



# Environment and Natural Resources Trust Fund (ENRTF) M.L. 2014 Work Plan

**Date of Report:** January 10<sup>th</sup>, 2014  
**Date of Next Status Update Report:** December 31<sup>st</sup>, 2014  
**Date of Work Plan Approval:**  
**Project Completion Date:** June 30<sup>th</sup>, 2016  
**Does this submission include an amendment request?** No

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**PROJECT TITLE: Expansion of Greenhouse Production**

**Project Manager:** Lana Fralich  
**Organization:** City of Silver Bay, MN  
**Mailing Address:** 7 Davis Drive  
**City/State/Zip Code:** Silver Bay, MN 55614  
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**Web Address:** www.silverbay.com

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**Location: Lake County**

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<b>Total ENRTF Project Budget:</b>	<b>ENRTF Appropriation:</b>	<b>\$176,000</b>
	<b>Amount Spent:</b>	<b>\$0</b>
	<b>Balance:</b>	<b>\$176,000</b>

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**Legal Citation:** M.L. 2014, Chp. 226, Sec. 2, Subd. 06k

**Appropriation Language:**

\$176,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the city of Silver Bay to expand and enhance a city-owned greenhouse facility to increase system production for locally grown food on a year-round basis and reduce water usage.

## **I. PROJECT TITLE: Expansion of Greenhouse Production**

### **II. PROJECT STATEMENT:**

Victus Farm's, located in the Silver Bay Eco-Industrial park, is a new partnership between the City of Silver Bay and UMD aimed at proving the economic viability of producing sustainable food and fuel year-round using a method that integrates fish, plants and algae in a closed loop system. The existing 8600+sq. ft facility is fully renewable, using biomass (wood pellets in flex fuel boilers) for heat, sunlight, recycled rainwater, and a future wind turbine or photovoltaics for electricity. The only other major input is organic fish feed. Outputs include fish, produce, rich compost and algal oil. Our goal is to demonstrate and improve the economic viability of this process to create a new sustainable industry for Minnesota and beyond. The facility also provides ongoing community education, systems research and future workforce training. Our production system has been evolving daily, and has already exceeded expectations. New innovative approaches have evolved that will lower costs and increase revenues. Increasing aquaponic food production could offset conventional agriculture production and eliminate many associated environmental problems such as nutrient pollution, sedimentation, soil erosion, herbicide and pesticide contamination. We plan to explore new ways to grow our fish and produce that will allow us to increase production per square foot, and reduce operational costs. We also plan to explore the addition of new plants and animals to diversify revenue sources and increase overall system revenues. Each project activity can be completed within Silver Bay's existing \$1.5 million facility while providing continued research and education within the university system. The City is now developing the existing freshwater system into a commercial scale for private investment. If we can demonstrate the concept's economic potential, and a commitment to continued public research, the private sector will duplicate these systems across Minnesota.

### **III. PROJECT STATUS UPDATES:**

**Project Status as of:** 12/31/14

**Project Status as of:** 6/30/15

**Project Status as of:** 12/31/15

### **Overall Project Outcomes and Results:**

### **IV. PROJECT ACTIVITIES AND OUTCOMES:**

#### **ACTIVITY 1: Introducing New Species**

##### **Description:**

The total biomass of fish in our system determines feed input hence nutrient availability. Fish biomass is ultimately limited by Oxygen availability. Therefore, plant production will ultimately be limited by the nutrients supplied by the fish. However, economic revenues depend on the relative amounts of the different types of plants (different growth rates, nutrient demands and market prices) growing in our system. So, we plan to explore the growth and economic potential of a variety of new plant species. Tomatoes, Peppers, Strawberries, Kale, Sprouts and Mushrooms currently top our list as high potential species to explore, others will likely surface as we progress on this front.

