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# Woody Biomass: A Renewable Resource for Southern Illinois

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# WOODY BIOMASS: A RENEWABLE RESOURCE FOR SOUTHERN ILLINOIS


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A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
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RESEARCH PAPER APPROVAL

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Approved by:

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TITLE: WOODY BIOMASS: A RENEWABLE RESOURCE FOR SOUTHERN ILLINOIS

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Buildup of greenhouse gasses in the earth's atmosphere, such as carbon dioxide, is contributing to an increase and variability of the earth's temperature. Buildup of carbon dioxide can cause gaseous sulfur and nitrogen oxides to form and they can pollute soils, rivers, and bodies of water. Since the buildup of the carbon dioxide affects the soils, rivers, and water supply, it also can lead to an issue with national security, development and economic growth issues; therefore, utilities, government agencies, and environmental groups are looking for clean ways to produce electricity. One of these clean ways is to cofire biomass with coal to produce electricity.

TABLE OF CONTENTS

## LIST OF TABLES

LIST OF FIGURES

## Introduction

What are your concerns about today's environmental issues that are constantly on your mind? For many Americans, worrying constantly about today's energy demand, has become the norm. So what shall we do about our rising concern about the rising energy demand? We know for a fact that our resources that we use for energy are running out, maybe not presently are they running out, but that will definitely run out sooner than we think. Another concern with the energy demand is the pollution we are causing by burning fossil fuels and their carbon emissions. One project that is being looked into is cofiring woody biomass with coal for the production of energy. Since firing woody biomass alone for the production of cellulosic ethanol is too expensive and not feasible, we are hoping to decrease the amount of carbon emissions released from firing coal alone.

So we are after what it would take to cofire coal and woody biomass together for the production of energy, and more specifically what it is going to take to entice Southern Illinois landowners to participate in the program. Some variables that we will be looking at are the carbon emissions released from cofiring coal and woody biomass together, the cost to harvest woody biomass stalks, the cost associated with the transportation of the woody biomass to the firing plant and the cost associated with the removal of the waste (ash) created from cofiring woody biomass with coal, and the population of maple, beech, birch, ash, hickory, and oak trees. Some of the sources that the data will be pulled from are the National Woodland Owners Survey, United States

Department of Agriculture's Forest Inventory Database Online, and the Carbon Online Estimator.

Background

Biomass is a renewable energy resource of organic non fossil material, and can be anything from waste wood material or crop residues to herbaceous and woody crops. These can specifically be grown to be burned with fossil fuels. Biomasses can be used for energy production in coal fired electricity generation (cofiring) as well as in transportation fuel production (cellulosic ethanol). When biomass is burned, it produces less ash than the amount of ash produced from firing coal, and since woody biomass would add to the amount of energy produced from cofiring coal with woody biomass, less coal would be used, thus creating less waste ash, and, in the long run, would save the power plant the cost the removing the waste. However, it generally has lower Btu's, and if you cofire it in boilers built for coal it creates problems with the slag/.Cofiring biomass is also an efficient way for society to reduce the level of greenhouse gasses in the atmosphere (Nienow, S., K. T., McNamara, A. R Gillespie,. and P. V Preckel. 1999). Instead of using fossil fuels in electricity and heat production, using biomass would cost less and provide larger carbon dioxide reductions per unit of biomass rather than substitution biomasses for diesel fuel and gasoline in automobiles.

Utilities are interested in cofiring biomass; however, they know very little about the cost associated with cofiring biomasses and are unaware of how to

start the programs for cofiring (Nienow, S. et al 1.999). However, utilizing woody biomass to produce energy is not a new idea. In the late 19th century, the majority of the energy produced came from wood combustion, but from 1870 to 1970 fossil fuels (coal, oil, and gas) became the primary sources of energy since their cost was lower and they were more readily accessible. Gas and oil prices soared in the late 1970's which prompted the Department of Energy to once again look into utilizing biomass for energy production. In 1978 Congress passed the Public Utility Regulatory Policies Act. This act provided incentives to co-generation and small power production facilities.

Since fuel shortages have not happened as expected, environmental concerns with the use of fossil fuels have arose and prompted the re-examination of alternative fuels. The Department of Energy co-funded feasibility studies of ten different biomass programs around the country to assess the commercial viability and environmental considerations for a variety of biomass systems in different locations. Utility companies would benefit from the cofiring of biomass fuel since it would reduce the amount of sulfur dioxide emitted from their boilers (Demirbas, Ayhan. 2003). Also the use of biomass fuels may reduce the amount of nitrogen oxides emitted, and as well minimize increases in atmospheric carbon dioxide.

The Biomass Crop Assistance Program (BCAP) provides financial assistance to owners and operators of agricultural and non-industrial private forest land who wish to establish, produce, and deliver biomass feedstocks. BCAP provides two categories of assistance (USDA Farm Service Agency):

- Matching payments may be available for the delivery of eligible material to qualified biomass conversion facilities by eligible material owners. Qualified biomass conversion facilities produce heat, power, biobased products, or advanced biofuels from biomass feedstocks.
- Establishment and annual payments may be available to certain producers who enter into contracts with the Commodity Credit Corporation (CCC) to produce eligible biomass crops on contract acres within BCAP project areas.

Background

To date, there are a few regions that are looking into using woody biomass to produce electricity in the Northern US States (Nienow, S., K. T., McNamara, A. R Gillespie,. and P. V Preckel. 1999; Keoleian, and Volk, 2005; Jianbang and Smith, 2006). Creation of woody biomass markets in Michigan and Minnesota are being pursued by departments of natural resources as wildlife habitat-friendly and sustainable renewable energy source, and also as a way to reduce carbon footprints. Also use of woody biomass in the western US is being pursued to find a linkage between ecosystem restoration/fuel reductions where removal of fuels from the site are critical for reducing and controlling fire risk. There has also been some research done to look into the issues of using woody biomass as a second generation cellulosic ethanol feedstock; however, the technology needed to convert cellulosic biomass into ethanol is not economically viable to date (Hamelinck C. N., G. van Hooijdonk, A. PC Faaij. 2005, Guo Z., C. Sun, D. L. Grebner. 2007).

Woody biomass, in the Southern Illinois region, represents a potentially important sustainable resource as well. There is predominately an oak-hickory forest population in the lower half of the Midwestern landscape. Much of this area has been unsuitable for agriculture and has remained predominantly an oak-hickory population. The oak-hickory forest type has been in steady decline as young trees needed to replace presently dominant individuals have been largely displaced by non-oak and hickory species (Ruffiner and Groninger 2006). It is appropriate to conduct a pilot program in Southern Illinois as this portion of the Midwest is farthest advanced in transitioning toward maple dominance of oak forests. Programs to prevent and reverse the transition to beech maple are underway. These programs usually involve felling of non-oak sterns to restart forest regeneration as well as intermittent prescribed burning; however, this work is limited due to its high costs, especially the costs associated with burning treatments (Ruffiner and Groninger 2006).

Restoration activities would benefit if improvement was made to felled material markets. Presently, felled material left on site show no measurable restoration benefits. In addition to promoting oak regeneration, these treatments will increase growth rate and value of future crop trees (Parker and Merritt 1995) where favorable markets are already well-established, increasing value to the landowner and regional value-added.

SUPPORTING LITERATURE

At the beginning of the 20$^{th}$ century, the United States switched from using biomass as a source for energy to fossil fuels. This switch was primarily

prompted by how cheap and available fossil fuels were at the time. As fossil fuel prices started to increase, there was also an increase in research and development and use for biomass as an energy resource. There are numerous crops that have potential to be energy crops through commercial energy farming (McKendry, 2002).

Biomass can be converted into three main types of products: electrical/heat energy, transportation fuel, and chemical feedstock. Some current technologies that are used to convert biomass are: thermal conversion, biomass power for generating electricity by direct combustion or gasification and pyrolysis, cofiring with coal, biological conversion of biomass and waste, biomass densification, domestic cook stoves and heating appliances, and solar photovoltaic and biomass based rural electrification (Demirbas, 2003).

From 1949 to 1990, the United States energy increased by 167%, and wood energy makes up a total of 82% for biomass use. In 1990, 3.3% exajoules of energy were produced from biomass, and by 1992, biofuels fired by biomass represented 6500 megawatts of electricity generation capacity in the United States (Hehenstein, and Wright, 1994).

A concern with utilizing woody biomass in the Southwest for energy production is that overharvesting will occur and land would be converted over into agricultural production; therefore, increasing herbicide usage. Increased herbicide usage and overuse can lead to contamination of wildlife (plants, soil organisms, above-ground insects/arthropods, mammals, birds) living in terrestrial

habitats. Wildlife within fields is most likely to be exposed to herbicides, particularly when fields are planted with crops (Freemark, K., C. Boutin).

Threats from high emission levels from greenhouse gasses which lead to climate change, has lead to increasing use of biomass for energy production. One giant positive to utilizing woody biomass for energy production is the amount of carbon dioxide produced from cofiring woody biomass is equal to the amount of carbon dioxide a woody biomass takes in during its life cycle. Thus, cofiring biomass with coal simultaneously provides among the most effective means of reducing new CO2 emissions from coal-based power plants and among the most efficient and inexpensive uses of biomass (Baxter, 2005).

As an all organic material from plants, biomass is can be produced by converting sunlight into plant material from photosynthesis. Conversion of biomass can be achieved by applications of numerous technologies, however, each of these techniques have their own specific set of requirements. Technological developments relating to the conversion, production, etc. promise the application of biomass at lower cost and with higher conversion efficiency than was possible before, and more advanced options to produce electricity are looking promising and allow a cost effective use of energy crops such as production of methanol and hydrogen by means of gasification (McKendry, 2002).

Since woody biomass has a lower moisture, ash, and nitrogen content, and higher energy values the potential for woody biomass can be found where

biomass is converted into thermal energy and gasification more efficiently than herbaceous energy crops.

Advantages of utilizing woody biomass for energy production are:

- Good conversion characteristics
- Moderate storage/harvest losses
- On stump storage
- Preexisting markets for wood
- Good harvest yields
- Low energy input to produce
- Low cost
- Composition with low contaminants
- Low nutrient requirements

Disadvantages would be:

- 5 – 10 year payback periods from planting to harvest
- Management practices and equipment used would differ from that of row crop agriculture
- Fuel preparation, storage, and delivery
- Ash deposition and fly ash utilization
- Fuel conversion
- Pollutant formation
- Corrosion

Over the past 15 years, the Department of Energy (DOE), through the Biofuels Feedstock Development Program, has funded research directed

towards creating a short rotation woody crop (SRWC) supply systems for many regions of the United States (Tuskan, 1998). The regions that the DOE have been primarily looking into are the north-central and southeastern United States, with alternatives within the Pacific Northwest and northeastern United States. Proposed harvest of SRWC would happen during a 6 to 10 year rotation. The proposed rotation would provide control for wind erosion year round, wildfire cover during the winter and spring when annual crops are not present, and during the fall, when crops are being harvested, SRWC would provide a natural habitat for wildlife.

Economically speaking, in order for cofiring biomass with coal to be cost effective, the location of where the biomass comes from needs to be within a reasonable distance to the plant where it is to be converted. The size of a plant also plays an important role in how much biomass is needed. For example, a larger production plant would need more biomass delivered to them than a smaller plant, therefore, the larger plant would be able to purchase and transfer in biomass that was located farther away. Meaning the more biomass you need, the lower the cost is per load of biomass. In a study that focused on the costs analysis of utilizing woody biomass, researchers found that transportation distance plays a very important role in the feasibility of utilizing woody biomass as an energy source (S. Gautam, R. Pulkki, C. Shahi, and M. Leitch, 2010). However, the capital costs for cofiring biomass are less than those associated with the stand-alone biomass projects such as wind turbines, or any other renewable projects, and since they capitalize upon existing generating stations

and can be operated – or not – at the plant’s discretion, cofiring projects are the lowest risk renewable energy projects, but at the same time, cofiring projects do not increase system capacity (E. Hughes, 2000).

