A FINANCIAL ANALYSIS OF HYBRID ASPEN PRODUCTION BY A PULP MILL IN NORTHWESTERN SASKATCHEWAN.

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ABSTRACT

Potential reductions in Crown fibre allocations are causing some pulp mills to consider alternative sources of fibre. This paper investigates the feasibility of a mechanical pulp mill in northwestern Saskatchewan establishing a hybrid aspen plantation to supplement Crown fibre supplies. Net Present Values of a variety of plantation scenarios are calculated using a spread sheet. The results are tested for sensitivity to land type, land quality, discount rate, tenure, future and current pulp prices, stocking rates, conversion rates, and woodlands costs. The results suggest that hybrid aspen plantations may be financially feasible. These findings support the need for biological research to develop a suitable hybrid aspen clone, and identify growth rates and a management regime appropriate for this region.

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INTRODUCTION

In Canada, although the majority of forests are owned by provincial governments, most of the processing facilities are owned by private companies. As a result timber processing companies have typically negotiated tenure agreements with provincial governments to secure access to Crown fibre resources. In Saskatchewan, Forest Management License Agreements (FMLA's) have generally been negotiated for twenty year periods and reviewed each five years at which time they are typically renewed for a further twenty years. Historically, tenure allocations have been sufficient to meet industries fibre needs and have been renewed without changes. However, recent pressure from other stakeholders, including aboriginal communities, environmental groups, and recreational users, has placed uncertainty on the long-term availability of current fibre allocations, and the probability of tenure renewal. Furthermore, tenure agreements in Saskatchewan are currently being renegotiated and, recent changes to tenure allocations in British Columbia suggest that future reductions in tenured timber supply are likely.

Industrial forest products firms are generally vertically integrated, operating both wood procurement divisions and wood processing facilities, with the woodlands division harvesting timber from Crown lands to meet the fibre input requirements of the processing sector. However, if Crown timber supplies are reduced, forest products companies have a number of alternatives available to supplement their remaining fibre supply including: increased wood purchases from private landowners; intensive management of remaining tenure allocations; or producing fibre on their own land.

The objective of this paper is to investigate the feasibility of a mechanical pulp mill expanding their woodlands operations to produce fibre by establishing plantations of hybrid aspen on land that they either purchase or rent. The results of this analysis may be relevant to the Mixedwood Belt of Saskatchewan, and similar regions across the prairie provinces, however the research focuses on a case study around Meadow Lake, Saskatchewan. Net Present Values (NPV) are used to evaluate the feasibility of plantations established on bush, pasture, and hay land. The paper first provides background to the study, the methodology used is then described and the base parameters identified. The results are then presented and tested with sensitivity analysis. The paper concludes with some discussion of the possible implications of the findings and suggestions for future research.

BACKGROUND

Although firms may increase the volume of wood they purchase from private producers to meet their fibre requirements, purchase wood tends to be unreliable. Private landowners are frequently unwilling to commit to long term arrangements for wood sales. Furthermore, many private landowners sell trees as part of a salvage operation from land clearing; they may not know in advance how much fibre they will be able to sell and when it will be available. As a

result the processing company may have difficulty developing forecasts and business plans. An analysis of the feasibility of hybrid aspen production by private landowners is presented in Salkie and White (1995).

Intensive management of public lands has several inherent problems. Since tenure arrangements are generally for twenty year periods, the forest industry is not guaranteed continued access to specific stands throughout a rotation. Although these agreements are renewed every five years for a further twenty years, the Forest Act is currently being amended and there is no guarantee that in this, or future amendments, additional restrictions will not be imposed in such a way that industry loses access to a tract of land, or is severely restricted in their management of that land. Further, since forest management plans must be approved by the Provincial Forestry Department, companies may be restricted in the management techniques available to them. Crown lands are also subject to close public scrutiny. Herbicide application on Crown land, for example, while not prohibited, has traditionally evoked a public outcry and the government may respond by requiring an Environmental Impact Assessment before deciding on the herbicide application.

Firms can establish hybrid aspen plantations on land that they either buy or rent, thus they can control production and ensure targets are met. When renting land, long-term rental agreements must be negotiated. Although problems may be encountered with such agreements due to land transfers resulting from a death or sale of the land, land rental allows the land costs to be spread out over a number of years. Land purchase, on the other hand, requires an immediate capital outlay but gives the company more freedom and security in the management of the land. As the land owner they can employ a number of management techniques and maintain full control of the land. There is no experience in Saskatchewan with the reaction of local communities to large scale land purchases by the forest industry. In other regions, some local governments have responded to such changes by amending land use regulations to control harvesting behaviour. Furthermore, even though the government is less likely to require an Environmental Impact Assessment, the public may still protest activities such as herbicide use causing a public relations problem for the company. However, of the three options, company operated plantations on owned or rented land may offer the best opportunity to the forest industry.

