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An Economic Assessment of using the Allowable Cut Effect (ACE) for Enhanced Forest Management (EFM) Policies: An Alberta Case Study

By R.L. Hegan and M.K. Luckert

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1.0 Introduction

A number of forest stakeholders are beginning to consider the benefits of enhanced forest management (EFM). Increasing forest management efforts are believed to help guarantee the existence of forests for future generations. Furthermore, EFM is seen as a means of maintaining or increasing current harvest levels as forest companies are faced with potential land base withdrawals for non-timber values, and catastrophic timber losses from fires. Accordingly, provinces such as Alberta and British Columbia are currently investigating policies to facilitate EFM.

Many silvicultural and management techniques, that could be considered elements of EFM, have been developed and used in Canada. However, there has been an absence of widespread adoption of these techniques. In a cross-Canada survey, Luckert and Haley (1989) found that most silviculture operations on Crown Land were not conducted due to forestry firms investing private capital for returns in forest management activities. Instead, management practices were the result of regulation or from being reimbursed by government. This absence of investment has caused governments to seek policy frameworks to provide incentives for tenure holders to practice EFM. Since much of the responsibility for forest management on Crown land in Canada is the responsibility of tenure holders, effective EFM may be more efficiently implemented through forest industry initiatives rather than prodding regulation and reimbursement subsidies (Luckert, 1998). Such an approach requires that timber harvesting firms realize a return on silviculture investments. Herein lies the challenge. Since EFM may have a hard time attracting investment capital given other market opportunities[1], policy changes are being aimed at trying to encourage incentives for EFM by improving returns to investing in future forests. One investment mechanism that the Alberta Forest Service is considering is the Allowable Cut Effect (ACE).

Formalized by Schweitzer *et al.* in 1972, the ACE is a by-product of sustained yield (SY) policies that allow investments in silviculture that increase future yields to

[1] A number of different kinds of market failures may cause investments in forest management to be beneficial from a social point of view, yet not provide incentives for tenure holders to invest private capital. Boyd and Hyde (1989) review several of these market failures. Furthermore, Luckert (1998) describes how tenure policies have historically been structured to preclude the attraction of investment capital for silviculture.

provide an immediate increase in the annual allowable cut (AAC).[2] An immediate increase in the AAC could then provide an immediate investment return for silviculture efforts and potentially induce more investment from tenure holders. The degree of this additional incentive will depend on the extent of the ACE, and how much of the benefits from ACE accrue to the tenure holder.

Despite the fact that the CE may create investment incentives, from a policy perspective, the ACE has also been shown to create investment distortions by allocating capital to silvicultural activities where returns are questionable (e.g. Klemperer 1975, Teeguarden 1973, Luckert 1996). Thus, more research into the ACE and subsequent potential distortions, is necessary in evaluating the ACE from a policy perspective.

The purpose of this paper is to derive empirical estimates of returns to selected silvicultural investments in the context of SY policies in order to assess strengths and weaknesses of the ACE as a facilitating mechanism for EFM. This information will provide insights into whether tenure holders have incentives to undertake EFM, and whether such activities are a wise use of capital. In the process of deriving estimated returns to EFM, the impact of alternative SY policies in influencing financial returns will be explored.

The structure of this paper is as follows. The next section will briefly review the literature on the ACE and describe how this paper extends previous studies. Next, the approach section will detail how a timber supply model is used to simulate the returns to EFM investments. The results section will report on the outcomes of the timber supply runs. The paper will conclude by assessing whether the ACE is likely to be a good basis for an EFM policy.

2.0 Economic Perspectives on the ACE

The empirical analysis of this paper provides an extension to the literature regarding the economics of the ACE. Previous literature may be divided into two sections. The first section examines the economic validity of the ACE and whether it should be included in evaluating timber investments for the best use of public capital.

[2] AAC's are calculated within the context of sustained yield policies. For a more in depth technical description of sustained yield and calculating AAC's see Pearse (1990).

The second section reviews whether the returns to tenure holders from ACE policies provide incentives for private firms to voluntarily invest in EFM.

2.1 Should the ACE be Included in Investment Analysis?

Schweitzer *et al.* (1972) defined the ACE and illustrated how the ACE can increase the financial rate of return to reforestation through increased cash flows from a greater average annual harvest. In their conclusions, the authors requested comments on whether the ACE should be included in assessing forestry investments. The initial response was to criticize the ACE within the overall economic criticism of SY policies (Teeguarden 1973; Lundgren 1973; Klemperer 1975; Walker 1977; Tedder and Schmidt 1980).

Economists have long criticized SY policy, citing high costs and dubious benefits of the policy. The costs of an even flow constraint on timber harvesting have been calculated in comparison to a scenario of a market-derived supply of timber without flow constraints (Thompson, 1966; Hyde 1980). In addition, the objectives behind SY policy have been disputed since the dreaded famine that initially prompted SY never materialized, and it is not clear whether SY enhances the economic stability of timber communities (Anderson 1974, Behan 1975, Pearse 1976, Hyde 1980, Dowdle 1984, Boyd and Hyde 1989).

