



MODELING PUBLIC FOREST LAND USE TRADEOFFS ON VANCOUVER ISLAND

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ABSTRACT

Because forestry accounts for about 10% of British Columbia's economy and 95% of B.C.'s total land base is publicly owned, forest land use policies are important to the provincial economy. In this paper, goal programming is used to examine the economic impacts of a stakeholders' process for allocating public land on Vancouver Island. Despite including recreational and nonuse benefits and tourist jobs, the results indicate likely losses of 4,500 direct jobs (1.5% of all jobs on the Island), a decline in government revenue by 5.5% or \$82.5 million per year, and an annual reduction in society's welfare by some \$440 million (constituting 0.5% of provincial GDP).

Keywords: forest land use conflicts, benefit-cost analysis, multiple accounts analysis, goal programming.

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BACKGROUND

The Government of British Columbia introduced a number of policy initiatives in the past several years that affect the province's forest industry. These include: (1) the 1991 *Protected Areas Strategy (PAS)*, which aims to increase the proportion of the province's preserved wilderness area from about 6.5% of the land base to 12%; (2) the 1992 *Timber Supply Review*, which will re-examine the forest inventory and determine sustainable regional harvests to prevent a potential downfall in future timber supply; (3) the 1994 *Forest Practices Code*; (4) the 1994 *Forest Renewal Plan* that aims to capture a greater share of potential forest rents, which are then to be used to employ in silviculture union workers displaced by planned harvest reductions; (5) a *Forest*

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Land Reserve (created in 1994) that prevents private forest land owners from putting forest land into competing uses (including agriculture); and (6) the *Commission on Resources and Environment (CORE)*, which began in 1992 and is charged with finding a consensus on land-use issues and making recommendations about how land is to be used. Implementation of *PAS* targets has subsequently defaulted to the *CORE* process.

Each policy will have an effect on the amount of timber available for commercial harvest. The *PAS* is expected to reduce timber availability by about 5%, the supply reviews could reduce it by a further 20%, and the Forest Practices Code could reduce the *allowable annual cut (AAC)* by between 10 and 20 percent. On the other hand, the Forest Renewal Plan and Forest Land Reserve are designed to encourage silvicultural investment through public expenditures and tax incentives.

The focus of this study is on land-use decisions and the *CORE* process on Vancouver Island. Aided by government and outside consultants, the *CORE* process consists of consensus seeking among different interest groups, each of which has its own objectives. Multiple accounts analysis has been the principal means for presenting alternative scenarios to participants in the *CORE* process. Multiple accounts analysis is employed because some items, such as regional employment, are simply incommensurable with measures of social welfare, while other items are difficult to measure, such as preservation and biodiversity values. The multiple accounts framework explicitly recognizes the difficulty of including all items in a social cost-benefit (economic efficiency) framework. In its standard form, multiple accounts analysis requires that economic efficiency, or net social well being (measured in monetary terms), be the account against which all other accounts are to be compared (van Kooten, 1995; U.S. Water Resources Council, 1983). A decision to protect wilderness or logging jobs needs to be judged in terms of its impact on economic efficiency. However, this is not the philosophy that appears to have evolved out of the *CORE* process. Rather, the multiple accounts approach employed by *CORE* treats all the accounts as equal, and does not require any comparison against the efficiency standard.

Given that the economic efficiency criterion is rejected as the account against which all others are to be compared, multiple accounts analysis is no longer the appropriate or even relevant tool of analysis. The reason is that decision makers need no longer be confronted with the information about tradeoffs among objectives. For example, multiple accounts analysis is not capable of judging between employment and wilderness protection. No weighting between these objectives is possible, except through the economic efficiency account. Rejection of the economic efficiency account as the principal account (numeraire) against which all other accounts are to be judged means that an alternative to multiple accounts analysis must be found. This alternative requires decision makers to prioritize objectives (preferably weighting them) and make clear the tradeoffs associated with alternative rankings of the objectives. One means for doing this is multiple-objective programming.

The purpose of this paper is to examine multiple land use on Vancouver Island using the framework of multiple-objective decision making. We begin with a discussion of the costs and benefits of reductions in timber harvest, attempting to maintain a distinction between economic surpluses (benefits and costs) and economic impacts (positive or negative). Economic surpluses are equivalent to the economist's measure of social well being; impacts refer primarily to items that are income redistributive in nature. For example, if someone is laid off in the forestry sector and finds a much lower paying job in another sector, the only true costs to society are the transactions cost associated with search, retraining and relocation. While important to the individual and perhaps to society, the reduction in pay constitutes an income transfer (or pecuniary externality), not an economic efficiency measure. Economic efficiency or social welfare simply seeks to measure the total value of goods and services available to society, including those not valued in markets. Thus, the costs of environmental protection are the foregone timber benefits, while the benefits are the amenity values (primarily recreational and passive-use values) of changes in forest land uses. Other items such as employment do not enter the calculation of social well being directly, but may nevertheless be important in land use decision making.

In this paper, a goal programming (*GP*) model is developed and used to analyze the allocation of land amongst alternative uses on Vancouver Island, which has been the subject of the province's *CORE* process. The purpose of the *GP* model is to determine impacts on employment, government revenues, and the ability to meet *PAS* and *AAC* objectives when goals are ranked in accordance with the views of a sample of B.C. residents. Since a regional input-output model is unavailable for Vancouver Island, the *GP* model can be viewed as an alternative (see van Kooten & Thompson, 1994; Waters, Holland & Weber, 1994). We begin in the next section by providing a background to land use on Vancouver Island, the current levels of harvest, employment and government revenues, and the recommended allocations of land. The parameters of the *GP* model consist of the goal rankings and the values placed on various "activities" associated with the goals, and are described in the third section. In developing these parameters, a major problem was that of allocating nonmarket values. In this regard, an allocation was made that favours non-timber activities, principally preservation and recreation. The actual values placed on non-timber commodities are also discussed there. The purpose throughout is to set forth our assumptions, which can readily be modified. The overall goal programming model is described in greater detail in the fourth section, while the simulation results are provided in the fifth section. The conclusions ensue.

