The Prairie Farm: An Experiment in Bioenergy Production, Landscape Restoration, and Ecological Sustainability

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Our Project Goal...

To develop a fresh, alternative approach to farming in the western corn belt by conducting farm-scale research to demonstrate how to make a sustained and earned living from restored natural grassland on converted cropland while protecting and enhancing the natural environment (multi-functional agriculture)
Multi-Functional Agriculture

“Farming produces not just food, fiber, and energy but also a host of societal benefits, including cleaner water, sequestered carbon, landscape amenities such as wetlands and wildlife habitat, and rural community employment”

Key Project Outcomes

• Seven-year project generated considerable hard data on the production, management, and marketing of biomass feedstock at the landscape scale to inform the nascent cellulosic biofuel industry.

• Abundant ecosystem services were recovered on low-input restored grassland creating a better balance between economics and environment than currently exists in high-input grain farming.
EcoSun Prairie Farms, Inc.

Est. April, 2007

South Dakota Non-Profit Corporation

IRS designated as 501 (c)(3) public charity
EcoSun Prairie Farms, Inc.
Prairie Farm Guiding Principles

• Restoration of drained wetlands to re-establish sub-irrigated conditions for high grass biomass and seed production
• Low input approach (less iron, fuel, biocides, etc.)
• Improved water retention and quality
• Greater atmospheric health through carbon sequestration
• Improved soil quality
Guiding Principles (ctd.)

• Use perennial, not annual, plants that are locally adapted and native

• Develop multiple income streams
Income Streams

**Present**
- Native grass hay/biofuel feedstock
- Native plant seed (upland and wetland)
- Specialty meats (e.g., grass-fed beef)
- Competitive research funding

**Future**
- Carbon credits
- Cellulosic biofuels
- Recreation (ecotourism, fee hunting)
Collaborating Organizations

• The Nature Conservancy ($100,000 in kind for seed)
• U. S. Fish and Wildlife Service ($150,000 cost-share for seed, fencing, wetland plugs)
• University of Minnesota (subcontract for biofuel feedstock research $30,000)
• Millborn Seed Co. (cost-share seed $15,000)
• Agricultural Research Service (staff support for economics analysis)
• POET (forage quality analysis for ethanol production)
• South Dakota State University (use of farm equipment and greenhouse space)
Re-establishing upland prairie across farmed landscapes

Subproject 1
Grass drilling in soybean stubble
Aerial spreading of seeds on snow
Seed harvest in virgin prairie
Mixed diversity planting
High diversity planting
Switchgrass seed
Big bluestem native hay
Prescribed fire
Mean Biomass at the Prairie Farm, 2010-2012

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Biomass (Mg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switchgrass</td>
<td>14</td>
</tr>
<tr>
<td>Prairie Cordgrass</td>
<td>12.5</td>
</tr>
<tr>
<td>Bluestem Mix</td>
<td>10.5</td>
</tr>
<tr>
<td>Warm &amp; Cool Mix</td>
<td>8.5</td>
</tr>
</tbody>
</table>
Biomass yield from planted mixtures and monocultures of native prairie vegetation across a heterogeneous farm landscape

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Findings from subproject 1

• Productive, native grassland valuable as seed, hay, and biofuel feedstock can be quickly and successfully established on retired cropland.

• Three-year average biomass yields ranged from 9.7-13.2 Mg/ha for the different mixtures planted.

• A strategic placement of monocultures and mixtures of species across the farm landscape offers a livable income and desired ecosystem services.
Re-vegetating wetlands across the landscape

Subproject 2
Construction of ditch plug
Berm reconstruction
After reconstruction
Planting cordgrass plugs
Planted Cordgrass
First-year cordgrass
Mature prairie cordgrass
Cordgrass plugging with tree planter
Prescribed burn in wetland
Haying in dry wetland
Growing *Spartina pectinata* in Previously Farmed Prairie Wetlands for Economic and Ecological Benefits

Cody J. Zilverberg · W. Carter Johnson · Arvid Boe · Vance Owens · David W. Archer · Craig Novotny · Malia Volke · Brett Werner

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**Abstract** Wetlands in the Prairie Pothole Region of the U.S. are threatened by continued drainage and conversion to cropland. Commercial incentives may increase wetland restoration in lieu of easements. Therefore, we evaluated two commercially available populations of prairie cordgrass (*Spartina pectinata* Link) by comparing two planting techniques and identifying zones of maximum plant vigor and biomass productivity. In the first experiment, plants were transplanted at 0.9- or 1.5-m spacing, and biomass no longer differed between treatments. Our economic analysis indicated establishment costs could be recovered with < 10 years of biomass and seed harvests. Because prairie cordgrass can be established using conventional techniques and provides positive net revenue, it should be considered for incorporation into...
Findings from subproject 2

• Wet soils limit planting options in wetlands; plugging was labor intensive but highly successful.

• Prairie cordgrass, a wetland obligate plant, yielded the highest biomass of all plantings.

