Crop Manual for Hybrid Poplar at the Metropolitan Wastewater Management Commission Biocycle Farm

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Introduction

GreenWood Resources (GWR) has completed Phases I and II of Hybrid Poplar Planting at the Biocycle Farm facility owned and operated by the Metropolitan Wastewater Management Commission (MWMC). One of the requirements of the Phase II project was to prepare this crop manual to be used by MWMC as a reference guide for the ongoing management of the hybrid poplar grown on the Farm. The following is the description of the crop manual from the Phase II Request for Proposal:

3-9 Manuals

3-9.1 Prior to Substantial Completion of the WORK, CONTRACTOR shall provide operations and maintenance manual(s) pertaining to plant materials, maintenance, pruning recommendations, herbicide treatment, fertilizing, growth information, harvesting, and market information. The manuals shall serve as the reference, maintenance, and harvesting guides for the OWNER.

3-9.2 As a minimum, two hard copies of each manual shall be provided. In addition, the CONTRACTOR shall provide an electronic copy of the manual(s) where available (in Microsoft Word and/or Adobe pdf).

3-9.3 Manuals shall include, but not be limited to, discussions of plant varieties available, diseases, disease treatments, harvesting methods, harvesting guides, harvesting estimates, technical and harvesting contact information, pruning guides and information, and anticipated growth rates for varieties provided.

In May of 2007 GreenWood Resources was also asked to conduct a site evaluation and complete a report on the Phase I planting. The scope of that report included:

- Evaluation of plantation health: discuss plant material varieties, weed control
- Irrigation: review and discuss management practices, irrigation scheduling
- Nutrition: review and discuss management activities
- Managing for solid wood: cultural activities and markets
- Plantation monitoring and record keeping: comment on current process

Since there is some overlap in the scope of the crop manual and this site evaluation and report, some of the information presented in this report may be redundant.

Plant Material

Existing Plant Material

Hybrid poplars are produced when different species are cross-fertilized. Through vegetative propagation, selected varieties can be reproduced indefinitely. There are many crosses between different species of poplar, but the four most common crosses used in the Pacific Northwest are combinations of:

- *Populus trichocarpa* – black cottonwood native to Oregon
- *P. deltoides* – Eastern cottonwood
- *P. nigra* – European cottonwood
- *P. maximowiczii* – Asian or Japanese poplar

Hybrids are selected for vigor, frost hardiness, disease resistance, drought resistance, stem form, and branching.

Figure 1: Varieties currently growing on the Biocycle Farm in Phases I and II:

Poplar Variety	Genus	Gender
OP367	*P. deltoids x nigra*	Male
50-197	*P. trichocarpa x deltoides*	Male
52-225	*P. trichocarpa x deltoides*	Female
184-411	*P. trichocarpa x deltoides*	Male
49-177	*P. trichocarpa x deltoides*	Female
195-529	*P. trichocarpa x deltoides*	Female
24-305	*P. trichocarpa x deltoides*	Male

Each of these varieties is in the public domain, meaning that they were developed in public funded programs and can be obtained without paying a royalty to the developer of the plant material. In fact, all but OP-367, were developed in the 1980s by a joint program at the University of Washington and Washington State University that was funded by the US Department of Energy.

- OP-367 is a male DxN hybrid that was bred by Oxford Paper in the 1930's. In many ways it is an industry standard with wide site adaptability throughout the western US. The parents are unknown, but thought to be an eastern cottonwood mother from the mid south and a black poplar male from Europe. It is very wind firm, insect resistant and drought tolerant.
- 50-197 is a male TxD hybrid. The black cottonwood mother came from Granite Falls, WA and the eastern cottonwood father came from Illinois. Although it was widely planted in both eastern and western Oregon and Washington, it is very prone to blowdown and susceptible to the poplar willow borer.
- 52-225 is a female TxD hybrid that is closely related to 50-197. It has the same female parent, making it a half-sibling, and the male parent is also from Illinois. It had limited planting in eastern OR for pulp use. It is not considered suitable for solid wood products because it has poor stem form and very large branches.
- 184-411 is a male TxD hybrid with the black cottonwood mother from Randel, WA and the male from the Red River Valley in OK. This hybrid is known for very impressive volume growth and can attain a very large size. However, because it appears to have a surface root system without a tap root, it is prone to blowdown.
- 49-177 is a female TxD hybrid whose mother came from Orting, WA and the male pollen came from Texas. This hybrid has been planted extensively in western and eastern OR and WA. The variety tends to break bud early in the spring and can remain active late

into the fall. For this reason it is susceptible to cold injury. It is a very stable tree with a well developed root system and therefore a low incidence of wind throw.