When looking into starting a project, concerns of the public must be taken into account. In a previous study conducted in Oregon, researchers looked into the perspectives of stakeholders about converting woody biomass into energy. Their hope was to show that utilizing woody biomass as an energy source would help solve problems related to forest management. They found that most stakeholders were focused on were renewable energy, forest restoration, and rural development. Researchers saw that more than one biomass utilization opportunity excited the survey participants. However, the participants saw forest restoration as a key dominating factor for issues instead of using the biomass as source of bioenergy. More or less they found that stakeholders saw that energy remained a by-product of forest restoration, rather than energy demands directing forest management (M. Stidham and V. Simon-Brown, 2010).

Other concerns of the participants in this study, when it came to perspectives of the general public, it was found that there were numerous issues that the general public may be concerned about. Concerns such as biomass supply, when the biomass has to meet certain requirements, and lack of trust between involved parties, where members feared that a project might be stopped last minute and funding and time would be wasted, topped participants’ concerns. To face these concerns, the researchers looked into social acceptability terms. Researchers saw the potential for collaboration, but

understood the concern of trying to get all groups participating to agree on a decision. Thus some stakeholders were interested in pilot programs where only a small area was affected during the process of utilizing woody biomass as a source of energy. Also researchers noted that the costs associated with harvest and transportation of the felled materials was a concern of the participants. In their findings they note that forest restoration was more important to involved participants than utilizing woody biomass for energy generation.

## Specific Objectives of the Research

The main objective of this project is to find out whether or not the Southern Illinois landscape can be used as a sustainable source of energy for Southern Illinois. We will be focusing on the use of woody biomass for cofiring in energy production in this research. We also will be looking into the cost associated with harvesting feedstocks available prior to burns and also the benefits associated with the removal and how the removal of the woody biomass provides opportunities for growth in local economies. Some benefits to the removal would be the restoration of native ecosystems, such as the quality of game habitats for deer and turkeys, water quality maintenance, floral biodiversity, and neotropical bird diversity (Ruffner and Groninger 2006, Rogers et al. 2008).

Since the Southern Illinois climate change mitigation is the main factor in the ecosystem service for US biofuel policies, our focus will be primarily associated on how carbon markets and prices affect the removal for woody biomass.

## Process

Since there is very little previous research work done looking at cofiring woody biomass with coal in energy production in Southern Illinois, I am having to analyze relatively new data and placing it into the frame work built for another cellulosic ethanol model.

Another limitation is that we had hoped to use individual county data to analyze the species of trees privately owned, and after collecting this data, it was decided that we would need to look at a larger area combination. Thus instead of individual counties alone, we are looking at two separate regions, the Illinois Claypan Region and the Southern Illinois Region. I have collected the data for each region separately and also combined both regions together. The purpose of looking at the regions individually and then collectively was to see if there was enough data available in each region to draw our results and conclusions (i.e., power in numbers).

## Data

Since we know that it is not cost efficient to use woody biomass alone for the production of cellulosic ethanol alone, we are looking to see if it is feasible to cofire woody biomass with coal to produce energy. One of the first steps is defining our region and the types of forest and woody biomass, as well the ownership types for the forests. The first results that were pulled from the Forest Inventory Data Online (FIDO) were pulled from only eleven counties in the

extreme southern tip of Illinois, Alexander, Gallatin, Hardin, Jackson, Johnson, Massac, Pope, Pulaski, Saline, Union, and Williamson. It was decided after looking into each county individually that the data was inconclusive.

After looking at the results again, it was decided to look into the entire the Southern Illinois Region, as defined by FIDO, which consists of 16 counties, Alexander, Franklin, Gallatin, Hamilton, Hardin, Jackson, Johnson, Massac, Perry, Pope, Pulaski, Randolph, Saline, Union, White, and Williamson. It was also determined that we would need to consider a larger area than just the Southern Illinois Region, so we also looked up data for the Illinois Claypan Region (also defined by FIDO). The Illinois Claypan Region consists of 26 counties, Bond, Calhoun, Clark, Clay, Clinton, Crawford, Cumberland, Edwards, Effingham, Fayette, Greene, Jasper, Jefferson, Jersey, Lawrence, Macoupin, Madison, Marion, Monroe, Montgomery, Richland, St. Clair, Shelby, Wabash, Washington, and Wayne. Another decision was to look into three primary forest type groups, oak/hickory, elm/ash/cottonwood, and maple/beech/birch.

Data was pulled for both regions separately and the Southern and Claypan regions were pulled together to see what the combined data would show. The data is spread out over a five year time frame and shows the acres of each forest-type group and also ownership for the acres by the forest-type group. Within the Southern Illinois region we find that 77% of the forest-type group is oak/hickory, 15% is elm/ash/cottonwood, and only 2% is maple/beech/birch. In the Illinois Claypan, 77% is oak/hickory, 21% is elm/ash/cottonwood, and 1% is maple/beech/birch. With the Southern Illinois and Illinois Claypan region

combined, oak/hickory contributes to 77% of the total forest-type, elm/ash/cottonwood contributes 18%, and maple/beech/birch has a 2% contribution rate.

As far as for the ownership of the forest groups, we are primarily interested in the land that is privately owned. In the Southern Illinois Region 68.3% of the three forest-types acres we are interested in are privately owned with the remaining acres being owned by the forest service, federal, state, and local governments. In the Illinois Claypan, 92.3% is privately owned. So overall all, 81.2% of the total forest-type acres for the Southern Illinois and Illinois Claypan region is privately owned. By avoiding utilization of biomass from national and state forests and parks, and only focusing on private land ownership, we can more effectively manage the removal of biomass and types new growth, thus establishing a woody biomass crop that would be most effective for cleaner and higher combustion rates and more aesthetically pleasing to the land owner and public.

Carbon Online Estimator

Much like the Forest Inventory Data Online, we are using the United States Department of Agriculture Forest Service's and National Council for Air and Stream Improvements Inc.'s Carbon Online Estimator (COLE) to help aide us with making our decisions based on cofiring woody biomass with coal in the production of energy. The primary purpose of the COLE Report is to allow users to view the specs of the above ground distribution of carbon. COLE also allows

users to examine the characteristics of carbon for the entire United States or by a specific state, region, or county.

With the COLE Database, we were able to breakdown our areas of study to include only the regions that were examined in the Forest Inventory Data Online (FIDO) Database. The three regions consisted of a total of 42 Illinois counties. The Southern Illinois Region consisted of 16 counties: Alexander, Franklin, Gallatin, Hamilton, Hardin, Jackson, Johnson, Massac, Perry, Pope, Pulaski, Randolph, Saline, Union, White, and Williamson counties. The Illinois Claypan Region included 26 counties: Bond, Calhoun, Clark, Clay, Clinton, Crawford, Cumberland, Edwards, Effingham, Fayette, Greene, Jasper, Jefferson, Jersey, Lawrence, Macoupin, Madison, Marion, Monroe, Montgomery, Richland, St. Clair, Shelby, Wabash, Washington, and Wayne counties. We also looked at Southern Illinois and Illinois Claypan as a region combined together.

Not only did we modify the reports to include only the counties that were wanted, we also selected two filter options. Since we are interested in reproducing certain wood types, we selected three carbon stocks in the forest type group filter: Oak/Hickory, Elm/Ash/Cottonwood, and Maple/Beech/Birch. In the ownership group filter, we selected Private since we are looking in to land that is not publicly or state owned.

Carbon Monitoring for Action

Another data base used to find the amount of electricity produced from fossil fuels was Carbon Monitoring for Action (CARMA). Carbon Monitoring for Action (CARMA) is a massive database containing information on the carbon

emissions of over 50,000 power plants and 4,000 power companies worldwide. Power generation accounts for 40% of all carbon emissions in the United States and about one-quarter of global emissions. CARMA is the first global inventory of a major, emissions-producing sector of the economy (CARMA, 2011).

The data was pulled for the Illinois counties involved with the project. The report pulled 22counties from Illinois with power plants. The power plants were Clay, Clinton, Crawford, Cumberland, Effingham, Fayette, Franklin, Hamilton, Jackson, Jasper, Madison, Marion, Massac, Monroe, Montgomery, Perry, Randolph, Saint Clair, Washington, Wayne, White, and Williamson. Of these counties, only five already use fossil fuels for energy production, Crawford, Effingham, Jackson, Madison, and Saint Clair.

From these counties, CARMA reported just how much energy was produced, the amount of carbon released from fossil fuel combustion, intensity (which is the MWh produced per pound), and the total carbon produced from these plants. From these results, the intensity was combined with the total carbon output from fossil fuels, and also percentages for the amount of carbon produced from fossil fuels we would like to see replaced with carbon output produced from woody biomass.

Data Progress/ Errors

After careful analysis of the first set of data retrieved, it was decided that we would remove the data for the Elm/Ash/Cottonwood Group and continue on with just Oak/Hickory and Maple/Beech/Birch. Upon retrieval of the new data for just private land owners in the Southern Illinois Region as well as the Illinois

Claypan Region, it was evident that we still did not have enough data for the Southern Illinois Claypan Region for Maple/Beech/Birch and for the Illinois Claypan for Maple/Beech/Birch. After careful consideration we decided to add the Illinois Prairie Region to the Central Illinois Region for Maple/Beech/Birch, and we have not decided what to do with the Southern Illinois Region. The following data is the new data that depicts the scenario if we continue without the Southern Illinois Maple/Beech/Birch.

The following tables show the MWh/Ton/Acre of Carbon production available from Woody Biomass, and also the MWh/Ton of Carbon produced from fossil fuels. The percentages listed with in the table are a portion of the total carbon emitted from firing fossil fuels, such as coal, natural gas, and oil, for energy production. To obtain the final information, data obtained were merged together and conversions of usage and production, and availability were processed.

The MWh/Ton/Acre of Carbon production available from woody biomass table is the product of merging the FIDO and COLE databases. The charts (appendix) depict the cross sectional data from the FIDO Database into the COLE Database for both the Southern Illinois Region, the Illinois Claypan Region, and the combination of the Southern Illinois Region and Illinois Claypan Region. Once merged, the following steps were processed. The Tonnes/Hectare were converted into Short US Tons/Hectare (1.1023), and then Converted into Short US Tons/Acre (2.471). Then to obtain the energy levels, we know that wood at 20% moisture, when fired, is equivalent to 15 Gigajoules/Short US Ton.

Thus we took the Short US Tons/Acre and converted them into GJ/Short US Ton/Acre. The final step was to take last results and convert the data into MWh/Short US Ton/Acre (0.278).

The MWh/Ton of Carbon produced from Fossil Fuels was achieved by taking the CARMA data obtained for Illinois power plants that currently use fossil fuels for energy production. Since we are not interested in going to a complete switch over from fossil fuels to woody biomass, it was decided find different levels of carbon emitted from the combustion of fossil fuels for energy production. It was decided that 10%, 15%, 20%, and 30% fossil fuel carbon production would be enough to proceed with the research (Carbon Monitoring for Action, 2011). In a USDA Forest Service Marketing Research project, it was found that efficient levers of cofiring could be reached at 10% to15%, and could be efficient to as much as a 40% cofiring mixture (Bergman and Zerbe, 2004). To obtain the amounts of the percentage of carbon produced from fossil fuel combustion, the Intensity level was combined with the percentages of fossil fuel carbon emitted, which resulted in MWh/pound of carbon emitted from fossil fuels, thus the results were converted into MWh/US Short Ton (2000).

