

**Economic Feasibility of Agricultural Land Conversion to Switchgrass in  
the Lower Fox River Watershed, Wisconsin**

by

**Anthony M. Rieth**

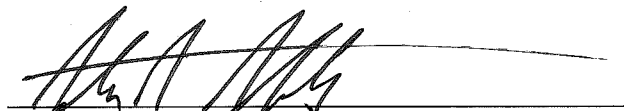
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## ABSTRACT

### ECONOMIC FEASIBILITY OF AGRICULTURAL LAND CONVERSION TO SWITCHGRASS IN THE LOWER FOX RIVER WATERSHED, WI

Anthony M. Rieth

Located in the four Northeastern counties of Brown, Calumet, Outagamie, and Winnebago, the Lower Fox River Watershed (LFR Watershed) extends from Lake Winnebago to the Bay of Green Bay. The most common land use in the watershed is agriculture, which helps contribute to the high phosphorus and total suspended solids loads that the Bay of Green Bay receives.

Corn, soybeans, alfalfa, and wheat dominate the major crop types in the LFR Watershed. Switchgrass is being investigated as a possible alternative crop in the LFR Watershed due to its ability to provide economic revenue to farmers while providing a myriad of environmental services for the watershed. Economic comparisons between traditional crops and switchgrass are sparse and generally geographically limited.

Lowland agricultural soils can be subjected to extended periods of water saturation, which can limit crop growth and affect crop yield. In Chapter 3 the economic comparison between a corn and soybean rotation and switchgrass on marginal lowland fields is investigated. Results indicate that both cropping patterns are profitable in the LFR Watershed, with a corn/soybean rotation generating an average profit of \$104.10 or \$133.73 per acre (depending on nutrient application type) per year and switchgrass generating an average profit of \$24.66 per acre per year.

Under an initial investigation, a corn and soybean rotation outcompetes switchgrass by \$80-\$110 per acre. However, switchgrass provides many environmental benefits, including reductions in phosphorus and total suspended solids runoff, sequestration of carbon, and provides habitat for animal species. Subsidy programs exist that recognize the importance of environmental benefits and increase the profitability of switchgrass. Some of the relevant programs in the LFR Watershed are described in Chapter 4 as well as the subsidy money that could be available. Most subsidy programs do not provide enough money to close the gap between switchgrass and traditional agriculture. However, the USDA administered Biomass Crop Assistance Program (BCAP) has the potential to help switchgrass profits exceed that of a corn and soybean rotation by \$20 to \$50 per acre per year.

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## **CHAPTER 1: INTRODUCTION**

### **1.1 Problem Statement**

Extending from the mouth of Lake Winnebago and flowing downstream to the Bay of Green Bay, the Lower Fox River Watershed (LFR Watershed) encompasses 411,194 acres (Baumgart, 2012) and is part of the larger Fox-Wolf Watershed Basin. (Figure 1) The LFR Watershed includes large portions of Brown County and Outagamie County as well as some of the land area in Calumet and Winnebago counties (Kousky, Olmstead, Walls, Stern, Macauley, 2011). A little over 11% of the state's population calls the four counties of Brown, Calumet, Outagamie, and Winnebago home (United States Census Bureau, n.d.).

Phosphorus (P) and Total Suspended Solids (TSS) levels in the LFR Watershed have been identified as excessive and are responsible for impairing local waterways, affecting ecosystem health, and negatively impacting activities practiced by individuals in the region. The main land use in the LFR Watershed is agriculturally related (50.2%). Agriculture has been identified as the largest contributor to P and TSS loading in the LFR Watershed at 45.7% and 65.7% of the total loads, respectively (The Cadmus Group, 2011, p. 32-33).

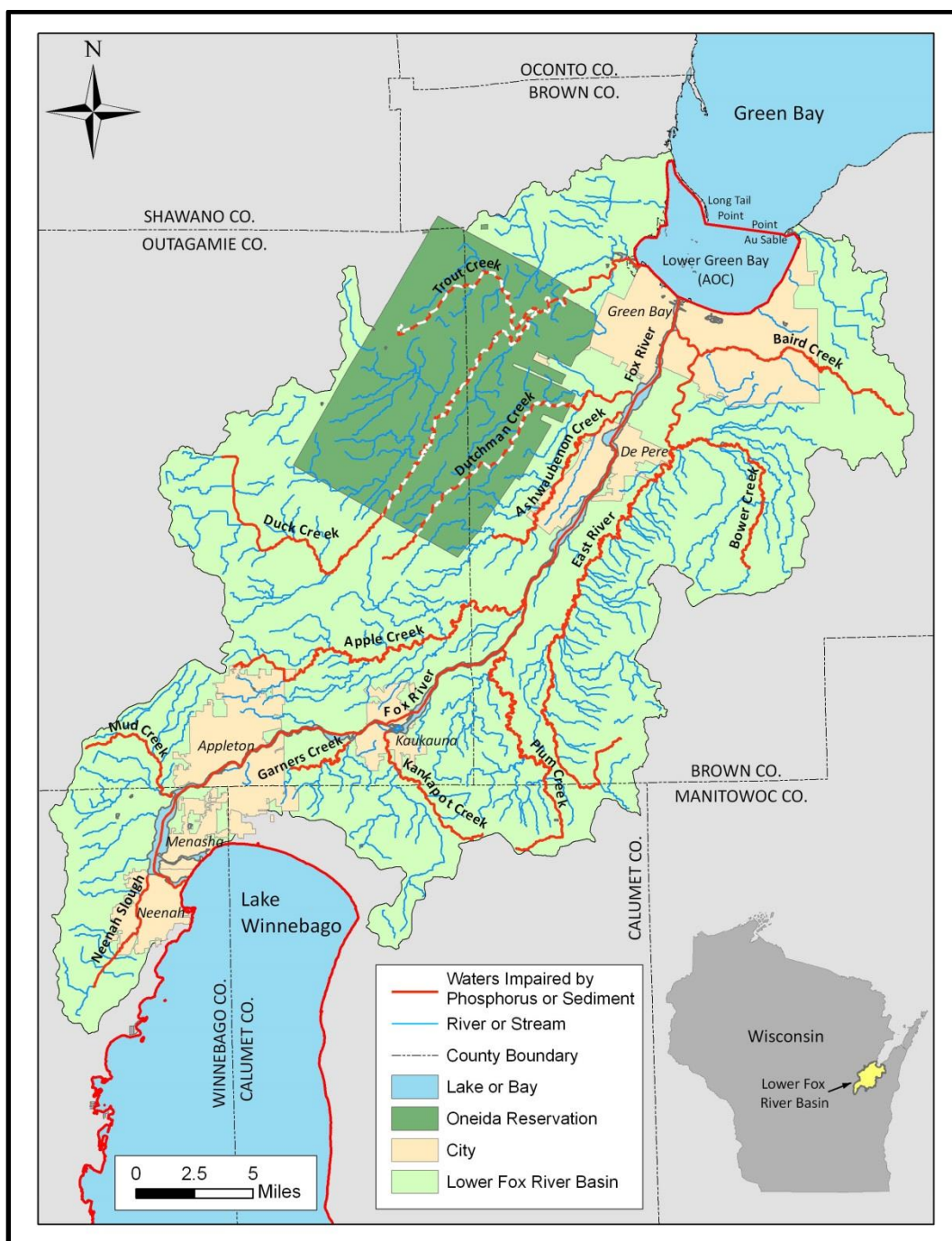


Figure 1. Map of Lower Fox River Watershed (The Cadmus Group, 2011)

The LFR watershed has had 27 segments listed on the state of Wisconsin's 303(d) Impaired Waters List due to phosphorus and/or sediment loading. A Total Maximum Daily Load (TMDL) is required for impaired waterways (The Cadmus Group, 2011, p. 8). A TMDL identifies pollutant contributors and their current pollutant contributions to a watershed, creates maximum loads for pollutants entering a waterway in the course of a year, and offers solutions to reduce contributions from each pollutant to the TMDL. In August of 2011, The Cadmus Group, Inc. released "The Total Maximum Daily Load and Watershed Management Plan for Total Phosphorus and Total Suspended Solids in the Lower Fox River Basin and Lower Green Bay" report for the Wisconsin Department of Natural Resources, Oneida Tribe of Indians of Wisconsin, and the U.S. Environmental Protection Agency. Having been accepted by the three above agencies, in May of 2012, their report highlights TMDL goals of reducing excess algal growth, increasing water clarity in Lower Green Bay, increasing growth of beneficial submerged aquatic vegetation in Lower Green Bay, increasing dissolved oxygen levels, and restoring degraded habitat (The Cadmus Group, 2011).

Best Management Practices (BMP) are activities that are done to minimize the impact an activity may have on the surrounding environment. An earlier report generated by The Cadmus Group (2007) identified eight possible agricultural BMPs that would lead to lowered P and TSS levels in the LFR Watershed. BMP number eight is titled "biofuel crops" and looked at converting up to 7% of the LFR Watershed's agricultural land from traditional crops to a switchgrass crop (The Cadmus Group, 2007, p. 10) The ramifications of crop conversion were studied by a team of researchers from the University of Wisconsin – Green Bay (Dornbush, von Haden, Baumgart, Fermanich, Rieth, & Stoll, 2012). In their report, economic analysis of land conversion was based on cropping information from the 2004-2008 time period. P and TSS reductions for crop

conversion were also modeled and a summarization of carbon (C) sequestration benefits was produced (Dornbush et al., 2012).

In this thesis, economic analysis of land conversion will be examined for the more recent 2008-2012 period to more accurately represent current conditions in the LFR Watershed. This thesis mirrors work done by Dornbush et al. (2012), but adjusts for changes in crop prices, farming practices and subsidy opportunities.

## **1.2 Objectives**

The main objective of this research was to determine the economic feasibility of converting agricultural land from growing traditional crops to growing switchgrass crops. This conversion question is asked in light of a public desire to reduce P and TSS loading in the LFR Watershed. In order to achieve this overall research goal, three specific sub-objectives were examined:

- 1) The cost effectiveness of growing switchgrasses versus traditional agriculture crops,
- 2) Existing subsidy programs that could influence the economic feasibility of growing switchgrasses and their associated program requirements, and
- 3) Discussion of model limitations and other challenges facing establishment of switchgrass crops in the Lower Fox River Watershed.

In addressing the main objective and sub-objectives of this thesis, reporting of work will be organized into the present and four additional chapters as described below. In Chapter 2, an enterprise model is described. Additionally, an examination of the various databases and the information that was collected to run the full-scale enterprise model is presented. Subsequently, in Chapter 3 the information described in Chapter 2 is utilized,

along with assumptions, to create an enterprise model. This chapter concludes with a profit comparison between corn/soybean rotations and switchgrass agriculture. In Chapter 4, the environmental benefits of planting switchgrass are investigated. The chapter starts with a review of economic studies that pertain to the phosphorus, total suspended solids, and other environmental benefits that are relevant to the LFR Watershed. Next, a few of the more relevant subsidy programs that are currently available for potential adoption in the project area are described. To the extent feasible, the subsidy discussion will include program descriptions of the subsidy values per acre and the qualifying requirements for program participation. Similar to Chapter 3, Chapter 4 ends with a comparison of profit margins for corn/soybean and switchgrass rotations, only this time including potential subsidy program values. Finally, Chapter 5 discusses the limitations of this research and implications of its findings. In addition, emerging and future issues that may affect the research findings are discussed and future research opportunities suggested.

## **CHAPTER 2: METHODS AND LITERATURE**

Proper economic comparison between two opposing business options requires an in-depth look at current, relevant information. Chapter 2 is a critical component of this thesis because it describes the use of a relevant economic model and the collection methods used to gather data that goes into the model. In the following sections of Chapter 2 current literature and data available at the time of this project is examined. Proper collection and understanding of the data and literature can be a painstaking and slow step, but is necessary to give the most accurate presentation of the topic at hand.

The subsequent sections will look at the enterprise model used for this research, the various databases that provide information and the literature most relevant to the past examination of traditional agriculture and grass crops.

### **2.1 Economic Enterprise Modeling**

Economic enterprise models were developed to incorporate expected expenses and revenues from a business to determine the profitability of potential decisions. Creation of an enterprise model requires determining what inputs and outputs occur under a given scenario. In the case of farming, variables useful to an enterprise model include the type of crop grown, expected crop yield, expected sale price, labor and equipment cost, and fertilizer cost.

The UW-Extension enterprise model was developed for traditional crop agriculture (Williams & Hargrave, 2010). The UW-Extension enterprise model was chosen for use in this study's analysis because it contained many relevant agricultural components, allowing for easy manipulation and adaptation of the program. UW-Extension developed their enterprise model for use by a single business (or individual). Because this study

focuses on an entire watershed over a given time range (not a single point in time or an individual business) the ability to manipulate the program was essential. In addition, because there is no existing enterprise model for switchgrass crops, using a model easily duplicated and altering it to meet the needs of a grass crop oriented model was necessary (Williams & Hargrave, 2010).

An essential step in using an enterprise model is to gather data for all of the variables needed to run the model. The data used to run the research scenarios were compiled from a variety of sources that are described in more detail in the following sections. General discussion of the variables will follow with the actual data applications presented in Chapter 3.

## **2.2 Information Gathering and Literature Review**

### **2.2.1 Lower Fox River Watershed Information**

The Lower Fox River Watershed is located in the Northeastern Wisconsin counties of Brown, Calumet, Outagamie, and Winnebago counties. Total land area within the four counties is 1,378,622 acres. Of the 1.38 million acres, the LFR Watershed (411,194 acres) comprises close to 30% of the land area. Of the four counties, Brown County contains the largest portion (201,568 acres) of the LFR Watershed within its borders. These 201,568 acres makes up 59% of Brown County's total land area and account for almost half of the entire LFR Watershed. Outagamie, Winnebago, and Calumet counties contain the rest of the LFR Watershed, with 36%, 8%, and 7% of the area respectively. A summary of county acreage totals, watershed acreage located in each county, percent of County in the LFR Watershed, and percent of the LFR in each county is presented in Table 1 (Baumgart, 2012).

Table 1. Lower Fox River Watershed and County Acreage

| County    | Total Area in County (Acres) | Area Located in Lower Fox River Watershed (Acres) | Percent of County Located in the Lower Fox River Watershed | Percent of Watershed Located in the County |
|-----------|------------------------------|---|--|--|
| Brown     | 342,208                      | 201,568   | 58.90%   | 49.02%                                     |
| Calumet   | 254,015                      | 28,479  | 11.21%   | 6.93%                                      |
| Outagamie | 412,226                      | 149,829   | 36.35%   | 36.44%                                     |
| Winnebago | 370,173                      | 31,318  | 8.46%  | 7.62%                                      |
| Total     | 1,378,622                    | 411,194   | N/A  | 100.01%*                                   |

Source: Constructed from data provided by Baumgart (2012)

### **2.2.2 Traditional Crop Yield Data for the Lower Fox River Watershed**

Corn, soybeans, wheat and alfalfa are major agricultural crops in the Lower Fox River Watershed. According to the United States Department of Agriculture's 2007 Census, these four crop types account for 70 to 80 percent of farmland in Brown, Calumet, Outagamie, and Winnebago counties (United States Department of Agriculture: Census of Agriculture, n.d.).

Switchgrass is well suited for growth on most landscapes, and is not as adversely affected by highly saturated or flooded soil compared to corn, soybeans, wheat, or alfalfa (Biomass Energy Resource Center, 2009). This makes switchgrass a good candidate crop for lowland, marginal fields. (Tilman, Hill, & Lehman, 2006). Seasonal flooding that occurs on low, marginal land in the spring can greatly reduce or prevent the planting of annual crops such as corn and soybeans, while adversely affecting young stages of wheat or alfalfa that overwinter in a growth state. If switchgrass was planted in the LFR Watershed it is likely that corn and soybean crops would be displaced from marginal lands. In addition, many studies such as Jain, Khanna, Erickson, & Huang (2010) and Brummer, Burras, Duffy, & Moore (2001) have reviewed the economic feasibility of



switchgrass agriculture by comparing it to corn and soybean rotations in other areas. For this study of the LFR Watershed, switchgrass will be compared against a rotation consisting of corn grain, corn silage, and soybeans. In addition to being more northerly located in the Midwest, the LFR Watershed soil types are of differing quality and composition than these prior studies.

To perform an economic comparison, it was necessary to gather information on crop yields and acreage planting patterns for the three above listed crops. The National Agricultural Statistics Service (NASS) is a branch of the United States Department of Agriculture (USDA) that collects and disseminates a variety of information and trends related to agriculture. The NASS maintains crop yield data through its searchable program called Quick Stats 2.0. In Quick Stats data can be sorted by year and is specific to individual counties. The program offers a variety of options: Appendix A (Crop Yields) contains the full steps taken to access the information used in this thesis research (United States Department of Agriculture: National Agricultural Statistics Service [NASS], n.d.). Crop yields for corn grain (Figure 2), corn silage (Figure 3), and soybeans (Figure 4) show some variability between counties, while yearly fluctuations in yields are more pronounced.

