BACKLOG TREATMENT AS A MEANS OF REDUCING COSTS OF DELIVERED WOOD IN NORTHERN ONTARIO

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ABSTRACT

Future average costs of delivered wood are calculated for northern Ontario by using estimates of the current average haul distance and merchantable volume per hectare in the region. These estimates are used to quantify the present value of the expected savings or losses of delivered wood that are associated with the treatment of backlog sites that have various projected future haul distances and merchantable volumes per hectare. The present value of the expected savings or losses is then compared with an estimate of the present value of the incremental treatment cost of the backlog renewal operations so that the net present value of the investment can be estimated. Sensitivity analysis shows that this approach is very sensitive to the discount rate used and to the investment period.

RÉSUMÉ

Les coûts moyens prévus du bois livré son calculés, pour le nord de l'Ontario, au moyen d'estimations de la moyenne actuelle de la distance de débardage et du volume marchand à l'hectare. Ces estimations permettent d'évaluer, compte tenu de la distance ou du volume prévus, les économies (ou les pertes) de bois livré, liées au rattrapage de stations perturbées. La valeur actuelle de ces économies ou pertes prévues est ensuite comparée à une estimation du coût actuel du traitement supplémentaire du reboisement de ces stations, de sorte qu'on peut estimer l'investissement actuel net. L'analyse révèle que cette méthode de calcul est très sensible au taux d'actualisation et à la période d'investissement.

TABLE OF CONTENTS

PURPOSE OF THE REPORT

This report defines costs of delivered wood in northern Ontario as a function of hauling distance and site productivity, then uses this relationship to examine and quantify the economic tradeoffs associated with harvesting sites of varying productivity that are various distances from a processing destination. The marginal value of the expected future cost savings (or losses) associated with backlog treatment can then be estimated.

DEFINITION OF BACKLOG

The term 'backlog' has recently gained a great deal of popularity among forest management decision makers in spite of the fact that no clear definition of the term exists. This has not discouraged various groups from estimating the magnitude of backlog area on a regional or national basis.

F.L.C. Reed and Associates (1980) refer to 1977 Ontario figures that suggest "40,000 hectares per year are being added annually to the backlog of unregenerated lands" in the province.

At the National Forest Regeneration Conference sponsored by the Canadian Forestry Association and held in Quebec City in 1977, estimates of the national backlog ranged from 4.7 million ha to 28.3 million ha (Paillé 1977). A range of this magnitude clearly attests to the ambiguity that surrounds definition of this element of the forest inventory.

For the purposes of this report, backlog will include areas with the following characteristics:

1. classed as productive and committed to forest production;
2. disturbed through natural or artificial processes (harvesting, fire, blowdown or pathogens);
3. not treated following these disturbances because of the high cost of treatment (absence of technology, lack of access), budgetary constraints or negligence in planning;
4. not satisfactorily stocked according to current assessments. (Assessments suggest that, without treatment, the areas will not become stocked within the period covered by management plans.)

ECONOMIC VALUE OF BACKLOG TREATMENT

It is important to appreciate that the value of reactivating backlog is actually the incremental value of treating these areas as opposed to not treating them. This incremental value can be estimated as the difference between the average future unit cost of delivered wood if backlog areas are not treated and the average future unit cost of delivered wood if backlog areas are treated. The economic value of recycling an area can, therefore, be estimated as the expected present value of the future cost savings of delivered wood (or losses) associated with the treatment. The present value of future cost savings of delivered wood attributable to the backlog treatment can then be viewed as the maximum amount that could be spent on backlog recycling operations *over and above* normal or 'average' treatment costs for current cutovers and recent disturbances.

In order to quantify this value, it is necessary to estimate expected future wood costs from an opportunity cost or 'benchmark' case, and to compare this with the expected future costs of delivered wood from treated backlog sites. The cost of wood from the benchmark case is the expected average future cost of wood if backlog sites are not recycled, or the future 'opportunity cost' of wood fiber. Cost estimates of future wood from backlog sites can then be compared with the expected average wood cost from the benchmark case to estimate the expected savings or losses that might be realized if this particular site were brought back into production today.

A number of assumptions are implicit in this treatment of the economics of backlog recycling. First, the analysis is relevant only over the long term because of the duration of the investment period. Second, this approach assumes that the only value that can be attributed to backlog recycling is future cost savings of delivered wood. However, if treatments undertaken today actually increase the wood supply in such a manner that the annual level of fiber production can be increased, the value of the associated incremental industrial consumption could also be attributed to the treatment.

WOOD COST AS A FUNCTION OF HAUL DISTANCE AND SITE PRODUCTION

Wood cost must be expressed as a function of readily quantifiable operational variables in order to differentiate sites along an economic dimension.

The first step in the analysis, then, is to define the cost of delivered wood as a function of physical operating variables. It will be assumed that the cost of delivered wood varies only with hauling distance and merchantable volume per hectare, and that all cost components can either be apportioned to one of these two physical variables or designated as a fixed cost. It is then possible to predict future wood costs by site, using only estimates of hauling distance and volume per hectare.

In order to allocate the direct portion of costs of delivered wood to haul distance and volume per hectare, it is necessary to examine individual wood cost components.

For several reasons, there is very little in the way of 'average' cost information for northern Ontario woodlands operations. Costing woodlands operations is very much a function of the nature of the operation and even the manner in which costs are allocated within an organization. In addition, cost information is considered confidential by most companies because it is such a major component of total production cost. Perhaps the most relevant study in this area is *Analysis of Wood Costs in the North American Forest Products Industries*[1].

Data for northern Ontario in this report are now 7 years out of date and, therefore, are relevant only in relative terms. With data from Statistics Canada[2] it can be estimated that the 1985 average unit cost of wood for pulp and paper mills in Ontario is approximately $40.00 per m^3. By using this estimate of the current cost of delivered wood and the cost components generated from the study cited in footnote 1, one can estimate wood cost components in 1984 dollars. Table 1 provides estimates of 1984 wood cost components in northern Ontario.

