Commercial Plantations of Tree Energy Crops

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Executive Summary

Little experience is available in the establishment and management of tree energy plantations in Michigan, despite conceptual appeal. A particular need is for the availability of established, commercial-scale (i.e., greater than 10 acre) trials that would facilitate research on operational-scale management. In this project, two commercial scale tree energy plantations were established in the western Upper Peninsula of Michigan. These plantations complement small-scale test plot networks and a commercial scale plantation established in the northern Lower Peninsula. In the spring and summer of 2010, the two retired agriculture fields were cultivated and hand-planted with hybrid poplar (mostly *Populus nigra x maximowiczii*) cuttings. Early results were positive, with high survival and acceptable growth. Some browse from native white-tailed deer was observed, and limited through the building of temporary fencing.

Introduction

Commercial-scale energy crop production is ideal on marginal or retired farmlands far from agricultural markets but close to biofuel facilities in rural forest/agriculture land matrixes. By locating plantations close to facilities transportation costs may be minimized. In parallel, by using marginal or retired farmlands competition with existing uses, especially for food production, is minimized, and new productive purposes are created that may enhance economic opportunities in remote regions.

The Upper Peninsula of Michigan (UP) is a remote, rural, and almost entirely forested region about 10.6 million acres in size (Froese et al. 2007). Forests, at over 8.4 million acres, dominate the UP landscape; however, a substantial area totaling 890,000 acres is presently in agriculture. If just one-third of these lands could be converted to tree energy plantations, with an average annual yield of 4 green tons per acre per year, more than 1 million green tons per year of raw biomass could be produced. At a rate of about 10,000 green tons per MW, this amount would be sufficient to feed a 100% biomass electric generation plant of about 100 MW in size. Alternatively, at a conversion rate of 40 gallons of ethanol per green ton the biomass produced on these lands could produce 40 million gallons of transportation fuel each year.

The feasibility of such forecasts depends critically on assumptions about plantation productivity. Presently, there are little empirical data available in Michigan on expected growth, yield, productivity and sustainability for hybrid poplar plantations. In part, this need has been addressed by a network of research plantations established through sponsored research at Michigan Technological University and Michigan State University (e.g., Froese and Miller 2009; Miller and Bender. These plantations typically involve small test plots, perhaps 1,000 square feet in size, the interior of which are large enough to simulate "whole field" conditions and provide reasonable data on growth and yield. As these trials mature a reasonable set of empirical data may be available to improve landscape-scale plans and forecasts for a biomass industry.

Test plots are too small, however, for multiple research objectives or for research on operational-scale management of tree energy plantations, like time-and-motion studies of harvest equipment, at realistic scales. As of 2010 apparently only one commercial-scale plantation (i.e., greater than 10 acres) has been established in Michigan. That plantation is 25 acres in size, planted in spring 2010 on site near the town of Onaway, in the Northern Lower Peninsula, funded by Wolverine Power Cooperative. Thus, establishing additional commercial scale plantations, especially in the UP, is a critical need. Until plantations have been established and allowed to develop research on stand management practices, harvest technology and operational efficiency, and many other questions demanding plantations of that scale will not be possible.

Objectives

The overall goal of this project was to establish plantings that will in the future serve as foundations for research and education that rely on established test beds. Possible applications are: (1) applied ecosystem science research involving water, nutrient and matter cycles in relation to management regimes and regional climate trends; (2) augmenting species screening and stand management investigations using a narrow set of near-commercial species or genotypes; (3) engineering and equipment studies including time-in-motion, LCA input development, machine testing and optimization under operational conditions; and (4) stakeholder engagement and education opportunities for emerging undergraduate and graduate programs in sustainability, biomass feedstock production and biomass supply chain systems.

