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HARVESTING WITH RESIDUAL BLOCKS OR LEAVE STRIPS: AN ECONOMIC COMPARISON

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Abstract

From the perspective of improving habitat quality for wildlife, harvesting (clearcutting) with residual blocks represents an alternative to large-area clearcuts, in which the harvested areas are separated by narrow leave strips of standing timber. In 1997, Quebec's Ministry of Natural Resources and Ministry of the Environment and Wildlife cooperated with Donohue Inc. and FERIC in a study that is comparing the economic impacts and wildlife utilization for the two harvest scenarios. This Technical Note describes the results of a comparative analysis of harvesting costs for the two approaches, and demonstrates that over a 30-year horizon, the approach with residual blocks averaged approximately \$0.45 to \$0.67 per m³ more expensive on an annual basis (over a 30-year period) than the current practice of using leave strips.

Introduction

For several years, the forest industry has sought alternatives to large-area clearcuts in response to various factors such as public pressures and concern about wildlife habitat, particularly in boreal softwood forests. One of the proposed approaches is harvesting (clearcutting) with residual blocks, in which the harvested areas are separated by unharvested stands of equivalent area.

In Quebec, for example, the regulations permit harvest areas of up to 150 ha with equivalent-size residual blocks left standing (Anon. 1996). In 1997, Quebec's Ministry of Natural Resources (Ministère des Ressources naturelles, MRN) and Ministry of the Environment and Wildlife (Ministère de l'Environnement et de la Faune, MEF), in cooperation with Donohue Inc. and FERIC, undertook a study with the goal of mea- suring the effectiveness of this harvesting approach in terms of habitat preservation and the populations of six wildlife indicator species (sparrows, squirrels, spruce grouse, hares, ducks, and moose). Within this cooperative project, FERIC's mandate was to compare the economic impact of scenarios based on harvesting with residual blocks and the conventional approach, which consists of performing a series of clearcuts separated by 60-m leave strips.

The current report provides the results of a harvesting cost analysis for the two scenarios using FERIC's *Interface* software.

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Methodology and Working Assumptions

In this project, MEF's work on wildlife densities is being carried out primarily in a harvested area within Donohue Inc.'s St-Thomas limits, about 30 km north of the village of St-Thomas (Que.). However, a larger area that was more homogeneous in terms of the forest cover, the topography, and the stream network was used for the simulation of harvesting costs. This area (about 3000 ha) was located northwest of the company's Myrica camp (130 km north of St-Thomas).

The overall analytical approach was to simulate the stages of road construction and harvesting for both scenarios over the same area, taking advantage of the spatial analysis capabilities of Donohue Inc.'s GIS software. Figure 1 illustrates the two harvesting scenarios for the simulated area.

With the assistance of a supervisor working on Donohue's operations, a realistic road network and block layout were established; both accounted for the delay before returning to harvest the 60-m leave strips in the first scenario and the residual blocks in the second scenario. The follow-up harvest would be done once the areas cut in the first year reached an acceptable level of regeneration (in Quebec, an average height of 3 m). After defining the road network and the harvested areas, the following data were calculated by the GIS software:

- the areas (respectively) of the entire sector, of the harvested blocks, of the residual blocks, of the streamside protection strips, and of the 60-m leave strips;
- the length of the roads;
- the average distance between the blocks;
- the perimeter of the blocks; and
- the average skidding distance.