Table 1. Northern Ontario wood costs, 1984

Cost component	Estimated share (%) of cost of delivered wood	Estimated 1984 $/m^3
Stump to roadside	37.5	15.00
Roadside to mill	20.0	8.00
Road construction and maintenance	10.0	4.00
Camp cost	12.5	5.00
Administration and overhead	12.5	5.00
Stumpage	7.5	3.00
TOTAL	100.0	40.00

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[1] Anon. 1977. Analysis of wood costs in the North American forest products industries. Dep. Ind. Trade and Comm., Resour. Ind. Br., For. Prod. Group, Ottawa, Ont. (unpubl.)

[2] Statistics Canada. Pulp and paper mills. Cat. No. 36-204. Annual. Various issues.

If it is assumed that there will be no new additions to the inventory of backlog area, then the two physical parameters of haul distance and site productivity for the benchmark case can be approximated by using current average haul distance and site productivity estimates. With data from the study cited in footnote 1 (p. 3), the following 'averages' were estimated:

'Average' truck haul:	160 km
'Average' site productivity of harvested stands:	100 m^3/ha

THE WOOD COST EQUATION

Because it is necessary to express wood cost as a function of only haul distance and site productivity, the degree to which wood cost components vary with these physical parameters must be estimated. Table 2 provides estimates of the direct and fixed portions of each wood cost component as a function of haul distance or site productivity.

Table 2. Variablity of cost of delivered wood with haul distance and site productivity.

	Variable portion	Fixed portion	Total
SITE PRODUCTIVITY			
Stump to roadside	15.00	----	15.00
Subtotal	15.00	----	15.00
HAUL DISTANCE			
Roadside to mill	6.00	2.00	8.00
Road construction and maintenance	4.00	----	4.00
Camp cost	5.00	----	5.00
Administration and overhead	1.00	4.00	5.00
Subtotal	16.00	6.00	22.00
COSTS NOT AFFECTED BY DISTANCE OR PRODUCTIVITY			
Stumpage	----	3.00	3.00
TOTAL	31.00	9.00	40.00

It is assumed that there is a direct linear relationship between haul distance[3] and the variable portion of hauling cost, and a nonlinear inverse relationship between site productivity and the variable portion of stump to roadside or harvesting costs. On the basis of these assumptions, the future cost of delivered wood can be expressed as a function of haul distance and site productivity:

$$F = 3.00 * (C^n) + [(6.00 * (C^n) + \frac{X}{160} * 16.00 * (C^n)) + (\frac{100}{Y} * 15.00 * (C^n))]$$

Where: F = future cost of delivered wood ($\$/m^3$)
X = future haul distance (km) of backlog treatment proposal
Y = future productivity of site (m^3/ha) of backlog treatment proposal
C = 1 + the estimated real, annual compound unit cost increase
n = investment period (years)

THE WOOD COST TABLE

At this point, a matrix is produced depicting expected future wood costs from sites various distances from the processing center with various volumes per hectare. Future wood costs can be estimated by increasing the real 1985 wood cost estimate of \$40.00 per m^3 at a specified rate.

Contrary to popular belief, real unit costs of wood are not increasing in Ontario or Canada. Figure 1 illustrates nominal (current) and real (constant) costs of roundwood pulpwood in Ontario and Canada between 1955 and 1982, the latest year for which data are available. These data suggest that unit costs of wood have in real terms decreased over the past 30 years. One possible explanation for this trend is the improvement of the cost efficiency of woodlands operations through improved planning practices and technical innovation in woodlands operations.

A full appreciation of the trend evident in Figure 1 is an important point in the economic analysis of backlog recycling. If delivered wood fiber is going to have much higher real unit values in the future, then the returns associated with the treatment of backlog will be that much greater. Figure 1 implies that real unit costs of wood will not increase dramatically in the foreseeable future if wood fiber consumption patterns and the supply base itself do not change significantly. It will be assumed in this analysis that real unit