This goal was divided into several objectives:

1. Identify and secure a license for use on one or more sites in the western Upper Peninsula that would be suitable for establishment of commercial-scale hybrid poplar plantations;
2. Develop a conversion, planting and maintenance strategy;
3. Complete site conversion, planting and site maintenance through the end of the first growing season; and,
4. Monitor growth and construct deer exclusion fencing, as needed.

Methods

Site Selection

Candidate sites were identified through informal communication with local agriculture extension agents, economic development agencies, farmers, and professional contacts within the PI's network of collaborators. Key criteria for acceptable sites included:

1. A minimum size of 10 acres of plantable area
2. Soil textures that were either:
    a. Common in the western upper peninsula, or
    b. Of better than average moisture holding capacity (7 inches or more)
3. Free of woody vegetation or encroaching tree regeneration
4. Accessible via established road
5. Landowner willingness to enter into a license arrangement with terms established by Michigan Technological University
6. Within a one-way travel time of 2.5 hours from the MTU campus

The terms of license agreements, including license fees, were set by Michigan Technological University. License costs were not included in the scope of this sponsored project and were borne by Michigan Tech. Total target area for planting was a minimum of 30 acres in total across one or more sites.

Site Preparation and Planting

Best management practices for establishment of hybrid poplar plantations were used in this project (e.g., Isebrands 2007). The clone selected was *Populus nigra x maximowiczii* "NM-6", which has been extensively planted in Minnesota, shown to be of high productivity in block plantings in Michigan (Froese and Miller 2009, Miller and Bender 2008) and has been less prone to deer browse in mixed plantings elsewhere in the State (Froese, unpublished data). The bulk of the planting stock were obtained as 8" cuttings from the Verso Paper Company in Alexandria, MN, augmented by some additional material from a commercial nursery in Michigan.

The selected plantation design was row planting of poplar cuttings at a default 6-foot square spacing; i.e., rows six feet apart and trees planted each six feet along the row, requiring about 1,200 trees per acre. This spacing is thought to be a compromise between high densities (e.g., 3,000 trees per acre), which favor bioenergy production, and low densities (e.g., 300 trees per acre) that favor roundwood production. Because the planting stock and labor required increase exponentially as inter-tree spacing declines, a compromise was required that allowed multiple project objectives to be met. To facilitate possible future research and demonstration objectives that require lower densities, approximately 30% of each site was planted at lower densities of 8-foot and 10-foot square spacing (about 680 and 435 trees per acre, respectively). Also, an area of approximately 1 acre in size was reserved at each site for the establishment of small block plantings using alternative planting stock (bare root stock, whips, and an alternative clone).

Site preparation was completed in May 2011 using broadcast application of glyphosate herbicide, followed by plowing and cultivation as soil conditions permitted. Cuttings were hand planted by planting crews during early June 2011. Bareroot stock was planted by hand in holes dug by tractor-mounted auger, and whips in 2-foot deep holes drilled with an extended masonry bit.

Weed and Deer Browse Control

Post-planting weed control was undertaken using a combination of mechanical methods, depending on soil conditions. Where the rock and stone content of the soil was low enough a tractor-mounted rototiller was used to cultivate the top layer of soil and mix in growing weeds. In areas of fields were rock content was high cultivation was completed using a tractor-mounted disc harrow.

Some deer browse was expected on all plantations, as white tailed deer are present throughout the western UP of Michigan. Anticipated browse levels were low because the western UP is generally thought to have high winter snow depths that limit deer densities to below those found in other regions.

Where deer browse proved to be high enough to warrant actions to limit tree damage, temporary electric fencing was constructed. The chosen design was a “3D” layout, which uses two rows of wire around the area to be protected (Hall et al. 1999). Fences were constructed using commercially available polypropylene/metal strand “polyrope”, temporary insulated posts, and energized using a solar-powered fence chargers.

Climate Data Collection

Baseline climate data were collected at each site in the first year by installing climate stations. These included solar-powered data loggers, collecting information on precipitation, temperature, relative humidity and solar insolation.

