**Can Forest Management Strategies
Sustain The Development Needs Of
The Little Red River Cree First Nation?**

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CAN FOREST MANAGEMENT STRATEGIES SUSTAIN THE DEVELOPMENT NEEDS OF THE LITTLE RED RIVER CREE FIRST NATION?

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ABSTRACT

In this study, we explore whether projected socio-economic needs of the Little Red River Cree Nation (LRRCN) can be met using the natural resources to which they have access. To answer this question, we employ a dynamic optimization model to assess the capacity of the available forest base to provide for anticipated future needs of the LRRCN. Results for alternative management strategies indicate that decision-makers face significant tradeoffs in deciding an appropriate management strategy for the forestlands they control.

Keywords: boreal forest, First Nations, forest management, sustainability

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1. INTRODUCTION

The prosperity and wellbeing of First Nations' communities requires economic development that sustains important environmental values and is compatible with their culture. Over the years, the federal government of Canada has promoted economic development in First Nations' communities through a series of programs, first promoting the migration of First Nations' people to urban centers in the mid-1960s, then implementing sectoral development in the 1980s, and, finally, undertaking community development within First Nations in the 1990s (Saku 2002). A strength of the community development approach, which involves the promotion of economic activity through local government bodies or community organizations, is that it is seen as providing greater involvement of First Nations in the decision-making process on issues concerning their economic and social development (Pierce et al 2000). First Nations seek economic development opportunities in the context of broader objectives that include: (i) greater control over economic activities on their lands; (ii) employment creation, and (iii) generating the wealth necessary to support self-government and improve socioeconomic conditions (Anderson 1997).

Federal and provincial governments in Canada have historically promoted economic activity in rural regions through the development of natural resources, with forests having played a key role in that development. Since more than 80% of First Nations' communities in Canada are located within forested regions, it is not surprising that forest resources are seen

as a potentially valuable livelihood or source of income that can support First Nations' goals of greater self-reliance (Ross and Smith 2002; Natural Resources Canada 2001). At the same time, local forests are also an important source of cultural and spiritual values, because of the environmental values they embody as well as their non-timber outputs (Parsons and Preston 2003).

For the most part, timber on provincial (Crown) lands in Canada is allocated to companies under long-term leases designed to encourage the construction and operation of processing facilities.[1] Lack of capital makes it difficult for First Nations to access timber on Crown lands directly under existing commercial arrangements, while prevailing legislation does not offer any formal legal role in the management of resources of importance to local communities (Ross and Smith 2002). Those forests situated on Indian Reserves or on other lands controlled by First Nations (e.g., settlement lands arising from the resolution of some comprehensive claims) are often too small to enable self-sufficiency through forest development. On-reserve forests may, however, provide a starting point for building technical capacity and developing partnerships, and one of the ways First Nations pursue their goals of increased economic self-reliance is through co-management agreements over Crown forests (Treseder and Krogman 1999; Natcher and Hickey 2002).

In this paper, we explore the strategies chosen by the Little Red River Cree Nation (LRRCN) in northern Alberta in pursuing economic development through such a co-management agreement. We examine the existing management strategy, which follows the approach of sustained-yield management and focuses on timber harvests, and contrast it with an alternative approach that focuses on sustainable forest management (SFM) and addresses both socio-economic and ecological sustainability objectives. We analyze the potential

outcomes of the two approaches in terms of the financial returns, harvest volumes, employment opportunities, and environmental impacts, and discuss how well each approach meets the objectives of the LRRCN.

The paper is organized as follows. The next section provides background information about the LRRCN and the area under consideration. Sections three and four describe the study objectives and methodology, respectively. An analysis of the model outcomes for several management scenarios is provided in section five. We conclude with an evaluation and discussion of possible development LRRCN strategies.

2. STUDY REGION

The LRRCN peoples have historically occupied portions of the Lower Peace River region in north-central Alberta and used these lands to support their culture and livelihood. The Nation signed Treaty No 8 with the federal government in 1899. The Treaty affirmed the right of LRRCN peoples to use the resources within their traditional area to sustain traditional vocations and way-of-life, while opening the treaty area for settlement and development of trade and commerce. The Nations' currently has 3,676 members , most of whom (3,161) live on three separate reserves (communities) within this region (DIAND 2003).[2] According to the 1996 census, 75 percent of the population was under the age of 30 (Statistics Canada 1996). This ratio is almost three times the Canadian average and is expected to increase further as the LRRCN population is projected to double over the next 25 years (Woodrow and Campa 2001). This demographic trend is a major concern because 85 percent of eligible community workers (age 15-65) are unemployed (Webb 2001).

