LAKE SUPERIOR
STATE UNIVERSITY

OFFICE OF THE PROVOST

APPLICATION FOR SABBATICAL LEAVE
(Refer to Section 15.4 of the Faculty Association Agreement)

I. Name Gregory Zimmerman Date 28 Oct 2012

Department Biology Ext. No. x2470

Home Address [redacted] Home Phone [redacted]

II. Application for leave during the following (*indicate semester and/or year*):

Fall ________ Spring 2013 Full Year ________

III. Number of years of faculty service (*minimum of 5 years required*) 17

IV. Tenure status (*tenure required*) Tenured Full Prof.

V. Semester or year of last sabbatical (*if applicable*) *N/A*
(*minimum of 5 years since last sabbatical required*)

VI. Title and description of sabbatical project (*attach pages as appropriate*). Include in the description a discussion of at least one of the following criteria: SEE ATTACHED

1. The strength of the relationship between a sabbatical leave proposal involving applied or theoretical research related to professional activities and the advancement of knowledge within disciplinary areas.

2. The strength of the relationship between a sabbatical leave proposal involving an external, professionally-related experience/study in a business, industrial, health care, scientific or educational setting and the improvement of instructional/professional activities at the University.

3. The strength of the relationship between a sabbatical leave proposal involving travel or advanced study and its yield in improving the quality of instruction at the University.

VII. Attach a statement agreeing to return to the University

Please return to the Office of the Provost.

Statement Agreeing to Return to the University

I attest that if awarded sabbatical for Spring Semester 2013, I will return to the University for the following academic year.

Gregory Zimmerman 28 Oct 2011

Weedy grasses for pellet fuel stock in Michigan's EUP

Application for Sabbatical
Submitted by Gregory Zimmerman for Spring Semester 2013

The proposed sabbatical is to extend my research in use of weedy grasses in the EUP as feed stock for making heating fuel pellets. This proposed work builds on 3 years of research I have completed in this area.

Prior work on this topic

I have been able to demonstrate the feasibility of using local weedy grasses including reed canary grass, Phragmites, and giant miscanthus for fuel. This initial phase of research was at the benchtop level, in which we produced 10s of pounds of pellets at a time. Reports of this research funded by Michigan Biomass Energy Office are attached, along with a poster from those projects. (It is interesting to note that the report comes up as the first item in a Google search of 'reed canary grass biofuel' and the poster comes up as the first item in a Google search of 'homegrown heating fuel.') I have also been collaborating with Bay Mills Community College on a USDA-funded project to look into practicality of growing switchgrass in the EUP for use as pellet fuel stock. Further research is required to move this idea toward practical implementation. Before people will get interested in grass-based fuel pellets, they will have to see that they can be made in quantities measured in tons, not just in pounds.

Benefits of Project

This work will advance knowledge in the development of this potentially important fuel source. The cost of propane continues to rise, pinching the household economies and profitability of farms. And all the while, weedy grasses are growing in profusion in the EUP (e.g, 1000s of acres of reed canary grass). These grasses could be used to make fuel pellets for heating. A home-grown fuel source would put these otherwise unusable grasses to work, help build our local economy by keeping money spent on fuel circulating locally, save energy costs, reduce dependence on outside sources of fuel and reduce greenhouse gas emissions. Grass pellets are cheaper and easier to make than wood pellets because, compared to wood, grasses are drier, easier to harvest, and easier to grind.

As an update to the work described in the attached reports, I have made one batch of pellets from Phragmites, an especially invasive species of wetlands in our region. If we could develop an economic use for Phragmites, the expenses of control efforts could be recovered by sale of the material for use in fuels. Also repeated harvesting of this weedy grass could also help control its spread.

Another potential source of feed stock is excess hay. In good haying years, our area produces many tons of excess hay. Shipping costs make it infeasible to ship to other areas that may need it, even if our hay met the quality requirements of users in other geographic areas (which it usually does not). Thus excess hay is either left unharvested, burned or left to rot. If excess hay could be used as a fuel stock, this unused resource could be made useful.

Project Objectives

I propose to use this sabbatical to answer two questions regarding production of heating fuel from grasses in the EUP, namely:

- how the pellet making process can be scaled up from benchtop to several-ton production level,
- how well excess hay and other grasses such as Phragmites work as pellet stock and whether they can be harvested in an appropriate way.

The new knowledge gained in this project will enhance my own professional development in this subject area, help position LSSU as a place students can come to work in this arena (more students are expressing interest in this topic for senior thesis work) and could help develop new economic activity in our area.

Such research would require full time attention over a one-semester time period. I am not able to devote the time required while teaching classes.