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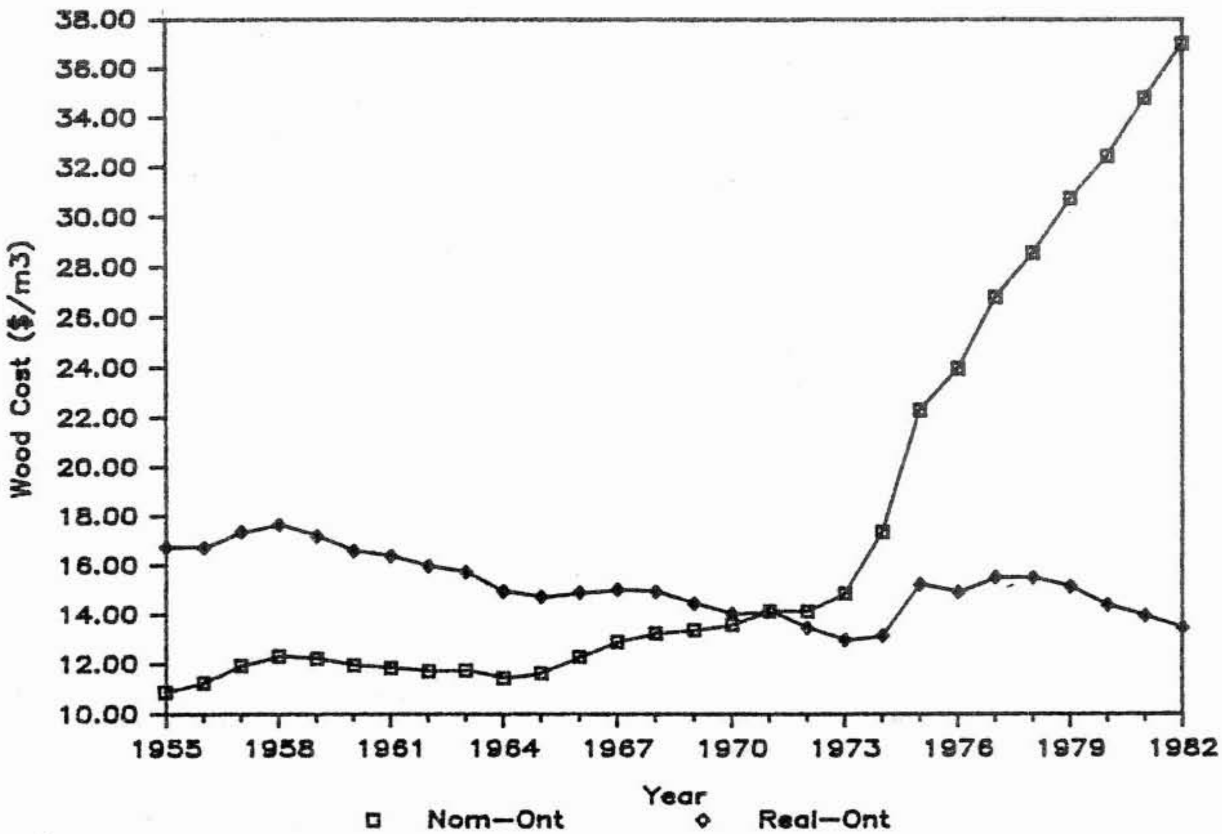
[3] It is unlikely that the variable portion of the cost of delivered wood attributable to hauling distance varies linearly with changes in hauling distance for any specific openation because of the logistical constraints related to transportation configurations. A linear relationship is assumed for purposes of illustration only. Managers should either define this relationship on the basis of their own operations or apply the linear assumption to an appropriate range of haul distances.



Source: Statistics Canada. Pulp and Paper Mills. Cat. No. 36-204. Annual. Various issues.

Figure 1. Nominal and real wood costs in northern Ontario and Canada, 1955-1982.

costs of delivered wood will increase at a rate of one half of one percent per year.

Table 3 illustrates estimated wood cost in 90 years for sites ranging from 80 m^3/ha to 240 m^3/ha, and haul distances ranging from 40 km to 320 km, with an increase in real unit cost of wood of one half of one percent per year. The expected cost of delivered wood from the benchmark case or the opportunity cost of not treating backlog sites appears at the matrix coordinate where haul distance is 160 km and merchantable volume is 100 m^3 per ha. The best estimate of the opportunity cost of this investment is \$62.66 per m^3.

Table 3. Estimated cost of delivered wood per m^3 by merchantable volume per hectare and hauling distance.

Backlog site merchantable volume at harvest (m^3/ha)	Estimated hauling distance from backlog site to mill (km)							
	40	80	120	160	200	240	280	320
240	30.16	36.42	42.69	48.95	55.22	61.48	67.75	74.01
220	31.05	37.31	43.58	49.84	56.11	62.37	68.64	74.90
200	32.12	38.38	44.65	50.91	57.18	63.44	69.71	75.97
180	33.42	39.69	45.95	52.22	58.48	64.75	71.01	77.28
160	35.05	41.32	47.58	53.85	60.11	66.38	72.64	78.91
140	37.15	43.42	49.68	55.95	62.21	68.48	74.74	81.01
120	39.95	46.21	52.48	58.74	65.01	71.27	77.54	83.80
100	43.87	50.13	56.40	62.66	68.93	75.19	81.46	87.72
80	49.74	56.01	62.27	68.54	74.80	81.07	87.33	93.60

THE PRESENT VALUE TABLE

Now that a table of future costs has been generated, the net present value (NPV) of the expected future cost savings for wood in relation to the benchmark case can be calculated for any given backlog proposal for which estimates of future hauling distance and site productivity are available. Net present value can be calculated by using the following equation:

$$NPV/ha = \frac{P\ [((40)\ (C)^n)-[(9)\ (C)^n + (X/160 * (16)\ (C)^n + 100/P * (15)\ (C)^n]]}{(1 + r)^n}$$

Where: P = productivity estimate of proposed backlog site (m^3/ha)
C = 1 + the estimated real, annual compound unit cost increase
n = investment period (years)
X = future haul distance of proposed backlog site (km)
r = real discount rate (%)

Table 4 represents 'best estimates' of the present value of the expected future cost savings for delivered wood associated with recycled backlog sites across a range of haul distance and site productivity classes. Estimates of future costs of delivered wood are taken from Table 3, and a real discount rate

Table 4. Estimated present value of future cost savings of wood per hectare by backlog proposal, merchantable volume per hectare, and hauling distance ($/ha).

Backlog site merchantable volume at harvest (m^3/ha)	Estimated hauling distance from backlog site to mill (km)							
	40	80	120	160	200	240	280	320
240	228.64	184.57	140.50	96.43	52.36	8.29	-35.78	-79.85
220	203.84	163.45	123.05	82.65	42.26	1.86	-38.54	-78.94
200	179.05	142.33	105.60	68.88	32.15	-4.57	-41.30	-78.02
180	154.26	121.21	88.15	55.10	22.05	-11.00	-44.05	-77.11
160	129.46	100.08	70.71	41.33	11.95	-17.43	-46.81	-76.19
140	104.67	78.96	53.26	27.55	1.84	-23.86	-49.57	-75.28
120	79.88	57.84	35.81	13.78	-8.26	-30.29	-52.33	-74.36
100	55.09	36.72	18.36	0.00	-18.36	-36.72	-55.09	-73.45
80	30.29	15.60	0.91	-13.78	-28.47	-43.15	-57.84	-72.53

Note: Real discount rate of 4%, 90-year investment period, real unit cost increase of delivered wood of one half of one percent per year.

of 4%, a 90-year rotation period, and an increase in unit wood costs of one half of one percent per year are used. The vertical axis in Table 4 represents the expected volume per hectare of the backlog proposal and the horizontal axis represents the expected future hauling distances from these sites. Note that the present value of treating a backlog site with the same estimated future haul distance and volume per hectare as the benchmark case is zero. This simply reflects the fact that at this point on the matrix, the expected future cost of wood for this site is the same as for the benchmark case.