Traditional use of the provincial forestlands and resources that surround the reserve communities remains critical to the economic, social and cultural sustainability of the LRRCN. Forest resources are also key elements in the community development strategies for achieving economic self-sufficiency. In 1995, the LRRCN and neighboring Tall Cree First Nation entered into a cooperative management planning agreement with the Alberta government and Tolko Industries Ltd., a private forest company (MOU 1996, 1999). The Memorandum of Understanding calls for the cooperative management of a 35,000 km^2 Special Management Area (SMA) situated in the lower Peace River region (Natcher and Hickey 2002). This management area is characterized by: (1) a 10,000 km^2 boreal sub-artic plateau, within which the two First Nations and the Province have cooperated to create a 6,000 km^2 protected area (the Caribou Mountains Wildlands Park), situated adjacent to the northwest quadrant of Wood Buffalo National Park; and (2) a 25,000 km^2 "working forest" landscape, bordering Wood Buffalo National Park on the west and south. First Nations' members can continue to hunt, trap and fish within the protected area and the neighbouring 44,000 km^2 Wood Buffalo National Park. This 50,000 km^2 potected landscape contributes to the maintenance of the First Nations' cultural sustainability and provides some economic opportunities related to ecotourism.

Within the 25,000 km^2 working forest, the LRRCN and Tall Cree hold forest tenures in four provincial forest management units (FMUs)[3] located to the west of Wood Buffalo National Park, namely, FMUs F3, F4, F6 and A9. These forest tenures are volume-based agreements, entitling the First Nations to an annual volume of deciduous and coniferous timber within these management units. Three other FMUs (F2, F5 and F7) are held by Tolko.

The 1995 cooperative management agreement established a commitment between Alberta, the First Nations and Tolko for the joint planning and management of forestry operations within several FMUs (F2, F3, F4, F5, F6 and F7). The agreement includes a long-term LRRCN' commitment to supply coniferous timber from FMUs F3, F4 and F6 to the Tolko lumber mill in High Level, and an agreement for the partners to collaborate on the development of compatible forestry management plans within their respective FMUs. In addition to the agreements with Tolko, there is a recent volume agreement between the First Nations and Footner Forest Products Ltd. (MOU 1999) to supply deciduous fiber to a new oriented strand board (OSB) mill, a joint venture between Ainsworth and Grant Forest Products. The Tolko mill consumes about 1 million m^3 of coniferous timber annually, while the OSB plant, when it reaches full operations, will produce 1 billion square feet annually from 1.2 million m^3 of aspen (Kryzanowksi 2001). Under both of these fibre supply agreements, LRRCN receives stumpage payments keyed to product prices (similar to the stumpage mechanism employed by the Alberta Government).[4]

The goal of the LRRCN is to develop and implement a forest management regime within the working forest that will ensure the community's economic sustainability while preserving forest landscape features critical to on-going traditional-use of the working forest and community cultural values. Our analysis focuses on F3, F4 and F6 management units (now amalgamated into FMU F23) for which comprehensive timber resource information is available (Figure 1).

<Insert Figure 1 about here>

3. STUDY OBJECTIVE

The current management regime in the region involves sustained yield management (SYM) that focuses on maintaining constant harvest levels. A multi-stakeholder planning process (the Alberta Forest Conservation Strategy) identified a public desire to move beyond sustained yield management to eco-system management. However, despite the introduction of new regulations that increase the flexibility of companies to practice such management, there have not yet been any legislative changes that enable license holders to affect the annual allowable cut or AAC (Alberta Centre for Boreal Studies 2001).

The forest resources available to the communities provide the most significant source of potential economic activity within the region. At the same time, LRRCN's wish to maintain the ecological integrity of the working forest and their culture has resulted in the identification of local criteria for the utilization of forest resources. The specific objectives addressed by these local criteria include generating paths for economic self-sufficiency, while protecting environmental amenities and non-timber values that are critical to the cultural needs of First Nations' peoples (Natcher and Hickey 2002). The challenge is to develop a forest management plan that achieves a balance between objectives given the forest resources currently available to the LRRCN.

The overall goal of this study is then to examine the potential for sustainable forest management on the above forest tenures to achieve those objectives. We investigate six possible management scenarios and their likely impact on the livelihood of the First Nations' people. The specific research objectives are:

(a) To develop models to assess the capacity of the forestland base to provide for the needs of the LRRCN under alternative management scenarios; and

(b) To elaborate and evaluate the tradeoffs under sustainable forest management strategies.

4. METHODOLOGY

The focus of this study is on the use of timber resources to support industrial operations as a basis for the economic sustainability of local communities. In order to achieve this objective, we developed models for long-term strategic forest planning and analyses.[5] The models are used to determine harvest schedules that maximize cumulative harvest volume and discounted stumpage revenue over an assumed 200-year planning horizon, 2000 to 2200, divided into twenty management decades. The 200-year planning horizon is chosen according to strategic planning practices in the province. The dynamic optimization character of the models addresses the effect of any period's management decisions on the future state of the forest and available future management options. Inventory data derived from the harvesting land base and yield data are used as the model inputs (see the Appendix for more detail on the inventory data).

Important changes occur in forestry as sustainable forest management replaces sustained-yield management. While sustained-yield management focuses on timber values and maintenance of harvest flows, sustainable forest management shifts the focus to multiple forest values. The government of Alberta continues to use sustained-yield management as its approach to forest management, although provincial forest policy is beginning to adopt the notion of management that attempts to emulate the natural dynamics of ecosystems. But it is

not clear what the implications such a management approach will have on desired social goods and services, such as even-flow harvest (Adamowicz and Veeman 1998).

