

**Project Title: Lowering the Cost of Bio-energy Feedstocks while Providing Environmental Services – A Win-Win Opportunity**

**Contract Number: RD3-1**

**Milestone Number: 4**

**Report Date: April 6, 2011**

**Principal Investigator: Dean Current**

**612-624-4299**

[curre002@umn.edu](mailto:curre002@umn.edu)

**Contract Contact: Bridget Foss**

**612-624-5571**

[foss0134@umn.edu](mailto:foss0134@umn.edu)

**Congressional District:**

**Minnesota fifth (U of M Sponsored Projects Administration)  
Minnesota fourth (U of M CINRAM)**

## MILESTONE REPORT

"Project funding provided by customers of Xcel Energy through a grant from the Renewable Development Fund."

### **Executive Summary (Period between 4/23/2010 and 10/22/2010)**

Project progress continues according to plan with a delay in the work on ash application which is being dealt with. Early results from our study of weed control options indicate that using cover crops provides good biomass yields during the establishment year while the biomass yield in the second year is lower than plots treated with herbicides. Overall, for the two years more biomass is produced from plots with cover crops. Our work on both establishment and harvest dates continues as planned. Songbird surveys carried out by our wildlife specialist with leveraged funding from other sources have shown no effect of biomass removal on wildlife abundance. That work will receive greater attention towards the end of the project. Watershed monitoring continues at our Elm Creek sites and we are doing preliminary testing of the SWAT and InVEST watershed modeling tools with our existing data. That work will continue and be refined as we collect new monitoring data and incorporate it into our modeling efforts. Our work on non-market ecosystem services continues and a report was prepared and presented during this period based on a survey of the value of those services. Rural Advantage continues to work on ecosystem services and is looking at payments for establishing pollinator habitat as an additional source of payments for ecosystem services. During this period we have been preparing a survey of agricultural landowners in a 9 county area that would serve as a fuelshed for the KODA Energy and proposed Madelia biomass facilities. That survey will be sent out over the winter and we should have preliminary results in the spring. Our Life Cycle Assessment team continues to structure that study and work closely with our other researchers to gather the data they need for their analysis.

**The project goal is to develop an efficient system for the production, pre-processing and delivery of biomass feedstocks for energy production that minimizes feedstock cost for energy facilities while maximizing landowner income and the environmental benefits of biomass production.**

The project objectives are:

- Establish, research cultural practices, and estimate costs and potential cost savings for the establishment, management, pre-processing and transport of perennial biomass feedstocks from field to energy facility.
- Estimate potential energy, wildlife, water quality, carbon and soil health benefits from targeted perennial biomass feedstock plantings.
- Value environmental benefits for potential payments to landowners who provide environmental commodities.
- Complete an integrated assessment of multiple ecological services markets currently being used; identify potential buyers of ecological services provided by perennial biomass energy crops; develop an integrated ecological services payment package.
- Develop a model for the production, pre-processing and delivery of perennial biomass feedstocks to energy facilities including a life-cycle assessment of the system from field to facility.

## **Technical Progress:**

### **I. Biomass crop production field to farm gate**

The objective of researching biomass crop production is to develop guidelines for production of biomass that can be provided to farmers. This series of research activities will help us understand issues in producing biomass crops on farm from planting through harvesting. Since many of the crops being considered for biomass production, and especially some of the native prairie species have not been produced commercially knowledge of production is limited to what is known about reestablishing prairies but not with commercial production in mind. We need to understand how to produce these new crops and how to manage them throughout the growing season through harvest.

**Note: We were able to obtain additional funding from Federal and local sources that has allowed us to expand our research on biomass crops. A report on that research is included as Appendix B.**

#### **Experiment 1: Establishment strategies for weed control**

**Objectives:** weeds often provide excess competition with native grasses and prevent their establishment. Our goal is to develop new approaches for weed control in establishing native perennial grasses and grass-forb polycultures. Establishment treatments include spring oat, and barley companion crops, herbicides, and mowing for weed control. Winter rye was dropped as a treatment because in preliminary trials it was shown to be too competitive.

**Experimental design:** Randomized complete block with three replications

**Accomplishment:** In October 2010, biomass yield was collected from native plantings established in 2009. Biomass yields of native plantings averaged from 1.4 to 2.2 tons per acre (Table 1). Lowest yields of native plants occurred for treatments that used a barley or oat grain companion crop for establishment in 2009. Greatest yields occurred for the treatments where an herbicide was used for weed control. For most treatments, perennial grasses were the greatest contributors to biomass yield. However, variable proportions of grass and broadleaf weeds were also contributed to yield.

In May 2010, new experiments were seeded at Belle Plaine and Rosemount, Minnesota. Yields of companion crops are shown in Table 2 and 3. Forage yields for oat and barley harvested for forage at the boot stage ranged from 3.2 to 4.7 ton/acre. These exceeded those for Canada Wildrye, a native grass, and volunteer weeds. Yields from the weedy treatment resulted from volunteer weeds within the site. These plots will be harvested for yield in fall of 2011.

**Interpretation:**

Typically, stands of native prairie plants are established in the spring and weeds are controlled by mowing. As a result, native prairie plants yield little biofuel in the seeding year. Oat and barley companion crops provide the opportunity for economic yield of grain or forage in the seeding year.

Our results show the barley or oat companion crops harvested for forage (at an immature stage) in the seeding year had a slight effect on native plant biofuel yield in the year after seeding compared to the mowed control. Average biomass yields across treatments of 1.4 to 2.2 ton per acre show the range in yield potential for a one year old stand in this environment.

**Experiment 2: Optimum planting dates for native perennial crops**

**Objectives:** There is debate regarding the best time to establish native perennial prairie plants. Some feel that winter and late spring overseeding is an effective and low cost approach. We determined the effect of planting date on the establishment of native perennial plants.

**Experimental design:** Randomized complete block with three replications

**Accomplishment:** We broadcast seeded a mixture of switchgrass, big bluestem and Indian grass with four native forbs and four native legumes on three dates: early December 2009 before snowfall; and March and June 2010. To provide variable amounts of cover, we also compared seeding into a tilled seedbed with seeding into a fall seeded oat companion crop. The seeding rate of the native plants was 50 seeds per square foot. The plots were seeded on a silt loam soil at Rosemount.

There is no new information to report for this Experiment. Beginning on 1 December 2010, and March and June 2011, we will repeat this experiment at Rosemount and Waseca, Minnesota.

**Experiment 3: Optimum harvest dates for native perennial biomass crops**

Native plants are typically harvested for biofuel after a killing frost in November, requiring long-term storage of the harvested biomass. With outside storage, plant biomass degrades and suffers

from a loss of dry matter. Instead of storage, an option is to have multiple harvests of forage from the field.

**Objectives:** Determine the effect of harvest date on the yield, energy content, ash content, and persistence of native perennial grasses and grass-forb polycultures

**Experimental design:** Randomized complete block with 4 replications. We sample plantings of switchgrass and native plant polycultures on four dates of harvest: September, December, March, May (before green-up)

**Accomplishment:** There is no new data to report, although we will be in the process of repeating harvests in 2010 and 2011.

#### **Experiment 4: Fertilizer replacement value of biofuel ash**

The combustion of herbaceous biofuels will generate a significant amount of ash that is often considered a waste product but that potentially could have value as a fertilizer. Recycling of this ash to the soil will be an environmentally sound practice that also provides a productive use of the ash generated by combustion.

**Objective:** The overall objective is to answer fundamental questions related to the agronomic use and potential environmental impacts of ash generated from combustion of herbaceous native perennial biomass at the Rahr Malting facilities.

#### **Accomplishment/update:**

All research on ash evaluation is delayed because since the Koda Power facility just went on-line they are currently not burning native grasses. Ash application will not occur till the ash is generated and characterized. Projected date of first application is in spring 2011.

**Tables for Objective 1 – Experiments 1-4**

**Table 1.** Effect of establishment treatments applied in 2009 on plant populations and yields of native biofuel plantings harvested in 2010.

