Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2018 ENRTF Work Plan (Main Document)

Today's Date: December 15, 2017

Date of Next Status Update Report: January 31, 2019

Date of Work Plan Approval:

Project Completion Date: June 30, 2021

Does this submission include an amendment request? No

PROJECT TITLE: Develop Market-Based Alternatives for Perennial Crops to Benefit Water Quality and Wildlife

Project Manager: Shawn Schottler

Organization: Science Museum of Minnesota

College/Department/Division: St. Croix Watershed Research Station

Mailing Address: 16910 152nd St. North

City/State/Zip Code: Marine-on-St. Croix, MN 55047

Telephone Number: 651-433-5953 x 18

Email Address: schottler@smm.org

Location: Statewide. Results are applicable statewide, but we will model the market scenarios in two watersheds, (one in the western part of the state and one in eastern part, e.g. Cottonwood and Whitewater) to provide real world estimates of water quality and wildlife habitat benefits.

Total Project Budget: $150,000

Amount Spent: $0

Balance: $150,000

Legal Citation: M.L. 2018, Chp. xx, Sec. xx, Subd. 8(c)

Appropriation Language:

I. PROJECT STATEMENT:

If we are going to make meaningful improvements to degraded waters and habitat for pollinators and grassland wildlife species, Minnesota must find a way to make perennial cropping systems profitable. This will require creating markets and incentives that stimulate farmers to put land into perennial vegetation/crops.

Despite millions of dollars spent on conservation practices, water quality has not improved in most agricultural watersheds, and grassland-dependent species continue to decline. The common denominator that benefits water quality and habitat are practices that incorporate perennial vegetation such as filter strips, wetlands, prairies, pastures, hay land, and grassed waterways. However, the cost of implementing these practices to a level that would create substantial improvements is estimated to exceed $1 billion per year. This is because the vast majority of conservation practices, including perennial vegetation, are simply not profitable—they require funding for implementation. Measureable improvements to water quality and habitat hinge on reshaping the discussion about affordable ways to implement perennial vegetation/crops. Instead of thinking about solving our water quality and habitat challenges by funding one conservation practice at a time, we need to think about how we can stimulate entire cropping systems that utilize large acreages of perennial crops. **We need to think about products such as electricity, fuel, meat, and industrial chemicals as markets that can be developed and modified to utilize large quantities of perennial feedstocks and thereby create a landscape that benefits water quality and habitat.** In other words, use markets as conservation best management practices.

We will design six market-based approaches that could stimulate the incorporation of perennial vegetation into cropping systems. While the technological aspects of some markets for perennials have been shown, minimal analysis has been done of the costs and benefits, nor the policy and economic incentives necessary to create demand for these cropping systems. An outcome from each of the six designed market approaches will be an estimate of the number of acres of the perennial crop necessary to satisfy the product demand. These acres of perennial crop (and the management techniques such as fertilizer and harvest dates) will be input to existing, calibrated watershed models to estimate the reduction in sediment, phosphorus and nitrate from each of the perennial cropping systems. The acres of perennial crop will be applied in various configurations (e.g. as buffer strips, or whole fields) to compare their efficacy. Equally important to cost-benefit analysis is the wildlife habitat value of the perennial cropping systems. To quantify the wildlife benefits, a habitat score based on number of acres, plant diversity, harvest timing and phenology will be calculated. This habitat score and the calculated water quality improvements will be combined with the cost estimate from the market evaluations to offer a cost-benefits analysis of each scenario. From these, recommendations of the requirements and feasibility of using market demand to stimulate perennial cropping systems will be offered.

Specific outcomes are:

a) Design and cost analysis of six market scenarios to stimulate adoption of perennial cropping systems.
b) Comparison of mandates, incentives and consumer promotion as drivers to create demand for perennial crops.
c) Estimation of reductions in sediment, phosphorus and nitrate in representative watersheds resulting from each market scenario and the associated perennial cropping system.
d) Development of a habitat score to provide a quantitative metric of benefits to wildlife created by the markets for the perennial crops.
e) Cost-benefit analysis of each market scenario and perennial crop.
f) Recommendations on using market drivers as the key to stimulating implementation of perennial cropping systems.

