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AN ANALYSIS OF AVAILABLE FEED STOCK MATERIAL FOR A CELLULOSIC ETHANOL PLANT

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CHAPTER 1: DEFINITION OF THE PROBLEM

Background

From January 2008 through September 2008 Baraga County, Michigan has experienced an un-adjusted unemployment rate average of 12.98%. This is significantly higher than the statewide average of 8.09% during this same time period. (www.milmi.org, 2008) While there are many successful businesses located in and around Baraga County, attracting new businesses to the area has proven difficult during the past several years. Many potential businesses decided to locate in either Houghton or Marquette counties, where there is greater population density.

In August of 2007, the Baraga County Board of Commissioners decided to resurrect the defunct Baraga County Economic Development Corporation (BCEDC). The Board selected eight (8) volunteers to head up the new BCEDC. The main intent of the new corporation is to establish new businesses in Baraga County. Shortly after the re-creation of the BCEDC, an out-of-state company, Mascoma Inc., approached representatives from Baraga County to assist in finding potential locations for a cellulosic biomass ethanol production facility.

A suitable location was located just south of the city of L'Anse. The location has most of the required utilities already in place, with a commitment from the county representatives to provide the rest of the infrastructure for the proposed plant, including the plant site acreage. Although the L'Anse site has many advantages over the other potential site locations, there are several questions that need to be answered before a company of this nature will commit to building a plant in the area.

Problem Statement

This project has allowed the author to determine if there is an adequate amount of sustainable, raw cellulosic feedstock material available to support a proposed 50 MGPY (Million Gallon per Year) ethanol plant in L'Anse, Michigan. This study has provided the Baraga County Economic Development Corporation with information that will be used to aid in securing the site in Baraga County for the proposed plant.

With the ability to provide up to 60 full-time positions in the economically depressed region of Baraga County, this study would give Baraga County an advantage over two other potential plant sites. These jobs, along with the 100 to 200 additional offshoot jobs that would result, are paramount to the future viability of Baraga County.

Research Objective

The overall objective of the proposed study was to verify that there is both an adequate amount of sustainable feed stock available and that there is a majority share (>50%) of support from the land owners for the proposed plant. The following questions were answered with the study:

1. What is the total amount of cellulosic material that is within an approximate 30 mile radius, including Keweenaw County, of the proposed plant site in L'Anse, Michigan?
2. How much of the material will be available to support the daily needs of the facility? This information will be further broken down into the net amounts, by product, available by individuals & business as a group and government in the area stated above.

3. What land is available to purchase within the next 24 months? This information will be analyzed and compared back against the overall population model to determine what affect, if any, this could have in available material.
4. What is the overall level of public support for the proposed plant?

CHAPTER II: LITERATURE REVIEW

Introduction

Henry Ford designed the first automobiles, beginning with the Model T, to run on ethanol made from hemp and corn. At the beginning of the last century, biofuels were a major competitor with oil—the first diesel engines relied on vegetable oil until the 1920's. An ardent proponent of biofuels nearly 100 years ago, Ford knew that the world needed a substitute for gasoline. "The day is not far distant when, for every one of those barrels of gasoline, a barrel of alcohol must be substituted, " he said. (Andersen, 2007, para. 1)

Americans have a voracious appetite for gasoline. At only 5% of the earth's population, we consume nearly a quarter of the world's oil. With 60% of the oil consumed in the United States being imported, the U.S. economy is now vulnerable to volatile energy markets and political instability in other countries. (Andersen, 2007, para. 4) With this kind of usage, it is little wonder why more emphasis is being applied to finding an alternative fuel that can help America wean off of foreign oil.

There appears to be a common message throughout the research literature in that a successful alternative to oil must have a large, readily available supply, be cost-competitive with gasoline, and have a net reduction in greenhouse emissions. (Dietrich & Temme, 2006, para. 11) America has been ramping up ethanol production the last 15 years, and is now responsible for 45% of what is made worldwide. More than 40% of the gasoline sold in the United States contains 10% ethanol. (Andersen, 2007, para. 13) As a result, numerous feasibility studies regarding ethanol production are being started on both the county and state level. One recent study being sponsored by the Missouri

Agricultural and Small Business Development Authority (MASBDA), is intending to develop "Sustainable, site specific forest harvest plans that can utilize lower quality forest material while at the same time promoting healthy forest management," according to Don Sheen, director of the Missouri Department of Agriculture. (Preston, 2008)

If converting biomass to ethanol can be made economically attractive, the potential feedstocks are myriad. They include agricultural waste, municipal solid waste, food processing waste, and woody biomass from small-diameter trees. (Rendleman & Shapoui, 2007, pg 23) The researchers' study focuses on the exclusive use of switchgrass and woody biomass to provide the raw material for ethanol production, although other materials would be available for use in the surrounding geographical area.

More than one article mentioned the use of government subsidies to promote this new fuel of hope throughout the masses. According to a 2008 article, subsidies and government mandates are driving the ethanol market, with politicians and lobbyists making the determinations about fuel production for the United States—not supply and demand. There were about 110 ethanol refineries running at the beginning of this year, with scores more due to come online in the next year or so. Why? Well, the leap is in no small part because the government is giving blenders a break of 51 cents per gallon to encourage production. As the Wall Street Journal has noted, that means that ethanol "typically has sold for up to 51 cents per gallon more than gasoline," (The government has also placed a 54-cent-per-gallon tariff on imported ethanol)

Lawmakers have forced oil companies to blend their gasoline with plant-based biofuels, particularly ethanol. When you hear that ethanol is a growing industry, keep in mind that they government added about $6 billion last year in ethanol subsidies.

President Bush's latest alternative –fuel program aims to increase the use of the corn-based additive to gasoline from the current 7.5 billion gallons to 35-plus billion gallons by 2017. (Hoar, 2008, para. 3 & 4) Others look at the subsidies as a necessity to allow this process and technology to get established and flourish. The director of the Energy Department's National Bioenergy Center, Michael Pacheco, once stated, "We're really making quite good progress. The costs have come down quite a bit. Just five years ago, a gallon of bio-based ethanol was $5, and today it's $2. With gasoline prices going up as much as they have the past several years, most people in the industry believe that those cost curves are going to cross over. When they do, there will be a major investment growth in biofuels.

Pacheco also stated the biomass industry is on the verge of taking off, but there is difficulty in taking that first step. "I think it will take some government assistance for the first plants to actually get built. To develop a new fuels technology like this is a very expensive proposition. But the investment community is ready to put a lot of capital into the growth of the biofuels industry. They want to be ahead of that curve." (Augustyn, 2006, para. 8 & 10)

Michigan Data Studies

Early in January of 2008, the president and CEO of the Michigan Economic Development Corporation, Mr. James Epolito stated, "Our Michigan Economic Development research team really has focused in on these cellulosic biofuels. We really learned a lot of that in Sweden. We went to Sweden and saw what they were doing in this enzymatic process – not a thermal process – to break down woody biomass and switchgrass. And that … (in turn generates) ethanol and black liquor." (Gustafson, 2008,

para. 11) Mr. Epolito went on to state, “When we get this plant up and running in Michigan, it will be the first in the U.S. creating ethanol through this cellulosic biofuel process.” (Gustafson, 2008, para. 13)

This is a direct correlation to the proposed research project, and could lead to a revitalized economic base for Baraga County and the surrounding areas, along with making Michigan a leader in this growing industry. A 1994 study found that 117 million cubic feet of round-wood was produced in the eight Western Upper Peninsula counties in Michigan, which counted for more than 30% of the State’s total output. These same counties accounted for more than 37% of the total pulpwood output also. (Hackett & Pilon, 1997, p. 10) This information was obtained by conducting an initial mail questionnaire, along with additional mailings, telephone interviews, and personal contacts until a 100% response rate was achieved. (Hackett & Pilon, 1997, p. 11)

If you take these percentages and apply them to the most recent forestation study completed in 2004 that estimates the total tree biomass for the state at 780 million dry tons, the eight Western counties could contain 234 million dry tons of tree biomass. (Brand & Hansen, 2004, p. 1) Of the values listed, hardwoods make up 76.8% of the total available biomass in the state. The majority of this, 52.4% of the 780 million total, is available on private land, with 12.1% of the 780 million total being privately owned softwood. (Brand & Hansen, 2004, p. 38)

Earlier in the year during an Alternative and Renewable Energy Summit, keynote speaker Jim Croce, President of NextEnergy, offered the following, “Whether correct or not, Michigan is viewed as being resistant to change, hesitant to increase regulations and an ‘environmental laggard,’ all of which hurts the state’s ability to recruit companies.

