Nitrogen Level					
0	18.3	0.34	4.71	20.6	6.12
50	18.6	0.26	4.45	20.4	6.21 ^a
100	21.5	0.44	4.75	26.3	6.03
<u>200</u>	<u>18.6</u>	<u>2.09</u>	<u>4.73</u>	<u>23.0</u>	<u>6.10</u>
LSD (5%)	ns	0.9268	ns	ns	0.1011
By Landscape Position					
Backslope	12.9	0.63	4.63	18.4	6.11
Summit	21.1	0.67	4.91	25.0	6.14
<u>Swale</u>	<u>23.8</u>	<u>1.04</u>	<u>4.44</u>	<u>24.4</u>	<u>6.10</u>
LSD (5%)	5.28	ns	0.2645	ns	ns

^a bias due to one replication lying adjacent to limestone road.

At the Derby site, the only one intensively characterized to date, landscape position and properties significantly influence yield and composition of switchgrass, regardless of N fertility. Because this site has less soil variability than others in the region, the variations in yield and composition may be due to differences in hydrology and soil chemistry. We are investigating the causes of this variability using 1-m deep soil cores already collected but not yet analyzed. If the results indicate yield limitations due to wetness, two yield enhancing options will be available to producers: (a) improve drainage (e.g. by tiling), or (b) switch to species more tolerant of wet conditions (e.g., reed canarygrass). Limiting chemical properties (e.g., low available K or pH) can be managed using standard agronomic approaches. Interpretation of the variable composition of switchgrass across landscapes is more problematic, but it presumably reflects root physiology differences resulting from variable soil properties. For example, wetter sites may have limited oxygen uptake which favors uptake of chloride relative to nitrate. We can better evaluate the causes of the yield and composition variability when we have results from additional plant and soil analyses (i.e. during 1999).

Summary

Switchgrass productivity and properties vary according to nitrogen fertilization, landscape position, and soil properties in the Chariton Valley. Yields around 2 T/Ac are probably attainable with current management and cultivars. Greatest yields are obtained under high levels of N fertilizer in swales that have thick A horizons. These sites are thought to be well-drained and possess ideal levels of other nutrients and pH; they are also suited to row crop production. The drawbacks to recommending high levels of N fertilizer are three: (1) lodging becomes a problem, (2) the environmental fate of the extra nitrogen is uncertain, and (3) the economic threshold has not been determined. Because results discussed above are only based on limited samples, concrete statements of yield potential and biomass production cannot be made until all data from the 1998 growing season is analyzed and the experiment repeated in 1999.

Publication

Lemus, R.W., N.E. Molstad, L. Burras, E.C. Brummer, and K.J. Moore. 1998. Switchgrass management and production in the Chariton Valley, Iowa. Agron. Abstr. p. 276. Presentation given at the 1998 American Society of Agronomy Meetings, 18-22 October. Baltimore, MD.

Task II Determine the effect of soil variability and environmental quality on switchgrass production

B. Assess soil erosion, soil tilth, and runoff characteristics in switchgrass fields

The routine presence of rills and gullies in established switchgrass fields indicates switchgrass monoculture does not prevent soil degradation to the level originally hoped. We speculate that initiation of the rills occurs when runoff from intense rain becomes channelized between clumps of switchgrass during the first year or two of establishment. These channels grow into gullies as intense rains and snowmelt runs off the highly sloping landscapes of the Chariton Valley. The switchgrass does not prevent the growth of the gully because its roots do not aggressively fill in the space between clumps and are undercut as gullies deepen. Consequently, switchgrass fields consist of two areas: (a) those typified by lush growth that stabilizes the soil and improves its tilth, and (b) localized regions of active gullies that grow and undercut the areas of lush growth.

Reconnaissance of about 25 well-established switchgrass fields in Lucas County was completed in fall 1998. Routinely, evidence of significant rill and gully erosion was noted. The pin method to evaluating rill extent and development was set up at 10 sites in Lucas County during fall 1998. These sites will be monitored through spring 1999 and evaluated for amount of erosion measured by soil level decline around the pins. Two possible solutions for preventing rill development are seeding a fast-growing cover crop with switchgrass or planting reed canarygrass, a species with aggressive rhizomes, in swales and other locations that have concentrated overland runoff.

Task II Determine the effect of soil variability and environmental quality on switchgrass production

C. Assess the carbon sequestration potential and impacts of switchgrass biomass

The soil carbon sequestration component of this project is being developed. A scope of work has been prepared for the sequestration research. A copy of the scope of work *Spatial and temporal dynamics of carbon sequestration in the Chariton Valley, Iowa* accompanies this report. This research will be supported in part by the US Department of Energy, Iowa Department of Agriculture and Land Stewardship's Division of Soil Conservation, ISU, and Iowa Farm Bureau. Initial work completed as a part of the scope has resulted in a preliminary assessment of the soil carbon sequestration potential across the Chariton River watershed in Iowa. A copy of this assessment *Soil carbon sequestration potential in the Chariton River watershed, Iowa* accompanies this report. The preliminary model suggests that eroded, well-drained loess or silty alluvial soils will have the highest potential to sequester soil carbon. It will be tested as part of William Weaver's Ph.D. project, which is currently beginning.

The Center for Global and Regional Environmental Research (CGRER) at the University of Iowa has initiated research to perform an analysis of the life cycle greenhouse gas emissions from growing and using switchgrass as biomass. In addition, the CGRER will use the results of this analysis to estimate the economic value of any impact on greenhouse gas emissions. As part of this research, the CGRER has worked to obtain the GREET Transportation Fuel Cycle Analysis Model from the Argonne National Laboratory. The GREET model provides a tool for estimating the emissions of regulated air pollutants and greenhouse gases from a wide variety of fuels and activities, on a fuel-cycle basis. CGRER is studying the applicability of this model to the Chariton Valley Biomass Project, primarily for estimating the emissions from transporting fuels to the power station. CGRER has also been compiling a literature review of studies related to agriculture and greenhouse gas emissions/sinks. Collection and review of these studies will provide us with the latest understanding of both above and below-ground carbon changes from switchgrass production. In addition, CGRER has been cooperating with others to develop a Geographic Information System (GIS) based methodology for estimating carbon profiles and carbon increments. While work has just initiated in this area, it does show potential as a means of quantifying and presenting carbon sequestration values for agriculture.

Task III Evaluate and develop switchgrass and reed canarygrass germplasm for bioenergy production and adaptation to Iowa

A. Evaluate switchgrass cultivars for yield and biofuel quality

The objective of this sub-task is to determine the biofuel potential of a diverse set of switchgrass cultivars and germplasm in the Chariton Valley.

Methods

Plant materials: 20 entries, consisting of released cultivars and experimental germplasms (from IA, NE, and OK)
Planting date/location: May 13, 1997, McNay Research Farm in Lucas County
Experimental design: Eight replications of a 4 x 5 rectangular lattice design
Plot size: 10' x 15', with a 5' alley between plots
Fertilization: 70 lb/Ac nitrogen in May 1998
Harvest treatments: November after killing frost; late March before green-up

Results and Discussion

No yield data were taken in 1997 due to weed competition. In 1998, yellow foxtail was problematic in plots with weak stands. Our original intent was to harvest four reps in November and the remaining four in March. However, stands in four replications were generally poor and these were not harvested.

Stand scores across all eight replications varied widely among cultivars, even though all were planted on a pure live seed basis (10 lb/Ac). Among the cultivars with the best stands were Cave-in-Rock (CIR) and derivatives of it (IA germplasms and Shawnee). Due to the poor stands of some varieties, their yields are likely underestimated.

Disease scores did not show major differences among cultivars for 1998.

Lodging susceptibility is an important trait as it impacts harvestability. The IA developed germplasms did particularly well; Kanlow had the worst lodging.

Dry matter yield varied widely among cultivars, though the differences were not statistically significant. We only harvested a 3' x 15' section from each plot in the four replications with acceptable stands so that we would have a section remaining, with border, for the late winter harvest. In retrospect, this area is too small for sufficient precision in separating entries. However, some trends are apparent--Kanlow is high yielding, as expected for a lowland cultivar. Winterhardiness will be its major problem for subsequent years, but since the 1997-98 winter was extremely mild, we did not see severe winterkill in the lowland cultivars. Cave-in-Rock's yield was not among the highest, despite having good stands. The late maturing Iowa germplasm (IA-LM) appears to have potential and will be evaluated further. Chemical constituents, leaf/stem ratios, and fiber concentrations will be determined during the winter.

Table III.1. Switchgrass variety and germplasm yields in 1998 at McNay Research Farm.

Variety	Stand	Lodging	Disease	Yield	
	score	score	score	kg/ha	T/A
Kanlow	4.5	3.5	2.0	6299	2.81
HDMDC3	3.3	1.8	2.0	6036	2.69
Shelter	2.9	3.0	1.9	5806	2.59
SU94-2CH	4.3	1.8	2.0	5719	2.55
IA-LM	5.0	1.4	2.1	5638	2.52
NU94-2CH	3.3	2.5	2.1	5635	2.52
SU92 ISO	1.8	2.3	2.0	5491	2.45
Carthage	4.3	3.1	2.3	5489	2.45
Blackwell	3.5	2.8	2.1	5407	2.41
IA-GT	5.0	1.9	1.9	5310	2.37
Alamo	3.8	2.3	2.1	4976	2.22
NL93-2CH	3.0	2.8	2.0	4911	2.19
CIR	4.5	2.0	2.1	4862	2.17
Shawnee	4.3	2.0	2.1	4730	2.11
HYLD-C3	4.0	2.1	2.0	4646	2.07
Pathfinder	1.3	2.3	2.1	4529	2.02
Trailblazer	2.8	2.1	1.6	4380	1.96
Sunburst	2.5	2.1	1.8	4185	1.87
Caddo	3.0	1.5	2.0	4169	1.86
<u>Forestburg</u>	<u>1.3</u>	<u>2.8</u>	<u>2.5</u>	<u>3887</u>	<u>1.73</u>
Mean	3.4	2.3	2.0	5105	2.28
Pr>F	0.0001	0.03	0.096	0.16	
LSD (5%)	1.3	1.2	(0.4)	(1615)	

Stand: 0=None 1=Poor (<50%) 3=Fair (50-75%) 5=Good(>75%). **Lodging:** % of the plants more than 35 degrees from perpendicular: 0=0%, 3=50%, 5=100%. **Disease:** 1=high (>75% of plants diseased) 2=Medium (50-75 % plants diseased) 3=low (<50% of plants diseased).

Task III Evaluate and develop switchgrass and reed canarygrass germplasm for bioenergy production and adaptation to Iowa

B.1. Evaluate harvest management and varietal performance of reed canarygrass for biofuel
(Dr. Michael Casler, University of Wisconsin, cooperating)

The objective of this sub-task is to determine the differences among currently available germplasm for biomass yield and quality under three harvest management scenarios.

Methods

Plant materials: Seven cultivars plus a mix of all seven (all low alkaloid except Common)
 Harvest treatments: Spring + Fall, Fall only, and Late Winter only
 Planting date/location: August 22, 1997, Agronomy Farm, Ames, IA; May 1998, Arlington, WI
 Experimental design: Randomized complete block design, four replications
 Plot size: 3' x 20', 3' border surrounding each plot
 Harvest dates: June 24, 1998; November 17, 1998; March 15, 1999 (estimated)
 Note: Test will be planted in southern Iowa in 1999; perhaps also Lexington, KY.

Results

Preliminary results from one year indicate that the two-harvest system is superior to a fall-only management. Few differences were noted among varieties under either system. A major factor to consider is the amount of water that needs to be dried from spring harvested material. Over-winter biomass losses will be assessed at the March 1999 harvest. Analysis of fiber concentration, CI, S, N, and other elements will be conducted this winter.

Table III.2. Reed canarygrass biomass yields in 1998 under two harvest treatments at Ames, IA.

Cultivar	Fall Harvest only			Spring & Fall Harvests		
	Spring	Fall	Total	Spring	Fall	Total
	(T/A, dry matter basis)			(T/A, dry matter basis)		
Bellevue	0	4.3	4.3	3.0	2.5	5.5
Common	0	3.7	3.7	3.0	2.8	5.9
Mix	0	3.2	3.2	3.2	2.7	5.9
PSC1142	0	3.9	3.9	2.9	2.6	5.4
Palaton	0	3.8	3.8	2.8	2.8	5.7
Rival	0	4.1	4.1	2.8	2.7	5.4
Vantage	0	3.6	3.6	3.0	2.6	5.6
Venture	0	3.6	3.6	2.7	2.9	5.6
Mean	0	3.8	3.8b	2.9	2.7	5.6a
LSD	0	0.5	0.5	0.5	0.4	0.6
Dry Matter %		64		29	68	

Mix=equal amount live seed of all cultivars

Task III Evaluate and develop switchgrass and reed canarygrass germplasm for bioenergy production and adaptation to Iowa

B.2. Evaluate diverse reed canarygrass germplasm and begin breeding new cultivars for bioenergy uses

The objective of this sub-task is to determine the biofuel potential of a diverse set of reed canarygrass germplasms from which new breeding germplasm can be developed. Much of this material is high in alkaloids, an anti-quality component for animal feed. Since all breeding to date has focussed on animal forage, many high yielding germplasms may have been overlooked.