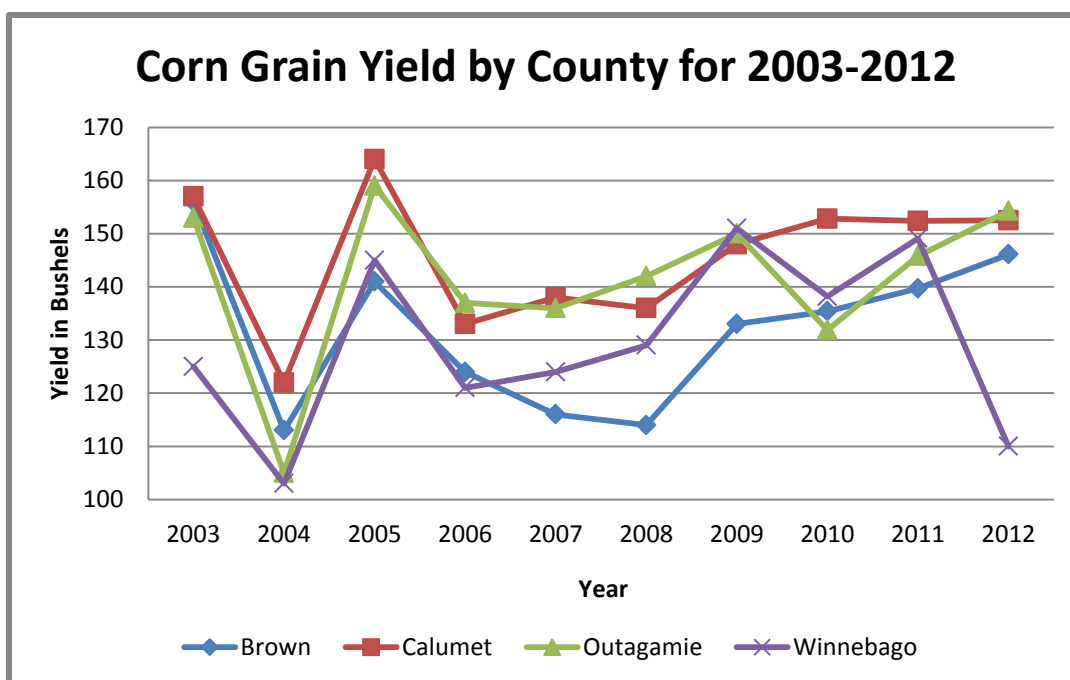


Figure 2. 2003-2012 Corn Grain Yield by County, Lower Fox River Watershed  
Source: Constructed from data provided by NASS ( n.d.)

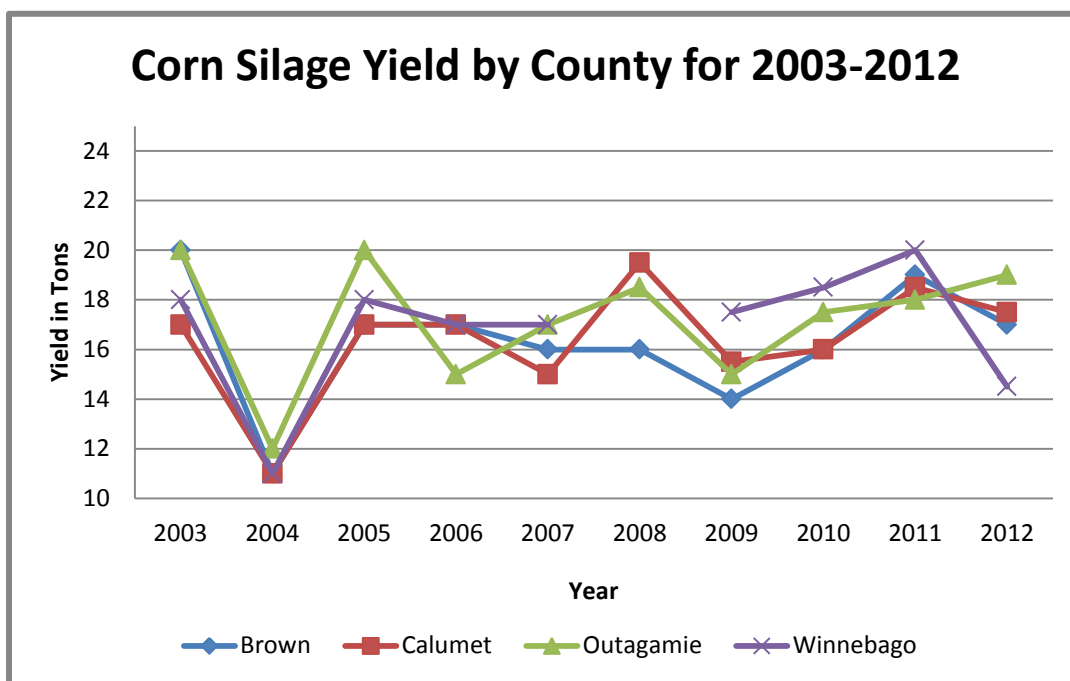


Figure 3. 2003-2012 Corn Silage Yield by County, Lower Fox River Watershed  
[\*Silage numbers were unavailable for Outagamie County for 2008 and were not included.]  
Source: Constructed from data provided by NASS ( n.d.)

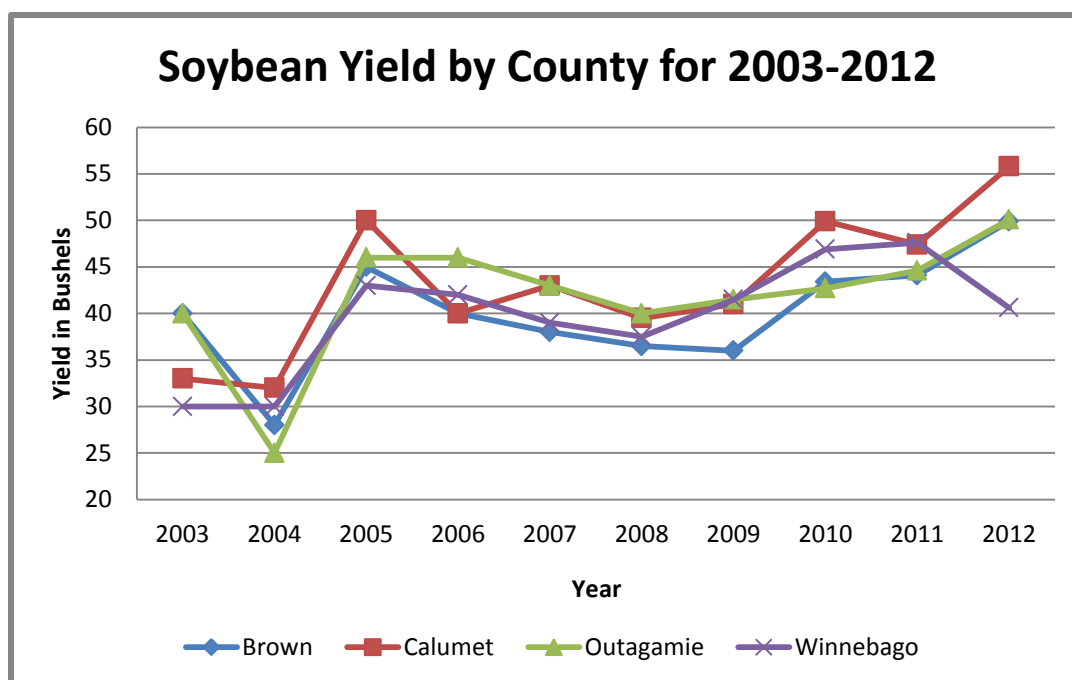


Figure 4. 2003-2012 Soybean Yield by County, Lower Fox River Watershed  
Source: Constructed from data provided by NASS ( n.d.)

Compilation of crop data occurs at a county level, and not a watershed level, which makes it inconsistent with the LFR Watershed study area. Interpreting crop yield data is difficult, due to the differences in average crop yields between counties (Table 2). Two methods could be employed to determine crop yield values for this paper, a weighted average of the four counties or selection of a county most representative to the LFR Watershed. Using the percent of the LFR Watershed in each county (Table 1) and multiplying that value times the ten year (nine year for Outagamie County, due to missing data from 2008) average yield (Table 2), a weighted average for each crop type was developed (Table 3). Weighted average crop yields are 136.10 bushels of corn grain, 16.68 tons of corn silage, and 40.94 bushels of soybeans per acre.

However, counties that have a large percentage of land not located in the LFR Watershed could have average yield values that are heavily influenced by non-LFR

Watershed Land and not representative of the LFR Watershed. For example, Calumet County, contains the smallest portion of the LFR Watershed (6.93%), but has the highest average corn grain and soybean yields from 2003-2012. Brown County comprises almost half of the Lower Fox River Watershed (49%). More importantly, 59% of the land mass of Brown County is contained within the Lower Fox River Watershed, making its crop yields much more representative of the Lower Fox River Watershed. Crop yields for Brown County are lower than the weighted 10-year average yields, (131.82 bushels of corn grain, 16.3 tons of corn silage and 40.09 bushels of soybeans per acre) with the most pronounced difference being for corn silage. Lower yields and a larger geographic influence prompted the use of Brown County yield data to represent the entire LFR Watershed from this point forward.

Table 2. Lower Fox River Watershed County 10-Year Average Yield Per Acre by Crop Type for 2003-2012

| <b>County</b> | <b>Corn Grain<br/>(Bushels)</b> | <b>Corn Silage<br/>(Tons)</b> | <b>Soybeans<br/>(Bushels)</b> |
|---------------|---------------------------------|-------------------------------|-------------------------------|
| Brown         | 131.82                          | 16.30                         | 40.09                         |
| Calumet       | 145.57                          | 16.40                         | 43.16                         |
| Outagamie     | 141.40                          | 17.20*                        | 41.89                         |
| Winnebago     | 129.53                          | 16.83                         | 39.81                         |

\*Silage numbers were unavailable for Outagamie County for 2008 and were not included making this a 9-year average yield.

Source: Constructed from data provided NASS ( n.d.)

Table 3. 2003-2012 Weighted Average 10-Year Yield by County, Lower Fox River Watershed

| Crop                 | 10-Year Yield<br>Type | County<br>(Percent of Watershed in the County) |                    |                       |                      | Cumulative<br>Total |
|----------------------|-----------------------|--|--------------------|-----------------------|----------------------|---------------------|
|                      |                       | Brown<br>(49.02%)                              | Calumet<br>(6.93%) | Outagamie<br>(36.44%) | Winnebago<br>(7.62%) |                     |
| Corn Grain (bushels) | Average               | 131.82   | 145.57             | 141.40                | 129.53               |                     |
|                      | Weighted Average      | 64.62  | 10.09              | 51.53                 | 9.87                 | <b>136.10</b>       |
| Corn Silage (tons)   | Average               | 16.30  | 16.40              | 17.20                 | 16.83                |                     |
|                      | Weighted Average      | 7.99   | 1.14               | 6.27                  | 1.28                 | <b>16.68</b>        |
| Soybeans (bushels)   | Average               | 40.09  | 43.16              | 41.89                 | 39.81                |                     |
|                      | Weighted Average      | 19.65  | 2.99               | 15.26                 | 3.03                 | <b>40.94</b>        |

Source: Constructed from data provided NASS ( n.d.)

### **2.2.3 Switchgrass Crop Yields for the Lower Fox River Watershed**

The NASS does not track yield data for switchgrass. In addition, available information related to yield data for switchgrass is limited, and often geographically specific. Multiple studies suggest established field yields between 4 and 4.5 tons per acre to be common, but variability across the United States can range from 2.5 tons per acre to as high as 11 tons per acre in highly productive agricultural lands (Pedroso, et al., 2011; Wang, Lebauer, & Dietze, 2010; Vogel & Mitchell, 2008).

Evaluations in Wisconsin indicate a yield range closer to 4 tons per acre, including those by Renz, Undersander, & Casler, (2009). Their results showed average values ranging from 2.91 tons to 4.57 tons of switchgrass per acre at four different sites in Wisconsin using four different cultivar types of switchgrass. In an article on economic evaluation of bioenergy crops (Jain, et al., 2010) average switchgrass yields for Wisconsin field trials were estimated around 4.05 tons per acre.

The Cadmus Group (2007) assumed established switchgrass yields of 4 tons per acre, which closely matches most of the Wisconsin field trials performed by Renz, et al. (2009). It is important to note that the study performed by The Cadmus Group (2007) assumed an eleven-year stand life with a 2 ton per acre yield on the establishment year and a 25% reseeding probability. Therefore yields would be equal to 2 tons per acre in year one, 3.5 tons per acre in year two (75% of field at 4 tons per acre and 25% of field at 2 tons per acre), and 4 tons per acre each year in years 3 through 11. Cumulative average yield over the eleven-year time span would be 3.77 tons per acre. This 3.77 ton per acre yield value is used for analysis in the rest of this study.

### 2.2.4 Consumer Price Index – CPI

In many of the following sections of Chapter 2, as well as select portions of the rest of the document, historical price data will be used. Because collection of monetary data for this project came from different time-periods, it is necessary to adjust data to a specific base year to ensure accurate comparisons. The most common form of price adjustment in the United States occurs by utilizing the Consumer Price Indexes (CPI). The United States Department of Labor's Bureau of Labor Statistics maintains a variety of CPI data. The Bureau of Labor Statistics is responsible for the collection of data related to changes in the prices of goods purchased by consumers (Figure 5). The Bureau of Labor Statistics tracks monthly changes and publishes the information on its website. The Bureau of Labor Statistics also tracks changes in CPI values for each calendar year and these are the most commonly used data for CPI adjustments (United States Department of Labor: Bureau of Labor Statistics, n.d.).

Data extracted on: July 16, 2013 (7:25:20 PM)

**Consumer Price Index - All Urban Consumers**

Series Id: CUUR0000SA0  
 Not Seasonally Adjusted  
 Area: U.S. city average  
 Item: All items  
 Base Period: 1982-84=100

Download: [.xls](#)

| Year | Jan     | Feb     | Mar     | Apr     | May     | Jun     | Jul     | Aug     | Sep     | Oct     | Nov     | Dec     | Annual  | HALF1   | HALF2   |
|------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 2003 | 181.7   | 183.1   | 184.2   | 183.8   | 183.5   | 183.7   | 183.9   | 184.6   | 185.2   | 185.0   | 184.5   | 184.3   | 184.0   | 183.3   | 184.6   |
| 2004 | 185.2   | 186.2   | 187.4   | 188.0   | 189.1   | 189.7   | 189.4   | 189.5   | 189.9   | 190.9   | 191.0   | 190.3   | 188.9   | 187.6   | 190.2   |
| 2005 | 190.7   | 191.8   | 193.3   | 194.6   | 194.4   | 194.5   | 195.4   | 196.4   | 198.8   | 199.2   | 197.6   | 196.8   | 195.3   | 193.2   | 197.4   |
| 2006 | 198.3   | 198.7   | 199.8   | 201.5   | 202.5   | 202.9   | 203.5   | 203.9   | 202.9   | 201.8   | 201.5   | 201.8   | 201.6   | 200.6   | 202.6   |
| 2007 | 202.416 | 203.499 | 205.352 | 206.686 | 207.949 | 208.352 | 208.299 | 207.917 | 208.490 | 208.936 | 210.177 | 210.036 | 207.342 | 205.709 | 208.976 |
| 2008 | 211.080 | 211.693 | 213.528 | 214.823 | 216.632 | 218.815 | 219.964 | 219.086 | 218.783 | 216.573 | 212.425 | 210.228 | 215.303 | 214.429 | 216.177 |
| 2009 | 211.143 | 212.193 | 212.709 | 213.240 | 213.856 | 215.693 | 215.351 | 215.834 | 215.969 | 216.177 | 216.330 | 215.949 | 214.537 | 213.139 | 215.935 |
| 2010 | 216.687 | 216.741 | 217.631 | 218.009 | 218.178 | 217.965 | 218.011 | 218.312 | 218.439 | 218.711 | 218.803 | 219.179 | 218.056 | 217.535 | 218.576 |
| 2011 | 220.223 | 221.309 | 223.467 | 224.906 | 225.964 | 225.722 | 225.922 | 226.545 | 226.889 | 226.421 | 226.230 | 225.672 | 224.939 | 223.598 | 226.280 |
| 2012 | 226.665 | 227.663 | 229.392 | 230.085 | 229.815 | 229.478 | 229.104 | 230.379 | 231.407 | 231.317 | 230.221 | 229.601 | 229.594 | 228.850 | 230.338 |
| 2013 | 230.280 | 232.166 | 232.773 | 232.531 | 232.945 | 233.504 |         |         |         |         |         |         |         | 232.366 |         |

Figure 5. Consumer Price Index 1982-1984 Base Level (United States Department of Labor: Bureau of Labor Statistics, n.d.)

Below is a chart that compares price levels between the years 2008 to 2012 (Table 4). Of interest in this research is the bottom bolded row, which shows the multiplier factor to convert values from 2008-2012 to the year 2012-dollar values. For example, a good that cost \$10 in 2008 would cost \$10.66 in 2012 ( $\$10 \times 1.06638 = \$10.66$ ). Notice that the multiplier factor is equal to original year value (column 2 entry) divided by the new year value. That is, converting a 2008 value to 2012 dollars uses a factor of 1.07018 (or  $229.594/214.537$ ) because the 2012 CPI value is roughly 7% higher than the 2008 CPI index value.

Table 4: CPI Adjusted Value Chart

| Year        |              | 2008           | 2009           | 2010           | 2011           | 2012           |
|-------------|--------------|----------------|----------------|----------------|----------------|----------------|
|             | <b>Value</b> | 215.303        | 214.537        | 218.056        | 224.939        | 229.594        |
| <b>2008</b> | 215.303      | 1.00000        | 1.00357        | 0.98737        | 0.95716        | 0.93776        |
| <b>2009</b> | 214.537      | 0.99644        | 1.00000        | 0.98386        | 0.95376        | 0.93442        |
| <b>2010</b> | 218.056      | 1.01279        | 1.01640        | 1.00000        | 0.96940        | 0.94975        |
| <b>2011</b> | 224.939      | 1.04476        | 1.04849        | 1.03157        | 1.00000        | 0.97973        |
| <b>2012</b> | 229.594      | <b>1.06638</b> | <b>1.07018</b> | <b>1.05291</b> | <b>1.02069</b> | <b>1.00000</b> |

Source: Constructed from data provided by United States Department of Labor: Bureau of Labor Statistics (n.d.)

### **2.2.5 Fertilizer and Manure Application Rates**

Agricultural operations routinely apply commercial fertilizers and manure to fields to increase nutrient availability to crops. Nutrient application typically increases crop yields and often improves profitability. Under-application of nutrients (fertilizers and manure) can result in lower yield and lost profit. Over-application of nutrients (fertilizers and manure) can result in unnecessary costs, which also leads to profit reduction. In addition,



excess nutrients from over-application of fertilizers and manure can lead to environmental degradation within a watershed.

