Proceedings of the Short-Rotation Woody Crops Operations Working Group

Second Conference
25-27 August 1998
Vancouver, Washington
USA

August 1999

SHORT ROTATION
WOODY CROPS
OPERATIONS
WORKING GROUP

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Boise Cascade Corporation
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Compiled by Bruce R. Hartsough
August 1999

These proceedings include papers presented by the authors and submitted to the organizers of the First Conference of the Short-Rotation Woody Crops Operations Working Group. The authors are responsible for the content of the individual papers. Please direct any questions to the authors listed for each paper.

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Prologue

Those growing short-rotation woody crops on a large scale have gained considerable experience in the two years since the First Conference of the Working Group was held in Paducah, Kentucky. For example, in 1996, only one large plantation owner on the west coast was harvesting on an operational basis. At present, three companies are harvesting, and another will soon join them. Unlike many bold experiments, SRWC production in North America has proved to be successful over the past several years. Yields from large-scale plantings have met expectations and in some cases exceeded them. The various operations – site preparation, planting, irrigation, pest management, harvesting and processing – are going relatively smoothly, although a considerable amount has been learned to streamline operations.

Many opportunities for improvements in operations still exist. Planting is still carried out by hand in many cases, especially in drip-irrigated plantations. Competing vegetation continues to be a major challenge and is a key limitation to early growth if not successfully controlled. Harvesting is carried out with conventional forestry equipment rather than with faster and less expensive machines that are tailored to uniform-sized and spaced trees on agricultural lands.

The short-rotation industry in North America is still primarily based on the production of clean chips for making paper. Over the last couple of years, however, many growers have been investigating product alternatives – solid wood, reconstituted structural products, and even garden mulch – that may provide higher returns. In addition, the use of SRWC to utilize and treat wastewater is on the increase, and two large-scale fuel supply endeavors – in Minnesota and in New York – are in the early stages of development. Each of these new product and/or use options will have an impact on what type of operations are needed to produce the optimal results, so experimentation and development of SRWC operations is likely to continue at a substantial level.

Based on all the comments I heard, the hundred or so individuals who attended the Second Conference were unanimous in rating it as an extremely worthwhile meeting. Credit for this must go primarily to two individuals: Conference Chair Gail Simonds of Westvaco Corporation, who arranged the excellent technical program as well as handling most of the advertising, paperwork, handouts and registration; and Local Host Chair Chuck Kaiser of Fort James Corporation, who arranged for all the meeting facilities and the excellent meals and refreshments in Vancouver, coordinated the transportation and lunches for both field tours, and knowingly arrived home late on his anniversary because he felt responsible for ensuring that the last tour was completed without a hitch. Bob Perlack (Oak Ridge National Laboratory) and Jim Shepard (NCASI) provided able assistance and advice in their roles as representatives of the Working Group's administrative sponsors.

All the speakers at the technical sessions should be commended for the quality of their presentations, and the session moderators - Lynn Wright (Oak Ridge National Laboratory), Bob Perlack and Jim Shepard – did a superb job of keeping the sessions on schedule. On the Westside Tour, Mark Madison and the rest of the CH2M Hill staff provided superb commentary and insights at the Woodburn and Riverbend wastewater reuse plantations, and Ray Ethell gave us a unique look at numerous uses for poplar as a solid wood product. Chuck Kaiser and others at Fort James Corporation, and Harry Quicke (American Cyanamid) filled the afternoon with valuable demonstrations of site preparation and vegetation management operations and results. Thanks to the staffs of Potlatch Corporation and Boise Cascade Fiber Farm, the Eastside Tour provided an

excellent introduction to the full range of operations for arid land SRWC plantations.
Several firms provided financial support for the conference: American Cyanamid Company, B.B. Hobbs Company, Boise Cascade Corporation, CH2M Hill, Morbark Sales Corporation, Netafim Irrigation, Supertrak, and Toro Ag/Drip In Irrigation. Netafim Irrigation also sponsored the hospitality suite.

As Chair of the Working Group, I would like to thank the outgoing members of the Steering Committee: Larry Burkholder of Morbark Sales Corporation, Chuck Kaiser of Fort James Corporation and Randy Richter of Simpson Paper Company. Chuck and Randy have been involved with the Working Group from its inception, and the two of them probably have more operational experience with SRWC than anyone in the United States. We will miss their input to the Committee, but expect that they will continue to be heavily involved with the Working Group in the future. And I would also like to thank those who have joined the Steering Committee for 1999: John Foote (Morbark Sales), Pat Moore (Potlatch), Steve Pottle (Boise Cascade), and Jim Tillman (Supertrak).

If you are not a member of the Working Group and would like to join, please see our web site for membership and other information: www.woodycrops.org

Bruce Hartsough
Proceedings Compiler and SRWC OWG Chair

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Farming Poplar in the Oregon Desert

Jake Eaton, Plant Materials Manager
Potlatch Corporation
Hybrid Poplar Program
Boardman, OR USA

Abstract

Potlatch Corporation is in the fifth year of converting 22,000 acres (9000 hectares) of Northeast Oregon center-pivot irrigated farmland to hybrid poplar. Conversion of this acreage will take place over a seven-year period with approximately 3,000 acres (1200 hectares) of new plantations established annually. The farm will provide a sustainable annual production of fiber beginning in the year 2000 and furnish 20% of the chip fiber for Potlatch's Pulp and Paperboard operations located at Lewiston, Idaho.

The Columbia River provides a stable source of irrigation water that in combination with the area's long sunny days, sandy loam soils, and 185-day frost-free growing season, creates an ideal environment for intensive poplar culture. Drip irrigation allows efficient delivery of water, fertilizer, and some pesticides to individual trees. State-of-the-art filtration, pumping, and water delivery systems are used to run the 200,000 gallon per minute irrigation system.

Farming activities focus on field conversion to drip irrigation, planting stock and clonal propagation, and plantation establishment and development. Conversion and site preparation activities involve pivot removal, field leveling, soil ripping, and incorporation of pre-emergent herbicide. A rigorous clonal testing program from breeding new material to selections for operational deployment results in new clonal material that is mass propagated at contract stoolbeds. Post planting activities include herbicide and manual release, cultivation, and intensive pest monitoring.

Currently, 15,000 acres (6000 hectares) are under management and irrigation system construction is underway on the 2,500 acres (1000 hectares) scheduled for planting in 1999. Mid-rotation tree performance is meeting expectations, and harvesting and processing planning is underway with the first harvest scheduled for fall, 2000.

Keywords: hybrid poplar, drip irrigation, clonal selection and propagation, fiber production.

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Introduction

Potlatch Corporation has acquired two contiguous center-pivot irrigated farms totaling 22,000 acres (9000 ha) 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. The decline has resulted from constraints on the Pacific Northwest timber supply brought about by environmental activism and a change in relative priorities of timber harvest versus other uses of public forestlands.

The Northeast Oregon location was selected for its optimal climate for intensive poplar culture. Long sunny days and a 185-day frost-free growing season provide abundant solar radiation. The soils are sandy, extremely well drained, and allow year-round operability. The Columbia River provides a secure and dependable long-term source of clean irrigation water. Both farms have well-developed irrigation infrastructures with relatively senior water rights allowing application quantities of 4.5 acre-feet per year. The location also has excellent barge, rail, and truck access.

Ground was broken on the hybrid poplar program in 1994 with the conversion of the first 800 acres (320 ha) to drip irrigation. The 1995, 1996, and 1997 plantings were approximately 3800 acres (1500 ha) each. In 1997 Potlatch made the decision to extend the crop rotation to seven years. To adjust the acreage to a sustainable even flow system based on a seven-year growth and harvest schedule, planted acreage will approximate 2500 acres (1000 ha) from 1998 to 2000. Beginning in the year 2000, the farm will provide a sustainable annual production of high quality fiber and furnish 20% of the chip fiber needs for Potlatch's Pulp & Paperboard operations at Lewiston, Idaho. Hybrid poplar fiber will mainly be used in bleached paperboard and tissue based consumer products. As an alternative end use of the fiber, Potlatch is currently investigating opportunities in the solid wood side of the business also.

Field Conversion

Potlatch purchased center-pivot irrigated agricultural land developed in the early 1970's. Prior to growing trees the farmland was used to grow a variety of crops including potatoes, onions, corn, wheat, and alfalfa hay in rotation. Conversion to drip irrigation is a requirement for poplar farming in our desert environment. Drip systems reduce system pressure requirements thus saving electricity, minimize water wasted by evaporation, minimize competing vegetation by reducing the area irrigated, and enable injection of necessary nutrients and some pesticides during the rotation cycle.

The existing center-pivot system presently waters crops in irrigated circles. This leaves corners of native desert outside of the circles that have never been farmed. The corners are very uneven from small sand dunes formed by years of blowing sand collecting around existing sagebrush plants.

Conversion to drip irrigation, inside and outside of the circles, occurs in two separate time frames. Corner conversion activities occur while crops are still maturing in the circles, 18 months before trees are planted. First, corners are mowed and large dunes leveled with a dozer. If there is a good grass cover and the ground is reasonably smooth, the area is left undisturbed. Disturbed corners are very susceptible to wind erosion. To prevent erosion, these areas are covered with straw. Specialized equipment shreds straw bales and spreads it evenly over the ground. Following this a grain drill is used to seed a winter wheat cover crop that will hold the soil through the following year. The drill also tucks the straw into the soil, helping to hold it until rainfall germinates the wheat and a cover crop is established. This process is generally completed by December, and these areas are ready for the final site preparation the following August.

Conversion activities inside the farmed circles begin the August prior to planting, immediately after the final crops are being removed. Several activities occur in quick succession.

The crop preceding hybrid poplar influences what happens next. Because of strong winds in our area, cover crops to prevent blowing sand and wind erosion is critical. The best crop to follow with hybrid poplar development is wheat. In this case the stubble is left and the fall and winter rains sprout the volunteer wheat resulting in a good cover crop. Potatoes or other row crops leave the field bare. In these instances winter wheat is sown and watered with the center-pivot.

Once the cover crop is established and able to exist until the onset of fall rains, the center-pivots are removed. Pivots are sold to buyers that are responsible for their removal. A quarter-mile long pivot with several towers can be removed in about two days. In coordination with the pivot removal, surveyors are brought in to layout the underground submains for the new drip system. In addition to staking the locations of new pipelines, the fields are surveyed and a grid system of check rows are located to ensure that tree rows are laid out straight.

When the surveying is completed a tractor mounted soil ripper is brought into the field to mark out the tree rows. This equipment rips two rows at a time, 10 feet (3m) apart to a depth of 24-30 inches (60-75cm). The operator works off of the surveyed grid of check rows and uses a marker bar to help locate the next row. If necessary, adjustments are made at the check rows to maintain straight rows ten feet apart. Consistent row spacing is critical to insure adequate space for tractor operation between tree rows. Once ripped the field is ready for irrigation construction.

Irrigation Construction

With 19,000 miles (30,400km) of drip tube and 26 million emitters, clean irrigation water is a must. Water from the Columbia River is moved to the plantations through 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 automatically clean themselves when the sediment load reaches a predetermined level. Down stream of the filters, chlorine is injected into the irrigation stream to control algae.

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 pest control products to four similar sized blocks. The underground construction begins with trenching and laying pipe on three sides of the block. The submain system is three sided to allow irrigation to be supplied from both ends of the block and facilitate automatic flushing of sediment and other contaminants from the system. Blocks are approximately one-quarter mile to one-half mile square (40-80 acres). Flexible hose risers are attached to the below ground submains at the block ends, and serve to bring the water back to the surface. Drip hose will eventually be attached to the risers. Risers are lined up with the rip marks to get the correct row spacing along the pipeline.

Once the submains and riser lines are installed, the manifolds are assembled. 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. A final filter is installed after the injection port to prevent drip tube contamination from mainline breaks. 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.

Site Preparation

All of the field conversion activities take place between August 1 and November 1 of the year prior to planting. Beginning around the first of November, or as soon as soil moisture is adequate, rototilling begins. The rototillers are six feet wide and till 3-4 inches(7-10cm) deep. The tillers center on the rip mark and the packer behind the tiller leaves two groove marks in the soil. These marks are one foot apart and indicate where the soil was ripped. Tilling in this pattern leaves a 4-foot (3.2m) strip of cover crop between each tree row. This is done to provide wind protection to the young trees. Installed on the tillers is a sprayer that applies a preemergent herbicide right in front of the tiller. Presently, products with the active ingredient Trifluralin are used. Tilling takes place throughout the winter months as weather allows and is completed by March 1st.

Installation of the drip hose begins in January and is completed by the first of April. The hose arrives from the manufacturer in rolls of predetermined lengths, with emitters or drippers attached along the hose at preset spacings. These emitters are pressure compensating and will put out a constant 0.75 gallons (3 liters) per hour over a range of pressures. A specialized implement mounted on a tractor spools these rolls out. It uncoils three rolls at a time as the tractor moves down the row. Care is taken to lay the hose between the groove marks left by the tiller. This assures that the tree will be planted at the rip mark. Drip hoses and submains are flushed thoroughly before final connections are made. At this point the field is ready to be irrigated.

Clonal Testing

Potlatch's clonal testing program begins with acquisition of new plant material. Our strategy has been to do some breeding of our own and acquire additional clonal material through the research cooperatives we are active in. Further, we are constantly looking worldwide to secure possession of material that has not been tested in our environment. The hybrids we are working with are crosses between four poplar species, including P. trichocarpa (black cottonwood), P.deltoides (eastern cottonwood), P. nigra (black poplar), and P. maximawiczii (Japanese poplar).

Newly bred clones enter a two-year screening trial, where the top 10-15%, based primarily on volume growth, are selected to move forward to the refinement phase. This three-year trial will begin to evaluate clone suitability to the Boardman environment, wood quality, and also expand our growth analysis work. The top 10% moves ahead to the final verification test. Its 4-7 year duration is designed to thoroughly evaluate volume growth (including stem form), environmental suitability, wood quality, disease and pest resistance. Current operational clones are included in the test and serve as the basis for comparison. Exceptional material can be identified at any time during the testing sequence and moved to clone banks to facilitate rapid scale-up.

Crosses between P. trichocarpa and P. deltiodes (TxD) and P. deltoides and P.nigra (DxN) have been used operationally. The TxD crosses generally produce the greatest biomass, but may not be as cold hardy as the DxN hybrids. The P. trichocarpa by P. nigra (TxN) crosses have shown great potential in testing and were included in operational plantings in 1998. To date, crosses between P. trichocarpa and P. maximawiczii (TxM) have not proven suitable to our hot and cold extremes, and our windy environment.

Clone testing is an ongoing process with new material entering different phases of the testing program each year. Many years are needed to confidently select new clones for operational use. Work currently underway in the Poplar Molecular Genetics Cooperative hopes to compress the testing period by identifying genes for desirable traits at an early age. Marker aided selection would also be valuable to select parents for future breeding.

In spite of long deliberate clonal testing programs, all of the risks associated with deploying new clones can not be eliminated. Extreme environmental conditions or disease and pest adaptations can result in crop damage or failures. Long-term risks have to be balanced against productivity gains in a comprehensive clonal testing program.

Planting Stock Development

Clonal material is mass propagated at contract nursery stoolbeds. Plant material for stoolbed development comes from company clone banks or outside purchases. Single-bud cuttings, cut from clone bank whips, are greenhouse propagated for stoolbed starter material. More rapid scale-up using a controlled green wood propagation technique is also possible. Extreme care is taken to assure clonal integrity is maintained during scale-up. Suspicious greenhouse and stoolbed material is discarded to avoid contamination.

Depending on the level of scale-up desired, smaller stoolbed cuttings can be saved when processing production cuttings for additional stoolbed development. Stoolbeds are generally planted at a 1 x 1 ft. (30 x 30cm) density and intensively managed to assure proper nutrition and irrigation. The goal is to maximize yields by growing branchless wands with very little taper. Insects and disease are monitored continuously and controlled promptly. At full production one acre of stoolbed will yield around 150,000 operational cuttings (see size specifications below).

Wands are processed when dormant. Crews harvest wands in the field and transport them to a processing facility. Most processing is done by hand. Cutters have lopping shears with length and caliper guides to aid in size determination. Generally accepted cutting size specifications for planting East of the Cascade Range are 8-9 inches (20-23cm) in length and 3/8-7/8 inch (1cm-2cm) in caliper. Processing is a labor-intensive activity and accounts for 60% of the cutting production cost. Cuttings are double bagged to prevent moisture loss, boxed, and placed in dark cold storage at 28 degrees F.

Plantation Establishment

An average of six different clones are planted each year. Plantations are established in monoclonal blocks. Generally, all four irrigation blocks (as many as 280 acres) in a field are planted with the same clone.

In Northeast Oregon planting begins in early April. Just prior to planting, the fields are sprayed with herbicide. The two-tank spray rig eliminates weeds that have escaped in the tilled strips and treats broadleaf weeds in the cover crop strips. All planting is accomplished by contract crews that can hand plant up to 240 acres (96ha) per day. Wet spots along the drip tube indicate where to plant. Care is taken to plant the cutting with buds pointing up, the top bud flush with the ground, and within a few inches of the emitter. Planting is completed by mid May. After the cuttings have been out for about six weeks, crews go through the plantations to replant any failed cuttings, move the drip tube to the west side of each tree, single multiple stems, and check emitter operation.

The first year after planting is critical to plantation establishment and performance. Hybrid poplar is not a shade tolerant plant. In areas where pre-emergent herbicide activity has been weak, new trees can be rapidly out competed by weeds. Grass competition can be controlled by any of the Fluazifop herbicides (eg. Fusilade) without damaging the poplar. Unfortunately, at a young age poplar is not compatible with most of the common herbicides. Because of this, manual release may be the only option to remove unwanted vegetation next to the trees. Once trees are established, tractor operated cultivation does occur between tree rows to remove vegetation strips, left to provide wind protection for new trees.

Pest monitoring begins soon after planting. Grasshoppers, wire worms, cut worms, and ants can damage young plants. Although damage from these insect pests is seldom economically significant, grasshoppers can cause defoliation and have been managed with Carbaryl insecticides. Other insect pests monitored for and controlled when necessary during the first year are the cottonwood leaf beetle and various caterpillars. Mammalian pests include deer, gophers, voles, and indirectly coyotes. Deer browse is generally local and tolerated. Gophers eat tree roots and voles can girdle stems. Effective control of rodent damage begins with thorough weed control, which eliminates habitat. The rodents seem to concentrate damage in local areas and can be held in check by poisonous baits. Coyotes chew through drip tube resulting in leaks and moisture stress on the trees.

Summary

The level of activity in the plantations decreases after the first year. Irrigation, fertigation, and pest monitoring form the basis of plantation management until harvesting activities begin. Annual stand inventories are conducted on each age class to assess performance and identify problem areas. To date, average growth rates of 60 plus feet (18m) in height and 6 plus inches (15cm) DBH have been observed on trees nearing the end of their fifth growing season. It appears that our target tree size of 70-75 feet (22-24m) tall and 8-9 inches (20-23cm) in DBH is realistic with a 7-year rotation.

Producing Short Rotation Willow Crops in the Northeastern United States

T.A. Volk, L.P. Abrahamson, E.H. White, R.F. Kopp, and C.A. Nowak
State University of New York
College of Environmental Science and Forestry
Syracuse, NY 13210

Abstract

The willow biomass-bioenergy program at the State University of New York College of Environmental Science and Forestry (SUNY-ESF) in Syracuse has focused on developing a commercially viable willow biomass production system since 1987. The Salix Consortium was recently formed to develop a commercial willow biomass industry. The near term use of willow biomass will be co-firing with coal at pulverized coal power plants in New York.

The production system for short rotation intensive culture (SRIC) willow in the northeast is based on local long-term research and an operational system in Sweden. It includes a double-row configuration with a density of approximately 15,300 trees per hectare. Unrooted cuttings are planted following agricultural type site preparation and complete weed control. Recent studies indicate that some conservation tillage approaches are as good or better than the traditional complete fall tillage system. Machinery for planting has been commercialized in Europe and is currently being modified by Cornell University and SUNY-ESF for conditions found in the northeastern United States. Equipment configurations include two and four row planters that use 25cm precut cuttings as planting stock or utilize 100 – 200cm whips, cutting each off at 12-24cm after insertion. Modifications to the two row planting system have significantly improved the effectiveness and efficiency of the system. Recent trials with mechanized weed control have been designed, increasing the available management options. Willow is harvested on a three to four year coppice cycle after a coppicing at the end of the first growing season. Coppicing promotes multiple sprouting and full site occupancy. Fertilizer, particularly nitrogen in organic or inorganic form, is commonly applied after each harvest. First rotation operational yields should be about 11 odt/ha/yr. Yields are expected to increase in later rotations as improved varieties of willow are commercialized and the production system is optimized. Field trials using both organic and commercial fertilizer are providing valuable information on the range of options that effectively and economically increase yields without damaging the environment.

Keywords: Willow biomass, Northeastern United States, Salix Consortium, production system, intensive culture

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Introduction

Two decades of research on short rotation poplar and willow at the State University of New York College of Environmental Science and Forestry (SUNY-ESF), in combination with long term research and practical experience from Europe, has resulted in the development of a system of short rotation intensive culture (SRIC) willow for the Northeastern United States. Over the past decade interest in the idea of SRIC willow has grown steadily. In 1994 the Salix Consortium was formed with the goal of building on the research base while transforming the knowledge and experience gained into a commercially viable industry. The Consortium has grown to include over 25 organizations from across North America, representing industry, government, agricultural and farming groups, environmental organizations, and universities.

The near term market for willow biomass is co-firing with coal at two pulverized coal power plants in New York. Alternative markets for energy and other products are being developed. The challenge facing the Salix Consortium is to simultaneously establish enough acreage, so there is a reasonable supply of willow biomass, while at the same time developing a reliable market, so there is a place to sell the biomass at the end of each rotation. It is a matter of having both the product and the market mature together. With concerted effort from members of the Salix Consortium, and support from the United States Departments of Energy and Agriculture through the Biomass Power for Rural Development program and a variety of other sponsors, this transformation is beginning to occur.

During the spring of 1998 the Salix Consortium established over 50 hectares of willow biomass crops on private land in western and central New York. Smaller trials have been located in three other states – Pennsylvania, Vermont, and Wisconsin – with plans for trials in New Jersey and Delaware in 1999. The 1998 scale up effort is the beginning of the Consortium’s goal of establishing over 400 hectares of willow biomass crops over the next three years. This expansion effort is providing an opportunity build on the solid research foundation of SRIC willow biomass production, and to optimize the system. The goal of this paper is to summarize the most pertinent details of the current SRIC willow production system for the northeastern United States.

Willow Biomass Production System

Site Preparation

Site preparation for willow biomass crops typically begins the growing season before planting. The specific practices employed vary depending on the history of each field. Of the 50 hectares planted in 1998, 80% were fields that had been out of cultivation for at least one growing season. Fields that have returned to woody cover are generally avoided because of the difficulty in successfully converting them to willow in one growing season.

Site preparation for a typical old field begins with mechanical control of vegetation (i.e. brush hogging or mowing) the summer before planting. After vigorous regrowth is established, contact herbicides are applied. Several weeks later the site is plowed and disked so that mechanical weed control benefits can be further realized. Amounts of field work required the following spring are minimized. On sites with significant erosion potential, a cover crop of winter rye, or other species, is sown. Fall preparation is especially important on sites with moderately poor to somewhat poorly drained soils. Such soils are predominant in the area where the Consortium’s scale up efforts is focused. Access to these sites is often delayed in the spring, so planting, not tillage operations, should be the focus once access is possible. Early results of trials at SUNY-ESF indicate that full fall site preparation followed by a cover crop is the most effective establishment approach for willow biomass crops (Volk, unpublished data). Plowing and disking in the fall without the use of a cover crop or in the spring produced similar establishment year results on a moderately well drained soil. However, it appears that second season results will show that spring tillage operations resulted in poorer weed control and thus reduced growth. On sites planted to annual crops such as soybeans, corn or small grains, site preparation can be delayed until the early spring if the site is accessible during that season.

Planting Systems

The current willow biomass crop system consists of planting genetically improved willow clones as unrooted hardwood cuttings at densities of about 15,300/hectare. Currently eight clones of willow and one poplar clone are used in large scale plantings (Kopp et al. 1997a). Planting is done as soon as sites are accessible in the spring – typically late April in the Northeast – until early June. Planting is done with mechanized planters specifically designed for dormant hardwood cuttings or whips. To facilitate the management of the site with machinery, trees are planted in a double-row system with 1.5m between double-rows, 75cm between rows, and 70cm between trees within rows. Each individual tree has about .65m^2 of growing space (Figure 1). Immediately following planting a preemergent herbicide is applied. Oxyfluoren and simazine are the two herbicides currently being used, based on the results of previous trials (Kopp et al. 1991). Trials are underway in conjunction with the USDA Forest Service in Rhinelander, WI to test other preemergent herbicides.

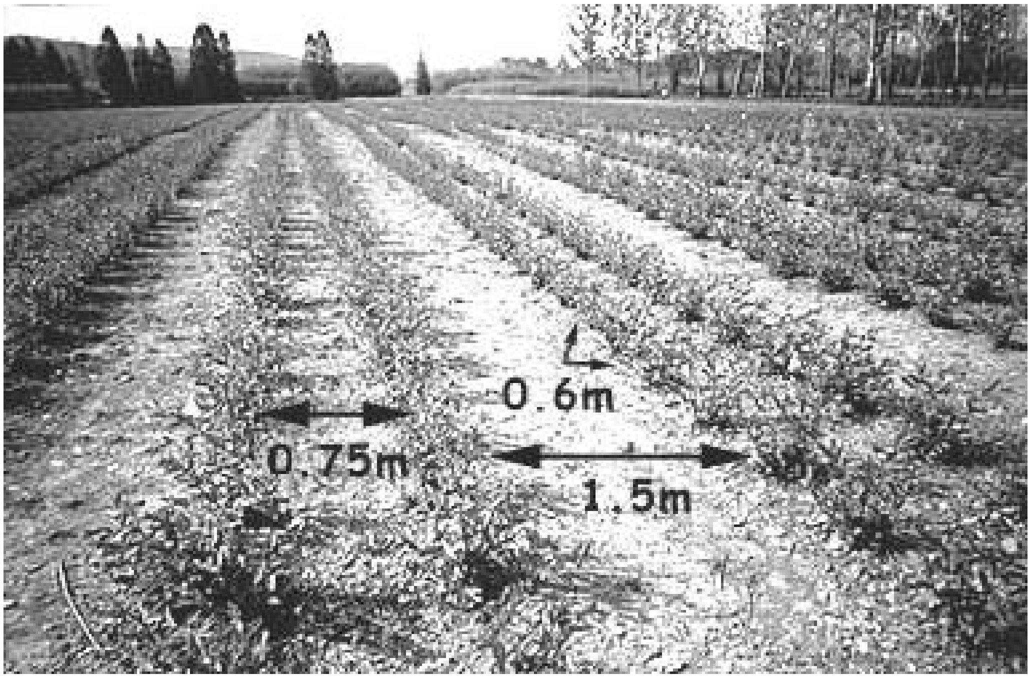

Figure 1. The double row spacing for SRIC willow facilitates the use of existing or slightly modified agricultural equipment. The willow is about 6 weeks old at the beginning of the first season of growth following coppice.

Agriculturally based planting and harvesting machines have been commercially developed in Europe and are being adapted to conditions in the northeastern United States. The two most common machines used to date are the Fröbbesta planter (Figure 2) and Salix Maskiner's Step planter (Figure 3), both of which were designed and produced in Sweden. The Fröbbesta planter uses 25cm hardwood cuttings as the planting stock. The Fröbbesta planter opens a slit in the ground to a depth of 20 – 25cm. Cuttings are fed manually into the planter and are driven into the opening by two pair of hydraulically powered rubber wheels. A pair of packing wheels closes the opening. Staff at Cornell University made modifications to the Fröbbesta planter. The main changes include improvements to the hydraulically driven "drive wheels", allowing the frame of the planter to float freely so it will adjust to changes in field conditions, and modifying the location and size of packing wheels and the discharge tube so that the planting slit is closed more rapidly and cuttings remain upright in the soil. (D. Aneshansley and R. Pellerin, personal communication). Initial trial results indicate that the survival for both poplar (*Populus nigra x maximowizii* – clone NM6) and willow (*Salix dasyclados* – clone SV1) was greater than 90% on both hand planted and machine planted plots. First year poplar biomass production was greater on the machine planted plots compared to hand planted plots. First year production of hand and machine planted willow clone SV1was not significantly different (Volk, unpublished data).

Figure 2. The Fröbbesta planter uses 25cm long cuttings as planting stock and plants one double row at a time.

Recent establishment trials in Europe have identified the Step planter as the most efficient and effective machine for willow biomass crops (Forestry Commission 1995). The Step planter uses willow whips – stems of one-year-old willow that are 1.0 to 2.0m in length – as planting material. The whips are fed into the machine between two belts that guide the whip into the planting mechanism. The whip is automatically cut to the desired length and simultaneously inserted into a slit in the ground made by a coulter. The length of the cutting can be varied from 12 to 24cm in two centimeter increments, which provides increased flexibility to work on a variety of different soil types. When the plant material is inserted into the ground, the planting portion of the machine is held stationary. Designing the machine with this temporary, stationary moment at planting was inspired by the pattern of people walking – hence the name of the machine - Step planter.

Figure 3. The Step planter uses 1 – 2 m whips as planting stock and plants two double rows at once.

