Addison County Regional Planning Commission:

How Can Addison County Incorporate Farmers Into A Search For Energy Alternatives?

Community Partners:

Harvey Smith

Jeff Owen

Nate Blumenshine

Chynna Hawes

Goudi Vandal

Rachel Korschun

Zach Hecht-Leavitt

Ben Hanna

Environmental Economics

Spring 2007

Professor Isham

I. Background

In his 2006 State of the Union, President George W. Bush proclaimed, "America is addicted to oil."[1] He again highlighted the importance of renewable fuels and energy independence in his 2007 address. This emphasis by the President of the United States on renewable energy and energy independence has placed these issues at the forefront of economic, social, and political agendas. As the United States and the rest of the world look more and more towards reducing dependence on non-renewable resources for their energy, biofuels have become much more prominent. In addition, the world has begun to worry more about global warming, and lowering greenhouse gas emissions. Biofuels, like grass, effectively lower carbon footprints, while often localizing energy economies.

Grass has been used in different forms as biomass for hundreds of years. Farmers in the Midwest once utilized grass for heating as a cheap and readily available option. Many different types of biomass have been tested, while pelleting for fuel began as recently as the 1970s.[2] Although there exists no large-scale production of grass pellets in the United States it has been done in Europe and Canada successfully. With 1.1 billion acres of farmland in North America[3], a shift towards using crops for biomass seems appropriate. The best place for grass pellets is where production costs for hay are low and heating costs are high, like New England.[4] Unlike many other biomass alternatives, grass does not have a political lobby[5] and therefore does not appear in front of our country's decision makers. In order for grass to become a viable option

---

1 Bush, George W. ,"*State of the Union 2006,*" The White House, <http://www.whitehouse.gov/news/releases/2006/01/20060131-10.html> 31 January 2006.
2 "Frequently Asked Questions," Grassbioenergy.org, 2006, <http://www.grassbioenergy.org> (30 April 2007).
3 Samson, R., et al., "Grass Biofuel Pellets: An Ecological Response to North America's Energy Concerns," Renewable Energy Action Project, < http://www.reapcoalition.org/> (30 April 2007).
4 Samson,R. et al.
5 Grassbioenergy.org.

forces both local and national need to come together to push for more diversified energy resources in the biomass sector.

II. Introduction

Our group was presented with the task to perform an economic analysis of growing grass crops in Addison County for use in biofuels. Farmers would sell this grass to some type of pelletizer, which would then distribute the pellets for biomass use. We focused primarily on the role farmers would have in grass pellet production and how grass could benefit them as a crop. We investigated the use of marginal land and how grass for biomass could assist farmers by augmenting their income. In order to discover the viability of this proposal our group began with an investigation of the historical use of biomass, and of grass pellets in that field. We then focused on three different types of grass and compared their benefits and drawbacks for production in the county. Then, we investigated the operation costs of producing grass including energy inputs and transportation. A large portion of our examination relied on GIS analysis of available land and a network analysis. Compiling this raw data we came up with a cost/benefit analysis of each of the different types of grass for energy pellet production. Another part of our assessment was working with local farmers and utilizing their reactions to adding grass production to their farms. Our group also investigated the existing subsidies for other crops to determine what kind of market competition grass would see, and what would have to change in order to make biomass grass feasible in the market. Also factored into our project were the social and ecological benefits of building a local energy economy. We concluded that with the current state of subsidies and production costs, grass on its own would not be a viable solution for use as biomass.

III. Grass Species for Pelleting in Vermont

It is clear from biomass literature that Miscanthus, Switchgrass and Reeds Canarygrass, all display significant advantage over many other agricultural biomass options. These species have been selected as ideal energy crops in different locations because they have an indeterminate growth habit, a perennial life cycle, and a rhizome system These traits all lead to positive ecological and economic characteristics.

Ecological Characteristics

- Efficient solar capture
- Long Canopy Duration
- Winter standing
- Non-invasive
- Clean Burning

Cost Related Characteristics

- Low Input
- Efficient Water use
- No Pest/Disease Problems
- Nutrient Recycling
- Use existing equipment

Switchgrass (Panicum virgatum) is the grass variety that the US Department of Energy has selected as its herbaceous biomass feedstock model for energy production. It was selected for its hardiness against poor soil and climate conditions, rapid growth and low fertilization requirements. It uses C4 photosynthesis which is the most efficient photosynthesis because it traps CO_2 in the photosynthetic cells so that there is a higher concentration of CO_2 and thus a higher rate of photosynthesis. In one season it can grow up to between 1.8-2.2 meters in height and produce between 6-8 t/acre of biomass.

The main concern with Switchgrass is its cold tolerance. The yield quoted in this study is from northern ecotypes that already produce significantly less then their southern counterparts. A study in Pennsylvania discovered that switchgrass yields decrease by 40% 2.8-1.76 t/acre during winters with above average snowfall. Also although conventional farm machinery can be used for harvest, about 21% of the harvest is left in the field by the baler.

Reed canary grass (Phalaris arundinacea) is cheaper, quicker, more adaptable and more reliable to establish than Switchgrass. It requires very little management and can be grown in soils of pH between 4.9 and 8.2. It produces best in poorly drained soils and is adapted to northern climates. It is a C3 photosynthesis perennial grass found throughout most of the world. C3 plants do not grow as fast as C4 grasses in the hottest conditions. It grows between 0.6 and 1.8 meters in a single growing season but produces only 2-4 t/ha of biomass.

