New York State Energy Research and Development Authority

Regional Model to Assess the Incremental Commercial Availability of Biomass Feedstocks for Biofuel and Bioproduct Investors in New York State

Final Report

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Regional Model to Assess the Incremental Commercial Availability of Biomass Feedstocks for Biofuel and Bioproduct Investors in New York State

Final Report

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Executive Summary

The goal of this project was to develop and test a methodology that would generate supply curves for different sources of agricultural and forest based biomass in upstate NY. The supply curves would indicate the amounts of biomass that are potentially available at different price points and provide organizations and individuals interested in developing biomass products for the production of bioenergy, biofuels and/or bioproducts. The methodology built on an existing GIS based assessments of a 25 mile radius supply shed around Syracuse, NY and used tax parcel data on land use and property size to refine the data set and identify specific parcels. This information was then combined with data collected on individual properties by field staff who visited each site and then held a face to face meeting with landowners.

The 25-mile radius supply shed circle in this project included 1,256,639 acres of land. Using the selection criteria adopted for this study (parcels with at least 10 acres of agricultural land, 25 acres of forest land, or both), 7,469 parcels qualified covering 613,499 acres or about 48.8% percent of the land area within the supply shed. This relatively low percentage of qualifying parcels reflects the fact that the study area has the City of Syracuse and its surrounding suburbs at its center. A random sample of 500 parcels was then selected and landowners were contacted and asked to participate in the study. Just fewer than 50 landowners representing 7,888 acres of land accepted the invitation to participate in the study. Following field visits to these properties some land was removed from the overall assessment because it was too swampy or inaccessible to be worked, in the case of forest land, or too poorly drained, overgrown with brush and young trees or inaccessible to be worked in the case of agricultural land. As a result the actual land area analyzed in the study was 6,462 acres. Wooded land was the predominant land use at 48.4% followed by row crops (30.1%), pasture (13.2), idle open land (7.5%) and other uses (0.2%).

Field visits were completed on each of the participating parcels to determine current land use and to estimate biomass production potential from both agricultural land and forests. This information along with aerial photos and soil and topographic maps was complied into a summary report that was provided to landowners. The forage species selector tool developed by Cornell University was used to estimate the yield potential of improved grass hay (production from newly established fields of cool season grasses such as reed canary grass) and unimproved grasses (grass and herbaceous material from existing fields). Corn stover yields were estimated using a formula developed by Iowa State University based on the cut, rake, and bale collection method. For NY conditions we assumed that only 50% of the available stover would be harvested. The soybean straw yield was based on information from Iowa State University and the University of Minnesota, using a rake and bale method, again reducing the estimated harvestable quantity to reflect New York field conditions. Expected willow yields were based on experiments to date in New York State. Where potential corn yields were 140 bushels or more the willow yield potential was assumed to be 5 tons. Where potential corn yields were between 120 and 140 bushels the willow yield potential was assumed to be 4.5 tons. Below 120 bushels the yield potential was estimated at 4 tons. Fields too steep or too wet to be harvested with a large forage harvester (modified to chip willow) were considered ineligible for willow production.

Data was collected from forested sub-parcels using basal area factor (BAF) 10 point samples on a rectangular sampling grid with a randomized start to quantify different variables describing forest stocking and quality, including basal area, species composition, sawtimber volume, pulpwood and biomass volume, and other forest characteristics. Data was input into the United States Forest Service NED-2 software program to generate standard forest stocking variables. Growth and yield functions in the model were used to provide forest management scenarios for each sub-parcel. The types of scenarios for a given sub-parcel were influenced by current forest stocking values. The list of scenarios is as follows: immediate conversion harvest, shelterwood harvest, thinning, and high grading. Current market prices were incorporated into each scenario to provide the landowner an idea of current and future revenues from forest operations.

A face to face meeting was then organized with each of the participating landowners. Information on the biomass production potential of their property was shared with them and information about their interest and willingness to produce and harvest different types of biomass from the sub parcels on their property was discussed. For the open land sub parcels where there was interest in producing biomass, landowners were asked what level of return per acre they wanted from the land and about whether they would produce the biomass themselves of have it produced under a contract agreement by a third party. If the landowner lacked the capacity or interest in producing the biomass with his/her own resources, then a minimum rental price was established and recorded for each sub-parcel. Utilizing production cost models for each type of biomass, it was possible to derive a roadside price for biomass required to meet the per-acre net return on the sub-parcel or sub-parcels in question. In the case of forested blocks, a target payment (equivalent of stumpage) per acre was established for each sub-parcel that the owner was willing to see harvested, including both the value of merchantable timber, as well as chipped pulpwood and slash, for each of the harvesting practices that were both feasible and something that the landowner would consider doing within the next five years. If the value of sawtimber at summer 2008 stumpage values reached the landowner's per acre target, chipped tops and other low grade material were presumed to be available at $5/dry ton. If the target was not met, no wood chips were considered available until the price of chipped low grade trees, tops and slash reached a hypothetical value high enough to meet the landowner's target per-acre income.

Combining data from field assessments and estimates of biomass production potential with the minimum rental price or net return per acre that would be required to elicit production of each type of biomass, it was possible to construct a cost curve estimating the number of tons that would be available at a given price. This data was then scaled up for the entire supply shed based on the random samples that were selected to generate supply curves for each of the sources of biomass studied.

The potential supply of unimproved grass hay in the region is just under 200,000 dry tons per year when cost is not a factor. Unimproved grass hay as an energy crop is restricted by the area now in grass hay within the supply shed, which was just less than 100,000 acres. Small amounts of unimproved grass hay (<50,000 dry tons per year) are available at the lower end of the cost range (about $65/dry ton), but the majority of the supply would come at a cost of over $125/dry ton.

While there is potential for producing improved grass hay for biomass in the region, it is costly. The lowest cost improved grass biomass is available starting at $125/dry ton and up to 150,000 tons could be available at this price. An additional 340,000 tons could be provided at prices between $125 – 200/dry ton. These estimates are based on a one cut system of cool season grasses, so costs per ton could decrease by using higher yielding warm season grasses or a two-cut system (first cutting for energy, second for forage) for cool season grasses.

Limited amounts of willow biomass would be available at under $40/dry ton and about 250,000 tons would be available at about $60/ dry ton. In contrast only very small amounts of unimproved grasses and no improved grasses are available at this price. The curve rises more slowly between $60 and $80/dry ton, reflecting the fact that most landowners indicated that they would want a premium rent to make the long-term commitment required for willow. At just over $100/dry ton about 350,000 dry tons of willow would be available in the region.

The limited amounts of corn stover and soybean straw that might be available make both unlikely sources of biomass for a medium or large-scale biomass facility in this supply shed. About 130,000 dry tons of corn stover and just over 70,000 dry tons of soybean residue are potentially available. These low amounts are dispersed over large areas, which will make it difficult to support efficient harvest and logistic operations.

These are significant amounts of forest biomass (480,000 – 530,000 tons) available from high grading operations and they are affordable at about $15 – 25/dry ton. The least expensive wood chips are those produced as a by-product of high-grade harvesting that is already taking place since the cost of these operations is being borne by the value of the sawtimber being harvested. Smaller quantities of woody biomass (315,000 – 375,000 dry tons) are potentially available from shelterwood harvests in the region. As with high grade cuts the availability of this material is largely driven by the availability of sawtimber from these harvests and the value for sawtimber at the time of the harvest. Due to the stocking levels and characteristics of the forest land assessed, there was not enough area to accurately create a cost curve for thinning operations.

In contrast to the methodology for developing a cost curve for cropped biomass – which was effective enough to be worth replicating with only minor modifications to the methodology, the assessment of forest biomass was more challenging and the results are not as certain. Forests do not have a defined three-year harvest cycle like willow, or an annual cycle like hay, which creates some additional challenges for modeling annual biomass production. As a result the project team did not have the same degree of confidence in the results of the forest biomass analysis. Nevertheless, the prices generated from the models are in the range of prices that are currently being paid for wood chips used for energy in upstate NY. In addition the inclusion of forest land provided a good vehicle for landowner education. Seeing that cost for woody biomass is at the low end of all the feedstock sources and that there is a considerable amount of forest cover in NY, additional work to refine these models would be beneficial so that developers could be more confident in their results.

This study successfully demonstrated that it is possible to merge GIS data, "ground truth" information about the actual productive potential of specific plots of land and forest, and an overlay of information about landowners as economic agents in a way that provides useful information to developers of biomass energy projects. The decision to gather information directly from landowners made this work more expensive, but provided more plausible information than what we might have been able to obtain from a mail survey or series of focus groups. Still, compared to the costs of a site specific wind resource assessment for a potential wind farm, these costs are not particularly high. In addition the information generated will allow a biomass developer to more accurately determine feedstock costs for their facility.

The development of this methodology and biomass production assessment tool has fed directly into another study around Morrisville, NY, with support from the NY Farm Viability Institute. This study is focused exclusively on cropped biomass, producing substantial savings in the area of field analysis of biomass production potential, and a much more straightforward analytic methodology that draws heavily on the lessons learned in this study. The lack of an assessment of forest biomass is a limitation of this second study, but funds were not available to support the refinement of this part of the assessment. The larger sample size in this second study has produced important efficiencies in conducting field work, and a better structure for capturing data is expected to substantially cut the time required to analyze data.

I. Background

While the potential supply of biomass available for bioenergy, biofuels and bioproducts is very large in upstate NY, the amount that can be acquired at affordable prices is not well know because of the limited size of the industry. This uncertainty is a major barrier to new investment in bioenergy, biofuel and bioproduct production in New York State. Work conducted at SUNY ESF, Cornell, and at the Department of Energy and Agriculture using GIS models has demonstrated the *technical availability* of feedstock, both statewide and regionally (C&S Engineers 2006, Castellano et al. 2009). Technically available biomass is the amount of biomass that is currently being produced or could be produced sustainably for long periods of time. Nevertheless, the methodology to date has assumed that a portion of landowners are willing to participate in the biomass supply chain and that the infrastructure is available to produce the biomass in question. Previous studies have based assumptions on such parameters as the number of forest owners who have forest management plans or rural landowner surveys designed for other purposes to estimate what percentage of the technical supply might be commercially available. Even with assumptions for these factors, these estimates have generally not included price points for this technically available biomass.

Entrepreneurs seeking private capital or loan financing for bioenergy, biofuels and bioproduct investments need to ensure that adequate feedstock will be available at a cost relative to the value of the products that will be produced to assure the feasibility of the investment in conversion technology. A satisfactory tool, from the investors' perspective, would generate a supply curve for each usable biomass feedstock potentially obtainable within an affordable hauling distance from the plant site, taking into account various procurement options (e.g. contracting with intermediaries, captive production on factory-owned land, etc.). It would provide this information at a low-enough cost to permit the investors to evaluate alternative plant sites as part of the pre-feasibility analysis, and deliver usable analytic results within several months. The objective of this proposal was to develop the methodology for such a tool, field test it in a selected location not associated with any particular project or investment, and refine it into an instrument that can be readily employed in any region of the state.

The approach selected built on technical assessments of biomass availability already done by SUNY – ESF (e.g. Castellano et al. 2009) using GIS in several areas of the state. The use of GIS methodologies for these types of assessments is fairly well refined and field tested. By building on an available GIS data set with Syracuse, NY as its base, this project focused on developing companion procedures to assess landowner interest in entering into commercial relationships that could lead to incremental regional biomass production – that is, production of biomass feedstock currently not being produced or harvested. The analysis did not focus on biomass already in commercial channels (e.g., residual wood supplies from the saw milling industry, forage hay; corn and oilseeds), since these products already have well-developed markets. The analysis included non-grain biomass sources about which there is sufficient agronomic and production/extraction cost information available for New York State to permit meaningful projections of production potential at various price thresholds. These include mixed unimproved grasses from existing fields, improved grass production from newly established fields of cool season grasses such as reed canary grass, shrub willow, low-value woody biomass from natural forests, and potentially available crop residues from corn and soybeans production.

The output from the development and implementation of this tool was a series of supply curves indicating the amounts of biomass that are potentially available at different prices points. Because production and harvesting logistics are different for each of these sources, separate supply curves were developed for each biomass source. These supply curves capture both the *technical potential* (estimated tons/acre/year of feasible biomass feedstocks) for each feedstock as well as their *commercial potential* (willingness of the landowner to enter into agreements and business arrangements at given price points that would make the biomass actually available to the bioproduct manufacturer).

II. Methodology

General approach

Types of biomass that could feasibly be produced within the study region and about which enough is known to model potential yields and production costs were the focus of this study. These sources included forest wood chips, chipped short-rotation woody biomass (shrub willow), unimproved grasses, selected improved grasses, corn stover, and soybean straw.

A complete list of rural properties considered capable of producing these forms of biomass on a commercial basis were identified with GIS tools, and a stratified random survey of these property parcels was drawn for study purposes. Invitations to participate in the study were mailed to owners of these properties, and all parcels for which a positive landowner response was received were included in the study. Woodlots and fields on these parcels were analyzed through a combination of on the ground field surveys and use of available yield models customized with data on the properties in question to estimate their technical production potential for all of the types of biomass studied. This analysis was followed by a structured, face-to-face interview with the landowner to determine receptivity to a range of biomass production operations and business arrangements. This direct interaction allowed us to assess how landowner opinions and perceptions influenced their willingness to participate in biomass production either as an active investor or a supplier of rented land to another agent. A brief phone survey of a number of non-respondents (owners of properties included in the sample who did not agree to participate in the study) was carried out to determine whether there was any difference in the type of landowner that agreed to participate and all owners of properties included in the same. Data covering property owned by participating landowners was analyzed after making adjustments dictated by the stratified sampling plan (larger properties were over-sampled in proportion to the size distribution of rural land parcels in the study region to ensure they were included). Except as noted, analysis treats acreage, rather than property owners, as the subject of study, with landowner preferences and economic motivations treated as an attribute of the acres that they contribute – or do not contribute – to the potential biomass production land base in the study region.

An advisory board was established early in the development of the project and included individuals from a range of organizations. This group provided valuable feedback during the development of the methodology of the project and models for the cost curves. Their input was particularly important in making decisions on how to structure the output of the cost curves so that it was useable by potential biomass end users in the region. Members of the advisory board included:

Doug Roll, AES, Inc.
Art Brooks, Brooks Forestry
Jim Olcott, Constellation Energy
Nathan Rudgers, Farm Credit of Western New York
Matt McArdle, Mesa Reduction Engineering, Inc.
Jack Santamour, Tree Source, Inc.
Peter Ridley, Anheuser-Busch, Inc.

B. Land base identification – ArcMap software was utilized to identify land within the study region that was a potential candidate for biomass production. Since the purpose of this study was methodology development rather than estimating supply for an existing or planned facility, the city of Syracuse was selected as the center of a study region because databases were already available and cleaned up because of some previous research. A 25 mile radius circular buffer was created around Syracuse City Hall using the BUFFER tool. This circle covered all of Onondaga County, where Syracuse is located, as well as portions of each of five neighboring counties. Using the circular buffer created in Step 2, the area of those counties that fell inside this 25 mile radius was selected using the CLIP tool. Because land ownership and parcel data is maintained at the county level, each county within the 25 mile radius was treated as an individual unit. County-level parcel data, including GIS coordinates, were obtained for each of the six counties, and all of the parcels within the study area were selected using the CLIP tool. Two subsets of these properties were selected - an agricultural land subset, and a wooded land subset – based on the New York State Office of Real Property Services (ORPS) codes assigned to them by local tax assessors.

Potential agricultural properties - those coded as “agricultural” (codes in the 100 series), as “rural residential” (codes 240-242) and “rural vacant land” (codes 320-322) - were selected using the SELECT BY ATTRIBUTES dialogue box. A second sort was conducted to eliminate those parcels less than 10 acres in size. Next, the National Land Cover Database (NLCD) was used to identify areas with classification numbers 71, 81 and 82 (Grassland\Herbaceous, Pasture\Hay and Cultivated Crops, respectively) utilizing the SELECT BY ATTRIBUTES dialogue box. The two selections – by ORPS code and area, and by NLDC – were then overlaid using the INTERSECT tool. This identified the complete set of properties in the region containing at least 10 acres of agricultural land.

A similar procedure was followed to produce a list of eligible forested properties. The tax codes utilized were basically those in the forest (900) series, eliminating those for forest preserve (931) and municipal parks, wetlands and other areas where harvesting is prohibited (963). The eligible area criterion for forestland was a parcel of at least 25 acres that intersected with NLDC classifications 41, 42, and 43 (Deciduous, Evergreen, and Mixed Forests).

The two subsets of the all parcels within the 25 mile radius were then merged, eliminating duplicates, to identify all parcels with either 10 acres of agricultural land, 25 acres of forested land, or both within the same property. The total number of parcels meeting one or both selection criteria totaled 7,469 properties. Properties excluded were, in the main, ones located in the developed urban and suburban area in the center of the study region, as well as village and smaller rural residential properties.

C. Sampling procedures – The 7,469 selected properties were stratified according to their total acreage, grouping those below 100 acres, between 100 and 300 acres, and over 300 acres. The smallest group contained 77% of the properties with 22% in the intermediate group and 1% of the largest group. In terms of land area, 52% of the total acreage was in parcels less than 100 acres, 38% in the 100-300 acre group, and 10% in the small number of properties larger than 300 acres. About half of the forest cover was in parcels of less than 100 acres. Forestland made up about 60% of the parcel areas classified as agricultural land. Individual parcels are only assigned one classification but often have multiple cover types and uses.

Assuming a target of 50 parcels for complete evaluation in the study, the goal was to obtain 22 parcels in each of the two lower size strata and 6 in the larger stratum. Anticipating a response to the mailed invitation of about 10%, random samples of 220, 220, and 60 were drawn from the respective strata out of the total number of eligible parcels in the region.