CORE'S LAND ALLOCATION FOR VANCOUVER ISLAND

The area of land on Vancouver Island and its current uses are provided in Table 1. The Vancouver Island *CORE* process initially identified five major land-use categories for Crown forest land on the Island, as briefly described below.

1. *Protected areas (PA)* are part of the province's Protected Areas Strategy. No extraction is permitted in these regions as the land is to be preserved for its ecological integrity and cultural/heritage attributes. Although recreation will be permitted, it would necessarily be confined to wilderness recreation in the sense that development would be restricted, as it would require disturbance of the landscape. The *PAS* seeks to protect 12 percent of the land base. No

TABLE 1. VANCOUVER ISLAND CORE AREA

DESCRIPTION	MILLION HECTARES
Crown land within Tree Farm Licenses (TFLs)	1.457
Crown land within Timber Supply Areas (TSAs)	0.624
<i>Total Crown tenures</i>	2.081
Private land within TFLs	0.172
Private land in managed forests outside TFLs	0.426
Other private land	0.319
<i>Total private land</i>	0.917
<i>Protected land</i>	0.341
<i>Total</i>	3.339

Source: CORE (1993).

mining or forestry will be allowed, so the AAC is zero.

2. Areas of *low intensity resource use* (LIRU)¹ are designed to protect scenic travel corridors and viewsapes, critical wildlife habitat (including wildlife corridors), cultural/heritage values and watersheds. While some resource extraction and logging will be permitted in these areas, their primary purpose is to act as a buffer zone around protected areas and to provide additional protection in areas that are ecologically sensitive. Recreation will be allowed, although it is not clear to what extent, as will gathering and harvest for sustenance. Annual timber harvests will be reduced below the areas' natural productivity.

3. Some areas will be identified for *integrated resource use* (IU). Commercial activities in these areas include logging, mining and energy, hunting and fishing, and recreation and tourism. The areas are also to be managed for wildlife and fish habitat, watershed functions, and other ecological functions, thus reducing the amount of timber available to the forest industry.

4. *High intensity resource use* (HIRU) refers to land management for a single use. This does not imply that other values are to be ignored, although this depends upon the use designation. Clearly, it will be difficult to manage for tourism on land that is used to grow trees. However, the dominant single use is likely to be forestry. Even where log-

¹ As understood by CORE, "resource use" refers primarily to commercial timber harvest rather than recreation, wildlife habitat and so on.

ging is designated as the sole use, it will need to accommodate other values such as protection of fish and wildlife habitat, with the new Forest Practices Code designed to bring this about.

5. *Settlement* refers to those lands that are settled and part of the infrastructure of society — residences, commercial and manufacturing plants, offices, roads and so on. In the current analysis, the area allocated to settlement is subtracted from total land, leaving 3.02 million hectares to be allocated among the other four categories of use.

Managing lands in the low-intensity and integrated-resource use categories will require information about the biological tradeoffs among resource uses, something that is currently unavailable. For example, some uses will be compatible with others (joint production occurs), while other uses are competitive. Not only is it necessary to identify resource use compatibilities and incompatibilities, but it is important to obtain information about the net marginal benefits to each of the alternative uses.² Optimal allocation of uses will be determined administratively, perhaps after public consultation, but it is unlikely to be based on biological tradeoffs and economic values.

In the current study, the working forest consists of the *HIRU*, *IU* and *LIRU* areas, but harvest levels might be lower than those that currently prevail. However, this will be due to the new Forest Practices Code, and not directly attributable to the land uses considered in the *CORE* process. Reductions in *AAC* brought about by non-*CORE* initiatives are ignored in this analysis.

DESCRIPTION OF GOALS AND DATA

The data used in the *GP* model consist of values for standing timber, nonmarket values, government revenues, employment, and the ranking of six management goals or objectives. The goals identified in Table 2 were developed at the 1989 Parksville Old-Growth Workshop and are thought to reflect the general public's expectations regarding wilderness protection in the province (B.C. Ministry of Forests, 1990).

² If prices are available, the price ratio can be used; otherwise, it will be necessary to estimate the net marginal benefit functions or employ shadow prices.

TABLE 2. WEIGHTS AND RANKING OF SOCIOECONOMIC ATTRIBUTES

ITEM	WEIGHT	RANK
Maintain the current level of timber harvest in B. C.	0.5290	6
Permanently withdraw from scheduled future timber harvest the old growth associated with the wilderness you desired to protect	0.5786	5
Maintain the maximum sustainable yield in timber harvest	0.7834	3
Secure regional stability by maintaining the current level of employment in forest industries	0.7924	2
Maintain the level of provincial government revenue from forest harvesting	0.6497	4
Maximize the net revenue from all forest land use, even if that means less timber harvests	0.8669	1

The goal rankings were derived from two surveys. The first was distributed at a socioeconomics workshop for members of the three *CORE* tables then in progress (June 1993). About 25% of the questionnaires distributed at the workshop were returned (14 completed questionnaires). As part of a B.C. wilderness protection survey conducted in two classes at the University of British Columbia during the Fall semester, 1993, respondents were asked to rank the same goals presented to the *CORE* participants. The first class was a second/third year land economics class that is considered an elective for students in the Faculties of Agriculture, Commerce and Business Administration, Arts and Science; the second class was a third year class in forest economics required of all students enrolled in the professional forestry program in the Faculty of Forestry. Prior to completing the surveys, students in both classes had been introduced to the province's land use conflicts and the positions of the various stakeholders. All students present in class at the time of the survey completed questionnaires, with 81 questionnaires received from the land economics class and 65 from the forest economics class. Although the education of students is above the provincial average, while their age and income are well below it, the students are familiar with the issues, are cognizant of the need to balan-

ce alternative uses, and are probably more representative of the future than those actually involved in the decision making process.³ Nonetheless, the student rankings were identical to those of the *CORE* participants. The goal rankings are also provided in Table 2.