In calculating the costs of SY, previous empirical work has been conducted at broad regional levels, and has therefore not explicitly dealt with forest level issues such as the ACE.[3] However, a number of theoretical/conceptual articles regarding the ACE were written. Two main criticisms of the ACE ensued. First, the ACE cross-subsidizes future benefits from forest management with the benefits received from harvesting the current stock of mature timber. This cross-subsidization between stock and flow rents contradicts the economic logic of investing in the future; where the values of current harvests should be independent of the values being derived from investing in future second growth stands. One consequence of cross-subsidization is that the benefits from investments that protect inventories are greatly reduced by the ACE (Bell *et al.*, 1975). Another consequence is that ACE incentives can cause capital to be attracted to those

[3] A notable exception was Tedder and Schmidt (1980) who identified the ACE phenomenon within a timber supply model. However, there were no analytical simulations presented.

stands with the largest inventory of mature timber, regardless of the productivity of the site for future growth (Teeguarden, 1978; Pearse, 1976). Second, the ACE is value blind. Since the ACE is a mechanism that is based on timber volumes, investments that influence quality alone are not considered.(Haley, 1972; Teeguarden, 1973). Therefore, investment decisions regarding quality can become distorted since the ACE incentives are focused on increasing volume yields.

In a second phase of the literature on the economic validity of the ACE, the ACE is considered an appropriate mechanism if SY policy is taken as given (McKillop 1979, Binkley 1980). In the pivotal analysis by Binkley (1980), the ACE is shown to reduce the costs of SY policy. Therefore, it is concluded that the ACE is a legitimate investment incentive for public capital because it reduces the costs borne from SY policies.

This perspective on accepting the ACE within a SY policy that is considered socially optimal, seemed to have silenced the critics of the ACE for some time. However, Luckert (1996) argues that SY should not be accepted as given, especially now that other competing paradigms are emerging. Therefore, the problems brought up by the initial critics of the ACE are a legitimate part of the overall debate of SY.

2.2 Does the ACE Provide Incentives for tenure holders to invest in ACE Activities?

To our knowledge there is only one study that has investigated ACE incentives for tenure holders. The results from a survey of forest management investment incentives for tenure holders by Luckert and Haley (1995), show that across Canada the ACE has largely been unsuccessful as a policy instrument for encouraging voluntary investment in forest management[4]. Luckert and Haley (1995) cite a number of reasons for the failure of the ACE to provide investment incentives. First, there may be other silvicultural policies, such as reimbursement programs or requirements, that exhaust most investment opportunities, leaving little for the ACE to stimulate. Second, the province may collect stumpage on incremental volume gains from forest management that could reduce incentives to undertake investments. Third, the incremental volume attributed to the ACE may not be of value to the tenure holder if, without investing, they are not even using

[4] The one exception being in Newfoudland, where provisions for the ACE were taken advantage of in 1985-1986 and 1990-1991 when silvicultural expenses were shared by the private and public sector.

their full AAC. Fourth, the costs associated with convincing provincial governments that an increase in AACE will occur, and the uncertainty associated with whether an increase will be awarded, may dissuade investments. Finally, if tenure holders perceive that their harvesting rights are insecure, benefits to ACE returns will be discounted by the uncertainty thereby reducing investment incentives.

2.3 Contributions of this Paper

The above review indicates that whether the ACE should be considered in forestry investment analysis is debatable. Insights into this question could be gleaned from empirically investigating how the ACE influences returns and incentives in actual forestry investment situations. Although Binkley (1980) showed how the ACE can reduce the cost of SY, there have, to our knowledge, been no studies that have empirically estimated this result. This paper will attempt to fill this void in the literature by estimating the Net Present Values (NPVs) attributable to SY policies with the ACE. These estimates of NPVs will: 1) indicate whether the ACE may provide tenure holders have incentives to undertake investment activities, and 2) provide indications of financial returns to alternative sustained yield/ACE policies.

3.0 Approach

To analyze the returns of selected EFM investments under various SY policies, a timber supply model was constructed for an aspen-white spruce, mixed wood forest using the Woodstock Forest Modeling System (Version 2.0) and the LP-solver C-WHIZ (Version. 2.0). A planning horizon of 200 periods was used, with each period representing a year. NPV's were calculated using stumpage rates of $\$5 / m^3$ for aspen and $\$15 / m^3$ for spruce, and a discount factor of 2 percent.[5]

Using this model, simulations were run to schedule various constrained flows of timber over the planning horizon according to a linear programming solution. The objective function and a set of constraints varied depending on the EFM investment and

[5] These stumpage rates and the discount factor were chosen based on their influence of the NPV for selected investments at the stand level according to the study on mixed wood investments in Alberta by Rodrigues *et al.* (1998). The criteria for choosing certain investment examples will be further explained in this section.

SY policy scenario being simulated. Each scenario depended on a combination of the following parameters:

- age distribution of the initial forest inventory,
- species composition of the AAC,
- type of EFM investment,
- harvesting flexibility around the AAC

In addition the effect of green-up constraints were also included, in a final set of simulations.