D. Contact with landowners

Addresses for owners of all of the properties in the study sample were identified from county tax rolls, and invitations (see Appendix A), including tear-off cards to be mailed back to the project coordinator, were sent out by ordinary mail. The total response, from a mailing list of 500, was 51, of which two properties were dropped because of address anomalies and four others dropped because owners decided not to participate at a later stage in the process. The final number of properties evaluated was 45 (Figure 1). All of those who responded to the initial survey were sent a second letter (Appendix B), which asked for return mailing of an affirmative agreement to have their property evaluated, and also a written explanation of project methodology. This letter also included an explanation of some of the terms being used in the study in order to save time during the interview process. A sample copy of the property report that landowners would receive during the interview was also included in this mailing (Appendix C). Landowners who did not return the agreement were contacted by telephone to confirm their understanding of how the project would proceed, including visits to their property by project staff to assess the potential of biomass production prior to the interview.

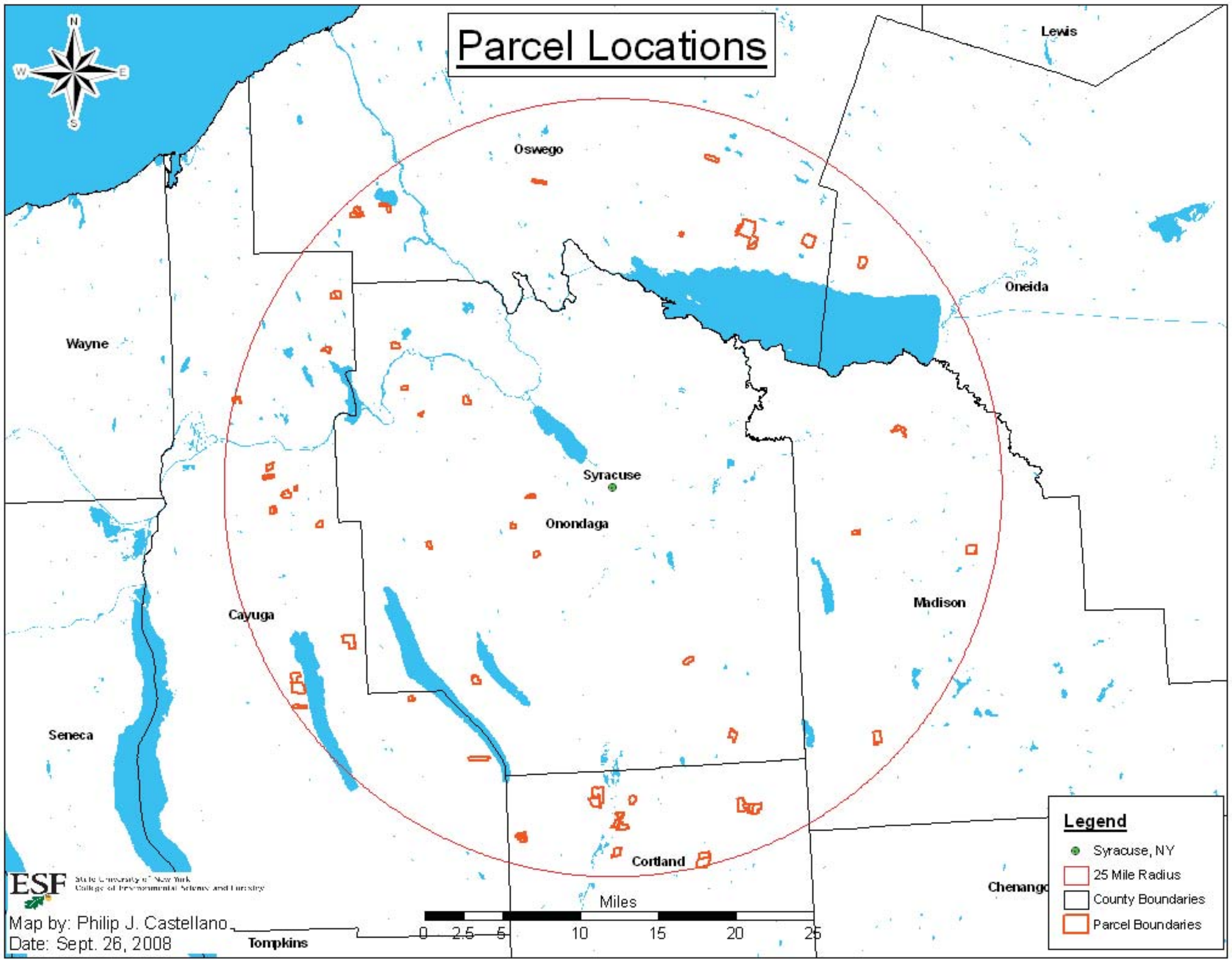


Figure 1: Location of the parcels where field assessments and landowner interviews were conducted as part of this study.

E. Property mapping procedures

Prior to the evaluation of selected properties and scheduling of landowner interviews, a preliminary biomass report was completed using the same format as the sample report already sent to participating landowners. Contents included a cover sheet, a description of the property (largely information from tax rolls and the preliminary map analysis described below), an aerial photo with sub-parcels superimposed, a topographic map with sub-parcels superimposed, a soils map with sub-parcels superimposed, a table giving the soils by acreage in each sub-parcel, a map of the property showing NLCD classifications, with New York Department of Environmental Conservation wetland areas superimposed, and technical assessments of agricultural and forest areas on each property.

Sub-parcels were defined by visual inspection of the aerial photo of each property. Substantial areas of contiguous woodlot or agricultural land not separated by a clear hedgerow or other barrier were identified as a single sub-parcel with a number assigned. Study property N had sub-parcels numbered N.1, N.2, N.3 etc. On most properties, there was a significant amount of land falling outside any of the defined sub-parcels, such as the areas immediately surrounding buildings, watercourses, swamps, ravines, and small, isolated blocks of open and wooded land. The definition of sub-parcels was based on the GIS technician's judgment and experience with the goal of identifying significant sub-areas with biomass production potential within each study parcel. These sub parcels should also follow the general tendency of landowners and those who work land to view different fields and woodlots as having different values and potential uses. The sub-parcels functioned as the essential units of analysis in the study, since on a typical agricultural parcel there were some fields that the owner would consider devoting to biomass crop production and others where they would not. The same variable pattern applied to woodlots. Procedures used to assess biomass output potential for agricultural and wooded sub-parcels are described in the sections that follow.

F. <u>Field evaluation procedures, open land</u>

A field technician walked each agricultural sub-parcel and made notes on current land cover and condition of the land. If the sub-parcel was in grass, the species or mix of species was identified. Any improvement such as drainage or clearing that was necessary to make agricultural production feasible was noted. Current uses were identified using the coding system described in Appendix D. These annotations were later corrected, in a few cases, on the basis of information gained in the subsequent landowner interview.

To determine the biomass production potential of each sub-parcel, the soils data collected was reviewed to identify the dominant soil type. Using the forage species selector tool developed by Cornell University, the yield potential of cool season grasses and unimproved grasses (if present) was determined. The forage species selector tool requires the county, zip code, soil type, drainage and pH as input to determine the yield potential. Since soil tests were not available, the median pH for that soil type in the county, based on soil samples tested at the Cornell Nutrient Analysis Laboratory between 2002 and 2006, was used. Yields for cool season grasses were estimated based on the model's yield potential for reed canary grass. Unimproved grass yields were based on the yield of the species observed during the field assessment. Warm season grasses were not assessed, since local yield potential data for these grasses has not been modeled to any extent. The forage species selector tool provides output for cool season grasses as a three cut system. Cornell recommends that yields be estimated at 60% when using a one cut system vs. a three cut system for biomass harvest. The forage species selector tool also provides a reference corn yield for that soil type in each zip code. The reference corn yield represents an average expected yield using best management practices.

Corn stover yields were estimated using a formula developed by Iowa State University based on the cut, rake, and bale method for stover collection. Corn has a 1:1 ratio of grain to plant material. It has an initial moisture of 30% before raking and field drying. Using the cut, rake and bale method, Iowa considers that a maximum of 60% is harvestable. For this study, we reduced that percentage to 50%, as New York field conditions are not always ideal for late fall operations. Therefore:

Corn Yield ____ bu/acre / 35.714 *.67 DM * .50 = Harvested Biomass (DM)

Example: Field producing 125 bushel corn

$$125/35.714 * .67 * .50 = 1.17 \text{ ton/acre}$$

Potential soybean yield potential was determined by the industry standard of one-third of the corn yield potential. The soybean straw yield was based on information from Iowa State University and the University of Minnesota, using a rake and bale method, again reducing the estimated harvestable quantity to reflect New York field conditions, and assuming the same 1:1 seed to plant material ratio by weight found with corn. Therefore:

Soy Yield ____ bu/acre / 33.333 * .50 = Harvested Biomass (DM)

Example: Field producing 40 bushel beans

40/33.333 * .50 = .60 ton/acre

Relatively little is known about the effect of soil type on willow yield over multiple rotations. Expected yields, based on experiments to date in New York State, are in the 4-5 DM ton per acre per year (12-15 tons in each 3-year harvest cycle). Where potential corn yields were 140 bushels or over the willow yield potential was assumed to be 5 tons. Where potential corn yields were between 120 and 140 bushel the willow yield potential was assumed to be 4.5 tons. Below 120 bushels the yield potential was estimated at 4 tons. Fields too steep or too wet to be harvested with a large forage harvester (modified to chip willow) were considered ineligible for willow production.

G. <u>Field evaluation procedures, woodlots</u>

To assess the forested sub-parcels, a field technician visited the properties, systematically sampling the forested portion using basal area factor (BAF) 10 point samples on a rectangular sampling grid with a randomized start to quantify different variables describing forest stocking and quality, including basal area, species composition, sawtimber volume, pulpwood and biomass volume, and other forest characteristics. The sampling grid covered the forested portion of the property; however, the distance between points along the major grid lines was calculated based on the total forest area and shape of each sub-parcel. The spacing between gridlines was based on the following guidelines:

- 25 acres or less = 4 x 4 chains (A chain is distance measurement commonly used in forestry that is equivalent to 66 ft)
- 25 - 50 acres = 5 x 5 chains
- 50 - 100 acres = 6 x 6 chains
- 100 – 200 acres 7 x 7 chains
- 200-plus 8 x 8 chains

Field analysis of the woodlots included 765 forest inventory points on 36 properties (the total number of study parcels with at least 25 acres of forested land). This came to just over 21 points per property. Data collected on each tree within the sampling point included species, diameter-at-breast-height (DBH), acceptable growing stock (AGS)/unacceptable growing stock (UGS) quality designation, and length of saw logs or pulpwood bolts. The quality of the growing stock was based on whether individual stems had the ability to produce a saw log in the present or future, with UGS characterized by visible signs of low vigor and poor health, including but not limited to major decay, fungal fruiting bodies, crown die-back, and unacceptable crown damage. Trees of unmarketable species, such as ironwood (*Ostrya virginiana*), striped maple (*Acer pensylvanicum*) and pin cherry (*Prunus pensylvanica*), regardless of vigor and health, were always designated as UGS.

Field data was analyzed with the USFS NED-2 software program. In addition to generating all the standard forest stocking variables, growth and yield functions were used to provide forest management scenarios for each sub-parcel. The types of scenarios for a given sub-parcel were influenced by current forest stocking values. The list of scenarios is as follows: immediate conversion harvest, shelterwood harvest, thinning, and high grading. Current market prices were incorporated into each scenario to provide the landowner an idea of current and future revenues from forest operations.

H. Landowner interview procedures

The landowner interview was arranged after the field assessments of open and forest land on the property were completed. The interview followed the rough outline of topics on the landowner interview sheet (Appendix E), but was managed to take the form of a natural conversation, permitting the landowner to elaborate on (or take detours into) areas of his or her particular interest. The interviewer asked more specific questions to fill in necessary blanks later in the discussion. In areas where it was difficult to get a definite response from a landowner (e.g., questions designed to elicit an estimate of the rent or return per acre that the landowner would need to receive to make a change in current use), some degree of interviewer judgment was required. For example, if a landowner said that "a fair rent" would be needed to allow the land to be used for biomass production but was not more specific about a dollar value, this was interpreted as the going rate in the area where the interview is taking place. If the interviewee was a farmer, detailed questioning was often needed to come up with a gross return per acre that would be "more than I'm making for corn."

Resistance to the idea of renting to a farmer, to allow logging, and to particular crops was also pursued far enough to ascertain the basis for the resistance. For example, if the reaction to the idea of working the woods was negative, an effort was made to determine whether the owner "wanted to leave the woods to "grow up naturally", or because he/she distrusted loggers. If it was the latter concern, the interview went on to determine whether the owner would consider permitting logging if it were supervised in such a way as to leave the woods in relatively good shape. If it was the former, some discussion was pursued to make the landowner aware that good silvicultural practices can produce a better stand of hardwoods more rapidly than simply leaving things "natural". This type of exploration made it possible to determine whether or not a given parcel was likely to be made available for a biomass harvest, and to proceed to defining threshold values for production of that biomass.

The major focus of questioning was what the landowner plans to do or would be receptive to doing within the next three- to five-year period. Longer-term plans were noted, but the chief focus was on what might occur within a more realistic planning horizon.

The neutral assumption with respect to culture and harvest procedures was current industry "best management practices". This means that strong opposition to the use of standard agricultural chemicals made a property ineligible for producing crops on a rental basis (though not on an own-production basis, with suitable adjustments for lower yields). Property where the owner would not permit opening access roads or the use of skidders and other heavy machinery would likewise not be counted for likely sawtimber and wood chip harvesting.

Each interview generally required about an hour. It opened with a brief explanation of the purpose of the study and how information from the landowner will fit into the study, and closed by thanking the landowners and providing them with a copy of the data on their parcels. Data from the interview was recorded on an Excel spreadsheet designed to provide direct input to the supply shed assessment model.

The bottom-line issues addressed through the interview were whether a landowner would consider producing a given type of biomass with his/her own resources, and if so what their target net return per acre would be. Utilizing production cost models for each type of biomass, it was possible to derive a roadside price for biomass required to meet the per-acre net return on the sub-parcel or sub-parcels in question. If the landowner lacked the capacity or interest in producing the biomass with his/her own resources, then a minimum rental price assuming a third party producer was established and recorded for each sub-parcel.

In the case of forested blocks, a target payment per acre was established in discussions with the landowner for each sub-parcel that the owner was willing to harvest within the next five years. If there was adequate stocking and species on a given parcel this price would include the value of the merchantable timber and any material that could be chipped for biomass. If the value of sawtimber at summer 2008 stumpage rates reached the landowner's per acre target (this was rarely the case because of the stumpage prices and the relatively low amount of quality trees on most woodlots in Central New York), then chipped tops and slash were presumed to be available at $5/dry ton. If the target payment per acre was not met based on the sawtimber value then wood chips were only available when the price of the chips reached a value high enough to meet the landowner's target per-acre income.

Additional descriptive information about the landowner and the property (e.g., were they involved in farming, did they rent any land to a farmer, past wood harvesting history, did they live on the property) was also gathered during the interview process.

I. Non-respondent survey

The non-respondent interview was conducted by telephone. An initial sample of 100 out of those included in the original mailing but who had not responded was drawn, and then another 50 to permit achieving 45 responses – equal to the number of study parcels. Non-inclusion of non-respondents were due to inability to match phone numbers to names and addresses, failure to contact a person after several phone calls, or unwillingness to participate once contacted. Non-respondents who were successfully contacted were asked the questions outlined in a script provided to the phone interviewer (Appendix F). The question asking whether they had received the flyer asking them to participate in the study was dropped after the first few interviews, since very few had any recollection of the flier. Landowners were asked if the acreage they own that we have from the tax rolls is correct; and, a few landowners indicated owning more than the acreage we asked about, and the interviewer then made sure that they understood which parcel was being discussed. A variety of reasons for owning the land were noted, but no effort was made to tabulate that response.

J. Statistical method for analyzing study data – The results of the invitation mailed to landowners to participate in the survey, organized by size stratum, were as follows:

Stratum	Total Parcels	Mailed	Responses
1 (<100 acres)	5749	220	15
2 (100-300)	1614	220	20
3 (>300 acres)	106	60	8

The actual sample represents slightly less than 10% of the target sample that received a mailed invitation. The sample-based estimates provided for the region represent the portion of the population that would respond to a mail solicitation such as the one sent to the original sample of 500 parcel owners. While it was certainly possible that some portion of the non-respondents would potentially be interested in producing biomass, neither the study nor the non-respondent survey provided direct information on that question. The non-respondent survey was simply designed to assess whether there appeared to be important differences between respondents and non-respondents on such variables as active involvement in farming that, a priori, might have been assumed to influence willingness to commit land to biomass crop production (see further discussion in the Lessons Learned section, below). The estimated totals below represent total acreages based only on information obtained from respondents.

Based on the response rate to the invitation, the sample was considered to represent an estimated 553 parcels and 53,732 acres (where parcel acres are based on the parcel acres in the original list sampled from). These estimates translate to 7.4% of all parcels (553/7469) and 8.75% of the acreage (53,732/ 613,499) of all parcels meeting the basic agricultural and/or forest area criteria.

By type of land (wooded or agricultural) evaluated, the sample represented:

25,566 acres of wooded area (standard error of 4,423 acres)

22,670 acres of agricultural area (standard error of 4,194)

The missing acreage needed to add up to the 53,732 in 553 parcels is accounted for by areas not evaluated in the study because they were found to be developed, lawns, farmyards, swamps, or other areas determined to be unsuitable for biomass production.

In order to project study parcel results to the supply shed, coefficients were developed to expand data from the study area for acres falling in a given stratum. Allowing for very large error terms resulting from the small sample size, this permitted estimation of a probable number of acres that would be available to produce biomass of each type at a given threshold cost of production – a central objective of this study.

III. Results

A. Estimated land area available for biomass production

A circle with a 25-mile radius includes 1,256,639 acres of land. Using the selection criteria adopted for this study (parcels with at least 10 acres of agricultural land, 25 acres of forest land, or both), the random selection of 500 properties drawn for the mailing of invitations was drawn from a total of 7,469 qualifying parcels. The total acreage in these parcels came to 613,499 acres, or about 48.8% percent of the land area within the supply shed. This relatively low percentage of qualifying parcels reflects the fact that the study area has the City of Syracuse and its surrounding suburbs (SMSA population of about 735,000) at its center.

The total land area covered by the final group of study properties (those whose owners accepted the invitation to participate in the study) was 7,888 acres (Table 1). The tables below indicate how that land breaks down by land use category using ORPS codes, and by land cover using the National Land Cover Data mapping system categories. The "supply shed" category gives the percentage of land falling within the entire region circumscribed by the 25 mile radius falling into those same categories, for reference purposes.

