WELFARE IMPLICATIONS OF THE ALLOWABLE CUT EFFECT IN THE CONTEXT OF SUSTAINED YIELD AND SUSTAINABLE DEVELOPMENT FORESTRY

MARTIN K. LUCKERT*

ABSTRACT

Welfare implications of the Allowable Cut Effect (ACE) have been largely ignored in the literature since the early 1980s. This paper re-assesses the welfare implications of the ACE in the context of sustained yield and sustainable development forestry. With respect to sustained yield forestry, the resolution of the ACE issue was incomplete. Concerns regarding the subsidization of silvicultural investments with existing timber values, and the inability of the ACE to consider values, were not reconciled with the acceptance of the ACE, which occurred upon realization that the ACE reduces the shadow price of sustained yield constraints. This paper attempts to reconcile these two phases in the literature. Furthermore, problems associated with the ACE were essentially assumed away with the acceptance of sustained yield, rather than considering ACE concerns as legitimate problems associated with sustained yield policies. The absence of a resolution to these issues could impede a transition from sustained yield forestry, focussed on timber volumes, to sustainable development forestry, that focuses on sustaining forest resource values. Although such a paradigm shift could potentially alleviate some of the concerns associated with the ACE, similar problems arise that are endemic to the use of sustainability constraints.

Keywords: ACE, harvest constraints, sustainable development, sustained yield.

~

INTRODUCTION

Although sustained yield policies originated in Europe, much of the modern debate surrounding the strengths and weaknesses of sustained yield have originated from issues surrounding federal forest lands in the United States. On these lands, it has been a long-standing policy of the U.S. Forest Service to pursue sustained yield management objectives. One issue that has arisen as a result of sustained

* Martin K. Luckert, Department of Rural Economy, University of Alberta, 515 General Services Building, Edmonton, T6G 2H1, marty.luckert@ualberta.ca.
Thanks to Dennis Teeguarden, Peter Boxall, and some anonymous referees for their comments on earlier versions of this paper. Funding for this project was provided by the Network of Centres of Excellence Programme in Sustainable Forest Management.

JOURNAL OF FOREST ECONOMICS, ISSN 1104–6899. © 2001 Department of Forest Economics, The Swedish University of Agricultural Sciences, SE-901 83 Umeå, Sweden. Manuscript received 1999-03-11. Revised manuscript accepted 2001-04-23.

yield policies involves the allowable cut effect (ACE). In 1972, Schweitzer *et al*. defined the ACE as an "...immediate increase in today's allowable cut which is attributable to expected future increases in (timber) yields". Having made this observation, the authors requested feedback on how the ACE should be considered in economic analysis.

The debate that ensued may be characterized by two stages. The first stage, was generally made up of arguments against the inclusion of the ACE in investment analysis.[1] The ACE, it was argued, was yet another reason for criticizing sustained yield policies, in that it distorted investment decisions.[2] This view was dominant until a second stage emerged where McKillop (1979), followed by Binkley (1980) and Contreras & Gregerson (1982), suggested that the incentives provided by the ACE may be legitimate if viewed as part of a sustained yield policy which reflects social welfare. Furthermore, Binkley (1980) concluded that "...if maximizing net worth is the objective of investments in timber production on the national forests (under even flow constraints), then their net benefits should be computed with the allowable cut effect"; and that taking the ACE into account "necessarily reduces the opportunity cost of the even flow constraint" (Binkley, 1980). The sting of anti-ACE arguments was further lessened when Binkley (1984) introduced a more generalized concept of the ACE that was independent of even flow constraints and old growth forests. It was concluded that ACEs arise from linkages of harvest levels between periods, and that: "Valid economic analysis of forest management activities requires inclusion of the positive and negative changes in the optimal harvest schedule associated with allowable cut effects."

The ideas presented in the second, or "acceptance stage" of the ACE literature apparently relieved the anxiety of those who expressed concerns about the ACE in the "criticism stage". The issue seems to have died, as almost noth-

[1] Authors pointing out the distorting effects of the ACE included Bell *et al*. (1975), Klemperer (1975), Pearse (1965, 1976), Teeguarden (1973), Tedder & Schmidt (1980), and Walker (1977). A notable exception to this trend was Lundgren (1973) who supported the inclusion of ACE in investment calculations.

[2] During this period sustained yield was being questioned by authors such as Schallau (1974), and Hyde (1976). Sustained yield critiques continued later with works such as Dowdle (1984) and Boyd & Hyde (1989).

ing has since been written on the welfare implications of the ACE in the context of sustained yield.

Upon reviewing the literature, this jump to accept the ACE seems odd, as the models that were introduced by Binkley (1980, 1984) did not directly address the concerns raised in earlier works. In reading the literature, it is not clear whether the authors in the criticism stage were shown to be wrong by authors in the acceptance stage, or whether the initial concerns regarding the ACE are still valid. In short, two very different attitudes towards the ACE were never reconciled.[3]

The first objective of this paper is to reconcile these two stages of the literature. It will be shown that the acceptance stage did not invalidate some of the initial concerns that were raised regarding the ACE. Despite the fact that the ACE was shown to reduce the costs of sustained yield policies in the second stage, the initial concerns regarding the potential distorting effects of the ACE were not shown to be incorrect. Instead, these distortions are the means by which costs of sustained yield are reduced.