Project Deliverables

The deliverable will be a report, poster and powerpoint presentation on how to scale production up and what feed stocks are most feasible and effective. Target audience for the report would be potential producers and potential users of grass pellets.

Work plan and timeline

1.0 Harvest reed canary grass, phragmites, giant miscanthus, obtain 1-year old hay.

2.0 Design and test large through-put production process (i.e., 3 tons of pellets rather than the several pounds of pellets we have done so far). This phase of the study will be done in collaboration with Bay Mills Community College. The College has a larger pellet press than ours and is interested in pursuing this line of research. We would track labor requirements, problems we run into in the production process and how we resolve them, labor requirements, machine time and associated costs.

3.0 Investigate effect of various feedstocks (reed canary grass, Phragmites, giant miscanthus, on quality of pellets (bulk density, energy content, fines content, ash content). Also investigate the response of Phragmites to defoliation (i.e., role pellet production could play in controlling this weedy species).

4.0 Develop external project reports for intended audiences, power point presentation, poster.

5.0 Write LSSU Sabbatical Report

	Oct 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013
1.0 Harvest	xxxx				
2.0 Design and test		xxxx	xxxx	xxxx	x

3.0 Pellet analysis	xx	xxxx	xx
4.0 External Reports		xx	xx
5.0 Sabbatical Report			xx

A Test of Reed Canary Grass as a Pellet Fuel Stock in Michigan's Eastern Upper Peninsula

By Gregory Zimmerman, Dept of Biology, Lake Superior State University

A report to Michigan Department of Energy and Economic Growth, Biomass Energy Office from Grant PLA 09-36 "Production and Use of Reed Canary Grass as a Biomass Heating Fuel"

DATE: 28 August 2009

Based on the increasing interest in alternative energy sources, we have recently looked at the potential for using reed canary grass as a source of heating fuel. Reed canary grass is an abundant, non-native species in Michigan's Eastern Upper Peninsula (EUP). Widely considered a nuisance species, it is not preferred forage for livestock nor is it preferred by wildlife. It is, however, being used as a heating fuel in Scandinavia and tests of this grass species are ongoing at Cornell University as well as in Canada.

In a recent previous project, we examined the energetics of using reed canary grass for use as a pellet fuel in Michigan's Eastern Upper Peninsula (EUP). The analysis was favorable. Specifically, given the energy content of reed canary grass (about 8000 BTU/lb – the same as wood or other plant material), the productivity (more than 1 ton/acre) and the fact that reed canary grass is a perennial naturalized to this area, we estimated that pelletized reed canary grass contains 32x the energy required to harvest and pelletize it. The latter point that it is a naturalized perennial simply means it requires no inputs of energy to grow it. It does not have to be planted, it requires no insecticides nor herbicides.

We then followed up that project with the present investigation in which we examined, at a small scale, the practicality of producing reed canary grass-based pellets and the burning of those pellets in a multi-fuel pellet stove. This project and the previous project were funded by Michigan's Department of Energy, Labor and Economic Growth's Biomass Energy Office as grants # PLA-07-48 and #PLA-09-36. Funds for these grants were made available to Michigan via US Department of Energy's State Energy Program

In this project, we harvested about ½ acre of reed canary grass from a field on Taylor Side Road, just south of Sault Sainte Marie, Michigan. This field appeared typical of the many fields of reed canary grass throughout the clay lake plain of eastern Chippewa County, Michigan. We harvested the material with a haybine in early November after the grass had gone dormant for the winter. We gathered the cut material by hand and stored it under a loafing shed roof (i.e., exposed to ambient temperatures but out of snow/rain) until the following March when we had procured the processing equipment. We did not dry it other than the natural air drying.

We ground the material to pass a ¼" screen, using a hammer mill obtained from PelletPros, Inc., a machinery dealer in Kewaunee, IL. The hammer mill (Model PP1000D, manufactured in China) included 15HP diesel motor. We did not meter fuel use, but it seemed minor (we processed the material we harvested in a few hours with less than a few gallons of fuel). For experimenting with binders, we also ground in the hammer mill corrugated cardboard we collected from used boxes, greyboard from food packages (e.g., cereal boxes), maple leaves and conifer needles collected from a yard in town. The cardboard and greyboard came out as fluff. We ground the few hundred pounds of grass in about 1-1/2 hours. The grinder emitted some fine material into the air. Nuisance dust masks (and of course eye and hearing protection) were needed for the operators. Besides the safety of the operators, the emission of fine particulates could represent an air pollution source and thus precautions should be taken to prevent their escape.