II. OVERALL PROJECT STATUS UPDATES: See Activity 1 below

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Define and Evaluate Six Market-Based Scenarios for Perennial Vegetation

ENRTF BUDGET: $ 150,000

Market Scenarios and Cost Analysis

The technology and desire to grow perennial crops (create supply) such as switchgrass or intermediate wheatgrass has progressed greatly in recent years. What has been missing is an understanding of how to make these crops profitable. Unless proactive efforts are instituted to create demand for the perennial crops they will remain unprofitable and non-viable alternatives, i.e. no farmer is going to make the change to a perennial crop unless they can be assured there is market that will buy it. The underlying principle of this project is that market demand, more so than product supply, is a driver for increasing perennial cropping systems. This project will demonstrate three principle drivers or levers that can be manipulated to increase the market equilibrium quantity for perennial crops: production subsidies (incentives); mandates; and consumer promotion/eco-labelling.

Incentives or subsidies are payments made to either producers or consumers of a product. They effectively lower the cost of production (in the case of producers) or lower the price of the product (consumers). Mandates are edicts requiring or restricting certain production methods, materials, or outputs. In the short run, mandates can increase the cost of production. Consumer promotion is often labels on the final product that indicate a differentiating factor between the product in question and its substitutes. Eco-labels are consumer labels that indicate the product is environmentally friendly, and can increase the price consumers are willing to pay for a product. All of these levers have the effect of increasing the equilibrium quantity of the product produced and sold.

To examine these levers, and their potential to stimulate changes in agriculture, six market scenarios for perennial cropping systems will be identified. Three will focus on the same product, perennial grass/alfalfa fed to crickets to create protein for pet rood, and while comparing the three market levers. The other three will each focus on a novel perennial cropping system created by either a subsidy, mandate, or consumer promotion. The potential scenarios likely to be considered are:

<u>Scenario 1: Alfalfa/grass fed to cricket as protein for pet food: ***Subsidy***</u>
Crickets could be raised on alfalfa or perennial grasses. The dried and ground crickets would then be used in pet food to provide protein. A policy centered on creating a subsidies that would lower the cost of production by providing a payment to the pet food producer will be evaluated and a cost analysis will be completed.

<u>Scenario 2: Alfalfa/grass fed to crickets as protein for pet food: ***Mandate***</u>
Similar market as Scenario 1 but a mandates would be used to require that a certain percentage of perennial grasses be used to feed the crickets. The production cost analysis will be similar to Scenario 1 but the differences in socio-political efforts will be evaluated

<u>Scenario 3: Alfalfa/grass fed to crickets as protein for pet food: ***Consumer Promotion***</u>
This scenario will offer a comparison of consumer promotion/eco-labeling for a the same product evaluated using subsidies and mandates in Scenarios 1 and 2. Consumer labels will be used to indicate that the final product was produced in a more environmentally friendly. Eco-labels, such as these, have been shown to increase consumer demand. A cost evaluation of how much more the consumer would have to pay for the “eco-friendly” product will be done.

<u>Scenario 4: Intermediate wheatgrass grain as hog feed: ***Subsidy***</u>
An alternative subsidy/incentive for another product requiring perennial grasses/grain will be examined. An example would be a subsidy for hogs fed a certain percentage of grain from perennial intermediate wheatgrass instead of corn. A cost analysis of how large the subsidy would need to be for producer to use intermediate wheatgrass grain versus corn will be completed.

<u>Scenario 5: Pastures with solar arrays: ***Mandate***</u>
A mandate for another product requiring perennial grasses will be examined. An example would be a mandate requiring a percentage of solar arrays to be placed in pastures used for grazing cattle. This

scenario provides for dual-use of a field--- production of ‘grass fed’ beef and electricity. The socio-technological factors and start-up costs necessary to create this type of scenario will be evaluated.

Scenario 6: Small business/home heating with switchgrass pellets: ***Labelling/Consumer Promotion***
An alternative consumer labelling scheme for another product requiring perennial grasses will be examined. An example would be consumer promotion efforts to encourage home and small business heating with pellets made from switchgrass. A cost analysis of switchgrass pellet production will be evaluated and compared to traditional heating methods.

For each scenario, a cost and return calculation (budget analysis) will be performed. This will compare the costs of production with market prices for the product in question. The production costs will be as comprehensive as possible, including any land, labor, fuel, transportation, processing, and/or other input costs. This will provide us with enough information to determine what price would be required to make the product attractive to a farmer. Once this information is calculated, for a given scenario, we will use existing literature on the appropriate driver to determine viability. For example, in Scenario 3 and Scenario 6, we will be focused on subsidies. We can determine what level of subsidy, directed at a certain point in the production process. This may look something like a subsidy of so many dollars per mass of perennial grass fed crickets used in pet food. Or, it may be a subsidy of so many dollars per area of perennial grass grown that is used to feed the crickets. For mandates, Scenarios 2 and 5, we will determine the effects of different types of mandates, such as requiring 50% of the cricket food being perennial grass and not corn, or requiring a certain percent of crickets in the pet food. In Scenarios 3 and 6, which deal with consumer labels, we can estimate potential increases in willingness to pay based on documented examples, and compare this with what we calculate the increased costs of production to be.

