Fiber farming using Populus hybrids, aspen, and European larch in Michigan's Upper Peninsula

Raymond O. Miller

(Draft 2/20/04)

Abstract

The rapid production of wood fiber for paper and other products can be achieved using carefully selected taxa grown under intensive cultural systems on the best sites. This study grew some promising taxa under growth optimizing conditions and examined the yield and incidence of damage under replicated conditions in the central Upper Peninsula of Michigan. After six growing seasons (half-way through the rotation) *Populus nigra* x *P. maximowiczii* was producing significantly more biomass (in excess of 3.6 dry tons per acre·year) than other taxa tested and was relatively free of insect and disease pests. Nine percent of these trees suffered wind breakage but they seemed to be recovering well from that damage. The study will continue for another six years to see if initial observations bear up over time.

Introduction

Wood fiber is the raw material that supports an extensive paper and oriented strand board industry in Michigan. This fiber presently comes from trees harvested in natural stands or plantations that are managed using traditional forestry techniques. It is possible, however, to grow wood fiber more quickly if intensive forest management systems are employed. Intensive systems require careful species selection, meticulous site preparation, control of weeds, fertilization, pest control, and occasionally irrigation (Stoffel, 1998). They are therefore more costly and complicated to employ than traditional systems. Because intensive forest management systems begin to resemble agriculture more than forestry, this concept has come to be called Fiber Farming.

A benefit of Fiber Farms is their ability to produce more fiber per unit of land and time. The time between establishment and harvest using traditional management systems is usually about 80 years. Fiber Farms promise to shorten that time, for some types of fiber, to about 12-20 years (Anonymous, 2002). If true, current fiber production could be quadrupled on some sites. This could provide an increase in total fiber production using the current forest land base. Alternatively, fewer acres may be required to produce the same amount of wood fiber presently consumed by forest industry – freeing some areas for alternative uses. In either case, the cost of land ownership and forest management can be spread over more product.

Shorter rotations allow the fiber producer to respond more rapidly to changes in demands from the fiber market. Short rotations also allow the producer to realize a return on his initial investment sooner than would be possible under traditional forestry practices. This is a business model that is appealing to many forest land owners in Michigan. Short rotation forestry is particularly suitable for people with small parcels, with abandoned agricultural fields, or to those looking for alternatives to Christmas tree production.

Fiber Farming is well established in the Pacific Northwest and is gaining popularity in Wisconsin and Minnesota (Riemenschneider, *et. al.*, 1996) but has yet to be adopted in Michigan. Researchers in the other Lake States have found that poplar species and taxa (the genus *Populus*) grow well in Fiber Farms and are valuable to the forest industry. European larch (*Larix deciduas*), which produces a completely different type of fiber, is another species with the potential to respond to intensive management in Fiber Farms. Although researchers in Michigan have conducted screening of various larch species and poplar taxa for many years, little work has been done to develop Fiber Farming techniques for these species in the state. This project was undertaken to gain experience and refine these techniques for sites in Michigan's Upper Peninsula and to obtain information about yields and pest resistance for some of the taxa that have shown promise in other Lake States.

As a side issue, we wanted to examine how the application of wood ash to the site prior to planting would effect tree growth. Disposal of this waste product concerns Michigan's fiber consumers. Current practice involves placing the ash in sanitary landfills but this is costly. Alternative, less expensive methods of disposal are being sought. Broadcast application of ash to agricultural land or to fiber farms is one possible disposal method. Here, we examine whether the application of ash has any effect on the growth and survival of trees in our plantation.

Materials and Methods

Experimental Design:
The test was arranged in a randomized split-plot design. There were four blocks, three main-plots per block, and six sub-plots per main-plot. The main-plots comprised 3 levels of ash application (0, 4, and 8 tons per acre) and sub-plots comprised four poplar taxa, aspen, and larch (described below). Each sub-plot was made up of 64 trees arranged in a square grid of 8 rows and 8 columns. Rows and columns were spaced 8' apart. Only the interior 16 trees were examined. The remaining trees formed a 2-row border that isolated the interior of the plot from competition effects of adjacent plots.