Table 1. Distribution of land use based on tax parcel codes for the acres that were selected and landowners agreed to include in the study.

Property Use Classification	Participating acres	Percent of participating acres
Agriculture	4,007.5	50.8
Forest	892.2	11.3
Vacant	623.8	7.9
Camp/recreation	855.3	10.8
Residential*	1,509.4	19.1
Total	7,888.1	100.0

*Includes only low-density residential with attached land

The actual land area analyzed in the study was 6,462 acres. The difference between this area and the larger total mapped area of the study parcels (c. 7,888 acres) is explained by the decision to remove acreage from consideration as possible biomass area after site visits by members of the project team. The most common reasons for removing property from consideration was that the land was too swampy or inaccessible to be worked, in the case of forest land, or too poorly drained, overgrow with brush and young trees or inaccessible to be worked in the case of agricultural land. The decision to disregard woodlots on properties with less than an aggregate total of 25 wooded acres also substantially reduced the number of acres analyzed, subtracting ten or fifteen acres from the total acreage of many predominantly agricultural properties.

Field assessment enabled researchers to determine current uses for agricultural land evaluated in the study. Extrapolating from data on the study parcels, the breakdown of agricultural land uses within the supply shed is estimated in Table 2.

Table 2. Estimated land areas for different agricultural uses in the 25 mile supply shed based on the field assessments of the parcels included in the study.		
Current Land Use	**Supply Shed Acres**	**Percent of Supply Shed**
Corn/soybean rotation	97,745	32.4
Corn alfalfa or forage grass rotation	65,296	21.6
Idle land that needs work	26,834	8.9
Improved forage	25,174	8.3
Unimproved grasses	22,235	7.4
Idle land, tillable	16,791	5.6
Clear alfalfa	16,082	5.3
Pasture	13,475	4.5
Small grains	12,745	4.2
Wildlife feed or habitat planting	5,311	1.8
Other active use	290	0.1

Grouping the data into a smaller set of categories relevant to this study, and including wooded land, the breakdown of land area within the supply shed is shown in Table 3.

Table 3. Estimated land areas for different uses in the 25 mile supply shed based on the field assessments of the parcels included in the study.		
Current land use	**Acreage in supply shed, projected**	**Percentage of suitable area* in supply shed**
Idle open land	43,625	7.5%
Pasture and forage crops	77,056	13.2%
Row crops and rotations	175,786	30.1%
Other active agricultural use	290	<0.1%
Wildlife habitat	5,311	0.1%
Wooded	282,818	48.4%
*assumption that only undeveloped private land found in parcels that have at least 10 acres of agricultural land and/or 25 acres of woodland are suitable for production of commercial biomass		

These tables suggest that the amount of idle land available to produce biomass in this region is limited to just over 43,000 acres. Nevertheless, field inspections showed that 61% of the idle land (26,834 acres) was not suitable for tillage without some restoration, usually in the form of restoring pre-existing drainage or clearing encroaching brush and small trees. Most of the active agricultural land in the region is supporting the livestock industry (dairy and horses).

While the major goal of this study was to generate supply curves connecting potential volume of available biomass to price, it is also informative to see how much of the theoretically available acreage (i.e., agricultural land of at least 10 acres in a single holding, forest land of at least 25 acres in a single holding) is, in fact, likely to be a candidate for supplying biomass at any price, since we would expect that some landowners would not consider allowing their woodlots to be harvested under any condition, or consider using their open land for one or another type of agricultural production.

Based on an assessment of the capability of the land and landowner interviews, we estimated that 545,391 acres in the supply shed could potentially supply grasses or willow when prices for biomass were not considered (Table 4).

Table 4. Potential land area in the supply shed that would be suitable for the production of perennial energy crops such as grass or willow.

Crop	Potential area in supply shed	Percent of agricultural area in supply shed
Improved grasses	265,458	87.9%
Unimproved grasses	90,482	30.0%
Willow	189,451	62.7%

The area that could produce unimproved grasses (grass hay) as an energy crop was obviously constrained by the number of acres already in that cover. Very little acreage was ruled out as a potential source of improved energy grasses, and surprisingly little area as a source of willow, given the questions often raised about whether or not landowners would be willing to make such a long-term commitment of their land to this use. This is not to say that landowners would make their land available for willow at a nominal rent (as many would, in the case of unimproved grasses), or without a contract that included some type of escalator clause and, for many landowners, a commitment to remove the willow on termination of the arrangement.

Although this study did not evaluate corn and soybeans as energy crops (though both can serve as such), it was necessary to determine how many acres could potentially produce these crops, both from a technical and a landowner preference perspective, before estimating how much crop residue might be available. From both a technical and a landowner preference perspective, a high percentage of the remaining agricultural land in the region could produce corn or soybeans (Table 5). The discrepancy between the number of acres that could potentially produce the primary crops and the residues reflects both the opinion of some landowners that it is better for the land not to harvest the residue and, in the case of some farmers, doubt that the residues could have enough value as an energy source to make it worth the trouble to harvest them.

Table 5. Land area in the supply shed that could produce corn or soybeans based on field assessments of the land included in this study.

Crop	Potential area in supply shed	Percent of agricultural area in supply shed
Corn	232,945	77.1%
Corn stover	163,275	54.1%
Soybeans	235,908	78.1%
Soybean straw	161,041	53.3%

While we found that the percentage of land that owners would consider – with appropriate economic incentives – as a source for biomass varied considerably by biomass type, the study identified only 179 acres (6.7%) of the total agricultural acres evaluated that the owners would consider unavailable for production of any biomass type whatsoever. Extrapolating this data according using the sampling strata, this suggested that only 16,520 acres (5.5%) of the agricultural land area within the supply shed would be categorically unavailable for producing biomass, at any price, because of landowner preferences. This is a relatively low number suggesting that there is more support for different types of biomass crop production than expected. Still, these numbers also include some acreage that would only be available at higher rental rates required by landowners to make the land available for biomass production.

Our study methodology enabled us to evaluate what types of harvest regimes were possible on each of the larger woodlots, and then to eliminate those that the landowner would not consider. A full conversion cut was always an option if the owner had any other plans for the land, which was rarely the case. A high grade cut was always technically possible, at least in theory, although in many cases the forest stands were too degraded to produce enough value for a logger to have any interest in working the stand at anything near current sawtimber and wood chip prices. Shelterwood cuts and thinning were considered only technically possible if stand densities were sufficient to justify that silviculture practice, which occurred on about 43% of the forest land (Table 6). About a third of the forest land was controlled by landowners who did not want to have any harvesting operations occurring in their forests.

Table 6. Potential forest land area in the supply shed where different forest management approaches could be employed to produce wood chips for biomass.

Harvest regime	Potential area in supply shed	Percent of forest land in supply shed[1]
Conversion cut	4,628	1.6%
High-grade cut	147,445	52.1%
Shelterwood cut	121,943	43.1%
Thinning cut	39,647	14.0%
Owner will not consider wood harvest	89,771	31.7%

[1] Values add to more than 100% because individual parcels could be suitable for more than one type of harvest regime.

B. Estimates of biomass availability by price

The interview process was designed to determine, for agricultural land, the minimum rental price or net return per acre (in the case of farmers) that would be required to elicit production of each type of biomass from each acre covered by the study. From these threshold values it was possible to determine a roadside price for the volume of biomass produced on that acre (assuming that the owner was receptive to that particular land use). Field analysis had also provided an estimate of the yield of biomass from that acre. The model also incorporated production cost estimates for each type of biomass that made it possible to estimate the price at which a farmer's per acre cost objectives would be met, as well as a production cost for a custom operator incorporating the minimum rental value for the acres available only on a rental basis. Combining that information made it possible to construct a cost curve estimating the number of tons that would be available at a given price for the entire supply shed, projecting acres available upwards from the study parcels to the regional scale.

The following figures present potential volumes by price for each of the biomass types studied for supply shed with a 25 mile radius centered on Syracuse, NY. The vertical axis is total amount, on a dry matter basis. The horizontal axis is the threshold price required to elicit a given amount of biomass. The first table for each biomass type presents that price in dollars per oven-dried ton (ODT), and the second is in dollars per million Btu. Costs are at the roadside on the property so they do not include additional handling, storage or transportation costs. The cost estimates for willow include interest on the initial investment in establishing this crop, since this investment may take as long as ten years to break even, depending on what one assumes concerning wood chip prices. Differences in the characteristics of the different types of biomass assessed will mean that these additional costs will vary among biomass types. For example, crop residues and grasses will have additional costs for storage and have a lower density than wood chips from forests or willow crops so they may be additional costs associated with those crops. In contrast, grasses can come off the field at a lower moisture content than wood chips, which impacts downstream processes and costs. These types of costs beyond the farm gate were not included in this project, but need to be considered in future assessments of biomass supplies in the region.

C. Cost curves for unimproved grass biomass

The potential supply of unimproved grass hay in the region is just under 200,000 dry tons per year when cost is not a factor (Figure 2 and 3). Unimproved grass hay as an energy crop is restricted by the area now in grass hay within the supply shed (less than 100,000 acres). Small amounts of unimproved grass hay (<50,000 dry tons per year) are available at the lower end of the cost range (about $65/dry ton), but the majority of the supply would come at a cost of over $125/dry ton. The lower costs are for hay that is available rent-free. This represents landowners that allow a farmer to cut grass hay for nothing on their property simply to keep the land open. More expensive unimproved grass hay (and the higher values are obviously unrealistic as an energy feedstock) imply either very high asking rental values, or the need to bid the hay away from use as a forage, or both.

The advisory board for this team requested that the costs be presented in $/million Btu as well since many end users in the region compare fuel costs based on that metric. This shows that costs for unimproved grasses start at about $5/MMBtu and increase to over $20/MMBtu. The largest amount of biomass from unimproved grasses is available between $5.50 and 9.00/MMBtu.

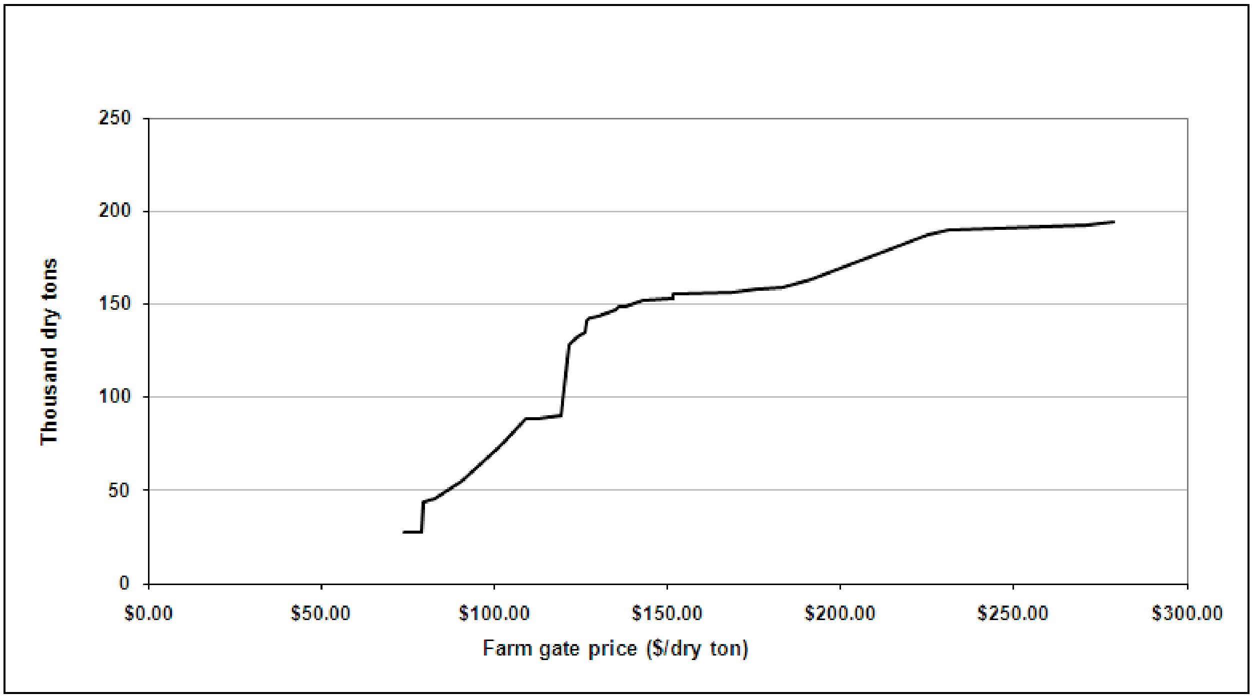


Figure 2. Amount of unimproved grass biomass (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/oven dry ton).

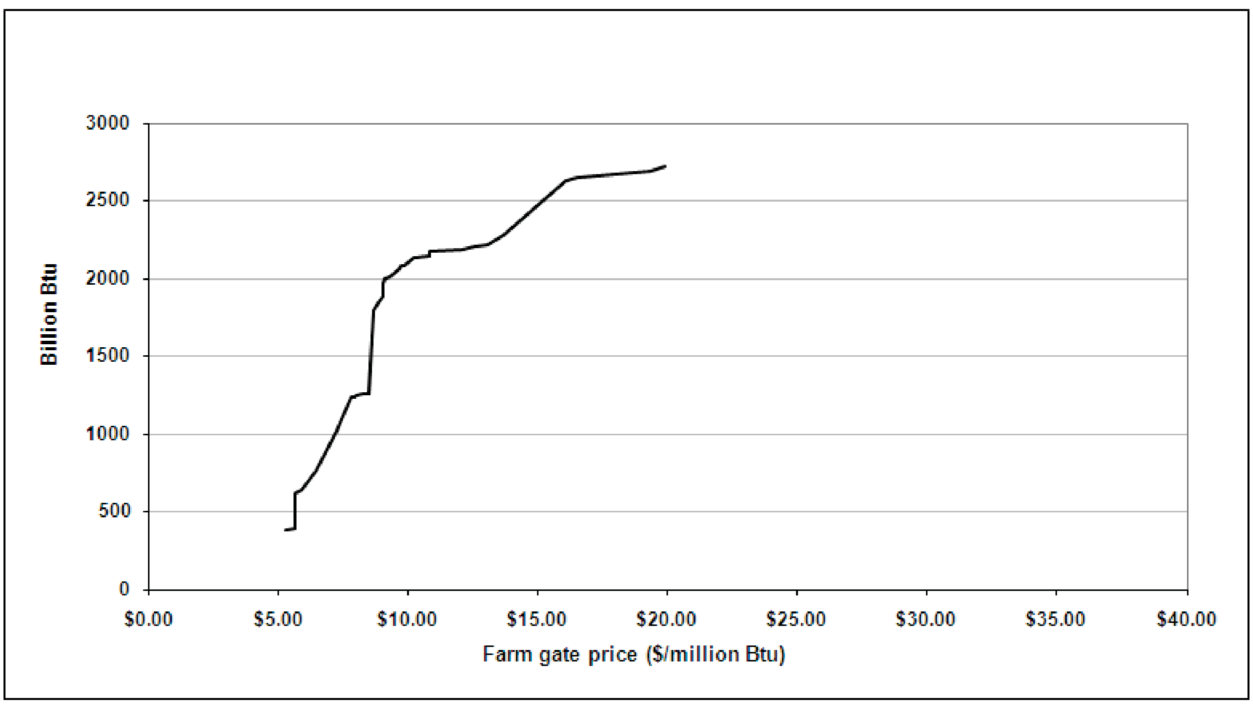


Figure 3. Amount of unimproved grass biomass (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/million Btu).

D. Cost curves for improved grass biomass

While there is potential for producing improved grass hay for biomass in the region, it is costly. The lowest cost improved grass biomass is available starting at $125/dry ton ($9.50/ MMBtu) and up to 150,000 tons could be available at this price (Figure 4 and 5). An additional 340,000 tons could be provided at prices between $125 – 200/dry ton. It is important to note that this cost curve is based on a late summer harvest (one cutting) of a cool season grass. At the time this study was conducted there was a lack of data on production costs and yields of warm season grasses like switchgrass in the central NY region. Switchgrass could out-yield the single cut cool season grass system modeled for this project by a factor of as much as two. Alternatively, cool season grasses in a two-cut system (first cutting for energy, second for forage), could move both of the cost curves to the left, probably making some improved grass hay available at less than $100/dry ton. Custom rates used in the production model for all field operations also put a conservative (upwards) bias into these cost estimates. We were comfortable using the custom rates, since there are relatively few landowners set up to produce hay in large bales and an efficient manner for an energy customer, and also observed that while higher yields do lower land and establishment costs per ton, harvest costs are proportional to volume. Higher values in the cost curves reflect both higher rents in some cases, and – for active farmers – the need to bid land out of row crops by offering a potential per-acre profit comparable to corn or soybeans.

