Energy Performance Systems, Inc.
Owner & Developer of the Whole Tree Energy™ Technology

Project Title: **Improving the Efficiency of Planting, Tending and Harvesting Farm Grown Trees for Energy**

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Congressional District: 6 (Equipment Building Location: Big Lake, MN)

MILESTONE 25 - SUMMARY REPORT
Annual Tending and Monitoring of Trees

Executive Summary:

Hybrid poplar plantings established near Graceville, MN were monitored November 1-2, 2011 for 5th year growth on the 80 acre site and for 4th year growth on the 10 acre production site and the 5 acre clonal trial. Growth rates were somewhat less than expected. This is most likely explained by weather conditions that included a very cold, wet spring and early summer resulting in lower solar radiation and higher incidence of leaf rust diseases plus droughty conditions in the latter portion of the growth season. Corn yields were also depressed achieving about 40% fewer bushels per acre than in recent years. The reduced growth rates were visually evidenced by height growth of only 1-2 feet in the larger trees, however, to our surprise, height growth was very good for smaller trees in lower lying areas that are normally wetter throughout the growth season particularly on the 5 acre clonal trial site. In some cases, those trees showed height increments of 5 to 7 feet. The resilience of these poplar trees was demonstrated by their ability to survive for several years under excessively wet soil conditions and then take advantage of droughty conditions that temporarily improved soil nutrient access in the lower lying areas. The very best growth plots at all sites are competitive with growth rates shown by average clones in the Pacific Northwest, notwithstanding the climate challenges of 2011. The basal area per acre production of the best growth plots are supporting the concept that trees planted at 5 ft x 5 ft spacing could be reaching the stage in the growth curve that would be economically optimal for harvest as an energy crop after 5 years of growth.

Technical Progress Milestone 25: Annual Tending and Monitoring in fifth year of project.

Introduction

This milestone report includes growth summaries of hybrid poplars established on the 80 acre site near Graceville, MN (Google Earth Photo 1), the 10 acre poplar production site (Google Earth Photo 2) east of Dumont, MN and the 5 acre clonal trial west of Dumont (Google Earth photo 3). The first two sites were monitored and measured on October 17, 2011by a

collaborator from the University of Minnesota's Natural Resources Research Institute (Dan Buchman) and the 5 acre site was measured in Mid-November by a collaborator associated with Iowa State University (Jud Isebrands). The project PI's also monitored the sites and took photos November 1&2. All photos referenced in the text are contained in Appendix A.

Tending and research activities on the EPS hybrid poplar study sites in Western Minnesota.

Maintenance in 2011 consisted of mowing of small patches of noxious weeds on the Graceville site in areas where the trees had not survived in earlier years. In areas with good tree survival and growth, there were no weeds due to stand closure (Photo 4). In areas not yet attaining stand closure, weeds did exist, but the height growth of those trees actually outperformed that of trees in areas with a closed canopy (Photo 5). The only tending that would normally be considered in four and five year old hybrid poplar stands would be pest control and fertilization. The fertilization trial established in 2010 showed no difference in growth, so fertilization did not appear to be needed at this time. No insect problems were noted during the year, so no pest control tending was required. Leaf spot problems did occur (Photos 6 & 7), caused by a long wet period during the early part of the growth season, but there is nothing that can be done about leaf spot diseases except to plant clones that are less susceptible in the future. The following statement was found in a University of Minnesota Extension bulletin about leaf spot diseases.

"Marssonina and Septoria leaf spots are two common diseases occurring on poplars, aspens, and cottonwoods. These diseases produce similar symptoms and have similar life cycles, but are caused by different fungi. Marssonina leaf spot is caused by several species of Marssonina, and Septoria leaf spot by Septoria musiva. Since these two diseases produce similar symptoms that may vary depending on the host and the severity of infection, a microscopic examination is needed to differentiate these two organisms.

Both fungi survive winter on fallen infected leaves. In the spring, the fungus produces spores that are wind blown or rain splashed from infected leaves to newly emerging leaves. Infection begins in the lower branches and progresses upward. Initially, symptoms appear as small, dark colored flecks on the leaves. Later, these flecks may expand into spots of various sizes and shapes. Some spots may eventually develop white to tan centers with dark margins. Infected leaves often turn yellow and drop from the tree.

