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Willow Biomass News

PROGRESS HIGHLIGHTS

2nd Quarter 1998

Feedstock Production and Infrastructure

- Willow bioenergy demonstration areas totaling 51 ha (126 acres) were established at 7 locations during 1998, with 40 ha (100 acres) in the Dunkirk power plant supply shed and 11 ha (26 acres) in central New York. The Consortium goal is 1000 acres by 2000.
- Planting rates for the Frobbesta planter was approximately 0.25 ha/hr (0.62 ac/hr). New planting equipment is expected to obtain 0.75 Ha/hr (1.5 acres/hr).
- SUNY-ESF made arrangements with the University of Toronto to coppice willow clones in their cutting orchards. As long as these orchards are available they are an important source of cutting production (100,000 cuttings/year) for the Consortium's scale-up planting efforts.
- The first of a series of willow biomass trials was established in Pennsylvania as part of the effort to expand the regional application of willow biomass corps.
- An additional 12,000 willow plants were established in cutting orchards and improvements were made to the irrigation system at the Saratoga Nursery. These modifications increase the sites planting stock production capacity to meet scale-up goals.

Power Plant Conversion and Testing

- Dunkirk Station plant staff are in the process of obtaining final bids for cofiring equipment. Construction is scheduled to begin in November.
- McNeil Station is undergoing gasification shakedown tests. The Consortium would like to test willow feedstocks at the Burlington gasifier by next year.

System Optimization and Experimental Studies

- The forty willow and poplar clones planted in the genetic selection trial established during 1997 at SUNY ESF were evaluated for a range of characteristics. Results could be used in future modeling efforts and will provide valuable information for a breeding program.
- SUNY-ESF continued the development of updated biomass equations using first and second year growth data. These equations will allow willow biomass growth to be tracked on an annual basis without using destructive harvests. Results using this method will be reported in the fall of 1998.
- A trial was established to determine if cutback after the first growing season can be avoided under certain circumstances. A successful trial would demonstrate one possible technique to reduce willow crop establishment costs.
- Staff from Cornell University Agricultural Engineering department modified the hydraulic system on the Frobbesta planters to allow the rollers to slow down or stop in the event of a jam. Although high speed Step planters are expected to replace the Frobbesta machines on larger parcels the Consortium believes that there is a need to continue improvements on the Frobbesta planters for use on smaller parcels.

Enterprise Development

- SUNY-ESF published both the "Willow Biomass: Developing a Source of Renewable Energy" brochure and the May 1998 issue of *Willow Biomass News*. This publication was distributed to over 450 individuals and organizations. Both publications will be distributed at other outreach activities.
- SUNY-ESF made a site visit to Niagara Mohawk's Harbor Point Research facility in Utica, NY to discuss the role that willow plantations could play as part of ongoing remediation efforts. This use supports the efforts to increase the value of the willow plantings by capturing other environmental benefits.
- Interest in the willow biomass program continues to grow. A wide variety of groups requested presentations and/or tours of the research plots at Tully, New York. Groups visiting during this quarter included the American Farm Bureau's National Forestry Advisory Committee and the Empire State Paper Research Institute.

1.0 INTRODUCTION

The project undertaken by the Salix Consortium is a multi-phased, multi-partner endeavor. Phase-I focused on initial development and testing of the technology and agreements necessary to demonstrate commercial willow production in Phase-II. The Phase I objectives have been successfully completed: preparing final design plans for two utility pulverized coal boilers, developing fuel supply plans for the project, obtaining power production commitments from the power companies for Phase II, obtaining construction and environmental permits, and developing an experimental strategy for crop production and power generation improvements needed to assure commercial success. The R&D effort also addresses environmental issues pertaining to introduction of the willow energy system. Beyond those Phase I requirements the Consortium has already successfully demonstrated cofiring at Greenidge Station and developed the required nursery capacity for acreage scale-up. This past summer 105 acres were prepared in advance for the spring planting in 1998.

Having completed the above tasks, the Consortium is well positioned to begin Phase-II. In phase II every aspect of willow production and power generation from willow will be demonstrated. The ultimate objective of Phase-II is to transition the work performed under the Rural Energy for the Future project into a thriving, self-supported energy crop enterprise.

1.1 Project Overview

The Salix Consortium pools the research and investment interests of over 14 corporations, associations, universities and regional government agencies in a well orchestrated program to develop a new energy crop enterprise. More than 37 farmers and landowners representing over 3000 acres of potential willow production have met with Consortium representatives and expressed interest in the new energy crop. Although some of these landowners/growers are too far away to be considered in this demonstration, 22 landowners representing 1900 acres of land are serious candidates to participate in the project (Appendix A). From this pool of acreage combined with utility owned land and other Consortium experimental plots, the availability of 1,000 acres willow for energy production is assured in Phase-II.

Consortium regional representation is focused in the Northeast, stretching from Ontario to Pennsylvania. Cofiring tests have been conducted at both Niagara Mohawk Power Corporation's (NMPC) Dunkirk, New York State Electric and Gas' (NYSEG) Greenidge, and GPU's Seward and Shawville power stations. The basic fuel handling system at Greenidge has demonstrated continuous firing at 10% by heat input. An initial test firing of the willow at Greenidge has already been performed and has provided insight into the remaining issues to be addressed in Phase-II to assure efficient use of the willow energy crop. NMPC recently completed successful tests of cofiring biomass at its Dunkirk Station and is now considering the retrofit of two boilers for cofiring. The focus of the Salix Consortium is on energy crop infrastructure and development first and conversion technology second in the belief that the major tasks ahead are to develop an economical crop production infrastructure for the business. Nonetheless, energy conversion

issues are effectively addressed in the program and advanced technologies through gasification are included with a realistic timetable for implementation. All of the preceding efforts contribute to the project team's belief that this Consortium will be the *first in the nation to develop an economically and environmentally sustainable business in energy crops for power generation* and ultimately a variety of high value energy products.

To meet this vision the Consortium has organized its activities into four distinct tasks:

- Task 1 - Feedstock Production and Infrastructure
- Task 2 - Power Plant Conversion and Testing
- Task 3 - System Optimization and Experimental Studies
- Task 4 - Enterprise Development

A brief description of the objectives of each task is provided below.