The University of Wisconsin – Extension (UWEX) performs research and provides educational resources on a variety of topics for public benefit, including agriculturally related materials. Beginning in the 1960s and continuing through the present time, UWEX has conducted soil testing and created nutrient application guidelines and publishing the results for public use. Fertilizer application recommendations for phosphorus (P) and potassium (K) are dependent upon crop type and yield goals, soil type and the amount of P and K already available in the soil. A combination of soil type and a price ratio of corn grain to nitrogen (N) fertilizer, an economic criterion, will dictate N application. Most agricultural soils in the Lower Fox River Watershed are of a loamy nature (Erb & Hagedorn, 2010-2012). Soil test values for P and K content have historically been high in the Lower Fox River Watershed, with P reaching levels of concern (University of Wisconsin-Madison Soil Testing Laboratories, 2011). Soil test data is available from the University of Wisconsin-Madison Soil Testing Laboratories (2011) and is reproduced below in Table 5.

Table 5: Soil Test Values (ppm) for Phosphorus and Potassium, Lower Fox River Watershed

| County    | Nutrient | Year    |         |         |
|-----------|----------|---------|---------|---------|
|           |          | 1995-99 | 2000-04 | 2005-09 |
| Brown     | P        | 40.0    | 36.0    | 36.0    |
|           | K        | 123.3   | 113.0   | 113.0   |
| Calumet   | P        | 38.2    | 38.0    | 36.0    |
|           | K        | 132.6   | 127.0   | 115.0   |
| Outagamie | P        | 42.0    | 48.0    | 42.0    |
|           | K        | 130.8   | 140.0   | 119.0   |
| Winnebago | P        | 45.2    | 52.0    | 47.0    |
|           | K        | 143.4   | 134.0   | 124.0   |

Source: Constructed from data provided by the University of Wisconsin-Madison Soil Testing Laboratories (2011)

Soil Test Result Categories are defined by the University of Wisconsin Extension and fall into specific nutrient level ranges by crop types. Laboski & Peters (2012) summarize the most current Soil Test Categories in their document for UW Extension titled “Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin.” The five categories (in order) of Very low (VL), Low (L), Optimum (O), High (H), and Excessively High (EH) exist for P, while K has a sixth category of Very High (VH) that falls between the categories of High and Excessively High. Figures 6 and 7 (below) show the P and K Soil Test Categories for various crop types (grouped as demand level in Figures 6 and 7).

| Soil group <sup>a</sup>  | Soil test category |         |             |          |                       |
|--|--------------------|---------|-------------|----------|-----------------------|
|  | Very low (VL)      | Low (L) | Optimum (O) | High (H) | Excessively high (EH) |
| —soil test P ppm <sup>b</sup> —  |                    |         |             |          |                       |
| Demand level 1: corn grain, soybean, clover, small grains (but not wheat), grasses, oilseed crops, pasture |                    |         |             |          |                       |
| Loamy  | < 10               | 10–15   | 16–20       | 21–30    | > 30                  |
| Sandy, Organic   | < 12               | 12–22   | 23–32       | 33–42    | > 42                  |
| Demand level 2: alfalfa, corn silage, wheat, beans, sweet corn, peas, fruits                               |                    |         |             |          |                       |
| Loamy  | < 12               | 12–17   | 18–25       | 26–35    | > 35                  |
| Sandy, Organic   | < 18               | 18–25   | 26–37       | 38–55    | > 55                  |
| Demand level 3: tomato, pepper, brassicas, leafy greens, root, vine, and truck crops                       |                    |         |             |          |                       |
| Loamy  | < 15               | 15–30   | 31–45       | 46–75    | > 75                  |
| Sandy, Organic   | < 18               | 18–35   | 36–50       | 51–80    | > 80                  |
| Demand level 4: potato   |                    |         |             |          |                       |
| Loamy  | < 100              | 100–160 | 161–200     | > 200    |                       |
| Sandy, Organic   | < 30               | 30–60   | 61–90       | 91–120   | > 120                 |

Figure 6: Phosphorus Soil Test Categories (Laboski &amp; Peters, 2012, p. 53)

| Soil group <sup>a</sup>  | Soil test category |         |             |          |                |                       |
|--|--------------------|---------|-------------|----------|----------------|-----------------------|
|  | Very low (VL)      | Low (L) | Optimum (O) | High (H) | Very high (VH) | Excessively high (EH) |
| —soil test K ppm <sup>b</sup> —  |                    |         |             |          |                |                       |
| Demand level 1: corn grain, soybean, clover, small grains (but not wheat), grasses, oilseed crops, pasture |                    |         |             |          |                |                       |
| Loamy  | < 70               | 70–100  | 101–130     | 131–160  | 161–190        | > 190                 |
| Sandy, Organic   | < 45               | 45–65   | 66–90       | 91–130   | —              | > 130                 |
| Demand level 2: alfalfa, corn silage, wheat, beans, sweet corn, peas, fruits                               |                    |         |             |          |                |                       |
| Loamy  | < 90               | 90–110  | 111–140     | 141–170  | 171–240        | > 240                 |
| Sandy, Organic   | < 50               | 50–80   | 81–120      | 121–160  | 161–200        | > 200                 |
| Demand level 3: tomato, pepper, brassicas, leafy greens, root, vine, and truck crops                       |                    |         |             |          |                |                       |
| Loamy  | < 80               | 80–140  | 141–200     | 201–220  | 221–240        | > 240                 |
| Sandy, Organic   | < 50               | 50–100  | 101–150     | 151–165  | 166–180        | > 180                 |
| Demand level 4: potato   |                    |         |             |          |                |                       |
| Loamy  | < 80               | 80–120  | 121–170     | 171–190  | 191–220        | > 220                 |
| Sandy, Organic   | < 70               | 70–100  | 101–130     | 131–160  | 161–190        | > 190                 |

Figure 7: Potassium Soil Test Categories (Laboski &amp; Peters, 2012, p. 54)

Data for the four counties in the LFR Watershed from 2005-2009 indicate that soil test P values are in the Excessively High range for corn grain, soybeans, and corn silage (Demand Levels 1 and 2), which include most of the commonly grown agricultural crops in the Lower Fox River watershed. Data from the same time-period show that soil test K values are in the optimum range for the most common agriculture crops. Nutrient uptake from the soil satisfies a portion of a crop's nutrient needs. Application of fertilizer and manure occurs to meet the portion of the crop's nutrient needs that are not met through soil nutrients.

The Laboski & Peters (2012) document contains a comprehensive list of P and K needs for crops based on soil test categories. Table 6 (below) is a synthesis of the nutrient values needed for Corn Grain, Corn Silage, and Soybean crops based off yield goals (Laboski & Peters, 2012).

Table 6: Phosphorus and Potassium Requirements for Three Common Agriculture Crops


| Crop Name               | Yield Goal<br>(Per Acre) | P <sub>2</sub> O <sub>5</sub> Rate Guidelines |     |     |    |    | K <sub>2</sub> O Rate Guidelines |     |     |     |    |    |
|-------------------------|--------------------------|---|-----|-----|----|----|----------------------------------|-----|-----|-----|----|----|
|                         |                          | VL  | L   | O   | H  | EH | VL                               | L   | O   | H   | VH | EH |
| Corn Grain<br>(bushels) | 71-90                    | 70  | 60  | 30  | 15 | 0  | 70                               | 55  | 25  | 15  | 5  | 0  |
|                         | 91-110                   | 80  | 70  | 40  | 50 | 0  | 75                               | 60  | 30  | 15  | 10 | 0  |
|                         | 111-130                  | 85  | 75  | 45  | 25 | 0  | 80                               | 65  | 35  | 20  | 10 | 0  |
|                         | 131-150                  | 95  | 85  | 55  | 30 | 0  | 85                               | 70  | 40  | 20  | 10 | 0  |
|                         | 151-170                  | 100   | 90  | 60  | 30 | 0  | 90                               | 75  | 45  | 25  | 10 | 0  |
|                         | 171-190                  | 110   | 100 | 70  | 35 | 0  | 95                               | 80  | 50  | 25  | 15 | 0  |
|                         | 191-210                  | 115   | 105 | 75  | 40 | 0  | 105                              | 90  | 60  | 30  | 15 | 0  |
|                         | 211-230                  | 125   | 115 | 85  | 45 | 0  | 110                              | 95  | 65  | 35  | 15 | 0  |
| Corn Silage<br>(tons)   | 10-15                    | 85  | 75  | 45  | 25 | 0  | 160                              | 145 | 105 | 55  | 25 | 0  |
|                         | 15.1-20                  | 105   | 95  | 65  | 35 | 0  | 200                              | 185 | 145 | 75  | 35 | 0  |
|                         | 20.1-25                  | 120   | 110 | 80  | 40 | 0  | 240                              | 225 | 185 | 95  | 45 | 0  |
|                         | 25.1-30                  | 140   | 130 | 100 | 50 | 0  | 285                              | 270 | 230 | 115 | 60 | 0  |
|                         | 30.1-35                  | 155   | 145 | 115 | 60 | 0  | 325                              | 310 | 270 | 135 | 70 | 0  |
| Soybeans<br>(bushels)   | 15-25                    | 55  | 45  | 15  | 10 | 0  | 75                               | 60  | 30  | 15  | 10 | 0  |
|                         | 26-35                    | 65  | 55  | 25  | 15 | 0  | 85                               | 70  | 40  | 20  | 10 | 0  |
|                         | 36-45                    | 70  | 60  | 30  | 15 | 0  | 100                              | 85  | 55  | 30  | 15 | 0  |
|                         | 46-55                    | 80  | 70  | 40  | 20 | 0  | 115                              | 100 | 70  | 35  | 20 | 0  |
|                         | 56-65                    | 90  | 80  | 50  | 25 | 0  | 130                              | 115 | 85  | 45  | 20 | 0  |
|                         | 66-75                    | 95  | 85  | 55  | 30 | 0  | 145                              | 130 | 100 | 50  | 25 | 0  |
|                         | 76-85                    | 105   | 95  | 65  | 35 | 0  | 155                              | 140 | 110 | 55  | 30 | 0  |

Phosphorus and potassium nutrient needs are based on expected yield of each crop and soil nutrient levels that are categorized as VL (very low), L (low), O (optimum), H (High), VH (Very High), and EH (Excessively High).

Source: Constructed from data provided by Laboski & Peters (2012)

The state of Wisconsin, and in particular the Lower Fox River Region, has a large dairy industry (Kousky, et al., 2011). A byproduct of the dairy industry is large volumes of manure, which can provide nutrients when applied to fields. The Nutrient Management Fast Facts sheet (Integrated Pest and Crop Management – Nutrient and Pest Management Program [Integrated], n.d.) provides information on average nutrient availability within manure applications. As a general rule of thumb, manure application

on a field continues until one of the three macro nutrients (N,P, K) needed for crops reaches the amount necessary for the expected crop yield. After that point, commercial fertilizer application supplies the remaining nutrient specific needs, which are yet deficient. Nutrient content from different manure sources varies (Figure 8) and for this reason the source of manure used deserves consideration (Integrated, n.d.).



# MANURE

information

## ESTIMATED AVAILABLE NUTRIENT CONTENT \*

1<sup>st</sup> Year [2<sup>nd</sup> Year]

| Manure units:<br>Solid (lb/ton); Liquid (lb/1000 gal) |                                    | N                     |             |        | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O |
|---|------------------------------------|-----------------------|-------------|--------|-------------------------------|------------------|
|   |                                    | time to incorporation |             |        |                               |                  |
|   |                                    | > 3 days              | 1 hr–3 days | < 1 hr |                               |                  |
| Dairy   | Solid, >20% DM                     | 2 [1]                 | 3 [1]       | 3 [1]  | 3                             | 6                |
|   | Solid, 11–20% DM                   | 2 [1]                 | 2 [1]       | 3 [1]  | 3                             | 5                |
|   | Liquid, 4–11% DM                   | 7 [2]                 | 10 [2]      | 12 [2] | 6                             | 17               |
|   | Liquid, <4% DM                     | 4 [1]                 | 6 [1]       | 7 [1]  | 3                             | 11               |
| Beef  | Solid                              | 3 [1]                 | 4 [1]       | 5 [1]  | 6                             | 10               |
|   | Liquid                             | 5 [2]                 | 6 [2]       | 8 [2]  | 6                             | 12               |
| Swine   | Solid                              | 7 [2]                 | 9 [2]       | 12 [2] | 10                            | 8                |
|   | Liquid, finish, indoor pit         | 17 [4]                | 22 [4]      | 28 [4] | 14                            | 22               |
|   | Liquid, finish, outdoor pit        | 7 [2]                 | 9 [2]       | 12 [2] | 6                             | 8                |
|   | Liquid, farrow-nursery, indoor pit | 8 [2]                 | 10 [2]      | 14 [2] | 6                             | 10               |
| Poultry   | Solid, chicken                     | 24 [5]                | 27 [5]      | 29 [5] | 35                            | 26               |
|   | Solid, turkey                      | 26 [5]                | 28 [5]      | 31 [5] | 35                            | 25               |
|   | Liquid                             | 6 [1]                 | 7 [1]       | 7 [1]  | 6                             | 7                |
| Horse   | Solid                              | 2 [1]                 | 3 [1]       | 4 [1]  | 5                             | 6                |

\* Because manure nutrient content can vary greatly, manure analysis is encouraged.

Figure 8: Nutrient Content Available from Various Manure Sources (Integrated, n.d)

Joint application of fertilizer with seeds at planting time (commonly known as “starter”) increases yield for some crops, including corn. Besides increasing yield, starter can potentially lower moisture content in corn at harvest time, which leads to reduced drying cost. Application rates for starter fertilizer vary, but Laboski & Peters (2012) suggest maximum application rates of 500 pounds per acre for Wisconsin. According to UW-Extension agricultural consultants in Brown County, an application rate of 100 pounds per acre for corn is common to the Lower Fox River Watershed. Soybean crops, in the otherhand, experience very little to no yield improvement with starter application.

As previously stated, both soil type and a ratio of nitrogen to Corn Grain prices affects nitrogen application for various crops. Laboski & Peters (2012) also discuss nitrogen application rates in their document. Figure 9, below, shows the optimal rate of nitrogen application and a suggested application range below the optimal rate.

|   | Nitrogen: Corn price ratio                 |                  |                  |                  |
|---|--|------------------|------------------|------------------|
|   | 0.05                                       | 0.10             | 0.15             | 0.20             |
| Soil and previous crop  | total lb N/a to apply*                     |                  |                  |                  |
| Loamy: high yield potential soil                                    |  |                  |                  |                  |
| Corn, forage legumes, legume vegetables, green manures <sup>d</sup> | 190 <sup>a</sup><br>170 — 210 <sup>c</sup> | 165<br>155 — 180 | 150<br>140 — 160 | 135<br>125 — 150 |
| Soybean, small grains <sup>e</sup>                                  | 140<br>125 — 160                           | 120<br>105 — 130 | 105<br>95 — 115  | 90<br>80 — 105   |
| Loamy: medium yield potential soil                                  |  |                  |                  |                  |
| Corn, forage legumes, legume vegetables, green manures <sup>d</sup> | 145<br>130 — 160                           | 125<br>115 — 140 | 115<br>105 — 125 | 105<br>95 — 110  |
| Soybean, small grains <sup>e</sup>                                  | 130<br>110 — 150                           | 100<br>85 — 120  | 85<br>70 — 95    | 70<br>60 — 80    |
| Sands/ loamy sands  |  |                  |                  |                  |
| Irrigated—all crops <sup>d</sup>                                    | 215<br>200 — 230                           | 200<br>185 — 210 | 185<br>175 — 195 | 175<br>165 — 185 |
| Non-irrigated—all crops <sup>d</sup>                                | 140<br>130 — 150                           | 130<br>120 — 140 | 120<br>110 — 130 | 110<br>100 — 120 |

Figure 9. Suggested Nitrogen Application Rates for Common Wisconsin Crops (Laboski & Peters, 2012, p. 38)

Increased demand for renewable energy products and meeting more stringent water quality requirements has led to an increase in the growth and harvest of switchgrass as an agricultural product (Christensen & Koppenjan, 2010). Due to a lack of long-term field trial data, phosphorus, potassium, and nitrogen application rates for switchgrass can vary greatly between literature sources. As discussed earlier, improper application of nutrients to a crop can result in reduced yields or excessive costs for an agricultural operator, both reducing profitability. The Cadmus Group, (2007) recommended that fertilizer application rates for N, P, and K in the Lower Fox River Watershed should occur at 90.91, 4.49, and 24.36 pounds per acre, respectively. While, a report by Agrecol in Southwestern Wisconsin suggests 45, 6.53, and 84.33 pounds of N, P, and K per acre, regardless of soil test considerations (Porter, Barry, Samson, & Doudlah, 2008). Laboski & Peters (2012) have provided refined nutrient application rates that vary by soil type and provide information of a more useful nature to individual farmers whose nutrient applications vary based on individual field characteristics.