A reconciliation regarding the acceptability of the ACE could prove important as alternative paradigms to sustained yield, such as sustainable development forestry, emerge. Since the Brundtland report, forest policies have increasingly been assessed under the goals and objectives of sustainable development.[4] In short, sustainable development seems to encapsulate two related criticisms of sustained yield that had emerged long before the Brundtland report. First, the tendency for sustained yield policies to concentrate on volumes of fiber production has been challenged by a concept of sustainable development that encompasses values from many forest resources. Second, because multiple forest outputs are considered, concepts of sustainable development recognize that providing for future generations does not necessarily imply that the har-

[3] Indeed, one of the reviewers for this paper pointed out that s/he did not believe there ever was an "acceptance stage" of the ACE among economists. Instead, based on an informal survey taken by the reviewer, the attitudes among economists were cited as, "Haven't we said all there is to say about that" and "Who would want to defend that".

[4] See for example Alston (1991) or Haley & Luckert (1995).

vest of one forest resource over time must be constant, or non-declining. Instead the focus is on maintaining the production of a variety of goods and services from forests over time, which could imply that flows of certain types of natural resource quantities actually decrease in order to promote the sustenance of other resource values.[5]

The second objective of this paper is to show that there may be some lessons from a resolution of the ACE debate that may help us understand potential problems in implementing sustainable development forestry. It will be shown that the resolution of the ACE debate in the context of sustained yield policies may be a valuable step in considering potential benefits and problems of implementing an alternative type of sustainability constraint associated with sustainable development forestry.

Following Binkley (1980), this paper will analyze the ACE from two perspectives. First, a "Net Present Value (NPV) maximization perspective" will be adopted. This approach represents the tact typically taken in cost benefit analyses where the objective is to maximize the discounted dollar values of a stream of goods and/or services. In this section the analysis will be limited to timber values as was the case in Binkley (1980). Next, the effects of the ACE will be assessed from a "social welfare maximizing perspective". This view goes beyond looking at benefits in terms of dollar values and considers whether the ACE will result in investments that will maximize the aggregated utility of individual members of society. In this section, considerations for non-timber values will be introduced. Finally, a sustained value constraint, consistent with concepts of sustainable development, will be compared and contrasted to the ACE.

THE NET PRESENT VALUE MAXIMIZING PERSPECTIVE

Most objections to the ACE were made from the perspective of maximizing net present value. From this perspective the objective of policy analysis is to assess how social welfare, expressed in dollar values derived from timber

[5] For example, in the Pacific Northwest of the United States, it has been decided that timber flows will decline in order to promote spotted owls.

harvests, may change depending on whether ACE incentives are included in NPV maximizing investment decisions. Within such an analytical context, concerns regarding the ACE arose because of two primary reasons: 1) the ACE subsidizes silvicultural investments with values of existing timber and; 2) the ACE is based on volume, not value. In the following paragraphs, a multiple period model is developed that is designed to investigate these two concerns of ACE critics.[6]

An ACE Model

The following model is predicated on the assumption that firms (whether private of governmental) own forested lands and seek to undertake silvicultural investments that maximize NPVs under sustained yield constraints. In jurisdictions like the U.S., the Forest Service may be considering forestry investments, while in jurisdictions such as Canada, private forest companies operating on public land may be considering such investments.[7] While these two types of firms are likely to have different objectives, we will assume, for the time being, that both are only interested in maximizing profits.

Assume that firms are operating under constraints, which spread out the harvest of mature timber over time until second growth forests are of harvestable age. Regeneration may occur naturally or may be enhanced by investments in reforestation. Further assume that the mature timber, having reached its maximum growth potential, is nonresponsive to silvicultural investments, while values of regenerated timber may be increased with such activities. Under these conditions, the firm will attempt to maximize the NPV achieved from mature and growing timber, subject to the sustained yield constraint that harvests in all periods must be equal. The maximization problem for the firm may be expressed as:

---

[6] The following is a simplified version of an ACE model presented in Luckert & Haley (1995).

[7] This model is not meant to represent private companies operating on private lands. While such companies may follow sustained yield practices, they are not required to, and may deviate from such costly activities during times when cash flows need to be increased.

$$\text{Maximize } NPV = P_C^M \sum_{t=1}^{z} C_t^M (1+r)^{-t} + P_C^J \sum_{t=z+1}^{\infty} C_t^J (1+r)^{-t} - I \qquad (1)$$

$$\text{S. T. } C_t^M + C_t^J = C_{t+n}^M + C_{t+n}^J \text{ (an even flow constraint)} \qquad (1a)$$

where

NPV = net present value received by the firm from selling stumpage,

C_t^M = quantity of currently existing mature timber harvested in period t,

P_C^M = stumpage price received for one unit of currently existing mature timber,

C_t^J = quantity of timber which is currently juvenile but will mature in the future for harvest in period t,

P_C^J = stumpage price that will be received for one unit of currently juvenile timber when harvested in the future,

$(1+r)^{-t}$ = a discount factor,

z = final period when old growth timber will be available,[8]

I = firm's silvicultural investment.