The Step planter will increase the efficiency of planting willow biomass crops over the current system using the Fröbbesta planter in a number of ways. The use of whips versus 20 - 25cm cuttings as planting stock will result in savings in the cost of planting material production since labor is not required to make the whips into cuttings. The Step planter works on two double rows at once, while the current Fröbbesta machine only plants a single double row at a time. Since two people are required to operate both the Step and Fröbbesta planters, the labor requirement for planting an given field is cut in half. In addition the Step planter's output is about .9 – 1.0 ha/hour while the Fröbbesta planter's output is 0.3ha/hour (Forestry Commission 1995). Trials in New York with the modified Fröbbbesta have recorded planting rates of about 0.25ha/hr. Trials with a Step planter are planned for the spring of 1999 in western New York.

Weed Competition

Weed competition is probably the largest single factor inhibiting the successful establishment of willow crops. Both annual and perennial weeds compete with newly established willows for moisture, nutrients, and in some cases light (Barkley 1983, Labrecque et al. 1994). Effective control of weeds during the first growing season is essential for the successful establishment, and long term productivity, of the crop. The main weed control effort occurs during site preparation where a combination of chemical and mechanical methods is used. If properly applied immediately after planting, a preemergent herbicide cap will control germination of new weeds until the middle of the first growing season. If perennial weeds are present, then alternative methods of control need to be employed. Once cuttings break bud and begin to grow, most contact herbicides can only be used with wick applicators or well controlled directed sprayers. Trials are planned to test some contact herbicides that have been successfully sprayed over top of growing hybrid poplar trees. Mechanical weed control using tractor mounted rototillers (Figure 4) or more traditional cultivation equipment, modified for the double row spacing, has also proven to be effective. If weed control is successful during the first year, the crop should fully occupy the site in the second growing season, making additional weed control efforts unnecessary.

Figure 4: The Badalini tractor mounted rototiller is used to control weeds in willow biomass crops. Individual heads are spaced to fit the double row spacing. This willow crop is early in its first year of growth following coppice.

Growth and Yield

Trees reach a height of 1 – 2m after during the first year of growth and typically produce two to four stems. Following the first year of growth, trees are cutback during the dormant season to force coppice regrowth. Coppiced willow produces an average of 5 - 15 stems, depending on the variety. Coppice regrowth during the second growing season rapidly occupies the site, reducing weed competition and increasing the rate of biomass accumulation. When first year establishment has been successful, fields that have been coppiced can be fully occupied by mid to late June (Figure 5). Recent results from Sweden indicate that biomass production is similar after four years of growth on coppiced and uncoppiced stands (N. Nordh, personal communication). Trials are underway in central New York to determine the impact of coppicing on weed competition and biomass production for five varieties of willow and one variety of poplar. Two approaches to coppicing, a traditional sickle bar mower and a disc mower will be tested.

Figure 5: When willow crops are well established, they close canopy early in the first growing season following cutback (mid June in this case).

Studies indicate that a three year rotation length is best for willow biomass crops in central New York (Kopp et al. 1997). With similar spacing among trees, rotations of four to five years are recommended for Swedish conditions (Willebrand 1993). Harvesting occurs during the dormant season so that the maximum amount of nutrients and carbohydrates are translocated to the root system. Vigorous coppicing appears to be related to the amount of nutrients and carbohydrates stored in the root system in the few weeks immediately prior to leaf fall (Sennerby-Forsse et al. 1992). Machinery for two approaches to harvesting, cut-and-chip and whole stem harvesting, have been developed. Machinery for the first approach cuts the stems and chips them as part of one process. Chips are transported to the power plant, and if they are not dried to below 30% moisture content, need to be used in the next one to three months before dry matter losses become significant. Examples of the cut and chip system include the Salix Maskiner Bender, the Austoft 7700, and the Claas Jaguar 695 all of which have been tested in Europe (Mitchell 1997, Spinelli and Kofman 1996) and are being evaluated for use in North America. Advantages of whole stem harvesting systems, such as the Empire 2000 or the Salix Maskiner Bundler are lower capital cost for the machinery, longer potential storage time for the material, and opportunity for natural drying to occur. The development of this specialized machinery over the last decade has significantly reduced the cost of SRIC willow production. Ongoing efforts to expand the range of crops that can be harvested with these machines will further reduce costs associated with willow biomass crops. Trials with some of the more promising equipment are planned for SRIC plots in the northeastern United States in the next few years.

After dormant season harvest, the trees resprout and fully occupy the site by early summer. Trials in New York have demonstrated that 10 annual harvests can be made without decreasing the vigor of the plants (Kopp et al., in preparation). Work in Sweden has indicated that as many as seven three-year coppice rotations may be achieved with good management and selection of plant materials (Danfors et al. 1998). As a result, the intensive site preparation required to make this systems successful is only required once every 20-25 years.

Fertilizers are applied to willow plantations at rates that will enhance wood production by amending site quality, without polluting nearby surface or ground water. Because harvest occurs after leaf fall, the majority of nutrients are translocated into the root system or recirculated in the leaf litter. Fertilizer application occurs once at the beginning of each three-year rotation in the spring after harvest. The current recommendation is 100 – 120 kg N/ha, which results in a 30 – 60% increase in yield after two years of growth (B. Ballard, personal communication). Because willows are actively growing during this time, and the root system is well established, there is very little leaching of nutrients. Ongoing trials conducted by SUNY-ESF using organic fertilizers, such as composted chicken manure, composted biosolids, and lime stabilized biosolids, indicate that yields after one year are comparable to using 100 kg/ha of slow release nitrogen (H. Agdebidi, personal communication). Organic amendments have the added advantages of releasing nutrients more slowly over the three year rotation and being a lower cost source of nutrients.

Yields of fertilized and irrigated SRIC willow grown for three years have exceeded 23 odt/ha/yr (Kopp et al. 1997b), which is among the highest yields reported for SRIC biomass crops in temperate regions of the world. Unirrigated trials in central New York have produced yields of 8.9 and 12.1 odt/ha/yr in the first and second rotations respectively. It is anticipated that commercial yields will be slightly lower than these trials due to variability in field conditions. Yields of the first larger scale trials will be available in the winter of 1998/99. Production in these trials, after two years of growth following cutback, has been in the range of 8 to 10 odt/ha/yr depending on the clone (Ballard, personal communication). These yields are expected to rise slightly after this – the third – growing season. The first commercial harvests are scheduled for the winter of 1999/2000. Commercial yields of willow in the first rotation are expected to be about 11 odt/ha/yr in the northeastern Untied States, with increases in the second rotation of 30 – 35%. Early in the next century improved varieties of willow will be available from breeding efforts at SUNY-ESF, and possibly in Europe, that should increase yields even further.

Summary

SRIC willow plantings in the northeastern United States show promise as a dedicated feedstock for energy production. The willow production system is founded upon long-term research, generally small scale trials that started with hybrid poplar in the 1970s and shifted to emphasize willow culture over the last decade. This shift--from poplar to willow--is supported by work in Europe, particularly in Sweden, where a SRIC willow production system has been at operational scale for the past decade.

The Salix Consortium has initiated scaling up efforts of SRIC willow acreage with the goal of establishing over 400 ha in the next three years. The production system being employed is based on double row planting of approximately 15,300 trees/ha, following complete site preparation, including herbicide application, plowing, and disking. Initial results using conservation tillage practices also show promise. Trees are planted in spring as unrooted, 12-24cm long cuttings, using either the Fröbbesta or Step planter. Trees are cut after the first year to promote sprouting. Weed control, using a combination of mechanical and chemical techniques, is essential during the first year of establishment. Harvesting occurs every three to four years in the winter after leaves fall from the trees. Modified agricultural equipment, or specially designed machines, is used to cut and chip the willows in one process. Whole stem harvesting machines have also been developed and provide different benefits. Following each harvest the plants resprout and can be harvested six to seven times. First and second rotation yields of 8.9 and 12.1 odt/ha/yr have been recorded in research trials. The first yields from larger scale trials will be available in 1999.

The willow system as described in this paper is currently expanding from research-level to commercial scale. Dynamics of the system are expected to change with such scale-up. These dynamics are being formally observed. Rigorous protocols for monitoring weed competition, insects and diseases, site nutritional status, survivorship, and biomass production are being used in all commercial plantings. Ongoing decisions about cultural treatments, such as weed control, are based on these data. Efforts are made to collect data that is research quality so that program successes and shortfalls can be described and the production system can be optimized.

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Short Rotation Eastern Cottonwood (Populus deltoides) in Southeastern Missouri

Dwight Rainwater
Westvaco Corporation
Wickliffe, KY

Introduction

Westvaco’s Fine Papers Mill at Wickliffe, KY is located just below the confluence of the Ohio and Mississippi Rivers. The mill has been in operation since 1970 and produces approximately 1,000 tons of market pulp and paper per day. This requires 1.3 million tons of wood per year with 85 percent hard and 15 percent pine. The paper products produced at Wickliffe are used for envelops, return postcards greeting cards, maps, books, catalogues magazines, promotional flyers and many other products.

Westvaco has had one of the most successful Mississippi River bottom land programs in the country. Growth is impressive, up to 100 feet in ten years, because of the abundance of nutrients that are deposited during flood situations. However, the free alluvial deposits are a mixed blessing because flooding is unpredictable. Often floods disrupt logging, field activities and in some years, eliminating tree planting completely.

Due to these flood situations on alluvial sites, Westvaco has taken other measures to assure that the Wickliffe Mill will have a steady supply of wood in the future. One of these new measures is fiber farming.

Prerequisites for Fiber Farming

1. Accessibility - Sites must be accessible year round in order to plant, cultivate and harvest.
2. Site must be located near the Wickliffe Mill.
3. 3-phase power must be available.
4. High quality water must be abundant.
5. Land availability.

Thousands of acres of former floodplain acreage lies on the protected side of the levee system in the Bootheel of Missouri. Most of this land has been cleared and is now in row crops. A large majority of this land consists of very well drained and somewhat doughty sandy loam. On this particular type of soil, irrigation is a must, in order to produce a decent yield crop. A preliminary review of the USDA Soil Survey for the Missouri Bootheel indicates that there are more than 200,000 acres that may be suitable sites for fiber farming.

The Robbins Fiber Farm Tract (240 acres) acquired in June of 1995 was selected because it meets all of the prerequisites. The Robbins Tract is located only 40 miles from the Wickliffe Fine Papers Mill. 3-phase power and abundant high quality ground water is available. While the soils are sandy, excessively drained and low in nutrients, they do permit excellent year-round equipment access and offer uninterrupted drip fertigation, free from the interference off natural rainfall events.

Westvaco has also recently purchased an 850-acre tract of land that is located on one mile south of the Robbins Tract. There are 150 acres of this new tract in operation, as of 1998, and plans to complete the entire tract by the year 2001.

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Drip irrigation and fertigation is the process of delivering precise amounts of water and fertilizer to the root zone of a crop through a series of spaced emitters. Fertigation was introduced in Israel in 1965, to grow crops on arid land previously incapable of being farmed. These particular drip tubes consists of pressure compensating emitters. Regardless of the water pressure in the tube (7-60 psi), the emitter will emit the exact same amount of water and fertilizer through each emitter. This allows for the most uniform crop, regardless of variation in elevation.

Two underground wells, each capable of producing 1200 g.p.m., are 100 feet deep and consist of 60 HP line shaft turbines to provide irrigation water to the system. The drip system is fully automated through the use of a Motorola irrigation controller. Two disc filters, each capable of filtering 1200 g.p.m., are located in the pumphouse to filter solid particles from the irrigation water. At this stage the water is also treated for algae and mineral that could clog the emitters Filtered and treated water is then pumped into one of three mainlines, exiting the house. These mainlines are for production, nursery and research areas. Before the irrigation water exits the pumphouse, a 7-0-7 liquid fertilizer is injected into one of the three mainlines by fertilizer pumps.

Westvaco is very environmentally conscious when any chemical is used on company land. Fertilizer storage regulations in the state of Missouri require concrete containment pads. In addition to fertilizer tanks, pesticide tanks are also stored in the pad. The second largest problem in fiber farming has been the Cottonwood Leaf Beetle. Digon 400 is a systemic pesticide that can be injected through the drip system to control Cottonwood Leaf Beetle.

The largest problem in fiber farming has been competition control. Cross-cultivation without damaging drip lines isn’t possible. There are no effective herbicides labeled for fiber farming that doesn’t damage first-year trees. Plastic mulch is being laid for competition control. Along with that benefit has come earlier root development due to increased soil temperatures.

Fiber Farm Management

1. Through the use of high tech controllers and drip lines exact amounts of water and fertilizer can be applied to plantations on a daily basis.
2. Tensiometers or TDRs can and should be used to measure soil moisture every day.
3. Pan evaporation measurements taken on-site should be used to calculate water moving off-site due to wind and temperature.
4. Using the tools above, water utilization of trees at any age or size can be calculated.

Southern Short Rotation Woody Crops Collaborative Research Program

Marilyn A. Buford
National Program Leader for Quantitative Ecology Research

Bryce J. Stokes
National Program Leader for Forest Operations Research

USDA Forest Service Vegetation Management and Protection Research
P. O. Box 96090
Washington, DC 22090-6090
Phone: 202-205-1561; FAX: 202-205-2497
email: mbuford/wo@fs.fed.us and bstokes/wo@fs.fed.us

Paper submitted on behalf of the SRWC Collaborative Research Program which includes eight USDA Forest Service Southern Research Station Research Work Units, USDA Forest Service Region 8, USDA Forest Service Savannah River Institute, Department of Energy/Savannah River, Oak Ridge National Laboratory, five Universities, and several forest industry companies.

Abstract

Hardwood removals in the South, often from bottomland and steep sites, have increased dramatically. Fiber from intensively managed sources can replace hardwood imports, provide regional resource supplies and employment, and displace procurement from and protect sensitive forest sites. As woody biofuel, farm-raised trees provide these advantages and can help meet increasing demands for an environmentally acceptable renewable energy source. The potential advantages of short rotation woody crops (SRWC) have generated strong interest with the forest community for these systems. There are, however, many management and operational questions concerning such large-scale tree plantations that relate to production efficiency and practices, maintaining environmental quality, and understanding ecological processes in support of sustainable management. Questions concerning efficient and environmentally acceptable production of short rotation woody crops in the South are being answered through a collaborative research program. Interested and committed cooperators currently include USDA Forest Service Savannah River Institute, Southern Research Station, and R8 State and Private Forestry; US Department of Energy/Savannah River Site; Oak Ridge National Laboratory, universities, and forest industry companies. The goal of the Southern Short Rotation Collaborative Research Program is to establish and communicate the scientific basis for environmentally sound implementation of short rotation woody crop systems for the southern United States.

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Introduction

There is a continuing controversy in the United States over how to resolve the conflicting public demand for increased amounts of wood and wood-derived products with decreased intervention in natural woodlands. One possible solution would be to import a larger proportion of our wood product requirements. This would solve a domestic supply problem, but might export our environmental risks while potentially opening our borders to new insects and pathogens. A more attractive solution would be to increase the productivity of domestic wood sources and manage them in a way that is environmentally acceptable. The use of short rotation, intensive cultural practices, or fiber farming, is a potentially important means of achieving higher productivity and meeting future demands for a sustainable source of fiber, chemical, and biofuel feedstocks.

Demand and consumption of fine, white paper and the hardwood pulp used in its manufacture has increased over the last decade. Despite a large increase in recycling rates, it is expected that demand for virgin fiber will continue to increase. The hardwood resource is often found on bottomland or steeply sloping sites, especially in the South, and the public has expressed concerns over harvesting timber in these sensitive areas. Forest products companies have responded to the demands by pursuing the development of short rotation, intensive culture of woody crops as a primary alternative for meeting these wood resource demands.

Short rotation woody crops (SRWC) offer many advantages over current fiber and biofuel sources. Pulp and chemicals from these intensively managed crops can replace those derived from hardwood imports. Properly implemented, woody crops can reduce seasonal and weather induced fiber supply shortages and they offer the potential to locate supplied near conversion facilities, reducing transportation energy and costs. By increasing output per unit area on marginal lands that might otherwise be unproductive, SRWC can displace procurement from, and thereby conserve, sensitive forest sites. Farm-raised trees can also serve as a renewable alternative to fossil fuels, helping to meet increasing demands for an environmentally acceptable domestic energy source. Biofuels can provide a local source of energy, keeping fuel dollars in the community and providing a stable employment opportunity for the local economy. On a national scale, woody crops for biofuels generate jobs and improve local economies, help reduce trade deficits, conserve fossil fuels, and meet increasing demands for an environmentally acceptable, renewable energy source.

These potential advantages have generated strong interest within the forest community for development of short-rotation, intensively managed, woody crop systems. Several forest industry companies have begun pilot SRWC programs in the southern US. There are over 20,000 ha of short rotation cottonwood plantations managed for fiber production in the Pacific Northwest. The Minnesota Department of Natural Resources is sponsoring a program for farmers to plant SRWC as an alternative crop in a conservation reserve program. Despite these commercially successful examples of SRWC production, there are many management and operational questions concerning such large-scale tree plantations that relate to: (1) production efficiency and practices, (2) maintaining environmental quality, and (3) understanding ecological processes in support of sustainable management. Research is needed to fully develop guidelines, practices and technologies that will lead to cost effective and environmentally acceptable implementation of this wood production concept at a large scale. The research will lead to accelerated understanding of biological processes, and help provide a competitive and sustainable hardwood resource supply.

Collaborative Approach

Following a meeting held at the Savannah River Site, Aiken, SC, in April 1996, a group of government, university, and industry representatives agreed to begin building a cooperative short rotation woody crops research effort. Significant land, infrastructure, and in-kind resources have been made available through the Savannah River Natural Resources Management and Research Institute to partially fund the establishment of large-scale experimental short rotation plantations. Committed cooperators seized the opportunity to pool federal, state, and industry resources to collectively and cost effectively resolve some of the issues slowing the development of SRWC systems. A cooperative research program led by the Southern Research Station and including 8 USDA Forest Service Southern Research Station Research Work Units, USDA Forest Service Region 8, USDA Forest Service Savannah River Institute, Department of Energy/Savannah River, Oak Ridge National Laboratory, 5 Universities, and several forest industry companies as members was formalized. The cooperative has a formal dues and management structure.

It was agreed that the program would be centered at the Savannah River Site and would enhance research done off-site by individual companies or institutions by providing a means of leveraging other resources to examine research questions, in a open forum, that are either too large, too sensitive, or cover too long a time horizon for any one entity to pursue. The program will maximize benefits of the on-site research by linking to off-site work through database and model development. These tools will provide a foundation for further, site-specific work to adapt SRWC systems to a user’s unique situation.

The main objectives of the program are to: (1) understand important ecological processes to develop sustainable management practices, and (2) develop the efficient and environmentally-acceptable production technology needed for such management. An integrated, interdisciplinary approach will use experimental and large-scale plantings on the Savannah River Site and at cooperators' installations. Our goal is to establish and communicate the scientific basis for environmentally sound implementation of short-rotation woody crop systems for the southern United States.

Primary Questions

The focus of work on-site will be upland marginal sites. Most of the existing SRWC research sites are located on flat farmland and management systems are being developed for those conditions. As SRWC systems become more widely used in the region, land availability and costs will push these systems onto more upland, marginal sites. There is currently little or no information available for managing these intensive systems on depleted, potentially erodible sites. Work on the Savannah River Site will meet that need.

The initial species of interest are eastern cottonwood (Populus deltoides), sweetgum (Liquidambar styraciflua), sycamore (Platinus occidentalis), and loblolly pine (Pinus taeda). The questions of interest fall into three major areas: (1) basics of production, (2) environmental assessment, and (3) management systems. These are described briefly below.

(1) Basics of Production These questions center on unknowns about the biology and ecophysiology underlying hardwood production under short rotation cropping systems. Efficient delivery and use of light, water and nutrients is a critical factor in maximizing SRWC productivity. Our understanding of soil carbon cycling and dynamics is relatively poor. The availability of soil carbon relative to other nutrients is a key factor in determining both short and long-term productivity, but the mechanisms controlling the relationships are not well-understood. Research will focus on both above- and below ground carbon accretion and allocation patterns relative to soil moisture, nutrient, and carbon dynamics; nutrient and water requirements, use efficiency, and

productive limits of the species; factors governing the nutrient supplying capacity of the soil; and the competitive interactions among the desired and competing vegetation.

(2) Environmental Assessment Questions in this area center on assessing the off-site and on-site impacts of short rotation hardwood cropping systems. Hydrologic information is needed to protect both surface and subsurface water quality and to provide the option of adding supplemental water to the crop. Non-point surface runoff and shallow subsurface drainage from fields must be mitigated. Research would consist of three parts: (1) assessing and quantifying water quality impacts of cultural treatments; (2) field experimentation to develop and test buffer strips to mitigate runoff from SRWC fields; and (3) assessing techniques and technologies to reduce water quality impacts. Existing surface and subsurface hydrologic models could be adapted to the experimental site, and used to design a hydrologic monitoring system and simulate the feasibility of managing surface water for irrigation purposes while maintaining desired water quality. Research is needed to determine what landscape level habitat changes will result from deploying large areas of these intensive cropping systems, and what the habitat values and potential wildlife uses of these areas are. Additional research would focus on assessing the long-term changes in soil productivity through monitoring carbon and nutrient depletion and accretion patterns associated with short rotation cropping systems.

(3) Management Systems Questions in this area focus on using current and evolving knowledge in the above areas and experimentation and testing to develop sustainable production systems. Conventional wood supply management and production systems are not efficient in short rotation hardwood cropping applications. New techniques and technologies must be engineered to produce fiber/biomass competitively and still minimize impacts to the site. Some specific concerns are vegetation control with/without herbicides, cultivation without soil loss, efficient water/fertilizer distribution systems, reduced-cost harvesting, and improved utilization and recovery. Research in this area will focus on determining the impacts and costs of a selected set of site preparation methods and tending options, and on harvest and tending technology development and cost. The objective is to synthesize our understanding of the factors and processes governing productivity, environmental impacts, potential insect and disease problems, and costs to define an appropriate suite of treatments that can constitute sustainable production systems for short rotation hardwood crops.

The underlying premise of the research is that an optimal combination of management inputs exists to balance economic and environmental constraints for a given species (or genotype)/site combination (Fig. 1). The long-term goal of the program is to identify those limits within the context of information needs supplied by the Advisory Committee. Initial research will focus on maximizing productivity of the stands and monitoring environmental effects. Three experiments will be installed initially focused on developing a mass balance for carbon and nutrients in these systems, understanding the genetic component of productivity, and pest impacts and interactions in these systems. Additional work will address sustainability, mechanization technology, and overall economics of the systems.

Research on experimental plantings at the Savannah River Site will be integrated with studies being conducted on existing SRWC research sites. A number of off-site cooperative studies are already underway. These studies are focused on the basics of production, environmental assessment, and developing integrated management systems -- the critical research needs.

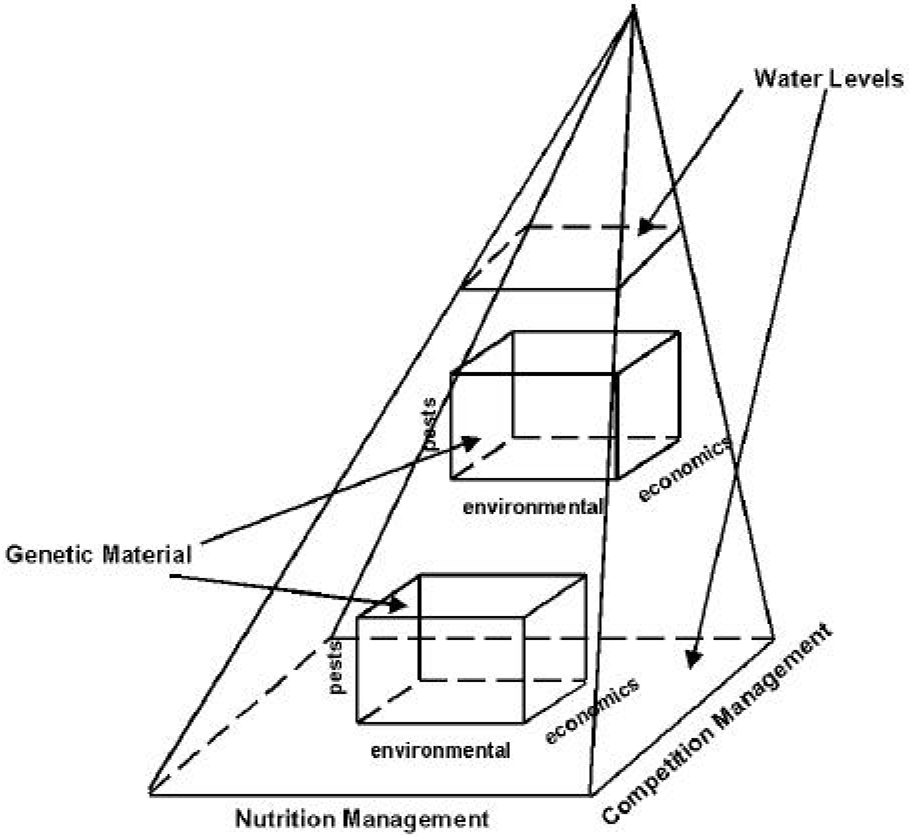

Figure 1. Conceptual model of strategy used to direct the research.

General Strategy

The general strategy of the program is to install, over a number of years, a series of experimental SRWC plantings for testing management alternatives and evaluating any associated off-site impacts. Each planting cycle will be designed based on the current understanding of the “best known” SRWC production technology. The highest priority research will focus on refining the optimal management systems based on minimizing economic inputs while maximizing biological productivity subject to environmental constraints. Additional fundamental, applied, and small-scale research that can be accommodated within the overall experimental design and that enhances the program goals will also be conducted. The program will advance our knowledge of the biological mechanisms controlling highly productive SRWC systems and define new management models for maximizing revenues within acceptable environmental limits. The research program will provide new management information through practical experience, as well as fundamental science from which to generalize the empirical results obtained.

Funding for the program will be through direct and in-kind contributions from collaborating agencies and institutions. Program scientists will collectively seek outside funding sources. Collaboratively financing the program is necessary to address the complex issues associated with

SRWC production systems and to generate the substantial research funding needed for an operational-scale experimentation.

The approach provides for a research cooperative organizational model, including a Manager and Advisory and Technical committees. The work is organized in an operational context through both on- and off-site experiments. Experiments may include applied and fundamental studies. Research proposals can be developed by the member organizations or by external groups. Both proposed research and results will be subject to both internal and external review. Research will be conducted by Forest Service, university, and industry scientists.

Some Expected Product/Outcomes

Some of the products and outcomes expected from the collaborative program are:

- Database of initial conditions, treatment effects, incremental response and costs, and fundamental biophysical information;
- Fully documented source of reference data on SRWC productivity, costs, and environmental impacts for comparison purposes;
- Identify mechanisms controlling highly productive SRWC plantations;
- Sustainable management systems for short rotation hardwood crops developed from synthesizing productivity, cost, environmental assessment, and mechanization systems information; and
- Predictive tools and models to generalize results across sites.

Goals and Functions of the Poplar Council of the United States

Randall J. Rousseau
Research Scientist
Westvaco
Central Forest Research Center
3901 Mayfield Road, Wickliffe, KY 42087
Chairman of the Poplar Council of the United States

Abstract

The Poplar Council of the United States provides a means by which interested individuals and organizations can meet and exchange ideas toward the ultimate goal of increased use of various Populus species and hybrids. The Poplar Council holds biannual meetings in different portions of the country in order to assess progress and address specific problems of that area. The meetings are intended to cover a wide variety of areas from propagation to end use and are aimed at both the researcher as well as the practitioners. Smaller regional meetings are also held on off years and are focused primarily on a specific topic. The Poplar Council of the United States is a chapter of the International Poplar Council.

Goal

The primary goal of the Poplar Council of the United States is to further the knowledge of the genus Populus through genetics, propagule production, physiology, pest resistance and economic aspects of production and end products. The Poplar Council actively promotes the use of various Populus species and hybrids for a wide variety of products, especially in the area of short-rotation woody crops.

General Background

The Poplar Council of the United States is a non-profit organization which has been in existence for over 25 years. The organization's name, "Poplar Council of the United States", was adopted in the mid-1980's, after the original North American Poplar Council split into what is known today as the Poplar Council of Canada and the Poplar Council of the United States. This split was agreed upon at the time because of difficulty in meeting arrangements and the need for each organization to be more in tune with its specific country's promotion of poplars. However, both organizations continue to hold joint meetings whenever possible which provides enrichment and a new flow of ideas among the various members. The Poplar Council of the United States is also a chapter of the International Poplar Council (IPC) and provides a representative to the International meetings to insure a flow of information to and from the parent organization. The 1999 International Poplar Council Meeting will be held in France while the 2000 meeting will be held in Portland, Oregon. These larger meetings provide an excellent opportunity for exchange of ideas and updates on current research on a global scale. The Poplar Council of the United States will help sponsor the meeting in Portland and encourages all of its members to attend.

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Membership

The membership varies in background and expertise, providing a diverse mix of people and talents. The diversity in backgrounds provides a unique setting for exchange of ideas and information. During the mid-80's the membership shifted from primarily US Forest Service researchers and industrial managers whose goals were based on production levels to mainly academic disciplines and endeavors. Current membership includes a number of silviculturalists, geneticists, physiologists, entomologists and pathologists. The Council should actively support biotechnology research on both a regional and national scale since the future lies in this area of research. Today various portions of the country are witnessing a resurgence of interest in poplars due to the great success evident in the Pacific Northwest. Hybrid cottonwood (Populus trichocarpa P. deltoides) plantations established by the James River Corporation along the lower Columbia River were among the first in the Pacific Northwest to realize the potential of poplars. Since that time other companies, including Boise Cascade and Potlatch have expanded on this approach and established extensive fiber farms east of the Cascades. The phenomenal productivity now being realized in the Pacific Northwest is the result of visionaries such as Reinhard Stettler and Paul Heilman and continues today with Toby Bradshaw, George Newcombe, Steve Strauss, Brian Stanton and Tom Hinckley. The success of these plantations has led to an expansion of this same idea to other portions of the country, especially in the southeastern United States. A number of companies including Boise Cascade, Champion International, International Paper, Union Camp and Westvaco have established trial fiber farms in various areas of the southeastern United States.