A number of researchers feel that innovative forestry should mimic certain key characteristics of landscapes originating from disturbances such as fires. These characteristics include: age distribution (including the proportion of old-growth), distribution of stand type and size, and patch shape and spatial arrangement of patches on the landscape (Alberta Centre for Boreal Studies 2000). In this study, we implement only distribution of old-grow forest as an important landscape attribute. Harvest rotations implied by sustained-yield management dramatically change the natural age distribution of the forest landscape. The difference between the managed and naturally disturbed landscape age class distributions implies either a loss of mature stands as a result of sustained-yield management or fiber loss as a result of longer rotations for preservation of mature forest.

In natural forests, proportions of over-mature stands and old growth (older than 100 years) increase as the fire cycle lengthens (Bergeron et al. 1998). A harvesting age of 100 years would result in 50% of the current age structure disappearing from managed forests. A harvest rotation of about 100 years would only preserve 22-46% of the current age structure and associated composition, depending on the region under consideration. If fires randomly burned 1% of the forest every year then, on average, 37% of the forest would be greater than 100 years of age (Alberta Centre for Boreal Studies 2000; Bergeron et al. 1998). For this study, we define a "sustainable management" scenario in terms of the proportion of managed forest landscape in "old-growth" (older than 100 years).

We examine quantitatively: (1) the impact of even-flow harvest on the distribution of old-growth over time, (2) the impact of old-growth requirements on fibre flow over time, and

(3) the measures to maintain old-growth characteristics of landscape while maintaining economically viable forestry.

We examine scenarios that differ by constraints and by the choice of the objective function. Constraints are imposed on both the harvest volume flow and the age structure of ending stand inventory. The first constraint reflects the sustained-yield requirement and it is set up in terms of non-declining harvest flow over the planning horizon. The second constraint reflects sustainable management, which is expressed by the need to maintain 30% of managed forest landscape in "old-growth" conditions. This requirement is based on estimates of old growth in boreal forests (Alberta Centre for Boreal Studies 2000, Bergeron et al. 1998). For this study, we selected the required proportion of old growth (target) to be lower than a published value because the latter refers to the natural forest. Economic objectives (employment and revenues) are linked to harvest volumes, while ecological and non-timber outputs are determined by the age class structure of the forest.

We found that the requirement for non-declining yield flow coupled with an age structure constraint significantly reduced both cumulative harvest volume and discounted stumpage revenue over the horizon. There are tradeoffs between the level of timber flows over time and forest conditions. The alternative that simultaneously maintains a certain level of ecological and non-timber outputs and non-declining yield is referred to as "sustainable management with *strict* harvest flow" constraints.

We consider a variation of this alternative by relaxing the non-declining harvest flow and allowing the variability in both deciduous and coniferous harvests to be no more than 10% over the planning horizon. We refer to this strategy as "sustainable management with *lax* harvest flow" constraints.

These three different strategies are examined using two alternative objectives: (1) maximizing the cumulative harvest volume, and (2) maximizing the cumulative discounted stumpage revenue from timber harvests over the planning horizon. Maximization of cumulative volume addresses concerns related to adequate timber supply for the mills. Maximizing net revenue from harvests (i.e., stumpage revenue) will generate the most economic wealth from the timber resource. One possible strategy then is to use higher revenue as a potential driver of future development and economic diversification. In the first, the cumulative volume of timber harvest is maximized, and, in the second, stumpage revenue is maximized. Six scenarios are generated by combining the two objectives–volume maximization and revenue maximization with the three management strategies, sustained-yield management, sustainable management with a strict harvest flow regime, and sustainable management with a lax harvest flow regime. The scenarios are summarized in Table 1.

<Insert Table 1 about here>

5. OUTCOMES FOR ALTERNATIVE MANAGEMENT SCENARIOS

Model outcomes in terms of total volume by forest type and discounted total stumpage revenue under different management scenarios are provided in Table 2. Several results are highlighted. The total volumes delivered over time depend both on the model objective and constraints. Under the volume maximization scenarios (1, 2 and 3), the cumulative harvests are greater by 3%, 12% and 17% compared to the corresponding harvests generated under the revenue maximization scenarios (4, 5 and 6). The requirements for maintenance of old

growth and non-declining timber flow have an even stronger impact on cumulative harvests than the objective function. Cumulative harvest volumes under scenarios 2 and 3 are 15% and 13% lower, respectively, than the volume generated under scenario 1. The corresponding total discounted revenues under scenarios 2 and 3 are 17% and 1.7% lower, respectively, than the total revenue generated under scenario 1 (Table 2).