Methods

Plant material: 121 germplasm sources (accessions) from throughout Europe and North America
Planting date/location: Transplanted mid-July 1998, Agronomy Farm, Ames, IA and Arlington, WI.
Plot design: Twenty plants per accession per location in each of two replications

Results

An evaluation for freezing tolerance was done on December 2, 1998 at Ames. Four plant introductions showed no evidence of frost damage, with all leaves completely green; another five were approximately 50% injured, based on dead, brown leaves and stems. All other entries were more than 90% injured, i.e., dried and brown. Though potentially useful for forages, the freezing-tolerant entries would be undesirable for biofuels. Visually, a broad range of biomass production potential is included in the test. However, due to confounding with transplanting effects, we did not take yield or quality data in 1998. Plants at Ames were mowed on December 2 at ~7.5 cm to remove topgrowth and provide even exposure to winter conditions.

Acknowledgments

We thank Mark Downing and Sandy McLaughlin at Oak Ridge National Laboratory, Marty Braster and Jim Cooper at the Chariton Valley RC&D, John Sellers for help with the field-scale harvesting and plot maintenance, Mark Smith for assistance with variety trials, and a host of undergraduate students for help with plot work, stem-leaf separations, grinding, and quality analyses. Thanks also to Stan Henning and his laboratory personnel for help with CI and S analyses.

Plan of Work for 1999

Project Title: Switchgrass Production in Iowa: Economic Analysis, Soil Suitability, and Varietal Performance

Subcontract No: 90X-SY510V

Subcontractor: Chariton Valley Resource Conservation and Development (RC&D), Inc.

The following consists of a description of the research activities planned for the remainder of the project period, including budget:

Background

This research directly supports the US Department of Energy's (DOE) Biomass Power for Rural Development Program sponsored Chariton Valley Biomass Project. The research being conducted will provide essential information regarding switchgrass as a biofuel feedstock as part of the project's efforts to develop a biomass energy industry in southern Iowa. The research examines the economic and agronomic aspects of producing switchgrass for biomass in an effort to provide guidance to farmers interested in incorporating energy crops into their operations. The research builds on similar work with switchgrass supported and conducted by Oak Ridge National Laboratory's Biofuels Feedstock Development Program. Research efforts are also being directed toward initiating an improvement program to make reed canarygrass a major bioenergy crop.

Research tasks, progress, planned activities, and budget

Task I Determine the economic potential of switchgrass as an agronomic crop for bioenergy

Research completed (refer to 1998 Annual Report)

- Completed review of relevant literature
- Assembled data for switchgrass production budgets from literature and individual producers
- Examined production issues in need of additional evaluation for the development of budgets
- Initiated collection of data required to analyze regional economic impacts and energy consumption

Research to be conducted in 1999

- Complete development of farm-level budgets for switchgrass production
- Estimate a production function with respect to fertilizer application (nitrogen)
- Estimate the breakeven price for switchgrass based on budgets and yield data
- Analyze breakeven price for switchgrass with respect to alternative land uses (corn and soybeans)
- Analyze breakeven price for switchgrass with respect to use of land in the Conservation Reserve Program (CRP) for biomass production
- Estimate the regional economic impacts of producing switchgrass to support a developing biomass energy industry in southern Iowa
- Analyze energy consumption for the production of switchgrass with respect to alternative land uses (corn and soybeans)

Task II - Determine the effect of soil variability and environmental quality on switchgrass production

A. Evaluate the effects of landscape position, soil properties, and nitrogen fertilizer on switchgrass yield and quality

Research completed (refer to 1998 Annual Report)

Plant analysis

- Biomass harvested in November 1998
- Biomass sampled in March, July, August, September, and November 1998
- Leaf/stem ratios determined
- Fiber and mineral analysis completed on March samples (Derby only)
- Samples through September prepared for laboratory analysis

Soil analysis

- Soil surface sampling completed for Derby and Millerton plots
- Soil cores (1 m) pulled from Derby and Millerton plots
- Soil fertility analysis completed for Derby plots
- Landscape field notes for Derby plots completed

Research to be conducted in 1999

Plant analysis

- Biomass harvested in November 1999
- Biomass sampled in March, July, August, September, and November 1999
- Fiber and mineral analysis conducted on remaining 1998 samples and 1999 samples
- Complete analysis of effect of nitrogen and landscape position on plant components and yield

Soil analysis

- Description of soil cores from Derby and Millerton
- LECO carbon analysis of surface samples
- Fertility analysis of surface samples from Millerton plots
- Hand cores at Millerton to determine A horizon depth
- Complete analysis of data and correlation with plant results

Proposed research activities past 1999

- March 2000 sampling and analysis to complete two full years of data

Task II Determine the effect of soil variability and environmental quality on switchgrass production

B. Assess soil erosion, soil tilth, and runoff characteristics in switchgrass fields

Research completed (refer to 1998 Annual Report)

- Fields identified for erosion/environmental quality measuring in Lucas County
- Transects marked and pins placed for erosion measurements

Research to be conducted in 1999

- Pulling and describing soil cores from all plots
- Quantifying amount of erosion along marked transects
- Compare estimates of overall erosion (including sheet and rill) between switchgrass and alternative land uses (corn and soybeans)
- Complete analysis of erosion levels in switchgrass fields

Task II Determine the effect of soil variability and environmental quality on switchgrass production

C. Assess the carbon sequestration potential and impacts of switchgrass biomass

Research completed (refer to 1998 Annual Report)

- Developed scope of work *Spatial and temporal dynamics of carbon sequestration in the Chariton Valley, Iowa*, a copy of which accompanies this report
- Initiated performance of scope of work tasks by completing the preliminary assessment *Soil carbon sequestration potential in the Chariton River watershed, Iowa*
- Initiated analysis of the life cycle greenhouse gas emissions from growing and using switchgrass as biomass

Research to be conducted in 1999

- Continue performance of tasks described in the accompanying scope of work *Spatial and temporal dynamics of carbon sequestration in the Chariton Valley, Iowa*
- Complete the life cycle CO₂-equivalent, SO₂, and NO_x emissions estimates for both switchgrass and coal
- Analyze the economic value of the net reduction/increase in greenhouse gas emissions resulting from the combustion of switchgrass with coal

Task III Evaluate and develop switchgrass and reed canarygrass germplasm for bioenergy production and adaptation to Iowa

A. Evaluate switchgrass cultivars for yield and biofuel quality

Research completed (refer to 1998 Annual Report)

- Plots at McNay scored for stand, disease prevalence, and lodging
- Harvested November 1998
- Samples prepared for laboratory analysis

Research to be conducted in 1999

- Harvest plots in March and November 1999
- Conduct laboratory analysis for fiber and mineral composition on 1998 and 1999 samples
- Analysis of selected samples for fuel analysis
- Complete analysis of varietal performance

Proposed research activities past 1999

- March 2000 harvest to complete second year
- Third and fourth year harvests or at least note-taking for persistence
- Establish a second test of the best performing varieties for more thorough evaluation, preferably at multiple locations

Task III Evaluate and develop switchgrass and reed canarygrass germplasm for bioenergy production and adaptation to Iowa

B.1. Evaluate harvest management and varietal performance of reed canarygrass for biofuel

Research completed (refer to 1998 Annual Report)

Harvest management and variety trial

- Tests established at Ames, IA and Arlington, WI (Dr. Michael Casler, cooperating)
- Test at Ames harvested (it was planted in fall 1997)

Germplasm evaluation and breeding

- Plots including the entire USDA plant introduction collection plus other breeding lines established at Ames and Arlington, WI (121 total accessions).

Research to be conducted in 1999

Harvest management and variety trial

- Establish test in southern Iowa at McNay Research Farm (not planted in 1998 due to wet conditions in spring and dry conditions in fall)
- Possibly establish test at Lexington, KY (Dr. Tim Phillips, cooperating)
- March 1999 harvest of Ames trial
- Harvest of Ames and Arlington trials—June and November 1999.
- Laboratory analysis of 1998-1999 samples for fiber and mineral composition
- Complete analysis of harvest management and variety performance

Germplasm evaluation and breeding

- Harvest plots in June and November 1999
- Prepare samples for laboratory analysis of fiber and mineral composition
- Take notes on height, vigor, leafiness, and other agronomic traits

Proposed research activities past 1999

Harvest management and variety trial

- Yield testing should continue for at least two more years at all locations
- Laboratory analysis of samples in succeeding years

Germplasm evaluation and breeding

- Evaluation through at least 2000, preferably through 2001 to get a better idea of persistence
- Laboratory analyses supporting the evaluation
- After second year (i.e., 2000), begin making selections to develop breeding populations
 - 2001: Intercross selections
 - 2002: Plant evaluation trials and breeding nurseries
 - 2003+: Evaluate new populations and make selections for new cycles

Budget

Tasks	Initial Budget	Expended as of 12/31/98	Balance as of 12/31/98	Budget for 1999 Activities (a)
Task I Economic Analysis				
Assistantships/Labor	\$39,000	\$7,030.61	\$31,969.39	\$31,969.39
Lab Supplies	10,000	50.50	9,949.50	9,949.50
Travel	3,700	67.50	3,632.50	3,632.50
Sub-Totals	\$52,700	\$7,148.61	\$45,551.39	\$45,551.39
Task II Soil Suitability				
Assistantships/Labor	\$31,500	\$11,002.16	\$20,497.84	\$19,656.00
Lab Supplies	20,194	5,276.24	14,917.76	14,459.28
Travel	4,150	1,450.32	2,699.68	4,000.00
Sub-Totals	\$55,844	\$17,728.72	\$38,115.28	\$38,115.28
Task III Varietal Performance				
Assistantships/Labor	\$12,500	\$1,158.15	\$11,341.85	\$10,500.00
Lab Supplies	20,194	5,276.24	14,917.76	14,459.29
Travel	4,150	1,450.32	2,699.68	4,000.00
Sub-Totals	\$36,844	\$7,884.71	\$28,959.29	\$28,959.29
Totals	\$145,388	\$32,762.04	\$112,625.96	\$112,625.96

- (a) Expenditure of the budget for 1999 activities and completion of project tasks take into consideration a request for a no-cost extension of the project period through 12/31/99. In some cases the budget for 1999 activities has been adjusted based on planned funding requirements and differs from the balance as of 12/31/98 from the initial budget.

Proposed Research Activities

The following research activities are related to, yet beyond the scope of, current project activities. It is the opinion of the researchers currently collaborating on the Chariton Valley Biomass Project that this research will provide information of significant importance in terms of supporting efforts to develop a biomass energy industry in Iowa.

Economic analysis

1. Examine the economic impact of producing and using switchgrass as biomass from a societal perspective, i.e., quantify the economic value of environmental benefits.
2. Examine the risk factors from the landowner's perspective associated with incorporating switchgrass production for biomass into farm operations and alternatives to addressing that risk.
3. Perform a more complete economic analysis of the use of land in the Conservation Reserve Program (CRP) for the production of switchgrass for biomass, e.g., impacts on the CRP, regional economy, availability of switchgrass with alternative reduced payment scenarios.
4. Complete a pre-feasibility study to assess the potential for a cellulose to ethanol conversion facility in southern Iowa.

Yield variability and its causes

1. Quantify actual yields on farms in the Chariton Valley. Results to date showed surprisingly low yields. Researchers are developing a small square baler with weigh bars and a global positioning system (GPS) unit integrated into it. We propose to look at a number of fields (e.g., 15) and harvest long transects through these fields at several landscape positions to better estimate yield potential.
2. Analyze soil quality and degradation in relation to the yield data in 1 above.
3. Develop a model to quantify the spatiality of landscapes and soils and their relation to biomass yields using GIS/GPS technology, i.e., synthesizing data from the ongoing research and items 1 and 2 above to make a predictive tool useful for economic and environmental planning.

Agronomic production practices

1. Further identification of the effects of fertility management on yield, particularly including the effects of lime (see 1998 Annual Report).
2. Characterize the effects of fertilization and establishment practices on weed populations.
3. Develop and evaluate cropping systems integrating multiple biomass species and multiple crop uses.

Breeding and genetics

1. Continue reed canarygrass evaluation and population development to develop truly biomass-type cultivars, which do not currently exist.
2. Collect seeds from native/naturalized reed canarygrass stands throughout the United States and Canada and evaluate at multiple locations as potentially high-yielding germplasm.
3. Develop useful "heterotic groups" of switchgrass by selecting winterhardy plants from lowland cultivars, which appear to have higher yields than upland cultivars when they don't winterkill (see 1998 Annual Report). Crossing winterhardy lowland with adapted upland germplasm could result in considerable heterosis (see forthcoming paper in *Crop Science*: E.C. Brummer, 1999, Capturing heterosis in forage crop cultivar development.)
4. Make crosses among various reed canarygrass germplasm to identify and develop heterotic groups for future cultivar development efforts.