Results

Selected Sites

A number of candidate sites were identified in Keweenaw, Houghton, Ontonagon, Baraga and Dickenson counties, which initially met the selection criteria involving soil suitability, size, access and distance from the MTU campus. Site visits were conducted in 2010 and candidate sites were ranked in order of preference, where parcel size and soil suitability were given priority. Unfortunately, a use license could not be negotiated for the highest-priority property (near Iron Mountain, MI).

Ultimately two sites were identified and placed under a use license with MTU that met the selection criteria (Figure 1). The first site is a 20-acre property near the community of Redridge, in Stanton Township, Houghton County MI. This site is about 11 miles by road from the MTU campus. Past use was for pasture or hay production but the parcel had been retired from active management for several years.

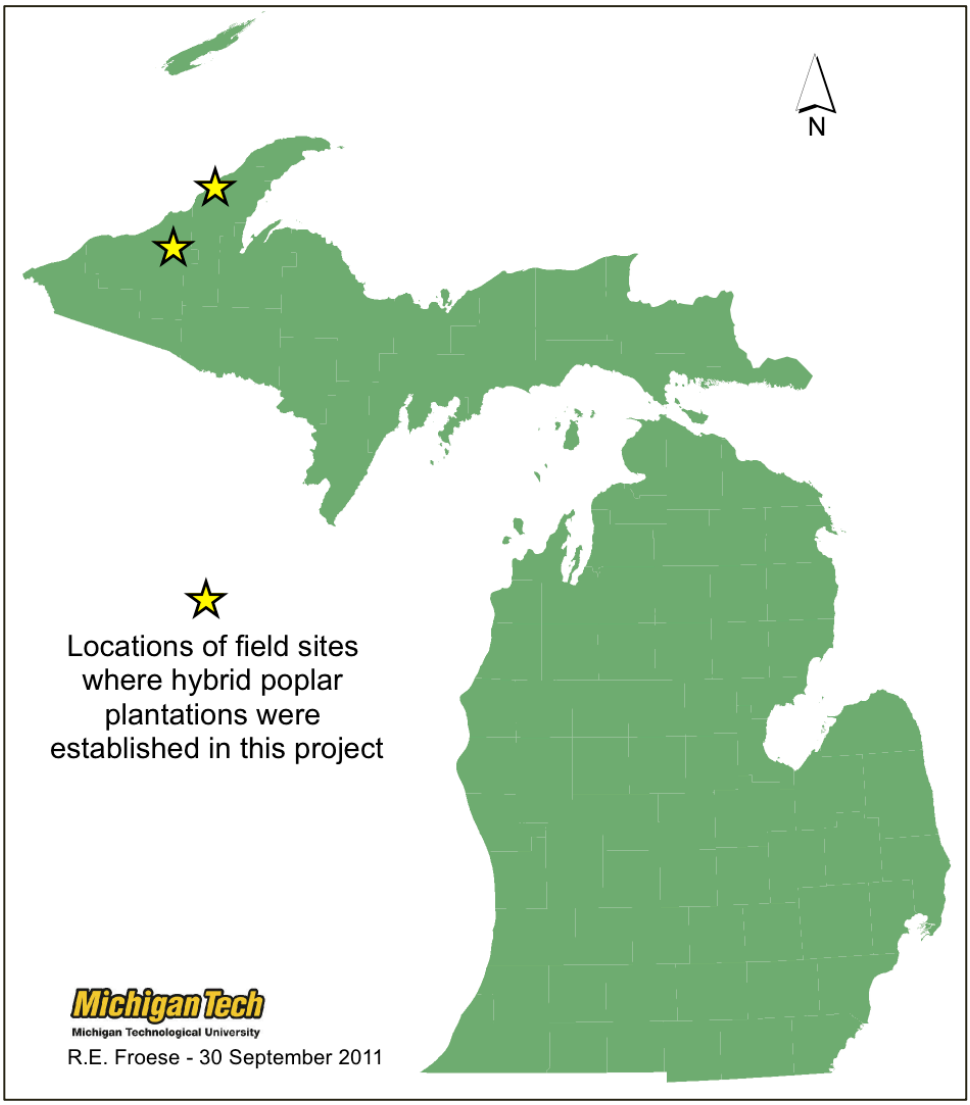

Figure 1. Locations of the sites selected for this project.