<Insert Table 2 about here>

The requirements for maintaining old growth and even timber flow reduce revenue; however, relative to the best available revenue, given by scenario 4, these requirements do not exhibit dramatic revenue reductions while cumulative harvests decline substantially. Overall stumpage revenue is maximized at $86.6 million with scenario 4, followed by $83.9 million for scenario 1, with both scenarios requiring even flow of harvest yields. The lowest revenue outcomes are generated under the sustainable management scenarios with strict harvest flow constraints; the revenue under this scenario is 13% lower than the revenue under scenario 4. It may come as a surprise that the $93.1 million revenue under scenario 6 is 7.5% <u>higher</u> than the revenue under scenario 4. This implies that high financial benefits are possible even when the conservation requirements are imposed. Higher coniferous harvests coupled with high market prices for softwood, compensate for the environmental restrictions. This outcome shows that one way to achieve better financial returns is by allowing higher variations in between-period harvests.

The outcomes in terms of average annual harvest volumes are an important indicator of a stable fibre supply to the processing facilities (Table 3). As expected, the requirement for

conservation of old-growth forests strongly affects the average annual harvest. On the other hand, the choice of the objective function used for generating forest management strategy is another important factor in determining annual harvests. Depending on the objective function chosen by LRRCN and the underlying market conditions, the supply of fibre to the facilities may be significantly different.

When analyzing LRRCN development strategies, the financial and timber volume benefits for each scenario have to be weighed against the corresponding ecological impacts. We use the average standing age structure over the horizon as a proxy for the ecological values of the forest for each of the six scenarios (see Table 4).

<Insert Tables 3 and 4 about here>

Under the even-flow yield strategies, the age distribution of ending inventory is skewed toward early succession stands. It accounts for 49% of the harvest land base, under volume maximization (Table 3, scenario 1) and 50% under revenue maximization (scenario 4). Under volume maximization, an even-yield strategy provides a stable flow of coniferous and deciduous harvest at annual levels of 356,714 m^3 and 403,707 m^3, respectively. Both coniferous and deciduous harvests reach the imposed harvest constraints in the late periods under the volume maximization regimes. This accounts for the spike in late harvests. The revenue maximizing strategy emphasizes coniferous harvests at the annual level of 370,523 m^3 under the projected high stumpage for coniferous wood; the annual deciduous harvest is constant at the level of 372,175 m^3 for the first 16 periods and then increases to 438,620 m^3.

The requirement for maintaining 30% of the land base in old-growth conditions coupled with an even harvest-flow constraint reduces harvest flow for both the volume and revenue maximization scenarios 2 and 4. Annual coniferous and deciduous harvests drop to 296,306 m^3 and 327805 m^3, respectively.

Under the sustainable management with lax flow regime (Scenario 3), the annual coniferous volumes fluctuate between 237,000 m^3 and 402,000 m^3 (Figure 2a). The range of annual deciduous harvest is even wider; it spreads from 259,000 m^3 and 505,000 m^3 (Figure 2a). The harvest pattern of coniferous versus deciduous harvests is inverted for sustainable management strategies under revenue maximization (Scenarios 5 and 6) compared to all other scenarios. Revenue maximization favors harvesting of more valuable forest types thus resulting in average annual coniferous volumes exceeding deciduous volumes. Average age distribution under even-flow yield scenarios 1 and 4 (Table 3) indicates relatively high proportion of standing inventory in the early seral stage, but this is not necessarily alarming.

The distribution of old-growth forest over time is presented in Figure 3. The old-growth distribution under the sustained yield strategy (scenarios 1 and 4) is unacceptable both ecologically and economically, as it does not protect future forest diversity or sustainable wood production. When the constraints are imposed to prevent depletion of forest resources, they are often binding for scenarios 2, 3, 5 and 6; the proportions of old forest either oscillate above the imposed requirement of 30 percent under the volume maximization scenarios (Figure 3b) or they stabilize at that level under the revenue maximization scenarios (Figure 3b). Requiring maintenance of the portion of harvest landbase in old growth conditions under the sustainable management scenarios results in stable proportions of mature forests in the second half of the planning horizon. However, this can only be achieved

by getting a significant portion of the landbase (about 50%) in the old-growth conditions during the period 4 and 5. Note that this pattern emerges also under the even yield management scenarios 1 and 4 despite their lack of any requirement on old growth conservation. This outcome is a consequence of the initial inventory age structure (Figure 4 in the Appendix) dominated by middle-aged deciduous forest. These stands grow old in the periods 4 and 5 and get depleted afterward.

<Insert Figures 2 and 3 about here>

6. EVALUATING THE ALTERNATIVE STRATEGIES FOR LRRCN

As the previous scenario analyses indicate, in selecting between several development strategies the LRRCN face tradeoffs among four different aspects: (1) total timber volume available to mills in the long term; (2) total discounted revenues generated over the planning horizon (wealth generated); (3) the time path associated with different management regimes (community stability); and (4) forest age structure (ecological concerns). LRRCN development objectives include capacity building as the basis for economic self-sufficiency and eventual self-governance, while preserving ecological, cultural and spiritual values.

Consider the outcomes of even-flow yield management as a benchmark to which the two sustainable management alternatives are compared. The even-flow yield strategy produces a stable supply of both coniferous and deciduous timber that could be used to support a primary wood processing facility (an option desired by LRRCN). However, the even-flow yield strategy is not without a number of associated costs. It leads to depletion of forest resources with about 75% of the harvesting land base in an early succession stage by

the end of the planning horizon. Because of ecological concerns and associated non-timber values, decision-makers have already been asked by community members to preserve additional wildlife habitat within the harvesting land base. Further, the relatively low financial returns associated with the even-flow yield strategy do not provide economic surpluses that can be used to fund economic development in other areas.