- 195-529 is a female TxD hybrid whose mother was collected from Grays, WA and the father is from Oklahoma. This variety has been planted sparingly in the PNW. It is known to grow well on some sites and has problems on others. This variability seems to be due to soil pH and where pH is above 7.5 the hybrid does not grow well. It has been planted in Eastern OR for pulp use because it has a high wood density.
- 24-305 is a female hybrid with the mother from Snohomish, WA and male pollen from MS. It is therefore a Westside hybrid exclusively and is not highly cold hardy. It was planted early on in Westside plantations for pulp use, but has been replaced by more productive varieties.

Available Sources and Varieties

Based upon their performance in the Biocycle Farm program thus far and the experience of other hybrid poplar growers in the Willamette Valley, the following varieties should be considered for future planting:

- OP-367
- 195-529
- 184-411
- 49-177
- 15-029

The remaining varieties have not performed well on the Biocycle Farm thus far or are not considered suitable for sawlog production for other reasons and should be phased out of future plantings.

Public domain varieties may be available from the following commercial nursery operations:

- Mount Jefferson Farms
Rob Miller
3394 Brown Island Road South
Salem, OR 97302
(503) 375-3132
- Segal Ranch
Willard Mears
2342 South Euclid Road
Grandview, WA 98930
(509) 840-1045
- Broadacres Nursery
Ray Ethell
PO Box 41
Hubbard, Oregon 97032
(503) 981-6509

These nurseries sell commercial volumes of cuttings each year, but quantities are limited based upon the capacity of cutting production beds, so cuttings planted in the spring would need to be ordered at least three to six months in advance.

GreenWood Resources has an intense tree improvement program that has produced a number of varieties suitable for sawlog production. A number of these varieties have been tested at a site in Halsey, Oregon and shown growth and yield well in excess of the better varieties currently growing on the Farm. GWR has offered MWMC these varieties in the past, but MWMC has declined citing concerns over using non-public domain or proprietary varieties.

Should MWMC be willing to use proprietary varieties, GWR would likely make them available for use on the Farm.

Growth and Yield Estimates

Growth and yield estimates for the trees on the Farm could be over a wide range. The growth rate of hybrid poplar is dependent upon a number of site-specific factors including:

- Soil fertility and drainage
- Nutrition
- Climate
- Leaf rust infestation
- Weed competition
- Density and spacing

Given these variations, a reasonable growth and yield curve for OP-367 grown under irrigation in the Willamette Valley is shown in figure 2.

Figure 2: Growth and yield curve estimate for OP-367 in the Willamette Valley.

Age	Trees per acre	Basal Area	Avg Dbh	Avg Height	Total Weight (GT)	Total Board Ft.	Sawlog Ft^3	Sawlog Weight (GT)	Pulp Ft^3	Pulp Weight (BDT)	Residuals (GT)
1	222	0.8	0.8	7.3	0.2	-	-	-	-	-	0.2
2	218	7.8	2.6	24.3	2.4	-	-	-	73	0.7	0.7
3	213	18.9	4.0	39.8	8.5	-	-	-	314	3.1	1.5
4	211	32.7	5.3	51.5	18.3	507	119	2.6	587	5.9	2.6
5	209	47.8	6.5	60.2	30.7	1,674	478	10.6	732	7.3	3.8
6	207	63.6	7.5	66.9	44.9	3,645	984	21.9	803	8.0	5.2
7	205	79.6	8.4	72.1	60.0	6,110	1,600	35.6	804	8.0	6.6
8	204	95.9	9.3	76.3	75.9	8,324	2,157	47.9	897	9.0	8.1
9	203	111.8	10.1	79.8	91.9	10,880	2,813	62.5	895	8.9	9.5
10	202	127.2	10.7	82.7	107.7	13,815	3,413	75.8	939	9.4	11.0
11	201	141.9	11.4	85.1	123.1	16,961	3,972	88.3	1,008	10.1	12.4
12	200	155.8	12.0	87.2	137.8	19,796	4,651	103.4	931	9.3	13.8
13	199	168.8	12.5	89.0	151.8	23,199	5,207	115.7	945	9.4	15.1
14	198	180.9	12.9	90.6	164.9	25,379	5,686	126.4	1,001	10.0	16.3
15	197	192.9	13.3	92.0	174.4	27,151	6,087	135.3	991	9.9	17.1

