HYBRID POPLAR OPPORTUNITIES FOR TEMBEC INC.

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14 January 2001

SUMMARY

Managing Short Rotation Intensive Culture (SRIC) hybrid poplar plantations on active or abandoned farmland may make good economic sense, provided the following principles are strictly adhered to: Use the best genetic material, target good quality soils, carry out good site preparation, cultivation and effective weed control, and use good general management practices.

GENETIC MATERIAL

There are currently several types of hybrid poplar clones on the market, but there is insufficient information on which hybrid poplar clones would be suitable for areas Tembec Inc. is targeting for possible SRIC hybrid poplar plantation management. Renewed efforts of breeding and selecting new and improved hybrid poplar clones would lead to immediate genetic gains in yield of minimal 20% over the existing clones on the market. In fact, if efforts were to be increased, a genetic gain of 30- 40% would not be unrealistic. This can only be accomplished by an ongoing, well-funded breeding and selection program, which needs to be integrated with operational SRIC hybrid poplar farming enterprises. It is advisable to establish a partnership between industrial partners and government for funding and operation of a tree improvement co-op.

SITE SELECTION

In order to determine if the right soil and climatic conditions exist within the regions Tembec Inc. is targeting, the company needs to carry out an intensive GIS-based land base search. Provided there is a sufficiently large land base, it would be prudent to proceed with an analysis of SRIC hybrid poplar plantation management.

Hybrid poplar requires a well-aerated soil with sufficient moisture and nutrients. Only farm sites with good soils are recommended for growth of hybrid poplar. There are also policy considerations that would preclude use of hybrid poplar on existing forest sites (e.g. the process of certification).

CULTURAL PRACTICES

Intensive cultural management is essential to capture the hybrid vigour of the hybrid poplar. Site preparation is done mechanically and in most cases requires use of herbicides to give trees a fast start. This leads to a shorter rotation, thus lowering costs. In Quebec, where herbicides cannot currently be used, successful establishment of SRIC hybrid poplar plantations will increase the length of the rotation.

MANAGEMENT CONSIDERATIONS

Provided Tembec Inc. proceeds with SRIC hybrid poplar plantation management, there is an immediate need to establish permanent yield plots for a few early selected hybrid poplar clones to establish the basis for yield over age curves. More clones can be selected and added to the yield trials in subsequent years. The company needs to maintain an inventory, initially consisting of survival and growth surveys in the first three years and periodic growth measurements after that. Continual technology transfer to the operational side is mandatory. Technology development remains an ongoing commitment. Failing to maintain this important phase of the strategy will lead to stagnation in the program.

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INTRODUCTION

Managing Short Rotation Intensive Culture (SRIC) hybrid poplar plantations on active or abandoned farmland may make good economic sense, provided the following principles are strictly adhered to:

- Use the best genetic material
- Target good quality soils
- Carry out good site preparation, cultivation and, above all, effective weed control
- Use good general management practices

1. SELECT GENETIC MATERIAL - HYBRID POPLAR CLONE SUITABILITY

Hybrid Poplar Clone Types

There are several types of hybrid poplar clones on the market. Traditionally the hybrid crosses of *Populus deltoides x Populus nigra* (*female x male*, referred to as DN, or DxN) have been in use the longest in North America and Europe. Unfortunately many have shown susceptibility to *Septoria musiva* stem canker and in the boreal region, where the canker is not a risk, the DN clones are usually not cold hardy enough. In Ontario DN2, DN74, DN177 and DN157 have been in use with some success.

Another successful clone type has been the NM, a *P. nigra x P. maximowiczii* cross. NM-6 in particular has been a good producer and NM-1 is still used in Ontario. NM-6 is very tolerant to *Septoria musiva* stem canker and can produce reasonable volumes; however, it is a very old clone and should by now have been replaced by more productive clones, were it not for a lack of further clonal development. NM-6 remains a good stand-by clone. It may not be cold hardy enough for the boreal region.

Successful clones in the Pacifica Northwest (PNW) and the southern interior of BC and Southwestern BC are the TD variety (*P. trichocarpa x P. deltoides*). In southern Quebec there is substantial success with the Boelare, a TD clone produced in Belgium. It seems resistant to *Septoria musiva* stem canker, against all predictions, as hybrids with *P. trichocarpa* parentage were deemed 100% susceptible! The TD clones would not survive the boreal climate and could only be considered for southern Quebec and Ontario.