Although most well suited for Vermont's climate Reed Canary Grass has some serious drawbacks in terms of its invasiveness and nutrient use. Nine US states list it as an invasive species. Certain strands are native to North America but the European strands that have been planted as forage crops are more aggressive and in some places have replaced almost all native grass species. Its rhizomal and seed propogation spreads quickly which is good during the first few years of growing but can be difficult to control its spread to other regions in an open prairie.

There are some problems with Reed canary grass in later years due to nitrogen deficiency in the soil, which would necessitate fertilizer and increased costs. In Vermont C3 photosynthesis may actually be an advantage because requires less enzymes and is thus able to photosynthesize at colder temperatures than a C4 grass.

Miscanthus (Miscanthus x giganteus) is the most reliable producer once it is established. It is a sterile hybrid perennial grass that uses C4 photosynthesis. It is ideal for energy production because it drops its leaves during the winter, leaving a tall dry stalk to be harvested in the spring. No drying is necessary and the energy production per ton is greater than any other of the grasses considered in this study. Once it has been established for over two years it can grow 3.5 meters in one season and produces 10-12 t/acre of biomass.

The problems with Miscanthus are its high planting costs and vulnerability to frost. The initial costs of planting are high because as a hybrid it does not self propogate from seeds. So it has to be planted using rhizomes taken from existing growths. Each rhizome, which can be as small as a four inch cutting of a root from an existing plant, must be planted more carefully than seeds. This also means that Miscanthus will not self-propogate like Reed Canary Grass or Switchgrass. Sugar cane and potato harvesters and potato planters can be used to plant the grass, but these are not common in Addison County, so planting costs will be even higher.

Another serious drawback of current Miscanthus varieties is their susceptibility to frost. The hybrid Miscanthus variety currently used as an energy crop originated in Japan as a cross between species that are native to subtropical and tropical regions of Africa and Asia. In central Europe, where Miscanthus is already being used as an energy crop, it is necessary to cover the fields with a bed of straw to protect the rhizomes underground from freezing. In Vermont the temperature is colder than central Europe and the main US studies in Illinois and Iowa that have successfully grown Miscanthus. So Miscanthus needs to be studied for Vermont soil and climate conditions to determine whether or not the rhizomal root system will survive a Vermont winter. European studies also had significantly lower yields 3.2-6 t/ha of biomass produced.

Grass Species	Dry Matter Yield (tons/acre/year)	Harvests per year	Seed/Fertilizer/pesticide cost ($/acre)	Planting and establishing cost ($/acre)	Harvesting (mowing and raking) $/acre	Baling and loading ($/acre)	Average 10-year Operation cost ($/acre/ year)
Miscanthus[6]	10	1	$393.00	$240.00	$18.00	$282.50	$324.50
Switchgrass[7]	6	2	$80.00	$220.00	$18.00	$169.50	$235.50
Reed Canary Grass[8]	2	2	$10.00	$220.00	$18.00	$56.50	$115.50

Miscanthus Total Production Cost = $36.38 per ton

Switchgrass Total Production Cost = $39.25 per ton

Reed Canary Grass Total Production Cost = $57.75 per ton

This table shows the different costs for grass production in Addison County. Many of the numbers represent an estimate based on previous studies performed in other regions of the country in combination with data from Addison County agricultural officials. Some serious assumptions have been made. We assume no land cost since the land used would be marginal land as described in our GIS study. The yields we used in the table are not for marginal land. We

---

[6] Heaton, Emily. Miscanthus for Renewable Energy Generation: European Union Experience and Projections for Illinois. University of Illinois. 16-10-2003
[7] Duffy, Mike. Costs of Producing Switchgrass for Biomass in Southern Iowa. Iowa State University. April 2001 http://www.hort.purdue.edu/newcrop/ncnu02/v5-267.html
[8] DTI. A trial of Suitability of Switchgrass and Reed Canary Grass as Biofuel Crops under UK Conditions. 8/2006 http://www.dti.gov.uk/files/file34815.pdf

also have not accounted for that fact that the first two years of Miscanthus and Switchgrass are not harvested or discounted the planting cost for the 10 year period. We have also not taken into account the rates of establishment that would mean more planting costs would be incurred.

The point of this table is to determine if, even with these idealized assumptions, whether the costs of these grass varieties make them too expensive to be considered as viable alternatives to other types of biomass already available. The following net present value estimate for Miscanthus shows that, even with assumptions that undoubtedly lower the cost of production, these planting these grasses is not a good option for farmers given the current market prices for biomass and lack of subsidies for the farmers that grow them.

NPV for Miscanthus Grass

Discount rate	**3%**	**8%**							
Market Price/ton	60								
Year	1	2	3	4	5	6	7	8	9
Material Costs	$393	$24	$9	$9	$9	$9	$9	$9	$9
Operation Cost	$240	$73	$369	$369	$369	$369	$369	$369	$369
Revenue	$0	$0	$600	$600	$600	$600	$600	$600	$600
Profit	-$633	-$97	$222	$222	$222	$222	$222	$222	$222
PV 3%	-$633	-$94	$209	$203	$197	$191	$186	$181	$175
NPV 3%			-$518	-$315	-$118	$74	$260	$440	$615
PV 8%	-$633.00	-$90.00	$190.33	$176.23	$163.18	$151.09	$139.90	$129.53	$119.94
NPV 8%			-$532.67	-$356.44	-$193.26	-$42.17	$97.72	$227.26	$347.20

Assumptions:

- Discount Rate of 3% based on Net National Welfare.

- Market Price based on cost of waste fibers which is greater than the $30 per ton cost for wood chips, and much less than the $150/ton that hay is sold for.

- Overhead costs of land or machinery are not included. This is consistent with our study that is focused on marginal land and assumes farmers would grow grass in addition to the other crops they already produce.