Crop Maintenance

Integrated Pest Management

Management of pests that impact the Farm, including weeds, diseases, insects and other animals should be consistent with the principles of Integrated Pest Management (IPM). The main aspects of IPM as they relate to the tree farm are:

- Become familiar with the target organism's biology and population dynamics,
- Monitor the target organism's population levels,
- Determine acceptable threshold levels of the disease, insect, animal, or weed,
- Employ an acceptable population control method for the organism. These control methods may be biological, mechanical or, as a last resort, chemical.

Insects

A number of insect pests can be expected to exist on the farm. Their populations will ebb and flow and at times, damage will reach a threshold that warrants control methods. The most effective defense against insect damage is prevention, because insect damage is highly influenced by the genetic makeup of the plant material. Some economically significant pests common to hybrid poplar are:

- Poplar and Willow Borer (*Cryptorhynchus lapathi*) – This insect bores into the bole of the tree causing weakening and stem breakage. Some varieties, including OP-367 are more resistant than others. It targets trees under stress, so maintaining overall stand health is an important aspect in control. Insecticide control with Lorsban is possible, but timing of application is critical. GWR is experimenting with the use of Imidacloprid insecticide for borer control and preliminary results are promising.

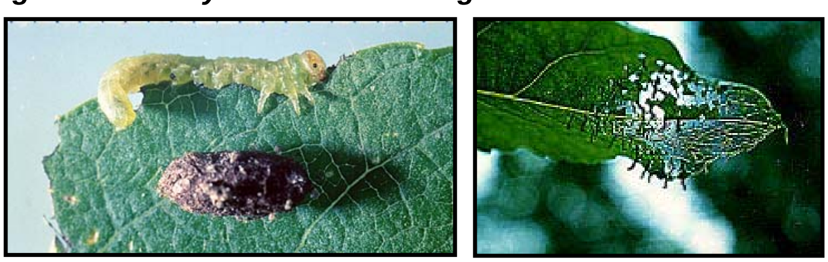
Figure 3: An adult borer and stem damage due to borer activity.

- Cottonwood leaf beetle (*Chrysomela scripta*) - This insect is a foliage feeder that can reduce tree vigor. Damage is done during the larval stage of the insect. It produces multiple generations throughout the year, so multiple applications of insecticide may be necessary. Effective insecticides include Dimethoate and Imidacloprid.

Figure 4: Cottonwood leaf beetle eggs, larvae feeding on leaf, adult.

- Poplar willow sawfly *(Nematus salicis-oderatus)* - This insect feeds on leaves and can defoliate trees during the growing season. The extent of damage depends on the population of natural predators and the susceptibility of the clones being grown. In general, TxD clones have been shown to be susceptible.

Figure 5: Sawfly larvae and damaged leaf.



- Other insects – Occasional outbreaks of aphids, webworms, grasshoppers, leafminers, leafrollers and army ants do occur. These are far less economically significant, but do occasionally require control measures.

Diseases

Poplar trees may suffer from a variety of diseases. The most serious diseases are those caused by fungi and include stem cankers, leaf rusts, leaf blights and leaf spots. Of these the most significant diseases are:

- Leaf rust, caused by various *Melampsora* species. Leaf rust is the most important disease on hybrid poplars in the Pacific Northwest. Initially, infections appear as yellow-orange pustules in early summer. The disease builds up throughout the growing season and can cause defoliation by late August or early September. The fungi over winter on poplar leaves, infect alternate coniferous hosts (Douglas-fir, larch, pines, etc.) in spring, and then spread back to the poplar host. The primary consequence of leaf rust is reduced growth and vigor due to the loss of green leaf area. The primary control is planting varieties that are resistant to rust. Serious outbreaks can be controlled by Bayleton.