The Renewable Portfolio Standard (RPS) will help create local markets for renewable energy that attract new businesses. Many states are 'leapfrogging ahead of us' and are more progressive in policy." (Gentry, 2008, para. 12) NextEnergy has been charged with implementing an economic development strategy for Michigan to accelerate research, development, and manufacturing of alternative energy technologies. (Gentry, 2008, para. 3)

During a recent speech Michigan's Governor, Jennifer Granholm stated, "As our nation seeks long-term energy security, Michigan is well-positioned to lead the way. Our world-class research capabilities, well-trained workforce, and economic incentives will help attract the companies working on new energy solutions and the jobs they will create." (MIBiz, 2008) As Michigan continues to develop its RPS, and positions itself as a leader in the alternative energy marketplace, opportunities will be presented and competition will be fierce amongst the individual counties to attract and retain these businesses.

Until this point, little to nothing has been done to determine what percentage of private land would be available for timber harvesting to support a regional cellulosic biomass ethanol facility. To the researchers' knowledge, this will be the first study of its kind in Michigan, particularly the Upper Peninsula of Michigan. With so much of the available biomass being held by private ownership, the importance of this study cannot be emphasized enough.

What Others Have Found

While there have been several studies conducted on ethanol production on the state and county level throughout the United States, there has not been one found that has

made a determination of the amount of biomass available from private land owners. Most, if not all, of the studies have focused on the total cost of establishing and running an ethanol facility in their area, along with a projected cost per gallon analysis for the ethanol fuel.

All of the studies that were reviewed went into great technical detail ranging from environmental impact to a review of potential sites. In one study, the resource assessment conducted with the study catalogued over 8.5 million bone dry tons of cellulose material available in Oregon in 1998. This would have the potential to produce over 500 million gallons per year of ethanol. (Graf & Koehler, 2000, p. 9)

Another point in the study that would have broad implications in having a site located in the region is being able to secure feedstock with long-term contracts at a relatively stable price. (Graf & Koehler, 2000, p. 22) The one thing that was missing from this particular report was how the research team obtained their information and what the sampling error was for each industry they reviewed.

The study that California conducted in 1999 estimated having 50 million bone dry tons of biomass residue available throughout the state. This would correspond to 200 million gallons of ethanol per year. The study focused its assessment on available feedstock in close proximity to biomass power plants or potential ethanol production plants. The three biomass residues that were researched were forest material, agricultural residues, and urban waste. (California Energy Commission, 2001, p. 12) This was the only state study that focused on available material in designated sites, as opposed to material available throughout the state.

The study that was conducted for the state of Maine was determined to be a pre-feasibility study and thus much of the data regarding biomass availability was either assumed, or derived based on the past seasons forest harvesting data. Maine has over 17 million acres of forestland, which covers 90% of the state's total land mass. The study used the previous years harvested forest, 566,685 acres, along with a national average of 9.5 bone dry ton per acre to assume that there would be as much as 5.1 million bone dry tons of biomass available from existing harvest sites. (BBI International, 2002, p. 64)

One additional note from the Maine study is found under the recommendation section, in which they advise to base a cellulose-to-ethanol facility on harvested acreage as opposed to general forest thinning. The main purpose behind this is that harvesting is an on-going process that holds some degree of dependability, while thinning can be greatly affected by governmental budgets. (BBI International, 2002, p. 72)

Although this next study was not intended to supply information on the amount of biomass that is available for ethanol production, the researcher feels that the results of this study are more indicative of what this proposed study will produce. In 2007 Baltimore County, VA had a study commissioned in which a breakdown of their forested land was studied. Of the 389,000 acres of total land in the county, only 130,258 are forested. Of this value, 75% is held by private owners. Also worth noting is the amount of land with protective easements, 11% of the total forested land. (BCDEPRM, 2007, p. 2)

Additional Data Studies

The last part of this chapter includes a brief review several studies and articles which contain values and data, which will be utilized in the calculations of available

biomass, or noteworthy concepts and information. In a recent study by the American Lung Association of 1,651 vehicle owners, more than 80% would prefer an E85-capable flexible fuel vehicle and E85 fuel brand recognized as a Clean Air Choice. (BioFuels Journal, 2006, para. 2) There is no mention on how this study was carried out, nor the questioning format used.

Ethanol is blended into gasoline and is projected to account for 4.3% of the total gasoline pool by volume in 2007, 7.5% in 2012, and 7.6% in 2030. (EIA, 2007, p. 1, para. 3) It is estimated that the factory cost to make vehicles capable of running on an E85 blend of gasoline is low, approximately $200 per vehicle, virtually all flex fuel vehicles built since 1992 have been produced for the sole purpose of acquiring CAFE credits, with approximately 5 million flex fuel vehicles produced in this time period. Most buyers are unaware that they own a flex fuel vehicle. (EIA, 2007, p. 7, para. 6)

Recent research and development of new processing methods has been paramount in attempting to reduce the costs associated with a cellulosic ethanol facility, along with increasing the yield of ethanol. A study by Dr. Y.Y. Lee of Auburn University, for Gulf Ethanol Corporation, reports that preliminary tests of a new fungible cellulose feedstock indicates the recovery of at least 10% more ethanol by weight and a 12% reduction in processing time. (BioFuels Journal, 2007, para. 3)

Results from another study involving switchgrass, has shown that this material produced 540% more energy that it needed to grow, harvest, and process in cellulosic ethanol. (ScienceDaily, 2008, para. 1) This five-year study was conducted by the University of Nebraska-Lincoln, and involved switchgrass fields in Nebraska, North Dakota, and South Dakota. (ScienceDaily, 2008, para. 2 & 3) Recent yield trials of new

experimental strains in the three states produced 50% higher yields than achieved in this study. (ScienceDaily, 2008, para. 13)

A 2008 report from the University of Georgia stated that researchers at the University had developed a new technology, which promises to dramatically increase the yield of ethanol from readily available non-food crops, such as Bermudagrass, switchgrass, Napiergrass, and even yard waste. The new technology features a fast, mild, acid-free pretreatment process that increases by at least 10 times the amount of simple sugars released from inexpensive biomass for conversion to ethanol. (ScienceDaily, 2008). Switchgrass is a fast-growing perennial plant native to the central and eastern U.S. and tolerant of many different soil types. To make cellulosic ethanol, switchgrass—or any cellulose-based plant—is broken down to make sugar, then fermented to make the fuel. Supporters say that when blended with petroleum products, ethanol from switchgrass results in a net energy gain of 334%, compared to just 21% for corn-based ethanol. (Augustyn, 2008, para. 4)

A 2005 USA Today article stated that agricultural residues, such as corn stalks, wheat straw, and rice stalks, normally are left on the field, plowed under, or burned. Collecting just one-third of these for biofuel production would allow farmers to reap a second harvest, increasing farm income while leaving enough organic matter to maintain soil health, and preventing erosion. The agricultural residues that could be harvested sustainably in the U.S. today, for example, could yield 14,500,000,000 gallons of ethanol—four times the current output—with no additional land demands. (Murray, 2005, para. 8)

Not all literature was positive regarding the immediate future of ethanol in America. According to Jim Murphy, author of a paper titled, "A Review of the Energy Independence & Security Act of 2007, and Its Impact on U.S. Grain and Oilseeds Production," the he concluded that cellulosic ethanol is "a dead duck" and has little chance of becoming a major contributor to the biofuels market. (Bevill, 2008, para. 2) He also added that the short-term goals set by the Act are virtually unattainable. Medium and long-term outlooks also failed to provide positive results for cellulosic ethanol. "It becomes a more chronic situation as time goes on, " Murphy said. "The law mandates blending of 16 billion gallons (of cellulosic ethanol) by 2022. Our estimate is that, at best, we're going to reach somewhere around 3 billion." (Bevill, 2008, para. 3 & 4)