In the remainder of this section, each of the goals is described in greater detail, particularly how it is implemented in the *GP* model. The goals are presented in the rank-order derived from the surveys.

Social Well-Being or Economic Efficiency

Since the land-use decision is to be made once-and-for-all, net discounted timber and non-timber values are used (with a 4% discount rate) and assigned on a per hectare (ha) basis. The economic benefit of logging (i.e., the surplus that society gains as a result of timber harvest) depends on site quality, species, location and so on. For the coast, the average net value is \$22,595/ha after adjusting the 1989 value reported by van Kooten (1995) to 1992 using the *CPI*, and this value is used in the *GP* model. It is assumed that, on *HIRU* and *IU* lands, the companies are able to capture the full benefits from logging, but that restrictions on logging practices on *LIRU* lands enable companies to capture only one-half of the benefits per harvested hectare (see Table 4).⁴ The reason is that logging operations need to be modified to accommodate other uses and that increases costs.

Nonmarket values are more difficult to measure and assign on a per hectare basis. Estimates of recreation values have been made by government economists and are provided by B.C. forest region in Table 3. A number of assumptions need to be made in order to allocate recreational values to different land uses. First, there are 3.4 million hectares of mature forest land in the Vancouver forest region, which includes Vancouver Island (B.C. Ministry of Forests

³ The ethnic composition of the students is more reflective of the diversity of the provincial population than that of *CORE*. The greatest ethnic diversity is found in the lower Fraser River basin ("lower mainland") and in non-resource sectors of the economy, while the *CORE* process is regional and focused on the resource sector, with natives having boycotted the process.

⁴ These are the benefits for each hectare that is actually logged. However, for the *IU* and *LIRU* categories, non-timber uses will also restrict the proportion of the working forest in these regions that can be harvested, as indicated below.

TABLE 3. POPULATION AND RECREATION VALUES

Population of British Columbia, forest recreation use and recreation preservation values, and passive-use benefits by forest region, \$1992.

	(1)	(2)	(3)	(4)	(5)	(6)
REGION	Total Popul.	Adult Popul.	Regional % of Popul.	Recreation Use Value (\$mil/y)	Recreation Preservation Value ^a (\$mil/y)	Passive- use Benefits (\$mil/y)
Vancouver	2,102,460	1,583,017	74.5	4.54	111.13	339.22
Price Rupert	83,048	53,602	2.5	4.97	4.49	11.49
Kamloops	328,398	239,572	11.3	10.03	11.23	51.34
Prince George	161,769	105,411	5.0	6.83	8.22	22.59
Nelson	148,195	104,84	4.9	8.15	9.40	22.47
Cariboo	59,495	39,376	1.8	5.11	2.87	8.44
<i>Total</i>	<i>2,883,365</i>	<i>39,476</i>	<i>100.0</i>	<i>39.62</i>	<i>147.34</i>	<i>455.53</i>

Source: B.C. Ministry of Forests (1991, pp. 15, 48–49, 51) and calculation. Values adjusted to 1992 using *CPI*.

^a Recreation preservation value includes preservation for purposes of future recreation and future wildlife viewing.

and Lands, 1993, p.37). Dividing total recreational value (use plus its option value) for the Vancouver forest by 3.4 million gives a recreational value of \$34/ha/year. If it is assumed that population rises at about 1.5% annually, then, as an approximation, an effective discount rate of 2.5% is applied rather than 4%. Thus, the discounted recreational benefit would be \$1,360/ha.

Some forms of recreation are compatible with logging but not with preservation, while others are compatible with preservation but not logging. Using province-wide data, the recreational values attributable to various activities are as follows: motoring accounts for 19.9% of total recreational value, boating for 11.8%, fishing for 11.2%, hunting for 9.4%, camping and swimming for 15.1%, hiking and skiing for 17.1%, and nature study for 15.5% (Murray & Reid, 1992). Motoring is not incompatible with high intensity resource use and integrated resource use, but motoring will be restricted in areas of low intensity resource use (say to one-half) and prohibited in protected areas. Boating is

TABLE 4. INPUTS IN GP-MODEL

Net benefit and other values used in Goal Programming Model^a.

	HIRU	IU	LIRU	PA
ITEM	Discounted Value (\$/ha) ^b			
Logging	22,595	22,595	11,298	0
Nature study	0	105.40	158.10	210.80
Hunting	127.84	127.84	127.84	0
Other recreation	1,021.36	1,021.36	886.04	750.72
<i>Preservation or passive use</i>				
- Low value alternative	0	997.10	1,994.20	3,988.40
- High value alternative	0	2,218.60	4,437	8,874
<i>Direct government revenue</i>				
- under Hanzlik's formula	165.20	165.20	82.60	0
- under LRSY	150.00	150.00	75	0
<i>Direct contribution to GDP</i>				
- under Hanzlik's formula	533.75	533.75	533.75	0
- under LRSY	481.25	481.25	481.25	0

^a Government revenues and GDP are not economic benefits as defined in the text.^b Using a discount rate of 4%, but adjusted for population growth in valuing nonmarket services.

assumed to be compatible with all land use recommendations, as is fishing, because forest practices have already changed sufficiently to prevent damage of waterways, primarily due to moral suasion. Hunting is assumed to be incompatible only with wilderness protection. Camping and swimming, and hiking and skiing, are assumed to be compatible with all land use designations, except wilderness protection since it is assumed no recreation will be permitted in PA areas. Nature study is permitted in all areas, but has no value in HIRU areas, one-half value in IU areas, three-quarter value in LIRU areas and full value in PAS areas. Based on the recreational values, percentages and these assumptions, the recreational values for different activities are provided in Table 4.

