Utilization of short rotation woody crops in the western USA

Jake Eaton

Plant Materials Manager, Potlatch Corporation Hybrid Poplar Program
Boardman, Oregon USA

1. ABSTRACT

In response to increased environmental regulation and declining public timber supply, Potlatch began farming short rotation hybrid poplar in 1993. The 7000-hectare (17,300-acre) farm, located in north central Oregon, is one of the largest drip-irrigated tree farms in the world. The Hybrid Poplar Program (HPP) became the first plantation in North America to earn Forest Stewardship Council (FSC) certification in 2001. The farm, originally designed to produce chip fiber, is in the final phases of conversion to manage for high quality saw log production.

The saw log management program emphasizes genetic selection of varieties suitable for solid wood products; branch pruning to maximize clear lumber recovery, and longer rotations to increase tree size. New plantations are started at a wider spacing (3 x 4.6 m) and managed for longer rotations (11 years).

Harvesting activities have been ongoing for four years with production of approximately 155,000 green-tons of chips annually as well as a small volume of logs to begin market development. Plantations managed for saw log production will start coming off the farm in 2005 and eventually approach a sustainable annual volume of 250,000 m^3 saw logs, 55,000 green-tons of chips, and 40,000 green-tons of residual biomass (bark, limbs, tops).

Opportunities exist to market hybrid poplar logs for use in plywood, furniture stock, molding, and other non-structural applications. The full tree utilization concept will also produce pulp chips from the smaller stem segments. Markets for residual biomass products are less certain.

Opportunities for marketing residual material are minimal at the current time. As a result, some of this material is ground up, spread over the harvested field, and incorporated into the soil to enhance long-term soil fertility. In addition some of the residual material is traded to a local dairy for compost that is returned to the farm. A small amount of the residual material is being sent to a small cogeneration facility. Given the volume of residual material produced on the farm annually, there is a great opportunity to use this material for bioenergy production.

2. INTRODUCTION

Potlatch Corporation acquired two contiguous center-pivot irrigated farms near Boardman, Oregon for intensive farming of hybrid poplar. A declining supply of economically available residual chips motivated Potlatch to aggressively develop hybrid poplar to augment its fiber supply. Some 17,300 acres (7000 ha) of plantations were developed to help meet the chip

fiber requirements of Potlatch's Lewiston, Idaho pulp mill. These plantations were densely planted (10 x 8 ft or 3 x 2 m) and managed for a six to seven year pulp rotation. As the early plantations approached harvest age it was apparent that the anticipated regional shortfall in fiber was not materializing. This created an opportunity for Potlatch to examine the use of hybrid poplar in higher value solid wood products.

After an extensive analysis of the opportunity to grow high quality saw logs on the Boardman farm, a business plan was developed and received Board of Directors approval in 2000. Hybrid poplar saw logs are now being produced and markets are being developed. The farm also received Forest Stewardship Council (FSC) Certification in 2001 and it's expected that this will enhance the market opportunities. This paper will discuss saw log management, drip irrigation, harvesting, and market development activities. In addition, the current state and future barriers and opportunities of bioenergy will be discussed.