3.1 Age Distribution and Yields of the Initial Forest Inventory

The ACE will depend on the volume of standing inventory available to exercise an immediate increase in the AAC from EFM investment. Therefore, one component of this paper investigates differences from having either a juvenile or mature starting age class distribution. Figures 1 and 2 represent two different starting age class distributions for a white spruce-aspen mixed wood forest. Figure 1 represents an age class distribution for a typical mature forest that has been subject to human and natural disturbances. Figure 2 represents an age class distribution for a juvenile forest with stands at various stages of early regeneration.[6] Assuming even-aged stands for both the mature and juvenile forests, volume composition between spruce and aspen is then determined by age and the corresponding yield curves. To simplify the analysis, all existing and regenerated stands will assumed to be on medium class sites. Figure 3 is the Alberta Phase III yield curves for existing white spruce and aspen mixed wood stands on medium site classes were used to determine volume composition. Subsequent yield curves adapted for regenerated stands with or without EFM are described later in sub-section 3.3. All yield curves are based on harvest volumes from clear cutting.

[6] The age distribution in Figure 1 was taken from data used by Hatton-MacDonald *et al.* (1998). Subsequently, the age distribution in Figure 2 was constructed to represent a juvenile forest with the same number of hectares as the mature forest depicted in Figure 1.

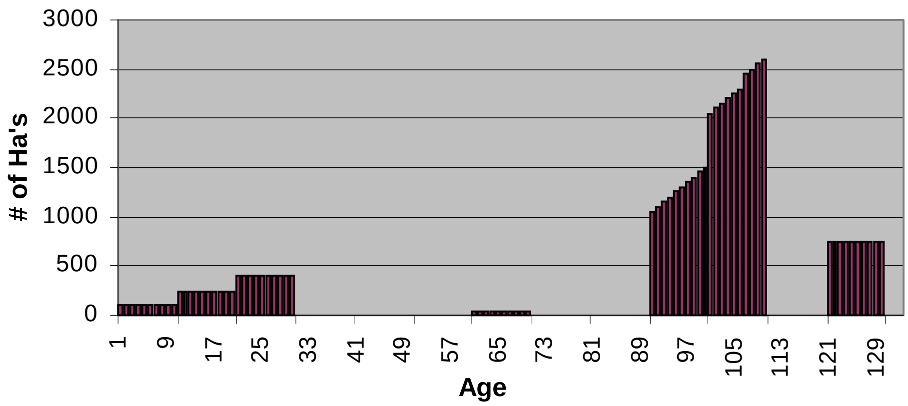


Figure 1: Mature Age Class Distribution White Sruce- Aspen Mixed Wood Forest in Alberta

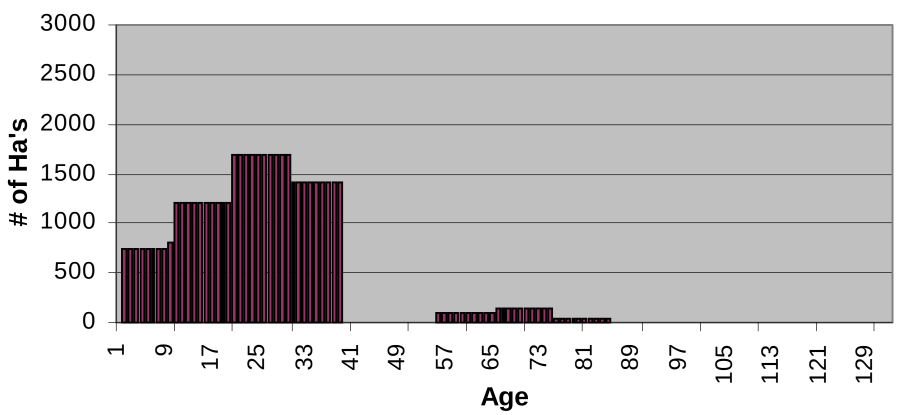
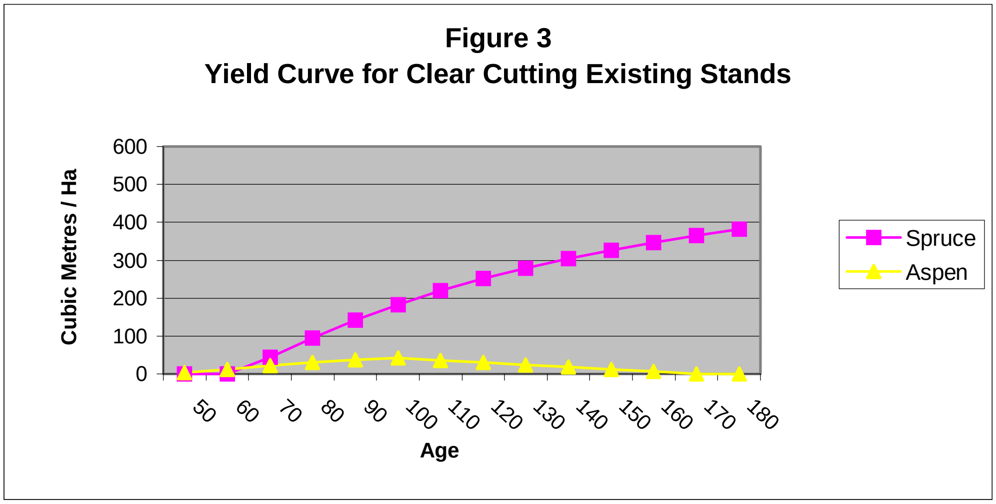


Figure 2: Juvenile Age Class Distribution White Spruce-Aspen Mixed Wood Forest in Alberta



3.2 AAC Composition

Two types of AAC compositions were used for modeling harvesting in a mixed wood forest, representing a current and an alternative SY policy. In Alberta, species composition of the AAC is determined by which species is dominant. Aggregation is according to coniferous and deciduous trees. A forest dominant in coniferous trees or made up of mixed wood has an AAC comprised of just coniferous timber volumes, with deciduous volumes harvested incidentally. For a forest dominant in deciduous trees, the AAC is comprised of just deciduous timber volumes with coniferous volumes harvested incidentally. Accordingly, given our forest makeup, simulations were run with an AAC of just coniferous volumes with deciduous incidental. However, in order to investigate an alternative SY policy of joint optimization, simulations were also run with an AAC made up of coniferous and deciduous volumes.