1.2 Description of Tasks and Goals

1.2.1 Task 1 - Feedstock Production and Infrastructure

Task 1 activities focus on acreage scale-up and willow field production activities. During Phase-II, the Consortium will establish 800 acres of willow in New York. To accomplish this the Consortium will ensure that sufficient planting stock is produced, production sites are prepared, and that planting, maintaining, and harvesting activities occur in a manner consistent with establishing an energy crop enterprise. All planning, land acquisition, and commercial field activity associated with this project are managed under Task 1.

1.2.2 Task 2 - Power Plant Conversion and Testing

Task 2 activities focus on resolving issues related to the power plants and conversion of a delivered willow product into electricity. The goals for Task 2 efforts in Phase-II include the retrofitting and continuous cofiring of biomass at Dunkirk Station, continued operation and testing of Greenidge Station, and gasification tests using willow at McNeil Station. The Consortium will also collect operational data such as manpower requirements and maintenance costs. However, emissions monitoring and ash testing activities will be managed under Task 3.

1.2.3 Task 3 - System Optimization and Experimental Studies

All research and development activities are managed under Task 3. This includes willow feedstock and production system R&D, environmental studies, and power generation optimization efforts. Specifically, the Consortium will seek to improve willow yields, pest resistance, and increase planting stock production at the nursery. The Consortium will also evaluate willow site preparation techniques, planting and harvesting equipment

1.2.4 Task 4 - Enterprise Development

Task 4 will focus on Business Development and Optimization activities that will lay the foundation for the long term viability of a willow production enterprise. The Consortium will investigate ways to capitalize on existing federal, state, and local government programs to increase the competitiveness of the crop. Forest management and agricultural tax structures, Conservation Reserve Programs, and eco-enterprise zones are examples of avenues being pursued. These activities, plus on-going outreach and technology transfer are aimed at ensuring the successful transition of this project from demonstration to commercialization.

2.0 DETAILED TASK PROGRESS REPORTS

2.1 Task 1 - Feedstock Production and Infrastructure

2.1.1 Nursery Operations

Saratoga Nursery staff made approximately 150,000 cuttings 25 cm in length from whips that were made in case a step planter was obtained. There are plans to obtain a step planter for the 1999 planting season.

SUNY-ESF reported that cuttings were planted in the 1997 native willow cutting orchard at Tully, NY to meet the original goal of 100 plants of each clone. Mechanical weed control was completed where necessary. A severe infestation of sawflies (*Nematus ventralis*) was controlled by application of carbaryl insecticide using backpack sprayers. As in the Tully demonstration planting described above, *S. eriocephala* clones were more severely damaged by sawflies than other willow species. Cuttings from this orchard will be used to provide planting stock for clone-site trials to be established in 1999.

SUNY-ESF made arrangements with the University of Toronto to coppice the clones in their cutting orchards that are being used in the scale-up efforts. Cuttings will be made from these orchards during the winter of 1998/99 to supplement cuttings produced by SUNY-ESF and the Saratoga Tree Nursery.

SUNY-ESF found that cuttings of several clones stored at the Saratoga nursery broke bud during storage. The effect this will have on cutting survival and growth after planting in the field is uncertain.

2.1.2 Acreage Scale-up Activity Dunkirk/Greenidge

This progress period marks the planting of the Consortium's first commercial scale willow plots. SUNY-ESF transported cuttings produced by NYDEC Saratoga Tree Nursery to Tully and Dunkirk, NY. Cuttings moved to Dunkirk were stored in a refrigerated trailer at Niagara Mohawk's Dunkirk Power Station. Planting was started in both central and western New York.

By month's end, approximately 7 ha were planted at the site in Leon, NY. The planted area was capped with simazine (2.25 kg ai/ha).

Willow bioenergy demonstration areas totaling 51 ha (126 acres) were established at 7 locations during 1998, with 40 ha in the Dunkirk power plant supply shed and 11 ha in central New York. The planting sites included Leon (8.5 ha), Pomfret (10 ha), and Sheridan (21.5 ha) in western New York, and Canastota (6 ha), Lafayette (2 ha), Tully (1 ha), and Wolcott (2 ha) in central New York (Table 1). All plantings were completed with Frobbesta planters which plant dormant unrooted cuttings at the standard double-row spacing (0.6 m within rows, 0.7 m between rows, and 1.5 m between double rows). All the plantings used blocks of clones replicated across sites so that studies can be superimposed over them in the future. Sites were treated with oxyfluorfen (1.1 kg ai ha⁻¹) or simazine (2.25 kg ai ha⁻¹) immediately after planting.

According to SUNY-ESF, above-normal precipitation was encountered throughout the growing season in western NY, causing delays in planting. Despite improvements that were made to existing drainage ditches at Sheridan, approximately 7 ha could not be planted. This included areas that were too wet to plow and/or disk this spring. Approximately half of this unplanted area probably will become accessible later in the season, but weeds became established due to delays in tillage operations. These areas will be disked and weeds will be controlled during summer 1998 so that sites can be planted in 1999. The other half of the unplanted area appears too wet and will be abandoned. A 6 ha field in Leon was not planted due to wet site conditions. This field will require further weed control, as well as drainage improvements, and will be planted in 1999.

The Pomfret site was not originally scheduled for planting in 1998. The decision to plant the site was made during late May 1998 because some of the original land scheduled for planting at Sheridan proved unsuitable. The Pomfret site consisted of 6 fields ranging from approximately 1 to 3 ha in size that were in corn during 1996 and fallow during 1997. The site was treated with glyphosate (1.1 kg ai ha⁻¹), plowed, disked three times, and planted.

Pomfret was exceptionally difficult due to dry soil conditions, a hard pan, and the soil's high clay content. Plowing depth was generally less than 25 cm, causing many cuttings to be planted shallower than desired. All fields were planted with one or two clones, including willow clones SV1, SA2, and S546 and poplar clones NM6 and EU (Table 1). Many of the cuttings planted at Pomfret were not dormant due to failure of a rented freezer. The effect this will have on survival is uncertain. A 1.5 ha field at Sheridan was also planted with cuttings that had begun to sprout.