Determination of passive-use benefits is more difficult. A summary of available passive-use benefits of wilderness protection is provided in Table 5. Choice of any value is bound to be controversial, so, in this study, we err on the

TABLE 5. PASSIVE-USE BENEFITS

Estimates of passive-use benefits of forest ecosystem protection in the U.S. and Canadian Pacific Northwest.

STUDY	SURVEY AREA	ESTIMATES OF BENEFITS FROM SURVEY ^a	TOTAL BENEFITS DISCOUNTED@4% (\$ bil.)
Rubin, Helfand, Loomis (1991)	Washington	\$46.67/household	≈ 1.5
Hagen, Vincent, Welle (1992)	U.S.	\$252.85/household	607
Brown, Layton, Lazo (1994)	Washington	\$96/household	≤ 3.1
Vold et al. (1994)	B.C.		
– doubling of wilderness		\$136/household	5.1
– tripling of wilderness		\$168/household	6.3
Watson (1994)	B.C.		
– mail survey of residents		\$371/household	13.9
– UBC students		\$326/household	17.9

^a US values were converted to Canadian units using C\$ = US\$0.75.

side of wilderness protection and assume that households would be willing to pay as much as \$300/year for increasing wilderness protection from its current level to the higher levels proposed under the province's Protected Areas Strategy. This value is high compared to some other studies (see Table 5), but high estimates are needed if the government's protected areas strategy is to be justified on economic efficiency grounds (van Kooten, 1995). If households consist of 1.4 adults on average and each household is *WTP* \$300 per year, passive-use benefits by forest region can be calculated; total annual passive-use benefits are then estimated to be \$455.5 million (see column (6) of Table 3).

Passive-use benefits for the Vancouver region need to be allocated on a per hectare basis. This is done in Table 6 using data on protected areas from the B.C. Ministry of Forests (1992b). For the Vancouver forest region, values range from \$99.71/ha to \$1,211.49/ha per year depending on what might be considered a reasonable means for assigning passive-use values to area. While the most reasonable estimate is likely one based on the area of mature timber (\$99.71/ha), an alternative estimate is one based on the current area of undeveloped watersheds (\$221.86/ha). As-

TABLE 6. ALLOCATION OF PASSIVE-USE VALUE

Allocation of passive-use value by three schemes for assignment, by forest region, \$/ha/year, 1992.

	(1)	(2)	(3)	(4)
REGION	By Area of Mature Timber ^a	By Total Area of Undeveloped Watersheds ^b	By Current Level of Protection ^c	By Potential of Protection ^d
Vancouver	\$ 99.71	\$221.86	\$1,211.49	\$774.47
Prince Rupert	1.80	0.85	24.70	12.12
Kamloops	21.63	57.68	194.46	121.65
Prince George	2.35	3.66	51.93	23.65
Nelson	16.16	20.29	133.72	70.21
Cariboo	2.37	16.01	272.18	27.40
Weighted averages ^e				
– Coast	\$81.14	\$106.17	\$1,007.48	\$612.14
– Interior	\$5.74	\$11.36	\$100.33	\$48.06
– Total	\$17.07	\$19.25	\$277.26	\$134.34

^a Col. 6, Table 3 divided by mature timber area.

^b Col. 6, Table 3 divided by total area of undeveloped watersheds.

^c Col. 6, Table 3 divided by total area of protected undeveloped watersheds.

^d Col. 6, Table 3 divided by area of undeveloped watersheds considered for protection under PAS.

^e Weighted by respective areas assuming 1/8 of Prince Rupert forest region is assigned to Coast.

suming population growth as before, the discounted values of land assigned to PA status would be \$3,988.40/ha and \$8,874.40/ha, respectively. Both values are used in the GP model. Land in the HIRU category is assumed to have no value if it is protected, while land that is protected in the IU and LIRU categories is worth one-quarter and one-half as much as that protected in regions where no other uses are permitted (see Table 4).

There is no available information about land-use tradeoffs (or conflicts), and this is an important area for future research. We proceed to model tradeoffs in a crude fashion, although this can be modified as more information becomes available. Conflicts among resource uses are modelled partly by making the value of an "activity" a function of the land use category, as was done above. Further, tradeoffs are modelled by restricting the amount of land used by an activity in a given category. In HIRU and PA

areas, recreationists are assumed to be able to access only a maximum of 60% of the land because restricting land use to a single purpose (whether commercial or preservation) reduces its availability for recreation. It should be noted, however, that construction of logging roads provides access for recreationists, and has been used to justify below-cost timber sales from public lands in the U.S. That is, the opposite is likely to be the case: instead of reducing recreational benefits, logging probably enhances certain kinds of recreational benefits.