We then began to experiment with producing pellets, using a small pellet press, also obtained from PelletPros (Model PP-PTO, also manufactured in China). The press features a flat die with material driven through by rollers. The pellet press attached to the 3-pt hitch of a tractor and ran off of the PTO. We used a small Holder brand tractor, provided by LSSU's Physical Plant.

After trying various amounts of moisture and the binders, we came upon the two successful recipes listed below. With too much moisture, the material clogs up the press, with too little moisture, pellets do not stick together. Too much oil makes pellets that exude oil into the bag they are stored in. We were unable to create pellets using ground maple leaves and pine needles. We made some pellets from 100% cardboard and some from 100% brewer's grain, but the idea is to use the resource of reed canary grass.

The two successful recipes were:
1). 5 gallon bucket of uncompressed ground reed canary grass (about 2.3 kg), 1.5 L of ground corrugated cardboard, 200 mL of used frier oil, 400 mL of water
2). 5 gallon bucket of uncompressed, ground reed canary grass (about 2.3 kg), 800 mL of wet, spent brewer's grain.

We stirred the ingredients in a larger tub by using a paint stirrer inserted in the chuck of an electric hand drill. We stirred the ingredients until they were evenly distributed (two to three minutes). A grinding method for the cardboard that didn't leave it so fluffy would improve the mixing process but we have not experimented with any other grinding method.

The material was then run through the pellet press. We experimented with various PTO speeds and found that the rated 540RPM provided the heat needed to form the pellets. Pellets formed at lower speeds were not as firm and the pellets were produced slowly. After about 15 min of running at 540RPM, the material warmed to a point of emitting water vapor and firm pellets were formed. We let the pellets cool to ambient temperature (about 20 minutes) in a shallow layer of pellets in the bottom of a bucket that we used to catch them from the press. We then placed the pellets in plastic bags for later test combustion in the stove.

The tractor was not especially loud, but hearing protection (and of course eye protection) is still recommended. The process did not eject fines into the air, so a nuisance dust mask was not necessary.

Pelletizing compacted the material to about 1/5th its original volume to a density of approximately 0.60 g/mL for recipe 1 and 0.55g/mL for recipe 2. Our pellets are slightly lighter than the standard of 0.64 g/mL (40 lbs per cubic foot) for hardwood pellets as set by the Pellet Fuel Institute. Thus our pellets would require slightly more storage space and more frequent filling of a user's stove.

Once we got the recipes established, we were able to make a recipe's worth of pellets in 10 minutes (after the pellet press ran for 15 minutes to reach optimal temperature). This time frame reflects production of test runs – a full production run of several pounds of material would likely go faster but we have not yet tried to make a production run of, say, 50 lbs of material.

We then tested the pellets in a multi-fuel stove (Quadrafire Mt Vernon) we purchased from a local dealer. We mounted the stove on a small utility trailer to make it portable for demonstration purposes. We bolted the stove to the trailer bed and installed a short (ca. 4') wall behind the stove and mounted the computerized thermostat on the wall. We passed a stove pipe from the stove, through the wall and up past the wall.

Both types of pellets fed well and burned well. In running the stove continuously for up to 2 hours at a time, we encountered no clinkers in the ash. The two hour time simply reflects an amount of time that the demo ran at the farmer's market. The stove seemed to produce what seemed like a good heat output within about 45 minutes. In an actual home installation, it would cycle off and on under control of the thermostat. We set the thermostat to a 10 degrees above the outside temperature so that observers would see the pellets burning.

We tested both pellets with the automated ignition feature of the stove which requires that the stove be plugged into an 100v AC power outlet. We also tested them with the stove running on a 12v battery, which required manual ignition (we used a blow-torch). The pellets lit readily with both methods of ignition.

We will be starting another project in which we will test other proportions of the above binders and to compare reed canary grass to switchgrass as a base stock for pelletizing and to test heat output of the stove, ash production and ash composition of reed canary grass pellets, switchgrass pellets and wood pellets. Characterizing emissions of particulates from the stove (as well as prevention of emissions of fine particulate matter during grinding) would be another area that should be investigated.

The production process described here is for lab-benchtop scale experimentation. The information would also be useful for an individual making pellets for his/her own use. According to our previous project, 3 tons of reed canary grass pellets would yield a BTU content equivalent to 800 gal of propane. For someone who already has hay harvest equipment and with reed canary grass on his/her property, we would expect a substantial savings in heating fuel.

This technology also has broader commercial potential for local industrial development. Based on the results of this project we are encouraged about the commercial potential. Commercialization will, however, require investigating larger capacity mixing and pelletizing.