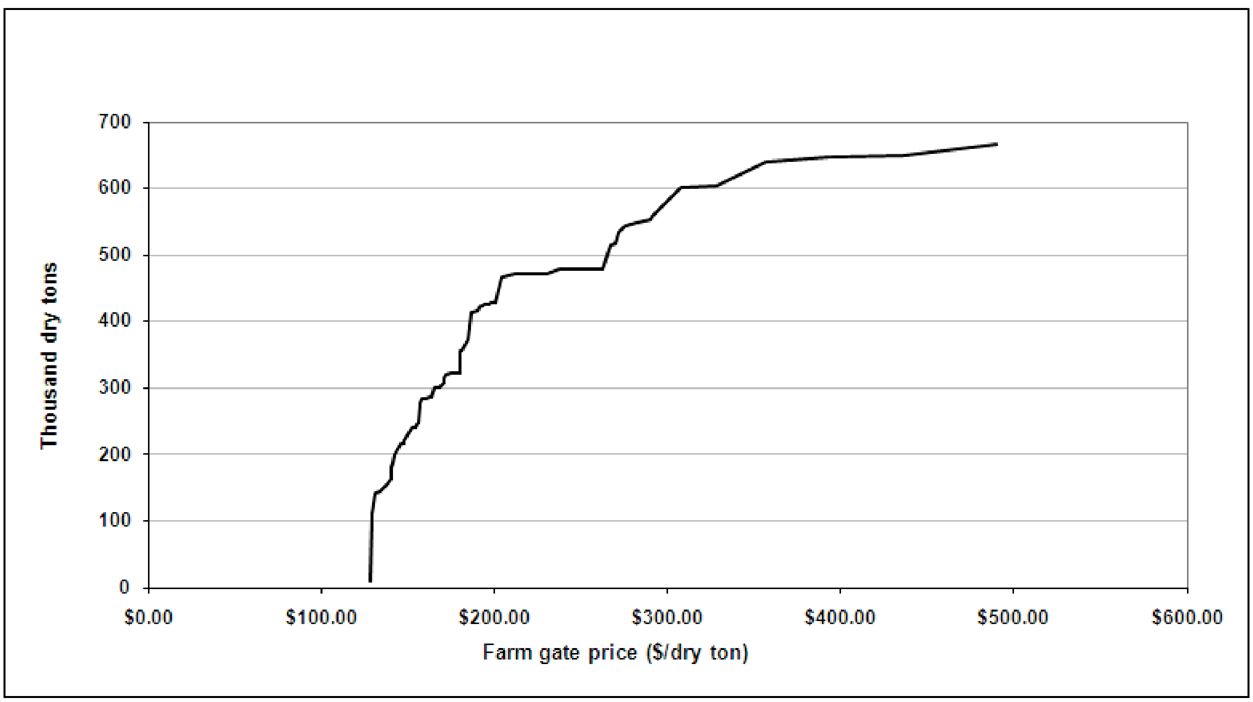


Figure 4. Amount of improved grass biomass (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/oven dry ton).

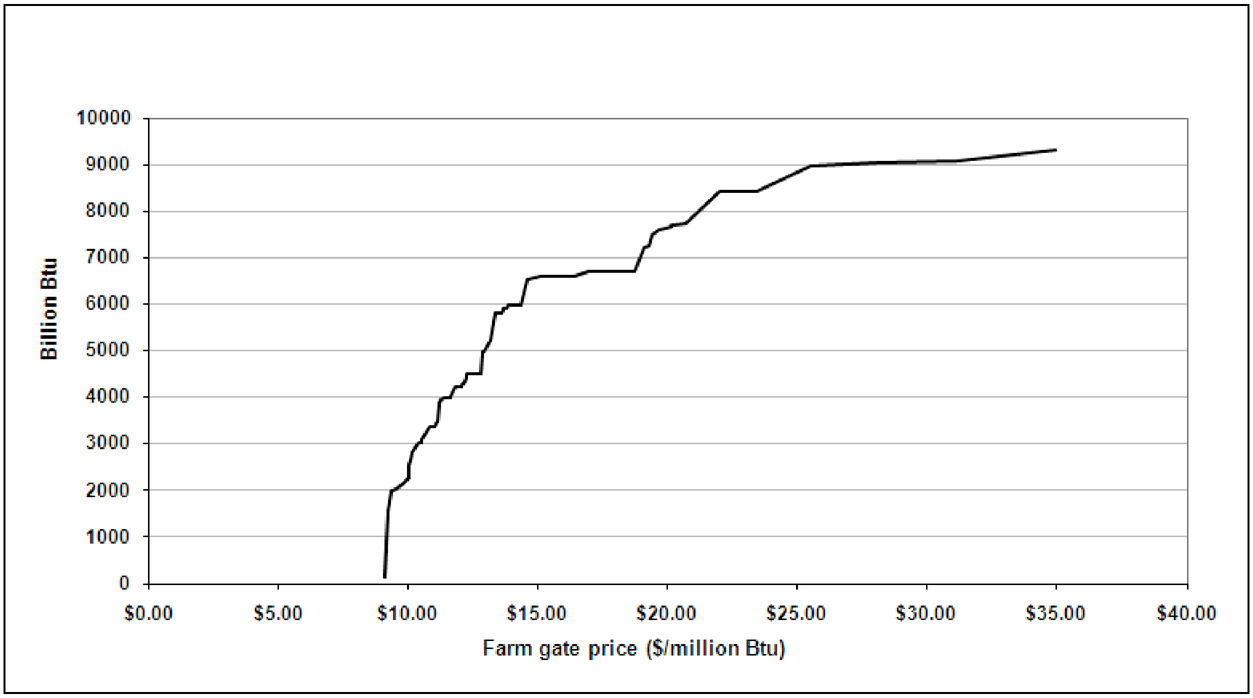


Figure 5. Amount of improved grass biomass (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/million Btu).

E. Cost curves for willow biomass

Cost of production on a contract basis sets the floor under willow production potential in this study, since the equipment required to plant and harvest this crop is not widely available, although a few farmers who were interested in willow indicated that they would happily manage land preparation with their own equipment. Limited amounts of willow biomass would be available at under $40/dry ton (Figure 6 and 7). The cost curve rises steeply up to about $60/dry ton when almost 250,000 tons would be available in the region. In contrast only very small amounts of unimproved grasses and no improved grasses are available at this price. The curve rises more slowly between $60 and $80/dry ton, reflecting the fact that most landowners indicated that they would want a premium rent to make the long-term commitment required for willow. At just over $100/dry ton about 350,000 tons of willow would be available in the region. Increases in production beyond that level comes from landowners reluctant to consider willow unless someone was offering them a per acre rental price that they could not refuse.

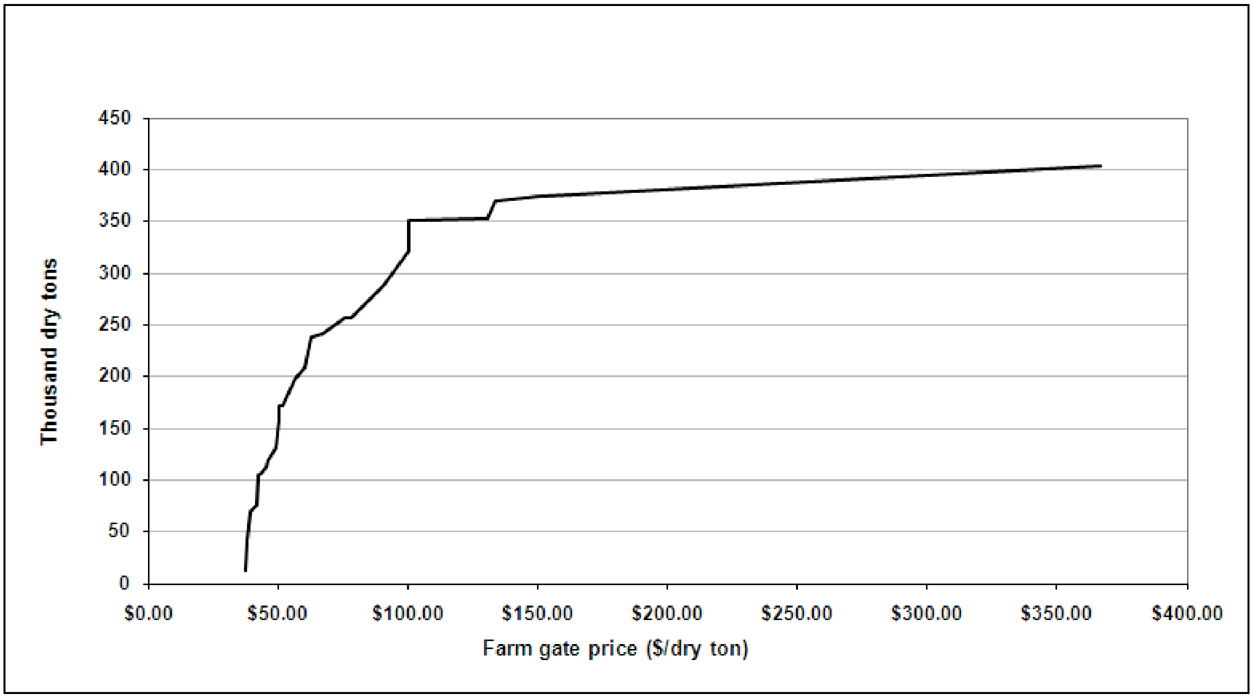


Figure 6. Amount of willow biomass (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/oven dry ton).

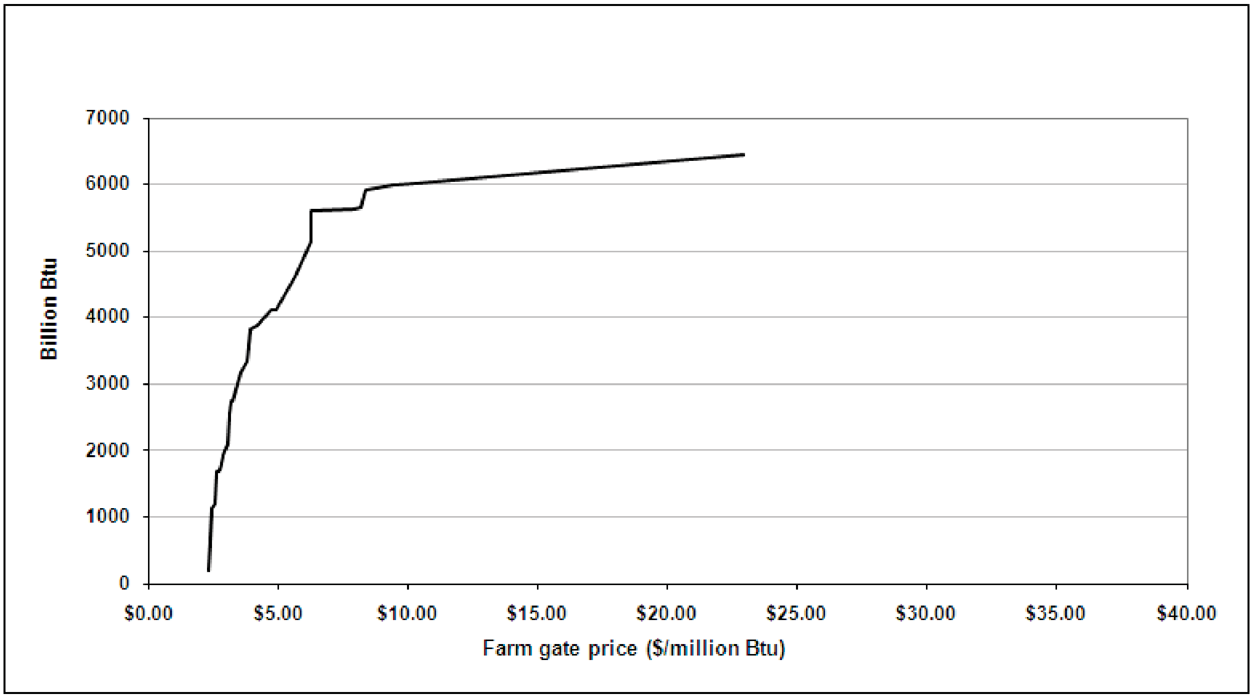


Figure 7. Amount of willow biomass (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/million Btu).

F. Cost curves for corn and soybean residues

The limited amounts of corn stover and soybean straw that might be available make both unlikely sources of biomass for a medium or large-scale biomass facility in this supply shed. About 130,000 tons of corn stover (Figure 8 and 9) and just over 70,000 tons of soybean residue (Figure 10 and 11) are potentially available. These low amounts are dispersed over large areas, which make it difficult to support efficient harvest and logistic operations. The lower costs of around $55/dry ton for corn residue and $50/dry ton for soybean residue in the supply curves represents the harvest cost on land that is already producing the crop in question whose landowners are indifferent to having crop residues removed for energy purposes. The higher costs are for land where the field crop in question is not already the established land use choice, and/or properties where the rental required by the landowner to put the land into row crop production would be high.

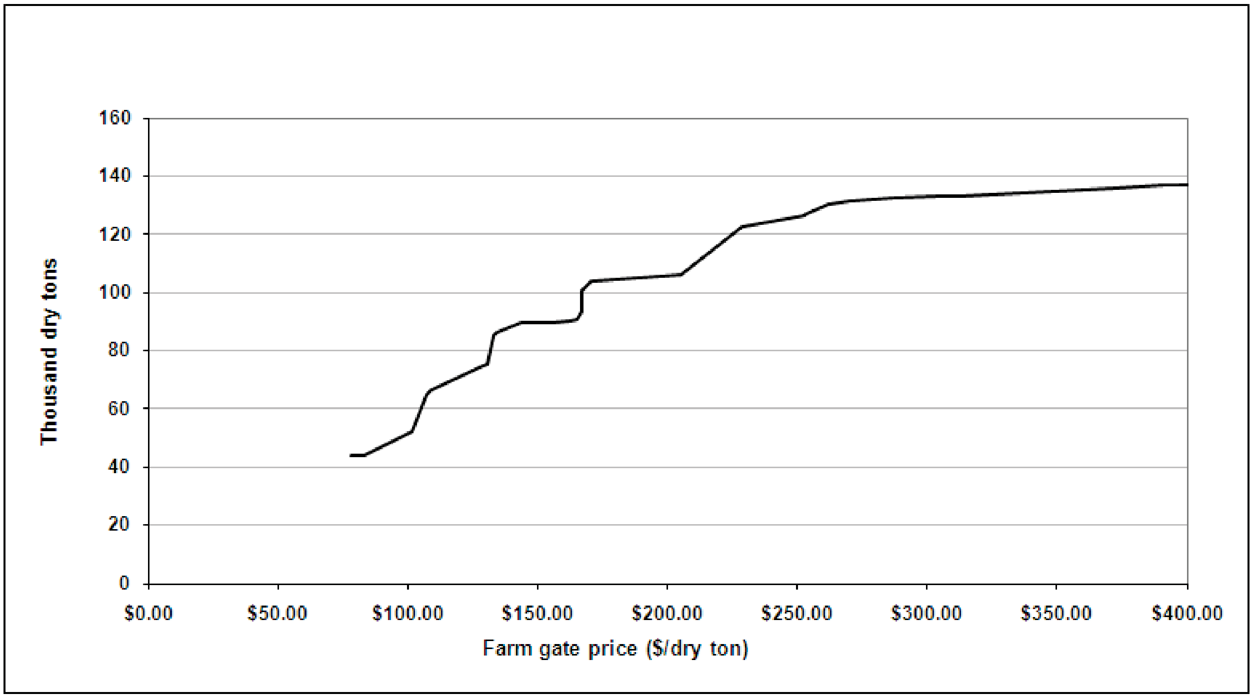


Figure 8. Amount of corn stover (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/oven dry ton).

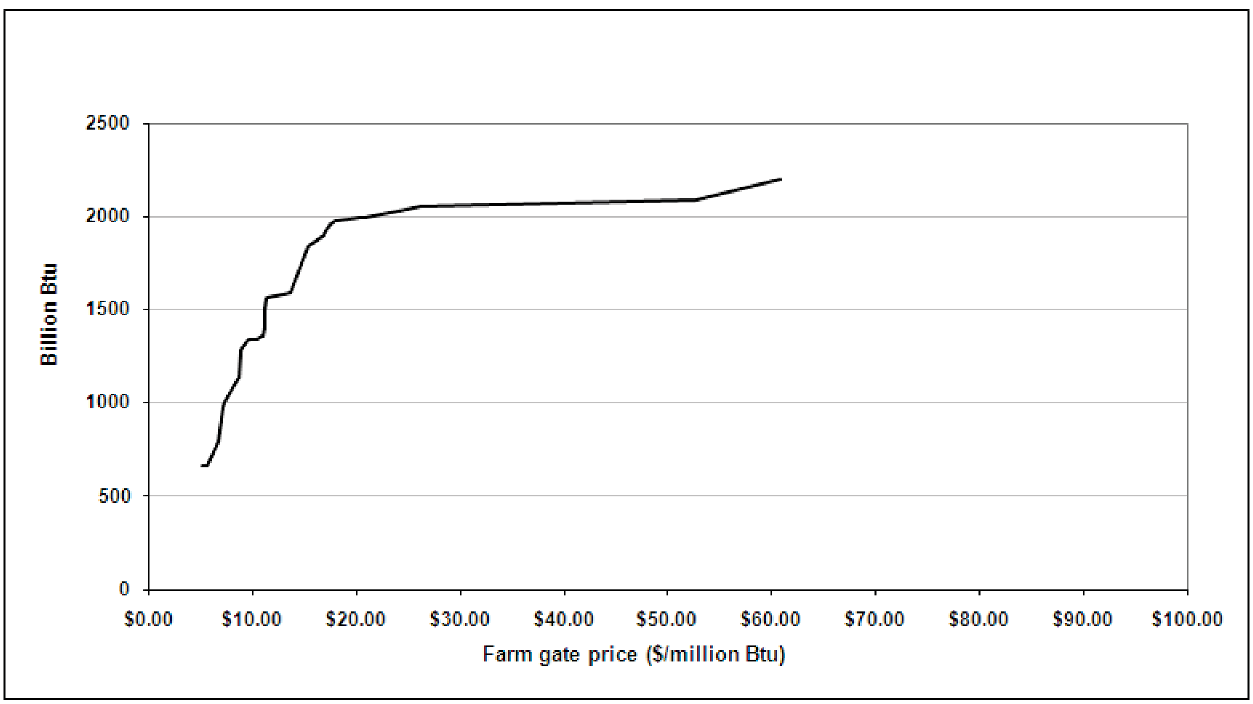


Figure 9. Amount of corn stover (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/million Btu).