Table 7: Phosphorus and Potassium Requirements (pounds) for Switchgrass

| Crop Name   | P <sub>2</sub> O <sub>5</sub> Rate Guidelines |    |    |    |    | K <sub>2</sub> O Rate Guidelines |    |    |    |    |    |
|-------------|---|----|----|----|----|----------------------------------|----|----|----|----|----|
|             | VL  | L  | O  | H  | EH | VL                               | L  | O  | H  | VH | EH |
| Switchgrass | 75  | 65 | 35 | 20 | 0  | 105                              | 90 | 60 | 30 | 15 | 0  |

Source: Constructed from data provided by Laboski & Peters (2012)



Table 8: Nitrogen Requirements (pounds) for Switchgrass

| Crop Name                 | Percent Soil Organic Content |         |           |       |
|---------------------------|------------------------------|---------|-----------|-------|
|                           | <2.0                         | 2.0-9.9 | 10.0-20.0 | >20.0 |
| Switchgrass (Seeding)     | 0                            | 0       | 0         | 0     |
| Switchgrass (Established) | 120                          | 100     | 75        | 50    |

Source: Constructed from data provided by Laboski & Peters (2012)

### **2.2.6 Fertilizer and Manure Costs**

Many organizations, such as the USDA's National Agricultural Statistics Service, track fertilizer prices over time. While documented increases and decreases in prices is useful in making economic decisions by agricultural producers, the geographic area covered by these surveys is generally quite large. The usefulness of collected information to specific regions, such as the LFR Watershed, is diminished when surveys take place over geographically large areas. For examples, historical fertilizer prices from NASS (United States Department of Agriculture: National Agricultural Statistics Service, 2013) are collected from Illinois, Indiana, Iowa, Minnesota, Missouri, Ohio, and Wisconsin. Average fertilizer prices (Figure 10) generated from the NASS survey (2013) may, or may not, be similar to fertilizer prices in the LFR Watershed. Fertilizer prices directly relevant to the Lower Fox River Watershed would be the best option for use in this research. However, because private companies dominate the fertilizer industry, there is no historical information for fertilizer prices at the LFR Watershed level (except those maintained by each company). Still, the need for average fertilizer prices at a level more local than an eight state region is crucial for economic analysis in this paper.

| <b>FERTILIZER: Prices Paid</b><br><b>North Central Region 1/, March 2010-2013</b> |                 |      |      |            |
|---|-----------------|------|------|------------|
| Commodity   | 2010            | 2011 | 2012 | 2013       |
|   | Dollars per ton |      |      |            |
| Anhydrous Ammonia   | 520             | 776  | 812  | <b>877</b> |
| Nitrogen Solution, 28%  | 260             | 358  | 381  | <b>395</b> |
| Sulfate of Ammonia  | 300             | 386  | 413  | <b>487</b> |
| Urea 44-46%   | 446             | 519  | 547  | <b>574</b> |
| Superphosphate  | 465             | 536  | 582  | <b>636</b> |
| Muriate of Potash   | 501             | 594  | 641  | <b>581</b> |
| 1/North Central States: IL, IN, IA, MI, MN, MO, OH, and WI.                       |                 |      |      |            |
| Source: USDA, NASS  |                 |      |      |            |

Figure 10. NASS Fertilizer Prices, 2010-2013 (NASS, 2013, p. 2)

A private entity collected information on fertilizer prices from 18 agricultural cooperatives in Wisconsin at regular intervals from 2008 to 2011 (Anonymous, n.d.). Using the survey information from the private entity and the fertilizer prices from NASS (2013), values for each fertilizer type for each year were CPI adjusted and averaged to 2012 values (Table 9). A larger variety of fertilizer types and a smaller geographic sampling area (the state of Wisconsin) led to the use of fertilizer prices from the anonymous survey (Anonymous, n.d.) for use in this paper. Manure costs utilized for this paper (Table 9) came from the USDA's Custom Labor Rates Guide publication, which is published every 4 years (United States Department of Agriculture: National Agricultural Statistics Service [NASS], 2011).

Table 9: Common Fertilizers and Average Prices

| Fertilizer Type              | Approximate N-P-K Percentage | Fertilizer Prices (Listed by Survey Source) |                                      |                                 |
|------------------------------|------------------------------|---|--------------------------------------|---------------------------------|
|                              |                              | Anonymous Survey <sup>1</sup>               | Wisconsin - Prices Paid <sup>2</sup> | Custom Labor Rates <sup>3</sup> |
| Starter (50% MAP + 50% DAP)  | 14.5-49-00                   | \$713.62                                    | -                                    | -                               |
| MAP (Monoammonium Phosphate) | 11-52-00                     | \$794.15                                    | -                                    | -                               |
| DAP (Diammonium Phosphate)   | 18-46-00                     | \$770.37                                    | -                                    | -                               |
| Super Phosphate              | 00-20-00                     | -   | \$539.57                             | -                               |
| Potash                       | 00-00-22                     | \$656.87                                    | \$591.60                             | -                               |
| Urea                         | 46-00-00                     | \$580.12                                    | \$515.45                             | -                               |
| 28%                          | 28-00-00                     | \$380.31                                    | \$340.06                             | -                               |
| 32%                          | 32-00-00                     | \$411.58                                    | -                                    | -                               |
| Anhydrous (ammonia)          | 82-00-00                     | \$814.30                                    | \$717.19                             | -                               |
| AMS (Ammonium Sulfate)       | 21-00-00                     | \$381.25                                    | \$374.29                             | -                               |
| Liquid Manure                | 10-06-17                     | -   | -                                    | \$0.01                          |

All fertilizer prices are displayed in 2012 dollars. All fertilizers are priced by the ton, except manure, which is priced by the gallon.

1 – Prices were from 2008-2011; all prices were CPI adjusted and averaged to fertilizer prices as 2012 year values. (Anonymous, n.d.)

2 – Prices were from 2010-2012; all prices were CPI adjusted and averaged to fertilizer prices as 2012 year values. (NASS, 2013)

3 – Manure prices came from NASS (2011).

### **2.2.7 Crop Information - Prices**

In addition to tracking crop yields, the NASS program also keeps records on crop sale prices. Price information was accessed via Quick Stats 2.0 for each crop type by year and originating state. Appendix B contains the necessary steps to retrieve this information.

Table 10 contains CPI adjusted corn grain and soybean price data for Wisconsin from the years 2008 to 2012 (NASS, n.d.)

Table 10: Average Corn and Soybean Prices for Wisconsin 2008-2012 (CPI Adjusted)

| <b>Crop Type</b> | <b>2008</b> | <b>2009</b> | <b>2010</b> | <b>2011</b> | <b>2012</b> | <b>Average</b> |
|------------------|-------------|-------------|-------------|-------------|-------------|----------------|
| Corn Grain (bu)  | \$4.15      | \$3.82      | \$5.55      | \$6.14      | \$6.90      | \$5.31         |
| Soybeans (bu)    | \$10.45     | \$10.30     | \$11.37     | \$12.66     | \$13.90     | \$11.73        |

Crop prices for each year were CPI adjusted to 2012 values and then averaged.

Source: Constructed from data provided by NASS (n.d.)

Unfortunately, NASS does not keep track of corn silage prices. Corn silage is sold by the ton and contains both corn grain and corn stover. Corn stover contains nutrients that would be spread back onto the field if the crop was harvested for corn grain. The sale price of corn silage needs to account for the value of the corn grain and the value of the nutrients removed in the corn stover. A quick way to estimate corn silage prices is to multiply the value of a bushel of corn by 8 and 10 (Burdine, Halich, & Lehmkuhler, 2009) to establish a lower and upper bound on the value of corn silage. For example, the average 2008-2012 corn grain price, \$5.31, indicates that the value of a ton of corn silage should be worth at least \$42.48 but no more than \$53.10. This method is useful for farmers trying to make quick transactions, but the large price range is difficult for use in

this paper. Even though this quick estimation method is not precise enough to be used in this analysis, it does provide a validation tool for other corn stover valuation methods.

A more accurate price evaluation method involves valuing both the corn grain content and the additional phosphorus and potassium removals that occur when harvesting corn silage. The average yield of corn silage for Brown County during 2003-2012 was 16.3 tons per acre. According to Lauer (2000), a yield of 16.3 tons of corn silage per acre would contain roughly 7.9 bushels of corn grain per ton. The Nutrient Management Fast Facts Sheet indicates that each ton of corn silage removes 3.6 pounds of phosphorus and 8.3 pounds of potassium (Integrated, n.d.).

The value of corn grain in silage can be determined by multiplying the amount of corn grain present by the price of corn grain. In this case, using the 2008-2012 average corn grain price of \$5.31 per bushel, 7.9 bushels of corn grain is worth \$41.97. The value of phosphorus and potassium is equal to the amount removed multiplied by the cost of each fertilizer. Therefore, the phosphorus removed from the harvest of corn silage has a value of \$2.19 and potassium has an additional value of \$4.54. A ton of corn silage should be valued at \$48.70, which falls between the quick estimation range of \$42.48 and \$53.10. Table 11 contains the 2008-2012 value of corn grain, phosphorus, potassium, and the overall average value of a ton of corn silage for 2008-2012.

Table 11: Valuation of a Ton of Corn Silage

|                     | Quantity* | Price per Unit | Value          |
|---------------------|-----------|----------------|----------------|
| Corn Grain (bu)     | 7.9       | \$5.31         | \$41.97        |
| Phosphorus (lbs)    | 3.6       | \$0.61         | \$2.19         |
| Potassium (lbs)     | 8.3       | \$0.55         | \$4.54         |
| <b>Total Price:</b> |           |                | <b>\$48.70</b> |

Sales price of corn silage is equal to the price of corn grain in the silage plus the replacement cost of the phosphorus and potassium removed in the silage.

Source: Constructed from data provided by Lauer (2000), Integrated (n.d.), and NASS (n.d.)

Similar to switchgrass yields, there exists a dearth of information on switchgrass prices. The current literature on switchgrass prices is not consistent. The Billion Ton Update, a nationwide analysis on biofuel prices, (U.S. Department of Energy, 2011) values switchgrass at \$60 per ton. More locally, the University of Wisconsin – Extension Service recommends valuing switchgrass equal to hay grass. Through personal communication, UW – Extension employee Ken Barnett indicated hay grass values for Wisconsin to be \$96.28 per ton (CPI Adjusted and averaged to 2012 dollars) for the 2004-2008 time-period (Barnett, 2011). More relevant to this geographic area, The Cadmus Group (2007) valued switchgrass at \$75 per ton, which continues to be a viable sales price (Erb & Hagedorn, 2010-2012). Much of this paper has mirrored the work of The Cadmus Group (2007), so a switchgrass sale value of \$75 per ton was used in the initial analysis.

Crop sales price data are an important component of the entire enterprise model. When possible, historical data were used to provide relevant prices. When sales price data was not available alternate pricing methods and literature searches were conducted

to determine the most accurate sales prices for this research. In Table 12 the sales prices used in subsequent economic analyses are summarized.

Table 12: Crop Prices for the Lower Fox River Watershed

| <b>Crop Type</b>  | <b>Sales Price</b>   |
|-------------------|----------------------|
| Corn Grain (bu)   | \$5.31 <sup>1</sup>  |
| Corn Silage (ton) | \$48.70 <sup>2</sup> |
| Soybeans (bu)     | \$11.73 <sup>1</sup> |
| Switchgrass (ton) | \$75.00 <sup>3</sup> |

<sup>1</sup> Table 10

<sup>2</sup> Table 11

<sup>3</sup> The Cadmus Group (2007).

### **2.2.8 Custom Labor Rates, Land Rent, and Interest Rates**

Land rent, tilling, planting, harvesting, and other activities related to farming have varied costs related to geographical differences, different machine costs and varied amounts of physical labor. These different costs are defined as Custom Labor Rates. Custom Labor Rates for each crop type were determined using the Wisconsin Custom Rate Guide 2010 developed by the USDA (NASS, 2011). A new custom rate book is produced every three years after surveying farmers in Wisconsin on equipment costs and the rate per hour paid to employees. Land rent costs were set at \$100 per acre. This land rent price is typical of what is paid in Northeastern Wisconsin (K. Erb; M. Hagedorn, UW-Extension Brown County, 2010-2012). Both crop types assumed the same land cost, which leads to the same land rent expense for both crop types.

Due to the large upfront costs involved in planting crops and purchasing equipment, farmers often develop purchase agreements that involve financing agreements. The UW-Extension enterprise model includes an 8% interest rate to cost categories that typically are financed. Similarly in this study an 8% interest rate is assumed for both the traditional farming and switchgrass models (NASS, 2011).

### **2.2.9 Subsidy Information – Corn and Soybeans**

For a variety of reasons, including economic viability of farms, the USDA offers subsidies for certain crops. Examples of current subsidies include direct payments, counter-cyclical payments, average crop revenue election payments, and disaster assistance. Farmers receive payments on a per bushel basis for production support and on an acreage basis for low yield periods and for natural disaster assistance (United States Department of Agriculture, 2012). The type and dollar value of subsidies paid during a year with good crop yields is different from that of a year with poor crop yields. In this study, the interest is in the average value of crop subsidies, regardless of the type of subsidy received. The Environmental Working Group (EWG) gathers subsidy data from the USDA and compiles the data on a yearly basis for crop and county. Information is available on the EWG's website (Environmental Working Group, 2012).

The value of subsidies paid for both corn and soybean crops were gathered for the years 2008 through 2012 for Brown County. The total value of each crop subsidy was then CPI adjusted to reflect 2012 dollars and averaged over the five year time period. Using the average acreage planted in corn and soybeans during the five year time period (NASS, n.d.), average subsidy value per acre was developed for both corn and soybean



crops. In Table 13, the average aggregate subsidy totals, acreage planted, and per acre subsidy values for corn, soybeans, and both crops combined are presented for Brown County.

Table 13: 2008-2012 CPI Adjusted Crop Subsidies for Corn and Soybeans

|                                 | <b>Corn</b>    | <b>Soybeans</b> | <b>Combined Total</b> |
|---------------------------------|----------------|-----------------|-----------------------|
| Average Subsidy (Dollars)       | \$3,091,683.83 | \$624,202.79    | \$3,715,886.63        |
| Average Acreage (Acres)         | 65,480         | 20,240          | 85,720                |
| <b>Average Subsidy per Acre</b> | <b>\$47.22</b> | <b>\$30.84</b>  | <b>\$43.35</b>        |

Subsidy values were collected by crop type for 2008-2012. Values were then CPI adjusted to 2012 dollars and averaged.

Source: Constructed by data from Environmental Working Group (2012) and NASS (n.d.)

### **2.2.10 Summary**

Economic enterprise models are used in comparing expenses and revenues from alternative business decisions. In this project the goal is to compare the economics of a corn and soybean farming model to the economics of a switchgrass farming model on lowland agricultural fields. Collection of expense and revenue data was necessary to create and run the economic enterprise model. The purpose of this chapter was to describe the process of gathering appropriate data to run an enterprise model between a corn-soybean scenario and a switchgrass scenario for the Lower Fox River Region for the 2008 to 2012 time period. Using the described data, an economic analysis is presented in Chapter 3.

## **CHAPTER 3: ANALYSIS OF BROWN COUNTY**

### **3.1 Current State of Agriculture in the Lower Fox River Watershed**

#### **3.1.1 Background**

The report generated by the Cadmus Group (2007), here after referred to as “Optimization Report,” incorporated many issues related to water quality initiatives including an economic analysis of growing switchgrass prepared by UW Extension Brown County. Their analysis factored in many variables and assumed that the amount of land converted within the region would not affect other sectors of agriculture in the region, such as dairy farming or the raising of beef cattle. Based on their analysis it was determined that approximately 7% of the current agricultural land, or roughly 14,000 acres, could be removed from current cropping conditions and planted in switchgrass without impacting other agricultural practices. Their analysis also estimated a per ton production cost of \$82.23 for switchgrass with an additional \$8.65/ton for transportation. The “Optimization Report defined key items and provided a solid platform for further development of a switchgrass market (The Cadmus Group., 2007).

While the Optimization Report provided an analysis for the cost of switchgrass production, it did not compare the economic differences between traditional crop revenues and switchgrass. Additionally, the report noted that the costs of switchgrass production would vary based upon changes in fertilizer prices and soil test levels (The Cadmus Group, 2007). In addition to performing an economic comparison between crops, the geographic location where switchgrass plantings occur deserves consideration. Lowland agricultural fields are prone to soil saturation or flooding during spring. When

either situation occurs, the result is delayed planting or reduced harvests of traditional crops, both of which translate to reduced profits for farmers. However, switchgrass yields appear less affected by adverse water conditions than corn or soybean crops, and persisting soil saturation may help increase grass production by providing moisture during the remainder of the growing season (Abrams, Knapp, & Hulbert, 1986). In addition, lowland ecotypes of switchgrass generally produce higher yields than their upland counterparts (Redfearn, 2008), suggesting that low cropland areas are optimal for switchgrass production.

In addition, a primary purpose of prior work in the Lower Fox River Watershed was to address phosphorus and sediment problems in the LFR Watershed. However, previous reports (The Cadmus Group, 2007 and The Cadmus Group, Inc., 2011) do not provide economic values for environmental benefits offered by non-traditional crops. Providing dollar values for positive environmental changes may be critical in social judgement regarding desirability of implementing switchgrass crops, especially if subsidy programs are necessary to make switchgrass more profitable than traditional agriculture. The rest of Chapter 3 focuses on providing an economic comparison between switchgrass and traditional crops.

### **3.2 Running the Economic Enterprise Model**

Conducting an economic analysis of switching corn and soybean crops to switchgrass crops in the Lower Fox River Watershed requires an economic enterprise model and a variety of inputs. Much of the framework used in this analysis is available from prior work conducted by the Cadmus Group (2007) and by Dornbush et al. (2012). In Chapter

2, information needed to perform an economic analysis was outlined. In the ensuing sections of this document, a variety of assumptions relevant to the Lower Fox River Watershed are presented and available data are used to produce the final economic comparison between traditional (corn and soybean) crops and switchgrass.

