View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Research Papers in Economics

Staff Paper P09-2 January 2009

Staff Paper Series

Economic Impacts of Establishing Short Rotation Woody Crops to Support Energy Production in Minnesota

by
William F. Lazarus and Douglas G. Tiffany

Department of APPLIED ECONOMICS

College of Food, Agricultural and Natural Resource Sciences

University of Minnesota

Staff Paper P09-2 **January 2009**

Economic Impacts of Establishing Short Rotation Woody Crops to Support Energy Production in Minnesota

by

William F. Lazarus and Douglas G. Tiffany

This paper represents research findings and conclusions contracted by the U.S. Forest Service through the University of Minnesota in accordance with provisions of **FS Agreement No. 04-JV-11231300-031**.

The analyses and views reported in this paper are those of the author(s). They are not necessarily endorsed by the Department of Applied Economics or by the University of Minnesota.

The University of Minnesota is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, color, creed, religion, national origin, sex, age, marital status, disability, public assistance status, veteran status, or sexual orientation.

Copies of this publication are available at http://agecon.lib.umn.edu/. Information on other titles in this series may be obtained from: Waite Library, University of Minnesota, Department of Applied Economics, 232 Classroom Office Building, 1994 Buford Avenue, St. Paul, MN 55108, U.S.A. A list of titles is also on the web at: http://www.apec.umn.edu

Copyright (c) (2008) by William F. Lazarus and Douglas G. Tiffany. All rights reserved. Readers may make copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

Abstract

The utilization of short rotation woody crops (SRWC) to produce wood on marginal crop and pasture land could greatly enhance the production of wood for various uses in Minnesota with utilization for energy being of current interest. SRWC involves the more intensive application of inputs on more valuable land than naturally regenerated forests that currently supply the bulk of the forest products industry in Minnesota. Breeding efforts to improve productivity and disease resistance in hybrid poplar species are making the technology of SRWC competitive with agricultural uses of marginal land. This study models the economic impact of a potential shift in use of the land resource by replacing production of hay and pasture that provides feed for cow-calf beef operations in northwest and west central Minnesota with SRWC. Regional economic impacts of such a shift are measured with established input-output techniques, using the software tool IMPLAN. To complete this analysis, the magnitudes and sectors of expenditures needed to produce either beef calves or hybrid poplar plantations were compared using farm records and hybrid poplar budgets. Construction of a $175 million energy conversion facility capable of making 44 million gallons of ethanol and 7.6 million gallons of mixed alcohols by catalytic means following gasification would result in creation of 2,412 jobs during the construction period, with $158 million in value-added (mainly employee compensation and business taxes). Operation of the facility after the end of construction, if supported by 200,000 acres of hybrid poplar production, would not change the number of jobs very much compared with using the land for cow-calf operations. However, the SRWC-related jobs would likely be at higher average salary levels and business tax collections would be higher, for a value-added increase of $80 million annually. In addition to greater wood supplies to support the forest products industry, logging pressures may be reduced on public forest land as a consequence of greater deployment of technology and methods that can result in production per acre that is eight to ten-fold greater than naturally regenerated forests.

Key words: Hybrid Poplar, SRWC, IMPLAN, economics, energy, ethanol, OSB

Contents

List of Tables

Introduction

The utilization of short rotation woody crops (SRWC) grown on marginal crop and pasture land for energy could make a significant contribution to meeting Minnesota's energy needs. This economic impact analysis is a follow-up to a similar report done a year ago that looked at the use of SRWC to produce wood products such as oriented strand board (OSB) [Lazarus and Tiffany, 2007]. The present analysis examines the economic contribution that SRWC might make to Minnesota's economy if utilized for energy rather than wood products.

When this project was originated the driving interest for utilization of wood produced from hybrid poplar plantations was for the production of oriented strand board (OSB). At that time wood from the naturally regenerated stands of timber was in high demand for use in paper and OSB. In order to have reasonable supplies of wood to maintain or expand the growing demand for wood, higher growth rates of wood from short rotation intensive culture would be needed to maintain the viability of the local mills and maintain local economic activities.

Since the original project was designed, the price for wood stumpage has fallen in Minnesota and the Lake States for a number of reasons. The housing sector in the U.S. is at last taking a breather, and the influence of multi-national forest products firms and national currency valuations have closed certain local mills seeking wood supplies for paper production or OSB. Now a new source of demand for wood is beginning to be recognized.

The new source of demand is that of utilizing forest resources for energy. Demand for wood has arisen from the plans to make liquid fuels such as methanol, ethanol, butanol, and pyrolysis oils from wood. Another usage of wood being realized is that of wood as a fuel for process heat. The cities of Virginia and Hibbing, Minnesota have each re-commissioned central steam plants to produce heat and power for those communities. In addition, plants producing ethanol and electricity at Little Falls, MN, Benson, MN, and Stanley, WI are moving ahead to utilize wood as a source of energy. The demand for wood for heat and power generation is strong because of efforts to reduce greenhouse gas emissions and control costs by substituting biomass for fossil fuels. Wood is more favorable to use than many other biomass fuels because of low NOx emissions and few issues of ash fusion caused by alkali metals. The 2007 Minnesota Legislative Session witnessed the passage of a bill to require the generation of 25 percent of electricity from renewable sources by 2025. Wood and other biomass fuels will have an important role in meeting this objective because they can support baseload power, which will be needed to complement highly variable wind farms, which has been very popular. We should expect greater demands on our forest resources to respond to the demand for building materials and also energy.

Economic Impact Analysis Methodology

Input-output analysis is the name given to an analytical framework developed by Nobel Prize-winning Professor Wassily Leontief in the late 1930s. A good general description of the methodology is Miller and Blair [Miller and Blair, 1985]. IMPLAN is a widely accepted economic impact analysis and forecasting model and database for the United

States. IMPLAN was developed originally by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the USDI Bureau of Land Management to assist in land and resource planning. It was developed further at the University of Minnesota and then privatized in 1993 with the formation of the Minnesota IMPLAN Group, Inc. of Stillwater, Minnesota which has continued development of the software and database. IMPLAN provides detailed estimates of the flows of goods and services to and from individual counties and regions.

