Welfare effects of increasing forest conservation in Finland: A computable general equilibrium analysis

Draft

Emmi Haltia[♣]
Department of Forest Economics
University of Helsinki

Abstract

The aim of this paper is to provide a theoretical framework for cost-benefit analysis of increased forest conservation in southern Finland. First, the cost-benefit rule is derived to make visible the exact components that should be considered in the cost-benefit analysis. If the project is large enough to have an effect on the equilibrium prices in the market, we need to use a computable general equilibrium (CGE) model to estimate the benefit and cost components.

Keywords forest conservation, cost-benefit rule, social accounting matrix, computable general equilibrium model

1. Introduction

Programme for conservation of forests in southern Finland has been one of the most discussed environmental and forest policy issues recently in Finland. Impacts of forest conservation on profitability of forestry and forest industries, on employment and on rural economies have been a major concern in the preparation of the conservation programme. However, sufficient research based knowledge on welfare effects of forest

[♣] From this version on, the paper will be written in collaboration with Johanna Pohjola and Maarit Kallio from the Finnish Forest Research Institute.

conservation in Finland is lacking. Welfare effects should be known when the decisions on the programme of biodiversity conservation in southern Finland are made in year 2007 after the experimental stage of the programme 2003-2006.

The forest conservation will generate costs presumably via direct compensations for forest owners for setting their forests aside of commercial use and via the reduction in timber and pulp wood supply. If the forest conservation project is large enough, the reduction in the supply could increase the timber prices and cause repercussion effects on other closely related markets and affect profits of the industries. The companies' profits end up as income to the households, and together with other income, prices of the forest products and value of the increased environmental amenity, they compose the welfare of a household (Johansson 1993). The values of environmental amenity, in other words the benefits of the forest conservation, are also various; forests produce market and non-market goods, and goods which can either be consumed or which have only existence value. The purpose of this study is to construct a computable general equilibrium (CGE) model to describe the effects of increasing forest conservation so that it is in accordance with the cost-benefit rule of the project. Though the cost-benefit analysis has been applied to examine the welfare effects of different environmental changes, the scientific cost-benefit analysis has not been applied to assess the large scale conservation of boreal forests so that market effects are also taken into account.

General equilibrium cost-benefit rules show how to build a cost-benefit analysis so that all the important benefits and costs are considered (Johansson 1993). There are, however, only few studies that have explicitly derived the cost-benefit rule and shown that the considered costs and benefits are those that should be compared to assess the social welfare effects of a project. Recently Håkansson et al. (2004) applied this approach to link the theory to the empirical application about the salmon-hydropower conflict in Sweden.

Costs of economic effects of forest conservation in Finland have been studied (Mäki-Hakola 2004, Leppänen et al. 2003, Linden and Uusivuori 2002), but the results are not applicable as such for cost-benefit analysis because they are not theoretically justified counterparts for the benefits from a stated preference study. They have, however, brought up important factors that have effect on the consequences of forest conservation, for example possibility to import pulp wood and saw timber, mainly from Russia, and the importance of the conservation method. If the conservation is based on the voluntary conservation contracts, the effect of conservation on timber market is smaller than the effect if the conservation is carried out with the traditional methods, in which state buys land from the owner (Mäki-Hakola 2004).

A CGE analysis of the effects of forest conservation in Finland is still lacking. Existing input-output (I-O) analysis (Mäki-Hakola and Toropainen 2005) are not sufficient because of the limitations of the method. For example, prices of inputs and outputs are fixed, production technology is such that fixed quantities of inputs must be used to create a unit of output, supply of inputs is unlimited and final output demand is exogenous. These limitations in the analysis of socioeconomic impacts of a change in policy may lead to flawed results (Alavalapati et al. 1998). A remedy could be the use of CGE model. CGE models are very flexible and they can be adjusted to a wide scope of situations. If the reality, however, differs substantially from the assumptions of the model, the results may be even more biased than those of I-O models (Alavalapati et al. 1998). Thereby CGE modelling assumptions need to be carefully chosen, justified and visible.

