# RURAL ECONOMY

**Welfare Implications of the Allowable Cut Effect in the Context of Sustained Yield and Sustainable Development Forestry**

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**Department of Rural Economy**
Faculty of Agriculture & Forestry,
and Home Economics
University of Alberta
Edmonton, Canada

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The authors is Associate Professor, Department of Rural Economy, University of Alberta, Edmonton.

In 1972, Schweitzer et al. defined the allowable cut effect (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 which 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] ACE, it was argued, was yet another reason for criticizing sustained yield policies.[2] This view was dominant until a second stage emerged where McKillop (1979), followed by Binkley (1980) and Contreras and Gregorson (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 ACE which was independent of even flow constraints and old growth forests. In this paper, 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 concerned about ACE in the “criticism stage”. The issue seems to have died, as almost nothing has since been written on the welfare implications of the ACE. This is not to suggest that economic criticisms of sustained yield policies have not continued.[3] Since the Brundtland report, forest policies have

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1 Authors pointing out the distorting effects of the ACE included Klemperer (1975), Pearse (1976), Teeguarden (1973), Tedder and 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), Hyde (1976) and Dowdle (1976).

3 See for example Dowdle (1984) or Boyd and Hyde (1989).

increasingly been assessed under the goals and objectives of sustainable development.[4] In short, sustainable development seems to encapsulate two criticisms of sustained yield which 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 which encompasses values from many forest resources. Second, concepts of sustainable development recognize that providing for future generations does not necessarily imply that harvest 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 purpose of this paper is to re-assess the welfare implications of the ACE in the context of sustained yield and sustainable development forestry. Following Binkley (1980), this paper will analyze 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, independent of the distribution of the benefits which investments create. Next, the effects of 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 ACE will result in incentives which will maximize the aggregated utility of individual members of society. As will become evident in the following analysis, adopting differing perspectives allows us to "... distinguish between an economic analysis of a forestry investment project within a given policy environment and economic analysis of the effects of the policies creating the environment" (Contreras and Gregorson 1982).

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4 See for example Alston (1991) or Haley and Luckert (1995).

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.

### *The Net Present Value Maximizing Perspective*

Most objections to the ACE are made from the perspective of social benefit cost analysis. From this perspective the objective of policy analysis is to assess how social welfare, expressed in dollar values and irrespective of distribution among individuals, 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 inextricably links stock rents associated with existing timber with flow rents enhanced by investments 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 which yield economic rents. That is, firms will shift resources from one use to another if the net returns in their second use are higher than the net returns in their present use (i.e. their opportunity cost). The firm is assumed to be operating under constraints which spread out the harvest of mature timber over time exactly 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 non-responsive to silvicultural investments, while values of regenerated timber may be increased with such activities. The maximization problem for the firm may be expressed as:

$$[1] \qquad \text{Maximize NPVR} = \sum_{t=1}^{z} (C_t^M)e^{-rt} + \sum_{t=z+1}^{\infty} E(C_t^J)e^{-rt} - I$$

where:

NPVR = net present value of economic rents received by the firm from selling stumpage;

$C_t^M$ = rents which will be received in period t, from selling currently existing mature timber;

$E(C_t^J)$ = expectation of rents which will be received in period t, from selling timber crops which are juvenile but will mature in the future;

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

$e^{-rt}$ = discount factor in continuous time;

z = final period when old growth timber will be available;

I = firm's silvicultural investment.

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

$$[2] \qquad dNPVR/dI = \sum_{t=1}^{z}(dC_t^M/dI)e^{-rt} + \sum_{t=z+1}^{\infty} E(dC_t^J/dI)e^{-rt}\} - dI/dI = 0$$

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. By moving dI/dI to the right hand side of Equation [2] it becomes apparent that in the presence of ACE, investments will proceed to the point where the expected marginal increase in rent attributable to silvicultural investment is equal to one.