Species and Clones:
Plant materials were selected for inclusion in this test based on superior performance in other plantations in the upper Great Lakes region (Hansen, *et. al.* 1994). Three hybrids of *Populus deltoids* x *P. nigra*: NE-222 (*P. deltoids* x *P. nigra* var. *caudina*), DN-5 (*P.* x *euramericana*, cv. 'Gelrica'), and DN-34 (*P.* x *euramericana*, cv. 'Eugenei') and one of *P. nigra* x *P. maximowiczii* (NM-6) were included. Cuttings of DN-34 were obtained from Hramor Nursery of Manistee, Michigan and cuttings of the other crosses were obtained from the Pope Soil and Water Conservation District of Glenwood, Minnesota. Containerized seedlings of European larch (*Larix decidua*) were provided by MeadWestvaco. The seedlot chosen was Mead #96-02-01 which is from a 'Sudetan' seed orchard maintained by the Aspen and Larch Genetics Cooperative of the University of Minnesota and is referred to by them as seedlot #XLD-7-96. Bare-root aspen hybrid (*P. tremula* x *P. tremuloides*) seedlings (from seedlot #XLD-T-296 of the same Aspen and Larch Cooperative) were obtained from the Michigan Department of Natural Resources' Brighton Tree Improvement Center.

Site Selection and Plantation Establishment:
An eight-acre agricultural field at Michigan State University's Upper Peninsula Tree Improvement Center in Escanaba, MI was selected for the test. The site was fairly level with deep, fine sandy loam soil of the Onaway series. These soils are well drained with high moisture capacity and high natural fertility with nearly neutral pH – excellent for agricultural or forestry[1]. Escanaba averages 28" of precipitation annually, 140 frost-free growing days, and 1,171 growing degree days[2]. The site had been continuously used for agriculture during the last 100 years, most recently for hay production and pasture.

Vegetation on the site was killed in the spring of 1997 with an application of glyphosate (Accord®). The site was then plowed to a depth of 7" and repeatedly cultivated throughout the 1997 growing season. An 8'-tall, electric fence was constructed during the summer of 1997 to exclude white-tailed deer from the test area.

Wood ash from a boiler at the MeadWestvaco paper mill in Escanaba was evenly applied at 0, 4, and 8 tons per acre to selected portions of the site (see experimental design above) in October of 1997. This ash was incorporated into the top 6" of the soil with a standard agricultural cultivator.

Aspen and larch seedlings and un-rooted cuttings of the four poplar taxa were planted in May of 1998. The spring of 1998 was exceptionally dry and so the plantation was watered twice during May, delivering a combined total of about 2.1 gallons of water to each tree. The herbicide linuron (Lorox®) was applied to all the poplar plots within two days of planting. Larch plots were hand-weeded as needed during the first year. This, together with mechanical cultivation, provided weed control during the first year.

---

[1] Soil Survey of Delta County and Hiawatha national Forest of Alger and Schoolcraft Counties, Michigan. USDA Soil Conservation Service.
[2] Michigan State Climatologist's Office. 30-year averages for the period 1951 through 1980. Growing degree days based on 50° F.

Plantation Maintenance:
Weeds were controlled in the plantation with a combination of mechanical cultivations and broadcast applications of imazaquin (Scepter®) and pendimethalin (Pendulum®) in the spring of the second through fifth years. Larch plots were not treated with these chemicals but received applications of sulfometuron (Oust®). Grass that escaped these treatments was spot treated with sethoxydim (Poast®) or fluazifop (Fusilade®) which act only against C_4 plants[3].

Trees were reduced to single stems in the fourth and fifth years. Lower branches were pruned at these times to facilitate access throughout the plantation.

Granular fertilizer was broadcast throughout the plantation in the spring of the third, fourth, and fifth years. The first application comprised 62 lbs/acre of elemental nitrogen, 5 lbs/acre of elemental phosphorus, and 187 lbs/acre of elemental potassium. The second two applications were double the rate of the first.

Measurements and Analysis:
As previously mentioned, measurements were made of the interior 16 trees of each sub-plot to avoid the uncharacteristic growth of trees on the plot edges. Total height of trees was measured at the end of each growing season. Diameter at breast height (BDH)[4] was measured at the same time on any tree that was tall enough. Height and diameter growth curves were developed for each species or taxa to visualize variations in growth physiology.

Various measures of tree damage were noted at the end of the sixth growing season. Observations were recorded for; incidence of wind breakage, presence of stem boring insects, evidence of decay at the base of each stem; and severity of cankering. Cankering was scored using a system devised by Ostry, *et. al.* (1989) where 0=no cankering, 1=branch cankers only, 2=minimal stem cankering, 3=heavy stem cankering, 4=killed by canker. An analysis of variance in damage scoring was conducted to discover trends among the data.