We are presently looking into various business models and opportunities for commercialization. Broad scale adoption of pellet fuels, wood and/or reed canary grass, could be beneficial in terms of reduced carbon emission compared to use of fossil fuels and reduces reliance on foreign energy sources.

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Professional Experience:

1995 to present:

Faculty, Dept of Biology, Lake Superior State University, Sault Sainte Marie, Michigan
Hired as Assistant Professor, Fall 1995
Tenured and promoted to Associate Professor Spring 2000
Elected to Department Chair, Fall 2000 to Summer 2008.
Promoted to Professor Spring 2008, Effective Fall 2008
Named Department Head, Fall 2008 through Fall 2009

Regularly teach Ecology, Field Botany, Biostatistics, Epidemiology, Plant Ecology.

Consistently supervise 2 or 3 senior thesis projects per semester, provide statistical consulting for several other senior thesis students. Regularly accompany students to regional scientific meetings.

Initiated and managed a week-long residential ecology field camp for high school youth beginning in 2005, continuing to present. From 2000, I have assisted summer science day camps for area 3-6 grade youth.

Helped initiate and provided field instruction for the annual Ecology and Culture Program for students of University of Shiga Prefecture. 1999- to present.

Coordinated LSSU's programming at Vermilion Station from 2000 to 2007. Worked with a major donor and former owner, Little Traverse Conservancy (present owner), and university faculty regarding site planning and LSSU's use of the site.

2000 to present:

Consulting Epidemiologist, Algoma Public Health, Sault Sainte Marie, Ontario. Work with the public health nurses and environmental health inspectors to produce community health status reports and advise program staff on evaluations of their projects.

Academic Credentials:

2, week-long courses (Community Based Participatory Research and Multi-level analysis), summer 2008 and 2, week-long courses (Cancer Epi and Logistic Regression), summer 2000, Summer Graduate Session in Epidemiology, University of Michigan, 2000.

Graduate course work in epidemiology and pathology, Colorado State University 1995

PhD Ecology 1986 Colorado State University

MS Biology 1983 North Dakota State University (coursework completed 1979), Fargo, ND

MS Statistics 1981 Oklahoma State University, Stillwater, Oklahoma.

BS Botany 1977 Ft. Hays State University, Hays, Kansas.

Current and recently funded projects

Grass-based pellet fuel production in Eastern Chippewa County. 2010-2012. Funded by USDA to Bay Mills Community College, Lake Superior State Univ and Michigan State University Experiment Station. Assessment of growth potential of switchgrass and reed canary grass as pellet fuel stock in EUP. Funding available for one LSSU student in this project.

Mitigation Wetland Monitoring 2009-2010. Contract with land owner to monitor a mitigation wetland for compliance with regulations. One student per year was hired on this project.

Michigan Math and Science Teacher Leader Collaborative. 2007-2009. Funded by Michigan Dept of Ed. This project is a collaborative managed by U of Michigan, Saginaw Valley SU, and Grand Valley SU to oversee work with Math and Science Centers, middle schools and other universities across the state.

Building an energy conservation partnership in Sault Sainte Marie Michigan. 2008-9. $18,000 funded by Energy Program, MI Dept of Labor and Economic Growth. Work with community members to build a partnership of building owners in business and public sector to examine energy conservation strategies and to facilitate energy audits and share results across the community.

Potential of reed canary grass as a biofuel in the Eastern UP. 2007-2009. Funded by Michigan Biofuels Inititiave, Biofuel Program, MI Dept of Labor and Economic Growth. G.Zimmerman, PI. This project examined yield and energy content of a weedy grass species common in the EUP as a potential pellet fuel along with making and burning such pellets.

Delisting criteria for fish and wildlife-related beneficial use impairments on the St. Marys River. 2007-2008. $22,000, funded by Great Lakes Commission. G. Zimmerman, PI, A Moerke, M Ripley, Co-investigators. This project worked with agencies and stakeholders to identify delisting criteria for particular beneficial use impairments responsible for the listing of the St. Marys River as an Area of Concern.

Groundwater Stewardship for agricultural producers in Chippewa, Luce and Mackinac Counties. 2003 – 2006, renewed for 2007-2009. $27,000 per year, funded by Michigan Dept of Agriculture. G. Zimmerman, Project Director. This project involves work with local farmers to identify and remediate threats to quality of groundwater in the three county area.

Binational Public Advisory Council for the St. Marys River Area of Concern. 1999 to present. Various grants averaging $3000 per year funded by the Great Lakes Commission to provide logistical and office support for the citizen's advisory group for clean up of the St Marys River.