Quebec has experimented with various crosses using *P. maximowiczii* as a parent and these hold promise for the boreal area. Promising hybrids of MB (*P. maximowiczii x P. balsamifera*) and MN have been tested in Quebec, as were several three-way crosses, using *P. maximowiczii* (e.g. EM, which is [DN]xM). These clones also seem suitable for the boreal region and some of the crosses (MB) have also shown resistance to *Septoria musiva* stem canker in the Sorel trials we visited.

Tembec Inc. has an excellent opportunity to test the various new Quebec hybrids, deemed suitable for the boreal area.

Breeding and Genetic Gain

Toby Bradshaw at the University of Washington commented (22 December 2000 – conversation) that a 20% genetic gain would be easy to realize over the base clone of NM-6, as used in Ontario and Quebec. He commented that Fort James Corp. (Brian Stanton) experienced an immediate 20% genetic gain of their own selected F-1 hybrids over the already highly selected University of Washington & Washington State University (UW/WSU) F-1 clones (Stettler-Heilman selections). This implies, according to Bradshaw, a realized genetic gain well in excess of 20%. He continued to stress that higher genetic gains would be very likely, once the right cross type has been found for the targeted area and "many thousands" of new clones have been created. In that case, gains of 30-40% would not be unrealistic. A promising, but yet to be confirmed, cross type for the boreal area could well be *P. maximowiczii x P. balsamifera* or MB (as observed by Pierre Périnet in Quebec's boreal area and now also tried at Millar Western's Linaria test site, north of Edmonton – personal observation).

Silvia Strobl (Ontario Ministry of Natural Resources - OMNR) was at one time the genetics specialist for the (now abandoned) Fast Growing Hardwoods Group (FGHG) of the OMNR at Brockville (Ont.). Although she is no longer involved with the hybrid poplar program, she commented (12 January 2001 – conversation) that Bradshaw's projections were well within the ranges reported in the literature. She did stress the importance of a well-designed and funded genetics program to sustain a hybrid poplar management enterprise. With Domtar planting only about 300 hectares of hybrid poplar per year, the OMNR could not justify funding and maintaining a breeding and selection project for this small operational program. She agreed with Bradshaw's recommendation that, in order to progress from the "NM-6 base case", many thousands of new clones would have to be created and tested. Another key point she made was that results from a breeding program would take at least five years with known parent trees, and 10 years, when starting from scratch. Based on a rough flow chart I made in early 2000 for a typical selection, breeding and testing cycle, I estimated that this would take 13 years.

For Minnesota, with further improvements of F-1 hybrids and emphasis on parental improvements, the expectation is that future yields will be approximately 25% better than what is being achieved now in operational plantations (i.e. the "NM-6 base case"). These yield forecasts seem realistic in light of what has been achieved by the trial plantation network in Minnesota, North Dakota, South Dakota, and Wisconsin on the best sites with the best clones.

Clonal Deployment & Clone Plasticity

The OMNR's FGHG has attempted to optimize clone-site matches. This was based on the concept that there was a clone for every site (read soil type and drainage condition). This involved detailed soils mapping and deploying the "correct" clone to each soil type. The results have been disappointing and expensive. Silvia Strobl concluded (12 January 2001 – conversation) that this concept turned out to be a myth. She emphasized only targeting the best sites possible (soil type and drainage condition) and I concur with that conclusion. Therefore the best operational results could be achieved using so-called "plastic" clones.

Plasticity can be defined as overall good performance within a site, within a region or across regions.

For example, the various companies in the PNW originally deployed, at the very most, about five to seven operational clones in their plantations. All these clones would have been developed by the UW/WSU poplar research project. Only one of these proved successful from as far north as the Salmon River Valley (North Vancouver Island) to the Willamette Valley (South of Portland, Or) and this could indeed be considered the ideal "plastic" clone. The equivalent in Eastern Ontario, southern Quebec and the Lake States would be NM-6. Only about three clones were successfully deployed from the Fraser Valley (Vancouver) to just northwest of Portland. The point I am trying to make is that searching for plasticity across regions will severely limit the choice of clones, whereas plasticity within a region would probably be the optimum.

Pierre Périnet indicated that the *P. maximowiczii x P. balsamifera* (MB) hybrids did well on heavy soils as opposed to the *P. deltoides female x P. nigra* (DN) clones. That bodes well for some of the soil conditions in the clay belt; however, that would require confirmation through testing.

