Short Rotation Forestry Harvesting - Systems and Costs

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Current Situation

Single stem short rotation plantations in the United States are largely dedicated to pulp production, with fuel as a secondary product. There are very limited plantings for fuel production, and others where the primary purpose is treatment of various wastewater's.

All production harvesting of single stem plantations is conducted with conventional forestry equipment. In the west, feller/bunchers, grapple skidders, chain fail delimber/debarker/chippers are used, and pulp furnish is transported in chip vans. Residues are comminuted, and transported to energy facilities. In the Southeast, felled and bunched trees are delimbed by skidders with irongate delimbers, and hauled to the pulp mill or a chipping plant in tree length form, where they are drum debarked and then chipped. Limbs and foliage are left on site.

So far, there have only been limited trials with other equipment. The Canadian NRCC/HYD-Mech FB-7* and FB-12 continuous-travel feller/buncher heads were tested in short rotation plantations. The FB-7 worked well, but with trees much smaller than those currently being grown for pulp. The FB-12, attached to an old carrier with poor hydraulics, was not very productive with larger trees. The head appeared to have inherent deficiencies, the main one being the accumulation approach: holding trees vertically but loosely. This tended to put overturning moments on the machine and limited the sizes of the bunches that could be built.

The Missoula Technology and Development Centre (MTDC) Harvester is a continuous-travel feller/buncher which has a collecting bunk and saw assembly mounted on a Timber/Jack 520A prime mover (Karsky, 1992). When trees are severed, a rotating "bat" knocks them into the collection bed where they lay horizontally. Bunches are side-dumped from the bunk. The MTDC Harvester was designed for dense natural stands of small trees; one test was also

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* The use of name brands and tradenames are for the convenience of the readers and is not an endorsement of the University of California or the USDA Forest Service.

conducted in James River Corporations hybrid poplar plantations in western Oregon. The machine left high stumps, and the butts of cut trees projects over the front of the bunk (Kaiser, 1996). The machine was modified to prevent the latter problem, but was not retested and is not currently being developed or used (Karsky, 1996).

Golob (1986) proposed the use of front-end loaders for transporting bunches of small whole trees to roadside. This concept is currently being employed operationally by a contractor who is harvesting hybrid poplar for Boise Cascade in eastern Washington.

Cable systems have been considered for use when soils are too wet to support tractive equipment, but tests of a Koller 300 at James River Corporation in western Oregon showed their costs to be prohibitively high (Hartsough en al 1992). Productivity was low, and labour costs were high because of inherent idle time for crew members. Intermediate supports, which were time consuming and costly to rig, were needed at close spacing on flat ground.

Trucking of tree lengths and/or whole trees has been tested. Legal weight limits are reached with delimbed short rotation poplar in Mississippi, but not during tests in western Oregon (Kaiser, 1994) Capacity payloads were reached in limited trials with hardwoods from natural stands in the upper Midwest (Schaller, et al, 1993), but weights of short rotation poplar were only half of legal capacity in a recent trial in eastern Washington (Moore, 1997).

In the near future, Simpson Paper plans to test a cut-to-length single-grip harvester and forwarder system in their eucalyptus plantations in California. They hope to investigate to potential for debarking with the harvester, as is done elsewhere (Gadd and Sowerby, 1995). Timbco Hydraulics, which produces feller/bunchers with self-levelling cable for steep terrain, has recently developed a feller/clambunk skidder that may be tested in short rotation plantations.

Underwriting Supplies

There are no new pulp mills relying on the short rotation resource; the plantations are offsetting other sources of fibre that were expected to become more expensive and/or less available. At present, short rotation material constitutes a very small segment of the total market, although not for some specific mills. In the short term there is no need to guarantee the supply, because substitutes could be purchased. Economics of the various sources is of course a big issue.

Companies would like to maintain uniform supplies, and there are several issues related to this. To date, most companies are growing their own supplies on purchased land. This provides control over the source, avoiding the chance of material being sold to another purchaser. Few nonindustrial landowners have been willing to take the risk to grow short rotation trees, largely because of the volatility of pulp and pulpwood prices; recent fluctuations have doubled or halved prices within a year. Recently, some companies have been offering contracts with guaranteed minimum delivered prices and first rights of refusal.

Move-in costs can drive up the cost of harvesting. Many companies with fee plantations have developed them in relatively large blocks, i.e. thousands of hectares, so move-in costs will be relatively small. This is a much more of a concern to the nonindustrial landowners who will have to absorb the additional costs.