An IMPLAN analysis begins with an assumption about the final demand being supplied by one or more sectors of the economy. It assumes that a particular sector produces and sells output to meet that demand. In the production process, it buys inputs ("inter-industry purchases") from other sectors (including from itself), and purchases primary inputs. The primary inputs are termed "value added" and are grouped into four categories: 1) employee compensation, 2) proprietary income (to proprietors or business owners), 3) other property income (such as rents), and 4) indirect business taxes. A fixed-price production function (vector of "gross absorption coefficients") defines the dollar amounts of these inter-industry and primary input purchases per dollar of output.

There are two main factors that affect the size of multipliers in IMPLAN studies: 1) how much of the study industry's direct impact (revenue or output) is used for purchases from other industries, relative to labor payroll, and 2) the structure of the local economy, and specifically whether it contains the industries that can supply those inputs that the study industry needs to purchase. Multipliers are higher when the study industry spends a high percentage of its revenue on purchases from other industries, because they then generate additional payroll and household spending beyond what the study industry generates directly. The structure of the local economy is important because the multiplier on imports is zero.

In the present analysis, production of one resource-based system (SRWC) is replacing another (hay, pasture, and beef). We model the economic impact of producing wood versus hay and pasture for beef production on the same land base.

Data needed to describe the direct impacts of SRWC include mainly: sales revenues; employment; payroll; payments to business owners; business taxes and rents paid; and reasonable estimates of costs of the main inputs required for the production process. In addition, estimates are required of how much of those purchases will be made in the region being considered versus imported from outside the region. These estimates are referred to as "regional purchase coefficients" or RPCs.

Study Area, Scenarios, Data Needs and Sources

Impact analysis looks at the effects of a positive or negative change in economic activity [Hughes, 2003]. An economic impact analysis begins by describing a study area and one or more scenarios that will be compared. An important assumption is where the SRWC will be grown and what current land uses it will replace. As mentioned above, this analysis is based on the assumption that the land use potentially replaced is marginal cropland or pastureland that does not produce very good yields of agronomic crops.

Economic impact analyses generally discuss two types of impacts: direct and secondary impacts. Secondary impacts are of two types, indirect and induced, which are described in more detail below. It is important to understand that the main role of the IMPLAN software is to estimate those secondary impacts, which are often expressed as a multiple of the direct impacts. Estimates of the direct impacts must be supplied by the user as a starting point for the IMPLAN analysis. The specific direct impacts analyzed are:

- operation of a thermochemical ethanol processing plant in the state of Minnesota utilizing as feedstock poplar wood grown in SRWC plantings in the state, partially offset by

- reduced agricultural output (beef calves) from the cropland and pastureland diverted to SRWC.

The assumption is made that the crops replaced would be hay and pasture. As discussed in more detail below, corn and soybeans are the state's largest crops in terms of acreage. Hay and pasture are cheaper to grow, however, and tend to be more common on the marginal lands of central and northern Minnesota where SRWC plantings would be likely to locate. The livestock enterprises that utilize most of the state's hay and pasture are beef cow-calf herds and dairy enterprises. For this analysis, beef cow-calf herds are assumed to utilize the hay and pasture rather than dairy enterprises because hay quality is less important for them and they are more common on the marginal lands of northern Minnesota. Corn grain and soybean meal are other major ingredients fed to beef cattle. A reduction in Minnesota beef cows and calves would reduce consumption of those feed ingredients as well as hay and pasture. Corn grain and soybean meal are more easily transported than hay, however, so it is assumed that the amounts of corn grain and soybean meal freed up by a reduction in beef cows would be exported out of the state rather than reducing production of corn and soybeans in the state.

The IMPLAN database used for the analysis is based on input-output relationships existing in the year 2006. The impacts are expressed in terms of 2008 prices.

The first step in an economic impact analysis is to determine the study area, which in this case is the state of Minnesota. Industry output, employment, employee compensation, and total value added for the state in 2006 is shown in Table 1. The largest component of value added is employee compensation, but income of business proprietors, along with property income and business taxes are also included in value added. Industry sectors are aggregated into two-digit North American Industry Classification System (NAICS) sectors. The SRWC production analyzed in this study falls into the "Ag, Forestry, Fish & Hunting" sector which represents 3.4 percent of total state employment. The other sectors of interest to this study are construction, since an energy conversion facility would need to be built, and manufacturing for operation of the facility once it is built. The construction sector makes up 5.6 percent of employment while total manufacturing is 10 percent.

SRWC Planting and Harvesting

While the focus of this study is on utilizing the poplar wood for energy, we also compare the results of that scenario with the original scenario of using it to make OSB paneling. The previous analysis used as a starting point the sales from IMPLAN sector 114, the "Reconstituted Wood Product Manufacturing" sector, in Minnesota. Wood purchases accounted for 13 cents per dollar of sector 114 product sales, or $54 million/year, in 2003, based on purchases made from the logging and sawmill sectors. That number was updated to $57 million for the present analysis based on the 2006 IMPLAN database[1]. A 4.5-ton annual growth increment, a 12-year stand life, and a $60/ton wood purchase price were assumed in that study. Those assumptions translate into a total poplar area of around 200,000 acres. That acreage is roughly nine typical townships of six miles square each. The 4.5-ton growth rate was based on hybrid poplar budgets produced by Bill Berguson of the Natural Resources Research Institute (NRRI) in collaboration with staff from Oak Ridge National Laboratory.

The poplar plantings would need to be established and the facilities constructed before harvesting and processing can take place. Annual plantings are assumed to be 12,500 acres per year for sixteen years at which point a total of 200,000 acres are in production. For this energy scenario, the annual growth increment in wood volume was reduced to four bone-dry tons/acre/year based on more recent poplar harvest data. The stand life was also reduced because log diameter would be less important for energy production. Harvest is assumed to take place in the eighth year rather than the twelfth. This first harvest is followed by coppicing and a second harvest in the sixteenth year, for an overall time commitment of seventeen years before the site can be replanted or shifted to some other use. More detail on the poplar planting and harvesting costs is presented in Lazarus [Lazarus, 2008b]. At four tons/acre/year, the annual physical volume available for harvest is then just under 1.4 million tons. A price of $81/ton would provide revenues sufficient to break even with the hybrid poplar production costs with an opportunity cost on capital of six percent per year. Wood purchases by the processing plant would amount to $65 million per year.