It is assumed that logging on *HIRU* lands is unrestricted (i.e., all of the area in this category is available for timber harvest if that is the optimal use), but only 75% of land in the *IU* category and 10% of the land in the *LIRU* category can be used for logging.⁵ Land can be preserved for biodiversity under any category, if that is the optimal use of such land. However, passive-use values are affected by other activities as noted above. It is assumed that nonuse values are a maximum on protected areas, but that they do not fall to zero in other regions (otherwise there would be no need to restrict logging, for example). Thus, passive-use values are assumed to be at one-half of their maximum on *LIRU* areas, one-quarter on *IU* areas, and non-existent on *HIRU* areas, even though logging may benefit biodiversity, especially of ungulates.

The goal of maximizing the net benefits from public lands does not imply that the land will be used only for forestry purposes. In practice, this goal is achieved by finding the optimal mix of timber and non-timber uses that maximizes the net surplus, although several researchers have recently argued in favour of single use (see Vincent & Binkley, 1993; Helfand & Whitney, 1994; Helfand & Rubin, 1994). Here it is achieved by maximizing the net benefit from each hectare in its sole use. Ignoring declining marginal preservation value, the maximum value if each hectare of Crown land (or 2.422 million ha)⁶ is used in preservation is about \$10 billion of discounted net surplus.

If 1.6 million hectares are used to produce logs, the surplus amounts to about \$36 billion. Hence, a goal of \$35 billion of net surplus is assumed.

⁵ See previous footnote.

⁶ This is the sum of the total Crown tenures and protected land in Table 1.

Employment

The timber and non-timber values in Table 4 are estimates of economic welfare and would be used in cost-benefit analysis, for example. These types of measures would be included in the economic efficiency account of the multiple accounts framework. Making judgements based on economic efficiency alone would mean ignoring the other accounts. We need information on these other accounts to construct a *GP* model. In addition to maximizing net social benefits from public land (economic efficiency account), an important goal is that of maintaining direct employment, thereby stabilizing regional economies, preventing costs associated with unemployment and so on. Employment in the Forest Industry sector accounts for about 4.5% of B.C.'s total employment of 1.5 million. This does not include forest-related employment in government or indirect and induced employment. Based on the 1992 log harvest, 1.64 direct provincial jobs were generated per 1,000 cubic metres of harvest (Price Waterhouse, 1992), but the ratio was smaller on Vancouver Island because Vancouver Island logs contributed to direct processing jobs on the mainland.

There are about 15,200 direct forestry jobs on Vancouver Island at current harvest levels. Assuming 1.18 direct jobs per 1,000 m³ of harvest on the Island (Price Waterhouse, 1992), the current harvest from Crown land of 12.2 million m³ contributes 14,396 direct jobs. The remaining jobs are attributed, in this model, to harvests from private land. To these we add an assumed 104 *direct* jobs in non-timber activities. These jobs are related to the land (*viz.*, land management) in the same way that we have separated logging jobs from forest sector jobs as a whole. The assumption about non-timber jobs is not important to the analysis, but is simply used to determine a target for the *GP* model of 14,500 jobs per year on Crown land.

Given that all lands are to be allocated once and for all, employment needs to be on a per hectare basis. However, each hectare is not harvested each period. The 14,396 direct forestry jobs is achieved by dividing the number of jobs by the size of the working forest. Thus, there are 0.009 jobs per hectare of land permanently assigned to the working forest. This level of jobs is attainable only if *Hanzlik's formula*, which converts virgin forests into normal forests

in one rotation period (Pearse, 1990, p.160), is used to determine harvest levels. However, if a stricter criterion is employed, such as long-run sustained yield (*LRSY*), the number of direct jobs that can be supported per hectare falls to 0.0076. This is determined by multiplying the current *LRSY* of 11 million m³ for Vancouver Island by 1.18 and dividing by 1.6 million ha (the size of the working forest).

There is little information about the relationship between employment and other uses of the land. There are about 88,400 direct jobs in tourism throughout B.C.; dividing by the public land area of the province gives about 0.001 jobs per hectare. However, tourism is defined in a way that is unrelated to recreation; rather, it refers to any spending by persons outside of their normal shopping region (Cavanagh & McDougall, 1992). Hence, the number of tourist jobs to be created by forest-based recreation and other activities will be substantially lower. Evidence from the *Kamloops Resource Management Area Plan*⁷ suggests that there are about 0.0001 direct tourist jobs/ha. A study by Clayton Resources Lt. and Robinson Consulting & Associates Ltd. (undated) indicates that the Valhalla wilderness area resulted in 0.0003 tourist-related jobs/ha (both direct and indirect) (see also Matas, 1993). We assume that each hectare assigned to recreation creates double the number of jobs indicated in the previous study, or 0.0006 person-years, while area assigned to nature study or hunting contributes 0.0005 jobs/ha by assumption. On the other hand, we assume that land that is left completely unused contributes to economic well being, but not to jobs. Further, we have not attempted to make any adjustments to possible losses in logging jobs due to technical changes or to gains resulting from new forestry practices that may be more labour intensive.

Long-Run Sustained Yield

Survey respondents considered maintaining maximum sustained timber yield to be an appropriate goal of land use policy (Table 2). The long-run sustained yield harvest level is below AAC because of old growth. Since *LRSY* is affected by the amount of land available to the forest industry, it varies according to the scenario being considered. Alternative scenarios are presented in Table 7, as are the different

⁷ Newsletters Numbers 1 and 2, 1993, put out by the Ministry of Forests.

target levels for *LRSY*. For the current harvest for Vancouver Island, *LRSY* is approximately 11 million cubic metres. This implies an average *LRSY* value of 6.875 m³/ha (11.0 million m³÷1.6 million ha), a figure used in all the scenarios; only the target level changes as a result of changes in the amount of land available for harvest.

Government Revenue

Government wishes to maintain its revenues so that it will not have to borrow, reduce spending on other programs, or increase taxes. In the analysis, only direct revenues accruing to the provincial government, but not the federal

TABLE 7. SCENARIOS AND CONSTRAINTS

Description of alternative scenarios and associated model constraints^a.