In another article, Steve Stein discusses several topics which conclude that all of the talk about "green" energy isn't actually as "green" as people first think. In one portion he states, that there remains a looming conflict between climate greens and oil independents even on the matter of cellulosic ethanol, and this has to do with the greens' attitudes toward the use of genetically modified ethanol. Ethanol will probably never be energy efficient until a much higher proportion of a given plant material can be converted to fuel. As second and third generation processes for converting plant matter to energy rely more on biochemical processes, genetic modification will almost certainly be involved. New microbial systems, capable of breaking down molecules and fermenting a wider range of biomass feedstocks, are the subject of experiments at universities throughout the country. As those experiments prove successful, there is a fair chance that environmentalists will raise obstacles to the cultivation of "nonnatural' plants, as they've done so often in the case of genetically modified food crops. (Stein, 2008, para. 39)

Another issue with biomass ethanol production is the distance a plant can be located from the raw material. According to one article, the process of harvesting tall-growing switchgrass is not dissimilar to mowing your lawn, but even thought weed is hearty, it can be fragile when it comes to production. "You cannot transport switchgrass very far," says Paul Nyren, director of North Dakota State University's Central Grassland Research Center. "The cost of building the industrial unit has yet to be determined, but it all just depends on getting a pilot plant up and running," he says. (Augustyn, 2008, para. 9)

This same concern was addressed in another article, which discussed the role of making smart choices in establishing a biomass industry. The article reiterates, one of the issues facing the industry is that moving biomass more than 50 miles to a processing facility could take a major bite out of profits. "In today's market, it takes something like 12.5 cents per ton mile to move stuff around or maybe more." Dick Caramical, president of Price Biostock Services, says. "If you move the procurement circle out to 100 miles, adding 50 miles of freight costs, you've just added $6-plus on a green weight basis to the cost of your biofuel. Figuring a 1 million ton per year facility, that's at least $6 million added to your raw material costs." Increasing the distance also makes supplying a biomass plant less attractive to the timber producer. "The producer is just like you or me," Carmical says. "He needs so much money everyday just to pay his bills. If you have him at a distance where he can make three or four loads a day, he has one set of economics. If you stretch him out to 100 miles, then he may only sell two loads a day. You as the consumer are going to have to pay the costs so he can make his living on two loads a day instead of three or four." (Kram, 2007, para. 4)

Another service that a company like Price Biostock offers to its clientele is to keep the peace between landowners and harvesters. According to Carmical, "You can get involved in brouhahas between the landowner and the harvesters. That is where we really earn our keep. We need to keep people happy so we can come back and harvest next time, but we also need to get the product delivered on a timely basis." (Kram, 2007, para. 6)

It is in these last several paragraphs of the report that the researcher feels a vital connection is made towards establishing a successful, high-production woody biomass ethanol facility. Without the backing of the community and surrounding land owners, a facility of this type cannot prosper and thrive.

Chapter III: Methodology

Research Strategy

The main tool that has been utilized to obtain the research data was a comprehensive questionnaire that was mailed out to 200 randomly selected land owners within a 30 mile, approximate, radius of the proposed site in L'Anse. Only landowners with parcels greater than or equal to 10 acres, single not combined, in size were considered for this study. The main purpose for this is due to the fact that it is typically not economically for harvesters to work on smaller acreage parcels.

Initially the researcher hoped to be able to send surveys to all land owners within this area, however financial backing of the survey fell through at the last moment and the researcher was forced to drastically reduce the number of questionnaires that were sent out. This data has been summarized in either a chart or graph format in generally represented in a percentage basis. All supporting secondary research data, relevant to data interpretation, has been obtained from public records, published reports, articles, and studies.

Data Collection and Analysis

The participants for the survey were obtained by accessing county court house records for land ownership. Most records were obtained for no cost however two counties, Marquette and Ontonagon, required payment for providing this information. All records were reviewed to exclude land owners who did not meet the size requirements of the study. The questionnaire included questions pertaining to what counties the individuals and businesses own land, what size parcels they have, if they are

forested or not, if they are used in agricultural harvesting, and what crops they currently grow.

Along with these types of questions, the questionnaire asked if the owner's property is currently up for sale, or if it will be within the next 24 months. The last question will ask the respondent their level of support for a cellulosic ethanol plant in our region. No names will be used on the questionnaire that would identify Mascoma as the potential business. This will be done to minimize bias towards Mascoma and the questionnaire. Response frequency of 50% or greater in favor, will allow the researcher to conclude that there is favorable support for this type of facility.

Land owned by the State of Michigan (SOM) and the U.S. Government were used in the calculation for the amount of available material, however they were excluded in from receiving a questionnaire. Both individuals and businesses that met the criteria of the report were included in the questionnaire selection process. Of the two hundred (200) questionnaires that were sent out, eighty-nine (89) participants responded back and eighteen (18) of the questionnaires were returned to researcher do to invalid addresses.

An analysis of the mean and variance for the collected data has been utilized where appropriate. Frequency analysis was used to display the results of the of the facility support question. Trend analysis has been utilized to provide a projection of data with a response rate less that 100%.

Reliability and Validity

With funding was not available to send out a survey to all land owners, estimated at 7,000+ unique land owners in the study area, the sample size (200) is a small percentage, less than 3%, of the total land owners in the research area. The response rate

of 44.5% further reduces the reliability of the data as a whole. The majority of the answers on the questions that were asked were able to be cross-referenced and compared to official county records. There were no major differences noted between the two data sets, therefore the validity of the questions is not in question.

Scope and Limitations

The scope of the project was to measure how much biomass feedstock is available within a set geographical location. This contains an evaluation of standing timber biomass and agricultural biomass, it does not include other sources of feedstock including paper mill sludge, sawmill waste, and non-recyclable paper material. These could significantly increase the availability of feedstock for the proposed mill.

One limitation is the size of the survey itself. By increasing the proposed radius value and the amount of land owner respondents, the values would invariably increase the total amount of available feedstock. The main reason for the shorter radius and limited, randomly selected participants that were used in the evaluation were due to time and monetary constraints. One assumption that the researcher has made is that the respondents in the sample set are an accurate representation of the larger population within the target area.

The last limitation was in the evaluation of the support for the proposed facility. The frequency value may not be an accurate representation of all residents within the projected radius area. The researcher believes that Mascoma is more interested in the support level of the land owners as opposed to all of the population, as the land owners have the greatest impact on raw material allocation and availability.

Chapter IV: Data Analysis

Introduction

A questionnaire (Appendix B) was designed and developed by the researcher to determine the amount of raw cellulosic woody-biomass material is available within a given radius of a proposed site in Baraga County, MI. The questionnaire contained 14 questions. Most questions had six options: "Baraga," "Marquette," "Houghton," "Keweenaw," "Ontonagon," and "Iron," which allow the respondents that ability to answer based on which counties they owned land in.

Several questions were setup to induce an initial "Yes" or "No" response and then have the respondent break the answer down further by county if a certain response was selected. Other questions were broken down into specific categories, generally by county, in which the respondent was requested to provide additional information.

On questions that had the respondent make a decision on the based only on content of the question, as opposed to providing numerical data values, the available answers were limited in scope and number to allow for a more accurate assessment of the results. There were no open-ended questions listed in the survey, except for the numerical data value questions. Some respondents own land in more than one county, and thus answered the questionnaire accordingly.

A total of 200 questionnaires, with cover letter (Appendix A), were distributed to randomly selected individuals, or businesses, that own parcels of land equal to or greater than 10 acres in size that are within the target study area. A total of 89 questionnaires were received that contained a filled out survey, although there were several surveys in

which the respondent did not provide an answer to one or more questions. A breakdown of the number of responses per question is shown in the table below.

Table 1. The Number of Respondents of Each Question

Question	Number of Responses	Number of Non-Responses	Total
1*	110	0	92
2*	101	0	9
3*	9	0	101
4	59	30	89
5*	110	0	101
6*	90	11	101
7	81	7	88
8*	110	0	101
9	82	7	89
10	80	9	89
11	80	9	89
12	67	22	89
13	84	5	89
14	89	0	89

*Some respondents recorded 2 or more answers

The Breakdown of Land Ownership

Questions 1 asked the respondents' which counties they owned land. This was done to establish a breakdown of land ownership per county. Another side effect of this question was to record how many individuals or organizations owned land in more than one county.

Land ownership by county is broken down in order of largest to smallest, by percentage, with the survey percentage following the county: Baraga (40.22%), Houghton (25.00%), Marquette (10.87%), Ontonagon (9.78%), Iron (7.61%), and Keweenaw (6.52%). There were eleven (11) respondents who owned land in more than one county, including one organization that owned land in five out of the six counties. Of

the nine (9) respondents who owned land as an organization, six (6) also owned individual land in one of the counties.