Treatment	Native plant	Populations		Biomass yield	Contribution to yield			
		Grass	Forb		Grass	Wild rye	Forb	Weed
		Per sq. foot		Tons/acre	----- Percent -----			
Barley as forage	Switchgrass	12	-	2.16	53	-	0	47
Barley as forage	Tertiary Grass Mix	16	-	1.93	47	-	0	53
Barley as forage	CP-25	6	2	2.07	13	-	60	27
Avg.		11	2	2.13	38		20	42
Barley grain	Switchgrass	4	-	1.27	37	-	0	63
Barley grain	Tertiary Grass Mix	6	-	1.56	33	-	0	67
Barley grain	CP-25	2	2	1.48	17	-	50	33
Avg.		4	2	1.43	29		17	54
Oat as forage	Switchgrass	15	-	2.26	85	-	0	15
Oat as forage	Tertiary Grass Mix	16	-	1.92	78	-	0	22
Oat as forage	CP-25	10	2	2.35	38	-	48	13
Avg.		14	2	2.18	67		16	17
Oat grain	Switchgrass	12	-	1.52	80	-	0	20
Oat grain	Tertiary Grass Mix	13	-	1.47	50	-	0	50
Oat grain	CP-25	7	2	1.13	23	-	60	17
Avg.		10	2	1.37	51		20	29
Canada wildrye	Switchgrass	5	-	1.52	19	47	0	35
Canada wildrye	Tertiary Grass Mix	9	-	1.58	11	37	0	52
Canada wildrye	CP-25	7	2	1.88	10	24	33	30
Avg.		7	2	1.66	13	36	11	39
Mow, (weed control)	Switchgrass	14	-	1.92	82	-	0	18
Mow, (weed control)	Tertiary Grass Mix	17	-	1.64	60	-	0	40
Mow, (weed control)	CP-25	12	1	1.72	27	-	47	27
Avg.		14	1	1.76	56		16	28
Herbicide, (weed control)	Switchgrass	10	-	2.38	85	-	0	15
Herbicide, (weed control)	Tertiary Grass Mix	16	-	2.11	67	-	0	33
Herbicide, (weed control)	CP-25	10	2	2.12	50	-	30	20
Avg.		12	2	2.20	67		10	23

**Note:** CP-25 is a mixture of perennial native grasses, legumes, and forbs; Tertiary grass mixture contains switchgrass, big bluestem, and Indian grass.

**Table 2.** Yield of barley, oat, wild rye and weed companion crops used for native biofuel crop establishment

<b>Crop</b>	<b>Rosemount #1</b>	<b>Rosemount #2</b>	<b>Belle Plaine</b>
	----- ton/acre -----		
Barley	3.54	3.60	3.24
Oat	3.75	4.74	3.28
Canada Wild Rye	3.03	2.31	2.02
Weeds	3.23	2.16	1.91

**Table 3.** Straw and grain yield of oat and barley companion crops used for native biofuel crop establishment

<b>Crop</b>	<b>Straw yield</b>			<b>Grain yield</b>		
	<b>Rosemount #1</b>	<b>Rosemount #2</b>	<b>Belle Plaine</b>	<b>Rosemount #1</b>	<b>Rosemount #2</b>	<b>Belle Plaine</b>
	----- ton/acre -----			----- bu/acre -----		
Oat	3.4	3.6	2.5	56.2	65.8	92.0
Barley	3.7	2.0	1.8	41.8	55.0	62.1

## II. Moving biomass from road/farm gate to facility

This activity will be undertaken by Koda Energy. Some of the work was initiated prior to the project start date as part of their commercial operations but they continue to evaluate other options for supplying biomass to their facility. Information from Koda Energy will be incorporated into the Life Cycle Assessment and as part of our supply chain analysis.

KODA will be evaluating different options to be able to guarantee a constant flow of biomass to their facility. They will be evaluating: 1) different feedstocks based on availability and price; 2) the potential for locating and developing a staging area where biomass feedstocks can be pre-processed prior to being transported to the facility; and 3) the logistics of moving feedstocks from the field/harvest site to their facility.

Koda is exploring different options for handling the needed supply for their biomass facility. They will be using a percentage of grasses and prairie mixes but are now considering a greater use of woody biomass. Our project, through other funding sources is also exploring dedicated woody crops as well as brushland harvest as part of prairie maintenance operations by the DNR and other organizations. We will be able to include that information in our analysis to the extent that information becomes available from our other research and other sources before the end of the project.

Another important issue that is being explored by Koda is the staging of the biomass supply. Because of limited available storage on site at the facility, Koda is considering establishing a site for gathering and preprocessing biomass that would then be moved to the facility. This is another area we will be able to report on as the project progresses.

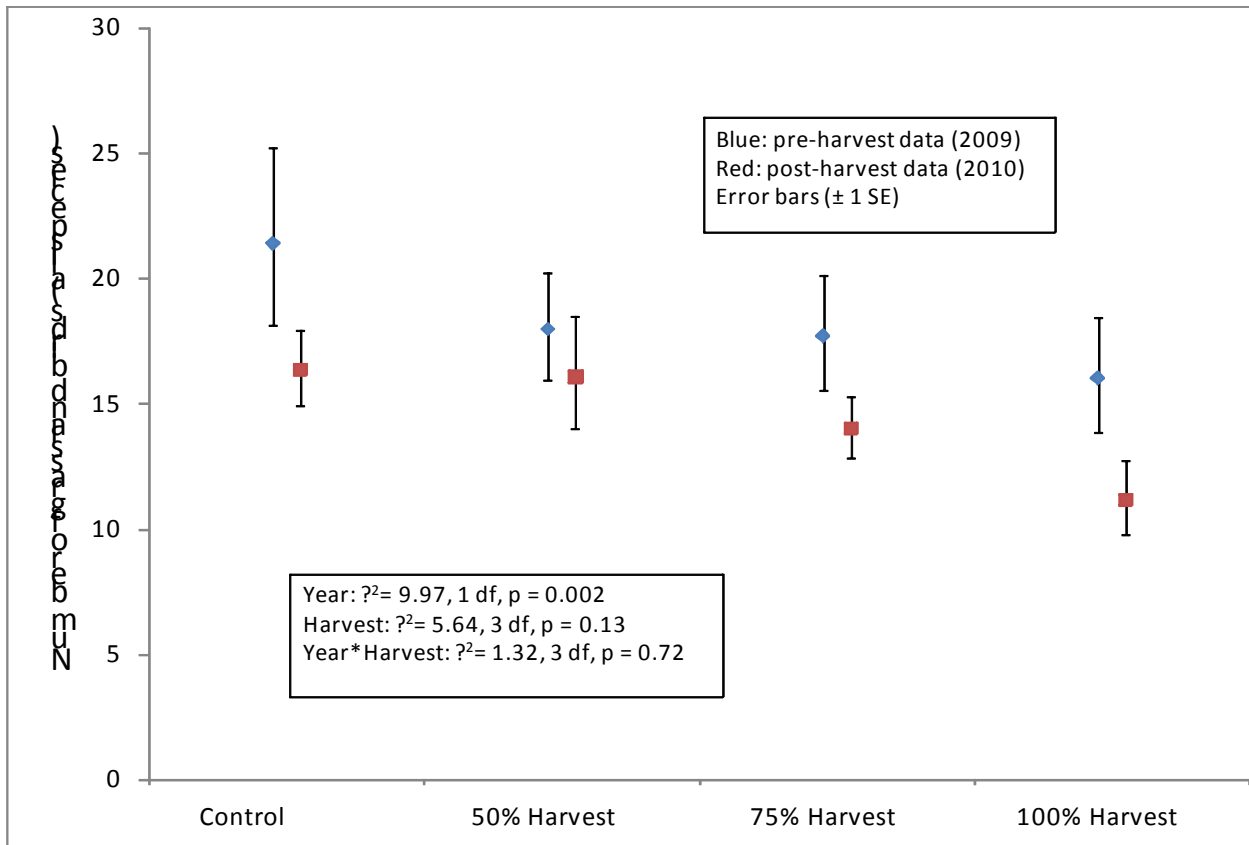
### **III. Measure and value environmental benefits**

In this area we will measure and evaluate the specific impacts of biomass crops on the environment including: 1) changes in grassland songbird populations on areas planted and managed for biomass feedstocks; 2) changes in water quality parameters (turbidity, sediment, nitrogen and phosphorus concentrations); 3) register values reflected in emerging ecosystem markets for water quality and carbon and others as they emerge such as biodiversity; and 4) preparation of a life cycle assessment which allows us to estimate environmental impacts associated with the production, harvest and combustion of biomass crops including an evaluation of resource use and emissions as the crops are produced, transported and combusted.