Scoping Contaminated Sediments on the St. Marys River. 2004-2006. $30,000 funded by USEPA-GLNPO.A public outreach project informing residents of the issues involved with contaminated sediments and gaining stakeholder input on addressing the problems. G Zimmerman PI.

Integrity of a wetland on a local military base. 2005-2006. $20,000. Funded by Mich Dept of Mil Affairs. G. Zimmerman, PI.

Ecological Integrity of Coastal Wetlands on the St. Marys River. 2004-2007. $750,000 funding to LSSU by the US EPA. Marshall Werner, PI; G. Zimmerman, Co-Investigator. I supervised the collection of the plant data by one student

Assessing ecological condition of an industrial waste site 1997 and 2003-4. .$12,000 Funded by Dow Chemical Company. G. Zimmerman, PI. This work constituted two separate projects assessing the ecological condition of the lime piles, a local waste site.

Northern Ontario Herbaria Database. 2003-2005. Funded by Ontario Living Legacy Trust to Algoma University College. LSSU's portion: $5,000. G. Zimmerman, Collaborator.

Ecological effects of intensive silviculture in a boreal forest. 2002-2003 and 2008. Funded by Ontario Living Legacy Trust to Ontario Forest Research Institute. F. Wayne Bell, PI. LSSU's portion $9000. G. Zimmerman, collaborator.

Recent Scientific Presentations

N Wheeler and G Zimmerman 2011. Forest Composition of Select Sites 32 Years After a Large Fire, Seney National Wildlife Refuge, Michigan. Michigan Academy of Sciences, March 2011

G. Zimmerman 2008. Building stakeholder relations for environmental restoration in the Laurentian Great Lakes. Presented to Special Symposium on Sustainability. Univerisity of Shiga Prefecture, Hikone Japan, November 2008

G. Zimmerman 2008 Canopy tree communities across a disturbance gradient in Michigan's Upper Peninsula.. Michigan Academy of Sciences Annual Meeting.

G.Zimmerman.2007 St. Marys River coastal wetland plant communities. Michigan Academy of Sciences Annual Meeting

L Fera and G. Zimmerman. 2006. The effect of HMG-CoA reductase inhibitors (statins) on ubiquinone levels: A meta-analysis. Northern Ontario Medical Research Conference, Sault Ontario.

Recent Publications

Zimmerman, G, FW Bell, JWoodcock, A Palmer, and J Paloniemi. 2011. Response of breeding songbirds to vegetation management in conifer plantations established in boreal mixedwoods. Forestry Chronicles 87: 217-224.

Riley, M, B Arbic and G Zimmerman. 2011. Environmental history of the St. Marys River. Journal of Great Lakes Research 37, Supplement 2: 5-11

Vanderburg, S, LWright, S Boston, G Zimmerman. 2010. Maternal Child Home Visiting Program Improves Nursing Practice for Screening of Woman Abuse. Public Health Nursing 27: 347–352.

Ciaschini PM, SE Straus, LR Dolovich, RA Goeree, KM Leung, CR Woods, GM Zimmerman, SR Majumdar, S Spadafora1, LA Feral, and HN Lee. 2010. Community based intervention to optimize osteoporosis management: randomized controlled trial BMC Geriatrics 10:60

Ciaschini PM, SE Straus, LR Dolovich, RA Goeree, KM Leung, CR Woods, GM Zimmerman, SR Majumdar, S Spadafora1, LA Feral, and HN Lee. 2009. Community-based intervention to optimise falls risk management: a randomised controlled trial. Age and Ageing 8: 724-730

Ciaschini PM, SE Straus, LR Dolovich, RA Goeree, KM Leung, CR Woods, GM Zimmerman, SR Majumdar, S Spadafora1, LA Feral, and HN Lee. 2008. Community-based randomised controlled trial evaluating falls and osteoporosis risk management strategies. Trials 2008, 9:62

Recent Community Service

Chair, 2011-12 Binational Public Advisory Council, St Marys River Area of Concern
Commissioner, EUP Regional Planning and Development Commission 2008-present
Member, Regional Economic Development Advisory Committee 2009-present
Resource Professional assisting Sault High Envirothon Team 2010-11
Steering Committee Member: Sault Area Resource Management and Sprawl Avoidance Initiative 2008-present
Active Volunteer Award, City of Sault Sainte Marie Economic Development Group
Frequently give talks to classes in area K-12 schools, often with university students assisting
Ongoing assistance to Chippewa/East Mackinac Conservation District programs

Potential of Reed Canary Grass as a Biofuel in Michigan's Eastern Upper Peninsula

Report for Grant PLA-07-48

Gregory Zimmerman, Lake Superior State University, Sault Sainte Marie, MI
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Introduction

Biofuels represent a potential means to reduce carbon emissions, reduce dependency on increasingly expensive fossil fuels, and provide jobs for the local economy. Biofuels can be used as feedstock for production of liquid fuels or for solid fuel for direct combustion for heating. This project examined the potential of reed canary grass, a cool-season, perennial grass, as a pellet fuel for heating.