The transition from mature to juvenile timber has been defined such that C_t^J and C_{t+n}^J = 0 in periods 1 through z, while C_t^M and C_{t+n}^M = 0 in periods z+1 through ∞. The problem has been structured in this way to investigate interrelationships between values of mature and growing timber in the next section.

A maximizing firm will invest resources in silviculture until the marginal increase in the net present value earned from additional volumes of timber produced is just equal to the incremental cost of investing. This can be expressed

[8] Note that z is exogenous to the firm given the assumption that firms are operating under constraints that spread out the harvest of mature timber over time until second growth forests are of harvestable age. Given that old growth volumes frequently contain greater volumes per hectare than juvenile stands, mature volumes may be spread over long periods before harvests of juvenile stands are capable of sustaining yields.

by equating to zero the difference between the incremental cost of silviculture and the derivative of Equation (1) with respect to silvicultural investment. That is:

$$\frac{dNPV}{dI} = P_C^M \sum_{t=1}^{z} \left(dC_t^M/dI\right)(1+r)^{-1} + P_C^J \sum_{t=z+1}^{\infty} \left(dC_t^J/dI\right)(1+r)^{-1} - dI/dI = 0. \qquad (2)$$

In the absence of the even flow constraint, the second term in Equation (2), concerning the responsiveness of mature timber to investment, equals zero. However, if firms are constrained by sustained yield requirements and can take advantage of the ACE, then all of the arguments in Equation (2), except dI/dI, increase with the level of investment in silviculture. The mature timber also becomes influenced by investments because of the way that C_t^M is defined within the even flow constraint in Equation (1a). Because $dC_t^J/dI > 0$ in periods z+1 through ∞, the equality implies that $dC_t^M/dI > 0$ as well, in periods 1 through z. By moving dI/dI to the right hand side of Equation (2) it becomes apparent that in the presence of the ACE, investments will proceed to the point where the expected marginal increase in net benefits attributable to silvicultural investment, derived from matured and growing timber, is equal to one.[9]

Subsidizing Silviculture with Existing Timber Values

Equation (2) shows that the ACE allows values resulting from investments in silviculture to be captured through the harvesting of both current timber crops and anticipated future crops and, consequently, can potentially stimulate silvicultural investments. However, although investments

[9] Note that in this model, a private firm, or the government, could choose to not invest in reforestation if the returns from the ACE were insufficient to justify expenditures. However, in practice, reforestation on public lands in North America generally proceeds, regardless of what economic analyses may dictate. Along these lines, one reviewer noted that a common assumption of sustained yield and the ACE is that all land contributing to the annual allowable cut (AAC) is assumed to be economic for producing timber. Although the ACE has been used to justify reforestation expenditures for stands where future benefits at the stand level are insufficient, in more cases than not, investments on public lands are simply undertaken without specific analysis regarding whether or not investments are economical, with or without the ACE.

will "…necessarily reduce the opportunity cost of the sustained yield constraint" (Binkley, 1980), this cross-subsidization will result in a lower *NPV* than could have occurred in the absence of sustained yield constraints. This reduction in *NPV* is caused by distortions from decisions regarding the harvest of current stocks and investments in future flows. Decisions regarding the depletion of stocks are distorted as equal annual harvests prevent user costs, influenced by prices and interest rates, from dictating harvest patterns over time.[10] Investments in flows are distorted by cross-subsidization which finances investments for enhancing new forests with existing timber values. As such the ACE confounds the economic logic of investing for future benefits, where marginal analysis would, in the absence of sustained yield constraints, view values of current harvests of old growth timber as being independent of future values of second growth stands.

The cross-subsidization of silvicultural investments with values from existing timber is the source of criticism for those who pointed out that the gains attributed to the ACE have little to do with the value of the additional wood produced by the silvicultural investment. This disjunction was a point of concern as economists saw it as a way of subsidizing unprofitable regeneration investments. Because of the interdependencies between existing timber values and investments created by the ACE, it has been shown that "when an immediate increase in harvesting is rationalized by using ACE, the attractiveness of investments in timber production is often increased" (Schweitzer *et al.*, 1972). Furthermore, in cases where investments are made for protecting timber inventories, the ACE "... greatly decreases the value of the benefits" (Bell *et a*l., 1975). Finally, ACE incentives may cause capital to be attracted to stands within management units with the largest inventories of mature timber, irrespective of the productivity of the site (Teeguarden, 1973; Pearse, 1976).[11]

---

[10] For a discussion on timber harvests and user costs, see Hyde (1980).