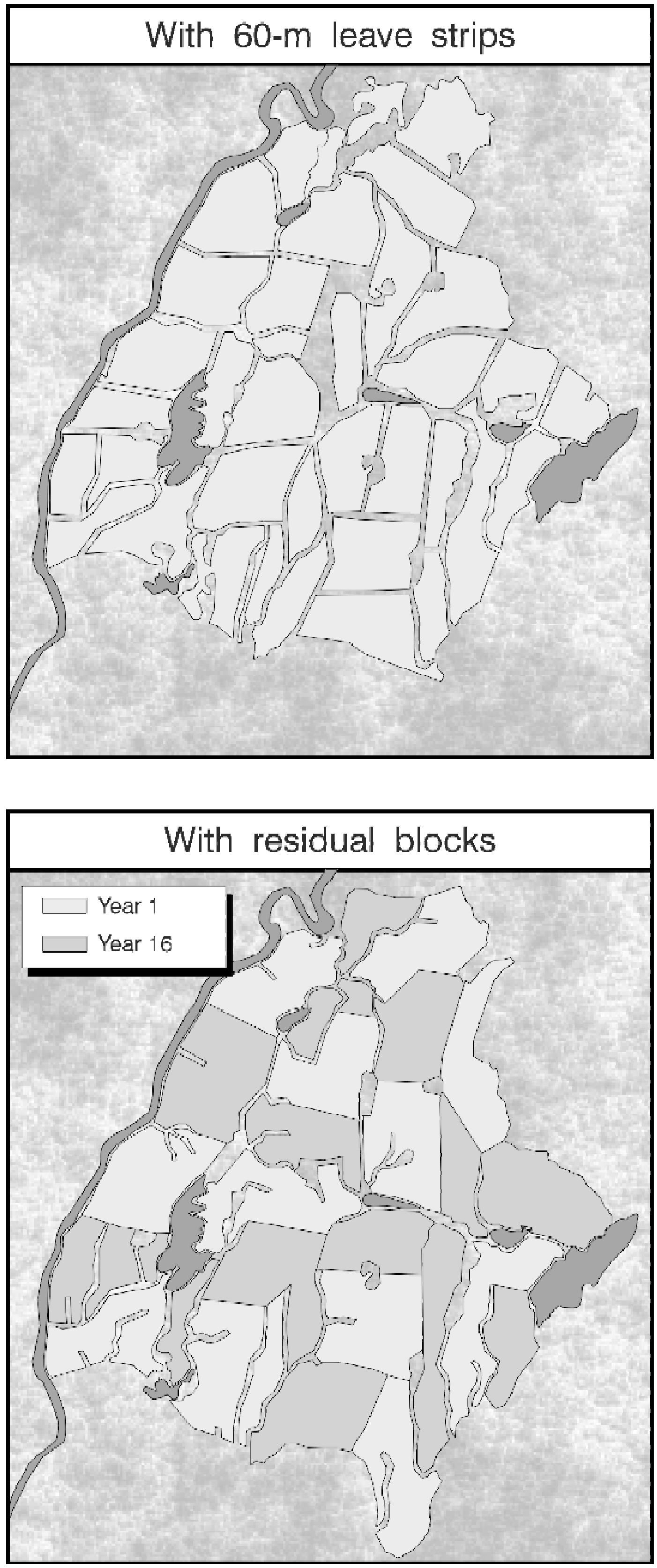

Figure 1. A comparison of the harvesting scenarios with 60-m leave strips and with residual blocks.

The direct harvesting costs with a full-tree system under the forest and site conditions for the study area were simulated using FERIC's *Interface* software. The harvesting phases comprised mechanized felling, extraction by cable skidder, roadside delimbing, and tree-length loading onto tractor-trailers. The average haul distance to the mill was assumed to be equivalent in the two scenarios. In addition, indirect costs that are difficult to link with specific volumes (e.g., administration and planning fees, which can vary with the area to be harvested) were excluded from the analysis.

Certain assumptions were used from the start to permit calculation of the costs of the two scenarios (Table 1) and to estimate the impact of the two approaches on the following variables:

- the length and thus the cost of the road network;
- the direct harvesting cost, including travel between the blocks; and
- block delineation costs, as a function of the perimeter of the blocks to be flagged.

Note that the costs presented in Table 1 and in all subsequent tables do not represent Donohue Inc.'s real costs, but nonetheless represent realistic estimates for this region of the country.