- Additional costs related to problems with establishment and/or losses of crops due to frost are not included.

- Costs for harvesting based on VT custom harvesters and does not include transport costs.

- Planting costs and operation labor cost based on study in Illinois.

Even with these assumptions 6 years is needed for a positive NPV. Although this analysis is presented for ten years, it is unlikely that a farmer would grow Miscanthus continuously for 9 years. Unless a very supportive market existed, Miscanthus would likely be rotated in with other commodity crops every 5 or 6 years.

V. GIS Calculation of Marginal Land

The analysis to identify the marginal agricultural lands in Addison County was conducted using ArcGIS 9.2. Lands were selected based on Current Use classification, and state determined Agriculturally Important soils, which also included criteria for slope, hydrography and bedrock.

The Following GIS Layers were used in this Analysis:

Information	Data Layer Name	Source
Land Cover	CU_ Addison.shp	Current Use Database, Middlebury College
County Boundaries	Boundary.region.counties	Middlebury College
Agicultural Soils	SO_AG01.shp	Vermont Center for Geographic Resources (VCGI.org)

There were several difficulties with identifying “marginal agricultural lands” in Addison County. In past studies of biomass resources, such as the Middlebury College Biomass Fuel Assessment the Vermont/New Hampshire Land Classification 7 (VTNHLC7) data has been used as the primary identifier for potential biomass lands. This data was not used for two reasons. The first the land classifications in the VTNHLC7 file do not define “marginal agricultural” lands. Additionally, the resolution of the VTNHLC7 is 26.7 meters, or one cell is approximately 1/5 of an acre, which is too coarse.

Rather than using remotely sensed land cover data, we collected land use data from the Current Use database. The current use database holds records all of the parcels within specific towns that have allocated any or all of the land to either forest or agriculture. Because it is in the tax payers’ significant interest to report how much agricultural land they have, the database is assumed to be complete. The second advantage to the current use database is that it identifies the locations and owners of each of the parcels, which would be very valuable for data correction and contacts were the project to advance further.

While the Current Use database was accessible, data was stored for each town. Significant work was done to incorporate all of the towns into one master database for Addison County. Once the data was assembled into one file, all Current Use Parcels that did not contain Agricultural land were removed from consideration.

In order to identify “marginal” agricultural areas, the remaining Current Use parcels were clipped by the Vermont State Agricultural Soils layer (SOAG). The SOAG layer included soils that had been classified as Prime, Statewide, and Local. These soils have been chosen to have “the best combination of physical and chemical characteristics for producing food, feed fiber, forage, and oilseed crops." In addition, "If the upper slope class limit of the soil map unit is between 9 and 15 percent then the areas of the soil map unit that exceed 8 percent slope don't qualify." The classification of the soils also excludes land use that urban, built-up and water. Tract size, location and accessibility were not included in the determination of Ag soils. Soil wetness characteristics were also taken into consideration for exclusion from Agricultural Soil classification. A final exclusion of soils was performed to remove bedrock areas that "are extensive enough to prohibit efficient farming." [9] Because the SOAG layer took into account slope, wetness and bedrock, there was no need for further limitations of the data.

Once the SOAG areas had been removed from each of the parcels area was recalculated. Since many of the parcels were not entirely Agricultural, this area represented both "marginal agricultural" lands in addition to other land types. To simplify these results to just agricultural lands, the area of all non-agricultural lands were identified for each from the Current Use database, and these were subtracted from the area calculation.

Basic validation of the data was performed using 1 meter color NAIP aerial photos of Addison County. The results seemed to encapsulate areas of marginal lands relatively well. In addition estimations of non-agricultural lands were also identified and were concurrent with the Current Use database.   As a final step for network analysis, the marginal lands data were converted from a polygon shapefile into a point shapefile for Network Analysis.

Our study based on GIS data showed that there was over 20,000 acres of marginal land in Addison County but according to FSA representatives we spoke with probably only 5,000 acres is actually unused. The following table is produced according to these two different estimates and the three different grass species. Jock Gill, of Biomass Commodities Corporation estimates

---

[9] VCGI.org GeologicSoils_SOAG.
http://www.vcgi.org/metadata/GeologicSoils_SOAG.htm

that he would use 100,000 tons of dry biomass in pellet production per year if he is able to build a pelletizer in Addison County. The wide range of production possibilities makes it hard to estimate whether this demand could be met with the marginal land no available without taking land that is currently used to produce food crops.

Table of Potential Crop Yields based on Marginal Land Assessment

Grass Type	Yield/acre	Total Yield on 5,000* acres of marginal land	Total Yield on 20,000 acres marginal land
Miscanthus	10	50,000	200,000
Switchgrass	6	30,000	120,000
Reed Canary Grass	2	10,000	40,000
*FSA estimate, GIS estimate.			

VI. Network Analysis

ArcGIS Network Analyst v. 9.2 was used in conjunction with data on trucking costs to arrive at estimates of the cost of transporting grass pellets from individual owner's plots of marginal land to a central pellitizer facility. The location of the central pellitizer was determined by calculating the mean center of all of the marginal lands as determined in the preceding section, weighted by total acreage. The travel times and distances to this center from the marginal land plots were calculated in Network Analyst by assigning all roads in a detailed transportation network maximum speeds based on their classification by the VT Agency of Transportation. The software chose the most efficient route (minimized travel time) from each marginal land location to the central pellitizer. These travel times and distances were combined with data on mpg and per hour independent contractor costs per hour to arrive at estimates of total transport costs for Addison County. This is the "individual owner" model.