Managers could use the expected present values of future cost savings shown in Table 4 in a number of ways. The present value of the treatment cost per hectare could be subtracted from the present value of future savings in Table 4 to approximate the net present value of the investment. If the net present value is positive, the investment is economically sound. Where financial resources are limited, schedules of backlog proposals could be analyzed and ranked in order of economic return.

SENSITIVITY ANALYSIS

In view of the broad nature of the assumptions and the long investment period involved, it is extremely important for managers to appreciate the sensitivity of this analysis to changes in the key estimates.

In order to examine sensitivity, it is useful to define a future cost savings objective in terms of net present value to serve as the minimum savings necessary to finance the incremental cost of backlog site preparation. Volume and distance coordinates for backlog proposals that meet this objective can then be identified from the present value matrix. The wood cost equation used to generate the present value matrix can be modified to reflect a change in one or more of the economic parameters and then a new present value matrix can be generated. The new range of volume per hectare and haul distance coordinates for candidate backlog areas that meet the present value objective can then be identified from the new matrix.

It will be assumed for this analysis that in terms of net present value the incremental treatment costs for backlog sites is \$150 per ha. This means that only sites that yield cost savings equal to or greater than \$150 per ha should be considered economically eligible for treatment.

Figure 2 depicts the "best estimates" of volume and haul distance coordinates of backlog sites that meet the objective of \$150 per ha. The curve represents the coordinates of backlog sites which, if treated, are expected to yield cost savings of \$150 per ha. The area above and to the left of the curve contains the range of coordinates of proposals for treating backlog areas so as to yield savings in excess of \$150 per ha.

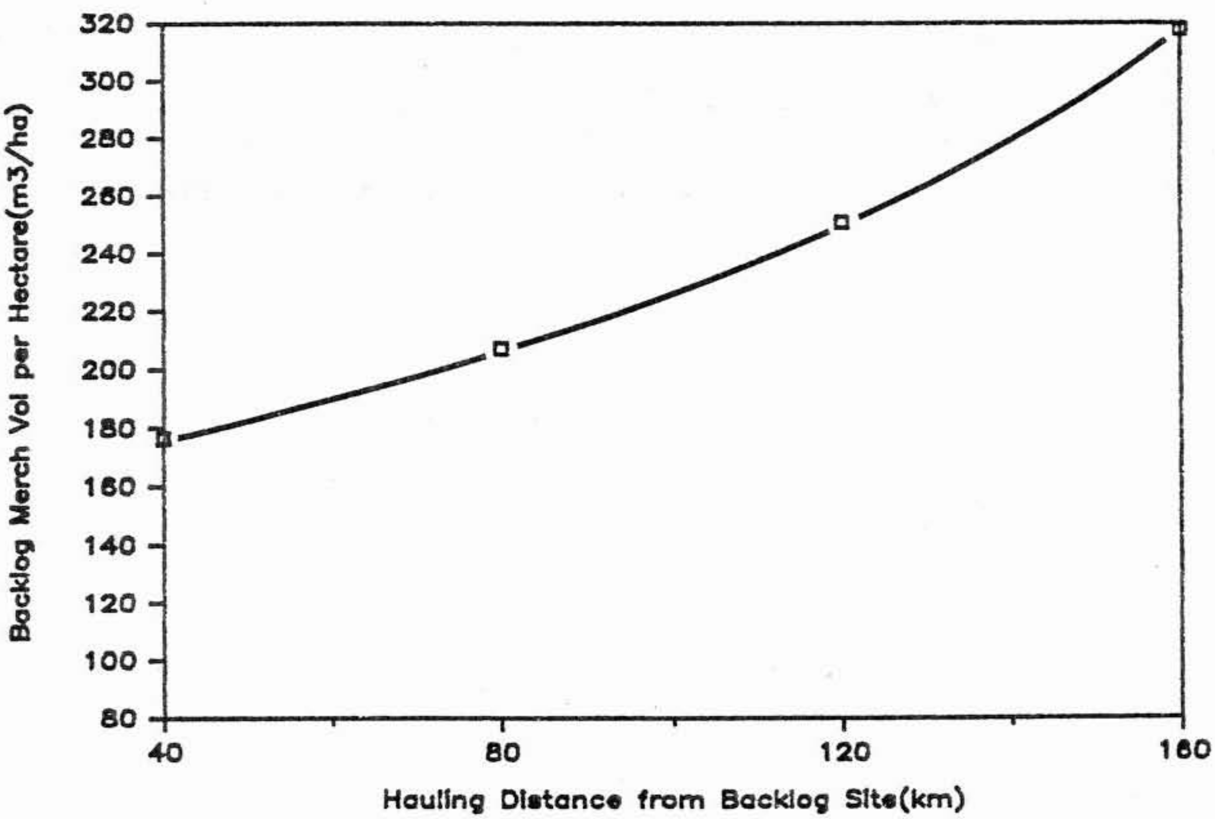
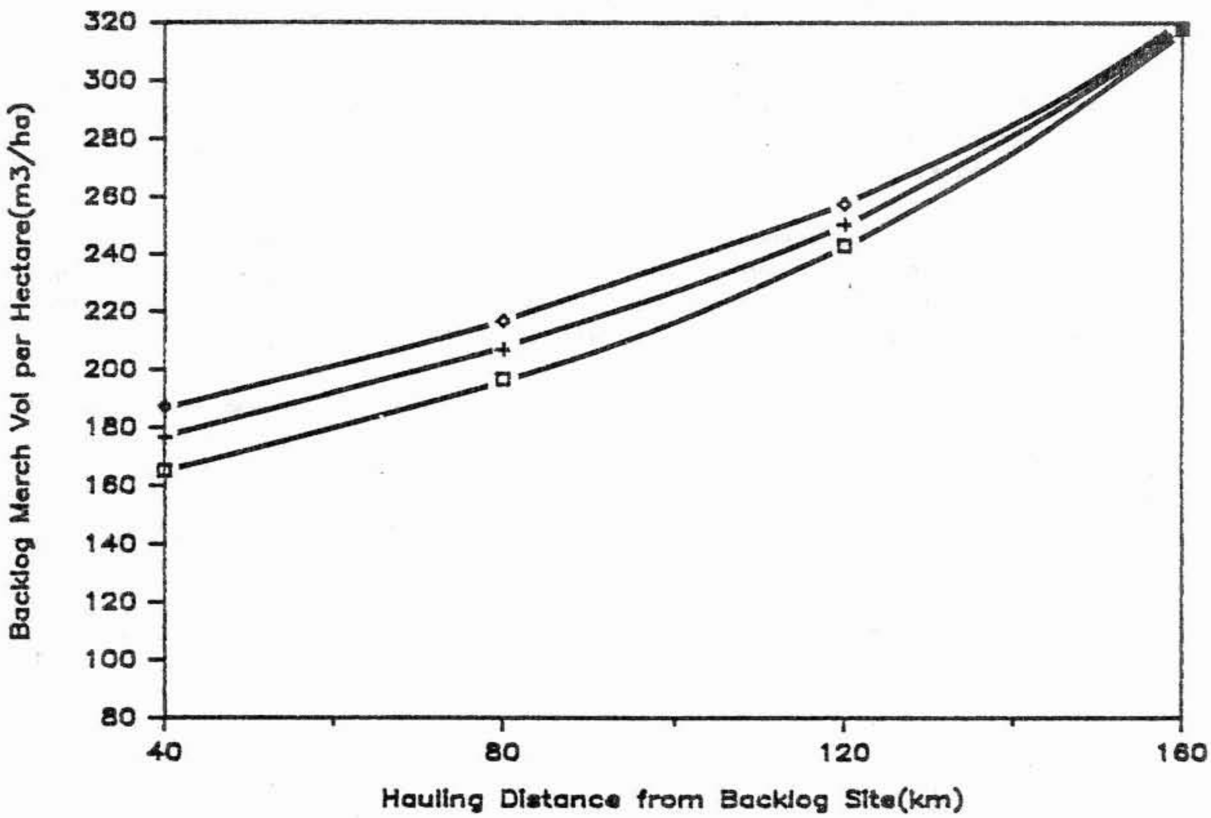