• Restoring wetlands with native, economically valuable plants such as cordgrass produced the highest per acre farm income from seed and hay sales.
Grass-Fed Beef
Mortenson Ranch Heifers
Prairie-Raised Beef
EcoSun Prairie Farms
Brookings, SD
www.ecosunprairiefarms.org
Marketing grass-fed beef
Increasing biodiversity in switchgrass plantings

Subproject 3
Pairing experiments
---------------
Switchgrass and Canada Milkvetch (upper photo)

Big bluestem and shorter pairings (lower photo)
Findings from subproject 3: Increasing switchgrass biodiversity

- Reliance on switchgrass monocultures for biofuel feedstock may miss opportunities for higher biomass and more ecosystem services.
- Certain native species, such as little bluestem, prairie cordgrass, and cup plant out-produce switchgrass on more extreme sites in heterogeneous fields.
- Tailoring mixtures of plants including forbs (flowers) to soils where they are best adapted for growth increases whole field biomass and numbers of insect pollinators, butterflies, and wildlife.
Strategic use of native species on environmental gradients increases diversity and biomass relative to switchgrass monocultures

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\textbf{ABSTRACT}

Switchgrass (\textit{Panicum virgatum}) monocultures are a leading feedstock choice for producing cellulosic biofuels. However, in natural stands, switchgrass is only dominant in a narrow ecological niche of the Tallgrass Prairie. This suggests that strategically selected monocultures or binary mixtures of species,
“Grassonomics”
Payoff for landscape restoration
Grassland Products Sold in 2014

• Hay (summer and fall cut) ~ 400 tons
• Prairie-raised beef (retail and wholesale) ~ 5,000 pounds
• Native plant seed (switchgrass, cordgrass, sedge, wedgegrass) ~ 8,000 pounds
Ongoing conversion of grassland to cropland in the northern Great Plains, declining wildlife populations, and worsening soil and water quality prompted a South Dakota group to search for agricultural practices that would balance environmental concerns with farm economics. Thus was Dakota. Guaranteeing five years was important for EcoSun because of the investment required to restore prairie and the low yields obtained from perennial plants in the establishment year. Restoration efforts began in 2008 with establishment of 24 ha (60 ac) of switchgrass (\textit{Panicum virgatum}) monocultures harvested, the only income was from switchgrass seed. The next year, a small quantity of summer hay and native wetland plant seed was added. By year five, the farm was generating revenue from many different sources: seed harvested from three grass species planted in monocultures (switchgrass: 3,435
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David Archer
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Summary

• Seven-year project generated considerable hard data on the production, management, and marketing of biomass feedstock at the landscape scale to inform the nascent cellulosic biofuel industry.

• Abundant ecosystem services were recovered on low-input restored grassland creating a better balance between economics and environment than currently exists in high-input grain farming.
“I Am The Grass.......... Let Me Work”

Carl Sandburg “Grass” 1918
DOCUMENTARY FILM
Grass Roots: The Prairie Farm Story (40 minutes runtime). Available at:
http://www.thegrassrootsfilm.com/

POST-DOCTORAL RESEARCHERS
Chang Oh Hong and Cody Zilverberg.

GRADUATE STUDENTS & GRADUATE THESES
Teoh, K.H. 2015. Improving ecosystem services and yield of bioenergy feedstocks through
topographically matched polycultures. MS thesis. South Dakota State University, Brookings, SD.

Bourlouin, N. 2012. Private and public benefits of innovative mix crop systems intended for
biofuels production in eastern South Dakota. MS thesis. South Dakota State University, Brookings, SD.


Heimerl, R.K. 2011. Comparisons of soil within a till plain across contrasting land uses. MS
Thesis. South Dakota State University.

Vahyala, I.E. 2011. Soil structure changes in bioenergy crop management systems. Ph.D. Disserta-
tion, South Dakota State University. Brookings, SD.

Erickson, L. thesis in preparation.

UNDERGRADUATE STUDENT WORKERS
Erin Beck, Nathan Ulmer, Levi Waddell, Levi Ringquist, Michael Mulvey, Charles Brunel,
Seth Owens, Alan Mayet, and Ben Stout. The EcoSun Prairie Farm was also the central
subject of Erin Beck's undergraduate honors project, “EcoSun Prairie Farms in Retrospect:
Assessing a Sustainable Grass Farm Model” (May 2015).
FARM TOURS (SAMPLE OF THE MANY TOURS PROVIDED)