This study concentrates specifically on hybrid aspen production on plantations in the Mixedwood belt of Saskatchewan. Until recently aspen (*Populus tremuloides* Michx.) was considered a weed species in Saskatchewan and few markets existed. Only small amounts of aspen were used to produce OSB and some types of pulp. However changing consumer preferences that resulted in increased acceptance of paper products that pure white, and new technology including CTMP pulp mills and paper machine modifications to facilitate the use of pulp from short-fibred species for printing and writing paper, resulted in new opportunities for aspen. This led to the construction of a closed loop BCTMP mill in northwestern Saskatchewan, and created a new market for aspen in the area.

Aspen may be managed through either extensive or intensive forest management. Extensive and intensive management can be differentiated by the amount of money invested in silviculture, the frequency and intensity of harvesting during the rotation, and the balance between concern for future returns versus concern for immediate returns (Smith 1986). Extensive forestry is more common in remote areas and/or poor sites. Anderson (1980) describes an intensive management system as one in which there is gene pool manipulation, land preparation, fertility

and pest management, and selection and control of stocking levels. Intensive management of aspen may increase the value of a stand by increasing yields.

One form of intensive management is hybridization. Anderson (1980) suggests that aspen is well suited to hybridization because it is very adaptable to different ecological conditions; has shown great potential for improvements to growth, form, and wood properties; has produced rapid genetic gains through selection and breeding; and has demonstrated hybrid vigour. Hybrid aspen may utilize sites better than native aspen, and have less rot and stain (Lester, In Process). Hybrid aspen are also suitable for other forms of intensive management, such as site preparation and disease control, because of their form, natural pruning, rapid growth, and suckering habits (Einspahr and Wyckoff 1978).

A number of studies have investigated the economic feasibility of aspen production. Two studies considered the feasibility of non-industrial private forest owners producing aspen with extensive management systems on private land. Such studies may indicate the potential profitability of woodlands operations within a forest products company. The Farm Woodlot Association of Saskatchewan (FWAS 1991) commissioned a report to evaluate Saskatchewan's private forest resource that included an economic evaluation of alternative woodlot operations. In this analysis they found that delivered wood prices needed to increase from $\$18.82/m^3$ (the delivered price at the time the study was undertaken)[3] to \$33/m before a grain farm-farm woodlot operation would cover all expenses and provide a return to labour of at least \$10/hour. Another study, conducted by D.A. Westworth and Associates (1994), investigated native aspen production in three locations around Alberta. They found that, assuming a 6% discount rate, the stumpage price needed to increase from current prices of \$1 to $\$2/m^3$ to between \$4 and $\$6.50/m^3$ before a pulp wood producing operation could break even. Both these studies required a sustained yield with either annual or regular harvests; stands could not be entirely clearcut and regenerated.

Other studies investigated the economic feasibility of hybrid aspen production. A study by the Institute of Paper Science and Technology, Aspen/Larch Cooperative at the University of Minnesota (Wyckoff 1991) analyzed the economic potential of growing hybrid aspen in the Lake States. Using a Faustmann approach, a description of which can be found in Pearse (1990) and Nautiyal (1988), they maximized Site Expectation Values (SEV) for hybrid aspen production under a variety of scenarios and compared the relative profitability of growing hybrid aspen, native aspen, and northern hardwoods. Hybrid aspen was more profitable than other species in all situations. Given a 4% discount rate, hybrid aspen production was feasible at stumpage prices of $\$_{US}10$/cord (using an exchange rate of $\$_{US}$ 1 to $\$_{CDN}$ 1.40 this is approximately $\$_{CDN}$ $5.7/m^3$) however, as the discount rate increased, the stumpage price required for stands to yield a positive return increased until, at a 10% discount rate, a price of \$30/cord (approximately $\$_{CDN}17/m^3$) was required. Native aspen only had a positive SEV at a 6% discount rate when price exceeded \$20/cord (approximately $\$_{CDN}11.3/m^3$), and northern hardwoods required a stumpage price of \$20/cord at a 4% discount rate before they yielded positive returns. Although at the time of the study these prices were considered unrealistic, aspen stumpage recently sold for $\$_{US}30$/cord (approximately $\$_{CDN}$ $17/m^3$) in Minnesota[1]. A study by the Ministry of Natural Resources, Government of Ontario (MNR 1983) investigated hybrid poplar plantations. They found that a

[1]Personal communication with Gary Wyckoff, Project Leader, Aspen/Larch Genetics Cooperative, University of Minnesota on February 6, 1995.

hybrid aspen plantation could not cover the cost of land rental or purchase when stumpage rates were \$8/ODT (approximately \$22.65/m^3).