Strategies that rely on intensive harvest activities at the beginning of the horizon may enable LRRCN to achieve high financial returns without sacrificing future use of forest resources. The sustainable management with the lax harvest flow regime offers an opportunity for greater financial returns at the beginning of the planning horizon. These returns could be diverted for building technical and professional capacity to be used by current and future generations. By virtue of the imposed ending inventory conditions, the sustainable management strategies ensure that forest resources will keep providing benefits to future generations. But these scenarios also result in declining harvest volumes relative to the even-flow yield strategy. Therefore, none of the management strategies considered (in which we utilize both the existing management regime of even-flow yield and consider alternative approaches incorporating sustainability) are able to meet all LRRCN objectives. What approach, then, can LRRCN take?

7. DISCUSSION

Canadian governments have traditionally relied upon the exploitation of forest resources uder sustained yield or even-flow policies that focus on harvesting and processing to generate economic activity. This approach has been criticized for not recognizing the increasing importance of other uses of forest resources and non-timber values (Howlett and Rayner

2001; Binkley 2000). Our results support the view that even-flow yield policies are inadequate as a driver of economic development. Further, the levels of even-flow timber will likely be inadequate for development of major secondary manufacturing facilities.

If timber availability could be enhanced, positive employment gains could be achieved by moving from simple supply of logging and forest services (current LRRCN employment) into the manufacturing of wood products. Pursuing such a strategy involves a significant financial investment in infrastructure and the education and training of employees, and investments in the provision of a stable future supply of fiber.

We examined sustainable management scenarios that mimic the forest age distribution achieved as a result of natural disturbance (mainly fire). Although we did not do so, the model permits the inclusion of additional constraints on preservation of wildlife habitat and structural diversity within the harvest land base. It is likely that, if new ecological constraints are introduced, financial and timber volume outputs may well be reduced. The same is true if there is an increase in natural disturbances, such as forest fires and insect outbreaks (perhaps the result of climate change). Given that the existing timber management regime is unlikely to satisfy LRRCN objectives, and that placing greater emphasis on ecological sustainability is likely to further reduce economic opportunities (given existing economic conditions and human capital within the communities), LRRCN may face unpalatable tradeoffs among these options unless they are able to develop alternative strategies that shift out those tradeoffs. But this, too, requires investment in either additional resources outside the community or in the capacity of community members at the same time that LRRCN faces a host of pressing social needs.

These strategies must also cope with the inherent uncertainty with respect to the forest resource and desired outputs. There may be unanticipated changes in forest structure due to natural disturbances associated with increased fire and insect risk from holding mature trees in inventory. The effect of climate change on growth and forest composition is also uncertain. Finally, while we modeled stumpage values as stationary, they are likely to be volatile from one planning period to the next. One method of dealing with this uncertainty that LRRCN can pursue is to diversify their development strategies, thereby spreading risks of relying on any one approach.

ENDNOTES

1. Provincial governments own more than 90% of the forest resources in BC, Alberta, Ontario and Quebec – the four largest provinces.
2. Fox Lake is the largest of the three communities, while John d'Or Prairie is the administrative center, and Garden River is located within Wood Buffalo National Park (LRRCN 2003).
3. They differ from Forest Management Agreements (FMAs), which give the tenure holder the exclusive right to the timber volume (specified by type) from a defined area.
4. The Alberta Government also collects stumpage on the volumes harvested under these tenures.
5. These are multi-period, linear programming models that are solved using the CPLEX routine on the GAMS platform (Brooke et al. 1998).

APPENDIX

Timberline Forest Inventory Consultants Ltd. determined the net land base currently available for timber harvesting within the F23 management unit. Determination of the net harvesting land base is founded on the current Alberta Timber Harvest Planning and Operating Ground Rules and applicable land-base exclusions (Timberline 2001a). The forest inventory was determined from the approved Alberta Vegetation Inventory (AVI version 2.1). To incorporate First Nations' requirements for forest management that is compatible with traditional land use and values, particular types of forestland are excluded from the harvest land base. Harvesting is prohibited on First Nations' reserves, protected areas, cultural areas, and special places and natural areas. The LRRCN also acknowledge the need to integrate wildlife values related to woodland caribou, wood bison and trumpeter swan into forest management plans. As a part of defining the harvesting land base, the wildlife habitat areas have been excluded. Further land-base exclusions consist of three major types: forest where stands are inoperable or isolated, and exclusions based on operating ground rules. The timber harvesting land base covers 384,603 ha or 39% of the F23 area, divided into 15 classes for which timber yield data are available (Timberline 2001a, 2001b). The forest resource within the region is made up of two predominant species-white spruce and aspen with a distinctly skewed age class profile-a large part of the inventory is found in mature timber and younger stands established after a fire.