28 Aug. 2014. Farm tour with Jeff Oien, Tatanka Wetland Bank, Crooks, SD.
2 Aug. 2014. Farm tour with farmers from Willow Creek Farm, Heron Lake, Minnesota.
17 Oct. 2013. Farm tour with Dr. Craig Spencer and ecology class from Augustana College.
23 Sept. 2013. Farm tour with Dr. Carol Johnston and Wetland Ecology class from SDSU.
6 Sept. 2013. Farm tour with woman farmer’s group from Nebraska.
20 Oct. 2013. Agricultural economics class led by Dr. Mike Miller from SDSU.
26 July 2013. Focused field tour open to invited stakeholders.
24 June 2013. Farm tour with Dr. Craig Spencer and an ecology class from Augustana College.
2 Oct. 2012. Farm tour with Dr. Mike Miller and economics class from SDSU.
20 Sept. 2012. Grassland ecology class (OLLI organization) led by Dr. Larry Tieszen (EROS and Augustana College).
9 July 2012. Farm tour with Dr. Meghann Jarchow, USD.
2 May 2012. Farm tour with staff from non-point source program SD DENR.
10 Oct. 2011. Farm tour with staff from POET.
1 Aug. 2011. Farm tour with 20 students from Virginia Tech.
2 Nov. 2010. Farm tour with Chris Misar, Graduate Student, SDSU.
26 Oct. 2010. Farm tour with staff from Millborn Seed Co.
8 Oct. 2009. Farm tour with Jerry Wilson, writer, SD Magazine.
19 Aug. 2009. Farm tour with Todd Mortenson (SD rancher).
24 July 2009. Farm tour with Dr. Megann Jarcow, current faculty member and sustainability program director, University of South Dakota, Vermillion.
3 June 2009. Field tour with Dr. Laura Jackson, current Director of the Tall Grass Prairie Center, UNI. Cedar Falls, IA.
PEER-REVIEWED PUBLICATIONS


BOOK CHAPTERS


OTHER PUBLICATIONS
Brule, J. February 26, 2014. TEDx Brookings reinvents rural. Collegian. (Carter Johnson was one of the speakers of the first TEDx event in Brookings).
no author listed. 2011. Second Civitas (Honors) Lecture Features Ecologist. Augustana College Mirror (front page; Promoting lecture by C. Johnson as part of Civitas lecture series.


Central Regional Sun Grant Center Annual Meeting, 26-27 Mar., 2013. Chicago, IL.


Johnson, C. 2011-2015. Documentary film. “Grass Roots: The Prairie Farm Story,” Research sponsored by the Sun Grant Center is reviewed in this film. Showings of the film were given at McCrory Gardens Visitor and Education Center, Brookings, SD, September 15, 2011; to a food and nutrition class at SDSU (Dr. Shelly Brandenburger) on November 27, 2011, April 17, 2013, November 16, 2013, April 21, 2014, and spring 2015; at the Dakota Rural Action Annual Meeting, Dahl Art Center, Rapid City, September, 2011; at International Conference on Sustainability, SDSU, May 2011; at Honors Program Colloquium, SDSU, September 2011; at Peace and Justice State Convention, October 2011.


Johnson, C. 2011. Biofuel Feedstock Production at the Prairie Farm. Seminar, NRCS Plant Materials Center, Bismarck, ND.


Johnson, C. 2010. South Dakota’s Prairie Farm: An Experiment in Economic and Ecological Sustainability. Invited seminar, University of Northern Iowa (sponsored by UNI Tallgrass Prairie Center and the College of Natural Sciences/Humanities and Fine Arts). April, 2010.


POSTERS


**FINAL REPORTS**

Biofuel feedstock crops in sub-irrigated lowlands. 2014. Final report to the U.S. Department of Energy and North Central Regional Sun Grant Research Center.


**GRANTS RECEIVED**

Improving production, resilience, and biodiversity of perennial mixtures and monocultures as biofuel feedstocks across environmentally heterogeneous landscapes. North Central Regional Sun Grant Center through a grant provided by the US Department of Energy Bioenergy Technologies Office under award number DE-FG36-08GO88073. 2012-2015. Contracted to South Dakota State University.

Biofuel Feedstock Crops in Sub-Irrigated Lowlands. North Central Regional Sun Grant Center through a grant provided by the US Department of Energy Bioenergy Technologies Office under award number DE-FG36-08GO88073. July 1, 2010 - 30 Sept. 2013. Contracted to South Dakota State University.


Landscape Scale Lignocellulosic Biomass Production, Economics, and Environmental Quality. North Central Regional Sun Grant Center through a grant provided by the US Department of Energy Bioenergy Technologies Office under award number DE-FG36-08GO88073. 2008-2011. Contracted to South Dakota State University.

Prairie Restoration Philosophy

“Our goal must change from preserving nature as separate from humans to the more necessary task of remaking ourselves so that we might function as a part of nature. Some humans are at work at this fundamental challenge just now…”

R. Manning. “Grassland”
Prairie Restoration Philosophy

“There is, after all, the possibility of a richer future. That is the promise of grass .... The grass can live again. Unlike forest, it recovers rapidly, some of it in a matter of five or ten years. There is a possibility of resurrection in a real and physical sense.”

R. Manning. “Grassland”
“The most insane example of till farming occurred (and is still occurring) in our own Great Plains, where vast acreages of prairie grasses were plowed up and turned into a dust bowl. Had that land been left in grass, and had forage crops been improved to carry more animals per acre, this whole area would be thriving today instead of surviving as a huge no-man’s land of subsidized corn and soybeans dotted with decaying towns and farmsteads.”

Gene Logsdon  All Flesh is Grass