Figure 2. Best estimates of volume and haul distance combinations that meet a savings objective of \$150/ha in present value terms.

Figure 3 tests the sensitivity of the range of economically eligible backlog proposals to a 15% variation in future hauling cost above and below the best estimate. The middle curve represents the best estimate as shown in Figure 2.



□ Increase of 15% from best estimate of future costs varying with haul distance
\+ Best estimate case
◇ Decrease of 15% from best estimate of future costs varying with haul distance

Figure 3. Sensitivity of economically eligible backlog sites to 15% variations in future hauling cost with a savings objective of $150/ha in present value terms.

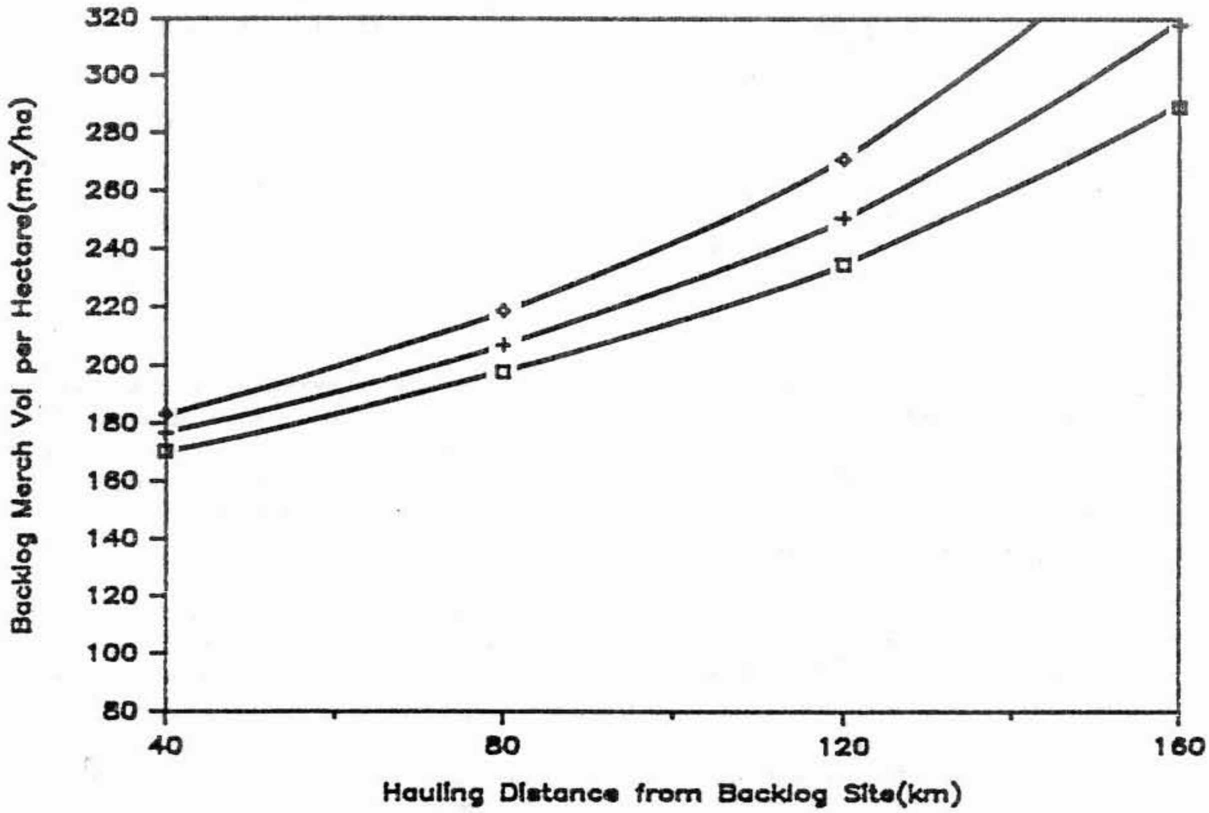
A number of observations can be made from Figure 3. First, if hauling costs increase, the range of economically eligible backlog sites increases for all proposals with estimated distances less than the benchmark estimate of 160 km. This is due to the fact that the potential for savings is higher except when the hauling distance of the backlog proposal is greater than the hauling distance estimated for the benchmark case.