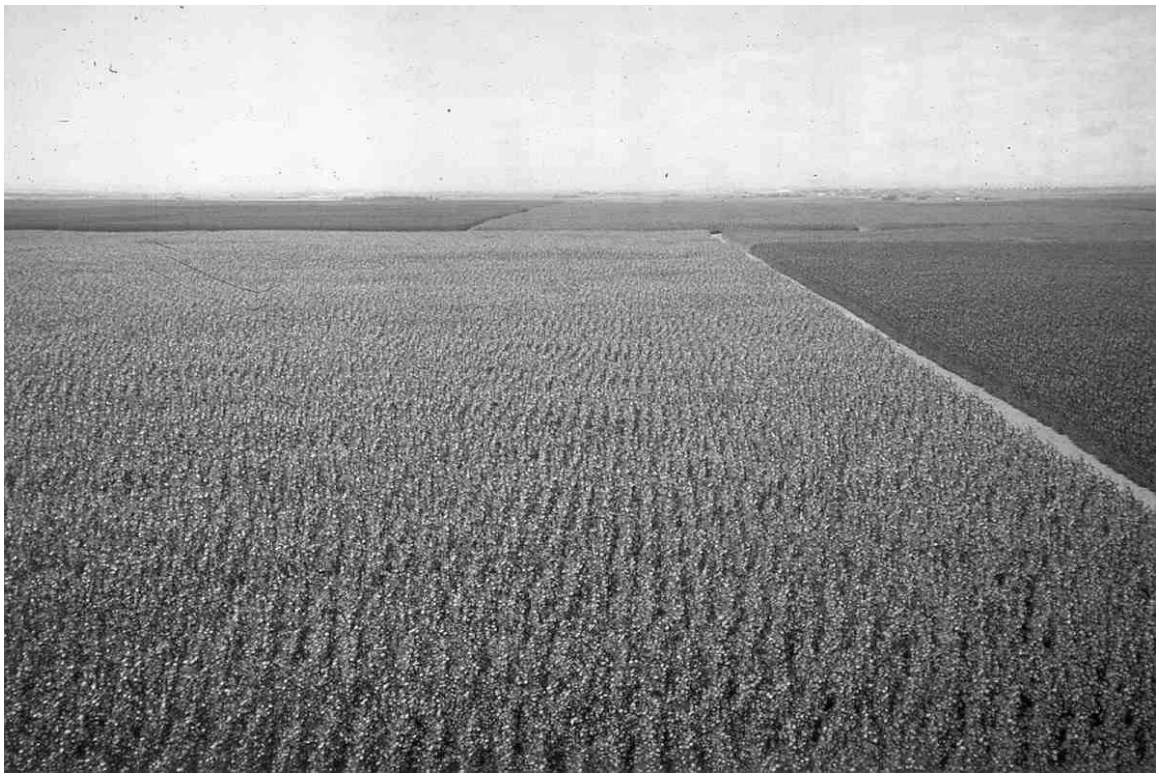

Figure 1. Potlatch poplar farm overview

3. SAW LOG MANAGEMENT PROGRAM

3.1 Variety selection

Moving to a saw log product changed the variety selection and deployment strategy. As the Potlatch HPP was developed, selection strategies concentrated on the stem biomass, pulp yield, and environmental suitability of the varieties chosen for pulp chip production. As a result, less importance was placed upon stem form, branch size and number; and wood quality characteristics such as strength, color, fastening ability, and milling. Selection protocols for the many varieties in various stages of testing have been modified to emphasize traits consistent with solid wood products.

Potlatch has been breeding new varieties of hybrid poplar since 1999. Select parents with good form, wood quality, and branch characteristics come from USA and European cooperators. The goal is to produce 2500 new genotypes per year that enter a three phase testing program. Protocols to quantify stem form, branch characteristics, disease and insect susceptibility, environmental suitability, and wood quality analysis are used to evaluate and select varieties for operational use.

3.2 Pruning

The program includes four annual lifts to a height of 24 feet (7 m). Pruning activities begin at age two with a lift to four-feet, followed by a lift to 9 feet (3 m) at the end of the third year. The first two lifts are done with lopping shears. The third lift after the fourth growing season goes to 15 feet (4.5 m) and the final lift to 24 feet (7 m) will be made after the fifth growing season. These two lifts are done with pruning poles. Epicormic branches are removed in a single operation done annually if necessary. Pruning quality is excellent when done by hand and the cost is in line with expectations. Crews have a diameter limit in each age class where trees below the limit are not pruned. They also omit trees with damage or poor form. All branch material is left on the ground and allowed to decompose.

In-house research has shown that tree performance is not negatively affected by the aggressive pruning regime. The objective is to limit the pruning core to a stem diameter of 4-5 inches (10-12 cm) and not remove greater than one-third of the live crown at any lift. Pruning later in the winter or into the spring has resulted in less epicormic sprouting.

3.3 Tree Spacing and Rotation Length

The farm configuration for drip irrigation sets the row spacing at ten feet. Irrigation risers from the underground submain system are fixed at ten-foot (3 m) intervals. Rather than modifying the risers to place the new rotation on a square spacing, trees are planted at a 15-foot spacing down the tree row. The planting layout across the field is in a diamond pattern, attempting to open the tree on all four sides. It is expected that the 150 square feet of growing space per tree will optimize the volume per acre with a 10-11 year rotation. Trials are underway to explore tree performance at wider spacing.