## Stock vs. Flow Rents

Equation [2] shows that the ACE allows rents 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, this cross-subsidization will result in a lower NPVR than could have occurred in the absence of sustained yield constraints, as decisions regarding the harvest of the current stock and investments in future flows are distorted. 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.[7] Investments in flows are distorted by cross-subsidization which finances investments for enhancing flow rents with stock rents. This cross-subsidization is the source of criticism for those who pointed out that the gains attributed to ACE have little to do with the value of the additional wood produced by the silvicultural investment. As such the ACE confounds the economic logic of investing for future benefits, where marginal analysis would, in the absence

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

of sustained yield constraints, view values of current harvests of old growth timber as being independent of future values of second growth stands.

Because of the interdependencies between stock and flow rents which ACE creates, 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, ACE "... greatly decreases the value of the benefits" (Bell, et al. 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).

The above concerns surrounding the cross-subsidization of rents are somewhat cloaked in Binkley's (1980) two-period model. In this model 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 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. The juvenile inventory, if not harvested in the initial period, is shown to grows at rate r, while the 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 $Q_{t+1}^M + Q_{t+1}^J(1+r)$ in the second period. Given the even flow constraint (EF), the firm cuts $C_t^F$ in the first period, which comes from the mature stand as volume $C_t^M$, while the juvenile stand may be left to increase in volume. In the second period, the firm cuts the remainder of the mature stand, $C_{t+1}^M = Q_t^M - C_t^M$, plus the grown juvenile stand $Q_{t+1}^J(1+r)$.

If an investment is undertaken in the juvenile stand, such that the growth rate increases to r', then the forest inventory available increases to $Q_{t+1}^{M}+Q_{t+1}^{J}(1+r')$ in the second period. The first panel of figure 1 shows that 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 $C_{t+1}^{F'}$. In the first period, this increase comes from increased harvests from the mature stand as cuts increase from $C_t^M$ to $C_t^{M'}$. In the second period, $C_{t+1}^{M'}=Q_t^M - C_t^{M'}$, is harvested from the mature stand while all of the available volume in the juvenile stand, $Q_1^J(1+r')$, is harvested.

The above disaggregation of Binkley's model supports the concerns of the ACE critics in that the cross-subsidization of stock and flow rents is made clear. However, the critiques of ACE did not stop here. There were also concerns voiced about the focus of 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. Binkley assumes that all volumes are homogeneous in value. Equation [2] shows how the NPVR created in the presence of ACE depends on the discounted values, not volumes, of $C_t^M$ and $C_t^J$. Nonetheless, following the assumptions of Binkley's (1980) analysis, $C_t^M$ and $C_t^J$ could be thought of as representing volumes and values if all volumes are homogenous. However, suppose that there are two investments, each with investment cost I, which produce the same increase in allowable annual cut. However, assume further that the second investment also increases quality. The increase in benefits created by the investment which increases AAC quantities alone may be denoted, $dC_t^{J,M}1/dI$, while the investment which increases quantity and quality $dC_t^{J,M}2/dI$. Therefore, in dollar terms, $dC_t^{J,M}1/dI < dC_t^{J,M}2/dI$ and the second investment is superior in terms of increasing net present value. However the use of ACE as a criterion will not allow the decision maker to distinguish between the two investments. Accordingly, if value, instead of volume is considered, then NPVR is reduced by ACE policies.

By failing to recognize heterogeneous values, Binkley's (1980) model effectively ignores 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 is dependent on increases in

timber volume resulting from silvicultural operations, it is inapplicable to investments which 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 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. Accordingly, if heterogeneous values of timber volumes are recognized, it is erroneous to conclude 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" (Binkley, 1980).

## Is the ACE Innocuous?

Within their context, Binkley's (1980) conclusions are powerful, and elegantly derived. However, these conclusions should not be taken as a vindication of the ACE as they do not satisfy two concerns frequently found at the heart of ACE debates: 1)cross-subsidization between stock and flow rents and 2) volumes of wood created which are heterogeneous in value. However, these concerns are of no consequence if the arguments of McKillop (1979), Binkley (1980) and Contreras and Gregorson (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 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 concern which caused concerns about ACE to arise in the first place is dismissed.[8] However, there are still other arguments which have been put forth in defense of the ACE.