These market estimates will provide a range of compared and contrasted products and market factors, which will result in different levels of shifts from corn to perennial grasses. An outcome from this analysis is that each scenario requires a certain amount of alternative perennial crop to satisfy the new market demand. This amount of a new crop can be translated into a number of acres required. This acreage is then input to the modeling efforts below to estimate water and wildlife benefits of the perennial cropping system.

Water Quality and Habitat Benefits

Creation of the market scenarios and perennial cropping system will result in an amount of acres needed to fulfill each market’s estimated demand. A watershed modeling framework will then estimate water quality benefits of each perennial crop scenario based of the designated number of market acres. Water quality benefits will be quantitatively represented by modeling flow, nitrate, total phosphorus (TP) and suspended sediment (SS). The framework is composed of the watershed model SWAT coupled with field-scale GIS analyses that will include metrics such as distance and travel time to perennial streams, field slope, likelihood of artificial drainage and land use history. SWAT is a very effective model for agronomic focused scenarios because of its explicit support for different agricultural cropping systems and management operations. However, SWAT is a watershed scale model while the scale of the perennial crop implementations are on an individual field or portion of a field. Therefore, field-scale GIS analyses will enable a watershed scale model like SWAT to perform more effectively at the smaller scales consistent with the crop implementations. Examples of utilizing these types of GIS analyses include modifying SWAT’s output to take into account more realistic distribution of sediment and phosphorus erosion as well as buffer strip effectiveness based on GIS calculated (actual) distances to the nearest streams, and the field slope characteristics.

The current plan entails simulating baseline conditions and then comparing results when acreage of perennial crops from the market scenarios are substituted (See list below). However, as the project progresses and intermediate results are generated, changes to these scenarios are possible:

(1) Baseline using current cropping and management practices.
(2) Cultivation and fall harvest of switchgrass for biomass combustion.

(3) Cultivation and three annual cuttings of alfalfa for cricket feed to make pet food.
(4) Cultivation and fall harvest of intermediate wheat grass (IWG) as hog feed.
(5) Pasture land with solar panels.

Placement and field configuration of the perennial crop implementations are important; as such, scenarios 2 through 5 will be simulated using at least two configurations including, but not limited to, the following:

A. Field buffer strips with a width of 240 feet (Buffer widths of 240 feet conform to multiples of typical farm machinery widths)
B. Rectangular 80 acre blocks (generally encompassing an entire field)

These configurations will be randomly placed in the modeled watersheds. The Cottonwood River and Whitewater River watersheds will serve as the modeled study watersheds. Both watersheds are heavily agricultural and collectively provide a wide range of soil, topographic and climate conditions. Both watersheds have flow and water quality data available for model calibration. The models will be calibrated at the watershed outlets for a period of approximately 20 years (preferably, the most recent 20 years). Field-scale predictions of flow, nitrate, TP and SS will be constrained by current literature from the agricultural regions of the upper Midwest.

Results will consist of modeled comparisons between the baseline scenario and each of the cropping scenarios on an average annual basis. As such, these will comprise relative changes in average flow volume and nitrate, total phosphorus and sediment mass per acre, per year over the calibration period. In addition, a weighted water quality index will be utilized similar to that implemented in BWSR's PTMapp ("Prioritize, Target, Measureable" application) project approach:

$$\text{Water Quality Score} = 0.5 \times \text{SS reduction} + (0.25 \times \text{nitrate reduction} + 0.25 \times \text{TP reduction}) \quad \text{eq. 1}$$

Lastly, the Habitat Score (outlined in following section) will be combined with modeled water quality scores and normalized by watershed area to get one pair of scores (Water Quality and Habitat) for each scenario. Example formats of the planned outputs appear in Tables 1 and 2.

Development of Habitat Score

Frequently, when perennial cropping systems are being promoted the water quality benefits are given primary, if not sole, consideration. However, from a natural resource perspective and value to the public, the benefits of these cropping systems as potential wildlife habitat are of equal importance. This project seeks to give equal weight to water quality and wildlife benefits and emphasize how perennial cropping systems that offer significant improvements to both should receive greater consideration. What is lacking in many water quality modeling efforts is an easy way to calculate a habitat value of the crops and management practices implemented. We will refine a method for generating a "habitat score" based on vegetation type, acreage and farming practices and will apply it to the watershed models used in this project.