Industry experts reviewing these wood purchase percentages felt that they were low for normal economic conditions and that a more typical number for wood purchases would be 30 cents per sales dollar. The $65 million in wood purchases at a breakeven price of

[1] Sector 114 sales were reported as $409 million /year in the 2003 IMPLAN database, which was used for that analysis. The 2003 IMPLAN database used for the original study was updated to 2006 for this version. The reconstituted wood manufacturing sector was more profitable in 2006 than in 2003, possibly due to the strong housing market in that year. Sector 114 sales were $600 million in 2006 compared to $409 million in 2003. However, in terms of input-output modeling employment and input purchases by that sector did not change very much. The increased sales translated into higher property income (corporate profits) but property income is treated as a leakage out of the study area so doesn't affect the indirect impact of the sector. Wood purchases by that sector rose only slightly, from $54 million to $57 million. The housing market collapse since 2006 has caused some of the Minnesota OSB plants to shut down. When shut down, of course, the economic impact of the OSB industry would be near zero. However, we looked at a possible future situation where the OSB plants start back up with purchases of wood and other inputs and employment at 2006 levels.

$81/ton would imply total OSB sales of $216 million, or around a third to half of actual sector 114 sales in the 2003-06 time frame. The OSB scenario impacts reflect that amount.

An IMPLAN economic impact analysis begins with an estimated final demand or sales of an industry. An IMPLAN production function then describes the value-added inputs and the purchases from other industries, as cents per $1 of final demand. All industry output is assumed to be expended on either inter-industry purchases or value-added.

Table 2 shows the value-added input requirements per dollar of industry output for the poplar planting and harvesting activities and the other scenarios analyzed. The SRWC planting and harvesting along with the energy facility construction and operation are assumed to just break even, so costs are included for labor but not for proprietor income (or “profit”). Earnings per worker are based on the $16/hour labor cost used in the hybrid poplar enterprise budget times a full-time worker equivalent of 2,250 hours per year. The main components of property income are land rent and financing.

IMPLAN also calculates what the sector being analyzed will purchase from other industry sectors. The production function coefficients in Table 3 show how much these purchases will amount to during the initial poplar planting period and later when both planting and harvesting are underway. As mentioned above, the SRWC planting and harvesting costs are taken from a hybrid poplar enterprise budget and cash flow analysis [Lazarus, 2008b]. A bridge table was developed linking the expense categories from that analysis to IMPLAN industry sectors (Table 3).

The poplar enterprise budget does not separate out the share of expenses going to local wholesale trade establishments from the share going to manufacturers. The expense items (and IMPLAN sectors) where wholesale trade involvement seems likely to be involved are: diesel fuel (petroleum refinery), urea fertilizer (nitrogenous fertilizer manufacturing), Roundup and Sureguard herbicides and insecticide (pesticides and other agricultural chemical manufacturing), tractor maintenance and repair (farm machinery and equipment manufacturing), and property liability insurance (insurance carriers). A margin of 15 percent is assumed for those sectors, and is subtracted from each expense category and moved to the wholesale trade sector.

IMPLAN also makes assumptions about how much of a given sector’s inter-industry purchases are purchased within the region and how much is imported from outside the region. For the purpose of this study, it is assumed that all of the wood needs of sector 114 are met from within Minnesota. Default IMPLAN estimates were used for the crop inputs listed in Table 3 and for the sector 114 inputs other than wood.

Biomass Energy Conversion facility

Table 4 shows the production function coefficients used to calculate purchases from other sectors and the value added amounts during construction of the energy facility. Table 5 shows those amounts for operation of the energy facility or the reconstituted wood manufacturing sector.

With the shift in thinking to energy, two engineering studies were identified as the most relevant data sources on the capital investment, operating requirements, and purchasing patterns of future wood energy conversion facilities. One is a National Renewable

Energy Laboratory (NREL) feasibility analysis of ethanol production in a thermochemical gasification process [Phillips et al., 2007]. The other study is by the Rock-Tenn Community Advisory Committee looking at alternative sources of thermal (process heat) energy for a large paper recycling plant in St. Paul, Minnesota [Rock-Tenn Community Advisory Panel, 2008]. The NREL plant is sized at 700,000 tons/year, or somewhat smaller than the wood products plant but of the same general order of magnitude. The Rock-Tenn feasibility plan looks at several fuel alternatives including a wood biomass gasification system that would utilize 267,229 wet tons of wood/year when operating on 95 percent wood and 5 percent natural gas. An accompanying report describes the wood as chips of 42-50 percent moisture. At the midpoint of 46 percent moisture, this is 144,000 dry tons. An area of 200,000 acres would then supply somewhat more than six plants of the size of the proposed Rock-Tenn plant.

The biomass energy conversion facility would be newly constructed, in contrast with the OSB scenario where the plants already exist. So, the energy version of the economic impact analysis examines two time periods: 1) during plant construction, and 2) during operation.

In the case of the facility plant construction, purchases from other industries were determined based on the equipment list in Phillips et al. (which included costs in 2005 dollars) and the capital costs for materials and equipment in the Rock-Tenn spreadsheet. Dr. Andy McAloon, cost engineer with the USDA Agricultural Research Service, helped assign each of the Phillips equipment items to one of the 509 IMPLAN industry sectors. The Rock-Tenn sector assignments were done by the authors.

The purchases from other industries were allocated to IMPLAN sectors as shown in Table 4 along with coefficients showing the percentage of each input that is assumed to be purchased from within the state of Minnesota. These regional purchase coefficients (RPCs) are the defaults from the IMPLAN database. Value-added components for the construction phase were assumed to be 1) labor and 2) property income. The allocation between these two components is important because property income is assumed to leave the state totally, as in the case of stock dividends paid to shareholders of publicly-traded corporations, while most labor income is assumed to be spent locally.

The labor cost for the Phillips analysis is based on the “Purchased equipment installation” item from their Table 14 and engineering and construction costs from their Table 15, which add to 30 percent of total project investment. A larger portion of the Rock-Tenn total project cost is labor, which comes to 40 percent if engineering and permitting is put in the labor category.