#### **A. Wildlife impacts**

##### **Overview of 2010 Accomplishments**

Using project funding obtained from the Legislative and Citizen's Commission on Minnesota Resources (LCCMR) and the National Fish and Wildlife Federation (NFWF), we conducted surveys on 20-acre (approx. 8 ha) plots located near Crookston (16 plots), Morris (16 plots), and Windom (28 plots; additional 50% harvest and block versus strip removals were conducted at Windom). These same methods and protocols will be used for surveying sites near Shakopee starting with the 2011 growing season. Each plot was surveyed twice using an area-based search method that covered the entire plot (Johnson and Igl 1995). Many birds, especially sparrows, were detected primarily by their songs, but blackbirds and bobolinks were detected by both sight and sound. Plots were surveyed in 2009 (pre-harvest data) and again in 2010 (post-harvest). Data from all grassland songbirds combined (19 species) are presented below.



There were significantly fewer birds detected in 2010 than in 2009 ( $P = 0.002$ ), but there was no evidence that bird abundance changed in response to biomass removal ( $P = 0.72$ ). There was a tendency for fewer birds to be detected in high-harvest plots, but this pattern was also present in the pre-harvest data and therefore does not reflect an effect of vegetation removal. This demonstrates the importance of using a before-after control-impact (BACI) study design to establish baseline patterns before manipulating vegetation through biomass removal. We found similar results for species richness (i.e., total number of grassland songbird species detected per study plot) and for each species with sufficient data to allow individual analysis (Grasshopper Sparrows, Savannah Sparrows, Clay-colored Sparrows, Sedge Wrens, Common Yellowthroats, Brown-headed Cowbirds, Red-winged Blackbirds, and Bobolinks). In all cases there was significant evidence of regional variation in bird abundances and some species showed evidence of annual variation, but no species showed an effect of biomass removal on abundance. We will be presenting preliminary results from these analyses at the 71<sup>st</sup> Midwest Fish and Wildlife Conference in December.

**Planned Activities for 2010-2011**

Songbird surveys will be initiated at the Shakopee plantings in the spring of 2011 using methodology identical to that reported here for the LCCMR project. Data from these plantings will be combined with the LCCMR data to test for overall effects of biomass removal on long-term dynamics of grassland bird communities.

## **B. Water quality assessment – Begin monitoring watershed**

### **Overview of 2010 Accomplishments**

Monitoring of flow discharge, TSS, nitrate nitrogen, and phosphorus continued through the summer of 2010 from subwatersheds in Elm Creek. Water quality and flow data are being summarized to compare subwatersheds that have over 90% annual crops that are nested within larger watersheds that have > 10% area of mixed perennial grasses, woody crops, and restored wetland-CRP complexes.

In addition to watershed monitoring, the role of perennial crops in riparian areas will be investigated following a major flood in Elm Creek that occurred in September 2010. Stream banks and floodplain areas that were planted with willow and mixed prairie grasses (both potential bioenergy crops) in 2009-2010 will be examined in the spring of 2011, to evaluate the effectiveness of these plantings in terms of stream bank and stream channel stabilization. Data collected on channel reaches above, within and below sections of channels with perennial plantings will help us assess additional possible benefits derived from such crops.

Hydrologic and water quality data up to 2009 are being used to develop relationships to test and validate models that will be used to scale up land use changes and to develop scenarios of different land areas planted to perennial crops for bioenergy production. GIS data of the Elm Creek watershed are being analyzed to determine potential areas that would be more suitable to perennial crops in contrast to current annual cropping practices. Areas that have slopes of 3-6% or greater and riparian areas will be delineated in the watershed. These areas will then be used in developing land use change scenarios for our modeling work to evaluate the extent to which such changes could improve stormflow, sediment, and nutrient export to Elm Creek. This analysis would provide the basis for evaluating water quality and hydrologic benefits of these potential bioenergy crops.

Computer runs of the Elm Creek watersheds have been initiated with both the SWAT model and the InVEST model – tier one during the summer-fall of 2010. Parameter relationships and model output will be compared with observed data in improving model performance and applying the models to land use change scenarios in the greater Elm Creek watershed. Collaboration is continuing with the Natural Capital Project, Stanford University with the InVEST model to compare benefits of using InVEST versus the SWAT model.

### **Planned Activities for 2010-2011**

Monitoring will continue on all project sites parallel to analysis of data from the field sites.

## **C. Integrated assessment of ecological service markets**

### **Overview of 2010 Accomplishments**

The Ecological Services Team continues to meet as needed. To date the team has accomplished the following:

- IATP market assessment: IATP continues their work and will be working on identifying new markets and changes in existing markets.
- Rural Advantage has included a report on their activities which includes: 1) Information and results of the Non Market Valuation Survey (some of this information is repeated

from the Milestone 3 report but is more complete in this version); 2) Identification of Ecological Commodity Buyers; 3) Development of a Model ECoPayPack Program; and 4) Background on their pilot program to provide payments for Pollinator habitat.

- The University of Minnesota together with Rural Advantage continues to prepare for sending out a survey to landowners in a 9 county area to identify constraints to adoption of perennial (grasses and woody species) biomass cropping systems. In this reporting period, the following activities were completed: 1) Preparation and small scale testing of the survey; 2) Two focus groups to get initial information from selected landowners to help in preparing the survey; 3) Acquisition of lists of landowners from which a random sample was drawn; and 4) Internal review of the survey by the project team. The survey is ready to be mailed and we will send out the survey towards the end of the year. We will have more detail on the survey and preliminary results in the Milestone 5 report.

#### **Planned Activities for 2010-2011**

We will continue our research into markets for ecological services as an ongoing process incorporating new information as it becomes available. The landowner survey will be mailed out, results compiled and preliminary results will be reported.

#### **D. Life cycle assessment**

##### **Overview of 2010 Accomplishments**

The LCA team continues to work with researchers to gather the data for their analysis. This is an ongoing process that will be integrated into a full LCA assessment towards the end of the project.

##### **Planned Activities for 2009-2010**

The LCA team will continue to gather information for the analysis and coordinate with other project researchers to ensure that the data generated by other research areas meets their needs for the LCA analysis.

### **IV. Economic assessment of biomass production and delivery system**

This research area looks at the financial and economic aspects of biomass production from the perspective of the landowner/farmer who may be interested in producing biomass feedstocks for the market and also the value of the environmental services (water quality, recreation, carbon) to society both qualitatively and quantitatively.

#### **A. Cost Benefit Analysis – Plan activities and begin data collection**

##### **Overview of 2010 Accomplishments**

We continue to review secondary sources of data on the production of biomass from perennial crops, particularly grasses.

### **Planned Activities for 2010-2011**

We will continue to gather data on:

- Costs of establishment
- Costs of maintenance of plantings (fertilization, weed control, etc.)
- Cost of harvest
- Transport costs (this will be done in coordination with KODA energy)

This information will be integrated with the data being developed through the planting and cultivation experiments.

## **B. Valuation of ecological services**

### **Overview of 2009 Accomplishments**

This will be done in coordination with **IIC** above. Results from **IIC** will be used to help determine how the public values ecological services which will allow us to use those values for our analysis. In addition to the information gathered through the survey, we will be gathering data on the emerging markets for carbon and water quality credits. Linda Meschke is involved in a USDA Conservation Innovation Grant project which is studying payments for environmental services in the Minnesota River Basin and Dr. Bill Easter and Dr. Dean Current on our team continue to serve on the National Advisory Committee for that project which will provide another source of information for this work.

### **Planned Activities for 2009-2010**

We will continue gathering data on existing options for payments for environmental services as well as new initiatives. This information will be combined with the data generated through the survey instrument.

**Project Status:** The project continues to meet the timeline with some minor delays but with good progress in most areas. The ash fertilization task continues to be delayed due to the lack of ash from grasses from the KODA energy facility. We are working with KODA and other partners to resolve this issue and expect to complete this task before the end of the project.

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## **V. Appendices**

### **A. Rural Advantage Report for Milestone 4**

- 1. Non Market Valuation Survey**
- 2. Identification of Ecological Commodity Buyers**
- 3. Develop a Model ECoPayPack Program**
- 4. Developing\_a\_Pollinator\_Habitat\_Credit\_Program**

### **B. Report on additional research leveraged through separate funding**

## **Appendix A - Rural Advantage Report for Milestone 4**

- 1. Non Market Valuation Survey**
- 2. Identification of Ecological Commodity Buyers**
- 3. Develop a Model ECoPayPack Program**
- 4. Developing a Pollinator Habitat Credit Program**

## 1. Non Market Valuation Survey

A non market valuation [NMV] survey was conducted for those environmental commodities that are only concepts or emerging interests and have no “real money” valuations at this time. NMV describes how value is assigned to features and services provided [ie, higher species of water fowl or song birds, recreational uses such as hunting and fishing, quality of life interests such as camping scenic byways and trails, etc.]. Members of the team collaborating on this component include Linda Meschke and Jeff Jensen- Rural Advantage; Jim Kleinschmit- Institute for Agriculture and Trade Policy; Dean Current – Center for Natural Resources and Agricultural Management; Wm. Easter- University of Minnesota; and Matthew Pham- Graduate Student, University of Minnesota who submitted the following report on the survey.