This study extends the previous work to examine the feasibility of hybrid aspen production by a vertically integrated forest products firm. In this situation the ultimate product is pulp rather than wood fibre. To determine the feasibility of hybrid aspen production by a pulp mill, the value of the end product, or pulp, must exceed the cost of producing, harvesting, hauling, and processing the wood fibre. This differs from previous work in which the plantation was judged profitable if the value of wood fibre exceeded the costs of producing the wood.

METHODS

The study area was defined as the area within 100 kilometres of Meadow Lake, Saskatchewan. This location was selected because of its proximity to the BCTMP mill located in Meadow Lake. One hundred kilometres is considered a reasonable haul distance in this area. The NPV was calculated for plantations established on bush, pasture, or hay land that the forest products company either purchased or rented. This methodology is based on the Faustmann approach. NPV's were calculated at discount rates of 3%, 4%, 6%, and 8%.

Land prices were based on recent land sales in the region; however actual prices may vary depending on the exact location and quality of the land. The company was responsible for property taxes with tax levels being identified in consultation with local governments. Rental rates were determined in accordance with current rates for alternative land uses. Grazing was assumed to be the alternative use of bush and pasture, and rental rates were derived according to the average carrying capacity of the land, assuming the land was grazed five months per year. The rent paid for hay land was set according to rates charged to rent land for hay production. Table 1 summarizes the land prices, rental rates, and annual taxes used in this analysis.

Table 1: Land purchase price, rental rates, and annual taxes

Land Type	Purchase Price[1] (\$/ha)	Rental Rate[2] (\$/ha/year)	Annual Taxes[3] (\$/ha/year)
Bush land	\$154.44	\$25.00	\$1.50
Pasture land	\$278.00	\$50.00	\$1.75
Hay land	\$386.10	\$50.00	\$2.35

[1]Personal communication with Stuart McNabb, Farm Credit Corporation Canada, on April 13, 1994.
[2]Personal communication with Dave Cubban, Saskatchewan Agriculture and Food, on May 13, 1994.
[3]Tax rates were provided by the Rural Municipality of Meadow Lake no. 588 and the Rural Municipality of Beaver River no. 622 on April 27, 1994.

This study is limited by insufficient growth and yield data for hybrid aspen. Very little

research has occurred in the prairies and, although considerable research has been conducted in the Lake States and Ontario, growth and yield relationships have not been identified for these regions. Several sources suggest that hybrid aspen growth may be double that of native aspen. Einspahr (1984) suggests that better triploid aspen grows approximately twice as fast as native aspen. Li et al (1993) estimated that the volume growth of hybrids would likely be double that of native aspen due to increased height and dbh. According to these references, and personal communication with Dave Cheyne[2] and Gary Wyckoff, a modified yield table was developed to estimate the growth rate of hybrid aspen. Yields were developed by increasing 'medium site' yields[3] of native aspen stands in the Mixedwood belt of Saskatchewan by 50% in the poor scenario, 100% in the medium scenario, and 200% in the high scenario. The modified yield tables assume a straight line growth function between the ten year increments identified by Kirby (1957) and provide growth and yield data at five year increments. This modified yield table is included as Table 2.

Table 2 Estimated yields of hybrid aspen stands in the Mixedwood Belt of Saskatchewan

Age (years)	**Poor** Merchantable Volume (m^3/ha)	**Medium** Merchantable Volume (m^3/ha)	**High** Merchantable Volume (m^3/ha)
30	10.65	14.20	21.30
35	32.10	42.80	64.20
40	53.55	71.40	107.10
45	93.90	125.20	187.80
50	134.25	179.00	268.50
55	185.40	247.20	370.80
60	236.55	315.40	473.10
65	263.78	351.70	527.55
70	291.00	388.00	582.00
75	308.48	411.30	616.95

[2]Dave Cheyne is Aspen Specialist with the Aspen Resource Centre, Canadian Forest Service, Natural Resources Canada.

[3]Kirby (1957) developed yield tables for native aspen stands in the Mixedwood belt of Saskatchewan. The tables are based on three site conditions: low; medium; and high.