<Insert Figure 4 about here>

The age class distribution of the starting inventory is shown in Figure 4. The starting inventory refers to the land base available for timber harvesting in 2000. We contrast the age

distribution of the coniferous harvest land base to that of the deciduous land base. A feature

of the starting inventory is the large area of both coniferous and deciduous forest in the 60- to

90-year age classes (63.4% of the harvesting land base). This spike in the age class

distribution is characteristic of previous disturbance regimes. About 11% of the merchantable

land base is in the early regeneration stage (the 10-year age class), with this high proportion

attributable to the 1998 Mikkwa fire. Compared to the proportion of coniferous stands in the

early regeneration stage (14.3%), a smaller proportion of deciduous stands are in the early

regeneration stage (only 6.7%). On the other hand, the smaller proportions of deciduous

stands in the higher age classes reflects the fact that deciduous trees reach maturity and decay

sooner than coniferous species, which also contributes to lower fire incidence.

To develop the stumpage revenue objective function, we used historical data to

estimate potential future prices of softwood lumber and OSB, the two principal products

currently manufactured from timber harvested under license. We used annual SPF 2x4

lumber and OSB prices for Western Canada (in Canadian dollars) as reported by Random

Lengths (Random Lengths 2003), and deflated them using the Canadian Consumer Price

Index. These prices are the same as those used by the Alberta Government in their stumpage

calculations (Alberta Government 2003b). We used time series analysis to investigate the

time trend of softwood lumber and OSB prices; for both sets of prices, we could not reject

the hypothesis that prices were stationary, exhibiting no trend. Thus, we employed a constant

price for both lumber and OSB in determining stumpage rates. The lumber and OSB prices

were converted back into nominal prices to estimate the current stumpage following Alberta

guidelines (Alberta Government 2003a), and then deflated back to real terms. This

methodology resulted in estimated stumpage rates of $8.52 per cubic meter for coniferous

wood for lumber production and $0.50 per cubic meter for deciduous OSB. A 5% real rate of

discount was used to calculate the present value of stumpage revenue.

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Table 1. Alternative Management Scenarios

Scenario	Objective to maximize	Harvest flow	End period harvest volume (million m^3)^a		Old forest (%)^b
			Coniferous	Deciduous	
1. Even yield management	Volume	nondeclining	4	4.5	none
2. Sustainable management– Strict harvest flow regime	Volume	nondeclining	none	none	30
3. Sustainable management– Lax harvest flow regime	Volume	up to 10% variation	none	none	30
4. Even yield management	Revenue	nondeclining	4	4.5	none
5. Sustainable management– Strict harvest flow regime	Revenue	nondeclining	none	none	30
6. Sustainable management– Lax harvest flow regime	Revenue	up to 10% variation	none	none	30

^{a} Limit on the final period harvest volume.

^{b} Requirement on the area of old forest expressed as the portion of the total harvest land base. Taking into consideration current age distribution caused by recent fire, this requirement applies to all planning periods except the initial five.
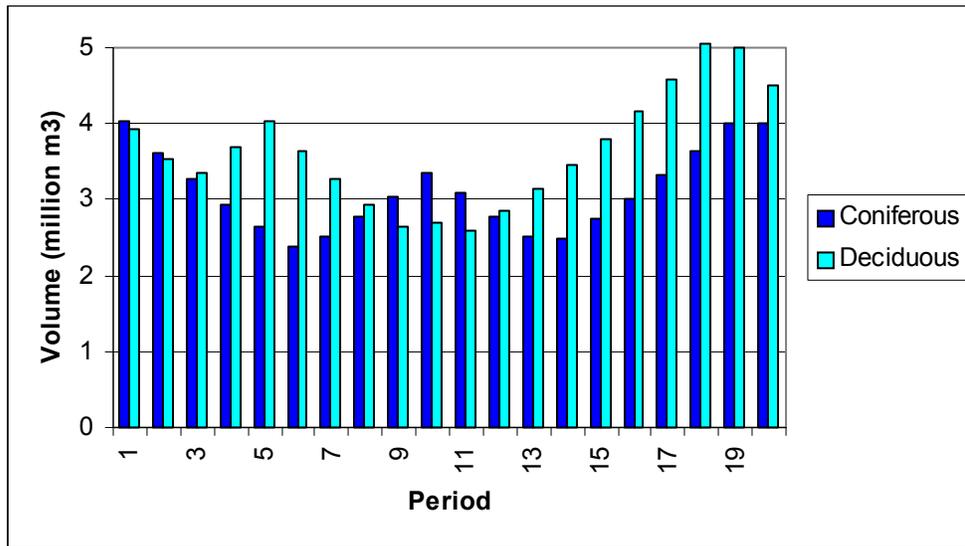
Table 2. Cumulative Harvest Volumes and Discounted Total Stumpage Revenue