Recommendations:

1. Tembec Inc. works closely with Pierre Périnet and Serge Morin of the Direction de la recherche forestière. Their new clonal material could also be tested in Tembec Inc.'s Ontario locations. This opportunity could give Tembec Inc.'s program the jump-start.
2. For the program to progress successfully from this stage, an ongoing, well-funded selection and breeding program is a requirement
3. As in successful agricultural enterprises, an integration of an operational poplar farming enterprise with continual testing of newly created hybrid crosses is a must. Therefore, during the initial years of the enterprise, the ratio of trial area to operational area will be high, but will gradually settle to a much lower and stable ratio as the enterprise grows in area.
4. Tembec Inc. select clones that show general plasticity over a range of sites and conditions within each region.

2. GOOD QUALITY SOILS - SITE SELECTION

The general rule is that for good to excellent growth performance, one needs the best varieties on the best sites, with the best crop tending. When these conditions are met, poplar can truly claim to be the fastest grower among all the species in the temperate zone. Do not to push hybrid poplar on marginal soils, because "lease rates are so low"; there usually is a reason why they are so low. Be prepared to pay a fair lease rate when renting land; rate has to be competitive with alternative crop opportunities.

Poplars require a well-aerated soil with sufficient moisture and nutrients to perform well. For optimum growth the soil needs to be sufficiently deep, have a medium texture with a groundwater table within reach of the roots, preferably at a depth of around 1.00 meter. Optimum soil pH should be in 5.0 to 7.5 range. Another important site factor is climate. Poplars thrive under conditions of high light intensity and warm daytime (and night-time) temperatures.

Saturated and waterlogged soils during the growing season starve the root systems of oxygen,

leading to drought-like symptoms. The leaves turn yellowish-green and remain very small. The tree becomes very stressed, is exhausting its reserves, while the roots are unable to function properly and the tree slowly dies. Most poplar varieties cannot tolerate these conditions for very long into the spring months and must have well-aerated soils by the beginning of June to survive and thrive.

Heavy soils (clay, clay loam and silty clay loam) were considered less favourable for poplar growth than coarser textured soils. Because of poorer aeration and drainage, they restrict equipment access during wet periods, rendering weed control ineffective. Survival is adversely affected and growth during the first few years can be disappointing. The lack of rapid growth and early crown closure leads to an abundance of weed competition, slowing tree growth even more. In recent years, advances in pre-emergent herbicides and application technology have led to improved weed control, enabling successful establishment of poplar plantations on these sites. If there is no possibility of using pre-emergent herbicides on these sites, heavy soils will pose a serious management challenge.

The table in Appendix I provides general guidelines for site selection.

Forestry Sites vs. Agricultural Sites

There are several reasons why hybrid poplar should not be managed on forestry sites:

- The biological reason is that the full value of hybrid vigour of hybrid poplar cannot be realized unless it is intensively managed like an agricultural crop. This precludes it from being managed on forestry sites. Silvia Strobl also indicated to me (12 January 2001 – conversation) that planting hybrid poplar on boreal forestry sites in Ontario would be a waste of money.

- A marketing and policy reason not to consider hybrid poplar for forestry sites is that planting of hybrid and/or exotic stock on forestry sites would seriously impair any future opportunities by Tembec Inc. to obtain Forest Stewardship Council (FSC) certification, without having to "restore" these lands to their original natural conditions (Silvia Strobl, 12 January 2001 – conversation). In an effort to get the best scenario for certification purposes, companies tend to make concessions that will run counter to the best interests of a SRIC hybrid poplar program. Therefore it would be critical to stress the agricultural nature of the SRIC hybrid poplar operations in any certification process and that could only be done when planted and managed on already existing active or abandoned farmland. Avoid getting lumped in with forestry, as this will restrict options later on (e.g. use of herbicides or other pesticides, possible introduction of BC-equivalent Forest Practices Codes etc.).

Lease vs. Purchase of Lands

The decision to lease or purchase land is a policy decision by the company. If there were a strong desire to have absolute control of the land base and the investments made on it, then purchase would be the option. This requires substantial capital outlay and the costs would have to be considered capital.
If land is plentiful and agricultural use is minimal (i.e. competition for the land is not there), then lease would be the obvious option. The cost of the leases could be expensed.
The best compromise is to lease the land with an option to purchase. A decision to purchase could be delayed.

Recommendations:

1. Carry out an intensive GIS-based land base search to determine the extent and suitability of potential SRIC hybrid poplar management sites. This would determine if there is a sufficiently large land base to proceed with an analysis of an SRIC hybrid poplar management strategy.
2. Target active and/or abandoned farmland only. The efforts of expensive selection and breeding will not result in the expected improvements in yield when the trees are managed under more traditional (forestry site) conditions.
3. Plan to put the best varieties on the best sites, with the best crop tending.
4. Ensure SRIC hybrid poplar management does not get lumped in with traditional forestry operations.
5. Work towards recognition of SRIC hybrid poplar management as a legitimate agricultural enterprise, allowing use of approved herbicides, especially in Quebec.
6. Consider leasing the land, with an option to purchase at some later date. Design the lease documents to ensure crop protection for the full rotation.