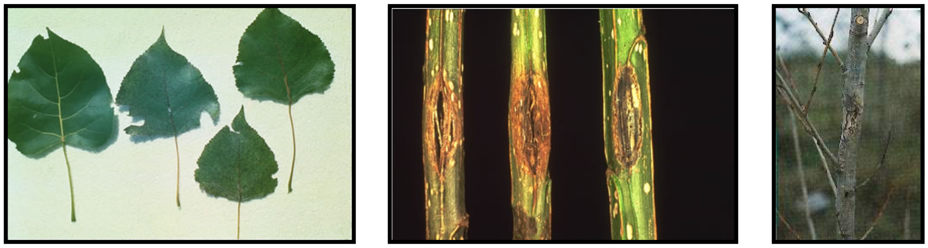
Figure 6: Leaf rust caused by Melapmsora.

- Venturia leaf and shoot blight (*Venturia populina)* - Venturia leaf and shoot blight ranks behing leaf rust as the second most important disease of poplars in the western areas of Oregon and Washington. It favors cool, moist conditions. Defoliation of susceptible clones can occur during the spring. Symptoms initially appear as olive-green "V"-shaped areas on the leaves. Blighted shoots appear as black shepherd's crooks and sometimes there are cankers on the small twigs and branches. Planting of resistant varieties is the only effective control method.

Figure 7: Leaf and shoot blight caused by Venturia.

- Septoria stem cankers *(Septoria musiva* or *Mycosphaerella populorum)* – This is the most serious poplar disease in North America, although it is primarily a concern in the mid-west. It has apparently been discovered in coastal regions of British Columbia, however, it is unclear whether it would adapt to the climate of the Willamette Valley. It causes both leaf spots and stem cankers. The canker is the more serious issue because it results in stem breakage.

Figure 8: Leaf and shoot blight caused by Septoria.



Weeds

Clean cultivation of the tree stands needs to be maintained throughout the rotation. After three to four years, the tree canopy should close so that shading will prevent excessive competition. Until that time, weeds should be managed using IPM. If control is necessary the following options exist:

- Mowing will be the preferred method. This will be especially effective in the established strips between tree rows. This will facilitate travel of the irrigation equipment and break up vole habitat. Cross mowing will also get much of the vegetation growing along the row between the trees, but this will leave an island around the trees themselves.
- If an herbicide application is warranted, a directed application would be most appropriate to leave the grass strips untreated. For un-pruned trees, this should only when trees are dormant to avoid herbicide contact with active leaf and stem tissue. Once trees are pruned, this can be done at any time. Some application to the tree stem and epicormic branch sprouts is safe, but drenching should be avoided. Products will vary based upon the weed load, but could include:
    - Glyphosate (Roundup Trade Name) for general weed control
    - Clopyralid (Transline TN) for thistle control. Transline should be applied prior to thistle bolting for best control.
    - Fluazifop (Fusilade TN) can be used for in-row grass control, but is only effective before the grass goes to seed.
- The same products can be sprayed via backpack sprayers as well. This reduces the amount of chemical used and insures that only the weeds at the tree get sprayed. The downside is that in order to cover the ground in a timely manor a large crew is needed.

Animal Damage

Girdling by voles can cause tree damage and possible mortality in the early years of a rotation. The most effective control method is good weed control, which reduces vole habitat and increases predation by raptors. If more aggressive control is necessary, zinc phosphide pellets or other baits are effective.

Figure 9: Stem damage caused by voles and surface runway.

Nutrition

Foliar Sampling Program

An ongoing assessment of the nutrition of the stand is part of any meaningful tree nutrition program. This is especially important on the Biocycle Farm since biosolids are being applied. The most accurate method of assessing nutrition in poplar trees is regular foliar sampling. Initially this should be done for each variety. Start by collecting fresh, fully developed leaves from 10 trees across the planting block. Try to collect 2-3 leaves from the upper part of the canopy and only collect from actively growing branches or tops. A pruning pole may be needed to access the upper crown. The collected leaves constitute a composite sample for the variety at a point in time. Oregon State University has a plant tissue analysis lab that can do the work to identify macro and micro nutrient levels and can also make recommendations for nutrition amendments. Collections in May, July and before buds set in September will give a meaningful sample from which to draw inference for tree nutrition.