Companies would prefer that supplies flow uniformly throughout the year, but limitations on harvesting season on specific sites can constrain production. Most companies compensate by growing on a range of site; faster-producing bottomlands are harvested during the drier season and higher ground provides the source during the wet months. In some areas, moderate changes in soil texture across the same large block will probably allow harvesting all year by migrating to sandier soil during the wet season. Other companies feel they will not be able to conduct operations when soils are wet. They are considering storing either whole trees, delimbed trees, debarked trees, or chips, during wet seasons for up to five months. An alternative might be to purchase chips or pulp on the open market during the wet season.

Environmental/Regulatory Issues

Uncertainty in markets for biomass fuel is a major concern. Companies with their own energy plants have little to worry about, but others might have to substantially modify their harvesting and plantation management practices if the local demand for wood fuel decreases or does not materialise. With increasing restrictions on in field burning, disposing of the residues could be a problem on drier sites, where the material may not decompose rapidly and fire danger may be high. The situation in California is a good example. Between the mid-1980's and mid-1990's, many biomass-fuelled electric power plants received high prices for the power they produced, under a special regulatory offer. Ten years after beginning power production under the offer, all plant contracts were re-negotiated, at the current avoided cost for the purchasers which is substantially lower than the original price. As a result, many plants have curtailed operations and fuel prices have dropped by 50%.

Short rotation plantations have so far avoided some of the environmental/regulatory problems that have plagued managers of native forests in the United States. Clearcutting and compaction are non-issues on agricultural lands converted to short rotation forestry. There are some concerns. For example, one company is debating how to satisfy regulations that prohibited runoff or infiltration of leachate from harvested trees that are stored on site. Habitat changes have also created potential problems, loss of habitat for some native species, or creation of cover that harbours predators of livestock on adjoining properties. In one case, local officials mistook short rotation plantations as lands that could be considered non-operational reserves, to offset residential/commercial development. Road conflicts and debates over weight limits have arisen in agricultural areas where log or chip trucks were not used in the past. Companies in the west prefer their short rotation operations to be classified as agricultural, because regulations for farming are less restrictive that those for forestry. In the Southeast, the opposite is true.

Harvesting Improvements

Harvesting cost is a major logistical issue in the long-term sustainability of short rotation forestry. For most companies, these operations are large experiments that will be terminated if they are not competitive with other sources of fibre. Therefore, improvements in harvesting technology may play crucial roles in the future size of the industry. Conventional forestry machines are designed for rough terrain and a wide range of tree sizes and are therefore usually oversized and more rugged than required for most short rotation applications.

Improvements over the conventional systems may come in a variety of areas, some incremental and some dramatic. In the former category, delimbing and debarking improvements and reduction in truck/trailer tare weights hold some potential. More radical improvements are possible by developing effective continuous-travel felling equipment, by combining functions to eliminate multiple handling, and by the developing and economic process to upgrade whole-tree chips to pulp quality.

Continuous-Travel Felling

In felling, costs might be reduced by developing continuous-travel machines, similar to those proposed by Golob (1986) and prototyped by Hyd-Mech for the Bioenergy Program of the National Research Council of Canada. Effective derivatives of the Hyd-Mech FB7 or FB12 would eliminate the stop-and-go, forward-and-backward travel pattern inherent to conventional feller/bunchers. Although limited studies show that feller/bunchers can be highly productive in short rotation plantations (McDonald and Stokes 1993), it is difficult to imagine a conventional machine competing with a continuous-travel machine over the long term. Based on the FB7 results (Stokes, et al., 1986) and Stokes unpublished data on the FB12 performance, Hartsough and Richter (1994) estimated that current felling and bunching costs could possibly be reduced by 40 percent. Continuous-travel machines would also eliminate the repetitive aspects of the operators job.

Accumulated bunches could be dropped on the ground or offload onto trailers in the field. In the long run, continuous-travel machines of some type will be the best option, but they will involve development costs, which may be substantial.

Combining Multiple Functions

To be effective, all functions on a multifunction machine must be well-utilised. Two concepts – feller/loaders and feller/chippers – have the most potential, because each is relatively simple and could be applied to both the pulp and biomass fuel areas.

Many agricultural crops such as tomatoes and sugar beets are loaded directly onto on-highway transport trailers in the field by the harvester. A similar concept for tree harvesting and transport has been proposed by several individuals, including the propontents of whole tree burners (e.g. Schaller, et at, 1993).