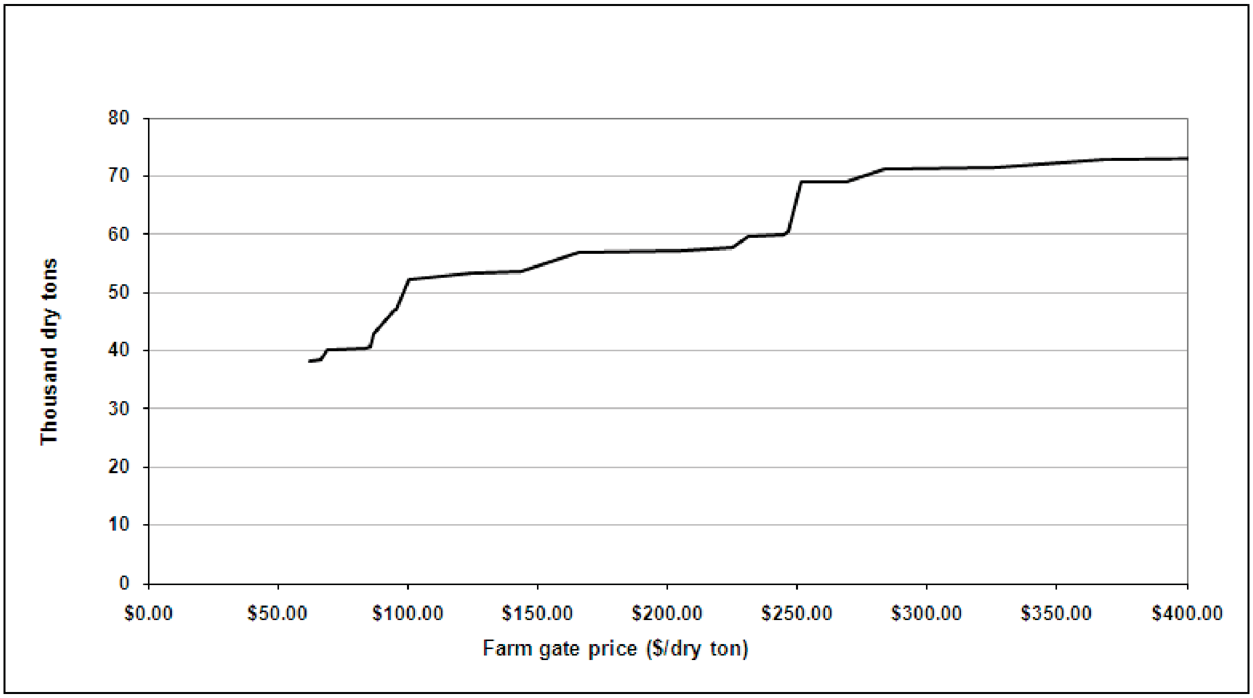


Figure 10. Amount of soybean residue (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/oven dry ton).

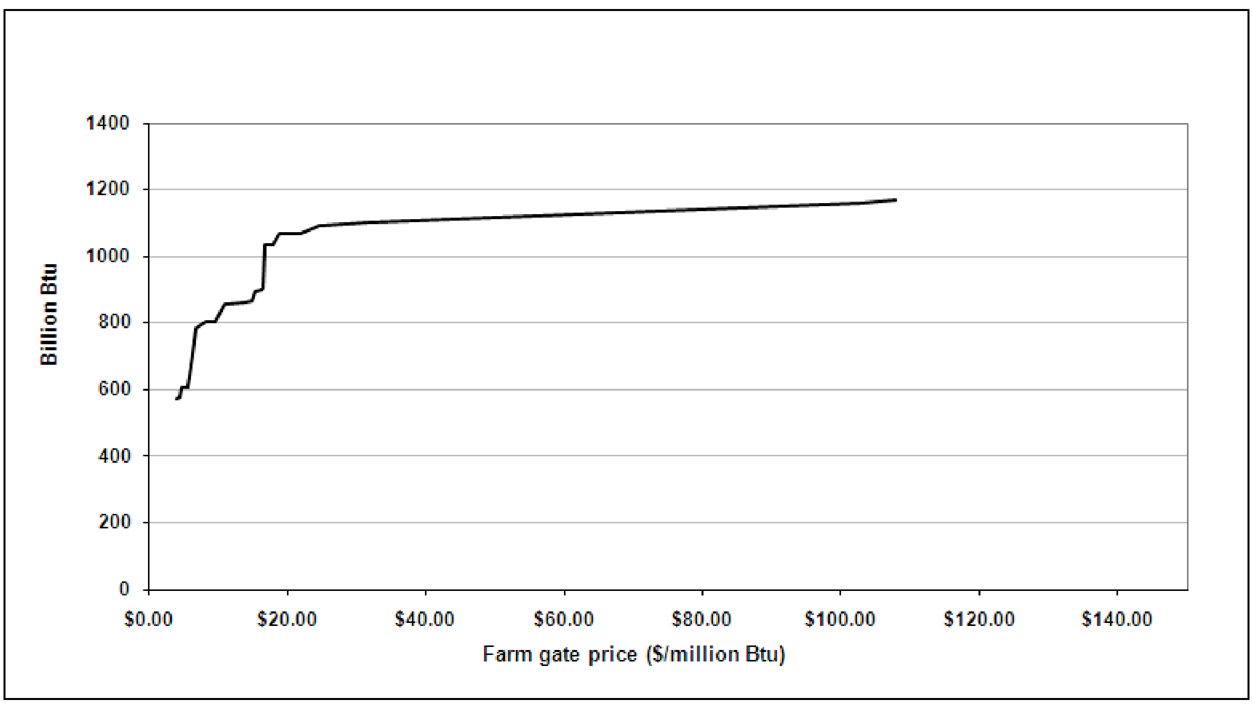


Figure 11. Amount of soybean residue (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY for different farm gate prices ($/million Btu).

G. Cost curves for forest wood chips

The cost calculations for forest wood chips were undertaken to reflect the manner in which woody biomass from forests would become available. Four different harvest scenarios (conversion cut, shelterwood cut, thinning, and high grading) were considered for each parcel based a summary of the inventory that was done and discussion with landowners. While we did consider a “conversion cut” (clearing the land to change the land use on the parcel) as an option, very little acreage was under consideration for clearing by landowners. As a result conversion cuts were an unimportant as a potential source of biomass. This is not surprising since we only looked at forested parcels that were at least 25 acres in size. There will be some biomass available from these types of operation in the region, especially in the more densely populated portions of the supply shed. Nevertheless, this assessment procedure was not designed to capture this material, which is only available once from a parcel so is often not considered a sustainable supply of biomass. We also considered the potential for regeneration through a thinning simply to improve the forest stand, even where there was little opportunity for a substantial production of wood chips in the process. Still, on many of the forested parcels the stand structure and density was too low to make these workable silvicultural practices. The number of acres in the thinning category and amount of biomass that was potentially available was so low that no effort was made to estimate cost curves.

The two types of harvesting that did generate a reasonable amount of potential biomass were selection and high grading. High-grading harvests represent the predominant form of harvesting that has taken place in this region for several generations (other than fuel wood harvesting), and we found this paradigm the one that most landowners understood. To analyze the supply of wood chips that would be available from either shelterwood cuts or high grading, it was assumed that higher value timber would always go to sawmills, and that both pulpwood (for which there is negligible local demand in this area except as a firewood resource) and chipped tops and slash would be the source of wood chips for energy use. If the value of sawtimber (based on summer 2008 stumpage rates) was sufficient to meet the landowner’s minimum per-acre return to agree to a timber harvest, then the value of the wood chips at roadside was assumed to be $5/dry ton to the landowner, while extraction cost was assumed to be $10/dry ton, making the floor price at the roadside $15/dry ton. If the value of sawtimber did not meet the owner’s target, it was assumed that the value of the chip by-product would have to be increased to a high enough value at the landing to make the harvest feasible from the landowner’s perspective. It was further assumed that shelterwood cuts or high grading would take place over the next five years, with chip availability divided evenly over that five year period. This is, admittedly, a somewhat contrived approach to estimating wood chip availability by price, underscoring the difficulty of improving on technical assessments of forest biomass availability with landowner data, at least in areas where hardwood sawtimber value has long driven commercial forestry.

These are significant amounts of forest biomass (480,000 – 530,000 tons) available from high grading operations and they are affordable from both a cost per ton ($15 – 25/dry ton) or million Btu ($1.00 – 1.50/MBtu) perspective (Figure 12 and 13). The least expensive wood chips in the graph are those produced as a by-product of high-grade harvesting that is already taking place. In these situations the majority of the cost of the harvesting operation and returns to the landowners is supported by the sawtimber that is produced. Because lower value material was included in these simulated harvests, they could represent an important improvement in forest management over traditional high grading. However these simulated cuts still removed most of the high value material from the stands in a single harvest operation instead of leaving some of this material behind for future harvests. With stumpage rates low, the value of wood chips has to rise considerably for it to be interesting to the landowner to have a logger in his or her woodlot. Nevertheless, as one might suspect from the pivotal role that the value of sawtimber plays in our estimation of wood chip values, both the shape and the height of the curve could change fairly dramatically with a recovery in hardwood lumber prices. As with other sources of biomass from agricultural system, this analysis also raises questions related to infrastructure. There are relatively few loggers in the region that are well-equipped to harvest wood chips in the forest on an efficient basis, and the depressed status of the forest industry is probably making this situation worse. The researchers were disappointed not to be able to come up with a clearer view of the wood chip price at which it would be economically interesting to begin to tend the forests in this part of the state. This will require some additional effort in order to effectively determine the amount of woody biomass that could be generated from thinning operations. Paradoxically, the generally poor condition of forest properties evaluated (little valuable standing timber, low stocking rates) acts as a deterrent on the use of wood chip sales to drive improved management practices that could accelerate these woodlots recovery as a productive resource.

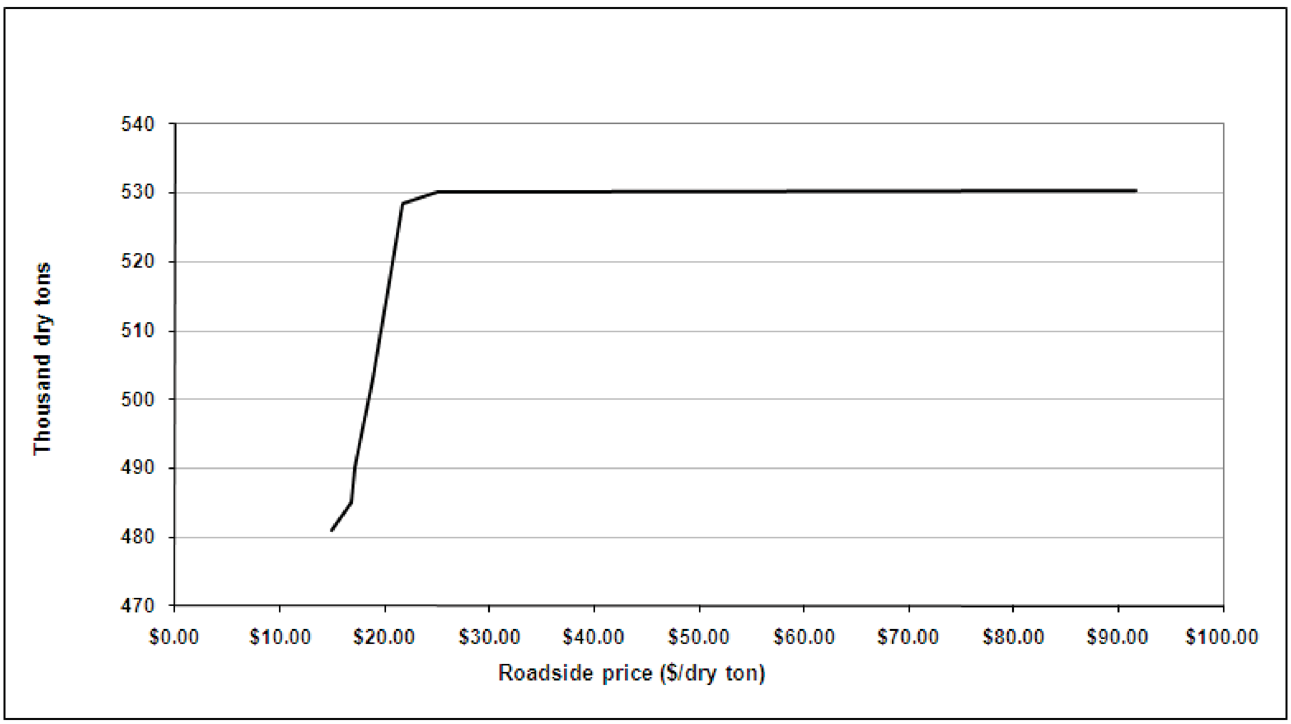


Figure 12. Amount of wood chips from forest land (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY through high grading harvests for different roadside prices ($/oven dry ton).

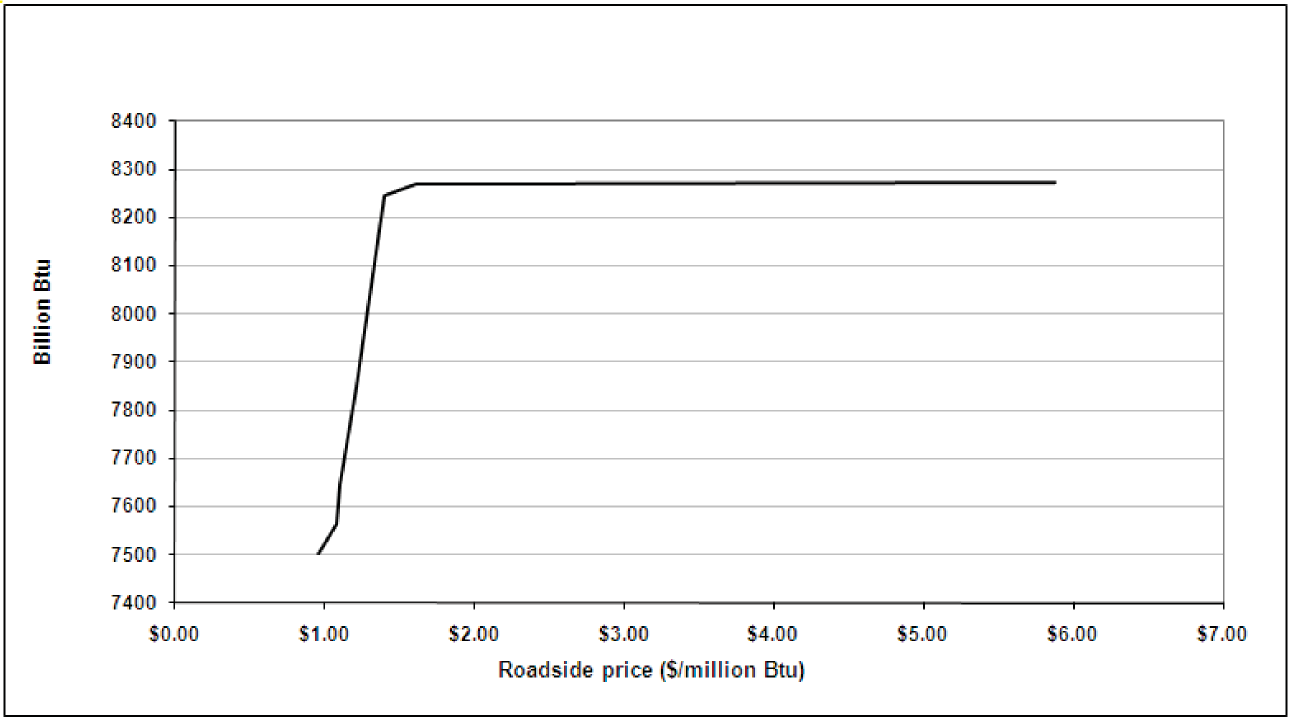


Figure 13. Amount of wood chips from forest land (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY through high grading harvests for different farm gate prices ($/million Btu).

There is a smaller quantity of woody biomass, 315,000 – 375,000 dry tons (Figure 14 and 15), that is potentially available from shelterwood harvests in the region. As with high grade cuts, the availability of this material is largely driven by the availability of sawtimber from these harvests and the value for sawtimber at the time of the harvest. Because of this associated value of the sawtimber from these operations, woody biomass is potentially available at a relatively low price at the roadside ($15 – 25/dry ton). As with the other sources of biomass, this is a roadside price and does not include handling and hauling costs. The same concerns about an available supply chain infrastructure to harvest and process this material effectively that was expressed for high grade harvests is also present for these types of operations as well.

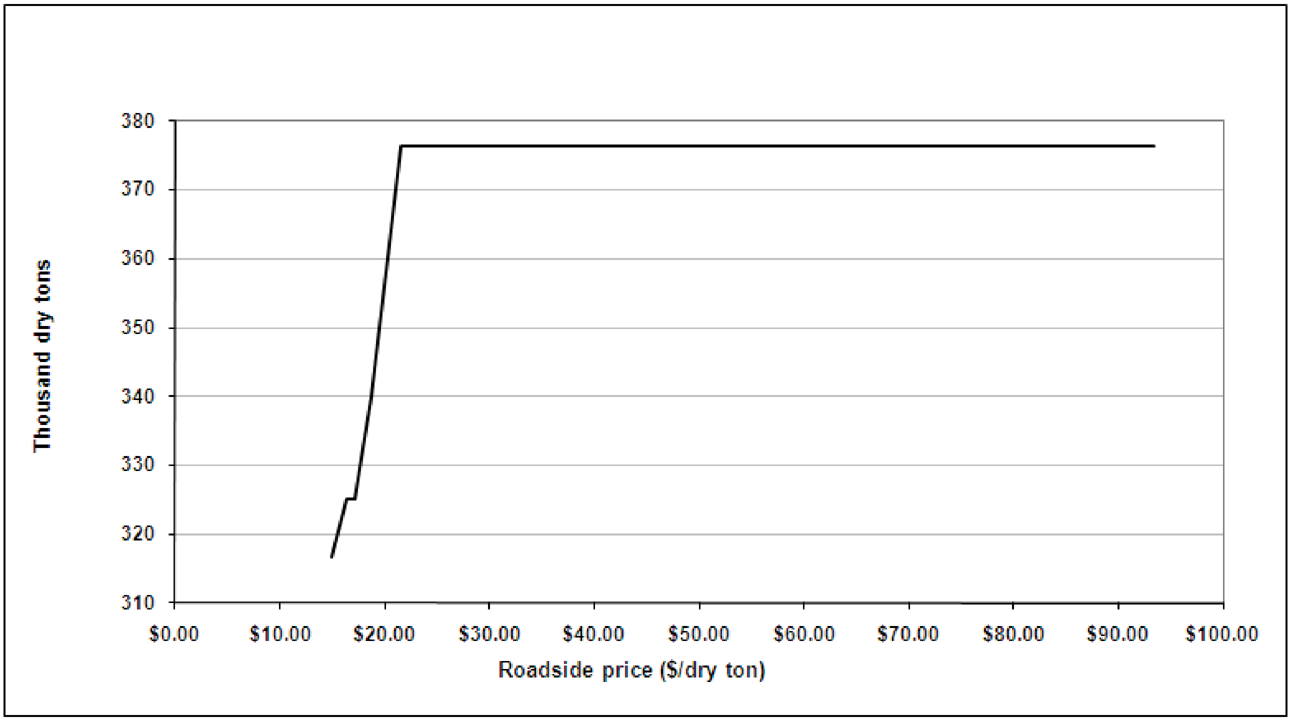


Figure 14. Amount of wood chips from forest land (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY through shelterwood harvests for different roadside prices ($/oven dry ton).