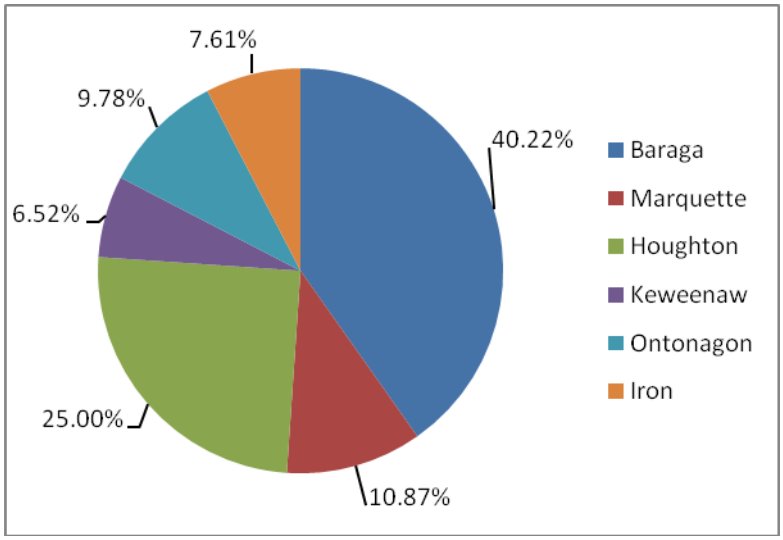

Figure 1. Response to Question 1: In which counties do you or your organization own land?

Amount of Land in the Survey

Questions 2 and 3 were used to determine how much land the respondents owned in each county, and were separated by individual owners (Question 2) and organizational owners (Question 3). The total individual land (Question 2) that was owned by the respondents is 12,580 acres. A breakdown by county is as follows, and is listed in order from largest to smallest: Baraga (31.71%), Keweenaw (25.52%), Houghton (19.51%), Marquette (12.44%), Iron (7.58%), and Ontonagon (3.24%). One interesting result that is worth mentioning is that even though Keweenaw County had the lowest amount of respondent ownership (6.52%), it has the second largest amount of land acreage (25.52%) in the survey. This equates out to an average of 535 acres per owner.

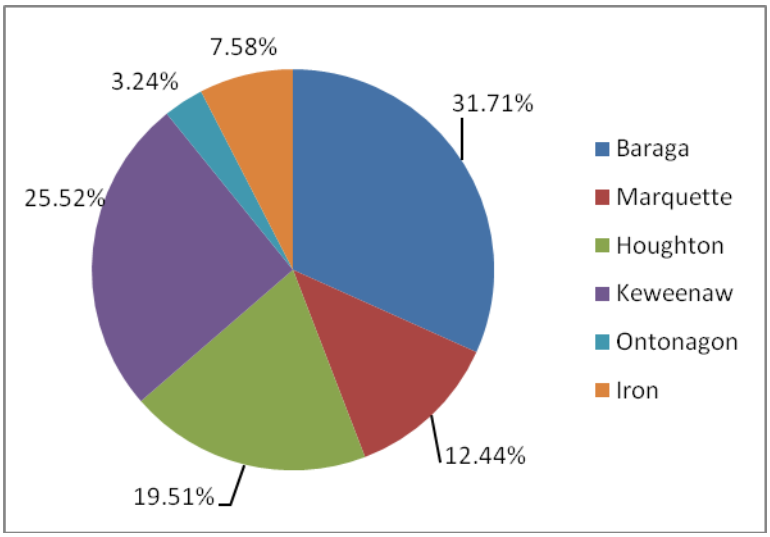

Figure 2. Responses to Question 2: What is the total amount, in acres, of land you own in the following counties, not counting parcels smaller than 10 acres?

The results of organization owned land (Question 3) is on a much smaller scale, 1375 total acres, when compared to that of the individual owners (Question 2). In fact only three counties reported organizational owned land. The breakdown from largest to smallest is as follows: Baraga (96.00%), Marquette (2.91%), Houghton (1.09%), Keweenaw (0.00%), Ontonagon (0.00%), and Iron (0.00%).

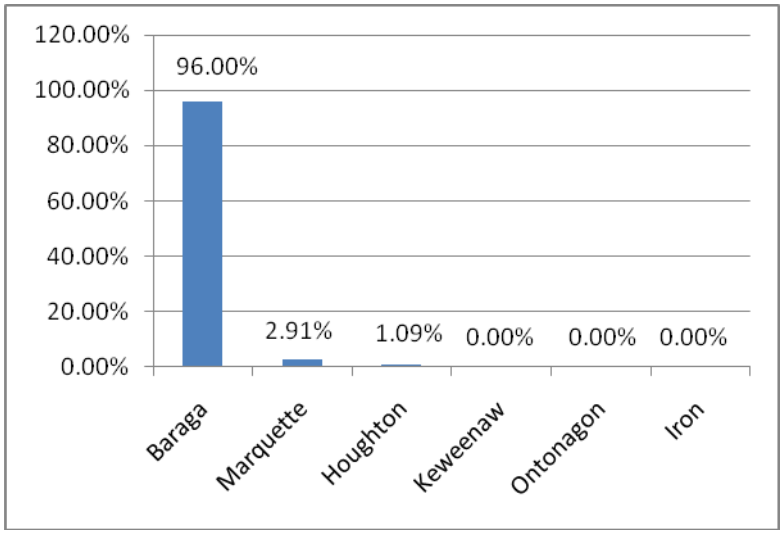

Figure 3. Responses to Question 3: What is the total amount, in acres, of land your organization owns in the following counties, not counting parcels smaller than 10 acres?

Land Owner Residence

Question 4 asked the respondents to answer if their individual or corporations primary residence was in one of the counties listed in the survey. This question was asked so the researcher can compare the results of Question 14, which establishes the level of support for the proposed facility, between county residents and non-county residents. The researcher believes that is will help the BCEDC and Mascoma in developing a focused marketing strategy to help attain support for the facility.

A total of 59 of the 89 respondents, or 66.3%, reside or have their organization reside in one of the six counties contained in the survey. The results of question 4 are listed as follows in order of largest to smallest: Houghton (91.3%), Marquette (60.0%), Baraga (59.5%), Ontonagon (44.4%) and Iron (42.9%).

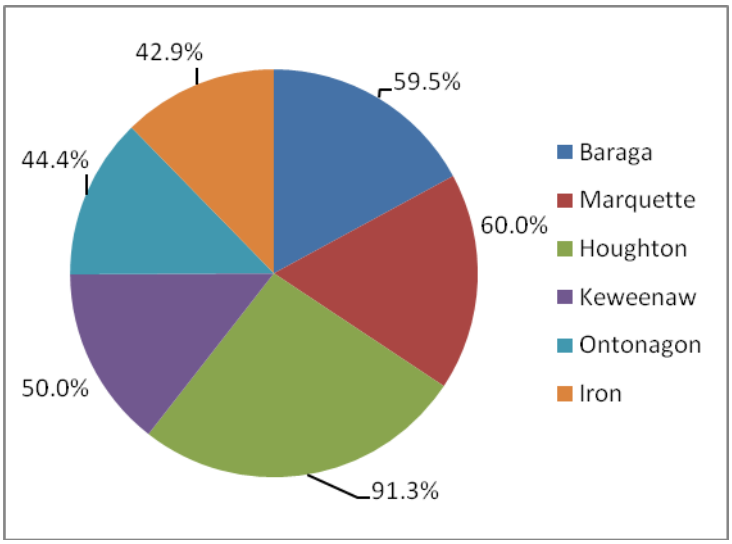

Figure 4. Responses to Question 4: Is your primary or corporate residence in one of the following counties?

Breakdown of the Owned Land

Questions 5, 6, and 7 were used to breakdown the reported land, by county, into specific percentages which are used in the final trend analysis to determine if there is enough sustainable biomass material available to support the proposed plant. Question 5 asked the respondents to provide an estimate on how much of their land is timbered, is agricultural, or lakes and swamps, defined on the survey as "other". These percentage breakdowns were then used to calculate the total amount of acreage that corresponds to each survey entry. This was accomplished by adding the individual and corporately owned together and multiplying the result by the percentage breakdown listed in question 5. This was done for each survey, and separated by county. The total amount of timbered acreage was determined to be 11,483.37 acres, or 82.05%. The total agricultural land was determined to be 673.57 acres, or 4.81%. The total "other" land was determined to be 1565.80 acres, or 11.19%.