There are some CGE studies that focus on the market effects of some policy change in order to protect forest biodiversity (Zhang et al. 2005, Das et al. 2005, Alavalapati et al. 1997). All these studies found that policy changes actually cause welfare effects, and despite their limitations, CGE models were applicable on this kind of problems. Some studies have also included natural capital and environmental benefits into the CGE models (Patriquin et al. 2003b). In this study the existence values of forest biodiversity are taken into account in the CGE model, in which we utilise the results of stated preference valuation studies (Lehtonen et al. 2003, 2005a, 2005b). A literature review of forestry related CGE studies states that these models could be improved by adding dynamics into the models, but generally CGE models fit in the analysis of policy induced changes on forestry sector (Stenberg and Siriwardana 2005). In Finland, forestry sector has been modelled in CGE analysis of effects of reducing CO_2 (Pohjola 1999).

Contribution of this study is the derivation of the cost-benefit rule for forest conservation assuming modest price changes. Due to price changes we need to apply a CGE model to estimate the costs and benefits of the conservation in accordance with the cost-benefit rule. Existence value of forest biodiversity will be included in the CGE model using the results of a stated preference study.

This article is organized as follows. The next section presents the general equilibrium cost-benefit rule for forest conservation. The second Section presents the social accounting matrix and in the third Section we present the CGE model for estimating the market effects of forest conservation. The final Section discusses some conclusions that can be made so far and outlines progress of this study.

2. The Cost-Benefit Rule

In this section we derive a static cost-benefit rule for increased forest conservation. An economy benefits from the forest conservation because people value forests as recreation areas, producers of pleasant scenery and habitats for endangered species, among other things. The effects of the conservation on the forest industries' profits, on the other hand, generate the costs of the conservation. These benefits and costs are compared to each other by using a cost-benefit rule. The derivation of cost-benefit rule for forest conservation follows Johansson (1993), especially sections 3.4 and 5.3, and the related appendices.

Assume that an economy consists of a representative household, a representative forestry firm, and a representative forest industry firm. The representative household receives positive utility from consumption (x) and from biodiversity and amenity values of forests (z). The representative consumer funds consumption and biodiversity services by exogenous income (y), incomes received from the firms' profits (π,π_f) and earned income. Forestry firm earns by selling timber and forest biodiversity conservation at prices (w_t, w_z), respectively. Thus, the forestry firm receives compensation w_z for each forest hectare z that is set aside of commercial use. The price of compensation depends on the prices of timber and pulp wood, because they have an effect on the forest firms' willingness to supply forest for biodiversity conservation.

In Finland, the conservation has traditionally been carried out by buying the forests from the private owners and strictly prohibiting all commercial use. This strategy is, however, very expensive especially in the southern Finland where are the most productive forest areas of the country. Conservation contracts for certain periods of time, for example for 20 or 30 years, have been proposed as a new method for forest conservation. A forest owner could voluntarily make a contract and get monetary compensation for the biodiversity conservation and the ownership of the land would remain at the initial owner. Thus the production of biodiversity could be an alternative for producing timber for forest industry. In this cost-benefit analysis we assume that the conservation is carried out using the conservation contracts, and the forest owners receive compensation for conserving forests.

If a representative household would be better of after the change in the level of forest conservation, then the project would be socially desirable. This criterion is based on potential Pareto principal which does not require that the losses of some households would be compensated by the gaining households (Johansson 1993). Household also works for forest industry and a part of household income consists of wage from the forest industry.