ITEM	SCENARIO				
	Current Situation	#1	#2	Multi-sector	Conservation
<i>General</i>					
Working forest (mil ha)	1.6	1.1	1.0	1.5	0.7
Harvest (mil m ³)	12.2	8.3	7.3	12.0	5.0
<i>LRSY</i> (mil m ³)	11.0	8.3	7.3	10.5	5.0
Land base protected (%)	10.2	14.3	15.3	12.0	18.7
<i>Goal targets</i>					
Net benefits (\$bil)	35	35	35	35	35
Direct employment (jobs)	14,500	14,500	14,500	14,500	14,500
<i>LRSY</i> (mil m ³)	11.0	8.3	7.3	10.5	5.0
Direct revenue (\$ mil)	240	240	240	240	240
GDP contribution (\$mil)	770	770	770	770	770
Protected area (mil ha)	0.400	0.400	0.400	0.400	0.400
Current harvest (mil m ³)	12.2	12.2	12.2	12.2	12.2
<i>Physical constraints</i>					
<i>HIRU</i> (mil ha)	0.008	0.198	0.682	0	0
<i>IU</i> (mil ha)	2.002	1.322	0.685	2.022	1.223
<i>LIRU</i> (mil ha)	0.071	0.424	0.540	0	0.574
<i>PA</i> (mil ha)	0.341	0.478	0.515	0.401	0.625

Source: CORE (1993)

^a Crown land only.

government, are considered. That is, employee taxes paid as a result of indirect and induced employment and revenues accruing to the federal government are ignored. In 1992, the provincial government received \$19.81 per m³ of harvest as revenue, while municipalities collected \$1.86/m³, for a total revenue of \$21.67/m³ (Price Waterhouse, 1993).

It is important that, as a goal, government revenues be maintained at the current level. Based on a revenue of \$21.67/m³ and a current harvest of 12.2 million cubic metres (based on *Hanzlik's formula*), government revenue would be \$264.4 million or \$165.20/ha. If it is based on the *LRSY* harvest of 11 million m³, revenue would fall to \$238.4 million, or \$148.98/ha (about \$150/ha). Given that harvest costs will be higher on *LIRU* lands, it is further assumed that the contribution to revenue falls by one-half when logging occurs on lands with that designation (Table 4). A target for provincial government revenue of \$240 million per year is assumed (Table 7). This target is more than \$20 million below current revenue.

Indirect revenues are examined by looking at the contribution of forestry to provincial *GDP*. Forestry accounts for some 10.5% of provincial *GDP*, which indicates a very high dependence on forest harvesting. A reduction in *GDP* signals lower federal and provincial government revenues, and an increase in expenditures on unemployment insurance and welfare. By dividing the forestry component of *GDP* by the annual timber harvest, it turns out that each cubic metre of timber that is harvested contributes about \$70 directly to *GDP*. Based on a current harvest of 12.2 million m³, the contribution to *GDP* is \$533.75/ha; based on a *LRSY* of 11.0 million cubic metres, it is \$481.25/ha (Table 4). Using the latter value, a second revenue goal is to maintain the contribution to *GDP* at \$770 million (Table 7). This goal is used to cover revenue changes due to indirect (and induced) effects, but it is below the current contribution to provincial *GDP*.

Protected Areas

Currently, about 10.2% of the land on Vancouver Island, or 341,000 hectares, is protected. Protected areas need to be expanded to 12% to meet the province's *PAS* objective, but

some argue that, given the importance of coastal versus interior forests, more than 12% of the Island's land base should be preserved. Alternative levels are provided in Table 7 for the scenarios examined in this study.

Maintain Current Harvest Level

The final goal considered here is that of maintaining current timber harvest levels at approximately 12.2 million cubic metres. This level of harvest is based on the *Hanzlik's formula*, which assumes that existing old growth in the working forest is to be converted to a "normal" forest over the next 80–100 years. The average per hectare level of harvest is determined in the same way as was the case for *LRSY*. By dividing the AAC by the working forest area, one obtains an average harvest of 7.625 m³/ha (12.2 million m³÷1.6 million ha). Target harvest levels are provided in Table 7.

GOAL PROGRAMMING MODEL FOR VANCOUVER ISLAND

Formally, the GP model is as follows (Lee, Moore & Taylor, 1985, pp. 668–700):

$$\begin{array}{ll}
 \text{Minimize} & w(d^- + d^+) \\
 \text{subject to} & ax + d^- - d^+ = G \\
 & cx \leq b \\
 & x, d^-, d^+ \geq 0
 \end{array}$$

In this representation, w is a vector of weights, d^- and d^+ are vectors of negative and positive deviations from the goal, x is a vector of land-use activities, a is a matrix of goal coefficients, G is a vector of goal targets, c is a matrix of technical coefficients, and b is a vector of physical constraints. An alternative to using weights would be to employ pre-emptive goal priorities (where a higher level goal needs to be satisfied before the next, lower goal is satisfied) (Lee, Moore & Taylor, 1985). Since goal programming is normative, implementation of goal programs is also normative. The results of the current model were compared with pre-emptive GP, but little difference was indicated.

The objective function is to minimize the deviation from any goal target. For the goals "net social benefits", "employment", "government revenue", "protected areas", and "maintain current harvest levels", only deviations below the target are penalized as exceeding target levels in these situations is actually welcomed. The same is not true of the *LRSY* goal, where both deviations above and below the target level are to be avoided. Goals are weighted using values derived from the survey respondents (Table 2).