Carbon sequestration

1. Further analysis of the relationship between soil quality and degradation in the Chariton Valley area and carbon sequestration.
2. Evaluate the effects of climate and management changes on carbon sequestration.
3. Perform full fuel cycle analyses on a wide range of fuels for electric generation including wind, solar, natural gas, etc. for the purpose of comparing these with similar analyses performed for switchgrass and coal.
4. Determine the value of carbon dioxide-equivalent emission allowance (and SO₂ and NO_x emission allowances) that switchgrass biomass and other energy sources (coal, wind, solar, natural gas, etc.) become most economically viable.

Spatial and temporal dynamics of carbon sequestration in the Chariton Valley, Iowa

Project Scope of Work

Lee Burras & William Weaver
Iowa State University

Introduction

Quantifying the dynamics of the carbon cycle is a priority topic within the scientific community because of its obvious importance in global change. A fundamental component of this cycle is soil carbon, which can be viewed as the balance between three pedological components: sources, sinks, and transformations (Chadwick et al., 1994). Under natural conditions, this balance results in a stable soil carbon component, both in terms of content and physiochemical properties. Under traditional agricultural systems (e.g., row-crop agriculture), the content and physiochemical properties are gradually degraded (e.g., see Cambardella and Elliott, 1993; Jastrow et al., 1996). This degradation results in a less chemically active organic fraction in soil, that in turn has less beneficial influence on aggregate stability and size. The lowered organic matter content and less stable soil structure within a soil results in reduced water holding capacity and increased susceptibility to erosion. Thus, a basic product of traditional dryland agriculture has been loss of sequestered carbon and its corollary general environmental degradation.

Luckily, alternative field management schemes offer great potential for not only stopping the ongoing loss of sequestered carbon but actually increasing soil carbon content. A conventional means of increasing soil carbon content in agricultural fields is to lengthen crop rotations via the inclusion of forages along with row crops. For example, Robinson et al. (1996) found that converting a field of Mollisols in Iowa from continuous row crops to a four year rotation has the potential to replace as much as 30% of the soil carbon lost due to continuous row cropping. A cropping scheme of even greater potential for increasing carbon sequestration is one wherein perennial grasses are the predominant species within a field. An example of one such perennial grass is switchgrass (*Panicum virgatum*, L.), which has been shown to promote high rates of soil carbon gain (Sanderson et al., 1996). The recent publication by Gale (1997) also has shown that improved conditions of soil physiochemical properties can rapidly follow increased soil carbon content.

From a practical perspective, increasing soil carbon sequestration entails more than simply asking farmers to switch their cropping practices. These farmers must be convinced of the economic viability of the new cropping scheme and comfortable that such a scheme will promote on- and off-farm environmental quality. In the case of Iowa, ongoing research suggests the optimum location to accomplish all three of these goals is in the south-central quadrant, e.g. the Chariton Valley. The optimum cropping scheme is perennial switchgrass production. The reasons for the economic and agronomic suitability of this region and switchgrass are beyond the scope of this proposal. The on-farm environmental factors favoring a switchgrass-based cropping scheme in the Chariton Valley include: (a) the rolling landscape consisting of dissected soil units, many of which are highly weathered and have low strength, (b) the highly variable rainfall patterns, and (c) the historically excessive erosion rates resulting from the

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combination of (a) and (b). An important off-farm improvement would be the reduced sediment load in local and distal waterways, which in turn will promote stream and lake clarity, oxygen content, and alga control.

The purpose of this proposed research is to quantify carbon sequestration dynamics, especially with respect to switchgrass, in the Chariton Valley. The foundation of this project rests upon three general hypotheses, which are derived from general carbon sequestration principles.

Hypothesis 1: The carbon sequestration potential for the Chariton Valley can be predicted using soil map unit attributes.

Hypothesis 2: Rates of actual carbon sequestration in a given soil map unit will be dependent upon soil attributes, land use history, and current types of management.

Hypothesis 3: Maximum carbon sequestration in the Chariton Valley can be obtained via successful management of switchgrass (*Panicum virgatum*, L.).

In order to test these hypotheses, we propose the following six specific research objectives:

- (1) quantify existing soil carbon amounts across the Chariton Valley,
- (2) evaluate the pedological controls on soil carbon spatiality,
- (3) quantify differences in soil carbon amounts due to cropping and land use history,
- (4) quantify carbon sequestration dynamics due to conversion of traditional crop land and pasture into switchgrass fields,
- (5) evaluate the immediate and long-term effect on soil quality of converting traditional crop land and pastures into switchgrass production, and,
- (6) integrate the findings from objectives 1 through 5 into a model capable of predicting the potential for carbon sequestration.

Methods

This proposed project will consist of three phases: (a) GIS-based preliminary model development that predicts the carbon sequestration potential for the Chariton Valley, (b) extensive field sampling, and (c) refined model development. In addition to predicting carbon sequestration potential, the initial GIS-based model will also serve to identify types of sites needed for the extensive field sampling phase. The field sampling phase will consist of sampling three types of sites - (1) switchgrass fields, (2) "old" row crop fields, and (3) "old" permanent ecosystems. The "old" row crop fields will provide information about the worst case for carbon sequestration (i.e., the lowest amount of soil carbon) in the Chariton Valley while the "old" permanent ecosystems (e.g., pastures, woodlots, alfalfa fields, and/or never cultivated parks/preserves) will give the best case for carbon sequestration (at least currently). The switchgrass fields will allow determination on how switchgrass does relative to the best and worst. It is expected switchgrass will prove to be better than the current best (e.g., a park), both in terms of the rate of carbon sequestration and in causing a higher equilibrium soil carbon content.

Within the switchgrass sites, the widest possible range of time of original establishment is needed. That is, this project will use switchgrass fields that are currently being established as well as ones that were established 10+ years ago (and everything in between). By sampling these, the rate at which carbon is sequestered can be determined. By itself this permits quantification on how long it takes a field to reach equilibrium soil carbon content (maximize C sequestered). Also, by coupling this with biomass productivity, changes in the rate of sequestration efficiency can be established.

104 For all three types of sites, it will be ideal that each field's past management (none, minimal
105 fertilization, high rates of fertilization.; no tillage, conventional tillage, etc.) is known in order
106 to determine best management practices to maximize carbon sequestration. This is
107 important because management strongly influences the soil carbon amounts at both ends of
108 the dynamics (i.e., - high management tends to produce more biomass but high
109 management also tends to increase rates of decomposition since the microbes are more
110 active; consequently since soil carbon content is the balance of those two factors it is hard
111 to predict what different management will do).

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113 All representative landscapes and soils will be sampled during the field stages. These will be
114 selected using the initial GIS database and in consultation with NRCS field personnel.

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116 The completion of the final phase will entail developing a multiple linear regression-based
117 model specific to the Chariton Valley conditions. Depending on the availability of resources,
118 this model will be compared to the more spatially and temporally sophisticated "Century
119 Model." A reason for comparing the models is analogous to having "quick tests" and
120 analytical procedures. The regression model will permit rapid evaluation of carbon
121 sequestration potential in a well-studied watershed whereas the "Century Model" will permit
122 more thorough prediction and evaluation from a regional perspective.

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128 **Calendar**
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<i>Time</i>	<i>Component</i>
Year One	Develop a preliminary evaluation of carbon sequestration using existing soil attributes and maps via GIS. Develop the sampling scheme necessary to quantify carbon amounts by soil map units across the Chariton Valley inclusive of the impact of cropping and land use history. This will be completed using the available GIS database.
	Conduct preliminary field sampling using the above scheme. This will consist of pulling and describing 1.5 meter deep 7.5 cm diameter soil cores using standard NRCS methods and terminology.
	Begin laboratory analyses for bulk density, carbon content, nitrogen content, pH, CEC, and particle size distribution.
Year Two	Finish field sampling as described above. Cores will be collected from all representative landscapes and soils.
	Finish laboratory analyses. Develop final multiple linear regression model. Present paper at the Soil Science Society of America conference (Salt Lake City, Utah)
	Write final report and dissertation as a series of manuscripts consistent with the six listed objectives. Present paper at the International Biomass Meetings. Present findings at Chariton Valley extension-like meetings.

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150 **Budget**

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Categories	Budget Estimate
Personnel (a)	\$50,560.00
Fringe Benefits (a)	12,640.00
Travel	9,869.20
Supplies	32,300.00
Equipment	7,000.00
Total Direct Charges	\$112,369.20
Indirect Charges (b)	28,092.30
Total Costs	\$140,461.50

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153 (a) Funds for salary, benefits, and related expenses for principal investigators, research

154 assistants, and technicians. A portion of salary, benefits, and related expenses for

155 principal investigators will constitute an in-kind contribution to the project.

156 (b) Indirect charges estimated at 25% of direct costs will constitute an in-kind contribution

157 to the project.

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160 **Expected Results**

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162 The hypotheses presented in the introduction will be validated. The most important aspects

163 being: (a) carbon sequestration potential will be found to be easily and accurately modeled,

164 and (b) switchgrass production will prove to be highly effective in sequestration of soil

165 carbon in the Chariton Valley.

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Bibliography

- Cambardella, C.A. and E.T. Elliott. 1993. Carbon and nitrogen distribution in aggregates from cultivated and native grassland soils. *Soil Sci. Soc. Am. J.* 57:1071-1076.
- Chadwick, O.A., E.F. Kelly, D.M. Merritts, and R.G. Amundson. 1994. Carbon dioxide consumption during soil development. *Biogeochemistry* 24:115-127.
- Chowdhery, A.A. 1989. Soil survey of Clarke County, Iowa. USDA-SCS.
- Gale, W.J. 1997. Carbon dynamics of surface residue and root-derived particulate organic matter in the whole soil and aggregate size fractions. Unpubl. PhD., Iowa State University, Ames, Iowa.
- Jastrow, J.D., T.W. Boutton, and R.M. Miller. 1996. Carbon dynamics of aggregate-associated organic matter estimated by C-13 natural abundance. *Soil Sci. Soc. Am. J.* 60:801-807.
- Robinson, C.A., R.M. Cruse, and M. Ghaffaezadeh. 1996. Cropping system and nitrogen effects on Mollisol organic carbon. *Soil Sci. Soc. Am. J.* 60:264-269.
- Sanderson, M.A., R.L. Red, S.B. McLaughlin, S.D. Wulfschleger, B.V. Conger, D.J. Parrish, C. Taliaferro, A.A. Hopkins, W.R. Ocumpaugh, M.A. Hussey, J.C. Read, and C.R. Tisch. 1996. Switchgrass as a sustainable bioenergy crop. *Bioresource Technology*.

Soil Carbon Sequestration Potential in the Chariton River Watershed, Iowa.

Lee Burras
Iowa State University

December 03, 1998

Prepared for the Chariton Valley RC&D to create the accompanying map "Potential for Soil Carbon Sequestration: Model Summary" using SSURGO and ISPAID databases.

Background

The following equation is designed to evaluate carbon sequestration potential by soil map unit across the Rathbun Lake watershed. Subsequently, it was used to generate a map of the watershed showing areas of high, moderate, and low potential for soil carbon sequestration. The equation is not suitable for mapping existing soil carbon reservoirs.

The overall potential for soil carbon sequestration is thought to be largely a function of past erosion, slope characteristics, soil drainage class, parent material, inherent fertility, and natural morphological characteristics. Ongoing field management is an additional parameter that is undoubtedly fundamental to carbon sequestration rates; however, currently available management data is not appropriate for making soil-by-soil interpretations. Consequently, management history is not considered in this version of the soil carbon sequestration potential equation although the likely ease of future management in different soils is considered. This equation uses only commonly available soil surveys and their data, which is available in SSURGO and ISPAID data bases.

Written in a conventional mathematical form, a reasonable first generation theoretical soil carbon sequestration potential equation is:

$$P = E * LS * DC * PM * F * AH * BH$$

where:

P = Carbon Sequestration Potential	PM = parent material value
E = map unit erosion value	F = inherent productivity index
LS = slope length & steepness value	AH = A horizon characteristics
DC = drainage class value	BH = B horizon characteristics

All factors in this equation are treated as being unitless because this version of the equation simply seeks to assess relative potential for soil carbon sequestration. It is not seeking to predict actual rates or amounts. In other words, this equation is only suitable for predicting which map units will have "high," "moderate," and "low" potential for incorporating more soil organic matter. The details of actual rates and amounts will need to be generated via site-specific field studies.

The intended base units for this equation are map units given in a second-order soil survey.

The lack of coefficients on equation terms reflects the current lack of field-testing on this equation. In other words - this equation must be used with caution. It is a first-generation theoretically-based equation needing extensive ground truthing in order to establish its level of reliability.