Pulp prices were taken from a number of sources and were based on Northern Bleached Hardwood Kraft (HBKP) prices, a likely substitute for pulp made from hybrid aspen. An exchange rate of $\$_{US}1$ to $\$_{CDN}1.40$ was used in estimating the Canadian equivalent of United States pulp prices. The average BHK price from 1985 to 1993 was $\$_{US}550$/t (RISI) and from 1983 to 1991, was $\$_{US}$ 567.50/t (Dils 1991). When valuing standing bush, a base price of $\$_{US}550$/t ($\$_{CDN}$ 783/t) was used. The results were tested for sensitivity to fluctuations in the pulp price ranging from $\$_{CDN}690$/t to $\$_{CDN}890$/t.

Future pulp prices were based on long run projections by RISI and Silvacom Ltd. RISI projected long run BHK prices ranging from $\$_{US}518$/t to $\$_{US}$ 1070/t for the period 1992 to 2007. Silvacom Ltd. (1994) projected prices ranging from $\$_{US}405$/t to $\$_{US}680$/t between 1994 and 1998. A base price for future pulp sales of $\$_{US}680$/t ($\$_{CDN}$ 950/t) was selected, and the model was tested for sensitivity to pulp prices of $\$_{CDN}700$/t and $\$_{CDN}1200$/t.

In valuing pulp production the conversion rate from cubic metres of aspen fibre to metric tonnes of pulp is also important. The conversion rate used for native aspen by Misitk Management Ltd., the company responsible for Woodlands operations for the BCTMP pulp mill in Meadow Lake, is 3 m^3 of fibre to 1 t of BCTMP pulp[4], however there are some indications that the conversion rate will be different for hybrid aspen. Li et al (1993) suggest that hybrid aspen may have better wood density, longer fibres, and better wood/pulp properties than native aspen, in addition if they have shorter rotations, there is likely to be less rot. These factors support the hypothesis that the conversion rate will be lower for hybrids than for native aspen. However, because the wood is harvested earlier, it is likely to have a higher proportion of juvenile wood which has a lower specific gravity than native aspen, this would suggest that hybrids have a higher conversion rate than native aspens. Due to these conflicting theories, the base analysis assumed that the conversion rate remained at 3 m^3/t of pulp, however sensitivity analysis was conducted to investigate the impact of conversion rates ranging from 2.75 m^3/t to 3.25 m^3/t.

The net pulp price is used to calculate the NPV of hybrid aspen plantations in a number of scenarios. The net price is derived by subtracting the cost of felling, limbing and topping, forwarding, and processing from the delivered pulp price. Mike Martel of Mistik Management Ltd. estimated the cost of hybrid aspen plantation development based on costs associated with native aspens and expected differences to hybrids. He estimates average woodlands costs of $\$18.35/m^3$ to cover felling, limbing and topping, and forwarding, and $\$159.80/m^3$ for milling costs. Sensitivity analysis was conducted to investigate the impact of a 10% increase in total woodlands costs.

Management scenarios were developed in consultation with: Dave Cheyne, Canadian Forest Service; Dave Cubban, Saskatchewan Agriculture and Food; Harvey Yoder, Alberta Agriculture and Food; and Derek Sidders, Canadian Forest Service. A minimum stand size of ten hectares was assumed to meet economies of scale associated with land clearing, stand establishment, and harvesting. The aspen was managed as an even aged stand; each hectare was planted at the beginning of the rotation, clear cut at the economically optimal rotation, and allowed to regenerate naturally through suckering. Although the Ministry of Natural Resources, Government of Ontario (MNR 1983) suggested that an aspen root system can only support four to ten rotations, in this analysis the

[4]Personal communication with David Harman, Mistik Management Ltd. on May 12, 1994.

initial planting was assumed to keep the land forested in perpetuity. This assumption does not affect the results because expenses and income derived after the fourth rotation do not affect the NPV of an operation. A replant of 10% was included for each subsequent rotation to allow for losses due to damage, compaction, and disease. A base stocking rate of 2000 trees/ha was selected from suggested stocking rates that ranged from approximately 1000 trees/ha to 4000 trees/ha (Wyckoff 1991) (MNR 1983) (Lester, In Process). Sensitivity analysis was conducted to investigate the affect of stocking rates of 1400 trees/ha and 2700 trees/ha. Planting stock were assumed to cost $.20/tree and tree planting approximately $0.15/tree[5].