The Rock-Tenn format also includes “contractor overhead and profit” of 13 percent of the total project cost, which is included in the “property income” component of value-added. The Phillips analysis does not include an explicit contractor profit item but does have “legal and contractor fees” as well as a small land cost, which together come to 8 percent of total project cost and are allocated to property income in the analysis. The value-added components then add to 38 percent of the expenditures in the Phillips analysis and 53 percent in the Rock-Tenn one.

The industry purchases are sorted from largest to smallest of the Rock-Tenn coefficients. The most noticeable difference is the 0.1363 coefficient in the Phillips analysis for the industry purchases from the metal tank-heavy gauge-manufacturing sector, which is mainly related to the equipment for processing the syngas into ethanol which is not done in the Rock-Tenn facility which only generates process heat. Also, the coefficient in the Rock-Tenn analysis for purchases from the industrial process furnace and oven manufacturing sector is larger (0.1844) than the 0.0770 for the Phillips column. This is for the gasifier unit, which is lumped together in the Rock-Tenn analysis but split among several sectors in the Phillips version.

At the time this analysis was being conducted, it was unclear which of these two facility designs might eventually be installed in Minnesota. So, for the purpose of the economic analysis, the two sets of coefficients were simply averaged as shown in the last column.

Table 5 shows the production coefficients and RPCs for the operation of the energy facility after construction is completed and compares them with the OSB coefficients. Note that the energy facility numbers include only operation, not construction, while the wood manufacturing sector numbers are an aggregate of the entire industry that presumably includes both construction and operation. The reconstituted wood manufacturing sector purchases from the logging and sawmill sector are shifted to the SRWC sector. The last column of Table 5 shows the percentage of each input that is assumed to be purchased within the state of Minnesota. These regional purchase coefficients (RPCs) are the defaults from the IMPLAN database. The items are sorted by energy facility column.

One observation one can make about Table 5 is that the wood input makes up over twice as much of total purchases for the energy facilities as for the wood manufacturing facility. In other words, the wood manufacturing sector adds more non-wood inputs and labor to the wood input than do the energy facilities. For the wood manufacturing sector, the sectors with the smallest coefficients are omitted to save space. The value-added portion of total purchases is somewhat less for the energy facility than for the OSB plant – 24 percent compared with 30 percent.

Reduced Hay, Pasture, and Beef Cow-Calf Production

The output of the cow-calf enterprises is assumed to be beef calves that are ready to be backgrounded at a location outside of Minnesota. There were 835,000 mature cows in Minnesota on January 1, 2006, of which 390,000 or a little less than half were beef cows. The 2006 calf crop was 830,000 animals.

The data source for the cow-calf and agronomic crop production functions is the FINBIN database compiled by the University of Minnesota's Center for Farm Financial Management [Center for Farm Financial Management, University of Minnesota, 2007]. To arrive at the inter-industry purchases required by IMPLAN, the calf purchases and transfers were included in expenses and added to gross returns for a measure of total output. The calf purchases and transfers amount to 65 cents/$1 of output.

The cropland and pastureland being switched to poplar production are assumed to be in mixed hay and pasture, with costs and returns represented by an average of the three-year FINBIN per-acre enterprise summaries for west central and northwestern Minnesota. The output of these enterprises is assumed to be fed to cow-calf herds represented by the FINBIN cow-calf enterprise summaries. Bridge tables were developed to link the FINBIN line items with IMPLAN sectors. The cow-calf data was incorporated into a production function modified from IMPLAN sector 11, “Cattle ranching and farming.”

Government payments in the mixed hay enterprise were included as part of gross output, which implicitly assumes that the payments will be lost if the land is converted to poplar. Fertilizer expenses were allocated equally among the nitrogenous fertilizers, phosphate fertilizers, and fertilizer mixing sectors.

As mentioned previously, the major feed ingredients fed to beef cattle are hay, pasture, corn grain and soybean meal (listed in the FINBIN reports as “protein supplement” which might also include other ingredients such as cottonseed meal and distillers grains). If reduced hay and pasture acreage were to cause a reduction in Minnesota beef cattle numbers, corn and soybean meal consumption by beef cattle would likely also decline. However, corn and soybean production in the state is assumed to remain the same with the difference showing up as increased exports of these crops out of Minnesota. The acreage switched to SRWC was allocated between hay and pasture based on the relative acreages required to supply the average amounts of each feed in the FINBIN cow-calf summaries at the average yields in the FINBIN mixed hay and pasture summaries. The FINBIN cow-calf report showed that pasture amounted to 19 percent and hay 81 percent of the total of forages plus pasture plus “other feed” costs, apart from the amounts of grains and protein. FINBIN gross return/acre is greater for hay ($126/acre) than for pasture ($26/acre). At those per-acre values, a feed cost that is 19 percent pasture and 81 percent hay in cost would be 54 percent pasture and 46 percent hay in acreage[2]. So, the mixed hay and pasture enterprise summary expense categories were converted to IMPLAN sectors and then combined in a weighted average of 81 percent hay and 19 percent pasture. The mix of hay and pasture would gross $72/acre, or $14 million on the 200,000 acres assumed to be replaced by SRWC. The mixed hay and pasture enterprise data was combined into IMPLAN sector 10, “All other crop farming.”

In the cow-calf enterprise, hay and pasture expenditures amount to around 29 percent of gross value. A $14 million reduction in hay and pasture then translates to a reduction in the cattle ranching enterprise output of $49 million. Including the calf finishing enterprise brings the hay and pasture expenditures down to 21 percent of the combined gross output, so the acreage reduction would translate to a cattle ranching and finishing output reduction of $68 million. The default IMPLAN production function for the animal slaughtering sector 67 shows purchases of livestock as 66 cents/$1 of slaughter plant output. That implies that a $68 million reduction in the production of finished steers and heifers translates to a $103 million reduction in slaughter plant output.

The FINBIN hay and pasture net returns and labor hours/acre results in income of $31,533/year, assuming 2,250 hours worked/year. Because of the cyclical nature of the cattle industry, a ten-year average was used for sector 11. The FINBIN data shows returns to the cow-calf enterprises over the past ten years averaging $89/cow, with 10.8

---

[2] That is, if you have a farm that is a combination of 54% pasture and 46% hay, then multiplying the 54% pasture portion of an average farm acre x the pasture gross value of $26/acre = $14, while the 46% hay portion x $126/acre = $58. Thus, the pasture portion of that typical acre is worth $14 / ($14 + $58) = 19% of the total $72 value of that average acre. The $58 of hay is worth 81% of the total $72 value of that acre.

hours/cow of labor. The “wages” earned by cow-calf producers average $8.22/hour, or $18,488/year at 2,250 hours/year:

Table 6 shows the crop farming sector production function coefficients that allocate the hay and pasture production expenses to IMPLAN industry sectors. The cattle ranching sector production function for allocation of the cow-calf enterprise expenses is shown in Table 7.