Meetings

The Biannual national meetings of the Poplar Council of the United States are held in various sections of the United States, with the 1997 meeting sponsored by Westvaco and held in western Kentucky. During this meeting, as with all of the Council meetings, there was both an indoor session and a field trip. The national meetings strive to combine a variety of topics concerning culture, propagation, breeding, biotechnology productivity and harvesting. This diversity of subject matter is to insure the wide-range of interests among the Council’s members are met. Today’s membership includes research scientists from industry and academia, growers who develop and propagate material for sale and managers who are interested in productivity and yields for either pulp and paper or saw timber. The field trips try to encompass the unique situations of that specific area. At the western Kentucky meeting, a fiber farm in Missouri and unprotected alluvial plantations were visited and presentations were given covering a variety of silvicultural and genetic techniques. During the off years, smaller regional meetings are held and focus on a more limited topic such as Septoria resistance in the mid-west.

Purpose of the Organization

The purpose of the Poplar Council of the United States is to further the knowledge of the genus Populus for the increased use of the wide variety of species and hybrids. This increase in knowledge includes both conventional and molecular genetics, propagule development (including techniques in growing, handling and storage), pest resistance, both above and below ground physiological characteristics and economic aspects of growing, production and end products. To accomplish this, the membership from the chairman on down must be willing to invest both time and effort into the various aspects of the Council. The Council should actively promote the use of poplars for a wide variety of products but especially in the area of short-rotation woody crops. The Council should also provide a means by which barriers between scientists, growers and managers can be overcome thereby increasing the use of poplars. Both the national and regional meetings provide a forum for free interchange of ideas, techniques and systems.

The Council relies heavily on its membership to provide areas for meetings and an interchange of ideas allowing a faster progression of knowledge. In the past, meetings were extremely open with the members freely exchanging ideas and experiences. While we fully understand some information among the various companies will be off limits, it is our hope than an attitude of openness will continue into the future so that we may all gain.

Future Goals of the Poplar Council of the United States

The primary future goal of the Poplar Council of the United States will be to support various research aspects in the genus Populus, especially in the area of biotechnology. Additionally, we would like to construct a database of information concerning recommended Populus clones on a regional scale and the availability of these clones through various growers across the nation. This information could be made available through a web site and would be updated on an annual basis.

National and regional meetings will continue with the 1999 national meeting scheduled for the mid-west in August of 1999. The Poplar Council will also continue to support and work with the International Poplar Council and will help sponsor the IPC Meeting in Portland, Oregon in the summer of 2000.

If you are interested in joining the Poplar Council of the United States or receiving a newsletter, please call or e-mail Randy Rousseau at Westvaco, (502) 335-6274, rjrouss@ westvaco.com, or Rick Hall at Iowa State University, (515) 294-1453, rbhall@ iastate.edu.

Woody Biomass Production of Sweetgum and American Sycamore Harvested on Different Cutting Cycles

K. Steinbeck
Warnell School of Forest Resources
University of Georgia, Athens, GA 30602

Abstract

Above-ground, woody biomass production of sweetgum and American sycamore did not differ significantly within species under three different combinations of cutting cycles over a 15-year period. The cutting treatments were: 1) no cutting until age 15 years; 2) cut at ages 4 and 15; and 3) cut at ages 4, 10, and 15 years after outplanting. Coppice growth generally achieved crown closure within one year after cutting by sycamore and during the second growing season by sweetgum. Therefore complete site occupancy was high, probably accounting for the uniformity of yields across cutting treatments. Sweetgum produced significantly more (2.08 tons/acre/yr.) woody biomass than sycamore (1.57 tons/acre/yr).

Key Words: Short-rotation forestry, biomass yields, Platanus occidentalis, Liquidambar styraciflua.

Introduction

At a biomass conference long ago and far away I got into a friendly argument with Dale Hall of King's College in London about yield differences between coppice and high forest systems. Neither of us had solid data to back our positions, but it seemed a worthwhile question. The study reported here was in part an outcome of that conversation. Its objective was to determine how the cumulative yields of several coppicing cycles during 15 years compared to those obtained when the stand was allowed to grow uncut for the same 15-year time span.

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Methods

Bare-root, 1-0 seedlings of sweetgum (*Liquidambar styraciflua)* and American sycamore *(Platanus occidentalis)* were planted in an abandoned agricultural field in the middle coastal plain of Georgia (Tattnall County) in 1978. Soils on the site are in the loamy, silicaceous, thermic family of the Arenic Plinthic and Plinthaquic Paleudults in the Fuquay and Leefield series. Together these two soil series constitute about 17% of the land area of Tattnall County. Their loamy sand A-horizons are underlain at about 20 inches by a sandy loam and sandy clay loam B-horizon. Both soils are very stronly acidic (pH 4.5-5.0) throughout, and are low in inherent fertility and organic matter. Site index for loblolly and slash pine is about 80 feet at age 50 (Anon., 1980). The heavier texture of the B-horizon impedes water percolation which may result in a saturated A-horizon in winter, but also results in good water retention during the growing season.

Seedlings were planted at a 4x8 foot spacing and fertilized with 500 lbs of 10-10-10 per acre in their initial growing season. No other fertilizer was applied for the remaining years. Both chemical and mechanical weed control were attempted in the first growing season. However, ragweed (*Ambrosia artemisiifolia) and Johnsongrass (Sorghum halepense)* and some other weeds invaded portions of the plantation during the summer.

The experimental design was a randomized, incomplete block with 8 plots for each species. Plots were 160 feet wide and about 200 feet long (0.75 acres). Four plots were subdivided into 3 subplots to which the following harvesting regimes were assigned: 1) Allow to grow for 15 years; 2) Cut at ages 4 and 15 years; and 3) Cut at ages 4, 10, and 15 years. Each of the remaining 4 plots were divided into only 2 subplots which received the coppicing treatments.

All harvesting was done in winter and the oven-dry, above-ground, woody biomass (boles, branches, bark, and buds) determined. For the harvest at age 4, all trees except for border rows were harvested and weighed. For the two later harvests, regression equations predicting dry weight from dbh were developed. For each species, more than 100 trees representing all diameter classes were felled, their branches cut from the stems, dried to constant weight at 70° C, and weighed. Diamters of trees in two random rows of each subplot to be cut were measured and used to estimate woody biomass production. Cut trees were left to decompose where they fell with the exception of those used to develop the biomass equations.

Results and Discussion

Sweetgum produced significantly (P>.01) more woody biomass than sycamore (Table 1). Growth patterns of the species also differed distinctly. Sweetgum grew slowly during the first 4 years, producing only 0.6 tons/acre/year vs. sycamore's 2.6 tons, a four-fold difference. After this initial lag, however, sweetgum grew faster than sycamore in all tharvesting treatments.

Regardless of whether the stands were allowed to grow undisturbed or were cut during the 15-year duration of this experiment, total above-ground woody biomass production did not vary significantly within species. Crown closure was generally achieved within one year after cutting in sycamore plots and during the second growing season for sweetgum. Therefore the duration of complete site occupancy was high even in the plots which were harvested frequently. This probably accounts for the uniformity of yields across treatments.

Table 1. Above-Ground Woody Biomass Production of Sweetgum and Sycamore Grown Under Differing Harvest Regimes.

Species/ Harvest Regime	Plantation Age 4 Years	10 Years	15 Years	Total
	Tons / acre			
Sweetgum[1]				
One harvest	-	-	35.27	35.27
Two harvests	2.71	-	26.43	29.14
Three harvests	2.71	12.95	13.20	28.86
Avg. / acre / yr.				2.07
Sycamore[2]				
One harvest	-	-	24.51	24.51
Two harvests	10.32	-	11.33	21.65
Three harvests	10.32	9.75	4.46	24.53
Avg. / acre / yr.				1.57

[1] Sweetgum Biomass Dry Weight (g) = 0.129 dbh $^{2.186}$ (mm)
[2] Sycamore Biomass Dry Weight (g) = 0.097 dbh $^{2.465}$ (mm)

This uniformity of yields under various rotation options should not be interpreted to mean that higher yields cannot be obtained with coppice management than with high forest methods in general. All trees in this experiment were planted at the same time and grew for the same length of time. If a treatment had been included in which new seedlings had to be planted every 5 years, cumulative above-ground yields for 15 years would have been lower due to the need to grow an adequate root system after each new planting. This would have been especially true for sweetgum with its slow initial growth. Furthermore, after the trees in the trees in the one-cut treatment at age 15 were finally harvested, their stumps produced fewer and slower growing sprouts.

On this upland site, woody biomass production over the 15-year period averaged 2.08 and 1.57 oven-dry tons/acre/year for sweetgum and sycamore, respectively. Wittwer et al. (1978) reported that sycamore produced about 2 tons/A/yr for 5 years on an unfertilized bottomland site in western Kentucky. Superior cottonwood clones averaged as much as 3 tons for 5 years in the north central states (Hansen, 1992). These higher yields elsewhere indicate that upland sites in the coastal plain will require fertilization for adequate hardwood growth. To wit, after this experiment was completed, these same plots were fertilized heavily and irrigated (fertigated) and then produced about 5 dry tons/A/yr. Interestingly, intensively managed sycamore grew faster than sweetgum, a reversal of the pattern reported here.

Conclusions

When hardwoods are grown at spacings which allow rapid crown closure, total above-ground wood biomass yields for a given, relatively short time (15 years) do not seem to be affected by differing harvesting regimes. This finding allows flexibility in timing harvests; trees can be stored on the stump and harvested at critical times like during wet weather emergencies. But very short (<2 years) cutting cycles will lead to reductions in root mass (Steinbeck and Nwoboshi, 1980). Furthermore, the smaller trees grown on short rotations will contain higher percentages of bark and twigs which will decrease fiber yields and increase nutrient removals.

A final caution: This study was conducted on only one site and its results may not be applicable to other sites.

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Hybrid Poplar Efforts in the Pacific Northwest

Jeff Nuss
GreenWood Resources, Inc.

Dick Moulton
Information Resources Northwest
and Columbia-Pacific Resource Conservation & Development
Montesano, WA

Abstract

Since the late 1980s to early 1990s, hybrid poplar trees have been a topic of much interest in the Pacific Northwest as apparent in the small sample of article headlines found in the Capital Press (a leading Northwest agricultural and forestry newspaper) and other regional news sources over the past few years.

“Interest in Cottonwoods grows”
“Poplars could be alternative”
“Most profitable poplar option”
“Grays Harbor embraces poplar as crop”
“Poplars increasingly popular as Northwest crop”
“Giving poplar a second look”
“Hybrid poplars: fiber for the future”
“Foresters eye cottonwood for marketplace potential”
“Billion-dollar potential? Hybrid poplar crop status is growing in the Northwest”
“Popular poplars: Oregon acreage growing as fast as trees”
“Markets available for poplar if enough trees can be grown”
“Can fast-growing trees help Harbor grow?”

This paper provides a brief summary of previous and current efforts related to hybrid poplar tree developments within the Pacific Northwest and concludes with a brief discussion on the future needs required for continued development of this industry in Pacific Northwest.

Previous and Current Efforts

From literally no commercial acreage a couple of decades ago, the Pacific Northwest has now more than 64,000 acres of hybrid poplar trees being developed. The majority of the acreage established in the Pacific Northwest has been primarily the result of four timber companies and their commitment to large scale hybrid poplar tree plantations. These four timber companies (Potlatch, Boise Cascade, Fort James (formerly James River), and MacMillan Bloedel) make up over 90% of the current commercial acreage planted in the Pacific Northwest. In addition to developing large scale plantations, Fort James and Georgia Pacific have had land-owners assistance programs to help get farmers to start growing hybrid poplars as a crop. The majority of these developments were focused on supply of chips for the pulp and paper market.

In addition to efforts made by timber companies, a number of public and private entities have been involved through the years working on ways to increase the development of hybrid

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poplar tree plantations in the Pacific Northwest. Various state universities (i.e. University of Washington, Washington State University, and Oregon State University) have had a long standing history in research and development activities associated with hybrid poplars in the Pacific Northwest. Some of the more notable publications resulting from these activities are:

> High Yield Hybrid Poplar Plantations in the Pacific Northwest, PNW356, produced by the University of Washington and Washington State University,
>
> Poplar Chip Production for Willamette Valley Grass Seed Sites, Research Contribution 11, by Oregon State University, and
>
> Product and Market Opportunities for Hybrid Poplar Wood in Oregon, Educational Material (EM) 8667, by Oregon State University Extension Service.

In addition to key publications, two hybrid poplar research cooperatives have been formed in the Pacific Northwest: Tree Genetic Engineering Research Cooperative (TGERC) at the Department of Forest Science at Oregon State University and Plant Molecular Genetics Cooperative (PGMC) at University of Washington.

Outside the university setting, a number of other entities have taken on hybrid poplar trees as a means to encourage economic development within a region. Columbia Pacific RC&D located in Aberdeen, Washington has been a committed agency to hybrid poplar tree developments going back to early 1993 with the completion of a business plan for a hybrid poplar tree growers cooperative within southwest Washington. This effort lead to formation of a limited liability company called Northwest Poplars, LLC which pursued investments into development of a 1,000 acre plantation. Columbia-Pacific RC& D also has worked on and came close to securing financial commitments for a chip-board plant located in Grays Harbor. However, it is believed the company decided to pull back due to the lack of significant acreage (10,000 acres) developed within the county. Currently, approximately 700 acres of poplar trees have been planted within Grays Harbor and the surrounding areas. Columbia-Pacific RC&D continues to build on developing a hybrid poplar tree industry within SW Washington and is currently working with a group (GreenWood Resources, Inc., Business Solutions, and Institute for Washington’s Future) to develop a strategic development plan for investment opportunities into a short-rotational tree plantation industry in Washington. The goal of this development plan is to secure funding to begin development of over 10,000 acres of tree plantations as well as address the product and market opportunities for higher valued uses (i.e. laminated strand lumber and oriented strand board, plywood, veneer, and solid-wood such as molding, windows, and doors) through existing or new specialty mills. This plan is being requested by Enterprise Washington, an economic development group headed by former Governor Mike Lowry. The primary focus of Enterprise Washington is to expanded the state’s economy into less prosperous rural and urban areas while preserving quality of life. It is the hope that this type of industry could result in a sustainable economic model for rural communities.

In eastern Oregon, a number 1-acre test plots have been established and monitored through a project funded by Oregon Economic Development Department (OEDD). The focus of these test plots is to explore growing strategies for higher end markets. This project is on-going, however based on the current results from the test plots a number of growers are expanding their acres into hybrid poplar trees. In addition, Battelle, in cooperation with South Yakima Conservation District and Washington Department of Ecology, is developing a computerized economic model to enable farmers to evaluate the costs and returns associated with traditional crops versus hybrid poplars.

As seen in the examples above, the focus of interest in developing hybrid poplar plantations, outside most of the large timber companies, is the potential of higher end markets for the trees produced. No example is more apparent of alternative uses for hybrid poplar then the new office build out of poplar products by the owners of Broadacres Nursery, Inc. This office is located in the Willamette Valley near Hubbard, Oregon and has been a great showcase of the many uses for poplar products.

The example of the potential higher value markets, via this office and current research activities, has expanded the interest of many parties throughout the Pacific Northwest. In order to assist in the communication and education required in the development and management of hybrid poplar tree plantations, a growers association has been formed. In addition, GreenWood Resources, Inc., a management company, is developing partnerships and/or limited liability companies for private and institutional investors interested in investment opportunities into short-rotational tree plantations.

The application of hybrid poplars to solve environmental problems has also seen an increase in the Pacific Northwest over the last few years. Much of these applications have been demonstrating the application of municipal, agricultural, and/or industrial effluent and biosolids to hybrid poplar tree plantations to beneficially reuse the water and nutrients. One example of this type of system moving into a full scale operation is the City of Woodburn's Development No. 1 which is the design and construction of 80 acres of a future 350 acre poplar tree reuse plantation. With the advent of stricter regulations associated with watershed water quality, it is believed a number of poplar tree systems ranging from riparian buffers to effluent and biosolids reuse will continue to grow throughout the Pacific Northwest.

One additional environmental driven opportunity currently developing is the carbon sequestration value of these hybrid poplar tree plantations. This development has implications of a global market and a number of parties have been meeting to discuss the future of this opportunity. As part of these meetings, a Pacific Northwest Carbon Sequestration Coalition has been formed with the goal to develop voluntary carbon offset programs which achieve global carbon dioxide reduction through market based proposed changes in vegetation management.

Conclusions

As seen from the vast efforts throughout the Pacific Northwest, hybrid poplar trees continue to attract the attention of many diverse interests. Although such a diverse interest complications the focus of specific future needs, an effort focusing on a common desire of building sound economic opportunities in an environmentally and sustainable approach should be at the core of the efforts. Working off of this foundation, a number of common desires and needs can be identified. Below is a list of some of these thoughts and should not be considered a complete list:

- Expand on the physical and mechanical properties of hybrid poplar.
- Continue to build on the awareness of alternative product use of poplar and work to develop key specialty markets for this wood in order to maximize the potential revenue sources.
- Continue to refine development management techniques (i.e. integrated pest management, weed control, planting densities, commercial thinning strategies, new clones, pruning activities, harvest approaches, post harvesting strategies, etc.) that result in overall cost reductions or development of more desirable products from the plantation.
- Explore ways of developing hybrid poplar tree systems that solve environmental problems and produce a return on investment

- Continue to build and expand on effective means of communicating the most recent developments in growing hybrid poplar trees to the widest audience possible (i.e. timber companies, product buyers, farmers, investment community, etc.).
- Build on the development of short-rotational tree plantations through private and institutional investors as well as continued commitments from the farming community.

Fiber, Energy and Carbon Sequestration in a Competitive Environment

William J. Nicholson
Potlatch Corporation
San Francisco, CA
(Chair, AF&PA Agenda 2020 Committee on Energy Performance)

Abstract

The commercial world looks at trees grown in either an agricultural or a forest environment as a source of solid wood products, fiber for pulp and paper, fuel, a source of chemicals, and an opportunity for carbon sequestration. One use for the fuel is the generation of electricity, a product to be marketed in an increasingly deregulated environment. The factors to be considered in evaluating whether fuel or electric power is an important market for biomass in the form of trees will be reviewed and suggestions on the effects of market competition in the relevant sectors will be discussed.

Raw Materials and Potential Markets

Most commercial wood products are derived from the wood (xylem) in the stem of the tree. Other components – including bark, branches, leaves and roots – can also be put to various uses.

Existing and potential markets can be categorized as construction materials (solid sawn lumber, moldings, engineered lumber, plywood, particleboard, Oriented Strand Board (OSB) and other composites), pulp and paper (unbleached and bleached), energy, chemicals, ground cover, animal bedding, mulch, and compost. Carbon sequestration may also be viewed as a potential product of growing and utilizing trees, as long as the carbon is not converted back to CO2 and released to the atmosphere.

The energy markets include firewood, solid or hogged fuel for generating heat, gaseous fuel, ethyl alcohol, and electricity. Electrical power is an energy market closely associated with the forest products industry.

History of Electric Power Generation and Marketing in the Forest Products Industry

Components of any electric power system include the fuel supply network, the power generation facility or facilities, high-voltage transmission lines, lower-voltage distribution networks, and the end-users.

During the early 1900s, the forest products industry often generated electric power at sawmills by using the large volume of unmarketable residues from the milling process. The generators supplied the needs of the mills themselves, and also of the towns in which they were located. Utility companies, with larger, more efficient and therefore cheaper generating stations, began displacing the forest industry power supplies to local communities in the early 1920s. From the 1930s to the early 1970s, the industry focused on self generation and supply.

Beginning in the late 1970s, a series of regulatory developments changed the relationship between power the forest products industry. In 1977, the Public Utility Regulatory Policies Act required utilities to purchase power from small producers, known as “qualifying facilities.” As a result numerous new electric generation facilities were built by forest products firms and independent energy service firms, between 1978 and 1992. During this period, each qualifying facility sold power at wholesale rates to the utility serving the area in which the facility was physically located.

In 1992, the Energy Policy Act allowed wholesale trading of power by all producers of users. This was followed, in 1996, by Federal Energy Regulatory Commission Orders 888 and 889, which required that utilities provide open access to transmission lines for power being traded under the Energy Policy Act. These effectively opened much larger geographic markets to small power producers.

Some states began deregulating electric utilities – effectively requiring them to compete on the open market – in 1997. Turmoil and uncertainties associated with the process led to general discussions in 1998 to reestablish regulations, but in the long-term, more deregulation is expected, including possible Federal deregulation as early as 2000.

As a result of deregulation, the forest products industry may once again supply energy to outside users. But the amount of new generation will depend on new technologies to reduce the costs of generation, how much more the public is willing to pay for “environmentally preferable power,” and if incentives are created for reducing carbon emissions.

Power Generation Technologies

Technologies used by the forest products industry to generate electric power have improved substantially. Low-efficiency wood-fired, low-pressure steam condensing turbines installed at sawmills during the early 1900s were replaced by moderate-pressure steam cogeneration units from the 1930s to 1960s. At the same time, pulp mills utilizing black liquor in recovery furnaces began to power similar cogeneration facilities. From the 1970s into the 1990s, improved technology has increased the pressure and therefore efficiency at which wood- and liquor-fired steam cogeneration and condensing generation units operate. Many plants, especially pulp mills, installed natural gas fired turbines with heat recovery or combined cycle (gas turbine + steam turbine) generation.

At present, gasification of wood or liquor with combined cycle power generation appears to be a developing efficient technology, but it is yet to be demonstrated at full scale. Also, problems with cleaning the hot gas from the gasifier before it is burned in the gas turbine need to be resolved.

The Market for Environmentally Preferable Power

Consumers may be willing to pay a premium for power from the forest products industry, if they consider it to be environmentally friendly. “Environmentally Preferable Power” is a term that may be applied to the mix of power from a specific supplier. A group of marketers make up the rules as to what qualifies as “Environmentally Preferable Power”, but in general the supplier must meet an environmental fuel specification, such as “Green E.” Suppliers with high proportions of biomass, solar, wind, geothermal, and perhaps small hydroelectric are viewed favorably; those with high proportions of fossil fuel, nuclear, and large hydroelectric are not. An environmental profile – analogous to a nutrition label on a food package – is created for each supplier, showing the resources used and a few indicators of environmental impact. Individuals can choose to purchase power from any supplier.

Nobody knows how much “Environmentally Preferable Power” is worth on the open market. And the value is likely to depend on several factors including who is buying, where they are located, how much power they are purchasing, the costs of alternative sources of power, and how the value is determined.

Incentives for Biomass Power

At present, federal law provides an incentive of $0.015/kwh for “Closed Cycle Biomass” power. No money has yet been appropriated or used for such power because of the narrow definition of “Closed Cycle Biomass;” only crops produced specifically for fuel are eligible; residues from existing operations, such as thinnings from natural stands or wood/fiber plantations, are not.

The issue of global climate change and carbon sequestration may have an impact on the feasibility of biomass power. There are two kinds of carbon: geologic and biologic/carbon cycle. Large quantities of the earth’s carbon is geologic, in the form of carbonate sedimentary rocks such as limestone or in fossil fuel deposits. (This carbon was once in the biologic/carbon cycle pool, but is now effectively locked up.) Biologic/carbon cycle carbon includes that in the atmosphere, and in the elements of the biosphere that store carbon: living organisms such as trees; organic matter within soils; forest products such as the wood in homes and other buildings; organic matter in landfills, etc.

The parties involved in the Kyoto Treaty agreed on a goal of reducing carbon dioxide emissions into the atmosphere. One way to do that is to sequester carbon in forests, via aforestation, reforestation, and prevention of deforestation. The “Kyoto Forest,” however, appears to be rather narrowly defined, representing about one percent of the present forest. Only new forests planted since 1990 on historically non-forested land may count. Existing forests are excluded. The Kyoto Treaty therefore has major disadvantages to the United States.

Energy Service Providers and the Forest Products Industry

Power generation is not a core business for the forest industry, so Energy Service Providers – who specialize in aspects of the energy industry – are marketing themselves as efficient partners. They may offer to do any of the following:

- Supply a fuel
- Supply a package of fuel and electricity
- Supply fuel, electricity, and steam
- Own and operate solid fuel boilers and steam turbines
- Own and operate the power and recovery island in a kraft pulp mill

While these suppliers may have more expertise in the power business, they have their own drawbacks that should be considered. For example, will the Energy Service Provider treat a shutdown problem with the same urgency that in-house employees would? Will long-term contracts between the Provider and forest industry company put unwanted constraints on the company's ability to respond to changes in energy markets?

The future of energy production for the forest industry promises to be interesting.

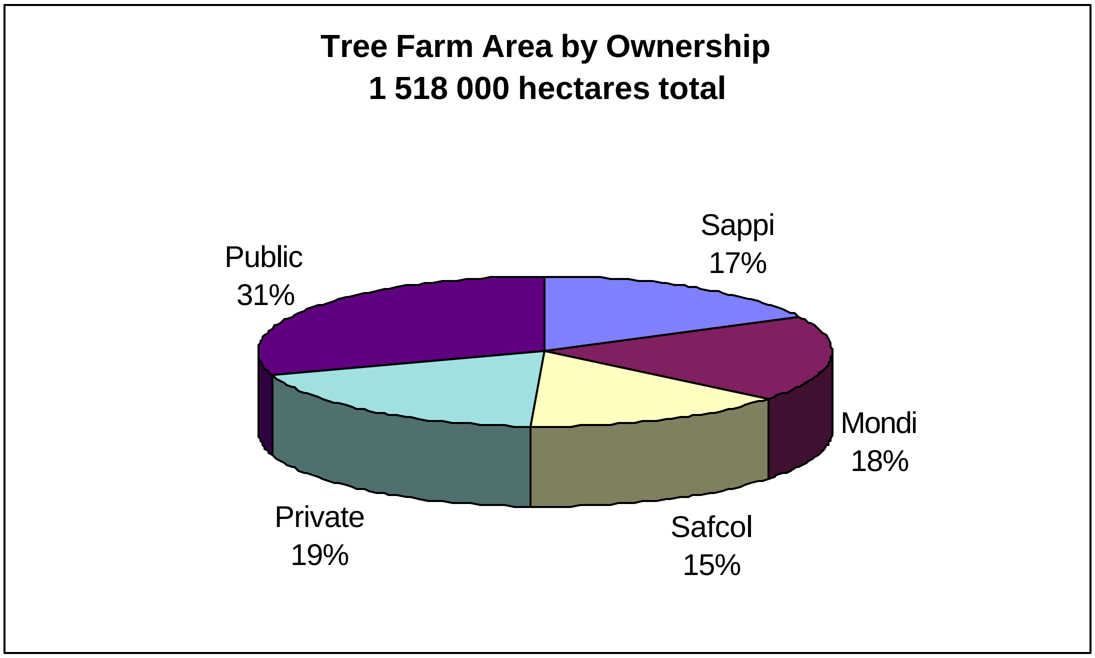
Short Rotation Forestry in South Africa: An Overview

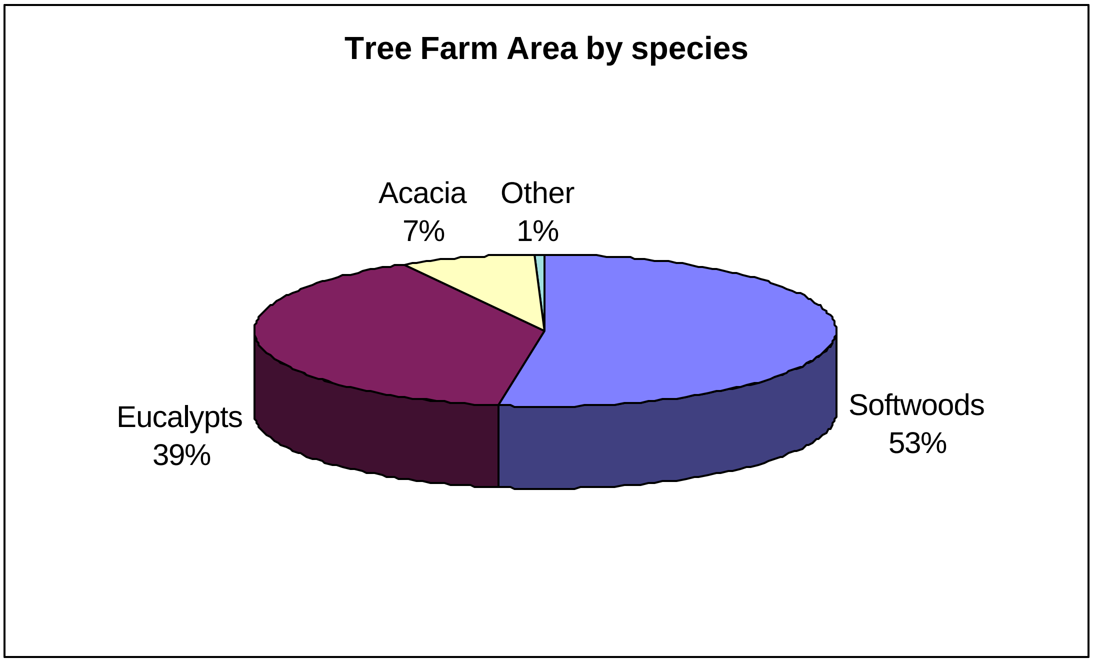
Andries Louis Terblanche
Sappi Forests, P.O. Box 1264, Vryheid, 3100, South Africa
Tel +27 (0)381 811059