Perennial grasses are good candidates for biofuels since they do not have to be planted every year, nor do they require application of agricultural chemicals. Since the crop value for bioenergy use is the carbohydrates, not the protein, the grasses can be harvested after they die back in the fall, and thus after the nitrogen and other nutrients have been translocated back into the roots and crowns. This late harvesting means that the nutrients stay in the perennial parts of the plants which in turn means that the crop does not need high levels of fertilization each year.

Grass biofuels can be harvested conventionally. In other words, growers would not have to purchase new harvesting equipment. While grass bales could be burned in large appliances such as boilers, for convenience and efficiency of handling, the grasses would typically be pelletized. Wood pellets are becoming a popular fuel for stoves, thus grass pellets represent a familiar technology. But compared to wood pellets, grass pellets have a relatively high ash content and must be burned in a stove capable of handling the ash (such as a corn stove).

Because they don't need to be planted, sprayed or fertilized each year, the energy inputs to grow perennial grasses are substantially less than that of annual crops such as corn and soybeans. Also, perennial grasses can grow in land unsuitable for row-crop production and thus do not represent competition for the world's food supply. In addition, wildlife can use perennial grass fields throughout the spring and summer. The fall harvest would be after, for example, bird species have nested and fledged their young.

Reed canary grass (*Phalaris arundinacea*) may be an ideal biofuel source for Michigan's Eastern Upper Peninsula. It grows luxuriously in fields that are too wet for other uses and it is already abundant across the EUP. (It is not a native species to the EUP. It was widely planted during the 1930s and then expanded beyond its planted areas.) It thrives in wet fields, which are common in the EUP. Although it is highly productive, these naturalized strains of reed canary grass are not as good of forage as the other hay grasses, such as timothy, planted in the EUP. It is not considered a desirable grass for forage in the EUP and wildlife agencies consider it a nuisance species. Although wildlife such as sharp-tail grouse can use reed canary grass fields through the spring and summer, deer do not eat it in large quantities.

Reed canary grass is presently used as a pellet fuel in Scandinavia and is described as a potential pellet fuel source in biofuel research projects at Cornell University. Grass biofuel researchers across the United States are concentrating their efforts on switchgrass, a highly productive warm-season grass. The cold, wet climate and poorly drained clay soils of the EUP are not suitable for growing switchgrass, but reed canary grass grows abundantly in the EUP, often in large fields in which reed canary grass is practically the only species growing.

The objective of this project was to assess the energy yield (BTUs per acre) and ash content of reed canary grass on a range of sites in the EUP, and to assess the potential for reed canary grass pellets as a locally produced energy source and potential economic base. Specific questions were 1) the energy yield per acre 2) the ash content 3) whether the energy yield and ash content vary with mid and late fall harvesting 4) the cost comparison of reed canary grass to other fuels.

Methods

We selected six reed canary grass fields in Chippewa County (Table 1). To evaluate production, we harvested 20, ¼ m^2 (50 cm by 50 cm) plots in each field. Plots were systematically placed to encompass the length and width of the field. We harvested the plots on 16-23 October 2007 then again during the week of 17-20 November 2007. We harvested the plots with grass shears, cutting the plants to a 3" stubble height. Harvested material was collected into paper bags, which were air dried in a lab at LSSU and weighed. We took a subsample of the air-dried material to obtain an oven-dried equivalence (oven dried at 60 C).

To obtain the energy content of the material, we ground oven-dried samples in a Wiley Mill to pass a 40-mesh screen then ran approximately 0.1 g samples through a Parr Microbomb Calorimeter. Energy content of the sample was corrected for fuse wire and acid content. Due to the consistency of the energy content values, we analyzed only two samples from each harvesting date for each field. Energy content in calories was then multiplied by the oven-dry proportion to get an energy content for air-dried material. This value was then multiplied by the air dried biomass to get an energy content per ¼ m^2 plot. These values were then converted to BTUs per acre.

Ash content was obtained from subsamples of the material placed in a muffle furnace using the loss-on-combustion method. A known mass of oven-dried material was fired at 500 C for 90 to 120 minutes then the residual ash weighed and ash content expressed on a percentage of air-dried mass. Due to the consistency of the ash values, we analyzed ash content on only 10 plots from each field for each harvest.