### **Results from Non Market Valuation Survey to Estimate the Values of Environmental Services**

A draft questionnaire was designed to address the research objectives developed under Rural Advantage’s work including the Madelia Project. In consultation with the ECoPayPack team, questions were developed and revisions made until everyone agreed on the survey's final content. Questionnaire pretesting took place over two weeks from July 6 to 17, 2009 by postal mail. After revising the survey to accommodate the recommended changes suggested by respondents taking the preliminary questionnaire, the final version was mailed on July 31, 2009. The returned questionnaires were collected during the period of July 31 through October 1, 2009.

A total of 2,500 surveys were mailed to respondents in Carver, Dakota, and Scott counties. By October 1, 2009, 725 respondents completed and mailed back the survey. The data analysis consisted of analyzing relationships between the respondents' willingness-to-pay (WTP) for improvements in recreational services as a result of the conversion to perennial grasses.

A summary of the average values and ranges for the WTP, number of visits, length of stay, demographic variables, recreational services, and environmental services are shown in Tables 1-4.

Table 1: Average Values and Ranges of Pre and Post-Perennial Grass Conversion for WTP, Number of Visits, and Length of Stay

	WTP Before	WTP After	Number of Visits Before	Number of Visits After	Length of Stay Before	Length of Stay After
Average Value	\$0.85	\$2.43	0.133 visits	0.694 visits	0.106 days	0.360 days
Range	\$0-more than \$15	\$0-more than \$15	0-more than 5 visits	0-more than 5 visits	0-more than 2 days	0-more than 2 days

Table 2: Average Values and Ranges of Demographic Variables

	Age	Education	Household Size	Income	Sex	Distance From Madelia
Average Value	58.8 years	15.024 years	2.68 people	\$78,771	68.8% Male 31.2% Female	77.54 miles
Range	27-97 years	8-19 years	1-8 people	\$0.00 - more than \$100,000	Male or Female	50.4 - 91.6 miles

Table 2 (continued)

	Property Value	Rent	Marriage Status	Employment	Farmland Ownership	Fraction of Income from Farming
Average Value	\$292,622	\$738.02	73.01% Married, 9.66% Single, 9.81% Widowed, 7.50% Divorced	51.93% Full Time, 9.87% Part Time, 6.72% Not Currently Employed, 31.47% Retired	93.98% None, 2.58% Own and Operate, 3.01% Own and Rent Out, 0.43% Lease from Others	0.98%
Range	\$0.00 - more than \$1,000.000	\$0.00 - more than \$1,500.00	Married, Single, Widowed, Divorced	Full Time, Part Time, Not Currently Employed, Retired	None, Own and Operate, Own and Rent Out, Lease from Others	0%-100%

Table 3: Average Interest in Recreational Services

	Hunting	Biking	Picnics	Hiking	Bird Watching	Photography
Average Interest	1.26	2.17	2.15	2.45	1.92	1.81

Table 3 (continued)

	Nature Walks	Wildlife Viewing	Camping	Horseback Riding	Nature Viewing
Average Interest	2.49	2.54	1.74	1.17	2.36

Note: The range of interest for all recreational services is from 0 (Not Interested) to 5 (Extremely Interested).

Table 4: Average Rank of Environmental Services

	Clean Water for Recreation	Safe Water for Drinking	Reduced Flooding/High Flows	Increased Plant Biodiversity
Average Rank	3.37	1.94	3.83	4.50

Table 4 (continued)

	Increased Animal Biodiversity	Global Climate Change Mitigation	Increased Green/Open Space
Average Interest	4.32	4.25	4.12

Note: The ranking scale for all environmental services is from 1 (Most Important) to 7 (Least Important).

Further analysis will be conducted to determine the strength each demographic variable or recreational service will have on a respondent's WTP and the number of visits a respondent would make to a recreational area. For example, Equation (1) will test the strength of each variable in explaining WTP for each respondent, denoted as  $i$ , before or after the perennial grass conversion:

$$WTP_i = \beta_{0i} + \beta_{1i}rec + \beta_{2i}age + \beta_{3i}educ + \beta_{4i}hhsiz + \beta_{5i}inc + \beta_{6i}sex + \beta_{7i}dist \quad (1)$$

where  $rec$  represents whether or not a participant is interested in a recreational opportunity,  $visit$  is the number of visits to a recreational area in Madelia,  $age$  denotes the respondent's age in years,  $educ$  represents the number of years of education,  $hhsiz$  is the number of people living in the respondent's household,  $inc$  represents the respondent's 2008 gross household income,  $sex$  indicates male or female respondent, and  $dist$  is the distance in miles the respondents live from the Madelia area based on zip codes. The recreational opportunities include hunting, biking, picnics, hiking, bird watching, photography, nature walks, wildlife viewing, camping/overnight stays, horseback riding, and nature viewing. As shown in Table 3, wildlife viewing, hiking, nature walks, and nature viewing were the most favored activities.

The following pages include documents developed as part of the survey work. The first is the cover letter sent with the survey. The survey tool is attached as a separate document to this report. Printing and mailing the surveys was completed by Rural Advantage staff. As surveys were returned they were then given to Mr. Pham for compilation and analysis. Survey protocols were followed so the survey results would be statistically valid.



1243 Lake Ave. Suite 222  
Fairmont, Minnesota 56031  
507-238-5449  
<http://www.ruraladvantage.org>

DENNIS BEISSEL  
25162 HOGAN AVE  
HAMPTON, MN 55031-9796  
Dear DENNIS,

Friday, July 31, 2009

Rural Advantage, in collaboration with the University of Minnesota, Department of Applied Economics, is conducting a survey of Carver, Dakota, and Scott County residents to determine the value they would place on environmental and recreational services, including how much they would be willing to pay to utilize these services. The services will be provided by a project that will convert environmentally sensitive land from corn and soybean production to perennial grasses and agroforestry crops for bioenergy and other uses. You were randomly selected to tell us your opinion about the importance of these environmental services to you and what value you place on them.

*Your feedback is highly respected since it will help us to determine the value of recreational and environmental benefits associated with the increase in grassland and perennial crop landscapes in Southern Minnesota.*

The enclosed questionnaire is designed to only take 5-7 minutes of your time. Many questions are designed to be answered by simply circling or writing in a number. Some questions will ask you to refer to the pictures on the back of this cover letter. Responses to the survey will be kept in the strictest of confidence, and no individuals or individual responses will be identified in the survey. We will send you the overall survey results, upon your request at the end of the survey.

We hope you will help us. Please complete the enclosed survey and return it in the postage-paid envelope as soon as possible, but no later than August 31, 2009. If you have any questions, please contact Matt at 612-625-9722 or send an e-mail to [pham0170@umn.edu](mailto:pham0170@umn.edu). Thank you for your help with this important research.

Sincerely:

Linda Meschke  
President, Rural Advantage

Matthew Pham  
M.S. Science, Technology, and Environmental Policy  
Candidate University of Minnesota



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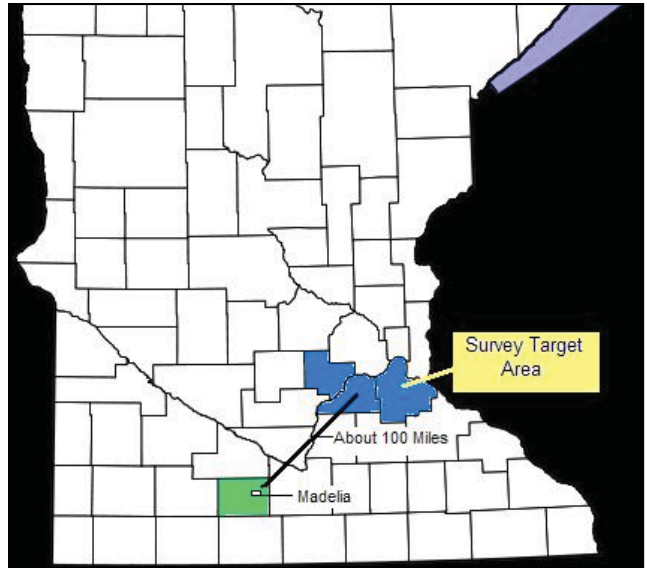
Rural Advantage is a nonprofit corporation based in Fairmont, Minnesota. Their mission is to promote the connections between agriculture, the environment and rural communities in order to improve ecological health, economic viability and rural vitality. Their objectives center around efforts to reduce agricultural nonpoint source pollution with major programming focused on the 3<sup>rd</sup> Crop Initiative, ECoPayPack development and building the Madelia Model concept. Contact Rural Advantage at 507-238-5449 or visit their website at [www.ruraladvantage.org](http://www.ruraladvantage.org) for more information.