3. CULTURAL PRACTICES

General Approach

Hybrid poplar usually shows excellent hybrid vigour (heterosis). The desirable hybrid poplar inherited the best from each parent and usually exhibits superior growth cf. each parent. It makes little sense to grow hybrid poplar on sites that are not intensively managed. The effect of hybrid vigour is lost and one could have just as well planted native balsam poplar.

Site Preparation

Proper site preparation for planting is essential to the successful establishment of poplar plantations. Without careful consideration given to site preparation, survival and subsequent growth of poplars may be drastically compromised. The main benefits to site preparation are reduction in cost of planting and later herbaceous weed competition control, reduction in damage caused to young poplars when mechanically cultivating, breaking of impervious layers in the soil, which will improve internal drainage and increase root penetration of young poplars, and aeration of the soil. The main purpose of this preliminary measure is to get poplars off to a fast start. In the preparation of agricultural land, combinations of conventional and minimum tillage methods, such as, disking, chisel ploughing, subsoiling, and mowing can be used. Additionally, many poplar growers have added herbicide treatments to their arsenal of site prep tools that aid in the reduction of early weed competition. Raised beds or bedding is a relatively new concept being utilized in poplar culture and has proven successful.

Planting & Stand Tending

The choice of planting stock type is governed by several conditions:

Presence or absence of deer,
Length of the growing season,
Soil moisture availability
Completeness of site prep and weed control.

- Presence of Deer – To Fence or not to Fence

When deer are present, plantation fencing can be a cost effective option when planting small size stock (e.g. cuttings). The decision to fence or not to fence depends on the incremental cost of using and planting large unrooted, dormant whips or rooted sets (stecklings of a large size) over the use of the smaller cuttings. In a small plantation, the use of the larger stock types will usually be the cheaper option, but when the plantation is large, fencing will be become the preferred option.

- Length of the Growing Season

When the growing season is the limiting factor, unrooted, dormant cuttings may not have sufficient time to develop and send out roots in the surrounding soil, resulting in a small plant that could easily be shaded out by competing vegetation.

- Soil Moisture Availability

When spring soil moisture (summer soil moisture to a lesser degree) is severely limiting, the survival of the unrooted cuttings may be threatened. This has been the case in northern Alberta for several years in a row. In these cases, a rooted dormant set (steckling) should have been the choice.

- Completeness of Site Prep and Weed Control

The method of using unrooted dormant cuttings in planting hybrid poplar is probably the lowest cost option; however, site preparation and weed control must be of the highest standard. Cuttings will develop good roots and shoots, but any shading of the shoots from any competing vegetation can do irreparable harm during the first few critical months of the plantation. Third year trial data from a vegetation management trial in hybrid poplar that I established, show that the volume per tree, after complete weed control (shielded backpack sprayer application of Roundup) during the first growing season, is double that of the untreated control. The untreated control also had high mortality. If complete site prep and weed control is not possible or is hard to achieve, use of larger rooted sets (stecklings) is desirable. A good example is the Domtar site we visited, where site prep was not adequate. Domtar may have saved money on the site prep, but will have to pay more for larger trees and higher planting cost, in order to expect adequate survival and growth. This does not imply that one could cut corners in site prep and weed control by simply planting rooted stecklings of substantial size. It is one thing to beat survival odds; it is quite another to maintain

excellent growing conditions. Competition by shading threatens the poplar in the first several months; competition for moisture and nutrients threatens the poplars throughout the establishment phase (till crown closure).

There is also still the potential of container-grown rooted stecklings (of smaller size), despite everybody's negative impressions during the field trip. I have discussed this with an experienced nursery grower at Pacific Regeneration Technologies (PRT) in Southwestern BC, who has had extensive experience growing and managing poplar crops and he concluded we should not close the door on development of container-grown rooted stecklings. Based on my own nursery experiences, I agree with that. When a nursery grows hybrid poplar in containers, it is usually a minor crop for the nursery and it may be managed under conifer conditions, rather than as a stand-alone crop. Pacific Regeneration Technologies (PRT) currently runs three Ontario container nurseries in Dryden, Cochrane (Birchill) and Swastika (North Gro). This company does have the expertise growing hybrid poplar container stock on the west coast.