Tomatoes will be grown two different ways. The first approach will utilize long stretches of PVC piping with two-inch holes drilled every 12 inches to hold the two-inch plastic cups containing the tomato plants. Each length of PVC will be periodically flushed with system water by pumping from trough through pipe back into trough. This will ensure the roots are constantly exposed to new nutrient rich system water from our plant production troughs. Second, tomato plants will be placed in larger 4 inch grow pots and placed in containers containing expanded shale. The shale filled container will be intermittently saturated with nutrient rich system water by a single pump (placed in production trough) running on a timer, and the water will then drain by gravity back into the production troughs. In both cases, tomato plants will be supported by vertical ropes hanging from the greenhouse rafters. Pepper and Strawberry plants will be grown in the same manner as the first approach described above for tomatoes. Kale will be grown using the same raft approach currently used for our lettuce.

Sprouts will be grown in the dark using a set of vertically stacked trays that allow nutrient rich system water to spill down over them. Finally, mushrooms will be grown by adding spores to plastic bags containing sterilized wood chips. These bags will be stored in a warm damp place under our fish production tanks until mushrooms are ready for harvest. Other species and variations of these methods will also be attempted until we arrive at a reliable and economically viable method for each species.

For each new plant species we will determine growth rate per unit area, marketability and price (including the effects of seasonality) to begin to compare different species based on their revenue generation potential per square foot. In addition to improving revenue generation potential per square foot, we will also increase the variety of the food produced in our system.

**Summary Budget Information for Activity 1:**

**ENRTF Budget: \$ 66,000**

**Amount Spent: \$ 0**

**Balance: \$66,000**

**Activity Completion Date:** June 30<sup>th</sup> 2016

<b>Outcome</b>	<b>Completion Date</b>	<b>Budget</b>
<b>1. Determine plant species growth rates/unit area</b>	June 30 <sup>th</sup> , 2015	\$40,000
<b>2. Determine plant species production, price and marketability</b>	Dec 30 <sup>th</sup> , 2015	\$16,000
<b>3. Determine plant species revenue generation potential</b>	June 30 <sup>th</sup> 2016	\$10,000

**Activity Status as of:** 12/31/14

**Activity Status as of:** 6/30/15

**Activity Status as of:** 12/31/15

**Final Report Summary:**

**ACTIVITY 2: Exploring New Growth Methods**

**Description:**

Currently we are growing our fish in tanks, and our produce (lettuce and basil) in rafts floating on the surface of shallow troughs (6 inches deep) in our greenhouse. We have four 16 x 48 foot troughs. This is enough surface area for approximately 600 heads of lettuce and 40 lbs of basil per week. We are planning to explore two new vertical growing methods and compare the results with our conventional 'raft' approach. These new vertical methods have the potential to support up to four times the production per square foot while lowering operational costs (labor, heating and electricity), and allowing us to move our fish out to the troughs.

Vertical columns will be made using standard 1.5 inch PVC piping suspended from the greenhouse rafters above the plant production troughs. Two elbows will be placed opposite one another every 6 inches up the 6-foot vertical pipe to hold plastic plant cups. Water will be intermittently pumped through these vertical columns (in on top and out through bottom) in a manner that keeps the plant roots bathed in the nutrient rich fish wastewater within the vertical column. We will also construct long lengths of standard 2 inch PVC pipe with 1.5 inch holes drilled in top side of pipe every 12 inches. These PVC pipes will be hung (at a slight grade) from the rafters above the troughs, and water will be intermittently pumped through them to keep plant roots submerged inside the piping. The water from both the vertical and horizontal piping will drain directly back into the trough beneath them.

We plan to compare the density, growth rates and relative health of a variety of plants (lettuce, basil, Kale, strawberries, peppers) grown in the PVC piping described above with our plants currently growing on the floating rafts. We will construct the columns and repeat the comparisons numerous times (to capture any

seasonality affects) with a wide variety of plants. In addition, we plan to estimate the potential revenue increases and capital cost reductions associated with these new potential plant-growing methodologies.