### Glossary

**Perennial** = A plant that lives for more than two years. They can be short-lived (only a few years) or they can be long-lived, as are some woody plants like trees. - *Wiki*

**Biomass** = Biomass is organic material made from plants and animals. Biomass contains stored energy from the sun. – *EIA, Energy Kids Page*

**Bioenergy** = Bioenergy technologies use renewable biomass resources to produce an array of energy related products including electricity, liquid, solid, and gaseous fuels, heat, chemicals, and other materials. – *U.S. DOE*



**BEFORE**



**A - Annual Row Crops in Spring**

**AFTER**



**B - Perennial Grasses in Spring**



**C - Annual Row Crops in Fall**



**D - Perennial Grasses in Fall**

## 2. Identification of Ecological Commodity Buyers

Identifying buyers of ecological value is a critical step in the development of payments for ecological services. If you do not have buyers, then incentives cannot be offered that add ecological value and assist in driving land management change. There are several *potential* buyers available and once our program has been developed to the point where we can offer something to the landowner we will be contacting them about official agreements that we can then pass on to landowners making changes in their land management activities that add ecological value.

When someone purchases ecological services what are they paying for? This question comes up often. Many people feel they are paying for the land or the practice. Rural Advantage feels that what they are buying is the *ecological value* of doing certain land management activities. This is hard to conceptualize because as a society we have not monetized this value. There are many examples of societal benefits this value could represent such as:

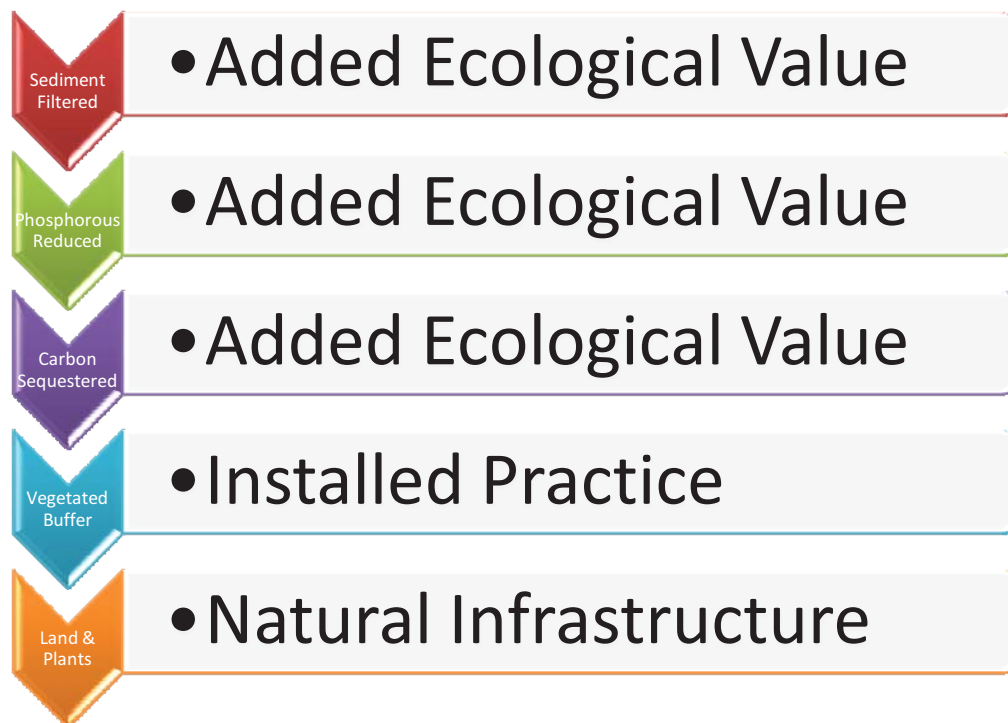
- Improved stream quality due to sediment runoff reductions
- Reduced nitrogen levels in drinking water
- Reduced greenhouse gas emissions
- More carbon sequestered
- More pheasant's, ducks, deer, etc. due to improved habitat
- Increased number of pollinators due to habitat availability
- Reduced nitrogen, phosphorous or pathogen levels in surface water
- Quality of recreational areas improved
- Less species on the endangered or threatened list.

The following diagram is one way to conceptualize ecological value. The land and plants are the *natural infrastructure* and generally there may be [does not have to be] an easement or contract with the landowner, who agrees to manage it around a certain set of parameters such as not mowing it during nesting season. The *installed practice* is the land management activity you are doing to increase the ecological value from that particular piece of land. In this example, it is the establishment of pollinator habitat. Establishing new pollinator habitat will result in more pollinators which in turn results in



better pollination of crops and increased yields. The *ecological value* is the increased number of pollinators and the resulting pollination. Theoretically, a buyer would desire and provide a payment for the added ecological value. The buyer may also pay for the practice and/or the land.

The following diagram illustrates where you may have multiple ecological values gained from a single practice. In this example of a vegetated buffer being installed, ecological value is provided through carbon sequestration, phosphorous reductions and sediment filtered. One buyer may be interested in buying all the ecological values or you might have three different buyers of these services.



Another factor that must be considered when trying to identify buyers is whether it is part of a regulated activity or is it voluntary. Regulated activities include water quality trading, air quality and wetland banking mitigation occurring at various levels now and with wellhead protection and storm water mitigation coming soon. Voluntary activities would occur when the buyer has no legal obligation to act. An example would be if Pheasants Forever, or some other wildlife group, would pay for quality wildlife habitat [the ecological value] that a landowner has developed for that purpose. Below is a litany of potential buyers for various ecological services. This is not intended to be a complete list, but rather a mechanism to show the scope of this emerging industry. Understand that these markets are emerging and there may or may not be developed programs for buyers at this time.

<b>Ecological Service or Program</b>	<b>V or R*</b>	<b>Potential Buyer[s]</b>
<b>Carbon</b>	V	Agragate [Iowa Farm Bureau] North Dakota farmers Union Carbon Credit MN Terrestrial Carbon Market US Forest Service Corporations with Social Responsibility Missions Socially Responsible Individuals Private Foundations
<b>Greenhouse Gas Emissions</b>	R	Xcel Energy Touchstone Energy Heartland Consumer Power District Alliant Energy Flint Hills Resources Murphy Oil Ashland Oil
<b>Water Quality Trading P, N, Sediment, flow</b>	R	Municipalities with WWTP Businesses with NPDES Permits
<b>Nitrogen, Phosphorous, Sediment or Flow</b>	V	Ag Corporations, Private Foundations, Socially Responsible Individuals
<b>Habitat</b>	V	Conservation Groups Conservation Related Retailers Conservation Related Corporations Specific Wildlife Species Organizations Private Foundations
<b>Habitat- Endangered Species</b>	R	US Fish & Wildlife Service USDA MN DNR MN Department of Agriculture Private Foundations
<b>Habitat- Pollinators</b>	V	Commodity Organizations for Crops Needing Pollinators [apples, strawberries, soybeans, etc.] Xerces Society Private Foundations Corporations with Social Responsibility Missions Socially Responsible Individuals
<b>Aquifer Recharge</b>	R	Municipalities with Wellhead Protection Plans Rural Water Programs Individual Home Owners
<b>Water Storage</b>	R	Source Water Communities Downstream Landowners
<b>Water Storage</b>	V	Downstream Landowners Great Lakes Commission