Table 1. Assumptions used in calculating the cost of the two scenarios

	With 60-m leave strips	With residual blocks
Average volume, year 1 (m³/ha)	115	115
Delay between interventions (years)	15	15
Average volume, year 16 (m³/ha)[a]	103.5	109.3
Road construction cost ($/km)	10 000	10 000
Road rehabilitation cost, year 16 ($/km)[b]	1 000	2 000
Block delineation cost ($/km of block perimeter)	40	40

[a] Windthrow is expected to reach 10% in the 60-m leave strips and 5% in the residual blocks after 15 years. Note that the estimate of 10% windthrow after 15 years in the 60-m leave strips is conservative. In certain areas at greater risk of windthrow (e.g., thin soils, mountains), this value could be considerably higher.

[b] Because of the lower volumes to harvest in the scenario with 60-m leave strips, investment in road rehabilitation is 50% lower than in the scenario with residual blocks.

Table 2. Results of the area and volume analyses for the two scenarios

	With 60-m leave strips		With residual blocks	
	Year 1	Year 16	Year 1	Year 16
Area of harvest blocks (ha)	2 486	157	1 434	1 414
Number of blocks	37	n.a.	12	11
Average area of cut blocks (ha)	67	n.a.	120	129
Volume harvested (m³)	285 890	16 250	164 910	154 550
Total volume (m³)	302 140		319 460	

Results

Volumes

Table 2 presents the volume and area data for the two scenarios. In the scenario with 60-m leave strips, 94.6% of the available volume in a given area is harvested in year 1, versus 51.6% in the scenario with residual blocks. Thus, in FERIC's simulation, 1.7 times as much area must be accessed each year for the scenario with residual blocks to be able to harvest a volume of timber equivalent to that in the approach with 60-m leave strips. However, the size of the cut blocks almost doubled in the scenario with residual blocks, from an average of 67 ha to 120 ha.

Roads

The main consequence of the approach with residual blocks is obviously the decreased wood volumes obtained per kilometre of road during the first years of harvesting. Despite this, the cost does not double because not all of the road network must be established immediately. Over the long term, costs are higher as a result of the added road maintenance required upon returning to the site to harvest the residual blocks. Table 3 summarizes the road lengths for the road networks illustrated in Figure 2.

In the scenario with residual blocks, it is not necessary to develop the road network to provide access to the entire area in year 1. However, the road layout must account for the need to return to the site to harvest the residual blocks, but without crossing harvested blocks in the process of regenerating. The difference in the road costs is high for the first 15 years ($2.49/m³ versus $3.40/m³) because of the smaller volumes that will be extracted per kilometre of road in the scenario with residual blocks.