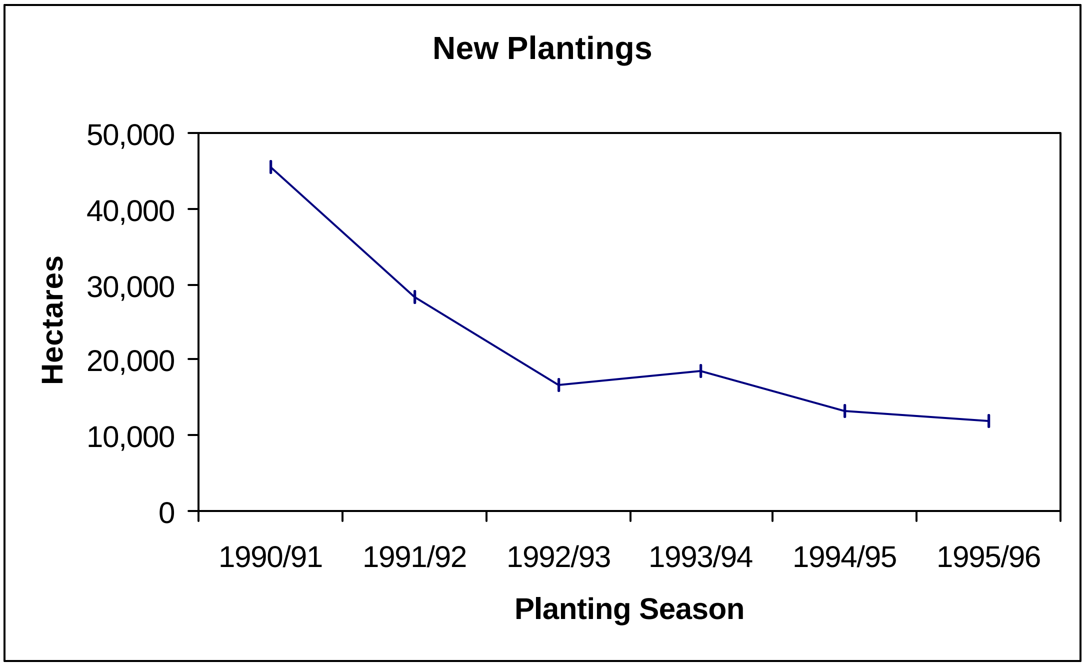
Abstract

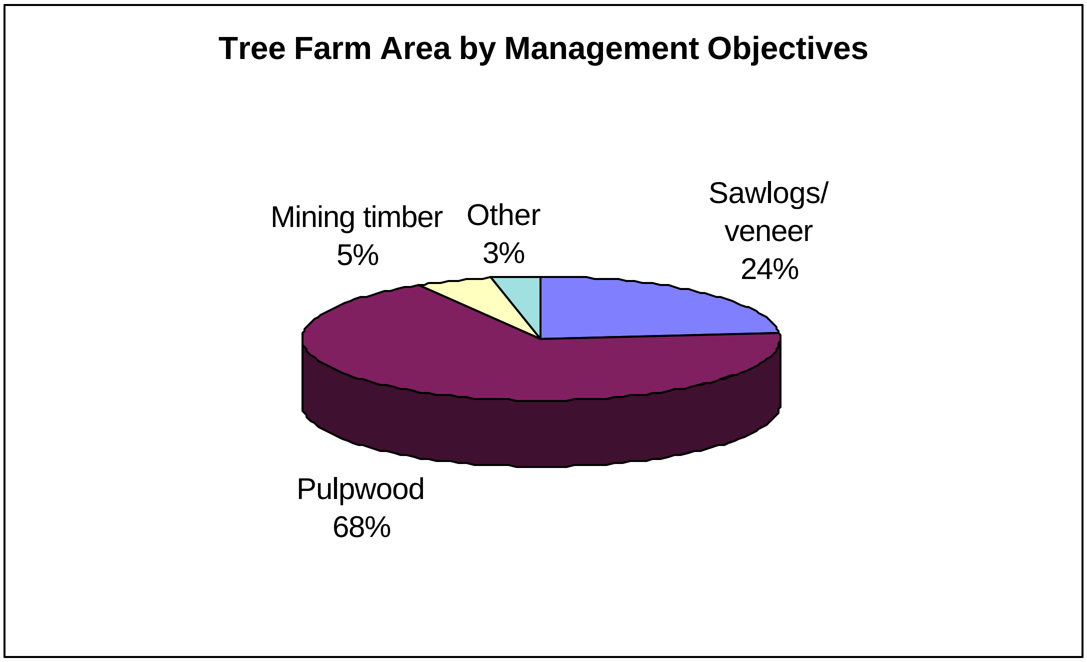
This paper presents a short overview on South African forestry. Plantation area in South Africa totals 1.5 million hectares representing 1.2 percent of the land area. All afforestation activities require a planting permit issued by the department of Water Affairs and Forestry. Containerized exotic seedlings are being planted on fiber farms. The principal tree species planted are pines, gum species, acacia species and to a lesser extent poplar. Rotation age ranges from 45 years for sawtimber to 6 years for gum pulp. Silvicultural activities are mostly manual operations with mechanization confined to soil preparation. Harvesting and extraction is a combination of manual and mechanical operations. Road and rail transport is practiced. Timber is being used for pulp production, construction material, mining timber, poles, fire wood, charcoal, chemical extractions and other smaller uses. Timber and timber products are sold on both the local and international markets.

South African tree farming scenario




Tree Farm Area by species
Acacia 7%
Other 1%
Eucalypts 39%
Softwoods 53%

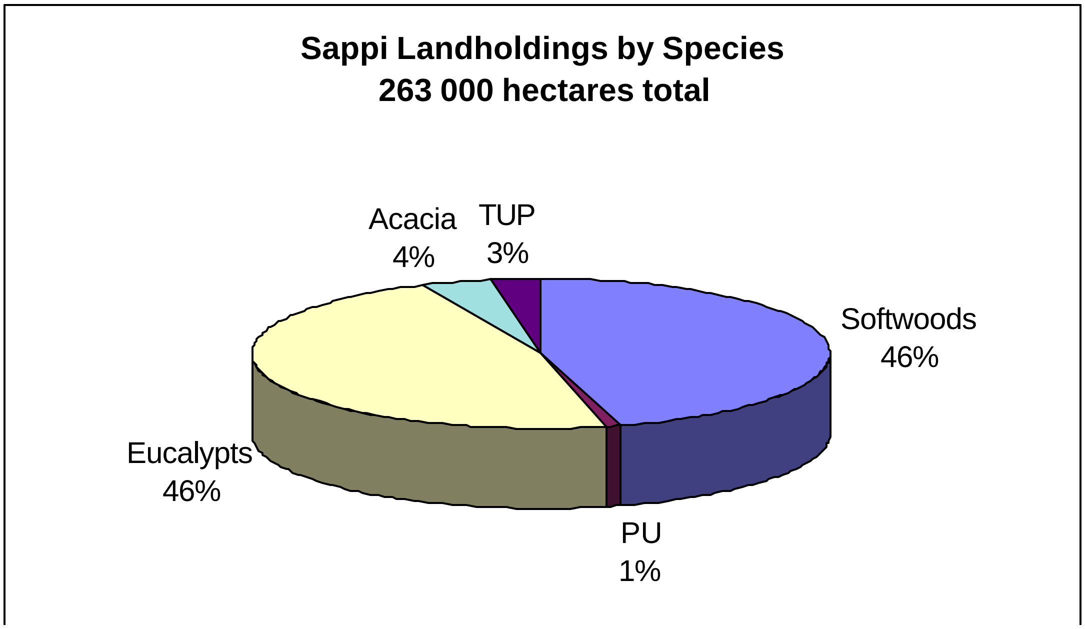

New Plantings
Hectares
50,000
40,000
30,000
20,000
10,000
0
1990/91
1991/92
1992/93
1993/94
1994/95
1995/96
Planting Season



Timber demand in South Africa, thousand cubic meters

PRODUCTION UNIT	**SOFTWOODS**	**HARDWOODS**
KRAFT	2640	0
FINE PAPERS	0	322
SAWLOGS	425	0
MINING TIMBER	0	294
POLES	0	35
SAICCOR	0	2520
OTHER	58	112
TOTAL	**3123**	**3283**

Sappi Forests



Tree farming scenario

* Permit application
* Soil surveys
* Land use planning
* Soil preparation
* Planting
* Watering
* Fertilization
* Weeding
* Harvesting
* Transport

Operations

* Four craft mills - wood based and waste paper based
* Two fine paper mills - wood based and bagasse based
* One dissolving pulp mill
* Three sawmills
* Three mining timber mills

* Own timber farming operations to be contracted out in 1999

Outgrow schemes

* MAP - Management Associated Programme
* SWP - Softwood Partnership
* Gumgrow - Eucalypts scheme
* SSS - Sappi Seedling Scheme
  Total of 50 000 ha with 184 growers
* PRP - Personal Relations Programme
  Total of 15 000 ha
* Grow - Peasant farmers
  Total of 8 000 ha with 9 000 growers

Project investment

* Capital investment of R 50 million or $ 8 million
* Investment serves as loans to farmers

Mr. Terblanche presented a large number of slides to illustrate the various types of operations on the different forest ownerships in South Africa.

The Effect of Transplant Grade and Soil Deterioration on Survival and Root Development of *Pinus patula* Transplants

Andries Louis Terblanche
Sappi Forests, P.O. Box 1264, Vryheid, 3100, South Africa
(work conducted while at University of Stellenbosch, South Africa)
Karen Chiswell
Mondi Forests, 179 Loop Street, Pietermaritzburg, 3201, South Africa

Abstract

Three different grades of containerised *P. patula* seedlings and one cutting grade were planted in pots and grown under a controlled environment for 60 days. Grades were allocated to transplants with different collar diameter and shoot length. Survival, root development and shoot growth of transplants were monitored. The effects of soil type and transplant dimension on survival and root growth were investigated. Transplant height, diameter increment, root development, survival and a quantitative scoring system were used to determine the ideal transplant grade as well as the effect of soil deterioration on transplant development. After 60 days, the small transplants (initial mean shoot length 67.3 mm and collar diameter 1.80-mm) had the best height increment ($p<0.001$) and second best diameter (non-significant) increment. Cuttings had the best diameter increment and second best increase in height. The cutting scored highest in the quantitative scoring ($p< 0.1$) with medium transplants (shoot length 21.2 cm and collar diameter of 3.5 mm) scoring second best. Large transplants (shoot length 40.4 cm collar diameter 4.2 mm) scored lowest. The smallest transplants could not be properly evaluated quantitatively because the root plug broke up during washing. Mortality associated with old lands did not occur in this trial.

Introduction

Grading of transplants is not a routine procedure in South African forestry because very little literature is published on this topic (Bayley, 1995). Foresters, however, generally agree those smaller seedlings, although not defined how small, should be planted for their better survival and growth.

Both stem diameter and shoot height is affected by nursery practices, for example, growing density, transplanting, top pruning, and root pruning. Stem diameter reflects the response of seedlings to the environment (survival) while shoot height is a good predictor of tree growth. Although these parameters indicate seedling performance potential, they do not reflect seedling vitality or vigour (Mexal and Landis, 1990). These parameters are also affected by time of sowing and other practices such as time of undercutting, fertilisation and nursery climate (Menzies *et al.*, 1986). Other morphological measurements such as transplant mass, number of first order lateral roots and presence of fascicle bundles can also be used to predict transplant performance and survival (Donald, 1992).

Small plants, because of their better shoot/root balance, will perform well under favourable site and climatic conditions. Difficult site combinations require larger, hardened plants, but the correct balance is difficult to achieve (Donald *et al.*, 1994). Reports of McGilvray and Barnett (1982, ex Romero *et al.*, 1986) revealed that containerised transplants with a higher

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Proceedings of the Second Conference of the Short-Rotation Woody Crops Operations Working Group, 25-27 August 1998, Vancouver, Washington, USA

shoot/root ratio performed better than those with lower ratios. Growth of *P. taeda* transplants was negatively correlated with low shoot/root ratios at time of planting.

With fast growing species in South Africa, it is difficult to keep the height/diameter ratio below 60:1 and topping may be required to procure it. Pine seedlings can be topped without having negative effect on subsequent growth however, topping has to begin early and must be repeated frequently to avoid a depleted leaf area. Topping can improve survival under harsh conditions although many foresters prefer untopped transplants as they believe that these grow faster. Where transplants cannot be planted on time, topping may be essential but care must be taken not to reduce the leaf area too drastically (Donald *et al*., 1994).

Hinze (1994) prescribes a nursery plant not older than one growing season since the roots may become distorted. If older than the prescribed age, root pruning is an option to minimise the problem. Dimensions of pine transplants no longer than 300mm height and a diameter of 3-5 mm are prescribed. Wessels (1987) also prescribes transplants not taller than 300mm. Hodgson (1979) visited several Transvaal open rooted nurseries during the growing season to determine the ideal *P. patula* seedling. Satisfactory seedlings ranged from ages 3 to 17 months, with stem lengths from 9cm to 26cm. The prescribed diameter should not exceed 3mm and should not be less than 1mm. SAFCOL's current pine transplant specifications are a height of 8-15cm and a collar diameter of >3mm (SAFCOL Forests timber growing policy Mpumalanga north, date unknown).

Lopushinsky and Beebe (1976) have shown that visual root quality is a stronger performance-predicting tool than quantitative measurements. In work with *P. ponderosa* transplants, Lopushinsky and Beebe (1976) found that survival of large rooted transplants increases by approximately 10% to 24%, compared to small rooted transplants. Kormanik (1987) found a strong correlation between number of permanent first order lateral roots with seedling size and performance. Hardwood seedlings with inferior lateral root development performed poorly.

Larger root systems will positively affect the rate of transpiration and gas exchange. Small-rooted seedlings are under water stress which cannot balance the transpiration losses from the needles. This might result in a reduction of photosynthate production which will limit root growth. High root volume has been shown to improve growth after planting (Rose *et al*., 1990). A large root area does not seem to compensate for root deformities (Håkansson and Lindström, 1995).

Materials and methods

Soil were collected from old agricultural lands and virgin grassveld in the plantations managed by Mondi forests in the North Eastern Cape. Both soils were of the Oakleaf Form and collection took place in the top 15 cm of the profile because planting and initial root growth takes place only in the topsoil layer. Half of both soils were sterilised to monitor the effect of pathogens on transplant survival and growth.

Three different grades of *P. patula* seedlings and one *P. patula* cutting were used. The grades were expressed as a mean collar diameter and height. Table 1 lists the grades of planting material used. It was decided to use dimension as grade rather than age since dimension is a function of the variable nursery regime and the season during which the transplant is raised. Transplants of the same age can therefore have different dimensions. All transplants were raised in a composted pine bark medium in Unigro 128 containers. Cuttings were propagated in Unigro 98 containers filled with a pine bark/vermiculite mix as growing medium.

Table 1. Grades of *P. patula* seedlings and cutting material used.

Growing material	Grade	Age	Mean Diameter (mm)	Mean Height (cm)
Seedling	Small	4 months	1.797	6.725
Seedling	Medium	7 months	3.487	21.200
Seedling	Large	12 months	4.201	40.401
Cutting	Cutting	12 months	4.371	25.812

Soil (old land/virgin), soil sterility (sterile/not sterile), and transplant grade (small, medium, large transplants and cuttings) were the three treatment factors investigated in this trial. The combination of these factors gave 16 treatment combinations as shown in Table 2.

Table 2. Treatment combinations used.

Soil type	Soil treatment	Transplant grade and cutting			
		Small	Medium	Large	Cutting
Virgin land	Sterile	X	X	X	X
	Non-sterile	X	X	X	X
Old land	Sterile	X	X	X	X
	Non-sterile	X	X	X	X

Plastic pots were each filled with 1130 g of the collected soil. A total of 80 pots were used, giving 5 replications of the 16 treatments. Transplants and cuttings were planted within one hour and watered with sterilised water to field capacity. All pots were fertilised with MAP to ensure a P status of 15 ppm. in order to optimise root development (Saayman, pers. Comm., 1995). Pots were placed randomly in growth cabinets (Conviron E15), set at 28 degrees C/16 degrees C, 16/8 hours day/night and 65 % humidity. When soil moisture dropped to 30 % of field capacity they were watered to 90 % of field capacity.

Occurrences such as fungal infestations and weed growth were recorded. Shoot measuring tree collar diameter and height at the beginning and end of the trial period monitored growth. Shoots were dried and weighed after 60 days. Roots were soaked and new root growth separated from the growing medium. Root growth potential was determined by cutting of the new root growth, drying and weighing it after a quantitative evaluation of the roots was carried out. Four persons served as evaluators to establish an unbiased quantitative rating. Quantitative root growth potentials could be established from the outcome of the four different scores averaged over the four observers (D. Saville, pers. Comm., 1997).

The first scoring criterion used was to divide the root plug into three even horizontal levels. Roots protruding from the plug was recorded to allocate a score. If root growth only took place in one level, a score of one was given with three as full marks. The second criterion used was the number of roots growing from the plug. The higher the count the better the score. Thirdly, the number of sides from which roots protruded was counted, with four as full marks. Lastly, the root concentration was determined. A possibility of three scores could be given. If 50% or more of the root growth took place from the bottom of the plug a score of one was given. This is also known as "onioning" (A.E. Bailey, pers. comm., 1995). If 50 % of the root growth took place from the bottom of the plug, and 50% from the sides a score of two was given. If root growth took place evenly from all the sides and less than 10 % from the bottom of the plug, full marks (three) was given.

A three-way analysis of variance was carried out with final shoot diameter, shoot diameter increment, final shoot height, shoot height increment, root mass, shoot mass, number of weeds and the quantitative scores as response variables. The significance of the main effects of soil (source), sterilisation and transplant grade on the response variables was tested, as well as the interactions soil x sterilisation, soil x grade, sterilisation x grade, and soil x sterilisation x grade. It was decided, for each of the three quantitative criterions, to use the average of the four observers' scores (D. Saville, pers. Comm., 1997). This was despite significant evidence of differences between the four observers, and weaker evidence of interaction between the observers and some of the treatment factors (i.e., observers sometimes ranked treatments differently).

Results

Table 3. Diameter (mm) and Height (cm) increment (means).

Soil type	**Soil treatment**	**Transplant grade**							
		Small		Medium		Large		Cutting	
		Diam	Ht	Diam	Ht	Diam	Ht	Diam	Ht
Virgin land	Sterile	0.752	10.80	0.900	6.90	0.928	5.90	0.902	9.40
	Non-sterile	0.708	8.30	0.358	7.40	0.458	7.60	0.928	6.70
Old land	Sterile	0.642	11.00	0.532	6.90	0.836	6.70	0.404	8.60
	Non-sterile	0.662	9.60	0.188	6.40	0.182	5.80	0.752	7.40

Table 4. Quantitative scoring (means).

Soil type	**Soil treatment**	**Transplant grade**							
		Small		Medium		Large		Cutting	
		H*	R**	H	R	H	R	H	R
Virgin land	Sterile	2.100	12.95	2.000	19.10	2.100	18.80	2.700	33.85
	Non-sterile	1.900	14.75	2.350	27.10	2.250	20.15	2.650	49.45
Old land	Sterile	2.200	16.60	2.150	12.65	1.850	8.10	2.800	32.40
	Non-sterile	2.300	14.90	2.400	23.15	2.350	21.75	2.600	22.80

* H = quantitative score, mean from three horizontal levels

** R = # roots from plug

Table 5. Quantitative scoring (means)

Soil type	**Soil treatment**	**Transplant grade**							
		Small		Medium		Large		Cutting	
		S*	P**	S	P	S	P	S	P
Virgin land	Sterile	2.600	1.800	2.800	1.750	2.950	1.550	3.900	2.300
	Non-sterile	2.900	1.750	3.500	2.250	3.400	1.900	3.700	2.500
Old land	Sterile	2.650	1.900	2.850	1.850	2.050	1.800	3.350	2.650
	Non-sterile	2.250	1.750	3.250	2.150	2.400	1.750	3.200	2.250

* S = # sides protruded

** P = Root concentration

Table 6. Weed count (means)

Soil type	Soil treatment	# Weeds
Virgin land	Sterile	1.10
	Non-sterile	0.15
Old land	Sterile	0.45
	Non-sterile	38.10

Table 7. Oven dry root and shoot mass (grams)

	Dry root mass	Dry shoot mass
P. patula transplant (small)	0.01313	1.4394
P. patula transplant (medium)	0.24612	3.3636
P. patula transplant (large)	0.36373	5.3176
P. patula cutting	0.76456	5.3176

Discussion

The objective of not putting transplants under stress was to test root and shoot development as well as survival in different soils. The effect of soils on transplant development and growth were isolated and tested for significance. Other external factors were excluded from confounding these effects. The transplants were at no stage under environmental stress. Water and fertiliser were applied as needed by the transplants.

Weeds were pulled out and counted as they germinated. It was significant ($p<0.001$) that old land soils had many more weeds than soils from virgin lands. Weed counts on old land soils, which had not been sterilised ranged from 20 to 61, weeds per pot (11309 square mm). The highest weed count in the virgin soil pots were 5 weeds per pot with a minimum of zero. However, sterilisation also had a significant effect ($p<0.001$), with non-sterilised soils being more weedy. The interaction between soil and sterilisation was highly significant ($p<0.001$). The non-sterilised, old land soil was weedy, and all other combinations not weedy. For sterilised soils, virgin land soil had insignificantly more weeds than the old land soil. The moisture and nutrient stress that the abundance of weeds inflicts on *P. patula* transplants can be responsible for high mortality in the field (Ellis, 1995).

No mortality occurred in any of the treatments. Mortality of transplants planted on old agricultural lands can only be explained by other sources of stress, which add to the difficulties caused by the old land soils. Poor soil structure due to repeated mechanical ploughing was responsible for the poor drainage in the pots filled with old land soils. When these pots were watered, the soil settled into the pot so that a fully filled pot ended up three-quarters full. After the initial wetting, it was difficult to water these pots due to the poor drainage. It was clear that the old land soils were structure less and a white fungus grew in the pots, which could be due to the bad drainage.

Transplant grade had a significant effect ($p<0.001$) on height increment after 60 days in the cabinets. The smallest transplants had the best height increment. While planting, it was noted that the smallest transplants showed no sign of wilting while all the other transplants showed signs of stress. Problems were experienced when lifting and planting the smallest transplants because the roots did not fully bind the growing medium. The chance of planting transplants with J-roots can be high in this situation. Mondi designed a planting pipe to minimise this problem. The Unigro plastic container makes it easy to lift these transplants since they can be dented on the sides to loosen the plug. Other containers can be more problematic. The cuttings had the second best height increment. Soil and sterilisation had no significant effect on height growth, and there was no significant evidence of interactions between treatment factors.

The effect of transplant grade on diameter growth was not significant ($p>0.05$). However, soil source ($p=0.01$) and sterilisation ($p<0.05$) had significant effects on diameter increment. Plants in virgin soils showed greater diameter increment than those in the old land soils, and sterilisation had a positive effect on diameter increment. The interaction of sterilisation and transplant grade was significant ($p<0.01$). For unsterilised soils, cuttings showed the highest diameter growth followed by small transplants. This was different for sterilised soils, with large transplants performing best, and cuttings worst.

Seedling grade had a significant effect ($p<0.001$) on root mass. The cuttings outperformed all the transplants in terms of root and shoot dry mass with the large transplant second and the medium transplant third. Dry root mass decreased as grade became smaller. Transplants raised in virgin soils had a significantly better ($p=0.003$) increase in dry root mass than those raised in old land soils. No significant differences in dry root mass could be determined between sterilised and unsterilised soils. Interaction between soil and transplant grade was significant ($p=0.001$). Root growth was better in virgin soils, except for the medium transplants where the reverse was true. The ranking of the transplant grades within the two soils was the same (i.e., cutting, large, medium).

The evaluation of root mass is under suspicion because it is difficult to completely separate roots and growing medium especially in the case of the small seedlings for the root plug deteriorated when washed. The difference in dry root mass between the smallest and largest reading was only 0.518 g. The number of roots developed is also of more value than the mass measurement (Lophushinsky and Beebe, 1976; Kormanik, 1987). Shoot dry mass is suspected to be of little value as no initial reading could be taken without damaging the transplant, and initial shoot mass was very variable. Transplants grown in soils collected from virgin grassveld showed a significant increase in dry root mass compared to old agricultural lands, as was expected due to soil structure deterioration in old lands.

Difficulty was experienced when evaluating transplants on a quantitative basis. The root plug, which was formed in the nursery by the container, was used as the base from which evaluation took place. Only growth from this plug was measured and evaluated. It was easy to identify the original plug in the case of the cuttings, and medium and large transplants. The small transplants had no plug left after the transplants had been washed out. The evaluation personnel agreed that it would do the small transplants an injustice if they were evaluated on this basis. Small transplants were quantitatively evaluated but it was felt that results couldn’t reflect the true picture. The results of small transplants were thus excluded from the analysis of the quantitative assessments.

Transplant grade had a significant effect ($p<0.001$) on the number of roots growing from the plug. Cuttings had the highest number, with medium transplants in second place and the large transplants scoring lowest. The contradiction between dry root mass and the number of roots protruding from the plug must be noted. Root mass might be an unreliable variable since the measurements were very fine and it was difficult to accurately separate the roots from the growing medium. Sterilisation had a significant ($p<0.05$) detrimental effect on root growth from the plug. The interaction between transplant grade and sterilisation was significant ($p<0.01$). Sterilisation had a detrimental effect on the number of roots developing in transplants, but not in cuttings.

Although cuttings had high growth vigour and the roots were evenly distributed and balanced, less than three roots (in most cases only one) grew from the base of the stem. A callus was formed at the point of initial root growth. When pulled, these roots broke off easily at that point. The callus is a point of potential weakness. Thus more work on root development in cuttings is essential, as trees may develop unstable root systems.

On the first quantitative scoring criterion, i.e. the horizontal scoring, transplant grade had a significant effect ($p<0.001$) on root distribution. Once again, cuttings outperformed all the others. Medium transplants ranked second followed by large transplants. The large transplants had very few roots protruding from the plug. Roots that did develop entered the soil at the bottom of the plug. This growth pattern looks like an onion and is called "onioning" by some researchers (Bailey, Pers. Comm., 1995). The large transplants were moribund and will recover very slowly, if ever. Roots, which have already grown around the stem (caging), will eventually strangle the transplant, causing stem weaknesses. This in turn may result in toppling which is usually confined to transplant planted plantations (Mason, 1985). There was significant soil x grade interaction ($p<0.05$) due to a change in ranking of the medium and large transplants for the different soils (large transplants ranked second on virgin soils). However, cuttings remained in top rank.

The development of roots on all sides of the plug was significantly affected by transplant grade ($p<0.001$) and by soil ($p<0.001$). Cuttings scored best, followed by medium and then large transplants. Virgin soils scored better then old land soils. There was no significant interaction between factors.

Transplant grade ($p<0.001$) and sterilisation ($p<0.05$) had a significant effect on the vertical distribution of roots. Sterilisation had a negative effect. Large transplants tended to be more moribund with new root growth concentrated at the bottom of the plug. Stem damage due to root strangulation could also be noted. Medium transplants were also bad cuttings were better and small seedlings showed no signs of strangulation or being moribund.

Unfortunately the small transplants could not be properly evaluated quantitatively. The roots developed well and no moribundness was noted. The chance of planting these transplants with J-roots is high. J-rooting will result in unstable trees with malformed root systems at a later age. The Mondi pipe planting seems to be an effective method to overcome this. A short pipe is pushed into the planting pit after the soil has been loosened. The transplant is lowered into the pipe and the soil is compacted while the pipe is being pulled out. This enables the planter to compact the soil without deforming the roots.

The fact that mortality did not occur in this trial after 60 days suggests that old land soils and the occurrence of pathogens (non-sterilised soils), in the absence of other potential harmful factors, is not the cause of transplant mortality. Other factors such as weeds and climate must also contribute to transplant mortality. The weed counts showed that weeds grow in abundance in old lands with unsterlised soils. Weed counts ranged from 20 to 61 weeds per 11309 square mm.

Conclusions

Transplant grade will influence the degree of shock a transplant experiences when planted in the field. Large transplants tend to be moribund and will have difficulty with root development and stability. Caging will also be a problem on these large transplants. The ideal transplant grade must not exceed a stem height of 212 mm and a collar diameter of 3.5 mm. It is unfortunate that difficulty was experienced with the quantitative evaluation of the small transplants (mean collar diameter of 1.79 mm and shoot length of 67.3 mm). These transplants outgrew all the other transplants and showed no signs of planting stress or root deformities. Transplant size should vary towards small, rather than large, transplants.

This trial reiterates the importance of total silviculture. The so-called old lands syndrome is a high risk because it includes most of the common problems that can be found in plantations such as weed competition, soil structure deterioration, pathogens, toxins, rodents, insects and soil nematodes. However, under ideal growing conditions, old land soils and pathogens in isolation appear not to be responsible for transplant mortality.

Shoot and root growth of cuttings was shown to be above average. If the potential problem of stem weakness at the stem base can be solved, cuttings can be planted with less risk of instability. It is therefore important to do more research on root development of cuttings, to prevent potential problems related to tree stability.