The household maximises its utility from consumption of goods, existence of forest biodiversity and leisure:

$$U = U(x, z, l) \quad (1)$$

$$s.t.\, y + \pi + \pi_f + w_l l - px - CV - \tau = 0, \quad (2)$$

where:

Acronym	Explanation
x	consumption goods
z	forest conservation
l	labour
y	exogenous income
π	forest industry firm's profit
π_f	forestry firm's profit
w_l	wage
p	price of the consumption goods
CV	compensating variation
τ	lump-sum tax collected from the consumers = direct cost of forest conservation

Compensating variation (*CV*) indicates the value of a project, i.e. the amount of money that household pays to remain at the same level of utility after the project than they were before it. Thereby, the compensating variation can be written:

$$V(p^1, w^1, w_l^1, \tau, y^1 + \pi^1 + \pi_f^1 - CV, z^1) = V(p^0, w^0, w_l^0, y^0 + \pi^0 + \pi_f^0, z^0) \quad (3)$$

We assume that the representative household does not receive any monetary compensation for forest conservation at the initial state (right hand side), but after the conservation project a forest owner may earn by conserving a part of the forest estate.

Utilising the necessary conditions for interior solution and substituting the demand and supply functions to (1) yields an indirect utility function:

$$V(p, y+\pi+\pi_f+w_l l-CV-\tau, z), \tag{4}$$

The total differential of the indirect utility function is:

$$\begin{aligned}&dV=V_Y dy+V_Y d\pi+V_Y d\pi_f+V_Y l dw_l-V_Y dCV-V_Y x dp\\&-V_Y d\tau-V_z dz=0\end{aligned} \tag{5}$$

where V_Y is the marginal utility of income evaluated at initial level of prices. Dividing through by V_Y converts the measure (5) from units of utility to monetary units:

$$\begin{aligned}&dV/V_Y=dy+d\pi+d\pi_f+l dw_l-dCV-d\tau-x dp+\\&(V_z/V_Y)dz=0\end{aligned} \tag{6}$$

Profit function of the forestry firm[1] is:

$$\pi_f=w_t T(K_t,z)+w_z z \tag{7}$$

where w_t is timber price, w_z is compensation paid for biodiversity production, and $T(K_t,z)$ is the concave timber production function in which K_f is forest capital and z forest conservation. If the conservation, z, is zero, then all the forest capital is used for timber production, and vice versa. The total differential of the profit function is:

$$d\pi_f=T dw_t+z dw_z=0 \tag{8}$$

Profit function of the forest industry is:

$$\pi=pF(T,l)-w_t T-w_l l \tag{9}$$

Here the production is a function of timber and labour. The total differential of (9) is:

$$d\pi=x^s dp-T^d dw-l^d dw_l=0 \tag{10}$$

[1] The import of timber is excluded at this stage of the model. Very likely, the imports will not have an effect on the cost-benefit rule. Imports should, however, be taken into account in the empirical model, because they will have effect on the forest industries possibilities to compensate the losses due to possibly increased domestic timber prices.

Substituting (8) and (10) into (6) and denoting the demand and supply functions with the superscripts produces:

$$dV/V_y = dy + x^s dp - T^d dw_t - l^d dw_d + T^s dw_t + z^s dw_z$$
$$+l^s dw_l - x^d dp - dCV - d\tau + (V_z/V_y)dz = 0 \qquad (11)$$

If prices adjust so that supply and demand equals, the first two terms on the left hand side of the equation (10) will vanish. Change in exogenous lump-sum income *y* is suppressed, because income is assumed to be constant over the change in forest conservation. Solving the equation for *dCV* yields

$$dCV = z^s dw_z - d\tau + (V_z/V_y)dz \qquad (12)$$

The project increases aggregated welfare and is socially desirable according to potential Pareto principle if $dCV > 0$. In other words, if forest owners' producers surplus plus consumers' WTP for conservation exceeds direct costs. This rule applies in the situation in which the project leaves the prices more or less constant.

When the project affects prices, we need to use compensated equilibrium prices. Accordingly, when assessing large changes in *z*

$$z^s = z^s\left[w_t^*, w_z^*, K_t, z\right] \qquad (13)$$

$$V_z = V_z[p^*, w^*, w_l^*, y^* + \pi^* + \pi_f^* - CV^*, z] \qquad (14)$$

$$V_y = V_y[p^*, w^*, w_l^*, y^* + \pi^* + \pi_f^* - CV^*, z] \qquad (15)$$

where $p^*=p(z)$, $w_i^*=w_i(z)$, $i=t,z,l$, $y^*=y(z)$, $\pi^*=p^*F(T^*,w_i^*)-w_t^*T^*-w_l^*l^*$, and $CV^*=CV(z)$ is such that the household stays at the initial level of utility after the change in forest conservation.