Fungal reproductive structures in the center of the leaf spot produce spores, which are rain splashed to nearby leaves throughout the summer. These spores cause new infections and spread the disease in an upward direction. If infection is severe, spots may coalesce causing entire leaves to brown and drop prematurely. Occasionally, severe infections by Septoria musiva may produce cankers (discolored and sunken areas) on the branches or trunk. These cankers mainly affect poplar hybrids.

There are no chemical controls available for Marssonina or Septoria leaf spots. However, these diseases generally do not cause serious harm to healthy trees. Trees that are severely defoliated for several years in a row are more susceptible to dieback and winter injury. Both diseases can be managed with sanitation and proper tree care. Rake leaves in the fall and prune dead or dying branches. Properly dispose of all infected material. Water trees during dry periods, mulch, and fertilize as needed to maintain tree vigor.

Monitoring and Measurement on the two 40 acre Graceville, MN sites – 5th growth year.

The University of Minnesota collaborator provided the tree diameter breast height (dbh) measurements and yield estimates to the project PI's prior to our monitoring and photo taking visit on November 1 & 2, 2011. Each plot included 25 planted locations. Some of the planted locations contained 2 or more stems per tree and the total number of stems varies considerably among plots. Average dbh per tree was obtained by measuring dbh of the 2 largest stems then taking an average. Since, individual stem dbh measurements were used for estimating basal area

from which the yields, average stem dbh measurements are also given. In some cases the average stem dbh is higher than the average tree dbh because the estimation of average tree dbh included 0 values where the tree is not surviving or was too short. In most cases the plots with the greatest number of trees with more than one stem resulted in the highest yields.

Table 1. Hybrid poplar growth and yield estimates from 5 year old plots representing the better areas of growth in the two 40 acre fields established in 2007 in Graceville, MN

Site	Loca-tion	Plot#	2011 Avg Dbh per tree[1] (in)	2011 Avg Dbh per stem[2] (in)	2011 No. stems in plot	2011 Basal area/ac (sq ft	2011 standing Yield odt/ac	2011 ODT/ac/ year
Graceville	West	1	2.71	2.95	23	77.99	21.92	4.38
Graceville	West	2	2.88	2.67	27	76.27	21.46	4.29
Graceville	West	3	2.75	2.37	29	67.53	19.02	3.80
Graceville	West	4	2.97	2.47	30	73.29	20.64	4.13
Graceville	West	5	3.31	2.36	35	82.83	23.33	4.67
Avg			2.93	2.57		75.5	21.27	**4.25**
Graceville	East	6	2.58	2.69	24	68.88	19.38	3.88
Graceville	East	7	2.87	2.39	30	68.91	19.42	3.88
Graceville	East	8	2.74	2.44	28	65.90	18.56	3.71
Graceville	East	9	3.42	2.25	38	76.35	21.53	4.31
Graceville	East	10	3.13	2.30	35	73.13	20.61	4.12
Avg			2.95	2.42		70.63	19.90	**3.98**
Overall Average								**4.12**

[1] All 25 tree locations were included in the average tree dbh estimate even if missing (0 values).
[2] Only surviving stems were included in average stem dbh (thus no 0 values included).

The yield calculations in table 1 show that the west and east fields near Graceville are producing similar growth rates with the average total basal area being just a little larger among the plots measured in the west field. Photo 8 shows a stem that is slightly larger than average and photo 9, one of the larger trees on the site.

Monitoring and Tree Measurement in the Poplar Production Trial south east of Dumont, MN

When the five acre production trial site was contracted in 2008, it appeared to be a relatively uniform site with good to high quality soils. However, it is obvious based on the 2010 aerial photographs that appearances can be deceiving. Starting from the northeast side of the field, five measurement transects were established each with three linear plots (of 150 feet length) per transect should have contained 30 trees. Unfortunately due to serious soils issues (possibly associated with a past history of dairy cattle manure deposits) on the north eastern end of the field, tree growth was seriously compromised and the presence of aggressive weeds forced some of the plots to be totally or partially mowed down. Tree number per plot varied primarily due to uneven planting spacing. Additionally the best growth area on the site was inadvertently not included in the original measurement plots, since five transects were deemed sufficient. The 2011 data collected on October 17 is summarized in table 2.