The management regime required to establish a stand of hybrid aspen on bush land differs from that required for plantations on pasture or hay land because the native aspen must first be removed and the root system eradicated. If native aspens are allowed to sucker back they will likely out compete planted seedlings because suckers are more shade and frost tolerant, have better initial height growth, and produce a denser tree cover than seedlings (Sims et al 1990). Standing bush is first harvested and then the root system, along with any grasses, herbaceous weeds, and shrubs, are controlled to reduce competition. Tree stumps need not be removed, nor should the land be converted to a field prior to planting, because seedlings can be planted in uneven terrain. Weeds and other competing vegetation are controlled through a combination of mechanical and chemical means. Table 3 details the management regime and associated costs.

Table 3 Management regime and associated revenues and costs required to eradicate standing aspen and establish hybrid aspen on bush land

Year of Activity	Management Activity	Cash Flow ($/ha)
0	harvest in winter (net value as pulp)	14 498.75
0	strip shear blade	(250.00)
0	mechanical control with a forestry mixer	(150.00)
0	spray	(70.00)
1	spray	(33.36)
1	2 passes with cultivator	(14.52)
1	Plant at 2000 trees/ha	(700.00)

[5]These costs were taken from Lester (In Process), MNR (1983), and from personal communication with David Harman, Mistik Management Ltd.

When establishing a hybrid aspen plantation on pasture or hay land, competing vegetation is controlled through a combination of chemical and mechanical treatments. In this analysis the same site preparation is used on both pasture and hay land because pasture land was defined as having minimal tree coverage, however the cost of site preparation on pasture would be higher if the degree of tree cover increased. Table 4 outlines the management activities, and associated costs, required to plant pasture or hay land with hybrid aspen.

Table 4 Management regime and associated costs required to establish hybrid aspen on pasture or hay land

Year of Activity	Management Activity	Cash Flow ($/ha)
0	spray in late summer with glyphosate	(33.36)
0	3 weeks later 4 passes with cultivator	(29.04)
1	Plant at 2000 trees/ha	(700.00)

The analysis was executed on a spreadsheet developed using Quattro Pro 5.0. The optimum economic rotation and the NPV for each scenario were identified. Sensitivity analysis was conducted to identify the effect of changes in the discount rate, growth rate, value of standing bush, future pulp price, conversion rate, operating expenses, and stocking rate. The results were also compared to a native aspen plantation.

RESULTS

Table 5 gives the NPV for plantations given a variety of discount rates, land types, and growth rates. The optimum economic rotation for hybrid aspen ranged from 45 to 60 years depending on the assumed discount rate. At discount rates of 3% and 4% the optimum economic rotation was approximately 60 years, at 6% it was 55 years, and at 8% it was 45 years. The rotation age was not affected by either the type of land or the expected growth rate. The NPV was slightly lower for a plantation established on rented land than one on owned land.

Table 5 **Net present value ($/ha) of hybrid aspen production**

	Owned Land			Rented Land		
	Poor Yield	**Medium Yield**	**High Yield**	**Poor Yield**	**Medium Yield**	**High Yield**
Discount Rate = 3%:						
Bush Land	27 090.25	31 758.90	41 096.18	26 461.36	31 130.33	40 467.29
Pasture Land	13 748.21	18 704.03	28 615.67	12 409.53	8 077.59	27 277.00
Hay Land	13 640.11	18 595.93	28 507.57	12 409.53	8 077.59	27 277.00
Discount Rate = 4%:						
Bush Land	20 238.29	22 614.18	27 365.95	19 805.23	22 181.12	26 932.89
Pasture Land	6 490.07	9 012.10	14 056.17	5 555.56	8 077.59	13 121.66
Hay Land	6 381.97	8 904.00	13 948.07	5 555.56	8 077.59	13 121.66
Discount Rate = 6%:						
Bush Land	15 347.17	16 057.57	17 553.37	15 109.94	15 845.34	17 316.14
Pasture Land	1 306.24	2 086.87	3 648.14	775.90	1 556.53	3 117.80
Hay Land	1 198.14	1 978.77	3 540.04	775.90	1 556.53	3 117.80
Discount Rate = 8%:						
Bush Land	13 999.81	14 279.42	14 838.64	13 860.50	14 140.11	14 699.33
Pasture Land	(124.29)	172.52	766.14	(452.55)	(155.74)	437.88
Hay Land	(232.39)	64.42	658.04	(452.55)	(155.74)	437.88

The results were examined for sensitivity to changes in the value of standing bush. In the base case, pulp was assumed to sell for $783/t. The NPV was then identified for current pulp prices of $690/t and $890/t. The results were very sensitive to these changes in all situations, however as the quality of the site improved, the sensitivity to original price decreased. Also, results were more sensitive to the value of standing bush at higher discount rates. A drop in current pulp prices from $783/t to $690/t reduced the NPV by between 13.2% to 36.6% on high yield land, and by 20% to 38.8% on low yield land. Table 6 presents the results of this analysis.