Site visits were completed at Leon and Sheridan, the first sites planted in 1998. Grass competition was observed in the Leon demonstration planting, so fluazifop-P-butyl (Fusilade 2000) was applied at the rate of 0.45 kg ai ha⁻¹. The treatment effectively controlled grass weeds. Several species of weeds that are not controlled by fluazifop-P-butyl including nutsedge, plantain, velvet leaf, and burdock were also observed. These weeds may need to be controlled mechanically if they begin to dominate the site. Overall, growth of willows was good

at Leon. Many trees were 0.5 m in height during mid-June. The demonstration area in Sheridan was slow to begin growth because trees were planted during an extended dry period. Trees sprouted and began to grow when drought conditions ended during mid-June. Weed control was good at Sheridan.

Planting rates were approximately 0.25 ha/hr/planting machine. This includes time for loading the planters with cuttings, turning around, and making minor adjustments and repairs.

Consortium staff continued efforts to secure additional land for willow bioenergy demonstration farms. A site in the town of Spafford, NY (approximately 50 km from Syracuse) was visited but deemed unsuitable due to poor drainage and excessive tree cover that would have made site preparation uneconomical.

2.1.3 Acreage Scale-up Activity Other Sites

At McNeil Station, BED investigated using compost for soil nutrient enhancement, but it turned out to be too costly and the tree height made it infeasible. Various granular fertilizer products were investigated, but the partners decided to postpone fertilization for the 1998 growing season until the tree canopies closed. This was predicated on the fact that the Burlington project has relied on mechanical rather than chemical weed control and applying fertilizer prior to crown closure would stimulate weed growth. They also conducted one mechanical weeding in mid-May and by late August, tree heights ranged from 6-10 feet. In August, weeds were mowed around the planting site perimeter to reduce weed seed formation.

2.2 Task 2 - Power Plant Conversion and Testing

2.2.1 Dunkirk Station

Retrofit activities for Dunkirk Station are proceeding. During this reporting period, the plant was still in the process of obtaining bids for equipment and A&E services.

2.2.2 Greenidge Station

No new activity has been undertaken at Greenidge during this reporting period. The station continues to cofire biomass as part of its regular operations.

2.2.3 McNeil Station

McNeil Station is still undergoing gasification shakedown tests.

2.3 Task 3 - System Optimization and Experimental Studies

2.3.1 Willow Feedstock R&D

Genetic Improvement

As a result of cooperative links with willow biomass research and development companies in Sweden, SUNY-ESF received cuttings of 12 of the most promising clones from the Swedish breeding program. The cuttings were planted at Tully, NY and will be monitored for growth and any indication of disease over the next two years.

SUNY-ESF transplanted willow seedlings produced during February - March 1998 by intra- and interspecific hybridization to individual leach tubes and placed under mist. Survival one week after planting was estimated to be 95%. A study was initiated to determine chromosome numbers of all clones used as parents during the past winter. Information from this study will be used to guide future breeding efforts and may explain why crosses between certain individuals failed.

Viability testing of pollen used during 1998 willow breeding efforts was completed. Greater than 40% of pollen grains in most samples were viable, with pollen viability exceeding 10% for all but three pollen samples.

The total number of crosses attempted during 1998 was 121, with 62 interspecific crosses. Several interspecific hybridization attempts were successful (Table 1). *S. dasyclados* clone SV1 successfully crossed with three of the five different *S. eriocephala* males used as parents, and with one of two *S. udensis* males. Viable seed was not obtained from any interspecific matings attempted with *S. purpurea* males. One of nine *S. purpurea* x *udensis* hybridization attempts was successful. Viable seed was produced from 100, 84 and 33% of intraspecific matings attempted between *S. udensis*, *S. eriocephala* and *S. purpurea*, respectively.

Pollen viability was eliminated as a possible reason for failure of crosses for 53 of the 68 crosses that failed. Crosses involving *S. purpurea* clones 94002 and PUR12 (15 crosses) all failed, including crosses with *S. purpurea* females. A reason for intraspecific hybridization failures with these two clones, or any of the others that failed, was not determined.

The forty willow and poplar clones planted in the genetic selection trial established during 1997 in cooperation with the USDA Forest Service were evaluated for time of budbreak. All of the clones broke bud during a three week period from mid-April to early-May 1998. Willow clones were the first to break bud (Table 2). The poplars broke bud approximately 2 weeks later than willows.

Sawflies (*Nematus ventralis*) defoliated many of the willows in the genetic selection trial during the third week of May. Damage was most severe on *S. purpurea* and *S. eriocephala* clones. Some poplars, particularly *P. nigra* x *maximowiczii* clones, were damaged. A qualitative survey of the damage was completed and the clones were ranked based on extent of defoliation. Sevin (carbaryl) insecticide was sprayed to stop further damage.

The first set of seasonal growth measurements were completed on 5 clones that are being studied intensively in a cooperative study with the USDA Forest Service in Rhinelander, WI. This is a genetic selection trial with a companion study in Wisconsin and is designed such that the ecophysiological basis of biomass productivity can be studied in detail. Stem diameter, height and leaf area of all stems of a subset of trees in each of 4 replicated plots were measured. The data will be used to develop a sampling methodology for the remainder of the season.

Beginning in mid-June, light interception measurements were completed weekly. Statistically significant differences ($P = 0.06$), were observed between clones with respect to the mean photosynthetically active radiation (PAR) intercepted on June 19th (Figure 1). The percentage of incoming PAR intercepted ranged from 53 % (poplar clone NM6) to 37 % (willow clone S301).

Willow seedlings that were planted in leach tubes during late April grew well and survival was greater than 95% for most families. Seedlings that failed were replaced if plants were available. Fertilizer (Miracle Gro) was applied in late May and plants will be fertilized regularly so that they are large enough to provide hardwood cuttings during fall 1998.

DNA extraction began from all of the willows used as parents in controlled crosses during 1998. The DNA will be used to create molecular fingerprints of these clones using amplified fragment length polymorphism (AFLP) technology. Spectroscopy indicated that DNA purity of most of the samples was adequate for AFLP use, and restriction digests will be completed to confirm these results. AFLP work will be completed using a new automated DNA sequencer purchased by SUNY-ESF which is expected to be brought on line during late June 1998.