Table 2. Hybrid poplar growth and yield estimates in the 4-year old 10 acre production site established in 2008 near Dumont, MN

Site	Plot location	Plot #	2011 Avg Dbh per tree [1] (in)	2011 No. of trees planted[2]	2011 Avg Dbh per stem[3] (in)	2011 No. of Stems	2011 Basal area/ac (sq ft)	2011 Standing Yield odt/ac	2011 odt/ac/yr estimate
Dumont	East	1	missing						
Dumont	Mid	2	1.63	28	1.69	27	27.83	7.89	1.97
Dumont	West[4]	3	2.68	28	2.33	33	55.28	15.59	3.90
Dumont	East	4	1.89	31	1.58	37	32.21	9.16	2.29
Dumont	Mid	5	1.12	32	1.03	35	14.66	4.24	1.06
Dumont	West	6	1.65	33	1.60	34	30.32	8.62	2.15
Dumont	East	7	missing						
Dumont	Mid	8	1.57	36	1.67	34	35.29	10.01	2.50
Dumont	West[4]	9	2.48	34	2.16	39	60.92	17.19	4.30
Dumont	East	10	2.13	30	1.83	35	39.89	11.30	2.82
Dumont	Mid	11	1.50	29	1.45	30	22.92	6.53	1.63
Dumont	West	12	1.99	33	1.87	35	40.22	11.39	2.85
Dumont	East	13	1.78	30	1.78	30	31.99	9.07	2.27
Dumont	Mid	14	1.38	30	1.38	30	17.65	5.05	1.26
Dumont	West	15	2.15	32	2.22	31	47.91	13.53	3.38
All plots Average + SD			1.84+ 0.41		1.77 + 0.31		34.72 + 11.91	9.84 + 3.34	**3.28 1.11**

[1] All planted tree locations were included in the average tree dbh estimate even if missing (0 values included).
[2] Planned trees per plot were 30 but due to uneven spacing the number of trees varies.
[3] Only surviving stems were included in average stem dbh (no 0 values included)
[4] In plot No. 3 the main stems of many of the trees were broken by windswept snow in winter of 2009 but regrowth of multiple stems resulted in substantially higher basal area. The effect of multiple stems is also seen in plot 9 but no explanation for the many stems is available.

Results from the five acre hybrid poplar clonal trial west of Dumont, MN.

Measurements of the clonal trial plots were obtained by Jud Isebrands in fall of 2009 when 2nd growth year heights were measured and in November 2011 when dbh of the 4th growth year stands were measured. The trees were planted as trimmed 1 year old rooted cuttings (called stecklings) (Photo 10). Each replicate is oriented in a North-South direction and includes higher to lower field positions. Replicate 1 is close to a natural area (east side), replicate 2 is in the middle and replicate 3 is close to a corn field (Photo 11) (west side) (Table 3). Since there were limited numbers of some clones, such as clones 4, 5 and 7, all of the clones are only represented in replicate 2. However the duplication of clones in the other two replicates allows some comparison of soil conditions on growth. Clones are represented by more than one plot per replication are separated by relative position indicated as N (north), M (mid), or S (south).