### **3.2.1 Yield Reductions Due to Marginal Lands**

Traditional crops located in areas prone to water saturation or accumulation typically fare worse than counterpart crops located on higher, better-drained soils. Switchgrass yields are generally the same or better in lowland areas than highland areas. For this reason, switchgrass could prove to be a replacement crop in lowland areas. To provide a proper comparison between the two cropping methods, one needs an analysis of crop yields for corn and soybeans located on lowland areas.. Thelemann, et al., (2010) found that corn and alfalfa yields suffer by as much as 40% when located on lowland areas. More locally, Dornbush et al. (2012) looked at average yields of corn silage, wheat grain, straw, and prairie grass crops in Brown County. Plots were established at higher (upland) and lower (lowland) topographic positions. Analysis showed that corn silage, wheat grain, and straw production were significantly less in lowland areas compared to upland areas. In contrast, prairie grass plantings in upland and lowland areas had comparable yields with no significant differences. Their conclusion was that “marginal” lowland areas are the best areas for grass plantings due to these lands being unsuitable for traditional crops but having little to no negative yield effects for prairie stands (Dornbush et al., 2012). Specifically, crop yield reductions of 27% occurred on fields with “somewhat poorly drained” soils, with yield reductions of 67% on fields containing

“poorly to very poorly drained lands,” relative to fields on “well-drained” soils (Dornbush et al., 2012). Prairie grass yields for upland and lowland areas were similar, indicating prairie grass yield to have much less risk in marginal growing conditions (water saturation, etc.).

Dornbush et al., (2012) utilized a GIS program to analyze the LFR Watershed and determined a total of 198,300 acres under agricultural use. After removing farm lots and fields smaller than 2 acres in size, 186,700 acres of tillable farmland were available (Dornbush et al., 2012). The Optimization Report (Cadmus, 2007) stated that converting more than 7% of the agricultural land in the region would affect other farming practices in the region by changing the amount of land available for traditional uses (such as corn and soybean crops). Because the intent was not to initiate any large-scale changes other than implementing switchgrass growth in marginal cropland areas, a cap of 7% of agricultural land was set. This set a target goal of 13,070 to 13,900 agricultural acres (7% of 186,700 or 198,300 acres, see above discussion) for conversion to switchgrass. The Dornbush et al. (2012) analysis utilized USDA-NRCS SSURGO soil layers to classify soils within the LFR Watershed by soil drainage type (upland, somewhat poorly drained, poorly drained, and very poorly drained). Fields were then analyzed based on their proportion of “somewhat to poorly drained” soils, “poor to very poorly” drained soils, and “upland” soils.

The first scenario, called SVP (Somewhat to Very Poorly drained soils), simulated the conversion of roughly 13,900 acres of field most dominated by “somewhat to very poorly” drained soils. Fields that had the largest proportion of land in “somewhat to poorly” drained and “poor to very poorly” drained soils were selected for analysis.

Similar to the first scenario, the second scenario, called PVP, (Poor to Very Poorly drained soils) simulated the same process for fields most dominated by “poor to very poorly” drained soils. Finally, the third scenario, called WQ-SVP, (Water Quality-Somewhat to Very Poorly drained soils) targeted conversion of the sub-watersheds in the LFR Watershed that had the worst water quality as defined by phosphorus runoff. While the selection criteria for each of the three options differed, analysis determined the percentage of soil classified as “somewhat to poorly” drained, “poorly to very poorly” drained, and “upland” for each of the three scenarios (Table 14).

Table 14: Percentage of Field in each Drainage Class for each Scenario

| Scenario | <b><u>Percent of Field in each Drainage Class</u></b> |                               |        |
|----------|---|-------------------------------|--------|
|          | Somewhat to Poorly Drained                            | Poorly to Very Poorly Drained | Upland |
| SVP      | 74.07   | 17.79                         | 8.14   |
| PVP      | 27.04   | 33.46                         | 39.50  |
| WQ-SVP   | 60.63   | 6.50                          | 32.87  |

Source: Constructed from data provided by Dornbush et al., (2012, p. 35)

Test plot analysis indicated yield reductions of 67% (or yields equal to 33% of upland soils) occur on “poor to very poorly” drained land compared to well-drained (upland) soils (Dornbush et al., 2012). Additionally, precision crop data (detailed, historical crop yields mapped against soil drainage types) indicated yield reductions of 27% (or yields equal to 73% of upland soils) occur on somewhat poorly to poorly drained soils compared to well-drained (upland) soils (Dornbush et. al, 2012). Expected yields from an acre of cropland after applying the appropriate yield reduction factors (73% yield for

“somewhat to poorly” drained soils and 33% yield for “poor to very poorly” drained soils) are displayed in Table 15 for each scenario.

Table 15: Expected Yield Factor by Scenario

| Scenario | Percent of Land in each Soil Type            |   |                           | Expected Yield Factor |
|----------|--|---|---------------------------|-----------------------|
|          | Somewhat to Poorly Drained Soils (73% yield) | Poor to Very Poorly Drained Soils (33% yield) | Upland Soils (100% yield) |                       |
| SVP      | 74.07  | 17.79   | 8.14                      | 68.08                 |
| PVP      | 27.04  | 33.46   | 39.50                     | 70.28                 |
| WQ-SVP   | 60.63  | 6.50  | 32.87                     | 79.27                 |
| Uplands  | 0.00   | 0.00  | 100.00                    | 100.00                |

Percentages of soils in different drainage classes from each scenario were multiplied by respective yield values from each soil drainage type and then added to determine the expected yield factor.

Source: Constructed by data from Dornbush et al. (2012, p. 35)

Of the three models, the SVP model shows the lowest expected yield factor, in part because it contains the smallest amount of upland soils. Conversely, the WQ-SVP has a larger expected yield factor because it contains a larger percentage of upland soils. Changes to an alternate crop (switchgrass) are most likely to occur when the impact on current revenue streams is the least, in other words, when the yield scenario is lowest (and therefore profit is lower). Crop yield reductions in this paper will utilize the SVP model reduction framework because it represents the harshest, or most pessimistic scenario to occur for traditional crops, thus a very conservative analysis. This scenario also has the greatest potential for public environmental program eligibility.

This paper assumes a “three year high yield average” for a maximum yield value for corn grain, corn silage, and soybeans in the LFR Watershed, similar to that from

Dornbush et al. (2012). A three-year high yield average is used to minimize the chance of an extremely good growing year that would skew the results of this analysis. To determine the three year high yield value, the top three yields from 2003-2012 for each crop type are averaged. This average high yield then has the yield reduction factor applied from the SVP scenario. For the years of 2003-2012, the average high yields for corn grain, corn silage, and soybeans are 147.7 bushels, 18.67 tons, and 46.33 bushels, respectively (Table 16). Applying the SVP yield reduction factor of 68.08%, the corn grain yield estimate used for this research is 100.55 bushels, while corn silage and soybeans are 12.71 tons, and 31.54 bushels respectively (Table 17).



Table 16. 2003-2012 Crop Yield Data for Brown County, WI

| Crop Type   | Year       |      |            |           |      |      |      |      |             |             | Three Year<br>High Average |
|-------------|------------|------|------------|-----------|------|------|------|------|-------------|-------------|----------------------------|
|             | 2003       | 2004 | 2005       | 2006      | 2007 | 2008 | 2009 | 2010 | 2011        | 2012        |                            |
| Corn Grain  | <b>156</b> | 113  | <b>141</b> | 124       | 116  | 114  | 133  | 135  | 140         | <b>146</b>  | 147.7                      |
| Corn Silage | 20         | 11   | <b>17</b>  | <b>17</b> | 16   | 16   | 14   | 16   | <b>19</b>   | <b>17</b>   | 18.67                      |
| Soybeans    | 40         | 28   | <b>45</b>  | 40        | 38   | 36.5 | 36   | 43.4 | <b>44.1</b> | <b>49.9</b> | 46.33                      |

Source: Constructed by data from NASS (n.d.)

Table 17. Estimated Crop Yield Values for Marginal Lands (SVP Scenario)

| Crop Type          | Three Year<br>High Average | Crop Yield after Applying<br>Yield Factor (68.08%) |
|--------------------|----------------------------|--|
| Corn Grain (bu)    | 147.70                     | 100.55   |
| Corn Silage (tons) | 18.67                      | 12.71  |
| Soybeans (bu)      | 46.33                      | 31.54  |

Three year high average yields (NASS, n.d.) were multiplied by a yield factors of 68.08% (Dornbush et al., 2012) to simulate the expected yield on marginal lands.

Source: Constructed by data from NASS (n.d.) and Dornbush et al. (2012)

### 3.3 Crop Expenses

Crop expenses are dependent upon crop needs and yields as explained earlier in Chapter 2. Crop yields of 100.55 bushels of corn grain, 12.71 tons of corn silage, and 31.54 bushels of soybeans per acre dictate the nutrient level needs. Literature gathered in Section 2.2.5 indicated that average soil nutrient levels in the LFR Watershed varied from Optimum to Excessively High. Because data on soil nutrient levels for selected fields are unavailable, in this research optimal soil nutrient levels are assumed for phosphorus, potassium, and nitrogen for all crop types analyzed. Table 18 lists the nutrient needs for corn grain, corn silage, soybeans, and switchgrass based on optimal soil nutrient levels and expected yields.

Table 18. Crop Nutrient Requirements (Pounds per Acre) based off Expected Yield

|                      | <b>Expected Yield</b> | <b>P (lbs)</b> | <b>K (lbs)</b> | <b>N (lbs)</b> |
|----------------------|-----------------------|----------------|----------------|----------------|
| Corn Grain (bushels) | 100.55                | 40             | 30             | 145            |
| Corn Silage (tons)   | 12.71                 | 45             | 105            | 145            |
| Soybeans (bushels)   | 31.54                 | 25             | 40             | 0              |
| Prairie Grass (tons) | 3.77                  | 35             | 60             | 100            |

Source: Constructed by data from Laboski and Peters (2012)

Two methods exist for estimating expenses of growing traditional crops. In the first method strictly commercial fertilizers, where the second method used a combination of manure application and commercial fertilizer application. In both scenarios, corn crops received an application of 100 pounds of starter, as is standard practice in the region (Erb & Hagedorn, 2010-2012). For the switchgrass crop, only one growing method is used. During the establishment year, switchgrass is assumed to receive commercial fertilizer

applications of phosphorus and potassium. Nitrogen is not applied to limit competition from weed growth. During years 2-11, switchgrass receives 100% manure application, which contains phosphorus, potassium, and nitrogen.

Using the above nutrient values, two fertilization methods and the economic enterprise model, expenses and revenues for each crop were established. Table 19 lists the various expenses, revenues, and overall profits for the various crop types under the adopted SVP scenario for this research.

Table 19. Crop Expenses, Revenues, and Profits (per acre), SVP Scenario

|   | No Manure Application |                 |                 | With Manure Application |                 |                 | Prairie<br>Grass |
|---|-----------------------|-----------------|-----------------|-------------------------|-----------------|-----------------|------------------|
|   | Corn<br>Grain         | Corn<br>Silage  | Soybeans        | Corn<br>Grain           | Corn<br>Silage  | Soybeans        |                  |
| Sales Value   | \$534.20              | \$618.88        | \$370.17        | \$534.20                | \$618.88        | \$370.17        | \$282.95         |
| Subsidy   | \$47.22               | \$47.22         | \$30.84         | \$47.22                 | \$47.22         | \$30.84         | N/A              |
| <b>Total Revenue</b>  | <b>\$581.42</b>       | <b>\$666.10</b> | <b>\$401.01</b> | <b>\$581.42</b>         | <b>\$666.10</b> | <b>\$401.01</b> | <b>\$282.95</b>  |
| <b>Cost Type</b>  |                       |                 |                 |                         |                 |                 |                  |
| Fertilizer  | \$137.68              | \$181.65        | \$40.99         | \$109.10                | \$103.61        | \$0.00          | \$4.67           |
| Manure  | N/A                   | N/A             | N/A             | \$19.83                 | \$25.67         | \$29.17         | \$36.19          |
| Seed  | \$75.00               | \$75.00         | \$48.00         | \$75.00                 | \$75.00         | \$48.00         | \$5.11           |
| Pre and Post Preparation<br>(Tillage, Planting, Herbicides) | \$75.50               | \$64.50         | \$48.50         | \$75.50                 | \$64.50         | \$48.50         | \$18.03          |
| Harvesting  | \$82.29               | \$115.00        | \$33.79         | \$82.29                 | \$115.00        | \$33.79         | \$92.02          |
| Land Rent   | \$100.00              | \$100.00        | \$100.00        | \$100.00                | \$100.00        | \$100.00        | \$100.00         |
| Interest  | \$20.56               | \$23.90         | \$9.27          | \$19.86                 | \$19.71         | \$8.33          | \$2.27           |
| <b>Total Expenses</b>                                       | <b>\$491.02</b>       | <b>\$560.05</b> | <b>\$280.54</b> | <b>\$481.58</b>         | <b>\$503.48</b> | <b>\$267.78</b> | <b>\$258.29</b>  |
| <b>Profit</b>   | <b>\$90.39</b>        | <b>\$106.05</b> | <b>\$120.47</b> | <b>\$99.84</b>          | <b>\$162.62</b> | <b>\$133.23</b> | <b>\$24.66</b>   |

### 3.4 Per Acre Profitability Analysis

Table 19 displays per acre expense estimates for the individual crops by fertilizer application method. However, farmers plant crops in rotations and the regional analysis required. This is to be included in economic analyses. One approach is to develop a representative ratio between study region corn grain, corn silage, and soybeans acreage (Table 20) by using data from the NASS (n.d.) website (Appendix C).

Table 20. 2008-2012 Corn Grain, Corn Silage, and Soybean Acreage and 5-Year Average, Brown County

| Crop Type   | <u>Year</u> |        |        |        |        | 5-Year Average | Percent of 5-Year Average Cropland Average |
|-------------|-------------|--------|--------|--------|--------|----------------|--|
|             | 2008        | 2009   | 2010   | 2011   | 2012   |                |  |
| Corn Grain  | 31,300      | 27,200 | 35,200 | 24,300 | 26,700 | 28,940         | <b>34.71%</b>                              |
| Corn Silage | 29,700      | 29,500 | 27,100 | 40,800 | 44,400 | 34,300         | <b>41.14%</b>                              |
| Soybeans    | 22,300      | 21,200 | 18,700 | 19,300 | 19,200 | 20,140         | <b>24.15%</b>                              |
| Total       | 83,300      | 77,900 | 81,000 | 84,400 | 90,300 | 83,380         | <b>100.00%</b>                             |

Source: Constructed by data from NASS (n.d.)

Application of the 5-year average crop acreage proportion to the economic returns of each individual crop type allows development of a weighted average net return or profit that represents an acre of agricultural land in the Lower Fox River (LFR) Watershed. Comparison of these values among traditional crops and switchgrass agriculture determines which is more profitable. The first column of Table 21 displays the different options examined in this thesis. Each option uses the profit generated by a crop type (Column 2) and applies the acreage percent to develop a crop weighted profit per acre.

Table 21. Crop Weighted Profit (per acre) in the Lower Fox River Watershed, SVP scenario

| Scenario              | Crop Type   | Profit   | Corn grain | Corn Silage | Soybeans | Switchgrass | Average Weighted Crop Profit | Crop Weighted Profit Per Acre |
|-----------------------|-------------|----------|------------|-------------|----------|-------------|------------------------------|-------------------------------|
|                       |             |          | 34.71%     | 41.14%      | 24.15%   | 100%        |                              |                               |
| Commercial Fertilizer | Corn Grain  | \$90.39  | \$31.37    | -           | -        | -           | \$31.37                      | <b>\$104.10</b>               |
|                       | Corn Silage | \$106.05 | -          | \$43.63     | -        | -           | \$43.63                      |                               |
|                       | Soybean     | \$120.47 | -          | -           | \$29.10  | -           | \$29.10                      |                               |
| Manure                | Corn Grain  | \$99.84  | \$34.65    | -           | -        | -           | \$34.65                      | <b>\$133.73</b>               |
|                       | Corn Silage | \$162.62 | -          | \$66.90     | -        | -           | \$66.90                      |                               |
|                       | Soybean     | \$133.23 | -          | -           | \$32.18  | -           | \$32.18                      |                               |
| Switchgrass           | Switchgrass | \$24.66  | -          | -           | -        | \$24.66     | \$24.66                      | <b>\$24.66</b>                |

Profit from each crop type was multiplied by the percent of land on which that crop type was grown to develop a weighted profit value. Weighted profit values from all crop types under each scenario were then added together to develop an aggregate profit value (per acre). This aggregate value represents the average expected net income or profit (per acre) that an agricultural operator can expect to earn in the Lower Fox River Watershed under each of the three scenarios.

As can be seen from this analysis, the corn and soybean mixture plantings generate higher returns per acre than switchgrass plantings in the SVP Scenario. Row crops grown with only commercial fertilizer applications yield \$79.44 more per acre than switchgrass plantings. When utilizing manure applications, row crop profits were \$109.07 more per acre than switchgrass. With estimated row crop profits higher than switchgrass profits it would seem that agricultural land conversion to switchgrass crops would be not be likely.

However, it is important to note that the analysis here focused on average crop yields for lands in the Lower Fox River Watershed. Estimation of crop yield values is done by taking the total crop production in bushels divided by the total acres harvested (NASS, n.d.). The NASS also tracks total acreage planted by each crop type for each county. The amount of land planted but which is not harvested presents an opportunity to convert non-profitable lands to a profitable purpose, switchgrass agriculture. Analysis of NASS data from 2003-2012 indicates an average of 6,869 acres of land not harvested in the four counties that make up the LFR Watershed (Table 22). This amount of land accounts for almost half of the targeted 13,900 acres of targeted land. While not all 6,869 acres lie within the LFR Watershed, it is likely that a good portion of the acreage does lie within the LFR Watershed. If this acreage is planted but not harvested, it represents a per acre planting cost of \$438.95 or \$468.58 depending upon whether manure or commercial fertilizer was used on the crops (making traditional crops less profitable). Without a harvestable crop, revenue generation does not occur resulting in an operating loss to the farmer. On these fields, an expected profit of \$24.66 could occur for switchgrass agriculture, making switchgrass an economically viable option to increase farm income, by reducing the risk of traditional crop failure when planted on marginal land.