Results of the Impact Analysis

Table 8 summarizes the overall impacts of shifting 200,000 acres of land from pasture and hay to poplar processed in thermochemical ethanol conversion facilities. The first panel presents the impacts on output. The second panel shows the numbers of jobs and the bottom panel provides the value-added impacts.

The first line in each panel shows the impacts of site preparation, planting and maintenance of the plantings over the first three years, when input requirements are greater than they are in later years. The “Plant trees …” scenario would be typical of year 2 when site preparation is taking place on 25,000 acres, planting is being done on a second 25,000 acres, and a third 25,000 acres is undergoing weed and insect control. The “Plant and harvest” scenario would be typical of year 19 when two 12,500-acre blocks are being harvested (one block from the original planting and one coppiced block).

Planting the 12,500 acres of trees with the first three years of expenditures would involve spending $10.2 million, for a direct impact on the state of Minnesota of that amount. When the indirect impacts on other supplier industries and induced household spending is accounted for, the overall impact is $20.9 million.

Constructing the biomass conversion facility has a considerably greater impact - $175.3 million in direct spending and $303.7 million in overall impacts. That would be a one-time impact on the economy. Phillips et al. project that construction would take place over a three-year period.

The next three lines in the table show the ongoing annual expenditures for planting and harvesting 25,000 acres of trees/year on a rotating basis to maintain the 200,000-acre stand on a 17-year cycle, and the impact of processing that wood in the energy facility. Not surprisingly, the construction activity has larger impacts than planting or harvesting the trees. The impact of ongoing facility operations is also shown. This line includes labor to operate the facilities as well as inputs such as olivine, baghouse bags, and denaturant for the ethanol. The impacts of that poplar production and wood processing is comparable to facility construction - $192.9 million in direct expenditures and $324.9 million in overall impact. The wood purchases amount to 57 percent of the overall energy facility expenditures ($111 million / $192.9 million = 0.57).

As in the earlier OSB analysis, the positive impacts of the poplar production are compared against the loss of hay, pasture, and beef calves that were previously produced on the land in question. That loss or negative impact is $49.0 million in direct expenditures and $109.1 million in overall impact. The net impact of this shift is positive for output and value added, although the number of new jobs is slightly less than the beef-related jobs lost. The crop and cow-calf activity is associated with 1,172 jobs compared with 1,113 jobs in polar production and processing. Returns to cow-calf enterprises have historically been relatively low, however, and that situation is reflected in the 2004-06 FINBIN beef cow operator labor and management returns that are used in this analysis.

One caveat regarding the poplar vs. hay-pasture-cow-calf jobs comparison: the poplar planting and harvesting jobs are based on machinery operation labor and hand labor for specific field operations directly associated with the enterprise. The hay, pasture,and cow-calf enterprise job numbers are based on labor disappearance reported by the farms in the FINBIN database. "Labor disappearance" is calculated from total annual labor hours by the operator, family, and hired workers. Total labor hours are generally estimated from the number of full- and part-time workers and time that each works on the farm. That total labor amount allocated to the crop and livestock enterprises on the farm using factors that reflect judgments about the relative labor required per acre or per head. FINBIN labor disappearance hours/acre for agronomic crops tend to be higher than estimates of machine operation labor only. For example, labor disappearance in a recent Minnesota corn budget was 2.4 hours/acre [Lazarus, 2008b]. However, tillage, planting, and combining an acre of corn with modern machinery can take as little as 0.4 hours [Lazarus, 2008a]. The labor disappearance numbers would likely include machinery maintenance, planning time, and other activities indirectly related to a particular enterprise as well as machine operation. So, the poplar-related jobs might be more similar to the hay-pasture-cow-calf jobs if both were based on labor disappearance. Labor disappearance numbers are not available for poplar, while a labor breakdown by activity is not available for cow-calf enterprises so more comparable labor estimates are beyond the scope of this study.

The net impact of the energy scenario is significantly less than the net impact of using the poplar for OSB that was presented in the earlier report. One reason is that wood purchases made up only 30 percent of the OSB plant operating inputs while they make up 57 percent of the energy facility inputs. In other words, OSB production requires purchases of a large volume of other inputs. Producing those other inputs generates a lot of indirect economic activity. Based on the energy facility feasibility studies available to the authors, energy production does not require as many other inputs so the impact is less. The energy vs. OSB comparison based on Table 8 is a bit misleading, however, because the OSB numbers were based on a national average of OSB plants, and likely included depreciation or capital replacement as some OSB facilities somewhere were likely constructed or renovated and those capital expenditures included in the IMPLAN production functions. In the present analysis, the facility construction costs are shown separately and not included in the net impact numbers, which are based on expenditures of an operating plant. If the entire construction expenditures were included in the net impact, it would be slightly larger than the OSB net impact.

Stakeholders are often more interested in how a new investment or business will affect a particular industry than in the impact on the overall economy. IMPLAN is able to generate reports on the sectoral breakdown of any of the measures or scenarios shown in Table 8. To conserve space, only the sectoral breakdown of the value added impact is shown here (Table 9). This table shows the results for constructing the energy facility in the left panel and for operating the facility with planting and harvesting the poplar in the right panel. The operating results have the reduced hay, pasture, and cow-calf activities netted out. Aside from the directly affected sectors, the greatest impacts are seen in wholesale trade, government, and health and social services.