Transportation costs were also modeled assuming that groups of farmers got together and arranged for transport of their collective harvests from a "collection point" central to their plots. This reduces costs considerably. A network of collection points was digitized, guided by proximity to suitable roads and aerial photography, and then each point was buffered out to 2.5 miles. Farmers within this 2.5 mile radius were assumed to operate together as a cooperative, take all their bales to the collection point, and have a contractor truck these bales from the collection point to the central pellitizer. This is the “group collection points” model.

GIS Analysis of Marginal Lands

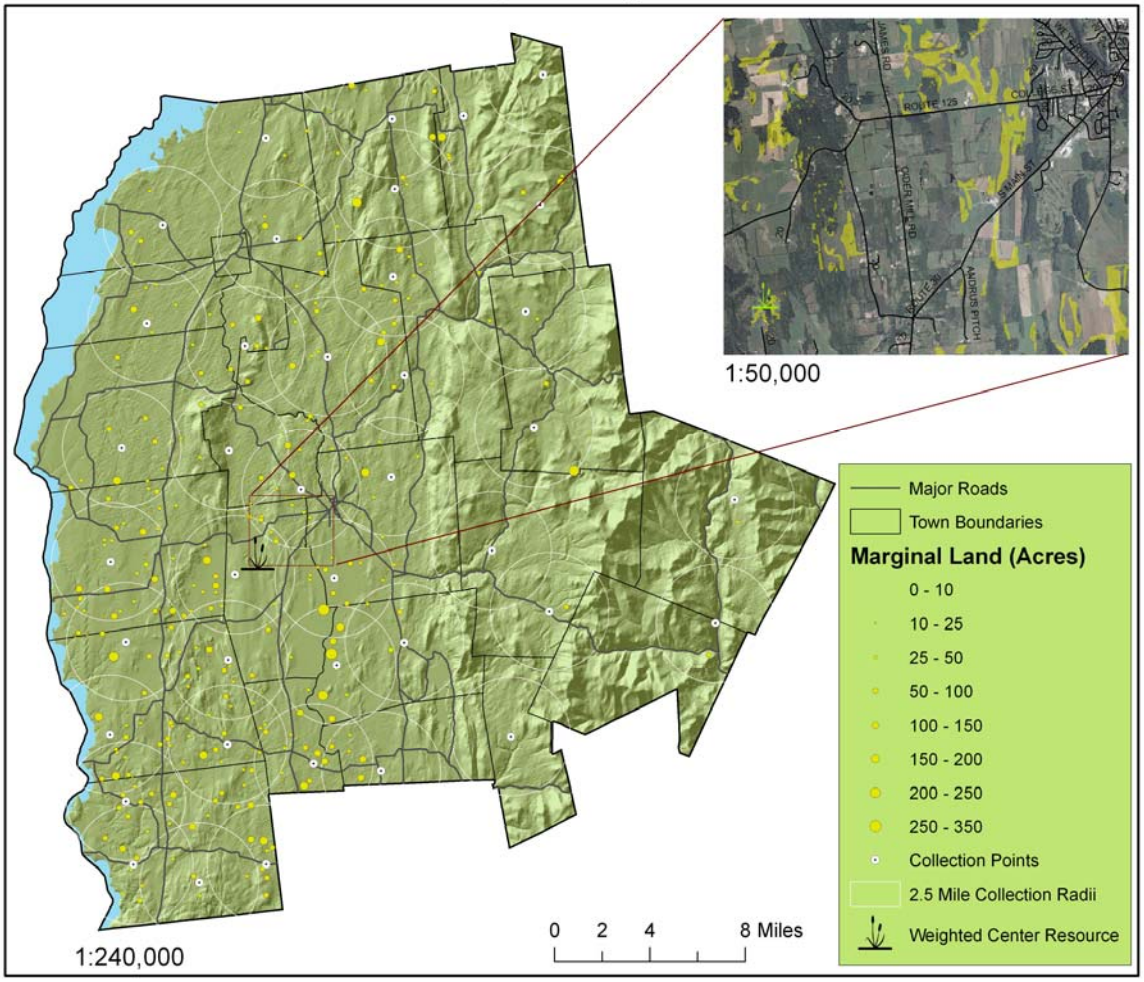

Table of Transportation Costs using and Individual Owner Method as well as a Group Collection Model.

Individual Owner Model			Trucking Costs/year				
Harvests/year	Travel Time/Year (hours)	Travel Distance/Year (miles)	Gallons of gas/year	Fuel cost (dollars/year)	On-Season ($75/hr)	Off-Season (65$/hr)	Total Transport Cost ($/ton) (20,000 marginal acres)
1	475	16700	1113	3173	35625	30875	0.19
2	950	33400	2227	6346	71250	61750	0.65
3	1425	50100	3340	9519	106875	92625	1.94
Notes: fuel cost of 2.85/gal. assumed, from vermontgasprices.com Assumes trucks get 15 mpg.							
Assumes all trucks can carry at least .5 ton of grass. Model assumes only 1 trip per parcel.							
Group Collection Points Model			Trucking Costs/year				
Harvests/year	Travel Time/Year (hours)	Travel Distance/Year (miles)	Gallons of gas/year	Fuel cost (dollars/year)	On-Season ($75/hr)	Off-Season (65$/hr)	Total Transport Cost ($/ton) (20,000 marginal acres)
1	18	637	64	182	1328	1151	0.01
2	35	1274	127	363	2655	2301	0.03
3	53	1911	191	545	3983	3452	0.11
Notes: Model assumes fuel cost of 2.85/gallon, trucks get 10 mpg, 1 trip/parcel.							
Assumes all trucks can handle a 5 ton payload. Each collection point services a 2.5 mile radius.							