The second site is a 10-acre property near the community of Mass City, in Greenland Township, Ontonagon County MI. This site is about 41 miles by road from the MTU campus. Past use for this property was similar to the Redridge site, but having been retired for much longer, perhaps more than 15 years. Both sites have reliable access across the owner's property and the property owners were excited about participating in the project.

Establishment

Unfortunately, because a license was ultimately not obtained for the highest-ranked property identified in 2010 the final site selection was not complete until early in 2011. Therefore, site preparation was not started in the fall as initially planned. This complicated site preparation for several reasons. Machine access is dependent on acceptable soil conditions (i.e., soils sufficiently dry to be trafficable) and soils were very wet in May and June of 2011. Also, herbicide application depends on sufficient plant development, so for increased effect a delay in site preparation until herbicides could be applied in mid-May was necessary.

Application of broadcast herbicides (glyphosate) was completed in late May and site preparation was completed by early June, undertaken by local contractors. Sites were prepared fist by deep cultivation with a moldboard plough, followed by leveling using a disc harrow or field cultivator. Equipment selections were made by local contractors to maximize efficiency. Because of excess moisture and equipment limitations approximately half of the Redridge site did not receive deep ploughing and was instead repeatedly worked using a field cultivator.

Figure 2. Hand planting of unrooted hybrid poplar cuttings (photo taken June 2011).

Planting stock was transported by truck to Michigan Technological University and kept refrigerated at approximately 38 F until the day of planting. Stock was transported to the site and stored under reflective cover until needed. Unrooted cuttings were hand planted by temporary laborers in mid June under near ideal weather conditions (Figure 2).

Figure 3. Early growth of cuttings at the Redridge site (photo taken in July 2011).

Weed control through initial site preparation was very effective (Figure 3). Establishment and early survival of the poplar cuttings was very high, exceeding 95% of the stock planted.

The weed community developed slowly in July and August, but was sufficiently developed by mid August to warrant treatment. Rototilling, where soils were suitable, was used for weed control; this was possible on the entire Mass City site and portions of the Redridge site, where rock content was low. Weed control was undertaken elsewhere using a combination of disc harrow and field cultivator. Precipitation was atypically low in August and September, which also had a negative effect on growth.

Fencing

Monitoring of plantation establishment through the end of July 2011 revealed little browse damage from white-tailed deer, with the exception of the field margins where adjacent land was in tree cover. By late August browse was observed throughout both the Redridge and Mass City locations, though the intensity was higher at the Redridge site likely because the site is secluded and surrounded on three sides by established forest.

Temporary electric fencing was installed at both sites in late Summer 2011 to reduce subsequent browse impact. Fences were monitored every second day for the first week after installation to detect any damage and to ensure they were operating correctly. Afterwards, fences were monitored weekly. No further browse was observed within fenced areas.

Discussion

This project was completed successfully, meeting all initial goals and despite some difficult challenges. Two sites were identified, use licenses were negotiated, and best management practices for hybrid poplar plantation establishment were followed. Weather and suboptimal timing delayed planting, but planting was finished after appropriate site preparation was completed in late spring within the recommended window.

Early survival was excellent, and trees achieved good growth with minimal weed competition until late in the growing season. Late season weed control and increasing deer browse through August depressed height growth somewhat on portions of the plantations. Overall those impacts were for the most part relatively small (apparently less than 20% of potential), especially after cultivation to control weeds and the construction of temporary fencing on portions of the plantations experiencing the greatest browse.

Literature Cited

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