Second, the magnitude of savings or losses decreases as hauling distance estimates for the backlog proposal approach the benchmark estimate. This is due to the fact that at the estimated benchmark hauling distance of 160 km, even though absolute costs have changed, the magnitude of savings and losses has not. The hauling cost for the benchmark case has been reduced or increased by the same amount as the backlog proposals for all proposals with a haul distance of 160 km.

Finally, a 15% variation in the hauling cost component of the wood cost function does not appear to have a dramatic impact on the range of economically eligible backlog sites across the relevant range of haul distances and volumes per hectare. This is because the cost savings are not experienced until the end of the investment period. When discounted to present value terms, these changes are not extremely significant.

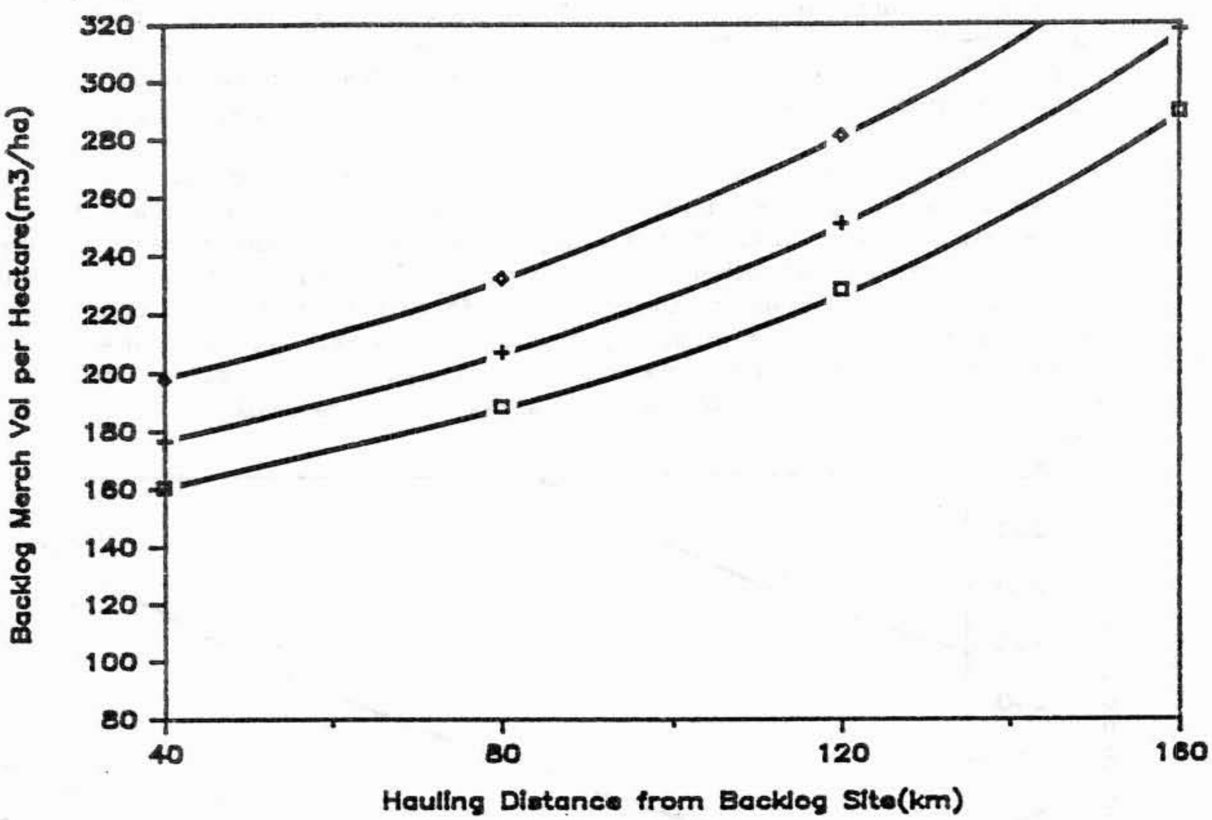
Figure 4 tests the sensitivity of the range of economically eligible backlog proposals to 15% variations in future harvesting cost on either side of the best estimate. The curve in the middle represents the best estimate as shown in Figure 2. The same observations made for hauling cost variations can be made for variations in harvesting cost. This time, however, more sites become eligible for treatment with increases in harvesting cost when estimated volumes per hectare for backlog proposals exceed the best estimates of 100 m^3 per ha. The magnitude of the impact decreases as the estimated volumes per hectare of backlog proposals approach the benchmark estimate because the magnitude of savings remains unchanged at the benchmark estimate of 100 m^3 per ha. Again, the margin of economically eligible sites does not appear to be extremely sensitive to changes in future harvesting costs. In addition, it appears that the analysis is more sensitive to changes in harvesting cost than to changes in hauling cost over the relevant range of volumes per hectare and hauling distances.