Biomass was estimated at the end of the sixth growing season based on the combined weights of the trees in each plot. Poplar tree weights were computed using a version of a predictor equation developed for these clones in similarly aged plantations in Minnesota and Wisconsin (Netzer, *et. al.,* 2002):

$$TreeWeight_{(Ovendry-pounds)} = 13.58 - 12.48DBH_{(inches)} + 5.03DBH^2_{(inches)}$$

This equation has not been tested for aspen and was never intended for use with larch. Because biomass estimates are a function of both individual tree growth and survival they provide the best overall measure of species and taxa suitability for use in Fiber Farms.

Results and Discussion:

Survival and growth:
Ash treatments had no significant effect on height, diameter, survival, or yield. This would indicate that at least 8 tons per acre of ash can be applied to forest sites like this without adverse effects to the trees. Wood ash tends to act like agricultural lime and de-acidify certain soils. This Onaway soil had a fairly high starting pH. Nutrient availability in more acidic soils may actually be improved through the action of wood ash on pH.

Survival was consistent across blocks but growth varied significantly among the blocks. This was not unexpected and is the reason for blocking in the first place. More importantly, there were no significant

---

[3] All trees and most broadleaf weeds fix carbon using the Calvin-Benson cycle (the C_3 process). Grasses and sedges among others fix carbon using the Hatch-Slack cycle (the C_4 process).
[4] Diameter at breast height is measured 4.5' above the ground on the stem.

interactions between blocks and either ash treatments or taxa. This means that treatment rankings were consistent from block to block.

Significant differences were present among taxa for all measures of growth and survival. The NM clone grew (Tables 1 & 2) and survived (Table 3) best. The three DN clones did less well but were superior to aspen and larch. Mean annual increment (Table 4) was highest for NM-6 at 3.65 dry tons per acre·year. The DN poplars produced about 2 dry tons per acre·year. These yields are comparable to those reported for 6-year-old plantations of similar taxa in Wisconsin and Minnesota. Mean annual increments there ranged from 1 – 4 dry tons per acre·year over 12 sites. Growth data reported from these other sites suggests that mean annual increments will continue at these levels for at least another 5 years (Netzer, *et. al.*, 2002).

The shape of the height and diameter growth curves (Figures 1 and 2) is similar for all species and taxa with rankings changing little over time. The slope of the curves is different and causes the species to differentiate more as time passes.

What is not obvious from the data but strikingly apparent on the ground, is the ability of NM-6 to fully occupy the growing space and exclude all weed competition in as little as three years. The efficiency with which this taxa uses solar radiation (and presumably soil resources as well) easily accounts for its superior growth and yield.

Damaging Agents:
The Achilles heel of most hybrid poplars is their susceptibility to insect and disease damage. Cankering by *Hypoxylon mammatum* in the case of aspen and *Septoria musiva* in the case of the other poplars has become established randomly throughout the plantation. Average tree scores are quite low, ranging from 0.04 for NE-222 to 0.21 for aspen (on the scale of 0 through 4 described earlier). There are no significant differences among the taxa at this time.

A butt rotting fungus (probably *Armillaria mellea*) has become well established in the plots of DN-5. Nearly 50% of all DN-5 trees are infected. The other taxa are relatively free of this problem (with incidence rates of 1 to 4%). Stem boring insects of various types are also beginning to make an appearance in all plots except, ironically, those of DN-5. The other taxa have relatively similar incidence rates of 4 to 6%.

No mortality has been attributed to insects or diseases at the end of the sixth growing season, but experience suggests that this will change with time. Eventually annual plot yields can be expected to drop as trees begin to die.

NM-6 trees have been susceptible to wind breakage in other plantations. 9% of the trees in NM-6 plots here were broken in high winds during 2002 and 2003. It was noticed, however, that side branches in these broken trees quickly obtained dominance and formed a new top. Tree height and diameter growth were undoubtedly reduced as a result of this breakage but it is difficult to predict how plot yields will be effected in the coming years. NM-6 grew more rapidly than any other taxa tested here. Perhaps if less fertilizer had been applied and, as a result, the trees grew more slowly, there would have been less breakage. That is a question for another investigation.

This study was designed with a 12-year life expectancy. This is the mid-way interim report. Future observations may well demonstrate differences in growth physiology among taxa that cause rankings to change. Disease and insect problems will also play a roll in the future yields of these taxa. Initial results are encouraging for prospective Fiber Farmers in Michigan but we council caution until the final report is available.

Acknowledgements

This work was funded in part by the Michigan Agricultural Experiment Station and by MeadWestvaco. This information is for educational purposes only. Reference to commercial products of trade names does not imply endorsement by Michigan State University or bias against those not mentioned. Contact the

author c/o Michigan State University, Upper Peninsula Experiment Station, 6005 J Road, Escanaba, MI 49829.