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Total Fiber Utilization Equipment System

John Foote
Morbark Sales Corporation
8507 South Winn Road
Winn, Michigan 48896
Telephone (517) 866-2381 or (800) 831-0037
Fax (517) 866-2786
http://www.morbark.com
morbark@worldnet.att.net

Introduction

Good Morning. My name is John Foote. I am currently the International Sales Manager and Forestry Specialist for Morbark. Some of you are long time customers of Morbark and some of you have never heard of us. Basically, we're the world's largest manufacturer of debarking, chipping and grinding equipment.

I have read the proceedings from the first Conference and the Charter. I've noticed in the Charter, one goal is to "develop a database such as operating parameters and costs of the currently available equipment systems." The total fiber utilization concept is one such system that Morbark can offer. So I'd like to accomplish two things today, the first is a brief introduction of Morbark's full range of equipment that is utilized in SRWC and secondly to highlight the total fiber utilization system.

I'll begin by showing a brief 10-minute video that gives a good overview of our complete equipment range and that shows our most popular equipment in operation. (A video was shown.)

Overview of Morbark Equipment

Norval Morey founded Morbark in 1957 on the basis of a hand-fed pulpwood debarker. Morbark today has over 30 acres under roof and about 600 employees.

The first section of our Product Guide covers the grinding equipment. These work great in slash piles, tops, short log pieces, stumps, really any kind of wood waste material. They use high speed hammermills and screens to grind and size the material. The end product is used mainly for biomass fuel, composting or landscape mulch.

I have seen some data earlier where a Morbark tub grinder was brought onto a job site to grind slash. The analysis of the performance was the production was great, but that some overs were produced that caused problems with the material handling equipment further down the line at the mill. There is a very easy way to fine tune that end product.

The grinders have two screens placed beneath the hammermill that size the end product. Morbark makes about 20 different screen sizes and you can mix and match these screens. For example, instead of having (2) 4" x 6" screens in the grinder, you can have a 2"x2" or a 3"x3" (for example) on the front side and a 4" x 6" (or anything else larger than the front side) on the back side. This will give you an initially smaller sized product, but still give you the production rates you want because of the larger holes on the back side.

Proceedings of the Second Conference of the Short-Rotation Woody Crops Operations Working Group, 25-27 August 1998, Vancouver, Washington, USA

These grinders can also be set up with a Morbark Flail Chiparvestor to process the small limbs and bark into biomass without having to handle that material a second time. This will be discussed in further detail later.

Morbark also manufactures a complete line of trommel screens. These are portable trommels to take the fines and overs out of a biomass product. Most of you will recognize the chippers on page 21-23 of the Morbark Product Guide. We have been building these Chiparvestors since the 1970's. The Model numbers designate the diameter size of tree it will chip. These machines have a reputation for strength, dependability, production and chip quality.

Flail Chiparvestors and 100% Total Fiber Utilization

On page 24-25, we have our Flail Chiparvestors. Page 25 shows the Total Fiber Utilization concept. The Models 2755 and 2348 will take multiple stems, delimb and debark these stems and produce a clean, high quality pulp chip. Depending on the size of material, production rates average in the 65 to 90 tons per hour range, with figures as high as 120 tons per hour when the entire operation is working at peak efficiency. These machines are available with either a single 990HP or 1050HP engine or twin engines (one for the flail and one for the chipper and hydraulics). The limbs and the bark that come out of these machines can then be conveyed directly into a grinder for biomass energy.

The advantages of this system are that you:

- Can increase fiber yield per acre 20-30% by utilizing the larger limbs for clean chips.
- Need to handle the wood only once. The Flail Chiparvestors are producing a high quality, clean pulp chip while simultaneously a Morbark tub grinder is processing the bark and limbs into an energy product.
- Thus, you're getting the highest value for the resource while dramatically reducing the handling costs of producing these end products.

Technology is also improving the efficiency of this type of equipment. Electronic engines are now becoming extremely popular. These engines are showing a 20-25% fuel savings, creating fewer emissions (no black smoke) and running quieter. Electronic RPM sensors can automatically stop the feed works when the engine rpms go down, reducing the possibility of overs. Since every site is different, digital readouts of the engine and flail rpms allow the operator to fine tune the machine at each job site to achieve the maximum chip quality and lowest bark content with the least operational costs.

We currently have a Model 2348 on its way to an SRWC plantation in Brazil. We will do some very extensive testing on Eucalyptus stands there. If anyone is interested in information on these tests, just contact me and I'll be happy to share that with you.

On page 26 of the Product Guide, we also offer a flail debarking system that is separate from the chipper. The stand-alone option is an excellent alternative if weight on a single machine is a factor or if you already operate/own a chipper.

On pages 27-30, we offer a complete line of drum style chippers. These chippers feature a chain conveyor infeed bed that assists in processing large, tangled piles of brush and slash. They range in size from 325Hp to 800HP. We also offer the Morbark Mountain Goat, which is a drum style chipper mounted on a Caterpillar undercarriage.

The final pages in our Product Guide cover the Morbark Log Loaders and a three wheeled feller buncher. Morbark has been building its own loaders for about 20 years and decided to offer self-contained log loaders to fill niches in this industry. These are the Models 1500B and the 1225C Loaders.

The small feller buncher is called the Wolverine Tractor. This machine carries a 15” or 18” disc saw or shear head. The smaller Wolverine 4300 is designed with a swing boom feature allowing the operator to cut more trees with less ground disturbance.

Conclusion

I’d like to thank you for coming today. If anyone is interested in further details on any of this equipment, please see me later, call Morbark at 1-800-831-0042, visit our web site at www.morbark.com or come to Winn and visit us.

Cut-To-Length Harvesting of Short Rotation Eucalyptus
at Simpson Tehama Fiber Farm

Bruce R. Hartsough
Biological & Agricultural Engineering
University of California
Davis, CA 95616

David J. Cooper
Simpson Fiber Farms, Inc.
22400 Sour Grass Road
Corning, CA 96021

Abstract

A system consisting of a cut-to-length harvester, forwarder, mobile chipper and chip screen was tested in a 7-year-old plantation. Three levels of debarking effort by the harvester (minimal, partial and full), and two levels of screening (with and without) were evaluated. The harvester had the lowest production rate and highest cost of the system elements. Harvester production rate was strongly affected by tree size and somewhat by debarking level. Bark contents for full debarking averaged 1.5%; screening apparently did not reduce bark content any further. Estimated stump-to-truck costs (without screening) for the system in stands of good form varied from $17/BDT for 11” DBH trees to $65/BDT for 3” trees. The system may be cost-competitive with whole tree systems.

Keywords: CTL harvesting, production, cost, bark content, screening

Introduction

At present, most short rotation woody crop harvesting on the west coast is carried out by systems that include feller/bunchers, skidders, chain flail delimber/debarkers, and chip vans for hauling the clean chips to the pulp mill. Residues from the flail are usually comminuted on site with a tub grinder or other device, and hauled in chip vans to a powerplant. This system works very well when a viable fuel market exists for the residues.

When fuel prices do not cover the costs of comminution and transport, managers must decide whether to leave the residues on site, and what system to use in this situation. One possibility is a cut-to-length (CTL) system consisting of a harvester and a forwarder. The harvester removes the branches and top at the stump, and cuts the tree to log lengths that may be selected by the operator. Residues are left distributed within the stand, recycling nutrients and eliminating disposal costs. In Australia and South Africa, harvesters have also been employed to debark eucalyptus stems. Howe (1994) studied a Bell TH 120 harvester clearcutting a eucalyptus plantation in South Africa. He reported a production rate of 11.8 m^3 per scheduled hour for felling, debarking and piling of 6-m logs on flat terrain for skyline yarding, with tree volume averaging about 0.24 m^3.

Although skidders could be used to transport delimbed and topped trees or log lengths, forwarders must be utilized to transport debarked logs, in order to avoid contamination by soil. Most forwarders are limited to carrying logs of about 20 feet or less in length. Forwarders generally travel on the mat of slash left by the harvester, and therefore have the potential to create less soil compaction than do skidders. Compared with skidding, very little dust is produced while forwarding.

Possible disadvantages of the CTL system include higher site preparation costs due to the on-site residues, and higher harvesting costs. Although rankings vary from study to study, in many cases CTL systems have cost more than whole tree skidding systems operating under similar conditions.

This study quantified the costs of a CTL system operating in eucalyptus, and the resulting bark content of chips from three levels of debarking intensity, with or without screening.

Approach

Stand

A seven-year-old stand of Eucalyptus viminalis was chosen for the trial. Seedlings had been planted on an 8-ft by 10-ft spacing. A sample cruise prior to harvest indicated that 490 stems per acre remained, including forks below breast height and standing dead stems. Trees averaged 5.6 inches DBH, 46 feet tall, and 3.3 cubic feet volume inside bark.

The trees, grown from unimproved seed, were highly variable in diameter (Figure 1), height and form. Almost a quarter of the trees were forked, and many trees had crooks. A majority of the trees were leaning due to the prevailing wind, and five to ten percent of the original trees were uprooted and leaning severely or on the ground. The uprooting was attributed to a high water table during the winter months. The terrain was flat, the soil surface was dry during the harvesting trial, and there was little or no undergrowth.

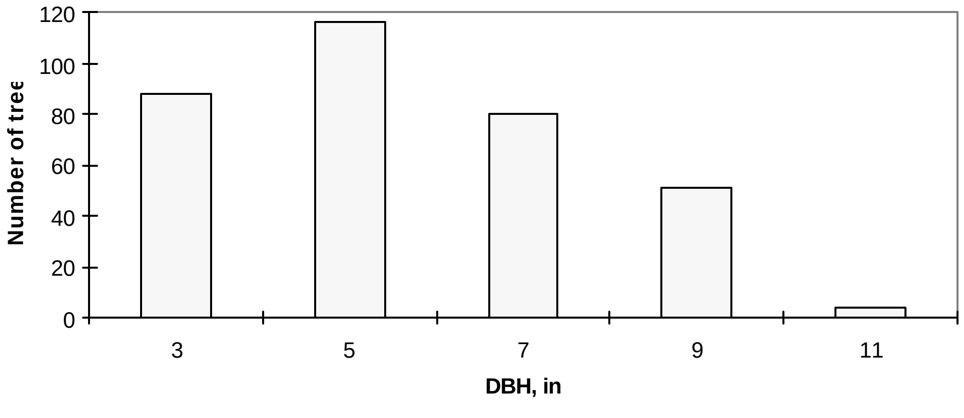

Figure 1. Distribution of diameters of the harvested stems.

Equipment and Harvesting Operation

Western Power and Equipment of Bend, Oregon, supplied a Bell TH120 tracked harvester with an SP 550 single grip harvester head, and a Bell T12B 12-ton forwarder. The harvester head was modified to improve its debarking performance in eucalyptus by replacing the chain-equipped rubber-tired feed rollers with steel rollers equipped with spiral cutting edges. When the harvester head is used on eucalyptus in South Africa, the double-bevel lower delimbing knives are replaced by single-bevel knives to improve debarking, but the head supplied for the tests had the standard double-bevel knives.

The equipment operator was well-skilled, with 8000 hours of experience on various harvesters. He also ran the forwarder during the single load that we observed, and was skilled with the forwarder as well.

Harvesting and forwarding were conducted on 21-23 July 1997. The operator used the first day to familiarize himself with harvesting in the test stand. Time-motion studies were carried out during the second and third days.

The harvester cut strips parallel to the 8-foot tree spacing direction. Three to four rows were cut per strip. Because of the down and leaning trees, logs were piled only on the side of the harvester opposite the uncut stand. Logs of up to 20 ft were cut if possible, although most were in the 16-ft to 18-ft range.

To investigate the debarking characteristics of the eucalyptus and resulting bark contents, three different specifications were followed by the harvester operator: “all” bark removed, “partial” debarking, and “standard” single-stroke delimbing with whatever debarking was accomplished. Removing “all” of the bark required between one and nine passes through the delimbing knives. (On forked or crooked trees, it was not possible to remove all of the bark.) For “partial” debarking, the operator used one to five strokes, with the goal of removing approximately half of the bark from each tree. On the first day of time-motion study, “all” the bark was removed. Half of the second day was devoted to the “partial” debarking specification, and half a day to “standard” processing.

The logs were forwarded to roadside and decked for chipping and screening, which were carried out on 28 July.

An experienced chipping contractor supplied a Morbark 20 chipper. Initially, the chipper’s boom and grapple pulled logs from the cold decks, but a front-end loader was added to speed the feeding rate. Some of the logs were chipped directly into chip vans. Others were chipped directly into an Oregon Mill Service (OMS) Super Beaver portable chip screening plant, and the screened chips were conveyed into vans.

Data Collection and Analysis

Height and diameter measurements were taken on a sample of trees before harvesting, and volumes calculated from diameter-height-volume relationships developed by Simpson for their Eucalyptus viminalis. Average log volume was calculated from total volume harvested and the total number of logs cut. We assumed a ratio of 32 bone dry pounds per cubic foot of bole wood under bark, and 50% moisture content, wet basis. For chip vans, we assumed 25 net green tons per load.

We conducted a time-motion study of the harvester and collected observations on over 300 stems, approximately a third of them under each debarking specification. The cycle for each stem was divided into the following elements: Move, Fell, Process, and Fork&Crook Delays. The latter were any times that could be specifically attributed to the poor form characteristics. Brushing time was recorded separately. Brushing consisted of cutting nonmerchantable trees, including standing trees of less than 3” DBH, and decayed dead and down trees. Some of the latter were up to 7 inches in diameter at 4.5 feet from the stump. Any other delays were also recorded separately. Along with the times for each tree, we recorded move distance, DBH, and number of logs cut.

Only one forwarder load was observed. The forwarding cycle was separated into TravelEmpty, Load, TravelWithin Stand while partially loaded, TravelLoaded to the roadside, and Unload which included decking.

The time-motion data for the harvester was statistically analyzed to estimate cycle time elements as functions of the stand characteristics and operating conditions. Since only one forwarder load was timed, forwarder relationships from another study (Hartsough et al 1977) were adjusted to give element times that were close to those observed. For chipping, results from a study of chipping directly from cold decks of CTL logs was used (Drews et al 1998).

Harvesting, forwarding and chipping cycle times and production rates were then calculated over ranges of tree size and forwarding distance, for each of the three debarking specifications. Since estimates were desired for future stand conditions, i.e. for trees with better form, adjustments were made to the observed harvester productivity and forwarder load size. The adjusted production rates were combined with estimates of hourly costs for the harvester and forwarder, to give costs per BDT.

Chip samples were taken from vans using the standard sampling apparatus at the pulp mill. The samples were analyzed for bark content, overs (>2”) and fines (<1/4”) by Simpson’s chip evaluation lab.

Results and Discussion

Cycle Times and Productivities

The time-motion data is summarized in Table 1. The harvester move distance was about 15% greater than calculated from theory, assuming straight, one-way travel and the observed 3.5 rows per strip. Theoretical distance is:

(43560 ft2/ac*trees/move) / (trees/ac*row spacing*rows/strip)

In the test stand, travel was not always straight or one way because of the leaning and down trees. The harvester also moved very frequently because of the stand conditions. For estimating production in future stands, we assumed that improved tree form would allow four rows to be cut on each strip. We also assumed that the harvester would move one tree spacing distance on each move and then cut a tree in each row before moving again.

Table 1. Cycle time elements and associated variables.

	Mean	Std. Dev.	Observations
Harvester			
Move, cmin/move	12.1	9.1	198
Trees/move	1.71		
Fell, cmin/tree	13.6	9.6	339
Process, cmin/tree	38.4	24.7	339
Brush, cmin/tree	9.2	23.2	340
Crook&ForkDelay, cmin/tree	3.2	11.0	340
OtherHarvProductiveDelays, % of cycle time	4.8%		
Move distance, ft/move	5.05	2.89	198
DBH, in	5.62	2.11	339
TreeVolume, ft3	3.31		
Logs/tree	1.82	0.71	340
Forwarder			
Travel empty, min/load	1.13		1
Load, min/load	9.11	(14 swings)	1
Travel within stand, min/load	3.44		1
Travel loaded, cmin/load	1.44		1
Unload/deck, cmin/load	5.17	(10 swings)	1
Travel empty dist, ft	130		1
Travel within stand dist, ft	140		1
Travel loaded dist, ft	200		1
Logs/load	106		1
Load size, ft3 (BDT)	193 (3.09)		1

Harvester cycle time relationships are shown in Table 2. Processing time increased with the specified level of debarking, and this is quantified in the regression relationship with the coefficients of the dummy variables, Partial and Full. Partial =1 for partial debarking, = 0 otherwise. Full = 1 for full bark removal, = 0 otherwise. (For Standard processing, both dummy variables are set to zero.)

While collecting data, we were able to clearly identify some of the additional time spent dealing with forks and crooks, but these averaged only a few centiminutes per tree, as indicated in Table 1. There was considerable other time that could not be clearly separated; the forks and crooks reduced the feed rate through the head, and decreased the length of stem that could be processed before a reversal or bucking cut had to be made. In stands without heavy leaners and down trees, logs can be piled on both sides of the harvester. This speeds processing because trees do not have to be rotated or moved as far. The leaning and down trees also increased felling times by restricting the directions from which the trees could be cut, and by requiring the operator to be more cautious to avoid hitting the ground with the chainsaw. In addition, brushing would almost be eliminated in higher quality stands of more uniform trees. Considering all of these factors, we estimated that harvester productivity would be increased by 30% or so in future stands of good quality compared to the one observed, for any given average tree size. Assuming 80% utilization, the productivity reported by Howe (1994) is similar to our adjusted rate for complete debarking of trees of comparable size -- just under a productive minute per tree for 9” trees -- so the adjustment seems reasonable.

Table 2. Harvester Cycle Element Relationships, cmin

Move, cmin/move = 6.09 + 1.189 * Distance
R^2 = 0.14, F = 33., n = 198
Fell, cmin/tree = 10.40 + 0.511 * DBH
R^2 = 0.02, F = 7.6, n = 338
Process, cmin/tree = 15.75 + (0.333 + 0.166 * Partial + 0.515 * Full) * DBH^2
R^2 = 0.57, F = 149., n = 339
Brush, cmin/tree = 9.24
Crook&ForkDelay, cmin/tree = -3.12 + 1.125 * DBH
R^2 = 0.05, F = 17., n = 340
Total productive time, cmin/tree = (Move/TreesPerMove + Fell + Process + Brush
+ Crook&Fork Delay) * (1 + OhterHarvProductiveDelays)
LogsPerTree = 0.7 + 0.2 * DBH

Relationships from a study of a CTL forwarder operating on the Stanislaus National Forest were adjusted to estimate cycle times under the easier operating conditions in the eucalyptus plantation. The adjusted relationships are shown in Table 3. When the observed values for travel distances and logs per load are used, the adjusted relationships give a total time per load that is within four percent of that observed for the single load.

The observed forwarder load size was only about 3 BDT or 6 green tons, about half the nominal capacity of the forwarder. This was due to poor packing of the relatively crooked logs, and due to the short lengths of many of the logs. With better trees, a higher percentage of the logs could be cut to maximum lengths, packing should be improved, and higher stakes could be used if needed. To estimate productivity in future stands of good quality, we assumed a forwarder load size of 6 BDT (12 green tons).

Table 3. Forwarder Cycle Element Relationships, cmin

LogWeight = TreeWeight/LogsPerTree
LogsPerLoad = LoadWeight/LogWeight
WithinStandDistance = (LoadWeight*43560ft2/ac)
/(TreesPerAc*RowsPerCorridor*RowSpacing*TreeWeight)
TravelEmpty+TravelLoaded = (152.95+0.488*TravDist + 0.01224*TravDist*Slope)
Load = 0.5*(642.54+10.7*LogsPerLoad)
TravelWithinStand = 0.67*(458.91+0.808*WithinStandDistance)
Unload = (360+2.2*LogsPerLoad)
ForwProductiveDelays, % of cycle time = 5.9%
Total productive time, cmin/load = (TravelEmpty+TravelLoaded + Load
+ TravelWithin Stand + Unload) * (1 + ForwProductiveDelays)

A front-end loader was used to feed the Morbark 20 chipper during the trial. A separate loader or skidder is commonly used to break down decks of whole trees, and in some cases with cut-to-length logs (e.g. Hartsough et al 1997). Using a chipper with an infeed deck, however, it is possible to chip at high rates directly from cold decks of CTL logs, thereby eliminating the cost of the loader or skidder. We used results from a CTL study where a Morbark 27 fed itself from cold decks (Drews et al 1998):

Total productive time per load = (1103. + 145.06 * ChipVanNetGreenWeight
- 9.99 * GreenLogWeight) * (1 + 11.1% ChipProductiveDelays)

Costs were estimated at about $95 per productive hour for the harvester, $78/PH for the forwarder, $95/PH for a Morbark 27 chipper and an additional $40/PH if the screen is included in the system. The costing assumptions are listed in the appendix. A spreadsheet was developed to calculate cycle times, productivities and costs per BDT of clean chips. Harvesting, forwarding and chipping/screening costs per BDT over ranges of tree size and operating conditions are displayed in Figures 2, 3 and 4.

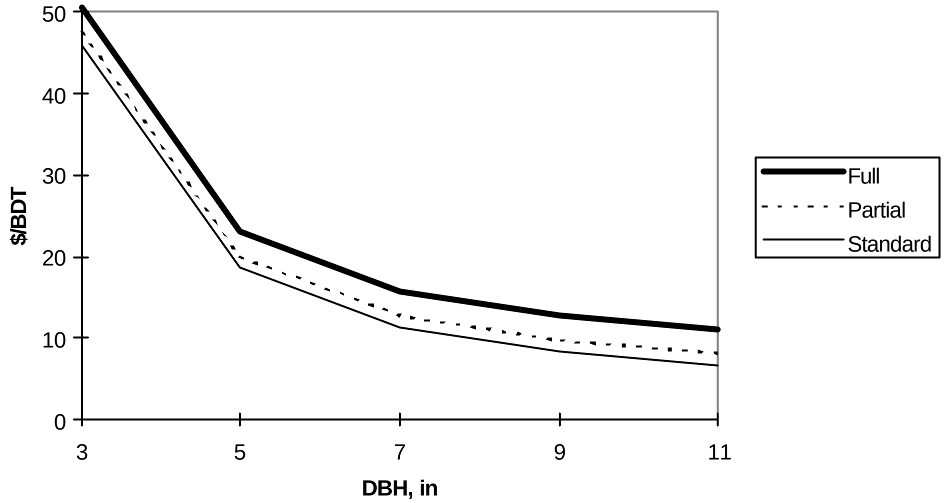

Figure 2. Estimated harvester costs in stands of good quality, for various levels of debarking effort.

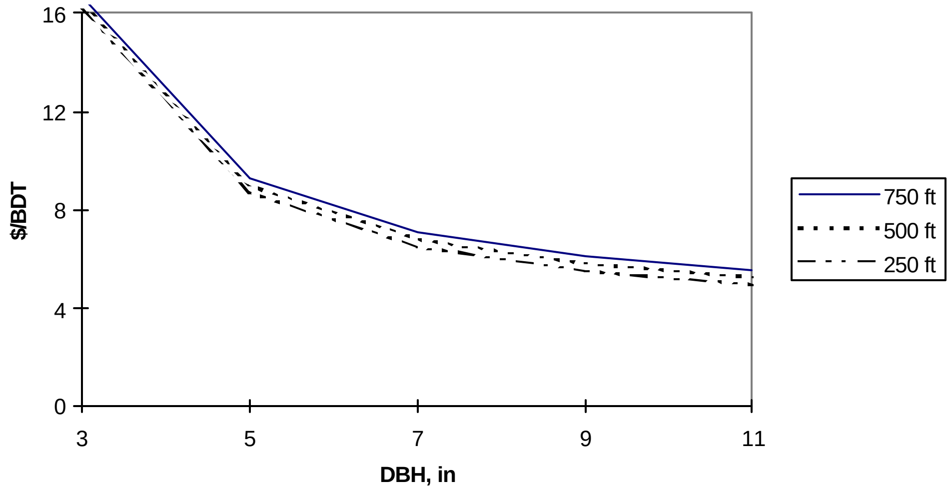

Figure 3. Estimated forwarding costs in stands of good quality, for three different forwarding distances.

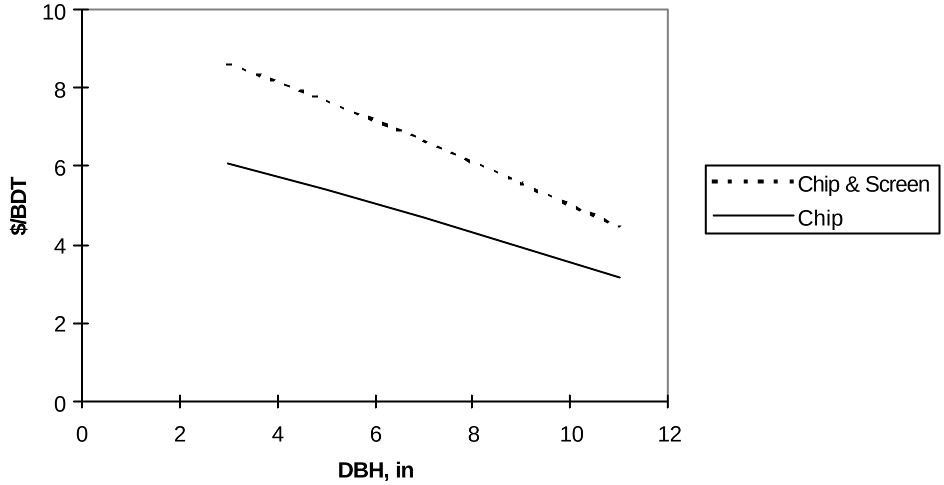

Figure 4. Estimated chipping or chipping/screening costs.

Production rates for a single harvester, forwarder and chipper are shown in Figure 5. For trees in the 5”-11” DBH range, a reasonably balanced system would include three harvesters, two forwarders and one chipper.

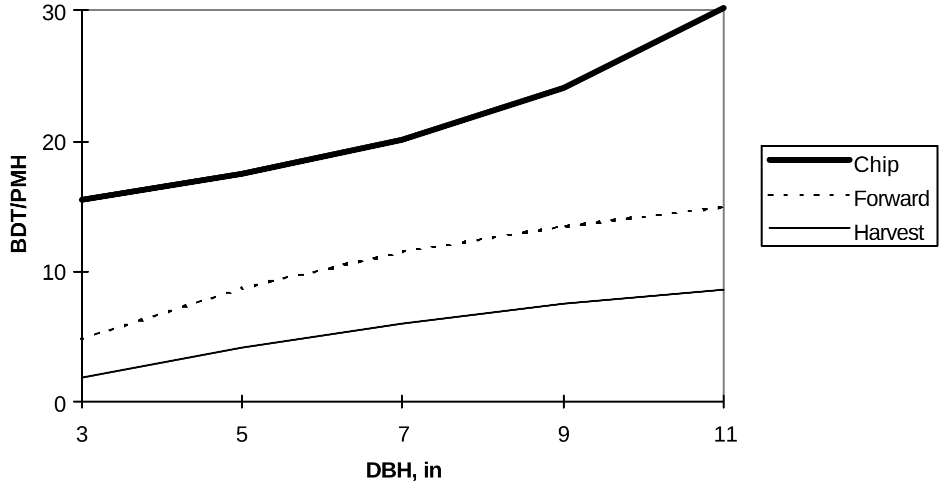

Figure 5. Production rates per productive machine hour for a harvester (full debarking), a forwarder (500 ft average distance) and a chipper.

Stump Heights

Initially, the harvester operator tried to cut fairly low stumps, but he was dulling the chainsaw frequently because of the gravelly soil and lack of duff and litter. He then cut higher stumps, which solved the dulling problem. Stumps, however, averaged 10.3 inches tall. This compared with an average of 4.8 inches for stumps left by a shear-equipped feller/buncher in an adjacent stand on similar terrain (Figure 6).

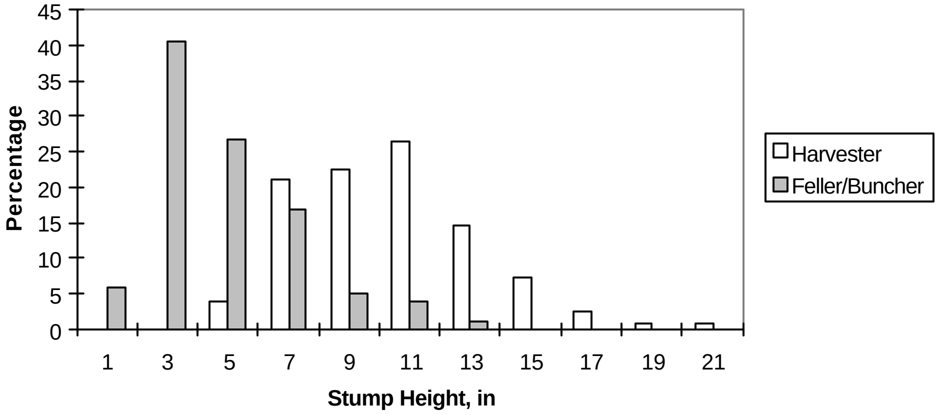

Figure 6. Distribution of stump heights, for trees cut by a shear-equipped feller buncher and by the chainsaw-equipped harvester.

Stump heights could be lowered with additional experience, and possibly by adding a spacer on the bottom of the harvester head to provide a gap between the saw and the ground. The leaning trees increased the stump heights because the head had to be raised to avoid contacting the ground with the saw chain. There also should be fewer problems with dulling the chain in soils with less rock. However, the duff and litter layer in SRIC plantations will probably remain rather thin so it is likely that shear heads will always be able to cut lower stumps than chainsaw heads.