\*Voluntary [V] or Regulatory [R] Market

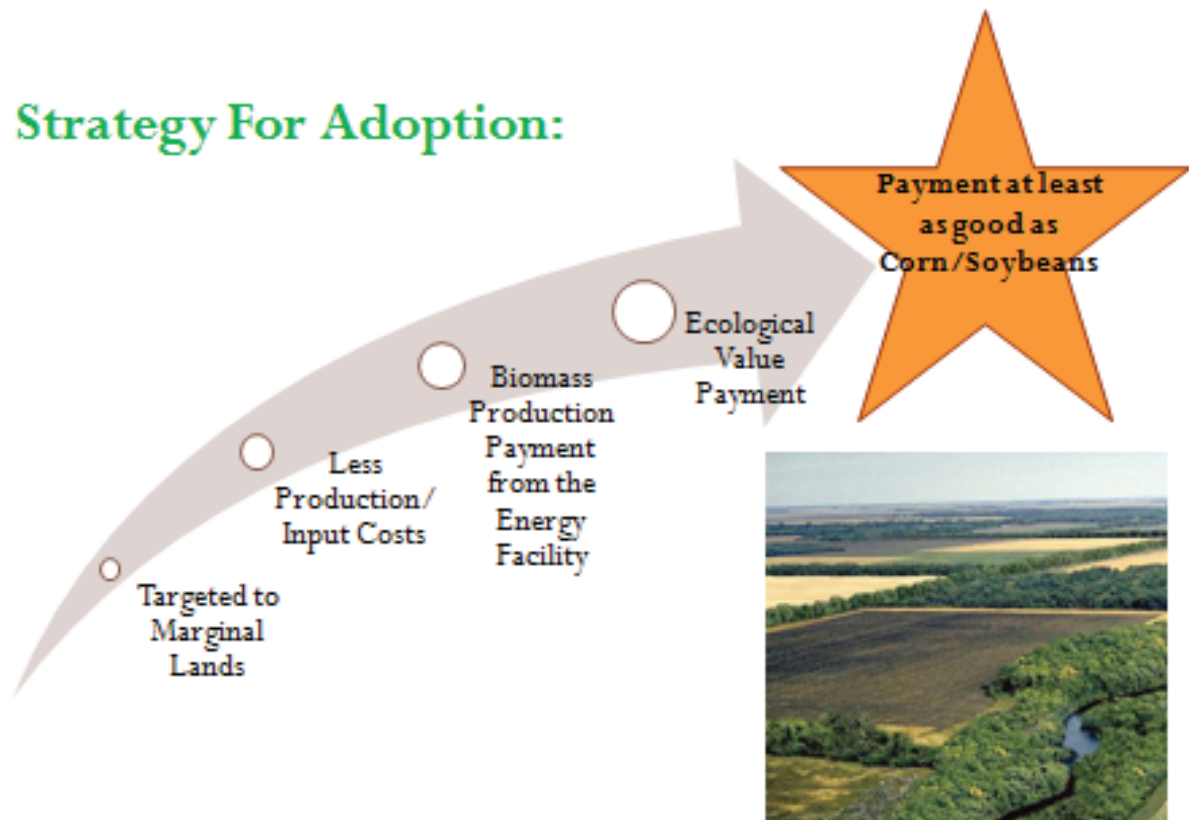
### 3. Develop a Model ECoPayPack Program

Rural Advantage has been working with advancing 3<sup>rd</sup> crops since their inception in 2003. One of the challenges of getting landowners and operators to change from their current cropping system to one that includes one or more ‘new’ crops is that there must be a market for that crop and it must be comparable to what they are getting from their current corn/soybean rotation. As the development of the Madelia Model occurred, we had a potential market, but was the economic return going to be enough to get growers to grow perennial biomass. The Madelia Model is a concept for rural economic development that uses a bio-refinery [utilizing perennial feedstocks] as a catalyst to create a market for perennial biomass and the accompanying economic development around such a system.

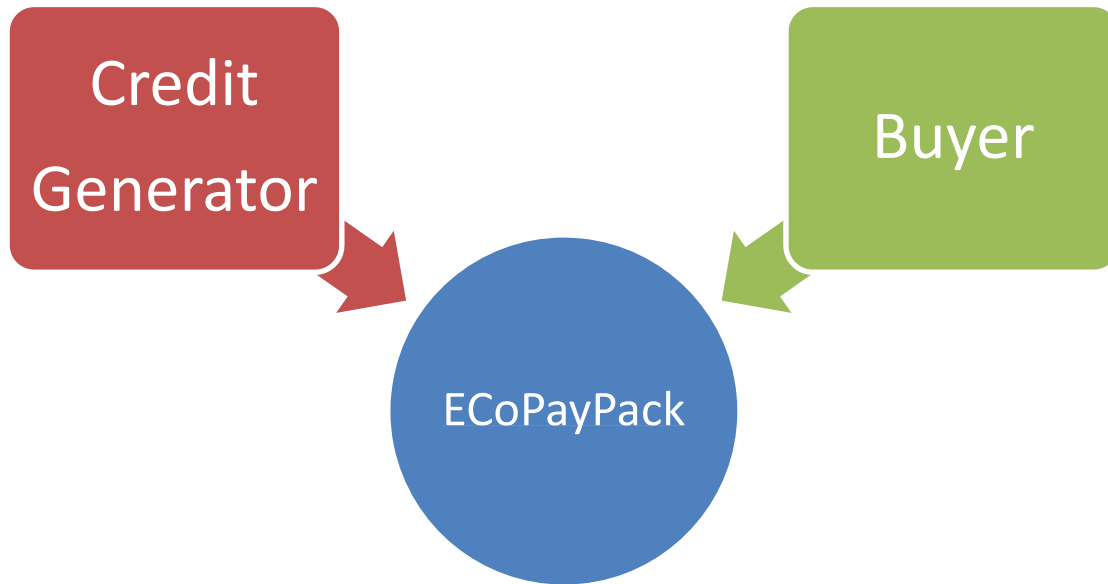
To address this issue, Rural Advantage, working with project partners, has developed the ECoPayPack concept to set up a system to provide payments for the ecological services provided by establishing 35,000 to 50,000 acres of perennials in south central Minnesota to supply a bio-refinery. This concept illustrates how perennial biomass crops can compete economically with corn and soybeans. While our main interest is around supplying native prairie mixes for bioenergy relative to the Madelia Model, this concept is readily transferable to other productive conservation on working lands crops across the state. This concept compliments the biomass production payment, from the energy facility, with an Ecological Commodity Payment Package [ECoPayPack] that supplies a payment to the landowner based on the ecological services or public benefit provided when you convert from an annual crop to a perennial crop that is managed in a sustainable way. Once developed, this concept could easily be adapted to allow existing perennial plantings to receive a payment for the ecological services they provide.

The ECoPayPack is a market based approach for an aggregator to “package” together payments for various ecological services and then pay out a single payment to the landowner. Ecological services that there are currently markets for include carbon, greenhouse gas emission reductions, nitrogen and phosphorous reductions, habitat improvement, sustainability standards, green space and aquifer recharge/ water storage. The following chart illustrates this strategy for adoption that gets perennial bioenergy crops to compete economically with corn and soybeans.

## Strategy For Adoption:



Rural Advantage sees their role with the ECoPayPack as that of a 'broker' between the credit generator and the credit buyer. Rural Advantage feels there is significant opportunity to receive a payment for multiple ecological values depending on the specific land management activities a landowner is willing to do. An individual landowner may not have the resources to identify, coordinate and enter into agreements with buyers on their own. In addition, buyers do not have the resources to identify and coordinate with landowners to develop appropriate land management changes. The chart below illustrates the base role of ECoPayPack a program of Rural Advantage.



Rural Advantage has partnered with the Conservation Markets of Minnesota [CMM], a project of the MN River Board. The goal of CMM is to establish a voluntary marketplace for ecosystem services transactions in the Greater Blue Earth River Watershed, Lower and Middle Minnesota Watersheds and the Sauk River Watershed. CMM is developing a framework and supporting policy to advance these markets. Rural Advantage has been partnering for the Lower and Middle MN areas. More information on this project is available at [www.conservationmarketsofminn.org](http://www.conservationmarketsofminn.org).

In order to accomplish the operation of ECoPayPack Rural Advantage will operate it as a program under Rural Advantage. As the program grows, it may be necessary to split off the program into its own entity. There are four main pieces to a successful program:

1. Program Framework and Policies
  - a. Develop policies, operation procedures, forms, credibility
2. Credit Generators
  - a. Identify, recruit, assure integrity, contracts, negotiate rates, develop longer term commitments
3. Credit Buyers
  - a. Identify, recruit, contracts, verify integrity, annual checks, 3<sup>rd</sup> party verifiers, payment procedures
4. Connecting Generators and Buyers
  - a. Market the program
  - b. Individually contact potential buyers
  - c. Identify and contact potential credit generators

## 4. Developing a Pollinator Habitat Credit Program

Rural Advantage developed procedures and protocols focused toward a Pollinator Habitat Credit in order to work through the process and develop a credible program to be offered publically. We identified and worked with one landowner, Heidi Morlock of Belle Plaine [EQIP eligible]. Using up to \$1,000 of discretionary funds Rural Advantage has, we worked with Ms. Morlock to determine appropriate policies and procedures. Using our processes she has developed ½ acre of new pollinator habitat on her farm for one Pollinator Habitat Credit. Each ½ acre of pollinator habitat is worth one credit. We have not yet identified a monetary value per credit. We have been discussing this with our pollinator expert consultants and will be finalizing a decision this fall. For this pilot project we also paid for establishment costs.