Data were analyzed by analysis of variance.

Results
The minimum yield on an air-dried basis was 1.5 tons/acre air on field 1 in the October harvest; the maximum yield was 2.5 tons/acre on field 2, also in the October harvest. Field 1 had a lower average harvest than the other fields (Figure 1). No consistent differences were observed between the October and November harvests.

Energy content per sample ranged from 4032 calories/gram to 4457 cal/g but no consistent differences were observed by field or harvesting date. The average energy content was 4298 cal/g with a 95% confidence interval of (4255, 4342) cal/g. The average energy content equates to 6958 BTU/lb, slightly less than the 8000 BTU/lb reported for grass pellets by Cornell University (www. grassbioenergy.org).

The resulting average energy yield per acre in the fields sampled in this study ranged from 22.08 MBTU/acre for field 1 to 32.05 MBTU/acre for field 2.

Ash content was consistently 6 to 9 percent with no consistent differences found by field or harvest date. The average ash content was 8% with a 95% confidence interval of (7.5, 8.3) percent ash.

Discussion
The calculated BTU per acre yields represent a maximum since these plots were harvested manually and all of the material was recovered. A typical mechanical harvesting of cutting, raking and baling would lose some amount of material. Even if the harvesting process captures only 80 percent of the material, the energy yield would still be 17 to 25 MBTUs per acre.

One measure of effectiveness of biofuels is the energy ratio – the amount of energy obtained from the fuel compared to the amount of energy required to obtain the fuel. According to two hay farmers in the EUP, under the conventional harvest described above, up to 4 gallons of diesel fuel could be required to harvest the reed canary grass, based on a one gallon/acre fuel consumption and four passes (cutting, raking, baling, moving the bale off the field). Each gallon of diesel fuel represents 130,500 BTUs. The energy efficiency of the harvested material is thus between 17/(4*0.1305) = 32.5 and 25/(4*.1305) = 47.9.

The energy efficiency of the final fuel product would depend on the yield and energy requirement for pelletizing and the efficiency of the stove used to burn the pellets. Reports indicate that pelletizing is an efficient process. The energy required to run the pelletizer is a small fraction of the energy in the grass (200 BTU/lb – www.reap.com). The process is also efficient in terms of the product produced (88% of the grass input is captured as pellets – www.cns-snc.ca/events/CCEO/graphics/ 2a_jannasch_paper.pdf). Pellet stoves are presently about 80% efficient, according to manufacturers' reports (e.g., www.pelletheat.org). Thus with 88% of the biomass energy made into the pellets, and energy yield of 97% compared to the energy required for pelletizing and 80% efficiency of combustion, the final energy yield would still be 11.5 to 17 MBTU/acre of heat produced in the stove, based on the average reed canary grass yield reported here. Our estimate of 30+ fold return on energy input is greater than the 14x roughly estimated by Cornell University (www.grassbioenergy.org).

Another final processing step would also have to be added to the finished product. To make the fuel convenient to use and to keep it dry, the pellets would have to be bagged. For example, wood pellets are generally sold in 40 lb bags. The bagging would add some small amount of energy requirement and cost to the final product.

For comparison, a home that presently requires 800 gal of propane for winter heating would require just over 4 tons of reed canary grass pellets, which represents 4 acres of reed canary grass at 1.5 ton/acre and including losses in the production process.

From an economic perspective, with diesel fuel approaching $5/gallon, the cost of fuel for conventional harvesting would be $20/acre. Other harvesting costs beyond just the fuel are difficult to determine. Machine wear and tear, depreciation, labor, and so on add production costs. Presently, hay is selling for about $100/ton, thus those other costs are the majority of the cost of hay production.

By comparison, wood pellets are presently selling for $200/ton, which, with a reported energy content of 8000 BTU/lb computes to $12.50/MBTU. Reed canary grass pellets would be economically competitive with wood pellets, and much lower cost than propane, the main heating source for rural applications. Propane is presently selling in the EUP for $2.50/gal, which equates to $27/MBTU. Even if the cost of pelletizing were extremely high, reed canary grass is very favorable economically to propane.

Whether from an energy or a cost standpoint, the efficiency would be much greater if the harvesting could be done in a single pass. By mowing and baling in a single pass (without raking), 2 passes through the field would be eliminated and the thus the harvesting costs halved. The three-pass harvest is for hay for animal feed which is harvested moist and needs to dry before baling. Reed canary grass to be used for biofuel would be harvested late in the fall when the standing stalks are senescent and thus already dry.