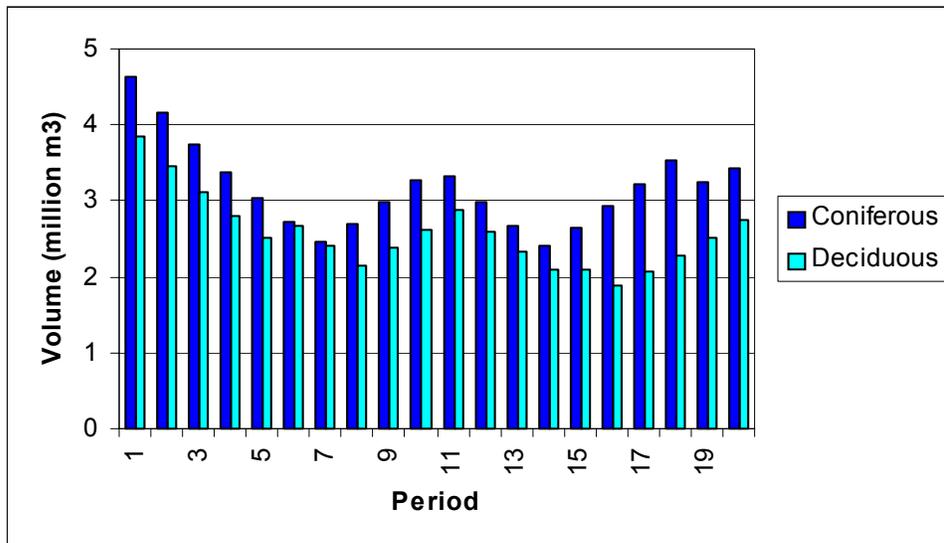| Scenario	Total Harvest (mil. m^3)		Discounted Stumpage Revenue ($ mil)	
	Coniferous	Deciduous	Coniferous	Deciduous
Volume Maximization				
1. Even yield management	72.208	83.422	78.742	5.176
2. Sustainable management– Strict harvest flow regime	61.428	70.449	65.409	4.203
3. Sustainable management– Lax harvest flow regime	62.133	72.807	77.737	4.710
Revenue Maximization				
4. Even yield management	74.105	77.093	81.789	4.772
5. Sustainable management– Strict harvest flow regime	65.496	52.194	72.288	3.346
6. Sustainable management– Lax harvest flow regime	63.454	51.415	88.776	4.316

Table 3. Average Annual Harvest Volumes (m^3/year)

Scenario	Coniferous	Deciduous
Volume Maximization		
1. Even yield management	361,042	417,108
2. Sustainable management–Strict harvest flow regime	307,139	352,245
3. Sustainable management–Lax harvest flow regime	310,666	364,035
Revenue Maximization		
4. Even yield management	370,523	385,464
5. Sustainable management–Strict harvest flow regime	327,480	260,972
6. Sustainable management–Lax harvest flow regime	317,268	257,075

Table 4. Age Distribution of the Standing Inventory over the Planning Horizon

Scenario	Portion of harvest landbase (%)		
	Young	Middle-aged	Mature
Volume Maximization			
1. Even yield management	49.0	34.2	16.9
2. Sustainable management–Strict harvest flow regime	36.7	29.6	33.7
3. Sustainable management–Lax harvest flow regime	37.1	30.0	32.9
Revenue Maximization			
4. Even yield management	49.7	33.8	16.5
5. Sustainable management–Strict harvest flow regime	38.0	29.1	32.9
6. Sustainable management–Lax harvest flow regime	39.8	29.1	31.1