[11] A reviewer of this paper pointed out that low productivity sites may be subject to repeated investments, as regeneration efforts fail, with the ACE being used each time as a means of harvesting additional profitable old growth stands. This process may, in turn, undermine efforts at sustained yield. Although the ACE may make this situation possible, repeated regeneration failures undermining sustained yield flows may also be viewed as a failure of governments to adequately regulate regeneration efforts.

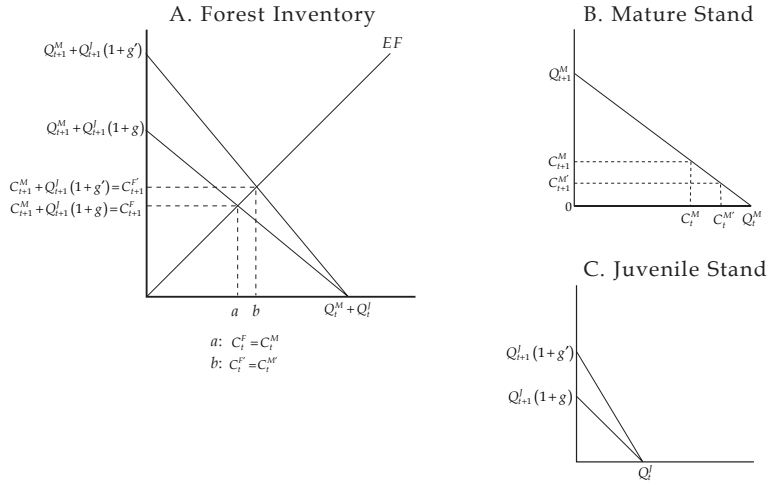

FIGURE 1. THE ALLOWABLE CUT EFFECT AT STAND AND FOREST LEVELS.

When Binkley (1980) introduced his two-period model, the concerns regarding cross-subsidization were not directly addressed. In his model, this issue is somewhat cloaked in that an inventory of trees, or any part thereof, may either be harvested immediately or allowed to grow for harvest in a future period. Given that changes in AACs due to the ACE are calculated at the forest level, and that Binkley's models are designed to depict the change in AAC due to the ACE, the inventories may be interpreted as representing forest level inventories. In reality, we would find this forest inventory to be made up of heterogeneous stands. Assume as depicted in the model presented above, that part of the forest inventory is comprised of old growth timber, non-responsive to change, while part of the inventory is comprised of forests responsive to silvicultural investments. This situation is depicted in Figure 1.

In the figure, volumes of available timber (Q) may be harvested in one of two periods (t or t+1) from mature (M) or juvenile (J) stands to make up the total forest (F) inventory volume.[12] The juvenile inventory, if not harvested in the initial period, is shown to grow at rate g, while the

[12] In order to investigate the intermixing of juvenile and mature harvests, the assumption in Equation 1, that all mature timber is harvested before juvenile, is dropped.

mature volume available is constant between the two periods. Accordingly, the total inventory at the forest level available to be harvested is $Q_t^M + Q_t^J$ in the first period or $Q_{t+1}^M + Q_{t+1}^J(1+g)$ in the second period (panel A). Given the even flow constraint (*EF*), the firm cuts C_t^F in the first period, which comes from the mature stand as volume C_t^M (panel B), while the juvenile stand may be left to increase in volume. In the second period, the firm cuts the remainder of the mature stand, $C_{t+1}^M = Q_t^M - C_t^M$ (panel B), plus the grown juvenile stand $Q_{t+1}^J(1+g)$ (panel C).

If an investment is undertaken in the juvenile stand, such that the growth rate increases to g', then the forest inventory available increases to $Q_{t+1}^M + Q_{t+1}^J(1+g')$ in the second period (panel A). Given *EF*, the investment will cause the cut in the first and second periods to increase, respectively, from C_t^F to $C_t^{F'}$ and from C_{t+1}^F to $C_{t+1}^{F'}$ (panel A). In the first period, this increase comes from increased harvests from the mature stand as cuts increase from C_t^M to $C_t^{M'}$ (panel B). In the second period, $C_{t+1}^{M'} = Q_t^M - C_t^{M'}$, is harvested from the mature stand (panel B), while all of the available volume in the juvenile stand, $Q_{t+1}^J(1+g')$, is harvested (panel C).

The above disaggregation of Binkley's (1980) model shows how the cross-subsidization issue may be fitted into Binkley's framework. However, in so doing, this reconciliation neither invalidates the cross-subsidization concern of early ACE critics, nor changes Binkley's general conclusion, that the ACE reduces the costs of sustained yield. Instead, the above elaboration merely shows, more precisely, how the ACE reduces the costs of sustained yield. However, the critiques of ACE did not stop here. There were also concerns voiced about the focus of the ACE on volumes as opposed to values.