Progress continued on developing a protocol for determining chromosome numbers of willows using root tips. After the protocol is optimized, chromosome numbers of all the willows used as parents in 1998 breeding efforts will be determined.

Efforts towards creating molecular fingerprints of all clones used as parents in controlled crosses during 1998 continued. DNA was purified from every clone from foliage collected on one date. A second foliage collection was completed and DNA extraction began. Two collections were made so that the reproducibility of the fingerprinting technique may be determined. Fingerprinting will begin during July or August using a new automated DNA sequencer purchased by SUNY-ESF with funding provided by SUNY. The unit is equipped with computer software for amplified fragment length polymorphism (AFLP) and uses fluorescent tags, rather than radioactive labels.

Progress continued towards determining chromosome numbers of willows in the SUNY-ESF collection. Chromosomes were observed but the protocol for producing large numbers of cells suitable for chromosome counts must be refined. After the protocol is optimized, chromosome numbers of all the willows used as parents in 1998 breeding efforts will be determined.

Heights of seedlings produced by controlled pollination during 1998 were measured to obtain an

early estimate of variation among families. The amount of variation within families was large for some families but small for others, and variation was large in families produced by both intra- and interspecific hybridization. Since seedlings were not placed on greenhouse benches using an experimental design, measurements may have been biased, so this data must be considered as a crude indication of what to expect in future replicated experiments.

Regular site visits to willow trials established in recent years have been initiated. Trials in Easton, PA, Wolcott, NY, and King Ferry, NY, were inspected for weed competition and insects and diseases. Willows at the Easton site sprouted and were developing rapidly with minimum weed competition. The willows at the Wolcott site sprouted but moderate weed competition was observed including velvet leaf and grass. Velvet leaf was controlled mechanically. The grass will be controlled with a grass-specific herbicide (fluazifop-P-butyl (Fusilade 2000) at the 0.45 kg ai ha⁻¹ rate) applied over actively growing willows. The King Ferry site recovered well from weed competition experienced during 1997. All the clones closed canopy, minimizing weed competition.

Nursery Production Improvement

SUNY-ESF reported that efforts to increase the amount of planting stock available for use in 1999 and beyond continued. By early June, many of the trees at the Saratoga Tree Nursery had reached a height of 1.2 m. Elevated risers ranging in height from 1.5 - 1.8 m that were installed over the past year will allow irrigation to continue into July, which should increase cutting production compared with 1997. Approximately 0.35 ha of additional land at the Saratoga Tree Nursery was prepared and planted with seven willow clones (S301, S365, Sx61, Sx64, Sx67, PUR12, and PUR34) during June 1998. Plans were made to remove some of the beds of older clones at Saratoga to make space for planting more promising willow clones next spring.

SUNY-ESF held a meeting with an irrigation specialist from Cornell University to discuss improvements in the irrigation system at Tully. Modifications to the system will be made as soon as possible.

Crop Improvement

SUNY-ESF staff met with staff from the Natural Resources Conservation Service (NRCS) to outline approaches for quantifying soil erosion potential in willow biomass crops. SUNY-ESF has data from previously established willow trials that can be used in the Revised Soil Loss Equation (RUSLE) model. Gaps in the data were identified and efforts will be made to collect this data during the 1998 growing season. NRCS staff visited two of SUNY-ESF's willow bioenergy demonstration planting sites to gain a better understanding of crop development.

SUNY-ESF established a study at Tully, NY to determine the effect of two different methods of coppice after the first year and omitting coppice treatment altogether. Discussion with researchers in Sweden last fall indicated that, for some varieties of willows, there was no

difference in production after four years between coppiced and non-coppiced treatments. There are concerns about the rate of canopy closure under non coppiced stands and how this will influence weed populations during the second year of growth. Six different varieties of willow representing a wide range of growth habits were planted in the standard double-row spacing. The trial will be replicated at two other sites near Syracuse.

SUNY-ESF completed the development and selection of updated biomass equations using first year data. These equations will allow willow biomass growth to be tracked on an annual basis without using destructive harvests. The equations will be refined so they can be used to make rapid assessments of standing biomass after three years of growth. This data will facilitate development of efficient harvesting procedures. Stem samples of willow clones S25, S301, S546, SA2, and SV1, and poplar clone NM6 were measured in the field, then cut, oven dried, and weighed. For each clone, 32 to 105 stems were collected from a total of six to nine stools from at least two sites. Log-transformed, diameter-squared, and non-linear models were considered for stems of each clone individually and combined. Several variables were considered, including height (H), diameter (D), D² and D²H. Data splitting was used for obtaining a validation data set, and mean squared error of prediction (MSEP) was used as a validation criterion. Transformation bias can be an issue when using log-transformed models and various bias correction approaches were tested.

Regression equations based solely on diameter adequately estimated tree biomass. Adding height to the stem-based regression models did not improve the models significantly, and increased the cost of data collection. Clone-specific models appear to be necessary. The performance of the log-transformed model and that of the non-linear model were comparable, and there was little justification for using a bias correction for log transformed models. With the exception of poplar clone NM6, the non-linear and log-transformed models performed equally well, suggesting that the two models were both reasonable. For NM6, the log-transformed model performed better.

Willow stem diameter measurements at 30 cm height were completed in the clone-site trial at Tully, NY. These plots are one-year-old shoots on five-year-old roots. Using allometric equations already developed at SUNY-ESF, an estimate of above ground oven dry stem biomass will be calculated. This data will be combined with data from other trials to develop equations for predicting foliar biomass from different clones at different stages of development. These equations will allow for more accurate assessments of nutrient cycling in willow biomass crops. Two year old stems were measured and collected from the willow clone-site trial in Somerset, NY for expansion of the biomass equations.

All laboratory analyses of samples collected in the fertilizer rate studies imposed over the willow clone-site trials at Tully, King Ferry, and Somerset, NY during 1997 were completed. Statistical analyses of these data will begin soon.