Figure 1: The study area F23 that combines the former F3, F4 and F6 forest management units
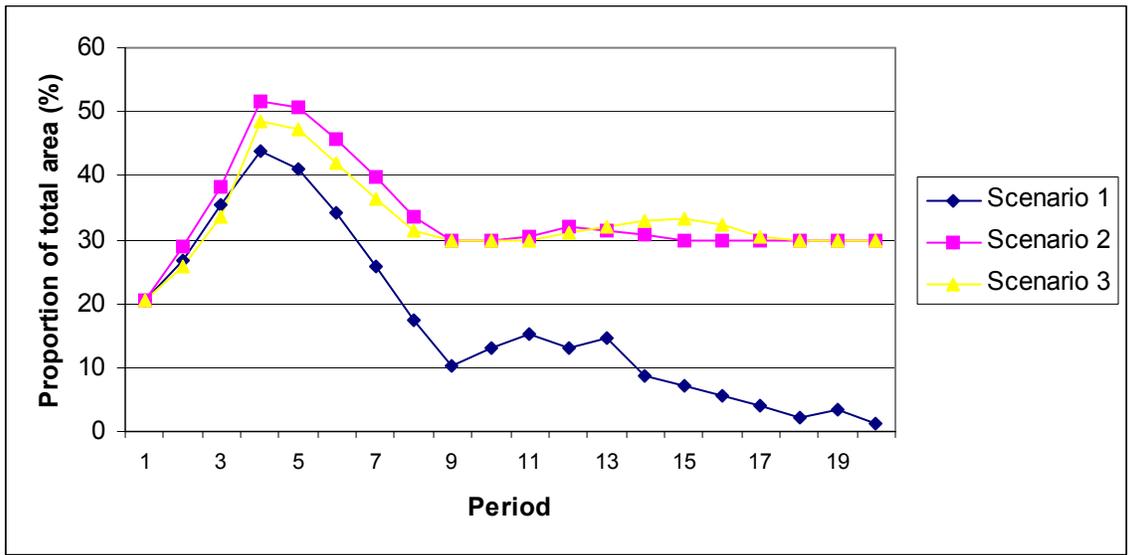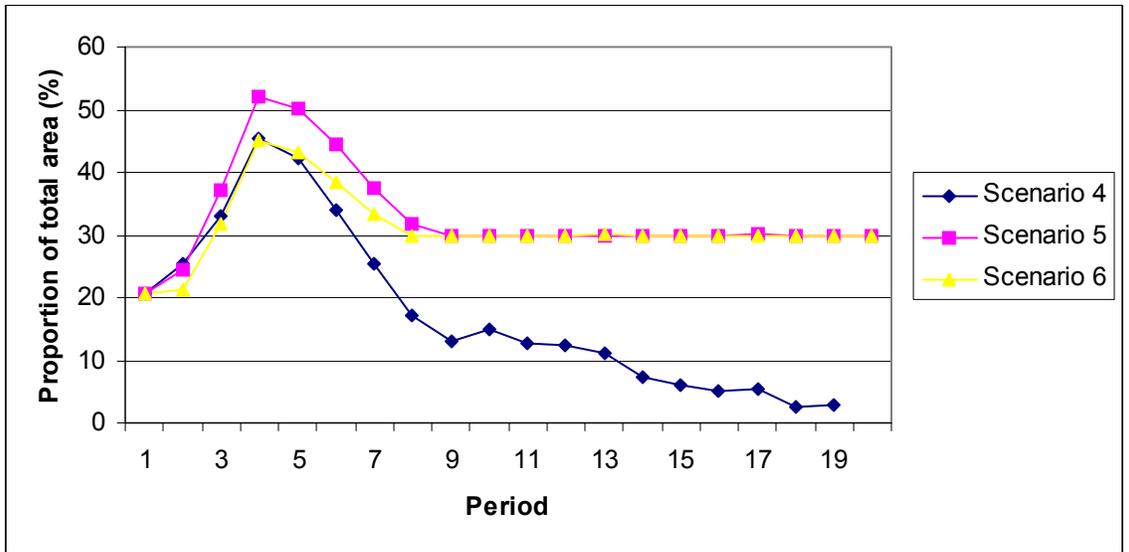
(a)

(b)

Figure 2. Harvest volumes by decade for the (a) volume maximization and (b) discounted stumpage revenue maximization scenarios, under the sustainable forest management strategy with lax harvest flow regime.

(a)

(b)

Figure 3. Temporal distribution of the mature and over mature forest (age over 100 years) as a percent (%) of the harvest land base, by management scenario.
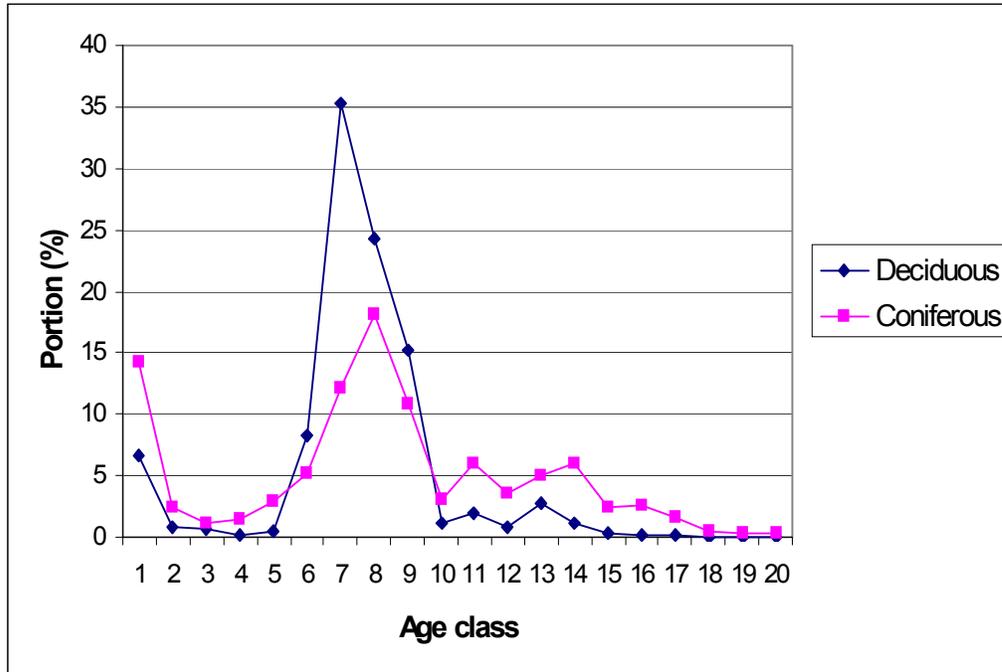
Figure 4. Age distribution (10-year intervals) of the initial inventory as a percent (%) of the harvest land base, by forest type.