Volumes vs. Values

A further difference in the above model (Equations 1 and 2) and Binkley's (1980) analysis lies in assumptions regarding the homogeneity of value. Equation (2) contains separate price variables that allow different volumes to have different values. However, Binkley assumed that all volumes in his model were homogenous in value. That is, in Figure 1, C_t^M and C_t^J could be thought of as representing volumes and values if all volumes are homogenous. Because

it does not recognize heterogeneous values, Binkley's (1980) model does not directly address the second major concern voiced early in the ACE debate regarding the distortions caused to values of investments created by ACE incentives. Haley (1972) and Teeguarden (1973) pointed out that because the ACE depends on increases in timber volume resulting from silvicultural operations, it might discriminate against investments that influence timber quality and, hence, value. Because the ACE regards wood as a homogeneous product, it is implicitly assumed that the old-growth timber harvested as a result of silviculturally induced future productivity increases is identical to the second-growth timber which actually results from timber investments (Haley, 1972). However, future timber inventory is likely to be different to the inventory currently being harvested in terms of species composition, tree size, wood quality and volume per hectare and, hence, in harvesting and transportation costs and unit values.

Equation (2) may be used to illustrate how the ACE may discriminate against quality. Suppose that there are two investments, I_1 and I_2, each with the same investment cost. Investment I_1 increases present and future harvests with the ACE, but not quality (i.e. dC_t^M/dI_1 , $dC_t^J/dI_1 > 0$, $P_C^J = P_C^M$). However, I_2 is an activity that increases quality, but actually *decreases* the harvestable volume in both periods (i.e. dC_t^J/dI_2 , $dC_t^M/dI_2 < 0$, $P_C^J > P_C^M$). In order for I_2, to be undertaken, the increase in value from the improved quality will have to overcome this reduction in volumes received in both periods.

Once again, the above elaboration of Binkley's (1980) model neither invalidates the concerns of the early ACE critics, nor changes the general conclusion, that the ACE reduces costs of sustained yield. As before, the example merely shows, more precisely, how the ACE may reduce the costs of sustained yield by discriminating against silvicutlural investments that increase quality and not volumes. Note, however, that the investment behavior created by the ACE is not void of the consideration of wood values. Equation 2, through the inclusion of price variables, shows that although the ACE may not take account of values, firms do. As such the resulting investment behavior occurs as firms attach values to the volume effects of the ACE.

Is the ACE Innocuous?

Within their context, Binkley's (1980) conclusions are powerful, and elegantly derived. Although he did not directly address the cross-subsidization and value\volume issues, his conclusion holds – from a NPV maximization perspective, the ACE allows us to enjoy the benefits of sustained yield at a reduced cost. The power from this conclusion rests in the realization that if firms voluntarily undertake ACE motivated investments, then the costs of sustained yield will be reduced, no matter what apparent distortions may be associated with the investment behavior. Maximizing behavior on the part of rational firms, no matter how convoluted, can only decrease costs of sustained yield constraints. Here lies the reconciliation of the critique and acceptance stage of the ACE literature. The critique stage elucidates how the ACE influences the dynamic investment behavior of firms, maximizing within a sustained yield framework, while the acceptance stage shows maximizing behavior to reduce the costs of sustained yield. As such the early critiques of the ACE are legitimate criticisms of sustained yield policies, but do not detract from the potential benefits of the ACE.

The legitimacy of the early ACE critics disappears, however, if the arguments of McKillop (1979), Binkley (1980) and Contreras & Gregerson (1982) are accepted. These authors noted that the ACE is not distortionary if the premise of sustained yield is accepted. With the acceptance of sustained yield, the so-called "distortions" become part and parcel to the maximization process within even flow constraints. However, these conclusions are of little use in assessing the social legitimacy of the ACE, because these conclusions are based on an implicit acceptance of sustained yield, which is part and parcel to the original concept of the ACE. In short, if sustained yield constraints are accepted as given, the very source of the ACE issues is dismissed.[13] Instead, issues associated with the ACE represent potentially important aspects of sustained yield policies that should be considered. However, there are still other arguments that have been put forth in defense of the ACE.

[13] Binkley (1980) supported his arguments for accepting sustained yield constraints by postulating a relationship between non-declining volumes of timber and social welfare. The appropriateness of this social welfare function given contemporary values is the subject of the next section.

In 1984, Binkley introduced a more general concept of the ACE that is not dependent on sustained yield constraints. Binkley concluded that: "Allowable cut effects stem from the production constraints which link harvests between periods, either production linkages or value linkages." and that: "Valid economic analysis requires inclusion of the positive or negative changes in the optimal harvest schedule associated with allowable cut effects." These conclusions were derived by showing that current harvests of profit maximizing firms would increase in response to two aspects of a forest management environment: 1) imperfect competition and 2) forest inventories whose growth rates are effected by inventory level. Essentially, this paper showed how these two conditions affect the user costs of firms, thereby influencing immediate decisions regarding the harvesting of timber.