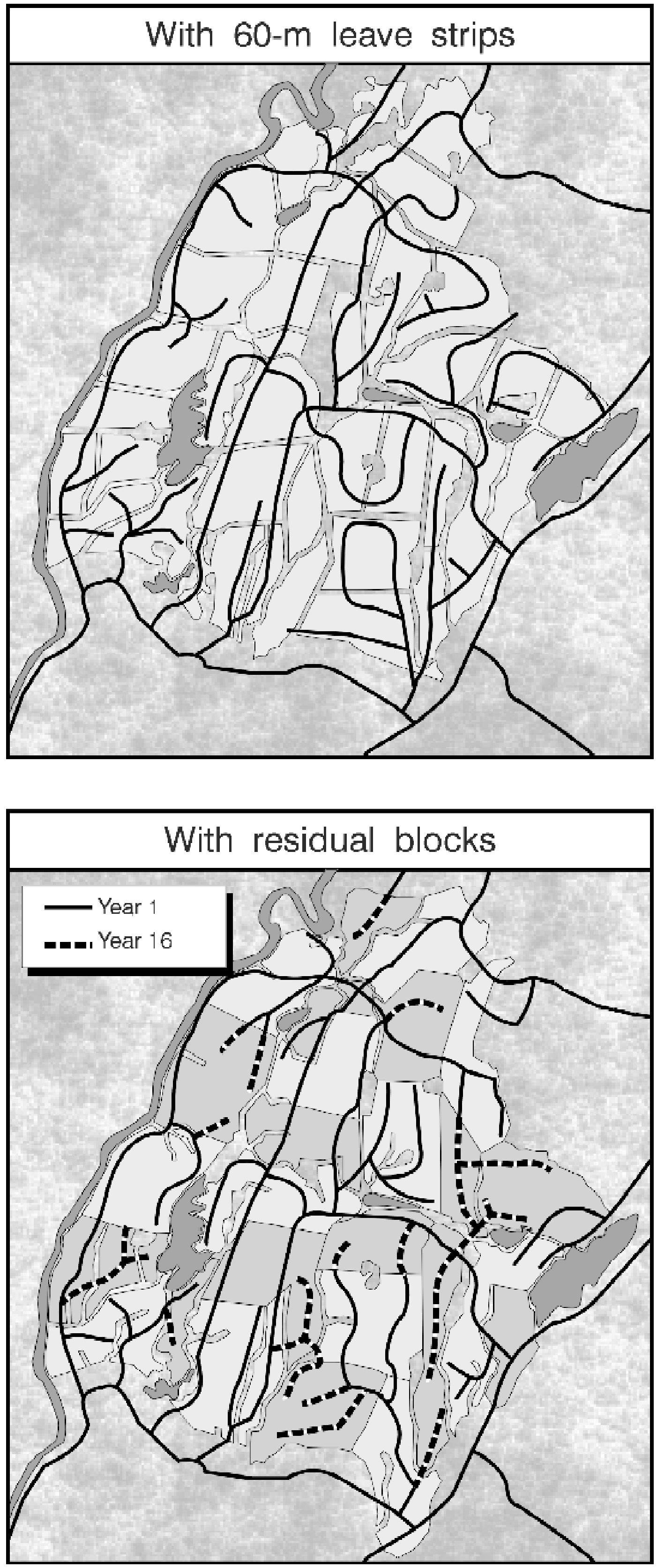

Figure 2. The network of access roads for the two scenarios.

Block Delineation

Another parameter that can be affected by the layout of the harvest blocks is the cost of flagging the perimeters of the blocks (Table 4). As can be seen, the cost of block delineation is a very minor component of the overall wood cost. The cost is lower in the scenario with residual blocks because of the lower total perimeter of the cut blocks.

Harvesting

The direct harvesting cost can be affected by the harvesting scenario that is chosen if the utilization rates of the harvesting machines decrease as a result of increased travel between blocks. An estimate of the harvesting costs for the two scenarios is provided in Table 5 for a full-tree harvesting system.

Table 3. Road network summary for the two scenarios

	With 60-m leave strips		With residual blocks	
	Year 1	Year 16	Year 1	Year 16
Road construction (km)	71.1	0.0	56.0	23.0
Volume harvested per km (m^3)	4 020	230	2 945	1 955
Road construction cost ($)	711 000	0	560 000	230 000
Road rehabilitation cost ($)	n.a.	71 100	n.a.	112 000
Road construction plus rehabilitation cost ($)	711 000	71 100	560 000	342 000
Total cost ($)	782 100		902 000	
Total cost ($/$m^3$)	2.49	4.38	3.40	2.21

Table 4. Cost of block delineation in the two harvesting scenarios

	With 60-m leave strips	With residual blocks
Perimeter of blocks and strips (km)	155.9	90.6
Total delineation cost ($)	6236	3624
Total cost ($/$m^3$)	0.02	0.01

Table 5. Direct harvesting costs for the two scenarios

	With 60-m leave strips		With residual blocks	
	Year 1	Year 16[a]	Year 1	Year 16
Cost of the phase ($/$m^3$)				
Mechanized felling	4.47	4.71	4.47	4.47
Extraction by cable skidder[b]	6.20	6.79	6.20	6.20
Delimbing	4.16	4.25	4.16	4.16
Loading	1.39	1.45	1.39	1.39
Total	16.22	17.20	16.22	16.22

[a] During recovery of the 60-m leave strips, the dispersion of the volumes is assumed to decrease machine utilization by 5% during felling, 4% during loading, and 2% during delimbing.