Table 22. Average Non-Harvested Acreage in the Four Counties that Make up the Lower Fox River Watershed, 2003-2012 period

| County            | Number of Non-harvested Acres by Crop |          |       |             |
|-------------------|---------------------------------------|----------|-------|-------------|
|                   | Corn                                  | Soybeans | Wheat | Total:      |
| Brown             | 1500                                  | 340      | 500   | 2340        |
| Calumet           | 720                                   | 250      | 500   | 1470        |
| Outagamie         | 850                                   | 620      | 433   | 1903        |
| Winnebago         | 422                                   | 350      | 383   | 1156        |
| Four County Total | 3492                                  | 1560     | 1817  | <b>6869</b> |

Non-harvested acres were derived by subtracting harvested acres per crop type (for each year) from acres planted by crop type (for each year). This figure was then divided by 10 (number of years). Source: Constructed by data from NASS (n.d.)

While the foregoing analysis indicates that switchgrass is less profitable than traditional crops, many potential subsidy situations exist which could allow switchgrass to become more profitable than row crops on marginal lands. It is estimated that prairie grasses on marginal lands in the Lower Fox River Watershed reduce phosphorus run off by 0.85 pounds per acre per year, reduce total suspended solids runoff by 342.59 pounds per acre per year and sequester in excess of 2.5 metric tons of CO<sub>2</sub> per acre (Dornbush et al., 2012). Other environmental benefits not provided by row crops, including increased wildlife habitat and increased flood control, are provided by switchgrass. From a social perspective, these are of much interest. In Chapter 4, the environmental benefits and potential subsidy programs that may apply to the Lower Fox River Watershed are discussed.



## **CHAPTER 4: ENVIRONMENTAL BENEFITS, ECONOMIC BENEFITS, AND POTENTIAL SUBSIDY PROGRAMS**

### **4.1 Environmental Issues and Benefits**

Phosphorus is an important nutrient in both terrestrial and aquatic ecosystems. In undeveloped areas, phosphorus is generally the limiting factor in aquatic ecosystems. Agriculture, industry, and residential development can lead to increased phosphorus contributions to aquatic systems. High levels of phosphorus fertilization in aquatic systems lead to eutrophication, a condition where excessive plant and algae growth occurs. Eutrophic systems generally suffer from nuisance algal blooms, reduced submerged aquatic vegetation, lowered oxygen levels and increased turbidity. Fish and other aquatic life suffer from habitat loss, oxygen depletion, and harmful algae. Increased total suspended solids (TSS) exacerbate the problem by contributing to additional water turbidity, decreasing sunlight penetration in the water column, and filling in voids between rocks in essential aquatic habitat. As the changes occur, recreation levels on eutrophic water bodies decrease as users start experiencing dirtier water, unpleasant algae blooms and reductions in fish catch rates. Negative environmental impacts translate to negative economic impacts, which affect all residents of surrounding communities (The Cadmus Group, 2011).

The state of Wisconsin has declared the Lower Fox River Watershed and Lower Green Bay as an Area of Concern (known as the Green Bay Area of Concern or AOC) due to excessive nutrient runoff and sediment loads. Creation of a Total Maximum Daily Load (TMDL) for the AOC led to a focus in determining the quantity and origin of both phosphorus (P) and total suspended solids (TSS) loads. In addition, the TMDL has led to

development of programs for allocating phosphorus discharge limits for agricultural, municipal, and industrial sources and has generated some solutions for combatting excessive phosphorus loads. The negative environmental and economic impacts that the Green Bay AOC experiences due to excessive phosphorus loading is of high concern (The Cadmus Group, 2011).

Changing marginal land crops from corn and soybeans to switchgrass would result in numerous positive environmental effects. Dornbush et al. (2012) concluded land conversion to a perennial grass would result in a reduced loading of 354 kg/ha of TSS and 0.907 kg/ha of P to the watershed per year. Over a target area of 13,900 acres (7% land conversion), this results in a reduced loading to the bay of Green Bay of approximately 2,200 tons of sediment and 11,250 pounds of P would occur on a yearly basis (p. 33). In addition, based off the work by Dornbush et al. (2012) an estimated onetime sequestration of approximately 3 metric tons of CO<sub>2</sub> per acre would result in the top 40 cm of soil (p. 16). As an aggregate total, this results in a reduction of 41,700 metric tons of CO<sub>2</sub> from the target area, as well as increased wildlife habitat and improved riparian zones for the targeted 13,900 acres.

Placing a value on environmental services, such as carbon sequestration and reduced nutrient runoff can be difficult and in many cases, there exists a dearth of information. In situations where analysis has occurred, the analysis rarely includes a comprehensive study and is generally restricted to a singular factor, such as phosphorus, that makes it hard to quantify the total impact that occurs. Environmental studies are usually region specific, which leads to difficulty in transferring the information between regions due to geographic ecosystem and economic differences.

While a full ecosystem analysis for the Bay of Green Bay is unavailable, some region specific studies are available to look at individual benefits to the region. For example, using a Monte Carlo simulation, the Wisconsin Department of Natural Resources (WDNR) has estimated the benefits of phosphorus removal in Wisconsin to be worth \$23.56 per pound more than the associated costs. The WDNR's estimate included changes in property values, recreation opportunities, and lake management costs (Wisconsin Department of Natural Resources, 2012, p. 30).

In another case study, Kousky et al. (2011) investigated the costs and benefits of protecting open areas for flood control. The study focused on the East River basin, a sub-watershed located inside of the Lower Fox River Region. Kousky et al. (2011) used a Hazus model developed by FEMA and current land use practices coupled with projected increases in development for the year 2025. The Hazus model was then used to analyze the probability of 10, 50, 100, and 500 year floods and the associated damages of each flood type. Projected annualized costs of flooding of 7,403 acres in the LFR Watershed would cost federal and local governments, businesses, and residents an estimated \$22.06 million. The annualized costs of buying this amount of acreage would be around \$5.1 million, resulting in an economic benefit of roughly \$16 million a year (Kousky et al., 2011, p. 38-43).

Moore, Provencher, & Bishop (2009) performed another analysis that looked at the value of water clarity improvements in the Bay of Green Bay. Using a stated preference survey, 1000 property owners (both bayfront and inland residents) in the counties of Brown, Door, Kewaunee, and Oconto counties were asked if they would pay to increase water clarity by 4 feet on Green Bay by reducing nutrient runoff. If the respondent(s)

answered yes, they were asked to use bid amounts of \$50, \$100, \$300, \$500, \$700, and \$1000 to indicate how much they would be willing to pay for the water improvement if an initiative was included in a local referendum. Analysis of the results indicated that local property owners in the nearby counties valued a 4-foot water clarity increase in the range of \$5.3 to \$10.2 million depending on which model was used (Moore et al., 2009, p 31). In another study (Stoll, Bishop, and Keillor, 2001) estimated per household benefits at roughly \$222 per year (p. 7) from achieving the water quality goals for the Lower Fox River AOC's remedial action plan.

Fishing in Green Bay is a popular recreational activity. Approximately 50,000 anglers spend 300,000 days on Green Bay open water and ice fishing each year (Breffle, Morey, Rowe, Waldman, & Wytinck, 1999). Increasing fish populations by 1% would result in an additional \$0.15 to \$0.30 per angler day, or \$45,000-\$90,000 in yearly angling benefits (Austin, Anderson, Courant, & Litan, 2007, p. 30). In a highly eutrophic system, such as Green Bay, reducing phosphorus levels in the water would help increase populations of desirable fish species.

While surveys are useful in assessing the user benefits of a proposed change, reduced costs are also useful in valuing system changes. One specific cost that is regularly incurred is dredging of the shipping canal in Green Bay. In 2013, 90,000 cubic yards of dredge material were planned for removal at a cost of \$1,741,000. A reduction of 2,200 tons of sediment from the Fox River could equate to \$15,000 savings in dredging costs (DredgingToday.com, 2013).

The Cadmus Group (2007) estimated the cost of removing phosphorus at a rate of \$240/kg (p. 23) for point sources in the Fox River Watershed. Using the point source

estimate, reducing 11,250 pounds of non-point source generated phosphorus from the Fox River Watershed would result in almost \$1,225,000 in savings.

Knowing the value of increased environmental benefits and the savings in costs can help in assessing a project, but a clear economic analysis that links alternative crop plantings to specific environmental benefits is not presently feasible. Clearly there are environmental benefits, which have been used to develop public programs to assist in their provision and that make alternative agricultural practices the creation of pollutant trading centers, etc. While difficult, it may prove worthwhile to make a project more economically feasible. In the next section currently available programs that could affect the profitability of a cropping pattern change are examined.

## **4.2 Environmental Programs Applicable to the Project Area**

### **4.2.1 Biomass Crop Assistance Program**

Administered by the USDA's Farm Service Agency, the Biomass Crop Assistance Program (BCAP) came to life in the 2008 Farm Bill. The BCAP program offers monetary incentives to agricultural producers for growing unconventional biomass crops (such as switchgrass) with an end goal of generating fuel sources for renewable heat, power, and biofuels (United States Department of Agriculture: Farm Service Agency [USDA], 2013).

To be eligible for payments, biomass crops have to be located in a designated BCAP area and contracts of five years or more are required. Crop producers and/or bioenergy facilities are eligible to submit applications to the USDA to become a BCAP area. If

accepted as a BCAP area, financial incentives can be quite substantial. Total incentive amounts vary in each BCAP area, however the general payment schedule for the BCAP program are described below.

- 1) Producers are eligible for up to 75% reimbursement of the establishment costs for producing biomass.
- 2) Producers can receive annual payments for up to five years on herbaceous plants and up to 15 years for woody biomass crops. The BCAP program links annual payments for switchgrass to the applicable CRP marginal land rental rate for the region. However, when sale of a biomass crop occurs, producers receive a reduction in the annual rental payment related to the use of the crop. For example, when conversion of the biomass crop into cellulosic biofuels occurs, land rental rates have a 1% reduction; Crops used for advanced biofuels have a 10% rental rate reduction; heat, power, or biobased products receive a 25% reduction; and there is a 100% reduction in the rental rate when using the biomass crop for anything other than the above listed uses.
- 3) Producers are eligible for matching payments up to \$45 per ton of biomass delivered to a conversion facility for the first two years of production.

Using information from the switchgrass model discussed earlier in this research, a potential subsidy value is available. Prior information assumed switchgrass establishment in year 1 and 25% reestablishment in year 2. Switchgrass yields of 2 tons per acre in year 1, 3.5 tons per acre in year 2, and 4 tons per acre during years 3-5. Land rent was set at

\$100 per acre. No cellulosic biomass conversion facilities exist in the Lower Fox River Region, however, pelletizing facilities do exist within or near the region, which would allow conversion of the switchgrass to pellets for heating uses. For that reason, a 25% reduction occurs for the land rental income portion of the subsidy. Estimated yearly subsidy available under the above listed scenario is displayed in Table 23; Displayed in Table 24 is the total subsidy received over the 5 year period, the average yearly subsidy over 5 years (minimum time required by contract), and the average yearly subsidy over 11 years (the life of the switchgrass stand). A revised comparison of the expected average profit for corn and soybean crops and switchgrass crops is displayed in Table 25 (USDA, 2013). Clearly the situation becomes more favorable for switchgrass to become a financially viable alternative to traditional corn and soybean crops.

Table 23. Biomass Crop Assistance Program Yearly Switchgrass Subsidy (\$/acre)

|                             | <u>Year</u>     |                 |                |                |                |
|-----------------------------|-----------------|-----------------|----------------|----------------|----------------|
|                             | 1               | 2               | 3              | 4              | 5              |
| Establishment Reimbursement | \$91.77         | \$20.00         | \$0.00         | \$0.00         | \$0.00         |
| Land Rental Income          | \$75.00         | \$75.00         | \$75.00        | \$75.00        | \$75.00        |
| Matching Biomass Payment    | \$90.00         | \$157.50        | \$0.00         | \$0.00         | \$0.00         |
| <b>Total Yearly Payment</b> | <b>\$256.77</b> | <b>\$252.50</b> | <b>\$75.00</b> | <b>\$75.00</b> | <b>\$75.00</b> |

Source: Constructed by data from USDA (2013)

Table 24. Aggregate Switchgrass Subsidy and Average Yearly Subsidy (\$/acre)

|  |          |
|--|----------|
| Total Aggregate BCAP Payments for Years 1-5      | \$734.27 |
| Average Payment over 5 years (Contract Minimum)  | \$146.85 |
| Average Payment over 11 years (Life of the Crop) | \$66.75  |

Table 25. Expected Yearly Profit including BCAP subsidy (\$/acre)

|              | <u>Row Crops</u>         |          | <u>Switchgrass</u> |                    |
|--------------|--------------------------|----------|--------------------|--------------------|
|              | Commercial<br>Fertilizer | Manure   | 5 Year<br>Average  | 11 Year<br>Average |
| Profit       | \$104.10                 | \$133.73 | \$10.22            | \$24.66            |
| BCAP Subsidy | N/A                      | N/A      | \$146.85           | \$66.75            |
| Total        | \$104.10                 | \$133.73 | \$157.07           | \$91.41            |

#### **4.2.1.1 Biomass Crop Assistance Program Areas:**

To date, there are 11 BCAP areas proposed or approved within the United States. Projects range from a few thousand acres up to 50,000 acres. Approved fuel sources vary by BCAP area but include Camelina, hybrid poplar, switchgrass, native prairie grasses, and giant miscanthus. In Table 26, information is provided on these eleven BCAP areas; geographic location approved for source, maximum acreage size, and funding availability. Relevant to this paper are BCAP Areas 1, 7, and 11 because approved biofuel sources are native prairie grasses or switchgrass (USDA, 2013).

Approval for BCAP Area Number 1 occurred in 2010. The area approved included 39 counties in Western Missouri and Eastern Kansas. Targeted enrollment was set at an initial 20,000 acres with the potential to expand to a maximum of 50,000 acres. Native grasses, legumes and forbs are to replace land farmed under traditional crops. A goal of three tons of biomass per acre per year would yield an aggregate total of 150,000 tons at peak production. BCAP Area 7 covers up to 20,000 acres between six counties in Kansas and Oklahoma. Targeted biofuels include switchgrass and other perennial grasses. In addition to establishment of new switchgrass planting on cropland, certain fields with existing stands of suitable perennial grasses and legumes are eligible. Sites must be



capable of producing 1.5 tons of biomass per acre per year. BCAP Area 11 covers eleven counties in North Carolina. The target area's approval included 3,200 acres of giant miscanthus and 1,100 acres of switchgrass. Participation in this program would require a five-year contract (USDA, 2013).

Table 26. Proposed or Active Biomass Crop Assistance Program (BCAP) Areas

| <b>BCAP Area</b> | <b>Geographic Area</b>              | <b>Biofuel Type</b>              | <b>Maximum Acreage</b> | <b>Funding Available</b> |
|------------------|-------------------------------------|----------------------------------|------------------------|--------------------------|
| BCAP 1           | Kansas and Missouri                 | Prairie Grasses                  | 50,000                 | Unavailable              |
| BCAP 2           | Arkansas                            | Giant Miscanthus                 | 7,788                  | \$1.35 Million           |
| BCAP 3           | Missouri                            | Giant Miscanthus                 | 3,400                  | \$3.822 Million          |
| BCAP 4           | Missouri                            | Giant Miscanthus                 | 3,850                  | \$4.815 Million          |
| BCAP 5           | Ohio and Pennsylvania               | Giant Miscanthus                 | 5,344                  | \$5.7 Million            |
| BCAP 6           | Oregon and Washington               | Camelina                         | 1,000                  | \$0.37 Million           |
| BCAP 7           | Kansas and Oklahoma                 | Prairie Grasses                  | 20,000                 | \$6.2 Million            |
| BCAP 8           | California, Washington, and Montana | Camelina                         | 50,000                 | \$24.5 Million           |
| BCAP 9           | Oregon                              | Hybrid Poplar Trees              | 7,002                  | \$17.127 Million         |
| BCAP 10          | New York                            | Shrub Willow                     | 3,500                  | \$4.288 Million          |
| BCAP 11          | North Carolina                      | Switchgrass and Giant Miscanthus | 4,300                  | \$3.996 Million          |

Source: Constructed by data from USDA (2013)

#### **4.2.1.2 Comparison Between the LFR Watershed and BCAP 1, 7, 11:**

As indicated above, a subsidy from the Biomass Crop Assistance Program could make switchgrass agriculture more profitable than traditional crops. While a subsidy program would be helpful, delineation of a BCAP area must occur before funding approval can be put in place. A reasonable question to ask is, would the Lower Fox River Watershed qualify as a BCAP area? A comparison between BCAP Areas 1, 7, and 11 and the Lower Fox Watershed is presented in Table 27. Categories investigated look at overall acres encompassing the counties where the BCAP areas are located, BCAP acreage, percent of total land, available funding, average harvested acreage of corn grain and soybeans, average corn grain and soybean yields, and average sales price for corn grain and soybeans. Data for BCAP Area 1 had to be collected prior to 2010 to negate any changes that had already occurred from the conversion of land use to BCAP agriculture. To be consistent, a five-year average (2004-2008) was used because it was prior to 2010, and coincided with a pre-existing analysis of the Lower Fox River Watershed.

Table 27. Comparison of BCAP Areas and the Lower Fox River (LFR) Watershed, 2004-2008 averages

| Area                         | Total<br>Acreage | BCAP<br>Acreage | Percent<br>of<br>Land | Available<br>Funding | <u>Average Acres<br/>Harvested</u> |            | <u>Yield (Bushels)</u> |          | <u>Prices (\$/Bushel)</u> |          |
|------------------------------|------------------|-----------------|-----------------------|----------------------|------------------------------------|------------|------------------------|----------|---------------------------|----------|
|                              |                  |                 |                       |                      | Corn<br>Grain                      | Soybeans   | Corn<br>Grain          | Soybeans | Corn<br>Grain             | Soybeans |
| BCAP 1                       | 14,931,840       | 50,000          | 0.33%                 | N/A                  | 34,538.18                          | 62,465.92  | 134.98                 | 38.04    | \$3.27                    | \$7.86   |
| BCAP 7                       | 3,391,360        | 20,000          | 0.59%                 | \$6,200,000          | 64,750.00                          | 7,625.00   | 182.38                 | 48.80    | \$3.40                    | \$7.76   |
| BCAP 11                      | 4,894,080        | 4,300           | 0.09%                 | \$3,996,000          | 21,704.73                          | 32,616.18  | 96.12                  | 27.93    | \$3.34                    | \$7.40   |
| LFR<br>Watershed<br>Counties | 1,378,622        | 13,900          | 1.01%                 | \$10,206,353*        | 247,805.00                         | 123,740.00 | 121.60                 | 37.50    | \$3.03                    | \$7.34   |

Total Acreage accounts for all acreage in all counties under a BCAP area. Percent of Land is computed by dividing the BCAP Acreage (for each area) by the Total Acreage (for each area).