Coppicing

Coppice culture has been inconsistent in its results. There are clonal differences that make it hard to predict how coppice culture will develop. The older the stump, the riskier the coppice production will be. Coppice usually returns with multiple stems, which may require intensive manual manipulation to reduce to one or two stems per stump. Total weed control would be problematic, unless done during the spring dormant season. Fort James Corp. attempted coppice culture in the PNW, but abandoned it in favour of starting fresh with better clones. Crown Vantage (Mississippi) used coppicing with eastern Cottonwood (*P. deltoides*) and claimed success. From personal observations at Crown Vantage I concluded that the result were inconsistent.

Use of Herbicides

The inability to use herbicides in Quebec poses a serious problem. As I understand it, no subsidy is available if the landowner uses herbicides. That promotes and encourages mediocrity in SRIC hybrid poplar management. This is probably another reason the Quebec Domtar group uses rooted sets (stecklings). By not having the ability to use herbicides in SRIC, the advantage of hybrid vigour is negated and one has to add several years to the rotation age, because successful stand establishment will be severely delayed.

Recommendations:

1. Follow through on the commitment to intensively manage hybrid poplar to ensure the best yield.
2. Seriously consider using the steckling approach used in Quebec. This method uses a rooted dormant tree, with roots ready to go. This could be especially important in the conditions Tembec Inc. want to operate under.
3. Try a variety of steckling lengths and monitor browse problems or lack thereof.
4. Investigate the merits of container grown stecklings.

5. I will repeat an earlier recommendation: Work towards recognition of SRIC hybrid poplar management as a legitimate agricultural enterprise, allowing use of approved herbicides, especially in Quebec.
6. Do not rely on coppice culture.

4. MANAGEMENT CONSIDERATIONS

Data Management

A well-designed system of data management (e.g. GIS data, inventory of plantations, trials, plus tree selections etc.) must be in place as soon as possible. To save time, the development should be carried out simultaneously with establishment of operational plantations and trials. It has been my experience that this frequently does not take place until several years after the start up of the program, thereby jeopardizing reporting systems which assists in evaluation of performance. This is a critical item, since this whole process is new.

- Yield Curves

  Even though the best performing clones cannot be identified until after five to 10 years, the company should consider immediately establishing a system of replicated permanent yield plots for three to five clones within each region. These plots must consist of at least 25 (5x5) measurement trees, buffered by one to two buffer rows of the same clone and should be measured yearly for heights and (when exceeding approx.2.0 meters) DBH. MacMillan Bloedel Poplar Farms (now Pacifica Poplars Ltd.) started an experimental outplanting in 1987 and established yield plots for three clones as early as 1988, based on initial performances of its small 1987 trial plot. The yield plots consisted of 64 buffered trees (8x8). None of these clones were selected for operational deployment, but one of them is still being measured for yield analysis, representing an average performer. In the following year (1990) new yield plots for three additional clones were established, based on the two-year performance data from the 1987 experimental planting. Two of these three clones were eventually deployed operationally and all three yield plots still contribute to the yield analysis. It is better to have information based on unproven clones than to have no information at all. A biometrician would be able to recommend the proper experimental design.

  As the SRIC hybrid poplar program matures, new yield plots for newly selected clones could and should be incorporated in the operational plantations, so they are managed to the same intensity as the rest of the plantations.

  These data would contribute to yield over age curves, which could be used to select the clones for operational deployment and to assess results from the inventory surveys (below).

- Inventory

  Inventory consists of three phases.

  - Survival and growth surveys after the first growing season, preferably following the spring flush in the second year, to assess overall survival and determine the need for fill planting in case of substantial mortality gaps.

- Survival and growth surveys after the (second or) third growing season, to verify first year survival and to measure height growth. DBH measurements are probably not realistic at this age.
- Periodic (e.g. every 3rd or 5th year) survival, height and DBH measurements. This information could then be compared with the yield curves from the permanent yield plots.

From Trials to Operations

- Continual Technology Development & Transfer

  SRIC hybrid poplar plantation management requires continual technology development and transfer to the operational side. Central to this will be the establishment of operational trials (e.g. clonal trials, herbicide trials, stock type trials, etc), where new and old hybrid clones and/or processes can be evaluated over time, so newly gained technology can immediately be channelled to operations. In the first year trials may well take up to 10 hectares. The size of these trial areas (established yearly) will probably remain fairly constant over the first five years, while the operational area increases rapidly. The success of this rapidly increasing operational area depends on the quality (not quantity) of these trial areas.