The results from the two tables (Table 1 and Table 2) show the current amount of carbon available from woody biomass combustion (solely from private land ownership) and also the percentage amount of carbon that is current being produced from fossil fuels that we would like to see replaced by woody biomass combustion. From the results, it is reasonable to say that there is enough woody biomass available in Illinois from private land owners to consider this project as

feasible. And since the woody biomass removed would be replaced on a continuous removal and planting cycle, it would also seem to be feasible for this project to be considered for long term energy production.

| MWh/Ton of Carbon produced from Fossil Fuels | | | | |
|---|---|---|---|---|
| County | 10% | 15% | 20% | 30% |
| Clay | 0 | 0 | 0 | 0 |
| Clinton | 0 | 0 | 0 | 0 |
| Crawford | 0.119172 | 0.178757 | 0.238343 | 0.357515 |
| Cumberland | 0 | 0 | 0 | 0 |
| Effingham | 0.025651 | 0.038476 | 0.051301 | 0.076952 |
| Fayette | 0 | 0 | 0 | 0 |
| Franklin | 0 | 0 | 0 | 0 |
| Hamilton | 0 | 0 | 0 | 0 |
| Jackson | 0.041879 | 0.062818 | 0.083758 | 0.125637 |
| Jasper | 0 | 0 | 0 | 0 |
| Madison | 0.092389 | 0.138584 | 0.184779 | 0.277168 |
| Marion | 0 | 0 | 0 | 0 |
| Massac | 0 | 0 | 0 | 0 |
| Monroe | 0 | 0 | 0 | 0 |
| Montgomery | 0 | 0 | 0 | 0 |
| Perry | 0 | 0 | 0 | 0 |
| Randolph | 0 | 0 | 0 | 0 |
| Saint Clair | 0.002462 | 0.003693 | 0.004924 | 0.007386 |
| Washington | 0 | 0 | 0 | 0 |
| Wayne | 0 | 0 | 0 | 0 |
| White | 0 | 0 | 0 | 0 |
| Williamson | 0 | 0 | 0 | 0 |
| | 0.281553 | 0.422329 | 0.563105 | 0.844658 |

Table 1.

| MWh/Ton/Acre of Carbon production available from Woody Biomass | | |
|---|---|---|
| Southern Illinois Region | | |
| | Total | |
| Oak/Hickory | 5252.905 | MWh/ton/acre |
| Maple/Beech/Birch | 0.000 | MWh/ton/acre |
| Total | 5252.905 | |
| | | |
| Illinois Claypan Region | | |
| | Total | |
| Oak/Hickory | 6766.840 | MWh/ton/acre |
| Maple/Beech/Birch | 10784.347 | MWh/ton/acre |
| Total | 17551.187 | |
| | | |
| Southern Illinois and Illinois Claypan Region | | |
| | Total | |
| Oak/Hickory | 6686.646 | MWh/ton/acre |
| Maple/Beech/Birch | 13836.869 | MWh/ton/acre |
| Total | 20523.515 | |

Table 2.

## Cost Analysis

Another key factor for utilizing woody biomass for energy production is the costs associated with removal, transportation, location, and the replanting of woody biomass. Since there are only five counties that currently utilize fossil fuels for energy production, the costs associated with transportation to and from the woody biomass removal site would greatly impact the feasibility of the project. Since there is already equipment available for woody biomass, the removal would not be a problem.

Transportation of the biomass is more likely the concern. Since the biomass is removed in stalks, it must be broken down in to wood chips or pellets before it can be delivered to an electricity plant. The double delivery would cause a greater cost, but one way the cost could be cut is if the equipment for chipping the stalks was located at the removal site. However, if the plants wanted pellets for cofiring, they would have to haul the wood to a facility where the chips could be compressed or more equipment can be delivered to the removal site for production Also wood pellets have been found to have a higher Btu combustion rate (R. Bain and R. Overend, 2002). Compressed pellets would provide a more consistent burn releasing a steady stream of energy output, whereas wood chips burn at an uneven rate causing shorter higher burst of energy output.

Location of the plant that the woody biomass would be delivered to play a major role not only for the cost of delivery, but for the amount that would need to be delivered to be profitable. The closer the plant is to where the woody biomass was taken down, the smaller the delivery cost. So the further away the plant is from the removal site, the amount that would need to be delivered would have to be greater to break even on delivery costs.

Studies have shown that the costs associated to cofire woody biomass with coal have been relatively uniform in many regions. In a Canadian Study, costs to remove, transport, and cofire woody biomass (for 1000 dry tons) was expected to reach nearly $47.16/MWh (Kumar, 2003). A study in West Virginia expected costs to range from $37 - $46/ dry ton/ MWh just for extraction costs, just a bit higher than the Department of Energy’s target cost of $35/dry ton/ MWh,

and without including extraction costs, they could see the cost being reduced to $27.78/dry ton/MWh (McNeel, Wang, Wu, Goff, 2008),. Another study reported the cost would near $53/MWh (Gan, Smith, 2006), which is not too far from another study that determined that at cofiring coal with woody biomass at a 15% level would result in an average cost of $50.37/MWh (English, et al.. 2007).

## Conclusion

The costs associated with cofiring will be the primary concern of harvesting trees and transporting them to energy facilities, as well as convincing private land owners that this would be a great opportunity not only for their region, but for the environment. Fortunately there is a substantial supply of woody biomass in Illinois for landowners and power plants to consider cofiring coal with woody biomass for energy production. Cofiring would not only help increase the esthetics of the region and reducing the carbon footprint we leave behind, but it can also prove to be another source of income for the private land owners that would chose to lease their land for such a project.

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APENDIX

| COUNTIES IN SOUTHERN ILLINOIS REGION |
|---|
| ALEXANDER |
| FRANKLIN |
| GALLATIN |
| HAMILTON |
| HARDIN |
| JACKSON |
| JOHNSON |
| MASSAC |
| PERRY |
| POPE |
| PULASKI |
| RANDOLPH |
| SALINE |
| UNION |
| WHITE |
| WILLIAMSON |

**Table 3:**

| COUNTIES IN ILLINOIS CLAYPAN |
|---|
| BOND |
| CALHOUN |
| CLARK |
| CLAY |
| CLINTON |
| CRAWFORD |
| CUMBERLAND |
| EDWARDS |
| EFFINGHAM |
| FAYETTE |
| GREENE |
| JASPER |
| JEFFERSON |
| JERSEY |
| LAWRENCE |
| MACOUPIN |
| MADISON |
| MARION |
| MONROE |
| MONTGOMERY |
| RICHLAND |
| ST CLAIR |
| SHELBY |
| WABASH |
| WASHINGTON |
| WAYNE |

Table 4:

| Inventory -- Illinois 2003-2007: area/volume | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Illinois (17) -- Area of sampled forest land by Forest type group and Site productivity (in acres) | | | | | | | | |
| | Site Productivity Class | | | | | | | |
| Forest-type group | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | Total | % of Total |
| Oak / hickory (500) | -- | 24,054 | 105,034 | 343,246 | 371,512 | 107,205 | 951,051 | 0.77 |
| Elm / ash / cottonwood (700) | -- | -- | 21,111 | 80,460 | 57,888 | 20,543 | 180,002 | 0.15 |
| Maple / beech / birch (800) | -- | -- | -- | 9,775 | 12,849 | -- | 22,624 | 0.02 |
| Totals: | 1,949 | 26,003 | 147,806 | 473,186 | 458,846 | 131,875 | 1,239,665 | 0.93 |
| % of Total | 0.002 | 0.021 | 0.119 | 0.382 | 0.370 | 0.106 | | |

(The color of each estimated value represents its percent sampling error (pse); if estimate is black , pse is less than or equal to 25%; if estimate is green , pse is greater than 25% and less than or equal to 50%; if estimate is red , pse is greater than 50%)

## Table 5: Southern Illinois Region

| Inventory -- Illinois 2003-2007: area/volume | | | | | | |
|---|---|---|---|---|---|---|
| Illinois (17) -- Area of sampled forest land by Forest type group and Ownership group (in acres) | | | | | | |
| | Ownership group | | | | | |
| Forest-type group | Forest Service (10) | Other Federal (20) | State and Local Gov't (30) | Private (40) | Total | % of Total |
| Oak / hickory (500) | 237,323 | 26,667 | 51,327 | 635,733 | 951,051 | 0.77 |
| Elm / ash / cottonwood (700) | 1,099 | 1,987 | 24,366 | 152,549 | 180,002 | 0.15 |
| Maple / beech / birch (800) | 5,732 | -- | -- | 16,892 | 22,624 | 0.02 |
| Totals: | 288,226 | 28,655 | 75,694 | 847,091 | 1,239,665 | 0.93 |
| % of Total | 0.233 | 0.023 | 0.061 | 0.683 | | |

(The color of each estimated value represents its percent sampling error (pse); if estimate is black , pse is less than or equa
to 25%; if estimate is green , pse is greater than 25% and less than or equal to 50%; if estimate is red , pse is greater than 50%

## Table 6: Southern Illinois Region

| Inventory -- Illinois 2003-2007: area/volume | | | | | | | |
|---|---|---|---|---|---|---|---|
| Illinois (17) -- Area of sampled forest land by Forest type group and Site productivity (in acres) | | | | | | | |
| | Site Productivity Class | | | | | | |
| Forest-type group | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | Total | % of Total |
| Oak / hickory (500) | 15,690 | 59,046 | 380,144 | 535,035 | 122,888 | 1,112,803 | 0.77 |
| Elm / ash / cottonwood (700) | 1,931 | 12,464 | 112,443 | 148,125 | 21,650 | 296,613 | 0.21 |
| Maple / beech / birch (800) | -- | -- | 7,958 | 10,244 | -- | 18,202 | 0.01 |
| Totals: | 17,621 | 71,510 | 507,723 | 698,259 | 144,538 | 1,439,651 | 0.99 |
| % of Totals | 0.012 | 0.050 | 0.353 | 0.485 | 0.100 | | |

(The color of each estimated value represents its percent sampling error (pse); if estimate is black , pse is less than or equal to 25%; if estimate is green , pse is greater than 25% and less than or equal to 50%; if estimate is red , pse is greater than 50%)

Table 7: Illinois Claypan Region

| Inventory -- Illinois 2003-2007: area/volume | | | | | |
|---|---|---|---|---|---|
| Illinois (17) -- Area of sampled forest land by Forest type group and Ownership group (in acres) | | | | | |
| | Ownership group | | | | |
| Forest-type group | Other Federal (20) | State and Local Gov't (30) | Private (40) | Total | % of Total |
| Oak / hickory (500) | 15,672 | 48,284 | 1,048,847 | 1,112,803 | 0.77 |
| Elm / ash / cottonwood (700) | 13,150 | 34,272 | 249,191 | 296,613 | 0.21 |
| Maple / beech / birch (800) | -- | -- | 18,202 | 18,202 | 0.01 |
| Totals: | 28,822 | 82,556 | 1,328,274 | 1,439,651 | 0.99 |
| % of Total | 0.020 | 0.057 | 0.923 | | |

(The color of each estimated value represents its percent sampling error (pse); if estimate is black , pse is less than or equal to 25%; if estimate is green , pse is greater than 25% and less than or equal to 50%; if estima red , pse is greater than 50%)

Table 8: Illinois Claypan Region

| Inventory -- Illinois 2003-2007: area/volume | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Illinois (17) -- Area of sampled forest land by Forest type group and Site productivity (in acres) | | | | | | | | |
| | Site Productivity Class | | | | | | | |
| Forest-type group | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | Total | % of Total |
| Oak / hickory (500) | -- | 39,744 | 164,080 | 723,390 | 906,547 | 230,093 | 2,063,854 | 0.77 |
| Elm / ash / cottonwood (700) | -- | 1,931 | 33,575 | 192,903 | 206,012 | 42,193 | 476,614 | 0.18 |
| Maple / beech / birch (800) | -- | -- | -- | 17,734 | 23,092 | -- | 40,826 | 0.02 |
| Totals: | 1,949 | 43,624 | 219,317 | 980,909 | 1,157,105 | 276,413 | 2,679,317 | 0.96 |
| % of Total | 0.001 | 0.016 | 0.082 | 0.366 | 0.432 | 0.103 | | |

