

A New Lease on Life for Marginal Farmland: Convergence of prairie restoration with biofuel production

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Abstract

The prairie ecosystem that occupied most of the North American continent has been mostly converted into agricultural farmland. The looming global scarcity of fossil fuels has spurred interest in producing ethanol from corn (*Zea mays*) but legitimate objections remain to the idea of supporting this vision. The purpose of this study was to initiate a prairie restoration on marginal soil of a 16.2-hectare farm in southeastern Minnesota and to determine which restoration procedure (only native grass species versus a mixture of grasses and forbs) was most effective for the establishment of prairie on the land that may yield biomass for biofuels. We planted 11.4Kg./ha of grasses on 4.7 ha and 0.70Kg./ha of forbs on 3.2 ha, in June 2007. An evaluation of species richness was conducted after 90 days in the five restored plots. The mean percent cover in the grass plots was 0.935, whereas the one in the grass-and-forbs plots was 0.944. A t-test with two independent samples complemented the computation of the diversity index and indicated that there was not a statistically significant difference in species diversity among the plots. This paper postulates a model of prairie rehabilitation in synergy with renewable energy production from native prairies. This could inspire agriculture in the Midwest of the United States to a vision of ecological restoration and sustainability.

Introduction

The fertile tallgrass prairie of North America stretched through 68 million hectares before European settlement (Smith 2001), and since then the development of large-scale agriculture, aided by mechanization and cheap fossil fuels, enhanced monoculture and an extirpation of prairies (Jackson 2002). Despite restoration efforts, a looming global scarcity of fossil fuels has spurred interest in renewable energy, especially ethanol from corn (*Zea mays*). However, legitimate objections remain to the idea of diverting significant quantities of corn into ethanol as corn remains a major food and thus increases in food prices could become inevitable. Its cultivation is best on fertile land and expanding its production to marginal soils may require ever-increasing off-farm inputs. The arguments sketched out above have recently been supported by the work of Tilman et al. (2006). They showed that low-input high-diversity (LIHD) mixtures of native grassland perennials are superior to corn or soybean in terms of usable energy, greenhouse gas reductions, and agrochemical pollution. Even though the study was conducted on small plots, its outcome inspired the authors to verify the applicability of these findings on a real-farm situation.

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Materials and methods

We have initiated a restoration effort in 2007 over a larger area in an effort to further validate the findings of Tilman et al. (2006), and to demonstrate the synergism that can exist between biofuel production and prairie restoration. The work consisted in restoring prairie on marginal soil of a 16.2-hectare farm in southeastern Minnesota to verify on a landscape scale how biomass production for biofuel can be combined with grass and restoration. Additionally, we intended to learn which restoration procedure (only native grass species, versus a mixture of grasses and forbs) was most effective for the establishment of prairie perennials on the land that may yield viable stalks to be pelletized and used, on-site, for heating purposes. The study area (Pork & Plants Farm) is located in the Whitewater watershed in Winona County, southeastern Minnesota, USA. To reduce reliance on the costly corn, 7.9 hectares were planted (4.7 ha of mixed grasses and 3.2 ha of mixed grasses and forbs) in June 2007 (Table 1).

Table1: Prairie plant species that were sown at Pork & Plants Farm.

Native grasses Scientific name	Pure live seed, kg	Native forbs Scientific name	Pure live seed, kg
Big Bluestem <i>Andropogon gerardii</i>	22.7	Long Head Coneflower <i>Ratibida columnifera</i>	0.3
Indian Grass <i>Sorghastrum nutans</i>	16.3	Maximilian Sunflower <i>Helianthus maximilianii</i>	0.3
Little Bluestem <i>Schizachyrium scoparium</i>	4.7	Partridge Pea <i>Chamaecrista fasciculata</i>	0.3
Side Oats Grama <i>Bouteloua curtipendula</i>	7.9	Black-eyed Susan <i>Rudbeckia hirta</i>	0.31
Blue Grama <i>Bouteloua hirsuta</i>	4.5	White Prairie Clover <i>Dalea candida</i>	0.42
Green Needle Grass <i>Stipa viridula</i>	9.0	Oxeye Sunflower <i>Heliopsis helianthoides</i>	0.42
Switch Grass <i>Panicum virgatum</i>	7.2	Purple Prairie Clover <i>Dalea purpurea</i>	0.25
Slender Wheatgrass <i>Agropyron trachycaulum</i>	9.0		
Virginia Wild Rye <i>Elymus canadensis</i>	9.0		
Total	90.8		2.3