The transportation analysis shows that the Group Collection Points model is definitely more efficient than the individual owner model. With these cost estimates it seems that transportation to a centrally located pelletizer would not significantly increase the price per ton of grass biomass. However, this model assumes coordinated cooperation between farmers and the transaction costs of this cooperation are not included in the estimate. This model also uses present day fuel costs that could fluctuate significantly in the future.

VII. Hay, Corn, and Soybean Cost of Production: Opportunity Cost

In the last 20 years farming has changed dramatically. Family farms are very much a phenomenon of the past. Large scale, technology-dependent, industrial farms are taking the place of small, local family farms because of growing societal and economic pressures. Vermont is one of the last agricultural states with mostly small-scale farms. There are 6,571 farms in Vermont, averaging 189 acres per farm[10]. However, it is getting increasingly difficult for these farms to compete on a statewide and national level. Of the 676 farms in Addison County alone, 292 are operating with net losses of an average of $17,090 per farm. Most of the hardships faced by Vermont farmers are due to the rising price of energy, and the subsequent rise in demand for ethanol.

Vermont's leading commodity for cash receipts in 2005 was dairy products, with a total value of $419,840 thousand dollars[11]. Hay was fourth on the list, (after cattle and greenhouse nursery,) with a value of $13,103 thousand dollars. Corn was ranked seventh, and soybeans were not listed in the top thirteen. The Dairy industry, that Vermont is so heavily dependent on, however, is difficult and unreliable. Because the government controls the price of milk, dairy

---

[10] United States Department of Agriculture, "2002 Census of Agriculture County Profile, Addison, Vermont." Nass.usda.gov/census/census02/volume1/VT/index2.htm
[11] Economic Research Service, USDA, August 1, 2006.

farmers do not actually know the price they are receiving until weeks after their product is shipped. Thus, Vermont farmers are increasingly turning toward growing soybeans and corn as a guaranteed source of revenue, with real returns. Furthermore, the market for hay is heavily reliant on the dairy industry, which is one of the largest consumers of hay.[12] These issues affect the hay farmer's marginal profit: the market price of hay, based upon dairies ability to pay, and the production cost of hay. This is relevant to the opportunity cost of selling dry hay to dairies, low quality hay for bedding, as well as hay for biomass. The growing profitability of corn and soybeans must also be factored into the opportunity cost of growing hay.

According to the USDA 2002 Census of Agriculture for Addison County, the majority of land, 80,608 acres, is used to produce hay. However, this is not indicative of the profitability of growing hay. A comparison of yield per acre shows that corn is the highest yield crop, growing at 104 bushels to the acre. It must be noted that yield is dependent on a number of uncontrollable factors, such as soil, fertilizers, and weather, as well as other variables that can be related to climate change.

Addison County					
	Corn (for silage)	Corn (For grain)	Soybean	Hay	Milk & Dairy Products
Acres Used	24,330	1,270	920	80,608	32,797 cows
Harvested	364,777 (tons)	153,559 (bu)	27,039 (bu)	257,010 (Dry tons)	

The market price received for corn and soybeans fluctuates daily. The current price of corn is $3.87 per bushel; soybeans are going for $6.65 per bushel[13]. Though this makes

[12] Kate Campbell, "Alfalfa growers aren't making Hay this year." Oct 18, 2006. California Farm Bureau Federation. http://www.cfbf.com/agalert/AgAlertStory.cfm?ID=692&ck

[13] The price of corn and soybeans are posted daily on agweb.com which also projects the future rise and fall of crop prices.

soybeans much more attractive, it must be weighed against yield and total cost of production.

The following table provides costs associated with the production of corn, soybeans and alfalfa hay.

Farm Costs (by commodity)			
	Corn[14]	Soybean[15]	Alfalfa[16]
Yield	104 (bu/acre)	43 (bu/acre)	3.1 (tons/acre)
Production Costs ($/bu)	1.38	3.44	1.7 (71 $/ton)
Market Price ($)	3.87 ($/bu)	6.65 ($/bu)	147.5 ($/ton)
Operation Costs ($/acre)	148	90	80-90
• Fertilizer ($/acre)	41.43	13.31	50
• Fuel, lube, & electricity	20.82	7.15	
• Seed ($/acre)	84	47	65 (10 year amortization)
• Harvest ($/acre)	31.81	22.63	104

[14] Corn data is taken from the 2001 USDA report on production costs. The figures are production costs for the Northern Crescent, but are not specific to Vermont. Linda Foreman. "Characteristics and Production Costs of U.S. Corn Farms." Aug. 2001. www.ers.usda.gov/publications/sb974-1/sb974-1.pdf.

[15] Linda Foreman & Janet Livezey. "Characteristics and production Costs of U.S. Soybean Farms." March 2002. www.ers.usda.gov

[16] Data for production costs of alfala is taken from the production costs of Alden Harwood, a farmer in Addison County. Harwood used to be a dairy farmer, but now has 500 acres of hay that he produces almost organically and sells mostly for horse feed. Some of the figures are dated, but those associated with operation costs are represented of his current costs.

Government Payments	3,368	5,762	0
Taxes and Insurance (per acre)	19.71	20.01	20
Total cost ($/acre)	175	216	240

Corn is the most profitable crop for farmers because it has the highest yield per acre. High yield keeps corn a profitable crop, despite high operation costs. Soybeans remain profitable because of high market prices even though there are large total costs and lower yields compared to corn. The relatively high operation costs of $80-90 per acre for alfalfa coupled with low yield of an average 3.1 tons per acre makes growing hay a much more difficult commitment than both corn and soybeans. Farmers who grow hay rely on receiving a reasonable price for their product that covers operation expenses. However, the price of hay varies greatly depending on quality. Low-end hay is sold for $50-60 a ton. High-end hay that is used to feed cattle can be sold for as high as $180 a ton.