Weed competition during the establishment year for willow biomass crops continues to present challenges. To address this issue, a combination of mechanical and chemical weed control

practices are being designed for testing. The USDA Forest Service in Rhineland and SUNY-ESF initiated a cooperative project to screen both pre- and post-emergent herbicides for use with willows. Cuttings from six different willow clones from the SUNY-ESF collection were sent to Rhineland. This material will be used to assess the tolerance of willows to herbicides that have been used in trials with hybrid poplar. Following the initial screening, additional trials will be established in both New York and Wisconsin to determine the possibilities for large-scale application.

Efforts are in progress to establish new studies to determine if coppicing willows at the end of the first growing season is necessary. The first cutback study was established at Tully, NY during April 1998. The second cutback study site was established at Lafayette, NY during May 1998. Six willow clones representing a wide range of growth habits were planted using the standard double-row spacing. The site was capped with oxyflourfen (Goal 1.6e at 1.12 kg ai/ha) immediately following planting. A third sister trial will be planted on a site near Syracuse during June 1998.

Information was collected on willow and poplar survival, soil moisture and soil temperature in the alternative site preparation study planted during 1997 at Lafayette, NY. Both mechanical and chemical treatments were used to control perennial weeds in the test plots.

Statistical analyses of laboratory data from stem, foliage and soil samples collected during 1997 in fertilizer rate studies imposed over willow clone-site trials at Tully, King Ferry, and Somerset, NY began. Development of new biomass prediction equations using data from two-year-old stems measured in the Somerset, NY clone-site trial continued.

2.3.2 Production Systems

Planting System Testing, Evaluation, and Optimization

Various problems were encountered during machine planting operations. On small parts of the Sheridan demonstration areas, the planters did not adequately heel in the furrow, requiring people to follow the planters to insure that the cuttings were adequately covered. Excessive wear was noted on rollers that drive cuttings into the ground after the completion of planting at the Leon site. Staff from Cornell University Agricultural Engineering department modified the hydraulic system on the planters to allow the rollers to slow down or stop in the event of a jam. This modification is expected to increase the longevity of the rollers. Woody roots that were not cut into small pieces during mechanical site preparation caused difficulties for planting at the Sheridan site. These roots accumulated around the blade that cut the slit in the soil as the planter was pulled and caused the cuttings to fall forward. This problem was partially eliminated by lowering the depth of the coulter, but probably could have been avoided by disking deeper with a heavier disk.

SUNY-ESF designed a tractor mounted roto-tiller to fit the double row spacing used with willow

biomass crops. The roto-tiller was used at demonstration sites in Tully and Lafayette, NY that were coppiced last fall. Both of these areas were old fields that contained a large population of perennial weeds before planting with willows. Some perennial weeds were not killed during site preparation and were beginning to grow due to the exceptionally warm spring. The roto-tiller did an excellent job of controlling weeds both within and between the double rows with minimal tree damage. It is anticipated that these efforts will allow the willows to grow above any incoming weeds and shade them out. The adaptation of this piece of equipment for willow biomass crops should greatly improve weed control measures. Monitoring of the fields will continue.

Methods to incorporate cover crops into the first two establishment years of willow biomass crops to reduce the risk of erosion during that period were discussed with NRCS staff. The ideas discussed were applied to a cover crop trial that was initiated in fall 1997 at Lafayette, NY. Three different management options were tested. All three approaches included application of post-emergent herbicide as a first step. Following herbicide application, the rye was either mowed and disked, disked without mowing, or left as standing dead material. Samples of above- and below-ground rye biomass were collected. The site was planted with three willow clones in a completely randomized block design after these treatments were applied. First- and second-year tree growth and survival will be measured. Preliminary results from SUNY-ESF site establishment trials indicated that a winter rye cover crop increased production of willow biomass crops during the first year. Collaboration with the NRCS will continue.

Harvesting System Testing, Evaluation, and Optimization

There was no activity on this subtask during this reporting period.

Evaluation of Other Supply Dynamics

There was no activity on this subtask during this reporting period.

2.3.3 Environmental Studies

SUNY-ESF completed laboratory analyses of soils collected from the alternative site preparation study at Lafayette, NY including pH, texture, cation exchange capacity (CEC), total nitrogen content, and carbon content. It initiated statistical analyses of this data and analysis of the nutrient concentration of foliar samples collected last August.

2.3.4 Power Generation Optimization

There was no activity on this subtask during this reporting period.

2.4 Task 4 - Enterprise Development

2.4.1 Business Optimization and Analysis

There was no activity on this subtask during this reporting period.

2.4.2 Enterprise Development

During this progress period, Consortium Partners attended the following conferences:

- 2) day 1 of the "Confronting Climate Change in the Hudson-Delaware Region" conference held at Ramapo College, NJ in April 1998—this meeting discussed the effects of climate change on human health, local ecosystems, global weather patterns, and progress of international agreements in Kyoto;
- 3) the "Role of Forests in Climate Change Planning in the Northeast" held in Saratoga, NY in May 1998; and 3) DOE's Cofiring Biomass and Coal meeting at the Edison Electric Institute in Washington, DC in June 1998.

SUNY-ESF published both the "Willow Biomass: Developing a Source of Renewable Energy" brochure and the May 1998 issue of *Willow Biomass News*.

The American Farm Bureau's National Forestry Advisory group visited SUNY-ESF's Genetics Field Station in Tully, NY to learn more about the willow biomass program. The group included representatives from 15 states. A slide presentation on the willow biomass program was followed by a tour of the demonstration and research plantings at Tully. The group was particularly interested in ways that the willow biomass system could be incorporated into nutrient management systems in existing farming operations.

SUNY-ESF made a presentation on the willow biomass program to the Empire State Paper Research Institute's annual meeting in Syracuse, NY on May 20th.

The USDA/FSA sent a letter stating that they decided not to approve the research proposal as presented by the Consortium. The Thank-you letter stated that when the Consortium has more erosion data, it would like an opportunity in the future to address FSA's concerns directly.

Public interest in the clone-site trial established last month at Easton, PA is developing. The individual who applied the pre-emergent herbicide was especially interested because his family owns a 160 ha farm that is close to a cement factory with a coal-fired utility. This type of interest is encouraging as this demonstration project gets underway and commercialization opportunities are explored.