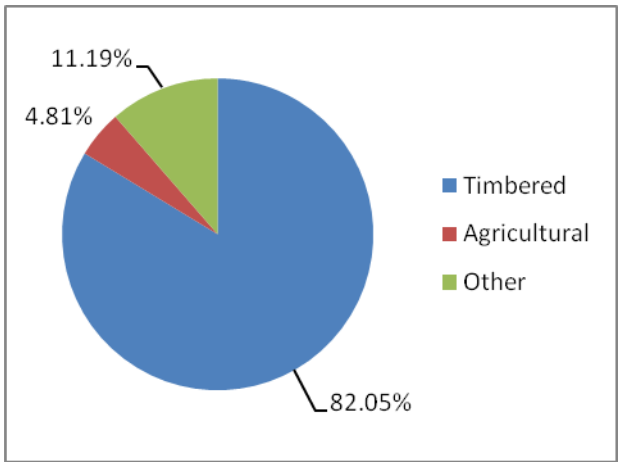

Figure 5. Calculation to the Response of Question 5: What percentage of this amount is timbered, agricultural, or other?

Question 6 then asked the respondent to breakdown their timbered land into the percentage of hardwood and softwood that reside on the parcel. The total amount of hardwood was determined to be 11,483.37 acres. The following is a breakdown of this

value by county and is listed from largest to smallest: Baraga (30.66%), Keweenaw (29.76%), Houghton (20.83%), Marquette (12.63%), Iron (4.76%), and Ontonagon (1.35%).

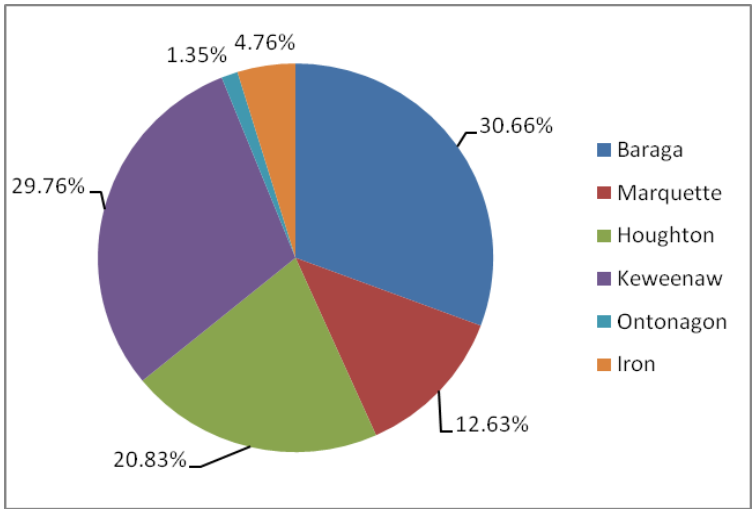

Figure 6. Results from Hardwood Calculation of Question 6: What is the percentage of hardwood and softwood on your timbered property?

The total amount of softwood was determined to be 2,896.53 acres. The following is a breakdown of this value by county and is listed from largest to smallest: Baraga (54.02%), Iron (12.13%), Houghton (11.12%), Keweenaw (10.59%), Marquette (7.53%), and Ontonagon (4.61%).

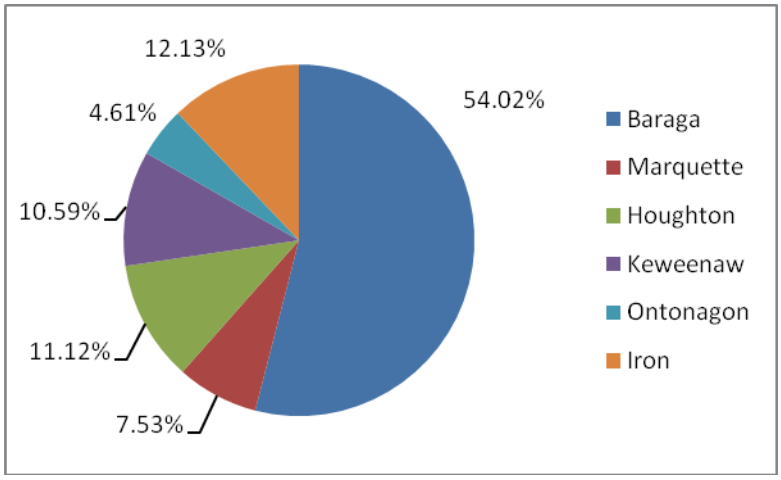

Figure 7. Results from Softwood Calculation of Question 6: What is the percentage of hardwood and softwood on your timbered property?

Question 7 asked the respondents to list the size, in acres, of any agricultural land that they own, along with the products that they grow on the land. The total amount of land was determined to be 673.57 acres. The following is a breakdown of this amount by county, listed from highest to lowest: Marquette (25.72%), Houghton (21.47%), Ontonagon (16.81%), Iron (16.70%), Baraga (13.37%), and Keweenaw (5.94%).

Of the respondents who utilized their agricultural land, the majority of them used the land to grow hay (72.45%), with corn (17.01%) being the second most abundant crop. Others that were mentioned were blueberries, apples, oats, and alfalfa.

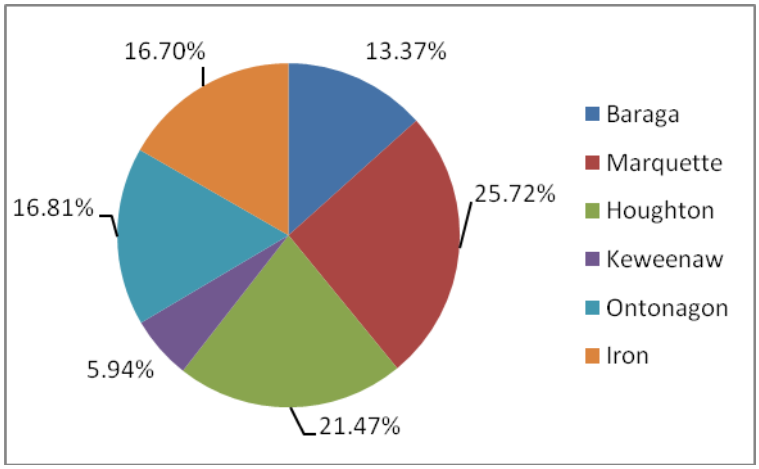

Figure 8. Results from Question 7: Are any crops grown on your agricultural land?

Length of Land Ownership

Question 8 asked the respondents to list how long they owned the land that they were reporting in the survey. The researcher was interested in seeing if land in these areas are held for long periods of time or if they change ownership frequently. The total number of years of ownership for all of the land reported on the survey equalled 2,646 years. If you take this total and divide it by the total number of respondents to question 1 (110), the average amount of time

the owner has owned the land is 24 years. The following is a breakdown of average land ownership by county, and is listed in order from longest to shortest: Houghton (36 yrs), Marquette (33 yrs), Ontonagon (26 yrs), Baraga (26 yrs), Iron (22 yrs), and Keweenaw (21 yrs). The longest land ownership is listed at 145 yrs in Houghton County. The shortest is 2 yrs and is in Baraga County.

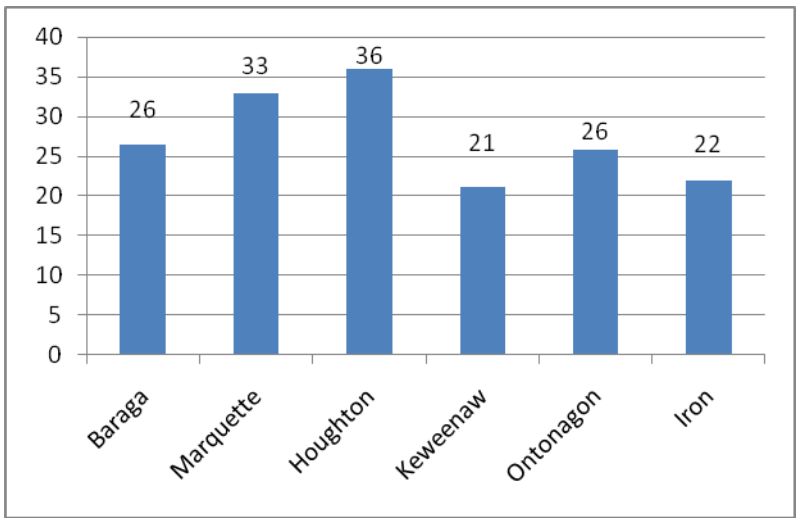

Figure 9. Results of Question 8 (average years): How long have your or your organization owned the land?