3.3 EFM Investments

Two EFM scenarios, one extensive and one intensive, were selected from a study by Rodrigues *et al.* (1998) on investment returns of mixed-wood siliviculture at the stand level in Alberta. Table 1 below shows these two different silivicultural regimes and a scenario of no investment with the corresponding NPV's at the stand level. The extensive investment consisted of an aerial seeding after clear cutting and vegetation management eight years after stand initiation with a glyphosphate treatment. At the stand level this

EFM regime produces a small positive NPV when the regenerated stand is harvested 100 years after stand initiation with a significantly shorter regeneration lag than the no investment scenario. There is a larger positive NPV with no investment (where the absence of EFM leaves the stand to sucker in our simulations) and harvesting 100 years after stand initiation. The intensive investment has the same regime as the extensive investment except that planted seedlings replaced aerial seeding which causes a shortened regeneration lag. At the stand level this EFM regime produces a negative NPV.

Table 1. The NPV of Investments at the Stand Level (Per Ha.)

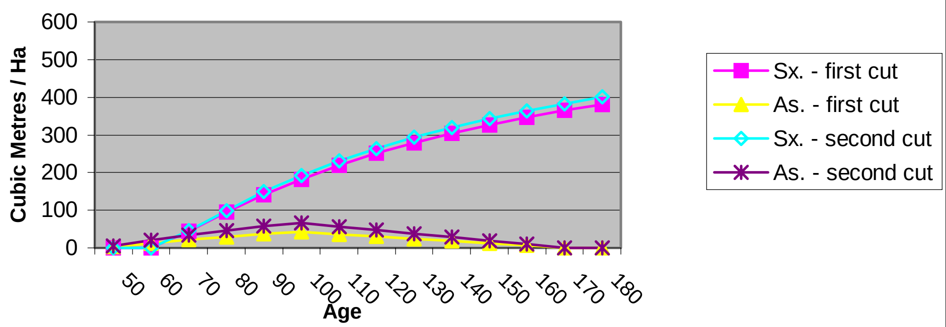
Investment	**None**	**Extensive**	**Intensive**
Regeneration Lag (yrs)	28	9	2
Silviculture Costs ($):			
Site Prep./ Planting at Yr. 0			920
Site Prep./ Aerial Seeding at Yr. 0		200	
Glyphosphate Treatment at Yr. 8		241	241
Present Value of Costs at Yr. 0 ($)		339.46	1081.98
Present Value of Stumpage From Yr. 100 at Yr. 0 ($)	271.46	376.45	550.18
NPV ($)	**271.46**	**36.99**	**-531.80**

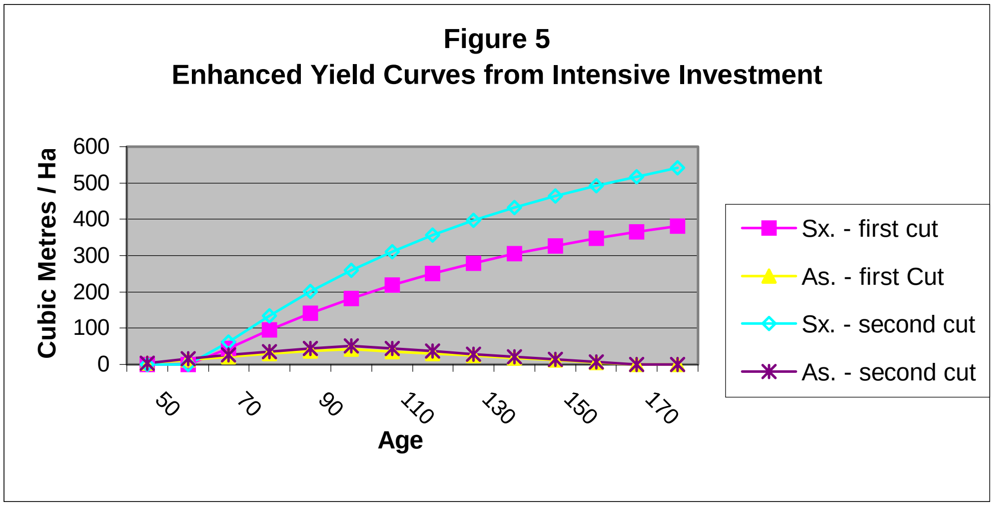
From a stand level perspective, a positive NPV implies that tenure holders may have incentives to make the investment, while a negative NPV implies that there is a disincentive to make such an investment. Note, however that in Table 1, the tenure holder would be best off making no investment. However, the results are not so obvious at the forest level since SY policy and the ACE will affect investment incentives.