Finally, if the plants grow well in the vertical and horizontal PVC piping, and the floating rafts can be eliminated we plan to explore the possibility of moving our fish into a single greenhouse trough beneath the vertical/horizontal PVC columns. If the fish are as healthy, can be stocked as densely (without using up available Oxygen) and grow as quickly in these troughs, then we could eliminate a great deal of water along with the heating and pumping costs required. We could also significantly decrease the needed square footage of the building along with all the fish tanks and plumbing that connects them. This arrangement also opens the door to far cheaper heating and filtration options.

**Summary Budget Information for Activity 2:**

**ENRTF Budget: \$ 110,000**  
**Amount Spent: \$ 0**  
**Balance: \$ 110,000**

**Activity Completion Date: 6/30/16**

<b>Outcome</b>	<b>Completion Date</b>	<b>Budget</b>
<b>1. Construct and test vertical and horizontal PVC columns</b>	12/31/14	\$30,000
<b>2. Determine density/plant growth rates/health using these columns</b>	6/30/15	\$20,000
<b>3. Compare plant density/growth rates/health with current 'raft' approach</b>	12/31/15	\$10,000
<b>4. Alter single trough (heat/filtration) to support fish growth</b>	12/31/15	\$20,000
<b>5. Determine fish density/growth rates/health in trough under columns</b>	6/30/16	\$10,000
<b>6. Compare with fish density/growth rates/health in current tanks</b>	6/30/16	\$10,000
<b>7. Estimate revenue gains/cost savings of new growth methods</b>	6/30/16	\$10,000

**Activity Status as of: 12/31/14**

**Activity Status as of: 6/30/15**

**Activity Status as of: 12/31/15**

**Final Report Summary:**

**V. DISSEMINATION:**

**Description:** Dissemination of project results will occur via a wide variety of methods. Project activities have and will continue to be widely reported in the regional media (TV, Newspaper, Radio etc...). Results will also be included in numerous presentations and tours to be scheduled over the next two years. Project results will be added to our project website ([www.victusfarms.org](http://www.victusfarms.org)). Finally, project results will be described in final reporting, journal publications and possibly a book on the subject.

**Status as of: 12/31/14**

**Status as of: 6/30/15**

**Status as of: 12/31/15**

**Final Report Summary:**

**VI. PROJECT BUDGET SUMMARY:**

**A. ENRTF Budget Overview:**

Budget Category	\$ Amount	Explanation
<b>UMD Contract:</b>		
Dr Mageau: UMD Assistant Professor -- .2 FTE	\$19,000	Coordinating all project work
Baylor Radtke: UMD Senior Research Assistant -- 1.4 FTE	\$60,000	Conducting project work
UMD Research Assistant: 1 FTE	\$31,000	Conducting project work
UMD Undergraduate Students: 1.2 FTE	\$24,000	Conducting project work
<b>Total Salaries</b>	<b>\$134,000</b>	
<b>Equipment, Tools and Supplies:</b>		
Fish Feed	\$9,000	Fuels all biological growth in production system
PVC Piping and Supports	\$5,500	For vertical and horizontal column construction
Water pumps:	\$3,500	Delivering water to columns and new trough
Hanging Materials:	\$2,000	For suspending PVC columns from rafters
Tools: (Table Saw, Drill etc...)	\$2,000	For all project construction
Seeds, Spores, Seedlings, animal cultures	\$3,000	For all new species inocula
<b>Total Equip, Tools and Supplies</b>	<b>\$25,000</b>	
<b>Printing:</b>	\$1,000	Data sheets, flyers, brochures, posters
<b>Travel:</b> UMD mileage	\$16,000	Daily Transport from Duluth (UMD) to Silver Bay
<b>Total UMD Contract</b>	<b>\$176,000</b>	
<b>TOTAL ENRTF BUDGET:</b>		<b>\$176,000</b>