An aerial over-view of the Escanaba Fiber Farm

Table 1. Average height of trees after 6 growing seasons in a Fiber Farm in Escanaba, MI.

Taxa	Ht (ft)	*
NM-6	36.8	
NE-222	31.8	
DN-5	27.4	a
DN-34	27.4	a
Aspen	23.3	
Larch	11.8	

* Treatment means not followed by the same letter are significantly different at the 0.05 level of probability according to the LSD criterion.

Table 2. Average diameters of trees after 6 growing seasons in a Fiber Farm in Escanaba, MI.

Taxa	DBH (in)	*
NM-6	4.7	
NE-222	4.0	
DN-5	3.6	
DN-34	3.3	
Aspen	2.5	
Larch	1.6	

* All treatment means are significantly different at the 0.05 level of probability according to the LSD criterion.

Table 3. Average survival within plots after 6 growing seasons in a Fiber Farm in Escanaba, MI.

Taxa	Survival (%)	*
NM-6	95	ab
Larch	91	abcd
DN-34	87	bcde
DN-5	81	cdef
NE-222	80	cdef
Aspen	76	def

* Treatment means not followed by the same letter are significantly different at the 0.05 level of probability according to the LSD criterion.

Table 4. Average total plot dry weight and mean annual increment (dry weight/acre and cords/acre) after 6 growing seasons in a Fiber Farm in Escanaba, MI.

Taxa	(total lbs/plot)	(tons/acre·yr)	(cords/acre·yr)[1/]	*
NM-6	1031	3.65	2.9	
NE-222	583	2.07	1.7	a
DN-5	523	1.85	1.5	a
DN-34	425	1.51	1.2	
Aspen	211	0.75	0.6	

* Treatment means not followed by the same letter are significantly different at the 0.05 level of probability according to the LSD criterion.
[1/] Assuming 1.25 dry tons per cord.

Figure 1.

