ENVIRONMENTAL AND ECONOMIC RESEARCH AND DEVELOPMENT PROGRAM

Maximizing Ecological Services and Economic Returns by Targeted Establishment of Biomass Grasslands for Electricity and Heat Generation in Wisconsin

Executive Summary
April 2012

PREPARED BY:

M.E. DORNBUSH (PI)[1];
P.D. BAUMGART[1];
K.J. FERMANICH[1];
A.M. RIETH[3];
J.R. STOLL[2];
A.C. VON HADEN[3];
[1]DEPARTMENT NATURAL AND APPLIED SCIENCES,
[2]DEPARTMENT OF PUBLIC AND ENVIRONMENTAL AFFAIRS,
[3]ENVIRONMENTAL SCIENCE & POLICY GRADUATE PROGRAM,
UNIVERSITY OF WISCONSIN-GREEN BAY

focus on energy[sm]
Partnering with Wisconsin utilities

This report was funded through the Environmental and Economic Research and Development Program of Wisconsin's Focus on Energy.

Table of Contents:

Executive Summary:

Our objective was to evaluate the economic and environmental outcomes of converting poorly drained, marginal agricultural areas into perennial, biomass yielding grasslands for electricity and heat Generation in NE Wisconsin. We targeted poorly drained, marginal cropland for three main reasons. First, planting these areas into annual row crops is often delayed, prevented, or unprofitable in wet years. However, seasonal (spring) soil saturation is expected to maximize warm season grass production by providing ideal moisture availability during the more commonly water-limited summer. Second, the wetter conditions and finer textured soils (more clay) characterizing low-lying areas in NE Wisconsin should maximize carbon-sequestration rates. Establishing grasslands in these areas will also maximize carbon (C) sequestration per unit lost agricultural productivity for food or fiber. Third, establishing perennial grasslands in the low-lying areas juxtapositioned between agricultural uplands and aquatic systems will reduce nutrient and sediment loading into aquatic systems, thereby providing an additional ecological service for the same land conversion costs in NE Wisconsin. In combination, we predicted that the establishment of biomass production systems should be targeted at low-lying locations to maximize farm profitability, C-sequestration, and water quality benefits. We also reasoned that this targeted approach could benefit additionally from shared interest and cost-sharing with existing US Department of Agriculture (USDA)/Natural Resource Conservation Service (NRCS) conservation programs, as well as potential phosphorus (P) trading opportunities between point sources and agricultural sources within the Fox-Wolf basin through the on-going Lower Fox River (LFR) Total Maximum Daily Load (TMDL) being conducted by the Wisconsin Department of Natural Resources, the US Environmental Protection Agency, and local partners in NE Wisconsin.

We addressed our above points using three interdisciplinary objectives integrating environmental, economic, and political perspectives. Objective 1 was to quantify and compare harvestable aboveground grass biomass and crop-grain yield, associated harvestable P contents, and C and P sequestration in soil and perennial roots in established upland and lowland native-species grasslands and crop fields. Objective 2 was to model changes in erosion and stream water quality resulting from conversion of upland and lowland crop fields to native-species grasslands in NE Wisconsin watersheds. Objective 3 was to create an economic analysis of the combined value of harvestable aboveground production (biomass or grain yield) and ecological services (e.g., C- and P-sequestration and water quality changes) associated with converting upland and lowland crop fields into native-species grasslands for the LFR watershed. This study provides information critical for an informed discussion of the economic benefits and challenges associated with the implementation of biomass based energy production within NE Wisconsin.

Key findings of Objective 1: to quantify and compare harvestable aboveground grass biomass and crop yield, associated harvestable P contents, and C and P sequestration in soil and perennial belowground biomass in established upland and lowland native-species, biofuel grasslands and crop fields.

Grass biomass production potential in NE Wisconsin was competitive with values reported from the Midwest in general, while row crop production was notably lower. Grass biomass production was equal in both upland and lowland topographic positions, but production was notably reduced for row crops in low lying areas. Targeting marginal fields, defined as those containing a significant proportion of lowland, seasonally wet soils, appears a viable strategy from a pure production standpoint. Our results

support the use of graminoid-dominated, diverse plantings, and we suggest greater research into the potential of specific legume selection and inclusion to meet nitrogen demands. We found no significant effect of grassland establishment on soil carbon pools, likely due to naturally slow accumulation rates, the variable nature of soil C stocks, or the lack of baseline, pre-establishment data from our grassland and row crop study plots. Soil phosphorus pools appear to have been redistributed to greater depths within grassland systems than observed in row crop fields, potentially reducing the likelihood of erosional losses of phosphorus into water bodies once row crop fields are converted to perennial biofuel grasslands. The significantly larger, and perennial, live belowground biomass present in grassland systems represents a large, and highly predictable, sequestration pool for both carbon and phosphorus, benefiting both atmospheric carbon content and phosphorus-based water quality concerns.