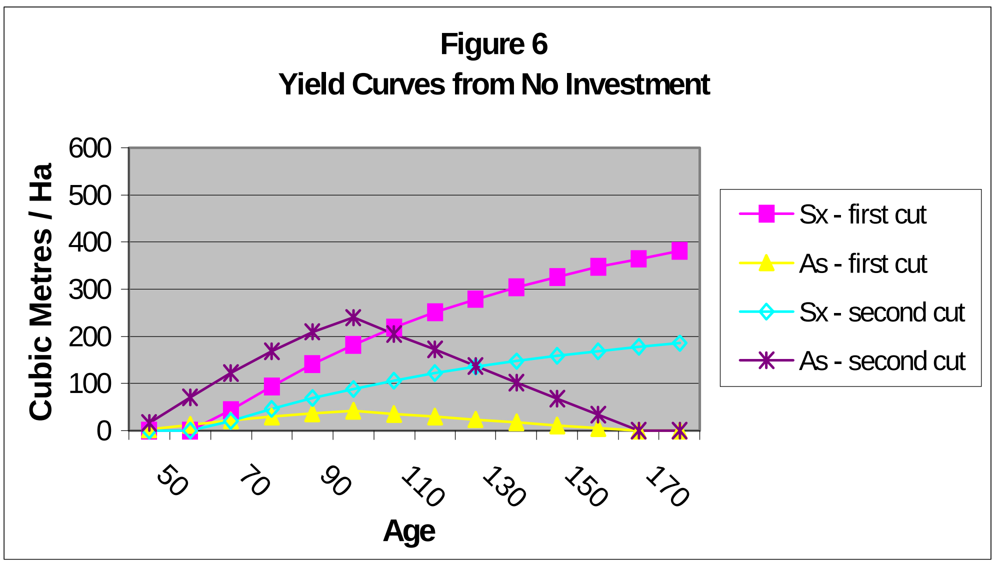
In the model, over the 200 year planning horizon the volume of timber from any area being initially cut is determined by the yield curves for existing stands in Figure 3. Subsequent harvesting on the same area will then yield timber according to the EFM investment scenario being simulated. Based on calculations by Rodrigues *et al.* (1998), Figures 4, 5, and 6 represent the yield curves for regenerated stands with extensive, intensive, and no investment respectively.

Simulations were run separately for each investment scenario and the scenario of no investment. For the linear programming solution this required that once an existing stand according to Figure 3 was harvested, it could only be regenerated according the corresponding yield curve in one of Figures 4, 5, or 6, depending on the investment being simulated.

Figure 4
Enhanced Yield Curves from Extensive Investment







3.4 Harvesting Flexibility Around The AAC

In Alberta, the AAC is defined as the maximum volume of timber that can be harvested every year over a two rotation planning period with an even flow harvesting constraint. Although, present SY policy in Alberta for FMA's does allow for some harvesting flexibility around the AAC. The amount of this flexibility will vary somewhat between FMA's because each tenure holder negotiates separately with the Alberta Forest Service to determine an AAC and subsequent harvesting plans. For our simulations, the

Alberta Forest Service was consulted regarding how to best characterize harvesting flexibility allowed around the AAC for FMA's in general.[7]

This paper is concerned with simulating both current and alternative SY policies. Table 2 shows the flexibility levels around the AAC that represent strict, present, and more flexibility than presently allowed under current SY policy. Strict even flow SY harvesting was initially simulated to establish both an AAC under no flexibility and subsequent parameters to then introduce flexibility. Flexibility under current SY policy is modeled as allowing annual harvests to be within plus or minus 25 percent of the AAC, and allowing five year harvest totals to be within plus or minus 10 percent of five years of the AAC. As well, every ten years in the planning horizon, the harvest total has to coincide with the total AAC. Doubling these parameters and only requiring the convergence every twenty years then represents twice the level of allowed flexibility. Total flexibility essentially disengages any temporal links between the harvesting of different stands, and thus, optimal management of each stand becomes independent of forest level effects.

Table 2. Scenarios of Flexibility Around the AAC

Flexibility Scenario	Annual Flexibility	5 Year Flexibility	10 Year Convergence	20 Year Convergence
No Flex.	0%	0%	Yes	Yes
Present Flex.	+/- 25%	+/- 10%	Yes	Yes
Twice Present Flex.	+/- 50%	+/- 20%	No	Yes
Total Flex.	100%	100%	No	No

The objective function being optimized depended on whether there were constraints to flexibility being modeled. For simulations of no flexibility, the objective function was to maximize harvested volumes. This corresponds to Alberta's definition of the AAC and SY forestry with regards to even flow. For simulations with flexibility, the objective function being maximized became the NPV of stumpage on harvested timber.

[7] Personal communications with Daryl Price, Alberta Forest Service, August, 1998.

3.5 Green-up Constraint

In addition to SY that regulates temporal volume flow of timber, a spatial green-up constraint that requires a regenerating stand to be fully established before an adjacent stand can be harvested, may also affect the ACE. This green-up constraint can be modeled in Woodstock, a non-spatial forest modeling system, by dividing each cutting unit in half and lagging the harvest between them by 20 years. However, incorporating the green-up constraint required the model be altered. With limitations in computing power, separate simulations had to be run using 5 year, instead of 1 year periods. Unfortunately, results using different period lengths between simulations are not comparable. Using 5 year periods implies a degree of total flexibility around the AAC during those five years. This kind of flexibility was purposely avoided by using the 1 year periods to best replicate SY policy. In addition, calculated NPV's between simulations with different period lengths are not easily comparable. Therefore, the green-up constraint, were compared to simulations that were rerun using five year periods.