The results of foliar analysis will be given in percentage of foliar concentration for a number of critical nutrients. Although ideal foliar concentrations for the entire range of micro and macro nutrients are not fully developed or understood, there is broad consensus on critical levels of some nutrients necessary for fast growth over a wide range of varieties. If foliar analysis levels are significantly different than these recommendations, deficiencies and/or toxicities may begin to affect tree health and survival. Soil amendments may be necessary to address these conditions. At that point a crop consultant would be needed to recommend the rate and formulation of amendments.

Figure 10: Recommended range of foliar concentration of selected nutrients.

	Deficient		Critical level		Adequate		Excess	
Element	Low	High	Low	High	Low	High	Low	High
	--- % ---							
N (NO3 - N)	0.01	0.05	0.05	0.10	0.20	0.30		
Total – N	0.50	1.00	1.50	2.00	2.00	3.00	3.50	4.00
P	0.05	0.10	0.10	0.15	0.20	0.40	0.50	1.00
K	0.50	0.50	0.50	1.00	1.00	2.50	3.00	
Ca (variable)	0.10	0.50	1.00	1.50	2.00			
Mg	0.10	0.15	0.20	0.20	0.20	0.40		
S	0.05	0.10	0.10	0.15	0.15	0.30	0.50	
-	--- ppm ---							
Fe	20.0	50.0	50.0	50.0	50.0	100.0		
Cl	500	1,000	1,000	5,000	5,000	10,000	15,000	20,000
Mn		20.0	20.0	50.0	50.0	200.0	500.0	
Zn	5.0	10.0	10.0	10.0	10.0	25.0		
Cu		5.0	10.0	10.0	10.0	20.0	25.0	
Mo		0.10	0.15	0.50	0.50	5.00		
B	5.0	15.0	15.0	20.0	25.0	100.0	200.0	

Biosolids Application

Since biosolids application is one of the intended purposes of the Biocycle Farm, the impact of those applications needs to be understood in the context of tree nutrition. In 2006 biosolid applications were initiated, but only during the month of August did somewhat regular applications occur where applications were made to all three units. It is unreasonable to expect that regular applications can be made throughout the growing season due to the availability of the material and the operations of the treatment plant. The purpose of the application is to primarily dispose of the materials in an environmentally sound way by applying them to farm land that grows trees. The timing and quantity of the application can however have an unintended affect on the trees. Every effort should be made to apply biosolids from April through August, with a tapering off of the application through August. Completing the application by September is important for the physiological process of dormancy initiation and preparing the trees for winter. Late season nitrogen applications can prolong the rapid growth of the trees and interrupt the normal dormancy sequence resulting in winter cold damage.

The elemental analysis of the biosolids shows high nitrogen and phosphorous with little else. Available nitrogen per acre in 2006 ranged from 100 to about 200 lbs/acre. The upper figure is very high when compared to historical operational rates in poplar tree farms, but below maximum levels reported in the literature for phytoremediation applications.

Some improvements can be made to the biosolid application program. First as mentioned above, regular applications through the growing season spaced approximately two weeks apart, and then tapering down with the final application completed by September. Secondly a more complete analysis of the biosolids is needed. It is important to know what if any micronutrients are included in the biosolids. With this information we can better predict deficiencies or toxicities in the future and make additional amendments as needed.

Irrigation

Much like the biosolids application program, one of the primary purposes of the Farm is to irrigate the trees with treated wastewater. Over the first three growing seasons, the operation of the treatment plant has been the primary driver of the timing and amount of irrigation water applied and there have been negative impacts on tree growth.

- During the 2004 growing season, daily applications were less than 0.10 acre-inches and the total for the year was less than three acre-inches. This level of irrigation is not adequate for the first year and plantation establishment suffered.
- In 2005 irrigation was started in May and continued through mid September. The July graphs show a good irrigation profile as regular applications were made throughout the month and daily totals were adequate. The annual total was 13.2 acre-inches. This total is still to low for optimum growth.
- In 2006 the irrigation didn't start until late June and daily applications were inadequate for tree needs throughout the growing season. Records show that some units did not get irrigated in some of the months. The records show that all units received less than three acre-inches for the entire growing season. The reduction in 2006 height growth versus 2005 was obvious in the field performance and the lack of adequate irrigation is likely one of the reasons.