(The color of each estimated value represents its percent sampling error (pse); if estimate is **black**, pse is less than or equal to 25%; if estimate is **green**, pse is greater than 25% and less than or equal to 50%; if estimate is **red**, pse is greater than 50%)

Table 9: Southern Illinois Region & Illinois Claypan Region

| Inventory -- Illinois 2003-2007: area/volume | | | | | | |
|---|---|---|---|---|---|---|
| Illinois (17) -- Area of sampled forest land by Forest type group and Ownership group (in acres) | | | | | | |
| | Ownership group | | | | | |
| Forest-type group | Forest Service (10) | Other Federal (20) | State and Local Gov't (30) | Private (40) | Total | % of Total |
| Oak / hickory (500) | 237,323 | 42,339 | 99,612 | 1,684,579 | 2,063,854 | 0.77 |
| Elm / ash / cottonwood (700) | 1,099 | 15,137 | 58,638 | 401,740 | 476,614 | 0.18 |
| Maple / beech / birch (800) | 5,732 | -- | -- | 35,094 | 40,826 | 0.02 |
| Totals: | 288,226 | 57,476 | 158,250 | 2,175,365 | 2,679,317 | 0.96 |
| % of Total | 0.108 | 0.021 | 0.059 | 0.812 | | |

(The color of each estimated value represents its percent sampling error (pse); if estimate is **black**, pse is less than or equal to 25%; if estimate is **green**, pse is greater than 25% and less than or equal to 50%; if estimate is **red**, pse is greater than 50%)

Table 10: Southern Illinois Region & Illinois Claypan Region

| Inventory -- Illinois 2003-2007: area/volume | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Illinois (17) -- Area of sampled forest land by Forest type group and Site productivity (in acres) | | | | | | | | |
| | Site Productivity Class | | | | | | | |
| Forest-type group | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | Total | % of Total |
| **Oak / hickory (500)** | -- | 24,054 | 105,034 | 343,246 | 371,512 | 107,205 | 951,051 | 0.77 |
| Mean Volume | | | | 107.51 | 70.94 | 19.37 | | |
| Live Tree | | | | 59.19 | 36.61 | 9.50 | | |
| Dead Tree | | | | 2.77 | 2.30 | 0.80 | | |
| Under Story | | | | 2.32 | 2.80 | 3.46 | | |
| Down Dead Wood | | | | 5.45 | 4.61 | 9.30 | | |
| Forest Floor | | | | 7.88 | 4.42 | 10.99 | | |
| Soil | | | | 45.95 | 45.95 | 45.95 | | |
| Total Non Soil | | | | 77.58 | 50.73 | 34.06 | | |
| | | | | | | | | |
| **Maple / beech / birch (800)** | -- | -- | -- | 9,775 | 12,849 | -- | 22,624 | 0.02 |
| Mean Volume | | | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | | |
| Live Tree | | | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | | |
| Dead Tree | | | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | | |
| Under Story | | | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | | |
| Down Dead Wood | | | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | | |
| Forest Floor | | | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | | |
| Soil | | | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | | |
| Total Non Soil | | | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | | |
| **Totals:** | **1,949** | **26,003** | **147,806** | **473,186** | **458,846** | **131,875** | **1,239,665** | **0.79** |
| **% of Total** | **0.002** | **0.021** | **0.119** | **0.382** | **0.370** | **0.106** | | |

(The color of each estimated value represents its percent sampling error (pse); if estimate is **black**, pse is less than or equal to 25%; if estimate is **green**, pse is greater than 25% and less than or equal to 50%; if estimate is **red**, pse is greater than 50%)

Table 11: Southern Illinois Region

| Inventory -- Illinois 2003-2007: area/volume | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Illinois (17) -- Area of sampled forest land by Forest type group and Site productivity (in acres) | | | | | | | | |
| | Site Productivity Class | | | | | | | |
| Forest-type group | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | Total | % of Total |
| **Oak / hickory (500)** | -- | 24,054 | 105,034 | 343,246 | 371,512 | 107,205 | 951,051 | 0.77 |
| Mean Volume | | | 132.14 | 100.22 | 66.70 | 16.08 | | |
| Live Tree | | | 73.93 | 57.80 | 39.52 | 9.83 | | |
| Dead Tree | | | 3.70 | 2.27 | 1.29 | 0.26 | | |
| Under Story | | | 2.34 | 2.52 | 2.82 | 3.01 | | |
| Down Dead Wood | | | 6.79 | 5.63 | 4.75 | 7.81 | | |
| Forest Floor | | | 9.13 | 5.93 | 4.75 | 5.37 | | |
| Soil | | | 45.95 | 45.95 | 45.95 | 45.95 | | |
| Total Non Soil | | | 9.13 | 74.15 | 53.12 | 26.28 | | |
| | | | | | | | | |
| **Maple / beech / birch (800)** | -- | -- | -- | 9,775 | 12,849 | -- | 22,624 | 0.02 |
| Mean Volume | | | 134.43 | 96.70 | 67.56 | 16.42 | | |
| Live Tree | | | 72.25 | 51.86 | 36.17 | 8.77 | | |
| Dead Tree | | | 9.72 | 9.72 | 9.72 | 9.72 | | |
| Under Story | | | 2.26 | 2.39 | 2.52 | 2.20 | | |
| Down Dead Wood | | | 5.19 | 5.19 | 5.19 | 5.19 | | |
| Forest Floor | | | 26.77 | 26.77 | 26.77 | 26.77 | | |
| Soil | | | 64.86 | 64.86 | 64.86 | 64.86 | | |
| Total Non Soil | | | 116.20 | 95.93 | 80.37 | 52.65 | | |
| **Totals:** | **1,949** | **26,003** | **147,806** | **473,186** | **458,846** | **131,875** | **1,239,665** | **0.79** |
| **% of Total** | **0.002** | **0.021** | **0.119** | **0.382** | **0.370** | **0.106** | | |

(The color of each estimated value represents its percent sampling error (pse); if estimate is **black**, pse is less than or equal to 25%; if estimate is **green**, pse is greater than 25% and less than or equal to 50%; if estimate is **red**, pse is greater than 50%)

Table 12: Illinois Claypan Region

| Inventory -- Illinois 2003-2007: area/volume | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Illinois (17) -- Area of sampled forest land by Forest type group and Site productivity (in acres) | | | | | | | | | |
| | Site Productivity Class | | | | | | | | |
| Forest-type group | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | Total | % of Total |
| **Oak / hickory (500)** | -- | 24,054 | 105,034 | 343,246 | 371,512 | 107,205 | 951,051 | 0.77 |
| Mean Volume | | | 126.90 | 99.49 | 68.22 | 17.02 | | |
| Live Tree | | | 71.08 | 55.92 | 38.48 | 9.64 | | |
| Dead Tree | | | 3.38 | 2.51 | 1.65 | 0.39 | | |
| Under Story | | | 2.32 | 2.51 | 2.82 | 3.09 | | |
| Down Dead Wood | | | 6.49 | 5.44 | 4.67 | 8.30 | | |
| Forest Floor | | | 9.12 | 5.90 | 4.70 | 5.78 | | |
| Soil | | | 45.95 | 45.95 | 45.95 | 45.95 | | |
| Total Non Soil | | | 9.12 | 72.28 | 52.30 | 27.20 | | |
| | | | | | | | | |
| **Maple / beech / birch (800)** | -- | -- | -- | 9,775 | 12,849 | -- | 22,624 | 0.02 |
| Mean Volume | | | 131.71 | 96.92 | 53.91 | 11.84 | | |
| Live Tree | | | 70.78 | 52.20 | 29.12 | 7.19 | | |
| Dead Tree | | | 6.59 | 6.51 | 6.06 | 2.78 | | |
| Under Story | | | 2.22 | 2.35 | 2.60 | 2.23 | | |
| Down Dead Wood | | | 5.17 | 5.17 | 5.17 | 5.17 | | |
| Forest Floor | | | 26.52 | 26.52 | 26.52 | 26.52 | | |
| Soil | | | 64.86 | 64.86 | 64.86 | 64.86 | | |
| Total Non Soil | | | 432.28 | 96.10 | 69.47 | 43.89 | | |
| **Totals:** | **1,949** | **26,003** | **147,806** | **473,186** | **458,846** | **131,875** | **1,239,665** | **0.79** |
| **% of Total** | **0.002** | **0.021** | **0.119** | **0.382** | **0.370** | **0.106** | | |

(The color of each estimated value represents its percent sampling error (pse); if estimate is **black** , pse is less than or equal to 25%; if estimate is **green** , pse is greater than 25% and less than or equal to 50%; if estimate is **red** , pse is greater than 50%)

Table 13: Southern Illinois Region & Illinois Claypan Region

| | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | | |
|---|---|---|---|---|---|---|---|---|
| AGE CLASS | MEAN VOLUME | LIVE TREE | DEAD TREE | UNDER STORY | DOWN DEAD WOOD | FOREST FLOOR | SOIL | TOTAL NON SOIL |
| YEARS | M3/HA | TONNES CARBON/HA | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 17.57 | 27.34 | 45.95 | 44.91 |
| 5 | 2.87 | 1.31 | 0.17 | 5.33 | 11.07 | 12.44 | 45.95 | 30.32 |
| 10 | 14.33 | 6.78 | 0.71 | 4.88 | 7.43 | 6.58 | 45.95 | 26.38 |
| 15 | 31.05 | 15.13 | 1.31 | 3.85 | 5.6 | 4.52 | 45.95 | 30.43 |
| 20 | 48.61 | 24.3 | 1.82 | 3.26 | 4.82 | 4.05 | 45.95 | 38.24 |
| 25 | 64.41 | 32.91 | 2.18 | 2.91 | 4.59 | 4.21 | 45.95 | 46.79 |
| 30 | 77.47 | 40.31 | 2.42 | 2.69 | 4.63 | 4.63 | 45.95 | 54.67 |
| 35 | 87.73 | 46.35 | 2.57 | 2.54 | 4.78 | 5.13 | 45.95 | 61.38 |
| 40 | 95.53 | 51.11 | 2.67 | 2.45 | 4.96 | 5.65 | 45.95 | 66.84 |
| 50 | 105.57 | 57.56 | 2.77 | 2.33 | 5.29 | 6.65 | 45.95 | 74.61 |
| 60 | 110.88 | 61.18 | 2.81 | 2.28 | 5.52 | 7.75 | 45.95 | 79.36 |
| 70 | 113.61 | 63.16 | 2.82 | 2.25 | 5.66 | 8.4 | 45.95 | 82.3 |
| 80 | 115 | 64.23 | 2.82 | 2.23 | 5.74 | 9.16 | 45.95 | 84.19 |
| 90 | 115.7 | 64.8 | 2.83 | 2.22 | 5.79 | 9.85 | 45.95 | 85.49 |
| 100 | 116.06 | 65.11 | 2.83 | 2.22 | 5.82 | 10.48 | 45.95 | 86.45 |