Also from an energetics and cost perspective, transportation of the reed canary grass bales and the resulting fuel pellets should be minimized. Efficiency would be maximized if the pelletizer were centrally located in the eastern UP, say in Dafter or, even better, a mobile pelletizer which would be moved from farm to farm. In either case, a group of farmers could create a co-operative to share the costs of the pelletizer. Pellets could then be marketed through the co-op to customers in the EUP.

Based on aerial images and idle hay acreage reported in the USDA's Agricultural Census for Chippewa County, we estimate that the EUP presently has several hundred acres presently in reed canary grass. These acres represent a substantial source of biofuel energy. More reed canary grass could be planted in just a part of the several thousands of acres of hay. By planning improved varieties of reed canary grass, yields could be increased, but that planting would add production costs and compete for food production. Also, as mentioned above, reed canary grass has an unfavorable reputation in the EUP thus landowners may prefer to use what's already there rather than bringing new fields into reed canary grass.

With escalating costs of shipping it may not be feasible to market reed canary grass pellets to distant markets. Thus the prospect of a large energy industry for the EUP based on reed canary grass pellets may not be realistic. But a localized fuel co-op could represent a significant economic advantage to the EUP by reducing fuel costs and thus production costs for farmers and businesses. Lower home heating costs add to farmers bottom line. Greenhouses, shops, animal facilities all need to be heated and if heated with a local energy source, could reduce their costs of production and keep farming economically feasible. Similarly, small business such as repair shops could remain in the black if they had access to lower cost heating. The pellets produced beyond what the co-op members needed could be sold to local customer and thus would represent an additional source of income for co-op members.

Reed canary grass thus represents an economic potential for the EUP both in terms of reducing fuel costs and providing another source of income for area farmers. A demonstration project is now required to show that the cost of producing and using the fuel is much less than propane and competitive with wood pellets.

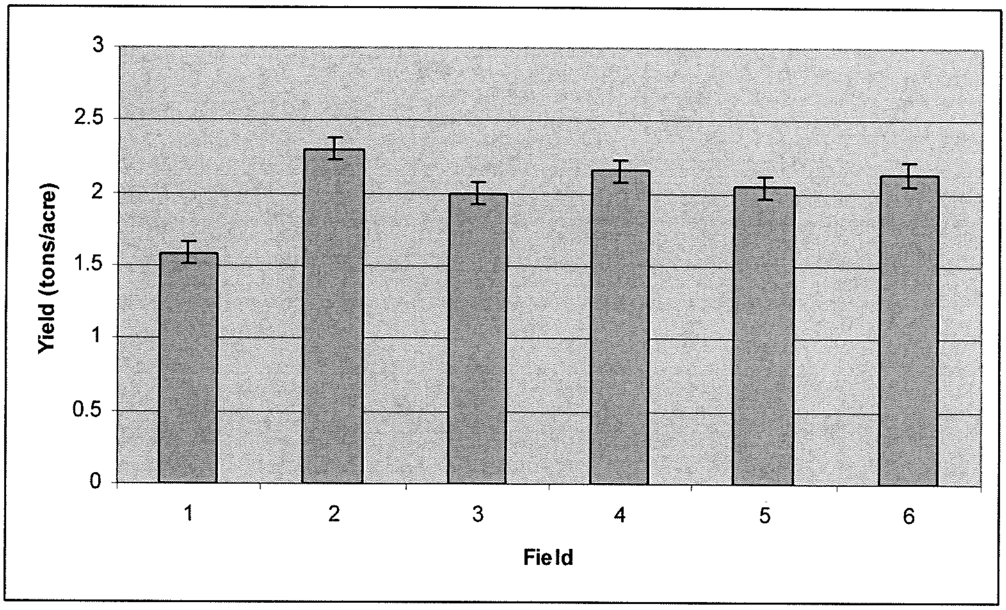

Figure 1. Average yield (both harvests) in six reed canary grass fields in Eastern Chippewa County, Michigan Fall 2008.

Table 1. Field locations for reed canary grass harvest, fall 2008.

Field	Site Name	Location Description
1	W 8 Mile	One mile S of 6 Mile Road on Taylor Side Rd, then ½ mi west on 7 Mile Road
2	E. 9 Mile Rd.	N side of 9 Mile Road, E of Riverside Drive
3	Dafter Post Office	NW corner of intersection of Soo Line Road & Dafter Road: just N of Dafter Post Office parking lot.
4	Wilson Rd.	Across road from 10184 S. Wilson Road.
5	Country Road Greenhouse	1718 S M-129
6	Sterlingville	Pennington Road & Riverside Road