According to Johansson (1993), it is extremely difficult to apply the cost-benefit rule if the project has a significant effect on prices. Some prices may increase and some decrease following the project, and thus the use of either initial or final prices do not offer any lower or upper bounds for the for the project's social profitability. In case that the project has a significant impact on the prices, we need to use an empirical model to find out the project's effect on the welfare. In the next sections we provide an outline for the empirical model.

3. Social Accounting Matrix

Social accounting matrices (SAM) have been used for policy analysis as themselves, and they are a basic data framework for CGE model (figure 1). CGE models may also use data of I-O tables which describe the flow of goods and services, and are a subset of SAM (Stenberg and Siriwardana 2005). SAM is, however, with its income and expenditure accounts, more useful in the situations in which the distributional issues are of interest (Alavalapati et al.1999). In addition, SAM framework can be very valuable calibration of the data and in construction of a hybrid model where data comes from different sources (Patriquin et al. 2002, Patriquin et al. 2003a).

Interactions between environment and economy can also be taken into consideration in environmentally extended SAM, ESAM (Xie 2000, Patriquin et al. 2003b). A problem with these environmental extensions is the measurement of environmental benefits or environmental damage (Patriquin et al. 2003b). In this study, we assume that the households get non-market benefits from the forest conservation and they should be taken into consideration in welfare analysis. In our analysis, we will utilise the results of valuation studies of forest conservation in southern Finland (Lehtonen et al. 2003, 2005a, 2005b) and formulate a limited version of ESAM.