The advantages of feller/chippers include a minimum amount of equipment and minimum handling. An effective chip/residue separation method is needed to make this concept feasible for the pulp industry.

If on-highway transport vehicles cannot be towed through the field, then continuous-travel feller/forwarders may provide reasonable alternatives.

Separation of Pulpwood from Residues

Chain costs represent the single largest operating cost component for chain flail delimber/debarkers. Stokes and Watson (1989) estimated that chain costs represent approximately 20 to 28 percent of the total flailing costs ($0.8 to $1.6 per BDT) assuming a life of 25 PMH per set of chains. But empirical tests on hardwoods in 1989, 1991 and 1944 have shown these early estimates to be low (Hartsough and Richter, 1994); chain costs may be as much as $5/BDT of chips. This discrepancy may be due to the differences between the strength properties of bark on conifers and hardwoods.. These differences might be exploited to design a more efficient debarking method for hardwoods.

Chain flail delimbing/debarking is considered the bottleneck in converting trees to wood chips at the landing. A more efficient concept such as a fast ring debarker (probably located at a central yard or mill) may be preferable in the long run.

The Finnish Massahake process separates whole tree chips into clean chips and residues. It has been under development in Finland for several years, and is promising because it allows whole-tree chipping at the stump or landing, and also allows landing-to-processing facility transport of highway-legal, full capacity chip vans.

Transportation

Recent reductions in log trailer weights (Stuart 1993) indicate a potential for similar reductions in chip van weights, but these reductions would not be unique to SRWC transport.

Given that highway trucks and/or trailers are loaded in-field for transporting agricultural crops, it appears feasible and highly desirable to do the same with SRWC, assuming that the trees or chips will be processed at a site other than the landing. This concept could be applied with log trailers or chip vans, used in combination with feller/loaders or feller/chippers. The trailers or vans could be towed in the field by standard on-highway tractors or by agricultural tractors.

A major concern is the feasibility of moving on-highway vehicles through the field while soils are wet. Options include central tire inflation (CTI), larger, lower-pressure tires, or load platforms that can be transferred from an in-field transporter to an on-highway vehicle. Storage buffers to supply the mills or plants during the wet season are alternatives to wet season harvesting, but debarking of stored trees is difficult, and chip quality decreases with storage time.

For whole-tree transport, changes are required to prevent limbs and tops from extending beyond the legal load dimensions, to prevent small broken material from falling from the load, and to compact the load.

Summary

To date, conventional forestry equipment and methods have been employed for all operational harvesting, processing and transportation of SRWC in the U.S. for pulp production. These operations are highly mechanised, the most common utilises feller/buncher , grapple/skidders, a chain flail delimber/debarker/chipper and chip vans. Another replaces the flail/chipper and vans with irongate delimbers, log trucks and a drum debarker. All deliver clean chips to pulp mills. Residues from the flail/chipper or drum debarker may be comminuted with a tub grinder or hammer hog and transferred to an energy production facility by van or conveyor.

Conventional forestry equipment is probably not optimal for SRWC plantations; it is used by default because it is reliable and the amount of SRWC harvested has not justified the full-cycle development of specialised equipment for larger trees.

One appointment improvement for harvesting large SWRC involves continuous-travel harvesting, to replace the stop-and-go, back-and-forth (or swing-and-return) motion of conventional feller/buncher. The readily negotiable terrain and straight rows are amenable to continuous straight line travel, which in theory should be faster (for the same machine power) than any other alternative. Essentially all agricultural harvesters and the successful machines for small SRWC all travel continuously.

Multi-function machines tend to require fewer operators, be less reliable and may not utilise to components as fully as single function equipment, but this depends on the combination. For SRWC, combinations with potential benefits include feller/loaders, feller/chippers and feller/forwarders. In addition, equipment capable of both primary and secondary transportation would eliminate unloading and reloading at roadside.

Improvements in separation of pulp and residues might include a better alternative to the inherently inefficient chain flail, and an economical means of upgrading whole-tree chips for use by pulp mills.

A list of "ideal" harvesting/processing/transportation systems for large SWRC might include the following two examples (and others):

1) Continuous-travel feller/chipper, combined primary/secondary chip transport, and separation of clean chips from residues.

2) Continuous-travel feller/loader, combined primary/secondary transport of whole trees, delimbing/debarking, and chipping.

Both systems could be used to produce either pulp chips or, by eliminating the separation step, wholetree chips. The feller/loader and transport components of the second system could also be used to deliver whole trees for energy.

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