The underlying theme of the Binkley (1984) paper was that ACE incentives are not only due to sustained yield constraints, but that they are part of a normal, non-distortionary, environment for economic firms. However, the first aspect of forest management environments, the lack of perfect competition, is a market failure with distortionary consequences. Therefore, the existence of an ACE due to imperfect competition does not make the firms' behavioral responses innocuous from a policy perspective. Instead, the resulting behavior only elucidates how the market failure is exhibited in a multi-period harvesting situation. With regards to the second aspect, interrelationships between growth rates and levels of forest inventories, it was clearly shown how such a situation could affect current harvest levels. These interrelationships are indeed non-distortionary, in the absence of market failures, in that they are part of the production processes that economic agents follow as they pursue profit maximization. Indeed, in standard economic theory, a number of economic variables, such as changes in interest rates, prices or costs, may change the user costs of firms, thereby changing current and future volumes harvested. However, arguments against the ACE, associated with sustained yield constraints, are quite different, in that they arise out of government policies.

In sum, if we constrain ourselves to assessing the inclusion of the ACE using a NPV maximizing perspective, the conclusions reached in the acceptance stage of the ACE lit-

erature do not illegitimatize the concerns raised early in the debate. Dismissing these concerns, on the grounds that a socially legitimate sustained yield policy makes these inefficiencies acceptable, is to fail to recognize that the ACE literature is part of the critique of sustained yield policies. In short, if sustained yield constraints are accepted as given, the very source of the concern that caused issues about the ACE to arise in the first place is dismissed. It may be argued that there are other, (non-even flow) types of ACE effects that are part of the normal management environment of forestry firms. Indeed the economic theory of user costs accounts for these effects. Some of the features of firms' production environments, such as imperfect competition, may create distortions that could call for government regulation. However, the ACE associated with even flow constraints is different in that we are considering whether and how a government policy is distorting the behavior of forestry firms.

Thus far, we have considered the ACE from a NPV maximizing perspective. However, social welfare may not be adequately served by measures of NPVs. In order to assess ACE policies, it may be necessary to look beyond dollar values of timber to social welfare.

The Social Welfare Maximizing Perspective

In analyzing the ACE from a social welfare maximizing perspective, a broader view is taken with regards to the social implications of ACE policies. This view may be taken by government forest services in their mandate to manage public resources for social welfare. However, it may not be the view of private forest companies that may be better characterized as profit maximizers. Accordingly, in this section we assume that government agencies are seeking to put in place policies with broader objectives.

As a means of assessing ACE policies, Binkley (1980) proposed a social welfare function which contains, as determinants, current volumes of harvest, future volumes of harvest and income derived from current and future harvests for the consumption of non-timber goods. Under such a scenario, sustained yield policies are valued not only for the income they create, but also for increases in the presence of current and future volumes. That is, "... timber pro-

duces social welfare directly rather than through the goods and services derived from it" (Binkley, 1980). Accordingly, concentrating on the income determinant, as is done in the net present value maximizing perspective, would provide an incomplete assessment of the social legitimacy of ACE incentives.

If we accept Binkley's (1980) social welfare function, then under certain conditions, it is possible that ACE incentives may be legitimate from a social welfare perspective. One could conceive of a situation where sustained yield policies, and their resulting ACE incentives, would cause investment incentives to create income and current and future harvest volumes that would coincide with the maximization of some definition of social welfare. Along these lines, McKillop (1979) hypothesizes that ACE incentives may be legitimate under the assumption that "... the flow constraint has been carefully chosen to meet certain well defined goals".

However, such a result would depend on sustained yield policies correctly reflecting the relative utility weightings of the determinants in the social welfare function. This result is extremely unlikely for several reasons. To begin with, as noted by McKillop (1979), "... the policy maker should be made aware of the costs of adhering to the constraint in terms of income forgone". Given that even flow policies were established long before the existence of ACE was recognized, it is doubtful that sustained yield policies could have been carefully chosen with due regard for all of the relevant opportunity costs caused by even flow constraints.

Furthermore, even if policy makers were aware of the complications that the ACE brings, one must question the form of the social welfare function that could legitimize such policies. To begin with, because ACE incentives are driven by volume, and not by value, utility would have to be derived from harvesting current and future volumes, irrespective of the quality or value of wood produced. If wood volumes are modeled as a homogenous product, then there is no means of considering the reasonable possibility that a society concerned with intergenerational equity might be concerned with the species, location and quality of timber available for harvest by future generations. Furthermore, with ACE policies causing current and future

volumes to be interdependent, society's utility for these volumes would also have to be linked. For example, utility could not merely be derived from knowing that some number of trees would exist in the future. Instead, utility would have to be dependent on how large of a volume of trees will exist relative to current harvests.

Binkley (1980) himself pointed out some further dubious assumptions implicit in his welfare function. First, notwithstanding technological progress and shifts in the prices of substitute materials, the social welfare function implies that, in the case of even flow constraints, the marginal value of timber outputs to society across all time periods is equal. Second, Binkley noted that his model assumes that a legacy of a non-declining, perpetual series of timber removals is more desirable, from an intergenerational social welfare perspective, than the bequest of other kinds of capital stocks such as public works, human capital or private productive capacity.