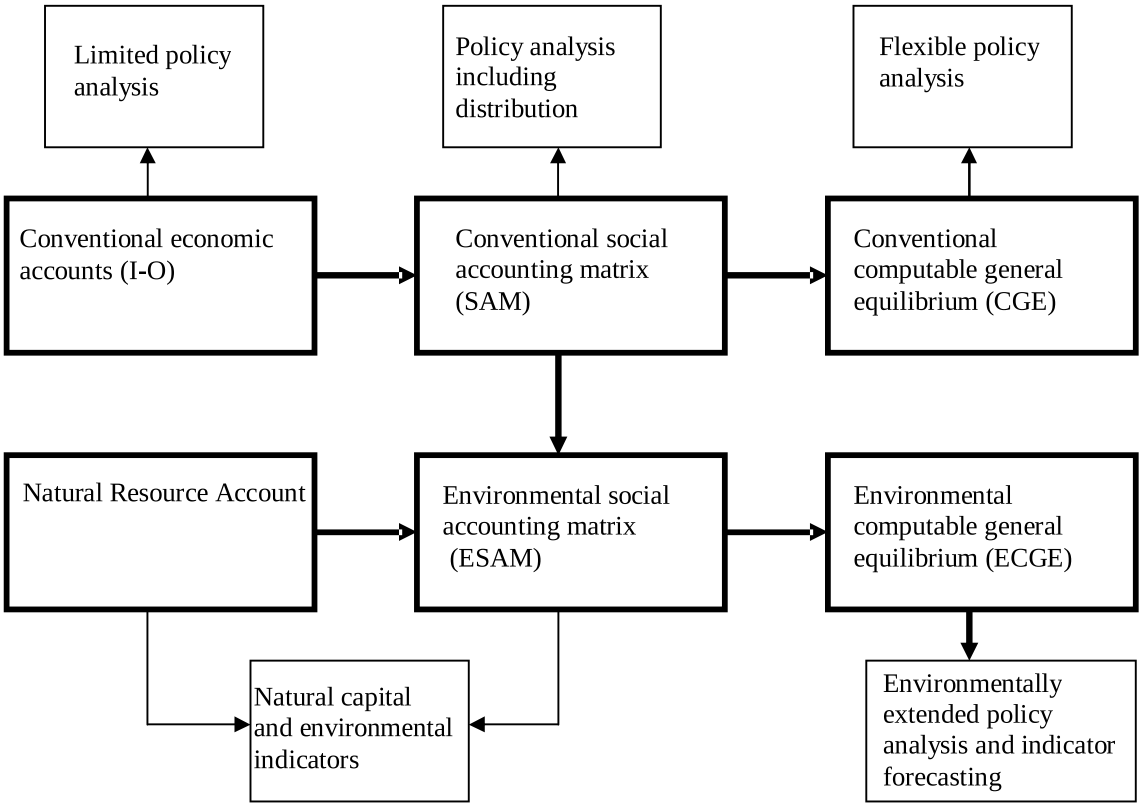

Figure 1. Use of I-O model, SAM, ESAM, CGE and ECGE in policy analysis (Patriquin et al. 2003b)

Table 1 presents the SAM of this study and interaction assumptions of CGE. There are three sectors of production, 1) forestry, 2) forest industry and 3) composite commodity. Forestry is thus here a production sector as in many earlier CGE models (Alavalapati et al. 1999, Das et al. 2005). To simplify the model, the pulp/paper industry and sawmills constitute one production sector, forest products. Similarly, forest owners sell only timber that means here both saw timber and pulp wood.

Factors of production include 1) labour, 2) capital, and 3) land that is used in the forestry sector for timber and biodiversity production.

		Receipts	Expenditures Factors of production			Household	Production					
			1	2	3	4	5	6	7	8	9	10
			Labour	Capital	Land	Consumers	Forestry	Forest industry	Composite commodity	Investments	ROW	Totals
1 Factors of production	1	Labour						Wages	Wages		Factor payment = wages	Total value added
	2	Capital						Interest	Interest			Total value added
	3	Land					Interest					Total value added
2 Household current account	5	Consumers	Factor payment = wages	capital income	capital income						Exogenous Income	Household income
4 Production	6	Forestry				Biodiversity payment		Price of timber		Investments		Total sales
	7	Forest industry				Household consumption/ Outlays		Intermediate transactions	Intermediate transactions	Investments	Exports	Total sales
	8	Composite commodity				Household consumption/ Outlays		Intermediate transactions	Intermediate transactions	Investments	Exports	Total sales
	9	Investments				Household saving	Consumption of fixed capital	Consumption of fixed capital	Consumption of fixed capital		Saving by ROW	Total savings
ROW	10	ROW	Payment to ROW			Transfer to ROW		Imports	Imports			ROW income
	11	Totals	Total value added	Total value added	Total value added	Total household expenditure	Total costs	Total costs	Total costs	Total investments	ROW expenditure	

Table 1. Framework for social accounting matrix.

The SAM in our paper does not include the government account. The only tax like payment, biodiversity payment, goes directly from the consumer to forestry even when the level of payment is a political decision based on the desired amount of forest conservation.

4. Computable General Equilibrium model

The CGE model of this paper is a static model for an open economy. Technical details of the model and the functional forms of the equations are still undecided, but the CGE model will follow closely the structure of the model presented in the Section 2 describing the cost-benefit rule.

Consumer

The representative consumer gains from the increase in the existence value of the forest biodiversity and pays a tax that is collected to finance the forest conservation project. The level of the forest conservation is a political decision and exogenous to the consumer. The conservation level defines the tax that the consumers pay for the biodiversity conservation because the tax equals the direct costs of the conservation. The direct costs are dependent on the conservation level because the direct costs are in this case the compensations paid for forest owners for setting their forests out of commercial use.