Table 6 **Percentage change in net present value ($/ha) of hybrid aspen production on owned bush land resulting from a change in current pulp prices**

	Current Pulp Price $690/t			Current Pulp Price $890/t		
	Poor Growth	Medium Growth	High Growth	Poor Growth	Medium Growth	High Growth
3 %	20.0	17.1	13.2	23.0	19.7	15.2
4 %	26.8	24.0	19.8	30.8	27.6	22.8
6 %	35.3	33.8	30.9	40.7	38.9	35.5
8 %	38.8	38.0	36.6	44.6	43.7	42.1

Results were also investigated for sensitivity to different future pulp prices. In all situations, although there was no difference in the absolute change in NPV given different types of land, the results were relatively more sensitive to future pulp prices on pasture and hay land than they were on bush land. On bush land, the effect of increased pulp prices was higher for high growth land than for low growth land. On pasture and hay land however, the quality of the land made little difference to the effect of changes to the future pulp price. Changes in the future price of pulp had less effect at higher discount rates. These results are presented in Table 7.

Table 7 **Net present value ($/ha) of hybrid aspen production at different future pulp prices**

	Future pulp price $700/t			Future Pulp Price $1200/t		
	Poor Growth	Medium Growth	High Growth	Poor Growth	Medium Growth	High Growth
Bush :						
3 %	23 177.76	26 542.24	33 271.20	31 002.74	36 975.55	48 921.17
4 %	18 247.21	19 959.40	23 383.79	22 229.37	25 268.95	31 348.11
6 %	14 730.88	15 235.85	16 320.78	15 963.46	16 879.29	18 785.95
8 %	13 765.49	13 966.99	14 369.99	14 234.13	14 591.85	15 307.29
Pasture:						
3 %	9 835.72	13 487.38	20 790.69	17 660.70	23 920.68	36 440.65
4 %	4 498.99	6 357.33	10 074.01	8 481.15	11 666.87	18 038.32
6 %	689.95	1 265.15	2 415.56	1 922.53	2 908.59	4 880.72
8 %	(358.61)	(139.91)	297.49	110.03	484.95	1 234.78
Hay:						
3 %	9 727.62	13 379.28	20 682.59	17 552.60	23 812.58	36 332.55
4 %	4 390.89	6 249.23	9 965.91	8 373.05	11 558.77	17 930.22
6 %	581.85	1 157.05	2 307.46	1 814.43	2 800.49	4 772.62
8 %	(466.71)	(248.01)	189.39	1.93	376.85	1 126.68

The profitability of a hybrid aspen plantation is also influenced by the conversion rate from aspen fibre to pulp. Sensitivity analysis was used to evaluate the impact of conversion rates of 2.75 and 3.25 on NPV. The models were relatively more sensitive when a plantation was established on pasture or hay land, than when one was established on bush land. This relative significance results from the lower NPV of pasture and hay land. Since the change in conversion rate caused the same absolute change in NPV, regardless of the land type, it was relatively more important on the lower valued pasture and hay land. Table 8 presents the results of this sensitivity analysis.

Table 8 **Net Present Value ($/ha) of hybrid aspen production on owned medium growth land at different conversion rates[1]**

	Conversion Rate = 2.75			Conversion Rate = 3.25		
	Bush	**Pasture**	**Hay**	**Bush**	**Pasture**	**Hay**
3 %	33 561.01	20 506.15	20 398.05	30 [illegible]4.03	17 179.16	17 071.06
4 %	23 531.28	9 929.20	9 821.10	21 838.17	8 236.09	8 127.99
6 %	16 341.43	2 370.74	2 262.64	15 817.37	1 846.68	1 738.58
8 %	14 387.35	280.45	172.35	14 188.10	81.19	(26.91)

[1]Conversion rate refers to the number of cubic meters of aspen fibre required to produce one tonne of pulp.

Harvesting costs are likely to increase in response to higher energy and transportation costs, and pressure to use more costly environmentally sensitive harvesting techniques. In a cut and skid operation, which is slightly more expensive than a mechanical operation, total woodlands costs have been estimated at $19.52/m^3, this amount was increased by 10% to investigate the potential impact of higher costs. Table 9 shows that higher woodlands costs have a negligible effect on the profitability of a hybrid aspen operation.