Irrigation Scheduling

It is important to have a standard irrigation schedule in mind, even if the constraints of the system will not allow that schedule to be followed. It may be possible for the limited quantities of water available to be applied in ways that give maximum benefit to the trees. In general, daily applications have been too low. A less frequent and greater quantity applied per cycle would drive the moisture down into the root zone to replenish moisture lost in the early season. The amounts applied appear to have covered daily evaporation-transpiration (ET) loss in most cases, but soil moisture was still in a depleted mode for the growing season. Irrigation should start early in the year and continue through early October. Cycles can be periodic and for long duration prior to the warm summer months. In an ideal situation daily ET needs would be replenished throughout the summer. Where the irrigation design makes this problematic it is always better to go with less frequent and longer duration cycles rather than short cycles that do not deliver water beyond the surface layers and that also result in greater surface evaporation. In July and August trees in the Valley will use upwards of two inches per week or 0.25 to 0.30 inches per day. Irrigation should also be continued to early October in the Willamette Valley. The late summer until early fall is dry and the trees will continue to draw moisture through this period. This ET rate equates to an 85-90 degree day with light winds, a day very typical in the summer. Annual totals for trees greater than five years old can reach 24 acre-inches.

Figure 11. Irrigation Quantities for Tree Farms in Oregon. The Eastside figures are from actual practice and the Willamette Valley figures are estimated from ET rates.

	Eastside Annual Acre-Inches		Willamette Valley Annual Acre-Inches	
Age	Low	High	Low	High
1	8	10	6	8
2	18	24	12	16
3	24	30	16	20
4	30	36	20	24
5-15	36	44	24	26

Figure 12. Monthly Irrigation Estimates for the Central Willamette Valley. This table is for trees greater than three years old. It assumes no precipitation during the growing season and as such needs to be adjusted to account for rainfall.

Month	Acre-inches to Apply
May	2.0
June	3.0
July	6.0
August	6.0
September	3.0
October	2.0
Total	22.0

Technology exists to remotely monitor soil moisture. GreenWood has deep experience in working with several types of sensors and can make recommendations to MWMC upon request.

Pruning

Pruning is used to improve the quality of saw logs by removing branches to produce wood with a clear grain. In order to maximize the volume of clear wood, it is important to minimize the size of the defect core. A tree pruned when it is 4 inches in diameter will have a defect core of 5-6 inches by the time the pruning scares have healed over. The remaining diameter growth will be free of knots. The desire for a small defect core must be balanced by the need to leave enough live crown on the tree to sustain growth. This live crown should be no less than 50% to 60% of tree height to avoid a severe impact to growth.

Assuming good establishment, pruning can start at the beginning of the fourth growing season. Pruning when the trees are actively growing will reduce the number of epicormic branch sprouts. These dormant buds are stimulated after the stem is exposed to sunlight. Pruning should not be done on the edge trees for this reason. A six-foot pruning height is reasonable for the first pruning. Continuing for each of the next three years, approximately six feet of branches and the sprouts are removed each year. This will take the pruned part of the stem to about 22-24 feet and will allow two 10 foot logs to be merchandised from the tree for manufacture. A general pruning schedule for Willamette Valley poplar trees is as follows:

Figure 13: Recommended pruning regime.

Age	DBH(in)	Height(ft)	Pruning Height(ft)	Percent Crown
3	4	40	6	85%
4	5	51	12	77%
5	6	60	16-18	72%
6	7	67	22-24	66%

The desired pruning techniques are well described in the Phase II request for proposal. Branches and sprouts should be removed just outside the branch collar using loppers or pruning saws. Stubs longer than ½ inch take longer to heal over and defeat the purpose of pruning for a small defect core. Care needs to be taken to avoid an incomplete cuts and removing a strip of bark down the trunk. These injuries can cause scaring and provide an opportunity for insect infestation.

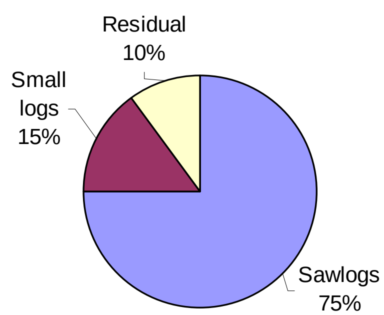
Harvesting

Tree Utilization at Harvest

Hybrid poplar trees in North America have been primarily grown on a six to eight year rotation for production of clean chips for the pulp and paper industry. Under this scenario, the whole tree was harvested, de-limbed, de-barked and chipped. However, in recent years, a multiple market strategy has been developed to maximize the value of the fiber coming from each part of the tree. Under this multiple market strategy the entire tree would be harvested and processed into three segments:

- Sawlogs. The main stem would yield sawlogs. Depending upon the specifications of the market, the small end diameter (SED) of the sawlog would typically range from 6" to 10". For the purposes of this study, a 6" SED will be assumed. This segment accounts for 75% of total biomass.
- Small logs. The main stem from 6" to 4" SED would produce small diameter logs for excelsior (see market analysis section). This segment accounts for 15% of total biomass.
- Residual. The main stem beyond the 4" SED, limbs, leaves and bark would produce a low grade or residual chip. This segment accounts for 10% of total biomass.

Figure 14: Whole tree biomass utilization to multiple markets.



Harvesting, processing and transportation will be the highest costs associated with the Farm each year. Using the most appropriate expertise, process and equipment is a key to controlling these costs. Although a number of factors could well change by the time the first trees are harvested at the Farm that could impact efficiency and cost, conservative assumptions about the harvesting systems and costs can be made based upon the current practices used to harvest hybrid poplar. About 55% of the world's wood harvest is harvested manually, e.g. with a chainsaw. The remaining 45% is harvested mechanically, using either the cut-to-length (CTL) or tree-length method (TL). Of the mechanically harvested portion, about 65% is harvested using the tree-length method and the remaining 35% using the cut-to-length method[1].

At present, most hybrid poplar in North America is harvested using tree-length systems. The most likely process for such a system at the Farm would be the following:

- A feller-buncher with a hot saw severs the tree at ground level.
- Rubber tired skidders yard the trees to a landing.
- A processor de-limbs and merchandizes logs to a 6" Small End Diameter (SED). The 6" minus logs would be chipped. The limbs, tops, leaves, and bark are chipped as well.
- Sawlogs are hauled on standard log trucks to the mill. Chips are hauled in chip vans.

The CTL system is more commonly used in smaller diameter stands in Scandinavian countries. That system would likely follow this process:

- A harvester removes the branches and top at the stump, and cuts the tree to log lengths that may be selected by the operator.
- A forwarder picks up sawlogs and chip logs, transports them to a landing, and loads them on trucks for transportation.
- Residues are left distributed within the stand, which recycles nutrients and eliminates disposal costs if no market exists for the residual[2].
- If there is a market for the residual, it is harvested with an energy wood harvester. This machine collects, compacts and bundles residual for easier handling and transportation. Although not yet common in the US, a number of these machines are in use in Europe[3].

Both systems likely have merit for harvesting hybrid poplar. Since it is currently in use on GWR managed farms, costs estimates for the tree-length system are more reliable. It also uses equipment currently in use on conventional logging operations throughout the Northwest. The CTL system is more expensive, specialized, complex, and uses newer technology. While they are in use in the Northwest, the relatively small scale of the annual harvest at the Farm may not attract a contractor with CTL equipment. However, over time the CTL system may prove to be more efficient and cost effective.

Figure 15: Cost estimates for hybrid poplar harvesting and processing.

Operation	$/GT
Fell and forward	$ 12.00
Sawlog processing and loading	8.00
Chip processing and loading	12.00
Grinding residuals	5.00

[1] "Cut-to-Length logging," Ponsse Oyj, accessed online at http://www.ponsse.fi/english/group/CTL/index.php#loppu on July 13, 2006.
[2] Hartsough, Bruce R.; Cooper, David J., "Cut-to-length harvesting of short-rotation eucalyptus," Forest Products Journal, VOL. 49, No. 10, 1999.
[3] Kryzanowski, Tony, "Using Slash for Power," Logging and Sawmilling Journal, January 2004.

The following harvesting contractors are currently working in hybrid poplar in the Northwest:

- C&C Logging – Large logging contractor with both TL and CTL systems.
  Frank Chandler
  (360) 636-0300
- Woodland Harvesting and Landscaping, LLC – Smaller contractor with smaller, light-weight equipment that may be better suited to harvest the Farm.
  Mark Smith
  (503) 936-5363
- Zepp Resources – Medium sized contractor based in Washington with extensive experience in hybrid poplar in western Oregon and Washington.
  Al Zepp
  (360) 482-4244
- Nash Contracting – Medium sized contractor based in the Hermiston area, but has experience in hybrid poplar in both eastern and western Oregon.
  Joe Nash
  (541) 449-1212

Markets for Hybrid Poplar

By the time the trees on Phases I and II of the Biocycle Farm are ready for harvest, the markets will likely be much different than they are today. There is a well developed market for the small log portion of the tree to be used as clean chips for the pulp and paper industry. However, GWR has taken the lead in developing a multiple market approach that will maximize the value of each part of the tree, including sawlogs and residuals.