Each of the seven goals (recall there are two revenue goals) is a constraint in the *GP* model. The parameter values and targets for the goal constraints are provided in Tables 4 and 7. The physical constraints in the model consist of restrictions on land use and are found in Table 8. The coefficients in each equation are read across a row, while the right-hand-side (*RHS*) constraints are found in the last column. The total area constraints are required to ensure that the sum of the activities does not exceed the total area allocated to that land use (denoted by *H*, *I*, *L* and *P*) under the given scenario. These constraint values are found in the bottom portion of Table 7. The recreation constraints limit recreation land use to 60% of the *HIRU* and *PA* areas.

TABLE 8. PHYSICAL CONSTRAINTS USED IN PROGRAMMING MODEL

USE/AREA	LOGGING	NATURE STUDY	HUNTING	OTHER RECR.	NONUSE	RHS
Total area						
<i>HIRU</i>	1	1	1	1	0	<i>H</i>
<i>IU</i>	1	1	1	1	1	<i>I</i>
<i>LIRU</i>	1	1	1	1	1	<i>L</i>
<i>PA</i>	0	1	0	1	1	<i>P</i>
Recreation						
<i>HIRU</i> (60%)	-0.6	-0.6	-0.6	0.4	0	0
<i>PA</i> (60%)	0	-0.6	0	0.4	-0.6	0
Logging						
<i>IU</i> (60%)	0.2	-0.8	-0.8	-0.8	-0.8	0
<i>LIRU</i> (20%)	-0.8	-0.2	-0.2	-0.2	-0.2	0

The logging constraints limit logging to 80% of the land in *IU* and 20% of the land in *LIRU*. Finally, a constraint not shown in Table 8 is the constraint on the size of the working forest. This constraint requires that the sum of all the areas put into logging must not exceed the size of the working forest (provided in Table 7).

SIMULATION RESULTS FOR VANCOUVER ISLAND

The *GP* model is simulated for each of the scenarios in Table 7, with the simulation results provided in Table 9. The current scenario, modified to take into account employment in non-timber activities (as discussed above), is used as the benchmark. Scenario #1 represents the government policy that was anticipated to be in place by 1995, while the remaining scenarios have been put forward by participants in the *CORE* process. The position of the environmental groups is denoted as the "conservation" scenario, while the position put forward by the forest companies, unions and forest-dependent communities is denoted as the "multi-sector" strategy. Scenario #2 simply represents another strategy that was considered.

Both a "low" and a "high" value of passive-use benefits is employed, but the simulation results indicate little difference between these. In Table 9, only the differences in land use are reported; as indicated in Table 9, more land is allocated to nonuse. Land is never allocated to hunting in this model because the value of land in hunting is too low relative to other uses and it does not add much to employment. However, hunting is likely to be compatible with logging and other uses, but that jointness in production was not modelled here. As expected, the reduction in social well being is somewhat lower for the case of high passive-use values, while the loss in direct employment is somewhat higher as more land is preserved.

The size of the working forest is an important constraint on land use, as is the availability of land in the *HIRU*, *IU* and *LIRU* categories. With the exception of the current scenario, land for logging activities (i.e., the working forest) is first allocated to *HIRU* areas, followed by *IU* and *LIRU* areas (subject to the constraints in Table 7).

The current situation results in the greatest net social benefits, the highest level of direct employment, the great-

est revenue for government and the highest per capita GDP, but it does not meet the objective of preserving 12% of the land base. Scenarios #1 and #2 result in significant losses

TABLE 9. SUMMARY OF SIMULATION RESULTS

Summary of major impacts of proposed land use changes on Vancouver Island.

ITEM	S C E N A R I O			
	#1	#2	Multi-sector	Conser- vation
<i>Changes in Socioeconomic Values</i>				
Net social benefits (\$ million/yr)	-352	-428	-72	-672
Direct employment (# of jobs/yr)	-4,028	-4,82	-750	-7,006
Direct revenue loss to B.C. government (\$mil/yr)	75.0	90.0	15.0	135.0
Reduction in provincial GDP (\$mil/yr)	240.6	288.8	48.1	433.1
<i>Changes in Land Use ('000 hectares)</i>				
<i>Low passive-use benefits</i>				
Logging (Total)	-500.0	-600.0	-100.0	-900
— High intensity use	+76.0	+448.8	-3.2	-3.2
— Integrated use	-576.0	-1,048.8	-96.8	-896.8
— Low intensity use	0	0	0	0
Hunting	0	0	0	0
Recreation	-265.6	-318.6	+77.0	-162.6
<i>Total protected area</i>				
(incl. nature study)	+765.6	+918.6	+23.0	+1,062.6
— of which nature study	-136.4	-136.4	-71.3	-136.4
<i>High passive-use benefits</i>				
Logging (Total)	-500.0	-600.0	-100.0	-900.0
— High intensity use	+194.8	+678.8	-3.2	-3.2
— Integrated use	-694.8	-1,278.8	-96.8	-896.8
— Low intensity use	0	0	0	0
Hunting	0	0	0	0
Recreation	-685.6	-685.6	+77.0	-685.6
<i>Total protected area</i>				
(incl. nature study)	+1,185.6	+1,285.6	+23.0	+1,585.6
— of which nature study	-136.4	-136.4	-71.3	-136.4

in employment and direct provincial government revenue, as does the conservation scenario, which likely has the least desirable properties. Ignoring the multi-sector scenario for a moment, direct government revenues are down by \$75–\$135 million per year, *GDP* is some \$240–\$433 million lower, and between 4,000 and 7,000 direct jobs are lost (which translates into 10,000–17,500 lost jobs throughout the economy as a whole using the B.C. employment multiplier of 2.5).