Figure 5 illustrates the range of backlog proposals that would be economically eligible for treatment if the total unit cost of delivered wood increased at a rate 15% above and below the best estimate of one half of one percent per year. It is apparent from Figure 5 that altering all future cost components by 15% has a significant impact on the range of eligible backlog sites. It is worthy to note that, as a result of the compounding effect, the impact of costs increasing at a rate greater than 15% of the best estimate is more significant than if costs increased at a rate of 15% less than the best estimate.



□ Increase of 15% from best estimate of future harvesting cost
+ Best estimate case
◇ Decrease of 15% from best estimate of future harvesting cost

Figure 4. Sensitivity of economically eligible backlog sites to 15% variations in harvesting cost with a savings objective of $150/ha in present value terms.



□ Increase of 15% from best estimate of real annual cost increase per unit of wood
+ Best estimate case
◇ Decrease of 15% from best estimate of real annual cost increase per unit of wood

Figure 5. Sensitivity of economically eligible backlog sites to 15% variations in compounded annual increases in total cost of delivered wood. (A savings objective of $150/ha in present value terms is assumed.)

Because of the time involved the analysis is extremely sensitive to the choice of discount rate and investment period. A real discount rate of 4% is taken from Row et al. (1981) as an appropriate discount rate for long-term forestry investments. An investment period of 90 years is chosen to reflect the average future rotation of managed softwood stands in northern Ontario.

Figure 6 tests the sensitivity of the range of economically eligible backlog proposals to 15% variations in the discount rate above and below the best estimate of 4%. Clearly, the analysis is also very sensitive to the choice of discount rate. All other things being equal, managers employing rates of return in excess of 5% would find it very difficult to justify backlog recycling solely for the purpose of reducing future wood costs. As in Figure 6, an increase in the discount rate above the best estimate has a greater impact on the range of economically eligible backlog sites than a decrease of the same magnitude.