With the above-mentioned mixes and hectareage, the plantings came down to an average of 11.4 kg./ha of grasses on 4.7 ha and 0.70 kg/ha of forbs on 3.2 ha, as recommended by the local soil and water conservation district office that donated the seed. An evaluation analysis of the vegetation in the five restored plots was conducted after 90 days (August 2007). Random quarter meter quadrats were used to assess plant cover (n=10), along a west-east transect of each of the five restored plots. Our interest focused primarily on measuring diversity (species richness) and plant cover (percentage) within the sampled areas. Species richness was evaluated by

considering the Margalef's index of diversity (diversity = $s-1/\log N$), where s is the number of species and N is the total number of individuals (Longino et al. 2002). Data collection occurred on August 25, 2007, when the plants had emerged from the soil (which had been disked prior to planting), and were already at a "rosette" stage. This allowed for an easy identification and measurement of the percent of plant cover in each sample quadrat.

Results

All five plots were uniformly covered by herbaceous vegetation and this included primarily unwanted weeds that infest corn crops. The mean percent cover in the grass plots was 0.935, whereas the one in the grass-and-forbs plots was 0.944. In the grass-only samples, we identified 2 prairie species, which occurred in 12 of the 30 samples (*S. scoparium* and *P. virgatum*). The mixed samples had a total of 4 prairie species in 11 of the 20 samples (*S. scoparium*, *P. virgatum*, *C. fasciculata*, *R. hirta*). A number of annual, early succession species were also found in all the samples. A count of the prairie plant species was accomplished in the 10 samples along each transect, for each plot. The mean number of prairie and nonprairie species and their respective Margalef's index are reported (Table 2). The Margalef's index of diversity may not be the best value to consider because it does not include the evenness of the individual plants' distribution in the system. Despite its limitations however, the Margalef's Index provided a preliminary indication that diversity (species richness) in the grass-and-forbs plots was slightly higher than in the grass-only plots (Table 2).

Table 2. Descriptive statistics and Margalef's Index of species richness for the grass and grass-and-forbs plots at Pork & Plants Farm in August 2007.

Sample number	Mean spp. # (grass plots)	Percent cover (grass plots)	Margalef's Index (grass plots)	Mean spp. # (grass & forbs)	Percent cover (grass & forbs)	Margalef's Index (grass & forbs)
1	1.0	0.92	0.5	6.0	0.96	5.0
2	2.0	0.95	0.5	4.0	0.95	1.5
3	2.0	0.95	1.0	5.0	0.92	2.5
4	3.0	0.94	1.0	6.0	0.92	2.5
5	3.0	0.98	1.0	4.0	0.96	1.5
6	4.0	0.96	1.5	7.0	0.94	3.5
7	3.0	0.90	1.0	3.0	0.94	1.5
8	3.0	0.93	0.5	4.0	0.94	1.5
9	4.0	0.91	1.5	4.0	0.95	3.5
10	1.0	0.91	0.5	7.0	0.96	3.5

A t -test with two independent samples complemented the computation of the diversity index and indicated that there was not a statistically significant difference in species diversity between the grass-only and the grass-and-forbs plots ($t = (48) = 1.76$, $p > 0.05$, two-tails).

Discussion and conclusion

The restoration effort at Pork & Plants Farm was limited in its first year as the vegetation may take a few more years (2–3) before it establishes a diverse community (Reichman 1987). The restoration technique (seed drilling) may be inexpensive and fast to accomplish but not as effective as transplanting seedlings that are capable of competing more aggressively against nonprairie plants. This is evident in that nonprairie species covered most of the surface in all the sample quadrats, indicating the challenge for the native seedlings to emerge when the soil might have had a conspicuous seed bank community of common agricultural weeds in place before the restoration took place. However, more research is needed in order to discover what specific prairie establishment might produce a specific prairie type (e.g., mainly grasses versus mainly forbs). Our effort demonstrates a feasible approach to a reestablishment of ecological services in our bioregion that is sustainable and supportive of organic farming practices. The pellets produced from the prairie plots that were restored at Pork & Plants Farm will be used as biofuel to heat one of the farm greenhouses. A pelletizer is a needed equipment to mince the dry biomass, at the end of the growing season. Questions concerning costs, social and environmental benefits, energy ratio, and carbon footprint remain unanswered at the moment. However, we remain convinced that prairie restoration has potential to reshape the design of farms and restore a sustainable agrarian culture in our bioregion. To this end, there is a need to educate farmers, ranchers, and landowners about these and similar opportunities. More important, there is a need to inspire students and educate them (Borsari and Vidrine 2005) to remediate the impacts of disturbance on the environment, which is inexorably caused by human activities. Thus, synergizing prairie restoration with biofuel production may become a promising model for the future of agriculture in the Midwest region of the United States and supportive of a vision of sustainability in modern agroecosystems.

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