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[8] 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 wherein he 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 profit maximizing firms’ current harvests 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 affected the user costs of firms, thereby influencing immediate decisions regarding the harvesting of timber. The underlying theme of this paper was ACE incentives are part of a normal, non-distortionary, environment for economic firms. However, the lack of perfect competition is a market failure with distortionary consequences. Therefore, the existence of an ACE effect due to imperfect competition does not justify the firms response 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 interrelationships between growth rates and levels of forest inventories, it was clearly shown how such a situation could affect current harvest levels. However these are non-distortionary in that they are part of the production processes, not government policies, that economic agents respond to 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.

In sum, if we constrain ourselves to assessing the inclusion of ACE using a NPV maximizing perspective, the conclusions reached in the acceptance stage of the ACE literature are questionable. Heterogeneous values of wood volumes cause the ACE to fail to optimally allocate resources within sustained yield constraints, and cross-subsidization between stock and flow rents raises serious efficiency questions regarding the merits of sustained yield policies and their accompanying ACEs. Dismissing these concerns, on the grounds that a socially legitimate sustained yield policy makes these inefficiencies OK, 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 which caused concerns about ACE to arise in the first place is dismissed.[9] It may be argued that there are other, (non even flow) types of ACE effects which are part of the normal management environment of forestry firms. Indeed the economic theory of user costs has long acknowledged these effects. Some of the features of these production environments, such as imperfect competition, may create distortions which 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 arguments for and against the inclusion of ACE from a NPV maximizing perspective. However, social welfare may not be adequately served by measures of NPV's. In order to assess ACE policies, it may be necessary to look beyond dollar values to social welfare.

## *The Social Welfare Maximizing Perspective*

In analyzing ACE from a social welfare maximizing perspective, a broader view is taken with regards to the social implications of ACE policies. 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 produces 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

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[9] 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.

and current and future harvest volumes which would coincide with the maximization of some definition of social welfare. 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 which ACE brings, one must question the form of the social welfare function which 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 nondeclining, 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 limitation of a social welfare function which 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.[10] With the recognition that non-timber resources contribute to social welfare, even flows of timber could become irrelevant. Instead, the focus of forest management could be on maintaining values of forest resources over time (Haley and Luckert, 1995).[11]

The implicit welfare assumptions needed to justify sustained yield policies is likely the reason why, increasingly, the sustained yield paradigm is being 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. If we adopt the criteria that values of goods and services provided by forests must be sustained over time, as suggested above, then society could be allowed to increase the current utility derived from the consumption of forest resources if it can be shown that current investments will increase future levels of utility provided by forest resources. This type of provision could be termed the Allowable Consumable UTility Effect (ACUTE).

## *Conclusions*

Concerns regarding ACE arose as several authors, taking a net present value perspective, identified perverse results which arose from investment incentives under sustained yield constraints. These results were later justified as being legitimate from a private profit maximizing perspective where sustained yield policies are taken as given. Furthermore, this perspective showed ACE to alleviate the opportunity costs of sustained yield constraints, instead of adding to them as earlier authors had implied. Accordingly, the issue regarding the appropriateness of ACE has largely disappeared.

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

[11] 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.

Unfortunately, the conclusions of the acceptance stage of the literature do not directly address the concerns voiced in the criticism stage. Volumes of trees may be heterogeneous in value causing the ACE to misallocate resources from a NPV perspective. Furthermore the cross-subsidization of rents between stocks and flows can cause inefficiencies in investments. 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. Although there are situations which 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 add concerns regarding the ACE to the debate.

Reviewing ACE policies from the perspective of net present value maximization is problematic, in that the relationship between dollar measures 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 ACE policies could promote social welfare. It may be that sustained yield policies, and their accompanying ACE's 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. If sustained yield is abandoned in favor of a concept of sustaining the utility which forest resources may provide, then the ACE may be replaced with a provision (ACUTE) that would allow the current consumption of utility to increase in return for investments which could be shown to increase future utility levels.