Table 14: Southern Illinois Region Oak/Hickory Private Ownership Group

| | | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | |
|---|---|---|---|---|---|---|---|---|
| AGE CLASS | MEAN VOLUME | LIVE TREE | DEAD TREE | UNDER STORY | DOWN DEAD WOOD | FOREST FLOOR | SOIL | TOTAL NON SOIL |
| YEARS | M3/HA | TONNES CARBON/HA | | | | | | |
| 0 | | | | | | | | |
| 5 | | | | | | | | |
| 10 | | | | | | | | |
| 15 | | | | | | | | |
| 20 | | | | | | | | |
| 25 | | | | | | | | |
| 30 | | | | | | | | |
| 35 | | | | | | | | |
| 40 | | | | | | | | |
| 50 | | | | | | | | |
| 60 | | | | | | | | |
| 70 | | | | | | | | |
| 80 | | | | | | | | |
| 90 | | | | | | | | |
| 100 | | | | | | | | |

Table 15: Southern Illinois Region Maple/Beech/Birch Private Ownership Group

| | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | | |
|---|---|---|---|---|---|---|---|---|
| AGE CLASS | MEAN VOLUME | LIVE TREE | DEAD TREE | UNDER STORY | DOWN DEAD WOOD | FOREST FLOOR | SOIL | TOTAL NON SOIL |
| YEARS | M3/HA | TONNES CARBON/HA | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 14.26 | 7.67 | 45.95 | 21.94 |
| 5 | 2.01 | 1.28 | 0.03 | 4.03 | 9.06 | 5.72 | 45.95 | 20.13 |
| 10 | 10.87 | 6.8 | 0.16 | 4.24 | 6.23 | 4.75 | 45.95 | 22.17 |
| 15 | 25.31 | 15.55 | 0.4 | 3.6 | 4.94 | 4.37 | 45.95 | 28.86 |
| 20 | 42.19 | 25.52 | 0.73 | 3.18 | 4.54 | 4.36 | 45.95 | 38.32 |
| 25 | 59.03 | 35.21 | 1.1 | 2.91 | 4.61 | 4.57 | 45.95 | 48.39 |
| 30 | 74.37 | 43.83 | 1.48 | 2.73 | 4.88 | 4.92 | 45.95 | 57.84 |
| 35 | 87.59 | 51.09 | 1.85 | 2.61 | 5.22 | 5.33 | 45.95 | 66.1 |
| 40 | 98.57 | 56.99 | 2.19 | 2.53 | 5.56 | 5.77 | 45.95 | 73.04 |
| 50 | 114.51 | 65.33 | 2.78 | 2.43 | 6.11 | 6.69 | 45.95 | 83.32 |
| 60 | 124.35 | 70.24 | 3.22 | 2.38 | 6.48 | 7.58 | 45.95 | 89.91 |
| 70 | 130.22 | 73.08 | 3.54 | 2.35 | 6.71 | 8.42 | 45.95 | 94.1 |
| 80 | 133.66 | 74.68 | 3.77 | 2.34 | 6.85 | 9.19 | 45.95 | 96.82 |
| 90 | 135.65 | 75.58 | 3.92 | 2.33 | 6.92 | 9.9 | 45.95 | 98.65 |
| 100 | 136.8 | 76.08 | 4.03 | 2.32 | 6.97 | 10.55 | 45.95 | 99.95 |

Table 16: Illinois Claypan Region Oak/Hickory Private Ownership Group

| | | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | |
|---|---|---|---|---|---|---|---|---|
| AGE CLASS | MEAN VOLUME | LIVE TREE | DEAD TREE | UNDER STORY | DOWN DEAD WOOD | FOREST FLOOR | SOIL | TOTAL NON SOIL |
| YEARS | M3/HA | TONNES CARBON/HA | | | | | | |
| 0 | 0 | 0 | 9.72 | 0 | 5.19 | 26.77 | 64.86 | 41.68 |
| 5 | 0.29 | 0.16 | 9.72 | 0.64 | 5.19 | 26.77 | 64.86 | 42.48 |
| 10 | 1.97 | 1.05 | 9.72 | 2.21 | 5.19 | 26.77 | 64.86 | 44.93 |
| 15 | 5.57 | 2.97 | 9.72 | 2.87 | 5.19 | 26.77 | 64.86 | 47.52 |
| 20 | 11.14 | 5.94 | 9.72 | 2.98 | 5.19 | 26.77 | 64.86 | 50.6 |
| 25 | 18.42 | 9.82 | 9.72 | 2.92 | 5.19 | 26.77 | 64.86 | 54.42 |
| 30 | 27.03 | 14.43 | 9.72 | 2.83 | 5.19 | 26.77 | 64.86 | 58.94 |
| 35 | 36.6 | 19.55 | 9.72 | 2.73 | 5.19 | 26.77 | 64.86 | 63.97 |
| 40 | 46.74 | 24.99 | 9.72 | 2.65 | 5.19 | 26.77 | 64.86 | 69.32 |
| 50 | 67.56 | 36.17 | 9.72 | 2.52 | 5.19 | 26.77 | 64.86 | 80.37 |
| 60 | 87.6 | 46.95 | 9.72 | 2.42 | 5.19 | 26.77 | 64.86 | 91.06 |
| 70 | 105.8 | 56.77 | 9.72 | 2.35 | 5.19 | 26.77 | 64.86 | 100.8 |
| 80 | 121.69 | 65.35 | 9.72 | 2.3 | 5.19 | 26.77 | 64.86 | 109.34 |
| 90 | 135.18 | 72.66 | 9.72 | 2.26 | 5.19 | 26.77 | 64.86 | 116.6 |
| 100 | 146.41 | 78.75 | 9.72 | 2.23 | 5.19 | 26.77 | 64.86 | 122.67 |

Table 17: Illinois Claypan Region Maple/Beech Birch Private Ownership Group

| | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | | |
|---|---|---|---|---|---|---|---|---|
| AGE CLASS | MEAN VOLUME | LIVE TREE | DEAD TREE | UNDER STORY | DOWN DEAD WOOD | FOREST FLOOR | SOIL | TOTAL NON SOIL |
| YEARS | M3/HA | TONNES CARBON/HA | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 15.49 | 8.92 | 45.95 | 24.41 |
| 5 | 2.23 | 1.27 | 0.05 | 4.25 | 9.74 | 6.28 | 45.95 | 21.59 |
| 10 | 11.8 | 6.7 | 0.26 | 4.37 | 6.59 | 4.95 | 45.95 | 22.87 |
| 15 | 26.94 | 15.26 | 0.61 | 3.66 | 5.11 | 4.42 | 45.95 | 29.05 |
| 20 | 44.14 | 24.96 | 1.02 | 3.19 | 4.58 | 4.34 | 45.95 | 38.1 |
| 25 | 60.82 | 34.33 | 1.45 | 2.91 | 4.56 | 4.53 | 45.95 | 47.77 |
| 30 | 75.62 | 42.62 | 1.85 | 2.72 | 4.77 | 4.87 | 45.95 | 56.82 |
| 35 | 88.05 | 49.56 | 2.18 | 2.6 | 5.07 | 5.29 | 45.95 | 64.69 |
| 40 | 98.13 | 55.18 | 2.47 | 2.51 | 5.37 | 5.74 | 45.95 | 71.26 |
| 50 | 112.29 | 63.03 | 2.89 | 2.41 | 5.87 | 6.68 | 45.95 | 80.88 |
| 60 | 120.67 | 67.66 | 3.16 | 2.35 | 6.21 | 7.57 | 45.95 | 86.96 |
| 70 | 125.47 | 70.3 | 3.33 | 2.32 | 6.42 | 8.41 | 45.95 | 90.78 |
| 80 | 128.17 | 71.78 | 3.43 | 2.31 | 6.54 | 9.18 | 45.95 | 93.23 |
| 90 | 129.68 | 72.6 | 3.48 | 2.3 | 6.61 | 9.89 | 45.95 | 94.88 |
| 100 | 130.52 | 73.05 | 3.52 | 2.3 | 6.65 | 10.54 | 45.95 | 96.06 |

Table 18: Southern Illinois Region & Illinois Claypan Region Oak/Hickory Private Ownership Group

| | | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | |
|---|---|---|---|---|---|---|---|---|
| AGE CLASS | MEAN VOLUME | LIVE TREE | DEAD TREE | UNDER STORY | DOWN DEAD WOOD | FOREST FLOOR | SOIL | TOTAL NON SOIL |
| YEARS | M3/HA | TONNES CARBON/HA | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 5.17 | 26.52 | 64.86 | 31.7 |
| 5 | 0.51 | 0.28 | 0.37 | 1.11 | 5.17 | 26.52 | 64.86 | 33.45 |
| 10 | 3.26 | 1.77 | 1.55 | 2.78 | 5.17 | 26.52 | 64.86 | 37.79 |
| 15 | 8.78 | 4.76 | 2.93 | 3.1 | 5.17 | 26.52 | 64.86 | 42.49 |
| 20 | 16.73 | 9.07 | 4.1 | 3.02 | 5.17 | 26.52 | 64.86 | 47.88 |
| 25 | 26.43 | 14.31 | 4.96 | 2.88 | 5.17 | 26.52 | 64.86 | 53.84 |
| 30 | 27.18 | 20.11 | 5.54 | 2.75 | 5.17 | 26.52 | 64.86 | 60.1 |
| 35 | 48.35 | 26.13 | 5.93 | 2.64 | 5.17 | 26.52 | 64.86 | 66.4 |
| 40 | 59.47 | 32.11 | 6.18 | 2.55 | 5.17 | 26.52 | 64.86 | 72.54 |
| 50 | 80.26 | 43.28 | 6.43 | 2.43 | 5.17 | 26.52 | 64.86 | 93.84 |
| 60 | 98.04 | 52.81 | 6.53 | 2.34 | 5.17 | 26.52 | 64.86 | 93.38 |
| 70 | 112.46 | 60.52 | 6.57 | 2.28 | 5.17 | 26.52 | 64.86 | 101.07 |
| 80 | 123.76 | 66.55 | 6.58 | 2.25 | 5.17 | 26.52 | 64.86 | 1070.08 |
| 90 | 132.42 | 71.16 | 6.59 | 2.22 | 5.17 | 26.52 | 64.86 | 111.66 |
| 100 | 138.94 | 74.62 | 6.59 | 2.2 | 5.17 | 26.52 | 64.86 | 115.11 |

Table 19: Southern Illinois Region & Illinois Claypan Region Maple/Beech/Birch Private Ownership Group

| Forest-type group | Site Productivity Class<br>225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | Total | % of Total |
|---|---|---|---|---|---|---|---|---|
| **Oak / hickory (500)** | | 24,054 | 105,034 | 343,246 | 371,512 | 107,205 | 951,051 | 0.77 |
| Mean Volume | | | | 1220.79 | 805.53 | 219.97 | 2246.29 | |
| Live Tree | | | | 672.08 | 415.71 | 107.92 | 1195.71 | |
| Dead Tree | | | | 31.40 | 26.12 | 9.11 | 66.62 | |
| Under Story | | | | 26.29 | 31.79 | 39.33 | 97.42 | |
| Down Dead Wood | | | | 61.83 | 52.35 | 105.58 | 219.75 | |
| Forest Floor | | | | 89.52 | 50.19 | 124.75 | 264.46 | |
| Soil | | | | 521.77 | 521.77 | 521.77 | 1565.30 | |
| Total Non Soil | | | | 880.90 | 576.04 | 386.71 | 1843.65 | |
| TOTAL (MWh) | | | | 3504.56 | 2479.50 | 1515.13 | 5252.90 | MWh/ton/acre |
| | | | | | | | | |
| **Maple / beech / birch (800)** | -- | -- | -- | 9,775 | 12,849 | -- | 22,624 | 0.02 |
| Mean Volume | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Live Tree | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Dead Tree | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Under Story | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Down Dead Wood | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Forest Floor | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Soil | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Total Non Soil | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| TOTAL (MWh) | | | | | | | 0.00 | MWh/ton/acre |