Table 3. Clone layout

			Replicate 3					Replicate 2					Replicate 1							
North	9	9	9	9	9	9	9	5	5	5	5	5	9	9	9	9	9	9	9	
May 30,2008	1	1	1	1	1	1	1	5	5	5	5	5	1	1	1	6	6	6	6	
	10	10	9	9	9	9	9	5	5	5	5	5	6	6	6	6	6	1	10	
	10	10	9	9	9	9	9	5	5	5	5	5	6	6	6	6	6	1	10	
	10	10	9	9	9	9	9	5	5	5	5	5	6	6	6	6	6	1	10	
Clone	10	10	9	9	9	9	9	5	5	5	5	5	6	6	6	6	6	1	10	
ID #	10	10	9	9	9	9	9	5	5	5	5	5	6	6	6	6	6	1	10	
1 = D105	10	10	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	1	10	
2 = 34	10	10	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	1	10	
3 = NM6	10	10	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	1	10	
4 = DN177	10	10	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	1	10	
5 = NE222	10	10	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	1	10	
6 = C9425-35	10	10	6	6	6	6	6	1	1	1	1	1	8	8	8	8	8	1	10	
= ISU 25-35	10	10	6	6	6	6	6	1	1	1	1	1	8	8	8	8	8	1	10	
7 = 91x04-03	10	10	6	6	6	6	6	1	1	1	1	1	8	8	8	8	8	1	10	
8 = 80x01112	10	10	6	6	6	6	6	1	1	1	1	1	8	8	8	8	8	1	10	
9 = DN 2	10	10	6	6	6	6	6	1	1	1	1	1	8	8	8	8	8	1	10	
10 = P. deltoides	10	10	9	9	9	9	9	3	3	3	3	3	9	9	9	9	9	1	10	
	10	10	9	9	9	9	9	3	3	3	3	3	9	9	9	9	9	1	10	
	10	10	9	9	9	9	9	3	3	3	3	3	9	9	9	9	9	1	10	
East	10	10	9	9	9	9	9	3	3	3	3	3	9	9	9	9	9	1	10	West
	10	10	9	9	9	9	9	3	3	3	3	3	9	9	9	9	9	1	10	
Corn	10	10	1	1	1	1	1	9	9	9	9	9	2	2	2	2	2	1	10	
	10	10	1	1	1	1	1	9	9	9	9	9	2	2	2	2	2	1	10	
	10	10	1	1	1	1	1	9	9	9	9	9	2	2	2	2	2	1	10	
	10	10	1	1	1	1	1	9	9	9	9	9	2	2	2	2	2	1	10	
	10	10	1	1	1	1	1	9	9	9	9	9	2	2	2	2	2	1	10	
	10	10	3	3	3	3	3	4	4	4	4	4	1	1	1	1	1	2*	10	
	10	10	3	3	3	3	3	4	4	4	4	4	1	1	1	1	1	2	10	
	10	10	3	3	3	3	3	4	4	4	4	4	1	1	1	1	1	3*	10	
	10	10	3	3	3	3	3	4	4	4	4	4	1	1	1	1	1	3	10	
	10	10	3	3	3	3	3	4	4	4	4	4	1	1	1	1	1	2*	10	
	10	10	8	8	8	8	8	6	6	6	6	6	3	3	3	3	3	2	10	
	10	10	8	8	8	8	8	6	6	6	6	6	3	3	3	3	3	3*	10	
	10	10	8	8	8	8	8	6	6	6	6	6	3	3	3	3	3	3	10	
	10	10	8	8	8	8	8	6	6	6	6	6	3	3	3	3	3	2*	10	
	10	10	8	8	8	8	8	6	6	6	6	6	3	3	3	3	3	2	10	
	10	10	9	9	9	9	9	8	8	8	8	8	9	9	9	9	9	3*	10	
	10	10	9	9	9	9	9	8	8	8	8	8	9	9	9	9	9	3	10	
	10	10	9	9	9	9	9	8	8	8	8	8	9	9	9	9	9	2*	10	
	10	10	9	9	9	9	9	8	8	8	8	8	9	9	9	9	9	2	10	
	10	10	9	9	9	9	9	8	8	8	8	8	9	9	9	9	9	3*	10	
	10	10	2	2	2	2	2	7	7	7	7	7	5	5	5	5	5	3	10	
	10	10	2	2	2	2	2	7	7	7	7	7	5	5	5	5	5	2*	10	
	10	10	2	2	2	2	2	7	7	7	7	7	5	5	5	5	5	2	10	
	10	10	2	2	2	2	2	7	7	7	7	7	5	5	5	5	5	3*	10	
	10	10	2	2	2	2	2	7	7	7	7	7	5	5	5	5	5	3	10	
	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	

The data presented in Table 4 shows the mean height response of the center 9 trees in each 25 tree plot in each replication. By fall 2009, trees reaching 11 feet or more were clones D105, NM6, DN 177, and DN2.

Table 4 Mean heights of the inner measurement plot of 9 trees in each plot.