Bark, Overs and Fines Contents

Full debarking effort by the harvester reduced the bark content significantly (at the 5% level) in comparison to partial or standard debarking (Table 4). Screening did not further reduce bark content. It may be that the remaining bark was more tightly bonded to the stems, did not separate from the wood during chipping and therefore would not screen out. Screening did significantly reduce (at the 5% level) overs and fines percentages.

Table 4. Overs, fines and bark contents for the tested screening and debarking treatments.

	Screened	Unscreened
Overs, %	4.3	6.1
Fines, %	0.3	0.9
Bark, %		
Full	1.6	1.5
Partial	5.7	3.7
Standard	3.4	

For full debarking with or without screening, the observed average bark content of about 1.5% still exceeded the desired threshold of 1%. On trees of better form, bark content should be less. It was difficult or impossible to remove much of the bark near crooks or forks because the harvester knives and rollers could not contact the boles. Also, the trees in the test stand had not been irrigated during part of the growing season just before harvest. Continuing to irrigate until shortly before harvest might lower wood-bark adhesion and improve debarking results.

Representatives of Bell indicated that debarking might improve as the feed rollers were broken in, because bark might not clog the gaps between the cutting edges on the rollers. They also expected the use of the more aggressive, single-bevel delimbing knives to improve bark removal. They reported good results with these knives in South Africa. Other modifications that might help:

- a third feed roller to increase contact with the bark,
- hourglass-shaped rollers to increase contact with the bark,
- slightly angled roller shaft axes to impart a slicing action between the roller cutting edges and the tree, and to produce a spiral motion of the stem through the head.

Site Preparation and Other Effects

After harvesting, the test stand was allowed to coppice regenerate, so there was no difference in site preparation or regeneration costs on this versus a coppiced whole tree site. Simpson replants the majority of its stands. If the stand had been planted, it was estimated that site preparation costs would have been increased by about 40% due to the higher stumps and residues. Increased fire danger is another possible negative. Expected benefits of the residues would include additional nutrients and higher soil moisture content during late spring due to the mulching effect.

Conclusions

In clonal stands of trees with better form, and with minor changes to the harvester to improve debarking, the harvester-forwarder-chipper system may be able to produce chips with bark contents of less than one percent. Then the question comes down to harvesting economics and secondary effects. Stump-to-truck harvesting costs for the system with full debarking effort are displayed in Figure 7. Costs of $33/BDT (1991 dollars) were reported for a whole tree feller/buncher-skidder-chain flail delimber/debarker system (Hartsough et al 1992). The whole tree system was operating in short rotation poplar that averaged about 6” DBH. The similar costs indicate that the CTL system might be competitive.

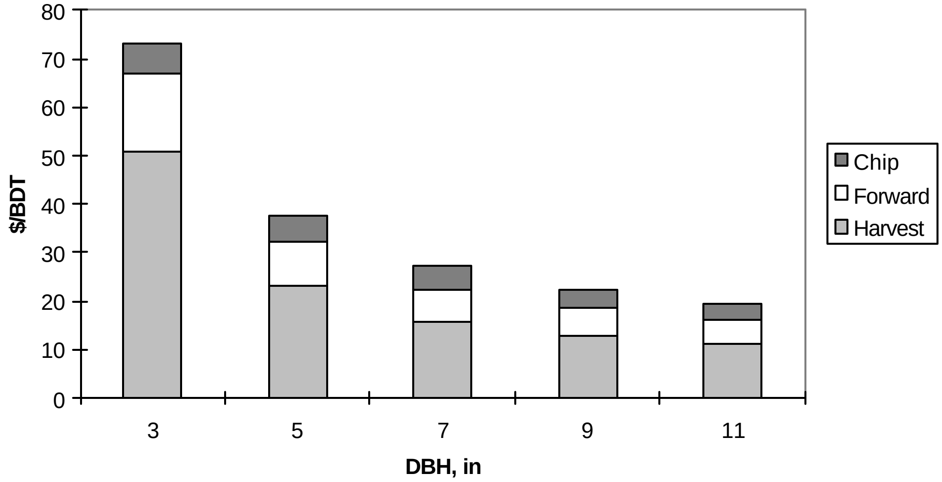

Figure 7. Stump-to-truck costs for harvesting (full debarking), forwarding (500 ft average distance) and chipping.

Acknowledgement: This study was funded in part by the USDA Forest Service Southern Research Station under Cooperative Agreement SRS-30-CA-96-058.

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Appendix A. Hourly cost assumptions and calculations.

1. Assumptions:	TH120 Harvester	T12B Forwarder	MB 27 Chipper	OMS SB Screen
Purchase price (P, $)	250000	200000	260000	180000
Machine Horsepower rating (hp)	100	80	600	80
Machine life (n, years)	5	5	7	7
Salvage value, percent of purchase price (rv%)	20%	20%	20%	20%
Utilization rate (ut%, ph/sh)	80%	80%	80%	80%
Repair and maintenance, percent of depr. (rm%)	110%	100%	100%	100%
Interest rate per year (in%)	8%	8%	8%	8%
Insurance and tax rate (it%)	7%	7%	7%	7%
Fuel consumption rate (fcr, gal/hp/ph)	0.029	0.025	0.023	0.025
Fuel cost per gallon (fcg, $/gal)	1	1	1	1
Lube and oil, percent of fuel cost (lo%)	37%	37%	37%	37%
Operator wage and benefit rate (WB, $/SH)	18	18	18	0
Scheduled hours per year (SH)	2000	2000	2000	2000
2. Calculations:				
Salvage value, (S, $) = (P*rv%)	50000	40000	52000	36000
Annual depreciation, (AD, $/year) = [(P-S)/n]	40000	32000	29714	20571
Average yearly investment (AYI, $)	170000	136000	170857	118286
Productive Hours per year (PH) = (SH*ut%)	1600	1600	1600	1600
3. Ownership costs:				
Interest cost (IN, $/year) = (in%*AYI)	13600	10880	13669	9463
Insurance and tax cost (IT, $/year) = (it%*AYI)	11900	9520	11960	8280
Yearly ownership cost (F$, $/year) = (AD+IN+IT)	65500	52400	55343	38314
Ownership cost per PH (F$/PH)	40.94	32.75	34.59	23.95
4. Operating costs				
Fuel cost, (F, $/ph) = (hp*fcr*fcg)	2.90	2.00	13.80	2.00
Lube cost, (L, $/ph) = (F*lo%)	1.07	0.74	5.11	0.74
Repair and maintenance cost (RM, $/ph)	27.50	20.00	18.57	12.86
Labor and benefit cost (WB/ut%, $/ph)	22.50	22.50	22.50	0.00
Op. cost per ph (V$/PH) = [F+L+RM+(WB/ut%)]	53.97	45.24	59.98	15.60
5. Total machine costs:				
Total cost per ph (T$/PH) = (F$/PH + V$/PH)	94.91	77.99	94.57	39.54

Appendix B. CTL harvesting productivity and cost spreadsheet output example.

I. Assumptions

Trees/ac	490
Rows/Corridor	4
Row Spacing, ft	10
Wood Density, BD lb/ft3	32
Wood MC, % wet basis	50%
Slope, %	0
Harvester Assumptions	
Debark Level (Standard, Partial, Full)	F
Productivity Improvement	30%
Forwarder Assumptions	
Travel Dist, ft (one way)	500
Load Weight, GT	12
Chipper Assumptions	
Load Weight, GT	25
Productive Delays	11%

DBH, in	Tree Vol, ft3	Tree Wt, BD lb	Logs/Tree
3	0.77	25	1.3
5	2.27	73	1.7
7	4.53	145	2.1
9	7.54	241	2.5
11	11.30	361	2.9

2. Harvester Calculations

Move Fraction	0.25
Dist, ft	8.9

	Unadjusted Cycle Time, min/tree						Adjusted		
DBH, in	Move	Fell	Process	Brush	Crook Delay	Total w/Delays	Total Min/tree	BDT/PH	$/BDT
3	0.04	0.12	0.23	0.09	0.00	0.51	0.39	1.87	50.64
5	0.04	0.13	0.37	0.09	0.03	0.69	0.53	4.11	23.06
7	0.04	0.14	0.57	0.09	0.05	0.94	0.72	6.03	15.74
9	0.04	0.15	0.84	0.09	0.07	1.26	0.97	7.49	12.67
11	0.04	0.16	1.18	0.09	0.09	1.65	1.27	8.57	11.08

3. Forwarder Calculations

			Cycle Time, min/load						
DBH, in	Logs/ Load	In-Stand Dist, ft	Travel	Load	Travel In Stand	Unload	Total w/Delays	BDT/PH	$/BDT
3	633	1081	3.97	37.05	8.93	17.52	75.66	4.76	16.39
5	280	366	3.97	18.21	5.06	9.77	41.50	8.67	8.99
7	174	184	3.97	12.51	4.07	7.42	31.38	11.47	6.80
9	124	111	3.97	9.87	3.67	6.34	26.74	13.46	5.79
11	96	74	3.97	8.36	3.47	5.72	24.14	14.91	5.23

4. Chipper Calculations

Van Weight, BDT	12.5

DBH, in	Log Weight, green lb	Total CycleTime w/Delays, min/load	BDT/PH	Chip $/BDT	Chip & Screen $/BDT
3	37.9	48.33	15.52	6.09	8.64
5	85.6	43.04	17.42	5.43	7.70
7	138.0	37.22	20.15	4.69	6.66

9	192.9	31.13	24.09	3.93	5.57
11	249.2	24.88	30.15	3.14	4.45

Lesson Learned from Growing Poplars with Waste Water

Mark Madison
CH2M Hill
Portland, Oregon

Abstract

One of CH2M Hill's areas of expertise is the growing of poplar trees for waste water reuse. CH2M Hill is currently using this technology in two major applications: municipal wastewater and industrial wastewater. In this presentation, we will discuss this technology in relation to issues of tree health, water uptake, water quality, permitting, and irrigation system management. Two projects will be used to illustrate the lessons learned: the City of Woodburn wastewater reuse system and the OREMET Titanium poplar tree land application project.

The City of Woodburn wastewater reuse system is an example of a project where municipal wastewater, relatively high in nutrients, is being used to grow trees. At this site, research was conducted to determine the evapotranspiration rate of the trees. Data were collected using several soil moisture devices, and conclusions were drawn based on tests done during times of both deficit irrigation and full irrigation. These findings will be discussed, along with information about the growth and health of trees at the project site.

The OREMET Titanium poplar tree land application project is an industrial wastewater reuse system. The applied water is low in nutrient content, but high in total dissolved solids. Both spray and drip irrigation systems were used at this site. For this project, various poplar clones were evaluated for their relative tolerance to wastewater with a high chloride content. The results were surprising. The special planting and irrigation management requirements of the project will be discussed in the presentation.

Overall, application of this technology appears very promising, offering facilities a viable approach to disposal of wastewater.

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Growth Response of Hybrid Poplars to Industrial and Municipal Waste

Dr. Jon D. Johnson
Poplar Research Program
Washington State University-Puyallup
7612 Pioneer Way E.
Puyallup, WA 98375
Tel. 253-445-4522
Fax. 253-445-4569
Email: poplar@wsu.edu

Abstract

Interest in short rotation hybrid poplar grown for biomass and fiber is great. With rotations as short as 6 years, depletion of soil nutrients and a subsequent drop in productivity is a large concern. To offset the added cost of fertilization, the use of both industrial and municipal waste has been suggested as a low cost alternative to maintaining soil nutrient capital while at the same time provide for a low cost means of disposing of these wastes. Results from two studies conducted in Washington using municipal biosolids and wood ash are reported. The biosolids stimulated growth and the response was comparable to chemical fertilizer. In contrast, the application of wood ash resulted in a growth reduction in proportion to the amount of ash applied. Low soil oxygen due to the large amount of fine particles added by these treatments and to frequent flooding of the site appears to be limiting poplar growth. The result suggest that a thorough assessment of site, clone, and type and amount of waste must be done before implementing these cultural practices.

Keywords: Biosolids, wood ash, hybrid poplar, growth

Introduction

The goal of waste application to forests is to increase tree growth by capturing chemical and physical attributes of the waste material while providing a low cost alternative for disposing of these industrial and municipal by-products (Cole 1997). The use of short rotation woody crops such as hybrid poplar and willows to dispose of these wastes is attractive due to their rapid growth, high nutrient demand, removal of the site's nutrient capital when harvested, and their short rotation (2 to 8 years).

Careful planning is required, however, when contemplating the application of a waste material on a tree crop (Cole 1997). One must consider the nature of the waste material, both chemical and physical properties, site characteristics including soil chemical and physical properties, application methods and species requirements. The preliminary results of two ongoing studies with hybrid poplars are presented. The first addressed the question of the feasibility of using municipal biosolids waste to provide nitrogen and the second looked at wood-fired boiler ash to increase soil pH. The objectives of the studies were: 1) To determine the potential of biosolids as a soil amendment to improve the growth of hybrid poplars, and to determine the effect of irrigation method on the release of nutrients from the biosolids; and 2) to determine the potential of wood ash as a soil amendment to improve the growth of hybrid poplars.

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Methods

Biosolids study

The study was installed in 1994 at the Washington State University Irrigated Agriculture Research and Extension Center in Prosser, Washington which is east of the Cascade mountain range and is located halfway between Yakima and Pasco. It consisted of a randomized block design with 3 soil treatments (control, biosloids at 5.6 dry tons per acre per year, chemical fertilizer at the equivalent N application rate), 2 irrigation methods (drip and micro-spray) and 2 clones (49-177 and 50-197), replicated 4 times. Soil treatments were applied at planting in April 1994 and continued annually each spring.

Response variables included soil and solution chemical analyses annually beginning in winter of 1994 and annual height and diameter in January of 1995, 1996, 1997 and 1998 (diameter only).

Wood Ash study

A 20 acre site adjacent to the Chehalis river in west central Washington was prepared in fall of 1995. The study consisted of a randomized block design with 4 soil treatments (control, lime at 7 tons/acre and comparable to the higher ash rate in terms of soil liming capacity, ash at 15 dry tons/acre and at 21 dry tons/acre) and 2 clones (15-29 and 50-197), replicated 4 times. The ash treatments were applied in late October 1995 and the lime in early November 1995. Site was disked in late March 1996 and was planted with hardwood cuttings in early April 1996.

Soil chemical analyses were conducted annually beginning in September 1995, and foliar nutrient analysis was conducted in September 1997 and 1998. Annual height and diameter measurements were taken in January of 1997 and 1998.

Results and Discussion

Biosolids study

Irrigation method had a significant effect on both height and diameter growth across soil treatments (Table 1). While both irrigation systems delivered equal amounts of water to the trees, the micro-spray method provided even distribution over the soil as opposed to point source for the drip method. This would have two effects: 1) more of the root system would be provided water with the micro-spray system minimizing water stress, and; 2) in the fertilizer and biosolids treatments, even distribution of water by the micro-spray system would hasten breakdown and movement of nutrients to the roots.

Comparing tree response to soil treatments in the micro-spray plots showed that both the fertilizer and biosolids treatments stimulated diameter growth over the controls in both 1996 and 1997. In 1997, the diameter response was showing separation among all three treatments with the largest diameter being in the fertilizer treated trees followed by the biosolids treatment and then the control (Table 1). Height growth was unaffected by soil treatments (Table 1). In addition, clone 50-197 consistently outgrew 49-177 in all treatment combinations (data not presented).

Table 1. Growth response of hybrid poplar trees irrigated by two methods and three soil treatments. Statistical comparisons are between irrigation method and among soil treatments within the micro-spray irrigation method. Values followed by different letters within a column and comparison indicate significant differences at P = 0.05 level.

Treatment	1996 diameter (cm)	1996 height (m)	1997 diameter (cm)
Micro-spray	10.3 a	11.7 a	12.4 a
Drip	9.2 b	11.1 b	11.5 b
Micro-spray – control	9.8 a	11.8 a	12.1 a
Micro-spray – fertilizer	10.5 b	11.8 a	12.8 b
Micro-spray – biosolids	10.4 b	11.6 a	12.5 ab

Wood Ash study

An analysis of the chemical and physical composition of the wood ash showed that the material applied to the poplars had a high pH, a high percentage of total solids and organic carbon which should provide an increase of soil pH along with a mulching effect (Table 2). In addition, the ash contained high levels of plant nutrients that should ameliorate any nutrient deficiencies present in the soil. The cations included calcium, magnesium, potassium and sodium and anions included sulfate and phosphorus. There was also a high level of available nitrogen, again suggestive of a positive effect on tree growth.

Table 2. Chemical and physical composition of the wood ash applied to the hybrid poplars. From Krejsl and Scanlon (1996).

Ash Testing Parameter	**Value**
PH	12.68
Total Solids %	74.9
Total Organic Carbon %	11.9
Calcium carbonate equivalency %	34
Lime Score	23.4
Nutrient Concentrations	mg/kg
Calcium	118,000
Potassium	26,000
Magnesium	11,100
Phosphorus	5,800
Sodium	5,600
Total Kjeldahl Nitrogen	2,700
Manganese	1,830
Chloride	710
Sulfate	45
Ammonia Nitrogen	1.4

Soil pH was affected by the soil amendments as expected, the lime and two ash treatments had significantly higher pH that were relatively constant over the two years (Table 3). Soil phosphorus concentrations increased in the two ash treatments from about 8 ppm in the control and lime plots to 11 and 12 ppm in the ash-1 and ash-2 plots, respectively. This is consistent with the chemical analysis of the ash (Table 2).

The observed growth response was not as expected given the positive effects the ash amendments had on soil chemistry (Tables 2, 3 and 4). Height and diameter growth was greatest in the control and lime treatments while Ash-1 and Ash-2 treatments exhibited linear decrease as the ash rate increased (Table 4). It was also apparent that clone 15-29 grew better across treatments than clone 50-197 (Table 4).

In an attempt to understand why the ash application reduced growth, the physical composition of the ash was determined (Table 5). The ash contained nearly 70% fine particles of less than 0.06 mm and combined with the high application rates, 15 and 21 dry tons per acre, it became evident that a significant amount of fine material was incorporated into the soil in these two treatments. Coupled with this site's proximity to the Chehalis river which has flooded every winter, it was hypothesized that the ash contributed to low oxygen in the soil and thus reducing growth.

Table 3. Soil pH levels over two years as affected by soil treatment. Values followed by different letters within a column indicate significant differences at P = 0.05 level.

Treatment	1996	1997
Control	5.35 a	5.60 a
Lime	6.08 bc	6.18 bc
Ash-1	6.45 c	6.00 b
Ash-2	6.15 bc	6.25 c

Table 4. 1997 height and diameter response of two hybrid poplar clones to soil treatment. Values followed by different letters within a column and comparison indicate significant differences at P = 0.05 level.

Treatment	Height 15-29 (cm)	Height 50-197 (cm)	Diameter 15-29 (cm)	Diameter 50-197 (cm)
Control	456.4 a	444.8 a	3.94 a	3.77 a
Lime	468.1 a	431.4 b	3.95 a	3.57 b
Ash-1	444.3 b	410.9 c	3.70 b	3.14 c
Ash-2	408.4 c	399.7 d	3.10 c	3.07 c

Table 5. Size analysis of the wood ash.

Sieve size (particle size retained)	% Retained
No. 10 (2 mm)	2.3
No. 20 (0.9 mm)	10.5
No. 40 (0.4 mm)	18.6
Pan (<0.06)	68.6

Acknowledgements: The author wishes to thank the following people for assistance with these projects. **Biosolids study:** Roberta King, Biosolids Project Manager, King County, Washington for providing the funding, Chuck Henry, University of Washington and Dave Evans, Washington State University-Prosser. **Ash study:** Jana Krejsl, Weyerhaeuser Corp. for funding and support, Steve Webster, Washington State University, Chehalis County, Washington, and Ken Baldwin, Weyerhaeuser Corp. The technical assistance of Gordy Ekuan and Curt Bod made the field measurements possible.

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Fertigated Hardwood Plantations in the Southeast

Ilan Bar
Staff Agronomist
Netafim USA
Altamonte Springs, FL

In the last few years fertigated hardwood plantations have been spread throughout the Southeast, Northeast and Northwest. Some of the plantations are fully commercial, some are semi-commercial (assessment fiber farms) and some are research studies. All the major paper companies are being involved, in one way or another, in fiber farming. International Paper, Georgia Pacific, Champion Paper, Union Camp, Westvaco, Mead Paper, Boise Cascade, Potlatch - just to name a few.

The results that have been achieved by using drip irrigation and fertigation technology on hardwood plantations (fiber farms), are truly a breakthrough in pulp and wood production. The yields and growth rates of fertigated plantations have broken records. For example: After two growing seasons of fertigated hardwood and pines in Georgia (International Paper), an eight fold increase in above ground biomas and six fold increase in leaf area were observed in Sweetgum in response to fertigation relative to control. Fertigation plus pest control on loblolly pines resulted in quadrupling the total biomas and tripling of leaf area (L. Samuelson, 1997).

In five months after applying fertigation to poplar cuttings in the sandy soil of the Bootheel of Missouri (Westvaco), some of them have reached a height of 16 feet. After six growing seasons of hybrid poplar fiber farms in the Pacific Northwest (Boise Cascade), the trees have reached heights of 70 feet and 7 - 8 inch DBH.

It is fully accepted and recognized that the fertigation technology can increase productivity to the level of ten or more dry tons per acre, which is about two-thirds more than we grow today. The only question remains to be answered is at what cost and does it pay. For that purpose, let’s examine the current market situation.

The demand for forest products is on the rise. The expected demand just for paper will increase by approximately 4% per year (Figure 1).

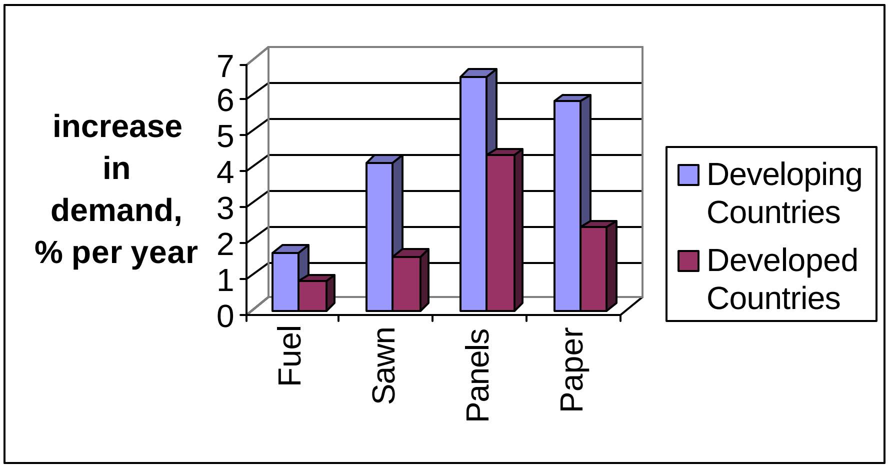

Figure 1. Expected increase in demand for forest products. Source: FAO

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On the other hand, there is a steady decline in the U.S timber land since 1962 (Figure 2) which is being exacerbated by shrinking availability of the existing stands. Urban development, environmental constraints, limited accessibility in harsh weather, pests, landowner objectives - all contribute to decreased availability.

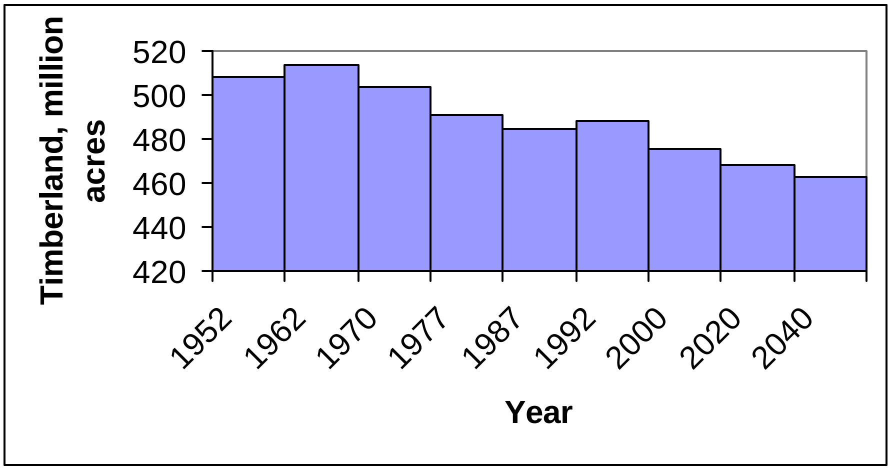

Figure 2. Decline in US timberland. Source: USDA

In fact, hardwoods in the upper Midwest and Southeast as well as softwoods in the Pacific Northwest are already scarce in some areas. The shortages vary by company, location, land use control and competition. In some years, mills in central South Carolina have had to haul wood from Tennessee which is about 400 miles round trip.

Environmental concerns such as mill effluent disposal, endangered species (red cockaded woodpecker in longleaf pine stands), wetland regulations, the sustainable forestry initiative, and biodiversity are all factors that are increasingly limiting availability.

In summary, the demand for hardwood and softwood fibers will surpass the actual availability while environmental pressure is rising. This creates a challenge to the paper companies - whoever meets it will win the competition.

Several options exist in order to meet the challenge:

1. Increase land base in the U.S.
2. Increase land base overseas
3. Import raw materials in the open market
4. Increase productivity of timberlands through intense management

John A. Luke, Jr. - Westvaco CEO and Chairman wrote: “The future of U.S. forestry can be framed in terms of gaps that need to be bridged in order to meet our competition. There are five: Information, Resources, Technology, Funding and Talent.”

We will address the technology gap, which intense management suppose to bridge it. What Is intense management? Currently the definition includes site preparation, high density planting, competition control and fertilization. The expanded definition will also include fertigation.

A drip fertigation system consists of a permanently installed delivery system which frequently applies water and nutrients. The benefit of such a system is that water and nutrition stresses are eliminated. Thus, plant growth potential is realized in an environmentally friendly manner.

As was mentioned previously, the ability of fertigation systems to increase productivity is a fact, and what remains to be seen is if it pays. To answer that question we need to know the economics of fertigated plantations today, and also the current and future direction of wood costs. The production of fertigated plantations will be determined by the following factors:

Income	Yield potential - 130-150 GT/Ac or 50 - 55 cords/Ac Assuming 600 trees/Ac, Ave. 7”-9” DBH & 70’ high, 6 years rotation.
Inputs:	
Land Cost	$300.00 - $1,000.00 depending on location, soil type, vegetation
Establishment / Regeneration Costs	$43.00 - $57.00 per acre (planting, site prep., competition control, lime)
Fixed costs	$1,000.00 - $2,000.00 per acre (well & pump, irrigation system & installation, equipment maintenance, vehicles, etc.)
Variable costs	$200.00 - $250.00 per acre (energy, repair & maintenance, manpower, fertilizer, pest control)

Based on these figures the break-even point is $75.00 / cord. Assuming 16% internal rate of return (double the interest rate), the market price should be at $90.00 / cord.

In a sensitivity analysis, it has been found that the yield (tree size, rotation period) and the system cost are the most significant factors affecting the break-even point.

In certain locations, in some periods of the year, in certain years, the market cost exceeded the cost of production (Figure 3).

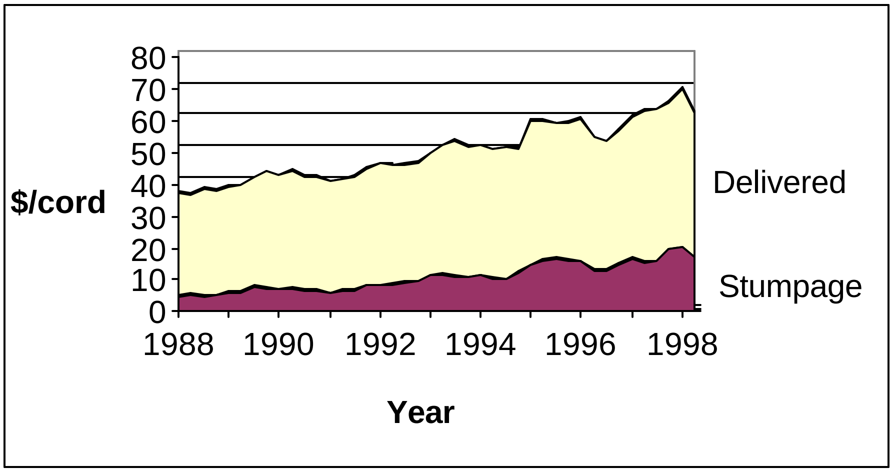

Figure 3. Hardwood pulpwood values in the Southeast

The trend of the cost line is toward constant increase (Figure 4). This means that in the near future the production costs in more fiber farms in the Southeast will be below the market price.

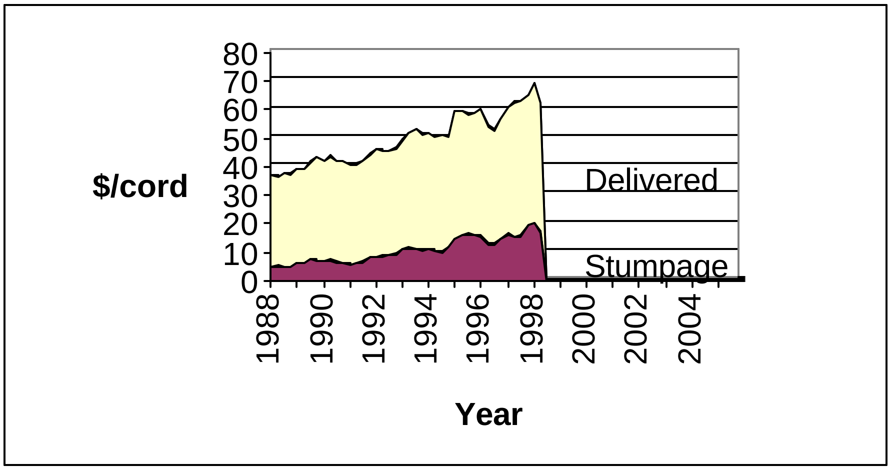

Figure 4. Hardwood pulpwood values in the Southeast and projected trend.