Equation Information

Table 1: Equation terms as well as sources and examples of their numerical values		
Term		Sources and examples of numerical values
E	map unit erosion	Values obtained directly from map units. <i>1 = minimally eroded map units</i> <i>2 = moderately eroded map units</i> <i>3 = severely eroded map units</i>
LS	slope length & steepness	Use <u>the inverse of the USLE LS</u> values for well-managed pastures. (see Table 2). <i>Values range from 0.2 to 7</i>
DC	drainage class	Values assigned using consociation drainage class and the following: <i>0.9 = excessively drained soil</i> <i>1.0 = well drained soil</i> <i>1.3 = moderately well drained soil</i> <i>1.6 = somewhat poorly drained soil</i> <i>1.9 = poorly drained soil</i> <i>2.0 = very poorly drained soil</i>
PM	parent material	Values assigned using the predominant parent material in the solum. <i>Values range from 1 to 2 (see Table 3).</i>
F	inherent productivity index	Values assigned using map unit corn suitability rating (CSR) times 0.01. For example, <i>0.05 = terrible inherent productivity</i> <i>0.40 = moderate productivity</i> <i>0.80 = high inherent productivity</i>
AH	A horizon characteristics	Values assigned using typical <u>maximum</u> 0.5 foot-depth bulk density values. <i>Values range from 1.2 to 1.6</i>
BH	B horizon characteristics	Values assigned <u>using the inverse</u> of typical <u>maximum</u> 3.0 foot-depth bulk density values. <i>Values range from 0.5 to 0.9</i>

Equation Information contd.

Table 2: LS values. Values are based upon maximum map unit slope steepness. All values are the invert of USLE LS terms for 100 foot long slopes and low ratio rill to interrill erosion, such as in meadows.

%slope	LS value	%slope	LS value	%slope	LS value
≤1	7.0	11	0.7	21	0.29
2	3.8	12	0.6	22	0.28
3	2.6	13	0.55	23	0.27
4	2.0	14	0.50	24	0.26
5	1.6	15	0.45	25	0.25
6	1.4	16	0.40	26	0.24
7	1.2	17	0.38	27	0.23
8	1.0	18	0.36	28	0.22
9	0.9	19	0.33	29	0.21
10	0.8	20	0.30	≥30	0.20

Table 3: Values applicable to the SSURGO PARENTMAT DATA (See Appendix A)

PM Abbrev.	Value	PM Abbrev.	Value	PM Abbrev.	Value
A	1.5	AO	1.8	LN	1.8
B	1.5	AR	1.5	LR	1.5
C	1.5	AS	1.7	LS	1.6
D	1.0	BC	1.0	LT	1.6
E	1.0	BS	1.0	MC	1.0
F	2.0	DC	1.0	MR	1.0
G	1.0	ET	1.5	MT	1.0
H	1.0	FC	2.0	PL	1.0
I	1.5	FR	1.5	PV	1.0
J	1.0	FT	1.5	QT	1.0
K	1.5	GV	1.0	QY	1.0
L	2.0	IC	1.8	SA	1.0
M	1.3	ID	1.0	SR	1.0
N	1.0	IG	1.0	TC	1.0
O	1.5	IP	1.0	TL	1.0
P	1.0	IR	1.0	TR	1.0
Q	1.0	IS	1.8	TU	1.0
R	1.0	IT	1.3	UC	1.0
S	1.5	IZ	1.0	US	1.0
T	1.0	JR	1.0	WK	1.0
U	1.7	LC	2.0	WS	1.0
V	1.2	LD	1.5	YK	1.0
W	1.8	LF	2.0	YM	1.0
X	1.0	LG	1.5	YR	1.0
Y	1.8	LH	1.5	YS	1.0
Z	1.0	LI	2.0	YT	1.0
AC	1.8	LJ	1.5		

Example calculations - Using Clarke County map units

Map Unit = 23C = Arispe silty clay loam, 5 to 9 percent slope.

$$P = E * LS * DC * PM * F * AH * BH \Rightarrow$$

$$P = 1.0 * 0.9 * 1.6 * 2.0 * 0.55 * 1.40 * 0.69 = \underline{1.5}$$

where:

E = 1.0	minimally eroded unit
LS = 0.9	9% slope – see Table 2
DC = 1.6	somewhat poorly drained soil
PM = 2.0	loess-derived soil - see Table 3, "L" unit
F = 0.55	CSR = 55
AH = 1.40	maximum BD value for 0.5 foot depth
BH = 0.69	inverse of maximum BD (1.45) value for 3 foot depth

Map Unit = 23C2 = Arispe silty clay loam, 5 to 9 percent slope, moderately eroded.

$$P = E * LS * DC * PM * F * AH * BH \Rightarrow$$

$$P = 2.0 * 0.9 * 1.6 * 2.0 * 0.50 * 1.40 * 0.69 = \underline{2.8}$$

where:

E = 2.0	moderately eroded unit
LS = 0.9	9% slope - Table 2
DC = 1.6	somewhat poorly drained soil
PM = 2.0	loess-derived soil – Table 3
F = 0.50	CSR = 50
AH = 1.40	maximum BD value for 0.5 foot depth
BH = 0.69	inverse of maximum BD value for 3 foot depth

Map Unit = 179D = Gara loam, 9 to 14 percent slope.

$$P = E * LS * DC * PM * F * AH * BH \Rightarrow$$

$$P = 1.0 * 0.50 * 1.3 * 1.0 * 0.40 * 1.55 * 0.57 = \underline{0.2}$$

where:

E = 1.0	minimally eroded unit
LS = 0.50	14% slope – Table 2
DC = 1.3	moderately well drained soil
PM = 1.0	till-derived soil – Table 3
F = 0.40	CSR = 40
AH = 1.55	maximum BD value for 0.5 foot depth
BH = 0.57	inverse of maximum BD value for 3 foot depth

Discussion of Examples

The preceding three examples show *moderately eroded* Arispe has noticeably greater soil carbon sequestration potential than either the uneroded Arispe on the same slope or Gara loam on a steeper slope. It must be immediately noted that the absolute values calculated (1.5, 2.8, and 0.2) cannot be used to state that eroded Arispe has about twice as much potential relative to the uneroded Arispe and about 14 times relative to the Gara. This equation is suitable for assessing likely trends. Thus, the only reasonable interpretation of the values calculated is highest soil carbon sequestration potential occurs in the eroded Arispe while the least occurs in the Gara.

In the case of the two Arispe units, the reason for the difference in values is simply that eroded soils have the potential to be "rebuilt" to their more-or-less original organic matter content. For that to happen, a field manager must (a) prevent future erosion, and (b) create an agroecosystem similar to native conditions. Both requirements can be met by growing a permanent vegetative cover such as switchgrass that is only minimally harvested. Under these conditions, the soil carbon content will re-equilibrate at its original, uneroded, unmanaged state. In other words, the soil carbon lost with erosion will be replaced by natural organic matter build up as roots and leaf litter decomposes in a stable soil. As an aside, the clay, silt, sand, nutrients, etc., that were simultaneously eroded will not be regenerated. Only organic matter will be. Also, this discussion does not address the rate of build up – it only evaluates the potential for build up.

The uneroded Arispe potential for sequestering additional soil carbon stems from two factors. First, any historically cultivated soil (which is 99% of Iowa) has lowered soil organic matter content relative to its native condition because cultivation accelerates the decomposition of soil organic matter. While not generally stated as such, accelerated decomposition is an intentional product of cultivation because it increases nutrient availability during crop growth. In reality, early row crop agriculture in Iowa was strongly influenced by the nutrients made available through vigorous plowing. Consequently, as with eroded Arispe, conversion of an uneroded soil into permanent vegetative cover will result in sequestered soil carbon.

The second reason why uneroded Arispe soils have a reasonably high potential to sequester additional carbon is effective field management can increase soil carbon amounts. In other words, the natural soil carbon content is not necessarily the maximum content. Higher contents are possible provided the environmental controls on soil carbon content are changed. Soil carbon content reflects the long term equilibrium between organic matter production (plant growth) and organic matter loss (decomposition, erosion, etc.). Consequently, if a farmer applies practices that promote growth beyond native amounts and/or inhibit losses to less than natural rates, a new higher soil organic matter content will occur. The management difficulty inherent to this idea is simply that most management practices which increase plant productivity also increase decomposition and/or erosion. For example, improved drainage increases soil oxygen levels, which in turn increases plant productivity by enhancing root growth, nutrient uptake, water uptake, etc. Of course, this oxygen also enhances microbial activity, which generally results in a downward shift in equilibrium soil organic matter content. Likewise, effective fertilization obviously increases plant productivity but those same fertilizers provide nutrients essential to the microbes that decompose soil organic matter. Consequently, the historical effect of both drainage and fertilization appears to be lowered soil organic matter content, especially in fields where much of the plant growth is harvested. Consequently, to assure a soil reaches its soil carbon sequestration potential vis-à-vis effective management means both plant productivity and organic matter losses must be explicitly addressed. What this means to an uneroded Arispe soil is: proper management can increase its soil carbon content.

The potential for increase appears quite high since the Arispe has a relatively high potential for plant productivity (as indicated by the CSR value being 55) but effective decomposition management will be paramount.

This equilibrium shift discussed in the preceding paragraph also applies to the eroded Arispe but only after native soil carbon content is re-established.

The Gara soil has the lowest potential to sequester additional soil carbon of the three example soils. This is due to its poor inherent properties. Being steeply sloping combined with a dense till parent material means the Gara stores little available water. Consequently, plant productivity will always be limited compared to most other soils in the Chariton Valley area, which in turn means organic matter build up is slow and limited relative to most other soils. Therefore its potential to sequester soil carbon is low, although it must be pointed out that steeply sloping Gara soils also have low potential for crop production and a high potential for degradation. Consequently, using the Gara to sequester even limited amounts of carbon may be its best possible use from an environmental quality perspective.

In sum, the Arispe and Gara examples can be used to make some general predictions about soil carbon sequestration potential. First, increasing carbon content will be easiest in soils that are out of sync with their environment due to erosion. Second, increasing carbon content appears promising in stable soils suited to management practices that promote more roots and less decomposition. Third, inherently productive soils offer greater potential than inherently nonproductive soils. Finally, the most difficult soils are the ones that defy effective management because of excessively steep slopes, droughty characteristics, etc. In other words, soil-landscape trends in carbon sequestration potential will in many ways mirror trends in crop productivity. The role of drainage class may be the one exception in explaining these trends.

Rationale explaining equation parameters

Soil carbon sequestration potential (P) is the product of competing environmental processes. As mentioned in the preceding section, soil carbon content derives from the long-term balance between plant (photosynthetic) productivity at a site and organic matter losses (decomposition, degradation, erosion, etc.). Consequently, the soils with the highest potential for sequestering carbon are the ones that have high plant productivity and low organic matter losses. Synthesis of numerous pedological studies from Iowa and other states suggest the maximum organic matter build-up occurs in level or depressional, poorly-drained silty or clayey textured soils formed in parent materials rich in weatherable minerals. The level or depressional location is important because these landscapes have minimal water erosion. The wet conditions prevent decomposition. Silty textures are ideal for two reasons: (a) they hold available water even during droughty periods, and (b) they are not subject to wind erosion. Clayey soils are ideal because decomposing organic matter becomes strongly complexed with the clay minerals (smectites) commonly found in Iowa. These clay-organic matter complexes are highly resistant to degradation. Additionally, clayey textures inhibit oxygen flow, which is another way of saying clayey textures inhibit decomposition. Weatherable minerals indicate inherent fertility, which is essential for sustained plant growth.

Table 4 gives a brief explanation for each term used in the carbon sequestration potential equation. In general, it is important to remember the goal of the equation is simply to differentiate soils based upon the likelihood of easily increasing their soil carbon content. It was not to develop absolute values that quantify the actual amounts of carbon that will be sequestered.

Table 4: Rationale behind terms used in the carbon sequestration potential equation.		
Term		General Trends & Rationale
E	map unit erosion	Eroded soils hold the greatest promise to sequester carbon because the original carbon has been selectively removed. Consequently, the magnitude of E is proportional to the erosion class since benign long-term revegetation of an eroded soil will drive its organic matter content up.
LS	slope length & steepness	The factors that promote water erosion (e.g., slope steepness) inhibit soil carbon sequestration. Conversely, the factors that promote sedimentation promote soil carbon sequestration. Consequently the USLE LS term can be used to help predict carbon sequestration potential. But since the processes of erosion and sequestration are opposites, this equation needs to, and does, use the inverse of the USLE LS.
DC	drainage class	In any given landscape, "wet" soils have more soil carbon than "dry" soils because wet, or hydric, conditions inhibit organic matter decomposition. Thus, drainage class is a direct predictor of soil carbon sequestration potential with the most poorly drained soils having the highest potential.
PM	parent material	Soil carbon sequestration occurs in the framework of the types, sizes, and arrangement of the minerals present in the soil. The primary control on mineral characteristics is the geology of a site, which in soil science is referred to as parent material. One reason the types of minerals matter is their weathering affects nutrient availability. Mineral size distribution is another way of saying soil texture. Sandy textured soils tend not to promote organic matter buildup whereas clayey textured soils do. Soils high in silt have ideal plant available water holding characteristics, which promotes overall plant productivity. The arrangement of minerals addresses the issue of bulk density, ease of root penetration, etc. The best parent materials are ones having low bulk density and primarily silt sized particles. In other words, loess is best.