		Rep 1		Rep 2		Rep 3	
Clone #	Clone Key	Mean Height (ft)	Range	Mean Height (ft)	Range	Mean Height (ft)	Range
1N[1]	D105	7.6	4.0-11.2	N/A		6.6	3.5-10.2
1S	D105	13.3	10.2-16.7	10.8	8.4-12.6	7.7	5.0-10.8
2	DN34	9.7	5.2-11.6	11.2	9.6-12.0	8.5	5.0-11.7
3	NM6	11.8	8.9-14.8	12.4	9.7-13.9	5.6	3.0-8.2
4	DN177	N/A		11.9	10.7-12.9	N/A	
5	NE222	10.0	6.1-11.9	10.6	8.8-11.4	N/A	
6	ISU24-35	7.3	5.0-9.1	10.7	7.5-12.2	5.4	4.0-7.2
7	91x04-03	N/A		8.0	5.3-10.8	N/A	
8	80x01112	5.3	3.0-7.6	7.2	5.2-10.7	4.7	4.2-5.5
9N	DN2			N/A		7.7	6.0-11.3
9M	DN2	11.0	9.6-11.9	11.9	9.9-13.7	7.5	4.0-10.1
9S	DN2	10.1	9.2-11.3			6.0	3.6-8.3

[1] The N(north), M(medium), and S(south) notations are an indication of relative position to other plots of the same clone – not an indicator of specific position in the field.

Table 5 summarizes the mortality and browse condition of all 25 trees per plot as of 2009, but the data is organized different than table 4 in order to reflect the actual position of the clones in the field. The clone comparison trial suffered very heavy deer browse on many the small trees but browse effects appears to be relatively random and not linked to clone or position. It is uncertain whether the mortality measured was due to extreme deer browse, weed competition or soil conditions or a combination thereof. The mortality and browse date is re-organized in table 5 to show the plots as they actually are positioned in the field. Visual monitoring each year has shown that trees in the south and southeast portion of the field suffered from wet soil conditions in most years and from standing water in 2010. A cluster of high mortality occurs in that region (table 6), but the lowest height growth is not correlated to the plots with highest mortality.

Several of the clones which were able to outgrow the deer browse early and those which were located in areas of better soils have shown excellent growth (Photo 12). The droughty conditions that occurred in the second half of the growing season in 2011 improved soil conditions in the southern portion of the field and the trees responded by adding 5 to 7 feet of growth and showing substantial diameter increases (Photo 13 is most likely of clone 7). Analysis of the growth of the trees based on the 2011dbh measurements is still in process. The dbh summary will be provided for the final report and will attempt to take into consideration the mortality and deer browse problems when evaluating clonal performance.

Table 5 Summary of mortality and browse damage within the whole 25 tree plot organized to duplicate N-S (top to bottom) and E to W (left to right) positions in field.

	Rep 3 – next to corn			Rep 2 – middle			Rep 1 – next to natural area		
N – S plot[2]	Clone #	% Mortality	% Browse	Clone #	% Mortality	% Browse	Clone #	% Mortality	% Browse
1	9N	12	24	5	0.4	0	6	8	12
2	1N	12	0	2	0	0.4	1N	8	0.4
3	6	36	0	1	0.4	0	8	0	12
4	9M	16	0.4	3	8	8	9M	20	0.4
5	1S	0.4	0.4	9	16	0	2	0	0
6	3	28	0	4	8	0.4	1S	0.4	0.4
7	8	60	0	6	0	16	3	0	0
8	9S	48	0	8	0	0	9S	8	0
9	2	8	0	7	0.4	0.4	5	20	0

[1] Clone key: 1 = D105, 2 = DN34, 3 = NM6, 4 = DN 177, 5 = NE 222, 6 = C9425-35 also ISU 25-35, 7 = 91x04-03, 8 = 80x01112, 9 = DN2.

Animal use of the sites.

Several types of wildlife are utilizing all of the sites; deer usage on all sites is very common, a probable badger hole was found on the west 40 field in Graceville in 2010 and on the 5 acre clonal trial site near Dumont this year. Several bird nests were found at all three sites.

Climate summary information for the Western-central Minnesota region in 2009 and 2010

The two weather station sites being used for estimation of growing conditions are about 15 miles north and west from the Graceville experimental sites. The Dumont experimental sites are about 10 to 12 miles south of Wheaton and about 16 to 18 miles east of Brown's Valley. The base temperature for growth of poplars is likely to be lower than the 50 ^{o}F base used for estimating growing degree days, but the data provides a comparison of the growing degree days with long-term records.