Hay production is largely controlled by climate. In a good year, some fields can produce up to 6 tons of hay per acre. On the other hand, some years it is difficult to get second and third cuts off, which can be devastating as the later cuts are more profitable. The quality of hay also depends on how well it is bailed, which is also subject to weather. Hay must be dried in the fields after it is cut, before being raked and baled. If it rains while the hay is on the field, not only is production set back, but the hay also risks getting moldy, which lowers the price farmers receive.

Farmers incur high production costs to circumvent some of these uncontrollable problems. Fertilizer, for example, is one of highest costs of production, regardless of what crop is being produced. Often times farmers reuse fertilizers and manure left over from previous crop rotations. This works in a corn to soybean rotation, as soybeans require less fertilizer. Chemicals to prevent mold from growing on baled hay is another relatively large cost. The cost to bale 800 pounds of hay is $13.50, which includes $3-4 of acid for preservation. Six to eight pounds of acid are used per ton of hay. The amount spent on acid, and the amount required depends on the moisture content of the hay, and thus the weather.[17]

Harvesting is by far the most costly operation involved in producing hay. This is because several different pieces of machinery are necessary to cut, rake and bale. The cost of running large equipment over the same field several times is exacerbated by ever increasing energy costs. A large 400-horse power tractor uses 20 gallons of fuel an hour.[18] The cost of seeding down is one of the higher costs incurred by cash crop farmers. A benefit of hay is the 10-year amortization of seeding down.[19] However, this makes growing hay a long time field commitment.

Most farmers grow more than one crop. In order for farmers to receive government benefits (not necessarily subsidies) they are required to rotate their fields every so often. Soybean and corn farmers often overlap because it is profitable to rotate fields between these two crops. Hay is a crop that is grown on most farms, for either crop rotation reasons, or self-sufficiency reasons. Dairy farms often grow hay to feed their cows. The following table provides the percentage of corn and soybean farms growing other crops.

Crop Overlap[20]		
	% Corn farms	% Soybean farms
Dairy:	47	29

[17] Farm of Art Hustess, 2 May 2007.
[18] Marzalkowski, Rick, Adam's Farm, 2 May 2007.
[19] Marzalkowski, Rick.
[20] Linda Foreman.

Corn:	--	57
Soybeans:	36	-
Hay:	78	--

There are large opportunity costs associated with growing hay, as measured by the foregone profits of corn and soybeans, the time spent by farmers, and the total costs of production. Because of large production expenses, it is not economically beneficial for farmers to sell their hay for under $80-90 a ton. If they cannot find a buyer at their asking price, farmers benefit more from storing their chemically preserved hay and waiting for a better offer than from selling it below their costs of production. It is also more economical for farmers to use their hay on their own farm than go under their price. Dairy farms always have a need for hay, which is too valuable on their own farm than would be worth selling for a low price. Furthermore, farmers dedicate the same, if not more energy producing hay, which could be better allocated to growing cash crops, which would have higher pay offs.

Opportunity Cost ($/acre)		
	Corn	Soybean
Hay:	240/175	240/216
	1.37	1.11

The above table provides an estimated opportunity cost of the total costs associated with growing hay as compared to growing corn and soybeans. Though these are simply estimated values, it gives incite into the forgone benefits of growing hay instead of corn or soybeans.

VIII. Visiting Addison County Farms: A Qualitative Assessment

In order to look beyond the numbers of cost-benefit analysis, we wanted to hear the opinions of farmers in Addison County who could potentially use their marginal lands to produce grass. As community partner Harvey Smith pointed out, farmers will grow just about anything on their land if the price is right. Therefore, we thought feedback from the very people whom our project could benefit was important. We also wanted to speak to Addison County agricultural officials who know the daily fluctuations in the prices of commodities such as corn, soy, hay, and dairy.

Along with our community partners Harvey Smith and Jeff Owen, we met with Jim Bushey, a leader in farm planning and management in central Vermont, and Craig Miner, the Addison County Executive Director at the Farm Service Agency (a branch of the USDA). During this meeting, Bushey, Miner and Smith explained to us the complexity of the federal agricultural subsidy laws. For instance, the price of corn had doubled in the last few years meaning that Addison County farmers would not be receiving direct subsidies for corn this year or for the next two to three years, perhaps. In other words, the opportunity costs of growing grass for biomass pellets are currently higher than normal. We also asked them about the current market for hay and grasses. According to Bushey, farmers who grow hay can receive anywhere from $100 to $150 for a ton of feed hay. That is roughly twice the $60 per ton that farmers could receive from a local biomass pelletizing plant. For farmers who grow hay, it is much more sensible to produce feed hay (feed hay is a higher quality grass than grass for energy).

While at the Farm Service Agency we also spoke with Jesse Hotte, co-owner of Addison Custom Harvesting. He is hired throughout the summer and fall to harvest crops for Addison County farmers, including cutting, raking, and baling hay. He provided us with the rates he charges for various aspects of his operation, which we include in this report's assessment of trucking, baling, and harvesting costs.

After our meeting at the Farm Service Agency, Harvey Smith and Jim Bushey accompanied us to three different farms in the county. The first farm we visited was the Adams

Farm, run by Rick Marszalkowski. Marszalkowski grows primarily corn and soy. He is adamantly against growing hay for energy on any of his land because of the low price he would receive for it. The prices he receives for corn and soy are too high for him to consider growing miscanthus, reed canary, or switchgrass. Marszalkowski believes that the best source of biomass grass could be from second home farmers or retirees who move into Vermont to enjoy a pastoral lifestyle. These people, according to Marszalkowski, do not have to heed the costs as much as a full time farmer like him and could probably produce a substantial amount of grass.