Key findings of Objective 2: to model changes in erosion and stream water quality resulting from conversion of upland and lowland crop fields to biofuel grasslands in N.E. Wisconsin watersheds.

We used Soil and Water Assessment Tool (SWAT) and Geographic Information System (GIS) models to simulate several agriculture-to-energy crop scenarios in NE Wisconsin. The first two scenarios targeted converting crop fields with either the highest proportions of somewhat poorly to very poorly drained soils, or the highest proportions of poorly to very poorly drained soils, respectively. However, both scenarios included incidental areas with soils classified as somewhat poorly drained, poorly drained, and very poorly drained. Somewhat poorly drained soils are generally defined as those soils that are wet at shallow depths for significant portions of the growing season, to the point that mesophytic crop growth is often limited in the absence of artificial drainage. Poorly drained soils are wetter, and are defined as those soils that are wet at shallow depths for long periods of the growing season, generally preventing the growth of mesophytic crops in the absence of artificial drainage. Very poorly drained soils are those soils that retain free water at the soil surface for much of the growing season, largely excluding the growth of mesophytic crops in the absence of artificial drainage. The third scenario targeted the somewhat poorly drained crop fields that were previously characterized to have high P yields (65 percentile of simulated phosphorus yields from the Lower Fox River watershed). We estimated that converting a modest 7% of the current agricultural cropland to energy crops would result in phosphorus reductions ranging from 4.9% to 6.5% relative to baseline loads from agricultural sources. Somewhat greater reductions were estimated for total suspended solids, with reductions ranging from 6.4% to 8.3%. Targeting crop fields that were most likely to have high P yields resulted in the greatest estimated reduction in P and total suspended solids. While the overall declines in P and total suspended solid loadings are small in comparison to the Total Maximum Daily Load (TMDL) targets for the Lower Fox River (LFR), the reductions were effective on an area-weighted management change basis.

Key findings of Objective 3: to create an economic analysis of the combined value of harvestable aboveground production (biomass or grain yield) and ecological services (e.g., C- and P-sequestration and water quality changes) associated with converting upland and lowland crop fields into native-species grasslands for Brown Co, Wisconsin.

Farm-scale returns for marginal low lying fields in the LFR sub-basin that were managed following our modeled corn silage, corn grain, soybean rotation ranged from -$51.04 to $29.13 per acre, while non-subsidized biofuel grasses in the same locations had returns of $25.52 per acre. Under all modeled scenarios, biofuel grasslands offered a viable alternative crop for the Lower Fox River sub-basin, independent of subsidies. When potential subsidies were also considered, returns from planting biofuel grasslands increased by up to $100 per acre, making biofuel grasses very attractive. Regional economic impacts based upon local expenditures and revenues supported the benefits of seeking a Biomass Crop Assistance Program (BCAP) designation and the associated establishment of a pelletizing plant for the Lower Fox River (LFR) sub-basin. Impact analysis for Planning (IMPLAN) modeling suggested that implementation of these changes in concert with increased biofuel grassland production would create 46 direct jobs and generate close to $7.7 million in direct economic impact. Total economic output in the region, according to the regional impact analysis, is expected to increase by $10.1 million. However, overall employment is expected to decline, with 32 jobs lost in the region following a reduction in row crop acreage, as row crop agriculture is a more labor intensive activity than production via biofuel grasslands and pelletizing activities.

List of Abbreviations:

BCAP	**Biomass Crop Assistance Program**
C	**carbon**
CEC	**conventional energy crop scenario**
CLU	**Wisconsin DNR common land unit field boundary**
CPI	**consumer price index**
GBMSD	**Green Bay Metropolitan Sewerage District**
GIS	**Geographic Information System**
IMPLAN	**Impact Analysis for Planning Model**
LFR	**Lower Fox River**
P	**phosphorous**
PVP	**poorly to very poorly drained soils**
SVP	**somewhat to very poorly drained soils**
SVP-WQ	**somewhat to very poorly drained soils with high P yields**
SWAT	**Soil and Water Assessment Tool**
TMDL	**total maximum daily load**
TSS	**total suspended solids**