Table 4 (contd): Rationale behind terms used.		
Term		General Trends & Rationale
F	inherent productivity index	Different soils have different potential for successful plant growth. The best indicator of <i>successful crop growth in Iowa</i> is the corn suitability rating (CSR). Consequently, CSR values offer a direct way to predict the photosynthetic potential of a soil. Furthermore, the CSR values are county-by-county specific, which permits indirect incorporation of the known trends in climate and soil properties that exist across the Chariton Valley area. This equation uses $1/100^{\text{th}}$ of the CSR just to keep most P values between 0 and 10.
AH	A horizon characteristics	-see BH-
BH	B horizon characteristics	The overall characteristics of a soil's solum must be considered in understanding plant growth and carbon storage. This is especially true when the A horizon properties contrasts sharply with the B horizon because root growth and microbial activity will be significantly affected by this contrast. One way to evaluate if a contrast occurs is to examine changes in bulk density with depth. Bulk density was selected because it directly affects root growth and microbial activity. By multiplying the A horizon bulk density by the inverse of the B horizon bulk density, the equation calculates a "1.0" (which means "no effect" in terms of an equation) when the two bulk densities are identical. Conversely, if the bulk density of the B horizon is greater than the A horizon, the calculated value will be less than one, which means soil carbon sequestration is inhibited relative to a similar soil having identical bulk densities with depth.

The terms used in the equation are obviously interrelated. After all, every property in a soil is spatially and genetically connected to every other property. Consequently, to prevent an over-emphasize of any given property, the final version of this equation will have to be modified. Three possible ways it will be modified are (a) the elimination of some of the existing terms, (b) the addition of new terms, and/or (c) the development of weighting coefficients for terms (e.g., " $3E*0.5LS*.....$ "). These modifications will be developed using field results.

Perhaps more importantly, the final version of this equation will need to directly evaluate the impact of long-term management on soil carbon sequestration potential. As discussed earlier, soil carbon sequestration can be enhanced via management that simultaneously promotes plant growth and inhibits decomposition and erosion. The ease of making both of these processes occur will vary depending on soil properties. Consequently, the success of attempting such management will vary across a field consistent with natural soil variability.

Summary

The potential to sequester soil carbon across the Rathbun Lake watershed is thought to be dependent on two factors: (a) inherent soil properties and (b) management. This paper and the resulting map examine only the inherent soil properties. Specific inherent soil properties considered to be of importance are (1) past erosion, (2) slope characteristics, (3) soil drainage class, (4) parent material, (5) inherent fertility, and (6) natural morphological characteristics. These factors were combined into the following equation, which was then used in conjunction with available soil databases to assign numerical values to soil mapping units that represent their relative carbon sequestration potential:

$$P = E * LS * DC * PM * F * AH * BH$$

where:

P = Carbon Sequestration Potential	PM = parent material value
E = map unit erosion value	F = inherent productivity index
LS = slope length & steepness value	AH = A horizon characteristics
DC = drainage class value	BH = B horizon characteristics

Results of this preliminary assessment of the carbon sequestration potential of soils in the Rathbun Lake watershed are summarized as follows:

- An estimated 156,096 acres or 44.1 % of the land in the Rathbun Lake watershed are assessed as having a high potential for carbon sequestration. Soil mapping units assessed as having the highest relative carbon sequestration potential include Arispe silty clay loam, 5 to 9% slopes, moderately eroded; Edina silt loam, 0 to 1% slopes; Grundy silty clay loam, 2 to 5% slopes; Haig silty clay loam, 0 to 2% slopes; Seymour silt loam, 2 to 5% slopes; Seymour silt loam, 5 to 9% slopes, moderately eroded; and Olmitz-Vesser-Colo complex, 2 to 5% slopes;.
- An estimated 126,048 acres or 35.6 % of the land in the Rathbun Lake watershed are assessed as having a moderate potential for carbon sequestration.
- An estimated 71,900 acres or 20.3% of the land in the Rathbun Lake watershed are assessed as having a low potential for carbon sequestration.

The accompanying map, Potential for Soil Carbon Sequestration: Model Summary, was generated with GIS and illustrates the results of the preliminary assessment.

Selected References

Chowdhery, A.A. 1989. Soil Survey of Clarke County, Iowa. USDA-SCS.

Iowa Soil Properties and Interpretation Database. 1996.

<http://extension.agron.iastate.edu/soils/PDFs/ispaid.pdf>. December 2, 1998.

Troeh, F.R., J.A. Hobbs, and R.L. Donahue. 1999. Soil and Water Conservation: Productivity and Environmental Protection (3rd Ed.). Prentice Hall, Upper Saddle River, NJ.

USDA NRCS. 1995. Soil Survey Geographic (SSURGO) Data Base: Fort Worth, TX.

APPENDIX THREE

INFORMATION AND EDUCATION

October 1998

- Traveled to Keswick to take photos of Jim Hall's switchgrass field and harvest. The switchgrass will be applied as a mulch to a construction site near Eddyville.
- Met with Marty Braster and Vince Sitzmann regarding support materials for the Rathbun Lake Watershed.
- Met with Marty Braster, Joe Sellers, and Mark Carlson regarding technical support with the biomass project.
- Traveled to Eddyville area to photograph construction site where switchgrass was applied as a mulch.
- Spent time on phone contacts, including: Iowa Forage and Grassland Council regarding annual meeting; Wendall Laing with the DOT regarding sign installment regulations; Jim Leer, contractor responsible for switchgrass application; Lowell Weile, Chariton Middle School instructor about a biomass presentation to accompany his environmental unit; and Craig Tordson regarding his support with project activities.
- Completed environmental poster (copy attached).

November 1998

- Arranged, prepared for, and attended project presentations for Lowell Wiele's Chariton Middle School seventh grade science class. Wrote article for local papers (copy attached).
- Created a brochure for the Rathbun Land and Water Alliance (copy attached).
- Prepared for and set up display for the Iowa and Forage and Grassland Council's Annual meeting in Des Moines. Coordinated the effort with Dewayne Johnson of the DNR.
- Traveled to Eddyville to take pictures of switchgrass that has been applied to the construction site. Will write article to accompany photos. Having some difficulty making contact with the contractor.

- Finalized project sign installment regulations with the Department of Transportation in Ames, as well as the county engineers in the counties where the signs will be installed.
- Photographed Rocky Lemus, Neil Molstid, and John Sellers taking samples during harvest at the switchgrass variety trial plots.

December 1998

- Completed article about Jim Hall utilizing his switchgrass as construction mulch (copy attached).
- Took photos of John Sellers installing cooperators sign. Also took photos of Vermeer baler for future public relations use. A copy of the sign installation regulations is attached.
- Spent some time running color copies of the Rathbun Land and Water Alliance brochure, and began layout of their billboard design.
- Began layout on *Switchgrass to Biomass* newsletter.
- Made contact with project participants to gather information regarding presentations made on behalf of the project. This information is needed for the Leopold Center's annual report, which is due the end of January.

What is the Rathbun Land and Water Alliance?

A nonprofit cooperation consisting of organizations and individuals who are committed to protecting our natural resources in southern Iowa. The Alliance provides direction to, promotes cooperation in, and supports efforts to protect land and water resources in the watershed of Rathbun Lake.

The purpose of the Alliance

- Protect Rathbun Lake for water supply, flood control, wildlife habitat, and recreational uses
- Provide protection for the land by decreasing soil erosion
- Increase profit for landowners and farming operations
- To protect our natural resources ensuring their existence for our children and future generations

- Alliance members and partners
- Rathbun Regional Water Association
- SWCD of Appanoose, Clarke, Decatur, Lucas, Monroe, and Wayne counties
- Charleston Valley Rural Economic Development
- Charleston Valley RC&D
- City of Corydon
- Iowa Department of Natural Resources
- USDA Natural Resources Conservation Service
- Iowa Farm Bureau
- US Geological Survey
- US Army Corps of Engineers
- ISU Extension
- IDALS Division of Soil Conservation

Rathbun

Land & Water Alliance

*A Cooperative Approach to Protecting and Enhancing Land
and Water Resources in South Central Iowa*

How can
the
Alliance
assist you?
→→→→→

Best
Management
Practices
→→→→→

Rathbun
Lake
Watershed
Water
Quality
Monitoring
Points
→→→→→

Current
and future
projects of
Alliance
members
and
partners
→→→→→

More
Information
→→→→→

- *Provide you with information about Best Management Practices that you can use on your land*
- *Provide cost share assistance for these practices through your local Soil and Water Conservation Districts*
- *Provide information about Rathbun Lake and efforts to protect and this important resource in southern Iowa.*
- *Planned grazing systems*
- *Cattle crossings*
- *Construction of ponds, terraces, buffer strips, and riparian buffers*
- *Nutrient management systems*
- *No-till and conservation tillage*

- Water quality protection information and education program
- Chariton River corridor and wetland and riparian habitat restoration
- Chariton Valley Beef Industry Initiative
- Chariton Valley Biomass Project
- Survey of land owners and residents who use water supplied by RRWA
- Development of a watershed assessment including:
 - develop a geographic information system for the watershed
 - establish a water quality monitoring program to assess impacts of pollutants entering Rathbun Lake.

A water quality monitoring program was initiated to assess the impact of pesticides, nutrients, and sediment in Rathbun Lake. The program consists of monthly and rainfall event sample collection and analysis from 17 sites within the lake and tributaries (see above map). The results will help determine sources of pollution in the watershed to guide water quality protection efforts. If you have any questions concerning the Alliance contact your local SWCD or the Rathbun Lake Project Coordinator at 515-872-1350.

Chariton Valley Biomass Project

Air Quality

- Absorbs CO₂, a greenhouse gas, from the atmosphere.
- Reduces fossil fuel emissions that contribute to:
 - ✓ Greenhouse gases;
 - ✓ Acid rain; and
 - ✓ Ozone depletion.

Water Quality

- Prevents sediment from entering streams and lakes.
- Reduces farm chemicals in run-off.

State of New York

Environmental Benefits of growing and using switchgrass as a biomass energy crop

Soil Quality

- Controls soil erosion.
- Enhances soil structure.
- Increases soil organic matter.

Wildlife Habitat

- Increases diversity in agricultural landscapes.
- Enhances existing or natural wildlife habitat.

143) Isabella Ours Shoreline of Province of Madrid Spain

The Charter House, Baltimore Project is funded in part by The Leonard Center for Sustainable Agriculture's United States Department of Energy's United States Department of Agriculture Food Bureau and U.S. Department of Interior Foundation.

The A&E Project is a 501(c)(3) non-profit organization administered by the U.S.E.'s United States Department of Energy and U.S. Department of Agriculture Food Bureau. The United States Department of Energy and U.S. Department of Agriculture Food Bureau is the primary sponsor of the project and the U.S.E. is the primary sponsor of the project. The U.S.E. is the primary sponsor of the project and the U.S. Department of Energy and U.S. Department of Agriculture Food Bureau is the primary sponsor of the project.

[illegible]

Chariton Middle School students roast marshmallows over switchgrass logs with their seventh grade science instructor, Lowell Wiele, as part of an experiment involving renewable energy.

CMS experiments with renewable energy

Chariton Middle School students in Lowell Wiele's seventh grade science class recently participated in an experiment involving renewable energy.

Each class member took their turn roasting marshmallows over heat produced by switchgrass logs. The switchgrass logs were recently manufactured as part of the Chariton Valley Project.

Chariton Valley Biomass project coordinator Marty Braster, and Vince Sitzman, Rathbun Lake Watershed coordinator, visited the

classes and explained the purpose of the project.

Switchgrass is currently being evaluated as a renewable energy source, as well as an alternative to row crop on the marginal land in southern Iowa.

The focus of the project is the potential use of switchgrass as a fuel to replace a portion of the coal burned at Alliant Power's (formerly IES Utilities) Ottumwa gen-

erating station.

In addition, the project is exploring various other uses for switchgrass such as paper, fiber board, mulch, animal bedding and logs through Prairie Lands Bio-Products, a group of switchgrass producers.

For more information about the project, contact Braster at 515-437-4376.

Chariton Valley Biomass Project

Cooperator signs

Installation guidelines

County engineers in Appanoose, Lucas, Monroe, and Wayne have stated that cooperator signs may be placed in switchgrass fields as long as the sign is placed on the land owner's side of the fence.

However, if a switchgrass field is bordered by a state highway the Iowa Department of Transportation says the following guideline must be followed. The sign face *must not be readable* from the highway.

* Please remember to contact the appropriate utilities before setting sign posts.

If you need more information regarding these guidelines, please contact John Sellers, 872-2657.

APPENDIX FOUR

**“A Progress Report and Renewal Request prepared for the
Leopold Center for Sustainable Agriculture”**

Report Date: January 28, 1999

Project Title: Development of Switchgrass as a Viable Agricultural Commodity for
Farmers in Southern Iowa 98-14

Co-Principal
Investigators:

James Cooper
Coordinator
Chariton Valley RC&D
Centerville, IA 52544
515-437-4376
cvrcd@se-iowa.net

Gerald A. Miller
Associate Dean, Extension and Industry Programs
Iowa State University Extension
110 Curtiss
Ames, IA 50011-1050
515-294-4333
soil@iastate.edu

Project Duration: Three years; FY98, FY99 and FY2000

Funds Awarded: FY1998 - \$30,000

FY1999 - \$30,000

Funds Requested: FY2000 - \$30,000

Signatures:

James Cooper
Chariton Valley RC&D Coordinator

Gerald A. Miller
Associate Dean, Extension and Industry Programs

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Nontechnical Summary

Project Title: Development of Switchgrass as a Viable Agricultural Commodity for
• Farmers in Southern Iowa 98-14

Co-Principal
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The Chariton Valley Biomass Project proposes to transform switchgrass, a native warm season grass used primarily for conservation and wildlife habitat, into a cash energy crop for farmers in southern Iowa. The project, now in its third year of development, is supported by a diverse partnership of public agencies, private organizations, and landowners. Specific project objectives include: development of technologies to produce electricity from the co-firing and gasification of switchgrass biomass; establishment and management of switchgrass biomass plantings; and an assessment of the environmental impacts of producing and using switchgrass to generate electricity.