[b] The average skidding distance is 350 m in each case except for year 16 in the harvest with 60-m leave strips; in this case, the average distance when harvesting the leave strips increases to 450 m.

Felling costs were generally not affected by the differences between the two harvesting scenarios. Despite a much greater average distance between the harvested areas in the scenario with residual blocks, the travel time between blocks was minimal in comparison with the time spent harvesting within the blocks. In contrast, in harvesting the 60-m leave strips in year 16, the feller-buncher's utilization rate was affected to some extent by the low harvest volumes and the large area over which they were spread.

In terms of extraction costs, the road network was designed so that the maximum average distance was limited to around 350 m. During the recovery of the 60-m leave strips in year 16, this average distance increased to about 450 m and skidding costs increased slightly.

As was the case for felling, the *Interface* simulation of roadside delimbing suggested that delimbing was not affected by the differences between the two scenarios, except during recovery of the 60-m leave strips; because the volumes in the leave strips were more dispersed over the site, delimbing costs increased slightly.

The simulation showed no negative effect on loading in the scenario with residual blocks. In effect, waiting time for the tractor-trailers could probably be used for travel between blocks. In addition, the volumes harvested per kilometre of road were sufficiently large to keep the loader's utilization rate high. A 4% correction was applied to the loader's utilization rate for recovery of the 60-m leave strips.

Overall, the direct harvesting costs were comparable for the two harvesting scenarios in year 1. However, the expected cost of recovering the leave strips (during year 16) would be higher because of the low volume to be recovered and the large area over which the volume is spread.

FERIC's simulation was performed using a full-tree harvesting system. With a shortwood harvesting system, the cost estimates would probably have been different, but the relative differences between scenarios would have been comparable.

Discussion

Table 6 presents a summary of the costs associated with the two scenarios, harvesting with 60-m leave strips and with residual blocks, if the two scenarios were adopted over a company's entire operating area. In this situation, the average cost for the initial years (1-15) must be considered separately from the cost for the years in which the second intervention occurs, whether for harvesting the 60-m leave strips or for harvesting the residual blocks.

In addition, there are two possible approaches in a harvesting scenario based on residual blocks. In approach A, the harvest in years 16 to 30 concentrates solely on the residual blocks left after the first 15 years. This approach takes full advantage of the road network established during the first 15 years of harvesting. However, after 30 years, the company must start over again at zero and open a completely new area for harvesting.

In approach B, harvesting in years 16 to 30 is divided equally between the residual blocks created by harvesting in years 1 to 15 and entirely new areas. As a result, the number of kilometres of road that must be built remains the same from year to year. This assumes that the wood volumes will be harvested over the whole area in the same proportions as were used in the simulation.

Based on this simulation, it can be seen that over a 30-year horizon, the average annual direct cost associated with the scenario with residual blocks is higher (by $0.45/m^3 in approach A and by $0.67/m^3 in approach B) than in the scenario with 60-m leave strips. This difference arises mainly from increased road construction and maintenance costs, particularly during the first 15 years of implementing this regime, in which the difference amounts to $0.90/m^3 in current dollars. A discounting rate of 4% and a planning horizon of 30 years (i.e., one cycle with approach A) were used in these calculations.

After the first 15 years, whether all the residual blocks (approach A) or only half of these blocks (approach B) are recovered annually, the cost difference between the two scenarios decreases, particularly since recovering the 60-m leave strips leads to a slightly increased harvesting cost.

Table 6. Total cost of the two harvesting scenarios over a 30-year period

	With 60-m leave strips		With residual blocks			
			Approach A		Approach B	
	Years 1-15	Year 16+	Years 1-15[a]	Years 16-30[b]	Years 1-15	Year 16+
Direct cost ($/m³)						
Roads	2.49	2.59	3.40	2.21	3.40	2.82
Delineation	0.02	0.02	0.01	0.01	0.01	0.01
Harvest	16.22	16.27	16.22	16.22	16.22	16.22
Total (current $)	18.73	18.88	19.63	18.44	19.63	19.05
Annual average over 30 years (constant $)[c]	19.87		20.32		20.54	
Difference[d]	—		0.45		0.67	

[a] Also for years 31 to 45 and so on.