  Unlike traditional forest management, where there is a substantial time lag between technology development and transfer, this period is very much shorter in SRIC management. Technology development remains an integral part of a successful SRIC system. Successful agricultural systems depend on continual development and testing of new crop varieties for production. It is no different for SRIC hybrid poplar production. If the technology development side were to be stopped or ignored, the production process would soon find itself stagnating instead of continually improving (e.g. Domtar in the Cornwall area). The very best the Domtar operations have to show for is the clone NM-6. As discussed in the section on breeding and genetic gain, vast improvements, in the order of at least 20% in genetic gain over NM-6, can be achieved by new selection and breeding. This requires committing to a long term breeding program. As Bradshaw pointed out, genetic gains in the order of 30-40% would not be unrealistic.

- Risk and Decision Making

  We will always operate with incomplete knowledge and it would be unreasonable to expect otherwise. The challenge therefore is to avoid "paralysis through analysis". If Tembec Inc. Inc. decided to embark on SRIC hybrid poplar management, I strongly recommend that the company maintain an active technology development and transfer process, including a breeding program. Initially the plantation program will be modest and limited in scope, as operational decisions (e.g. what clone to use; what site prep to use, which herbicides to use etc.) are going to be based on limited and incomplete knowledge. This knowledge will probably originate from people like Pierre Périnet, Serge Morin and others knowledgeable in poplar management.

  Tembec Inc. must therefore be prepared to expect challenges from time to time with plantation performance, i.e. the company must make provisions for risk in its projections. Risk factors will not always be readily recognizable, let alone quantifiable. It is reasonable to expect that risk to decrease over time as more knowledge becomes available.

Government Linkages and Partnerships

Some time ago I concluded from the Domtar experience, that reliance on government funding alone (e.g. through the now defunct Brockville Hardwoods Group of the OMNR), could lead to long term failure in obtaining the necessary technology and clonal material needed to successfully manage SRIC hybrid poplar plantations. Selection and breeding efforts cannot show clear results within 10 years; it takes a long-term commitment before the first products of tree improvement can be utilized. Silvia Strobl (12 January 2001 – conversation) also emphasized this and illustrated this fact by saying that the FGHG was on the verge of identifying several clones with resistance to *Septoria musiva* stem canker, when funding was withdrawn.

Now that the funding has dried up for the Domtar program, their hybrid poplar program is clearly stuck in neutral and is even sliding backwards. Although government programs and funding tend to stimulate industry to become actively involved in SRIC hybrid poplar plantations, it would be advisable for industry to form a partnership with government to develop the capability to embark on a selection and breeding project for hybrid poplar, ensuring long-term access to improved material. The partnership would imply both government and industrial funding. Should government pull out in the future, there will at least be the industrial component to salvage the efforts that have gone into technology development. The situation in Ontario is worrisome. There have been numerous clonal trials, either by the FGHG or by the University of Toronto (Louis Zsuffa), but these trials have been abandoned and, to my knowledge, no one is trying to salvage the data. From what limited understanding I obtained during the trip, the tree improvement partnership in Ontario, as managed by Dennis Joyce, could be an appropriate form of cooperation between industry working and government. Forming a tree improvement cooperative is a cost effective way of producing suitable genetic material for future use. It would be too large an undertaking for any company to attempt on its own.

At the moment the Quebec government seems committed, but there can be no assurance this will continue. Only a few years ago, Gilles Vallée informed me, during the poplar Council of Canada annual field trip, that poplar research and breeding was facing an uncertain future. Fortunately he was incorrect. For the Ontario operations, Tembec Inc. can only rely on limited technology transfers from the OMNR and will have to develop a heavy reliance on the Quebec experience. For the BC operations, there is absolutely no government program at all to help develop the SRIC technology and companies would have to rely on memberships in the two research cooperatives in Washington and Oregon, or would have to support new initiatives by WSU to embark on a breeding program.

Human Resources and Costs

- Human Resources

  I have assumed that a partnership with government and other industrial partners will be in place to carry out a breeding program, and that the SRIC hybrid poplar program is rolling at Tembec Inc. I would anticipate the following human resources needs in five years time:

  - Overall Management – 1 Manager, 1 GIS/Database Technician, 1 Clerical Staff

    The manager is responsible for the overall coordination of the Technology Development staff, the Farm Management staff and the property acquisition experts

(who could be on contract). The Manager also assumes the role of the Champion in promoting the concept within and outside the company. The Manager would also be the point man in dealing with the various government departments on various issues (e.g. getting farm status). The GIS/Database Technician coordinates all the data requirements and assumes responsibility for the design of a GIS and database system. He would oversee any contract work on these systems. The Clerical staff could be part or fulltime and also assists in data entry.