Land for Sale

Question 9 asked the respondents if they had any land for sale, or if they were planning on having land for sale within the next 24 months. This question was asked to help determine where the greatest amount of activity is being seen in the region and to potentially use this information to determine if a company such as Mascoma should look at purchasing these lands to secure their biomass resources. There were a total of 10 responses that answered yes to this question. This corresponds to 3,110 acres that are or will be available for purchase. The following is a breakdown of this figure by county going from largest to smallest: Keweenaw with 1500 acres (48.23%), Houghton with 985 acres (31.67%), Baraga with 515 acres (16.57%), Ontonagon with 80 acres (2.57%), Marquette with 30 acres (0.96%), and Iron with 0 acres (0.00%).

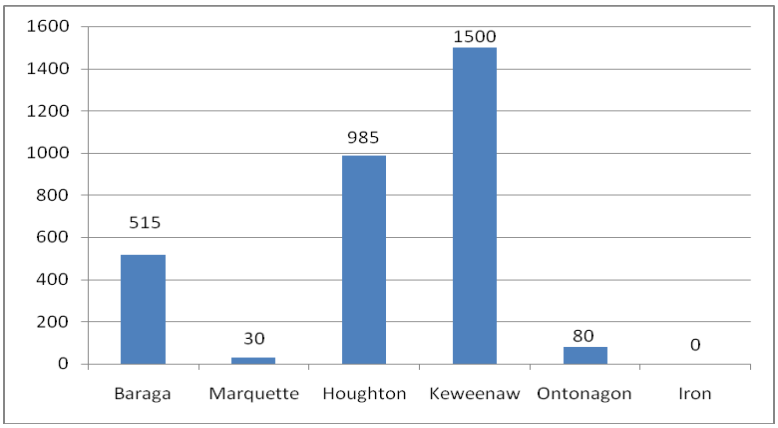

Figure 10. Response from Question 9: Do you or your organization have any land for sale, or are you planning to sell within the next twenty-four months?

Logging of the Land

Questions 10 and 11 ask the respondents if they had any of their land logged along with their level of satisfaction (Question 10) and if they would consider having their timber harvested and to what degree (Question 11). This was asked to find out if past logging in the area is a liability that needs to be addressed for future resource allocation programs. A total of 80 people responded to question 10, with 41 people stating that they have had their land logged in the past. Of the responses, 53.7% noted a positive experience, 19.5% had a some-what positive experience, 9.8% were neutral, 4.9% were some-what negative experience, and 9.8% reported a negative experience.

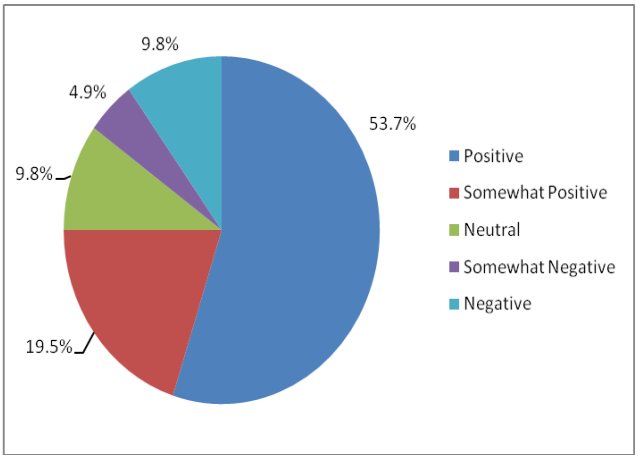

Figure 11. Response from Question 10: Have you or your organization ever had any of your land logged or harvested?

Question 11 asked all respondents if they would ever consider having their land logged, and to what degree. Out 80 respondents, 40 people responded yes to the question. Each respondent that answered yes was asked to rate the amount of logging they would allow on their land. In the survey people had to choose from one of four categories. These categories are listed by amount of timber they would have logged off of their land, in a percentage basis. The selections were clear cut which equals 100% of the timber being removed from the land, heavy cut which equals 75%, medium cut which equals 50%, and finally select cut which equals 25%. The following is a breakdown of their answers, listed in order from highest to lowest frequency: Select Cut (72.5%), Medium Cut (20.0%), Heavy Cut (5.0%) and Clear Cut (2.5%). These values were used in determining the total amount of woody biomass available for this project.

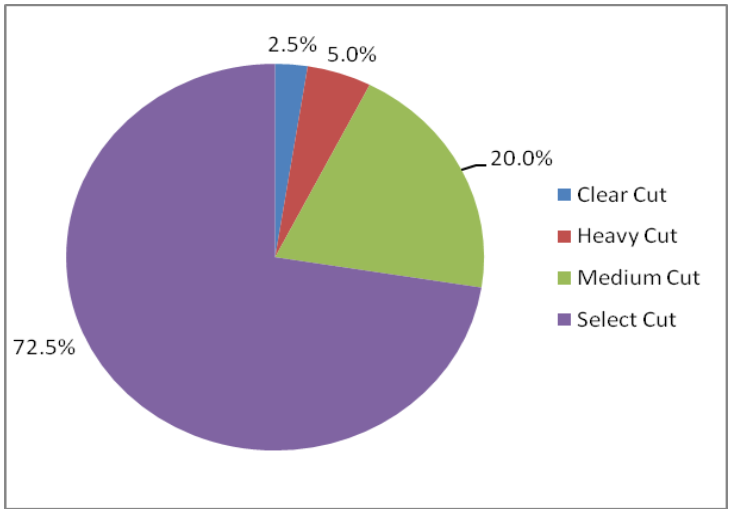

Figure 12. Reponses to Question 11 (yes only): If approached, would you consider logging your timbered land?

Agricultural Land

Question 12 asked all respondents if they would consider converting their agricultural land, as defined in question 5, to a viable ethanol producing plant such as switchgrass. This question was asked to determine what percent of owners would convert their land, including owners who would possibly consider converting their land. Of the 63 respondents, 24 (35.82%) said they either would or would possibly consider this proposal. The resulting breakdown is as follows and is listed by county, in order from highest to lowest: Baraga (48.10%), Houghton (19.00%), Iron (13.81%), Marquette (0.30%), Ontonagon (0.30%), and Keweenaw (0.15%). This information is used in proportion to calculate the total amount of potential switchgrass biomass that would be available in this region.

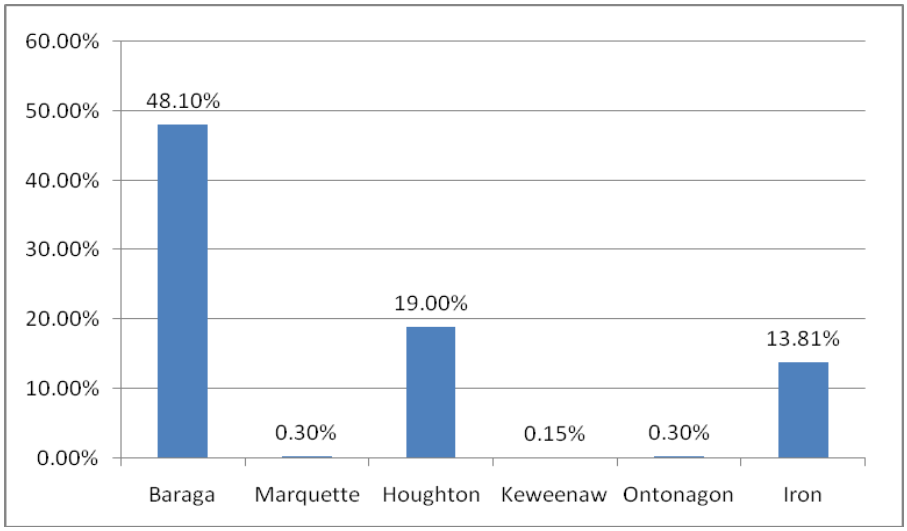

Figure 13. Reponses to Question 12 (yes and possibly only): If approached, would you consider converting your agricultural land to grow a commercially viable ethanol producing plant?