Table 1. Output, Employment, and Labor Income in Minnesota, 2008[3]

Industry	Industry Output*	Employ-ment	Employee Compen-sation*	Total Value Added*
11 Ag, Forestry, Fish & Hunting	10,598	120,144	801	3,507
21 Mining	2,189	7,048	404	986
22 Utilities	6,780	12,476	1,228	4,887
23 Construction	24,744	195,730	7,808	11,193
31-33 Manufacturing	135,386	352,252	22,496	34,169
42 Wholesale Trade	27,997	142,255	9,952	18,881
48-49 Transportation & Warehousing	14,254	123,804	5,235	7,306
44-45 Retail trade	23,658	372,687	8,409	15,474
51 Information	17,724	65,591	4,110	8,024
52 Finance & insurance	38,593	182,616	12,400	22,161
53 Real estate & rental	22,036	115,870	1,924	14,072
54 Professional- scientific & technical services	26,300	203,933	10,217	15,021
55 Management of companies	14,452	66,503	7,013	8,923
56 Administrative & waste services	9,824	171,052	4,172	5,882
61 Educational services	3,818	76,199	1,855	2,131
62 Health & social services	32,721	414,053	16,710	20,026
71 Arts- entertainment & recreation	3,470	74,878	1,307	2,044
72 Accomodation & food services	10,845	215,689	3,401	5,245
81 Other services	10,512	186,263	4,050	5,356
92 Government & non NAICs	42,759	395,760	20,987	39,163
Totals	478,660	3,494,801	144,479	244,451

*Millions of dollars

[3] Values were taken from the IMPLAN database.

Table 2. Value-Added Input Requirements Per Dollar of Industry Output for the Sectors Analyzed

IMPLAN sector	Employee Compensation	Proprietor Income	Property Income	Indirect Business Taxes	Total Value Added	Earnings /worker
-	- - - ($ Expenditures/Output $) - - -					($/year)
SRWC planting (average of first three years of 17-year stand life)	0.1992	-	0.1929	0.0266	0.4186	$36,000
SRWC planting and harvesting (average across 17-year stand life)	0.1923	-	0.1935	0.0298	0.4156	$36,000
Energy facility construction	0.3500	-	0.1050	-	0.4550	$50,089
Energy facility operation	0.0719	-	0.1953	0.0267	0.2418	$50,408
Reconstituted wood manufacturing	0.1642	0.0035	0.2335	0.0051	0.4063	$54,963
Crop farming (hay and pasture)	0.0177	0.1352	0.1533	0.0185	0.3247	$26,764
Cattle ranching (cow-calf)	0.0135	0.2614	-	0.0060	0.2809	$18,488

Table 3. Bridge Table Linking SRWC Production Expense Categories to IMPLAN Sectors

SRWC Expense Category	IMPLAN Sector Name	Plant poplar trees	Plant and harvest trees	Regional Purchases %
Seedlings	Forest Nursery--Forest Products	$ 0.1507	$ 0.0298	100%
Diesel Fuel Gal./Acre	Petroleum Refinery	$ 0.0866	$ 0.2167	84%
Urea Fertilizer	Nitrogenous Fertilizer Manufacturing	$ -	$ 0.0585	6%
Roundup, Sureguard, and Insecticide	Pesticides and Other Ag. Chemical Manufacturing	$ 0.1127	$ 0.0223	10%
Tractor & Implement Maint. & Repair Cost/Ac.	Farm Machinery and Equipment Manufacturing	$ 0.1612	$ 0.1675	80%
Property Liability Insurance	Insurance Carriers	$ 0.0056	$ 0.0063	100%
15% of purchases of fuel, urea, pesticides, and insurance	Wholesale trade	$ 0.0646	$ 0.0832	
	Total inter-industry purchases/$ of output	$ 0.5814	$ 0.5844	
	Employee Compensation	$ 0.1992	$ 0.1923	
Rent and financing	Property Income	$ 0.1929	$ 0.1935	
	Property taxes	$ 0.0266	$ 0.0298	
	Total value added	$ 0.4186	$ 0.4156	
	Total expenditures	$ 1.0000	$ 1.0000	

Table 4. IMPLAN Production Function and Regional Purchase Coefficients for Construction of Energy Conversion Facility, Cents Per Dollar of Final Demand

	Phillips et al. Study	Rock-Tenn Study	Average Used Here	Regional Purchases
Inter-industry purchases by IMPLAN industry sector				
Industrial process furnace and oven manufacturing	0.0770	0.1844	0.1307	0%
Metal tank- heavy gauge- manufacturing	0.1363	-	0.0682	4%
Manufacturing and industrial buildings	0.1231	0.0049	0.0640	100%
Other communication and energy wire manufacturing	0.1081	0.0174	0.0627	11%
Ferroalloy and related product manufacturing	0.0931	0.0160	0.0546	0%
Conveyor and conveying equipment manufacturing	-	0.1064	0.0532	56%
Iron and steel mills	-	0.0629	0.0315	3%
Air and gas compressor manufacturing	0.0444	-	0.0222	0%
Turbine and turbine generator set units manufacturing	0.0258	-	0.0129	50%
Switchgear and switchboard apparatus manufacturing	-	0.0172	0.0086	29%
Ready-mix concrete manufacturing	-	0.0145	0.0072	0%
Sheet metal work manufacturing	-	0.0112	0.0056	6%
Power boiler and heat exchanger manufacturing	0.0109	-	0.0055	3%
All other industrial machinery manufacturing	-	0.0089	0.0044	41%
Metal can- box- and other container manufacturing	-	0.0045	0.0022	24%
AC- refrigeration- and forced air heating	0.0012	0.0021	0.0017	0%
Iron- steel pipe and tube from purchased steel	-	0.0033	0.0017	0%
Overhead cranes- hoists- and monorail systems	-	0.0032	0.0016	56%
Metal valve manufacturing	-	0.0031	0.0016	8%
Paint and coating manufacturing	-	0.0023	0.0011	0%
Electric power and specialty transformer manufacturing	-	0.0021	0.0010	20%
Motor and generator manufacturing	-	0.0020	0.0010	11%
Asphalt shingle and coating materials manufacturing	-	0.0012	0.0006	100%
Scales- balances- and miscellaneous general purpose machinery	-	0.0009	0.0004	65%
Gypsum product manufacturing	-	0.0008	0.0004	0%
Engineered wood member and truss manufacturing	-	0.0008	0.0004	0%
Total inter-industry purchases	0.6200	0.4700	0.5450	
Value added components				
Labor	0.30000	0.40000	0.3500	
Property income	0.08000	0.13000	0.10500	
Total value-added	0.38000	0.53000	0.45500	
Total expenditures	1.00000	1.00000	1.00000	