- Technology Development – 1 Professional & 1 Senior Technician

  One Professional would maintain liaison with the operations and represent Tembec Inc. at the Breeding Co-op and do the planning and reporting. The Senior Technician would be responsible for the establishment and maintenance of trials. The Professional should be prepared to lend assistance to the Technician from time to time to accomplish the various tasks. For more routine tasks, the Technician would hire, on a contract basis, additional temporary help during the field season. The Technician is charged with the quality control on work carried out by the contract staff. This is an important responsibility.

  This team will, over time, become the company's expert group on SRIC technology development. For the first three to five years this team will have to rely on outside expertise.

- Property Acquisition – 1 contract Property Expert & 1 contract Soils Expert

  The phase of property acquisition (lease and/or purchase) could easily be contracted out to an outside expert, in close coordination with a soils expert (also on contract basis) and the Manager of the Poplar Group. These contractors would probably not be fulltime.

- Farm Management Staff – Staffing varies with farm size

  I anticipate 3 fulltime staff for every 4,000 hectares of plantations (one Professional and two Technicians), augmented with 3 to 6 seasonal field staff (could be summer students), depending on needs.

- Costs

There are no publicly available cost data for Ontario or Quebec hybrid poplar operations, because company cost data are usually proprietary and there is a lack of appropriate experience. Although I have been working on this issue for Alberta conditions (unrelated to this report for Tembec Inc.), any meaningful data would not be ready for use for at least another month.

Recommendations:

1. Immediately establish a system of replicated yield plots for three to five clones within each region.
2. Design and implement an inventory method to track operational survival and height growth at least twice during the first three years and carry out periodic growth measurements (height, DBH and survival) at later stages in the rotation.
3. Consider central technology development, with strong input from and communication with operations.
4. Tembec Inc. carry out sensitivity analyses when doing the economic analysis, so risk can be dealt with in "what if" scenarios.
5. Form a partnership with government and other industrial partners to develop the capability to embark on a selection and breeding project for hybrid poplar, ensuring long-term access to improved material. This implies funding by all parties. A cooperative structure may be best and the emphasis must be on operational tree breeding and testing. Avoid bringing other initiatives (e.g. development of cultural regimes etc.) into this Co-op, as this will tend to scatter the direction.
6. Tembec Inc. could consider commissioning a separate report on management costs for SRIC hybrid poplar management. This report would draw on equipment productivity data from other regions with SRIC hybrid poplar management experience and local Ontario or Quebec cost structures in agricultural operations.

APPENDIX I

The following table summarizes the influence of soil texture and drainage condition on site quality for poplar. This table is adapted from Donald I. Dickman and Katherine W. Stuart.

The influence of Soil Texture and Drainage Condition on Site Quality for Poplar

	Natural Drainage Class		
Dominant Profile Textures	Well and Moderately Well Drained	Somewhat Poorly Drained	Poorly and Very Poorly Drained
Fine Clay (> 60% clay) *)	Fair	Fair	Poor
Clay (40-60%) *)	Good	Good	Poor
Clay Loam and Silty Clay Loam *)	Good	Good	Poor
Loam and Silt Loam *)	Good to Very Good	Good	Poor
Loam and Silt Loam 25-50 cm over well-decomposed peat **)	Good to Very Good	Fair	Poor
Loam and Silt Loam marbled with well-decomposed peat **)	Good to Very Good	Fair to Good	Poor
Sandy Loam	Very Good	Fair to Good	Poor
Loamy Sand	Very Good	Fair to Good	Poor
Sand	Poor	Fair	Poor
Sandy Loam 35-100 cm over Clay	Very Good	Fair	Poor
Sandy Loam 50-100 cm over Loam to Clay Loam	Very Good	Fair	Poor
Sandy Loam 50-100 cm over Sand	Good	Very Good	Poor
Loamy Sand 35-100 cm over Clay	Very Good	Fair	Poor
Sand to Loamy Sand 50-100 cm over Loam to Clay Loam	Very Good	Very Good	Poor
Sand to Loamy Sand 100-150 cm over Loam to Clay	Good	Very Good	Poor
Muck	N/A	N/A	Poor

*) Availability of better herbicides and improved application technology have enhanced the suitability of heavy soils for poplar production.
**) Personal experience in Northwest Washington.

Yellow fields indicate potential to improve suitability through ditching, installing drain tile, subsoiling, ditching etc.

APPENDIX II

GENERAL REVIEW OF ONTARIO AND QUEBEC POPLAR TOUR

The following comments are in order of the tour agenda and address topics of general interest, without going into technical detail.