Table 9 **Net Present Value ($/ha) of hybrid aspen production on owned medium growth land when future woodlands costs increase by 10%**

	Bush		Pasture		Hay	
	base case	**plus 10%**	**base case**	**plus 10%**	**base case**	**plus 10%**
3 %	31 758.90	31 644.03	18 704.03	18 703.41	18 595.93	18 595.31
4 %	22 614.18	22 555.72	9 012.10	9 011.78	8 904.00	8 903.68
6 %	16 057.57	16 039.47	2 086.87	2 086.75	1 978.77	1 978.65
8 %	14 279.42	14 272.54	172.52	172.42	64.42	64.32

Sensitivity analysis was used to investigate the impact of changing the stocking level from a base level of 2000 trees/ha to 1400 trees/ha and 2700 trees/ha. Different stocking levels have been shown to change stand density, growth, and disease and pest resistance (Lester, In Process),

however it was not possible to estimate the affect of these changes on aspen yields because of poor growth and yield data. To provide an indication of the magnitude of yield response required to compensate for different stocking levels, the percentage yield change needed to achieve the same NPV at different stocking levels was calculated. At discount rates of 3% or 4%, yields needed to increase or decrease by less than 2% to compensate for increased or decreased stocking levels. At higher discount rates, yields needed to change by between 6% and 8% at a discount rate of 6%, and by between 16% and 20% at a discount rate of 8% in order to maintain the initial NPV. Very little difference was observed between plantations on owned and rented land. Table 10 presents the results of this analysis.

The feasibility of producing hybrid aspen on bush land was compared to that of managing existing stands of native aspen. Native aspen require minimal management because it suckers back after harvest thus planting is not required for regeneration. Vegetation control would also be unnecessary because native aspen suckers should out compete most vegetation. On medium quality land hybrid aspen was more profitable than native aspen at discount rates below 8%; however native aspen appears more profitable at 8%. Table 11 presents the results of this analysis .

Table 10 **Yield changes required to retain a constant NPV for hybrid aspen production at different stocking levels on medium level land**

	Owned Land			Rented Land		
	1400 trees/ha	2000 trees/ha	2700 trees/ha	1400 trees/ha	2000 trees/ha	2700 trees/ha
Discount Rate = 3%:						
Bush Land ($/m^3)	-1.15%	0	+1.3%	-1.1%	0	+1.3%
Pasture Land ($/m^3)	-1.05%	0	+1.2%	-1.05%	0	+1.2%
Hay Land ($/m^3)	-1.05%	0	+1.2%	-1.05%	0	+1.2%
Discount Rate = 4%:						
Bush Land ($/m^3)	-2.1%	0	+2.5%	-2.1%	0	+2.5%
Pasture Land ($/m^3)	-2.0%	0	+2.4%	-2.0%	0	+2.4%
Hay Land ($/m^3)	-2.0%	0	+2.4%	-2.0%	0	+2.4%
Discount Rate = 6%:						
Bush Land ($/m^3)	-6.8%	0	+7.9%	-6.8%	0	+7.9%
Pasture Land ($/m^3)	-6.3%	0	+7.5%	-6.4%	0	+7.4%
Hay Land ($/m^3)	-6.4%	0	+7.4%	-6.4%	0	+7.4%
Discount Rate = 8%:						
Bush Land ($/m^3)	-17.8%	0	+20.0%	-17.4%	0	+20.5%
Pasture Land ($/m^3)	-16.4%	0	+19.2%	-16.3%	0	+19.2%
Hay Land ($/m^3)	-16.4%	0	+19.2%	-16.3%	0	+19.2%

Table 11 **Net present value ($/ha) of native aspen produced on medium growth bush land compared to hybrid aspen production on similar land**

Discount Rate	Native Aspen	Hybrid Aspen
3 %	23 631.60	31 758.90
4 %	19 058.59	22 614.18
6 %	15 765.11	16 057.57
8 %	14 884.78	14 279.42

DISCUSSION

The results of this analysis suggest that hybrid aspen production may be economically viable for industrial forest products companies in Saskatchewan. Hybrid aspen production was more profitable on bush land than on either pasture or hay land in all situations. Plantations on bush land are the most profitable because, although more site preparation is required to plant hybrid aspen on bush land than on pasture or hay land, the revenue generated by processing the standing aspen exceeds the extra site preparation costs. The cost of purchasing bush land is currently less than the value of standing timber, thus one would expect market forces to drive up prices, however, even if market corrections occur, they will likely only compensate for the value of standing bush sold as fibre. Since pulp mills process the fibre into a more valuable end product they should continue to be able to purchase land for less than the value of the standing bush as pulp. The NPV of a plantation established on owned bush land was approximately double one established on pasture or hay at a 3% discount rate, and the difference increased at higher discount rates. At an 8% discount rate, the NPV on bush land was more than eight times that on pasture or hay.