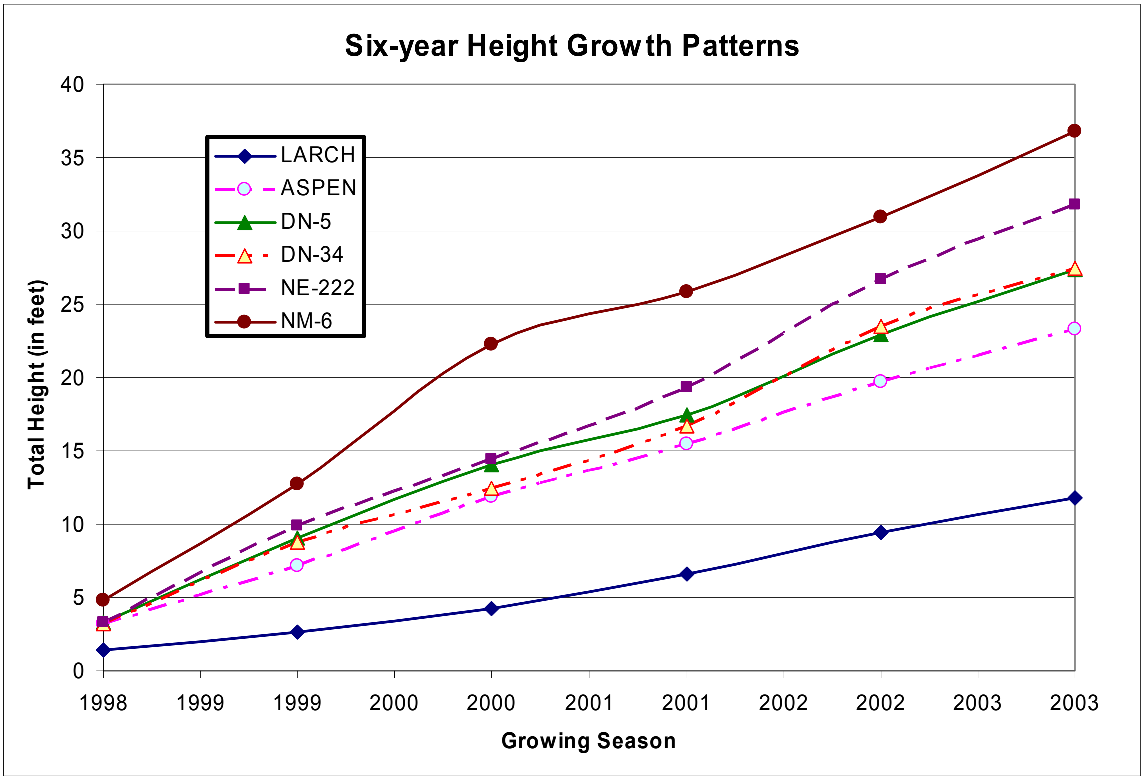
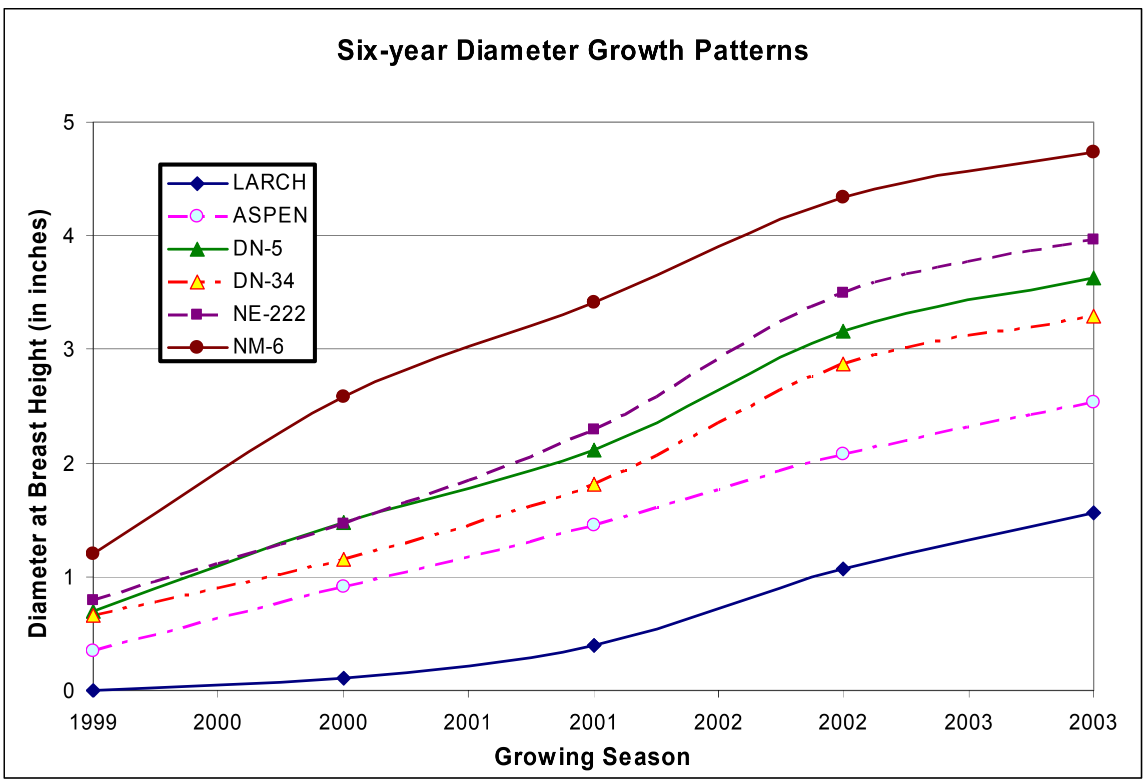


Figure 2.



Literature Cited:

Anonymous, 2002. Hybrid poplars as an alternative crop. Natural Resources Special Report #2. University of Minnesota Extension Service, College of Natural Resources.

Hansen, E. A., *et. al.* 1994. Field performance of *Populus* in short-rotation intensive culture plantations in the north-central U.S. Research Paper NC-320. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 13p.

Netzer, D.A., *et. al.* 2002.Growth, yield, and disease resistance of 7- to 12-year-old poplar clones in the north central United States. General Technical Report NC-229. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 31 p.

Ostry, M.E., L.F. Wilson, and H.S. McNabb, Jr. 1989. Impact and control of *Septoria musiva* on hybrid poplars. General Technical Report NC-133. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station.5 p.

Riemenschneider, D.E., D.A. Netzer, and W.E. Berguson, 1996. Intensive culture of hybrid poplars in Minnesota. IN: Proceedings of the First Conference of the Short Rotation Woody Crops Operations Working Group, Paducah, KY, September 1996.

Stoffel, R., 1998. Short rotation woody crops – hybrid poplar. IN: Proceedings of Improving forest productivity for timber…a key to sustainability. Duluth, MN December 1998.