The habitat score is not based on benefits to any particular fauna, but rather founded in the premise that size, floristic diversity and minimal disturbance are basic attributes of good habitat.

$$HS = \sum(\text{Area}_i \times C_i \times D_i \times M_i) \times 100 / WA \qquad \text{eq. 2}$$

HS = the combined Habitat Score for perennial crops or vegetation added to a watershed.
Area = the total acreage of any particular perennial crop/vegetation (i)
WA = watershed area in acres

C_i, D_i and M_i are modifiers related to floristic diversity and management of the perennial crop:

C_i is a modifer for the configuration of how the perennial crop is implemented. For example,
C_i for 200 foot buffers = 0.85
C_i for 80 acre fields = 1.0
C_i for 40-foot-wide strips/waterways = 0.75
C_i for whole field implementation such as inter-row cover crops = 1.0

D_i is the modifier for floristic diversity of the crop or cropping system:
D_i for grass monocultures = 0.75
D_i for mixed grass planting = 0.9
D_i for single species forb crop (e.g. alfalfa or camelina) = 0.8
D_i for multiple species of forb = 0.9
D_i for mixed plantings (forbs+grasses, e.g. prairie) = 1.0

M_i is the modifier related to how the crop is managed:
M_i for undisturbed = 1.0
M_i for fall harvest = 0.9
M_i for harvest during nesting season = 0.5
M_i for termination in the spring (e.g. for rye inter-row cover crop) = 0.1
M_i for low intensity grazing = 0.7
M_i for high intensity grazing = 0.6

This habitat score provides a simple, quantitative and comparative measure of the potential wildlife benefits of the perennial crops/vegetation added to a watershed. While the specifics of what is good habitat can be somewhat nebulous, the appreciation that there is a continuum of habitat value ranging from annually plowed fields, to seasonally harvested perennial vegetation, to blocks of undisturbed, highly diverse grasslands is almost obvious---the essence of which is captured by the habitat score. The habitat score along with the water quality score (Table 2) give a simple summary of the water and wildlife benefits of the perennial cropping systems created by each market scenario. Putting both of these, side-by-side in a simple table, facilitates the discussion about which market scenarios offer the best benefits per implementation cost.

Table 1. Modeled Water Quality Benefits from APC Scenarios. *(Blank cells in the table will be filled as part of the final report.)*

Scenario	***Config.***	***SS Reduction %***	***Nitrate Reduction %***	***TP Reduction %***
Watershed 1 (Cottonwood)				
1. Baseline	--	0	0	0
2. Switchgrass biomass	A			
2. Switchgrass biomass	B			
3. Alfalfa for Crickets	A			
3. Alfalfa for Crickets	B			
4. IWG for hogs	A			

4. IWG for hogs	B			
5. Pasture w/Solar Panels	A			
5. Pasture w/Solar Panels	B			
Watershed 2 (Whitewater)				
1. Baseline	--	0	0	0
2. Switchgrass biomass	A			
2. Switchgrass biomass	B			
3. Alfalfa for Crickets	A			
3. Alfalfa for Crickets	B			
4. IWG for hogs	A			
4. IWG for hogs	B			
5. Pasture w/Solar Panels	A			
5. Pasture w/Solar Panels	B			

Table 2. Water Quality & Habitat Scores for APC scenarios normalized across both study watersheds. *(Blank cells in the table will be filled as part of the final report)*

Scenario	***Config.***	***Water Quality Score***	***Habitat Score***
1. Baseline	--	0	0
2. Switchgrass biomass	A		
2. Switchgrass biomass	B		
3. Alfalfa for Crickets	A		
3. Alfalfa for Crickets	B		
4. IWG for hogs	A		
4. IWG for hogs	B		
5. Pasture w/Solar Panels	A		
5. Pasture w/Solar Panels	B		

Cost-benefit summary and socio-political recommendations.

The budget analysis (part 1 above) provides a cost estimate for adoption of each market scenario, and the watershed modeling results provide an estimate of the resulting water and wildlife benefits. The habitat score and water quality benefits (score and actual pollutant reductions) will be divided by the respective cost estimate of each market scenario to give a dollar per benefit estimate. This cost-benefit summary can be used to evaluate which of the market scenarios offer the most cost-effective means for achieving our natural resource objectives—but more importantly, the summary provides a demonstration of the financial dynamics and environmental magnitude of creating markets for perennial cropping systems. The markets scenarios presented in this project are mostly intended to serve as examples to stimulate and augment the discussion about how we can pay for land use practices that benefit water and wildlife. Using the scenarios developed for this project we will compare and contrast the effectiveness of using incentives, mandates or consumer promotion as drivers of perennial cropping systems and provide recommendation on the socio-political changes necessary to bring these markets to reality. Results from this project will be summarized in a final report and a concise four-page fact sheet. The fact sheet will highlight the necessity of creating markets for perennial crops, present the six market scenarios along with their associated cost-benefit analysis as examples, and offer a summary of the recommendations on the socio-political efforts required to create cost-effective markets for perennial cropping systems.