Relative to other scenarios, the conservation strategy may not be an effective method for protecting wilderness. While the recommended official level of wilderness protection would increase from 341,000 to 625,000 ha, or by 110,000 ha more than any rival proposal, *de facto* preservation is much higher under all scenarios. For the conservation strategy, *de facto* wilderness preservation increases by 1.06 million ha over the benchmark level, but scenario #2 achieves 0.92 million ha of *de facto* protection at a much lower cost in terms of the accounts that matter.

What, then, is the shadow value of a unit of wilderness protection in terms of the three most important parameters of concern to residents — the net well being of society, employment and provincial government revenues? The per hectare impacts are summarized in Table 10. Compared to the results in Table 9, the multi-sector strategy does not appear to be as desirable as a means for protecting wilderness, while the conservation strategy does not do as badly. This is mainly because of the large increase in wilderness protection under the conservation strategy compared to the multi-sector scenario.

Respondents to the surveys indicated that the primary goal of government policy should be to maximize the net social benefits of land use, regardless of whether these originate with logging or some other activity that precludes logging. Despite attaching high values to non-timber uses of forest lands, the current study finds that net social benefits are substantially reduced as a result of changes to current land use practices under all scenarios except the multi-sector proposal. The multi-sector strategy maintains that the amount of land to be protected should not exceed 12 percent, as recommended by the government's own Protected Areas Strategy (Government of British Columbia,

TABLE 10. IMPACTS PER HECTARE

Impacts per hectare of wilderness preserved on Vancouver Island.

ITEM	S C E N A R I O			
	#1	#2	Multi-sector	Conser- vation
<i>Prescribed Preservation</i>				
Reduction in net social benefits (\$/ha)	\$64,230	\$61,490	\$30,000	\$59,150
Direct employment loss (# of jobs/ha)	0.029	0.028	0.013	0.025
Direct revenue loss to B. C. governmentt (\$/ha)	\$547.45	\$517.24	\$250.00	\$475.35
<i>De Facto Preservation</i>				
Reduction in net social benefits (\$/ha)	\$11,494	\$11,648	\$78,261	\$15,810
Direct employment loss (# of jobs/ha)	0.005	0.005	0.033	0.007
Direct revenue loss to B. C. government (\$/ha)	\$97.96	\$97.98	\$652.17	\$127.05

1992; B.C. Ministry of Forests, 1992a). Logging benefits should be maximized subject to that restriction.

CONCLUSIONS

In February 1994, the Commission on Resources and Environment presented its recommendations for land use on Vancouver Island (CORE 1994), but the comprehensive land use plan for Vancouver Island will likely please no side in the debate over logging and environment. The CORE report recommends that land be allocated to the following five land-use categories (with percentages in each category as indicated):

- (1) Protected area (PA) 13.0 %;
- (2) Regionally-significant land (RSL) 8.1 %;
- (3) Multi-resource use area (MRU) 72.8 %;
- (4) Cultivation use area (CU) 2.9 %; and
- (5) Settlements (S) 3.2 %.

These land use categories are different from those used during the *CORE* process, but that was likely to avoid the impression that one group's proposal was favoured over another. It appears, however, that regionally-significant lands will be similar to lands in the *PA* category because restrictions on use are prohibitive, making logging uneconomic. Nonetheless, while levels of protection are close to those under the conservation scenario, a harvest level slightly larger than that of scenario #2 will be permitted.

Taking a mid-point between scenarios #1 and #2 likely gives a good estimate of the losses one might expect under the *CORE* recommendations. Thus, some 4,500 direct jobs (1.5% of all jobs on the Island) could be lost, government revenue could decline by 5.5% or \$82.5 million annually, and society could be worse off by some \$440 million per year (which amounts to 0.5% of provincial *GDP*). Since passive-use benefits have been included in the calculations (and have actually been assumed higher than any reported in the literature), one can only conclude that the *CORE* recommendations for Vancouver Island will make B.C. residents worse off in general, regardless of how one measures well being.

Further, the *CORE* recommendations for Vancouver Island are only one government initiative. Similar recommendations can be expected for other *CORE* regions, while other initiatives will compound the adverse impacts on the well being of society, particularly as these attempt to preserve more of the same amenities that the *CORE* seeks to preserve. There comes a point where additional protection of nonmarket amenities, particularly those related to biodiversity, have no value to society.

Finally, the *CORE* processes and the other forest sector initiatives raise an issue about beneficiaries. It appears that environmental groups are the major beneficiaries of recent government policies. The redistributive impacts are borne most clearly by forest sector workers, but they are also dispersed among the province's and even the nation's taxpayers. The reason is that forest land is publicly owned, so environmental groups can easily target decision makers. Property rights to the land and its resources, on the other hand, appear ephemeral at best. This situation has resulted in successful rent seeking by those who are able to transfer bene-

fits (even though they are primarily psychic in form) from others in society to themselves, at a very high cost to society.

In a comprehensive study of the regional impacts of reduced timber harvests on the economy of Oregon, Waters, Holland & Weber (1994) concluded that dynamic growth in the Portland metropolitan area would nearly outweigh negative impacts of reduced harvests, but that "timber-induced job loss will be severe and difficult to replace" in periphery areas. Even though the economy of B.C. is more dependent on forestry than Oregon, it is unlikely that timber-induced job losses will be very significant in the Vancouver metropolitan area because growth in Vancouver is greater than in Portland as a result of in migration and offshore investment. Because of greater dependence on forestry, it is possible that regional impacts of reduced harvests could be even more severe than in Oregon's periphery. However, this is mere speculation as the inter-regional models for examining such effects are not available for B.C. This study attempted to fill this gap using a regionally-specific goal programming model.

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