Table 5. IMPLAN Production Function and Regional Purchase Coefficients for Operation of Energy Conversion Facility, Compared to Reconstituted Wood Manufacturing Sector, Cents Per Dollar of Final Demand

	Energy Facility Operation	Reconsti-tuted Wood Manu-facturing	Regional Purchases
Short-run woody crop harvesting	0.7181	0.3000	100%
Insurance carriers	0.0067	0.0016	66%
Other basic organic chemical manufacturing	0.0048	-	35%
Water- sewage and other systems	0.0042	-	100%
Sand, gravel, clay and refractory mining	0.0035	-	6%
misc. nonmetallic mineral products	0.0026	-	0%
Petroleum refineries	0.0156	0.0455	84%
Natural gas distribution	0.0009	0.0107	100%
Other basic inorganic chemical manufacturing	0.0009	0.0455	9%
Coated and laminated paper and packaging materials	0.0007	-	0%
Plastics packaging materials- film and sheet	-	0.1051	
All other forging and stamping	-	0.0066	
Management of companies and enterprises	-	0.0051	
Adhesive manufacturing	-	0.0049	
Monetary authorities and depository credit interme	-	0.0047	
Commercial machinery repair and maintenance	-	0.0043	
Semiconductors and related device manufacturing	-	0.0043	
Rail transportation	-	0.0043	
Other sectors not listed	-	0.0571	
Total inter-industry purchases	0.7582	0.6943	
Employee Compensation	0.0719	0.2798	
Proprietary Income	0.0000	0.0160	
Property income	0.1953	-	
Indirect business taxes	0.0267	0.0098	
Total value added	0.2418	0.3056	
Total expenditures	1.0000	1.0000	

Table 6. Bridge Table Linking Hay and Pasture Enterprise Production Expense Categories to IMPLAN Sectors[a]

FINBIN Expense Category	IMPLAN Sector Name	IMPLAN Sector	Purchases /Output $	Regional Purchases %
Utilities	Natural gas distribution	31	0.0109	78%
Fuel & oil	Petroleum refineries	142	0.0879	84%
Fertilizer (1/3)	Nitrogenous fertilizer manufacturing	156	0.0328	19%
Fertilizer (1/3)	Phosphatic fertilizer manufacturing	157	0.0328	19%
Fertilizer (1/3)	Fertilizer- mixing only- manufacturing	158	0.0328	0%
Repairs	Farm machinery and equipment manufacturing	257	0.2300	80%
15% of farm machinery manufacturing, Insurance carriers, natural gas distribution, petroleum refineries & fertilizer	Wholesale trade	390	0.0797	100%
Farm insurance	Insurance carriers	427	0.0245	100%
Custom hire	Machinery and equipment rental and leasing	434	0.0200	60%
Dues & professional fees	Accounting and bookkeeping services	438	0.0035	86%
Miscellaneous	Other sectors	11	0.0539	100%
Total $ inter-industry purchases/$ of output			0.6087	

[a]The $ of purchases/$1 of output are based on a crop mix of 81% mixed hay and 19% pasture.

Table 7. Bridge Table Linking Beef Cow-Calf Enterprise Production Expense Categories to IMPLAN Sectors

FINBIN Expense Category	IMPLAN Sector Name	IMPLAN Sector	$ Purchases /Output $	Regional Purchases %
Corn, corn silage, bedding	Grain farming	2	0.0793	NA
Hay, Pasture	All other crop farming	10	0.2934	100%
Utilities	Power generation and supply	30	0.0193	78%
Complete ration, protein, vitamins, minerals, other feedstuffs	Other animal food manufacturing	47	0.0779	84%
Fuel & oil	Petroleum refineries	142	0.0248	84%
Machinery leases, mach & bldg depreciation	Farm machinery and equipment manufacturing	257	0.0315	80%
Supplies + 15% of farm machinery manufacturing, Insurance carriers & petroleum refineries	Wholesale trade	390	0.0313	100%
Hauling and trucking	Truck transportation	394	0.0045	91%
Repairs	Building material and garden supply stores	404	0.0421	100%
Farm insurance	Insurance carriers	427	0.0135	100%
Dues & professional fees	Accounting and bookkeeping services	438	0.0044	86%
Marketing	Management consulting services	444	0.0107	78%
Veterinary	Veterinary services	449	0.0356	92%
Total $ inter-industry purchases/$ of output			0.6682	

Table 8. Impacts of Planting 200,000 Acres of Marginal Cropland and Pastureland to SRWC from Agronomic Crops Fed to Beef Herds With Calves Exported Out of Minnesota and Processed for Energy or for Oriented-Strandboard Paneling.

	Direct	Indirect/ Induced	Total
		Output	
		(millions)	
Plant trees, expenditures during the first three years, 12,500 acres each year	***$10.2***	***$10.7***	***$20.9***
Construct biomass conversion facility, 44 mill. gal.	***$175.3***	***$128.4***	***$303.7***
Plant and harvest trees on a continuous rotation, 25,000 acres replanted each year, 200,000 acres total	$111.3	$102.1	$213.4
Operate biomass conversion facilities, not including wood supply	$81.6	$29.9	$111.5
Total tree plant/harvest and facility operation	$192.9	$132.0	$324.9
Reduced impact from shifting away from hay and pasture fed to cow-calf enterprises	$(49.0)	$(60.1)	$(109.1)
Net impact of shifting land away from hay/pasture and toward poplar/energy	$143.9	$71.9	$215.8
Compare to Utilization for OSB, 200,000 total acres	***$216.0***	***$120.7***	***$336.7***
Reduced impact from shifting away from hay and pasture fed to cow-calf enterprises	***$(49.0)***	***$(60.1)***	***$(109.1)***
Net impact of shifting land away from hay/pasture and toward poplar/OSB	***$167.0***	***$60.6***	***$227.6***
		Employment	
Plant trees, expenditures during the first three years, 12,500 acres each year	***39***	***65***	***104***
Construct biomass conversion facility, 44 mill. gal.	***1,507***	***905***	***2,412***
Plant and harvest trees on a continuous rotation, 25,000 acres replanted each year, 200,000 acres total	261	478	739
Operate biomass conversion facilities, not including wood supply	194	180	374
Total tree plant/harvest and facility operation	456	657	1,113
Reduced impact from shifting away from hay and pasture fed to cow-calf enterprises	(809)	(363)	(1,172)
Net impact of shifting land away from hay/pasture and toward poplar/energy	(353)	294	(59)
Compare to Utilization for OSB, 200,000 total acres	***1,019***	***844***	***1,862***
Reduced impact from shifting away from hay and pasture fed to cow-calf enterprises	***(809)***	***(363)***	***(1,172)***
Net impact of shifting land away from hay/pasture and toward poplar/OSB	***210***	***480***	***690***