In order to assess what type of sustainablility criteria is appropriate, research is needed which investigates how people derive utility from flows of resources over time.[12] If this research is to be of use to policy makers, it will have to go beyond the the NPV maximization perspective taken in the criticism stage of the debate to address

[12] Luckert and Adamowicz (1992) have begun research in this area by investigating reasons behind individuals choices of income derived from alternative paths of harvests over time.

concepts of social welfare assoicated with sustaining resource use over time. This work will also have to go beyond accepting the status quo as a reflection of social welfare and investigate welfare implications of alternative sustainablility constraints.

## *Literature Cited*


Alston, R.M. 1991. Are sustained yield and sustainable development equivalent? In proceedings of the National Convention of the Society of American Foresters. San Fancisco: Society of American Foresters. 310-315.

Bell, E., R. Fight and R. Randall. 1975. ACE: The two edged sword. J. of For. 73:642-643.

Binkley, C.S. 1980. Economic Analysis of the Allowable Cut Effect. For. Sci. 26:633-642.

Binkley, C.S. 1984. Allowable cut effects without even flow constraints. Can. J. For. Res. 14:317-320.

Boyd, R.G. and W.F. Hyde. 1989. Forest Sector Intervention: The Impacts of Regulation on Social Welfare. Ames: Iowa State University Press. 295 pp.

Contreras A. and H. Gregersen. 1982. Policy considerations in forestry project evaluation. J. of For. 80:63-364.

Dowdle, B. 1984. The Case for Selling Federal Timber Lands. pp. 21-46. In Selling the Federal Forests. A.E. Gamache, editor. University of Washington.

Haley, D. 1972. The economic analysis of activities designed to accelerate stand growth in the context of the managed forest. Stand Management Committee, Western Forestry and Conservation Association., Seattle Wash. 9 p.

Haley, D. and M.K. Luckert. 1995. Policy instruments for sustainable development in the British Columbia forestry sector. pp. 54-79. In: Institutions for sustainable development in natural resources in British Columbia. A.D. Scott and D. Cohen, eds. UBC Press, Vancouver. 213p.

Haley, David and M.K. Luckert. 1990. Forest Tenures in Canada - A Framework for Policy Analysis. Forestry Canada, Economics Directorate, Information Report E-X-43. 104 p.

Hyde, W.F. 1976. Economics of National Forest timber harvests: a rejoinder. J. of For. 74:823-824.

Hyde, W.F. 1980. Timber supply, land allocation, and economic efficiency. Baltimore: Johns Hopkins University. 224p.

Klemperer, W.D. 1975. The parable of the allowable pump effect. J. of For. 73:640-641

Luckert M.K. and D. Haley. 1989. Funding mechanisms for silviculture on Crown land: status, problems and recommendations for British Columbia. Forest Economics and Policy Analysis Project, University of British Columbia, Vancouver B.C. 59 p.

Luckert M.K. and D. Haley. 1990. "The implications of various funding mechanisms for privately managed public forest land in Canada". New Forests 3:1-12.

Luckert, M.K. and D. Haley. 1995. The allowable cut effect (ACE) as a policy instrument in Canadian forestry. Canadian Journal of Forest Research. 25: 1821-1829.

Luckert, M.K. and W. Adamowicz. 1993. Empirical measures of factors affecting social rates of discount. Environmental and Resource Economics. 3(1): 1-22.

Lundgren, A.A. 1973. The allowable cut effect: Some further extensions. J. of For. 71:357,360.

McKillop, W. 1979. Analytical techniques and social constraints in policy formulation. pp. 124-131. In: Timber issues in British Columbia, (McKillop and Mead eds) Univ. of B.C. Press, Vancouver.

Pearse, P.H. 1965. Distortions in the market for forest land. For. Chron. 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? J. of For. 72:214-216.

Schweitzer, D.L.R., R.W. Sassaman, and C.H. Schallau. 1972. Allowable cut effect: some physical and economic implications. J. of For. 70:415-418.

Tedder P.L. and J.S. Schmidt. 1980. Allowable cut effect and the ECHO algorithm. For. Sci. 26:374-376.

Teeguarden, D.E. 1973. The allowable cut effect: A comment. J. of For. 71:224-226.

Walker, J.L. 1977. Economic efficiency and the National Forest Act of 1976. J. of For. 75:715-718.

## Figure 1: The Allowable Cut Effect at Stand and Forest Levels