**Explanation of Use of Classified Staff:** N/A

**Explanation of Capital Expenditures Greater Than \$5,000:** N/A

**Number of Full-time Equivalent (FTE) Directly Funded with this ENRTF Appropriation:** N/A

**Number of Full-time Equivalent (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:** 3.8 FTE

**B. Other Funds:**

Source of Funds	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
<b>Non-state</b>			
U of MN Grant and Aid	\$32,000	\$0	Salary, equipment and supplies
U of MN Duluth Start-up funds	\$12,000	\$0	Salary, equipment and supplies
<b>State</b>	\$	\$	
<b>TOTAL OTHER FUNDS:</b>	<b>\$</b>	<b>\$</b>	

**VII. PROJECT STRATEGY:**

**A. Project Partners:**

Lana Fralich, City Administrator, Silver Bay, MN will oversee project and reporting. Dr. Mageau, UMD Assistant Professor, and Baylor Radtke, UMD Researcher, will coordinate work with new species introductions and production system design changes for innovative new growth methodologies. Research assistants and students from UMD will help with all proposed activities as directed.

**B. Project Impact and Long-term Strategy:**

The City of Silver Bay has taken a non-conventional approach to economic development by being the developer. Typical municipalities wait for a business to come into their community, Silver Bay is creating the businesses that can co-locate within our 110 acre Eco-Industrial Park. In today’s tough economy, businesses are not willing to invest in the time and costs involved in proving a concept. If the public takes the role in this early project development, the private sector is more likely to invest in actual business thus forming a positive public-private partnership. However, by taking on the role as the developer it is important for our City to align itself with researchers, educators, and financial partners to help prove the concepts identified in order to entice the private investor. The long-term strategy is to build out the park, expand Victus Farms throughout the state, and secure the University educational system as the leader in this innovative project development. Each of the project activities identified in this proposal is an extension of the initial proven concept of a closed loop system using renewable energy sources and creating food and fuel for local consumption. Future funding needs will be important to continue fostering new ways to improve efficiencies, creating new concepts, and enhancing student and workforce development especially during these start up years. We expect that as the private sector expands these proven concepts, they will invest in research and development funds to the University in exchange for the knowledge obtained. This provides the private sector current University findings at an annual fixed cost.

**C. Spending History:**

<b>Funding Source</b>	<b>M.L. 2008 or FY09</b>	<b>M.L. 2009 or FY10</b>	<b>M.L. 2010 or FY11</b>	<b>M.L. 2011 or FY12-13</b>	<b>M.L. 2013 or FY14</b>
DEED				\$579,975	
IRRRB				\$300,000	
Legislature – Taconite Tax				\$299,975	
Lake County				\$50,000	
City of Silver Bay – in kind				\$87,310	
UMD – CLA				\$26,000	
U OF MN – NMSDP				\$10,000	
UMD – Strategic Initiative				\$3,000	
City of Silver Bay - cash				\$105,000	

**VIII. ACQUISITION/RESTORATION LIST:** N/A

**IX. VISUAL ELEMENT or MAP(S):** Block 4, Lot 1 is location of Victus Farms.

**X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET:** N/A

**XI. RESEARCH ADDENDUM:** N/A

**XII. REPORTING REQUIREMENTS:**

Periodic work plan status update reports will be submitted no later than 12/31/14, 6/30/15, and 12/31/15. A final report and associated products will be submitted between June 30 and August 15, 2016.

<b>Environment and Natural Resources Trust Fund</b>								
<b>M.L. 2014 Project Budget</b>								
<b>Project Title:</b> Expansion of Greenhouse Production								
<b>Legal Citation:</b> M.L. 2014, Chp. 226, Sec. 2, Subd. 06k								
<b>Project Manager:</b> Lana Fralich								
<b>Organization:</b> City of Silver Bay, MN								
<b>M.L. 2014 ENRTF Appropriation:</b> \$ 176,000								
<b>Project Length and Completion Date:</b> 2 Years, June 30th, 2016								
<b>Date of Report:</b> Jan 10th, 2014								