Actually, in the year 2004 (which is one rotation from now) the average market price in some states in the Southeast will exceed the production costs by a significant margin (Figure 5).

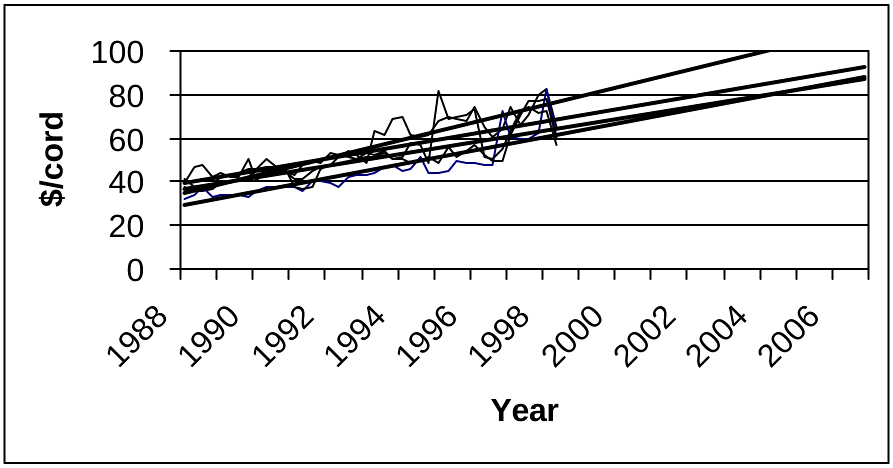

Figure 5. Delivered hardwood pulpwood values; average trends for four states in the Southeast.

There are some “soft “ issues that may become additional drivers to move toward fiber farming. Mill water re-use, environmental threats to landbase, fast track genetic improvements, increase mill efficiencies with mono-culture, ability to directly control resource, cost and availability - just to name a few.

Globally, the demand is outpacing supply and will drive up pulp prices. The challenge is to increase productivity while managing costs. Economics now favor fertigated hardwood plantations. This option will become more attractive as pulp prices increase.

Herbicide Registration and Labeling for Use in Short Rotation Woody Crops

Jeffrey Birk
Cyanamid Agricultural Research Center, American Cyanamid Company
P.O. Box 400 Princeton, NJ 08543-0400

Abstract

With increased interest in the production of short rotation woody crops (SRWC), trees are often being grown and managed more like row-crops and less like forest products. The adoption of row-crop practices for purposes of producing SRWC has caused producers to look to agronomic herbicides for solutions to their weed control problems. Herbicides currently registered for use in agronomic crops often have use rate limitations and/or other restrictions that diminish their effectiveness for weed control in SRWC. Questions concerning limitations on use rate and application frequency are often asked by SRWC producers when trying to use agronomic herbicides for weed control. An understanding of the herbicide registration process and requirements can answer these questions and help assure that SRWC production needs are considered when a new herbicide is being developed and registered for use.

Introduction

Like the production of many crops, control of competitive vegetation during establishment and early growth of short rotation woody crops (SRWC) is essential. Control of competitive vegetation helps insure survival of the stand and allows for greater growth, free of competition for light, nutrients and water. Vegetation control can be achieved with mechanical and/or chemical means. Traditional mechanical weed control methods such as mowing and cultivation, while effective, can cause mechanical damage to newly planted trees and stand loss. Mechanical methods must also be repeated throughout the growing season to maintain relatively weed free conditions. Chemical weed control through the use of herbicides offers certain advantages over mechanical weed control, provided appropriate herbicides are available to the grower. Herbicides applied either alone or in combinations have the potential to offer season long weed control with acceptable tree tolerance. Lack of herbicide tolerance after bud break and the long growing season, particularly in southern latitudes can be a challenge to herbicide users. Additionally the availability of herbicides suitable for use in SRWC is limited. Herbicides currently being used in SRWC were developed for traditional row crop and/or noncrop uses.

Registration of new herbicides for use in short rotation woody crops

Environmental Protection Agency (EPA) registration of new herbicides for use in short rotation woody crops (SRWC) can be accomplished in two ways. The quickest and easiest method is to add SRWC use (fiber farm, hardwood release, etc.) and necessary use directions to an existing product label and submit for EPA approval. The more lengthy and costly option is to develop and register a new active ingredient for use in SWRC.

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Development and registration of new herbicide active ingredient for non-food uses such as SRWC

Development and registration of a new active ingredient for non-food herbicide use such as SRWC would require a minimum of three to five years development time at a cost of 25 million dollars and one to three years for EPA review. Development would include field efficacy trials, formulation development, manufacturing process development, and the conduct of required EPA guideline studies for the registration of a new active ingredient and product formulation. These required studies include the areas of mammalian toxicology (acute and mutagenicity), toxicity to non-target plants and wildlife (aquatic invertebrates, fish and birds), environmental fate (degradation in soil and water, leaching potential, and field dissipation) and plant protection (seed germination, seedling emergence, vegetation vigor and aquatic plant growth). In addition product chemistry and acute toxicity studies are required for the herbicide formulations being registered.

Clearly the development and registration of a new herbicide active ingredient requires a large commitment of both human and financial resources. One question that must be asked when considering the development and registration of a new herbicide is, what is the market potential for such a product and do potential sales justify the investments of time and money? It is unlikely that a company could justify the development of a new herbicide for use solely in SRWC. A more likely scenario would be that the decision to develop a new herbicide would be based on a larger market opportunity such as a major agronomic crop with additional use potential in industrial, forestry and/or SRWC markets.

Addition of SRWC use to existing herbicide product label

If an existing herbicide has been shown to have potential utility for weed control in SRWC, the herbicide label can be easily amended to include use in SRWC. By adding an appropriate site description (fiber farm) to the label and necessary use directions, the label can be submitted to the EPA for approval. If use directions (application timing, rate, target species) do not vary significantly from those of the existing product label, then EPA approval can be expected within two to six months from the time of submission. Once approved by the EPA, new container labeling can be prepared or a supplemental label can be issued to support the use.

Depending on the herbicide being used, additional changes to the existing product label may be necessary to allow for use in SRWC. Preexisting geographical restrictions (states, portions of states) may need to be changed to allow for use in areas growing SRWC. Soil texture or pH restrictions may need to be address with regard to the SRWC use. Also species controlled, application rates, tank mix partners and application timings may need to be modified. These changes may require additional time for EPA review.

Unlike row crops such as corn and soybeans, that typically require effective weed control for the first few months after planting or until canopy closer, hardwood trees grown as SRWC, require full season weed control for at least the first two to three years after establishment. For this reason, herbicide rates typically used in row crops, may not be adequate for season long weed control in SRWC. The maximum rate per acre per year at which a herbicide can be applied is generally dictated by the rate at which field dissipation studies were conducted for registration of the herbicide active ingredient. This rate may or may not be greater than the current labeled use rate. If higher use rates are desired for use in SRWC, then the conduct of additional soil dissipation studies would be required to support the higher use rate.

Summary

As the need for efficient production of hardwood fiber increases, producers will continue to look for more effective means of weed control. Current herbicide options have been selected from available crop, industrial and forestry use herbicides. Required label changes for the adaptation of existing herbicide products for use in SRWC can be minimal, but optimization of a given herbicide active ingredient for use in SRWC may require significant label changes, necessitating the conduct of additional EPA guideline studies to support the desired label changes. The development and EPA registration of a new active ingredient for use solely in the SRWC market is likely to be cost prohibitive, but the SRWC herbicide market will continue to grow and should be remembered as an additional use for new herbicides being developed for other markets.

An Integrated Approach to Rodent Damage Management in Hybrid Poplar Plantations

Brian W. Moser, Pest Management Coordinator/Wildlife Biologist
Potlatch Corporation Hybrid Poplar Program
P.O. Box 38, Homestead Lane, Boardman, OR 97818

Abstract: Voles (*Microtus* spp.) can cause extensive girdling damage to tree orchards and plantations during periods of peak population densities. Integrated Pest Management (IPM) concepts can be useful in managing rodent populations in intensively managed plantations. IPM practices such as population monitoring, knowledge of the pest's biology, and a combination of biological, cultural, genetic, chemical, and physical controls are necessary in order to effectively manage rodent pests on a large scale. Various vole monitoring and control techniques are presented and their uses and limitations are discussed .

Keywords: Voles, *Microtus*, integrated pest management, animal damage management, hybrid poplar

Introduction

The potential for hybrid poplars to produce large amounts of biomass in a relatively short rotation period has resulted in extensive efforts by several companies to establish irrigated plantations in the Columbia Basin of eastern Oregon and Washington. Initial start-up costs, as well as maintenance of these high-tech operations are very expensive. In order for these operations to prove profitable, the cost of producing poplar fiber must be kept to a minimum.

Wildlife damage to hybrid poplar plantations is a serious threat to the economical production of short-rotation wood fiber. Many species of wildlife have the potential for causing damage through their foraging activities, including rodents, lagomorphs, and deer. Rodent damage to the trees appears to be the largest problem at this time. Rodents feed on the cambium of the lower boles by chewing away the bark and eventually girdling the tree (Hygnstrom et al. 1994). Partially damaged trees may show signs of stunted growth due to nutrient deficiencies, and insects and diseases can become established at the damage points. In addition, partially girdled trees are more susceptible to blow down by high winds. Furthermore, completely girdled trees will die and result in a complete economic loss.

A review of the relevant literature suggests that microtine rodents (voles) are the species causing the damage to the trees (Hygnstrom et al. 1994). Two vole species have been documented to occur on hybrid poplar plantations in eastern Oregon that can potentially cause damage to trees. These species are the montane vole (*Microtus montanus*) and the long-tailed vole (*Microtus longicaudus*).

Vole damage to forest and agricultural plantations has been documented in Europe (Hansson 1986, Hornfeldt et al. 1986), Asia (Sullivan 1991), and North America (Askham 1988, Kennedy et al. 1989, Sullivan and Martin 1991). Vole populations in these northern latitudes tend to have cyclic fluctuations every 3-5 years (Krebs and Myers 1974, Taitt and Krebs 1985). Extensive tree damage often occurs during the peak years of these cycles, when population densities have been reported to reach up to 25,000/acre (Hygnstrom et al. 1994). Unless control measures are taken, economic losses to plantations during peak years can be devastating.

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Traditional control programs for vole damage have generally been limited to the application of toxic baits when damage to trees becomes apparent. However, relying only on one technique limits the effectiveness of one's control program. Furthermore, taking control measures after the damage has occurred results in an unacceptable economic loss. A more effective approach would be to utilize integrated pest management (IPM) strategies such as population monitoring in order to determine when to apply control measures. In addition, rather than relying on one control method, a variety of methods should be used, some of which are more preventative than others. Using an integrated approach to vole management is more cost effective, more environmentally sound, and results in reduced damage to plantations.

Monitoring

Monitoring techniques can be broken down into two broad categories: 1) monitoring the vole population; 2) monitoring the vole activity. Each method has its advantages and disadvantages, as outlined below.

Population Monitoring

Monitoring is accomplished by trapping individuals in order to estimate the population size at that point in time. Usually a standardized capture rate (e.g., # animals captured per 100 trapnights) is used to describe the population rather than trying to estimate the total number of animals in the population. Although population models are available that attempt to estimate population sizes (White et al. 1982), these often complicated models are not necessary in order to effectively monitor rodent populations. Population monitoring is conducted over time in order to identify trends in population fluctuations.

Several methods can be employed to trap voles. Live-trapping with box-traps, kill-trapping with snap-traps, and both live-trapping and kill-trapping with pitfall traps have all been shown to be effective, depending on the vole species in question. Some vole species are more prone to one trap type over another, therefore it is essential that you know which species you are dealing with so that you can trap with the most effective trap type available (Boonstra and Rodd 1983, Williams and Braun 1983, Korn 1986, McComb et al. 1991). Regardless of which trap type you use, it is essential to place the traps near the vole's runway. Voles use these subnivean runways almost exclusively, and spend very little time simply wandering randomly like some mouse species.

Traps can be arranged in either grids or transects. Standard trap spacing is usually 10 to 15 meters apart. Generally, traps are set in the evening and checked in the morning. Traps should be set for a minimum of 2 nights in a row, preferably 3 or more because some vole species have shown an aversiveness to traps until they become used to them after 2 or 3 days. In addition, trapping for a longer period allows you to collect more data on the vole population. If live-trapping techniques are used, captured animals should be marked so that if they are recaptured later they will not be counted twice.

Trapping should be conducted on permanent plots at least 4 times per year in order to identify both seasonal and annual population fluctuations. Different age classes should be treated as unique habitats due to the differences that can be found in the understory vegetation. Trapping and management decisions should be tailored to fit the needs of each age class. Also, a standard trapping protocol should be adhered to in order to compare trapping results between different fields and different trapping times.

When choosing a trap type, one should consider not only its effectiveness but also the time investment it takes to set and check the traps. Although box-traps are usually very effective, they are also the most time consuming due to the fact that each animal captured has to be handled while it is alive, which complicates the data collection. In addition, some live traps are bulky and more difficult to transport than smaller traps such as snap-traps. If used, box-traps can be baited with peanut butter or rolled oats.

Snap-traps are easy to set and transport, and are often less expensive than box-traps. Standard mousetraps are usually too small to effectively use on voles, of which most species are larger than house mice. A more effective trap is the Museum Special, which has been used effectively by field biologists for years to trap animals as small as mice and as large as chipmunks. These traps can be most easily baited with peanut butter, and most animals are killed instantly upon capture making it relatively simple to collect the necessary data.

Pitfall traps can be used as either kill-traps or live-traps. When used as kill-traps, they are often filled with water or a preservative so that drowned animals are kept in a suitable condition for identification later. Smaller canisters (such as 2 lb. coffee cans) can be used if they are filled with fluid to prevent escape. Otherwise, containers as large as 5-gallon pails can be effectively used. Once pitfall traps are buried, they can be left permanently and covered when not in use. This makes for a large initial time investment but significantly reduces the time that would normally be needed to transport them in the future. Pitfall traps can be initially set and then checked as infrequently as once a week. An advantage is that the trap never becomes full as a box-trap or snap-trap does. It is constantly trapping over the entire time period. Once the trapping period is over, the pitfalls can be checked. Besides requiring less time investment, pitfall traps are often the least expensive because they can frequently be obtained for free.

Once trapping has been carried out 2 or 3 times during the year, you will begin to understand which habitats voles prefer, and you will begin to sense the relationship of vole population densities and tree damage. Once this relationship unravels, you will know when you need to employ control methods.

Activity Monitoring

Several methods are available to monitor vole activity in plantations rather than directly monitoring the populations (Byers 1975, Tobin et al. 1992). The apple slice index (ASI) has been effectively used in apple orchards (Byers 1975) to evaluate presence/absence of voles. Apple slices are placed in a grid pattern or transect and left overnight. Slices are evaluated in the morning for signs of gnawing. One assumption is that it is voles gnawing on the apple slices and not another animal. The number of apple slices either missing or containing chew marks can be tallied and used as an index of vole activity. This is a quick, inexpensive method for assessing vole activity.

Another method that is more qualitative than quantitative is to simply look for vole activity in the plantation (Tobin et al. 1992). Signs to look for include runways that have no vegetation growing in them, grass clippings and feces in the runways, and burrow entrances in the plantation. These signs will indicate presence/absence but may not reveal population levels.

Yet another technique to monitor vole activity is to monitor the new tree damage within the plantation. This data can be collected during annual crop assessment data collection. An obvious drawback to this method is that the damage has already occurred by the time it is noticed. Therefore, this method should only be used as a supplemental technique to monitoring vole populations and to assess annual damage to the plantation.

Control Methods

Control methods for voles in plantations can be divided into 5 broad categories: 1) cultural; 2) biological; 3) genetic; 4) physical; and 5) chemical. Usually a combination of control methods works best rather than relying on only one method.

Cultural control is defined as any method that reduces vole habitat within and around the plantation. This includes the use of cultivation, herbicides, and burning. Cultural control is probably the most important means of vole management (Spencer and Barrett 1980, Davies and Pepper 1987, Hygnstrom et al. 1994). Voles will usually thrive in any environment where heavy vegetative cover, especially grasses, abound. This is because voles rely on grasses and forbs as food and cover during most of the year. Any effort to reduce ground cover usually results in a reduction of the vole population. Furthermore, cultivation not only reduces understory vegetation but it also destroys the burrow systems. Digging new burrows requires tremendous amounts of energy by the voles and often results in reduced physical fitness due to the extra stress. This can lead to a further reduction in the population. It is important to control vegetation around the base of the trees. Controlling vegetation between rows will reduce vole populations, but it also may cause voles to utilize the vegetation in the tree rows. Voles will often feed on trees that are covered by vegetation because this vegetation affords the voles cover from predators (B. W. Moser, unpublished data).

Biological controls are those that occur naturally. Often, these controls can be enhanced. For example, nest boxes for raptors can be placed on plantations to encourage avian predators to hunt and rear young on the plantations. In addition, perches can be placed at strategic points to encourage hunting in these areas. Furthermore, terrestrial predators can be managed in such a way as to encourage their populations to flourish. Simply allowing predators such as coyotes and snakes to roam free without being harassed will often result in an increase in their population densities. It must be noted that biological controls themselves will not completely control rodent populations (Sullivan and Sullivan 1980, Askham 1990). Biological controls work best when used in conjunction with other control methods.

Genetic control is defined as using specific planting material that is naturally resistant to herbivores. Studies have shown that some tree species and certain clones are naturally resistant to mammalian herbivores (Jogia et al. 1989, Bucyanayandi et al. 1990, Hansson 1994, Bergeron et al. 1998). Tree species and varieties within species often differ in their chemical composition of secondary compounds, which are used as a natural defense against herbivores. Secondary compounds are often found at different levels in trees depending on the species, geographical origin, and/or clone. Identification of planting material that has relatively high levels of secondary compounds would be advantageous in the fight against voles. In addition, it may be possible to transfer the genes responsible for the production of secondary compounds from one tree to another using advanced genetic engineering techniques (Jermy 1990).

Physical barriers can be placed around the bases of trees to deter voles from feeding. This approach has been shown to be effective in reducing vole damage to lodgepole pine seedlings (Zimmerling and Zimmerling 1998) as well as hardwood seedlings (Davies and Pepper 1989). Materials that have been historically used include plastic and wire mesh, metal flashing, and PVC pipe. Although this can be an effective method, it can also be cost prohibitive on a large scale. Research is currently underway on other physical barriers such as rodent fences to keep voles from immigrating into agricultural fields (G. W. Witmer, personal communication). Trapping is another method of physical control. Although effective in killing voles, it is usually inefficient on a large scale due to the labor-intensive nature of trapping.

Chemical controls should be relied upon when a combination of the other four controls fail—and they will. Traditionally, acute toxicants such as zinc phosphide formulations have been found to be most effective against voles (Hunter et al. 1987). However, rodents can develop a resistance to zinc phosphide baits if they consume a sublethal dose and become ill. Rodents generally do not develop a resistance to anticoagulants. However, they must consume more of these baits over a longer period of time in order for them to be effective. Due to environmental constraints such as the threat of wet weather during the baiting period, these baits often aren't as effective. Both of these toxicants can be applied either aerially or by ground equipment. It is important to apply them during dry periods so that they will not deteriorate before being consumed. This is often during the fall, when vole populations are usually at their annual peak. During periods of high rodent densities multiple applications may have to be made in order to get effective control. Hunter et al. (1987) found that zinc phosphide baits were most effective when used after mowing and/or raking the understory vegetation.

Repellents are another class of chemicals that are intended to deter feeding by voles. A number of topical repellents are available, however few if any actually work under field conditions and most are relatively expensive. This is another area where further research is needed to identify effective compounds that will work under the harshest of conditions.

Conclusion

Although it is very difficult to completely eliminate vole damage to large plantations, damage reduction is possible when using an integrated approach to vole management. Population monitoring is essential to understand when to begin taking reactive control measures such as applying toxicants. In addition, taking proactive control measures such as controlling vegetation and enhancing habitat for predators is also helpful in reducing the chance of a large outbreak of voles. Using a combination of control methods will usually provide the greatest results in the struggle against the vole in plantation management.

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Imazaquin Applications for Competition Control in Eastern Cottonwood (Populus deltoides) Plantations

Andrew W. Ezell
Department of Forestry, Mississippi State University, Starkville, MS

Jeff Portwood
Crown-Vantage Corporation, Vicksburg, MS

Harry Quicke
American Cyanamid Company, Auburn, AL

Abstract

Imazaquin was applied in screening trials overtop both dormant (prebudbreak) and actively growing eastern cottonwood (Populus deltoides) cuttings. Rates of application during the prebudbreak trials were 0.125, 0.25 and 0.50 lb ae/A with three replications of each treatment at sites on Fitler Managed Forest near Vicksburg, Mississippi. None of the treatments damaged the cottonwoods and all provided good competition control with the 0.25 and 0.50 lb rates providing excellent control for up to 90 days after treatment (DAT). After that time, the residual control in the 0.50 lb treatment was significantly greater than in the other rates.

In the trials overtop actively growing trees, imazaquin was applied in May to plots which had received a preemergent treatment. Three rates, 0.125, 0.25 and 0.50 lb ae/A, were used with three replications of each treatment on Fitler Managed Forest. Again, none of the treatments damaged the cottonwoods. The plots were evaluated at 7, 30, 45, 60 and 90 DAT with all the treatments providing good weed control for the duration of the study. However, the 0.25 and 0.50 lb rates exhibited greater residual activity in the 90 DAT evaluation.

In 1997, imazaquin was applied in the form of Scepter 70DG as a postemergent treatment overtop actively growing cottonwood. Rates of application were 0.11, 0.22 and 0.44 lb ae/A. In addition, a tank mix of 0.22 lb ae/A imazaquin and 2 lb ai/A pendamethalin was applied. All treatments were replicated three times at study locations on Fitler Managed Forest and near Wickliffe, Kentucky. None of the imazaquin treatments damaged the cottonwoods but the addition of pendimethalin could result in a negative crop growth response relative to straight imazaquin when used overtop actively growing cottonwood. No surfactants were added to any of the treatments in an effort to evaluate crop tolerance to the herbicide.

Of particular note was the competition control in the 1997 treatments which were applied to areas that had not received any preemergent herbicide treatment. Weed control in the 1997 plots was poor when compared to the screening trial results. At 8 weeks after treatment, percent clear ground averaged less than 20% at Wickliffe and less than 30% at Fitler as compared to 60-70% in the earlier trials. The importance of preemergent applications is demonstrated in order to obtain optimum efficacy.

In summary, imazaquin demonstrates excellent competition control crop safety when applied to eastern cottonwoods or hybrid poplars. It has excellent potential for use in plantation management.

Keywords: Imazaquin, eastern cottonwood, preemergent, postemergent

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Introduction

Eastern cottonwood is a tree species capable of rapid growth when planted on appropriate sites and given sufficient cultural treatment to ensure establishment and early development. This species is extremely sensitive to all forms of competition, and one of the greatest threats to successful establishment of cottonwood plantations is competition from undesirable vegetation. The successful establishment of eastern cottonwood plantations depends on a wide variety of factors including sufficient site preparation, critical attention to spacing, use of properly prepared cuttings, and competition control. In addition to competing for the resources of the site, undesirable vegetation also increases the difficulty of early cultivation by decreasing the operator's ability to see the planted row. Historically, mechanical cultivation was the only competition control used in cottonwood plantations and while this form of cultivation may be important for aeration and competition control, it can result in serious injury and/or mortality to young cottonwood sprouts. Any delays in mechanical cultivation which are caused by inclement weather and unacceptable site condition only result in greater growth and development of competing vegetation and concomitant increased growth loss and damage to the eastern cottonwood.

Previous studies have demonstrated the efficacy of preemergent herbicide applications for eastern cottonwood plantations and the impact on first-year survival. This paper will discuss the efforts to develop alternatives for both pre- and postemergent competition control.

Imazaquin is a herbicide which has demonstrated control on a wide spectrum of herbaceous plants. This material also had great potential for crop tolerance by the cottonwood. This paper reports on the initial screening trials and subsequent field examinations regarding the use of imazaquin in either pre- or postemergent applications over planted eastern cottonwood cuttings.

Study Objectives

The objectives of these combined field studies were as follows:

(1) to evaluate the efficacy of imazaquin for herbaceous weed control in either preemergent or postemergent applications.

(2) to evaluate the crop tolerance response of eastern cottonwood to various rates of imazaquin applied at either preemergent or postemergent timings.

Materials and Methods

Study Sites

All screening trials were conducted on Fitler Managed Forest which is approximately 30 miles north of Vicksburg, MS. The 1997 postemergent field trials were installed both at Fitler Managed Forest and on Westvaco Corp. land which is located near Wickliffe, Kentucky.

Treatments

Between 1992-1995, imazaquin was applied in the form of Scepter herbicide at the rate of 0.125, 0.25, and 0.50 lb ae/A in both pre- and postemergent screening trials (hereafter referred to as 'screening trials'). In the 1997 postemergent field trials, imazaquin was applied in the form of Scepter 70 DG at the rate of 0.11, 0.22, and 0.44 lb ae/A. In addition, a tank mix of 0.22 lb ae/A imazaquin and 2 lb ai/A pendamethalin was applied in 1997. All treatments in all studies were replicated three times with each treatment applied over-the-top of the planted cottonwoods. Preemergent applications were completed in January*, and postemergent treatments were applied in mid-May**.

* applied prior to bud break
** applied after leaves developed and actively growing

Applications were completed with a CO_2 powered backpack sprayer utilizing a TK2.5 Floodjet nozzle in the screening trials and a 4-nozzle boom with 8002 tips in the 1997 field trials. All treatments used a total spray volume of 20 gallons per acre, and no surfactant was added to any of the mixtures. Each treatment plot was a swath 6 feet wide and 300 feet long with the planted cottonwoods serving as the center line of the treated plot.

Evaluation

Plots were evaluated at 30, 60, 90, and 120 days after treatment (DAT) in the preemergent screening trials for both competition control efficacy and crop tree damages. In the postemergent trials, evaluations were completed at 7, 30, 45, 60 and 90 DAT for the same variables. All evaluations were completed by ocular estimates, and crop trees were examined closely for any damage symptoms including foliar discoloration or necrosis, fasciculation, rosetting, stunting, or terminal dieback.

Results

Screening Trials

None of the treatments damaged the cottonwoods in either test. All the treatments provided good competition control with the 0.25 and 0.50 lb rates providing excellent control for 90 DAT (Table 1). A rate response was evident by the 90 DAT evaluations, and after that time, residual control in the 0.50 lb treatment was significantly greater than the other rates in the preemergent trials. The 0.25 and 0.50 lb rates both exhibited greater residual activity in the 90 DAT evaluations for the postemergent screening trial (Table 1).

The level of competition control at 60 and 90 DAT is a significant item for comparison to the 1997 study. The postemergent screening trial was installed on an area which had received operational preemergent treatment. In 1997, the study was installed on areas which had not received any preemergent applications at either study location.

1997 Field Trial

Weed control in the 1997 study was poor when compared to the earlier screening trials. At 60 DAT, average percent clear ground ranged from 20 to 33 percent at Fitler and 10 to 17 percent at Wickliffe for the imazaquin treatments (Table 2). Adding pendamethalin increased competition control, but could result in a negative growth response when applied to actively growing cottonwoods. When compared to the 60-70 percent clear ground at 60 DAT in the screening trials, the importance of preemergent applications is clearly demonstrated if optimum efficacy is to be obtained.

Table 1. Percent clear ground in imazaquin screening plots over eastern cottonwood (average all reps)

Treatment -- lb ae/A —	**Evaluation Timing (DAT)[1]**			
	30	**60**	**90**	**120**
	- - - - - - - - - - - *percent* - - - - - - - - - - -			
Preemergent				
0.125	**73**	**70**	**53**	**13**
0.25	**77**	**75**	**60**	**20**
0.50	**80**	**80**	**67**	**33**
Postemergent				
0.125	**70**	**66**	**27**	**-**
0.25	**80**	**66**	**43**	**-**
0.50	**85**	**66**	**50**	**-**

[1] DAT = days after treatment

Table 2. Percent clear ground in the 1997 imazaquin field trials at 60 DAT[1] evaluation time (average all reps).

Herbicide	**Rate**	**Location**	
		Fitler	***Wickliffe***
		- - - - - - - ***Percent*** - - - - - - -	
Scepter 70 DG	0.11 lb ae/A	20	17
Scepter 70 DG	0.22 lb ae/A	20	10
Scepter 70 DG + Pendamethalin	0.22 lb ae/A 2.00 lb ai/A	56	32
Scepter 70 DG	0.44 lb ae/A	33	33

[1] DAT = days after treatment

Summary

Overall, imazaquin has demonstrated an exceptional combination of competition control and crop tolerance in these field studies. Scepter now has an approved label for use in cottonwood plantation management.