4.0 Simulation Results

Table 3 shows the extent of the ACE from combinations of investment alternatives, starting forest inventories, and AAC compositions. The most notable difference in the ACE's is found between variations in starting inventory. As expected, the ACE is largest with a mature starting forest inventory because mature reserves are available for immediate AAC increases. No simulations with a juvenile starting forest inventory produced a positive ACE. Another notable result is that with AACs for deciduous and coniferous volumes being considered simultaneously, there are actually reductions in AACs due to silvicultural investments. With investments targeted towards increasing coniferous volumes, combined species AACs can decline. Results further show that ACEs are larger for intensive investments, than for extensive investments as greater increases in volumes are produced with more intensive activities.

Table 3. AAC's and the ACE

Starting Inventory/ AAC Composition	AAC with No Investment	AAC with Extensive Investment	ACE[2.]	AAC with Intensive Investment	ACE
Mat. / Sx AAC[1.]	106833	132306	25473	150116	43283
Mat. / Sx and As AAC	158812	146338	-12474	164576	5764
Juv. / Sx AAC	10631	10631	0	10631	0
Juv. / Sx and As AAC	17727	17717	-10	17717	-10

1.The starting forest inventories in this table are differentiated as mature (Mat.) and juvenile (Juv.). The AAC compositions are differentiated as being comprised of just white-spruce volumes (Sx AAC) or aspen and white-spruce volumes (Sx and As AAC).
2. Although the ACE is by definition only an increase in the AAC (Schweitzer, Sassaman, and Schallau 1972), both positive and negative changes are calculated in this table.

The results in Table 3 are also limited to reporting only volumes attached to the ACEs, with neither values nor costs associated with investments. By adding values, we can assess whether tenure holders would likely invest in EFM from ACE incentives. Therefore, Table 4 builds on Table 3 by adding value estimates, in the form of NPVs, and with variations in AAC flexibility. First, let us analyze the results in Table 3. The results in the “No Flex.” rows of Table 4 correspond to the results discussed above for Table 3. The results in Table 4 show that with a juvenile forest, the changes in NPVs are negative. This decrease in the NPV with investment relates to the negative or zero ACEs shown in Table 3 for a juvenile forest, being combined with investment costs. For the mature forest scenarios, results also mirror Table 3, somewhat, in that increased NPVs are generally obtained for scenarios that consider only coniferous AACs. An exception occurs with total flexibility, in that the NPVs decrease with investment. This occurs because, as shown in a previous section, intensive and extensive stand level investments decrease NPVs. With the absence of sustained yield constraints in the total flexibility simulations, the ACE disappears causing forest level investments to mirror stand level results.

Table 4 also shows that a positive ACE in Table 3 does not ensure a positive NPV. In Table 3, the simulation of intensive investment with a mature forest and a combined coniferous and deciduous AAC, produced a positive ACE. However, the results in Table 4 show a corresponding decrease in the NPV when investment costs are considered. In this case a positive ACE is not associated with an incentive to make the investment.

In comparing investment incentives, positive NPVs are only obtained in the Mature Forest scenario where AACs are based solely on coniferous volumes. Whether positive or negative, the direction of the change in the NPVs are consistent whether intensive or extensive investments are undertaken. In all simulations, the extensive investment has a more favorable return (or smaller loss) than for the intensive investment.

Table 4. NPV's of Simulated Investment Scenarios.[1.]

Starting Inventory	AAC Composition	Flexibility Around the AAC[2.]	NPV with No Investment	NPV with Extensive Investment	% Change[3.]	NPV with Intensive Investment	% Change
Mature Forest	Sx AAC	No Flex.	81674734	94514059	0.157	88675487	0.086
		Present Flex.	82187807	95197471	0.158	89276128	0.086
		Twice Flex.	83705376	96666971	0.155	90483272	0.081
		Total Flex	157114715	148294600	-0.056	120000000	-0.236
	Sx and As AAC	No Flex.	107069610	97560884	-0.089	89329070	-0.166
		Present Flex.	107973225	98338621	-0.089	90350132	-0.163
		Twice Flex.	109619197	99760458	-0.090	91539172	-0.165
		Total Flex	157114715	148294600	-0.056	120000000	-0.236
Juvenile Forest	Sx AAC	No Flex.	12739514	1104287	-0.913	-23796443	-2.867
		Present Flex.	14968416	7365307	-0.508	4241187	-0.717
		Twice Flex.	15059526	7437384	-0.506	4490024	-0.702
		Total Flex	39082332	36541242	-0.065	28743776	-0.265
	Sx and As AAC	No Flex.	7874983	-3892370	-1.494	-32951524	-5.184
		Present Flex.	10517120	-	-	-	-
		Twice Flex.	10910484	-	-	-	-
		Total Flex	39082332	36541242	-0.065	28743776	-0.264

1.The NPV's are shown in dollars, calculated with a discount rate of 2%. Spaces without a NPV (or a value for % Change) are the result of an infeasible solution for the linear programming problem. The infeasible solutions here occur when the objective function is to maximize NPV when there is flexibility allowed around the AAC, and the LP solver (C-Whiz) cannot find a positive value.
2.The different flexibility level around the AAC are expressed as no flexibility allowed around the AAC (No Flex.), the present level of flexibility allowed around the AAC according to present SY policy (Present Flex.), twice the present amount of flexibility allowed around the AAC (Twice Flex.), and total flexibility allowed around the AAC (Total Flex.).
3. The % Change is the rate of change in the NPV (for that given level of flexibility around the AAC) from the simulation of no investment.