<b>ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET</b>	<b>Activity 1 Budget</b>	<b>Amount Spent</b>	<b>Activity 1 Balance</b>	<b>Activity 2 Budget</b>	<b>Amount Spent</b>	<b>Activity 2 Balance</b>	<b>TOTAL BUDGET</b>	<b>TOTAL BALANCE</b>
<b>BUDGET ITEM</b>	<b>Introducing new animals and plants</b>		<b>Exploring new growth methods</b>					
<b>UMD Contract:</b>								
Dr. Michael T. Mageau - UMD Assistant Professor - 10% FTE plus 44% fringe per year	\$7,500		\$7,500	\$11,500		\$11,500	\$19,000	\$19,000
Baylor Radtke - UMD Senior Research Assistant - 70% FTE plus 14% fringe per year	\$21,000		\$21,000	\$39,000		\$39,000	\$60,000	\$60,000
UMD Research Assistant - 50% FTE plus 14% fringe per year	\$10,500		\$10,500	\$20,500		\$20,500	\$31,000	\$31,000
UMD Undergraduate Students - 2,400 hrs @ \$10/hr	\$10,000		\$10,000	\$14,000		\$14,000	\$24,000	\$24,000
<b>Equipment, Tools, Supplies</b>								
Fish Feed (9,000 lbs @ \$1/lb)	\$3,500		\$3,500	\$5,500		\$5,500	\$9,000	\$9,000
PVC Piping and supports -- for construction of vertical and horizontal columns	\$1,000		\$1,000	\$4,500		\$4,500	\$5,500	\$5,500
Water Pumps -- for new trough design flows, and feeding water to new vertical/horizontal columns	\$1,500		\$1,500	\$2,000		\$2,000	\$3,500	\$3,500
Hanging materials -- ropes/chains, clips and fasteners for suspending PVC vertical and horizontal columns from the greenhouse rafters				\$2,000		\$2,000	\$2,000	\$2,000
Misc tools - table saw, drill, drill bits etc..	\$1,000		\$1,000	\$1,000		\$1,000	\$2,000	\$2,000
Seeds, spores, seedlings	\$2,500		\$2,500	\$500		\$500	\$3,000	\$3,000
<b>Printing:</b> Data Sheets, flyers, brochures, posters <i>(List types of printing costs anticipated.)</i>	\$500		\$500	\$500		\$500	\$1,000	\$1,000
<b>Travel expenses in Minnesota:</b> Dially Transport from Duluth (UMD) to Silver Bay	\$7,000		\$7,000	\$9,000		\$9,000	\$16,000	\$16,000
<b>COLUMN TOTAL</b>	<b>\$66,000</b>	<b>\$0</b>	<b>\$66,000</b>	<b>\$110,000</b>	<b>\$0</b>	<b>\$110,000</b>	<b>\$176,000</b>	<b>\$176,000</b>

**VICTUS FARMS, SILVER BAY, MN**  
**PROJECT TITLE: EXPANSION OF GREENHOUSE PRODUCTION**  
**LCCMR ENTRF ID #174-F**



*An 8600+ square foot facility designed to use woody biomass pellets to heat water for fish, produce, and algae production in a closed loop system, resulting in no waste.*

*Victus Farms, 120 Mensing Drive, Silver Bay, MN  
A partnership between the City of Silver Bay  
and the University of MN Duluth's CSCD*



*The photo to the left shows the inside of the greenhouse where lettuce, basil, and algae are being researched and produced in a raft style approach. LCCMR funding will be used to research a vertical system approach and expanding research into new plant species.*



*Currently, seedlings are started in cups and placed onto styrofoam rafts which allow plant roots to absorb the nutrient waters.*

*Tilapia, as shown to the right, is the fish species of choice to produce the nutrient wastewater source for the plants. They are currently grown separately inside the building, but research will help determine if they can be included directly in the troughs of the greenhouse. Results are to improve economic viability while maximizing and diversifying food production.*