KEMPTVILLE NURSERY

- Poplar production 100 K cf. conifer seedling production 500K. Poplar considered incidental crop.
- Poplar production for Domtar and CH_2M Hill (phyto remediation).
- Below standard cultural practices at Nursery – very weedy; will affect entire nursery and deemed poor nursery practice (cf. Berthierville).
- Ability to produce rooted (dormant) sets (whips or stecklings) 1.50 to 1.80 m range.
- Unrooted, dormant cuttings (30 cm) @ $ 0.27 – 0.30 per ctg. Reasonably priced.
- Rooted sets (whips or stecklings) priced @ $ 0.40 – 0.50 per set. Competitive with Berthierville, but not of similar high quality.
- No standards for production of quality cuttings or whips, e.g. lacking standards for presence of live bud near top of cutting/whip.
- Mass processing with multi stems at pneumatic cutter results in either substandard material (apparently acceptable to Domtar) or high waste if standards apply.

DOMTAR PLANTATIONS

- Limited clonal choices leave yields at stagnant level. Domtar still relying on old (proven) clones without effort to move into more productive ones in future. Lacks selection and breeding commitment since closure of Brockville Fast Growing Hardwoods Group.
- Pushed hybrid poplar on sites which were too marginal. After first rotation of hybrid poplar, some of these properties now destined for management of alternate species (e.g. naturally established Ash under poplar canopy). Hybrid poplar crops on these properties do not meet original yield expectations. MacMillan Bloedel (now Weyco) experience on "off site" soils on Vancouver Island confirms this.
- Thinning. Domtar planning to thin some older plantations. It has been my observation that: From silvicultural perspective little gain, other than removing damaged and poorly producing trees. At these ages no sufficient response from remaining crop trees. Strategy may well be used by Domtar to "store stand on stump" while salvaging trees elsewhere that were damaged by the ice storm. Thinning in the PNW to reduce stems per ha to encourage larger stem sizes: expensive fibre! Decision to thin to waste; cannot afford recovery.
- Coppicing. Domtar attempted use of coppicing in starting second rotation. Coppice inconsistent, requiring intensive manual manipulation to reduce to single stem per stump. Total weed control problematic, unless done during spring when the trees dormant. Coppicing attempted in the PNW; not considered desirable. Crown Vantage (Mississippi) used coppicing with eastern Cottonwood (P. deltoides); claimed this was viable. From personal observations: results extremely inconsistent.

- Some young Domtar plantations insufficient weed control; trees overwhelmed by grasses. Once plantation established and weeds not properly controlled in site prep phase, impossible to "make silk purse out of sow's ear". We observed newly ploughed and disked field; consensus that Domtar not gone far enough to meet good site prep standards and would run into serious weed control issues again. Jim Henry pointed out, soil clods still too large to allow pre-emergent herbicide penetration; I concur. May have been question of cost. Usually by cutting back in site prep, poplar farmer pays at time of cultivation!
- Domtar pays landowner low rental in form of a stumpage. Landowner takes on substantial portion of risk associated with catastrophic events (e.g. ice storm), selection of substandard clones and possibility of less than adequate site preparation and cultivation by Domtar.
- Little evidence of deer browse problem on any of Domtar plantations. Use of cuttings as stock justified.

QUEBEC TOUR

- Nursery at Berthierville:
    - Very good production system of rooted sets (called stecklings in Quebec).
    - Nursery weed free from nursery management perspective. Weeds extremely well controlled, resulting in lower costs of production.
    - Vertical box pruning and precision planting of cuttings, leading to uniform rooted sets.
    - Direct costs of production rooted sets $ 300 per thousand (Nursery production poster); confirmed in discussions. Estimated purchase price $ 400 - 500 per thousand; very competitive and in line with price charged at Kemptville nursery. Prices substantially lower than BC for equivalent stock!
- Field Trips Quebec
    - All sites visited in Quebec were trial sites; did not visit any operational sites.
    - Long term selection and breeding efforts by Direction de la recherche forestière now yielding important results, not only for Quebec, but also for other regions in Canada, except southern interior and SW coastal regions of BC.
    - Research program shows (stable?) resistance against Septoria stem canker (Septoria musiva) achievable, especially with new crosses with Japanese/Korean poplar (P. maximowiczii) and even several Belgian hybrids between P. trichocarpa and P. deltoides!
    - Pierre Périnet indicated program would soon yield several new clones for use in boreal region, where threat of Septoria is small or non-existent.
- Discussions in Ontario and Quebec about planting stock types indicated use of unrooted, dormant cuttings and rooted, dormant sets (stecklings) outperform rooted container-grown stecklings.