Table 3 Growing Degree Days ^{o}F (base 50) in 2011 at two locations near Graceville and Dumont. BV = Browns Valley, Minnesota, W = Wheaton, Minnesota

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
BV	0	0	0	12	154	424	722	598	279	164	0	0	2353
W	0	0	0	16	191	454	777	613	299	173	0	0	2521

Table 4 Growing Degree Days ^{o}F (base 50) in 2010 from January through October.

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
BV	0	0	7	72	243	495	663	686	200	99	-	-	2465
W	0	0	9	85	291	509	692	677	218	122	-	-	2603

Average annual growing degree days ^{o}F (base 50) over the period 1981 to 2010 is 2633 for Browns Valley and 2703 for Wheaton, thus 2010 experienced close to normal conditions, while 2011 experienced 100 to 300 fewer growing degree days than the 30 year norm.

Table 5 Precipitation in 2011 at two locations near Graceville and Dumont

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
BV	1.11	1.65	1.91	1.42	3.79	3.89	6.46	1.79	0.47	0.77	0.02	-	23.28
W	1.33	1.30	1.07	1.48	3.36	4.12	8.01	2.52	0.41	0.79	0.05	-	24.44

Table 6 Precipitation in 2010 at two locations near Graceville and Dumont

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
BV	1.59	1.68	2.01	1.81	2.20	4.31	2.14	5.43	4.55	1.84	-	-	27.56
W	1.17	1.28	1.21	1.87	1.81	2.94	2.49	3.95	7.42	1.96	-	-	26.10

Average **annual** precipitation over the 30 year period of 1981 to 2010 was 24.79 inches for Browns Valley and 24.84 for Wheaton. Average **growing season** precipitation (April-October) over the period 1981 to 2010 was 20.04 inches at Browns Valley and 20.22 in Wheaton. The 2011 total precipitation in Browns Valley and Wheaton was rather similar to both the 30 year annual and growing season averages but less than was experienced in 2010. However the monthly distribution of the precipitation was quite different between 2010 and 2011. The high rainfall levels in May, June and July of 2011 created a cool wet environment early in the growth season which is particularly favorable for the leaf diseases described earlier. In 2010 the highest monthly rainfalls occurred later in the growing season (August and September).

Summary and Discussion

Using the 2nd through 5th year growth data from the two Graceville 40 acre fields and the 2nd through 4th year data from the Dumont site plus making conservative assumptions about basal area at the end of year 1, it is possible to compare the growth of NM6 in Minnesota with two clones grown relatively near Olympia, Washington at slightly lower density (figures 2 & 3). The density of the Washington experimental trials was about 43 sq ft per tree (planted at the equivalent of about 6.5 x 6.5 ft) whereas the density in the Minnesota large scale trials was about 25 sq ft per tree. On the Graceville, MN site the average growth over 10 plots is similar to growth of the slower growing Washington clone D01 over the 5 years of measurement to date. However, the growth rate of the best single plot of NM6 in Graceville started out similar to the best Washington clone at ages 1 and 2 but slowed in years 3 through 5. The best single plot on the Dumont site appears to be following a similar growth trajectory as the best plot at Graceville, both showing excellent growth potential for the Minnesota climate.

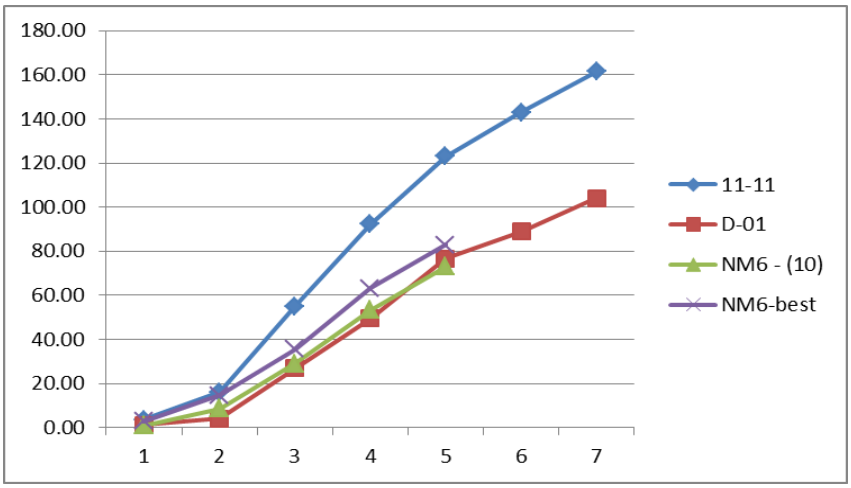

Figure 2. Comparison of basal area of two clones (11-11 and D-01) grown in the Pacific Northwest with NM6 grown in Graceville, Minnesota.