Outcome	Completion Date
1. Define and research six market scenarios for perennial cropping systems	June, 2020
2. Estimate water quality improvement and habitat value relative to market costs	December, 2020
3. Summarize cost-benefit comparison and provide recommendations	June, 2021

First Update: January 31, 2019

Second Update: June 30, 2019

Third Update: January 31, 2020

Final Update: June 30, 2020

IV. DISSEMINATION:

Results from this project will be summarized in a final report and a concise four-page fact sheet. The fact sheet will highlight the necessity of creating markets for perennial crops, present the six market scenarios along with their associated cost-benefit analysis as examples, and offer a summary of the recommendations on the socio-political efforts required to create cost-effective markets for perennial cropping systems. In addition, the concept and objectives of market based solutions to benefit water and wildlife will be presented orally at over 10 venues throughout the State over the duration of the project. Venues will include professional conferences and statewide meeting to audiences of state and federal natural resource managers, policy makers, non-profit advocacy groups, and agricultural producers.

First Update: January 31, 2019

Second Update: June 30, 2019

Third Update: January 31, 2020

Final Update: June 30, 2020

V. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview: See attached budget spread sheet

Explanation of Use of Classified Staff: NA

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Total Personnel Hours: 1020 hr/yr for 3 yr	0.5 /year, 1.5/project

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Total Personnel Hours: 208 hr/yr for 2yr	0.1/year, 0.2/project

B. Other Funds:

SOURCE OF AND USE OF OTHER FUNDS	**Amount Proposed**	**Amount Spent**	**Status and Timeframe**
Other Non-State $ To Be Applied To Project During Project Period:			
NA	$ NA	$ NA	
Other State $ To Be Applied To Project During Project Period:			
NA	$ NA	$ NA	
Past and Current ENRTF Appropriation:			
Funding History: ENRTF M.L. 2016 Chp 76 Sec 3 Subd 08c. $179,000: Establishment of permanent habitat strips within row crops. ENRTF M.L. 2015 Chp 226 Sec 2 Subd 03g. $900,000: Watershed-Scale Monitoring of Long-Term Best-Management Practices	$	$ $ 179,000 $ 900,000	 Ends 06/2019 Completed
Other Funding History:			
NA	$ NA	$ NA	

VI. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	**Title**	**Affiliation**	**Role**
Dr. Jeff Peterson	Ag-economist	U of MN, Water Resources Center	Economic and market evaluations
Dr. Lucy Levers	Research Associate	U of MN, Water Resources Center	Economic and market evaluations

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

The markets scenarios presented in this project are mostly intended to serve as examples to stimulate and augment the discussion about how we can pay for land use practices that benefit water and wildlife. Results from this project are intended to serve as both specific examples of the socio-political changes needed to stimulate perennial cropping systems and as the spark to ignite a larger effort to find ways to create demand for these crops.

VIII. REPORTING REQUIREMENTS:

- The project is for 3 years, beginning July 1, 2018 and ending June 30th, 2021
- Periodic project status update reports will be submitted Jan. 31st and June 30th of each year.
- A final report and associated products will be submitted between June 30 and August 15, 2021**.**

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2018 Budget Spreadsheet

Project Title: Develop Market-Based Alternatives for Perennial Crops to Benefit Water Quality and Wildlife
Legal Citation: -- Subd. 8c
Project Manager: Shawn Schottler
Organization: Science Museum of MN
College/Department/Division: St. Croix Watershed Research Station
M.L. 2018 ENRTF Appropriation: $150,000
Project Length and Completion Date: 3 years. June 30, 2021
Date of Report: February 15, 2018

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits) - Overall	$125,000	$0	$125,000
SCWRS Senior Scientist: Shawn Schottler 37% FTE for 3 years. Salary =70%, Benefits =30% (Total estimate $105,000)			
SCWRS Assistant Scientist: Jason Ulrich 12% FTE for 2 years. Salary =70%, Benefits =30% (Total estimate $20,000)			
Professional/Technical/Service Contracts			
University of Minnesota, Water Resources Center: Research Assistant (or equivalent), to conduct market evaluation and feasibility analysis.	$25,000	$0	$25,000
COLUMN TOTAL	**$150,000**	**$0**	**$150,000**