In order to examine the effects of changing flexibility on NPVs, selected results from Table 4 are plotted in Figures 7 and 8. It is evident in the figures that as flexibility is increased, so do NPVs. This is particularly evident between the “Twice Flex.” and the “Total Flex.” scenarios as NPVs climb steeply. The results thus show that even if firms were allowed to harvest at twice the estimates of current flexibility, they would still be too constrained in their cutting operations to greatly increase NPVs. A key difference between Figures 7 and 8 is that in Figure 8, the no investment scenario dominates the other scenarios at all flexibility levels. However, in Figure 7, the no investment scenario is dominated by extensive and intensive investment scenarios, under all flexibility levels except for total flexibility. As discussed above, the dominance of the no investment scenario with total flexibility is due to the inferior performance of any silvicultural investment without the ACE.

The results presented above so far are estimated in the absence of green-up constraints. To analyze the effects of including the green-up constraint, the comparisons of simulations with and without the green-up constraints, using five year periods, are presented in Tables 5 and 6.[8] Since in the previous simulations a juvenile forest never accommodated an ACE, only mature forest simulations were conducted. Also, only “strict even flow” scenarios were simulated.

Results show that the addition of green-up constraints reduced the returns, and lessened the losses, from ACE policies. These results occur because the ACE is not allowed to increase as much, for positive scenarios, with green-up constraints in place. The pattern of gains and losses parallel the yearly results with positive returns to ACE policies only when coniferous volumes are considered in isolation.

[8] Recall that limitations in computing power would not allow 1 year periods to be simulated.

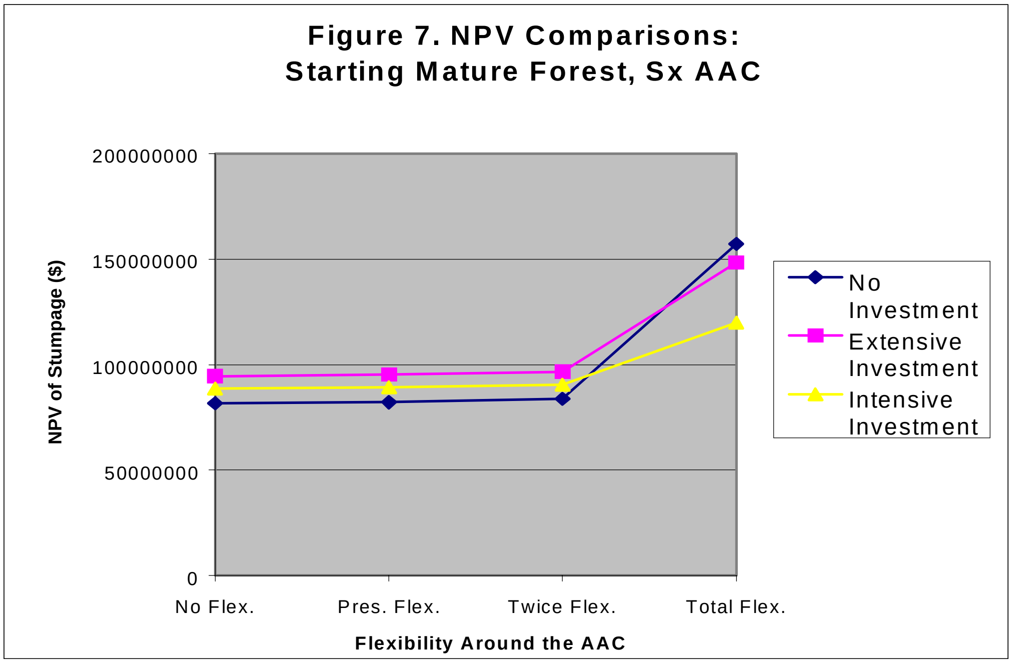


Figure 7. NPV Comparisons:
Starting Mature Forest, Sx AAC
NPV of Stumpage ($)
200000000
150000000
100000000
50000000
0
No Flex.
Pres. Flex.
Twice Flex.
Total Flex.
Flexibility Around the AAC
No Investment
Extensive Investment
Intensive Investment