In addition, we worked with a group of selected scientists, ecologists, pollinator experts and state and federal technical experts to review our protocol and advise of necessary changes. The following describes the processes we developed to offer the Pollinator Habitat Credit to potential credit generators. To date we have just been working with the one producer. When a credit buyer is secured, we would be in a position to offer the program to a broader audience. Attached to this report is a file titled “Pollinator Packet.” This file contains the forms and materials we are using for the Pollinator Habitat Credit program. We will be following up the pollinator credit with additional programs for other ecological values. Similar processes will be followed in developing them.

To date we have had tremendous interest in the Pollinator Habitat Program. It seems to resonate well with the public. We have some potential funders who may have interest in being a buyer of some credits. We are unable to list those at this time as we are in a discussion stage and no commitments have been made. We hope to offer a program to credit generators in 2011.

### *Background on Pollinators*

Bees and other native pollinators are a vital component of our ecosystem and food supply. It has been estimated that animals pollinate approximately 35% of all crops grown throughout the world. While managed honey bees comprise the lion’s share of pollinator services, native pollinators are significant contributors. In the year 2000, native bees pollinated roughly \$3 billion worth of crops in the US. In many cases these crops are entirely dependent on bees and other invertebrates for pollination. For instance, sunflowers, apples, and alfalfa seed are completely dependent on pollinators with pumpkins, squash, and raspberries 80%-90 % dependent.

Providing good quality habitat is a straightforward way to attract and increase native bee populations. In addition to bees and other native pollinators, beneficial insects such as predatory beetles and parasitic wasps use the same habitat. A 2006 estimate put the value of natural control of pests by beneficial insects at \$4.5 billion annually.



Native pollinators generally have three needs: food and nesting habitat, as well as habitat protection from herbicides and insecticides. Providing these three things should result in greater numbers, as well as a wider diversity, of pollinators.

### **Forage Habitat -**

Food for bees and other native pollinators comes from pollen produced by a wide array of locally adapted flowering plants. These include perennial forbs, native grasses, and woody shrubs & trees. The primary consideration for providing forage habitat is diversity. It is important to employ a diverse mix of species that bloom at different times ensuring a continuous food supply. Equally important is selecting plants that have diverse colors, flower sizes, and growth characteristics. Woody species such as American Plum, Chokecherry, and Pussy/Black Willow are excellent early season sources of food.

### **Nesting Habitat -**

Nesting habitat typically comes in two forms; ground nests (70%) and wood tunnel nests (30%). Providing high quality foraging habitat with a wide diversity of perennials will also help with nesting habitat since untilled ground is a pre-requisite for many native pollinators. More specifically, bare dirt and direct sunlight. These conditions can be achieved through active management. Old brush piles can many times address the roughly 30% of pollinators that require old beetle tunnels as nests. Proximity of nests to food resources is an important consideration when planning nesting habitat. The average foraging range for native bees is anywhere from 50 feet to in excess of a ½ mile. Thus natural nesting habitat must be in close enough proximity to foraging habitat for pollinators to be present. Similarly, artificial tunnel nests, an option for landowners without natural nesting habitat, should be strategically placed close to food sources.

### **Habitat Protection -**

Protection from herbicides and insecticides is important for the long-term health of native pollinator communities. This can be achieved through sound management decisions that minimize insecticide/pesticide use or provide for a buffer to mitigate deadly effects. Timing and the formulation of the insecticide/pesticide are two additional considerations that require management. Toxic substances should never be applied to plants in bloom. Targeting the application to those times when pollinators are not active is one technique that can reduce negative impacts.

The Rural Advantage ECoPayPack – Native Pollinator Credit is designed to establish high value habitat for native pollinators. To ensure this goal is met, participants must adhere to the following Performance Standards:

- Planting must maintain a diverse mix of at least 15 native species (preferably local ecotype) that must include at least three early, three mid, and three late flowering species and should comprise at least 75% of the pollinator habitat plot.
- Plants that produce toxic nectar will not be planted.
- Minimum grass seeding rate will be 5.0 PLS lb/acre and minimum forb seeding rate will be 2.0 PLS lb/acre with at least one forb being a legume. The mixture will result in a 50:50 grass to forb ratio based on seeds per square foot.
- At least one forb must be a legume.

- Plants must remain undisturbed and be available throughout the growing season.
- Monitoring for invasive species and plant community composition is required for on-going maintenance.

*Rural Advantage/ ECoPayPack Pollinator Habitat Credit Materials [these forms are in an attached file named “Pollinator Package”] The forms are 95%+ completed.*

#### **ECoPayPack Form RA-1-2010, Native Pollinator Credit Application**

This document is the initial program application outlining what specific ecological services the landowner/manager is interested in developing; as well as relevant location and personal information.

#### **ECoPayPack Form RA-2-2010, Native Pollinator Credit Application**

This document is the initial application that would be filled out for the specific Native Pollinator Habitat Credit. It describes the two options for earning native pollinator credits, as well as soliciting information useful in determining eligibility, and finally providing a brief synopsis of what the credit entails.

#### **ECoPayPack Form RA-3-2010, Project Diagram Sheet** [not included in packet]

This document provides additional detail as to the exact location of the proposed native pollinator site.

#### **ECoPayPack Form RA-4-2010, Species Inventory List**

The species inventory list has been developed to assist landowners with taking inventory of any existing species to determine qualification in an enhancement situation, as well as provide suggestions for new plantings on desirable species compositions. Species on this list came from a number of sources:

1. MN NRCS Biology Job sheet #16
2. Selecting Plants for Pollinators – a publication of the Pollinator Partnership and the NAPPC
  - A. Eastern Broadleaf Region
  - B. Prairie Parkland Region

#### **ECoPayPack Form RA-5-2010, Management Plan**

This describes the base management plan required to obtain a credit. Program requirements, specifications, establishment practices, site operation and maintenance are listed. The landowner could go beyond these minimum requirements. This is the real “meat on the bones” of the credit needing to provide integrity and assurance to the buyer. It is perhaps here more than anywhere else that we seek feedback on the program.

#### **ECoPayPack Form RA-6-2010, Guidance Sheet**

This document will be used for marketing the program and describes a little bit about what bees need providing context to some of the performance standards.

#### **ECoPayPack Form RA-7-2010, Task Log**

This document is a supplemental document that landowners/managers will use to document actions and tasks they have performed on the site.

**ECoPayPack Form RA-8-2010, Verifier Log**

This document is used by a 3<sup>rd</sup> party verifier to ensure compliance with the specifications laid out in the management plan.

## **B. Report on additional research leveraged through separate funding**

### **INNOVATIVE, DIVERSIFIED AGROFORESTRY PLANTINGS IN SUPPORT OF ENERGY SECURITY, ENVIRONMENTAL QUALITY, AND LOCAL ECONOMIES**

ALTERNATIVE PERENNIALS IN AGROFORESTRY

METROPOLITAN COUNCIL EMPIRE SITE SUMMER REPORT

AUGUST 9, 2010

*Prepared by*

Josh Gamble  
Graduate Research Assistant  
University of Minnesota  
Department of Agronomy and Plant Genetics  
Department of Forest Resources

### **Executive Summary**

This report summarizes establishment progress and early data collection for a diverse agroforestry planting located on approximately 2.5 acres of agricultural land owned by the Metropolitan Council near its Empire Wastewater Treatment Facility. The agroforestry planting is designed as an alley cropping system, with herbaceous energy crops planted between rows of short rotation woody perennials. The research began with plot establishment in spring 2010 and will continue through the 2013-growing season.