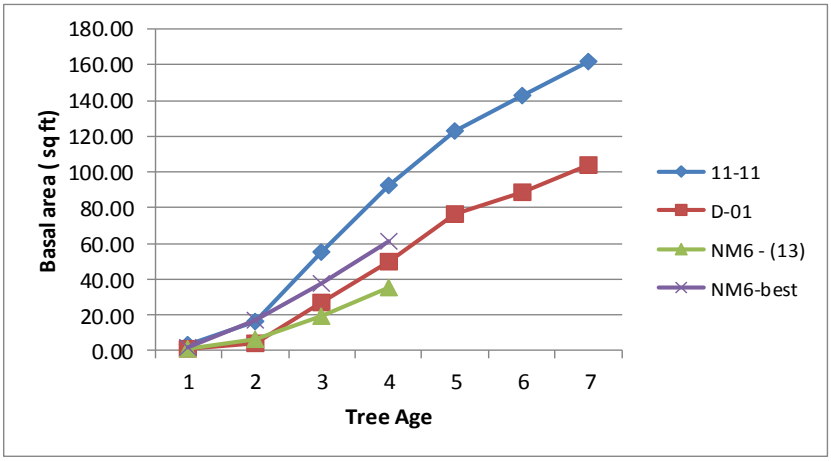

Figure 3. Comparison of two clones (11-11 and D-01) grown in the Pacific Northwest with NM6 grown in Dumont, Minnesota

It had been hoped that 2011 growth in both the 4 and 5 year old stands would be even better than last year since growth should still be in an acceleration phase. Instead the growth rate was similar or slightly less than in 2010. According to University of Minnesota hybrid poplar expert, Bernie McMahon, the leaf diseases (Marsonnina and Septoria leaf spot) attacked stands all over Minnesota and contributed to slowed growth. Based on the graphs above, the growth rate on the Graceville site suffered only a slight decrease, while the growth rate at the Dumont production trial site suffered a more obvious decrease. Visual inspection indicated that the Dumont site was particularly hard hit by the Marsonnina leaf fungus, as evidenced by the early leaf fall. Photos taken in mid-September at the Dumont site (Photo 14) showed that most of the leaf canopy had fallen at least a month before normally expected. Nevertheless, the best single plot growth trajectory at Dumont as shown in purple in Figure 3 does not appear particularly abnormal. While all stands were likely affected to some degree by leaf diseases, the best single plot measured in the 5 year old Graceville could also be affected by intra-tree competition since the basal area per acre is about 82 square feet. If such growth rates could be obtained over most of the field, then a planned harvest for energy after 5 years of growth (or a thinning if multiple use of the wood is preferred) would be totally on target.

Perhaps the most interesting observation from the 2011 growth monitoring is the excellent resilience shown by poplars in general and particularly the NM6 clone. This was demonstrated in several ways. First was the observation that some of the NM6 trees in lower lying areas of the fields (whose growth had been suppressed in previous years due to wetness), were not only surviving but thrived under 2011 conditions, adding up to 7 feet of growth even with the leaf disease problem. Second was the fact that while corn yields in western Minnesota area were as much as 40% below recent yields, the average growth rates of the trees were actually near normal based on comparisons with growth curves in other areas of the country. Third was the observation that at least some of the clones in the 5 acre clonal trial (including NM6) were able to survive the severe weed competition and deer browse that occurred in the first and second years after planting and eventually put on growth at a rate that is very competitive with that of the NM6 on the other two sites. The clone trial growth data to support that observation will be available in the final report but photo 12 shows trees similar in size to those in photos 4 and 8 of this report.