Information and education activities, supported primarily by the Leopold Center for Sustainable Agriculture, have been used to communicate project activities and accomplishments to interested landowners; professionals with public and private organizations; researchers working in the field of renewable resources in general and biomass energy in particular; and the general public. Specific information and education activities performed during the project's first two years of Leopold Center support have included: more than three dozen news reports and articles; the distribution of 1,800 sets of project fact sheets and brochures; 600 issues of the project newsletter; six project related publications; project displays, slide set, and web site. In addition, 16 presentations have been delivered to 1,300 professionals with public agencies, representatives of private organizations, and landowners. A total of 18 project field days, demonstrations, and meetings have been conducted for more than 350 participants.

In addition to the activities described above, planned information and education efforts include presentation and display materials and scientific and extension publications that will address topics including the establishment and management of switchgrass for biomass; the economics of switchgrass production and use for biomass; and the environmental impacts of producing and using switchgrass biomass.

The total estimated cost of the biomass project's information and education activities in fiscal year 2000 is \$54,678. Funds requested from the Leopold Center to support these activities in fiscal year 2000 is \$30,000. The balance of \$24,678 in support for fiscal year 2000 will be provided as in-kind contributions and additional grants from other project partners.

In addition to the Leopold Center for Sustainable Agriculture, agencies and organizations cooperating with the Chariton Valley Biomass Project's information and education activities include Chariton Valley RC&D, Iowa Farm Bureau Federation, Prairie Lands Bio-Products, US Department of Energy, Iowa State University, and Soil and Water Conservation Districts in Appanoose, Lucas, Monroe, and Wayne Counties.

Technical Report

Project Activities and Findings

Communication of project activities and accomplishments are a principal goal, and therefore essential to the overall success, of the Chariton Valley Biomass Project. Efforts have been made to incorporate information and education activities into all aspects of the project. In order to appreciate the breadth and importance of these activities, this section of the report provides an overview of the current status of the project. The remainder of the report addresses the information and education efforts planned and completed for the project.

Chariton Valley Biomass Project: Current Status

- Design, Installation, and Testing of Conversion Technologies

Co-fire Technology

Project engineers have completed the preliminary design of co-firing facilities to be installed at Alliant Power's Ottumwa Generating Station (OGS). Engineers with Alliant Power and the US Department of Energy (DOE) have initiated the final design of these facilities. Plans are for the final engineering design to be completed and installation of co-firing facilities at OGS to begin in 1999. A series of large-scale tests of the co-firing facilities are scheduled for 2000 to demonstrate the technical feasibility of combining switchgrass with coal as fuel to generate electricity. Project partners have made presentations regarding the technical aspects of the planned co-firing facilities. Similarly, the preliminary design report has been made available to others in the United States working on similar projects. Demonstrations and presentations are planned in conjunction with the installation and testing of co-firing facilities.

Gasification Technology

Researchers at Iowa State University (ISU) continue to develop and test alternative systems for the gasification of switchgrass as a means of generating electricity. Presently research has focused on the development and testing of systems to clean gas produced using switchgrass. The results of this research will be used to develop plans for demonstrating the commercial potential of gasification technology as a means of generating electricity using switchgrass. Researchers at ISU have made presentations of their research results. A report of research findings to date has been completed and is being made available to others working on similar efforts.

- Switchgrass Fuel Supply

Producer Cooperative

The switchgrass producer organization Prairie Lands Bio-Products continues to play an essential role in the Chariton Valley Biomass Project. Currently, 47 producers who own and manage over 4,400 acres of switchgrass are cooperating with the project. Most of these producers are members of Prairie Lands. Member producers are regularly called upon to provide technical advice on all aspects of the project. In addition to participating in, and providing direction to, the project's information and education activities, areas of the project in which members of Prairie Lands have been most active include: recruitment of producer cooperators; assistance with the establishment, management, and harvest of switchgrass; participation in the agronomic and environmental research activities; evaluation of the economics of switchgrass production; design of a biomass procurement system; and design of the handling and processing components of the co-firing facility. Prairie Lands communicates its activities to its members and others primarily through monthly and periodic special topic meetings and newsletter.

Agronomic Research

As part of the project's switchgrass fuel supply development, researchers at ISU continue to conduct fertility trials, assess genetic variability for biofuel traits, and estimate farm-level budgets and regional economic impacts of producing and using switchgrass for biomass. In addition, researchers have initiated work to evaluate and demonstrate alternative cropping systems that may combine crops, hay, and grazing with biomass production. Researchers have made a series of presentations regarding the results of this work. A report of research activities and findings to date has been completed and is being made available to others conducting similar research. The report can be obtained at <http://www.public.iastate.edu/~brummer>.

- Assessment of Environmental Impacts

Research conducted by ISU and the University of Iowa continues to assess the overall environmental impacts of producing and using switchgrass for biomass. Specifically, this research is examining the benefits of switchgrass as a best management practice to protect water quality; the effectiveness of switchgrass in reducing soil erosion; the impact on wildlife habitat of planting, managing, and harvesting switchgrass for biomass; the potential for switchgrass to sequester carbon; and the net impact on greenhouse gas emissions of growing and using switchgrass as a fuel. Meetings, presentations, and articles have been used to communicate information regarding the environmental assessment activities of the project.

Strategies and Methods

Strategies and methods employed by the Chariton Valley Biomass Project have proven to be effective in accomplishing the project's information and education objectives. Specifically, these strategies and methods include:

- **Active Producer Involvement:** Members of the Prairie Lands Bio-Products producers' organization play an active role in directing and conducting information and education activities. As in the initial year of project support from the Leopold Center, written agreements between Chariton Valley RC&D, Prairie Lands, and the project's information and education specialist are in place. Copies of these agreements accompany this report.
- **Assistance from ISU Extension:** Researchers and extension professionals at ISU continue to play major roles in essentially all aspects of the Chariton Valley Biomass Project. Information and education activities are integral to the project related activities performed by ISU. These activities include preparing materials for and conducting presentations, meetings, field days, and demonstrations; the preparation of scientific and extension publications; and technical assistance to producers and other project partners. As in the previous year of project support from the Leopold Center, a written agreement between Chariton Valley and ISU Extension has been developed. A copy of this agreement accompanies this report.
- **Advisory Committee:** Planning, oversight and review of the project's information and education activities continues to be the responsibility of an advisory committee consisting of representatives from Chariton Valley RC&D, ISU Extension, Iowa Farm Bureau Federation, Prairie Lands, and the project's information and education specialist.

Mention should be made of improvements in methods developed to conduct the project's information and education activities. Specifically:

- **Role of ISU Extension Specialists:** The project has broadened its use of ISU expertise to include an active role in project information and education activities by local ISU Extension Specialists. In addition to their technical knowledge, these professionals are familiar with the biomass project, have strong and well established relationships with producers and others in the project area, and conduct many information and education activities similar in nature and content to those planned by the project.

- Partnership with Related Projects: There are several other initiatives underway in south central Iowa with sustainable resource use and economic development goals that are similar to those of the Chariton Valley Biomass Project. These include the Chariton Valley Beef Industry Initiative and the Rathbun Land and Water Alliance. Cooperation between the Biomass Project, Chariton Valley Beef and the Alliance on certain information and education activities such as meetings, presentations, displays, and field days has proven to be an effective and beneficial use of resources. Cooperative information and education efforts with agency partners working on related issues including the Iowa DNR Energy Bureau (renewable energy) and USDA NRCS (grassland management) have also been cost-effective and successful.

Plan of Work for Fiscal Year 2000

The original proposal outlines a work plan for the information and education activities of the Chariton valley Biomass Project. The activities specified in this work plan in addition to others described below will continue to be performed in fiscal year 2000:

- Project Newsletter: "Switchgrass to Biomass," a newsletter published with the intent of informing partner organizations of project activities, will continue to be published and distributed at least two times annually. The newsletter mailing list consists of approximately 146 community leaders, producers, and resource professionals. The mailing list will continue to be revised to add others who express an interest in keeping informed about the project.
- Project Fact Sheets and Brochures: A set of project fact sheets, originally produced to provide up-to-date information on project objectives, accomplishments, current activities, and partners, will continue to be revised regularly and made available at all project related activities and on request. It is anticipated that these fact sheets will continue to be the primary means of disseminating written information regarding the project. A brochure has been developed that describes the purpose and activities of the Prairie Lands Bio-Products producer organization. In addition, a brochure presenting an overview of the project was developed. These brochures will be revised as needed and made available at project related events and on request.
- Press Coverage: Print media coverage, particularly in area newspapers and magazines, will continue to be an important aspect of the project's information and education activities. During fiscal year 2000, efforts will be made to expand media coverage by both local radio and television. This coverage will be used primarily to announce and report on planned project related events. As in the previous year, results from the project's research activities will be used as material for articles in newspapers and magazines.

- **Project Signage:** Signs have been fabricated that recognize farmers and partner organizations working together on the Chariton Valley Biomass Project. These signs will continue to be distributed to, and installed by, cooperating producers on land being used to grow switchgrass for the project. Additional signs will be fabricated and installed as needed.
- **Project Slide Set:** A set of slides previously developed for the Chariton Valley Biomass Project will continue to be used for presentations by project partners. This slide set is being revised, expanded, and improved through the addition of up-to-date information, photographs, and graphics regarding project activities. In addition, a computer-generated presentation using Power Point software will be completed and available for use.
- **Project Displays:** A portable display will be developed to be used at project events such as meetings and conferences. In addition, the display will be placed at the various locations of partner organizations, e.g., Iowa Farm Bureau offices, John Deere and Vermeer implement dealers. The displays will be used to increase public awareness of the Chariton Valley Biomass Project as well as to recognize the important role that partners hosting the display play in the project. Special mention should be made of the project's participation in the development of one or more permanent displays in partnership with the Iowa DNR, US Army Corps of Engineers, and Rathbun Land and Water Alliance. Plans are for these displays to be installed at high public use areas at facilities on Rathbun Lake. The displays will highlight the environmental benefits of the Chariton Valley Biomass Project in general and switchgrass production for biomass specifically.

Additional project related posters will be developed as a complement to the original set of posters completed in 1998. The original posters provided an overview of the Chariton Valley Biomass Project and information regarding the agronomic and environmental aspects of the project (see page 8). The additional posters will provide an opportunity to expand on these and other aspects of the project and to communicate in greater detail the results of project activities.

- **Project Field Days and Demonstrations:** Field days and demonstrations planned for the coming year will address the agronomic aspects of switchgrass production as well as be related to the installation and testing of co-firing facilities at the OGS. Project partners, producers, the media, and others interested in the project will be invited to attend the field days and demonstrations.

- **Project Publications:** Project related research will continue to be the primary source of information for scientific and extension publications and reports. As in the past, these publications will be distributed to partner organizations, researchers conducting similar work, and others interested in the project through mailings, electronically, and at ISU Extension and Soil and Water Conservation District offices in the project area. Specific mention should be made of a planned publication to address growing interest in, and requests for additional information about, frost seeding techniques for the establishment of switchgrass.
- **Project Web Site:** Arrangements have been made with a local Internet service provider for the development and maintenance of a project-specific web page. The page is being designed and will be fully operational in the coming months. It is anticipated that this new web page will facilitate the location of up-to-date information regarding the Chariton Valley Biomass Project. Links to biomass related sites will be included as well as the web sites of project partners. The web page contents will be periodically revised with new project related information. A counter will be included on the web page in order to track its use.
- **Project Coordination and Reports:** The information and education specialist will continue to communicate with project partners on a monthly basis. This level of coordination helps to ensure the availability of up-to-date materials and identify opportunities for information and education activities. The specialist will continue to prepare and distribute monthly written reports to members of the advisory committee.

Publications

The results of project activities, including those directly related to the agronomic and environmental impacts research, have been used to prepare scientific and extension publications related to the development of a switchgrass-based biomass energy industry in southern Iowa. It is anticipated that project activities, particularly research being conducted by ISU, will continue to provide material for publications. As previously reported, mention should also be made that project related research will contribute to the completion of degree requirements for, and be documented in theses prepared by, graduate students at ISU. Publications prepared during the reporting period include:

Cooper, J. 1998. *Policy Considerations for Biomass Commercialization and its Impact on the Chariton Valley Biomass Project*. In *Proceedings of Bio-Energy '98: Expanding Bio-Energy Partnerships*. Madison, Wisconsin. A copy of this paper accompanies this report.