In this study we can utilise numerical data of the existence values of forest biodiversity in Finland. The preliminary analysis produced fairly high willingness-to-pay (WTP) measures for increased conservation using the binary choice contingent valuation (CV) method (Lehtonen et al. 2003). The results, however, indicated that due to preference uncertainty and respondents' willingness to support forest conservation even at high level of personal costs, traditional welfare measures calculated in the preliminary analysis might differ from the actual willingness to pay. To improve the accuracy of the willingness to pay estimates we have analysed possibilities of applying different distributional assumptions

(Lehtonen et al. 2005a) and allowing respondent uncertainty (Lehtonen et al. 2005b). The results of these CV studies show that the estimation method and distributional assumptions have significant effects on the WTP estimates. The estimates used in the cost-benefit analysis must therefore be carefully chosen. Probably a sensitivity analysis and lower and upper bound estimates should be calculated.

Using the data on the existence values of the forest biodiversity has an effect on the selection of the functional form for consumer's utility function. Respondents of the valuation study were not asked to consider the possible price changes due to forest conservation. It would very likely have been too difficult. Because of this we should try to find a separable function for consumer utility.

Production sectors

Production sectors are described with the profit maximisation equations. The profits in the model are set to zero according to competitive market and constant return to scale assumption. These assumptions imply also that the prices equal the corresponding marginal costs.

Forestry

Forestry firm maximises income from selling timber and forest biodiversity services. An important issue here is to find a good functional form combining timber and biodiversity supply.

Forest industry

Imports of timber were excluded from the model of Section 2 even though they may have important role in the empirical model. Forest industry may compensate the lower supply of wood and increased prices by importing more. If importing wood is possible and the costs are sufficiently low, then the firms are more independent on domestic timber prices and the decreasing welfare effect of forest conservation is not as substantial as in the case where the import prices are high (Mälkönen 2004). In addition, if forest industry is able to import also saw timber along with pulp wood that has constituted the major part of the import, then conservation will affect at forestry, not forest industry (Mäki-Hakola and Toropainen 2005).

Composite commodity

Composite commodity sector is a combination of all other industries in the economy but the forest sector.

Government

Government is excluded from the institutions for simplicity, and the only tax like payment, biodiversity fee, goes directly from the consumer to the forest owner. The level of the tax, however, is directly dependent on the political decision about the scale of conservation.

Rest of the world

This study concentrates the welfare effects of conservation in Finland, and thus all the other countries are handled as one area, rest of the world (ROW). Finland imports timber from ROW, exports final products of forest industry, and imports and exports the composite commodity. Domestic and foreign products are imperfect substitutes and they are differentiated according to Armington approach (Armington 1969).

5. Discussion

We present here a static model of a Finnish forest sector, even if the use of intertemporal model could be more realistic in a case of growing natural resource as forest (Stenberg and Siriwardana 2005). This choice was done to simplify the model in the beginning, but possibilities to include dynamics of forests into the model will be examined in the future.

Another expansion of the model will be the differentiation of the consumer groups and regions. According to our assumptions, the conservation will have different effects on different agents of the Finnish economy and on separate regions.

References

Alavalapati, J. R. R., Percy, M. B., and Luckert, M. K.1997. A computable general equilibrium analysis of a stumpage price increase policy in British Columbia. Journal of Forest Economics 3 (2), 143-169.

Alavalapati, J. R. R., Adamowich, W. L., and White, W. A. 1998. A comparison of economic impact assessment methods: the case of forestry developments in Alberta. Canadian Journal of Forest Research 28, 711-719.

Armington, P 1969. A theory of demand for products distinguished by place of production. International Monetary Fund Staff Papers.

Das, G. G., Alavalapati, J. R. R:, Carter, D. R., Tsigas, M. E., 2003. Regional impacts of environmental regulations and technical change in the US forestry sector: a multiregional CGE analysis. Forest Policy and Economics 7(1): 25-38.

Horne, P., Koskela, T., and Ovaskainen, V. Ed. 2004. Safeguarding forest biodiversity in Finland – Citizens' and non-industrial private forest owners' views. Metsäntutkimuslaitoksen tiedonantoja 933. In Finnish, summary in English.