Next, we visited a dairy operation, the Blue Spruce Farm in Bridport. We spoke to Eugene Audet, one of the co-owners of the farm. Blue Spruce grows most of its own feed, and, according to Audet, does not have the space nor incentive to grow energy grass rather than feed hay. He also mentioned the low price of a ton of energy grass would receive and reiterated that he needs to focus production costs on growing the best feed hay possible, not on grass for biomass pellets.

Finally, we visited the Huestes Farm, run by Art Huestes. Huestes runs a primarily dairy operation but also grows feed hay and sells it to local farmers. In step with Marszalkowksi and Audet, Huestes said the price he receives for his current crop, good feed hay ($180/ton), is simply much more than he could receive for energy hay. Further, when asked about the amount of underutilized marginal lands in the county (on which energy grass could be grown), Huestes shook his head. According to him, there simply is not much if any “underutilized” land in the county; farmers are not going to let land sit idly.

IX. Subsidies and a Focus on Ethanol

In addition to the opportunity costs of growing grass for biofuels as opposed to corn or soybeans in Addison County is the presence of heavy subsidies on these crops. As pointed out in the previous section in Vermont the two main crops creating economic barriers against grass are corn and soybeans. In the United States and throughout the world there exists a large movement against farm subsidies. Many people believe that they are a cause of overproduction of certain crops and that they discriminate against small farms by favoring large agribusinesses.[21] Since 1996 there has been a long-term decline in US crop prices, which have lead to increasing subsidies over the years.[22] However, recently because of an increased emphasis on biofuels prices of corn and soybeans have skyrocketed. One issue when trying to attach market ideas to farming is that it involves a large number of fixed costs, which leads farmers to not follow market prices as much when determining how much to grow.[23] Farmers usually do not take land out of production due to low demand.

Subsidies to corn and soybeans involve many complicated components and not simply direct support. The main components of the subsidies proposed for the 2007 Farm Bill are direct payments, marketing assistance loans, revenue-based counter cyclical payments, and conservation-based direct payments. Marketing assistance loans allow farmers to store crops and pledge them as collateral for loans. This allows farmers to store their crops in order to receive a better market price for it. Direct payments are what people usually think of when they think of subsidies. Since 1996 farm policy has triggered these payments once the price of a crop falls

[21] Beitel, Karl, "US Farm Subsidies and the Farm Economy: Myths, Realities, Alternatives," Food First: Institute For Food and Development Policy, Summer/Fall 2005, <http://www.foodfirst.org/backgrounders/subsidies> (12 April 2007).
[22] Beitel, Karl.
[23] Beitel, Karl.

below a certain point.[24] However, the proposal in the 2007 Farm Bill ties direct payments to historical fixed acreages and yields to avoid incentives for changing crop production to benefit from subsidies more.[25] The USDA calculates direct payments by multiplying 85% of a farm's base acreage by a farm's direct payment yield and by the direct payment yield.[26] A revenue-based counter-cyclical payment comes into effect when revenues of farmers fall below a certain level. Conservation Direct Payment Rates are the same as direct payments except that farmers receive a better direct payment level for incorporating sustainable farming techniques into their crop production.[27] The following table shows the rates for different types of subsidies.[28]

Marketing Assistance Loans:				
Crop	Current	Average of Proposed Loan Rates over 2008-10012	Proposed Maximum	
Corn ($/bu)	1.95	1.89	1.89	
Soybeans ($/bu)	5.00	4.92	4.92	
Direct Payments:				
Crop	Current Law 2007	USDA Proposal 2008-2009 and 2013-2017	USDA Proposal 2010-2012	
Corn ($/bu)	0.28	0.28	0.30	
Soybeans ($/bu)	0.44	0.47	0.50	
Conservation Direct Payment Rates:				
Crop	Proposed Direct Payment Rate 2008-2009	Conservation Enhanced Payment Rate 2008-2009 2013-2017	Proposed Direct Payment Rate 2010-2012	Conservation Enhanced Payment Rate 2010-2012

---

24 Beitel, Karl.
25 "Title I: Commodity Programs," USDA: 2007 Farm Bill Proposals, 31 January 2007, <http://www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1UH?contentidonly=true&contentid=2007_Farm_Bill_Title1.xml> 13 April 2007.
26 "Title I: Commodity Programs."
27 "Title I: Commodity Programs."
28 "Title I: Commodity Programs."

	2013-2017			
Corn ($/bu)	0.25	0.28	0.26	0.29
Soybeans ($/bu)	0.47	0.52	0.50	0.55
Source: USDA Farm Bill 2007 Proposal				

In addition to regular crop subsidies the recent push for ethanol, via the Energy Policy Act of 2005, has propped up the United States' corn market even more. There is a federal $.51/gallon excise tax for meeting the renewable fuels standard that goes to refiners. In addition there exists a $.54/gallon tariff on imported ethanol to keep prices low in the United States. In 2006 14.3% of the United States corn crop went to ethanol production. If 100% of corn went to ethanol the United State's gas consumption would only drop 12%.[29] Corn ethanol costs $2.53/gallon to produce.[30] Ethanol subsides account for $1.05-1.38/gallon of the cost of gasoline while gas subsidies account for only .3 cents per gallon.[31] Also, in the United States there is a monopolization of the ethanol market. Eight companies produce over 90% of ethanol.[32]

Many of these subsidies are renewed and built upon in the 2007 Farm Bill. However, currently with the emphasis on corn and soy for biofuels the market prices of these crops are such that many of the subsidies do not come into effect. But, prices cannot be guaranteed in the future; therefore subsidies must still be accounted for. Without a major shift in subsidies and

[29] Taylor, Jerry and Peter Van Doren, "Ethanol Makes Gasoline Costlier, Dirtier," Cato Institute, 29 January 2007, <http://www.cato.org/pub_display.php?pub_id=7308> (2 May 2007).
[30] Taylor, Jerry and Peter Van Doren.
[31] Taylor, Jerry and Peter Van Doren.
[32] Koplow, Doug, "Biofuels, At What Cost?" October 2006.

production, or an inclusion of grasses used for biofuels into subsidies, the future of growing grass profitably for biofuels seems unlikely.