Cooper, J., M. Braster, and E. Woolsey 1998. *Overview of the Chariton Valley Switchgrass Project: A Part of the Biomass Power for Rural Development Initiative*. In Proceedings of Bio-Energy '98: Expanding Bio-Energy Partnerships. Madison, Wisconsin. A copy of this paper accompanies this report.

Lemus, R. W., N. E. Molstad, L. Burras, and E. C. Brummer. 1998. *Switchgrass Management and Productivity in the Chariton River Valley*. Poster presented at the 1998 Agronomy Society of Agronomy Meetings held on October 18-22, 1998. A copy of the poster abstract accompanies this report.

Smeenck, Jerod, and Robert Brown. 1998. *Indirectly Heated Fluidized Bed Biomass Gasification using a Latent Heat Ballast*. In the proceedings of Bio-Energy '98: Expanding Bio-Energy Partnerships Conference. A copy of this paper accompanies this report.

Teel, Alan, and Stephen Barnhart. 1998. *Switchgrass Seeding Recommendations for the Production of Biomass Fuel in Southern Iowa*. Iowa State University Extension Publication Pm 1773, Ames, Iowa. This publication may be found at <http://www.exnet.iastate.edu/Pages/pubs/Masterlist2.html#pm> A copy of this publication accompanies this report.

Press Coverage

Project activities and highlights were distributed to, and published in, a variety of print media. These publications provided project-related information to a broad audience, ranging from the general public to the scientific community. Copies of printed press coverage accompany this report.

<u>Newspapers</u>	<u>Circulation</u>	<u>Audience</u>	<u>Published</u>
• Chariton Newspapers	3,100	general public	two articles
• Iowa Farm Bureau Spokesman	107,320	ag community	one article
• Iowa Farmer Today	77,000	ag community	one article
• Iowegian	3,000	general public	two articles
• Ottumwa Courier	19,000	general public	two articles

<u>Periodicals</u>	<u>Circulation</u>	<u>Audience</u>	<u>Published</u>
• The Conservationist	46,000	general public/ natural resource community ag community	one article
• The Furrow			
Canadian edition	110,000		one article
Midwest edition	300,000		one article
<u>Other publications</u>	<u>Circulation</u>	<u>Audience</u>	<u>Published</u>
• Energy	1,100	general public/	one article
• Homegrown Energy	1,500	general public/ renewable energy community	one article
• Iowa Watch		scientific/ environmental community	one article
• Western Biomass Quarterly		ag community/ renewable energy community	one article

Education and Outreach

In addition to the publications and press coverage described above, the following information and education activities have been completed that are directly related to and supportive of the Chariton Valley Biomass Project:

- **Printed Materials:** A set of project fact sheets developed in 1997 was updated to reflect current activities and partners in the project. More than 300 sets were distributed during the reporting period, i.e., mailed, to individuals who expressed interest in the project. The fact sheets were also made available at conferences and field days. Copies of the fact sheets accompany this report.
- **Project Brochures:** More than 500 brochures highlighting Prairie Lands Bio-Products and Chariton Valley Biomass Project were distributed at two conferences, field day, and the Iowa State Fair. Prairie Lands members also distributed the brochures to individuals who express interest in the organization and project. The brochure details the group's involvement in the project and is used as a membership recruitment tool. The project brochure is distributed on request. Copies of the brochures accompany this report.

- Project Newsletter: The project newsletter, *Switchgrass to Biomass*, continues to be used as a vehicle to update and inform partners, producers, community leaders, and others of project activities. The mailing list was updated to include individuals interested in keeping informed about the project. The mailing list currently includes 146 names and addresses. Two issues have been prepared and distributed during fiscal year 1999. Copies of each newsletter issue accompany this report.
- Project Slide Set: The slide set developed during the initial year of Leopold Center support has been used by partners for four presentations (described below). The slide set was designed and developed to present a comprehensive overview of the Chariton Valley Biomass Project and to allow presenters to select the number of slides and level of content to accommodate a wide variety of audiences.
- Project Displays: Project displays were developed for, and presented at, the Iowa Forage and Grassland Council Annual meeting held in Des Moines, on November 24, 1998 and for the Value-Added Bridges Conference held in Ames, on September 10, 1998. Audiences from both conferences totaled 250 and consisted primarily of the agricultural, natural resources, and economic development communities. Special mention should be made of a project display that was developed for the 1998 Iowa State Fair. The display was exhibited in the Iowa DNR building during the entire duration of the fair. The exhibit was also available for viewing by more than 15,000 Hy-Vee, Inc. employees during an appreciation celebration held at the Iowa State fair grounds on September 12-13, 1998. The display was a cooperative effort between the Chariton Valley Biomass Project and the Iowa DNR. Information presented in the display is described in the publication *Homegrown Energy*, copies of which accompany this report.

Five sets of four display posters were developed that provided an overview of the Chariton Valley Biomass Project and information regarding the agronomic and environmental aspects of the project. The posters have been displayed at most of project-related presentations (described below). The posters are versatile in that they can be used separately or as a group and target a range of audiences. Sets of the posters are available through ISU Extension and Soil and Water Conservation Districts in the project area. These partners have agreed to periodically display the posters in their offices and to make them available to others for their use. One set is maintained for use by the project's information and education specialist or other partners. Reproductions of the posters have been made available to partner organizations and others on request. Copies of the posters accompany this report.

- **Project Signage:** An initial supply of project signs have been designed and fabricated. These signs will be used to identify project research and demonstration sites as well as switchgrass fields of producers cooperating with the project. Project partners, including the Leopold Center, are listed on each sign. Guidelines for the installation of signs have been coordinated with, and approved by, the Iowa Department of Transportation (DOT) and county engineers from the four county area where the signs will be displayed. Signs, posts, and hardware are being distributed to producers for installation. Facsimiles of the signs accompany this report.
- **Project Web Site:** In an effort to more effectively provide project related information via the world wide web, arrangements have been made with a local Internet service provider to develop and maintain a web page for the Chariton Valley Biomass Project. The web page is currently being designed and should be fully operational in the coming months.
- **Project Presentations:** Presentations delivered as part of the biomass project's education and outreach efforts include the following:

Chariton Valley Biomass Project: An Overview, presented by Marty Braster, Chariton Valley Biomass Project Coordinator, on February 20, 1998, to the Chariton Rotary members. Audience consisted of 50 community and civic leaders.

Chariton Valley Biomass Project: An Overview; presented by Jim Schweizer, Prairie Lands Bio-Products, Inc. board member, in March 19, 1998 to the Centerville High School Agriculture classes. Audience consisted of high school students interested in agriculture.

Chariton Valley Biomass Project: An Overview: presented by John Sellers, Prairie Lands Bio-Products, Inc. vice-president, in March 20, 1998 to the Chariton High School Agriculture classes. Audience consisted of 25 students interested in agriculture.

Biomass-Switchgrass Initiative, presented by Dr. Gerald Miller, on June 19, 1998 at Iowa State University. Five audience members were Department of Energy representatives including Argonne National Laboratory representatives.

Energy Crops, A Landowner Perspective, presented by Jim Cooper, Chariton Valley RC&D Coordinator, held June 23, 1998 in Washington, DC, hosted by Edison Electric Institute and cosponsored by the Department of Energy. Audience numbered 50 and consisted of the energy community.

Biofuels, Agriculture, and Climate: Balancing the Interrelationships of Economics, Environment, Energy, and Policy, a roundtable discussion presented by Dr. Robert Brown, ISU Research Scientist, Jim Cooper, Chariton Valley RC&D Coordinator, Mark Downing, Economist with Oak Ridge National Laboratory, Paul Miller, USDA NRCS Manure Management Specialist, Virginia Tolbert, Environmental Task Manager with Oak Ridge National Laboratory, and Gary Walling, Alliant Power Project Engineer and facilitated by Tim Kautza, USDA NRCS Natural Resource Planner at the Soil and Water Conservation Society Annual Conference on July 6-9, 1998 in San Diego, California. Audience numbered 60 and consisted of a diverse group, primarily those concerned with soil and water conservation issues, including the agricultural and academic communities and government agency representatives.

Project Review, presented by Gary Walling, Alliant Power Project Engineer, at the Department of Energy Semiannual Biomass Project Review, in Sandia Labs, Livermore, California, on July 14-16, 1998. Audience numbered 70 and was comprised of federal government agencies.

Iowa Biomass Energy Efforts, presented by Ed Woolsey, Chariton Valley Biomass Project Manager, on September 18-19, 1998 at the Iowa Renewable Energy Association Annual Fair. Audience numbered 45 and consisted on members of the general public interested in renewable energy and energy efficiency.

- **Project Field Days and Meetings:** As part of the education and information outreach efforts, the following meetings and fields days were conducted

Project Field Day/Demonstration: The Chariton Valley Biomass Project was featured during a field day held on August 19, 1998 in Albia, Iowa to demonstrate alternative establishment techniques for switchgrass. The event was organized by Monroe County ISU Extension and Soil and Water Conservation District. A presentation given by Prairie Lands member, John Osenbaugh provided information to interested landowners regarding switchgrass seeding methods. Project materials were available to participants at a booth display attended by Prairie Lands board member Don Clark and the project's information and education specialist. Audience numbered more than 50 and consisted primarily of producers and others from the agricultural community.

Biomass Economic Roundtable Discussion: A roundtable discussion regarding the economics of switchgrass production was held on August 31, 1998 at Centerville between a group of 14 producers, resource professionals, custom operators, and representatives of implement dealers. Dr. Mike Duffy, ISU Economist, facilitated the discussion, as part of the research being conducted to estimate the on-farm and regional economic impacts of producing and using switchgrass biomass.

Project Meetings: Six informational meetings regarding the Chariton Valley Biomass Project were conducted during which project activities and accomplishments were reviewed and discussed with representatives of the US DOE, USDA, IDALS, ISU, Iowa Farm Bureau Federation, Alliant Power, Soil and Water Conservation Districts, and local, state, and federal elected officials. More than 50 people attended these project meetings.

Evaluation

The evaluation plan for information and education activities that was included in the original proposal consisted of the following criteria: 1) timely preparation of materials designed to increase and maintain support for the project; 2) number of news reports and coverage provided by media contacts; 3) use of information and education materials within and outside of the project area; and 4) attendance at project activities and events. A summary of information and education activities for the reporting period in terms of applicable evaluation criteria follows:

- **Project Press Coverage:** A total of 14 news reports and articles related to project activities have been published and broadcast by 11 media sources. Project news reports and articles have reached audiences at the international, national, state and local levels. Future press coverage will continue to be improved by the regular preparation and distribution of press releases and articles and increasing the number of media contacts.
- **Printed Materials:** Fact sheets about the biomass project have been available from its early phases. The current set of fact sheets is revised on a regular basis with updated project information. An estimated 300 sets of the three fact sheets have been distributed at project events. Fact sheets are regularly distributed to interested individuals, usually landowners, in response to requests for information related to the project. The quality of project fact sheets will be maintained by regularly updating and expanding the contents to reflect current developments.
- **Project Brochures:** More than 500 brochures highlighting Prairie Lands Bio-Products and Chariton Valley Biomass Project were distributed at project events during the reporting period. Prairie Lands members also distributed the brochures on request directly to interested individuals.

- **Project Newsletter:** Two issues of the newsletter have been produced during this reporting period. More than 300 copies of the newsletter were distributed to cooperating and interested landowners and representatives of project partners and sponsors to keep inform them of activities. The mailing list was updated to include individuals interested in keeping informed about the project. The mailing list currently includes 146 names and addresses.
- **Project Slide Set:** Preparation of the initial set of slides was completed in late 1997 with photographs that document activities since the beginning of the project. This slide set has been improved through the addition of up-to-date information, photographs, and graphics regarding project activities. Four presentations made use of the project slide set during the reporting period.
- **Project Displays:** Project displays were developed for, and presented at, three special events during the reporting period including the Iowa Forage and Grassland Council Annual, Value-Added Bridges Conference , and 1998 Iowa State Fair. Five sets of four display posters were developed that provide an overview of the Chariton Valley Biomass Project and communicate information regarding the agronomic and environmental aspects of the project.
- **Project Signage:** A supply of project signs has been fabricated. These signs will be used to identify project research and demonstration sites as well as switchgrass fields of producers cooperating with the project. Signs, posts, and hardware are being distributed to the close to 50 producers cooperating with the project for installation.
- **Project Web Site:** Arrangements have been made with a local Internet service provider to develop and maintain a dedicated web page for the Chariton Valley Biomass Project. The web page is being designed and should be fully operational in the coming months.
- **Project Presentations:** Eight presentations have been prepared and delivered during this reporting period. These presentations have been made to audiences at the international, national, state and local levels. Audiences have consisted of estimated 300 professionals with public agencies, representatives of private organizations and landowners. Future project presentations will be enhanced as a result of continual improvements to printed materials, displays and slide set.

- Project Field Days, Demonstrations and Meetings: Eight field days, demonstrations and meetings have been conducted this reporting period. These events have been attended by over 100 professionals with public agencies, representatives of private organizations and landowners. The quality and effectiveness of future field days, demonstrations and meetings will be enhanced as a result of improvements to printed materials and displays and efforts to increase attendance by targeted audiences and media contacts.