Land Locked

Question 13 asked the respondents to list any portion of their land that is currently landlocked. The researcher believes that this question is important as to provide a better

understanding of the potential accessibility issues that may be present in the region being studied. Of all the responses only four people noted issues with accessibility to their land. Not one of the respondents noted more than 50% of their land as having access issues. This has allowed the researcher to not include any type of de-rate correction factor for calculation of the total amount of biomass available in the research area.

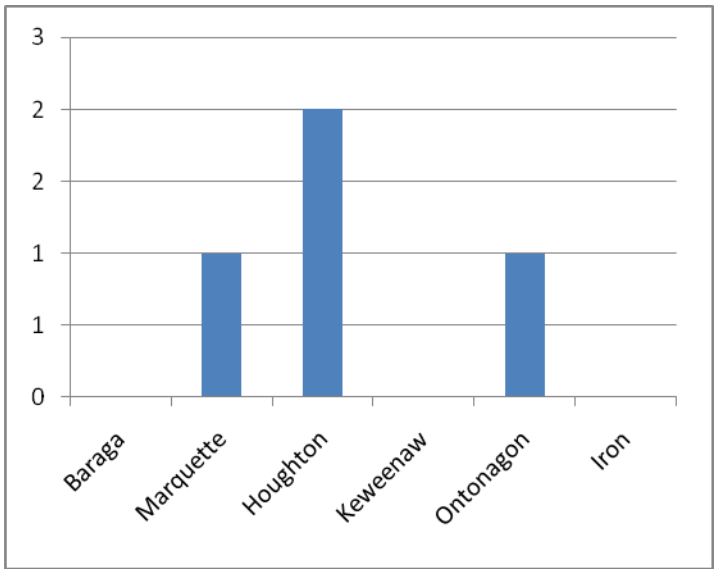

Figure 14. Response to Question 13: What percentage of your property is landlocked or without any legal means of access?

In or Out of Favor

The last question of the survey, question 14, asked the respondents to list if they supported having a biomass ethanol production facility in the western Upper Peninsula of Michigan. This is one of the most critical questions on the survey and can have the greatest impact on future development and implementation of this technology in this region. All 89 of the survey respondents answered this question. The survey gave the reader four choices in this category. Besides the standard “yes” and “no” answers, the reader was able to select either “undecided” or “need more information”. While at the

surface these last two selections may appear to be the same answer to the question, and in a sense they are.

The reason why this was stated this way was to help in the development of appropriate marketing propaganda and to provide a targeted effort in this area. The breakdown of the responses is as follows and is listed in order of response frequency: Yes (56.3%), Need More Information (21.3%), Undecided (13.8%), and No (8.8%). These values were used as a limiting factor in the calculation of the available biomass in the research area.

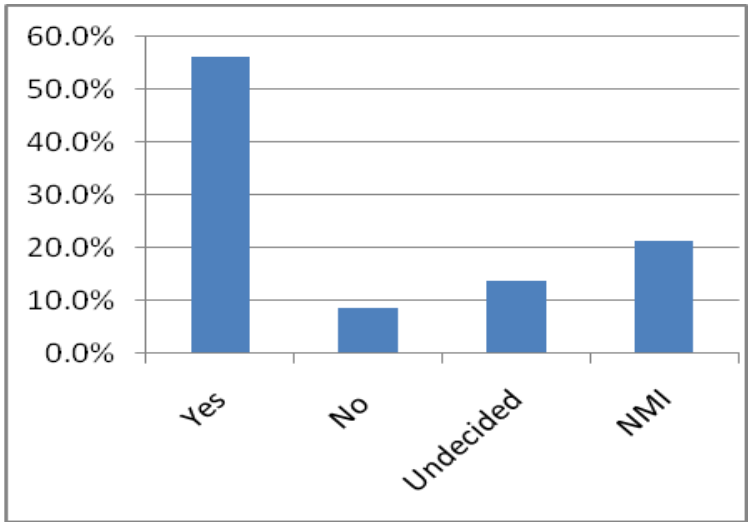

Figure 15. Results of Question 14: Are you or your organization in favor of having a bio-mass based ethanol facility locate to the Western Upper Peninsula?

Final Calculations

Now that we have our baseline information established the researcher is now able to calculate the estimated amount of available woody biomass available in the given region. The first step in determining this value is to calculate the total land area, in acres, that fall within the research area. Taking information presented on the State of Michigan (SOM) website, the following information has been ascertained: Baraga County has a

land area of 904.16 square miles, with an inland water area encompassing 24.51 square miles; Houghton County has a land area of 1011.74 square miles, with an inland water area encompassing 30.20 square miles; Iron County has a land area of 1166.49 square miles, with an inland water area encompassing 44.67 square miles; Keweenaw County has a land area of 541.20 square miles, with an inland water area encompassing 48.00 square miles; Marquette County has a land area of 1821.31 square miles, with an inland water area encompassing 51.42 square miles; lastly Ontonagon County has a land area of 1311.63 square miles, with an inland water area encompassing 17.23 square miles. (SOM website, 1990)

Taking the total land area for each county and subtracting out the inland water area gives a value for the total land area available within each county. Take this amount and multiply this by 640 acres/square miles to get total land acres for each county. This amounts to the following: Baraga County equals 562,976 acres, Marquette County equals 1,132,729.60 acres, Houghton County equals 628,185.60 acres, Keweenaw County equals 315,648.00 acres, Ontonagon County equals 538,470.40 acres, and Iron County equals 717,964.80 acres for a total of 4,185,920.00 acres.

Since not all of Marquette, Ontonagon, and Iron Counties fall within the 30 mile radius limit, the total available acreage for these counties have been adjusted. The available acreage value for Marquette County has been adjusted to 25% of its total value, or 283,182.40 acres. The available acreage value for Ontonagon County has been adjusted to 65% of its total value, or 538,470.40 acres. The available acreage value for Iron County has been adjusted to 35% of its total value, or 251,287.68 acres. The adjustment percentage was estimated by the researcher by comparing the approximate

area of each county that falls within the distance requirements to the remainder of the county outside of the requirement. The new, adjusted, value that is used for the remaining calculation is 2,579,750.08 acres.

Figure 2. Conversion of Land Size in Square Miles to Total Acres

Calculation of Total Acreage						
County	Land Area (sq miles)	Inland Water (sq miles)	Conversion Factor (acre/sq mile)	Total Acres	Adjusted Acres	% of Adjusted Acres
Baraga	904.16	24.51	640	562,976.00	562,976.00	21.82%
Marquette	1821.31	51.42	640	1,132,729.60	283,182.40	10.98%
Houghton	1011.74	30.2	640	628,185.60	628,185.60	24.35%
Keweenaw	541.2	48	640	315,648.00	315,648.00	12.24%
Ontonagon	1311.63	17.23	640	828,416.00	538,470.40	20.87%
Iron	1166.49	44.67	640	717,964.80	251,287.68	9.74%
			Available Acres =	4,185,920.00	2,579,750.08	100.00%

The next step in the calculation process is to take the adjusted acres, by county, and convert the figures over to gallons of ethanol. Michigan has an average of 41 dry tons per acre of timberland. (Hansen & Brand, 2004, pg. 6)

To convert an acre of hardwood biomass to gallons of ethanol, you multiply the amount of material per acre, referred to as bone-dry-ton (BDT) by the number of acres and take this sum and multiply it by 76 gallons/BDT. (Meskal, 2007, para. 6) This value was then multiplied by 74.78%, which is the total amount of hardwood land acreage compared to the total timbered land acreage available.

To convert an acre of softwood biomass you take the same steps as for the hardwood conversion, but substitute the 76 gallons/BDT value with 66 gallons/BDT. (NREL, 2004) Along with this, you then multiply this value by 25.22%, which is the total amount of softwood land acreage compared to the total timbered land acreage available.

To convert an acre of agricultural land to gallons of biomass, you multiply the total number of available acres by 100 gallons per ton of biomass, and then multiply the result by the biomass yield, which ranges between 5-10 tons per acre. The researcher selected a 5 ton yield for the calculations as this would be the lowest yield that would be expected per acre. (Treehugger website, 2008) Once this total is known, you then multiply this value by 4.81%, which is the total amount of agricultural land acreage compared to the total land acreage available.