The Potlatch farm operates under an agricultural exemption from the State of Oregon. To be considered agriculture, and not forestry, the plantations are required to be harvested in less than 12 years. The benefits of the agricultural exemption out-weigh those of being able to extend the rotation. The 10-11 year rotation provides some flexibility if market conditions warrant a delay in harvest for one year. Under this scenario, all trees will be harvested during their eleventh year and will be a minimum of ten-years-old.

4. DRIP IRRIGATION SYSTEM

Drip irrigation was chosen because of its lower pressure and consequently lower energy requirements. Drip also has the benefit of providing the highest water use efficiency of all forms of irrigation, nearly 95 percent. The Potlatch farm has a very sandy soil with undulating hills and automated drip irrigation is the only economical way to grow a tree crop in these conditions.

With nearly 14,300 miles (24,000km) of drip tube and 20 million emitters, clean irrigation water is a must. Water from the Columbia River is moved to the plantations through pressurized mainlines and an irrigation canal. Screen filters are installed at pumping stations along the canal. Primary filtration for silt and organic matter takes place here. These filters use 200-micron screens and automatically clean themselves when the sediment load reaches a predetermined level. Down stream of the filters, chlorine and bromine are injected into the irrigation stream to control algae and bacteria.

The drip irrigation system uses the infrastructure of mainlines that supplied water to the old center-pivots. A manifold system is installed at the old pivot point that distributes water, fertilizer, and some pest control products to four similar sized blocks. Blocks are approximately one-quarter mile to one-half mile square (40-80 acres, 16-32 hectares). Flexible hose risers are attached to the below ground sub-mains at the block ends, and serve to bring the water back to the surface. Drip hose is attached to the risers.

The manifold consists of all the hardware necessary to distribute water to each of the four blocks. A master valve regulates mainline pressure to prevent excessive pressure on the drip lines. The manifold has an injection port for fertigation and chemigation. Electronic valves regulate the flow to each block. Sensors for pressure and flow are also located at the manifold. Irrigation, injection, and system monitoring are all automated and controlled by a central computer.

Irrigation schedules are generated each week throughout the growing season. The schedule gives ample water to the trees while at the same time not over-watering. In addition to pushing water past the root uptake zone, over-irrigation wastes money and resources. Weekly irrigation scheduling decisions are made in a team process, where large databases and operational parameters are analyzed and debated. Some of the databases include current soil moisture, tree evapotranspiration (ET) models, growing degree-days, historical irrigation schedules, and the current and predicted weather forecast.

A network of sensors, with one located in each field determines soil moisture. These are wired directly into the manifold controller to allow real-time assessment of the soil moisture conditions. Sensors are buried at one-, two-, and three-feet depths.

By use of the soil moisture monitoring tools, the water needs of the trees are tracked very closely. The needs of the trees vary from one age class to another with the dramatic differences occurring between age one, two, and three. Once age four is reached there is little difference between tree water needs as canopy leaf area becomes fairly constant. There are also some slight differences in water needs from one variety to another, but these are much more subtle than those between the early age classes.

5. HARVESTING

The HPP began harvesting activities in 2000. After making the commitment to saw log management, the variety and age class mix on the farm was analyzed to determine which fields would be thinned, pruned and grown for extended rotations. Those varieties that were deemed unstable for reasons of blow down or pest susceptibility were moved into the removal category. Over the last four years these pulp plantations have been harvested, replanted and are now being managed for saw logs on the second rotation.

The first harvesting activities were processed in field. The trees are cut with a mechanized feller with accumulator arms and bunched as they are brought to the ground. A front-end loader carries bunches of trees to the mobile chipper. Trees are chipped and blown into chip vans for transport off the farm. The in field processing works well for stems that are sized for pulp chips, but it does not provide the best opportunity for capturing saw logs. Further, this method results in heavy slash being left on the site and dramatically increases field clean up and site preparation costs.