A further characterization of a social welfare function that could justify sustained yield and the ACE, is that the welfare focus would have to be on timber. To the extent that constraints cause timber flows to be sustained, other forest resources may decline.[14] With the recognition that non-timber resources contribute to social welfare, even flows of timber could become secondary.

The implicit welfare assumptions needed to justify sustained yield policies are likely the root cause of why the sustained yield paradigm is being increasingly challenged with a new sustainable development paradigm. If a sustainable development paradigm were adopted, then one could envisage eliminating the quantitative constraints of sustained yield of timber. However, the absence of allowable annual cuts may require some sort of replacement if we are to ensure the sustainable development of forests.[15]. Instead, the focus of forest management could be on main-

[14] The example of the spotted owl in the Pacific Northwest, once again, comes to mind.

[15] A number of authors (e.g. Markandya & Pearce, 1991) have discussed why markets may fail with respect to allocating resources over time.

taining values of forest resources over time (e.g. Haley & Luckert, 1995).[16]

A number of key similarities and differences between the ACE and a non-declining value constraint are noteworthy. First, problems associated with the ACE being value blind are corrected with a value constraint, in that values are the focus. However, the second key problem with the ACE, regarding the cross-subsidy of investments with existing stocks, would be present with a non-declining value constraint, as it is with the ACE. While the ACE causes volumes over time to be linked, a value-based constraint would cause values over time to be linked. Therefore, as was the case with the ACE, questions regarding whether the social constraint is worth the cost would still be relevant. However, the costs of cross-subsidization would likely be reduced with a value constraint, as compared to the ACE. By focusing on sustaining values instead of sustaining volumes, there are more strategies to employ as sustainable paths are sought among varying levels of production of different types of forest resources.

Finally, the ACE and a value constraint are similar yet different with respect to implications regarding legacies of capital for future generations. Similarities between the ACE and a value constraint arise, in that both implicitly assume that, respectively, sustained flows of timber and forest values are preferable, from an intergenerational social welfare perspective, than the bequest of other kinds of capital stocks that are being forgone outside of the forestry sector. The value constraint does broaden the content of the legacy from sustained timber volumes to sustained forest values. However, the value constraint does not consider that declines in the forestry sector may be desirable if substituted with compensating gains in other sectors of the economy.

SUMMARY AND CONCLUSIONS

Concerns regarding the ACE arose as several authors, taking a NPV perspective, identified apparently perverse results that arose from investment incentives under sustained yield constraints. These results were later justified as be-

[16] Similar concepts are common in the economic literature on sustainable development. For example, Pezzy's (1988) concepts of sustainable development involve non-declining utility per capita over infinite time horizons.

ing legitimate from a NPV maximizing perspective as it was shown that the ACE alleviates the opportunity costs of sustained yield constraints. Furthermore, it was argued that if sustained yield was accepted as a given, then the ACE was appropriate. Subsequently, the issue regarding the appropriateness of the ACE has largely disappeared.

Unfortunately, the conclusions of the acceptance stage of the literature do not directly address the concerns voiced in the criticism stage. The ACE may cause incentives to discriminate against investments in quality, and may cross-subsidize silvicultural investments with existing timber values. Both of these concerns may be dismissed if sustained yield policies are accepted as a given. Along these lines the acceptance of the ACE also becomes easier if it is viewed as a normal part of the management environment of firms operating in markets. Although there are market factors that would cause firms to increase immediate harvests in return for changes in future yields, such cases are not a result of public policy. The issue at hand is how public policies affect the behavior of forestry firms and whether these actions further social welfare. Given that the ACE under debate is part and parcel of sustained yield policies, it is legitimate to not accept sustained yield policies as a given, and to consider concerns regarding the ACE in the sustained yield debate. Indeed, unless the concerns raised in the initial critiques are included, we will fail to understand the source of the opportunity costs of sustained yield.

Reviewing ACE policies from the perspective of net present value maximization is problematic, in that the relationship between dollar measures over time and a social welfare function is questionable. Accordingly, attempts were made during the acceptance stage of the ACE literature to assess ACE policies within the context of social welfare. However, it is only under very specific conditions that the ACE, as part of sustained yield policies, could promote social welfare. It may be that sustained yield policies, and their accompanying ACEs do further social welfare. Indeed, whether and how society derives welfare from income and the temporal availability of timber for harvesting is an empirical question. However, current trends towards sustainable development suggest that it is no longer sufficient to ensure society that our forests will supply continuous volumes of timber.

Newer concepts of forest management associated with sustainable forest management maintain that values of forests need to be sustained over time. Although such a paradigm switch may alleviate many of the concerns associated with the ACE, a number of similar problems arise that are part and parcel to sustainability constraints.