After running this set of calculations, total available gallons of hardwood ethanol is calculated to be 6,011,191,234 gallons. Breaking this down by county results in values of: Baraga (1,311,815,599 gal), Marquette (659,855,997 gal), Houghton (1,463,763,409), Keweenaw (735,505,546), Ontonagon (1,254,714,003), and Iron (585,536,681). The total available gallons of softwood ethanol would be 1,764,049,099 gallons. Breaking this down by county results in values of: Baraga (384,966,479 gal), Marquette (193,641,881 gal), Houghton (429,557,208), Keweenaw (215,842,059), Ontonagon (368,209,398), and Iron (171,832,074). And finally the total available gallons of agricultural ethanol would be 7,775,240,333 gallons. Breaking this down by county results in values of: Baraga (13,547,829 gal), Marquette (6,814,690 gal), Houghton (15,117,077), Keweenaw (7,595,964), Ontonagon (12,958,110), and Iron (6,047,154).

Figure 3. Conversion Total Acres to Gallons of Ethanol

County	Hardwood	Softwood	Agriculture
Baraga	1,311,815,599	384,966,479	13,547,829
Marquette	659,855,997	193,641,881	6,814,690
Houghton	1,463,763,409	429,557,208	15,117,077
Keweenaw	735,505,546	215,842,059	7,595,964
Ontonagon	1,254,714,003	368,209,398	12,958,110
Iron	585,536,681	171,832,074	6,047,154
Total Gal	6,011,191,234	1,764,049,099	7,775,240,333

At this point in the calculation process, we breakdown the previous totals by the amount of land ownership is government owned and the amount that is owned by individuals or corporations. According to one source, 38% of forest land is owned by the government in Michigan, which 52% is owned privately. The researcher could not find any data as to how much agricultural land was owned by the government, so the percentages for the forest land were carried over to calculate the agricultural land division. (Hansen & Brand, 2004, pg. 2)

After running the calculation, the following ethanol gallon values were determined: Hardwood – 3,125,819,442 in private ownership and 2,284,252,669 in government ownership; Softwood – 917,305,532 in private ownership and 670,338,658 in government ownership; Agricultural – 4,043,124,973 in private ownership and 2,954,591,327 in government ownership. These values are then broken down further by multiplying the corresponding values for the timbered sections by the percentages calculated from question 11's respondents. For simplicity, these same percentages for privately owned timber were used for the government owned timber. These values are

2.5% for 100% of the timber, 5.0% for 75% of the timber, 20.0% for 50% of the timber, and 72.5% for 25% timber. The agricultural land also used a percentage adjustment that is based on the combination of "Yes" and "Possibly" answers from question 12. This value is listed at 35.82%.

Along with these calculation variables, several other variables were used to help determine the total sustainable output each year. For both the government and private land totals, a harvesting cycle factor was introduced. This was necessary due to the fact that it takes approximately 20 years for timbered land to be ready to re-harvest. All timbered values were divided by 20 to determine what is truly available when practicing sustained forestry. Agricultural land is harvested each year and thus does not carry this factor.

Keeping with the same sustainability initiative, the values for the available were further reduced by 95% as not all land would be available to harvest during a single year and would follow the same cycle as the timbered harvest. The researcher multiplied all values by 5% to mimic the 20 year growing cycle (20 yrs x 5% = 1 yr availability). After the addition of these criteria, the calculation for the government owned land shows a projection of 55,456,156 gallons of ethanol being available on a yearly basis.

There is one additional factor that must be taken into account when calculating the final ethanol numbers for privately owned land. Referring back again to question 11, 50% of the respondents stated that they would have their timbered land harvested. This is the final adjustment in the calculation for private land ethanol availability. This value is projected to be 27,676,039 gallons of ethanol being available on a yearly basis.

Figure 4. Calculation of Government Total

Government Land Only (38% of total land)			
Harvesting	Hardwood	Softwood	Agricultural
100%	2,855,316	837,923	
75%	4,282,974	1,256,885	
50%	11,421,263	3,351,693	
25%	20,701,040	6,074,944	
Agri Harvest			52,918,054
Total	39,260,593	11,521,446	52,918,054

Year cycle	20	20	1
Available	1,963,030	576,072	52,918,054

Total =	**55,457,156**	**gallons per year**

Figure 5. Calculation of Individual Total

Private Land Only (52% of total land)			
Harvesting	Hardwood	Softwood	Agricultural
100%	3,907,274	1,146,632	
75%	5,860,911	1,719,948	
50%	15,629,097	4,586,528	
25%	28,327,739	8,313,081	
Agri Harvest			72,414,179
Total	53,725,022	15,766,189	72,414,179
Adj. Total	26,862,511	7,883,094	25,938,759

Year cycle	20	20	1
Available	1,343,126	394,155	25,938,759

Total =	**27,676,039**	**gallons per year**

Chapter V: Summary, Conclusions, and Recommendations

Summary

Appendices

Questionnaire Questions

1. Individual land owners only: What is the total amount in acres of land you own in the following counties not counting parcels smaller than 10 acres?
   Baraga _____ Marquette _____ Houghton _____ Keweenaw _____
   Ontonagon _____ Iron _____

2. Organizations only: Please indicate how much land is owned in each of the following

counties:
Baraga _____ Marquette _____ Houghton _____ Keweenaw _____
Ontonagon _____ Iron _____

3. In which of these counties do you or your organization own land? Check all that apply.

Baraga _____ Marquette _____ Houghton _____ Keweenaw _____
Ontonagon _____ Iron _____

4. Is your primary or corporate residence in one of the following counties? Please select the appropriate county.

Baraga _____ Marquette _____ Houghton _____ Keweenaw _____
Ontonagon _____ Iron _____

5. What percentage of this amount is timbered, agricultural or other, such as swamps and Lakes, etc.?
Baraga County : timbered _____ agricultural _____ other _____
Marquette County : timbered _____ agricultural _____ other _____
Houghton County : timbered _____ agricultural _____ other _____
Keweenaw County : timbered _____ agricultural _____ other _____
Ontonagon County : timbered _____ agricultural _____ other _____
Iron County : timbered _____ agricultural _____ other _____

6. What is the percentage of hardwood and softwood on your timbered property?
Baraga County: hardwood _____ softwood _____
Marquette County: hardwood _____ softwood _____
Houghton County: hardwood _____ softwood _____
Keweenaw County: hardwood _____ softwood _____
Ontonagon County: hardwood _____ softwood _____
Iron County: hardwood _____ softwood _____

7. Are any crops grown on your agricultural land?
Yes _____ No _____

If yes, what products are grown and what is the size, in acres, of land that they grow on?
Baraga County: _____
Marquette County: _____
Houghton County: _____
Keweenaw County: _____
Ontonagon County: _____
Iron County: _____

8. How long have you or your organization owned the land?
   Baraga County: _____
   Marquette County: _____
   Houghton County: _____
   Keweenaw County: _____
   Ontonagon County: _____
   Iron County: _____

9. Do you currently have any land for sale, or are you planning to sell within the next twenty-four (24) months?
   Yes _____ No _____ If yes, please list total acres in each county.
   Baraga County: _____
   Marquette County: _____
   Houghton County: _____
   Keweenaw County: _____
   Ontonagon County: _____
   Iron County: _____

10. Have you or your organization ever had any of your land logged or harvested?
    Yes _____ No _____

    If yes, was the experience: positive, somewhat positive, neutral, somewhat negative, or negative: _____

11. If approached, would you consider logging your timbered land?
    Yes _____ No _____

    If yes, at what level? (% indicated total area of cut with 100% being the maximum)
    clear cut (100%) _____ heavy cut (75%) _____ medium cut (50%) _____
    selective cut (25%) _____

12. If approached, would you consider converting your agricultural land to grow a Commercially viable ethanol producing plant such as corn or switchgrass?
    Yes_____ No_____ Possibly_____

    If yes or possibly, how many acres would you consider converting?
    Baraga County: _____
    Marquette County: _____
    Houghton County: _____
    Keweenaw County: _____
    Ontonagon County: _____
    Iron County: _____

13. What percentage of you property is landlocked or without any legal means of access?
    Baraga County: _____
    Marquette County: _____
    Houghton County: _____
    Keweenaw County: _____
    Ontonagon County: _____
    Iron County: _____

14. Are you, or your organization, in favor of having a bio-mass based ethanol facility locate to the Western Upper Peninsula?
    Yes _____ No _____ Undecided _____ Need more information _____

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