Over the last two years we have developed a Central Processing Area (CPS), located near the center of the farm. The shear head on the felling machine was swapped for a saw head to improve saw log quality. Trees are felled and bunched in the field in a similar manor. A grapple pick up machine then loads stems onto wood wagons for transport to the CPS. At the CPS the pulp loads go to the chipper and the saw log loads go to the log processor.

All residual material is also concentrated at the CPS. Hog fuel is loaded into manure spreaders that return the organic matter to the harvested field. Some of the residual material is loaded into trucks that take the hog fuel to a composting facility and a small amount goes to a co-generation energy plant. A fixed processing and merchandizing line will be built next year to maximize saw log and chip recovery.

The harvesting activities have served to generate cash flow to continue the farm conversion to saw log management. Two primary customers have been served in the pulp chip market. We currently sell clean chips (< 0.5% bark content) into the fine paper and tissue markets and dirty chips (2% bark content) to a customer for use in producing a fiberboard for door skin manufacture.

In addition to pulp chips we glean saw logs wherever we have larger stems. The saw logs are selected in the field and sorted at the time of felling. The saw logs are unloaded at the CPS at the log processing station where a dangling processor cuts bolts to length. The sections of the stem that will not make the saw log specifications go to the chipping station. The saw logs that we are currently recovering are being used to develop markets for the hybrid poplar resource.

6. MARKETING

A portfolio of products is being developed from the hybrid poplar resource. In keeping with the whole tree utilization concept, these products will be saw logs, veneer, chips, hog fuel, carbon, and biomass for energy conversion. The FSC certification has been a positive marketing tool for the wood and it has opened doors to products to use the wood in. The HPP is partnering with a local mill that processes the logs into lumber and then dries the lumber. We also have a joint marketing team that is working with potential customers to determine where the wood can best be used. Marketing involves the introduction of a new species and the methodical demonstration to potential customers that this species will work for the products they make. As such, the marketing efforts started at an early date, well before significant volumes of saw logs were ready to be harvested. The volume of saw logs will increase dramatically after 2005, and the HPP will reach full production in 2007.

The lumber that is currently being produced is from the bottom log on trees that have not been pruned. The resulting lumber is primarily lower grade material. Even though the grade is low,

customers like the bright color; ability of the wood to take glue, stain, and paint; and ease of finishing. The lumber is primarily being used in the furniture, cabinet, paneling, and molding markets. We have sorted the higher-grade material and it has been used as appearance grade material in furniture. Customer feedback has been very positive and the lumber marketing outlook for the hybrid poplar resource is promising.

Interest has also been high for using the hybrid poplar for veneer. Poplar has been used successfully for center core material in plywood. Clear veneer could be used as face material to compliment poplar edge glued panels. We are currently exploring opportunities with veneer, including new processing technologies.

The farm will always produce a small volume of chips. Mills that require hardwood chips to improve the printability or softness of their paper use poplar chips. Poplar chips have also replaced red alder in tissue mills. Chip volume will decrease from current levels until stabilizing when saw log volume is maximized. We have recently had to turn away customers as the volume goes down, and as we move forward we will maintain only the highest margin customers.