Table 8. (continued)

		Value Added (millions)	
Plant trees, expenditures during the first three years, 12,500 acres each year	***$3.5***	***$4.1***	***$7.6***
Construct biomass conversion facility, 44 million gal.	***$98.2***	***$60.2***	***$158.3***
Plant and harvest trees on a continuous rotation, 25,000 acres replanted each year, 200,000 acres total	$45.4	$36.6	$82.0
Operate biomass conversion facilities, not including wood supply	$33.0	$12.5	$45.4
Total tree plant/harvest and facility operation	$78.3	$49.1	$127.4
Reduced impact from shifting away from hay and pasture fed to cow-calf enterprises	$(23.5)	$(26.1)	$(49.6)
Net impact of shifting land away from hay/pasture and toward poplar/energy	$54.8	$23.0	$77.8
Compare to Utilization for OSB, 200,000 total acres	***$66.0***	***$61.8***	***$127.8***
Reduced impact from shifting away from hay and pasture fed to cow-calf enterprises	***$(23.5)***	***$(26.1)***	***$(49.6)***
Net impact of shifting land away from hay/pasture and toward poplar/OSB	***$42.5***	***$35.7***	***$78.2***
		Value Added/worker (dollars)	
Plant trees, expenditures during the first three years, 12,500 acres each year	**$89,366**	***$63,321***	***$73,176***
Construct biomass conversion facility, 44 mill. gal.	***$65,116***	***$66,502***	***$65,636***
Plant and harvest trees on a continuous rotation, 25,000 acres replanted each year, 200,000 acres total	$173,629	$76,696	$110,968
Operate biomass conversion facilities, not including wood supply	$169,522	$69,446	$121,464
Total tree plant/harvest and facility operation	$171,877	$74,715	$114,495
Reduced impact from shifting away from hay and pasture fed to cow-calf enterprises	$29,073	$71,820	$42,328
Compare to Utilization for OSB, 200,000 total acres	***$64,813***	***$73,270***	***$68,644***
Reduced impact from shifting away from hay and pasture fed to cow-calf enterprises	***$29,073***	***$71,820***	***$42,328***

Table 9. Sectoral Breakdown of the Value-Added Impacts of the Energy Facility Construction and Operation, Including Poplar Planting and Harvest Net of Reduced Hay, Pasture, and Cow-Calf Production

	Energy Facility Construction			Poplar Planting, Harvest, and Energy Facility Operation		
Sector with NAICS Code	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total
11 Ag, Forestry, Fish & Hunting	-	0.2	0.2	21.9	1.1	22.9
21 Mining	-	0.1	0.1	-	0.4	0.4
22 Utilities	-	1.4	1.4	-	0.1	0.1
23 Construction	98.2	6.5	104.7	-	0.1	0.1
31-33 Manufacturing	-	5.6	5.6	33.0	3.8	36.8
42 Wholesale Trade	-	4.2	4.2	-	5.7	5.7
48-49 Transportation & Warehousing	-	1.4	1.4	-	0.4	0.4
44-45 Retail trade	-	6.5	6.5	-	0.8	0.8
51 Information	-	1.1	1.1	-	0.4	0.4
52 Finance & insurance	-	4.5	4.5	-	1.7	1.7
53 Real estate & rental	-	3.7	3.7	-	0.9	0.9
54 Professional- scientific & tech svcs	-	2.6	2.6	-	0.1	0.1
55 Management of companies	-	0.9	0.9	-	0.4	0.4
56 Administrative & waste services	-	1.2	1.2	-	0.5	0.5
61 Educational svcs	-	0.6	0.6	-	0.2	0.2
62 Health & social services	-	7.1	7.1	-	2.0	2.0
71 Arts- entertainment & recreation	-	0.6	0.6	-	0.2	0.2
72 Accomodation & food services	-	2.1	2.1	-	0.8	0.8
81 Other services	-	1.7	1.7	-	0.6	0.6
92 Government & non NAICs	-	8.2	8.2	-	3.1	3.1
Total	98.2	60.2	158.3	54.8	23.0	77.8

References

Center for Farm Financial Management, University of Minnesota, *FINPACK Farm Financial Database* (web page), http://www.finbin.umn.edu/, undated, accessed 7/3/2007.

Hughes, D.W. "Policy Uses of Economic Multiplier and Impact Analysis." *Choices* (2003).

Lazarus, William. Machinery Cost Estimates. 10/2008a. University of Minnesota Extension. http://www.apec.umn.edu/faculty/wlazarus/documents/mf2008.pdf.

Lazarus, William. Energy Crop Production Costs and Breakeven Prices under Minnesota Conditions, Staff Paper P08-11. 12/2008b. St. Paul, MN, Department of Applied Economics, University of Minnesota. http://www.apec.umn.edu/faculty/wlazarus/documents/EnergybudStaff_Paper.pdf.

Lazarus, William F. and Tiffany, Douglas G. Economic Impacts of Establishing Short Rotation Woody Crops to Support Oriented Strand Board Plants in Minnesota, Analysis Conducted for the USDA Forest Service under FS Agreement No. 04-JV-11231300-031 . 7/25/2007.

Miller, R.E. and P.D. Blair. *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, New Jersey: Prentice-Hall, 1985.

Phillips, S., Aden, A., Jechura, J., Dayton, D., and Eggeman, T. Thermochemical Ethanol via Indirect Gasification and Mixed Alcohol Synthesis of Lignocellulosic Biomass, *Technical Report* NREL/TP-510-41168. 4/2007.

Rock-Tenn Community Advisory Panel. Project Economics Documents from the June 16 RCAP Meeting. 6/16/2008. http://rtadvisory.org/public_meetings/main.php.