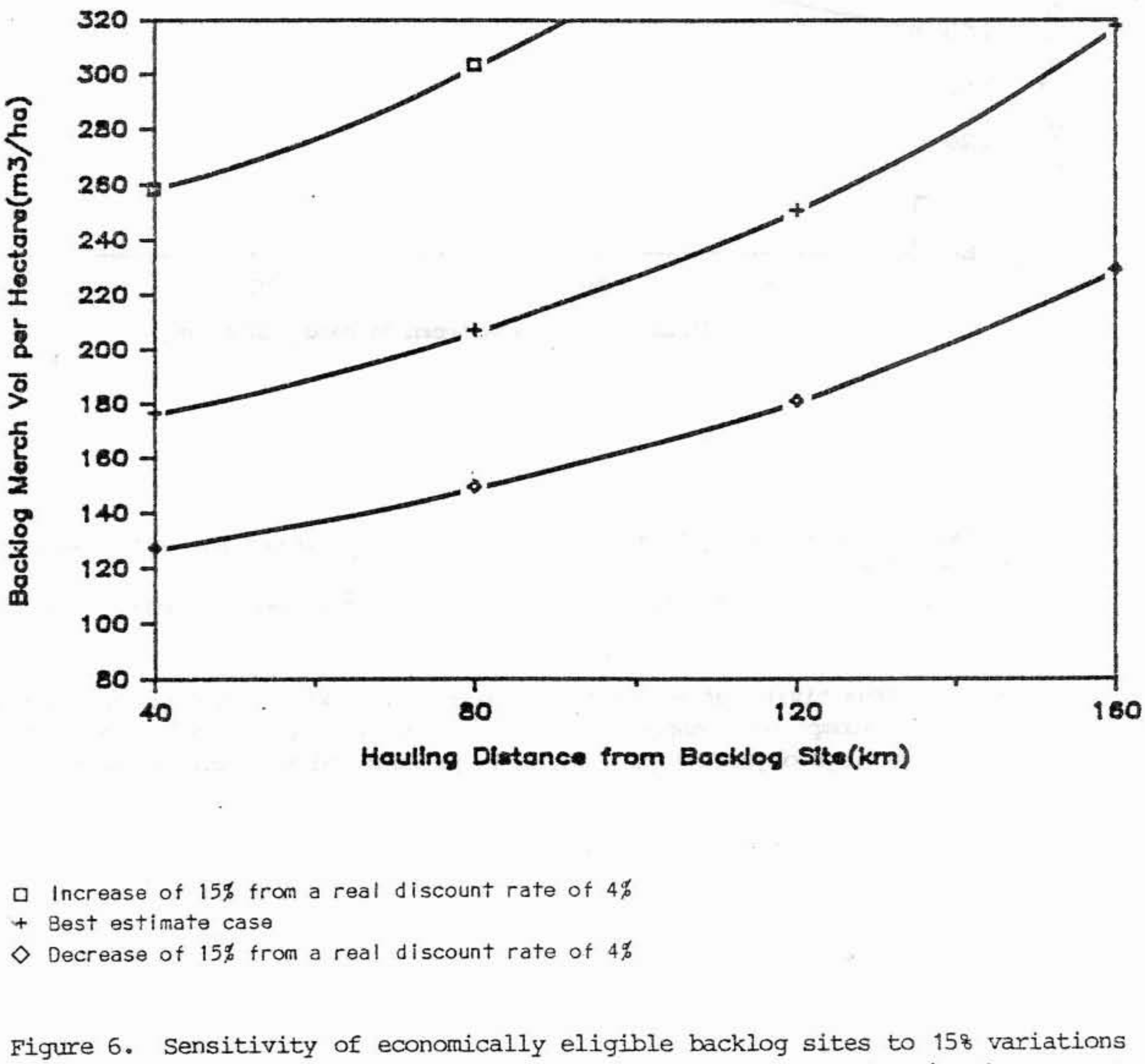
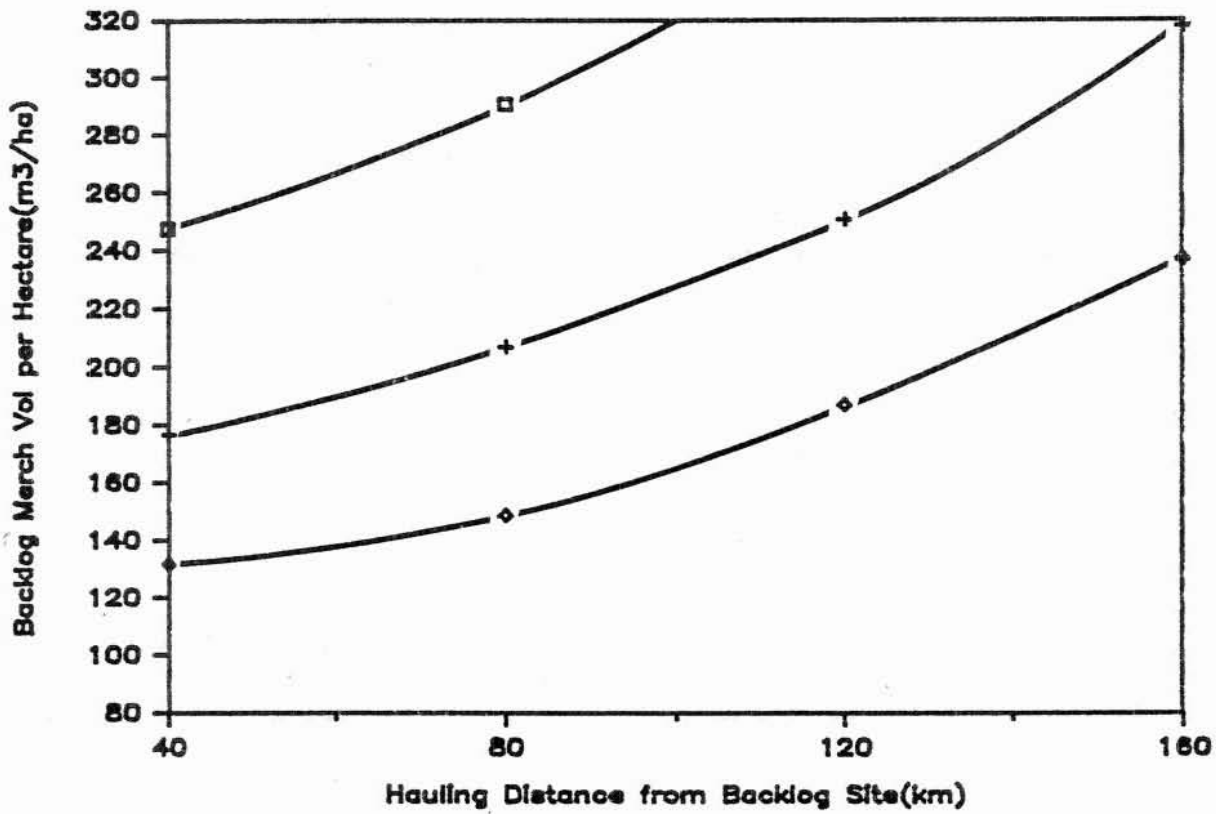


Figure 6. Sensitivity of economically eligible backlog sites to 15% variations in the discount rate. (A savings objective of $150/ha in present value terms is assumed.)

Figure 7 tests the sensitivity of the range of economically eligible backlog proposals to 15% variations in the investment period above and below the best estimate of 90 years. A reduction in rotation age greatly increases the range of economically eligible backlog proposals because the returns, defined as cost savings, are realized sooner. Again, because of the compounding effect, an increase in the rotation age of 15% above the best estimate has a greater impact on the range of eligible backlog sites than a decrease of 15%.



□ Increase of 15% from the best estimate of the investment period
+ Best estimate case
◇ Decrease of 15% from the best estimate of the investment period

Figure 7. Sensitivity of economically eligible backlog sites to 15% variations in the investment period. (A savings objective of \$150/ha in present value terms is assumed.)

DISCUSSION

Defining the cost of delivered wood as an aggregate function of physical site and non-site variables can provide managers with an economic dimension necessary for the efficient scheduling of backlog treatment. For purposes of illustration, this analysis employs only two independent variables--volume per hectare at the time of harvest and expected hauling distance; however, managers should be encouraged to use other physical variables such as average stand diameter, terrain, load size and road class in order to define a cost function which more appropriately reflects the operating environment. Managers should also be encouraged to employ economic parameters which best reflect the financial objectives and constraints particular to their own organization.

If an average incremental treatment cost is assumed as it has been in this analysis, this approach can be used to rank backlog proposals by future savings potential. If incremental treatment costs can be estimated for each proposal, different proposals can be ranked by net present value. This approach could be a powerful planning tool in areas other than backlog scheduling. The cost function itself could provide an economic dimension to the forest inventory, and this information would be invaluable in the preparation of operating plans.

In spite of the manner in which this approach is employed, managers should be fully aware of the sensitivity of present value to changes in the key variables. Estimates of the physical parameters for the benchmark case and the cost function should be altered periodically to reflect operational dynamics and changes in the physical resource.

This approach to backlog scheduling offers one more dimension to operational planning procedures. The approach would ensure that the financial objectives of the manager's organization are being met, and further, that financial and operating constraints are being considered in the operational planning process.

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