SUNY-ESF planned and executed educational activities in conjunction with the clone-site trial establishment in Easton, PA. A presentation was made to students and faculty at Lafayette College and several students voluntarily joined the planting crew.

SUNY-ESF presented several posters on different research studies at the Spotlight on Research program at SUNY-ESF on April 14. Presentations included:

- Adegbidi, H.G. and R.D. Briggs. Assessing nitrate and ammonium leaching in organically amended soils.

- Ballard, B. D., S. V. Stehman, and R.D. Briggs. Non-destructive biomass estimation of short rotation bioenergy crops using allometric equations: model selection and evaluation for five willow clones and one poplar clone.
- Nordman, E.E., D.J. Robison, and L.P. Abrahamson. Screening willow and poplar biomass production clones for insect resistance.
- Tharakan, P.J., L.P. Abrahamson, D. J. Robison, and J.G. Isebrands. First year growth and development of willow and poplar crops as related to photo synthetic characteristics

Staff from the SoCNY RC&D visited Cabbage Hill Farms in Mount Kisco, NY to discuss using willow in greenhouse heating. Cabbage Hill is a research and demonstration farm dedicated to the preservation of rare breeds and the practice of sustainable agriculture and aquaponics. Currently it heats the greenhouse and the fish tank water with a wood furnace. It has been using wood harvested from the 200-acre farm, which is running out. RC&D discovered that Cabbage Hill is very interested in using a cogeneration gasifier system for heat and electricity and are in need of a new, sustainable wood source.

RC&D spoke with Leslie Wheeler at Pellet Fuels Institute and Averill Cook regrading using willow as a raw product for pellet manufacturing. Cook's business, Catamount Pellet Fuel Corp. has traditionally produced pellet fuel for residential stoves but is branching out into commercial fuel. He feels that there is potential to use willow in commercial fuels because efficiency and ash content requirements are less stringent.

Staff from the RC&D also spoke with Mark Drisdelle, owner of Dellpoint Technologies Inc. He developed a high efficiency residential stove which can burn pellets made from bark and other waste materials. This stove was demonstrated at the August 1997 Bioenergy Conference in Montreal. Drisdelle is interested in seeing studies of ash content in willow. He has been in contact with Murray Carter, John Gilliland, and Salix Mechanica, who will distribute his stove. The stove should be commercially available in the U.S. in the fall of 1998.

SUNY-ESF made a site visit to Niagara Mohawk's Harbor Point Research facility in Utica, NY to discuss the role that willow plantations could play as part of ongoing remediation efforts. Discussions with staff at the site were encouraging. Piles of dredge material from the Erie Canal were inspected to determine the potential for establishing a screening trial with willow. The spoils are contaminated with polycyclic aromatic hydrocarbons (PAH) and recent work at Cornell University has indicated that rates of PAH degradation varied depending on the variety of willows used. Permission has been requested from the Canal Corporation to prepare the site so a trial can be established this spring.

RC&D established contact with Bonnie Gale of The American Willow Growers Network and has been invited to submit an article for its next newsletter.

The Vermont Farm Bureau expressed interest in the planting and The Natural Resources Conservation Service showed interest in using willows for riparian planting.

RC&D made several presentations to four SWCD in the area and to the SoCNY RC&D Annual Meeting. It also asked partners for input on the Community Meeting Planning outline and set July 15th as the date to meet with Agricultural Service Center staff from Chautauqua, Cattaragus, and Erie Counties.

RC&D established contact with Al Brown in Chautauqua County and exchanged information about the project and his land. They also discussed which western NY press would be interested in writing about the project.

APPENDIX A

Willow Biomass News



WILLOW BIOMASS NEWS

State University of New York College of Environmental Science and Forestry, Syracuse, NY 13210

Vol. 2, No. 1, May 1998

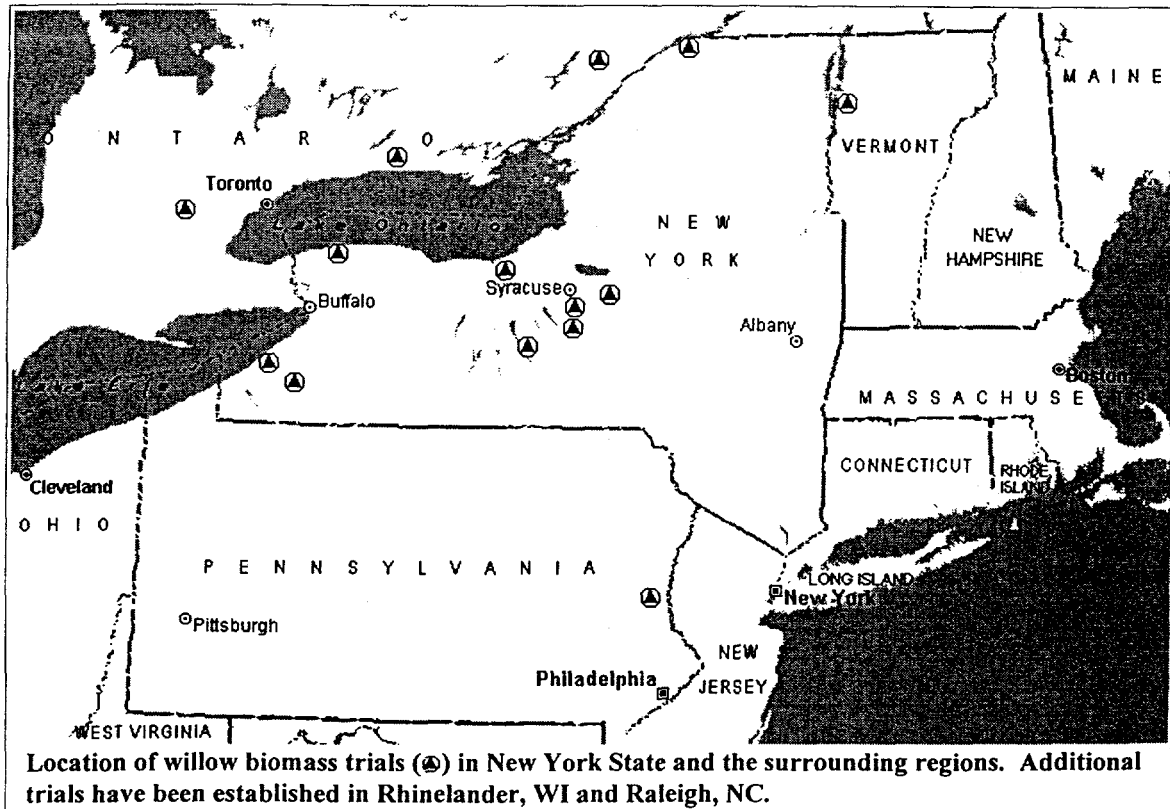
Willow Biomass Crops Taking Root Across New York and Beyond

Timothy A. Volk

Research on the biology and production system of willow biomass crops has been an area of focus for over a decade at the State University of New York College of Environmental Science and Forestry (SUNY-ESF). This work, in

environmental organizations, and universities.