In conclusion, the evolution of forest policy will depend heavily upon weaknesses associated with sustained yield and the potential emergence of a replacement paradigm that is considered to be better. In order to understand problems associated with sustained yield forestry, it is important to characterize the opportunity costs of sustained yield constraints within the environment of the ACE. This environment includes incentives for investments that subsidize silvicultural investments with existing timber values and incentives that may discriminate against improvements in quality. The potential emergence of a different type of sustainability constraint may alleviate some of these problems. However, any type of sustainability constraint applied in a dynamic investment setting implies consequences that may seem nonsensical. To accept these consequences, given the acceptance of the larger sustainability policy is to fail to completely consider the strengths and weaknesses of the larger policy. As we move forward in considering alternative sustainability paradigms, it may behoove us to allow nagging doubts to remain regarding whether the internal dynamic consequences of the overarching policy are acceptable. If we do not, we may be stuck with sustained yield (or any other future sustainability policy) longer than we should.

REFERENCES

Alston, R.M., 1991. Are Sustained Yield and Sustainable Development Equivalent? In *Proceedings of the National Convention of the Society of American Foresters* (San Francisco: Society of American Foresters), 310–315.

Bell, E., Fight, R. & Randall, R., 1975. ACE: The Two Edged Sword. *Journal of Forestry*, 73, 642–643.

Binkley, C. S., 1980. Economic Analysis of the Allowable Cut Effect. Forest Science, 26, 633–642.

Binkley, C. S., 1984. Allowable Cut Effects without Even Flow Constraints. *Canadian Journal of Forest Research*, 14, 317–320.

Boyd, R. G. & Hyde, W. F., 1989. *Forest Sector Intervention: The Impacts of Regulation on Social Welfare* (Ames: Iowa State University Press).

Contreras, A. & Gregersen, H.,. 1982. Policy Considerations in Forestry Project Evaluation. *Journal of Forestry*, 80, 63–364.

Dowdle, B., 1984. The Case for Selling Federal Timber Lands. In *Selling the Federal Forests*, edited by A. E. Gamache (University of Washington), 21–46.

Haley, D., 1972. *The Economic Analysis of Activities Designed to Accelerate Stand Growth in the Context of the Managed Forest* (Seattle Washington: Stand Management Committee, Western Forestry and Conservation Association).

Haley, D. & Luckert, M. K.,. 1995. Policy Instruments for Sustainable Development in the British Columbia Forestry Sector. In *Institutions for Sustainable Development in Natural Resources in British Columbia*, edited by. A. D. Scott and D. Cohen (Vancouver: UBC Press), 54–79.

Hyde, W. F., 1976. Economics of National Forest Timber Harvests: a Rejoinder. *Journal of Forestry*, 74, 823–824.

Hyde, W. F., 1980. *Timber Supply, Land Allocation, and Economic Efficiency* (Baltimore: Johns Hopkins University).

Klemperer, W. D., 1975. The Parable of the Allowable Pump Effect. *Journal of Forestry*, 73, 640–641.

Luckert, M. K. & Haley, D., 1995. The Allowable Cut Effect (ACE) as a Policy Instrument in Canadian Forestry. *Canadian Journal of Forest Research*, 25, 1821–1829.

Lundgren, A. A., 1973. The Allowable Cut Effect: Some Further Extensions. *Journal of Forestry*, 71, 357–360.

Markandya, A. & Pearce, D. W., 1991. Development, the Environment, and the Social Rate of Discount. *The World Bank Research Observer*, 6 (2), 137–152.

McKillop, W., 1979. Analytical Techniques and Social Constraints in Policy Formulation. In *Timber issues in British Columbia*, edited by W. McKillop and **XX** Mead (Vancouver: University of British Columbia Press), 124–131.

Pearse, P. H., 1965. Distortions in the Market for Forest Land. Forestry Chronicle, 41, 406–418.

Pearse, P. H., 1976. *Timber Rights and Forest Policy in British Columbia*. Report of the Royal Commission on Forest Resources. Victoria B.C. 1, 228–229.

Pezzy, J., 1988. *Economic Analysis of Sustainable Growth and Sustainable Development*. Working Paper prepared for the Environment Department, Washington D.C., World Bank.

Schallau, C. H., 1974. Can Regulation Contribute to Economic Stability? *Journal of Forestry*, 72, 214–216.

Schweitzer, D. L. R., Sassaman, R. W. & Schallau, C. H., 1972. Allowable Cut Effect: Some Physical and Economic Implications. *Journal of Forestry*, 70, 415–418.

Tedder, P.L. & Schmidt, J. S., 1980. Allowable Cut Effect and the ECHO Algorithm. *Forest Science*, 26, 374–376.

Teeguarden, D. E., 1973. The Allowable Cut Effect: A Comment. *Journal of Forestry*, 71, 224–226.

Walker, J. L., 1977. Economic Efficiency and the National Forest Act of 1976. *Journal of Forestry*, 75, 715–718.