Table 20: Southern Illinois Region MWh/Ton/Acre of Carbon Production Available

| Forest-type group | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | Total | % of Total |
|---|---|---|---|---|---|---|---|---|
| | Site Productivity Class | | | | | | | |
| **Oak / hickory (500)** | -- | 24,054 | 105,034 | 343,246 | 371,512 | 107,205 | 951,051 | 0.77 |
| Mean Volume | | | 1,500.42 | 1,138.04 | 757.38 | 182.54 | 3578.39 | |
| Live Tree | | | 839.50 | 656.36 | 448.75 | 111.62 | 2056.24 | |
| Dead Tree | | | 41.97 | 25.81 | 14.65 | 3.00 | 85.43 | |
| Under Story | | | 26.62 | 28.65 | 32.02 | 34.18 | 121.47 | |
| Down Dead Wood | | | 77.06 | 63.93 | 53.88 | 88.64 | 283.50 | |
| Forest Floor | | | 103.65 | 67.34 | 53.88 | 61.02 | 285.89 | |
| Soil | | | 521.77 | 521.77 | 521.77 | 521.77 | 2087.06 | |
| Total Non Soil | | | 103.65 | 842.02 | 603.13 | 298.46 | 1847.25 | |
| TOTAL (MWh) | | | 3214.62 | 3343.92 | 2485.46 | 1301.22 | 6766.84 | MWh/ton/acre |
| | | | | | | | | |
| **Maple / beech / birch (800)** | -- | -- | -- | 9,775 | 12,849-- | | 22,624 | 0.02 |
| Mean Volume | | | 1,526.43 | 1,098.04 | 767.15 | 186.43 | 3578.04 | |
| Live Tree | | | 820.44 | 588.87 | 410.71 | 99.56 | 1919.59 | |
| Dead Tree | | | 110.37 | 110.37 | 110.37 | 110.37 | 441.49 | |
| Under Story | | | 25.70 | 27.08 | 28.61 | 25.02 | 106.42 | |
| Down Dead Wood | | | 58.93 | 58.93 | 58.93 | 58.93 | 235.73 | |
| Forest Floor | | | 303.98 | 303.98 | 303.98 | 303.98 | 1215.90 | |
| Soil | | | 736.49 | 736.49 | 736.49 | 736.49 | 2945.96 | |
| Total Non Soil | | | 1,319.50 | 1,089.29 | 912.61 | 597.86 | 3919.26 | |
| TOTAL (MWh) | | | 4901.84 | 4013.06 | 3328.86 | 2118.63 | 10784.35 | MWh/ton/acre |

Table 21: Illinois Claypan Region MWh/Ton/Acre of Carbon Production Available

| Forest-type group | 225+ cubic feet/acre/year (1) | 165-224 cubic feet/acre/year (2) | 120-164 cubic feet/acre/year (3) | 85-119 cubic feet/acre/year (4) | 50-84 cubic feet/acre/year (5) | 20-49 cubic feet/acre/year (6) | Total | % of Total |
|---|---|---|---|---|---|---|---|---|
| | Site Productivity Class | | | | | | | |
| **Oak / hickory (500)** | -- | 24,054 | 105,034 | 343,246 | 371,512 | 107,205 | 951,051 | 0.77 |
| Mean Volume | | | 1,440.98 | 1,129.72 | 774.64 | 193.29 | 3538.63 | |
| Live Tree | | | 807.10 | 635.01 | 436.89 | 109.44 | 1988.44 | |
| Dead Tree | | | 38.43 | 28.54 | 18.74 | 4.41 | 90.11 | |
| Under Story | | | 26.30 | 28.46 | 31.96 | 35.13 | 121.86 | |
| Down Dead Wood | | | 73.65 | 61.73 | 52.97 | 94.27 | 282.62 | |
| Forest Floor | | | 103.54 | 67.03 | 53.37 | 65.66 | 289.59 | |
| Soil | | | 521.77 | 521.77 | 521.77 | 521.77 | 2087.06 | |
| Total Non Soil | | | 103.54 | 820.71 | 593.81 | 308.90 | 1826.96 | |
| TOTAL (MWh) | | | 3115.29 | 3292.97 | 2484.15 | 1332.86 | 6686.65 | MWh/ton/acre |
| | | | | | | | | |
| **Maple / beech / birch (800)** | -- | -- | -- | 9,775 | 12,849-- | | 22,624 | 0.02 |
| Mean Volume | | | 1,495.54 | 1,100.53 | 612.15 | 134.46 | 3342.69 | |
| Live Tree | | | 803.68 | 592.77 | 330.66 | 81.59 | 1808.70 | |
| Dead Tree | | | 74.79 | 73.92 | 68.76 | 31.55 | 249.02 | |
| Under Story | | | 25.25 | 26.68 | 29.47 | 25.37 | 106.77 | |
| Down Dead Wood | | | 58.71 | 58.71 | 58.71 | 58.71 | 234.82 | |
| Forest Floor | | | 301.14 | 301.14 | 301.14 | 301.14 | 1204.55 | |
| Soil | | | 736.49 | 736.49 | 736.49 | 736.49 | 2945.96 | |
| Total Non Soil | | | 4,908.61 | 1,091.19 | 788.84 | 498.41 | 7287.04 | |
| TOTAL (MWh) | | | 8404.20 | 3981.43 | 2926.21 | 1867.72 | 13836.87 | MWh/ton/acre |

Table 22: Southern Illinois Region & Illinois Claypan Region MWh/Ton/Acre of Carbon Production Available

| | | | | | | | | Energy | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| region_id | name | plant_count | energy_2007 | fossil_2007 | intensity_2007 | Intensity (MWh/to | carbon_2007 | 10% | 15% | 20% | 30% |
| 3672 | Clay | 2 | 3744.1599 | 0 | 1762.344 | 0.881172 | 3299.248 | 374.416 | 561.624 | 748.832 | 1123.248 |
| 3687 | Clinton | 3 | 401.1774 | 0 | 2103.124 | 1.051562 | 421.8628 | 40.11774 | 60.17661 | 80.23548 | 120.3532 |
| 3736 | Crawford | 2 | 917862 | 0.9835 | 2423.4189 | 1.21170945 | 1112182 | 91786.2 | 137679.3 | 183572.4 | 275358.6 |
| 3747 | Cumberland | 1 | 7838.5449 | 0 | 1591.2791 | 0.79563955 | 6236.6572 | 783.8545 | 1175.782 | 1567.709 | 2351.563 |
| 3845 | Effingham | 2 | 136871.0938 | 0.5367 | 955.8636 | 0.4779318 | 65415.0586 | 13687.11 | 20530.66 | 27374.22 | 41061.33 |
| 3879 | Fayette | 1 | 7970 | 0 | 1112.2629 | 0.55613145 | 4432.3662 | 797 | 1195.5 | 1594 | 2391 |
| 3905 | Franklin | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4020 | Hamilton | 1 | 77.8073 | 0 | 2666.364 | 1.333182 | 103.7314 | 7.78073 | 11.6711 | 15.56146 | 23.34219 |
| 4136 | Jackson | 2 | 550161.125 | 0.7032 | 1191.0959 | 0.59554795 | 327647.3125 | 55016.11 | 82524.17 | 110032.2 | 165048.3 |
| 4147 | Jasper | 1 | 8839558 | 0 | 2159.478 | 1.079739 | 9544417 | 883955.8 | 1325934 | 1767912 | 2651867 |
| 4365 | Madison | 8 | 3482223 | 0.9978 | 1851.8621 | 0.92593105 | 3224299 | 348222.3 | 522333.5 | 696444.6 | 1044667 |
| 4388 | Marion | 1 | 19829 | 0 | 1349.439 | 0.6747195 | 13379.0195 | 1982.9 | 2974.35 | 3965.8 | 5948.7 |
| 4411 | Massac | 2 | 8954309 | 0 | 2089.5601 | 1.04478005 | 9355283 | 895430.9 | 1343146 | 1790862 | 2686293 |
| 4484 | Monroe | 1 | 314.9276 | 0 | 1836.931 | 0.9184655 | 289.2502 | 31.49276 | 47.23914 | 62.98552 | 94.47828 |
| 4493 | Montgomery | 2 | 6199564 | 0 | 2127.9551 | 1.06397755 | 6596197 | 619956.4 | 929934.6 | 1239913 | 1859869 |
| 4657 | Perry | 1 | 181613 | 0 | 1375.941 | 0.6879705 | 124944.3984 | 18161.3 | 27241.95 | 36322.6 | 54483.9 |
| 4733 | Randolph | 2 | 14300000 | 0 | 1978.582 | 0.989291 | 14100000 | 1430000 | 2145000 | 2860000 | 4290000 |
| 4801 | Saint Clair | 3 | 5716.0029 | 0.0681 | 723.0921 | 0.36154605 | 2066.5979 | 571.6003 | 857.4004 | 1143.201 | 1714.801 |
| 5078 | Washington | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5104 | Wayne | 1 | 296.0298 | 0 | 1681.921 | 0.8409605 | 248.9493 | 29.60298 | 44.40447 | 59.20596 | 88.80894 |
| 5134 | White | 2 | 559.9966 | 0 | 1649.7629 | 0.82488145 | 461.931 | 55.99966 | 83.99949 | 111.9993 | 167.999 |
| 5149 | Williamson | 2 | 1937591 | 0 | 2805.2251 | 1.40261255 | 2717690 | 193759.1 | 290638.7 | 387518.2 | 581277.3 |

| | | intensity | | | | Carbon | | | |
|---|---|---|---|---|---|---|---|---|---|
| region_id | name | 10% | 15% | 20% | 30% | 10% | 15% | 20% | 30% |
| 3672 | Clay | 0.0881172 | 0.132176 | 0.176234 | 0.264352 | 329.9248 | 494.8872 | 659.8496 | 989.7744 |
| 3687 | Clinton | 0.1051562 | 0.157734 | 0.210312 | 0.315469 | 42.18628 | 63.27942 | 84.37256 | 126.5588 |
| 3736 | Crawford | 0.121170945 | 0.181756 | 0.242342 | 0.363513 | 111218.2 | 166827.3 | 222436.4 | 333654.6 |
| 3747 | Cumberland | 0.079563955 | 0.119346 | 0.159128 | 0.238692 | 623.6657 | 935.4986 | 1247.331 | 1870.997 |
| 3845 | Effingham | 0.04779318 | 0.07169 | 0.095586 | 0.14338 | 6541.506 | 9812.259 | 13083.01 | 19624.52 |
| 3879 | Fayette | 0.055613145 | 0.08342 | 0.111226 | 0.166839 | 443.2366 | 664.8549 | 886.4732 | 1329.71 |
| 3905 | Franklin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4020 | Hamilton | 0.1333182 | 0.199977 | 0.266636 | 0.399955 | 10.37314 | 15.55971 | 20.74628 | 31.11942 |
| 4136 | Jackson | 0.059554795 | 0.089332 | 0.11911 | 0.178664 | 32764.73 | 49147.1 | 65529.46 | 98294.19 |
| 4147 | Jasper | 0.1079739 | 0.161961 | 0.215948 | 0.323922 | 954441.7 | 1431663 | 1908883 | 2863325 |
| 4365 | Madison | 0.092593105 | 0.13889 | 0.185186 | 0.277779 | 322429.9 | 483644.9 | 644859.8 | 967289.7 |
| 4388 | Marion | 0.06747195 | 0.101208 | 0.134944 | 0.202416 | 1337.902 | 2006.853 | 2675.804 | 4013.706 |
| 4411 | Massac | 0.104478005 | 0.156717 | 0.208956 | 0.313434 | 935528.3 | 1403292 | 1871057 | 2806585 |
| 4484 | Monroe | 0.09184655 | 0.13777 | 0.183693 | 0.27554 | 28.92502 | 43.38753 | 57.85004 | 86.77506 |
| 4493 | Montgomery | 0.106397755 | 0.159597 | 0.212796 | 0.319193 | 659619.7 | 989429.6 | 1319239 | 1978859 |
| 4657 | Perry | 0.06879705 | 0.103196 | 0.137594 | 0.206391 | 12494.44 | 18741.66 | 24988.88 | 37483.32 |
| 4733 | Randolph | 0.0989291 | 0.148394 | 0.197858 | 0.296787 | 1410000 | 2115000 | 2820000 | 4230000 |
| 4801 | Saint Clair | 0.036154605 | 0.054232 | 0.072309 | 0.108464 | 206.6598 | 309.9897 | 413.3196 | 619.9794 |
| 5078 | Washington | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5104 | Wayne | 0.08409605 | 0.126144 | 0.168192 | 0.252288 | 24.89493 | 37.3424 | 49.78986 | 74.68479 |
| 5134 | White | 0.082488145 | 0.123732 | 0.164976 | 0.247464 | 46.1931 | 69.28965 | 92.3862 | 138.5793 |
| 5149 | Williamson | 0.140261255 | 0.210392 | 0.280523 | 0.420784 | 271769 | 407653.5 | 543538 | 815307 |