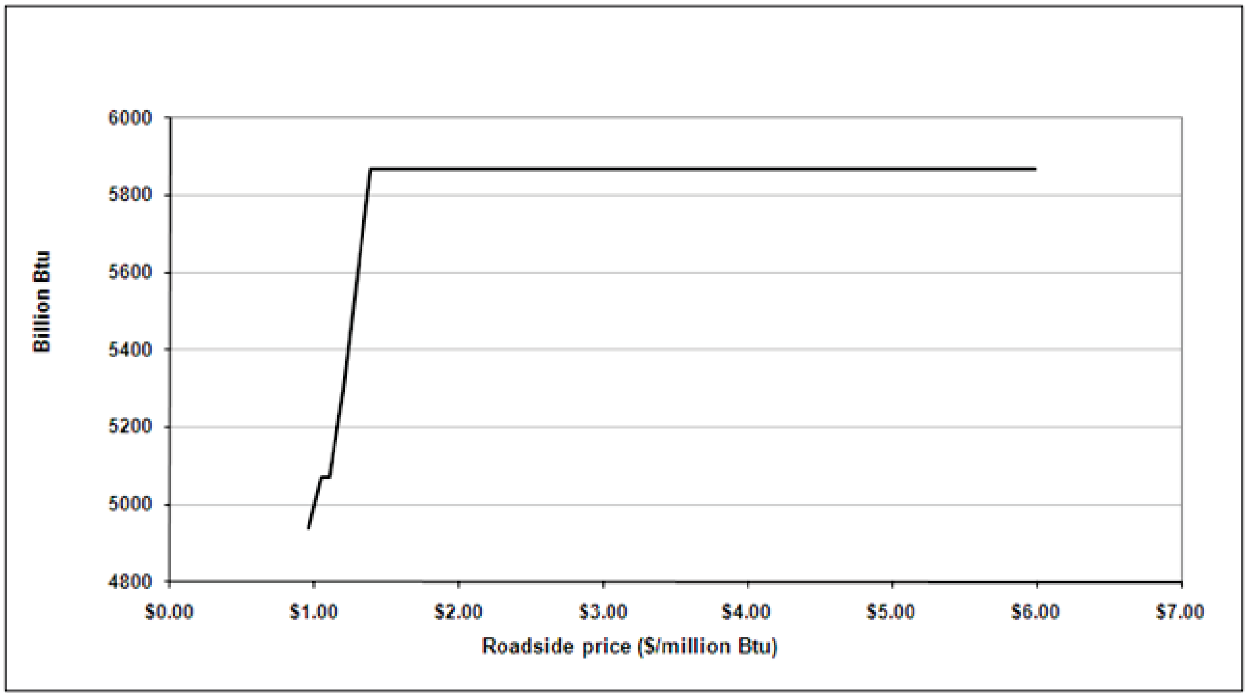


Figure 15. Amount of wood chips from forest land (oven dry tons) that could be produced in a 25 mile radius around Syracuse, NY through shelterwood harvests for different farm gate prices ($/million Btu).

IV. Implications for the development of a biomass supply chain

Although the condition of the forests in the supply shed is not conducive to intensive management either for sawtimber or energy purposes, about half the forest is available for either high grade or shelterwood cutting, economics permitting, from the perspective of the landowner.

The percentage of agricultural land potentially available to produce improved grasses or willow is even higher, costs permitting. The steady progress that is being made to increase potential productivity of both grasses and willow offer considerable promise for developing these crops as an energy source in this region, but not at a Btu cost comparable to natural gas or coal – at least where we find those prices during the current economic downturn. Still, wood chips and willow biomass produced for under $ 25/Mbtu (at $3.00 per gallon and an 85% efficient system the cost for heat from fuel oil is about $25.00/Mbtu. Thus biomass may be cost competitive with fuel oil used for heating applications in the region; but most of the unimproved grasses, ¾ of the improved grass, and all of the willow and forest biomass is available below that price. The additional costs of hauling the biomass from the farm or forest to an end user and differences in operating efficiency of biomass and oil systems would also need to be considered in a more complete comparison.

V. Considerations for future research

A. Response bias – A random selection of 100 properties was drawn from the list of 500 properties selected for the original mailing for a phone interview of non-respondents designed to determine whether those who mailed back the invitation to participate in the study appeared to be a different group from those who did not. No effort was made to determine whether non-respondents were more or less likely to be willing to grow biomass, since the overall project methodology assumed that it would be next to impossible to obtain useful insight on that central issue without a face-to-face discussion with the property owners focused on how each piece of their property is now being used and their reaction to different future options – including considering potential economic returns. Questions for the phone survey were selected if they met three criteria: data that was also being collected in the course of property evaluations and interviews, information that could be collected with some degree of confidence through a phone enquiry, and a list that could be covered in less than ten minutes. The interview script appears in Appendix F. Difficulty in coming up with phone numbers associated with property owner names and addresses drawn randomly from tax rolls, difficulty of reaching some landowners by phone, and unwillingness of some landowners to be interviewed made it necessary to draw an additional 50 names from the list of 500 in order to reach the target of 45 phone interview responses, equaling the number of completed property owner face-to-face interviews.

The following table summarizes results of the phone survey:

Land/landowner characteristic	Respondents (%)	Non-respondents (%)
Resident on property	44	62
Farms some of property	40	51
Rents some of property to a farmer	42	37
Harvests firewood	48	53
Has logged in the past five years	44	53
Plans to log in the next five years	33	31
Financial return is an important factor in ownership	48	53
Percent of property agricultural land (average)	44	56
Percent of property wooded (average)	47	40
Total acres in parcel (median)	119	114

The follow up phone survey indicated that there were very few differences between the group of people that were surveyed and those that did not respond to the invitation to participate in the study. The data in the table above suggest that farmers, and also owners who resided on the property in question were somewhat under-represented. One could hypothesize that the under-representation of farmers represents "survey fatigue" in a group that is regularly contacted by government agencies and others who are trying to gather data on the farm economy. It is possible that resident landowners, whose main objective for their property is often linked to living in a rural setting, are less likely to be looking for alternative uses for their property compared to those who do not live on the property on a regular basis.

B. <u>Sample selection and number of study properties</u> – Sample selection was stratified by tax parcel acreage, to assure that larger properties, which represent a disproportionate share of total acreage within the supply shed, were not under-represented. This seems to have been an appropriate research strategy, since the subject of the analysis was acreage rather than landowners. A larger sample might have made it possible to determine whether analysis of a smaller number of properties than the number of properties actually analyzed could have produced equivalent results. However, with only 45 properties in the final study group, no effort was made to determine whether a smaller sample would have served as well.

C. Data gathering efficiency and cost – Given the variability in responses, ownership views, and land use patterns encountered with the properties analyzed, there is little question that analyzing a larger group of properties would have been informative, had the project budget permitted an expanded effort. Some cost savings – permitting analysis of a larger sample – could have been achieved with more experience in managing field work, and with a higher number of study properties to reduce travel time for field assessments and interviews. The largest expenditure in the field studies was related to traveling and conducting the face to face interviews, but a considerable amount of effort was also spent selecting the properties and developing and refining the individual property biomass assessments. Since this was the first time this approach had been used in the field, a number of these steps took more time. As they were refined over the course of the project and non essential steps were identified, the overall cost of collecting this data declined. Future efforts using this approach would be considerably more efficient since the lessons learned here would not have to be repeated.

D. Lessons learned – This study successfully demonstrated that it is possible to merge GIS data, "ground truth" information about the actual productive potential of specific plots of land and forest, and an overlay of information about landowners as economic agents in a way that provides useful information to developers of biomass energy projects. The decision to gather information directly from landowners made this work both relatively expensive and, we believe, considerable more plausible than what we might have been able to obtain from a mail survey or series of focus groups. However, compared to the costs of a site specific wind resource assessment for a potential wind farm, these costs are not particularly high. In addition the information generated will allow a biomass developer to more accurately determine feedstock costs for their facility.

The transactional nature of the interview process – interviewers sharing information about the landowners property as well as cropping and forestry options with which landowners were often completely unfamiliar, in exchange for what interviewers believe were frank responses to relatively sensitive questions – appeared to successfully build trust, and permit the interviewers to approach difficult questions (e.g., the rent an owner would like to receive to commit his land to a given use by a third party) from enough different angles to get a useable answer. The technique required mature, experienced, and knowledgeable interviewers, which necessarily contributed to the project's overall cost. Given the relatively subjective nature of some of the information gathered, questions could be raised about the reliability of the data. The interview technique was beta tested by the field interviewers, who then wrote their results independently to see if they were "hearing the same thing", or interpreting what they heard differently. While results on scalar variables were not identical, they were very close, and results on matters that required a specific answer from the interviewee were identical. Nevertheless, researchers believe that both selection and preparation of interviewers is essential to producing valid results from an analysis that includes this large amount of interview data.

The sampling approach used to draw conclusions about a body of data (landowner interests in more than 7000 tax parcels within 25 miles of a potential production site), would appear to be a sound approach to analyzing the questions researchers were trying to address. A small sample produces a large margin of error, although we do not see any reason to believe that there is a systematic bias in any direction that we can identify. We consider cost estimates conservative in the sense of biased to the high side for reasons mentioned earlier in this report. If one were to make a business decision regarding an investment in a bioenergy plant on the basis of this report, prudence would argue for considering only a biomass type that would be available at a cost the plant could afford in an amount considerably larger than what the plant would require.

The forest analysis proved to be a good vehicle for landowner education, and it also produced information about the condition of forests in the region that has been useful to one of the project leaders in a different context. In contrast to the methodology for developing a cost curve for cropped biomass – which was enough of a success to be worth replicating – the project team did not have the same degree of confidence in the results of the forest biomass analysis. Forests do not have a defined three-year harvest cycle like willow does, or an annual cycle like hay. The decision to conduct harvest operations for sawtimber, biomass or other products is influenced by current stumpage prices (or the demand for sawtimber, from the logger's perspective), to some extent by the paper industry, to a significant extent by the demand for firewood in this region and, increasingly demand from pellet mills and other energy sector customers. Modeling annual output in this setting – particularly since the vast majority of forest owners have non-economic motivations for forest ownership – depends on a number of assumptions that were not incorporated into these models so that it is difficult to place high degree of confidence in this particular set of results. Still, the prices generated from the models are in the range of prices that are currently being paid for wood chips used for energy in upstate NY. Since forest biomass was only one of six feedstocks being assessed in this project, more time could not be devoted to improving the in forest data collection and cost models developed. Seeing that cost for woody biomass is at the low end of the all the feedstock sources and that there is a considerable amount of forest cover in NY, additional work to refine these models would be beneficial so that developers could be more confident in their results.

It is possible to model the maximum sustainable yield of forests in any region under various transparent assumptions (e.g., removal at less than the current rate of growth), and information that about half of the forest area in blocks larger than 25 acres in the region is potentially available for harvesting is useful in this context. However, because a mixture of factors other than price often determine a landowner's willingness to harvest sawtimber or biomass from forest land and the fluctuating prices for sawtimber from week to week or year to year, the reliability of this supply is sometimes seen as somewhat uncertain. As a result dedicated energy crops like grasses of willow may be seen as a more predictable source of biomass for larger scale facilities despite their higher price.

The tool that was developed and lessons that were learned during this project were used for another study around Morrisville, NY, with support from the NY Farm Viability Institute. The Morrisville study focused exclusively on the potential supply from dedicated energy crops. Because of the development work that was done in the current project, the method used for field analysis of biomass production potential around Morrisville was more straight forward, efficient and accurate while costing less per acre assessed. The larger sample size in this second study produced important efficiencies in conducting field work. A better structure for capturing data that built directly off the formats developed in the Syracuse project substantially reduced the time required to analyze data. The information collected during the Morrisville study was more focused because lessons learned during the Syracuse project allowed the team to refine the data that had to be collected and questions that had to be asked in order to generate a reliable result.

An improvement in the face to face interview process was to bring a laptop with biomass crops production models to the interview. This provided an opportunity for landowners to see real time simulations of costs and returns for the cropped biomass options under various management and cost scenarios. This process helped landowners to be more specific about their preferences and improved the accuracy of the data that was collected. The lack of an assessment of forest biomass is still a limitation of this second study, but funds were not available to support the refinement of this part of the assessment.

APPENDIX A – INVITATION TO PARTICIPATE IN STUDY

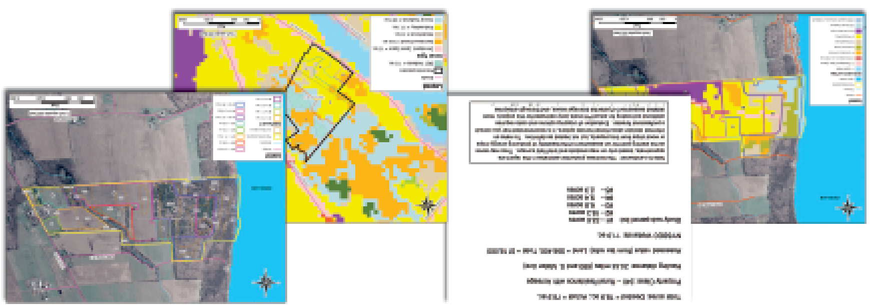
ESF
State University of New York
College of Environmental Science and Forestry

Renewable Energy Research
320 Bray Hall
1 Forestry Drive
Syracuse, NY 13210

New York Landowners: SUNY-ESF is conducting a research study in your area.

The study will evaluate how properties in Central New York could contribute to the needs of a bioenergy or biofuel plant located in Syracuse. There is no cost or obligation to participate in this research project.

Participants will receive a report on their property's biomass output potential. We will not disturb the land or attempt to influence landowners' use of their property.



This project is funded by the New York State Energy Research and Development Authority (NYSERDA)

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL
FIRST-CLASS MAIL PERMIT NO. 2486 SYRACUSE NY

POSTAGE WILL BE PAID BY ADDRESSEE

RENEWABLE ENERGY RESEARCH
320 BRAY HALL
SUNY-ESF
1 FORESTRY DRIVE
SYRACUSE, NY 13210-7900

This project is funded by the New York State Energy Research and Development Authority (NYSERDA) as part of its ongoing effort to expand the state's renewable energy options.

The SUNY College of Environmental Science and Forestry (ESF) offers you an opportunity to learn more about your property's potential to produce biomass that can be turned into energy.

This project — a study of this region's potential for producing agricultural and forest products that can be converted into bioenergy — is for research purposes only. We will not disturb the land or attempt to influence landowners' use of their property. We will simply gather information and the participating landowners will learn more about potential uses for their property.

This project will study a range of possible bioenergy feedstocks, including wood chips from low-value forest trees, shrub willow, perennial grasses, and agricultural crop residues.

We invite participation from owners of property that includes enough open or forested land to support commercial production of feedstocks. The study will evaluate how properties in Central New York could contribute to the needs of a bioenergy or biofuel plant located in Syracuse, taking into consideration owners' individual interests and preferences.

Study participants will receive our team's technical assessment of potential annual output of bioenergy feedstock from their own property. The assessment will integrate map data, crop and forest production models, and the results of an on-site evaluation, summarized in a detailed written report. A member of our research team will provide the landowner with the report during a one-hour interview designed to make connections between the land's output potential and the landowner's interests and plans for future use of the property. The names and addresses of study participants and all interview data will be kept entirely confidential.

This project is funded by the New York State Energy Research and Development Authority (NYSERDA) as part of its ongoing effort to expand the state's renewable energy options.

If you'd like us to put you on the list of people interested in participating in this study, please provide the information requested on the attached postcard and drop it in the mail within the next few days.

Thank you for considering our request for your collaboration in this important study.

For additional information, contact:

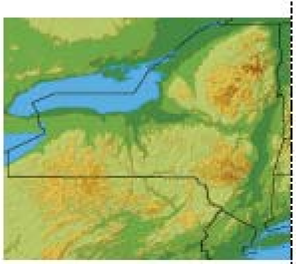
Philip Castellano
pjcastel@syr.edu

Timothy Volk, Ph.D.
tavolk@esf.edu
315-470-6774

This is a scientific research study. Participants are under no obligation.

This is an information gathering effort.

Participating landowners will learn more about potential uses for their property.



☑ **Yes!** **I am interested in participating in the Regional Bioenergy Feedstock Study**

Name: ____________________

Contact me by telephone at: ____________________

I prefer to be contacted by e-mail at: ____________________

The names and addresses of study participants and all interview data will be kept entirely confidential.

My mailing address is: ____________________

____

____

ESF State University of New York College of Environmental Science and Forestry

The informational report that you will receive at the end of the study can be used to better your future.

APPENDIX B – SECOND MAILING TO PARTICIPATING LANDOWNERS

ESF

State University of New York
College of Environmental Science and Forestry

Department of Forest and Natural Resources Management

Date:

To: [name and address from list of those who were selected from the group who sent in postcards]

Thank you for your interest in participating in our study of this region's potential for producing agricultural and forest products that can be converted into bioenergy. This letter is to inform you how we would like to proceed with this study and request permission to access your property to assess its potential to produce different types of biomass. Your individual property that has been randomly selected from several thousand parcels in the area for this study is located in the town of on Road, Street, Route. You will note that on the acknowledgement form below that we have assigned your property a study number rather than use tax property identification number in order to avoid distributing that information. We will use this number in all future communications with you about your property.