## Plant materials

### **Short rotation woody crops**

- Willow clone 9882-42 “Fish Creek” (*Salix purpurea* x *S. purpurea*)
  - Characteristics
    - With over 450 species, the *Salix* genus provides ample genetic diversity for creating hybrids to suit a variety of site conditions
    - Willow propagates very easily from cuttings, has a quick growth cycle, and will regrow following harvest
    - Up to eight harvests can be made before replanting is required
    - Typically, harvests occur every 3 – 4 years using modified agricultural equipment that cuts and chips the biomass
    - For this research, willow biomass will be harvested in the fall following the fourth growing season
    - Willow yields are typically in the range of 4 – 7 tons/acre/year and up to 28 tons/acre after four seasons
  - Establishment:
    - Planted as 8 – 10 inch unrooted cuttings
    - Planted in a “twin row” configuration with 2.5 feet between rows, 5 feet between double rows and 2 feet between plants within a row for a planting density of approximately 6,000 plants/acre
    - 2,160 total willow clones were planted at the Empire site
- Poplar clone NM6 (*Populus maximowiczii* x *P. nigra*)
  - Characteristics
    - Cold hardy, disease resistant variety
    - A top ranked clone for use in the north central states
    - Will grow up to 10 feet per year in good growing conditions and climate
    - Typically harvested every 5 years for bioenergy (or 10- 15 years for pulp and paper)
    - For this research, poplar biomass will be harvested in the fall following the fourth growing season
    - Clone NM6 has been found to yield in the range of 6 – 7.5 tons/acre/year and up to 29 tons/acre after four seasons
  - Establishment
    - Planted as 8 – 10 inch un-rooted cuttings
    - Rows planted 4 feet apart with 4 feet between plants within a row for a planting density of approximately 2,700 plants/acre

- 900 total poplar clones were planted at the Empire site

## Herbaceous biomass crops

- Switchgrass (*Panicum virgatum*)
  - Characteristics
    - Most popular herbaceous biomass crop in the Midwestern states
    - Many improved varieties bred for biomass production
    - Switchgrass yields range from 2 - 7 tons/acre/year, when looked at over a 4-year period (Casler and Boe, 2003). Recent University of MN trials showed yields between 4 and 6 tons/acre
    - Unlimited persistence with single late fall biomass harvests
  - Establishment
    - Yellow tag certified seed from Feder's Prairie Seed; seed origin is near Blue Earth, MN
    - Seed was hand broadcast at a rate of 12 pounds of pure live seed (PLS) per acre
- Prairie Cordgrass (*Spartina pectinata*)
  - Characteristics
    - Very productive native warm season grass; adapted to wet or upland soil conditions
    - Recent University of MN trials showed yields between 8 and 9 tons/acre.
    - Will harvest once per year in late fall
  - Establishment
    - Planted live rhizomes of "Red River" Prairie Cordgrass at 1 foot by 1 foot spacing. Cuttings were obtained from University of MN research plots in St. Paul and Waseca
    - 12,600 total Prairie Cordgrass rhizomes were hand planted at the Empire site
- Native prairie polyculture
  - Characteristics
    - Though typically less productive than monoculture plantings of grasses, native prairie mixes may offer additional environmental benefits such as habitat and food for wildlife (e.g. pollinating insects) and reduced carbon impact due to reduced inputs
    - Will harvest once per year in late fall
  - Contains 11 species, a mixture of 3 grasses, 4 legumes and 4 forbs:

Canada Wild Rye	<i>Elymus canadensis</i>
Switchgrass	<i>Panicum virgatum</i>
Big Bluestem	<i>Andropogon girardii</i>
Partridge Pea	<i>Chamaecrista fasciculata</i>
Purple Prairie Clover	<i>Dalea purpureum</i>
Canada Milkvetch	<i>Astragalus canadensis</i>
Showy Tick-Trefoil	<i>Desmodium canadense</i>
Wild Bergamot	<i>Monarda fistulosa</i>
Maximilian Sunflower	<i>Helianthus maximiliani</i>
Smooth Blue Aster	<i>Symphotrichum laeve</i>
Yellow Coneflower	<i>Ratibida pinnata</i>

- Establishment
  - Yellow tag certified seed from Feder’s Prairie Seed; seed origin is near Blue Earth, MN
  - Seed was hand broadcast at a rate of 15 pounds of pure live seed (PLS) per acre
  
- Alfalfa / Intermediate Wheatgrass mixture
  - Characteristics
    - Alfalfa (*Medicago sativa*) is a commonly used forage legume, Intermediate Wheatgrass (*Thinopyrum intermedium*) is a late maturing perennial grass suitable for single annual harvests
    - Used “Rush” Intermediate Wheatgrass cultivar
    - Used Pioneer Alfalfa variety 54V48
  - Establishment
    - Wheatgrass was broadcast at 8 pounds pure live seed (PLS) per acre
    - Alfalfa was broadcast at 5 pounds pure live seed (PLS) per acre

## **Establishment summary**

### **To date:**

- May 26, 2010: The site was field cultivated and packed to provide a firm seed bed.
- May 27, 2010: Hand planting of un-rooted tree stock was completed.
- May 28, 2010: Hand broadcast seeding of the native prairie polyculture, Switchgrass and Alfalfa / Intermediate Wheatgrass mixture was completed. The herbaceous plots were packed again immediately following seeding.

- May 31, 2010: Hand planting of Prairie Cordgrass rhizomes began at the site. Pre-emergent herbicides, Goal and Princep PE, were applied to the woody crops to control weeds.
- June 24, 2010: Hand planting of Prairie Cordgrass was completed.
- July, 2010: Tree rows were hand weeded as needed.
- July 5, 2010: Herbaceous crops were mowed for weed control.
- July 6, 2010: Tree survival was estimated; dead or dying trees were replaced.
- July 19, 2010: Herbaceous crops were mowed for weed control, except Prairie Cordgrass, which was hand-weeded.
- July 20, 2010: Deer repellent was applied along the perimeter of each replicate.
- July 23, 2010: Data was collected to estimate plant populations in each herbaceous treatment except Prairie Cordgrass.
- July 28, 2010: Plot boundaries were mowed for clear identification. Tree rows were hand weeded. Deer repellent was applied along the perimeter of each replicate.

**Upcoming:**

- August 2010: Soil samples will be collected at the site to estimate baseline soil organic carbon (SOC) at depths from zero to 6 inches, 6 to 12 inches, 12 to 24 inches and 24 to 36 inches.
- September 2010: Plant populations will be estimated for all treatments, disease and insect incidence will be estimated for woody treatments.
- October 2010: Stem height and diameter data will be collected for woody treatments. Woody treatments will be coppiced to encourage re-sprouting and rapid growth in spring 2011.

## **Preliminary data**

### **Tree emergence and survival**

On July 6, 2010, initial tree emergence and survival data were collected. Where tree stock did not bud or had died since emergence, the replicate, plot, row and tree numbers were recorded and the tree was replaced with fresh un-rooted tree stock. The results are summarized below.

*Table 1: 40 day tree survival by replicate and plot*

<b>Replicate</b>	<b>Plot</b>	<b>Dead / Not Emerged</b>	<b>Live Plants</b>	<b>Survival (%)</b>
A1	Willow (North)	39	681	94.6
	Poplar (South)	31	269	89.7
A2	Poplar (North)	22	278	92.7
	Willow (South)	66	654	90.8
A3	Poplar (North)	23	277	92.3
	Willow (South)	39	681	94.6

*Table 2: 40 day tree survival by species*

<b>Species</b>	<b>Dead / Not Emerged</b>	<b>Live Plants</b>	<b>Survival (%)</b>
Willow	144	2, 016	93.3
Poplar	76	824	91.5

## Herbaceous plant population estimates

On July 23, 2010, data was collected to estimate plant populations in each herbaceous treatment except for Prairie Cordgrass. Counts of desired and weed species were obtained in four randomly selected 1-foot by 1-foot sampling quadrates within each plot. Results for each plot were compiled by treatment and are summarized below.

Table 3: Plant counts by treatment and species, July 23, 2010

Treatment	Species/type	Count (plants / ft <sup>2</sup> ) *
Switchgrass	<i>Panicum virgatum</i>	27.1
	Broadleaves	6.8
	Other grasses	0.8
Alfalfa / Intermediate Wheatgrass	<i>Medicago sativa</i>	12.9
	<i>Thinopyrum intermedium</i>	19.6
	Other broadleaves	5.6
	Other grasses	0.6
Native Prairie Polyculture	<i>Elymus canadensis</i>	2.1
	<i>Panicum virgatum</i>	5.1
	<i>Andropogon girardii</i>	2.6
	<i>Chamaecrista fasciculata</i>	0.0
	<i>Dalea purpureum</i>	0.3
	<i>Astragalus canadensis</i>	0.7
	<i>Desmodium canadense</i>	0.2
	<i>Monarda fistulosa</i>	0.4
	<i>Helianthus maximiliani</i>	0.0
	<i>Symphyotrichum laeve</i>	0.0
	<i>Ratibida pinnata</i>	1.3
	Other broadleaves	6.2
	Other grasses	0.2

\*Counts reflect average plants per square foot based on 24 random samples