Despite the high opportunity costs of corn and soybeans and their attachment to subsidies, there exist other concerns relating to the production of these crops. Corn and soybeans grown at large quantities for things such as biofuels often are not farmed sustainably. Corn and soybeans are the top two users of pesticides in the United States.[33] The use of pesticides has serious ecological repercussions, especially tied to run-off and the pollution of water. Also, the issue of biogenetics is tied to corn and soybeans. Soybeans have the highest crop coverage for biotech crops.[34] Although not water intensive in Vermont (only 4% of corn acreage irrigated in Northern Crescent), corn does use 2.2lbs/acre of herbicides (only .1lbs/acre of pesticides)[35]. Agricultural harms like nutrient leaching from soils, and soil erosion also must be factored into the ecological impacts of corn and soybean production.

X. Social and Ecological Benefits

A discussion of grass production in Addison County should highlight the importance of a variety of non-economic areas that would benefit from a local grass economy. Often in cost-benefit analyses researchers do not factor in important social and ecological benefits. Using grass pellets as a source of energy localizes energy production. The benefits of localism include increased communal connections, energy independence, and keeping money in communities. Communal connections are very hard to place an economic value on. However, given an increased flow and velocity of money within the local economy, which is generally thought to increase GDP an estimate is around $2 per ton of grass. Energy independence is just as hard to

[33] "Briefing Room: Soybeans and Oil Crops," USDA: Economic Research Service, 13 March 2007, <http://ers.usda.gov/Briefing/SoybeansOilCrops/> 12 April 2007.
[34] "Briefing Room: Soybeans and Oil Crops."
[35] Koplow, Doug.

value, except many estimates show that the US government's involvement in the Middle East has cost over $20 thousand per household. Some of the ecological benefits of using grass pellets, instead of other biomass options, include reduced carbon emissions, use of renewable energy, soil conservation, and aesthetic land cover. All of these social and ecological benefits should be taken into account for the cost-benefit analysis, even if it is difficult to place a price on them.

XIII. Conclusion

The various aspects of our study, both quantitative and qualitative, lead us to conclude that grass production in Addison County is not economically viable based on the following reasons:

1. The production costs for the three most likely grass species candidates for Vermont are all high and their success in Vermont's climate is uncertain.
2. The amount of marginal land in Addison County is enough to produce the necessary grass for a pellet plant only if we take the high end estimates.
3. The current prices of feed hay make it unrealistic for farmers to consider growing a similar product with lower market value.
4. Farmer's will need to see a profit opportunity to switch to energy crops.
5. The current subsidies for ethanol based on corn and soy make growing grass for energy unprofitable.
6. The social benefits of grass compared to other biomass options are not that great.

Given the present conditions, growing grass for energy use is not a viable supplement to the incomes of local farmers. At this time, farmers are better off focusing on traditional crops such as soy beans and corn, even if future prices of these crops are uncertain. As for biomass pellets, timber and waste fibers, including paper and cardboard waste, are currently the cheapest available option for a pelletizing plant in Addison County.

However, if a biomass pelletizing plant is constructed in Addison County, it could prove to farmers that the market for energy grasses exists. Grass could become a realistic option for farmers in Addison County if research into accurate yields and costs specific to Vermont and Addison County shows lower costs, if biotechnology improves plant tolerance to environmental stress and increase tons per acre, or if baling technology improves and significantly reduces harvesting costs. However, the main factor that could change the economic benefits for farmers in choosing to grow grass as an energy crop is government subsidies. If grass gets a subsidy in the near future, it will not be a surprise to see many doubtful farmers fully embracing grass as the new American product that will help us become energy independent.

One other thing to consider is the ecological costs of widespread use of biomass for energy. Biofuels come from renewable resources like timber and agricultural crops, such as corn, soybeans, and grass. However, there are ecological costs to using these resources for energy production. Vermont and Addison County have a limited supply of timber that can be harvested sustainbly. With multiple end points on the demand side these already stressed resources could suffer more. Agricultural products also have serious ecological repercussions associated with them. High-yield crops often involve irrigation, pesticides, and herbicides. Each of these things can be extremely detrimental to ecosystems. Due to these ecological concerns of biomass and biofuels, complete or a high dependence on these resources for energy should be approached carefully.

Another possible factor that could help grass succeed in Addison County is second-job farmers (people concerned less with earning profit but rather seeking to live a farmer's lifestyle) that could provide enough energy grass to a fuel a biomass pelletizing plant. Full-time farmer Rick Marszalkowski suggested this, believing that second-job farmers would enjoy contributing to Addison County's energy independence while not needing to worry about the ever-changing agricultural market. Whether this is at all a possibility should be studied further. If grass can be grown in this way to supplement timber and waste fibers, there may well be a future for a biomass pelletizing plant in the county, a positive step towards energy independence.