Table 23: Fossil Fuel Usage in Illinois for Energy Production

Southern Illinois Oak-Hickory Group

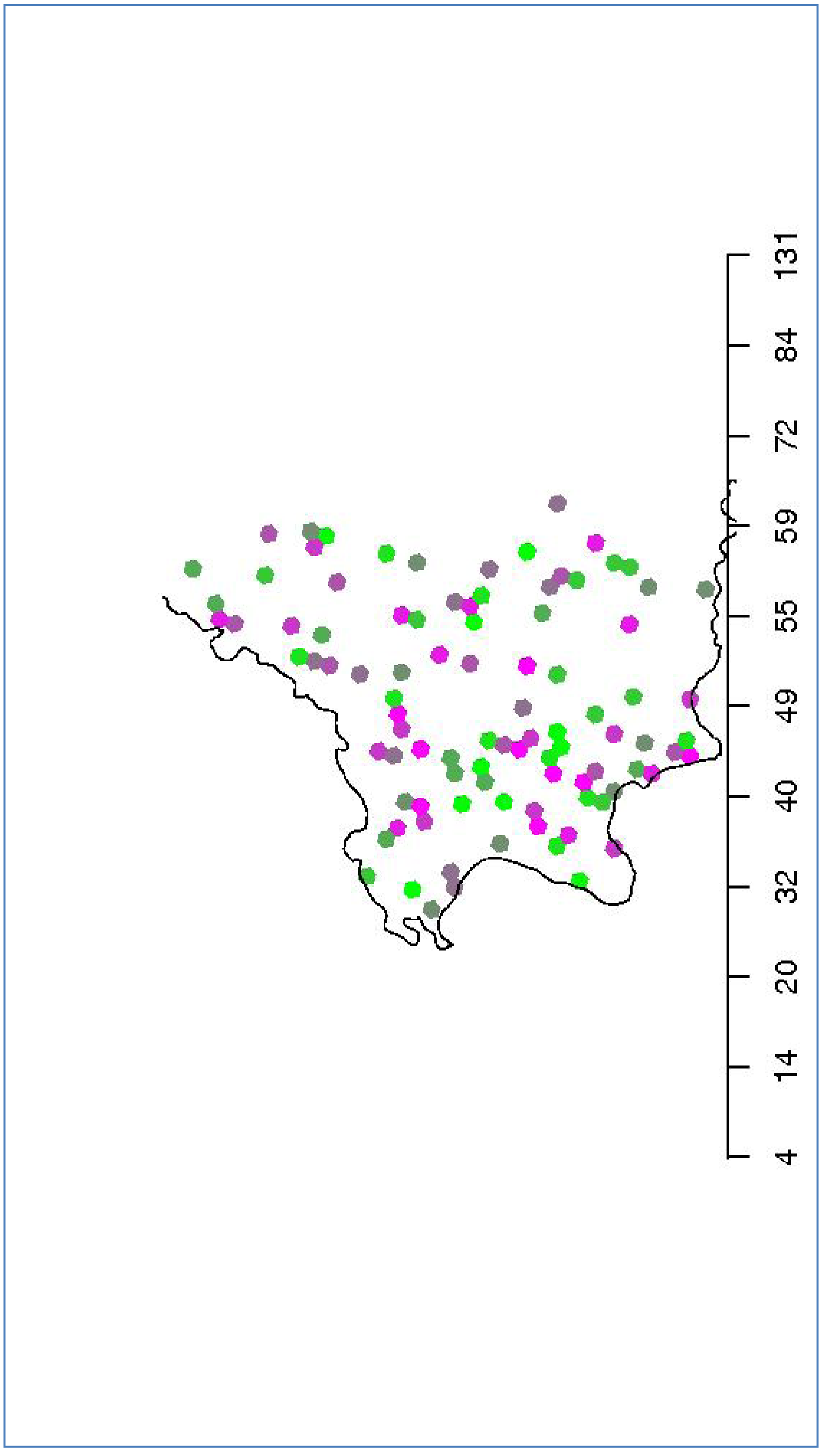


Figure 1: Hex map of Total Aboveground Carbon (metric tons/hectare) for Illinois

Illinois Claypan Oak-Hickory Group

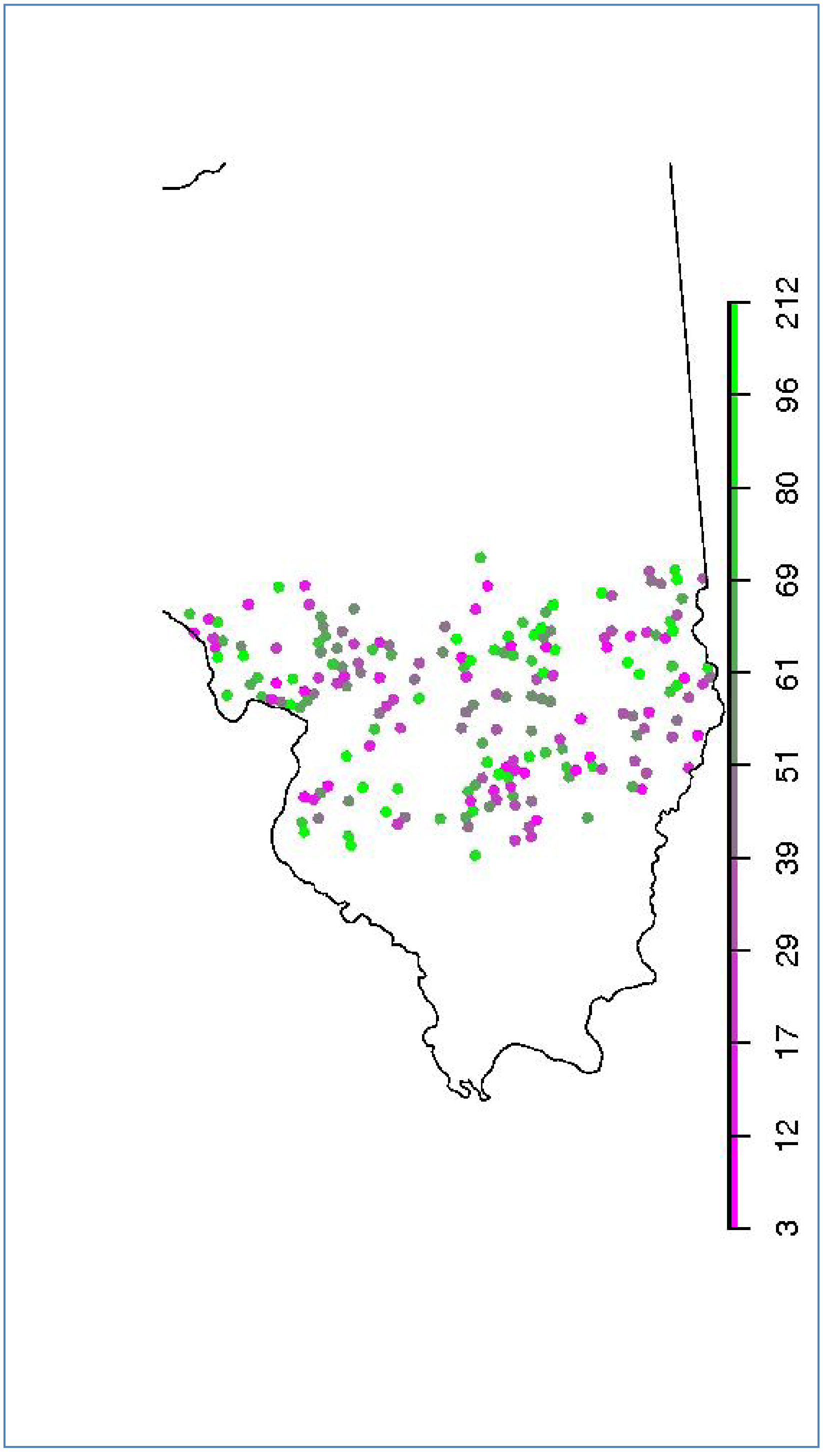


Figure 2: Hex map of Total Aboveground Carbon (metric tons/hectare) for Illinois

Southern Illinois & Illinois Claypan Oak-Hickory Group

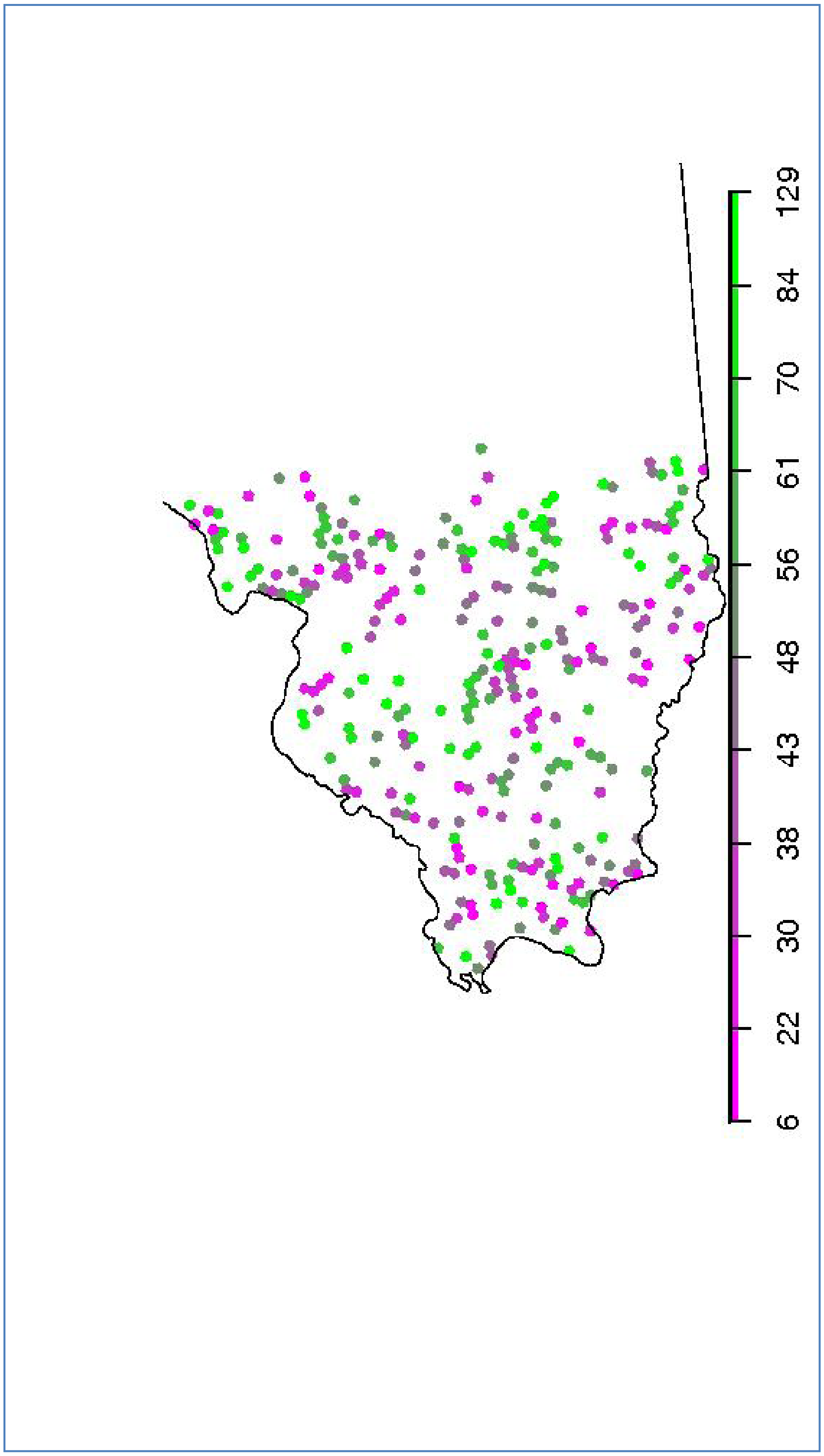


Figure 3: Hex map of Total Aboveground Carbon (metric tons/hectare) for Illinois

Illinois Claypan Maple-Beech-Birch Group

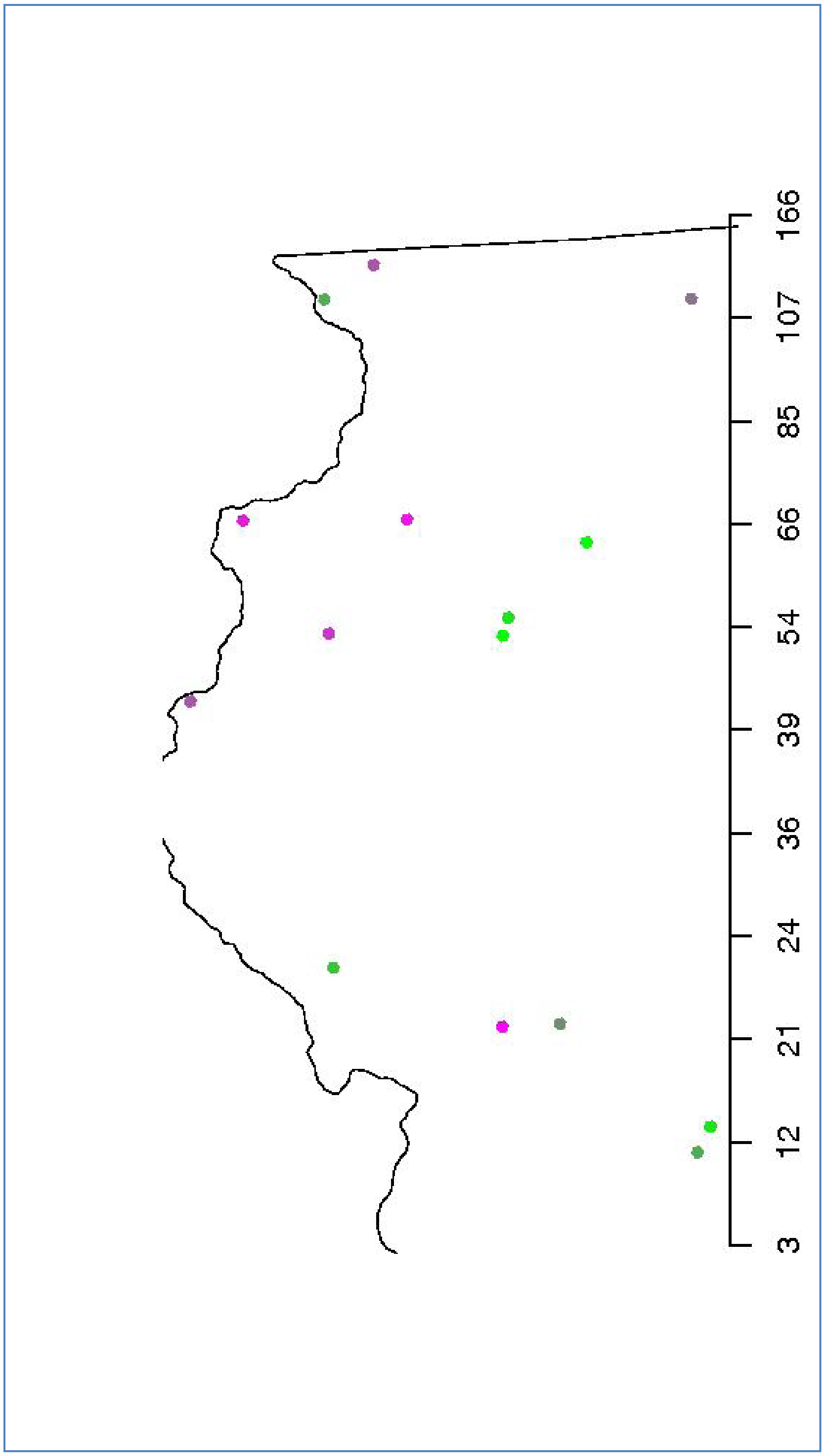


Figure 4: Hex map of Total Aboveground Carbon (metric tons/hectare) for Illinois

Southern Illinois & Illinois Claypan Maple-Beech-Birch Group

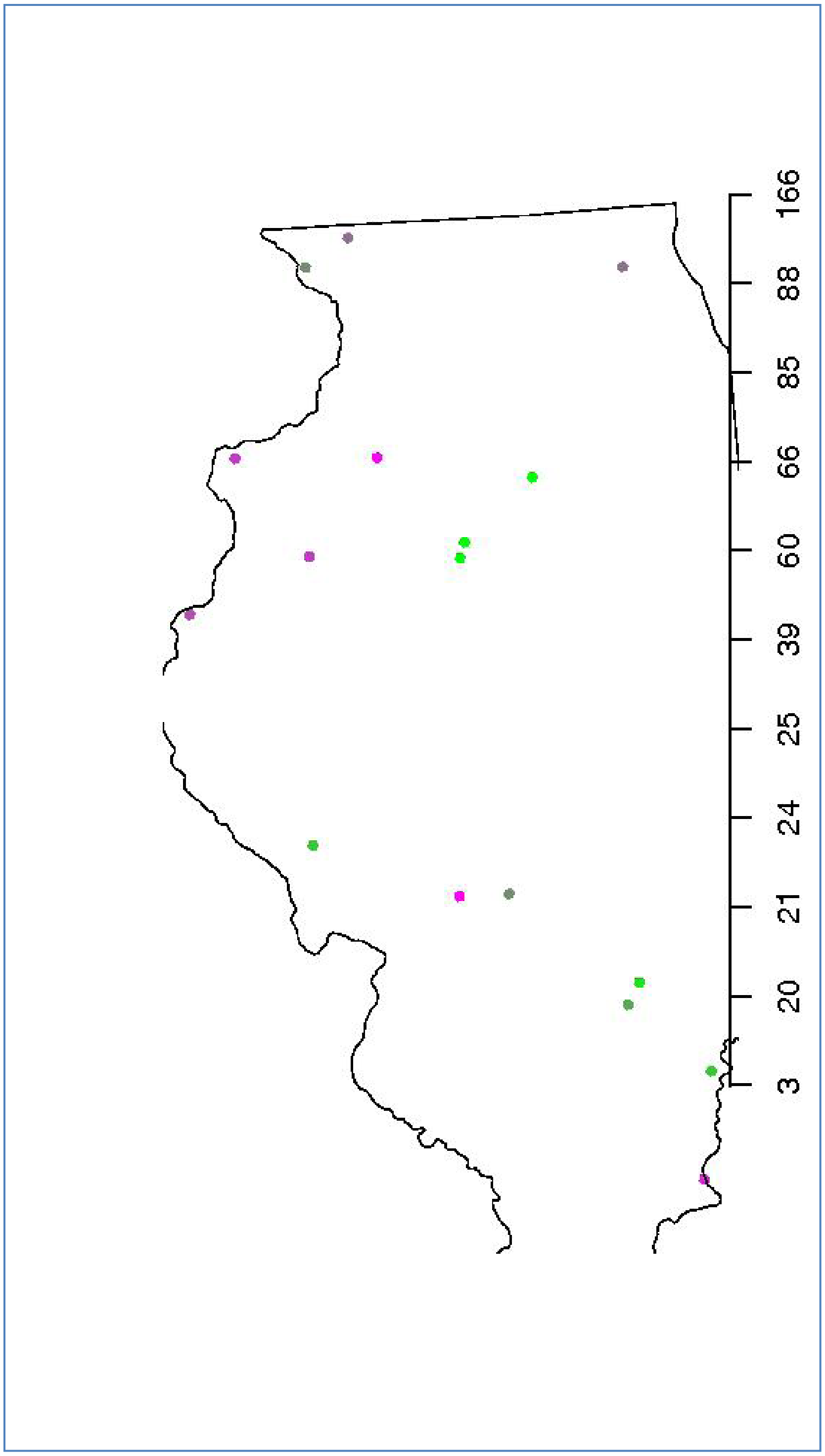


Figure 5: Hex map of Total Aboveground Carbon (metric tons/hectare) for Illinois

**Table 5.** Average Feedstock Demand Prices by Utilities

| Scenario and Residue | U.S. Dollars per Dry Ton | | | |
|---|---|---|---|---|
| | 2% Cofire | | 15% Cofire | |
| | Farmgate Feedstock Demand Price[a] | Delivered Feedstock Demand Price[b] | Farmgate Feedstock Demand Price | Delivered Feedstock Demand Price |
| *NoCtax:* | | | | |
| Agriculture residues | NA[c] | NA | NA | NA |
| Forest | $24.66 | $28.48 | NA | NA |
| Mill waste | $23.67 | $28.86 | NA | NA |
| Dedicated crop | NA | NA | NA | NA |