[b] Also for years 46 to 60 and so on.

[c] Discounting rate of 4% and a 30-year period, based on $\sum_{1}^{30} \textit{annual discounted cost} \times \left(\frac{(1 + rate)^{30}}{(1 + rate)^{30} - 1} \right) \times rate$

[d] In comparison with the scenario with 60-m leave strips.

Obviously, *these results are based on simulations* and not on data from actual harvests. However, FERIC worked with Donohue Inc. to ensure that the spatial arrangements of the roads and of the cut blocks were realistic. As a result, the order of magnitude of the results appears to be realistic, but the actual results could well vary depending on the assumptions used for the simulation.

Despite a slightly higher average annual cost, the scenario with residual blocks could lead to various benefits in terms of the annual allowable cut in an area. If the windthrow risk decreases because of the larger stands of residual forest, there would be a significant increase in the volume available for recovery in the second harvest.

Note that several indirect costs that would have to be addressed by managers in a real operation were not included in FERIC's analysis. For example, the scenario with residual blocks spreads the work over a significantly larger area each year. This would probably increase management, supervision, and inventory costs, despite an equivalent annual harvest volume.

Depending on the approach chosen for the harvest with residual blocks (A or B), the protection costs and the risk of losses to windthrow, fire, insects, and other factors would be different. In one case, the entire available volume in an area is harvested over a 30-year period (approach A), whereas in the other, operations extend over 45 years (in approach B, 15 years for the initial access to the area, 15 years to harvest half the residual blocks, and 15 years to harvest the remaining residual blocks). However, approach B evens out the number of kilometres of road to build each year, and this facilitates the management and allocation of contracts with contractors, as well as the preparation of annual budgets.

These costs and benefits are difficult to quantify but are nonetheless real. They must thus necessarily form part of the overall analysis of the cost of the two harvesting scenarios.

In a similar, unpublished analytic exercise carried out in 1995 with Gérard Crête and Fils Inc. (St-Séverin, Que.), FERIC found a $0.57/m³ cost difference in favor of the approach with leave strips compared with the approach with residual blocks (approach A). This difference was also attributable in large part to the additional costs of roads and, to a lesser extent, to increased travel by the delimber. In this analysis, which was based on real data, the cut blocks were smaller (on the order of 25 ha), and this increased the significance of travel between the blocks in comparison with the time spent working within the blocks.

Conclusions

The simulation reported in this Technical Note, conducted for an area of around 3000 ha, permitted an evaluation of the cost difference between two harvesting scenarios that differed in the spatial arrangement of the harvested areas. The scenario with 60-m leave strips gave the lowest average direct annual cost ($19.87/m³), whereas the scenario with residual blocks was $0.45/m³ more expensive if all the available volume in the blocks was recovered over a 30-year horizon and $0.67/m³ more expensive if the harvesting was divided so as to obtain half of the harvest from the residual blocks and the remainder from new stands.

Apart from the economic aspects, the overall goal of this project is to verify *in situ* the quality of wildlife habitat and consequently the wildlife population density as a function of the spatial distribution of the harvest blocks. It is possible that in the context of sustainable forest management, the improvement in habitat quality associated with the residual blocks scenario could make this method more attractive. Nonetheless, the cost increase associated with this approach, particularly over the first years of implementing the scenario, must be recognized. Wildlife population studies will be conducted by MRN and MEF over the next three years to provide more insight into this issue.

FERIC's *Interface* software can permit the analysis of various harvesting scenarios as a function of the spatial distribution of the harvested areas and of the unique constraints that arise from each combination of stand, terrain, and harvesting equipment.

References

Anon. 1996. Regulation respecting standards of forest management for forests in the public domain. (Forestry Act.) Gov. of Quebec, Ste-Foy, Que. R.S.Q.c. F-4.1, r.1.001.1, 28 May 1996 (section 79).

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