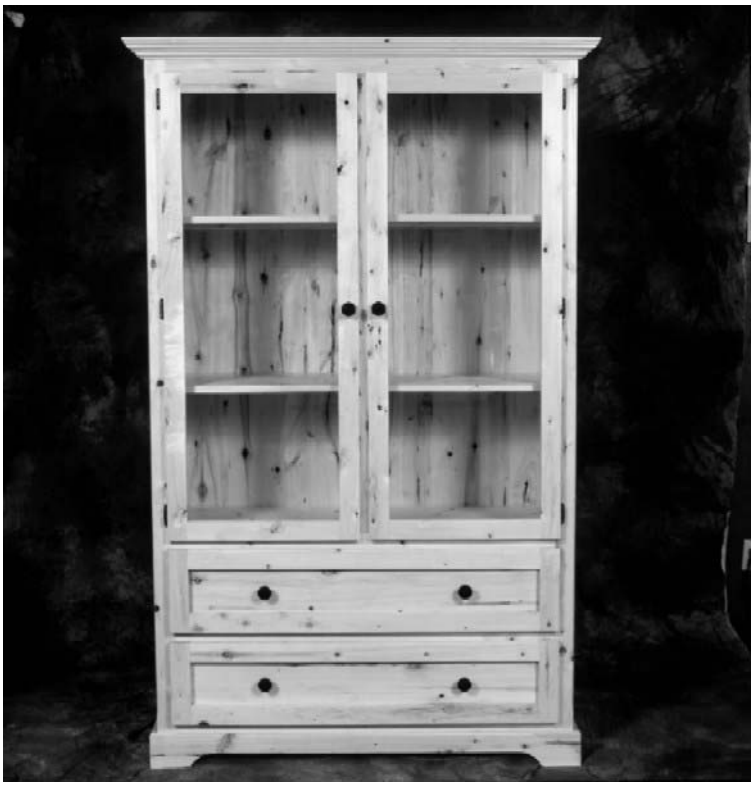

Figure 2. Poplar hutch

Minor products include hog fuel, carbon, and biomass for energy. The HPP currently trades hog fuel to a local dairy, which with the manure produces compost. We get compost in return to use as a nutrition source in our plantations. Approximately half of the hog fuel produced is returned to the field. This will provide a long-term nutrition resource in our plantations. Both of these practices will decrease our use of commercial fertilizers. Hog fuel is also used for dust abatement on the farm.

The carbon storage attributes of the farm could generate significant revenues in the future. We have made a preliminary calculation of the quantity of carbon sequestered on the farm and have made probes into the market place to determine what it is worth. Markets are in the early phases of establishment and market values for carbon have been highly variable. Our research shows that there will be a benefit for those who wait until the market matures.

7. OPPORTUNITIES FOR BIOENERGY

The forest products industry in the United States has long been a leader in biomass to energy conversion. Today, the majority of the energy used in the forest products industry is generated from biomass, and several producers are self-sufficient. These systems work because the biomass is produced from materials processed on the site and virtually no transportation is needed to get the biomass to where it will be converted. Further, burning the biomass to create electricity avoids costly disposal charges, thus enhancing the favorable economics.

The HPP produces approximately 40,000 green tons of residual biomass per year. A very small percentage of this total has been transacted to the bioenergy market. In these cases the material has been given away to help avoid disposal costs on the farm. The HPP continues to investigate opportunities to generate value from this material.

In most regions of the USA, electricity prices are still below the set point where bioenergy becomes competitive. Without government subsidies or mandates to support bioenergy development it is unlikely that large-scale adoption of this technology will occur in the near future. The current administration does not recognize international calls for limiting greenhouse gas emissions. Instead, a voluntary program has been called for with the hope that future technology breakthroughs will create clean energy sources and curb the potential for global warming. However, there is a grassroots upwelling in the USA to address global warming at the state level. If this movement gains momentum it could force a consolidated policy at the federal level and open the door for bioenergy projects.

The greatest opportunity for biomass to energy conversion exists in the regions of the United States where agricultural residues are significant enough to provide furnish for ethanol or small-scale power plants. Often times these residuals are burned in the field after harvest (wheat stubble, corn stalks). To be successful, cost effective systems of recovering these residues from the field must exist and transportation to a facility must be minimized. The State of Minnesota has become the leader in the USA in promoting bioenergy.

In spite of the technology to do so, short rotation woody crops grown for bioenergy are currently not economical in the US. Unless such projects are subsidized or mandated by state or federal government, they will not be a large part of the future energy portfolio of the US.

8. SUMMARY AND CONCLUSIONS

Producing hybrid poplar saw logs on a 10-12 year rotation is feasible and the Potlatch HPP has developed a business plan to make this a reality. The farm will start harvesting large volumes of saw logs in 2005 and eventually approach 250,000 m^3 per year.

Short Rotation Crops for Bioenergy: New Zealand, 2003

Potential markets for the wood have been identified in furniture stock, molding, veneer, and other non-structural materials. Current saw log production is being used to develop markets for this new species. Poplar chip markets are strong, but markets remain to be developed for residual biomass and sequestered carbon.

The future of bioenergy projects in the USA remains uncertain. Technological barriers are being solved in preparation for when bioenergy production becomes economical. Minor disruptions in the supply of energy, such as the 2001 California energy crisis, could quickly change the economics and brighten the future for bioenergy in the USA.