Håkansson, C., Johansson, P-O. and Kriström, B. 2004. Cost-benefit analysis of environmental change: Linking theory to empirical observations. Paper presented at EAERE Summer School 2004.

Johansson, P-O., 1993. Cost Benefit Analysis of Environmental Change. Cambridge University Press.

Just, R.E., Hueth, D.L., Schmitz, A., 1982. Applied Welfare Economics and Public Policy. New York, Prentice Hall.

Lehtonen, E., Kuuluvainen, J., Pouta, E., Rekola, M. and Li, C-Z. 2003. Non-market benefits of forest conservation in southern Finland. Environmental Science and Policy 6, 195-204.

Lehtonen, E., Kuuluvainen, J., Ovaskainen, V., Pouta, E., and Rekola, M. 2005a. Influence of logit model assumptions on estimated willingness to pay for forest conservation in southern Finland. Department of Forest Economics, University of Helsinki, Reports 35.

Lehtonen, E., Kuuluvainen, J., Li, C.-Z., Pouta, E. and Rekola, M. 2005b. Preference uncertainty in contingent valuation: case of forest conservation southern Finland. Manuscript.

Leppänen, J., Linden, M., Uusivuori, J. and Pajuoja, H., 2003. The private cost and timber market implications of increasing strict forest conservation in Finland. Forest Policy and Economics. Forest Policy and Economics 7(1): 71-8.

Linden, M. and Uusivuori, J. 2002. Econometric analysis of forest conservation: the Finnish experience. Environment and Development Economics 7:281-297.

Mäki-Hakola, M. 2004. Metsien suojelun vaikutukse puumarkkinoilla – mallitarkastelu. Pellervo Economic Research Institute, Working Papers No. 73. p. 52.

Mäki-Hakola, M. and Toropainen, M. 2005. Economic and social impacts of forest nature conservation – regional and national input-output analyses. Pellervo Economic Research Institute, Reports No. 194. 127 p. In Finnish, summary in English.

Mälkönen, V. 2004. Optimal forest cnservation under endogenous mode of competition: The role of timber imports. In: Essays on Environmental Policy and Strategic Behavior in International Trade. Dissertation. Department of Economics, University of Helsinki, Reports Nr 101:2004. Dissertationes Oeconomicae.

Patriquin, M. N., Alavalapati, J. R. R., Wellstead, A. M., and White, W. A. 2002. A comparison of impact measures from hybrid and synthetic techniques: A case study of the Foothills Model Forest. The Annals of Regional Science 36, 265-278.

Patriquin, M. N., Alavalapati, J. R. R., Wellstead, A. M., Young, S. M., Adamowich, W. L., and White, W. A. 2003a. Estimating impacts f resource management policies in the Foothills Model Forest. Canadian Journal of Forest Research 33, 147-155.

Patriquin, M. N., Alavalapati, J. R. R., Adamowich, W. L., and White, W. A. 2003b. Incorporating natural capital into economy-wide impact analysis: A case study from Alberta. Environmental Monitoring and Assessment 86, 149-169.

Pohjola, J. 1999. Economywide effects of reducing CO_2 emissions: A comparison between net and gross emissions. Journal of Forest Economics 5 (1), 139-168.

Stenberg, L. C., and Siriwardana, M. 2005. The appropriateness of CGE modeling in analysing the problem of deforestation. Management of Environmental Quality: An International Journal 16 (5): 407-420.

Williamsson, T., Hauer, G. and Luckert, M. K. 2004. A restricted Leontief profit function model of the Canadian lumber and chip industy: potential impacts of US countervail and Kyoto ratification. Canadian Journal of Forest Research 34: 1833-44.

Xie, J. 2000. An environmentally extended social accounting matrix. Environmental and Resource Economics 16, 391-406.

Zhang, J., Alavalapati, J. R. R., Shrestha, R. K., and Hodges, A. W. 2005. Economic impacts of closing national forests for commercial timber production in Florida and Liberty County.