\*Estimated Funding required at the prior-estimated 5 year per acre payment of \$734.27 per acre (Table 22.

Source: Constructed by data from USDA (2013)

From Table 27, it is evident that the Lower Fox Watershed targeted BCAP acreage falls in the mid-range of similar projects. The total acreage of corn and soybeans harvested in the LFR Watershed appears to be a larger portion of the total land use. However, corn grain and soybean yields are within the range of yields of these other three existing or proposed BCAP areas. Crop prices for 2004-2008 indicate that the BCAP 1, 7, and 11 receive a higher sale price than that of the LFR Watershed. From this information it appears that the LFR Watershed seems to be a viable contender for a BCAP Project Area.

#### **4.2.2 NRCS EQIP Programs**

The USDA's Natural Resource Conservation Service (NRCS) offers programs that address water quality issues and soil loss on agricultural fields. Close investigation of some of these programs indicates there is potential for subsidy payments under a switchgrass crop scenario.

One NRCS program that applies is Forage and Biomass Planting 512 under the Environmental Quality Incentives Program (EQIP). To receive compensation under this program, conversion of agricultural cropland to switchgrass would require a 5-year contract. In addition, soil test analysis and proper fertilizer application according to the UW-Madison, Department of Soil Science recommendations is required. A one-time payment of \$165.06 per acre is available for most agricultural fields. Some "higher-priority" fields may qualify for a one-time payment of \$190.46 (United States Department of Agriculture: Natural Resource Conservation Service, 2012). Average yearly profit is listed below in Table 28. While a subsidy would help switchgrass

be more profitable under this program, traditional agriculture still generates a higher income for agricultural operators. This program alone is not enough to “tip the scales” towards switchgrass plantings.

Table 28. Expected Profit under Forage and Biomass 512 Subsidy Program (\$/acre)

|                            | <u>Row Crops</u>      |          | <u>Switchgrass</u> |                    |
|----------------------------|-----------------------|----------|--------------------|--------------------|
|                            | Commercial Fertilizer | Manure   | 5 Year Average     | 11 Year Average    |
| Profit                     | \$104.10              | \$133.73 | \$10.22            | \$24.66            |
| Forage and Biomass Subsidy | N/A                   | N/A      | \$33.01 to \$38.09 | \$15.01 to \$17.31 |
| Total                      | \$104.10              | \$133.73 | \$43.23 to \$48.31 | \$39.67 to \$41.97 |

Source: Constructed by data from United States Department of Agriculture: Natural Resource Conservation Service (2012)

#### **4.2.3 Partners for Fish & Wildlife Program**

The United States Fish and Wildlife Service works to promote and protect fish and animal population levels on a national scale through various programs including long-term monitoring, invasive species reduction, and habitat restoration (United States Fish and Wildlife Service, n.d.) The Partners for Fish and Wildlife Program provides technical and financial assistance to landowners that restore and enhance wildlife habitat. Selection for an eligible project is limited and payment is contingent upon available funding. Landowners approved for this project are eligible for reimbursement of up to 100% of the establishment costs on approved acreage (United States Fish and Wildlife Service, n.d.) Estimated establishment costs of switchgrass are \$222.37 per acre. Comparison of traditional agriculture revenues and switchgrass including this subsidy are shown below

in Table 29, shown below. Once again, switchgrass is profitable, but not to the extent to “tip the scales” when compared to traditional crops.

Table 29. Expected Profit under Partners for Fish and Wildlife Subsidy Program (\$/acre)

|   | <u>Row Crops</u>         |          | <u>Switchgrass</u> |                    |
|---|--------------------------|----------|--------------------|--------------------|
|   | Commercial<br>Fertilizer | Manure   | 5 Year<br>Average  | 11 Year<br>Average |
| Profit                                    | \$104.10                 | \$133.73 | \$10.22            | \$24.66            |
| Partners for Fish and<br>Wildlife Subsidy | N/A                      | N/A      | \$44.47            | 20.22              |
| Total                                     | \$104.10                 | \$133.73 | \$54.69            | 44.88              |

Source: Constructed by data from United States Fish and Wildlife Service (n.d.)

#### **4.2.4 Water Quality Trading – Phosphorus**

Use of water quality trading occurs in water bodies that suffer from excessive pollution and strict regulation to reduce the pollution levels. Water quality trading involves crediting individuals who reduce pollutant discharges and allows the purchasing of those credits by other pollutant dischargers. Organizing a water quality market in the LFR Watershed would allow organizations, such as a sewer district, to purchase phosphorus credits from farmers who reduce phosphorus by planting switchgrass.

Using the trading guidelines (Wisconsin Department of Natural Resources, 2013), phosphorus reductions from switchgrass plantings fall under a 2:1 trading ratio. The 2:1 ratio indicates that for every 2 pounds of phosphorus removed by switchgrass, one pound of phosphorus is dischargeable by the purchaser of the credit. As defined by the Cadmus Group (2007), the removal cost of phosphorus in the LFR Watershed is \$240 per

kilogram or \$108.86 per pound (p. 23). After applying the 2:1 ratio, the maximum rate a discharger would be willing to pay for a pound of phosphorus removed by switchgrass is \$54.43. Dornbush et al. (2012) estimated phosphorus runoff reductions of 0.85 pounds per acre per year when switchgrass is grown compared to traditional crops (p. 33). Disregarding any transaction costs, this would leave a maximum phosphorus trading value of \$46.27 per acre per year. This amount is still not sufficient, by itself, to “tip the scales” from traditional crops towards switchgrass.

#### **4.2.5 Carbon Trading**

Carbon trading is yet another potential subsidy available for use in the Lower Fox River Watershed. The Dornbush et al. (2012), work on grasses in the LFR Watershed indicates they can store 2.5 metric tons per acre of carbon or more over the life of the grasses (p. 16). Analysis of carbon storage can be difficult, but indications are that the below ground biomass carbon offers the quickest large quantity storage of carbon, while soil carbon storage offers the best long-term storage option. Traditional crops also have the capacity to store carbon in below ground biomass. However, for these crops tilling at the end of the growing season destroys root structures and negates any temporary carbon storage they perform during the growing season. Work in the LFR Watershed indicates below ground biomass of grasses has the capacity to store between 1.56 and 2.31 tons of carbon (top 40 cm of soil), while work by Tufekcioglu et al. indicates a storage capacity of 2.42 to 4.77 tons of carbon (top 35 cm of soil) (Tufekcioglu, Raich, Isenhardt, & Schultz, 2003, p. 194-196).



Carbon trading has experienced volatility in the past. However, trading regimes have stabilized and the volume of trading has increased. The average market values for a metric ton of carbon in 2009 were \$6.50 but fell to \$6.00 per ton in 2010 (Peters-Stanley, Hamilton, Marcello, & Sjardin, 2011, p. iv). Assuming a carbon sequestration rate of 2.5 metric tons per acre and a \$6.00 per ton selling price, switchgrass could generate an additional \$15 per acre in onetime carbon trading revenue. Averaging this value across the eleven-year life span of a switchgrass crop equates to \$1.36 per acre per year, clearly a benefit but insufficient to cause a change from traditional cropping of corn and soybeans in the Lower Fox River Watershed.

#### **4.2.6 Comparison of Potential Subsidy Situations**

While the growth of switchgrass on lowland fields as an agricultural crop is profitable, it faces an \$80-100 deficit when compared to that of traditional agricultural crops. Investigation of possible subsidy programs reveals the potential for subsidy payments; however, in most cases a deficit is still apparent. Of the programs investigated, the Biomass Crop Assistance Program seems to offer the most promise to “tip the scales” toward switchgrass. Under a required 5-year contract period, it appears that switchgrass would be \$20 to \$50 per acre per year more profitable than traditional agriculture. However, when looking at the full eleven-year life cycle of the switchgrass, traditional agriculture shows a \$10 to \$40 greater profit per acre per year. Figure 11 shows a comparison of the profit levels achieved by the various cropping types and subsidy programs.

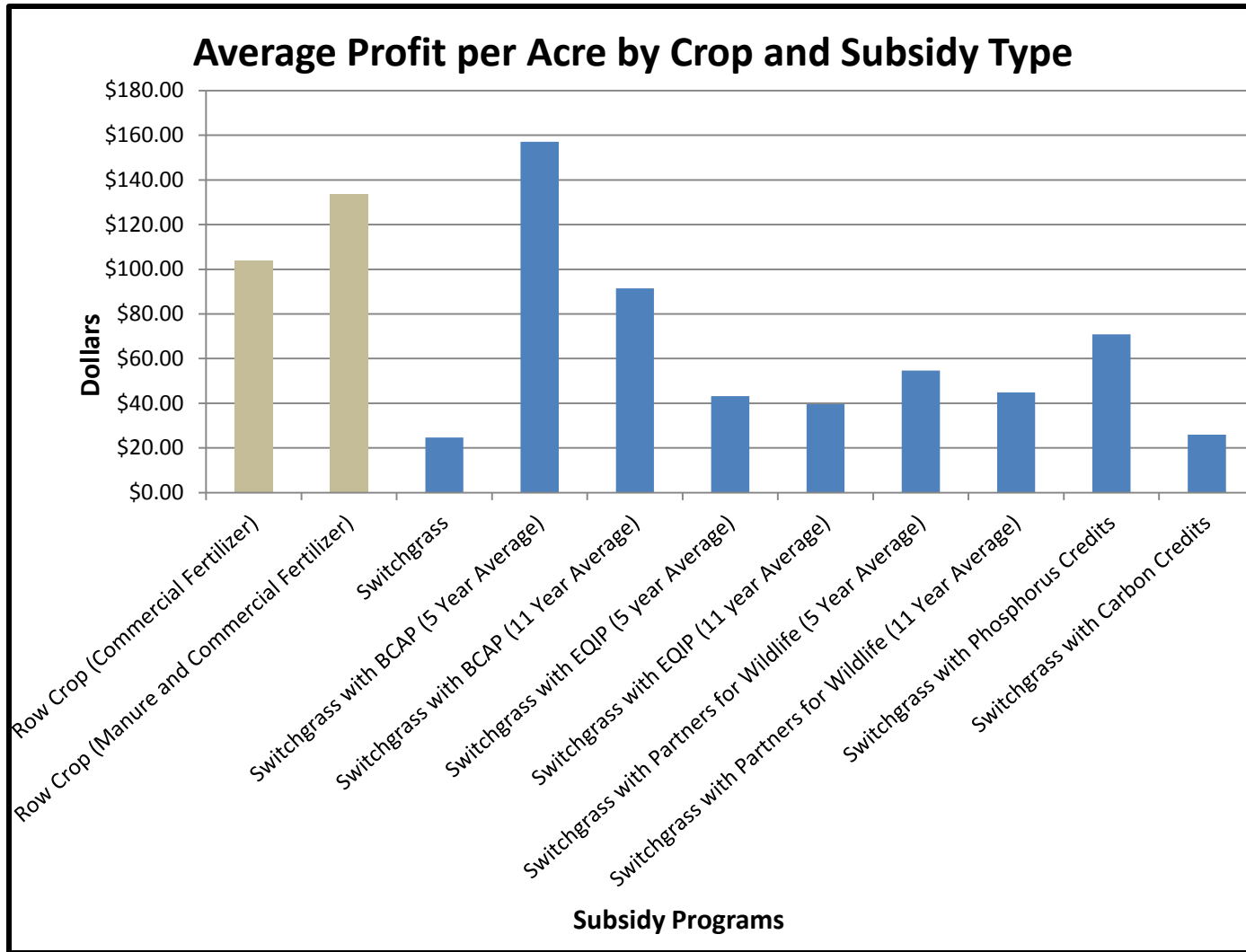


Figure 11. Comparison of Profit by Different Cropping Types and Subsidy Program

### **4.3 Summary of Findings**

Initial economic analysis indicates that switchgrass generates a profit of \$24.66 per acre compared against \$104.10 to \$133.73 per acre (depending on fertilizer method) for corn and soybean rotations. While analysis indicates switchgrass profit is \$80 to \$100 per acre less than traditional row crops, this analysis occurred under conservative assumptions that favor row crops. In addition to the initial analysis being conservative, environmental benefits provided by switchgrass were not included. Inclusion of subsidy programs (that were designed to encourage positive environmental changes) increases profits of switchgrass and reduces the disparity between switchgrass and traditional crops. In the case of the Biomass Crop Assistance Program, profits from switchgrass crops can even exceed that of traditional crops. Relaxing certain assumptions from the initial economic analysis changes the results between traditional crops and switchgrass. Some of these altered scenarios are presented in Chapter 5. In addition, Chapter 5 includes discussion on directions for future research.

## CHAPTER 5: CONCLUSION AND DISCUSSION

### 5.1 Conclusion

Detailed analysis in this paper indicated that conversion of marginal, lowland agricultural fields from row crops to switchgrass in the Lower Fox River Watershed is attainable and may be socially desirable. Initial analysis performed indicated that row crop agriculture is \$80-\$100 per acre more profitable than switchgrass; however, that analysis was designed to be conservative (using the SVP Scenario) in favor of the well-established and long practiced row crop agriculture that exists in the LFR Watershed. In addition, the impact of positive environmental changes is unaccounted for in traditional agricultural economic analysis, but yet provides a tangible social benefit to the LFR Watershed. Watershed reductions in phosphorus loads and total suspended solids loads of 3.6% and 4.3% (respectively) indicate a step in the right direction in achieving the Lower Fox River Total Maximum Daily Load (Dornbush et al., 2012, p. 33). Coupling carbon sequestration, habitat creation, increased recreation opportunities and other environmental benefits with water quality increases the value of lowland field conversion to switchgrass.

Subsidy situations for planting switchgrass in the LFR Watershed are available and do provide economic incentive for marginal land conversion. As discussed in Chapter 4, the additional revenue provided by most subsidy programs (excluding the Biomass Crop Assistance Program) does not cover the full difference in profit between row crops and switchgrass. However, once again, it is important to note that methods of analysis in Chapter 3 were designed to be advantageous to row crops, making any conclusions regarding conversion to switchgrass stronger. In a less restrictive analysis, especially

when coupled with existing subsidy programs, switchgrass would provide more economic benefit on lowland agricultural fields relative to traditional row crops.

## **5.2 Discussion**

Analysis in Chapter 3 focused on comparison of row crop agriculture (corn and soybeans) to switchgrass. The analysis was designed to be conservative in favor of row crop agriculture. In addition to choosing a focus on the SVP Scenario, crop yield comparisons used historical high yield values for corn and soybeans while using average expected values for switchgrass. Sales price data for row crops focused on a five year average from 2008-2012, even though there was a sharp spike in prices from 2010-2012 relative to previous years. Conversely, switchgrass prices assumed a conservative value of \$75 per ton (The Cadmus Group, 2007), while indications are that switchgrass prices could actually be higher. When sold, switchgrass closely resembles “poor quality hay” at market (Barnett, 2011; Erb & Hagedorn, 2010-2012). Historical data indicates a sales value of poor quality hay at \$96.28 per ton (CPI adjusted to 2012 dollars) (Barnett, 2011), while current (2013) values of poor quality hay are over \$100 a ton (Dairy Management, n.d.). When considered individually, some subsidy programs in Chapter 4 are ineffective at addressing the gap in profit of row crops and switchgrass. However, some of these subsidies could potentially be coupled to create larger revenue streams that would shift the balance making switchgrass more profitable than row crops.

Realistically, there are a number of future possibilities worth exploring. A brief synopsis of five configurations is considered under the SVP Scenario with results presented in Figure 12. These future possibilities for the Lower Fox River Watershed

compare the initial economic analysis to five alternatives that adjust only one component of crop yield or sales prices at a time. When yields are adjusted, the corresponding fertilizer costs and harvesting costs are also adjusted as appropriate for the analysis.

Figure 12. Optional Economic Scenarios for the Lower Fox River Watershed (\$/acre)



Under the initial analysis performed in Chapter 3, row crop yields are derived from a three-year high maximum. When average yield values from Brown County are used instead of high yields, the difference in profit per acre between row crops and switchgrass decreases to \$20 to \$47 per acre (Figure 12, top right). Different varieties of switchgrass cultivars can be expected to increase yields, with up to 10 tons per acre already documented (Vogell & Mitchell, 2008). By increasing switchgrass yields to 5 tons per acre, the profit gap drops down to \$13 to \$42 per acre (Figure 12, middle left). Valuation of switchgrass at \$100 per ton also increases revenue streams and makes switchgrass \$14 more profitable per acre when compared to commercial fertilized row crops or only \$15 below row crops fertilized with a combination of manure and commercial fertilizer. Similarly, a 10% decrease in the sales price of corn and soybeans lowers the profit gap between switchgrass and row crop agriculture by \$50-\$60, down to a difference of \$27 to \$56 dollars per acre (Figure 12, bottom left). The difference in profit between row crops and switchgrass in the four future possibilities just range from \$56 below to \$14 above traditional row crops. Considering that corn and soybeans have been subsidized \$47.22 and \$30.84 per acre in the recent past (Environmental Working Group, 2012), these scenarios present a very realistic opportunity for agricultural land conversion to switchgrass, especially when combined with the subsidy programs mentioned in Chapter 4 for which switchgrass may be eligible. Additionally, if the BCAP Program and phosphorus trading combined, (Figure 12, bottom right) converting lowland agricultural fields to switchgrass in the LFR is possible and profitable even under the most conservative analysis presented in this research.