After receiving the enclosed acknowledgement letter from you, we will assemble mapped data that is publicly available for your property including land cover types, soils data, and slope (We have included a sample set of maps for a property in the region for your information). We will then arrange for on-site assessment visits by members of our research team to supplement the information we have on the maps. These assessments will involve a visual inspection of agricultural and open fields and some basic assessment of the size, species and potential volume of wood on forest land. Explanations of the different types of feedstock that will be evaluated by the team and that will be included in the summary property report are included in this package. Team members involved in this assessment will be employed by one of the project partners - SUNY-ESF or Central New York Land Management. Prior to visiting your property, one of the team members will call you and let you know when we plan on assessing your property. It is not necessary for you to be present during the site visits, which are for measurement and visual assessment purposes only.

Once results of the on-site visit have been compiled into a summary property report, we will contact you to schedule a face-to-face interview at a time that is mutually convenient with you and either Dan Conable or Chuck Kyle, who are members of our project team. It is anticipated that the interview will take about one hour. Dan or Chuck will provide you with a copy of the report that summarizes the biomass feedstock production potential on your property and will explain the information contained in the report. The major focus of the interview will be on how you are using your property now and your thoughts about possible future uses for your property.

All study participants will receive a copy of final results of our study, from which they can assess how their own property fits into the regional assessment of land that could produce biomass for bioenergy. Individual property information, property owners' names and the specific location of their properties will not be included in any public report or publication.

If you have any questions about this process, please contact Dan Conable at 529-0634 or dconable@att.net.

Thank you again for being willing to participate in this research project.

Timothy A. Volk, Project Director

Regional Bioenergy Feedstock Study

Acknowledgement Form

[name]

This confirms my agreement to participate in the Regional Bioenergy Feedstock Study conducted by SUNY-ESF and Central New York Land Management. I understand that my property will be visited by one or more members of the study team within the next few weeks to conduct an on-site assessment of crop and/or forest product production potential. I understand that members of the team will notify me of the approximate time when they will visit my property. Once that work is complete, I will be available for a face-to-face interview of about one hour at a time that fits my schedule and that of the interviewer.

The best way to contact me to inform me of site visits and arrange a time for an interview is:

Name: ____

Phone: ____

Mobile Phone: ____________________________________

E-mail: ____

Signature ____

APPENDIX C – SAMPLE PROPERTY REPORT

SAMPLE PROPERTY REPORT – EXPLANATIONS

After our field visits and assessments, one of our project staff members will come to discuss the results of the summary property report for your parcel. The report will include an estimate of the potential for cropped feedstocks from properties that have at least 10 acres of open agricultural land and of wood for properties that have at least 25 acres of forested land.

We are evaluating the potential for producing these cropped feedstocks:

Improved grasses – these are a perennial crop, meaning that they are planted once and harvested for a number of years before it is necessary to plant them again. Some of the species that are being studied for planting in this manner are reed canary grass, switch grass, and big bluestem. The production of these grasses is minimal in the first year after planting, after which they achieve their full production potential.

Unimproved grasses – these are also perennial, usually a mixture of grasses that have self-seeded or been planted more than ten years ago on a field that is being regularly cut for low-quality hay, or simply to keep the ground open. Typical grasses on this kind of field are timothy or orchard grass. They are likely to yield less than improved grasses, but you save the cost of planting.

Corn stover – these are the stalks that are left over after you harvest corn for grain. This feedstock is available only as a by-product of growing corn on a particular piece of property, and they are worth a great deal less than the corn. Removing all of the corn stover has some impact on soil fertility. We will evaluate the potential of each field to produce corn, and calculate potential corn stover yield from the potential corn yield.

Soybean straw – These are the stalks left over after harvesting soybeans. This feedstock is also available only as a by-product. We will evaluate the potential of each field to produce soybeans, and calculate potential soybean straw yield from the potential soybean yield.

Shrub willow – This is a bushy relative of willow trees that grows about twenty feet high, and can be harvested by machinery similar to corn harvesters with special heavy-duty cutting heads that chop the willow into chips that can be turned into energy. Shrub willow is grown from cuttings that put out their own roots after planting. Growing shrub willow would require hiring someone with a specialized planter to put in the cuttings, and then hiring a custom operator to harvest the crop. Willow produces a crop every three or four years, and can be harvested continuously for twenty years or more.

Forest-harvested wood chips – Woodlots can also produce wood chips that can be used as energy feedstock. Most woodlots have some quantity of “merchantable timber”, meaning trees of desirable species like maple and cherry that are large enough to produce logs that a commercial sawmill might purchase to make lumber. After harvesting these logs, branches that cannot be milled into lumber are left over. There are usually many trees of undesirable species or sizes too small for milling in a typical woodlot. In our evaluation, we estimate both the quality of merchantable timber and tops and lower quality (or pulp) wood that could be chipped as well.

There are many different ways to harvest a woodlot. We consider four options:

- **A conversion cut**: This would take place only if the landowner wanted to remove all the trees from a particular part of their property, either because they wanted to build on that site or convert that land to agricultural use. This type of cut produces the maximum amount of biomass, but it can also add additional costs, since it may involve removing both the trees and tree stumps.
- **A high-grade cut**: This practice consists of harvesting only those trees that are merchantable. The landowner is paid a "stumpage" fee for the desirable timber and lower quality stems used for pulp wood or firewood. Tops (treetops and branches) can be chipped or left in the forest.
- **A shelterwood cut**: This is a forestry practice designed to regenerate a woodlot. It focuses on the seed source and growing conditions for the regenerating seedlings. First, most of the trees are removed, leaving mature, seed-producing trees as "parents". This opens up the stand, providing plentiful water, sunlight and nutrients for seedlings, while also offering protection from too much exposure. Second, the overstory of parent trees will be removed once the seedlings are established – hopefully in 5-10 years. Parent trees are chosen based on species, commercial value, spacing and health.
- **A thinning cut**: Many woodlots would produce more merchantable timber in the long run if crooked, lower-quality, and other trees crowding the most promising trees were systematically removed on a regular schedule. Hence, the objective of a crown thinning is to enhance the growth and development of the best trees. The crown thinning removes dominant and co-dominant trees of lesser value, poor form and health, allowing light to reach more foliage in the upper canopy of the selected, higher quality residual trees. This will improve diameter growth of residual trees. The crown thinning method leaves the overtopped and intermediate trees that do not interfere with those of better canopy positions.

To analyze your property, we will use aerial photographs and land cover maps, like the example attached, to divide the parcel up into numbered "subparcels" – basically separate fields and woodlots. We will then evaluate the productive potential of each subparcel. The unit for corn stover, soybean straw, grasses, and wood chips is tons per acre. For corn and soybeans it is bushels per acre. We also lead off our estimates with a current value for each of these products. This enables us to calculate a gross return per acre for each. By "gross", we mean before making any allowance for costs. If the yield is a small one, there might be no one willing to harvest the crop or the wood, unless you were willing to pay for the work than the crop or wood harvest would produce. However, these prices change constantly; higher prices for hay or wood chips could change the picture completely. We'll be happy to discuss this with you during the interview.

SAMPLE PRELIMINARY BIOMASS FEEDSTOCK REPORT

SYRACUSE REGIONAL ASSESSMENT

SUNY ESF/NYSERDA BIOMASS PRODUCTION POTENTIAL STUDY

Confidential Report – information has been gathered for study purposed only, and will be made available only to the property owner and with members of the research team

Owner: XXXX.

Tax map number: XXXXX

Address: XXXXX

Road location: XXXXXX

Total acres: Deeded = 78.9 ac.; Actual = 78.9 ac.

Property Class: 240 – Rural Residence with Acreage

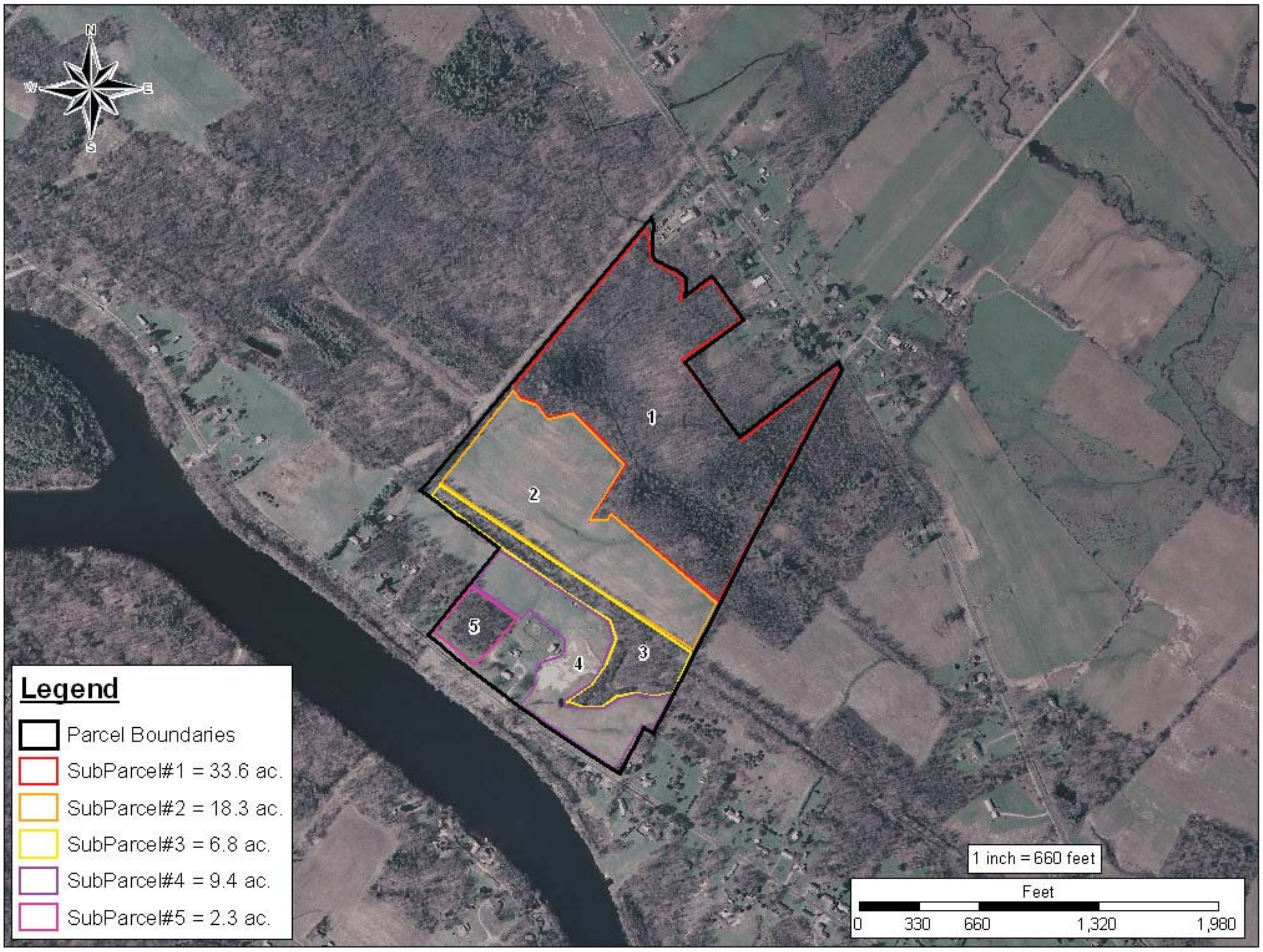
Hauling distance: 24.44 miles (690 and S. Midler Ave)

Assessed value (from tax rolls): Land = $56,400; Total = $118,000

NYSDEC Wetlands: 11.0 ac.

Study sub-parcel list:
- #1 - 33.6 acres
- #2 - 18.3 acres
- #3 - 6.8 acres
- #4 - 9.4 acres
- #5 - 2.3 acres

> Note to Landowner: The biomass production estimates in this report are approximate, based only on map analysis and brief field surveys. They may serve as the starting point for an assessment of the feasibility of producing energy crops or wood chips from this property, but not treated as definitive. To make an informed decision about forest harvest options, it is recommended that you consult a professional forester. Evaluation of cropping options and costs requires additional soil testing for actual PH levels (only estimated for this project), more detailed assessment of potential drainage issues, and thorough enterprise budgeting, if this is work you intend to carry out yourself. Cornell Cooperative Extension is a good starting point to obtain basic information on costs and culture practices appropriate for this region of the state.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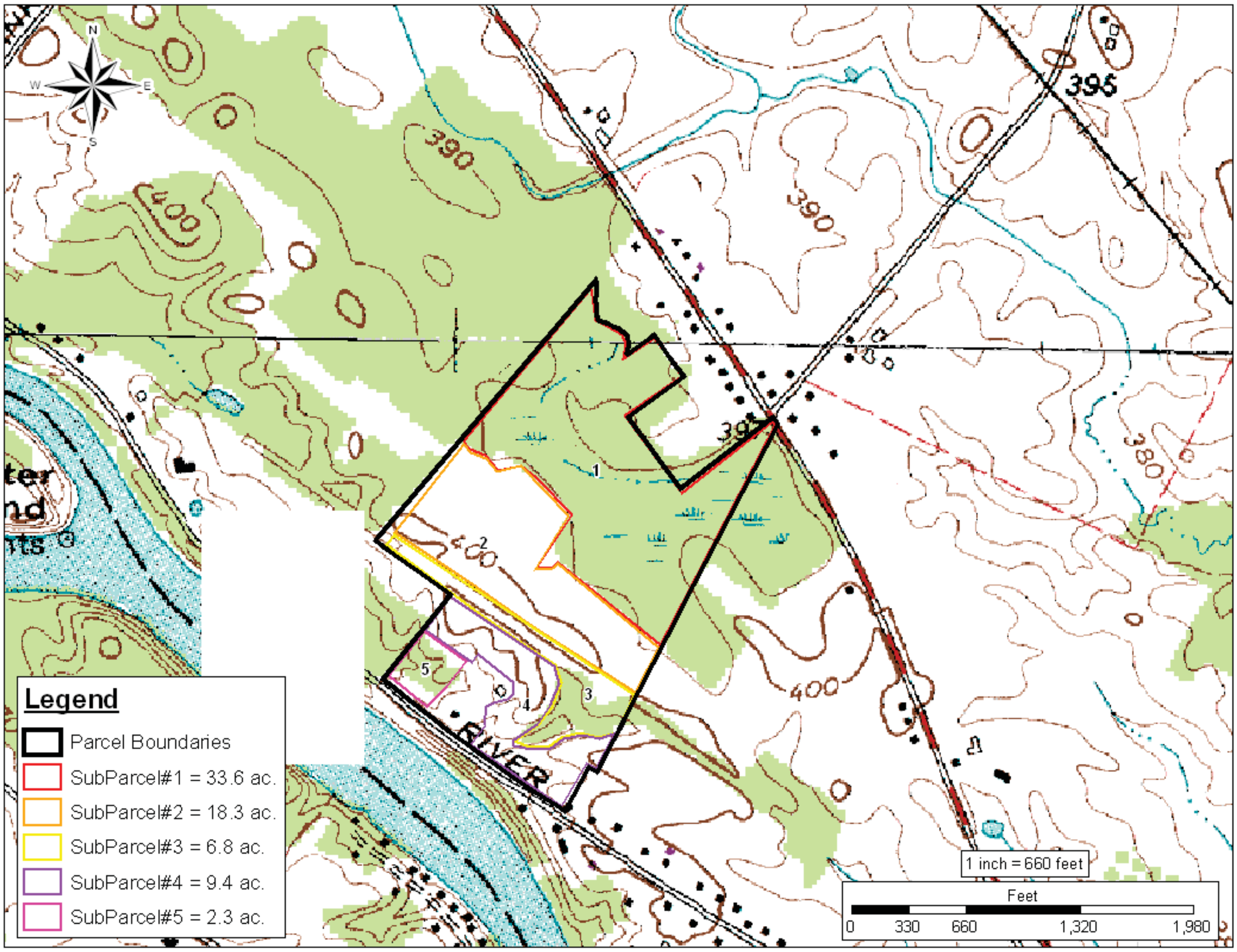
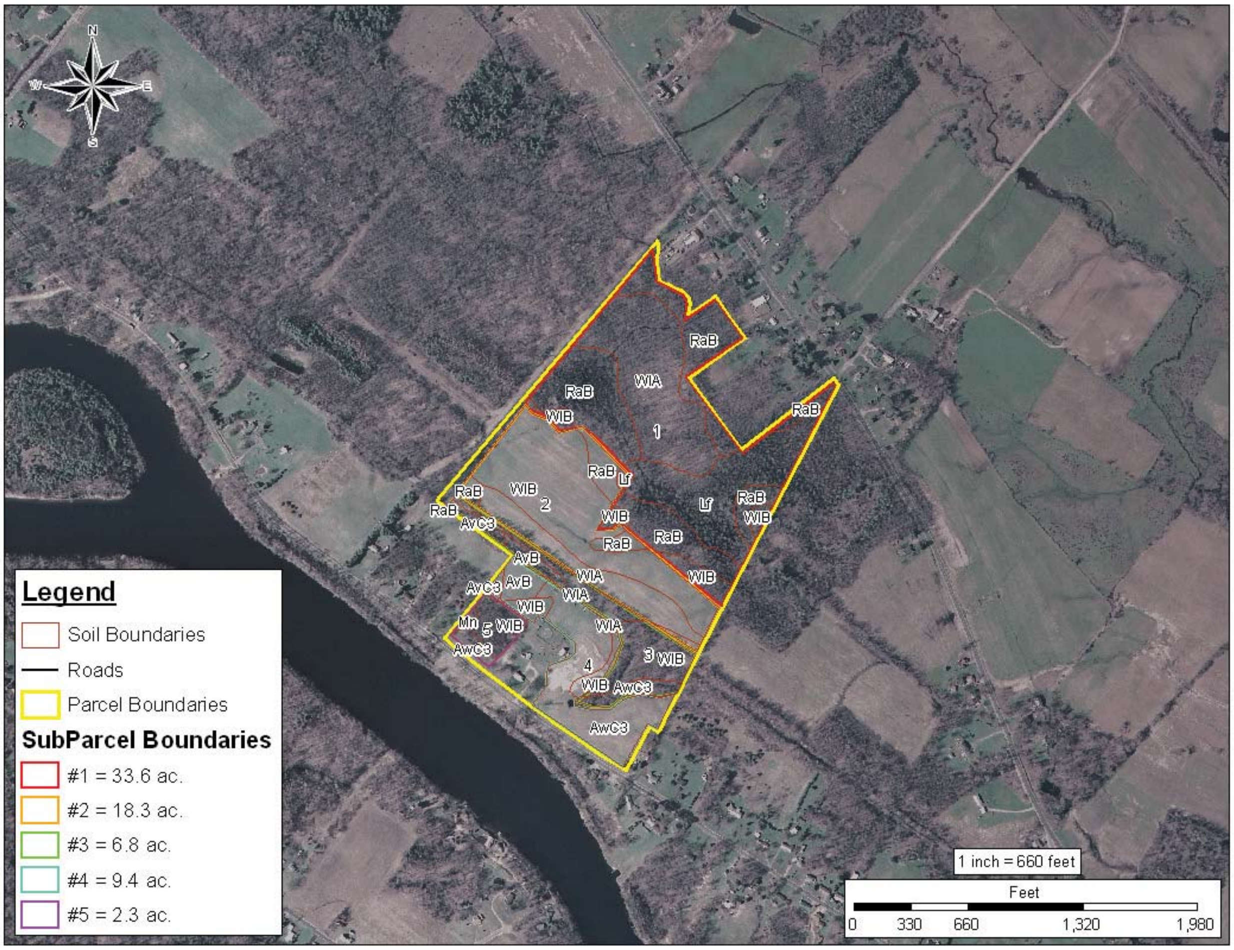
Legend
Parcel Boundaries
SubParcel#1 = 33.6 ac.
SubParcel#2 = 18.3 ac.
SubParcel#3 = 6.8 ac.
SubParcel#4 = 9.4 ac.
SubParcel#5 = 2.3 ac.
1 inch = 660 feet
Feet
0 330 660 1,320 1,980