The model was very sensitive to changes in the discount rate since many of the costs and revenues in hybrid aspen production occur 50 to 60 years after planting. As the discount rate increases, the importance of costs and revenues at the end of the rotation become less relatively significant than costs and revenues incurred at the beginning of the rotation. Although hybrid aspen plantations were feasible under some assumptions at all discount rates, at a discount rate of 8% the plantations exhibited a negative NPV on poor growth owned pasture or hay land, and on poor and medium growth rented pasture and hay land.

The NPV was higher on owned pasture and hay land than it was on rented land, however it had little impact on the NPV of a plantation established on bush land. This is because rental rates for pasture and hay land are much higher than for bush land. The NPV was the same on rented pasture and hay land because the same management and site preparation was required, and the rental rates, although derived differently, were the same. If pasture land had more tree cover that was assumed in this analysis, the cost of site preparation would increase and the NPV would decrease.

The NPV varied as the value of the standing bush changed. Two alternative scenarios were run in which the initial pulp value was either lower or higher than the base case. A lower initial price reduced the NPV of bush land while the opposite result was observed at higher initial pulp values.

These results demonstrate the relative importance of initial income and expenses in this type of analysis. If the plantation is established on land with a valuable existing stand of aspen, the operation is more profitable. However, since higher standing bush values actually reflect on the existing stand of native aspen, and not on the hybrids planted on the site, the same effect would be observed if the land was left in native aspen, or cut and converted to some alternative land use.

The results were also tested for sensitivity to changes in predicted future pulp prices. Although on bush land the results were less sensitive to changes in pulp prices at higher discount rates, plantations established on hay and pasture land were more sensitive at higher rates. This discrepancy can be explained by the different times at which the various income and expenses are incurred in the alternative scenarios. In a plantation established on bush land, income is obtained at the outset with expenses being incurred annually until the end of each rotation. As the discount rate increases, the present value of annual expenses decreases thus, relative to the initial income, they become less significant. However, with pasture and hay land, no income is derived until the end of the rotation. As the discount rate increases the present value of future income decreases and operations become increasingly marginal. As a result, any change in future value represents a large percentage change in the profitability of an operation.

The conversion rate from wood fibre to pulp is also important. Generally, a lower (higher) conversion rate increases (decreases) the NPV in all situations because less (more) fibre is required to produce a given quantity of pulp. However, because plantations on pasture or hay land are marginal at higher discount rates, as the discount rate increases, any changes to profitability resulting from changes in the conversion rate become relatively more important. Hybrid aspen plantations on bush land, on the other hand, are not marginal operations thus, although the relative importance of changes in the conversion rate increases at higher discount rate, they are relatively less significant.

Woodlands costs may go up in the future in response to changing transportation costs, longer haul distances, and new environmental regulations. However, when woodlands costs were increased by 10% to reflect these changes, there was less than a 1% decline in the NPV. This is not surprising because woodlands costs account for only approximately 10% of the total cost of mechanical pulp production.

Yields had to change to compensate for different stocking rates. Sensitivity analysis demonstrated that when the stocking level was varied by 35%, yields had to change by as much as 20% when the discount rate was 8% to maintain the same NPV. At discount rates of 3% or 4% however, different stocking rates required yield changes of less than 3%.

Land suitable for hybrid aspen plantations could also be used for grazing, crop production, hay production, and plantations of other trees. Even if a decision had been made to produce wood fibre on a tract of land, the potential of hybrid aspen production should be compared to native aspen production. Hybrid aspen production was more profitable on bush land than native aspen production at discount rates ranging from 3% to 6%; however natives were more profitable at discount rates of 8%. If the comparison were made on pasture or hay land, hybrid aspen production would be more profitable in every situation because, although both plantations would involve the same establishment and management costs, hybrid aspen grows faster thus the NPV of future harvests would be higher.

CONCLUSIONS

A more detailed analysis of hybrid aspen production would require more information about the silvics of hybrid aspen. Genetic research is needed to develop a hybrid aspen clone suitable for production in northwest Saskatchewan, and to identify reasonable growth and yields for such stands. If the costs of this research and development were incorporated into a feasibility study, the NPV would decrease in all instances. Further research is also required to identify: optimum stocking rates, and the effect of changes in stocking rates on biomass production; requirements for stand establishment and vegetation control; the risk of loss to disease and pests, and possible control mechanisms; and likely responses to management techniques such as fertilization and irrigation. The results of this study however, suggest that further research into hybrid aspen production in northwestern Saskatchewan may be warranted.

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