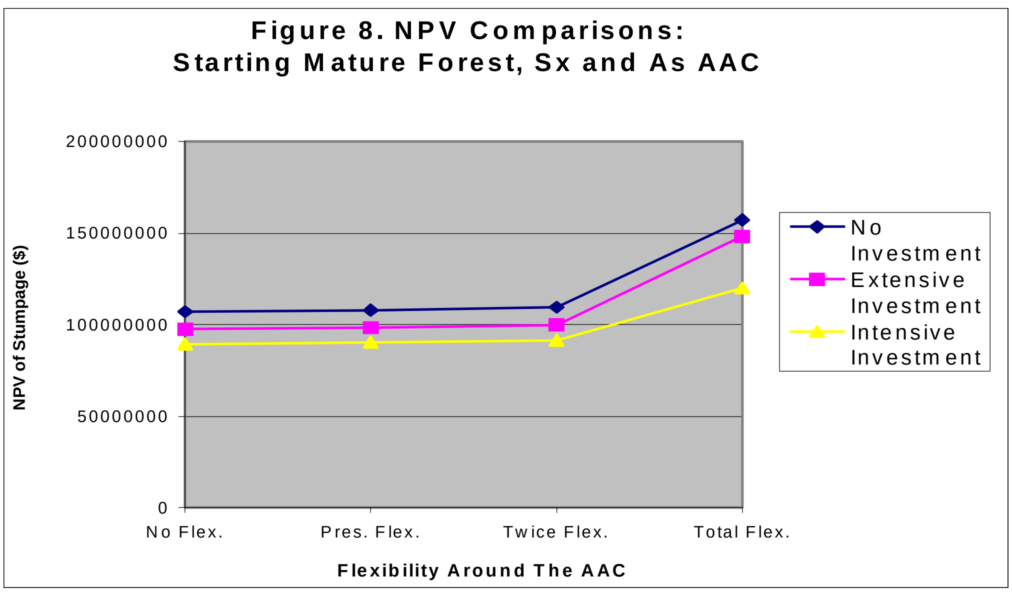


Figure 8. NPV Comparisons:
Starting Mature Forest, Sx and As AAC
NPV of Stumpage ($)
200000000
150000000
100000000
50000000
0
No Flex.
Pres. Flex.
Twice Flex.
Total Flex.
Flexibility Around The AAC
No Investment
Extensive Investment
Intensive Investment

Table 5. Simulation Results using 5 yr. Periods for Strict SY (Mature Starting Inventory Only).

AAC Composition	**No Investment**		**Extensive Investment**				**Intensive Investment**			
	AAC	NPV	AAC	ACE	NPV	% Change in NPV	AAC	ACE	NPV	% Change in NPV
Sx AAC	552,094	87,749,200	682,255	130,161	101,339,271	0.155	786,501	234,407	96,261,405	0.097
Sx and As AAC	817,955	114,871,933	752,375	-65,580	104,671,476	-0.089	846,706	28,751	96,259,433	-0.162

Table 6. Simulation Results using 5 yr. Periods for Strict SY and the Green-Up Constraint (Mature Starting Inventory Only).

AAC Composition	**No Investment**		**Extensive Investment**				**Intensive Investment**			
	AAC	NPV	AAC	ACE	NPV	% Change in NPV	AAC	ACE	NPV	% Change in NPV
Sx AAC	542,604	140,717,457	668,593	125,989	156,980,051	0.116	768,577	225,973	145,737,503	0.036
Sx and As AAC	773,103	172,505,872	735,254	-37849	161,171,846	-0.066	825,517	52,514	144,922,450	-0.160

5.0 Summary and Conclusions

The simulations above suggest a number of potential impediments to introducing an EFM policy based on the ACE. First, results show that positive ACEs only occur under limited conditions. If initial forest structures are dominated by juvenile stands, ACEs may be zero or negative. If initial forests are dominated by mature age classes, and if AACs are calculated based on deciduous and coniferous volumes, investments to increase softwood volumes can lead to positive or negative ACEs. Positive ACEs are obtained when mature starting inventories are combined with calculations of softwood AACs, treating deciduous volumes as incidental.

The ACE volumes, alone, however, give little indication of whether tenure holders will have incentives to undertake ACE investments, or whether scarce private funds are being squandered if ACE investments are undertaken. Having a positive ACE is a necessary condition for positive returns to ACE investments, but it is not a sufficient condition given that benefits and costs of ACE investments are ignored. Therefore, NPVs are also calculated for ACE investments. Financial results show that returns to ACE investments are negative for all juvenile forest simulations, all mature forest simulations that consider coniferous and deciduous AACs, and for mature softwood AACs, where total flexibility in cutting constraints are allowed. The only positive returns to ACE investments were found under the mature forest, coniferous AAC scenarios, under cut constraints. In these cases, there are significantly higher returns to extensive investments than for intensive investments.

Adding green-up constraints to harvesting does not seem to change the general nature of the above results. Indeed, the addition of green-up constraints reduced the returns to ACE investments in the few cases where positive returns were possible.

A number of policy implications fall out of these results. First, it is only under limited conditions that the ACE will provide incentives for Enhanced Forest Management. If these results are considered, together with the impediments to ACE identified by Luckert and Haley, 1995) the probability of tenure holders undertaking ACE incentives seems low. In those few cases where positive returns to ACE investments occur, it is questionable whether it would be in society’s interest to have these investments undertaken. ACE results are only positive under a partial analysis scenario where deciduous volumes are ignored in calculating an AAC. Accordingly, it could be that coniferous tenure holders have ACE incentives, but at the cost of considering effects of deciduous production. Furthermore, with the ACE being an artifact of sustained yield, benefits decrease as more harvesting flexibility is introduced into the system. With emerging paradigms challenging SY, it is questionable whether investment incentives should be built around sustained yield constraints. Evolving concepts of Sustainable Forest Management may alter considerably the premise upon which the ACE is based.

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