The Consortium's goal is to build on the research base while transforming the knowledge and experience gained into a commercially viable industry. The challenge ahead is to simultaneously establish enough acreage, so there is a reasonable supply of willow biomass, while at the same time developing a reliable market, so there is a place to sell the



combination with efforts in Sweden, the United Kingdom and other northern European counties, has laid a solid foundation for the development of an industry in the northeastern United States centered around willow biomass crops. Over the past four years the Salix Consortium (Salix is scientific name for willow) has grown to include over 25 organizations from across North America, representing industry, government, agricultural and farmer groups,

biomass at the end of each rotation. It is a matter of having both the product and the market mature together. With concerted effort from members of the Salix Consortium, and support from the US Departments of Energy and Agriculture through the Biomass Power for Rural Develop program and a variety of other sponsors, this transformation is beginning to occur.

Willow Biomass News is published semi-annually by SUNY College of Environmental Science and Forestry with input from members of Cornell Cooperative Extension and South-Central NY Resource Conservation and Development, Inc.. Support for the newsletter is received from USDA CSREES.

Timothy Volk, Editor
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During the spring of 1998 the Salix Consortium established over 130 acres of willow biomass crops on private land in western and central New York. This is the beginning of the Consortium's goal of establishing a commercial scale demonstration project. About 1000 acres of willow biomass crops will be planted in New York over the next four years. The majority of land being planted in 1998 is located in western New York in Chautauqua and Cattaraugus counties. The properties are close to Niagara Mohawk Power Corporation's (NMPC) Dunkirk power station, which will be the primary market for the willow biomass. The plant will mix the biomass with coal and cofire it to generate

electricity. Smaller areas of willow will be established in Wayne, Onondaga, and Madison counties.

As the expansion of willow biomass crops continues in New York, interest in the system is growing across the north central and northeastern portions of the country. Last year demonstration and research plots were established in Rhinelander, Wisconsin in conjunction with the USDA Forest Service and Burlington, Vermont, in conjunction with Burlington Electric. This year trials were established in Easton, Pennsylvania at Lafayette College and in Raleigh, North Carolina at NC State University. Discussions are underway to establish trials at two other locations in Pennsylvania, as well as sites in New Jersey and Delaware in the spring of 1999. The idea of growing willow biomass to produce energy and generate a host of other benefits for the environment and local communities is taking root throughout the region.

T. Volk is Biomass Program Director at the State University of New York College of Environmental Science and Forestry



Small Scale Willow Biomass Power Generation Project Launched in Northern Ireland

Timothy Volk

Last fall a switch was thrown in Northern Ireland that initiated a direct link between willow biomass crops and the production of heat and electricity. The switch was connected to a small scale combined heat and power (CHP) unit on a farm where over 100 acres of willow biomass crops will be grown as a dedicated fuel source. The goal of the project is to demonstrate the benefits and technology associated with both the production and use of willow biomass crops at a single site in a rural community. The remainder of the 650 acre farm will continue to be cropped with a mixture of grains and potatoes. To date about half of the area dedicated for willow biomass crops has been planted. The remaining area will be established in the spring of 1998. The timing of plantings are staggered so that each year 1/3 of the willow biomass crop completes a three-year rotation and is harvested. Until the first willow biomass harvest in 1999, forest residues will be used as a fuel source. Since the production and use of willow biomass crops are located on one site, there are additional possibilities for integrating the willow crop into the rest of the farming operation. One good example is the expanded use of the ventilated grain floor dryer that was installed at the farm.

several years ago. Willow is harvested in the late fall or early winter after leaf fall, when the grain in the dryer is almost ready to be removed. So the willow crop fits nicely into the timetable for using the dryer. The heat and electricity needed to dry both crops will come from the CHP unit that will be fueled entirely with willow chips.

The CHP unit for the project is a downdraft gasifier that will produce about 100 kW of electricity and 150 kW of heat in the form of hot water. A typical residence in the United States has a peak electrical demand of 5 - 10 kW, so the gasifier produces enough energy to supply 10 - 20 homes during peak demand. A key to making the project successful is the gasification process that converts the wood chips into methane, hydrogen and carbon monoxide. This is done by strictly controlling the temperature and pressure, as well as the amount of air, in the gasifier. Under these conditions the wood chips give off their volatile gases without combustion. This mix of gasses is then cleaned and cooled before being fed into a dual fuel gas and diesel engine to power a generator. Each pound of wood produces about 0.5 kWh of electricity as well as heat for the farm and the grain drier. The electricity is being sold back to the grid at a guaranteed price while the heat is being used for heating buildings on the farm as well as drying grain and chipped willow.



The combined heat and power plant on John Gilliland's farm will convert willow biomass chips to electricity.

To make this project, the first of its kind in the United Kingdom, a reality the farmer, John Gilliland, joined with other biomass enthusiasts and gasification experts to form

Rural Generation Ltd. Support was sought and received from the federal government in the form of a grant covering half the capital cost of the gasifier and an agreement for a set price for the electricity sold back to the grid. With this support and high production potential of willow biomass crops, the payback period should be about six years. The success of the project has opened the door to a wide array of opportunities to apply this technology in rural settings including farms and small industries, in several parts of the world.