| Urban waste | $21.96 | $27.98 | NA | NA |
| *LowCtax:* | | | | |
| Agriculture residues | $54.79 | $57.07 | $46.41[d] | $58.25 |
| Forest | $53.48 | $58.46 | $40.13 | $60.60 |
| Mill waste | $54.29 | $57.97 | $40.18 | $60.63 |
| Dedicated crop | $54.91 | $55.85 | $42.71 | $59.29 |
| Urban waste | $54.92 | $56.07 | $41.70 | $59.20 |
| *HighCtax:* | | | | |
| Agriculture residues | $55.00 | $57.72 | $55.00 | $61.29 |
| Forest | $55.00 | $58.46 | $55.00 | $64.22 |
| Mill waste | $55.00 | $58.10 | $55.00 | $64.28 |
| Dedicated crop | $55.00 | $58.54 | $55.00 | $63.71 |
| Urban waste | $55.00 | $58.30 | $55.00 | $62.45 |

[a] Farmgate feedstock demand price is the average price the utility would be willing to pay the supplier given the scenario and cost of other feedstocks and the costs involved in transporting, handling, and on-site storage.
[b] Delivered feedstock demand price determined based on information from ORIBAS and includes transportation, handling, and on-site storage costs.
[c] NA is none available at the estimated value.
[d] A much larger quantity of residues would be demanded by power plants resulting in increased transportation costs and increased investment costs resulting in a lower feedstock demand price.

(English, B.C., K. Jensen, J. Menard, M. E. Walsh, C. Brandt, J. Van Dyke, S. Hadley. 2007)

Figure 6: Average Feedstock Demand Prices.

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Major Professor: Silvia Secchi