Specific points of interest from these field tests include:

1. Imazaquin did not damage eastern cottonwood in either preemergent or postemergent applications.
2. A slight rate response was evident, but 0.22 lb ae/A provided adequate control.
3. Preemergent control is essential if optimal results are to be obtained from postemergent applications.
4. Tank mixes with pendamethalin should be used as preemergent applications for best results.

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Appendix 1.
List of Conference Attendees and Authors

Lawrence P. Abrahamson
SUNY-ESF
1 Forestry Drive
Syracuse, NY 13210
Phone: 315-470-6777
Fax: 315-470-6934
E-mail: ceect@mailbox.syr.edu

Tom Agens
Boise Cascade Fiber Farm
PO Box 500
Wallula, WA 99363
Phone: 509-546-3445
Fax: 509-546-9964
E-mail: tom_agens@bc.com

R. Bruce Arnold
R.B. Arnold Associates, Inc.
130 West Lancaster Avenue
Suite 301
Wayne, PA 19087-4031
Phone: 610-964-9757
Fax: 610-431-0264

Emile Audy
Domtar Papers
609 12th Range Box 1010
Windsor, Quebec, Canada
Phone: 819-845-8543
Fax: 819-845-8230

Mike Bacca
Simpson Fiber Farms, Inc.
22400 Sour Grass Road
Corning, CA 96021-9325
Phone: 530-824-9756
Fax: 530-824-0578

Bill Bailey
American Cyanamid
PO Box 531
Shasta, CA 96087
Phone: 530-247-1315
Fax: 530-247-1320

Keith Baldwin
Champion International
PO Box 38
Alexandria, MN 56308
Phone: 320-834-3350
Fax: 320-834-3355
E-mail: trees@gctel.com

Ilan Bar
Netafim Irrigation
548 North Douglas Avenue
Altamonte Springs, FL 32714
Phone: 407-788-6352
Fax: 407-862-0259

Michael Bazett
Bazett and Associates
630 Montreal Street
Victoria, BC, Canada V8V 4Y2
Phone: 250-383-7518
Fax: 250-383-7517
E-mail: mbazett@direct.com

Bill Berguson
Natural Resources Research Institute
5013 Miler Trunk Highway
Duluth, MN 55811
Phone: 218-720-4296
Fax: 218-720-9410
E-mail: bberguso@sage.nrri.umn.edu

Jeff Birk
American Cyanamid Company
Agricultural Products Research Division
PO Box 400
Princeton, NJ 08543-400
Phone: 609-716-3134
Fax: 609-275-5238
E-mail: birkj@pt.cyanamid.com

Dr. John R. Blake
USDA Forest Service
Savannah River Institute
PO Box 700
New Ellerton, SC 29809

Phone: 803-725-8721
Fax: 803-725-1807

Robert P. “Perry” Bosshart
New England Forest Resources
Mead Publishing Paper Division
35 Hartford Street
Rumford, ME 04726
Phone: 207-369-2007
Fax: 207-369-2531
E-mail: rpbl@mead.com

Jeff Bradshaw
Netafim Irrigation
5470 East Home Avenue
Fresno, CA 93727
Phone: 209-453-6800
Fax: 209-453-6803

Dina Brown
Oregon State University
Yamhill County Extension
4401 SE Rice Lane
Amity, OR 97101
Phone: 503-835-3208
E-mail: dandj@macnet.com

Marilyn Buford
USDA Forest Service
Attn: Vegetation Management
and Protection Research
PO Box 96090
Washington, DC 20250
Phone: 202-205-1561
Fax: 202-205-2497
E-mail: mbuford/wo@fs.fed.us

Jill Calabro
University of Wisconsin
Department ot Forest Ecology and Mgt.
1630 Linden Drive
Madison, WI 53706
Phone: 608-265-9832
Fax: 608-292-9922
E-mail: jmc@plantpath.wisc.edu

Ami Charitan
Netatim Irrigation
5470 East Home Avencue
Fresno, CA 93727
Phone: 209-453-6800
Fax: 209-453-6803
Thomas M. Clonts
Stone Container Corporation
PO Box 21607
Columbia, SC 29221
Phone: 803-359-7232
Fax: 803-359-6822
E-mail: Thomas_Clonts@sto.com

Mark Coleman
USDA Forest Service
Forestry Sciences Lab
5985 Highway K
Rhinelander, WI 54501
Phone: 715-362-1145
Fax: 715-362-1166
E-mail: mcoleman@newnorth.net

David J. Cooper
Simpson Fiber Farms, Inc.
22400 Sour Grass Road
Corning, CA 96021-9325
Phone: 530-824-9756
Fax: 530-824-0578

Jeff Donohue
Boise Cascade Corporation
PO Box 1060
DeRidder, LA 70634
Phone: 318-462-4016
Fax: 318-462-4058
E-mail: Jeff_Donahue@bc.com

James A. “Jake” Eaton
Potlatch Corporation
PO Box 38
Boardman, OR 97826
Phone: 541-481-2620
Fax: 541-481-2623
E-mail: jaeaton@potlatchcorp.com

Henriette Emond
CH2M HILL
825 NE Multnomah

Suite 1300
Portland, OR 97232
Phone: 503-235-5022 ext.4347
Fax: 503-235-2445
E-mail: hemond@ch2m.com

Ray Ethel
Broadacres Nursery
PO Box 41
Hubbard, OR 97032
Phone: 503-981-6509
Fax: 503-981-6803
E-mail: broadacr@hqitcfarm.com

Andrew W. Ezell
Department of Forestry
Mississippi State University
Box 9681
Mississippi State, MS 39762
Phone: 601-325-1688
Fax: 601-325-8726
E-mail: andye@mces.msstate.edu

John Foote
Morbark Sales Corporation
PO Box 1000
Winn, MI 48896
Phone: 517-866-2381
Fax: 517-866-2280

David Foushee
Boise Cascade Corporation
307 West Industrial Road
Jackson, AL 36545
Phone: 334-246-8227
Fax: 334-246-1697
E-mail: David_Foushee@bc.com

Thomas Fox
Rayonier
PO Box 819
Yulee, FL 32041
Phone: 904-225-5393
Fax: 904-225-0370
E-mail: tom.fox@rayonier.com

William S. Fuller
Weyerhauser Technology Center
WTC 2B2
PO Box 2999
Tacoma, WA 98477-2999
Phone: 253-924-6120
Fax: 253-924-4239
E-mail: fullerb@wdni.com

Ana Paula Hahn
Westvaco Corporation
PO Box 1950
Summerville, SC 29484
Phone: 843-851-4741
Fax: 843-875-7185
E-mail: aphahn@westvaco.com

Fred Harned
Netafim Irrigation
5470 East Home Aveneue
Fresno, CA 93727
Phone: 209-453-6800
Fax: 209-453-6803

Bruce Hartsough
Bio and Ag Engineering
University of California
Davis, CA 95616
Phone: 530-752-8331
Fax: 530-752-2640
E-mail: brhartsough@ucdavis.edu

Gregory Harvey
United States Air Force
1801 10th Street
Area B WPAFB, OH 45434
Phone: 937-255-7716
Fax: 937-255-4155
E-mail: Gregory.Harvey@WPAFB-AF.MIL

Mark Hewitt
Netafirn Irrigation
540 Meadows Drive South
Richiand, WA 99352
Phone: 509-627-2626
Fax: 509-627-6565
E-mail: mhewitt@aol.com

Bryan B. Hobbs

B.B. Hobbs Company
PO Box 437
Darlington, SC 29540
Phone: 843-395-2120
Fax: 843-393-3595
E-mail: bbhobbs@flosc.net

Kurt Hollenstein
Oak Ridge National Laboratory
Environmental Science Division
PO Box 2008 MS 6185
Oak Ridge, TN 37831
Phone: 423-425-0741
Fax: 423-576-6661
E-mail: hollensteink@ornl.gov

Tom Houghtaling
Minnesota Power
30 West Superior Street
Duluth, MN 55802
Phone: 218-722-2641
Fax: 218-723-3916
E-mail: thoughtaling@mnpower.com

H.J. John Iverson
Domtar Forest Products
810 Second West Street
Cornwall, Ontario, Canada K6H 5S3
Phone: 613-938-4665
Fax: 613-938-4684

Jon Johnson
Poplar Research Program
Washington State University
7612 Pioneer Way East
Puyallup, WA 98375
Phone: 253-445-4522
Fax: 253-445-4569
E-mail: poplar@wsu.edu

Leonard R. Johnson
University of Idaho
Forest Products Department
Moscow, ID 83844-1132
Phone: 208-885-6600
Fax: 208-885-6226
E-mail: ljohnson@uidaho.edu

Jim Jordahl
CH2M HILL
825 NE Multnomah
Suite 1300
Portland. OR 97232
Phone: 503-235-5022 ext.4353
Fax: 503-235-2445
E-mail: jjordahl@ch2m.com
Chuck Kaiser
Fort James
Lower Columbia River Fiber Farm
79114 Collins Road
Clatskanie, OR 97016
Phone: 503-728-2171
Fax: 503-728-2721

Alan Kottwitz
Boise Cascade Fiber Farm
PO Box 500
Wallula, WA 99363
Phone: 509-546-3445
Fax: 509-546-9964
E-mail: alan_kottwitz@bc.com

Elliott P. Levine
US Department of Energy
Office of Industrial Technology
1000 Independence Avenue, SW
Washington, DC 20585
Phone: 202-586-1476
Fax: 202-586-7114
E-mail: elliott.levine@oit.doe.gov

Matthew W. Lowe
Temple-Inland Forest
PO Drawer N
Diboll, TX 75941
Phone: 409-829-1710
Fax: 409-829-7342
E-mail: mlowe@templeinland.com

Mark Madison
CH2M HILL
825 NE Multnomah
Suite 1300
Portland. OR 97232

Phone: 503-235-5022 ext. 4453
Fax: 503-235-2445
E-mail: mmadison@ch2m.com

Peter McAuliffe
Pacifica Poplars, Inc.
2190 Mowbray Court
Abbotsford. BC, Canada
Phone: 604-853-9693
Fax: 604-853-9444

Timothy P. McDonald
USDA Forest Service
520 DeVall Drive
Auburn, AL 36849-5418
Phone: 334-826-8700
Fax: 334-821-0037
E-mail: tmcdonald@srs_auburn@fs.fed.us

Wilma McNabb
Biofuels Feedstock Development Program
Oak Ridge National Laboratory
PO Box 2008
Oak Ridge, TN 37831-6422
Phone: 423-574-8029
Fax: 423-576-9939
E-mail: wmx@ornl.gov

Roy Merritt
Netafim Irrigation
5470 East Home Avenue
Fresno, CA 93727
Phone: 209-453-6800
Fax: 209-453-6803

Brian Merrymen
Edman Company
5224 l2th Street East
Tacoma, WA 98424
Phone: 253-922-5118
Fax: 253-922-5119
E-mail: edmanco@aol.com

Dr. J.G. John Mexal
Department of Agronomy
and Horticulture
PO Box 3Q
Las Cruces, NM 88003
Fax: 505-646-6041
E-mail:jmexal@nmsu.edu

Kevin C. Mills
Potlatch Corporation
PO Box 38 Homestead Lane
Boardman, OR 97818
Phone: 541-481-2620
Fax: 541-481-2518

Patrick Minogue
American Cyanamid
119 Devonshire Road
Warner Robins, GA 31088
Phone: 912-929-0806
Fax: 912-328-8612
E-mail:
Patrick_Minogue@py.cyanamid.com

Anthony Mollisch
Westvaco Corportaiton
P0 Box 1950
Summerville, SC 29484
Phone: 843-851-4658
Fax: 843-871-1035

Pat Moore
Potlatch Corporation
PO Box 38
Boardman, OR 97818
Phone: 541-481-2620
Fax: 541-481-2623
E-mail: pwmoore@potlatchcorp.com

Al Mortenson
Boise Cascade Fiber Farm
PO Box 500
Wallula, WA 99363
Phone: 509-546-3445
Fax: 509-546-9964
E-mail: al_mortenson@bc.com

Brian Moser
Potlatch Corporation
PO Box 38

Boardman, OR 97826
Phone: 541-481-2620
Fax: 541-481-2623
E-mail: bwmoser@potlatchcorp.com

Richard Moulton
Columbia-Pacific Resource and
Development
512 West End Place #2
Montesano, WA 98563
Phone: 360-249-4378
Fax: 360-249-4378

Neal R. Murdaugh
Westvaco Corporation
Route 1 Box 63
Olar, SC 29843
Phone: 803-368-8051
Fax: 803-368-8044
E-mail: nrmurda@westvaco.com

Tom Murn
Potlatch Corporation
PO Box 504
Cloquet, MN 55720
Phone: 218-879-0435
Fax: 218-879-0452
E-mail: tpmurn@potlatchcorp.com

Tom Nichols
Boise Cascade
8599 Yetra Lane
Cloquet, MN 55720
Phone: 218-244-3621
Fax: 218-879-4178
E-mail: Tom_Nichols@bc.com

Bill Nicholson
Potlatch Corporation
244 California Street
Suite 610
San Francisco, CA 94111
Phone:415-956-2973
Fax: 415-956-2971
E-mail: wjnichol@potlatchcorp.com

Christopher Nowak
SUNY-ESF
1 Forestry Drive
Syracuse, NY 13210

Hank Page
Jefferson Smurfit Corporation
P0 Box 626
Callahan, FL 32011
Phone: 904-879-3051
Fax: 904-879-1537
E-mail: hpage@smurfit.com

Bob Perlack
Oak Ridge National Laboratory
PO Box 2008
Building 4500 N
Oak Ridge, TN 37831-6205
Phone: 423-574-5186
Fax: 423-574-8884
E-mail: perlackrd@ornl.gov

Kent L. Pittard
DuPont Vegetation Management
111 Westview Place
Kalama, WA 98625
Phone: 360-673-1231
Fax: 360-673-1232

Steve Pottle
Boise Cascade Fiber Farm
PO Box 500
Wallula, WA 99363
Phone: 509-546-3445
Fax: 509-546-9964
E-mail: steve_pottle@bc.com

Harold Quicke
American Cyanamid
234 Pine Hills Avenue
Auburn, AL 36830
Phone: 334-821-8801
Fax: 334-821-8803
E-mail: harold_quicke@py.cyanamid.com

Clarence H. Rail
CHR Design Inc.
7129 NE 29th Street
Ankeny, IA 50021
Phone: 515-964-1169
Fax: 515-964-5284

Dwight Rainwater
Westvaco Corporation
PO Box 458
Wickliffe, KY 42087
Phone: 502-335-3151
Fax: 502-335-6290

Jim Rakestraw
Union Camp Corporation
PO Box 1391
Savannah, GA 31402
Phone: 912-238-7611
Fax: 912-238-7607
E-mail: jim.rakestraw@ucamp.com

Don Rice
Fort James
Lower Columbia River Fiber Farm
79114 Collins Road
Clatskanie, OR 97016
Phone: 503-728-2171
Fax: 503-728-2721
E-mail: riced@clatskanie.com

Heidi Rieckermann
Jefferson Smurfit Corporation
PO Box 626
Callahan,FL 32011
Phone: 904-879-3051
Fax: 904-879-1537

Anne Rilling
Jefferson Smurfit Corporation
PO Box 1469
Brewton, AL 36424
Phone: 334-867-8373
Fax: 334-867-8331
E-mail: arilling @smurfit.com

Daniel Robison
North Carolina State University
Box 8008 - Jordan Hall
Raleigh, NC 27695
Phone: 919-515-5314
Fax: 919-515-6193
E-mail: robison@cfr.ncsu.edu

Robert E. Rogers
Paciifica Poplars
#10 - 1065 Herring Gull Way
Parksville, BC, Canada V9P 2N1
Phone: 250-248-4672
Fax: 250-248-7389

Fred Roguske
Lake Country Resources
PO Box 1072
Willmar, MN 56201
Phone: 320-235-4431
Fax: 320-235-5489

Randall J. Rousseau
Westvaco Corporation
PO Box 458
Wickliffe, KY 42087
Phone: 502-335-6274
Fax: 502-335-6231
E-mail: rjrouss@westvaco.com

Terry Rucker
Boise Cascade Fiber Farm
P0 Box 500
Wallula, WA 99363
Phone: 509-546-3445
Fax: 509-546-9964
E-mail: terryrucker@bc.com

Regis Saint-Amand
Domtar Papers
609 12th Range Box 1010
Windsor, Quebec, Canada
Phone: 819-845-840
Fax: 819-845-8299

Bill Salisbury
Potlatch Corporation
PO Box 38 Homestead Lane
Boardman, OR 97818
Phone: 541-481-2620
Fax: 541-481-2518

Bill Schuette
Fort James Corporation
349 NW 7th Avenue
Camas, WA 98607
Phone: 360-834-8374
Fax: 360-834-8309
E-mail: Bill.Schuette@fortjamesmail.com

Zvi Sella
Netafim Irrigation
5470 East Home Aveneue
Fresno, CA 93727
Phone: 209-453-6800
Fax: 209-453-6803

Brian Sept
Boise Cascade Corporation
Midwest Woodlands
400 3rd Avenue East
International Falls, MN 56649-2446
Phone: 218-285-5859
Fax: 218-285-5211
E-mail: sept_brian@bc.com

James P. Shepard
NCASI
PO Box 141020
Gainesville, FL 326 14-1020
Phone: 352-377-4708 ext.227
Fax: 352-371-6557
E-mail: J_Shepard@src-ncasi.org

Gail M. Simonds
Westvaco Forest Resources
PO Box 458
Wickliffe, KY 42087
Phone: 502-33-6272
Fax: 502-335-6231
E-mail: gmsimon@westvaco.com

Jason Smesrud
CH2M HILL
825 NE Multnomah
Suite 1300
Portland, OR 97232
Phone: 503-235-5022 ext.4372
Fax: 503-235-2445
E-mail: jsmesrud@ch2m.com

Klaus Steinbeck
Warnell School of Forest Resources
University of Georgia
Athens, GA 30602
Phone: 706-542-1376
Fax: 706-542-8356
E-mail: ksteinbe@arches.uga.edu

Bryce Stokes
USDA Forest Service
P0 Box 96090
Washington, DC 20090-6090
Phone: 202-205-1147
Fax: 202-205-2497
E-mail: bstokes/wo@fs.fed.us

Louis Terblanche
Sappi Forests Ltd.
PO Box 1264
3100 Vryheld
South Africa
Phone: 27 381 81 1059
Fax: 27 381 81 1960

Virginia Tolbert
Oak Ridge National Laboratory
P0 Box 2008 MS 6422
Oak Ridge, TN 37821

Timothy A. Volk
SUNY-ESF
133 Illick Hall
Syracuse. NY 13210
Phone: 315-470-6774
Fax: 315-470-6934
E-mail: tavolk@mailbox.syr.edu

Chuck Wierman
Boise Cascade Fiber Farm
P0 Box 500
Wallula, WA 99363
Phone: 509-546-3445
Fax: 509-546-9964
E-mail: chuck_wierman@bc.com

George Wiltsee
Appel Consultants, Inc.
23905 Plaza Gavilan
Valencia, CA 91355
Phone: 805-253-3492
Fax: 805-253-3493
E-mail: gwiltsee@earthlink.net

Art Wiselogel
NREL
1617 Cole Boulevard
Golden, CO 80401
Phone: 303-275-4466
Fax: 303-275-3799
E-mail: art_wiselogel@nrel.gov

Lynn L. Wright
Oak Ridge National Laboratory
PO Box 20 MS 6422
Oak Ridge, TN 37831-6422
Phone: 423-574-7378
Fax: 423-576-8143
E-mail: wrightl@ornl.gov

Wayne D. Young
Domtar Forest Products
810 Second Street West
Cornwall, Ontario, Canada K6H 5S3
Phone: 613-938-4698
Fax: 613-938-4684

Mike Young
Champion International Corporation
PO Box 39
Norway, MI 49870
Phone: 906-563-7535
Fax: 906-563-7515
E-mail: youngm@champint.com

Appendix 2. Tour Itineraries

West Side Tour: Thursday, August 24, 1998

7:00 a.m. - 8:30 am	Leave Vancouver, WA and travel to Woodburn, OR
8:30 a.m. - 9:30 a.m.	Tour City of Woodburn, Poplar Tree Reuse Site
9:30 a.m. - 10:30 a.m.	Travel from Woodburn Site to McMinnville, OR
10:30 a.m. - 11:30 a.m.	Tour the Riverbend Landfill Site
11:30 a.m. - 1:00 p.m.	Travel from McMinnville Site to Clatskanie, OR Lunch at City Park
1:30 p.m. - 2:30 p.m.	Alternative Site Preparation Site (Howard Rototiller / Seppi Orchard Flail)
3:00 p.m. - 4:00 p.m.	American Cyanamid Field Trial (Harry Quicke)
4:30 p.m. - 5:00 p.m.	First Year Tree Plantation – Alternative Site Preparation Techniques
5:00 p.m. -	Return to Vancouver, WA

Thanks to the Fort James Corporation

East Side Tour: Friday, August 25, 1998

7:00 a.m. - 10: a.m.	Travel to Boardman, OR
10:00 a.m. - 10:45 a.m.	Potlatch: test site
10:45 a.m. - 11:15 a.m.	Potlatch: irrigation conversion, site preparation, planting, weed control, etc.
11:15a.m.- 11:30a.m.	Potlatch: driving tour of tree development: rl,r2,r3
11:30 a.m. - 1:00 p.m.	Potlatch Office: lunch, tours and discussion of automated scheduling system
1:00 p.m. - 1:30 p.m.	(Optional stop) Boise Cascade: r7, discussion of tree development and management – weather, diseases, insects, etc.
1:30 p.m. - 2:30 p.m.	Boise Cascade: harvesting, site clean-up
2:30 p.m. - 3:00 p.m.	Boise Cascade: site preparation and replanting
3:00 p.m. - 6:00 p.m.	Return to Vancouver, WA

Lunch hosted by the Drip In Irrigation Company

Thanks to the Potlatch Corporation and the Boise Cascade Corporation

Appendix 3.

SRWC OWG Steering Committee Minutes
Monday, Aug. 24, 1998, Vancouver, WA

Administrative discussions

Dues: Suggestion made to charge membership fee for the proceedings. In other words, the proceedings from the meetings are available free to members. Since we need to make membership a worthwhile venture, we should not put the proceedings on the Web Site, until shortly before the next meeting. The proceedings would be used as an advertising tool.

Tax ID number: Some institutions could not write a membership check without having one. Jim Shepard said that he would look into getting a not-for-profit recognition for the group.

Web Site: The Steering committee agreed that a simpler, more direct web site location would be desirable. Lynn and Bob agreed to work on getting a more directly accessible web site address. The address will be advertised in the next newsletter and on other related web sites. It was suggested that we have a counter on the web site. (Ed. Note: The new web address is WWW.WoodyCrops.org.)

Forest Service support: Bryce Stokes indicated that he was trying to drum up more Forest Service support of the SRWC-ORG. He was encouraging several different Forest Service Research Stations to contribute funds to the group.

Activity suggestions from Steering Committee

Maintain the web site: It should provide quick reference to who is doing what, such as irrigation studies, references to other relevant information and special reports. Web site should have a counter to monitor it’s usage rate.

Keep a mailing list: Some debate about whether the mailing list should be on our web site for anyone to access or whether access should somehow be restricted. It was suggested that members be queried as to whether they felt comfortable about having their names openly available on the web site.

Produce a Newsletter: Frequency of at least 2 times per year. Keep newsletter on the web site and send out paper copies. A suggestion was made that we get some information from Brazil and Europe into the newsletter. Gail Simonds mentioned that Bill Hannon of Westvaco had just come back from Brazil and could be a good source of information.

Produce short executive summaries of research studies of interest to SRWC operations and publish in the newsletter.

Persuade companies and researchers to share anecdotal results of new methods in newsletter.

Organize technical committees around specific topics. Possible committee topics are: pesticide & herbicide regulations, nutrition, irrigation, harvesting, cultural practices. It was agreed that the Steering Committee would look for a champion for each area to form topical working groups, to accumulate information and to put notes in the newsletter. Volunteers for leadership of specific areas included Bruce Hartsough for harvesting, Harry Quicke for vegetation/pest control, Roy Merritt and Burt Aronoff for irigation, and Jon Johnson and Mark Coleman for fertilization/nutrition.

Organize regional working groups to stimulate more frequent contact on areas of shared interest within a region.

Create chat rooms or bulletin boards for people to share information on operations topics.

Continue holding meetings every other year. The idea of holding the next workship in New York with a focus on willow was well accepted. People enjoyed having the visitor from South Africa. It was suggested that we bring over 1 to 2 people from Europe to share their experiences with willow. Lynn Wright agreed to make that happen for the year 2000 meeting.

Persuade Morbark or other equipment manufacturers to provide demonstrations. Either use e-mail to inform SRWC-OWG members or provide the membership list to manufacturers to use in advertising demos.

As a result of the Steering committee discussions, a long list of possible activities was provided to the members in attendance and they were asked to establish priorities. The results were as follows:

Top priority (21 of 36 responses) – Publish timely summaries in newsletter.
Second Priority (20 of 36 responses) – Establish technical committees.
Third Priority (5 of 36 responses) – Focus on environmental issues.
Other areas of interest included – genetics, utilization issues, publicity and promotion activities

From the responses and comments, it could be discerned that the members wanted to see the web site provide the following types of information:

References to new publications
International links
Information on upcoming meetings or demonstrations of interest.

Appendix 4. SRWC OWG Steering Committee, 1998-1999

Voting Members

Lawrence Abrahamson, State University of New York
College of Environmental Science and Forestry
1 Forestry Drive, Syracuse, NY 13210
315-470-6777 phone, 315-470-6934 fax
ceext@mailbox.syr.edu

John Blake, USDA Forest Service
Savannah River Institute
P.O. Box 710, New Ellenton, SC 29809
803-725-8721 phone, 803-725-1807 fax
jblake/r8_savannahriver@fs.fed.us

John Foote, Morbark, Inc.
P.O. Box 1000, Winn, MN 48896
517-866-2381 phone, 517-866-2280 fax
morbark@worldnet.att.net

† Bruce Hartsough, University of California
Biological & Agric. Engineering, Davis, CA 95616
530-752-8331 phone, 530-752-2640 fax
brhartsough@ucdavis.edu

Tom Houghtaling, Minnesota Power Co.
30 W. Superior St., Duluth, MN 55802
218-722-2641 phone, 218-723-3916 fax
thoughtali@mnpower.com

Evan Hughes, Electric Power Research Institute
3412 Hillview Ave., Palo Alto, CA 94303
650-855-2179 phone, 650-855-2002 fax
ehughes@epri.com

Pat Moore, Potlatch Corporation
P.O. Box 38, Boardman, OR 97818
541-481-2620 phone, 541-481-2623 fax
pwmoore@potlatchcorp.com

Bob Perlack, Oak Ridge National Laboratory
P.O. Box 2008, Bldg 4500N, Oak Ridge, TN 37831
423-574-5186 phone, 423-574-8884 fax
perlackrd@ornl.gov

Steve Pottle, Boise Cascade Fiber Farm
P.O. 500, Wallula, WA 99363
509-546-3445 phone, 509-546-9964 fax
steve_pottle@bc.com

James Shepard, NCASI
P.O. Box 141020, Gainesville, FL 32614-1020
352-377-4708 ext. 227 phone, 352-371-6557 fax
j_shepard@src-ncasi.org

Gail Simonds, Westvaco-Timberlands
P.O. Box 458, Wickliffe, KY 42087
502-335-3151 phone, 502-335-3150 fax
gmsimon@westvaco.com

Ron Stoffel, MN Dept. of Natural Resources
2605 Aga Drive Unit 6, Alexandria, MN 56308
320-762-7812 phone, 320-762-5689 fax
ronald.stoffel@dnr.state.mn.us

Bryce Stokes, USDA Forest Service VMPR Staff
P.O. Box 96090, Washington, DC 20090-6090
202-205-1147 phone, 202-205-2497 fax
bstokes/wo@fs.fed.us

Bruce Upchurch, Union Camp Corporation Forest Engineering
P.O. Box 1391, Savannah, GA 31402
912-238-7113 phone, 912-238-7607 fax
bruce_upchurch@ucamp.com

‡ Lynn Wright, Oak Ridge National Laboratory
P.O. Box 2008, Building 1059, Oak Ridge, TN 37831-6422
423-574-7378 phone, 423-576-8143 fax
wrightll@ornl.gov

Nonvoting Affiliate Members

Burt Aronoff, Toro Ag/Drip In
7904 Flourtown Ave., Wyndmoor, PA 19038
215 233-2307 phone, 215 233-2607 fax
driptape@aol.com

Roy Merritt, Netafim Irrigation Inc.
548 N. Douglas Ave., Altamonte Springs, FL 32714
813 505-1125 mobile, 813 961-3621 office, 813 908-0375 fax

Harry Quicke, American Cyanamid Company
234 Pine Hills Avenue, Auburn, AL 36830
334 821-8801 phone, 334 821-8803 fax
harold_quicke@py.cyanamid.com

† - Chair through 1999
‡ - Vice-chair/chair-designate through 1999

Voting members to be named:

Harvesting operators (2 sought)
Contractor/operator

Members whose terms ended in 1998

Larry Burkholder, Morbark Industries
Charles Kaiser, Fort James Corporation
Randy Richter, Simpson Timber Company

The American Cyanamid Company salutes the Short Rotation Woody Crops Operations Working Group for its pioneering work. American Cyanamid's forestry group is pleased to underwrite the printing and distribution of these proceedings.

American Cyanamid's forestry group places a high priority on research and development. For more information about American Cyanamid's forestry research call 800-545-9525, ext. F2164 or visit American Cyanamid's forestry web site at www.forestrymanagement.com.