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APPENDIX A

Photo 1 Google Earth image taken in 2005 of Graceville West (left) and East (right) fields, overlain with sample plot locations established in 2007.

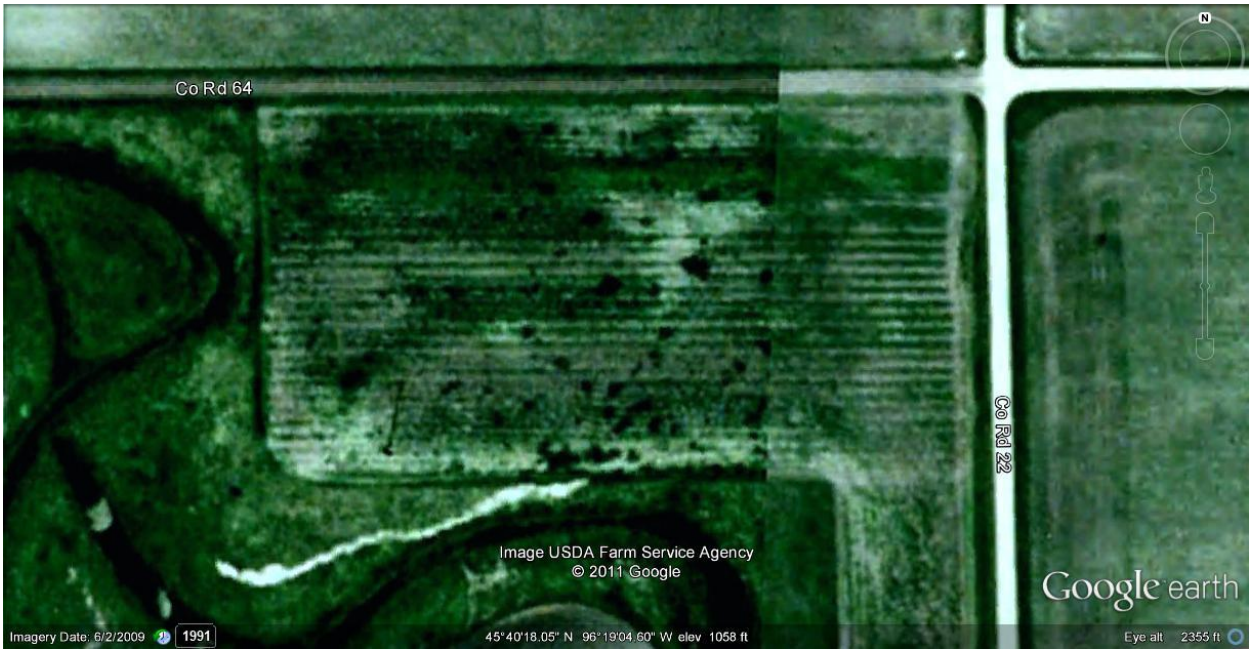

Photo 2 Google Earth Image of Dumont Production Trial taken in 2009.

Photo 3 Google Earth image of Dumont Clone Comparison Trial Site taken in 2005. The arrow point to a mid site location north to south and east to west. Corn was established on the left (west side) between the trees and the road, and the right (east side) was a natural area.

Photo 4 Closed canopy on 5 year old Graceville site.

Photo 5 Graceville Age 5 trees in area without closed canopy.

Photo 6 Blackened edges of leaf suggest Marsonnina leaf spot disease.

Photo 7 Hybrid poplar leaf that included round spots likely associated with Septoria leaf spot.

Photo 8 Example of a slightly larger than average sized stem (~ 3.1 dbh) on the Graceville site.

Photo 9 David Ostlie measuring one of the larger 5 year old trees (~4.2 inches dbh) on the Graceville site.

Photo 10 Image of a steckling - the plant type used for establishing the clone comparison trial.

Photo 11 View of area between corn planting and tree planting sprayed with herbicides. Weed competition in the tree planting was severe in 2008. The open pathway may have allowed ease of access by deer to replicate 3.

Photo 12 Some of the best growth as of November 2011 on the clonal comparison plot

Photo 13 Excellent current year height growth in 2011 of trees in the clone comparison trial that had limited growth in previous years due to standing water and high pH.

Photo 14 Four year old hybrid poplar stand experiencing early defoliation in September 2011 due to leaf spot disease