Legend
Parcel Boundaries
SubParcel#1 = 33.6 ac.
SubParcel#2 = 18.3 ac.
SubParcel#3 = 6.8 ac.
SubParcel#4 = 9.4 ac.
SubParcel#5 = 2.3 ac.
1 inch = 660 feet
Feet
0 330 660 1,320 1,980
RIVER
390
400
395
380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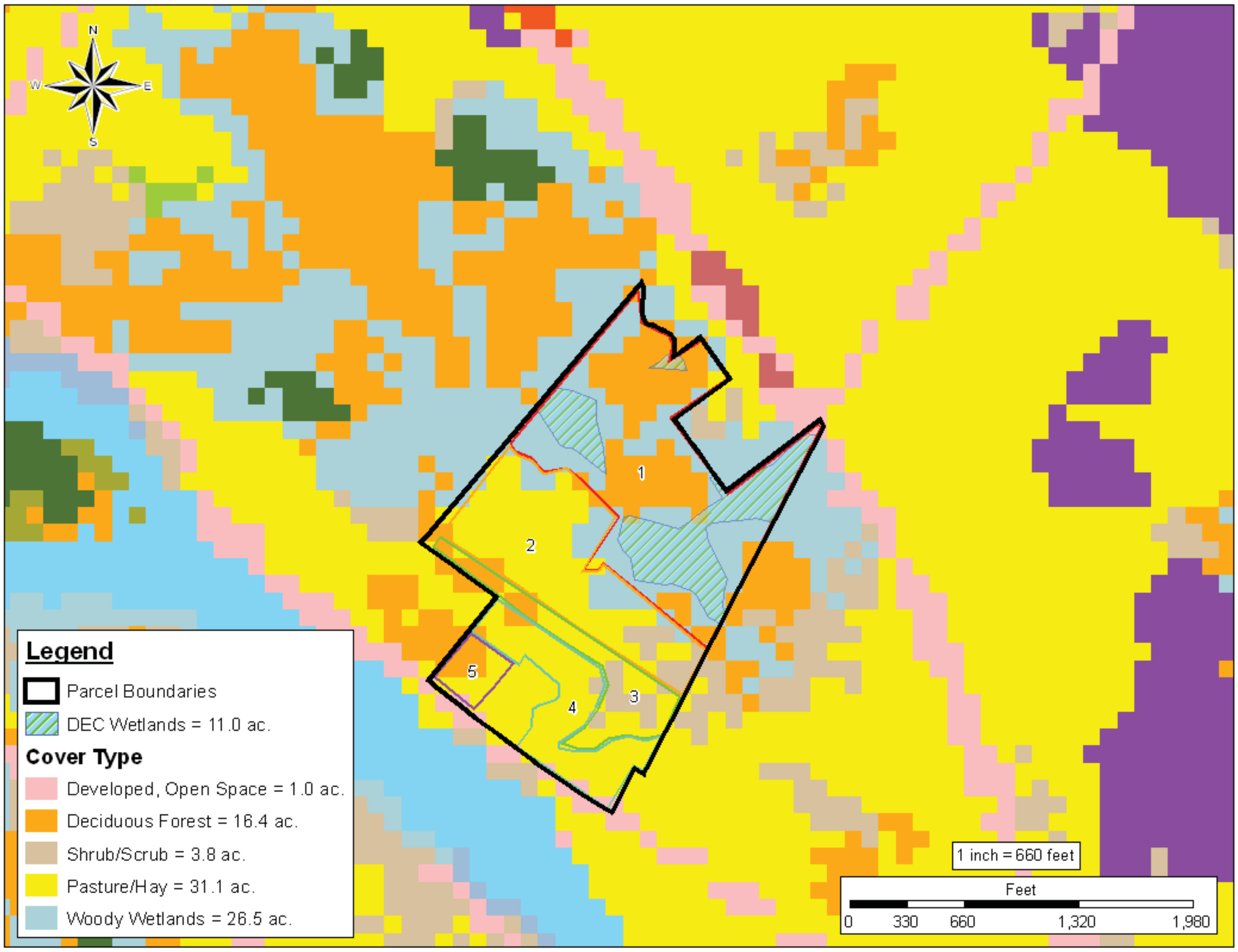
WIB
RaB
RaB
AvB
WIA
WIB
AvC3
AvB
WIA
WIB
Mn
5
WIB
WIA
AwC3
3
WIB
4
WIB
AwC3
AwC3
Legend
Soil Boundaries
Roads
Parcel Boundaries
SubParcel Boundaries
#1 = 33.6 ac.
#2 = 18.3 ac.
#3 = 6.8 ac.
#4 = 9.4 ac.
#5 = 2.3 ac.
1 inch = 660 feet
Feet
0 330 660 1,320 1,980

SubParcel Soil Acreages

SubParcel #	SubParcel Acreage	Cover Type	Mapping Unit Symbol	Soil Acreage	Mapping Unit Name	Farmland Soil Classification
1	33.6	Deciduous/Wetlands	RaB	13.9	Raynham silt loam, 0 to 6 percent slopes	Prime farmland if drained
1	33.6	Deciduous/Wetlands	WIA	9.9	Williamson very fine sandy loam, 0 to 2 percent slopes	All areas are prime farmland
1	33.6	Deciduous/Wetlands	Lf	7.8	Lamson very fine sandy loam	Farmland of statewide importance
1	33.6	Deciduous/Wetlands	WIB	2.1	Williamson very fine sandy loam, 2 to 6 percent slopes	All areas are prime farmland
2	18.3	Pasture/Hay	WIB	11.9	Williamson very fine sandy loam, 2 to 6 percent slopes	All areas are prime farmland
2	18.3	Pasture/Hay	WIA	4.3	Williamson very fine sandy loam, 0 to 2 percent slopes	All areas are prime farmland
2	18.3	Pasture/Hay	RaB	1.6	Raynham silt loam, 0 to 6 percent slopes	Prime farmland if drained
2	18.3	Pasture/Hay	RaB	0.4	Raynham silt loam, 0 to 6 percent slopes	Prime farmland if drained
2	18.3	Pasture/Hay	Lf	0.1	Lamson very fine sandy loam	Farmland of statewide importance
3	6.8	Deciduous/Pasture	WIB	3.1	Williamson very fine sandy loam, 2 to 6 percent slopes	All areas are prime farmland
3	6.8	Deciduous/Pasture	WIA	1.5	Williamson very fine sandy loam, 0 to 2 percent slopes	All areas are prime farmland
3	6.8	Deciduous/Pasture	AwC3	1.1	Amboy-Williamson complex, rolling, severely eroded	Not prime farmland
3	6.8	Deciduous/Pasture	AvB	0.5	Amboy very fine sandy loam, 2 to 6 percent slopes	All areas are prime farmland
3	6.8	Deciduous/Pasture	AvC3	0.5	Amboy very fine sandy loam, 6 to 12 percent slopes, severely eroded	Not prime farmland
3	6.8	Deciduous/Pasture	RaB	0.1	Raynham silt loam, 0 to 6 percent slopes	Prime farmland if drained
4	9.4	Pasture/Hay	AwC3	7.0	Amboy-Williamson complex, rolling, severely eroded	Not prime farmland
4	9.4	Pasture/Hay	AvB	1.0	Amboy very fine sandy loam, 2 to 6 percent slopes	All areas are prime farmland
4	9.4	Pasture/Hay	WIB	0.6	Williamson very fine sandy loam, 2 to 6 percent slopes	All areas are prime farmland
4	9.4	Pasture/Hay	WIB	0.5	Williamson very fine sandy loam, 2 to 6 percent slopes	All areas are prime farmland
4	9.4	Pasture/Hay	AvC3	0.2	Amboy very fine sandy loam, 6 to 12 percent slopes, severely eroded	Not prime farmland
4	9.4	Pasture/Hay	WIA	0.1	Williamson very fine sandy loam, 0 to 2 percent slopes	All areas are prime farmland
5	2.3	Deciduous Forest	WIB	1.6	Williamson very fine sandy loam, 2 to 6 percent slopes	All areas are prime farmland
5	2.3	Deciduous Forest	AwC3	0.5	Amboy-Williamson complex, rolling, severely eroded	Not prime farmland
5	2.3	Deciduous Forest	Mn	0.2	Minoa very fine sandy loam	Prime farmland if drained
5	2.3	Deciduous Forest	AvC3	0.02	Amboy very fine sandy loam, 6 to 12 percent slopes, severely eroded	Not prime farmland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Legend
Parcel Boundaries
DEC Wetlands = 11.0 ac.
Cover Type
Developed, Open Space = 1.0 ac.
Deciduous Forest = 16.4 ac.
Shrub/Scrub = 3.8 ac.
Pasture/Hay = 31.1 ac.
Woody Wetlands = 26.5 ac.
1 inch = 660 feet
Feet
0 330 660 1,320 1,980

AGRICULTURAL BIOMASS POTENTIAL - TECHNICAL ASSESSMENT

Property No. **sample**

Date visited: 10/1/2008

Value assumptions:

Corn/bushel	$4.50
Soybeans/bushel	$10.00
Residue/dry ton	$65.00
Hay/dry ton	$85.00
Wood chips/dry ton	$64.00

Subparcel number: **2**		**Acres:**		**18.3**	
	bushels/acre	**residue (tons/acre)**	**hay, chips (tons/acre)**	**current gross ($/acre)**	**Notes**
Corn	115	1.1		$589.00	Needs minor drainage improvements to grow corn here
Soybeans	38.3	0.6		$422.00	
Unimproved grasses			2.6	$221.00	
Improved grasses			2.5	$212.50	
Shrub willow			4	$256.00	

Subparcel number: 3		Acres:		6.8	
	bushels/acre	Residue (tons/acre)	hay, chips (tons/acre)	current gross ($/acre)	Notes
Corn				$0.00	ag production not feasible; abandoned rail bed and gas pipeline
Soybeans				$0.00	
Unimproved grasses				$0.00	
Improved grasses				$0.00	
Shrub willow				$0.00	

Subparcel number: 4		Acres:		9.4	
	bushels/acre	Residue (tons/acre)	hay, chips (tons/acre)	current gross ($/acre)	Notes
Corn	140	1.3		$714.50	
Soybeans	46.6	0.7		$511.50	
Unimproved grasses			1.6	$136.00	This is the current land cover.
Improved grasses			3.1	$263.50	
Shrub willow			5	$1,062.50	

FOREST BIOMASS POTENTIAL - TECHNICAL ASSESSMENT

Property No.	**sample**
Date visited:	9/29/2008
Sub-parcel no.:	**1**
Acres	**33.6**
Est. timber value ($/1000 BF):	**$359**
Est. pulp value ($/dry ton):	**$70**
Est. chip value ($/dry ton):	**$64**

		merchantable timber (BF/acre)	**pulp wood (tons/acre)**	**wood chips (tons/ acre)**	**current (gross $/acre)**	**years to next cutting**	**timber (BF/acre) at next cutting**	**Notes**
Conversion cut		2,294	20	15	$3,183			
High-grade cut		2,536	14	7	$2,337	35	3,600	Main merchantable timber species are red maple and ash
Shelterwood cut					$0			Not feasible on this parcel because density too low to indicate practice
Thinning cut		1,879	14	3	$1,846	7	2,000	

APPENDIX D – AGRICULTURE LAND USE CODES USED DURING ON SITE FIELD ASSESSMENTS OF PARCELS

AG LAND USE CODES – FIELD ASSESSMENT

1) Idle ag land (nothing harvested in the last two years), tillable

2) Idle ag land, needs some clearing

3) Pasture

4) Grass hay (unimproved grasses, being cut annually)

5) Improved forage (legume/timothy blends, etc.)

6) Clear alfalfa

7) Corn/soy rotation

8) Soy/grass or cover crop rotation

9) Small grains

10) [not used]

11) Corn/alfalfa or forage grass rotation

12) Orchard

13) Other active ag use

14) Wildlife feed or habitat planting

APPENDIX E – LANDOWNER INTERVIEW SCRIPT

Ice – breakers

Length of ownership; why they own it; who had the place before; what they've done with the property in the past; what they like about it most; what they'd like to change.

Lifestyle interests

Hunting, ATV and snowmobiling, hiking, other; interest in privacy (not wanting close neighbors); other things they like to do on the property.

Farming interests

Prior uses (earlier owners); own farming history; relations with farmers at this time; ideas about rents; ideas about sale values; inclination to rent and stipulations; inclinations to sell; ag use concerns (ag chemicals, noise, traffic, manure, timing of operations); potential to work land themselves (interest, experience, equipment, business plan); willingness to invest in tile, lime, hedgerow removal, etc.; willingness to make longer-term commitment. Strong preferences/opposition to particular crops. Go over options in terms of what they might cost and return (detail depending on landowner's level of base knowledge and interest).

Forestry

Prior logging; plans to log; interest in having place logged; interest and experience with silviculture and willingness to carry out in future even under pessimistic cost assumptions; ideas about logging; restrictions; areas they might want clear-cut. Go over options in terms of costs and returns (details depending on landowner's base knowledge and interest).

Receptivity (Y/N)

- Corn __
- Stover harvest __
- Soybeans __
- Soybean straw harvest __
- Unimproved grasses __
- Cropped perennial grasses __
- Shrub willow __
- Conversion (clear-cut) __
- High-grade __
- Shelterwood cut __
- Thinning cut __

Cropland rental (Y/N) ____

Rent threshold ________

Term threshold ______

Land sale (Y/N) ______

Sale threshold

Whole parcel A____ $____/acre
Open land A____ $____/acre
Woodlots A____$_____/acre

Lives on the property (Y/N) ___
Actively involved in farming (Y/N) _

Gas lease/etc. (Y/N) __

Own capability __

- Interest (3) □
- Experience (5) □
- Equipment (7) □
- Active business plans (9) □

Financial motivation __

- □ Has land based business (9)
- □ Already analyzed options (7)
- □ Questions about costs/returns (5)
- □ Ownership cost concerns (3)

Operations tolerance __

- □ Leave property natural (1)
- □ Avoid all chemicals (3)
- □ Road, erosion concerns (5)
- □ Minor irritations (noises, smells) (7)

Non-commercial use __

- □ Main reason for purchase (9)
- □ Active rec. use (7)
- □ Ideas about rec. use (5)
- □ Routine privacy concerns (3)

APPENDIX F – NON-RESPONDENT SURVEY SCRIPT

My name is XXXXXXXXXXX. I am calling from the College of Environment Science and Forestry in Syracuse. We are conducting a study of forest and agricultural products that could be turned into energy. Late last year we mailed a brochure to you, inviting you to participate in this study. We did not hear back from you but we would still like to ask you a few questions, if you have about five minutes.

Did you receive the brochure about our project? YES___ NO___

[if they say yes, and that they wanted to be included, but didn't get around to mailing it, or lost it, or whatever, tell them that we have already selected the group of properties that will be studied in detail, but if they give their address at the end of this interview, we can send them a summary of results.]

You were included in the first mailing because the tax rolls show that you have XX acres of rural property in XX County. My questions are about that property.

[if they say they have more than one property, let them figure out which one has the acreage we're talking about]

Can you tell me what percent of the land is in woods, and what percent is open land?

___ WOODS ___ OPEN LAND [note – this doesn't have to equal 100% -- they can leave out land that is in swamps, brushy fields, lawns, etc.]

Do you live on the property? YES___ NO___

Do you farm any of the land? YES___ NO___

Is any of the land rented to a farmer? YES___ NO___

Has any of the wooded land been harvested in the last ten years?
YES, firewood only ___ YES, timber (and firewood) ___ NO___

Do you plan to have any of the wooded land cut for timber in the next five years? YES___ NO___

What are your main reasons for owning this land?

[Jot down reasons; if they mention a business use or income as an important reason mark YES]

Financial motivation **YES___ NO___**

[note – this was a 1-9 scale in our interviews; we made a score of 7, 8, or 9 on that scale the equivalent of a "yes" in for respondent/non-respondent comparison purposes]

Would you like to receive a copy of the report on our study?

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise and funding to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce their reliance on fossil fuels. NYSERDA professionals work to protect our environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York since 1975.

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Energy Research and
Development Authority

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fax: (518) 862-1091

info@nyserda.org
www.nyserda.ny.gov

State of New York
Andrew M. Cuomo, Governor

Regional Model to Assess the Incremental Commercial Availability of Biomass Feedstocks for Biofuel and Bioproduct Investors in New York State

Final Report 11-30
September 2011

New York State Energy Research and Development Authority
Vincent A. Delorio, Esq., Chairman | Francis J. Murray, Jr., President and CEO