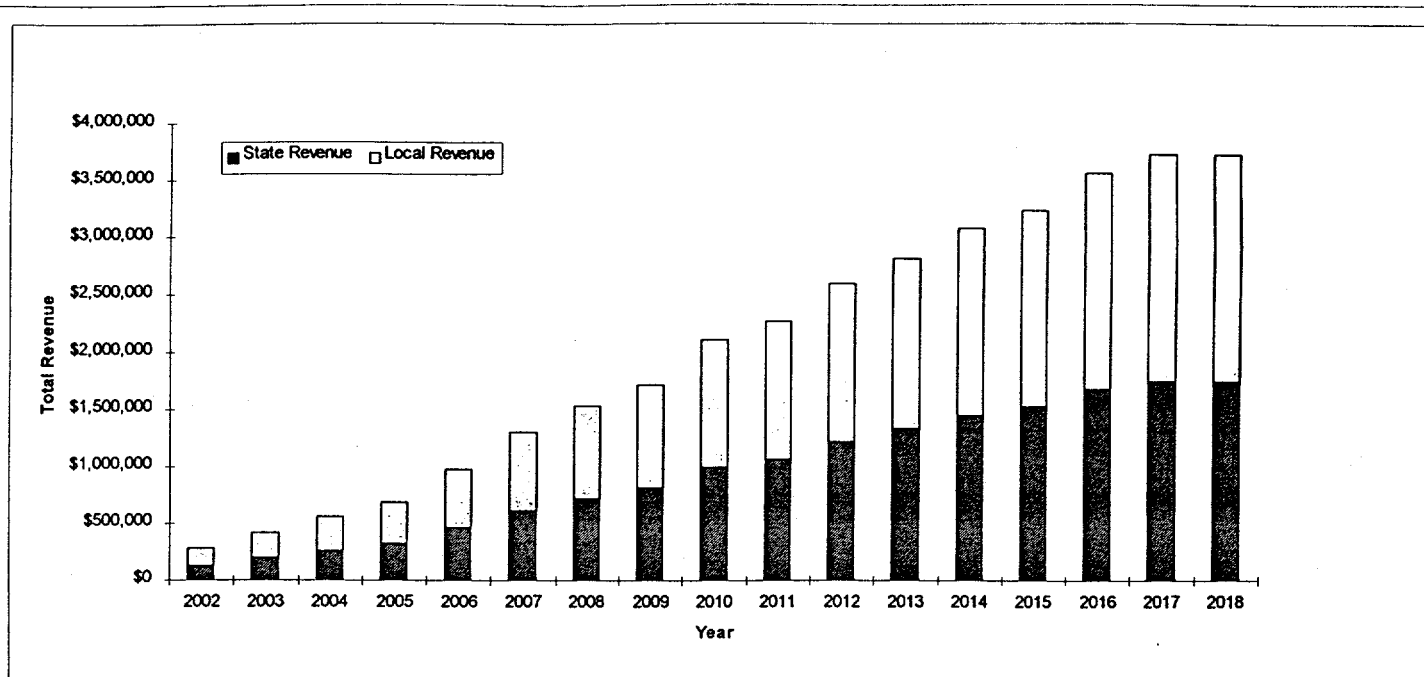
The Commercialization of Biomass Energy

George Proakis

The commercialization of short-rotation willow bioenergy crops has the potential of growing into a valuable new industry in New York State. The establishment of a homegrown fuel source will provide much needed economic development and employment opportunities in rural communities. Syracuse Research Corporation (SRC) is working with SUNY-ESF, Niagara Mohawk and other members of the Salix Consortium to quantify the economic impact of the biomass industry in New York, and accelerate the widespread commercialization of biomass as an alternative fuel.

Currently, New York State exports approximately \$1000 per person, per year to purchase energy from out-of-state. Meanwhile agriculture, the largest industry in the state, is an industry undergoing a long-term decline. Biomass offers the potential to reduce New York's dependency on out of state energy while providing an alternative crop for the agriculture industry. At currently planned levels, the commercial use of biomass will create over 375 jobs in central New York, while placing over 40,000 acres of land back into productive use. In addition to these economic development benefits, biomass offers an environmentally cleaner, renewable, and locally produced energy source for power producers.

Models have been developed by SRC researchers, with the help of students from SUNY-ESF and the Maxwell School at Syracuse University, to assess the economic benefits associated with biomass commercialization. To date, the SRC study has shown that power producer's capital investments for biomass retrofits will be recoverable within as little as four years. The SRC study has also determined the level of financial benefits associated with the potential value of SO₂ and NO_x pollution credits accruable from the



Projected state and local revenue generated annually as a willow biomass industry develops.

cleaner burning biomass fuels. The value of these credits to the power producer can significantly reduce the gap between the current cost per BTU of coal, and that of dedicated willow biomass feedstocks. The SRC study has shown that the creation of an in-state biomass agricultural industry cluster would generate almost four million dollars annually in local and state tax revenues. The use of a small percentage of these additional tax revenues in the form of grants, loans or tax incentives, for biomass producers, could make large-scale use of biomass commercially competitive with coal within the next five years.

George Proakis is a policy analyst with the Syracuse Research Corporation



Willow Biomass Crops for Bioenergy Field Day. Wednesday September 2, at Tully, NY. 11 - 2 PM

The field day provides an excellent opportunity to see and learn first hand about the production and use of willow biomass crops in New York State and the surrounding region. Willow biomass crops provide a source of environmentally friendly, renewable fuel and an alternative

crop for landowners. The field day will include an overview of the program, walking tour of willow biomass trials, and demonstrations of specialized equipment and a discussion of opportunities for landowner participation. The field day is hosted by SUNY-ESF and Cornell Cooperative Extension and will be held at the SUNY-ESF field station at Tully, 15 miles south of Syracuse. The program is free and a light lunch will be provided. For more information, to register for the event, or for directions to the field day contact:

ESF Continuing Education
SUNY College of Environmental
Science and Forestry
Syracuse, NY 13210
315/470-6891

Willow on the World Wide Web (www.esf.edu/willow)

SUNY-ESF has developed a World Wide Web page that provides additional information about the willow biomass program as well as links to other biomass and bioenergy sites. Previous issues of Willow Biomass News, the Willow Producer's Handbook, research summaries and other items are current or will soon be available. Come visit us at: www.esf.edu/willow