Cooperative Efforts

Project partners and sponsors include a number of public agencies and private organizations. A list of these cooperators and brief description of their role in the project's information and education activities follows:

<u>Agencies and Organizations</u>	<u>Information and Education Role</u>
Chariton Valley RC&D	Overall planning and coordination. Contribution of equipment and supplies.
Iowa Farm Bureau Federation	Liaison with farm organizations, agribusiness and producers. Contribution of staff and member time.
Prairie Lands Bio-Products	Responsible to plan and oversee information and education activities. Contribution of members' time.
Leopold Center for Sustainable Agriculture	Funding for information and education activities.
US Department of Energy	Funding for information and education activities.
Iowa State University	Professional assistance with planning and performing information and education activities.
Soil and Water Conservation Districts in Appanoose, Lucas, Monroe and Wayne Counties	Local sources of project information and education for producers. Contribution of staff time.

Budget Request

The budget request to support the Chariton Valley Biomass Project's information and education activities in fiscal year 2000 follows:

<u>Category</u>	<u>Leopold Center</u>	<u>In-Kind Contributions</u>	<u>Additional Grants</u>	<u>Total</u>
Salaries and Wages				
Professional		\$ 4,120	\$ 9,318	\$13,438
graduate student(s)				
technical support				
hourly	\$ 1,600	1,920		3,520
Stipends				
Benefits	400		2,330	2,730
Travel	1,000		3,190	4,190
Equipment		600		600
Supplies	5,000	1,200		6,200
Publication Costs	2,000		2,000	4,000
Computer Time				
Contractual	20,000			20,000
Construction				
Other				
TOTAL DIRECT COSTS	\$30,000	\$ 7,840	\$ 16,838	\$54,678

Budget Explanation

- The funds requested and line items for fiscal year 2000 are consistent with those in the fiscal year 1999 budget.

Personnel

Personnel supported with Leopold Center funds requested include:

- Clerical support staff with Chariton Valley RC&D (salaries and wages and benefits); an estimated 10% FTE.
- Information and Education Specialist (contractual); an estimated 400 hours.
- Partial support of ISU Extension staff assisting with information and education activities (contractual); an estimated 13% FTE.

Additional Grants

The US DOE is a primary financial sponsor of the Chariton Valley Biomass Project. A portion of the funds provided by the DOE support information and education activities related to the project. This includes partial support for the project field coordinator's participation in information and education activities, travel, and publication costs.

Enclosures

Agreements

- Cooperative agreement between Chariton Valley Resource Conservation and Development, Inc. and Iowa State University Cooperative Extension Service
- Cooperative agreement between Chariton Valley Resource Conservation and Development, Inc. and Prairie Lands Bio-Products, Inc.
- Contractual agreement between Prairie Lands Bio-Products, Inc. and Kathleen Chester, Information and Education Specialist.

Information and Education Materials

- Project newsletters two issues
- Project posters four
- Project fact sheets two sets of three
- Department of Energy Update one
- Project signage facsimiles
- Prairie Lands brochure one
- Project brochure one
- Project press coverage

Newspapers

Chariton Newspapers	two articles
Iowegian	two articles
Iowa Farm Bureau Spokesman	one article
Iowa Farmer Today	one article
Ottumwa Courier	two articles

Magazines

The Furrow	one article
The Conservationist	one article

Other publications

Homegrown Energy	one article
Western Biomass Quarterly	one article
Energy	one article
Iowa Watch	one article

- Publications

Cooper, J. 1998. *Policy Considerations for Biomass Commercialization and its Impact on the Chariton Valley Biomass Project*. In Proceedings of Bio-Energy '98: Expanding Bio-Energy Partnerships. Madison, Wisconsin.

Cooper, J., M. Braster, and E. Woolsey 1998. *Overview of the Chariton Valley Switchgrass Project: A Part of the Biomass Power for Rural Development Initiative*. In Proceedings of Bio-Energy '98: Expanding Bio-Energy Partnerships. Madison, Wisconsin.

Lemus, R. W., N. E. Molstad, L. Burras, and E. C. Brummer. 1998. *Switchgrass Management and Productivity in the Chariton River Valley*. Poster presented at the 1998 Agronomy Society of Agronomy Meetings held on October 18-22, 1998.

Smeenk, Jerod, and Robert Brown. 1998. *Indirectly Heated Fluidized Bed Biomass Gasification using a Latent Heat Ballast*. In the proceedings of Bio-Energy '98: Expanding Bio-Energy Partnerships Conference.

Teel, Alan, and Stephen Barnhart. 1998. *Switchgrass Seeding Recommendations for the Production of Biomass Fuel in Southern Iowa*. Iowa State University Extension Publication Pm 1773, Ames, Iowa.

APPENDIX FIVE

Quarterly Biomass Stakeholder Meeting Minutes

October 21, 1998

1 p.m. to 3 p.m.

Wallace State Office Building

Des Moines, Iowa 50319

Attendees:

Gary Walling, Alliant Power

Jeff Carter, BioFuels Corporation

Jim Cooper, Chariton Valley Resource Conservation & Development

Marty Braster, Chariton Valley Resource Conservation & Development

Ed Woolsey, E. L. Woolsey and Associates

Vickie Friedow, Farm Service Agency

Norm Olson, Iowa Energy Center

Robert Brown, Iowa State University, Center for Coal and the Environment

Mike Duffy, Iowa State University, Leopold Center for Sustainable Agriculture

Lyle Asell, USDA Natural Resources Conservation Service

Sharon Tahtinen, Iowa Department of Natural Resources

Angela Chen, Iowa Department of Natural Resources

Ward Lenz, Iowa Department of Natural Resources

Alison Kovac, Iowa Department of Natural Resources

Introductions and Opening Remarks :

Sharon Tahtinen

Sharon Tahtinen welcomed attendees and called the meeting to order.

Chariton Valley Resource Conservation & Development (RC&D):

Jim Cooper,
Marty Braster
Ed Woolsey

Jim Cooper:

Project partners' were unable to secure an amendment that would allow closed-loop tax credit legislation to apply to Alliant Utilities partnership with the Chariton Valley RC&D biomass project during this past legislative session but are confident that this initiative will be successful in the up-coming session.

Project partners were successful in attaching a provision that would make switchgrass production for biomass an eligible use for Conservation Reserve Program acres to a USDA

budget amendment. This amendment, however, was defeated. Partners plan to reintroduce this provision as a separate amendment during the next session and are working to ensure that this amendment will receive broad-based support.

In both cases, project partners were encouraged by the fast-track attention and support these initiatives received from Iowa legislators.

Marty Braster:

Chariton Valley RC&D has approximately 4,000 acres under contract for switchgrass production. Nearly 3,000 of these acres are already established in switchgrass. Project partners plan to harvest about 1,000 acres of new switchgrass stands this fall.

The conversion technology team is reviewing R. W. Beck's co-firing test design report.

Project partners are creating preliminary models and using Geographic Information Systems technology to target acres in the Rathbun Lake watershed that are ideal for establishing in switchgrass to protect water quality, provide wildlife habitat, and sequester carbon.

Ed Woolsey:

Project partners have compared pre- and post-frost switchgrass for densification qualities and have discovered that the drier, post-frost grass is preferable for densifying into logs and other products.

Iowa State University, Center for Coal and the Environment: Robert Brown (CfCE)

CfCE completed the Phase I of the Chariton Valley project report.

CfCE obtained year-end funds (FY 1998) from the U.S. Department of Energy, Office of Industrial Technologies for trace contaminants analysis.

CfCE developed a successful multi-fuel feeder for its gasifier.

CfCE's plans for the near future include incorporating analytical equipment for trace contaminants into its gas analysis system, adding a loading hopper to its new feed system,

moving its gasifier to the new BECON facility, developing a hot gas filtration system to control particulate and remove vapors/gaseous contaminants, exploring recent inquiries from manufacturers regarding commercial development of the ballasted gasifier, and supporting analysis of Chariton Valley switchgrass samples.

Alliant Power:

Gary Walling

Alliant is reviewing R. W. Beck's co-firing test design report. This report recommends that Alliant seek additional engineering resources for the final design.

Alliant is reviewing a possible matching funds arrangement with the Department of Energy regarding boiler modifications for the test burn.

Walling believes that the earliest possible date for the test burn would be in the spring of 2000, based on the number of acres of switchgrass required to provide the 4,000 tons needed for a week-long test burn as well as to supply switchgrass needed for other project activities.

Iowa Energy Center (IEC):

Norm Olson

Work on Iowa Energy Center's (IEC) Biomass Conversion Facility (BECON) site is progressing smoothly. The anaerobic digester planned for the site will be constructed next spring.

IEC will have five systems operating at BECON next year: anaerobic digestion, thermal gasification, pyrolysis, biodiesel and ethanol production, and secondary energy processing technologies (i.e. micro-turbines, fuel cells, sterling engines, etc.).

BioFuels Corporation (BFC):

Jeff Carter

BFC's biomass conversion facility in Cedar Rapids is completed and gasifying clean industrial by-products and producing electricity for commercial consumption. Biomass available for the plant's electricity generation is plentiful, allowing BFC to be very selective about the type of by-products it processes.

Iowa Department of Natural Resources (IDNR):

Alison Kovac

The IDNR executed two contracts with Chariton Valley RC&D for the development and demonstration of alternative switchgrass cropping systems and the investigation of the effects of switchgrass plantations on wildlife habitat.

Kovac drafted a project summary sheet (attached) to help stakeholders track project progress. She will contact stakeholders by e-mail or phone to obtain project-status updates before each Quarterly Biomass Stakeholders meeting and will distribute the summary sheet at the meeting. Information on the sheet will be updated and revised during the meeting as necessary.

Project Integration and Partnerships

Norm Olson inquired about possible opportunities for partnership with the Harlan, Iowa corn stover project. Marty Braster answered that Prairie Lands Bio-Products, Inc. has explored the opportunity to provide Tom Schechinger and his partners with switchgrass to supplement corn stover for processing into furfural at the Great Plains Chemicals plant in Omaha. Members of the producers' organization decided, however, that transportation costs involved would be too high to make this a profitable venture.

Jeff Carter stated that BFC's biomass conversion facility has the capability to gasify switchgrass to produce electricity, but economics do not justify this right now. BFC is currently being paid to process clean industrial by-products. Switchgrass, on the other hand, must be purchased from producers. The possibility does exist, however, for BFC to demonstrate the gasification of switchgrass at the plant. Yet the company is reluctant to carry out such a demonstration due to the publicity that would, necessarily, be involved. The company has worked to keep a low profile because media attention can result in

unwanted public attention. While the biomass conversion facility has nothing to hide, BFC recognizes that perception is often more important than reality. Unfortunately, the public is apt to misunderstand the unfamiliar term, "biomass." The public may, for example, associate this term with bio-hazards or bio-waste. BFC has to be cautious in order to protect its interests and the interests of its customers who pay to have their by-products processed. As a result, BFC avoids the terms "waste" and "biomass." The company prefers to use terms like "clean industrial by-products".

Alison Kovac posed a question to the group rising out of discussions that took place at the Bio-Energy '98 conference. Some conference participants suggested that the biomass industry avoid talking about waste; others indicated that waste-management is one of the premier benefits offered by the biomass industry and should be advertised. In light of Jeff Carter's comments, Kovac asked which position suits members of the group. Robert Brown said that he often uses the terms "agricultural residues" and "energy crops" to avoid confusion. Gary Walling indicated that the more specific one can be in the use of terms the better. Because "waste" can impose additional regulatory hurdles and invite negative media attention and public concern, using an alternative term is preferred.

Norm Olson stated that IEC is willing to test switchgrass in energy applications at the BECON facility, work with project partners to educate the public about biomass, and find solutions for the confusion about and misunderstanding of the term.

Robert Brown mentioned that the U.S. Environmental Protection Agency is conducting conferences on climate change and that Stan Johnson at Iowa State University is proposing that the EPA sponsor a conference in Iowa in March. If this conference comes to fruition, Chariton Valley RC&D may have an opportunity to be involved. Lyle Asell interjected that Chet McClaughlin (EPA) has indicated that a conference may be taking place in Iowa on December 1. McClaughlin expressed a special interest in positive effects that agriculture can have with regard to climate change, e.g. carbon sequestration. Sharon Tahtinen added that Jerry Schnoor at the Center for Global and Regional Environmental Research will be conducting EPA-funded focus group activities with agricultural organizations during the next several months.

Progress Made on Opportunities

During the last meeting, Ed Woolsey requested that IDNR staff investigate the possibility of a mandate requiring the use of renewable energy (or a certain percentage of renewable

energy) at state facilities. In response, Angela Chen reported that she has been investigating opportunities for promoting the use of alternative energy resources in a deregulated atmosphere. She indicated that the response to green marketing in the residential sector has been very positive. Chen and other Department staff will continue to monitor developments with regard to renewable energy mandates and marketing efforts. Currently, financing assistance is available through the Energy Bureau to support the implementation of cost-effective renewable energy projects at state facilities.

Other Items / Next Meeting Date

The next Quarterly Biomass Stakeholder Meeting will be scheduled for mid-to-late January at the Wallace State Office Building.