### 5.3 Directions for Future Research

The present research has demonstrated switchgrass is an economically viable option in marginal croplands. While this paper is a contribution, there are still questions to be answered in the future. Changing weather patterns may affect cropping patterns and crop yields, which in turn affect profits. Many farmers are investigating the use of field tiles to expedite water from soils in lowland areas. Use of field tiles can increase crop yields of traditional crops, which would increase the revenue gap between traditional crops and switchgrass. Growth of switchgrass for use as a biofuel source is possible, but currently there are no biomass conversion facilities within a feasible distance of the Lower Fox River Watershed. Creation of a biomass facility in the Lower Fox River Watershed could increase demand for switchgrass, driving up prices and quantity of switchgrass grown in the LFR Watershed.

Establishment of switchgrass plots throughout the Lower Fox River Watershed would be useful in verifying costs and yields generated in this paper. Test plot data would also track switchgrass yields over time and pinpoint bottlenecks to establishment at a larger watershed scale. Additionally, further development of a phosphorus-trading program in the Lower Fox River Watershed would be useful in distributing financial incentives to farmers for environmental benefits provided by switchgrass growth. The Biomass Crop Assistance Program provides a large subsidy that vastly increases the profitability of switchgrass. However, to establish a BCAP Area, an aggregate of farmers or a conversion facility must apply for and receive BCAP status. Further investigation into establishment of a biomass conversion facility in the region as well as BCAP eligibility would be greatly beneficial in the establishment of switchgrass crops in the region.

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## **APPENDIX A – CROP YIELDS**

After opening the Quick Stats 2.0 Database

([http://www.nass.usda.gov/Quick\\_Stats?](http://www.nass.usda.gov/Quick_Stats?)) the user is offered a variety of options. To retrieve the appropriate data, users must select their options in a left to right and top to bottom order. Retrieval of 2003-2012 corn grain yield for Brown County will be demonstrated in the following steps; the same steps can be duplicated for other counties or crop types.

To retrieve 2003-2012 corn grain crop yield for Brown County, the user must select:

- SURVEY from the Program field,
- CROPS from the Sector field,
- FIELD CROPS from the Group field,
- CORN from the Commodity field,
- YIELD from the Category field,
- CORN, GRAIN – YIELD, MEASURED IN BU / ACRE from the Data Item field,
- COUNTY from the Geographic Level field,
- WISCONSIN from the State field,
- BROWN from the County field,
- 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012 from the Year field,
- ANNUAL from the Period Type field.

A computer screenshot of the steps taken is displayed below (Figure 13).



NASS - Quick Stats x USDA/NASS QuickStats A x

quickstats.nass.usda.gov

USDA United States Department of Agriculture  
National Agricultural Statistics Service

2007 CENSUS OF AGRICULTURE

Quick Stats [Home](#) [Recent Statistics](#) [Feedback](#) [Help](#)

**Program:**  
CENSUS  
SURVEY

**Sector:**  
ANIMALS & PRODUCTS  
CROPS  
ECONOMICS  
ENVIRONMENTAL

**Group:**  
CROP TOTALS  
FIELD CROPS  
FRUIT & TREE NUTS  
HORTICULTURE  
VEGETABLES

**Commodity:**  
BARLEY  
BEANS  
CANOLA  
CORN  
COTTON  
CRUDE PINE GUM  
FEED GRAINS & HAY  
FIELD CROP TOTALS  
FLAXSEED

**Category:**  
PROGRESS, MATURE, 5 YEAR AVERAGE  
PROGRESS, PLANTED  
PROGRESS, PLANTED, 5 YEAR AVERAGE  
PROGRESS, SILKING  
PROGRESS, SILKING, 5 YEAR AVERAGE  
RELATIVE WEIGHT  
SALES  
STOCKS  
YIELD

**Data Item:**  
CORN, GRAIN - YIELD, MEASURED IN BU / ACRE  
CORN, GRAIN - YIELD, MEASURED IN BU / NET PLANTED ACRE  
CORN, GRAIN, IRRIGATED - YIELD, MEASURED IN BU / ACRE  
CORN, GRAIN, IRRIGATED - YIELD, MEASURED IN BU / NET PLANTED ACRE  
CORN, GRAIN, NON-IRRIGATED - YIELD, MEASURED IN BU / ACRE  
CORN, GRAIN, NON-IRRIGATED - YIELD, MEASURED IN BU / NET PLANTED ACRE  
CORN, SILAGE - YIELD, MEASURED IN TONS / ACRE  
CORN, SILAGE, IRRIGATED - YIELD, MEASURED IN TONS / ACRE  
CORN, SILAGE, NON-IRRIGATED - YIELD, MEASURED IN TONS / ACRE

**Domain:**  
TOTAL

**Select Location (one or more)**

**Geographic Level:**  
AGRICULTURAL DISTRICT  
COUNTY  
NATIONAL  
STATE

**State:**  
SOUTH DAKOTA  
TENNESSEE  
TEXAS  
UTAH  
VIRGINIA  
WASHINGTON  
WEST VIRGINIA  
WISCONSIN  
WYOMING

**Ag District:**  
EAST CENTRAL

**County:**  
ADAMS  
ASHLAND  
BARRON  
BAYFIELD  
BROWN  
BUFFALO  
BURNETT  
CALUMET  
CHIPPEWA

**Select Time (one or more)**

**Year:**  
2012  
2011  
2010  
2009  
2008  
2007

**Period Type:**  
ANNUAL

[Clear](#) [Get Data](#)

Figure 13. Snapshot of Crop Yield Search

Then the user selects the “Get Data” button. A new screen will open up. Below is a computer screenshot of the data results (Figure 14). Getting the data into a database where it can be easily manipulated is important. Clicking on the “Spreadsheet” link in the upper right corner of the webpage opens a CSV file (comma-separated values) in Microsoft Excel where data manipulation can occur.

The screenshot shows the USDA NASS Quick Stats web application. The browser address bar displays the URL: `quickstats.nass.usda.gov/results/6D18AAAA-90B0-3E0E-8094-104B30260FC3`. The page header includes the USDA logo and the text "United States Department of Agriculture National Agricultural Statistics Service". The main heading is "Quick Stats". Below the heading, there are navigation links: "Home", "Recent Statistics", "Feedback", and "Help". A red instruction text reads: "Double click any cell below to filter the data by that item. Right click on column heading to pivot or hide columns." Below this, there is a "Navigation History: Data" link and a "Save :: Spreadsheet :: Printable :: Map :: (10 rows)" link. The main content is a table with 16 columns: Program, Year, Period, Geo Level, State, State ANSI, Ag District, Ag District Code, County, County ANSI, Commo, Data Item, Domain, Domain Category, and Value. The table displays 10 rows of data for the year 2012, showing crop yield for corn in Wisconsin, measured in bushels per acre. The values range from 113 to 146.1.

| Program | Year | Period | Geo Level | State     | State ANSI | Ag District  | Ag District Code | County | County ANSI | Commo | Data Item                                  | Domain | Domain Category | Value |
|---------|------|--------|-----------|-----------|------------|--------------|------------------|--------|-------------|-------|--|--------|-----------------|-------|
| SURVEY  | 2012 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 146.1 |
| SURVEY  | 2011 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 139.7 |
| SURVEY  | 2010 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 135.4 |
| SURVEY  | 2009 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 133   |
| SURVEY  | 2008 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 114   |
| SURVEY  | 2007 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 116   |
| SURVEY  | 2006 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 124   |
| SURVEY  | 2005 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 141   |
| SURVEY  | 2004 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 113   |
| SURVEY  | 2003 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN, GRAIN - YIELD, MEASURED IN BU / ACRE | TOTAL  | NOT SPECIFIED   | 156   |

Figure 14. Results of Crop Yield Search Window

## **APPENDIX B – CROP SALES PRICE DATA**

After opening the Quick Stats 2.0 Database

([http://www.nass.usda.gov/Quick\\_Stats?](http://www.nass.usda.gov/Quick_Stats?)) the user is offered a variety of options. To retrieve the appropriate data, users must select their options in a left to right and top to bottom order. Retrieval of sales price data for corn grain for Brown County will be demonstrated in the following steps; the same steps can be duplicated for other counties or crop types.

To retrieve 2003-2012 corn grain sales prices for Brown County, the user must select:

- SURVEY from the Program field,
- CROPS from the Sector field,
- FIELD CROPS from the Group field,
- CORN from the Commodity field,
- PRICE RECEIVED from the Category field,
- CORN, GRAIN – PRICE RECEIVED, MEASURED IN \$ /BU from the Data Item field,
- STATE from the Geographic Level field,
- WISCONSIN from the State field,
- 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012 from the Year field,
- ANNUAL from the Period Type field.

A computer screenshot of the steps taken is displayed below (Figure 15).

NASS - Quick Stats x USDA/NASS QuickStats A x

quickstats.nass.usda.gov/#6D18AAAA-90B0-3E0E-8094-104B30260FC3

USDA United States Department of Agriculture  
National Agricultural Statistics Service

2007 CENSUS OF AGRICULTURE

### Quick Stats

Home Recent Statistics Feedback Help

**Program:** CENSUS SURVEY

**Sector:** ANIMALS & PRODUCTS  
CROPS  
ECONOMICS  
ENVIRONMENTAL

**Group:** CROP TOTALS  
FIELD CROPS  
FRUIT & TREE NUTS  
HORTICULTURE  
VEGETABLES

**Commodity:** CORN  
COTTON  
CRUDE PINE GUM  
FEED GRAINS & HAY  
FIELD CROP TOTALS  
FLAXSEED  
FOOD GRAINS  
GRAIN STORAGE CAPACITY  
GRASSES

**Category:** CONDITION, EXCELLENT  
CONDITION, FAIR  
CONDITION, GOOD  
CONDITION, POOR  
CONDITION, VERY POOR  
PRICE RECEIVED  
PRICE RECEIVED, ADJUSTED BASE  
PRICE RECEIVED, PARITY  
PRODUCTION

**Data Item:** CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU  
CORN, GRAIN - PRICE RECEIVED, MEASURED IN PCT OF PARITY  
CORN, SILAGE - PRICE RECEIVED, MEASURED IN \$ / TON

**Domain:** TOTAL

**Select Location** (one or more)

**Geographic Level:** NATIONAL STATE

**State:** TENNESSEE  
TEXAS  
UTAH  
VERMONT  
VIRGINIA  
WASHINGTON  
WEST VIRGINIA  
WISCONSIN  
WYOMING

**Select Time** (one or more)

**Year:** 2012  
2011  
2010  
2009  
2008  
2007

**Period Type:** ANNUAL  
MONTHLY

**Period:** MARKETING YEAR

Clear Get Data

Figure 15. Snapshot of Crop Prices Search Window

Then the user selects the “Get Data” button. A new screen will open up. Below (Figure 16) is a computer screenshot of the data results. Getting the data into a database where it can be easily manipulated is important. Clicking on the “Spreadsheet” link in the upper right corner of the webpage opens a CSV file (comma-separated values) in Microsoft Excel where data manipulation can occur.

The screenshot shows a web browser window with the URL `quickstats.nass.usda.gov/results/B0FEA7CD-F357-3FE4-B38F-3FDFB276B346`. The page header includes the USDA logo and the text "United States Department of Agriculture National Agricultural Statistics Service". Below the header is a navigation bar with links: Home, Recent Statistics, Feedback, and Help. A message states: "Double click any cell below to filter the data by that item. Right click on column heading to pivot or hide columns." Below this is a navigation history section showing "Data" and a "Save :: Spreadsheet :: Printable :: Map :: (10 rows)" link. The main content is a table with 12 columns: Program, Year, Period, Geo Level, State, State ANSI, Commo, Data Item, Domain, Domain Category, Value, and an empty column. The table contains 10 rows of data for corn prices in Wisconsin from 2003 to 2012.

| Program | Year | Period         | Geo Level | State     | State ANSI | Commo | Data Item   | Domain | Domain Category | Value |  |
|---------|------|----------------|-----------|-----------|------------|-------|---|--------|-----------------|-------|--|
| SURVEY  | 2012 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 6.9   |  |
| SURVEY  | 2011 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 6.02  |  |
| SURVEY  | 2010 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 5.27  |  |
| SURVEY  | 2009 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 3.57  |  |
| SURVEY  | 2008 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 3.89  |  |
| SURVEY  | 2007 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 4.11  |  |
| SURVEY  | 2006 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 3.04  |  |
| SURVEY  | 2005 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 1.94  |  |
| SURVEY  | 2004 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 2.15  |  |
| SURVEY  | 2003 | MARKETING YEAR | STATE     | WISCONSIN | 55         | CORN  | CORN, GRAIN - PRICE RECEIVED, MEASURED IN \$ / BU | TOTAL  | NOT SPECIFIED   | 2.35  |  |

Figure 16. Results of Crop Prices Search

## **APPENDIX C – CROP ACREAGE**

After opening the Quick Stats 2.0 Database

([http://www.nass.usda.gov/Quick\\_Stats?](http://www.nass.usda.gov/Quick_Stats?)) the user is offered a variety of options. To retrieve the appropriate data, users must select their options in a left to right and top to bottom order. Retrieval of 2003-2012 corn acreage for Brown County will be demonstrated in the following steps; the same steps can be duplicated for other counties or crop types.

To retrieve 2003-2012 corn acreage for Brown County, the user must select:

- SURVEY from the Program field,
- CROPS from the Sector field,
- FIELD CROPS from the Group field,
- CORN from the Commodity field,
- AREA PLANTED from the Category field,
- CORN – ACRES PLANTED from the Data Item field,
- COUNTY from the Geographic Level field,
- WISCONSIN from the State field,
- BROWN from the County field,
- 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012 from the Year field,
- ANNUAL from the Period Type field.

A computer screenshot of the steps taken is displayed below (Figure 17).

USDA National Agricultural Statistics Service

2007 CENSUS OF AGRICULTURE

## Quick Stats

Home Recent Statistics Feedback Help

**Program:** CENSUS SURVEY

**Sector:** ANIMALS & PRODUCTS  
CROPS  
ECONOMICS  
ENVIRONMENTAL

**Group:** CROP TOTALS  
FIELD CROPS  
FRUIT & TREE NUTS  
HORTICULTURE  
VEGETABLES

**Commodity:** CORN  
COTTON  
CRUDE PINE GUM  
FEED GRAINS & HAY  
FIELD CROP TOTALS  
FLAXSEED  
FOOD GRAINS  
GRAIN STORAGE CAPACITY  
GRASSES

**Category:** AREA HARVESTED  
AREA PLANTED  
AREA PLANTED, NET  
CONDITION, EXCELLENT  
CONDITION, FAIR  
CONDITION, GOOD  
CONDITION, POOR  
CONDITION, VERY POOR  
PRICE RECEIVED

**Data Item:** CORN - ACRES PLANTED  
CORN, IRRIGATED - ACRES PLANTED  
CORN, NON-IRRIGATED - ACRES PLANTED

**Domain:** TOTAL

**Select Location (one or more)**

**Geographic Level:** AGRICULTURAL DISTRICT  
COUNTY  
NATIONAL  
STATE

**State:** SOUTH DAKOTA  
TENNESSEE  
TEXAS  
UTAH  
VIRGINIA  
WASHINGTON  
WEST VIRGINIA  
WISCONSIN  
WYOMING

**Ag District:** EAST CENTRAL

**County:** ADAMS  
ASHLAND  
BARRON  
BROWN  
BUFFALO  
BURNETT  
CALUMET  
CHIPPEWA  
CLARK

**Select Time (one or more)**

**Year:** 2012  
2011  
2010  
2009  
2008  
2007

**Period Type:** ANNUAL

**Period:** YEAR

Clear Get Data

Figure 17. Snapshot of Crop Acreage Search Window

Then the user selects the “Get Data” button. A new screen will open up. Below (Figure 18) is a computer screenshot of the data results. Getting the data into a database where it can be easily manipulated is important. Clicking on the “Spreadsheet” link in the upper right corner of the webpage opens a CSV file (comma-separated values) in Microsoft Excel where data manipulation can occur.

The screenshot shows a web browser window with the URL `quickstats.nass.usda.gov/results/6C02C7A0-2F09-3986-A409-3F3B8AEBF44B`. The page header includes the USDA logo and the text "United States Department of Agriculture National Agricultural Statistics Service". Below the header is a "Quick Stats" section with navigation links: Home, Recent Statistics, Feedback, and Help. A message states: "Double click any cell below to filter the data by that item. Right click on column heading to pivot or hide columns." Below this is a table with 15 columns: Program, Year, Period, Geo Level, State, State ANSI, Ag District, Ag District Code, County, County ANSI, Commo, Data Item, Domain, Domain Category, and Value. The table contains 10 rows of data for the year 2012, showing corn acreage planted in Wisconsin. The values range from 62,200 to 71,400 acres.

| Program | Year | Period | Geo Level | State     | State ANSI | Ag District  | Ag District Code | County | County ANSI | Commo | Data Item            | Domain | Domain Category | Value  |
|---------|------|--------|-----------|-----------|------------|--------------|------------------|--------|-------------|-------|----------------------|--------|-----------------|--------|
| SURVEY  | 2012 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 71,400 |
| SURVEY  | 2011 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 65,500 |
| SURVEY  | 2010 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 66,000 |
| SURVEY  | 2009 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 62,500 |
| SURVEY  | 2008 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 62,000 |
| SURVEY  | 2007 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 66,000 |
| SURVEY  | 2006 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 71,400 |
| SURVEY  | 2005 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 64,000 |
| SURVEY  | 2004 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 55,500 |
| SURVEY  | 2003 | YEAR   | COUNTY    | WISCONSIN | 55         | EAST CENTRAL | 60               | BROWN  | 009         | CORN  | CORN - ACRES PLANTED | TOTAL  | NOT SPECIFIED   | 62,200 |

Figure 18. Results of Crop Acreage Search