Sawlogs

Comprehensive testing of hybrid poplar for solid wood applications has been undertaken by US and Canadian forest products labs and private companies over the past several years. This testing was followed by credible volume production runs conducted by GWR and Potlatch Corporation. These tests had the following results:

- Hybrid poplar is an excellent choice for trim, moulding, and cut stock.
- It serves as an excellent substitute for ponderosa pine, radiata pine, and white fir in softwoods, and alder in hardwoods.
- The wood is easily milled, can take screws and nails well, and can be used for nearly any non-structural application.
- It can be peeled and dried to produce veneer for use in plywood.

The results of this market development work led to the conversion of over 30,000 acres of hybrid poplar in the Northwest from pulpwood to sawlog production. In 2007, GWR organized a timber investment fund made up of institutional investors and the Collins Companies to consolidate ownership of these farms and build a sawmill dedicated to producing hybrid poplar lumber. The sawmill will be operational in 2008. The lumber produced by that mill will be marketed under the trade name Pacific Albus. This web page contains information on the mill construction and a marketing brochure for Pacific Albus lumber.

http://www.collinswood.com/M1_WoodProducts/M1H4_Pacific_Albus.html

At this point in the market development process, GWR and the Boardman sawmill are the only large volume users of hybrid poplar sawlogs. Managers of the Biocycle Farm should continue to monitor market development of hybrid poplar over the next five to seven years as the Phase I and Phase II trees reach a sawlog rotation age to identify opportunities to market sawlogs.

Chips

Clean chips for pulp and paper production have been the primary market for hybrid poplar in Northwest. Depending upon the equipment and product mix of a given pulp mill, these chips can be an important source of the raw material. A list of mills that currently use hybrid poplar chips is shown in figure 14.

Figure 16: Possible customers of hybrid poplar chips in western Oregon and Washington.

Company	Location	Contact Number
Georgia-Pacific	Camas, WA	(360) 834-8173
Georgia-Pacific	Toledo, OR	(541) 336-8080
Boise Paper Company	St. Helens, OR	(503) 397-2900
Blue Heron Paper Company	Oregon City, OR	(503) 650-4211

Residuals

The current markets for residuals are hog fuel for biomass energy production and mulch for agricultural and landscaping applications. These markets currently offer pricing that covers the cost of grinding and transportation plus a nominal profit. Possible customers of the residual are listed in figure 15.

Figure 17: Possible customers of hybrid poplar residuals in western Oregon and Washington.

Company	Location	Contact Number
Georgia-Pacific	Wauna, OR	(360) 834-8266
SP Newsprint	Newberg, OR	(503) 538-2151
Rexius	Eugene, OR	(541) 342-1835
H & H Wood Recyclers	Vancouver, WA	(360) 892-2805

However, the longer-term market for residual is likely in biomass energy and biofuels. The national goal for biofuels production dictates the production of 30% of the nation's gasoline demand with biofuels, primarily ethanol, by 2030. Projected production cost targets are $1.07 per gallon. Annual U.S. ethanol production is currently about 4 billion gallons primarily made from corn grain ethanol. To meet the national goal, production will increase 15 fold to about 60 billion gallons per year from a variety of plant materials, primarily lignocellulosic biomass[4]. Because of its wood properties and rapid growth rate, poplar has been identified as one of the primary feedstocks for this production stream. Other possible feedstocks include agricultural wastes that are in plentiful supply in the southern Willamette Valley. GWR is participating in a number of public and private initiatives to overcome the remaining technical barriers to biomass ethanol production. By the time of the initial harvest at the Biocycle Farm, it is possible that some ethanol production facility would be in place to purchase harvest residuals.

[4] "Breaking the Barriers to Cellulosic Ethanol: A Joint Research Agenda," US Department of Energy Office of Science and Office of Energy Efficiency and Renewable Energy, DOE/SC-0095, June 2006.